50-263

STRESS ANALYSIS

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50-263
6/15/84

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Director of NRR
June 15, 1984
Attachment (1)

STRESS ANALYSIS

FISHER CONTROLS COMPANY

MARSHALLTOWN, IOWA 50158

AUTOMATIC CONTROL EQUIPMENT
SINCE 1880

Reply to: **FISHER CONTROLS COMPANY**, R. A. Engel Technical Center, P.O. Box 11, Marshalltown, Iowa 50158

March 19, 1981

Mr. Dick Goranson
Northern States Power
Monticello Nuclear Generating Station
Monticello, MN 55362

Subject: 18" Type 9200 containment isolation valves
Fisher Serial Numbers 127571-6 and 127579

Dear Dick:

I have completed a response to the action items of our 3/4/81 meeting in Marshalltown. This response substantiates our earlier conclusion that a change should be made to a 17-4 PH shaft (SA564/630) and limited angle of opening of 40° or less. The attached response also includes several attachments of reference and support material.

If you require further clarification, call at your earlist convenience.

Lee Waite

Lee Waite
Nuclear Qualification Engineer

W4M1

RESPONSE

Northern States Power, Monticello
Containment Isolation Butterfly Valves
18" 9210 Inflatable T-Ring
S.N. 127571- 127576, 127579; Shop Order P-73605-02; -05
Flow into Hub T = 180°F ΔP Shutoff = 62 psig ΔP = 56 psig
17-4 PH Shaft (SA 564 GR 630) Cast Carbon Steel Disc
#1 Bushing (SS/TFE)

To determine the appropriate maximum angle of opening the stresses due to loading (including dynamic torque) will be considered for all critical locations. This includes the following considerations:

1. Stress in the shaft at the disc hub* due to bending and torsion.

2. Stress in the shaft at the disc hub due to torsion and transverse shear.

3. Stresses at the pinned disc shaft connection.

4. Stresses in the disc.

5. Stresses at the keyed actuator shaft connection.

6. Stresses in the actuator.

7. Stresses in the shaft bushing.

Stresses in other components such as the body or seal system are not affected by dynamic torque. Case 1, 2, 3, 5 and 7 above are investigated with the use of a computer program which determines allowable pressure drop due to stress in the various components. This will be discussed in detail later. Case 4 can be checked by comparing the pressure drop to the maximum allowable pressure drop given in CFG 20D-20 of the Fisher Continental Sales Handbook. This table is based on empirical data and shows the maximum allowable pressure drop for cast steel discs by valve size, shaft class, seal type and flow direction. CFG 20D-10 also gives material and temperature derating factors. For the case of the specific subject valves:

18" 9200 Class 2 shaft
Inflatable Seal, Flow into Hub
WCB disc (cast Steel)
180°F
Maximum ΔP for this disc is 109 psig.

This is well above the 56 psig ΔP required by NSP.

For case 6 the actuator will be treated as a single component capable of handling torques less than or equal to the maximum rated output of actuator. The torques transmitted to the actuator are determined using the computer program mentioned above. Again this will be discussed later in detail.

* The point on the shaft at the edge of the disc nearest the actuator can be shown to be the location of highest stress in the shaft (excluding pin or key: 3 & 5 above). This will discussed later.

For the specific subject valves:

656-60 actuator
6-30 psi signal
4" stroke

The maximum rated output of the acuator can be found in Bulletin 61.1-656, July 1975 (Attachment 1). For a 656-60 with 6-30 psig input the actuator can output up to 5773 in-lb torque. Therefore, the actuator-linkage hardware has been designed to safely operate in situations in which the torque transmitted from the shaft is less than or equal to 5773 in-lb.

The computer program for determining allowable pressure drop vs. angle of opening and actuator torque vs. angle of opening can be 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. See Attachment 2 for modeling of the loading including shear, moment and torque diagrams. Attachment 2, page 4 shows the equations for determining bushing and packing torque. The seating torque and dynamic torque are empirically derived values and come from CFG 40B-10 of the Fisher Continental Sales Handbook.

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 Ves[illegible] Code. S is equal to 1/4 of the minimum tensile strength or 2/3 of the mini[illegible] yield strength, whichever is less. For shear stresses 0.75 S is used.

The program calculates stress and changes ΔP iteratively until the allowable strength matches the stress. This determines the maximum allowable pressure drop for that angle of opening based on the stress at a single point. Therefore, this process is done for cases 1, 2, 3, 5 and 7 for each angle of opening. Attachment 2 explains the equations used for calculating stress in the shaft at the disc hub due to torsion and shear and due to bending and torsion (case 1 and 2). Attachment 3 explains the stress calculations for the pin and key connection and for bushing stress (cases 3, 5 and 7).

The program output (Attachment 4) shows a ΔP which is calculated at each point for each angle of opening, including two ΔP for case 1 (one based on maximum shear stress, one based on maximum tensile stress) for a total of 6 ΔP's. The smallest ΔP of these 6 is then repeated as allowable ΔP at the bottom of the column. The actuator torque for the lowest ΔP (allowable ΔP) is also listed. From attachment 4 it can be seen that for case 1, 2, 3, 5 and 7 the allowable ΔP doesn't drop below 56 psig until after 50° open. The change in allowable pressure drop between 50° and 60° may seem large. It is important to note, however, that if $P_1 \cong 75$ psia, the effective pressure drop at 60° is 15 psig. If a 15 psig effective drop produces excessive stresses and p_1 remains the same, then the actual pressure drop must be limited below 15 psig. That is, the drop must be less than the drop for a choked flow condition. Again, in this case the limiting pressure drop is found at 50° open for cases 1, 2, 3, 5 and 7.

Going back to case 6 (actuator stress), it was determined that the maximum actuator torque must be less than or equal to 5773 in-lb. The limiting angle due to this criteria is 40°.

The following table is a summary of the information just given and that included in Attachment 4 regarding the limitations on opening angle:

Stress Consideration	Stress Allowable	Limiting Angle
1. Shaft at disc hub bending and torsion	52.5 Ksi	60° ($70° - \Delta P_2 = 27$)
2. Shaft at disc hub torsion & transverse shear	26.25 Ksi	60° ($70° - \Delta P_3 = 19.0$)
3. Pin Connection	26.25 Ksi	50° ($60° - \Delta P = 10.6$)
4. Disc	---	O.K. all angles
5. Key Connection	26.25 Ksi	60° ($70°\ \Delta P = 7.9$)
6. Actuator	---	40° (50° T = 6966 in-lb)
7. Bushing	10. Ksi*	O.K. all angles

Limiting Angle - 40° due to actuator.

* Bushing strength has been determined by testing at Fisher Continental.

W4M4

FISHER® Controls

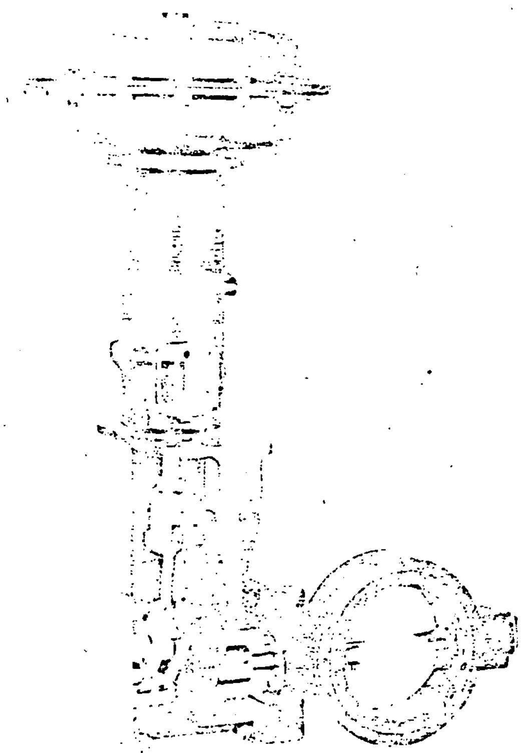
Type 656 Diaphragm Actuator

July 1975 | Bulletin 61.1:656

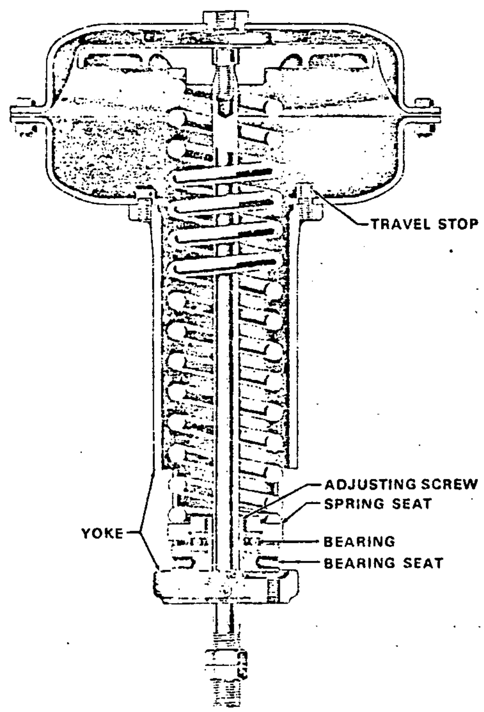
The Type 656 is a yokeless, direct-acting diaphragm actuator for either throttling or on-off service. Principle applications include operation of butterfly and built-in turbine valves, louvers, dampers, and other similar equipment.

Features

- **Mounting Versatility**—Four tapped holes in the actuator base permit either bracket or plate mounting.
- **Long Stroke**—Deep casings provide up to 4-1/8 inches of maximum travel (in a Size 60 actuator).
- **Application Versatility**—Wide spring selection is available for nearly any control application. Spring selection procedure is quick and accurate.
- **Severe Service Capability**—Rugged yoke and casings help provide stability and corrosion protection.



MOUNTED ON 9500 SERIES BUTTERFLY VALVE



TYPICAL CONSTRUCTION

Figure 1. Type 656 Actuator

Specifications

MAXIMUM RECOMMENDED CASING OPERATING PRESSURE — 35 psig*

SIZES AND MAXIMUM ALLOWABLE CASING PRESSURES

Actuator Size	Maximum Casing Rating (Psig)
30	125
40	65
60	40

NET STEM FORCE OUTPUT — See table 1

TORQUE OUTPUT FOR BUTTERFLY VALVES — See table 2

TRAVEL DATA

ACTUATOR SIZE	MAXIMUM RATED STEM TRAVEL (INCHES)		MAXIMUM STEM RETRACTION ADJUSTMENT (INCHES) WITH OPTIONAL HANDWHEEL
	Standard Travel Stop	Optional Travel Stop	
30	2-1/8	Not available	3/4
40	3-1/2	3	1-1/2
60	4-1/8	3-13/16	2

MAXIMUM OPERATING TEMPERATURE — 150°F with standard diaphragm material†

CONSTRUCTION MATERIALS

Part	Material
Diaphragm	Nitrile (standard†)
Diaphragm plate and yoke	Cast iron
Diaphragm casings, spring, spring seats, travel stop, stem, bearing, bearing seat and bearing race	Steel
Adjusting screw	Brass

CASING CONNECTION — 1/4" NPT

MOUNTING AND STEM THREAD INFORMATION — See figure 2

WEIGHT DATA

Actuator Size	Approximate Shipping Weight (Pounds)
30	50
40	70
60	160

OPTION — Top-mounted handwheel/adjustable travel stop

*Control and stability may be impaired if this pressure is exceeded.
† Consult your Fisher representative for fluid and temperature capabilities of nonstandard materials.

Table 1. Stem Force Output and Other Actuator Data

ACTUATOR SIZE	TYPICAL SPRINGS[1]			NET STEM FORCE (POUNDS)[2]			EFFECTIVE DIAPHRAGM AREA (SQUARE INCHES)	
	Maximum Range (Psig)	Part Number	Color Code	Stem Fully Retracted[3]	Stem Fully Extended,[4] with Diaphragm Loading as Shown		Stem Fully Retracted[3]	Stem Fully Extended[4]
30	2.5-9.6	1F3616 27032	Aluminum and orange	165	522	20 psig	66	48
	3.0-12.5	1K5098 27032	Aluminum and dark green	211	390			
	4.3-17.6	1N7515 27032	Aluminum and red	297	157			
	3.7-18.4	1F1770 27092	Tan	257	118			
	3.9-23.9	1F1771 27092	Pink	277	382	30 psig		
	3.1-26.1	1F1772 27092	Brown	211	249			
40	3.1-12.7	1L2174 27042	White	330	545	20 psig	100	69
	6.0-27.4	1L2173 27042	Dark green	630	270	30 psig		
	4.3-31.2	1N8440 27082	None[5]	450	367	35 psig		
60	3.7-13.1	1K1627 27082	None[5]	796	1205	20 psig	215	160
	3.5-16.1	1N9373 27082	None[5]	753	750			
	7.1-27.0	1K1628 27082	None[5]	1462	682	30 psig		
	6.9-33.5	1P2702 27042	None[5]	1441	500	35 psig		

1. Others available; consult your Fisher representative for their characteristics.
2. For maximum rated stem travel with standard travel stop and zero handwheel limitation.
3. Stem force equals initial spring compression with zero loading pressure.
4. Stem force equals: (loading pressure X diaphragm area with stem fully extended) minus force of spring at maximum compression. Higher pressures can be used, but they must not exceed maximum allowable casing pressure or create stem force greater than safe load limit of any control device component.
5. Part number stamped on spring.

Table 2. Torque Outputs (Inch-Pounds) for Springs Commonly Used with Butterfly Valves*

INPUT SIGNAL	WITH POSITIONER		20 PSIG			35 PSIG		
	WITHOUT POSITIONER		3-15 PSIG			6-30 PSIG		
ACTUATOR SIZE			30	40	60	30	40	60
MAXIMUM RATED TRAVEL (INCHES)†			2-1/8	3-1/2	4-1/8	2-1/8	3-1/2	4-1/8
SPRING PART NUMBER			1K5098 27032	1L2174 27042	1K1627 27082	1F1772 20792	1L2173 27042	1K1628 27082
60-Degree Maximum Disc Rotation	Stem Fully Retracted		328	819	2076	328	1638	4152
	Stem Fully Extended	With Positioner	664	1563	4506	836	1754	5773
		Without Positioner	266	621	1931	438	812	3198
90-Degree Maximum Disc Rotation	Stem Fully Retracted		189	472	1197	189	945	2394
	Stem Fully Extended	With Positioner	383	901	2598	482	1011	3329
		Without Positioner	153	358	1113	252	468	1844

*Make sure the lowest torque output of the desired actuator size is sufficient for the valve torque required.
† With standard travel stop and zero handwheel limitation.

ACTUATOR SIZE	DIMENSION									
	A	C	E		H	J	S (Stem Thread)	X	Y (4 Holes)	
			Without Handwheel	With Handwheel					Bolt Circle Diameter	Thread
30	2.62	11.38	12.38	19.31	2.12	6.75	1/2-20	.75	2.88	3/8-16 UNC
40	3.12	13.12	17.88	28.38	2.25	8.75	3/4-16	.75	2.88	3/8-16 UNC
60	3.12	18.62	27.25	39.06	2.50	8.75	3/4-16	1.25	3.88	1/2-13 UNC

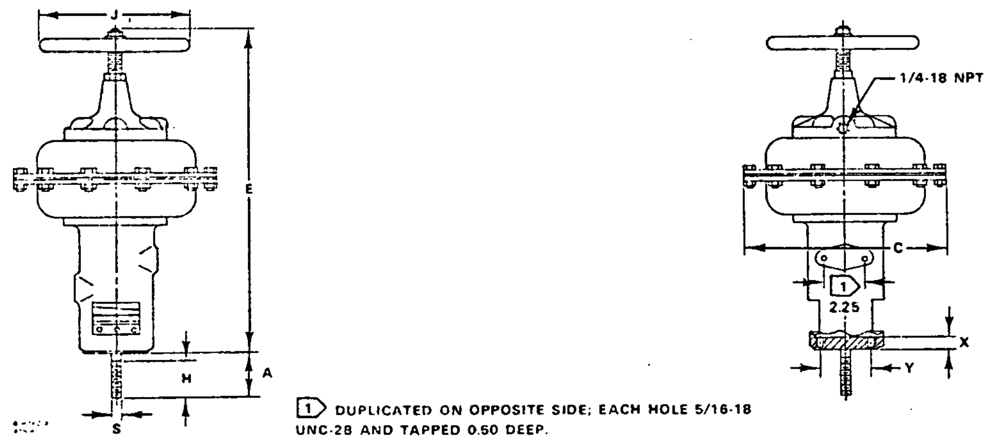


Figure 2. Dimensions, Inches

Installation

The Type 656 may be installed in any position. Dimensions are shown in figure 2.

Ordering Information

When ordering, specify:

1. Type number and size

2. Desired spring from table 1 or 2

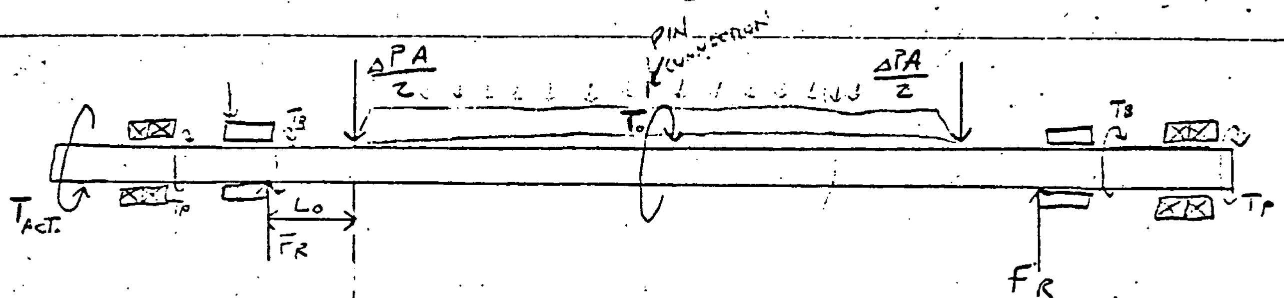
3. Handwheel and/or optional travel stop, if desired (see Specifications)

4. Magnitude and type of loading pressure (for instance: 3-15 psig, controller output signal)

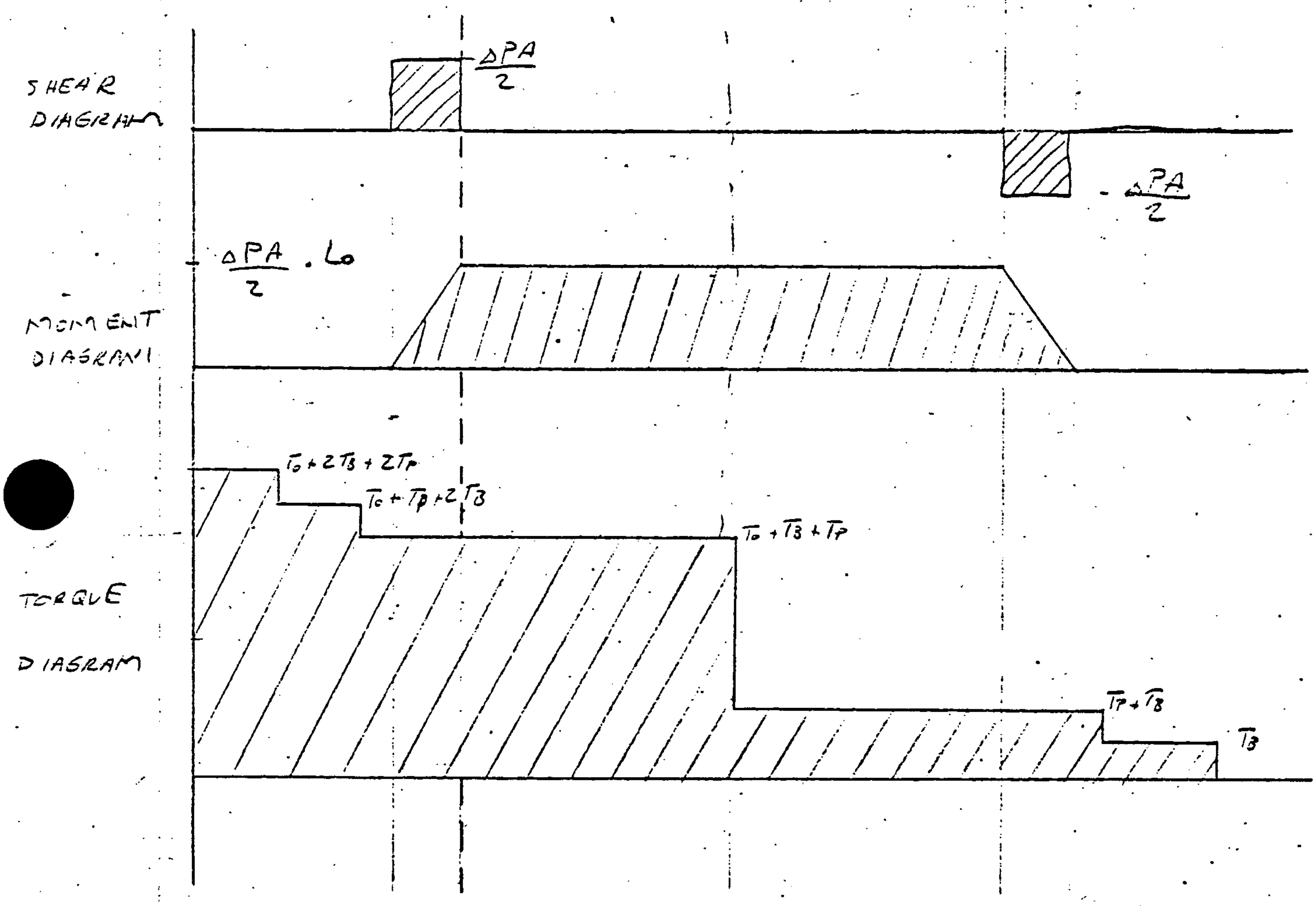
ATTACHMENT 2

BUTTERFLY VALVE SHAFT STRESS CALCULATIONS

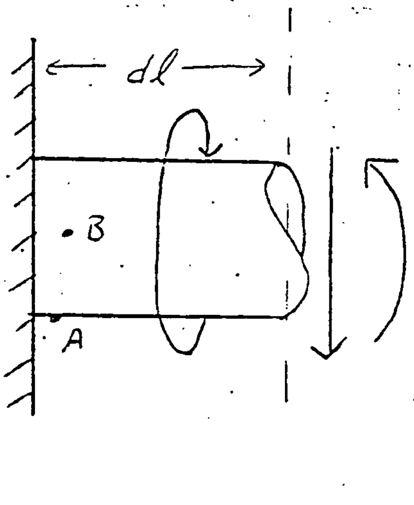
LRW 2/24/81



LOADING FOR 9200 SHAFT



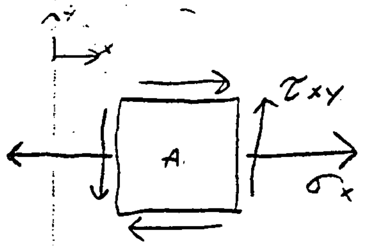
↑ Point of worst case stress



Loaded case $V = \frac{\Delta PA}{2}$ $M = \frac{\Delta PA}{2} \cdot L_o$

$T = T_o + T_B + T_P$

COMBINED LOADING STRESS AT POINT A



τ_{xy} - Torsional Shear
σ_x - bending stress

$\sigma_x = \dfrac{M \cdot r}{I}$ M = moment r = radius of shaft

$I = \dfrac{\pi d^4}{64}$

$\tau_{xy} = \dfrac{T \cdot r}{J}$ T = torque $J = \dfrac{\pi d^4}{32}$

$$\sigma_{max} = \sigma_x/2 + \sqrt{(\sigma_x/2)^2 + (\tau_{xy})^2}$$

$$= \frac{M(d/2)}{2I} + \sqrt{\left(\frac{M(d/2)}{2I}\right)^2 + \left(\frac{T(d/2)}{2I}\right)^2}$$

$$= \frac{d/2}{2I} \cdot \left(M + \sqrt{M^2 + T^2}\right)$$

$$\sigma_{max} = \frac{16}{\pi d^3} \cdot \left(M + \sqrt{M^2 + T^2}\right)$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + (\tau_{xy})^2}$$

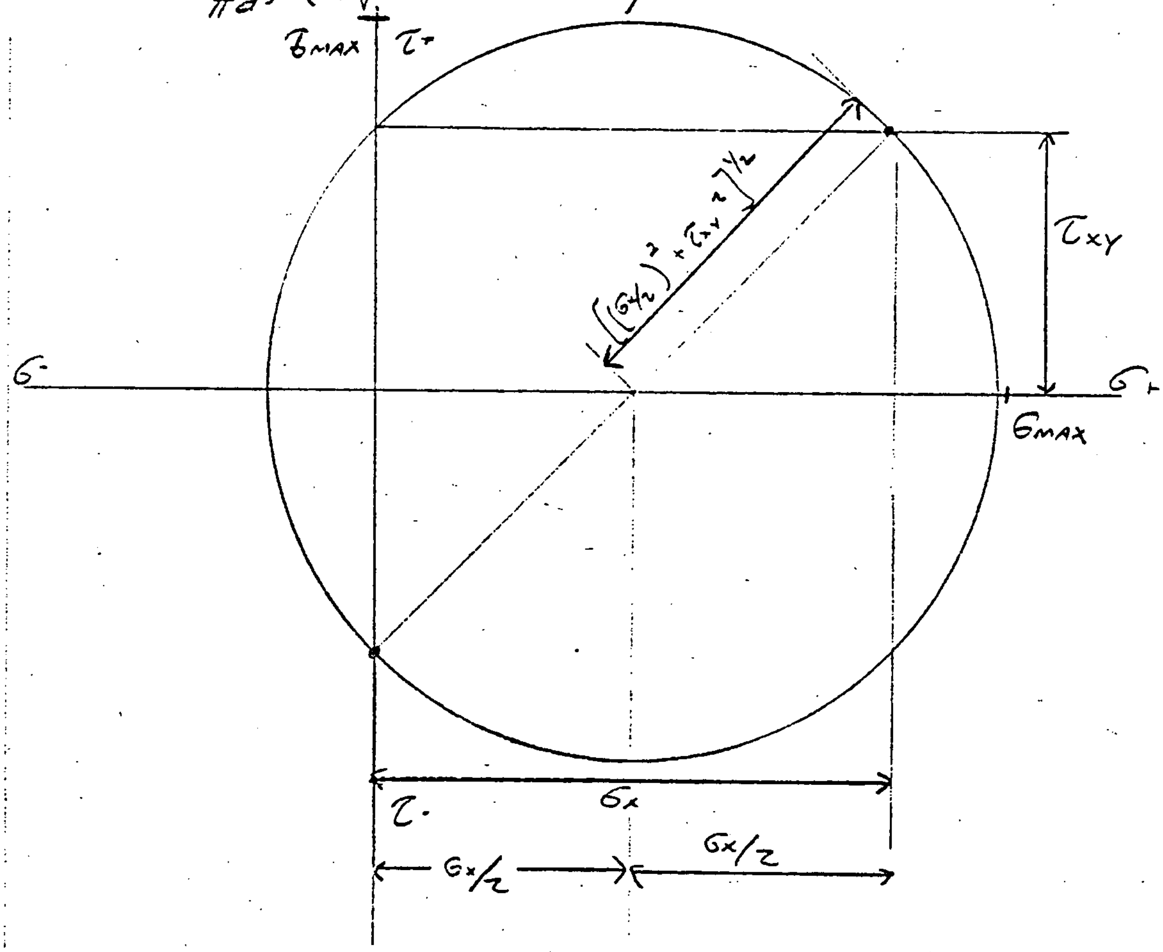
$$= \sqrt{\left[\frac{M(d/2)}{2I}\right]^2 + \left[\frac{T(d/2)}{2I}\right]^2}$$

$$\tau_{max} = \frac{16}{\pi d^3} \sqrt{M^2 + T^2}$$

COMBINED LOADING AT POINT A CONTINUED

$$\sigma_{MAX} = \frac{16}{\pi d^3}\left(M + \sqrt{M^2 + T^2}\right)$$

$$\tau_{MAX} = \frac{16}{\pi d^3}\left(\sqrt{M^2 + T^2}\right)$$



MOHR'S CIRCLE SHOWING STRESSES AT POINT A

Max shear: τ_{xy}

Max Tensile: σ_{MAX}

Stress Intensity: $2\tau_{xy}$

$$M = \frac{\Delta P A}{2} L_o = \frac{\Delta P}{2} \frac{D^2}{4} \pi L_o$$

$$T_T = T_{DYNAMIC} + T_{SEATING} + T_{BUSHING} + T_{CAM} + T_{INERTIA} + T_{PACKING}$$

$T_{DYNAMIC}$ - comes from handbook

$T_{SEATING}$ - " " "

$T_{BUSHING}$ - $\frac{\pi D^2}{16} \mu \Delta P d$ for 1 bushing ←

$T_{packing}$ · $50 d^{1.5}$ for 1 side packing

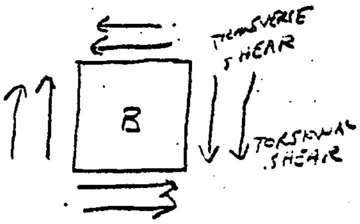
The maximum stress intensity at point A will be

$$2 \cdot \tau_{max} = \frac{32}{\pi d^3}\sqrt{M^2+T^2}$$

$$= \frac{32}{\pi d^3}\sqrt{\left(\frac{\pi}{8}\Delta P D^2 L_0\right)^2 + \left(T_{Dynamic} + T_{SEATING} + \frac{\pi D^2}{16}\mu\Delta P d + 50 d^{1.5}\right)^2}$$

For class 1 shafts this stress intensity should be compared to 25% of the min. tensile stength or 2/3 of the min yield, whichever is smaller.

COMBINED LOADING STRESS AT POINT B



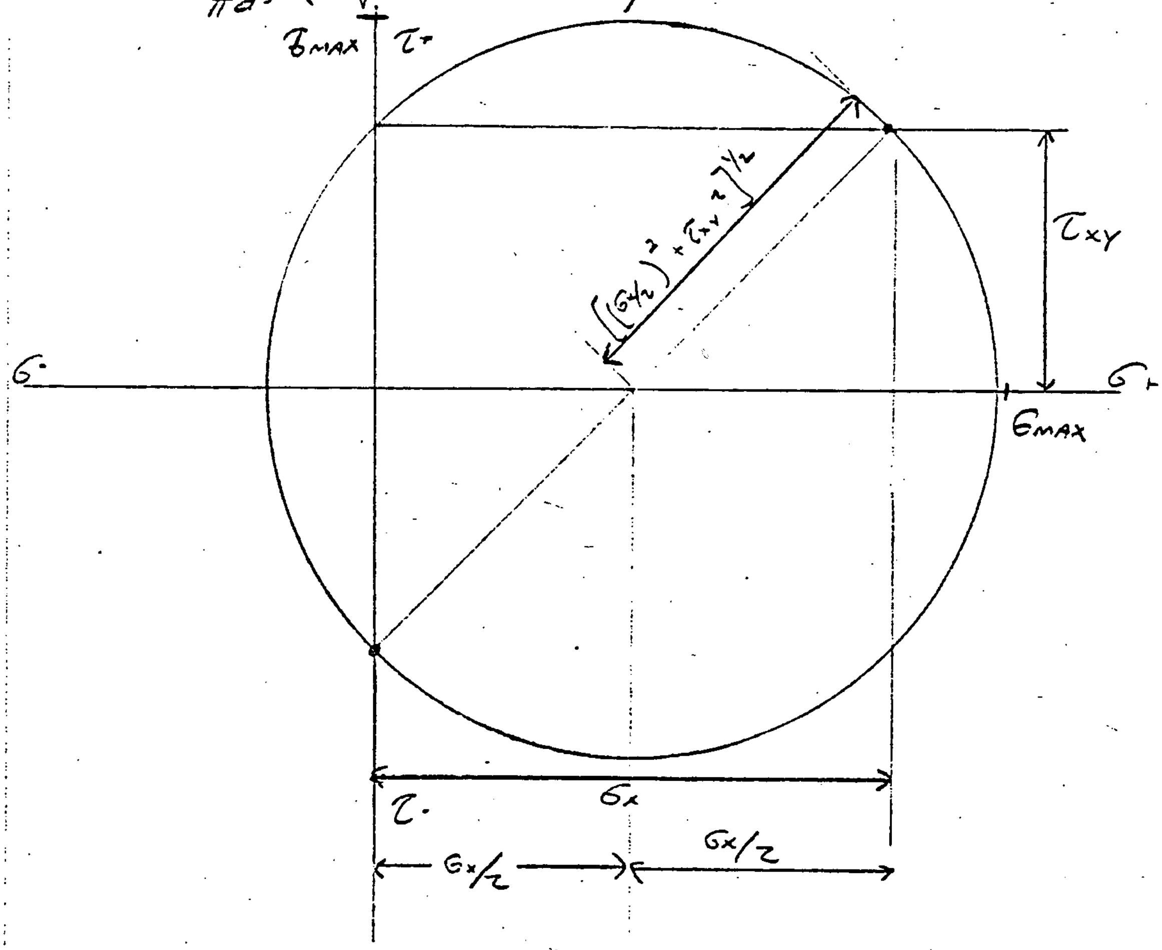
Torsional Shear = $\tau_T = \frac{Tr}{J}$

Transverse Shear = $\tau_s = \frac{VQ}{Ib} = \frac{4V}{3A}$ for a solid circular bar

COMBINED LOADING AT POINT A CONTINUED

$$\sigma_{MAX} = \frac{16}{\pi d^3}\left(M + \sqrt{M^2 + T^2}\right)$$

$$\tau_{MAX} = \frac{16}{\pi d^3}\left(\sqrt{M^2 + T^2}\right)$$



MOHR'S CIRCLE SHOWING STRESSES AT POINT A

Max Shear: τ_{xy}

Max Tensile: σ_{MAX}

Stress Intensity: $2\tau_{xy}$

$$M = \frac{\Delta P A}{2} L_o = \frac{\Delta P}{2}\frac{D^2}{4}\pi L_o$$

$T_T = T_{DYNAMIC} + T_{SEATING} + T_{BUSHING} + T_{CAM} + T_{INERTIA} + T_{PACKING}$

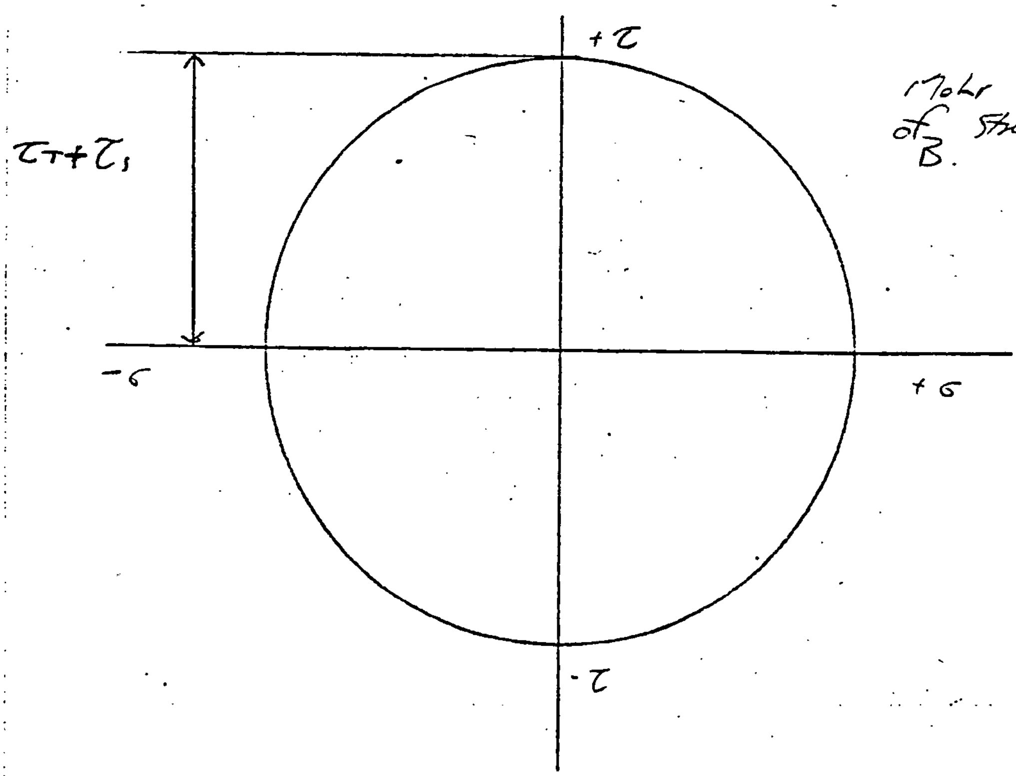
$$\tau_{max} : \frac{Tr}{J} + \frac{4V}{3A}$$

$$= \frac{T\,r}{\frac{\pi d^4}{32}} + \frac{4V}{3\pi r^2} = \frac{32\,T\,d}{\pi d^4\ 2}$$

$$\tau_{max} = \frac{16\,T}{\pi d^3} + V\,\frac{16}{3\pi d^2} = \frac{16}{\pi d^2}\left(\frac{T}{d} + \frac{V}{3}\right)$$

$$V = \frac{\Delta P A}{2} = \frac{\Delta P\ \pi D^2}{8}$$

$$\tau_{MAX} = \frac{16}{\pi d^2}\left(\frac{T_{DYN} + T_{SEAT} + \frac{\pi D^2 \mu \Delta P d}{16} + 50\,d^{1.5}}{d} + \frac{\Delta P \pi D^2}{24}\right)$$



Mohr Circle Representation of Stresses at point B.

AGAIN STRESS INTENSITY IS:

$$2 \cdot \tau_{max} = \frac{32}{\pi d^2}\left(\frac{T_{DYN} + T_{SEAT} + \frac{\pi D^2 \mu \Delta P d}{16} + 50 d^{1.5}}{d} + \frac{\Delta P \pi D^2}{24} \right)$$

This should be compared to .25 min tensile or .667 min yield, whichever is smaller.

MATERIALS

	SA 564 Gr 630 17-4 - PH H 1075	SA 479 Gr 316 316 SS. Annealed
MIN TEN.	145	75
MIN YIELD	125	30
SM	48.3	20.
S allowable	36.2	18.7
920°	52.5	27.9

Stress at the pinned connection.

The loading at the pin connection can be seen in attachment 2 or the loading diagram. The only loading that affects this connection is torsion. The stress can be calculated:

$$\tau = \frac{T\,(d/2)}{J} \cdot S_c{}^{*}$$

where T = torque at pin connection
d = shaft diameter
S_c = stress concentration factor

$$\tau = \frac{16T}{\pi d^3} S_c{}^{*}$$

The stress at the keyway is similar. S_K is stress concentration factor at the keyway.

$$\tau = \frac{16T}{\pi d^3} S_K{}^{*}$$ for stress at the keyway.

The bearing load calculated is due to static-pressure differential on the disc.
The load on each bushing is:

$$L = \frac{\pi (D/2)^2 \,\Delta P}{2}$$

To determine stress an effective loading area is determined. This area is the shaft

* $S_c = 1/C_1 = 2$
$S_K = 1/C_2 = 1.333$

diameter times the effective bushing length
This gives a projected loading area.
The effective bearing length is approximately
1 shaft diameter based on Fisher bearing experience.
Therefore the stress equation becomes:

$$S = \frac{\pi D^2 \Delta P}{8 d^2}$$

AL..D. . PRESSURE DROP CALCULATION

NO..HERN STATES POWER, CONTAINMENT ISOLATION BUTTERFLY VALVES
18 INCH 9210 INFLATABLE T-RING SN 127571-127576,127579
SHOP ORDER P-73605-02;-05
FLOW INTO HUB TEMP.=180 F DP,SHUTOFF=62 PSIG DP=56 PSIG 17-4 PH SHAFT
#1 .USHING (SS/TFE) CAST DISC
DATE 3/1./81 LEE WAITE

IN.UT DATA

A..	0.0	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	0.0
D..SC	17.486	17.486	17.486	17.486	17.486	17.486	17.486	17.486	17.486	0.0
D..FT	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	0.0
D..	1.810	1.810	1.810	1.810	1.810	1.810	1.810	1.810	1.810	0.0
TS	680.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.-	0.0	33.000	67.500	109.500	234.000	423.000	802.500	1620.000	2565.000	0.0
D..N	62.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000	0.0
D..TPF	1.000	1.000	0.500	0.250	0.250	0.200	0.200	0.140	0.140	0.0
S..H	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.0
S..SH	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.0
C1	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.0
C2	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.0
B..TYP	1	1	1	1	1	1	1	1	1	0

GE..ERATED VARIABLES

S.	52500.00	52500.00	52500.00	52500.00	52500.00	52500.00	52500.00	52500.00	52500.00	0.0
S	26250.00	26250.00	26250.00	26250.00	26250.00	26250.00	26250.00	26250.00	26250.00	0.0
S	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	0.0

OU.PUT

D..TP(1)	79.7739	79.3310	79.3108	79.4704	78.4383	77.0835	70.6247	61.9407	36.2480	0.0
D..TP(2)	79.6782	78.7873	78.7466	79.0688	76.9639	74.1177	58.7997	27.8988	6.6987	0.0
D..TP(3)	253.5573	228.3059	227.4960	234.3808	200.7675	172.5807	90.6133	19.0131	6.5690	0.0
D..TP(4)	1466.6135	1160.1216	1150.2896	1233.8545	825.8640	483.7407	10.6330	5.2851	3.3420	0.0
D..TP(5)	1124.3528	971.4963	966.5933	1008.2698	804.7935	634.1670	137.9797	7.8731	4.9847	0.0
D..TP(6)	187.2447	187.2447	187.2447	187.2447	187.2447	187.2447	187.2447	187.2447	187.2447	0.0
AL..W.DP	79.6782	78.7873	78.7466	79.0688	76.9639	74.1177	10.6330	5.2851	3.3420	0.0
ALT.TOR.	1725.4094	3368.8745	3421.4585	2974.2292	5151.9961	6966.4922	8831.6719	8602.6836	8792.1445	0.0

ATTACHMENT 4

Program Inputs

DDISC - Disc diameter - drawing

DSHFT - Shaft Diameter - shop order —Attachment 5

DLO - Hub to bushing distance - drawing

TS - Seating torque - CFG 40B10 Sales Handbook

TI - Inertial torque - 0 - not applicable

DM - CAM factor - 0 - not applicable

DTF - Dynamic torque factor - CFG - 40B10 Sales Handbook

DPIN - Inlet pressure (psig)

DELTPF - Effective pressure drop factor - CFG - 40B10 Sales Handbook

STSH - Shaft derating factor - CFG - 20D10 - Sales Handbook

SBUSH - Bushing derating factor - CFG 20D10 - Sales Handbook

C1 - Pin Concentration factor - 0.5

C2 - Key concentration factor - 0.75

BSHTYP - Type of bushing - CFG - 20D10 - Sales Handbook

Outputs

DELTP(1) - Allowable ΔP based on maximum tensile stress on shaft at hub due to bending and torsion.

DELTP(2) - Allowable ΔP based on maximum shear stress on shaft at hub due to bending and torsion.

DELTP(3) - Allowable ΔP based on maximum shear stress on shaft at hub due to torsion and transverse shear.

DELTP(4) - Allowable ΔP based on stress at pin connection.

DELTP(5) - Allowable ΔP based on stress at key connection.

DELTP(6) - Allowable ΔP based on stress at bushing.

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

PHONE: (412) 264-8010—TWX: (412) 269-5150—TELEX: 086-765

PAGE 1 OF 2

ORDER NO. 73605-02

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69		X	

VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
Heavy Pattern T-Ring	127573-74		

SOLD TO:
Bechtel Corporation
P. O. Box 648
Monticello, Minnesota 55362
Attention: Office Manager

SHIP TO:
Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK: PO #5828-M-49-AC

VIA: Truck prepaid and add

VALVE DESCRIPTION

B.M.

TYPE	FLANGE	CLASS	BODY	SEAT	DISC
9210	150 RF	2	C/STEEL ☆	E.P.T.	C/STEEL ☆

SHAFT	PINS	FOLLOWERS
316 S/S	C/STEEL	BRONZE X

PACKING	PLAIN	SEAL SYSTEM
O-Ring	O-RING	H-14266

GUARD BUSHINGS: S/S w/TFE

BRACKET AND LINKAGE

B.M.

PIPE RUN: HORIZONTAL X

LINKAGE SET: 0 MINIMUM DEGREES, 90 MAXIMUM DEGREES

POWER ACTUATOR DESCRIPTION

B.M.

QTY.	ACTUATOR TYPE
3	FISHER 656-60

INST. SIGNAL 6 to 26 — BENCH SET 6 to 30 — PRESSURE TO ACTUATOR ... TO OPEN X CLOSE

NA MANUAL ACTUATOR DESCRIPTION

B.M.

VALVE SERVICE

FLUID	MAX. SHUT OFF PRES.	TEMP.
AIR	2	150 °F

MOUNTING INSTRUCTIONS: X

PRICE

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL OPER. & MAINT. INST.	PARTS LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2	2		X

SPECIAL INSTRUCTIONS: FLOW TO FLAT L FLOW INTO HUB

FURNISH QTY (2) ... LIMIT SWITCH TO SHOW OPEN ...

FURNISH ASCO # ... VALVE ... SOL TO OPEN ...

FURNISH HYDROSTATIC TEST ...

FURNISH RADIOGRAPH ... MAGNETIC PARTICLE TEST, DYE PENETRANT TEST, PERFORMANCE AND LEAKAGE ...

FURNISH MILL TEST REPORT

TAG: PO# 5828-M49 AO-2377, AO-2387, AO-2...

SEE PAGE # 2 FOR MORE INSTRUCTIONS.

(1) FURNISH ... VOL TANK

DBT/mlk

P. 73605-02

21-007854
21039353
21005638
11013117
11001879

TERMS: NET 30 DAYS F.O.B. SHIPPING POINT

CUSTOMER REC'D DATE

ORDER P-73605-03

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

PHONE: (412) 264-3010--TWX: (412) 263-5150--TELEX: 085-785

PAGE 1 OF 2

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69		X	

AGENT ORDER NO.	VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
21-007856	Heavy Pattern T-Ring	127575-76	7-7-69	

SOLD TO: Bechtel Corporation
P. O. Box 848
Monticello, Minnesota 55362
Attn: Field Office Manager

SHIP TO: Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK: PO #5828-M-49-AC

VIA: Truck prepaid and add

VALVE DESCRIPTION

B.M.

QTY.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC	FISH DISC	DISC DIA
2	12"	9210	150 RF	2	C/STEEL	EPT	C/STEEL		

SHAFT	PINS	ALLOY FRY	DUCTILE	ST/ST	FOLLOWERS BRONZE	OTHER
316 S/S	C/STEEL				X	

PACKING	TEFL.	PLAIN	STUFFING BOX PURGED	LUB.	GRAPHITAR	STAINLESS	LANTERN GLAND ¼ PLUG	STICK LUB.	ISOL. VALVE	ALEMITE
O-Rings		O-RING								

INBOARD BUSHINGS	ROLLER BEARINGS	EXTENSIONS OPEN	PLAIN	CAST ON	OTHER	SEAL SYSTEM	SCHEMATIC NO.
						H-14266	

BRACKET AND LINKAGE

B.M.

PIPE RUN PERPENDICULAR	PARALLEL	PIPE RUN HORIZONTAL	VERTICAL	MINIMUM DEGREES	LINKAGE SET MAXIMUM DEGREES
X		X		0	90

POWER ACTUATOR DESCRIPTION

B.M.

QTY.	ACTUATOR TYPE	MODEL NO.	BORE	STROKE	POSITIONER	MODEL NO.	BYPASS	CALIB.	DIRECT	REVERSE
2	Fisher 656-60			4						

HANDWHEEL SIDE MOUNTED	TOP MOUNTED	TO	INST. SIGNAL	BENCH SET	PRESSURE TO ACTUATOR	PUSH ON TO OPEN	CLOSE
			6 to 26		6 to 30	X	

MANUAL ACTUATOR DESCRIPTION

B.M.

QTY.	DESCRIPTION	REG.	DE CLUTCH	POSITION	CHAIN LINEAR FT.	LEVER DISC CLOSED	DIA HOLE	CENTERS

VALVE SERVICE

FLUID	MAX. SHUT OFF PRES.	TEMP	STAT. PRES.	MOUNTING INSTRUCTIONS CONT'L FURN AND MT	CUST FURN CONT'L MT	CUST FURN AND MT	ITEM	PRICE
Air	62#	120°F	62#	X			A, B	2463.??
							C, D	4926.??

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL OPER. & MAINT. INST.	PART LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2	2 75	76	X

SPECIAL INSTRUCTIONS: FLOW INTO FLAT & HUB

1C FURNISH Qty (2) Lee Valve [illegible] Limit Switch to
SHOW OPEN AND CLOSED [illegible]
1A FURNISH ASCO 830064 [illegible] Valve, [illegible]
SOL TO OPEN B[illegible]
FURNISH Hydrostatic Test [illegible]
FURNISH [illegible] Magnetic [illegible]
Dye Penetrant Test, [illegible] Leakage Test
FURNISH [illegible]
TAG [illegible] AO-[illegible]
SEE PAGE [illegible]
D FURNISH [illegible]

21-007856
2102F235
21004359
10003765
10001452

TERMS: NET 30 DAYS F.O.B. SHIPPING POINT

DET/mlk
P-73605-03

CUSTOMER REQ'D DATE 6/[illegible]

CONTINENTAL QUOTED DATE

OUR SHOP ORDER P-73605-04

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

PAGE 1 OF 2

PHONE: (412) 264-3010 – TWX: (412) 269-5150 – TELEX: 086 735

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69		X	

AGENT ORDER NO.	VALVE TYPE	SERIAL NO.	
21-007854	Heavy Butterfly T.K. WE	127571	

S O L D T O
Bechtel Corporation
P. O. Box 848
Monticello, Minnesota
Attention: Office Manager

S H I P T O
Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK: PO #5828-M-49-AC

VIA: Truck prepaid and add

VALVE DESCRIPTION — B.M.

QUAN.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC
1	18	9210	150# RF	2	C/STEEL *	E.P.T.	

SHAFT: 316 S/S — PINS: C/STEEL — ALLOY — DUCTILE — FOLLOWERS — OTHER

PACKING: O-Ring — PLAIN: O-Ring — STUFFING BOX PURGED — LUB. — GRAPHITAR — STAINLESS — LANTERN GLAND

INBOARD BUSHING: 93 m/TFE — OUTBOARD BEARINGS — OPEN — EXTENSIONS PLAIN — CAST ON — OTHER — SEAL SYSTEM: H-14266 — SCHEMATIC NO.

BRACKET AND LINKAGE — B.M.

PIPE RUN: HORIZONTAL X — VERTICAL — LINKAGE SET: 0 MINIMUM DEGREES — 90 MAXIMUM DEGREES

POWER ACTUATOR DESCRIPTION — B.M.

QTY.: 1 — ACTUATOR TYPE: Fisher 656-60 — STROKE: 4 — POSITIONER — MODEL NO. — BYPASS — AIRSET

INST. SIGNAL: 6 to 30 — BENCH SET: 6 to 30 — PRESSURE TO ACTUATOR ... X — CLOSE

MANUAL ACTUATOR DESCRIPTION — B.M.

QTY. — DESCRIPTION — REQ. — DE CLUTCH — POSITION — CHAIN LINEAR FT. — LEVER — DISC CLOSED — DIA. — CENTERS

VALVE SERVICE

FLUID	MAX. SHUT OFF PRES.	TEMP	STAT. PRES.
Air	62	196 °F	62 M

MOUNTING INSTRUCTIONS: CONT'L FURN AND MT. X

ITEM	PRICE
10,11	3463.00
10,12	2618.00

PRINT INSTRUCTIONS

CERT. TRANS.: 1 — PRINTS: 2 — INSTALL OPER. & MAINST. INST.: 2 — PART LIST: 2 — PRICED PARTS LIST — X HOLD FOR APPROVAL

SPECIAL INSTRUCTIONS:

FLOW INTO FLAT

1a. Furnish (2) (G) 3BEG-3RC2 Limit Switch to Show
1b. Open and Closed Position
1c. Furnish "ASCO" 8300 44 3-way Sol. Valve Energ...
... to Open Butterfly Valve
Furnish Hydrostatic Test @ 425 PSI
Furnish Radiograph ... Magnetic Particle Test
Dye Penetrant Test ... & Leakage Tests
Furnish Mill Test Reports
TAG: M 5828-M49 AC 2878
See Page 2 for ...
Furnish ... 2643

DET/mlk

P-73605-04

21-007854
21028468
21005184
13006483
11001258

TERMS NET 30 DAYS F.O.B. SHIPPING POINT

CUSTOMER REQ'D DATE 6/7/...

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

PAGE 1 OF 2

P- 73605-05

PHONE: (412) 264-3010 — TWX: (412) 269-5150 — TELEX: 086-745

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AO	3/6/69			

	VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
[illegible]	Heavy Partial T-Kink	127579		

Bechtel Corporation
P.O. Box 348
Monticello, Minnesota 55362
Extension Office Manager

SHIP TO

Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK:PO #5828-M-49-AO

VIA Truck prepaid and add

VALVE DESCRIPTION

B.M.

QUAN.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC
1	12	9210	150RF	2	C/STEEL *	EPT	C/STEEL *

SHAFT: 316S/S
PINS: C/STEEL

PACKING: O-Ring
PLAIN: O-Ring

INBOARD BUSHINGS: TFE
SEAL SYSTEM: 11-14266

BRACKET AND LINKAGE

B.M.

PUSH ROD: PERPENDICULAR / PARALLEL
PIPE RUN: HORIZONTAL / VERTICAL
0 MINIMUM DEGREES — LINKAGE SET — 90 MAXIMUM DEGREES

POWER ACTUATOR DESCRIPTION

B.M.

QTY	ACTUATOR TYPE	MODEL NO.	BORE	STROKE	POSITIONER	MODEL NO.
1	Fisher 656-60			4		

HANDWHEEL: SIDE MOUNTED / TOP MOUNTED
INST. SIGNAL: 6 to 20 — 6 to 30 — [illegible]

MANUAL ACTUATOR DESCRIPTION

B.M.

QTY / DESCRIPTION / POSITION / CHAIN / LINEAR FT.

VALVE SERVICE

FLUID	MAX. SHUT OFF PRES.	TEMP	STAT. PRES.
Air	62		62

MOUNTING INSTRUCTIONS: CONT'L FURN. ANT MT / CUST. FURN CONT'L MT / CUST. FURN AND MT

ITEM	PRICE
10,1E	2457.00
10,1D	1,031.00

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL. OPER. & MAINT. INST.	PART LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2			X

SPECIAL INSTRUCTIONS:

FLOW INTO FLAT

1E Furnish (2) [illegible] limit switches to show open and closed position

1D Furnish Asco 8300A4 3-way Sol Valve. Energize Sol to open butterfly

Furnish Hydrostatic Test @ 425 psi

Furnish Radiograph, Magnetic Particle Test

Dye Penetrant Test, Performance & Leakage Test

Furnish Mill Test Reports

Eng. PO 5828-M-49 AO-2281

See Page 2 for more instructions

D) Furnish 1333 [illegible] Vol Tank

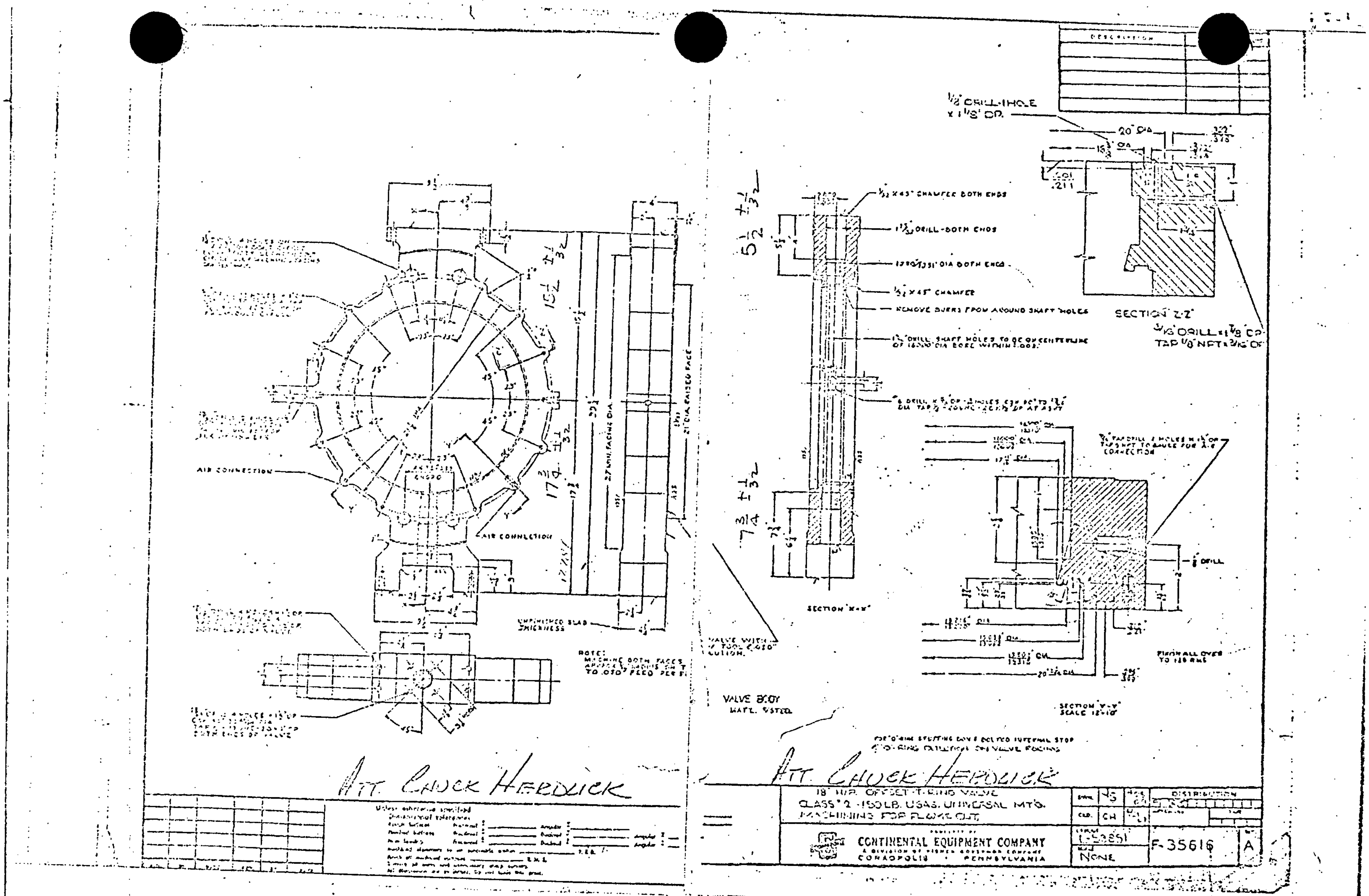
DST/mlk

P-7360505

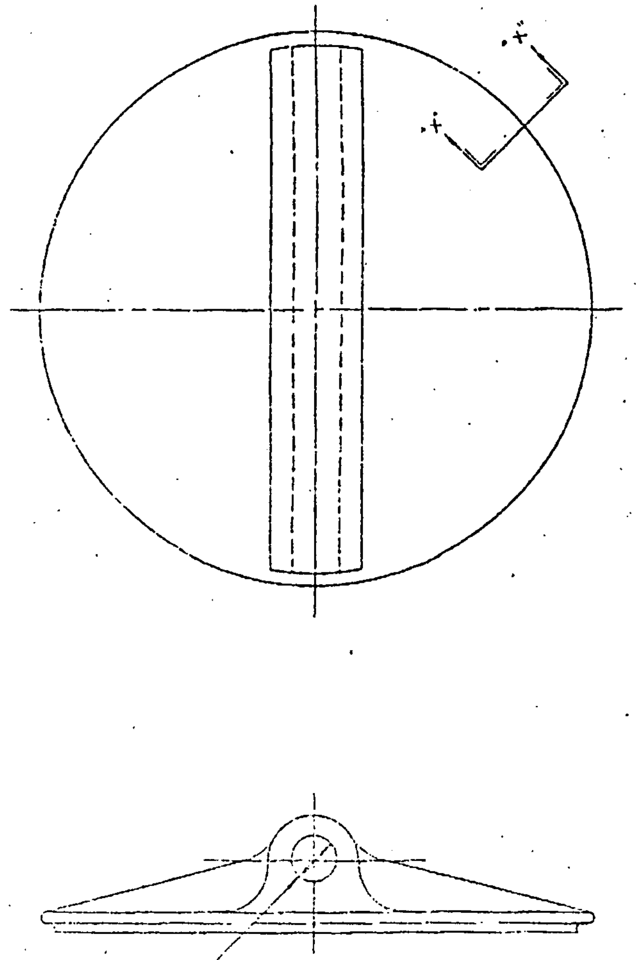
21-007854
21013311
21002179
1-004437
1-000726

TERMS: NET 30 DAYS F.O.B. SHIPPING POINT

CUSTOMER REQ'D DATE 6-11-69

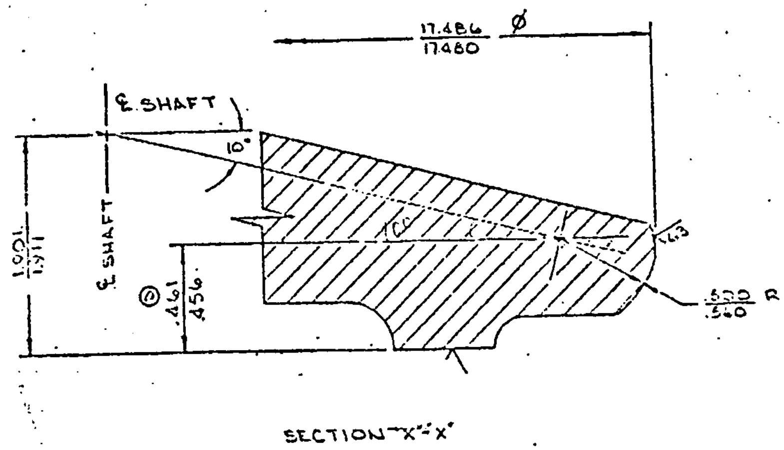


CONFIDENTIAL



ATTN. CHUCK HERDLICK

FINISHED



FINISHED

ATTN. CHUCK HERDLICK

INACTIVE DRAWING

TOLERANCES UNLESS SPECIFIED
POSITIONAL ± ____ ∠ ± 1/2°
SURFACE FINISH 250 CARB ✓
DO NOT SCALE THIS DWG
ANSI Y14.5

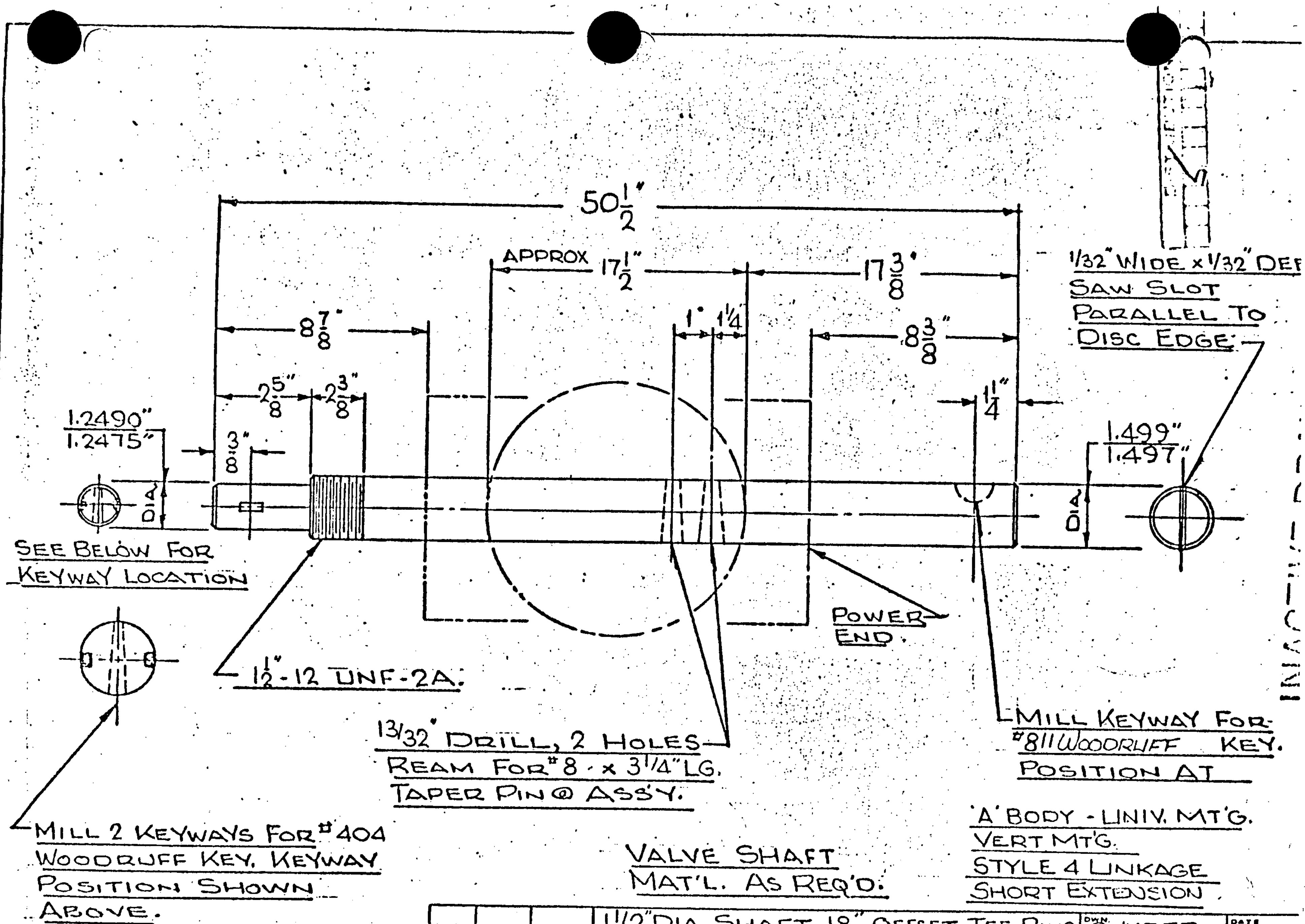
CST'G. DET. F32584
CALCULATION SH'T.
J10204

CONTINENTAL DIVISION

DISC MACHINING DETAILS
18" TYPE 9200
FISHER CLASS "2"

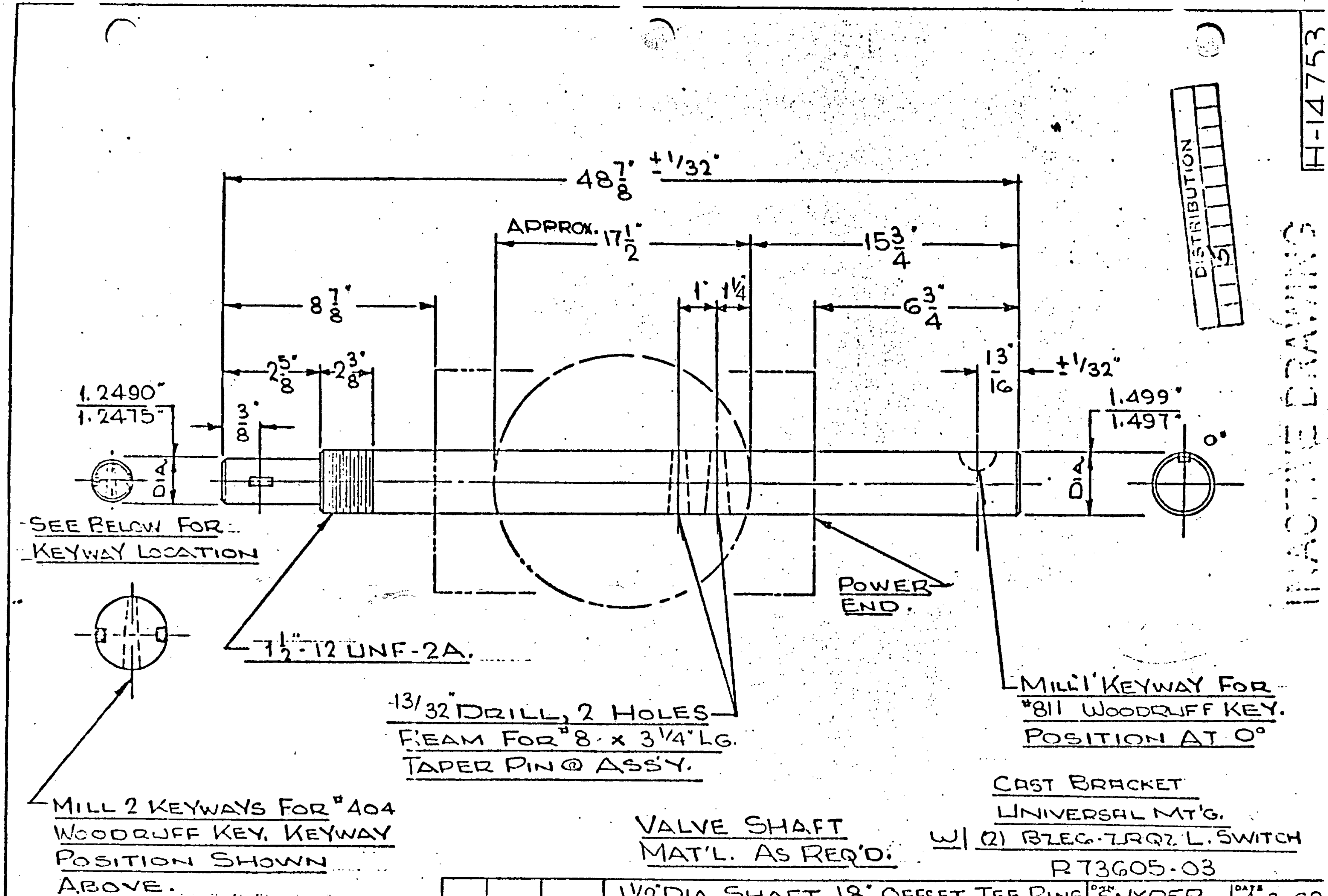
DWG. NO.
F36263 D

CONFIDENTIAL



CONFIDENTIAL

REV.	BY	DATE			
			1 1/2" DIA. SHAFT 18" OFFSET TEE RING VALVE - CLASS 2 - 150 # A.S.A. W/(1) 2PC3 NUMATIC - ON BACK END.	DWN. SNYDER	DATE 4-29-6
				CHD. D WEBER	5-1-6
				LAYOUT NO.	SCALE N.T.S.
			CONTINENTAL EQUIPMENT COMPANY A DIVISION OF FISHER GOVERNOR COMPANY CORAOPOLIS • PENNSYLVANIA	DWG NO. H-15192	A



REV.	BY	DATE

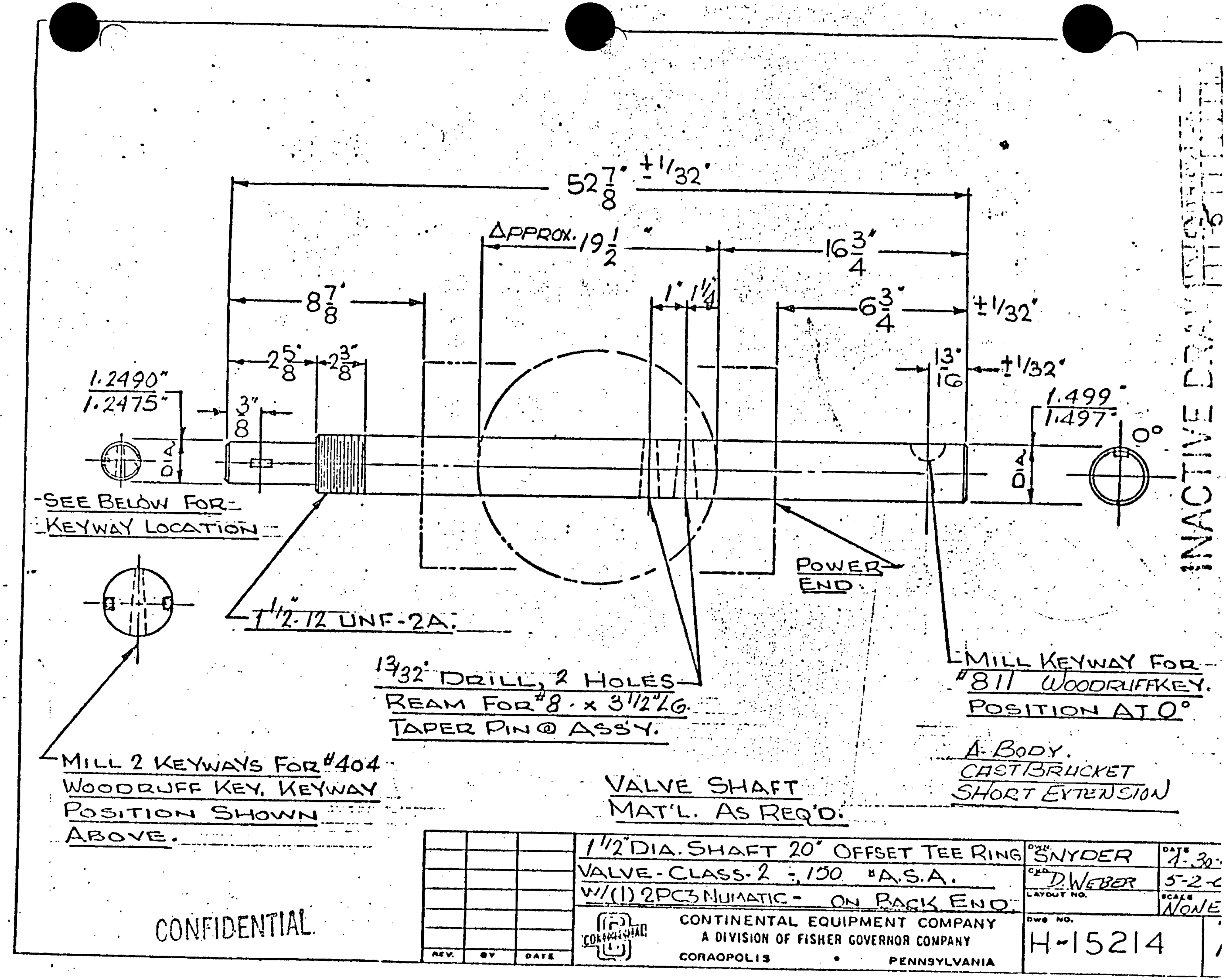
1 1/2" DIA. SHAFT 18" OFFSET TEE RING VALVE - CLASS - 2' - 150 #A.S.A. W/(1) 2PC3 NUMATIC - ON BACK END.

DR. SNYDER — DATE 4-3-69
CKD. D WEBER — 5-1-69
LAYOUT NO. —
SCALE NONE

CONTINENTAL EQUIPMENT COMPANY
A DIVISION OF FISHER GOVERNOR COMPANY
CORAOPOLIS • PENNSYLVANIA

DWG NO. H-14753 — REV. A

CONFIDENTIAL


52 7/8" ± 1/32"
APPROX. 19 1/2"
16 3/4"
8 7/8"
1" 1 1/4"
6 3/4"
± 1/32"
2 5/8"
2 3/8"
13/16"
± 1/32"
1.2490"
1.2475"
3/8"
DIA
1.499"
1.497"
DIA
0°
SEE BELOW FOR KEYWAY LOCATION
POWER END.
1 1/2"-12 UNF-2A.
13/32" DRILL, 2 HOLES REAM FOR #8 × 3 1/2" LG. TAPER PIN @ ASSY.
MILL KEYWAY FOR #811 WOODRUFF KEY. POSITION AT 0°
A-BODY. CAST BRACKET SHORT EXTENSION
MILL 2 KEYWAYS FOR #404 WOODRUFF KEY. KEYWAY POSITION SHOWN ABOVE.
VALVE SHAFT
MAT'L. AS REQ'D.
INACTIVE
CONFIDENTIAL
1 1/2" DIA. SHAFT 20" OFFSET TEE RING
VALVE - CLASS 2 - 150 # A.S.A.
W/(1) 2PC3 NUMATIC - ON BACK END.
CONTINENTAL EQUIPMENT COMPANY
A DIVISION OF FISHER GOVERNOR COMPANY
CORAOPOLIS • PENNSYLVANIA
REV. BY DATE
DWN. SNYDER
DATE 4-30-
CKD. D. WEBER
5-2-
LAYOUT NO.
SCALE NONE
DWG. NO. H-15214

Director of NRR
June 15, 1984
Attachment (2)

RESPONSE TO NRC QUESTIONS

FISHER CONTROLS COMPANY

MARSHALLTOWN, IOWA 50158

AUTOMATIC CONTROL EQUIPMENT
SINCE 1880

Reply to: FISHER CONTROLS COMPANY, R. A. Engel Technical Center, P.O. Box 11, Marshalltown, Iowa 50158

December 4, 1981

Northern States Power Company
Monticello Nuclear Generating Plant - Unit 1
Attn: R. A. Goranson
P.O. Box 600
Monticello, Minn. 55362

Subject: Northern States Power Order: MQ-05913
Fisher Controls Order: 099X-DIR-44455
Engineering Response/NRC Questions
18" Type 9200/656-60 Valve Assemblies
Serial No: 127571-76, 127579

Ref:

a. Bechtel P.O. 5828-M-49-AC
Fisher Order: 21-007854
(CCN: P73605-02 thru -05)

b. Letter, Fisher Controls (L. R. Waite) to Northern States Power (R. A. Goranson) dated 03/19/81;
Subject: 18" Type 9200 Containment Isolation Valves;
Fisher S/N: 127571-6 and 127579

c. Fisher Order 16-37743 (CCN: BD091) for replacement parts.

d. Letter, Fisher Controls (S. Hanzlik) to Northern States Power (R. Goranson), dated 04/27/81; Subject: 9200 Butterfly Valve Shaft Stress Analysis done by Fisher Controls for Northern States.

A. <u>Valve Assembly Data</u>

The following data is supplied in accordance with subject order 099X-DIR-44455 for engineering documentation for seven similar butterfly valves originally supplied per Reference a. above:

Valve Assembly Construction

20" Type 9210 Butterfly Valve, Class 150 RF, offset Disc
Type 656-60 Diaphragm Actuator, Bench Set 6-26 psig
ASCO Type 830064 3-way solenoid
Microswitch Type BZE6-2RQ2 Limit Switches (2)
Inflatable EPDM T-Ring Seal (with Pressurization System):
  Fisher Type 164A switching valves (2)
  Numatic 2PC3 3-way valve
  Volume tank (2643 cu. in.)

Fisher Assembly Drawings: (Furnished as Attachment 1)

P-73605-04	(S/N: 127571)
P-73605-02	(S/N: 127572-73)
P-73605-02-1	(S/N: 127574)
P-73605-03	(S/N: 127575)
P-73605-03-1	(S/N: 127576)
P-73605-05	(S/N: 127579)

Notes:

1. All seven valves are similar in construction; all use the same basic body, disc, 656-60 actuator and connecting linkage. Significant differences may be summarized as follows, and least favorable constructions will be considered in responding to the NRC questions:

   a. Two valves (S/N: 127571 and 127579) are provided with valve shafts 50½ inches long, with fabricated actuator mounting brackets, and with the actuator mounted parallel to the pipeline; all the rest are provided with 48 7/8 inch shafts, with cast actuator mounting brackets, and with the actuator mounted perpendicular to the pipeline.

   b. Some of the valve bodies are provided with double "O" ring seals on one flange face, with leakoff connections between. The remainder have no "O" ring grooves on the flange faces.

2. The subject valve assemblies were fitted with new 17-4PH shafts (SA 564/630), taper pins, and elastomers (T-rings and O-rings for the bodies) in April 1981 (Ref. d.). The modified construction is the construction being addressed in this document.

Service Conditions: (For ON-OFF Service)

a. Normal: (Air)

Shutoff ΔP: 62 psid
Specified Design Flow: 6800 SCFM
Design Temperature: 150°F to 180°F
Radiation: 300 mrem/hr gamma
Specified Supply Pressure: 80-105 psig
Maximum Actuator Casing Pressure: 40 psig*

*It is assumed that a regulator is used to limit the pressure to the 656-60 actuator.

b. DBE conditions:

Flowing ΔP: 56 psid at open angles.
Seismic Requirements:
0.82 g in any horizontal direction
0.04 g in the vertical direction
Fail Closed (upon loss of Electrical or Pneumatic power)

c. Normal Flow Direction:

Flow into hub side of disc: S/N 127574, 127576
Flow into flat side of disc: All others

d. Stroking time: 5 seconds to close

B. Response to NRC Questions

(Specifically "Clarification of Sept 27 [1979] letter to Licensees Regarding Demonstration of Operability of Purge and Vent Valves" - See Attachment 2)

Question 1:

"The ΔP across the valve is in part predicated on the containment pressure and gas density conditions. What were the containment conditions used to determine the ΔP's across the valve at the incremental angle positions during the closure cycle?"

Response:

The peak containment pressure/temperature conditions were used in the analysis of the valve/actuator construction at all open angles. No assumptions are made regarding partial closing before peak containment pressure is reached; therefore, the analysis presented applies regardless of the rate of containment pressure buildup or actuator stroking time.

Specifically, a constant containment pressure of 56 psid and 180°F was used in determining fluid conditions across the valve at all open angles of rotation (10° to 90°). (See Attachment 4 of Ref. C). When closed, a shutoff ΔP of 62 psid was used (at 180°F). Material properties were used at the maximum temperature condition (180°F).

Question 2:

"Were the dynamic torque coefficients used for the determination of the torques developed based on data resulting from actual flow tests conducted on the particular disc shape/design/size? What was the basis used to predict torques developed in valve sizes different (especially larger valves) than the sizes known to have undergone flow tests?"

Response:

Dynamic torque factors used in butterfly valve sizing were developed from test data obtained from models with similar disc configurations and flow characteristics. The dimensionless aspect ratio (defined as the ratio of the disc diameter to the hub diameter) was judged to be a significant parameter for evaluation of dynamic torques at various opening angles. Therefore, a series of water flow tests were conducted with a group of 4" and 6" butterfly valve models constructed with various aspect ratios, ranging from 3:1 to 14:1 (such as 3:1, 5:1, 8:1, 11:1, and 14:1), in various disc configurations (conventional, offset, cammed), and in both flow directions (normal and reverse).

The test were conducted using the Fluid Controls Institute (FCI) specifications for test arrangement and conduct, per FCI paper 58-2.

Note: Normal flow is flow into the hub side of the disc with the seal on the downstream side; reverse flow is flow into the flat side of the disc with the seal facing upstream.

The basis followed by Fisher in using incompressible (water) flow model tests to establish dynamic torque coefficients applicable to large diameter valves in compressible flow service is presented in the ISA Transactions article provided as Attachment 3 ("Effect of Fluid Compressibility on Torque in Butterfly Valves" by Floyd P. Harthun, ISA Trans. Vol. 8, No. 4, 1969).

a. On Page 282 of the referenced paper, a relationship is developed relating Torque to the nominal valve diameter and pressure drop, for incompressible flow conditions, namely:

$$T_D = K_1 D^3 \Delta P \text{ (Eqn. 10-B)}$$

in which K_1 is a dimensionless torque coefficient for incompressible flow. It may be noted that this relationship applies to various valve sizes, as well as to various pressure drops. The K_1 value is determined by test (using water), for various rotation angles as shown in Figure 1, Page 283 of the ISA paper.

b. The referenced ISA paper then considers dynamic torques developed during compressible fluid flow. In this case, the actual torque is no longer linear with respect to ΔP; for convenience, however, a similar relationship is developed, using a ΔP_e factor as follows:

$$T_D = K_1 D^3 \Delta P_e \text{ (Eqn. 25)}$$

This relationship (Eqn. 25) permits determination of dynamic torques for various valve sizes under conditions of compressible flow, providing K_1 and ΔP_e are determined.

c. Figure 5, Page 284 summarizes the rationale presented in the ISA paper; this Figure shows a plot of calculated and experimental torque values for various pressure drops and flow conditions. The straight line labeled "Incompressible Flow" is a representation of the relationship: $T_D = K_1 D^3 \Delta P$, while the curved line represents compressibl flow torque values, following the relationship: $T_D = K_1 D^3 \Delta P_e$. Test data for compressible flow is also plotted, showing close agreement with the calculated values.

d. Reference is made to Figures 6, 7, and 8, page 285 of the ISA paper showing a comparison of test data and calculated data for various angles of rotation. Close agreement with ΔP_e torque values for compressible flow is indicated. [Note: There are a few typographical errors in the ISA document figures: the $\Delta P/P_1$ values given in the captions to Figure 7 should be 0.155 and in the caption to Figure 8 should be 0.466.]

Application of the conclusions from the ISA paper are presented in Attachment 4: "Torque-Pressure Drop Relationships Used in Dynamic Torque Coefficient Selection", which is a representation of the Figure 5 curves from the ISA paper. This shows how the torque values for compressible flow are conservatively determined and related to incompressible flow torques. It should be noted that the compressible flow curve reaches a choked flow condition at larger ΔP values (for critical flow), resulting in a maximum torque value (T_c), which cannot be exceeded, regardless of how large ΔP becomes.

a. A ΔP_{eff} value* is obtained from the Fisher sizing tables based on the absolute inlet pressure value, type of disc, and flowing fluid.

b. If the actual ΔP is less than ΔP_{eff}, then ΔP_{act} is used, which predicts a more conservative (greater) torque, but less than T_c. (Shaded area - Attachment 4).

c. If the actual ΔP is <u>greater</u> than ΔP_{eff}, then the ΔP_{eff} value is used, corresponding to T_c (the maximum possible torque). This again is conservative, predicting a higher torque than is actually present.

d. An actuator is selected, based on the predicted maximum torque requirements. The actuator must be able to provide the necessary torque to open, close, or maintain the valve.

The particular aspect ratio of the subject valve construction is approximately 5:1, relating closely to the aspect ratios of the test models used in establishing the sizing and capacity tables. See Attachment 5 for representative capacity and dynamic torque curves of a 6" Type 9200 test model with a 5:1 aspect ratio. Note that the dynamic torque tends to close the valve for certain opening angles.

*The ΔP_{eff} value (not to be confused with ΔP_e used in the ISA paper) is based on critical flow conditions which will produce the maximum possible dynamic torque.

Question 3:

"Were installation effects accounted for in the determination of dynamic torques developed? Dynamic torques are known to be affected, for example, by flow direction through valves with off-set discs, by downstream piping backpressure, by shaft orientation relative to elbows, etc. What was the basis (test data or other) used to predict dynamic torques for the particular valve installation?"

Response:

Fisher does not possess quantitative details regarding the effect on non-uniform fluid flow. The sizing data available is based on the assumption of uniform flow conditions.

All Fisher sizing procedures are based on a pressure drop across the valve that is supplied by our customer; if downstream piping produces a backpressure, and if the customer wants to take credit for this effect, the existence of the backpressure should be reflected in the sizing ΔP provided. As stated previously for the subject accident conditions, the sizing ΔP across the valve is taken to be equal to the peak accident containment pressure for all angles of disc opening; this approach is conservative if backpressure actually does exist.

All Fisher sizing data is based on dynamic torque determination tests which were performed with uniform flow profiles and on valve discs with representative geometries. The effects of a non-uniform flow profile, due to piping elbows, "T"-connections, etc., upstream, are discussed below.

The concern over geometrical piping system effects is relevant, since Fisher typically sizes butterfly valves assuming a uniform flow profile, while various piping configurations directly upstream could produce a non-uniform flow as illustrated by Figures A & B of Attachment 6. The two configurations are differentiated by a 90° rotation of the valve shaft with respect to the flow profile.

a. Valve/Flow Orientation, Figure A

If it has been determined that plant layout is such that the valve is oriented to the flow as depicted in Fig. A (Attachment 6), the non-uniform fluid profile is not expected to produce an additional torque on the valve disc since both "wings" of the disc (as split by the shaft) will be subjected to the same flow with respect to time.

b. Valve/Flow Orientation, Figure B

If it has been determined that plant layout is such that the valve is oriented to the flow as depicted in Fig. B (Attachment 6), the non-uniform flow will affect the performance of the valve. The flow profile shown will probably produce some amount of torque, Tp, in the direction shown in Fig. B; obviously, if the torque rotational direction is coincident with valve closure, the non-uniform flow profile will assist closure; however, if the torque direction is coincident with valve opening, the profile will oppose closure.

NOTE: The above explanation must be coupled with exact installation details by the utility to determine how the closure function of a particular valve will be affected.

In the development of the dynamic torque coefficients, flow direction has been considered. In the case of flow into the hub, a factor of 1.5 is used (when selecting torque coefficients) as compared to flow into the flat side of the disc; this is done in the interests of convenience and conservatism because the Fisher model tests indicate torque values are 1 to 1.5 times higher when flowing into the hub side.

Fisher suggests that if you desire more specific performance information, the way to produce that would be through actual testing of identical valve assemblies under conditions you define. To address the possiblity of Fisher performing these tests under contract, your request should be directed to:

Scott McLagan
Assistant Sales Manager - Power
Fisher Controls Company
205 S. Center St.
Marshalltown, Iowa 50158
Telephone: (515)754-3408

Question 4:

"When comparing the containment pressure response profile against the valve position at a given instant of time, was the valve closure rate vs. time (i.e. constant or other) taken into account? For air-operated valves equipped with spring-return operators, has the lag time from the time the valve receives a signal to the time the valve starts to stroke been accounted for?

NOTE: Where a butterfly valve assembly is equipped with spring-to-close air operators (cylinder, diaphragm, etc.), there typically is a lag time from the time the isolation signal is received (solenoid valve usually de-energized) to the time the operator starts to move the valve. In the case of an air cylinder, the pilot air on the opening side of the cylinder is approximately 90 psig when the valve is open, and the spring force available may not start to move the piston until the air on this opening side is vented (solenoid valve de-energizes) below about 65 psig, thus the lag time.

Response:

Reference is made to the response to Question 1 above. "The peak containment pressure/temperature conditions were used in the analysis of the valve/actuator construction at all open angles." Therefore, since the maximum conditions were considered at all permissible open angles, the valve closure rate vs. time was not an applicable consideration; likewise, the containment pressure buildup rate was not a factor, either. A more detailed time sequence commentary is provided as follows:

a. In the case of a diaphragm, spring-return actuator (such as the Type 656-60, Push Down to Open), full travel is achieved at a diaphragm pressure of approximately 25-27 psig. Diaphragm pressurization up to 35 psig is done to provide the maximum torque capability (hold-open torque). Therefore, the spring will not start to move the valve shaft linkage until some diaphragm pressure bleed-down through the solenoid occurs (when the solenoid is de-energized).

b. When calculations were done to determine the allowable ΔP at open angles (see response to Question 5 below), the assumption was made that the peak containment pressure (56 psig) was present immediately at the onset of the accident condition. This is a conservative approach since the buildup from ambient to 56 psig will require some finite time (in the order of several seconds). No time-history study was made, since maximum conditions were assumed at the onset.

c. The Type 656-60 actuator has a casing volume of 902 cu. in. for full stroke (4.125"), with a clearance volume of 216 cu. in. The pressurized volume has to be expelled through a 1/4" NPT connection (Cv=0.59) connected to a Fisher Type 164A switching valve and an ASCO 830064 solenoid, in order for closure action to occur. There is some restriction in the solenoid (Cv=0.75), but the pressure line to the actuator is rapidly vented when the normally-closed solenoid is de-energized [upon receipt of the closure (safety-mode) signal]. The main restriction is the 1/4 NPT connection on the upper diaphragm casing and on the 164A switching valve.

d. Production valve stroking times were demonstrated as required (for each valve assembly) prior to shipment. At this point, the best stroking time data could be obtained by timing the installed valve assemblies during a field stroking test, conducted at the plant site.

e. When stroking time calculations or testing is done, lag times due to diaphragm overpressure venting are considered and included when supplying stroking data, i.e. the closure/opening times are noted from the time the solenoid signal is received, not from the time the actuator starts to move.

Question 5:

"Provide the necessary information for the table shown below for valve positions, from the initial open position to the seated position (10° increments if practical)."

Valve Position Min. Degrees - 90° (full open)	Predicted ΔP (across valve)	Maximum ΔP (capability)

Response:

As stated in the response to Question 4 above, no time-history study has been performed, since a maximum ΔP value (56 psi) was used at all open angles; therefore, no "Predicted ΔP" values are provided or applicable.

A study has been made of the allowable ΔP (capability) and the associated torque requirements for various opening angles. This has been presented in our 03/19/81 letter (Reference b); excerpted data from this letter are provided below, based on a maximum P_1 and maximum ΔP of 56 psig (for open angles) and a P_1 and ΔP of 62 psig (when closed).

Valve Position (Open Angle)	Allowable ΔP (Psid)	Operating Torque ($In\text{-}lb_f$)	Gas Flow Coefficient (Cg)
0°	62	1578	0
10°	56	2685	4,809
20°	56	3233	11,884
30°	56	2780	29,963
40°	56	4990	54,700
50°	56	6843	103,155
60°	11	9664	159,543
70°	5	8937	196,838
80°	3	8532	202,758
90°	3	8532	211,638

NOTES: 1. Certain of the allowable ΔP values given in the table above are based on a P_1 of 56 psid. A substantially higher ΔP could be tolerated at open angles, if P_1 were higher than 56 psig, i.e. the 56 psid ΔP values are not based on stress limitations; instead, they are consistent with a P_1 of 56 psig.

2. The operating torque is the torque required to operate the valve, not the torque output of the 656-60 actuator. At most open angles flow tends to close the valve so the operating torque is that required to open the valve farther or hold it open. In the interests of conservatism, the operating torque values listed are for flow into the hub side (the highest torque requirements) since some of the subject valves are installed that way (flow into hub side).

   It may be noted that the "Operating Torque" values listed above differ from the "Actuator Torque" values given in the analysis printout furnished with the 3/19/81 letter. The reason is that the "Actuator Torque" values are those associated with the "Allow ΔP" values given above them on the analysis printout, while the "Operating Torque" values were calculated based on the allowable ΔP values shown just to the left on Page 9 of this document.

3. A full 56 psid pressure differential would not be experienced at the valve (at open angles) because of critical flow limitations; therefore, only the effective ΔP must be considered in torque calculations, a substantially lower value.

The results of the study indicate that the valve can safely withstand a maximum ΔP of 56 psi (or 62 psi, when closed) at all open angles 0°-50°, as far as valve component stresses are concerned. However, the maximum opening angle must be limited to 40° because of the capability of the Type 656-60 actuator. At angles over 40° open, the torque level exceeds the maximum actuator output of 5773 in-lb_f, as stated in the referenced 03/19/81 letter.

NOTE: The subject valves have been provided with travel stops to limit the maximum opening angle to 40°; this was done at the time the shafts were replaced in April 1981.

<u>Question 6</u>:

"What Code, standards or other criteria, was the valve designed to? What are the stress allowables (tension, shear, torsion, etc.) used for critical elements such as disc, pins, shaft, yoke, etc. in the valve assembly? What load combinations were used?"

<u>Response</u>:

Type 9220 butterfly valves are designed according to the ASME Boiler and Pressure Vessel Code, Sections III and VIII. Allowable stresses are also taken from the ASME B & PV Code. Loads considered in the design of these valves include all typical pressure and flow-induced loads. Worst case load combinations were normally used. The design is compatible with ANSI Class 150 pressure/temperature ratings for temperatures from +20 to +300°F. These valve bodies are provided with flat-face flanges to mate with ANSI Class 150 (B16.5) raised-face flanges.

The methods used in analyzing critical components are described in detail in the 03/19/81 letter (Reference b). The primary critical components are the shaft, disc, and bearings. A summary of critical loadings is presented as follows:

Stress Consideration	Stress Allowable
1. Shaft at disc hub (1.5S) (bending and torsion)	52.5 Ksi*
2. Shaft at disc hub (0.75S) (torsion and transverse shear)	26.25 Ksi*
3. Shaft at Pin Connection (0.75S)	26.25 Ksi*
4. Shaft at Key Connection (0.75S)	26.25 Ksi*
5. Bushing	10.0 Ksi**

* Based on ASME Code Section III allowable stress(S) of 35 Ksi for 17-4PH, Condition H1100 (Table I-7.1, Appendix I)

** TFE-lined SST bushing strength determined by testing at Fisher-Continental.

The shaft is considered to be the most critical component under most conditions, since the pins and keys are selected to be stronger than the shaft. Therefore, separate calculations for pins and keys are not necessary. Stress concentration factors are considered when evaluating the shafts at the pins and keyways. The maximum disc load occurs when the disc is in the closed condition, and acceptable disc strength values have been established based on testing and experience.

The subject valves were ordered to confrom to AWWA Standard C-504-66. Stresses resulting from seismic loading were specified to be in accordance with the USAS B31.1.0-1978 Power Piping Code. (Reference Bechtel Specification 5828-M-49)

Question 7:
Question 8:

Response:

Due to an NRC error in the numbering sequence, no questions 7 or 8 exist.

Question 9:

"For those valve assemblies (with air operators) inside containment, has the containment pressure rise (backpressure) been considered as to its effect on torque margins available (to close and seat the valve) from the actuator? During the closure period, air must be vented from the actuator's opening side through the solenoid valve into this backpressure. Discuss the installed actuator bleed configuration and provide the basis for not considering this backpressure effect a problem on torque margin. Valve assemblies using 4-way solenoid valves should especially be reviewed."

Response:

The following comments apply in the case of external pressurization due to a possible containment pressure rise during a Design Basis Event:

a. The control piping schematic for the subject valves is included as Attachment 7 (Drawing H-14266). This piping system is rather complex, since the valves are equipped with Type 656-60 spring-return actuators and with an associated seal pressurization system. The spring side of the diaphragm actuator is vented to the local ambient conditions; if the pressure side is vented (through the solenoid or 164A) to the same local ambient conditions, no pressure differential will exist across the diaphragm as a result of a surrounding local pressure rise. The spring will still drive the actuator to the safety-mode (closed) position and maintain that position as long as the solenoid remains de-energized and as along as no subsequent re-opening signal is received.

   In the event of a delay in solenoid de-energization, a local ambient pressure rise will reduce the ΔP across the diaphragm, which will initially partially close the valve. When the solenoid subsequently de-energizes and vents, the spring would complete the closure stroke.

b. In the event the external ambient pressure is maintained at an elevated level for a prolonged period with the solenoid still energized, and providing the air supply regulator is vented to the same ambient level with a sufficiently high supply pressure available, the regulator would eventually adjust the air supply to the diaphragm actuator to re-establish the initial full-open position.

c. Adequate spring-driven torque output is available from the actuator to close the valve from any open position up to 40° open (regardless of external ambient pressure), providing the spring side of the diaphragm casing is vented (locally). The torques discussed in response to Question 5 above are the opening torques, since dynamic flow effects tend to close the valve or have a neutral effect in the opening range of interest (0°-40°). (See typical curve in Attachment 5.) In any event, the torque values are well within the capabilities of the 656-60 actuator, provided the valve is pinned at a maximum angle of 40° open. (Note: The spring driven torque capabilities given below are based on an initial actuator bench set of 6 psig for initial compression of Spring 1K1628 when the valve is in the closed position.)

(1) AT 0°, the actuator spring will produce a torque of approximately 2395 in-lb_f to close, which is well in excess of the 1578 in-lb_f required (at a ΔP of 62 psid).

(2) At open angles to 40°, the actuator spring is adequate to supply the torque needed to overcome the frictional torque load of 836 in-lb_f. Additional spring driven closure torque is available as the valve is opened farther, reaching approximately 4444 in-lb_f at 40° open.

(3) At the open angles of concern, dynamic forces will tend to close the valve, assisting the spring in this respect, when the diaphragm air pressure drops to zero. If the diaphragm air supply is maintained, the actuator can withstand the maximum torque developed at 56 psid (4990 in-lb_f) at 40° open, since the listed maximum torque capability of the Type 656-60 actuator is 5773 in-lb_f (See the 03-19-81 letter, Reference b).

(d) An external pressure rise could affect the seal pressurization system momentarily, assuming the Type 164A switching valves are locally vented. In time, however, if the solenoid had not tripped and if the regulator had re-established the original control pressure differential (above the new ambient), the seal pressurization system would return to its original condition (depressurized when the valve disc is open).

(e) The solenoid used (ASCO Type 830064) is a three-way direct-acting solenoid. It is connected in the normally-closed mode (pressure to Port B), so that de-energization will vent Port A through Port C.

Question 10:

"Where air operated valve assemblies use accumulators as the fail-safe feature, describe the accumulator air system configuration and its operation. Provide necessary information to show the adequacy of the accumulator to stroke the valve, i.e. sizing and operation starting from lower limits of initial air pressure charge. Discuss active electrical components in the accumulator system, and the basis used to determine their qualification for the environmental conditions experienced. Is the accumulator system seismically designed?"

Response:

The volume tank provided with this valve assembly is provided for the purpose of maintaining pressure in the inflatible seal when the valve is closed and when no line air supply is present. The volume tank performs no function in powering the valve actuator at any time. Valve stroking upon loss of electrical or pneumatic power is provided solely by the spring, in conjunction with the solenoid and 164A switching valve (in series with solenoid and actuator).

Question 11:

"For valve assemblies requiring a seal pressurization system (inflatable main seal), describe the air pressurization system configuration and operation, including the means used to determine that valve closure and seal pressurization have taken place. Discuss active electrical components in this system, and the basis used to determine their qualification for the environmental condition experienced. Is this system seismically designed?

For this type valve, has it been determined that the "valve travel stops" (closed position) are capable of withstanding the loads imposed at closure during the DBA-LOCA conditions?"

Response:

The purpose of the seal pressurization system is to provide air pressure to the disc seal when the disc is closed and to remove the air pressure to the seal before opening the disc and when the disc is open. In addition, a volume tank and check valve is provided to maintain the seal pressurization, even when the normal control air supply drops to zero psig.

The seal pressurization system is shown on Drawing H-14266 provided as Attachment 7. The principal components are explained as follows:

a. The only electrical component is the ASCO Type 830064 solenoid mentioned in the response to Question 9 above. This is a three-way solenoid with a general purpose solenoid enclosure, brass body, 3/8 NPT connections, CV=0.75, bronze body, stainless steel seat, Class A coil construction, 29 watts AC or 23 watts DC, suitable for a maximum differential of 60 psi (Form U) or 125 psi (Form F or G). Port B is connected to the air supply. Port A is connected to the 656-60 actuator through a Type 164A switching valve, and Port C is vented. The solenoid weight is 8.6 pounds. If additional data on the specific solenoids used is needed, the stamped nameplate information should be noted and the manufacturer should be consulted (Automatic Switch Company, Florham Park, New Jersey).

b. Valve position (for the seal pressurization system) is detected by the Numatic 2PC3 Valve, which permits seal pressurization when the disc is at the 0° position. This Numatic valve is operated by a cam directly attached to the valve shaft. For further details on the Numatic 2PC3 Valve, the manufacturer should be consulted (Numatics, Inc., Highland, Michigan).

c. The Fisher Type 164A switching valves are provided to control the sequencing of the seal pressurization system and the valve stroking. One Type 164A (in series with the solenoid and the 656) insures that the 656 actuator is not pressurized (to stroke open), while the seal is pressurized. The second Type 164A insures that the seal remains depressurized until the control air (from the solenoid) is depressurized. As soon as the valve disc reaches 0°, then the Numatic 2PC3 permits pressurization of the seal (as described above). Details on the construction, performance, and maintenance of the Fisher Type 164A are provided in the Bulletin and Instruction Manual included in Attachment 8.

The seal pressurization system was not specifically designed for use in seismic applications.

NOTE: While not part of the seal pressurization system, two limit switches were provided to indicate valve position at the limits of travel. These are identified as Microswitch Type BZE6-2RQ2, single-pole, double-throw, UL and CSA listed: L74; 15 amps; 125, 250, or 480 VAC, side-mounted, with roller-lever, but without seal boot. If additional information on these limit switches is needed, Microswitch should be consulted.

The "disc stop" provided in the valve body is not intended to function as a travel stop; instead it is provided for disc alignment only, for positioning the disc at the 0° position in the process of assembly.

The travel stop function is provided as a modification to the actuator mounting bracket; additional parts are provided as indicated on Fisher Drawing G34225, Rev. B, furnished as Attachment 9. These parts were installed on each valve assembly (at the time of shaft replacement in April 1981) and were adjusted to limit the maximum travel to 40° open. The travel stops provided are consistent with the maximum loading anticipated during DBA-LOCA conditions, because the effect would be to close the valve, not an additional loading on the travel stops. Maximum loading of the travel stops would occur when the actuator is at maximum pressurization, at 40° open.

Question 12:

"Describe the modification made to the valve assembly to limit the opening angle. With this modification, is there sufficient torque margin available from the operator to overcome any dynamic torques developed that tend to oppose valve closure, starting from the valve's initial open position? Is there sufficient torque margin available from the operator to fully seat the valve? Consider seating torques required with seats that have been at low ambient temperatures."

Response:

Reference is made to the responses to Questions 5, 9, and 11 above. It was shown that the valve body design is adequate to withstand a ΔP of at least 56 psid at any open angle up to 50°, and a ΔP of 62 psid when closed. Valve disc travel limitations are needed at a maximum opening angle of 40° because of the Type 656-60 actuator limitations.

Since these are ON-OFF service valves, there will be no dwells at intermediate opening positions. Only the end point valves are critical as long as there is sufficient actuator torque capability to provide the required torque while passing through intermediate positions. As mentioned previously, only approximately 836 in-lb_f of torque is needed at open angles to overcome frictional effects. The dynamic torque developed will tend to close the valve, assisted by the spring compression torque (ranging from approximately 2395 in.-lbs_f at 0° to approximately 4444 in.-lb_f at 40° open). Therefore, adequate capability exists to insure valve closure if open. At the seat (0°), the spring torque (2395 in.-lb_f) well exceeds the seating torque required (1578 in.-lb_f), insuring seating. When closed, the valve seal will pressurize to provide the shutoff capability.

The valve actuator and linkage has been designed to be capable of safely handling the maximum output capabilities of the Type 656-60 actuator (5773 in.-lb_f). The maximum load (4990 in.-lb_f) will be experienced while holding the valve disc open at 40° at 56 psid, prior to receipt of the valve closure signal (loss of diaphragm pressurization), but this maximum load is well under the maximum actuator capability.

These valves are intended for indoor installation at normal operating temperatures of 150°-180°F, according to the valve data sheets. This is well within the capabilities of Type 9200 valves with an EPDM T-ring seal, and is accounted for in the sizing coefficients used in calculating allowable stresses and maximum ΔP values. "Low ambient temperatures" are assumed to be nominal room temperature (100°F), and the difference in seating torque (as compared to that at 180°F) would be slight, at most. Short-term temperature transients at elevated temperatures (above 180°F) will also have little significance as far as seating torques are concerned, because of the mass of the surrounding metal in the valve body.

Question 13:

"Does the maximum torque developed by the valve during closure exceed the maximum torque rating of the operators? Could this affect operability?"

Response:

The responses to Questions 5, 9, and 12 above, have addressed these topics.

Question 14:

"Has the maximum torque value determined in #13 been found to be compatible with torque limiting settings where applicable?

Response:

See the responses to Questions 5, 9, and 12 above in which torques are limited as a consequence of restricting the valve travel to 40° open, maximum. In this manner, the valve actuator linkages are not subject to excessive loads in the event a 56 psid ΔP is present, prior to actuator diaphragm depressurization. Valve actuator travel stops have already been installed to limit maximum opening to 40°. The full operational capability of the valve is available in the opening range from 0° to 40°, except for the reduction in C_g due to partial opening (see the table of C_g values in response to Question 5).

Question 15:

"Where electric motor operators are used, has the minimum available voltage to the electric operator under both normal or emergency modes been determined and specified to the operator manufacturer, to assure the adequacy of the operator to stroke the valve at DBA conditions with these lower limit voltages available? Does this reduced voltage operation result in any significant change in stroke timing? Describe the emergency mode power source used."

Response:

This question is not applicable since none of the subject valves are equipped with electric motor operators.

Question 16:

"Where electric operator units are equipped with handwheels, does their design provide for automatic re-engagement of the motor operator following the handwheel mode of operation? If not, what steps are taken to preclude the possibility of the valve being left in the handwheel mode following some maintenance, test, etc., type operation?"

Response:

This request is not applicable; see Response to Question 15, above. No manual handwheels are provided, either.

Question 17:

"Describe the tests and/or analysis performed to establish the qualification of the valve to perform its intended function under the environmental conditions exposed to, during and after the DBA following its long term exposure to the normal plant environment."

Response:

a. Aging

No aging analyses or tests were completed to verify "end of life" accident capabilities of the subject valves. These valves were originally sold to the defined (normal) environmental conditions based on material suppliers' information and in-service experience. Fisher does recommend, however, that all elastomeric parts be replaced every four years.

b. DBA Environments

The flowing condition ΔP has been established as 56 psid at open angles. The valve is to fail closed upon loss of electrical or pneumatic power. No temperature or radiation conditions have been established, as far as is known.

The intended DBA environment function of the subject valve assemblies is for the valve to perform its safety-mode function at the onset of the accident event, i.e. to close upon receipt of the safety-mode signal and remain closed. It is understood that resumption of normal function operation (on-off cycling) is not intended or required following a DBA condition.

The only components significantly affected by radiation would be the elastomeric parts, and of these, only the T-Ring is involved in the safety-mode function. A discussion of radiation effects and replacement recommendations is provided in the Response to Question 21 and in Attachment 14.

c. Seismic

Bechtel Specification 5828-M-49 identifies the seismic levels as being 0.82g in any horizontal direction, combined with 0.04g in the vertical direction. Stresses resulting from these seismic loads shall be in accordance with the USAS B31.1.0-1967 Power Piping Code.

There is no record of qualification analysis or testing other than submission of a shock test report (Test Report No. F607-2420 by Associated Testing Laboratories, Inc., 10/11/61). It should be borne in mind that there was no resonant frequency requirement and that the seismic levels were specified to be low. Fisher did no environmental or seismic testing for qualification to DBA conditions, and no flow testing has been done (by Fisher) to demonstrate valve closure under the specific DBA conditions identified (ΔP of 56 psid).

The OEM manufacturer should be contacted for qualification data on the electrical components (ASCO solenoids and MICROSWITCH limit switches). Fisher has no qualification documentation on these items as the particular components concerned are not used in current nuclear service applications. The OEM suppliers would need component nameplate data in order to identify the particular items. Fisher does not have a record of the nameplate data (Lot Number, Date, Serial No., etc.) for the components used.

Question 18:

"What basis is used to establish the qualification of the valve, operators, solenoids valves? How was the valve assembly (valve/ operators) seismically qualified (test, analysis, etc.)?"

Response:

Reference is made to the response to Question 17 above. No qualification data was provided, except for the shock test report referenced. No prediction of resonant frequency was provided, and no stress analysis was submitted. At the time (12-12-68), the shock test report was judged to be adequate for the low-level requirements identified. A present-day seismic qualification would be quite different, of course, (because of improved analysis and testing techniques), and no assumption can be made about present-day adequacy, based on the 1968 data. If a current Fisher evaluation of seismic adequacy is desired (based on 1968 requirements or new requirements), contact Scott McLagan at the address listed in the Response to Question 3 above.

Question 19:

"Where testing was accomplished, describe the Type Tests performed, conditions used, etc. Tests (where applicable) such as flow tests, aging simulation (thermal, radiation wear, vibration endurance, seismic) LOCA-DBA environment (radiation, steam chemicals) should be pointed out."

Response:

No type testing was done for the valves on the subject order. A certain amount of recent environmental/seismic testing has been done on large Type 9200 butterfly valves and on related actuators (Type 656-60NS) but none is directly applicable to the equipment furnished on the subject order. In the course of time, a number of product line modifications have been made, so the current qualification data relates to recent construction configurations.

Question 20:

"Where analysis was used, provide the rationale used to reach the decision that analysis could be used in lieu of testing. Discuss conditions assumptions, other test data, handbook data, and classical problems as they may apply."

Response:

No analysis was done (except for that necessary to make the proper sizing selections).

Question 21:

"Have the preventive maintenance instructions (part replacement, lubrication periodic cycling, etc.) established by the manufacturer been reviewed, and are they being followed? Consideration should especially be given to elastomeric components in valve body, operators, solenoids, etc., where this hardware is installed inside containment."

Response:

Fisher normally furnishes instruction manuals for each valve assembly component when it is shipped. Instruction sheets are also provided for the OEM components, if available. Instruction manuals and/or Bulletins for the Fisher components are also furnished as attachments to this document (See Attachments 8, 10, 11, 12). It should be noted that only part of the valve assemblies have cast mounting brackets for the 656-60 actuator; the remainder have fabricated brackets with essentially the same linkage components. If instruction sheets or manuals are needed for the OEM components, the manufacturer should be contacted directly.

As mentioned previously, Fisher recommends that elastomeric parts be replaced at four-year intervals (or sooner). The OEM manufacturer's recommendations should be followed for such items as solenoids.

In the case of the subject valve assemblies, elastomeric failure in the actuator will not interfere with performance of the safety-mode function. The spring will drive the actuator linkage and valve shaft to the 0° position. Likewise, the solenoid spring will drive the solenoid to the vent position regardless of the condition of elastomers.

Integrity of the elastomeric T-ring seal in the valve body is necessary, however, in performing the safety-mode function. The inflatable T-ring elastomer used is EPDM (Ethylene-propylene-diene); "EPT" designation means the same thing. (See ASTM D-1418-77.)

All the elastomeric parts in the valve body (including the T-rings) were replaced at the time of the shaft replacement in April 1981. The following comments apply for the replaced T-ring components:

a. The replacement inflatable T-rings were molded from EPDM Compound No. C-3929-EP by Colonial Rubber Company. A copy of the certifications provided by Colonial is provided in Attachment 13. (The T-rings were fabricated per Fisher Drawing G-12846.)

b. Documents listing characteristics and properties of the T-ring EPDM material are provided in Attachment 14. NORDEL is DuPont's tradename for EPDM material, and a chart showing the properties of this material is provided. Note that the upper temperature limit for continuous service is 145°C (293°F), well above the maximum specified temperature of 180°F.

c. The radiation resistance capability of the EPDM T-rings was addressed in Fisher's 5/14/80 letter to Mr. John Windschill of Northern States Power. The statements and conclusions provided in this letter still apply. A copy of the letter is provided in Attachment 14, together with all the supporting documents addressing radiation resistance of EPDM material.

All the TFE/SST bushings were also replaced at the time of shaft replacement in April 1981. There was no change in material or design for these bushings.

In conclusion, the data submitted herein (per NSP Order MQ-05913) addresses the applicable Questions in the "Clarification of the Sept. 27 Letter to Licensees - - - ". The responses provided are based on the as-shipped construction (except as modified during the April 1981 shaft replacement, witnessed by Fisher representatives).

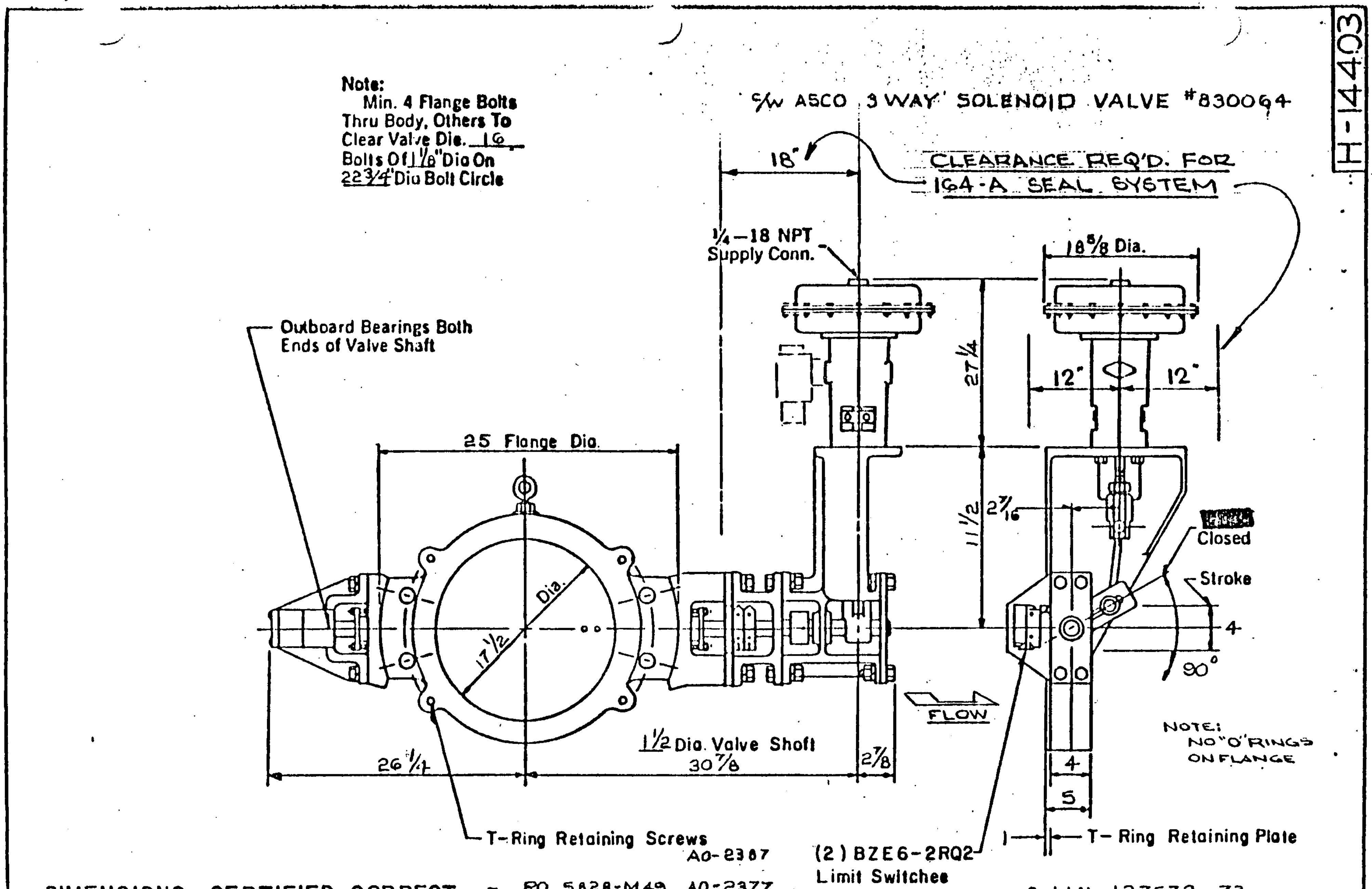
In the event there are further inquiries or if further supplemental qualification effort is needed, please contact Scott McLagan, Assistant Sales Manager - Power, at the address provided previously (in the response to NRC Question 3).

Prepared by:

John Dresser

John Dresser
Nuclear Qualification Engineer

Attachment 1: Fisher Assembly Drawings
P73605-02
P73605-02-1
P73605-03
P73605-03-1
P73605-04
P73605-05



DIMENSIONS CERTIFIED CORRECT Tag PO 5828-M49, AO-2377 Serial No. 127572-73

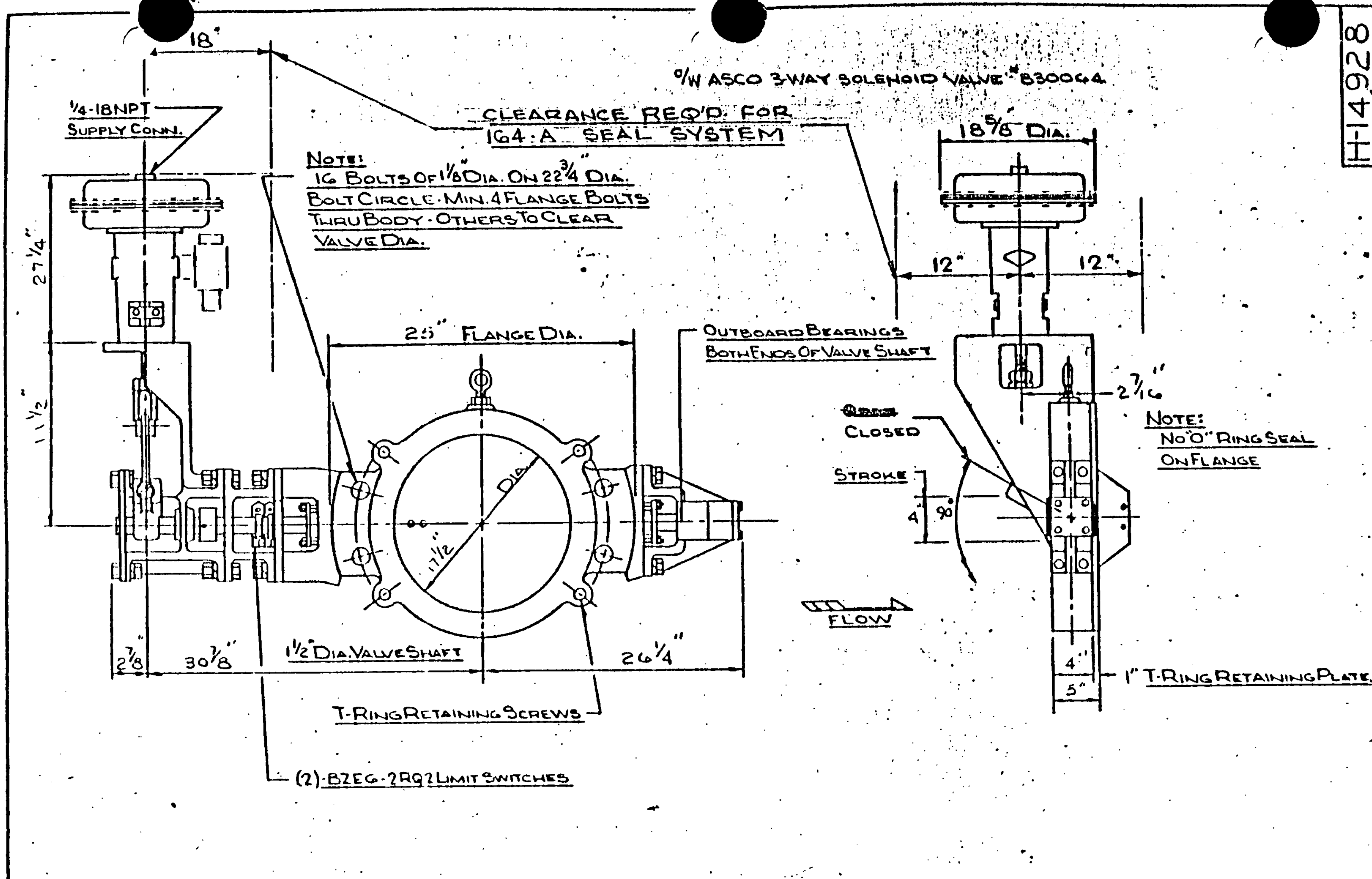
For Becthel Corp.
Your P.O. #5828-M-49-AC
Our P-73605-02 Agent (21) 21-007854
March 25, 1969 BY R. D. EINHOUSE

REV	BY	DATE

18" 9210 Heavy Pattern T-Ring Valve
150# U.S.A.S. Rating. Class 2.
656— 60 Fisher Diaphragm Actuator

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

DWN L T	DATE 3-19-69
CKD	
LAYOUT NO	SCALE NONE
DWG NO P-73605- 1-14403-1	



TAG: PO-5828-M49, AO-2896

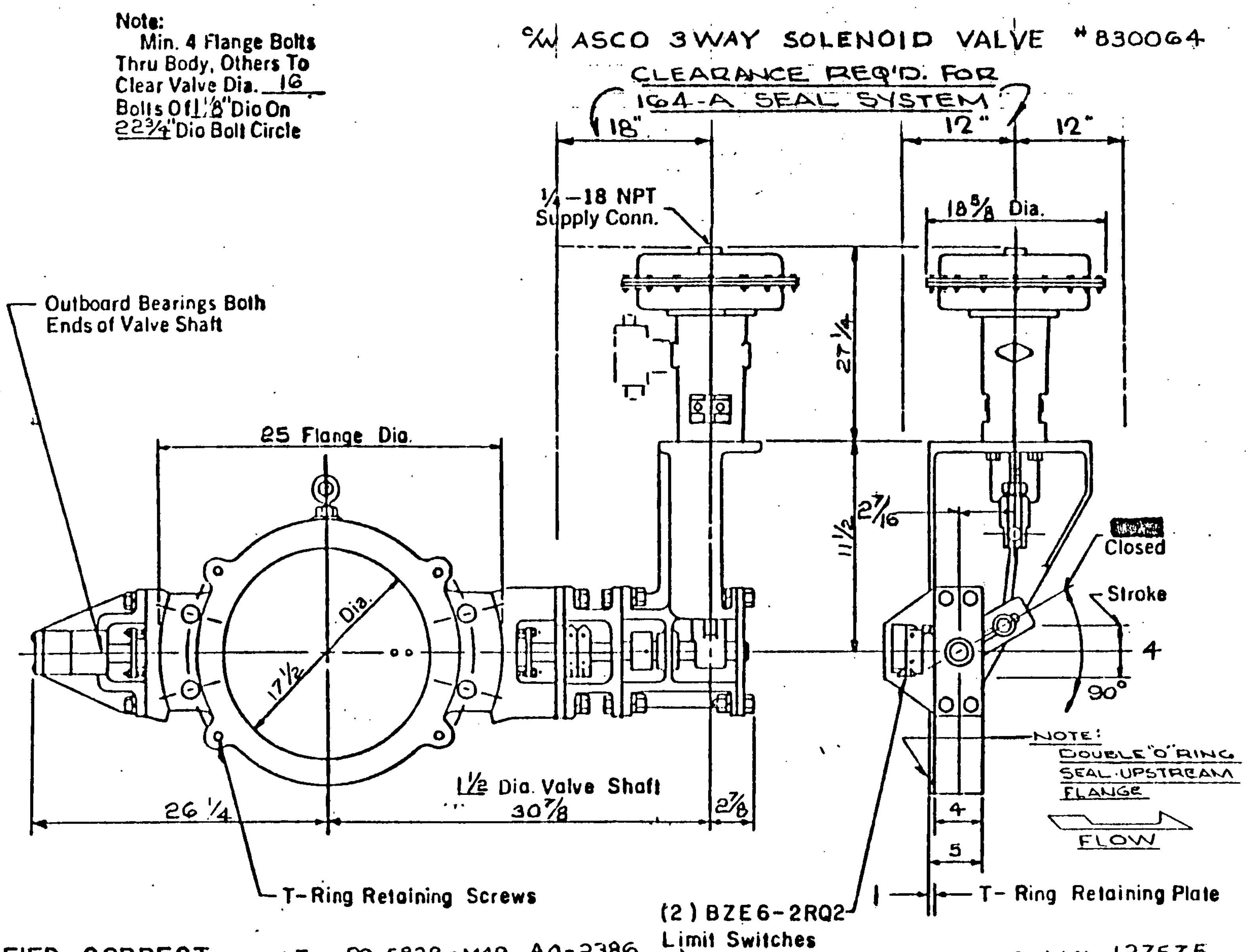
SERIAL No. 127574

TYPE 9210 18" HEAVY PATTERN T-RING VALVE 150 LB. USAS RATING CLASS "2" 656-60 FISHER DIAPHRAGM ACTUATOR	DWN JOSEPH WIRTH	DATE 4-16-69	
	CKD.		
	LAYOUT NO.	SCALE NONE	
CONTINENTAL DIVISION FISHER GOVERNOR COMPANY Coraopolis, Pennsylvania 15108	DWG. NO. H-14928 P-736[illegible]02-1		

REV.	BY	DATE

DIMENSIONS CERTIFIED CORRECT FOR
Bechtel Corp., P.O. #5828-M-49-AC,
Our P-73605-02, Agent: 21-007854,
April 17, 1969
R. D. EINHOUSE

H-14403



DIMENSIONS CERTIFIED CORRECT

For Becthel Corp.
Your P.O. #5828-M-49-AC
Our P-73605-03 Agent (21) 21-007854
March 25, 1969 By R. D. EINHOUSE

Tag: PO 5828-M49 AO-2386

Serial No. 127575

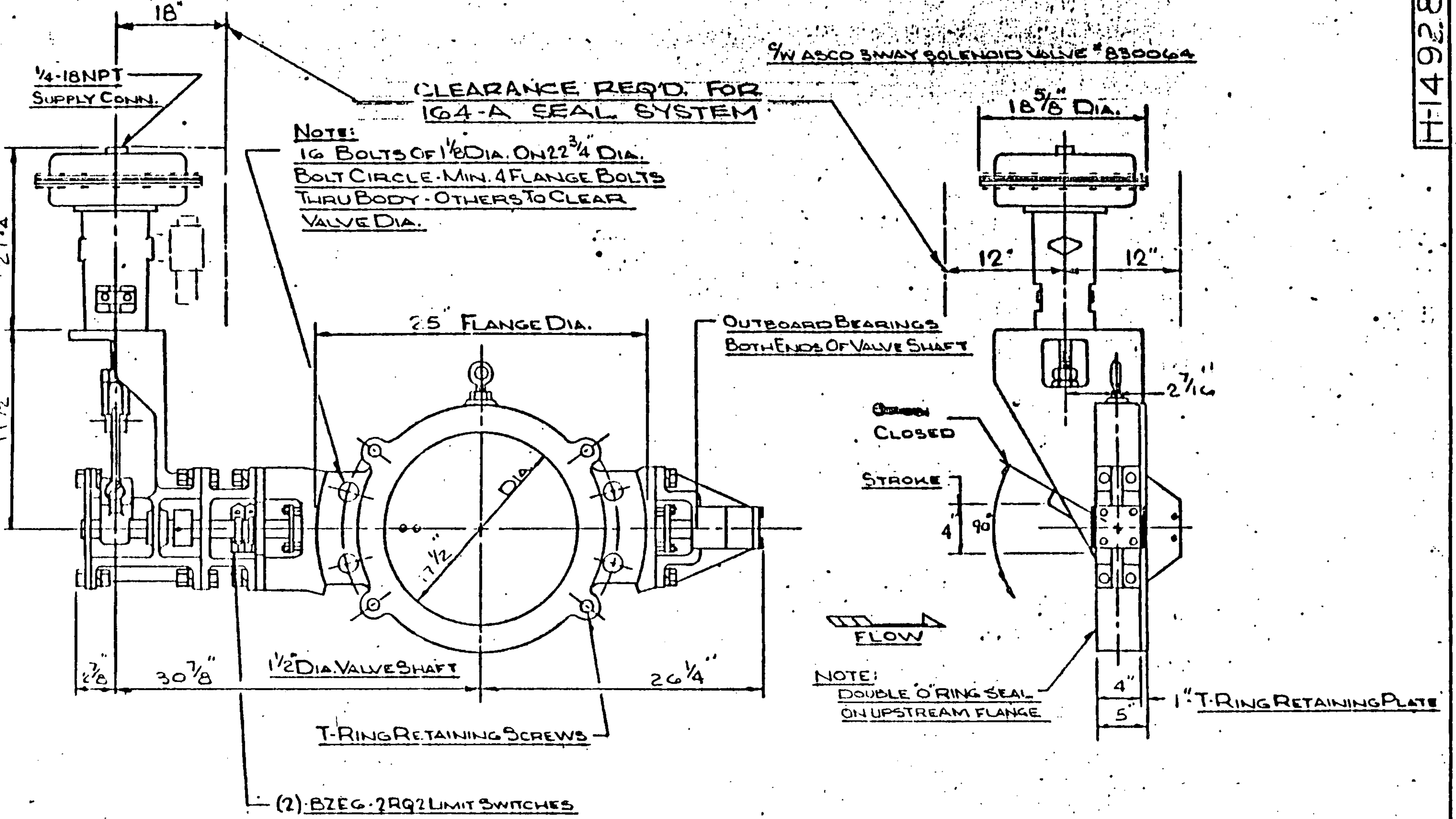
18 9210 Heavy Pattern T-Ring Valve
150# U.S.A.S. Rating. Class 2.
656— 60 Fisher Diaphragm Actuator

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

REV	BY	DATE

DWN L T — DATE 3-19-69
CHD
LAYOUT NO — SCALE NONE
DWG NO P-73605-[illegible]-14403-1

H-14928



DIMENSIONS CERTIFIED CORRECT FOR
Bechtel Corp., P.O. #5828-M-49-AC,
Our P-73605-03, Agent: 21-007854,
April 17, 1969

R. D. EINHOUSE

TAG: PO 5828-M49 AO-2383

SERIAL No 127576

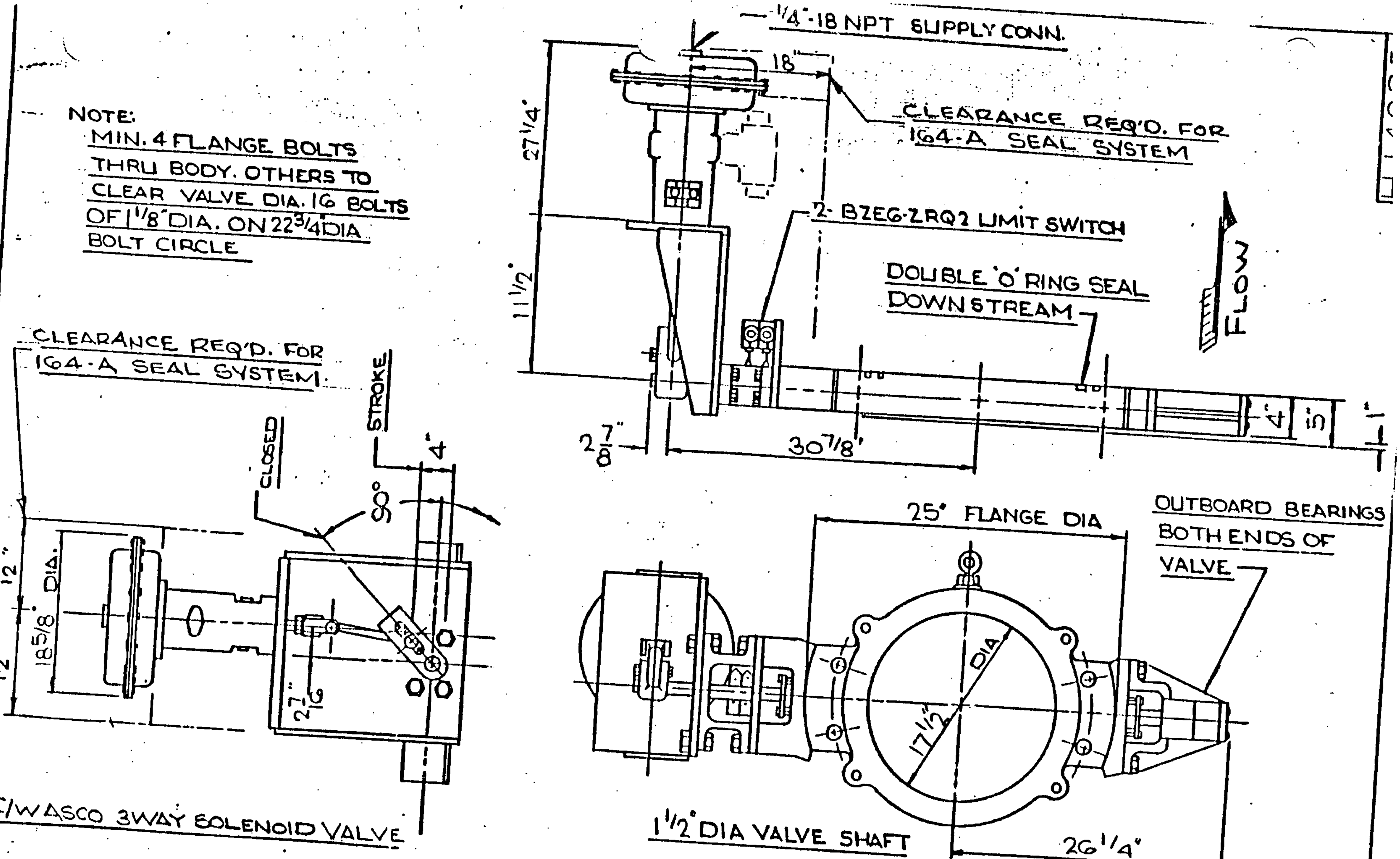
TYPE 9210 - 18" HEAVY PATTERN T-RING
VALVE 150 LB. USAS RATING CLASS "2"
656-60 FISHER DIAPHRAGM ACTUATOR

REV	BY	DATE

DWN JOSEPH WIRTH | DATE 4-16-69
CKD.
LAYOUT NO. | SCALE NONE

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

DWG NO. H-14928
P-736 -03-1



DIMENSIONS CERTIFIED CORRECT FOR
Bechtel Corp., P.O. #5828-M-49-AC,
Our P-73605-04, Agent: 21-007854,
April 17, 1969

R. D. EINHOUSE

TAG: PO 5828-M49 AO-2378 SERIAL No. 127571

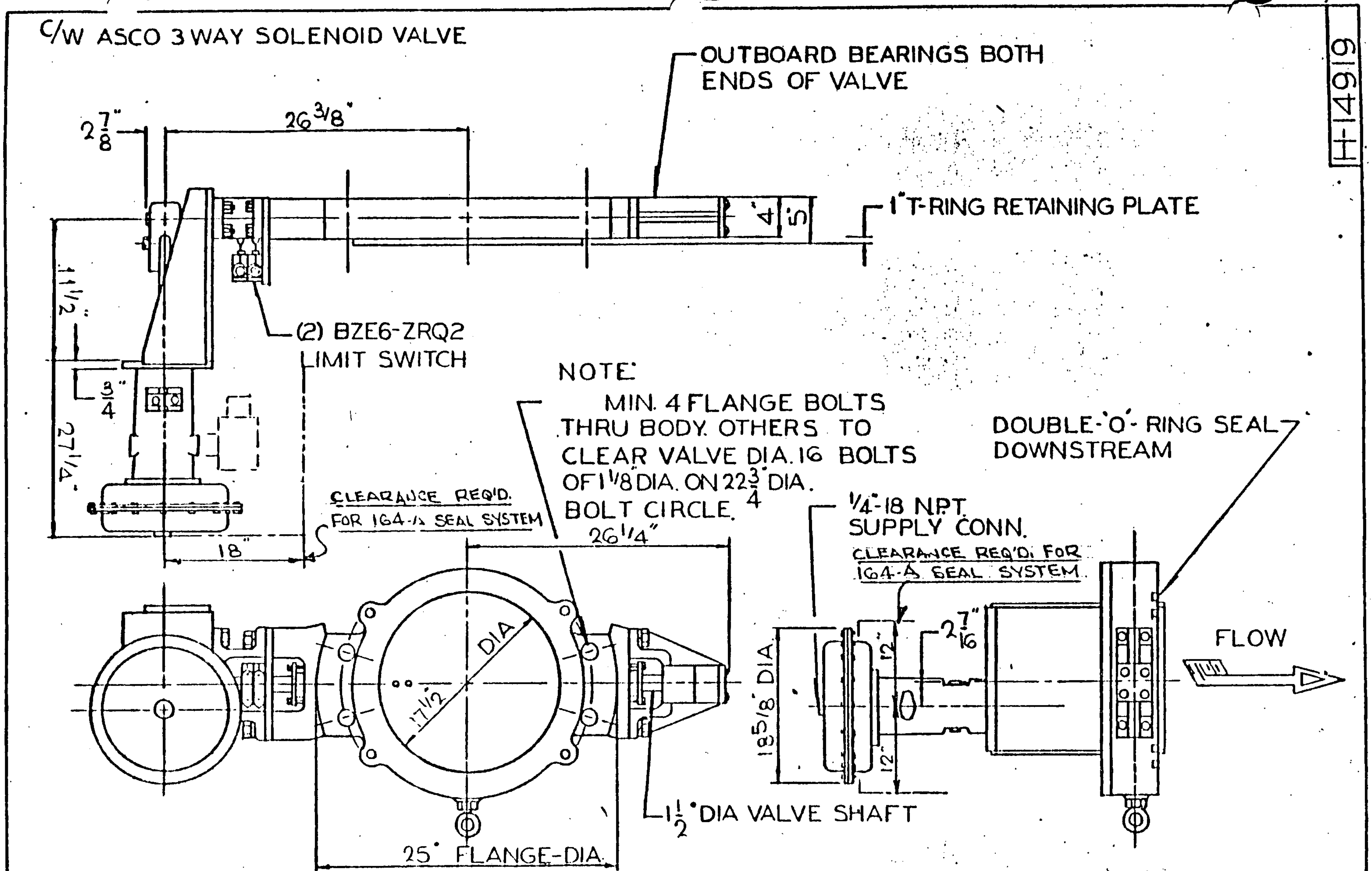
18" 9210 HEAVY PATTERN 'T' RING VALVE
150 LB. USAS - CLASS #2
656-60 FISHER DIAPHRAGM OPERATOR

REV.	BY	DATE

FISHER Controls

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

DWN SNYDER	DATE 4-16-69
CKD.	
LAYOUT NO.	SCALE NTS
DWG NO. P-73605-04	49251



SERIAL No. 127579

TAG: PO 5828-M49-AO-2381

18" 9210 HEAVY PATTERN T-RING VALVE
150 LB USAS RATING-CLASS 2
656-60 FISHER DIAPHRAGM OPER.

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY

DWN SNYDER	DATE 4-15-69
CKD.	
LAYOUT NO.	SCALE N.T.S.
DWG. NO. P73605-05	14919-B

DIMENSIONS CERTIFIED CORRECT FOR
Bechtel Corp., P.O. #5828-M-49-AC,
Our P-73605-03, Agent: 21-007854,
April 7 1969
R. D. EINHOUSE

OUR SHOP ORDER P- 73605-02

Controls

FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108
PHONE: (412) 264-3010—TWX: (412) 269-5150—TELEX: 086-785

PAGE 1 OF 2

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69		X	

AGENT ORDER NO.	VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
21-007854	Heavy Pattern T-Ring	127572-74	7-7-69 DET	

SOLD TO
Bechtel Corporation
P. O. Box 848
Monticello, Minnesota 55362
Attention: Office Manager

SHIP TO
Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK: PO #5828-M-49-AC

VIA: Truck prepaid and add

VALVE DESCRIPTION — B.M.

QUAN.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC	FISH DISC	DISC DIA.
3	18"	9210	150RF	2	C/STEEL *	E.P.T.	C/STEEL *		

SHAFT	PINS	ALLOY KEY	DUCTILE	ST./ST.	FOLLOWERS BRONZE	OTHER
316 S/S	C/STEEL				X	

PACKING	TEFL.	PLAIN	STUFFING BOX PURGED	LUB.	GRAPHITAR	STAINLESS	LANTERN GLAND 1/4" PLUG	STICK LUB.	ISOL. VALVE	ALEMITE
O-RING		X O-RING								

INBOARD BUSHINGS	ROLLER BEARINGS	OPEN	EXTENSIONS PLAIN	CAST ON	OTHER	SEAL SYSTEM	SCHEMATIC NO.
S/S w/TFE.						H-14265	

BRACKET AND LINKAGE — B.M.

PUSH ROD PERPENDICULAR	PARALLEL	PIPE RUN HORIZONTAL	VERTICAL	LINKAGE SET MINIMUM DEGREES	MAXIMUM DEGREES
X		X		0	90

POWER ACTUATOR DESCRIPTION — B.M.

QTY.	ACTUATOR TYPE	MODEL NO.	BORE	STROKE	POSITIONER	MODEL NO.	BYPASS	GAUGES	DIRECT	REVERSE	AIRSET
3	FISHER 656-60			4							

HANDWHEEL: SIDE MOUNTED | TOP MOUNTED | TO | INST. SIGNAL 6 TO 26 | BENCH SET 6 TO 30 | PRESSURE TO ACTUATOR | PUSH ON. TO: OPEN X CL

No MANUAL ACTUATOR DESCRIPTION — B.M.

QTY.	DESCRIPTION	REG.	DE CLUTCH	POSITION	CHAIN LINEAR FT.	LEVER °DISC CLOSED	°DIA. HOLE	°CENTERS

VALVE SERVICE / MOUNTING INSTRUCTIONS

FLUID	MAX. SHUT OFF PRES.	TEMP.	STAT. PRES.	CONT'L FURN. AND MT.	CUST. FURN. CONT'L MT.	CUST. FURN. AND MT.	ITEM	PRICE
Air	62#	150 °F	62#	X			1A, 1B, 1C, 1D	2383.08 ea. 7149.24 NF

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL OPER. & MAINST. INST.	PART LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2	2		X

SPECIAL INSTRUCTIONS:

1C FURNISH Qty (2) PER VALVE BZE6-2RQ2 LIMIT SWITCH TO SHOW OPEN & CLOSED POSITION
1D FURNISH ASCO # 830064 3-WAY SOL. VALVE. ENERGIZE SOL TO OPEN BUTTERFLY
FURNISH Hydrostatic Test @ 425 psi
FURNISH RADIOGRAPH MAGNETIC PARTICLE TEST DYE PENETRANT TEST, PERFORMANCE AND LEAKAGE TEST
FURNISH MILL TEST REPORTS
TAG: PO# 5828-M49 AO-2377, AO-2387, AO-2396
SEE PAGE # 2 FOR MORE INSTRUCTIONS
(1) FURNISH ~~1512~~ IN³ Vol. TANK
1643

DET/mlk
P- 73605-02

21-007854
21089353
21005638
~~16015117~~
16001879

TERMS: NET 30 DAYS F.O.B. SHIPPING POINT

CUSTOMER REQ'D DATE 6/11/69

CONTINENTAL QUOTED DATE

FORM 0076 - 6/66

FISHER Controls

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108
PHONE: (412) 264-3010—TWX: (412) 269-5150—TELEX: 086-785

OUR SHOP ORDER P- 73605-03

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69		X	

AGENT ORDER NO.	VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
21-007854	Heavy Pattern T-Ring	127575-76	7-7-69 DET.	

SOLD TO
Bechtel Corporation
P. O. Box 848
Monticello, Minnesota 55362
Attention: Office Manager

SHIP TO
Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK: PO #5828-M-49-AC

VIA: Truck prepaid and add

A VALVE DESCRIPTION — B.M.

QUAN.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC	FISH DISC	DISC DIA.
2	18"	9210	150# RF	2	C/STEEL*	EPT	C/STEEL*		

SHAFT	PINS	ALLOY KEY	DUCTILE	ST./ST.	FOLLOWERS BRONZE	OTHER
316 S/S	C/STEEL				X	

PACKING	TEFL.	STUFFING BOX PLAIN	PURGED	LUB.	GRAPHITAR	STAINLESS	LANTERN GLAND 1/4" PLUG	STICK LUB.	ISOL.VALVE	ALEMITE
O-RING		~~PLAIN~~ O-RING								

INBOARD BUSHINGS	ROLLER BEARINGS	OPEN	EXTENSIONS PLAIN	CAST ON	OTHER	SEAL SYSTEM	SCHEMATIC NO.
						H-14266	

BRACKET AND LINKAGE — B.M.

PUSH ROD PERPENDICULAR	PARALLEL	PIPE RUN HORIZONTAL	VERTICAL	LINKAGE SET MINIMUM DEGREES	MAXIMUM DEGREES
X		X		0	90

B POWER ACTUATOR DESCRIPTION — B.M.

QTY.	ACTUATOR TYPE	MODEL NO.	BORE	STROKE	POSITIONER	MODEL NO.	BYPASS	GAUGES	DIRECT	REVERSE	AIRSET
2	FISHER 656-60			4							

HANDWHEEL SIDE MOUNTED	TOP MOUNTED	TO	INST. SIGNAL	BENCH SET	PRESSURE TO ACTUATOR	PUSH DN. TO: OPEN	CLOSE
			6 TO 26		6 TO 30	X	

No C MANUAL ACTUATOR DESCRIPTION — B.M.

QTY.	DESCRIPTION	REQ.	DE CLUTCH	POSITION	CHAIN LINEAR FT.	LEVER *DISC CLOSED	*DIA. HOLE	*CENTERS

VALVE SERVICE

FLUID	MAX. SHUT OFF PRES.	TEMP.	STAT. PRES.
AIR	62#	180°F	62#

MOUNTING INSTRUCTIONS

CONT'L FURN. AND MT.	CUST. FURN. CONT'L MT.	CUST. FURN. AND MT.
X		

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL OPER. & MAINST. INST.	PART LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2	2		X

ITEM	PRICE
1A, 1B	2463.08 EA
1C, 1D	4926.16

SPECIAL INSTRUCTIONS:

1C FURNISH Qty (2) PER VALVE BZEL-2RQ2 LIMIT SWITCH TO SHOW OPEN AND CLOSED POSITIONS
1d FURNISH ASCO# 830064 3-WAY SOL VALVE, ENERGIZE SOL TO OPEN BUTTERFLY
FURNISH Hydrostatic TEST @ 425 psi
FURNISH RADIOGRAPH MAGNETIC PARTICLE TEST
DYE PENETRANT TEST, PERFORMANCE AND LEAKAGE TEST
FURNISH MILL TEST REPORTS
TAG: PO# 5828-M49 AO-2383 AO-2386
SEE PAGE #2 FOR MORE INSTRUCTIONS
(1) FURNISH ~~222~~ 10^3 Vol TANK
2643

DET/mlk
P- 73605-03

21-007854
21026235
21004359
~~16008755~~
16001452

TERMS: NET 30 DAYS
F.O.B. SHIPPING POINT

CUSTOMER REQ'D DATE 6/11/69
CONTINENTAL QUOTED DATE

FORM 0076 - 8/65

FISHER Controls

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108

PAGE 1 OF 2

OUR SHOP ORDER P- 73605-04

PHONE: (412) 264-3010—TWX: (412) 269-5150—TELEX: 086-785

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69		X	

AGENT ORDER NO.	VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
21-007854	Heavy Pattern T-Ring	127571	7-7-69 DET	

SOLD TO
Bechtel Corporation
P. O. Box 848
Monticello, Minnesota
Attention: Office Manager

SHIP TO
Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK: PO #5828-M-49-AC

VIA: Truck prepaid and add

VALVE DESCRIPTION — B.M.

QUAN.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC	FISH DISC	DISC DIA.
1	18	9210	150# RF	2	C/STEEL *	E.P.T.	C/STEEL *		

SHAFT	PINS	ALLOY KEY	DUCTILE	ST./ST.	FOLLOWERS BRONZE	OTHER
316 S/S	C/STEEL				X	

PACKING	TEFL.	PLAIN	STUFFING BOX PURGED	LUB.	LANTERN GLAND GRAPHITAR	STAINLESS	1/4" PLUG	STICK LUB.	ISOL. VALVE	ALEMITE
O-RING		~~PLAIN~~ O-RING								

INBOARD BUSHINGS	ROLLER BEARINGS	OPEN	EXTENSIONS PLAIN	CAST ON	OTHER	SEAL SYSTEM	SCHEMATIC NO.
S/S w/TFE						H-14266	

BRACKET AND LINKAGE — B.M.

PUSH ROD PERPENDICULAR	PARALLEL	PIPE RUN HORIZONTAL	VERTICAL	LINKAGE SET MINIMUM DEGREES	MAXIMUM DEGREES
X		X		0	90

POWER ACTUATOR DESCRIPTION — B.M.

QTY.	ACTUATOR TYPE	MODEL NO.	BORE	STROKE	POSITIONER	MODEL NO.	BYPASS	GAUGES	DIRECT	REVERSE	AIRSET
1	FISHER 656-60			4							

HANDWHEEL SIDE MOUNTED/TOP MOUNTED	TO	INST. SIGNAL	BENCH SET	PRESSURE TO ACTUATOR	PUSH DN. TO: OPEN	CL
		6 TO 26	6 TO 30		X	

No MANUAL ACTUATOR DESCRIPTION — B.M.

QTY.	DESCRIPTION	REG.	OE CLUTCH	POSITION	CHAIN LINEAR FT.	LEVER °DISC CLOSED	°DIA. HOLE	°CENTERS

VALVE SERVICE / MOUNTING INSTRUCTIONS

FLUID	MAX. SHUT OFF PRES.	TEMP.	STAT. PRES.	CONT'L FURN. AND MT.	CUST. FURN. CONT'L MT.	CUST. FURN. AND MT.	ITEM	PRICE
AIR	62#	180°F	62#	X			1A, 1B 1C, 1D	~~2463.00~~ NET 2618.08

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL OPER. & MAINST. INST.	PART LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2	2		X

SPECIAL INSTRUCTIONS:

1c FURNISH Qty (2) EZE6-2RO2 LIMIT SWITCH TO SHOW OPEN AND CLOSED POSITION

1d FURNISH ASCO # 830064 3-WAY SOL. VALVE ENERGIZE SOL. TO OPEN BUTTERFLY VALVE

FURNISH HYDROSTATIC TEST @ 425 PSI

FURNISH RADIOGRAPH MAGNETIC PARTICLE TEST, DYE PENETRANT TEST PERFORMANCE & LEAKAGE TESTS

FURNISH MILL TEST REPORTS

TAG PO 5828-M49 AO-2378

SEE PAGE 2 FOR MORE INSTRUCTIONS

1) FURNISH ~~[illegible]~~ in³ VH TANK

2643

DET/mlk

P-73605-04

21-007854
21028468
21005186
~~16009488~~
16001728

TERMS: NET 30 DAYS F.O.B. SHIPPING POINT

CUSTOMER REQ'D DATE 6/11/69

CONTINENTAL QUOTED DATE

FORM 0078 - 6/66

FISHER Controls

CONTINENTAL DIVISION
FISHER GOVERNOR COMPANY
Coraopolis, Pennsylvania 15108
PHONE: (412) 264-3010—TWX: (412) 269-5150—TELEX: 086-785

OUR SHOP ORDER P- 73605-05

CUSTOMER ORDER NO.	DATE	EXPORT BOX	SUBJECT TO INSPECTION	ESTIMATED SHIPPING DATE
5828-M-49-AC	3/6/69			

AGENT ORDER NO.	VALVE TYPE	SERIAL NO.	REV. NO. 1	REV. NO. 2
21-007854	Heavy Pattern T-Ring	127579		

SOLD TO
Bechtel Corporation
P. O. Box 848
Monticello, Minnesota 55362
Attention: Office Manager

SHIP TO
Bechtel Corporation
% Northern States Power Company
Monticello, Minnesota
MK:PO #5828-M-49-AC

VIA: Truck prepaid and add

A VALVE DESCRIPTION — B.M.

QUAN.	SIZE	TYPE	FLANGE	CLASS	BODY	SEAT	DISC	FISH DISC	DISC DIA.
1	18	9210	150RF	2	C/STEEL *	E.P.T.	C/STEEL *		

SHAFT	PINS	ALLOY KEY	DUCTILE	ST./ST.	FOLLOWERS BRONZE	OTHER
316 S/S	C/STEEL		X			

PACKING	TEFL.	STUFFING BOX PLAIN	PURGED	LUB.	LANTERN GLAND GRAPHITAR	STAINLESS	1/4" PLUG	STICK LUB.	ISOL.VALVE	ALEMITE
O-RING		O-RING								

INBOARD BUSHINGS	ROLLER BEARINGS	EXTENSIONS OPEN	PLAIN	CAST ON	OTHER	SEAL SYSTEM	SCHEMATIC NO.
S/S w/ TFE						H-14266	

BRACKET AND LINKAGE — B.M.

PUSH ROD PERPENDICULAR	PARALLEL	PIPE RUN HORIZONTAL	VERTICAL	LINKAGE SET MINIMUM DEGREES	MAXIMUM DEGREES
	X		X	0	90

B POWER ACTUATOR DESCRIPTION — B.M.

QTY.	ACTUATOR TYPE	MODEL NO.	BORE	STROKE	POSITIONER	MODEL NO.	BYPASS	GAUGES	DIRECT	REVERSE	AIRSET
1	FISHER 656-60			4							

HANDWHEEL SIDE MOUNTED | TOP MOUNTED | TO | INST. SIGNAL 6 TO 26 | BENCH SET 6 TO 30 | PRESSURE TO ACTUATOR PUSH ON. TO: OPEN X CLOSE

C MANUAL ACTUATOR DESCRIPTION — B.M.

QTY.	DESCRIPTION	REQ.	DE CLUTCH	POSITION	CHAIN LINEAR FT.	LEVER °DISC CLOSED	°DIA. HOLE	°CENTERS

VALVE SERVICE FLUID	MAX. SHUT OFF PRES.	TEMP.	STAT. PRES.	MOUNTING INSTRUCTIONS CONT'L FURN. AND MT.	CUST. FURN. CONT'L MT.	CUST. FURN. AND MT.	ITEM	PRICE
Air	62#		62#	X			10,18 10,10	~~2489.00~~ NE: 2639.00

PRINT INSTRUCTIONS

CERT. TRANS.	PRINTS	INSTALL OPER. & MAINST. INST.	PART LIST	PRICED PARTS LIST	HOLD FOR APPROVAL
1	2	2	2		X

SPECIAL INSTRUCTIONS:

1C FURNISH QTY(2) BZEL-2202 LIMIT SWITCHES TO SHOW OPEN AND CLOSED POSITION
1D FURNISH ASCO # 830064 3-WAY SOL VALVE ENERGIZE SOL TO OPEN BUTTERFLY
FURNISH HYDROSTATIC TEST @ 425 PSI
FURNISH RADIOGRAPH MAGNETIC PARTICLE TEST, DYE PENETRANT TEST PERFORMANCE & LEAKAGE TEST
FURNISH MILL TEST REPORTS
TAG: PO 5828-M49 AO-2381
SEE PAGE 2 FOR MORE INSTRUCTIONS
1 FURNISH 1322 IN3 Vol TANK
2643

DET/mlk
P-73605-05

21-007854
21013311
21002179
~~16004437~~
16000726

TERMS: NET 30 DAYS
F.O.B. SHIPPING POINT

CUSTOMER REQ'D DATE 6-11-69
CONTINENTAL QUOTED DATE

Attachment 2: "Clarification of Sept. 27 (1979) Letter to Licensees Regarding Demonstration of Operability of Purge and Vent Valves", 3 pages (Topics 1-6, 9-21)

CLARIFICATION OF SEPT. 27 LETTER TO LICENSEES
REGARDING DEMONSTRATION OF OPERABILITY OF PURGE AND VENT VALVES

1. The ΔP across the valve is in part predicated on the containment pressure and gas density conditions. What were the containment conditions used to determine the ΔP's across the valve at the incremental angle positions during the closure cycle?

2. Were the dynamic torque coefficients used for the determination of torques developed, based on data resulting from actual flow tests conducted on the particular disc shape/design/size? What was the basis used to predict torques developed in valve sizes different (especially larger valves) than the sizes known to have undergone flow tests?

3. Were installation effects accounted for in the determination of dynamic torques developed? Dynamic torques are known to be affected for example, by flow direction through valves with off-set discs, by downstream piping backpressure, by shaft orientation relative to elbows, etc. What was the basis (test data or other) used to predict dynamic torques for the particular valve installation?

4. When comparing the containment pressure response profile against the valve position at a given instant of time, was the valve closure rate vs. time (i.e. constant or other) taken into account? For air operated valves equipped with spring return operators, has the lag time from the time the valve receives a signal to the time the valve starts to stroke been accounted for?

<u>NOTE:</u> Where a butterfly valve assembly is equipped with spring to close air operators (cylinder, diaphragm, etc.), there typically is a lag time from the time the isolation signal is received (solenoid valve usually deenergized) to the time the operator starts to move the valve. In the case of an air cylinder, the pilot air on the opening side of the cylinder is approximately 90 psig when the valve is open, and the spring force available may not start to move the piston until the air on this opening side is vented (solenoid valve de-energizes) below about 65 psig, thus the lag time.

5. Provide the necessary information for the table shown below for valve positions from the initial open position to the seated position (10° increments if practicle).

Valve Position (in degrees - 90° = full open)	Predicted ΔP (across valve)	Maximum ΔP (capability)

6. What Code, standards or other criteria, was the valve designed to? What are the stress allowables (tension, shear, torsion, etc.) used for critical elements such as disc, pins, shaft yoke, etc. in the valve assembly.? What load combinations were used?

9. For those valve assemblies (with air operators) inside containment, has the containment pressure rise (backpressure) been considered as to its effect on torque margins available (to close and seat the valve) from the actuator? During the closure period, air must be vented from the actuators opening side through the solenoid valve into this backpressure. Discuss the installed actuator bleed configuration and provide basis for not considering this backpressure effect a problem on torque margin. Valve assembly using 4 way solenoid valve should especially be reviewed.

10. Where air operated valve assemblies use accumulators as the fail-safe feature, describe the accumulator air system configuration and its operation. Provide necessary information to show the adequacy of the accumulator to stroke the valve i.e. sizing and operation starting from lower limits of initial air pressure charge. Discuss active electrical components in the accumulator system, and the basis used to determine their qualification for the environmental conditions experienced. Is the accumulator system seismically designed?

11. For valve assemblies requiring a seal pressurization system (inflatable main seal) describe the air pressurization system configuration and operation including means used to determine that valve closure and seal pressurization have taken place. Discuss active electrical components in this system, and the basis used to determine their qualification for the environmental condition experienced. Is this system seismically designed.

For this type valve, has it been determined that the "valve travel stops" (closed position) are capable of withstanding the loads imposed at closure during the DBA-LOCA conditions.

12. Describe the modification made to the valve assembly to limit the opening angle. With this modification, is there sufficient torque margin available from the operator to overcome any dynamic torques developed that tend to oppose valve closure, starting from the valve's initial open position? Is there sufficient torque margin available from the operator to fully seat the valve? Consider seating torques required with seats that have been at low ambient temperatures.

13. Does the maximum torque developed by the valve during closure exceed the maximum torque rating of the operators? Could this affect operability?

14. Has the maximum torque value determined in #13 been found to be compatible with torque limiting settings where applicable?

15. Where electric motor operators are used, has the minimum available voltage to the electric operator under both normal or emergency modes been determined and specified to the operator manufacturer, to assure the adequacy of the operator to stroke the valve at DBA conditions with these lower limit voltages available. Does this reduced voltage operation result in any significant change in stroke timing? Describe the emergency mode power source used.

16. Where electric operator units are equipped with handwheels, does their design provide for automatic re-engagement of the motor operator following the handwheel mode of operation? If not, what steps are taken to preclude the possibility of the valve being left in the handwheel mode following some maintenance, test etc. type operation.

17. Describe the tests and/or analysis performed to establish the qualification of the valve to perform its intended function under the environmental conditions exposed to during and after the DBA following its long term exposure to the normal plant environment.

18. What basis is used to establish the qualification of the valve, operators, solenoids, valves? How was the valve assembly (valve/operators) seismically qualified (test, analysis, etc.)?

19. Where testing was accomplished, describe the type tests performed conditions used etc. Tests (where applicable) such as flow tests, aging simulation (thermal, radiation, wear, vibration endurance, seismic) LOCA-DBA environment (radiation, steam, chemicals) should be pointed out.

20. Where analysis was used, provide the rationale used to reach the decision that analysis could be used in lieu of testing. Discuss conditions, assumptions, other test data, handbook data, handbook data, and classical problems as they may apply.

21. Have the preventive maintenance instructions (part replacement, lubrication, periodic cycling, etc.) established by the manufacturer been reviewed, and are they being followed? Consideration should especially be given to elastomeric components in valve body, operators, solenoids, etc. where this hardware is installed inside containment.

Attachment 3: ISA Transactions, Vol. 8, No. 4, 1969
"Effects of Fluid Compressibility on
Torque in Butterfly Valves" by
Floyd P. Harthun

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Volume 8 Number [illegible]

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AMERICA

Effect of Fluid Compressibility on Torque in Butterfly Valves

FLOYD P. HARTHUN

ISA TRANSACTIONS: 8 (281-286) 1969

Effect of Fluid Compressibility on Torque in Butterfly Valves*

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A technique is presented by which the shaft torque resulting from fluid flow through butterfly valves can be determined with reasonable accuracy for both compressible and incompressible flow. First, the general torque relationship for incompressible flow is established. Then, an effective pressure differential is defined to extend this relationship to include the effect of fluid compressibility. The application of this technique showed very good agreement with experimental test results.

INTRODUCTION

THE APPLICATION of butterfly valves in various automatic control systems requires proper actuator sizing for efficient control. Thus, a thorough knowledge of the fluid reaction forces acting on the valve disc is required. Extensive experimental work[1] has been performed in the past to establish a relationship to determine these forces and thus determine the resultant shaft torque. The general form of this relationship has been established and confirmed. However, by using the classical fluid momentum approach, a similar relationship can be obtained in which the torque is shown to be directly proportional to the measured valve pressure differential for a given disc position. This relationship along with most of the previously published torque information is adequate for incompressible flow. Although the effect of fluid compressibility on torque has been recognized, no useful relationship has been developed. The primary objective of this investigation is to extend the established torque relationship to include the effect of fluid compressibility.

*Presented at the 1968 ISA Annual Conference; revised August, 1969.
†Research Engineer.

DEVELOPMENT OF GENERAL TORQUE RELATIONSHIP

The total shaft torque required to operate butterfly valves can be separated into two major components:

1. Dynamic torque—that portion of the total operating torque attributable to the fluid reaction force of the flowing medium acting on the valve disc.
2. Friction torque—that portion of the total operating torque attributable to friction in the packing and bushings.

Since each of these components is independent of the other, a separate evaluation of each component affords the best approach to this problem. This investigation is limited to an evaluation of the dynamic torque component. If the friction on the valve shaft is assumed to be independent of direction of rotation, it can be readily isolated. The torque required to rotate the valve disc is measured in a clockwise and a counterclockwise direction through full travel. Since friction always opposes motion the difference between these values will be twice the actual shaft friction.

The dynamic torque for butterfly valves is a function of the fluid reaction forces acting on the valve disc. It would be difficult to determine these forces by purely analytical techniques. Experimental determination of the pressures and velocity profiles in the immediate area of the disc would also be quite difficult. However, if a control volume is selected so the boundaries are points of known pressure and velocity, an analysis of these forces can be made from the change in fluid momentum through this control volume.

INCOMPRESSIBLE FLOW

An expression for dynamic torque is developed assuming incompressible flow. This torque is a function of the fluid reaction force, F, and a moment arm, D, which is a characteristic dimension of the valve disc.

$$T_D = f(F, D) \tag{1}$$

Using the fluid momentum approach, the force, F, is given by:

$$F = M\Delta V \tag{2}$$

where

F = sum of external forces acting on fluid
M = mass flow rate
ΔV = fluid velocity change through the control volume

The mass flow rate, M, is given by

$$M = \rho A V \tag{3}$$

By using a proportionality constant, B_1, the mass flow rate can also be defined as

$$M = B_1 A(\rho \Delta P)^{1/2} \tag{4}$$

Equations (3) and (4) are combined to obtain the following expression for fluid velocity:

$$V = B_1(\Delta P/\rho)^{1/2} \tag{5}$$

The velocity change through the control volume, ΔV, in Equation (2) can be expressed in terms of the velocity at the valve disc by use of a proportionality constant, B_2

$$F = B_2 M V \tag{6}$$

By substituting the expressions for mass flow rate Equation (4) and fluid velocity Equation (5) into Equation (6) the force on the valve disc is

$$F = B_1{}^2 B_2 A \Delta P \tag{7}$$

For a given valve size, the flow area, A, for any angle of disc rotation, θ, can be written as

$$A = B_\theta \frac{\pi D^2}{4} \tag{8}$$

The force, F, acts upon a moment arm which is a function of the disc diameter, D. Now, the dynamic torque can be written as

$$T_D = B_3 F D \tag{9}$$

Combining Equations (7), (8), and (9)

$$T_D = \frac{B_1{}^2 B_2 B_3 B_\theta \pi D^3 \Delta P}{4} \tag{10}$$

or

$$T_D = K_1 D^3 \Delta P \tag{10-A}$$

where

$$K_1 = \frac{B_1{}^2 B_2 B_3 B_\theta \pi}{4} = \frac{T_D}{D^3 \Delta P} \tag{10-B}$$

Equation (10-B) is defined as the dimensionless torque coefficient which can be determined experimentally from tests conducted with incompressible flow.

COMPRESSIBLE FLOW

The dynamic torque for butterfly valves is proportional to the mass flow rate and velocity change through a selected control volume for both compressible and incompressible flow (i.e., $T_D \propto M\Delta V$). Therefore, the approach used to obtain an expression for this torque assuming incompressible flow can be extended to compressible flow by re-defining these two variables.

First, assume that the velocity at the valve disc, V_d, is proportional to the velocity change through the control volume. Then, the dynamic torque can be expressed as

$$T_D \propto M V_d \tag{11}$$

The velocity at the valve disc is given by

$$V_d = \frac{M}{\rho_d A} \tag{12}$$

By combining Equations (11) and (12) the dynamic torque is shown to vary directly as the square of the mass flow rate and inversely with the fluid density at the valve disc.

$$T_D \propto \frac{M^2}{\rho_d} \tag{13}$$

Determining the flow rate of a compressible fluid through a control valve by analytical techniques is quite difficult because of valve geometry. The major problem is to establish the pressure differential between the valve inlet and the vena contracta. However, by defining the physical system in which the valve is installed to conform with specifications given by the Fluid Controls Institute (FCI).[2] empirical relationships developed specifically for determining flow rate for control valves can be considered. Several such empirical relationships have been developed; however, only one, the Universal Gas Sizing Equation,[3] has been shown to accurately define the flow rate for any valve configuration. This equation is given by

$$Q = \sqrt{\frac{520}{GT}} P_1 C_1 C_2 C_v \sin\left[\frac{59.64}{C_1 C_2}\sqrt{\frac{\Delta P}{P_1}}\right]_{rad} \tag{14}$$

Equation (14) can be rewritten to obtain an equivalent expression for mass flow rate.

$$M = 1.06\sqrt{\rho_1 P_1} C_1 C_2 C_v \sin\left[\frac{59.64}{C_1 C_2}\sqrt{\frac{\Delta P}{P_1}}\right]_{\mathrm{rad}} \tag{15}$$

The sine function in Equations (14) and (15) is used to define the transition between incompressible flow occurring at low pressure ratios ($\Delta P/P_1$) and critical flow.

Let

$$\theta = \left[\frac{59.64}{C_1 C_2}\sqrt{\frac{\Delta P}{P_1}}\right]_{\mathrm{rad}} \tag{16}$$

Rewriting Equation (15) in the following manner:

$$M = 1.06\sqrt{\rho_1 P_1} C_1 C_2 C_v F \tag{17}$$

The factor, F, is bounded by the following:

$$\begin{aligned} F &= \sin\theta \qquad \text{for } \theta < \pi/2 \\ F &= 1.0 \qquad \text{for } \theta \geq \pi/2 \end{aligned} \tag{18}$$

By substituting Equation (17) for the mass flow rate in Equation (13), the dynamic torque for a given valve is given by

$$T_D \propto \frac{\rho_1 P_1 (C_1 C_2 \sin\theta)^2}{\rho_d} \tag{19}$$

19

The only parameter in Equation (10) that cannot be readily obtained is the density at the valve disc, ρ_d. Assuming that the change in the ratio of fluid density at the valve inlet to fluid density at the valve disc with increasing pressure ratio is small relative to the total change in mass flow rate, the torque expression can be simplified in the following manner:

$$T_D \propto P_1 (C_1 C_2 \sin\theta)^2 \tag{20}$$

Therefore, for compressible flow:

$$T_D = K_2 P_1 (C_1 C_2 \sin\theta)^2 \tag{21}$$

For small values of pressure ratio ($\Delta P/P_1$) Equation (21) reduces to the incompressible torque relationship given by Equation (10-A).

As

$$\Delta P/P_1 \rightarrow 0$$

$$\sin\theta = \theta \text{ (radians)}$$

$$T_D = K_2 \, (59.64)^2 \Delta P \tag{22}$$

The expression in Equation (22) is equivalent to the expression in Equation (10-A):

$$K_2 (59.64)^2 \Delta P = K_1 D^3 \Delta P$$

$$K_2 = \frac{K_1 D^3}{(59.64)^2} \tag{23}$$

By substituting the expression in Equation (23) for the coefficient K_2 in Equation (21), a general expression for dynamic torque for compressible flow is obtained using the dimensionless torque coefficient established for incompressible flow.

$$T_D = K_1 D^3 P_1 \left[\frac{C_1 C_2}{59.64}\right]^2 \sin^2\theta \tag{24}$$

For convenience the form of Equation (24) is simplified.

$$T_D = K_1 D^3 \Delta P_e \tag{25}$$

where

$$\Delta P_e = P_1 \left[\frac{C_1 C_2}{59.64}\right]^2 \sin^2\theta \tag{26}$$

Equation (26) is defined as the pressure differential contributing to the dynamic torque on butterfly valves with conditions of compressible flow.

EXPERIMENTAL RESULTS

The first step in the experimental evaluation was to establish the dimensionless torque coefficient, K_1, as a function of valve disc rotation as defined by Equation (10-B). A test was conducted on a 4-in. valve under the following controlled conditions:

1. The valve was installed in a 4-in. test line with a minimum of 12 pipe diameters of straight pipe upstream.
2. The pressure taps were located according to FCI specifications and attached to the test line according to specifications in the *ASME Power and Test Code.*[4]
3. Water at ambient temperature was used as the flowing medium.
4. The inlet pressure and outlet pressure were held constant.
5. The test was conducted at a low pressure ratio ($\Delta P/P_1 = 0.088$) to ensure incompressible flow.

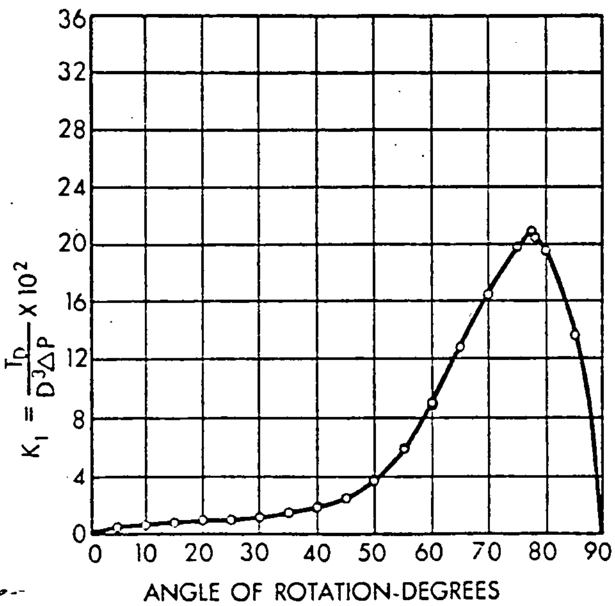

Figure 1. Dimensionless torque coefficient, 4-in. butterfly valve incompressible flow: $P_1 = 100$ psig, $P = \Delta 10$ psi.

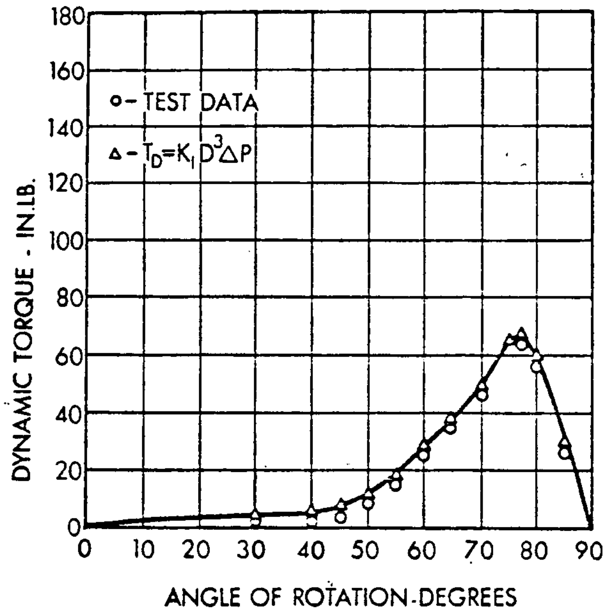

Figure 2. Dynamic torque vs. angle of disc rotation, 4-in. butterfly valve, comparison of experimental results with calculated torque, incompressible flow: $P_1 = 100$ psig, $\Delta P = 5$ psi.

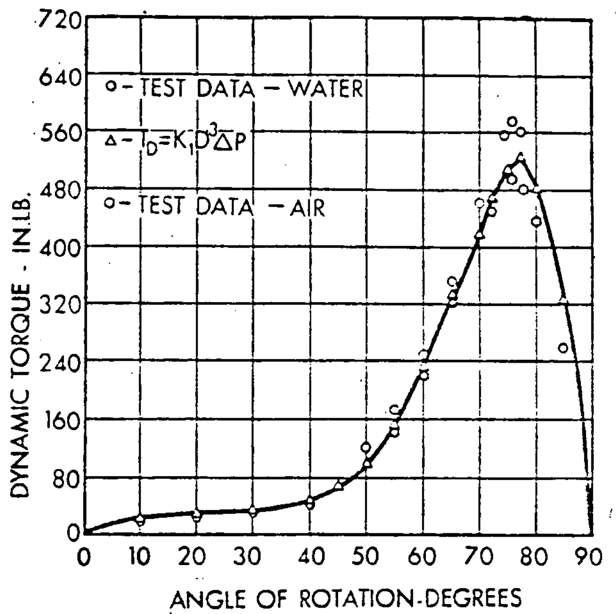

Figure 4. Dynamic torque vs. angle of disc rotation, 8-in. butterfly valve, comparison of experimental results with calculated torque, incompressible flow: $P_1 = 100$ psig, $\Delta P = 5$ psi.

Torque measurements were made at selected increments of disc rotation (0–90°). A transducer, consisting of a steel bar with strain gages attached, was fixed to the valve shaft and used in conjunction with an oscillograph to measure and record the shaft torque. The data from this test were used to determine the dimensionless torque coefficient plotted as a function of disc rotation on Figure 1. The curves plotted on Figure 2 show excellent agreement between measured torque and the torque calculated using this coefficient.

The next step was to verify that the torque coefficient is indeed applicable to other valve sizes provided geometric similarity is reasonably well maintained. The results on Figures 3 and 4 again show very good agreement between measured torque and calculated torque for two 8-in. valves.

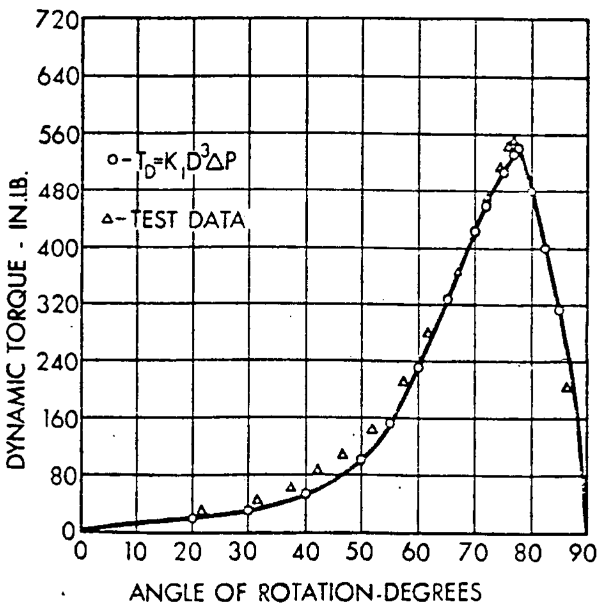

Figure 3. Dynamic torque vs. angle of disc rotation, 8-in. butterfly valve, comparison of experimental results with calculated torque, incompressible flow: $P_1 = 100$ psig, $\Delta P = 5$ psi.

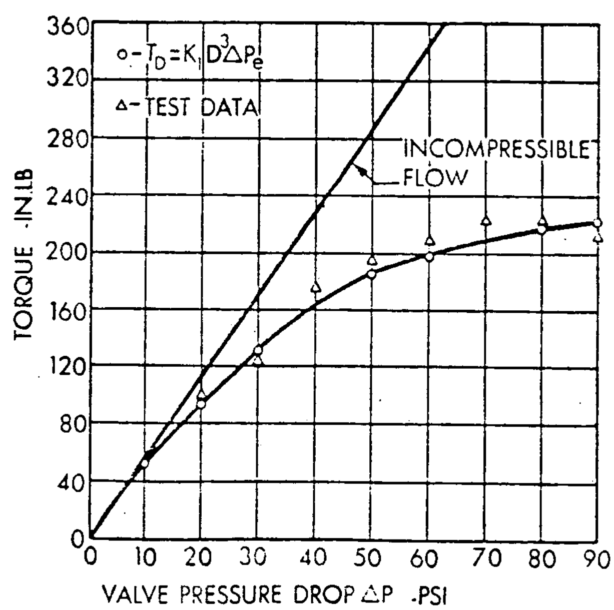

Figure 5. Dynamic torque vs. valve pressure drop, 4-in. butterfly valve, 60° disc rotation, comparison of experimental results with calculated torque, compressible flow: $P_1 = 214.4$ psia, flowing medium = air.

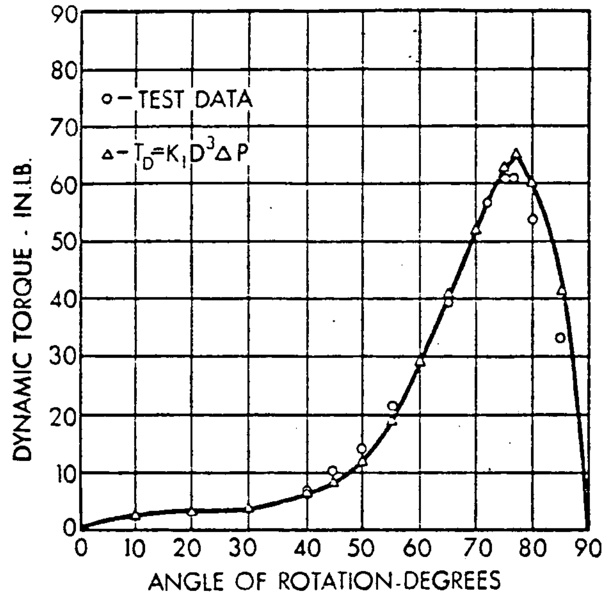

Figure 6. Dynamic torque vs. angle of disc rotation, 4-in. butterfly valve, comparison of experimental results with calculated torque, compressible flow: $P_1 = 114.4$ psia, $\Delta P = 5$ psi ($\Delta P/P_1 = 0.0446$), flowing medium = air.

It should be noted that discs in the two 8-in. valves were of substantially different geometric shape. Using the ratio of disc diameter to hub diameter as an indicator, these ratios were 4.56:1 and 3.55:1 for the valves used to obtain the data for Figures 3 and 4, respectively. The difference in torque magnitude for these valves with a 5 psi pressure differential shown in Figures 3 and 4 is the result of this difference in geometry. The disc in the 8-in. valve used for the test in Figure 3 was geometrically

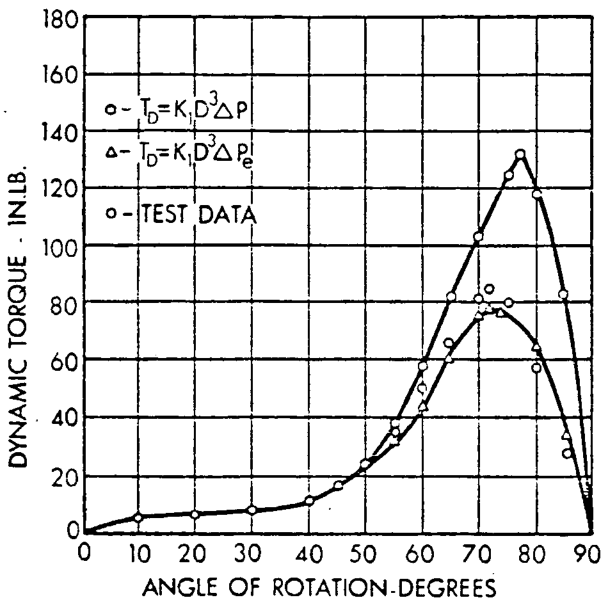

Figure 7. Dynamic torque vs. angle of disc rotation, 4-in. butterfly valve, comparison of experimental results with calculated torque, compressible flow: $P_1 = 64.4$ psia, $\Delta P = 10$ psi ($\Delta P/P_1 = 0.115$), flowing medium = air.

0.155

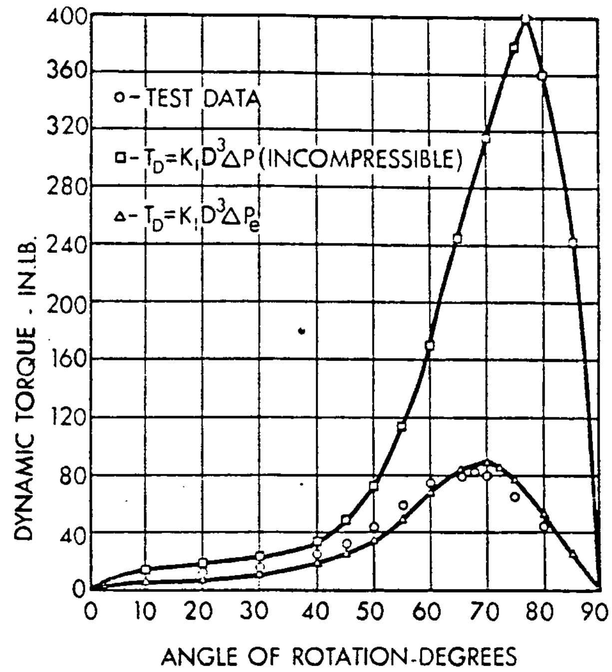

Figure 8. Dynamic torque vs. angle of disc rotation, 4-in. butterfly valve, comparison of test results with calculated torque, compressible flow: $P_1 = 64.4$ psia, $\Delta P = 30$ psi ($\Delta P/P_1 = 9.466$), (critical flow) flowing medium = air.

0.466

similar to the disc in the 4-in. test valve used to establish the torque coefficient, K_1.

The extension of the dynamic torque relationship to include the effect of fluid compressibility is accomplished by defining an effective pressure differential as shown in Equation (25). The curves on Figure 5 show the transition from incompressible flow to critical flow with increasing pressure ratio for a 4-in. valve set at 60° disc rotation. Here again there is very good agreement between the torque calculated using Equation (24) and the experimental results. The incompressible torque curve is also shown on Figure 5 to emphasize the effect of fluid compressibility.

The curves on Figures 6 through 8 are presented to compare experimental results with torque calculated using Equation (24) for full 90° disc rotation. At low pressure ratios, the torque using air as the flowing medium is essentially equal to the torque for incompressible flow (Figure 6). As the pressure ratio is increased, the effect of fluid compressibility becomes more pronounced as shown in Figure 7. Once critical flow has been attained, no further increase in torque is realized by increasing the valve pressure differential as shown on Figure 8.

CONCLUSIONS

A technique is presented which can be used to determine the dynamic torque for butterfly valves with reasonable accuracy. The basic torque relationship developed for incompressible flow is extended to include the effect of fluid compressibility. The method presented is developed using the Universal Gas Sizing Equation to define an effective pressure differential for the transition from incompressible flow to critical flow. Application of this method shows excellent agreement with experimental test results.

NOTATION

A = Flow area, in.^{2}
$B_1, B_2,$
B_3, B_θ = Constants of proportionality
C_1 = C_g/C_v
C_2 = Correction factor for variation in specific heat ratio
C_g = Gas sizing coefficient
C_v = Flow coefficient
D C = Nominal valve diameter, in.
F = Force, lb
G = Specific gravity
K_1 = Dimensionless torque coefficient
M = Mass flow rate, lb/s
P_1 = Inlet pressure, psia
ΔP = Valve pressure differential, psi
ΔP_e = Pressure differential affecting dynamic torque
Q_i = Flow rate incompressible fluid, scfh
C_c = Flow rate compressible fluid, scfh
T = Absolute temperature, °R
T_D = Dynamic torque, in. lb
V = Fluid velocity, in./s
ρ_1 = Fluid density at upstream pressure tap, lb/in.^{3}
ρ_d = Fluid density at valve disc, lb/in.^{3}

REFERENCES

1. Keller, I. C., and Salzmann, I. F. January 1936. Aerodynamic Model Tests on Butterfly Valves." *Escher-Wyss News*. 9.
2. *Recommended Voluntary Standards for Measurement Procedure for Determining Control Valve Flow Capacity*. 1958. Fluid Controls Institute, Inc., paper FCI 58-2.
3. Buresh, J. F., and Schuder, C. B. October 1964. "The Development of a Universal Gas Sizing Equation for Control Valves." *ISA Trans.* 3:322-328.
4. *Flow Measurement: Instruments and Apparatus. Supplement to the ASME Power Test Codes*. ASME report PTC 19.5; 4-1959.

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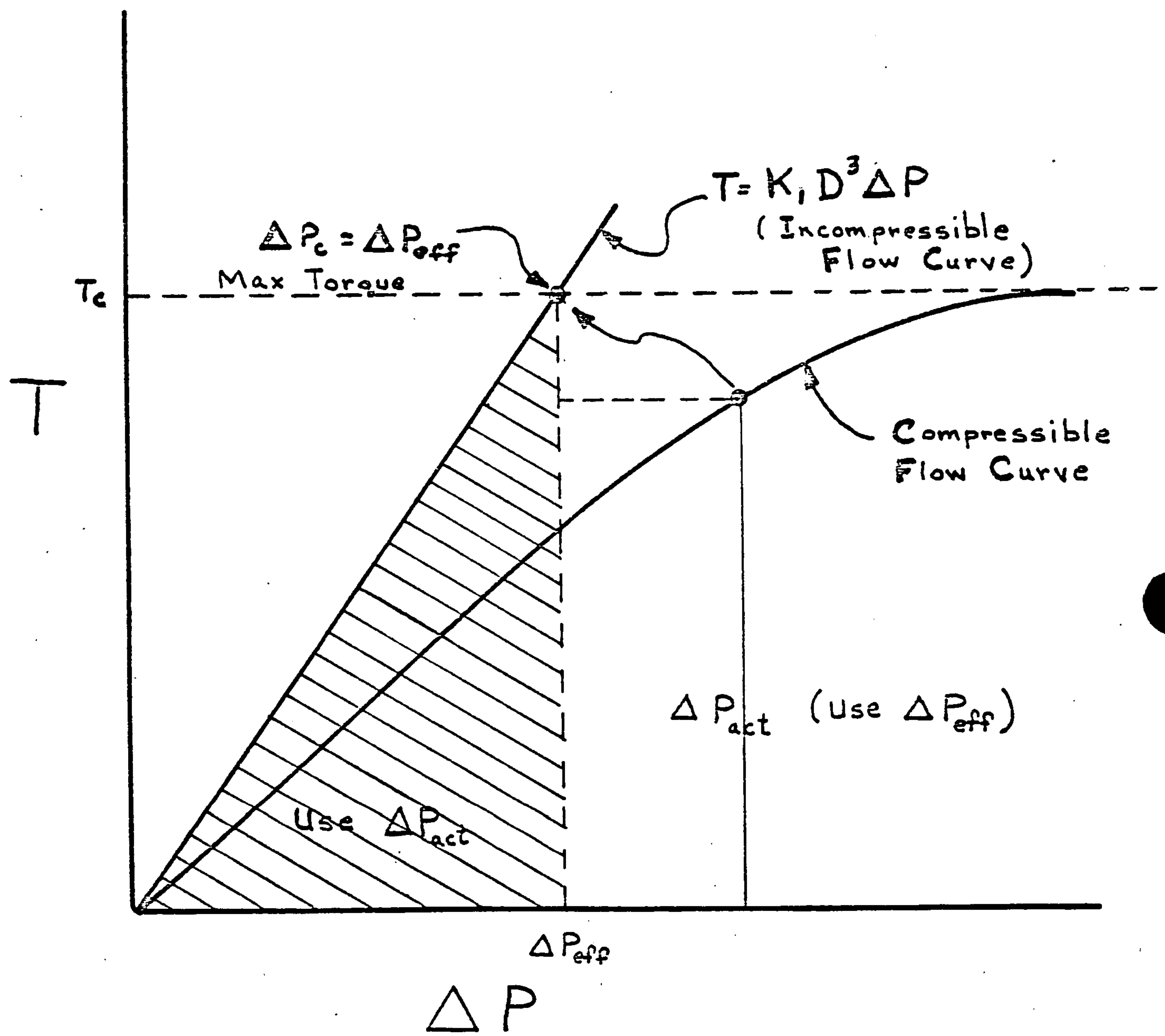
Attachment 4: Torque-Pressure Drop Relationships Used in Butterfly Valve Dynamic Torque Coefficient Selection



Torque - Pressure Drop Relationships
Used in Dynamic Torque Coefficient
Selection

Attachment 5: Capacity and Dynamic Torque Curves Determined in Fisher Lab Tests for 6" Type 9200 Test Valves, Aspect Ratio 5:1

FISHER CONTROLS COMPANY

MARSHALLTOWN, IOWA

Project No. CD75-115

LABORATORY REPORT

PROBLEM 983
REPORT 13
PAGE 1
DATE 7-7-76

TITLE: CAPACITY, CHARACTERISTIC AND TORQUE TESTS OF 5 TO 1 ASPECT RATIO DISC IN 6" - 150 LB. TYPE 9200 BUTTERFLY VALVE

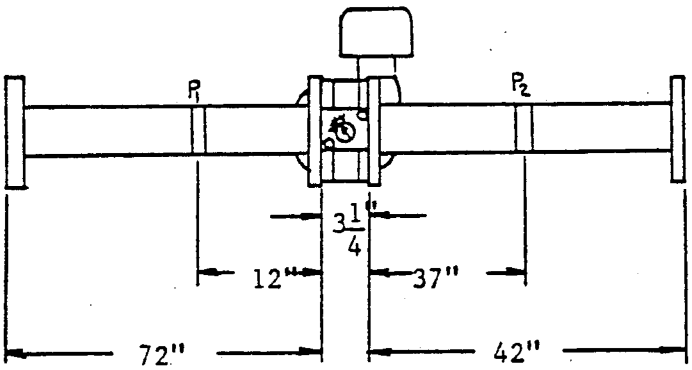
VALVE BODY:
TYPE 9200
SIZE 6"
RATING 150 lb.
DWG F41629-B

VALVE TRIM:
DISC TYPE 5 To 1 Aspect Ratio (Flame-cut)
DISC DWG 75-115DXX2002-A
RETAINER RING DWG ---

FLOW DIRECTION:
NORMAL BODY INSTALLATION ____
REVERSE BODY INSTALLATION X
(seal upstream)

SEAL TRIM:
TYPE ---
MATERIAL ---
DWG ---

TEST SETUP:



TESTS PERFORMED:
1. Water Capacity & Characteristic
2. Air Capacity & Characteristic
3. Dynamic Torque Test

TEST RESULTS:
1. CHARACTERISTIC CURVE(S): SEE FIG(S). 1
2. CAPACITY: SEE FOLLOWING TABLE FOR SIZING COEFFS CALCULATED FROM TEST DATA

Disc Rotation Degrees	10	20	30	40	50	60	70	80	90
Liquid - C_v	54.5	80.8	114	164	247	385	630	1090	1370
Gas - C_g	1570	2210	2850	4010	6550	10200	14900	20600	25700
Steam - C_s	78.5	111	143	201	328	510	745	1030	1290
$C_g/C_v = C_1$	28.8	27.4	25.0	24.5	26.5	26.5	23.7	18.9	18.8
K_m									

3. Maximum $K_1 = 0.12$ See Figure 2 for dynamic torque curve

William C. Scheffert
William C. Scheffert
Research Department

Approved: Larry T. Swartz

PROBLEM 983
REPORT 13
FIGURE 1

DATE 7-1-76
WCS

FISHER CONTROLS COMPANY

FLOW VS TRAVEL CHARACTERISTIC

BODY SIZE 6" DESIGN/TYPE 9200 B/F BODY DWG. F41629-B

SEAL CONSTRUCTION ______ SEAL DWG. ______

MEASURED PROTECTOR RING DIA. ______ PROTECTOR RING DWG. ______

BALL/DISC TYPE 5 TO 1 ASPECT RATIO BALL/DISC DWG. 75-115DXX2002-A

VALVE FLOW DIRECTION: ☒NORMAL ☒REVERSE

⊙ WATER TEST

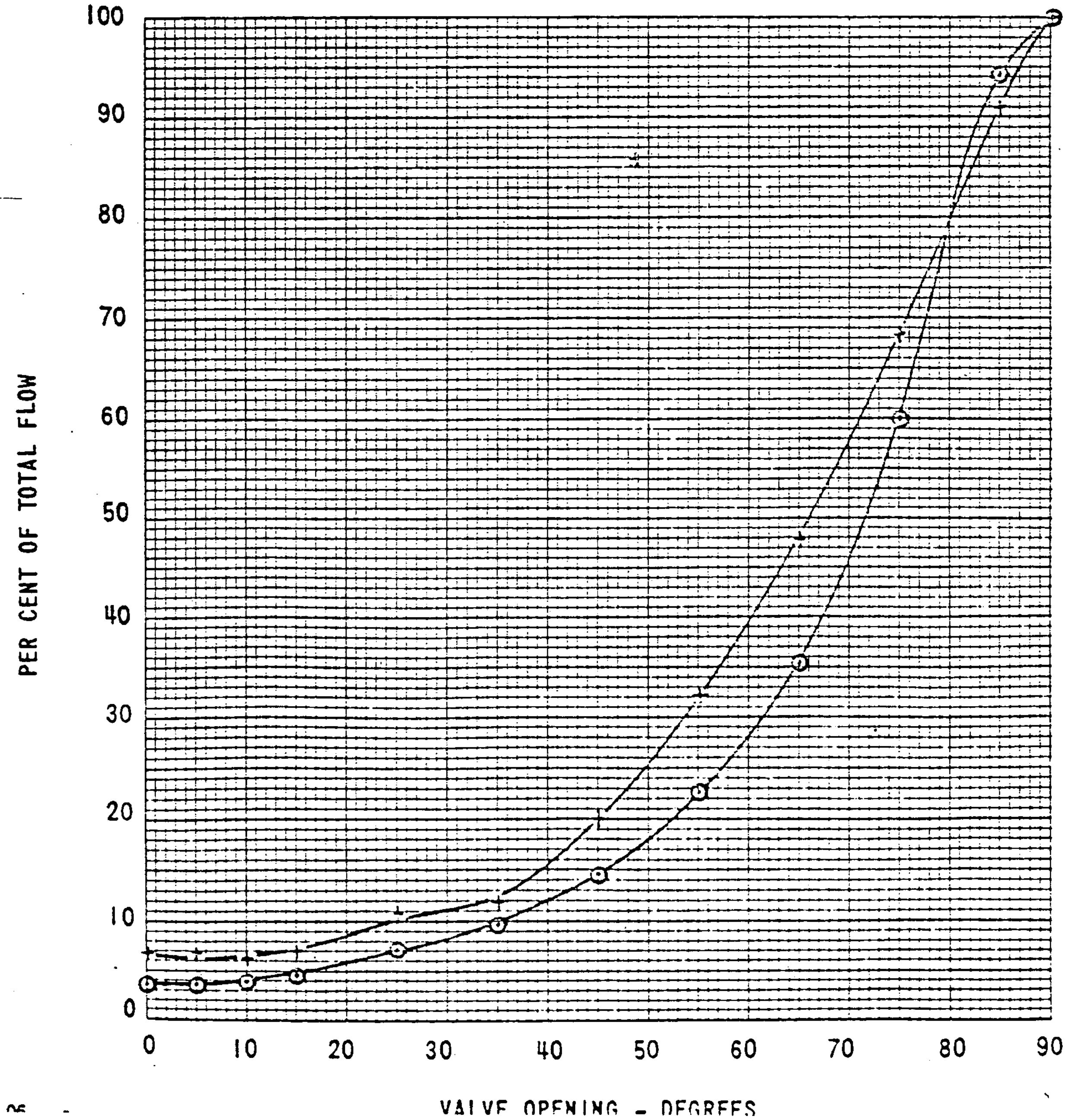
BODY INLET PRESSURE >100 PSIG BODY PRESSURE DROP 5 PSI

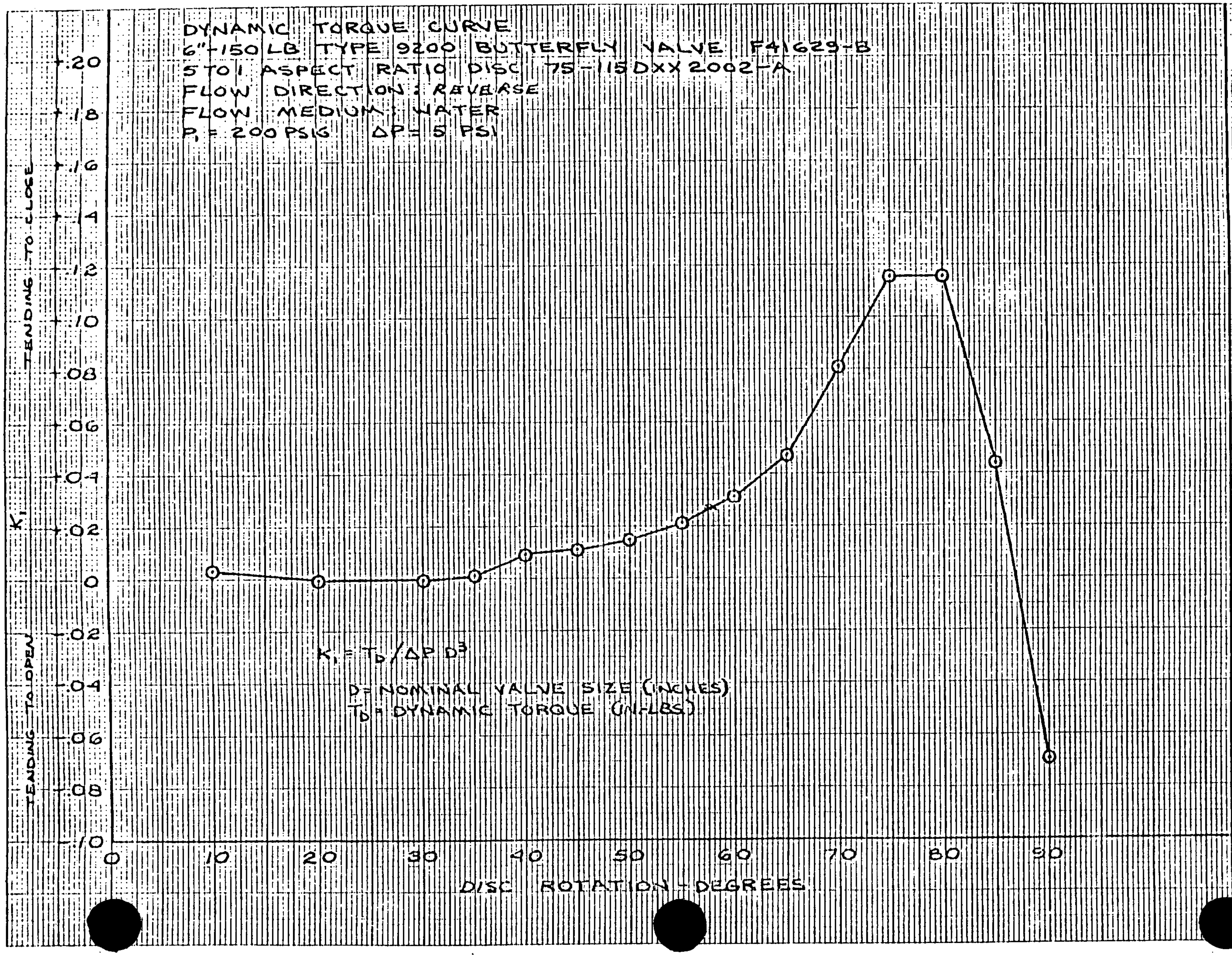
AVERAGE C_v = 1370

+ AIR TEST

BODY INLET PRESSURE 64.3 PSIA BODY PRESSURE DROP CRITICAL

AVERAGE C_g = 35700





7-6-76
WCS

PROB. 983
REP. 13
FIG. 2

Attachment 6: Piping System Sketches, Figures A and B

BY DGB DATE 4-6-80 SUBJECT SHEET NO. 1 OF

CHKD. BY DATE JOB NO.

ATTACHMENT 6

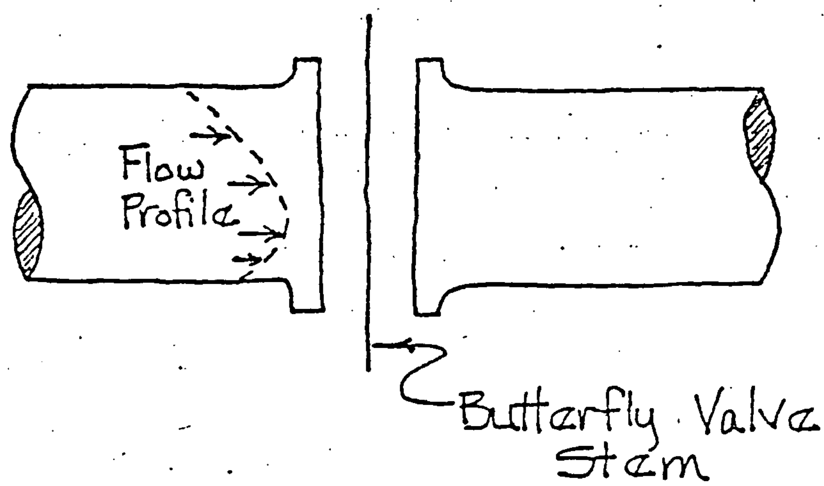


FIGURE A

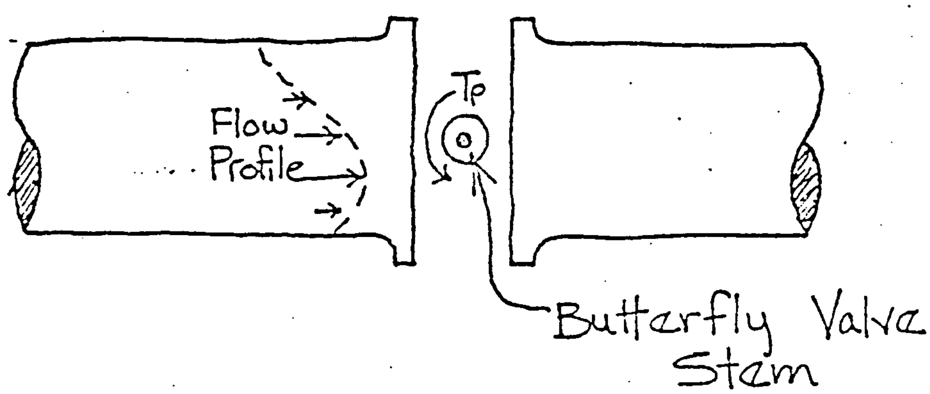
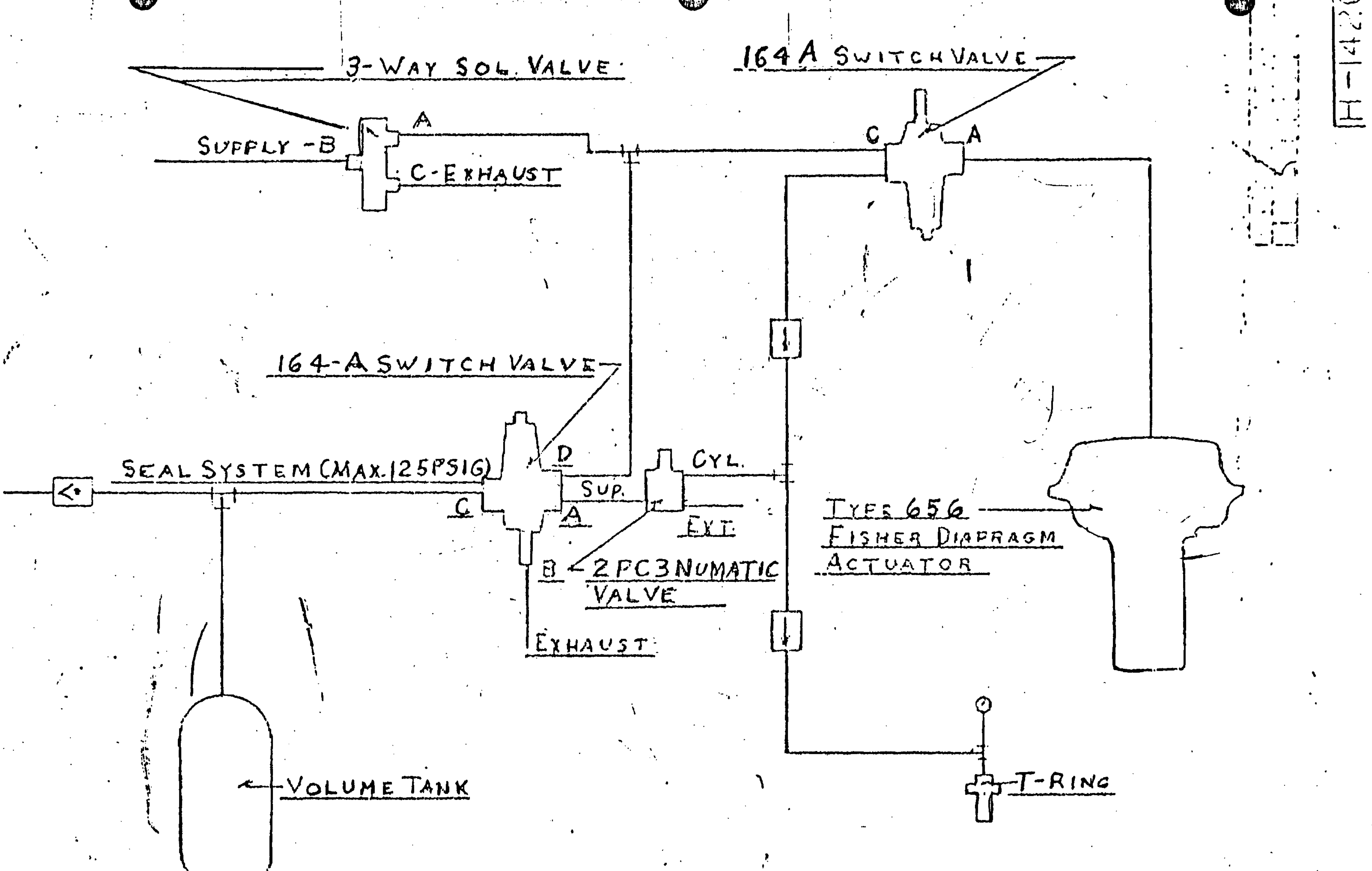


FIGURE B

Attachment 7: Drawing H-14266. Type
656 Fisher Diaphragm Operator
w/164-A Seal System Assembly



			TYPE 656 FISHER DIAPRAOM OPER. W/ 16[illegible]A SEAL SYSTEM ASSEMBLY

CONTINENTAL DIVISION

DWG. NO. H-14266

Attachment 8: Bulletin and Instruction Manual for Fisher Type 164A Switching Valve

Types 164 and 164A Switching Valves

The Types 164 and 164A switching valves are pneumatically operated and controlled units, built with a wide range of capabilities to handle those switching applications that involve venting, on-off control, and failure modes.

Operation of either valve occurs when the pneumatic signal changes as indicated in table 1. With its two ports, the Type 164 switching valve is typically used as a normally open on-off switch, while the Type 164A switching valve directs flow through three ports. Additionally, the Type 164A provides on-off capability when one of its three ports is plugged.

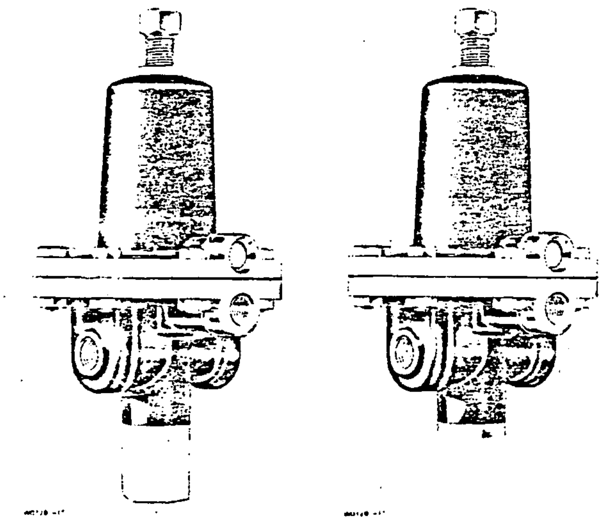
The Types 164 and 164A switching valves share the same basic construction (see figures 1 and 2), except that where the Type 164A switching valve has a part containing port B, the Type 164 switching valve has a plug.

Features

- **Versatile**—Constructions throughout the product line provide three-way or on-off pneumatic switching to suit a variety of applications.

- **Easy, Accurate Adjustment**—With a choice of springs for optimum resolution, the switching point is set to a specific requirement by an adjusting screw atop the spring case.

- **Rugged, Compact Construction**—The unit is small enough for easy installation in limited space, yet rugged enough to be mounted on the actuator.



TYPE 164A TYPE 164

Figure 1. Switching Valve Constructions

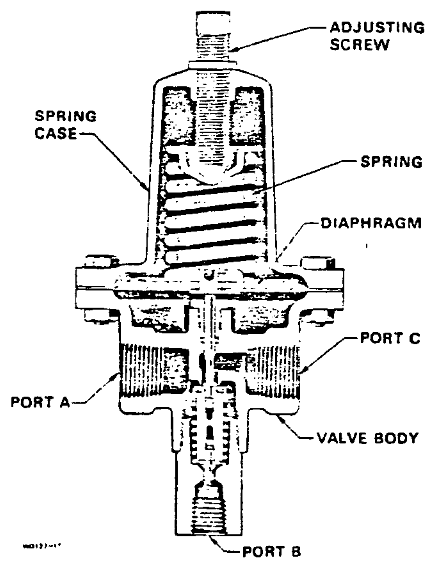


Figure 2. Sectional View of Type 164A Switching Valve

Specifications

AVAILABLE CONFIGURATIONS	**Type 164**: Two-way switching valve **Type 164A**: Three-way switching valve
MAXIMUM VALVE BODY PRESSURE	250 psig (17.2 bar)
SET PRESSURE RANGES	See table 1
MAXIMUM DIAPHRAGM PRESSURE	100 psig (6.9 bar)
OPERATIVE TEMPERATURE LIMITS*	−20 to 150°F (−29 to 66°C)
FLOW COEFFICIENTS (C_v)	Depends on construction and flow path (see figure 2) as follows: **Type 164**: 26.6 (Port A to Port C) **Type 164A**: 15.0 (Port A to Port B) or 26.6 (Port A to Port C)
CONNECTIONS	**Type 164**: Ports A and C—■ 1/4-inch NPT or ■ 1/2-inch NPT; Vent and control pressure connection (Port D)—1/4-inch NPT. **Type 164A**: Ports A, B, and C—■ 1/4-inch NPT or ■ 1/2-inch NPT; Vent and control pressure connection (Port D)—1/4-inch NPT
CONSTRUCTION MATERIALS	See below
APPROXIMATE WEIGHT	4 lbs (1.8 kg)
OPTIONS	Closing cap

CONSTRUCTION MATERIALS

Part	Material
Spring Case	■ Aluminum or ■ Cast iron (Accepts optional closing cap)
Valve Body	Aluminum
Valve Disc	Brass and synthetic rubber
Diaphragm and O-rings	Nitrile
Spring	Steel
Closing Cap (Optional)	Brass

*Defined in ISA Standard S51.1—1976.

Table 1. Spring Information

SPRING RANGE*		SPRING PART NUMBER	COLOR CODE	MAXIMUM PRESSURE CHANGE ON DIAPHRAGM FOR FULL STROKE	
Psig	Bar			Psi	Bar, Differential
Type 164 or Type 164A Switching Valve					
3 to 15	0.2 to 1	1D8923 27022	Red	2.25	0.2
5 to 20	0.3 to 1.4	1D7515 27022	Cadmium	2.5	0.2
5 to 35	0.3 to 2.4	1D6659 27022	Blue	4	0.3
30 to 60	2 to 4.1	1D7455 27142	Green	5.75	0.4
40 to 100	2.8 to 6.9	1E5436 27142	Yellow	11	0.8
Type 164 Switching Valve Only					
80 to 150	5.5 to 10.3	1P9013 27142	Brown	16	1.1
130 to 200†	9.0 to 13.8†	1P9013 27142	Brown	16	1.1

*Ranges shown are recommended for best performance. All springs listed can be adjusted to 0 psig.
†Requires diaphragm head with part number 1P9014 25062.

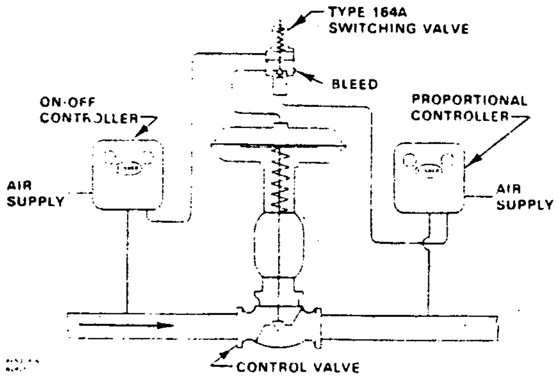


Figure 3. Typical Switching Valve Application

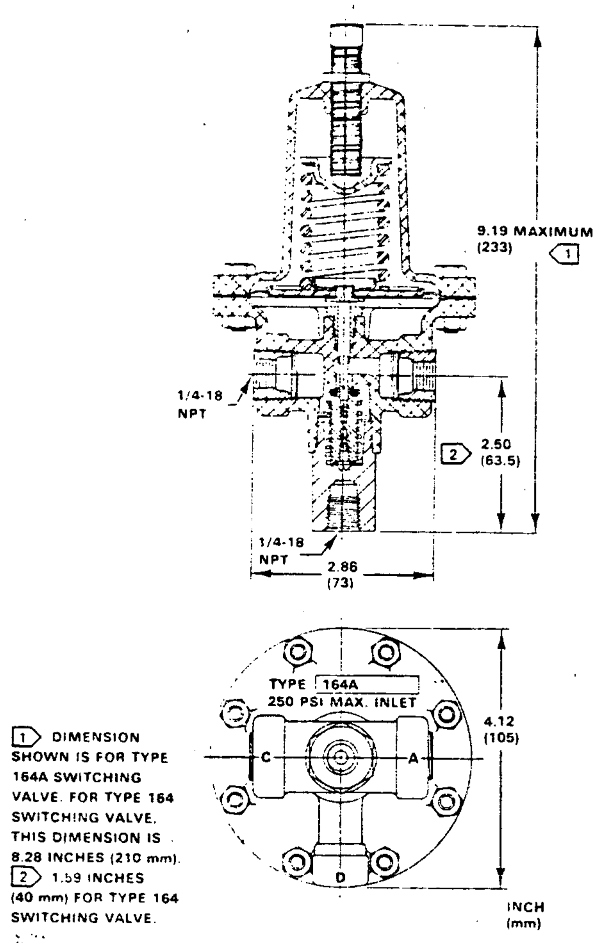


Figure 4. Dimensions

Principle of Operation

Refer to figures 2 and 4. Control pressure enters the switching valve through port D and registers on the underside of the diaphragm. Control pressure overcomes the spring force and the diaphragm and valve disc are raised, closing port C and opening port B of the Type 164A switching valve. In this condition the Type 164 construction is turned off and the Type 164A construction provides a flow path from A to B.

If, either intentionally or through pneumatic failure, the control pressure drops below the spring force, the diaphragm and valve disc move downward, opening port C and closing port B of the Type 164A switching valve. Now both constructions provide a flow path from port A to port C.

The pressure change necessary to switch the valve depends on the spring used and the setting of the adjusting screw on the switching valve.

Installation

The switching valve can be mounted in any position, providing the vent in the spring case is free from obstruction. Connect the pneumatic control line to the port marked "D" on the valve body. Ports A and C (and B on the Type 164A valve) are connected for the desired switching valve response to loss or decrease in pneumatic pressure.

Figure 3 shows a typical application of the Type 164A switching valve. If the control valve inlet pressure falls below a predetermined setting, the on-off controller turns off control pressure to the switching valve. This causes the switching valve to bleed the control valve diaphragm pressure to atmosphere, closing the control valve. The control valve remains closed until the inlet pressure is restored to the desired setting.

Dimensions are shown in figure 4.

Ordering Information

When ordering, carefully review the "Specifications" table and specify your selection whenever a choice is offered, including the desired spring number.

In addition, specify:

1. Type number of switching valve
2. Size and type number of actuator on which the switching valve is to be mounted
3. Whether the switching valve is to be mounted on the actuator casing or on the actuator yoke

Instruction Manual and Parts List

Types 164 & 164A

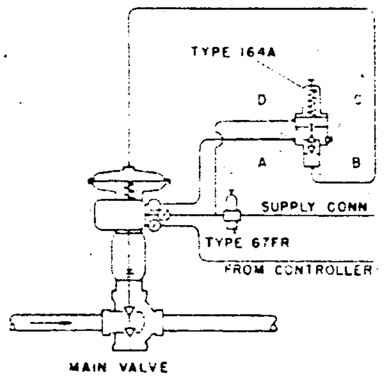


Figure 1—Type 164A Dwg. No. AE5377

Lock-up system using Type 164A to close air circuit to diaphragm of main valve in case of plant air failure. Main valve will remain in position it occupied at time of supply pressure failure.

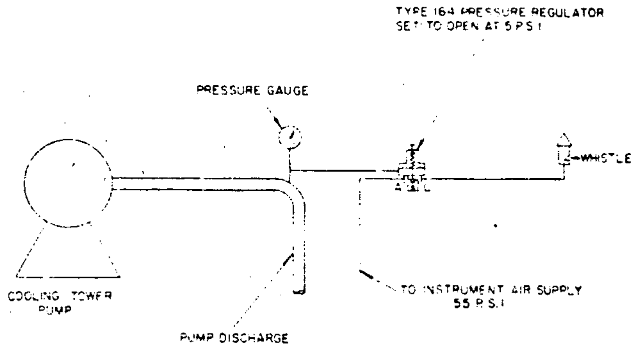


Figure 2—Type 164 Dwg. No. AF8400

Warning system using Type 164 two-way valve to activate a whistle when pump discharge pressure falls.

TYPE NUMBER EXPLANATION

Type 164 - Two-way regulator, diaphragm operated, normally open valve.

Type 164A - Three-way regulator, same as above, except a special adaptor is used to provide the third outlet.

INSTALLATION

Thoroughly clean and blow out all pipe lines to remove pipe scale and other foreign material. Make sure the regulator is clean before making the installation, and apply pipe compound to the male threads.

This valve can be installed in any position in the pipe line. The installation should be made so that moisture cannot enter the vent, but do not plug the vent. If desirable to pipe the vent away, the vent outlet is tapped ¼"x18NPT.

A typical installation of the Type 164A when used as a pneumatic lockup is shown in Figure 1. The three Type 164A ports are identified as "A", "B" and "C". Flow can go from A to B, A to C, C to A, B to A, but not B to C or C to B. The control line connection is identified as "D" and is ¼" NPT. The ports are either ¼" or ½" NPT, depending on customer specifications.

Series 164A regulators can be used either as two-way, or three-way valves. The bottom connection is plugged in the first use and is open on three-way applications.

The two-way Type 164 regulator is normally open, and pressure applied under the diaphragm closes the port. The 164 should be installed so that flow goes from port "A" to port "C". A typical 164 installation is shown in Figure 2. Maximum inlet pressure for both the 164 and 164A is 250 psi.

ADJUSTMENT

The regulator is set for the pressure shown on the paper label attached to the spring case. The spring ranges available are shown in the table. To increase the setting within a given spring range, loosen lock nut (Key No. 13 Figure 3) and turn adjusting screw (Key No. 12 Figure 3) clockwise. Turn adjusting screw counterclockwise to decrease pressure setting. Be sure to tighten locknut after pressure adjustment is made.

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FM—8-70
JSS
FORM 1283F
(Supersedes Form 1283E)

Spring Dwg. No.	Spring Color	Spring Outlet Pressure Range	Maximum Pressure Change on Diaphragm For Full Stroke
1D8923	Red	3-15 psi	2 psi
1D7515	Cad. Plate	5-20 psi	2½ psi
1D6659	Blue	5-35 psi	4 psi
1D7455	Green	30-60 psi	5¾ psi
1E5436	Yellow	40-100 psi	11 psi
1P9013	Brown	80-150 psi	16 psi
1P9013	Brown	130-200 psi*	16 psi

NOTE: All six springs can be adjusted to 0 psi. The above ranges are recommended for best performance. Spring 1P9013 for Type 164 only.

* With Diaphragm Head Dwg. 1P9014

MAINTENANCE (See Figure 3)

If necessary to inspect or replace the Type 164 disc holder assembly, (Key No. 6) remove body plug (Key No. 10). This allows valve disc holder, spring, (Key No. 3) and stem (Key No. 7) to slide out. In the same manner the body plug (Key No. 10) can be removed on a Type 164A to replace disc holder assembly (Key No. 6) and the inner valve "O" ring (Key No. 5).

If the diaphragm needs replacing, loosen locknut, (Key No. 13) and back off adjusting screw (Key No. 12). Remove casing nuts (Key No. 15) and lift the spring case (Key No. 2) off the assembly. This exposes the spring (Key No. 4) which can be lifted out, and the diaphragm assembly which can also be lifted out. When reassembling, replace the adjusting screw before tightening the diaphragm casing nuts. This assures slack in the diaphragm which is essential to proper operation.

ORDERING PARTS

When corresponding with the factory or representatives regarding this regulator, give the type number stamped on the body of the regulator as well as the spring range on paper label attached to spring case. When ordering parts, be sure to give complete parts number of desired parts.

Parts Reference

KEY	PART NUMBER	PART NAME	MATERIAL
1	T10638 0801	Body	Aluminum Die Cast
2	2P9015 0801	Spring Case	Aluminum Die Cast
3	1D6668 2722	Valve Spring	Spring Wire, CD PL
4		Regulator Spring	Spring Wire, CD PL
	1D8923 2702	0-15 psi, Red	
	1D7515 2702	0-20 psi, CD PL	
	1D6659 2702	0-35 psi, Blue	
	1D7455 2714	0-60 psi, Green	
	1E5436 2714	0-100 psi, Yellow	
	1P9013 2714	0-150 psi, Brown (Type 164 only)	
5*	1D6825 0699	O-Ring (2 req'd)	Synthetic Rubber
6*		Valve Disc Assembly	Brass & Buna N
	1D6656 000A	Type 164	
	1E4567 000A	Type 164A	
7	1D9638 3517	Valve Stem	Stainless Steel
8	1D6669 1409	Stem Guide	Brass
9*		Diaphragm Assembly	Sub Assembly
	1D6662 000A	For Standard Springs	
	1D6662 9902	For Spring Dwg. 1P9013	
10		Body Plug	
	1D6652 0901	Type 164	Aluminum
	1E4397 1401	Type 164A	Brass
11	1D6671 2507	Upper Spring Seat	Steel, CD PL
12	1D9954 4870	Adjusting Screw	Steel, CD PL
13	1D6677 2898	Locknut	Steel, CD PL
14		Cap Screw (8 req'd)	Steel
	T10760 2405	Type 164	
	1A3508 2405	Type 164A	
15		Hex Nut (8 req'd)	Steel
	1A3457 2412	Type 164	
	1E9853 2414	Type 164A	
16	0L0783 4306	Vent Screen	Monel
22	1E4566 3503	O-Ring Retainer Screw	Stainless Steel

* Recommended Spare Part

Parts Reference

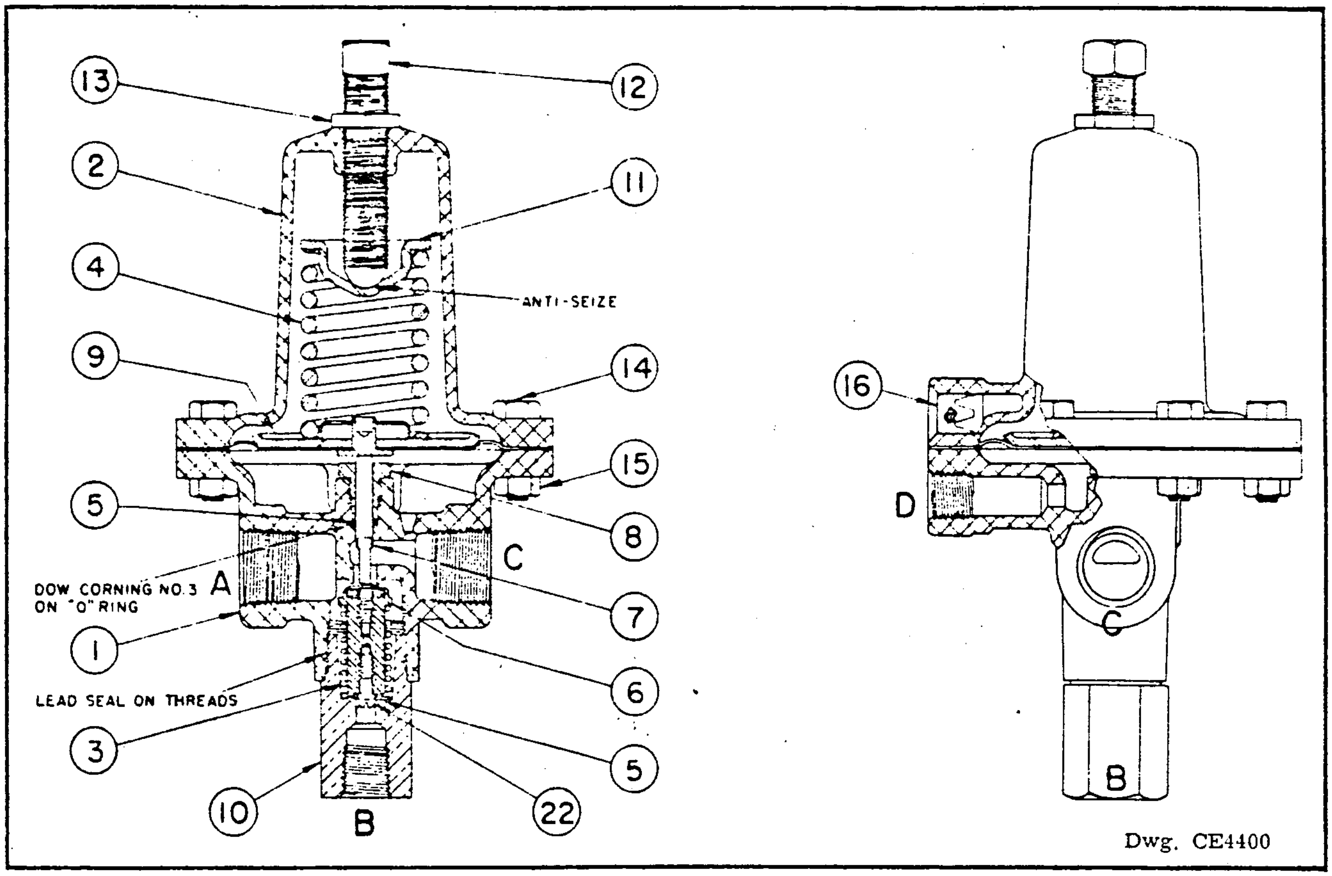


Figure 3—Type 164A

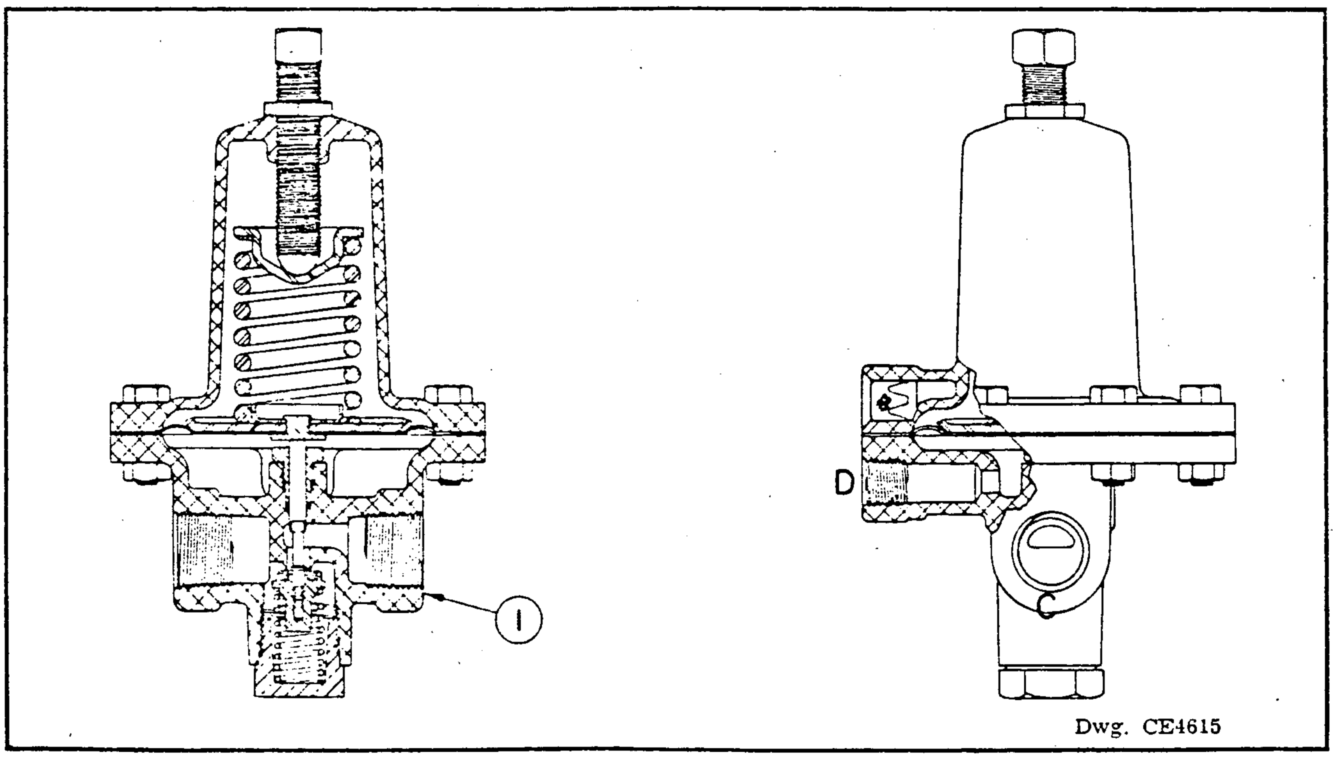
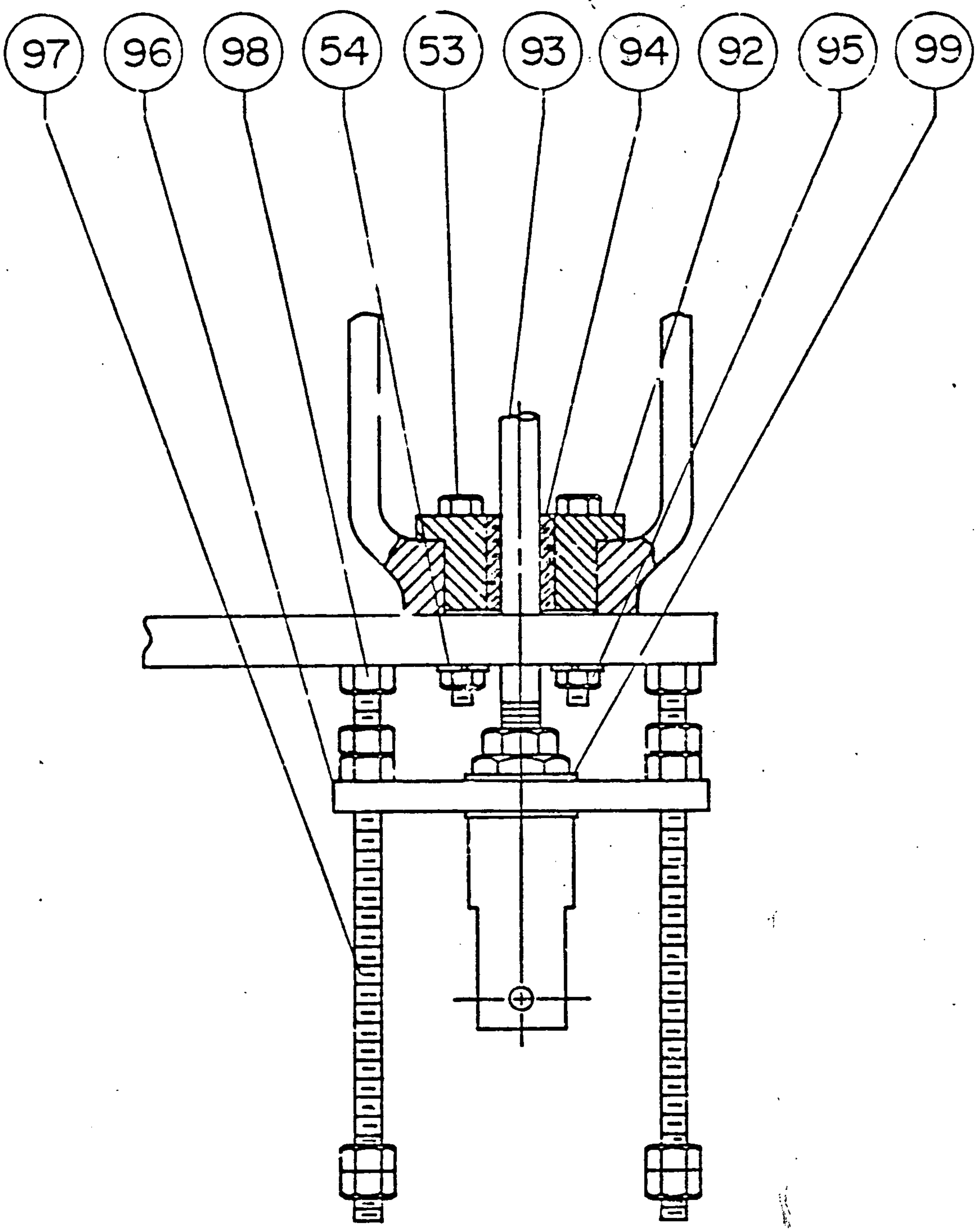


Figure 4—Type 164

Except for the valve disc assembly (6), and the 3-way adaptor or body plug (10), All parts are interchangeable with Type 164A.



YOKE-TYPE ACTUATOR MOUNTING PARTS
W/ OPTIONAL TRAVEL STOP

ASSEMBLY DRAWINGS OPTIONAL CONSTRUCTION OF BRACKET ASS'Y.	DWN.	MAM	9-23-77
	CHKD.	JPK	10-17
FISHER Controls — FISHER CONTROLS COMPANY CONTINENTAL DIVISION Coraopolis, Pennsylvania 15108	DRAWING NO.	G34225	REV. B

Attachment 9: Assembly Drawing G34225
"Optional Construction of
Bracket Assembly"

Attachment 10: Bulletin and Instruction Manual for Type 9200 Butterfly Valves

9200 Series Butterfly Control Valve Bodies for Nuclear Service

Fisher 9200 Series valves are offset-disc butterfly valves with an adjustable elastomer T-ring seat suitable for extremely stringent shutoff requirements. These valves are often used as nuclear-service valves for on/off applications such as containment isolation and for throttling or on/off flow control of component cooling water or auxiliary service fluids.

Design criteria for pressure-retaining components of 9200 Series valves meet the requirements of the ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, Sections III and VIII, and the valve body assemblies can be furnished with the ASME "N"-stamp symbol.

The standard plate steel or cast steel 9200 Series wafer-style valve is installed between pipeline flanges. An optional steel single-flange style body is available with a pipeline flange on one end and a buttwelding connection on the other end or with a buttwelding connection on both ends. This optional construction can be welded directly to a containment vessel wall.

These valves are available in 4-inch through 96-inch sizes for process temperatures to 400°F and, depending upon size, pressure drops to 150 psi.

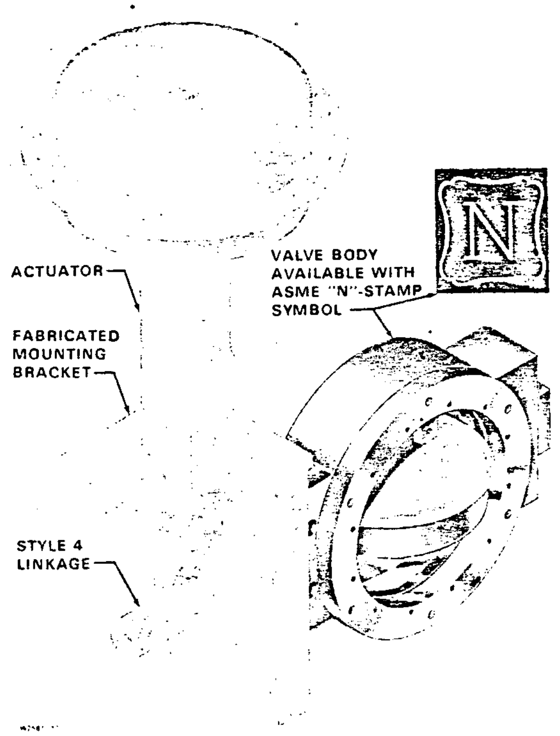


Figure 1. 9200 Series Specification B-1 Valve Body with Type 656 Actuator

Features

• **Compliance with Nuclear Code and Other Requirements**—Fisher Controls Company holds the ASME Certificate of Authorization to use the "N"-stamp symbol on these valve body assemblies. All ASME requirements for Class 1, 2, and 3 nuclear-service valves, as well as special customer assembly, cleaning, painting, and packaging requirements, can be met. In addition, compliance of valve and actuator assemblies with specified seismic and environmental criteria can be documented with seismic analysis calculations and/or actual test results

• **Economical**—Standard plate steel construction requires less extensive nondestructive examinations than cast construction, reducing cost and delivery time. Standardized valve/actuator size combinations ensure sufficient actuator power while reducing actuator selection time and documentation cost and delay

• **Excellent Shutoff without Excessive Seating Torque**—Offset disc design allows disc/T-ring contact around 360 degrees of disc circumference. Elastomer T-ring is field adjustable so that shutoff can be maintained without excessive disc/T-ring interference and associated high seating torque. Reduced interference also minimizes T-ring wear to prolong T-ring life

• **Reduced Leak-Off Piping Requirements**—Sizes through 24 inches use valve shaft packing on one side of valve only; only one leak-off connection to pipe

Specifications

AVAILABLE CONFIGURATIONS AND BODY SIZES

9200 Series Specification B-1: Offset-disc butterfly control valve body with adjustable elastomer T-ring seat contained between the retaining ring and valve body as shown in figure 2. Valve shaft sealed with packing on actuator side and with a blank-off plate on the other side. Available in ■ 4, ■ 6, ■ 8, ■ 10, ■ 12, ■ 14, ■ 16, ■ 18, ■ 20, and ■ 24-inch sizes

9200 Series Specification C-1: Offset-disc butterfly control valve body with adjustable elastomer T-ring seat contained between the retaining ring and the valve disc face as shown in figure 3. Valve shaft sealed with packing on both sides. Available in ■ 30 through ■ 96-inch sizes in 6-inch increments

BODY STYLE

Flangeless (wafer-type) body with four flange bolt holes (see figures 1 and 4) for installation between two pipeline flanges

END CONNECTION STYLES

4 Through 24-Inch Sizes: Mate with ANSI Class 150 (B16.5) raised-face flanges

30 Through 96-Inch Sizes: Mate with ■ ANSI Class 125 (B16.1) flat-face flanges (through 72-inch size only), ■ AWWA C207 flanges, or ■ MSS SP-44 flanges

MAXIMUM INLET PRESSURE[1]

4 Through 24-Inch Sizes: Compatible with ANSI Class 150 pressure/temperature ratings for temperatures from +20 to +400°F

30 Through 96-Inch Sizes: ■ 75 psig for temperatures from +20 to +400°F (in accordance with ASME Code Case 1678, approved December 16, 1974) or ■ higher pressures upon request

MAXIMUM PRESSURE DROP[1]

Shutoff (0 Degrees of Disc Rotation)

4 Through 24-Inch Sizes: 150 psi

30 Through 96-Inch Sizes: 75 psi

Flowing: See table 1

CONSTRUCTION MATERIALS

Body,[2] Disc,[2] and Retaining Ring[3]: ■ Steel plate (ASME SA515 GR 70) or ■ other materials available upon request

Shaft: 17-4PH stainless steel (ASME SA564 GR630 H1075)

Taper Pins: Same material as shaft

Blank-Off Plate[2] (Through 24-Inch Size Only): 316 stainless steel (ASME SA240 GR316)

Blank-Off Plate Bolting (Through 24-Inch Size Only)

Studs:[2] Steel (ASME SA193 GR B8M)

Nuts:[2] Steel (ASME SA194 GR 8M)

T-Ring: ■ EPDM (ethylene-propylene) or ■ nitrile; ■ Viton[4] is also available for non-nuclear applications

Retaining Ring O-Ring (Through 24-Inch Size Only): EPDM (ethylene-propylene)

Blank-Off Plate Gasket (Through 24-Inch Size Only): Spiral-wound gasket of 304 stainless steel and asbestos

Packing: Alternated rings of Crane[5] 187-I and laminated-graphite (Grafoil[5]) packing

Bushings: ■ Graphite-impregnated bronze (bushing 2) or ■ alloy 6 (bushing 3)

Bushing Retainers and Retainer Tube: 316 stainless steel

Packing Follower: Steel

Packing Lantern Rings and Washers: 316 stainless steel

Packing Box Studs and Nuts: Steel

Thrust Collars

Shaft Diameters to 1-1/2 Inches (Through 18-Inch Valve Size): Cadmium-plated steel clamp-type collars with brass washers between collars and bearing surfaces

Shaft Diameters over 1-1/2 Inches: Bronze collars pinned to valve shaft

Actuator Mounting Bracket: Fabricated Steel

OPERATIVE TEMPERATURE[1, 7]

With EPDM T-Ring: +20 to +300°F

With Nitrile T-Ring: +20 to +200°F

1. None of the pressure or temperature limitations in this bulletin, nor any applicable code limitation, should be exceeded.
2. Pressure-retaining part.
3. Pressure-retaining part on 4-inch through 24-inch sizes only.
4. Trademark of Du Pont Co.
5. Trademark of Crane Packing Co.
6. Trademark of Union Carbide Corp.
7. This term is defined in SAMA Standard PMC 20.1-1973.

Specifications (Continued)

With Viton T-Ring: +20 to +400°F (Do not use with water over 180°F or steam)

ACTUATOR TORQUE REQUIRED
See table 1

FLOW DIRECTION
Flow is permissible in either direction, but valve is normally installed with T-ring retaining ring facing downstream

FLOW COEFFICIENTS
See Fisher Catalog 10

SHUTOFF CLASSIFICATION
Fisher Class VI (less than one bubble per minute using air at a pressure drop of 150 psi for 4 through 24-inch sizes and 75 psi for 30 through 96-inch sizes)

DISC ROTATION
■ Clockwise to open or ■ counterclockwise to open (when viewed from actuator side of valve) through 90 degrees of disc rotation.

ACTUATOR MOUNTING
Fabricated actuator-mounting bracket is used to mount Fisher Type 480-15, 481-15, 656 and 864 actuators. Style 4 adjustable linkage, shown in figure 1, is used with Fisher actuators for travels of 4 inches and less and valve shaft diameters of 1-1/2 inches and less. Fixed linkage is used for longer travels and larger valve shafts.

Actuator can be ■ perpendicular to (standard) or ■ parallel with pipeline (adaptor required for parallel mounting of actuators requiring a mounting bracket) with actuator to ■ right (standard) or ■ left of valve (when viewed from valve inlet)

With perpendicular mounting in horizontal pipeline, actuator can extend ■ above (standard) or ■ below pipeline. With parallel mounting, actuator can extend ■ upstream or ■ downstream.

ACTUATOR/VALVE ACTION
■ Push-down-to-open (extending actuator stem opens valve) or ■ Push-down-to-close (extending actuator stem closes valve)

MATING FLANGE CAPABILTIES
Compatible with welding-neck and slip-on flanges

CODE CLASSIFICATIONS
Valve body, disc, and shaft components designed in accordance with allowable stress levels as specified in ASME Boiler and Pressure Vessel Code, Sections III and VIII

Valve body assemblies available as nuclear code Class 1, 2, or 3 valve with ASME "N"-stamp symbol

TESTING REQUIRED
All nondestructive examinations (NDE) required for Class 1, 2, and 3 nuclear-service valves can be furnished; for current list of NDE requirements, see Fisher Catalog 11

PACKING BOX TYPE
Leak-off type packing box with 1/2-inch NPT female leak-off connection

VALVE SHAFT DIAMETERS
See figure 7

APPROXIMATE WEIGHTS
See figure 7

OPTION
Single-flange steel valve body with ■ full set of flange bolt holes on one end and buttwelding-end connection on the other end as shown in figure 2 or with ■ a buttwelding end connection on both ends. Flanged end connection available as noted in "End Connection Styles" above; buttwelding-end connection available per ■ ANSI B16.25 or ■ as specified

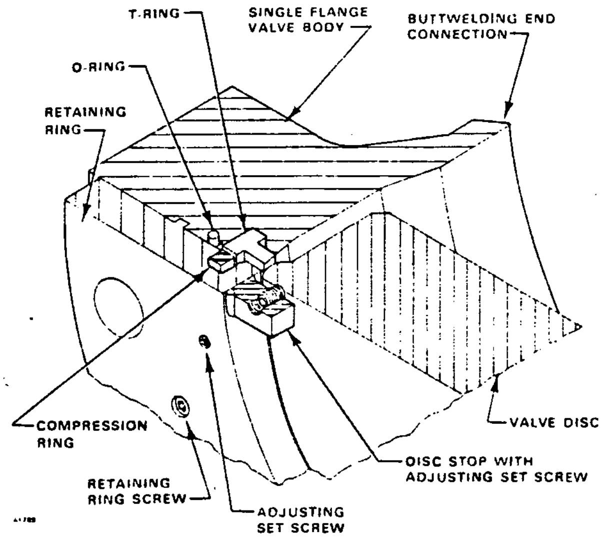


Figure 2. 9200 Series Specification B-1 Valve T-Ring Details (Optional Single-Flange/ Buttwelding End Construction)

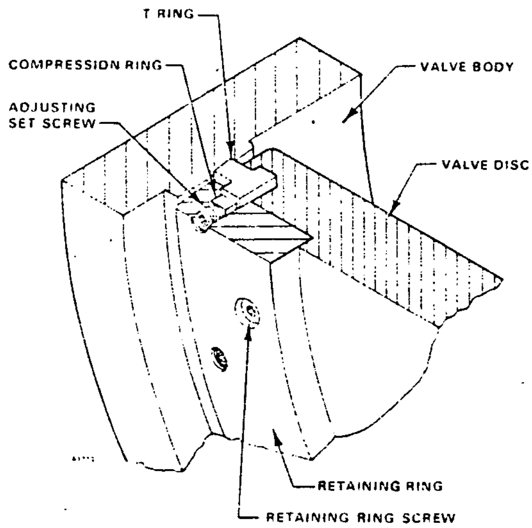
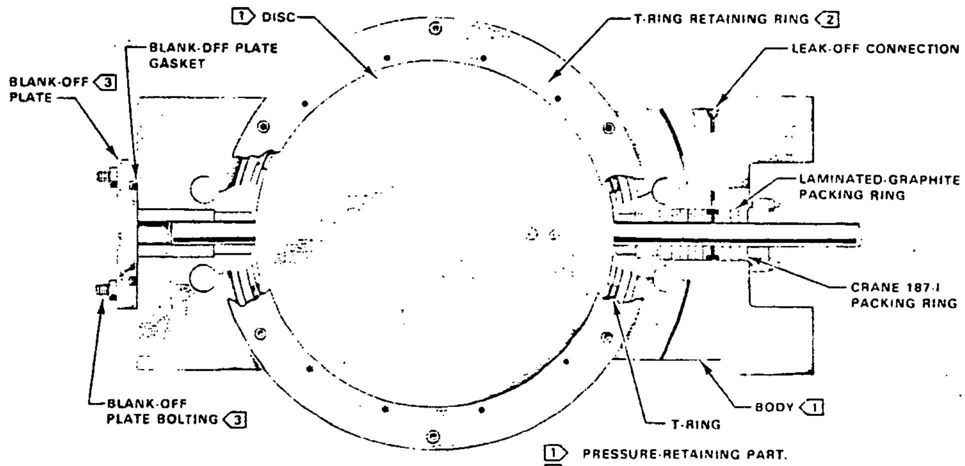


Figure 3. 9200 Series Specification C-1 Valve T-Ring Details



1 PRESSURE-RETAINING PART.
2 PRESSURE-RETAINING PART ON 4-INCH THROUGH 24-INCH SIZES (SPECIFICATION B-1) ONLY.
3 PRESSURE-RETAINING PART ON 4-INCH THROUGH 24-INCH SIZES (SPECIFICATION B-1) ONLY. NOT USED ON 30-INCH OR LARGER SIZES (SPECIFICATION C-1)

Figure 4. 9200 Series Specification B-1 Valve Body

Valve and Actuator Selection

Note

Valve and actuator selection can be made from table 1 for 4-inch through 72-inch valves, pressure drops to 150 psi (depending upon valve size), and process temperatures from +20 to +400°F (depending upon elastomer T-ring material selected and application).

The torques in the "Actuator Torque Required" column of the table are the maximum torques encountered when the disc is being closed (or opened) against the shutoff (0-degrees of disc rotation) pressure drop shown in the table. Pressure drops shown for open disc angles (60 or 90 degrees) are the maximum flowing drops that the torques in the "Actuator Torque Required" column will permit. (Where necessary, maximum pressure drops shown for open angles have been limited by strength capabilities of construction materials.)

Table 1. Valve and Actuator Selection

VALVE SIZE[1] (INCHES)	VALVE SHAFT DIAMETER (INCHES)	OPERATIVE TEMPERATURE	BUSHING TYPE[2]	MAXIMUM PRESSURE DROP (PSI) Angle of Disc Opening (Degrees)			ACTUATOR TORQUE REQ'D (INCH-POUNDS)	RECOMMENDED ACTUATOR TYPE AND SIZE
				0	60	90		
4	5/8		2	150	49.7	16.9	410[3]	656 Size 40 w/35 psig supply[4]
			3	150	59.1	21.5	525[3]	656 Size 40 w/ 35 psig supply[4]
6	3/4		2	150	36.4	12.1	925[3]	656 Size 60 w/35 psig supply[4]
			3	150	46.1	15.0	1250[3]	656 Size 60 w/35 psig supply[4]
8	1		2	150	30.5	10.1	1820[3]	656 Size 60 w/35 psig supply[4]
			3	150	40.4	14.2	2575[3]	480-15 Size 40 w/80 psig supply[5]
10	1		2	150	24.7	8.1	2780[3]	480-15 Size 40 w/80 psig supply[5]
			3	144	16.0	8.1	3960	480-15 Size 60 w/80 psig supply[5]
12	1-1/4		2	150	22.7	7.6	4425[3]	480-15 Size 60 w/80 psig supply[5]
			3	150	27.0	9.0	6550[3]	480 Size 80 w/80 psig supply[5]
14	1-1/4		2	150	19.7	6.5	5360[3]	480-15 Size 60 w/80 psig supply[5]
			3	140	19.5	6.4	7950	864 Size[6] 6 x 20 w/80 psig supply[5]
16	1-1/2		2	150	18.9	6.3	7785[3]	480 Size 80 w/80 psig supply[5]
			3	150	22.5	7.5	11,900[3]	864 Size[6] 6 x 20 w/80 psig supply[5]
18	1-1/2		2	150	15.7	5.0	10,550[3]	864 Size[6] 6 x 20 w/80 psig supply[5]
			3	129	15.0	4.9	15,950	864 Size[6] 8 x 20 w/80 psig supply[5]
20	1-3/4	EPDM T-Ring: -20 to +300°F; Nitrile T-Ring: -20 to +200°F; Viton T-Ring: -20 to +400°F	2	150	16.5	5.4	13,100[3]	864 Size[6] 6 x 20 w/80 psig supply[5]
			3	148	13.0	5.8	20,550	864 Size[6] 8 x 20 w/80 psig supply[5]
24	2		2	150	15.0	4.9	20,700	864 Size[6] 8 x 20 w/80 psig supply[5]
			3	137	15.0	4.9	33,170	864 Size[6] 10 x 20 w/80 psig supply[5]
30	2		2	75	6.5	2.1	17,732[3]	864 Size[6] 8 x 16 w/80 psig supply[5]
			3	75	6.2	2.0	27,932	864 Size[6] 8 x 20 w/80 psig supply[5]
36	2-1/2		2	75	6.3	2.0	28,830	864 Size[6] 8 x 20 w/80 psig supply[5]
			3	75	5.9	2.0	46,830	864 Size[6] 10 x 24 w/80 psig supply[5]
42	2-1/2		2	75	5.5	1.7	40,020	864 Size[6] 10 x 20 w/80 psig supply[5]
			3	75	5.2	1.7	64,770	864 Size[6] 12 x 20 w/80 psig supply[5]
48	3		2	75	5.3	1.7	58,675	864 Size[6] 12 x 20 w/80 psig supply[5]
			3	75	5.1	1.7	97,750	Contact Fisher Representative
54	3-1/2		2	75	5.3	1.7	83,555	Contact Fisher Representative
			3	75	5.0	1.6	141,680	Contact Fisher Representative
60	3-1/2		2	75	4.8	1.5	103,585	Contact Fisher Representative
			3	75	4.6	1.5	175,660	Contact Fisher Representative
66	4		2	75	4.7	1.5	137,570	Contact Fisher Representative
			3	75	4.5	1.5	237,320	Contact Fisher Representative
72	4-1/2		2	75	4.7	1.5	180,130	Contact Fisher Representative
			3	75	4.5	1.5	313,630	Contact Fisher Representative

1. For larger sizes, contact the Fisher sales representative.
2. Bushing 2 — graphite-impregnated bronze; bushing 3 — alloy 6
3. Within torque capabilities of Fisher manual handwheel actuators
4. With or without valve positioner. Selection valid only if full actuator travel, standard 6 to 30 psig (nominal) spring, and positioner supply (or maximum diaphragm input signal) of 35 psig are used
5. With or without valve positioner. If 480 Series actuator without positioner is desired, substitute Type 481 or 481-15 for Type 480 or 480-15. Section valid only if full actuator travel and minimum positioner supply pressure (or cylinder operating pressure) of 80 psig are used.
6. Cylinder bore diameter (inches) x maximum actuator travel (inches).

All pressure drops shown are within the strength capabilities of the materials shown in the "Specifications" table.

After determining the proper valve size using Fisher Catalog 10 and the sizing nomographs or slide rule, refer to table 1. Check the maximum allowable pressure drop at the appropriate open angle (either 60 or 90 degrees) to be certain it equals or exceeds that which will be encountered in service.

Recommended Fisher actuator types, sizes, and operating pressures for each selection are shown at the right of the table. In addition, other actuator types, such as electric and spring-return pneumatic rotary actuators are also available in recommended combinations with 9200 Series valve bodies. All combinations in table 1 are predetermined to have sufficient torque output at the stated operating conditions.

Selection from among the recommended combinations reduces documentation cost and possibility of delay. Contact the Fisher sales representative if other combinations are required.

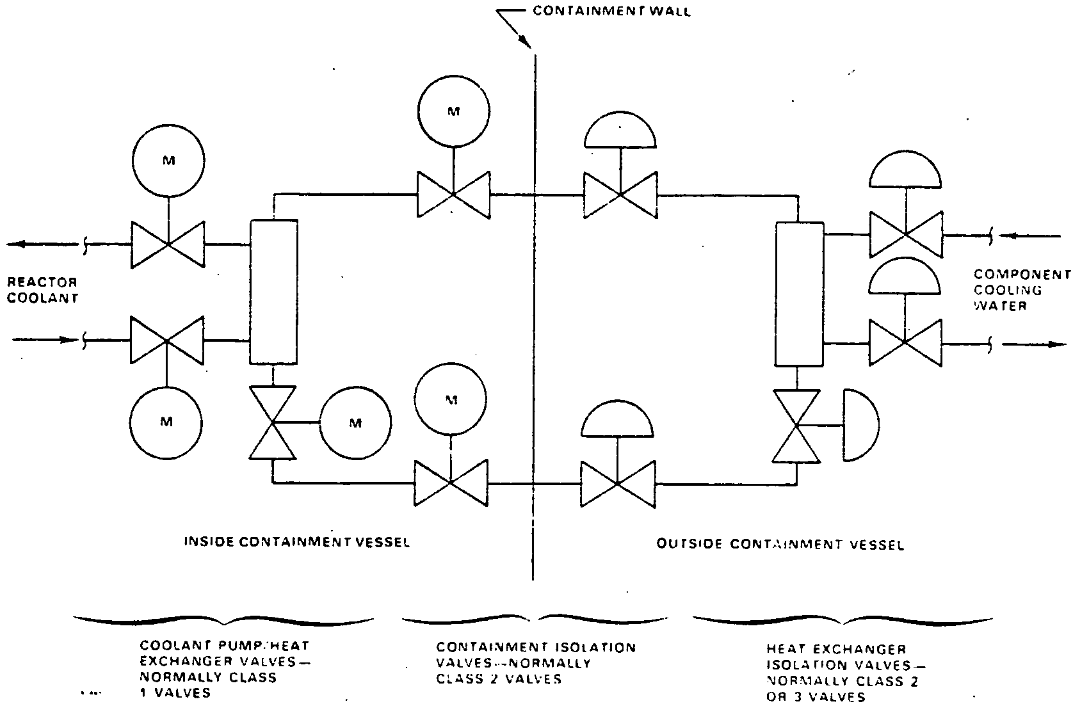


Figure 5. Typical Applications for Class 1, 2, and 3 Nuclear-Service Valves Shown in a Component Cooling System

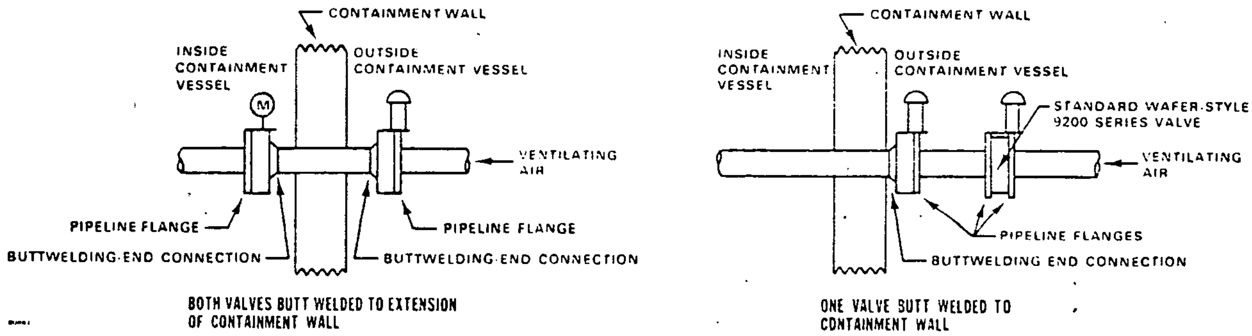


Figure 6. Typical Installations for Single-Flange 9200 Series Valves with One Buttwelding-End Connection and One Flanged Connection (Being Used as Isolation Containment Valves in Ventilating Air System)

Installation

The actuator will be mounted on the valve in the orientation specified when the unit was ordered. This orientation is normally selected based upon the desired mounting position in the pipeline, available space at the point of installation, etc.

For 30-inch and larger valve sizes, factory seat leak testing must be performed with the valve in the same position as is intended for the actual installation. For these larger sizes, install the valve in the same position as was specified when the valve was ordered, or a field re-adjustment of the T-ring may be required to attain the desired shutoff capability. T-ring adjustment is provided by a compression ring and adjusting set screws as shown in figures 2 and 3.

Flow through the valve can be in either direction, but the valve is normally installed with the T-ring retaining ring facing downstream. For 30-inch and larger sizes, it may be desired to install the valve such that the T-ring retaining ring faces the nearest manhole or other pipeline access point. This will facilitate T-ring inspection and maintenance.

VALVE SIZE	LETTERED DIMENSION						MINIMUM ALLOWABLE DIAMETER OF MATING PIPE OR FLANGE	APPROXIMATE WEIGHT OF VALVE BODY ASSEMBLY (POUNDS)
	A	B	C	E*	F	S		
4	4.00	6.50	8.50	6.25	3.25	5/8	3.64	70
6	6.00	7.50	10.50	6.25	3.75	3/4	5.56	100
8	8.00	9.00	10.50	6.25	3.75	1	7.81	130
10	10.00	10.00	12.00	6.25	3.75	1	9.81	175
12	12.00	12.00	14.00	7.62	4.75	1-1/4	11.50	320
14	13.25	13.00	15.50	7.62	4.75	1-1/4	13.00	375
16	15.25	14.50	17.50	7.62	4.75	1-1/2	15.12	475
18	17.00	15.00	18.50	7.62	5.00	1-1/2	16.75	520
20	19.00	17.00	20.50	8.75	5.50	1-3/4	18.88	685
24	23.00	20.00	21.50	8.75	6.00	2	22.75	1040

*Standard E dimensions shown are valid for actuator selections shown in table 1. Special E dimensions may be required for other actuator types.

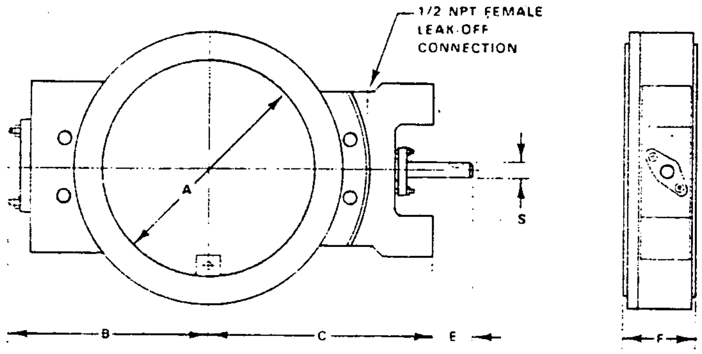


Figure 7. Dimensions (Inches)

The 9200 Series valves are supplied with a disc travel stop. If the valve body and actuator have been ordered separately or if the actuator has been removed for maintenance, be certain that proper rotation direction will be obtained from the actuator before installing.

If spiral-wound line flange gaskets are to be used with the 4-inch through 24-inch sizes, be certain the gaskets are of a type and size that will not overlap the cap screw or adjusting screw holes in the T-ring retaining ring. Under line flange bolting compression, spiral-wound gaskets can be damaged by the cap screw or adjusting screw holes.

Ordering Information

Application

When ordering, specify:

1. Type of Application
   a) Throttling or on/off
   b) Reducing, relief, or back pressure
2. Controlled fluid (include chemical analysis of fluid if possible)
3. Specific gravity of controlled fluid
4. Fluid temperature (normal and minimum and maximum anticipated)
5. Range of flowing inlet pressures
6. Pressure Drops
   a) Range of flowing pressure drops
   b) Maximum at shutoff
7. Flow Rates
   a) Minimum controlled flow
   b) Normal flow
   c) Maximum flow
8. Maximum allowable leakage rate
9. Specify the position in which the valve will be installed (e.g., valve in horizontal pipeline with valve shaft horizontal). Seat leak testing will be performed with the valve in the same position as is intended for the actual installation.
10. Nuclear-code class and all nuclear and special requirements
11. Line size and schedule

Valve Body Information

Refer to the "Specifications" on page 2. Review the description at the right of each specification and in the referenced table. Indicate the choice wherever there is a selection to be made.

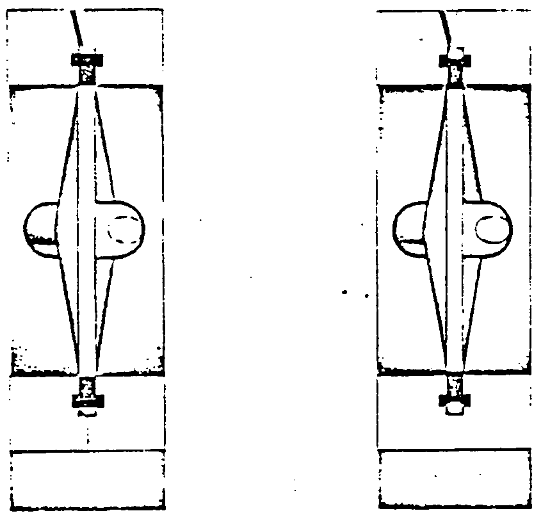
Actuator and Accessory Information

Specify the desired actuator type and size from the appropriate actuator bulletin. Also refer to the specific actuator and accessory bulletins for additional ordering information.

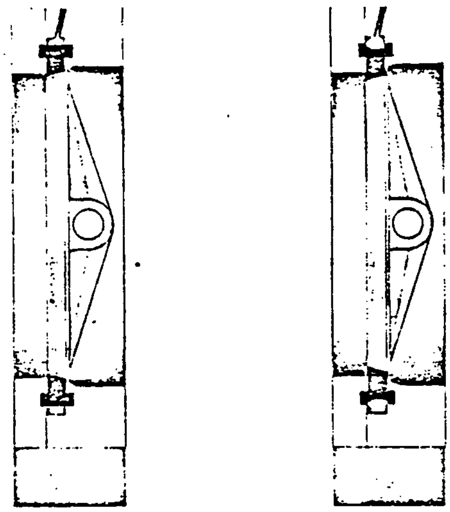
FISHER® Controls

T-ring Butterfly Valve Seal Systems

October 1969 | Bulletin 51.4:9200(S2)
Old Catalog Number 92.05



Type 9000 T-Ring angular shaft design showing seal chamber exhausted (Fig. 1), and pressurized (Fig. 2).



Type 9200 T-Ring offset disc design showing seal chamber exhausted (Fig. 3), and pressurized (Fig. 4).

DESCRIPTION

The T-Ring seal system has two purposes. It pressurizes and exhausts the seal chamber of the Continental T-Ring Butterfly Valve. However, to fully understand why a seal system is necessary, we must first know what happens to the valve's elastomer T-Ring seal at pipeline pressures.

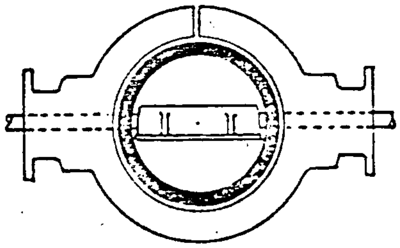
When the pipeline pressure increases beyond 3 psig, or the temperature is higher than 100° F., the elastomer T-Ring seal becomes distorted allowing leakage to occur between the periphery of the closed disc and the elastomer seat. By pressurizing the seal chamber the elastomer seat is pressed against the periphery of the closed disc affording bubble-tight shut-off. Exhausting the seal chamber allows retraction of the elastomer seal from the disc. When the T-Ring Butterfly Valve is used for pressures below 3 psig and service is for normal ambient temperatures, (70-100°F.) the seal system is not required. In this instance the closing and opening action of the disc upon the elastomer seal seat is similar to conventional rubber lined valves. The disc in closing is pulled into the elastomer seal seat which has been sized for an "interference" fit.

MANUAL SEAL SYSTEMS — In manual T-Ring seal systems a manually actuated valve controls the pressure to the seal chamber.

AUTOMATIC SEAL SYSTEMS — In automatic T-Ring seal systems, pneumatic or electrically actuated valves control the pressure to the seal chamber.

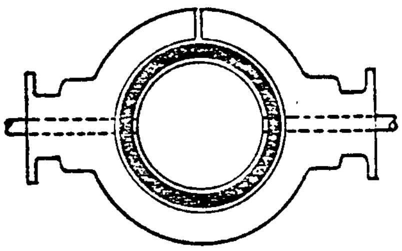
Both manual and automatic seal system designs are available for use with T-Ring Butterfly Valve installations. Since variations of these two basic designs are possible, usually dependent upon valve actuation, the design best suited for a specific application is always selected.

Illustrations show T-ring seal position during butterfly valve opening and closing sequences.



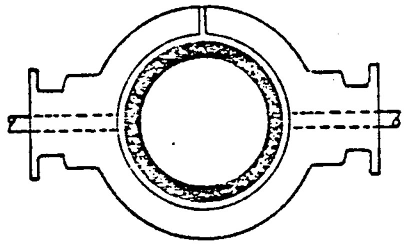
1

Disc open, 90° position. No pressure in seal chamber.



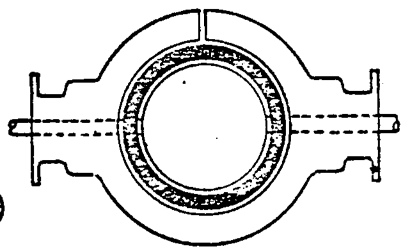
2

Disc rotates to closed, 0° position. No pressure in seal chamber. Note clearance between disc and T-seat.



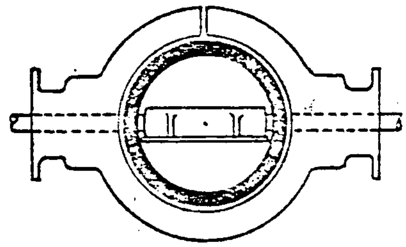
3

Disc closed. Seal chamber pressurized. T-seat is "pressure sealed" against disc. Result: bubble tight shut-off.



4

Disc closed. Seal chamber exhausted. Note clearance between disc and T-seat.



5

Disc rotates to open position. No pressure in seal chamber.

APPLICATION

The Continental seal system provides the following distinct advantages of T-Ring Butterfly Valves over conventional, tight shut-off valves of "interference" design.

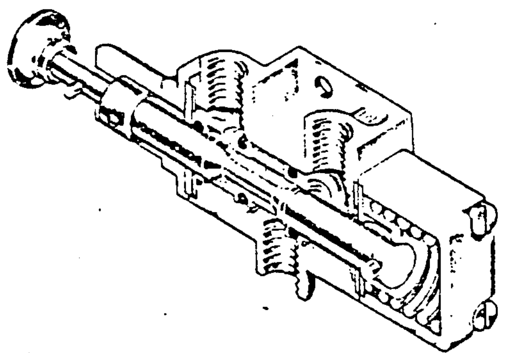
- The elastomer seal is retracted from the periphery of the valve disc prior to actuation. This prevents abrasive action of the disc upon the elastomer seal for longer seal life.
- Approximately 200,000 cycles of disc opening and closing so long as the process gas or liquid is compatible with the T-Ring elastomer.
- Bubble-tight shut-off is provided for pressure drops to 360 psi.
- Leak-tight shut-off is provided for vacuums to 10^{-6} mm Hga.

PNEUMATIC PRESSURES — In most applications clean air is used. However, under certain conditions various gases from the process system can be used, if compatible with the T-Ring elastomer.

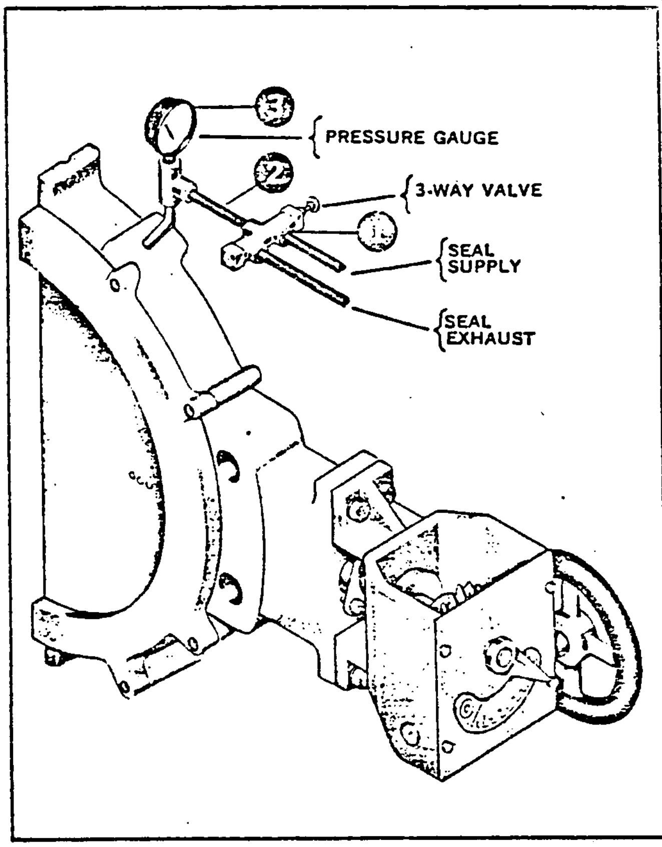
LIQUID PRESSURES — Any clean liquid compatible with the T-Ring elastomer can be used whether the pressure is derived upstream from the process system or from an auxiliary source.

VACUUM SERVICE — For vacuum service to 10^{-6} mm Hg absolute where tight shut-off is required 80 to 100 psig supply pressure must be used in the seal chamber for activating the T-Ring seal. This seal pressure should be exhausted to the atmosphere, and not to the downstream piping where it may disrupt the vacuum level.

MANUAL SEAL SYSTEM



Cutaway view of non-adjustable manual 3-way valve as used in manually controlled seal systems.



Manually controlled seal system showing piping arrangement, 3-way valve and pressure gauge installed on a T-ring butterfly valve.

DESCRIPTION

The manually controlled seal system is designed for use with Continental Types 9000 and 9200 lever or handwheel actuated T-ring butterfly valves. It provides a simple and inexpensive method of applying pressures to the valve's seal chamber. The system utilizes a maximum of 200 psig air or 500 psig oil and water service, and maximum temperatures to 180°F.

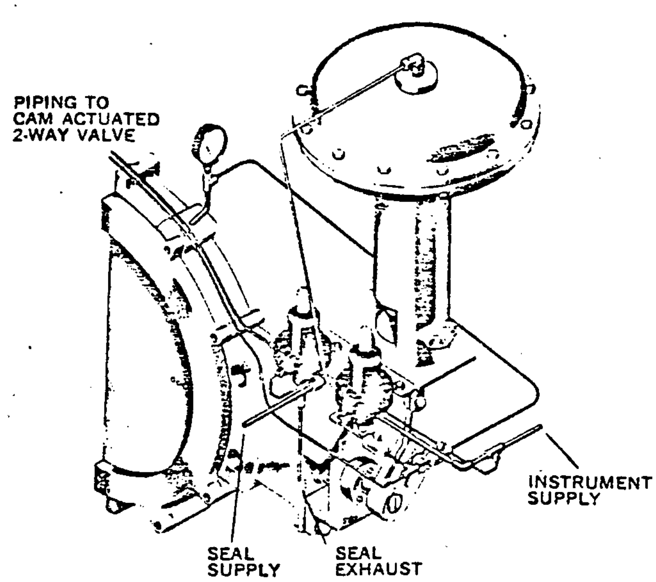
OPERATION

(1) **3-Way Valve** — The manually operated 3-way valve is opened to seal system line pressure whenever butterfly valve disc is in closed position allowing the valve's seal chamber to become pressurized. By pressurizing seal chamber the valve's T-ring elastomer seal is pressed against the periphery of the closed disc affording bubble-tight shut-off. Closing the 3-way valve to seal system line pressure exhausts the seal chamber allowing retraction of the elastomer seal from the periphery of the butterfly valve disc.

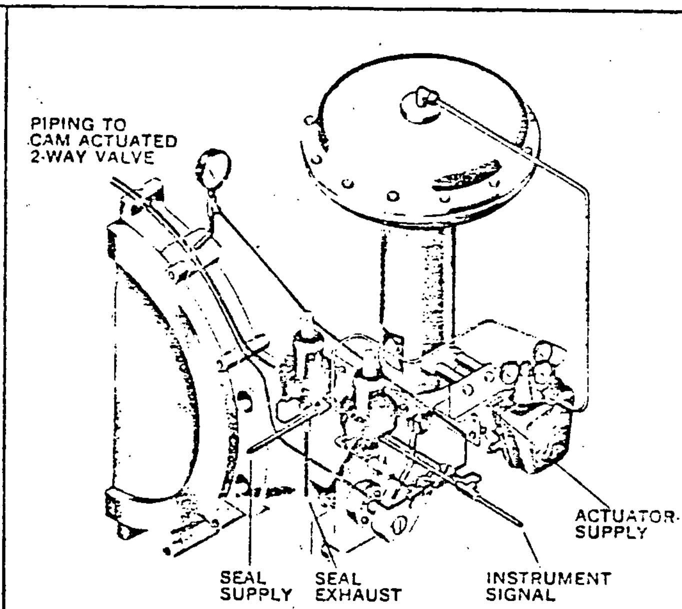
(2) **Piping** — Consists of copper tubing under normal conditions with the necessary fittings. All seal system components and T-ring butterfly valve bodies are threaded to receive 1/4" N.P.T. pipe connections.

(3) **Pressure Gauge** — Indicates seal chamber pressure. A complete range of gauges is available depending upon the seal pressure used.

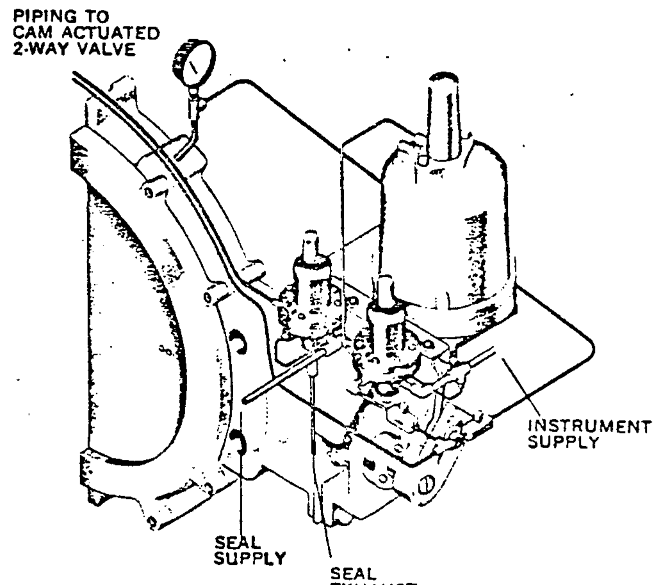
164A AUTOMATIC SEAL SYSTEM



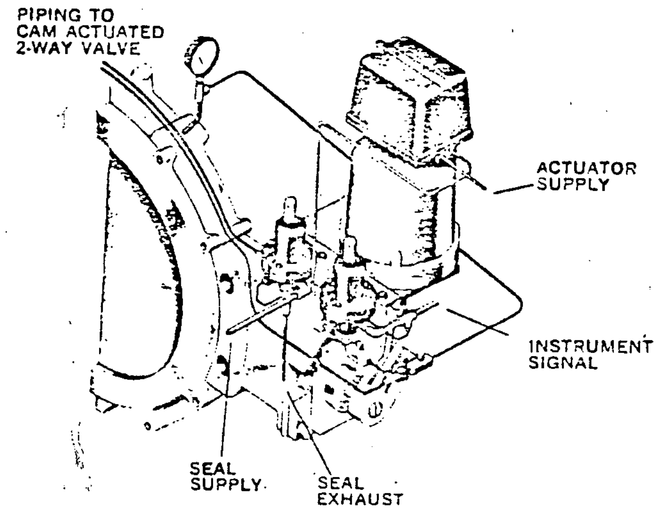
Type 656 Fisher diaphragm actuator (without positioner) mounted to a Type 9210 butterfly valve.



Type 656 Fisher diaphragm actuator and a Type 3560 positioner mounted to a Type 9210 butterfly valve.



Type 481 Fisher P.O.P. actuator (without positioner) mounted to a Type 9210 butterfly valve.



Type 480 Fisher P.O.P. actuator and a Type 3570 positioner mounted to a Type 9210 butterfly valve.

INSTRUMENT SUPPLY — That pressure which controls the action of the actuator when positioner is not furnished.

SEAL SUPPLY — Pressure, controlled by the seal system, used to pressurize the seal chamber.

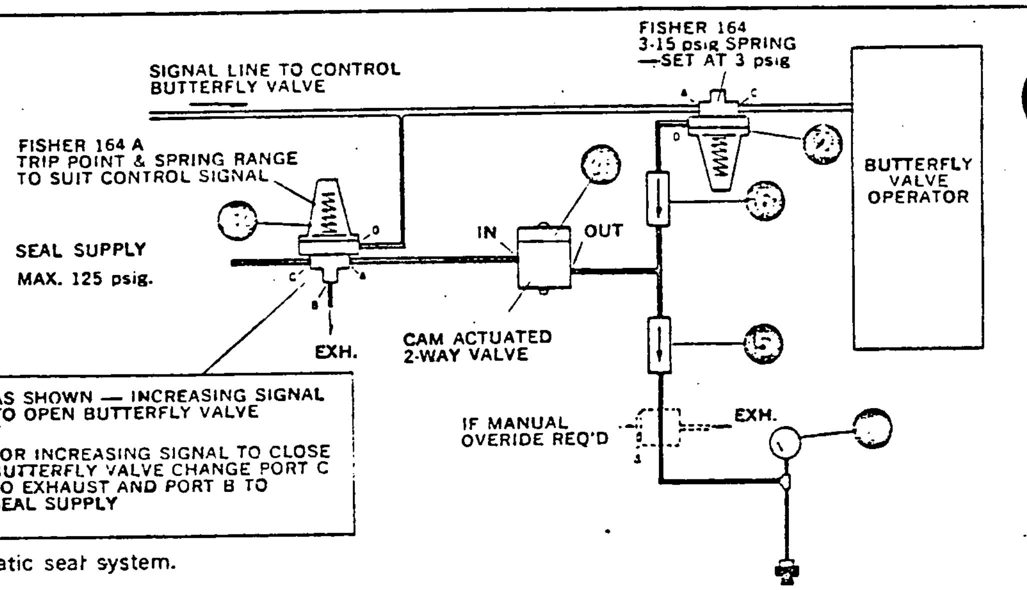
INSTRUMENT SIGNAL — Pressure which controls the action of the valve positioner.

ACTUATOR SUPPLY — Pressure used by valve positioner to control actuator.

SIGNAL LINE — Tubing or piping through which the instrument supply or signal flows.

DESCRIPTION

The Type 164A automatic seal system is designed for pneumatically actuated butterfly valves either with or without positioners. Its specific purpose is to assure pressurization of the valve's seal chamber after disc closing, or exhaustion of the valve's seal chamber prior to disc opening. This prevents wear from abrasion between the disc's periphery and the elastomer seal seat. The seal system can be used with either diaphragm or piston actuators and their combination with auxiliary manual control. System service requirements are for clean air or vapor with signal pressures to 125 psig, seal pressures to 125 psig, and maximum temperatures to 150°F.



Schematic of a 164A automatic seat system.

1 **Pressure Gauge** — Indicates seal chamber pressure. A complete range of gauges is available depending upon the seal pressure used.

2 **2-Way Valve** — Prevents the signal pressure from reaching or escaping from butterfly valve actuator whenever seal chamber is pressurized. This in turn prevents the opening of the butterfly valve disc until the seal chamber has been exhausted.

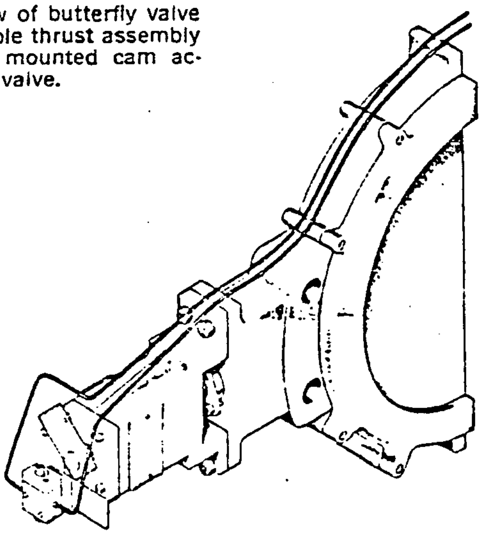
3 **3-Way Valve** — Activated by the instrument signal or instrument supply pressure to the butterfly valve actuator, it controls the pressurization or exhaustion of the seal chamber.

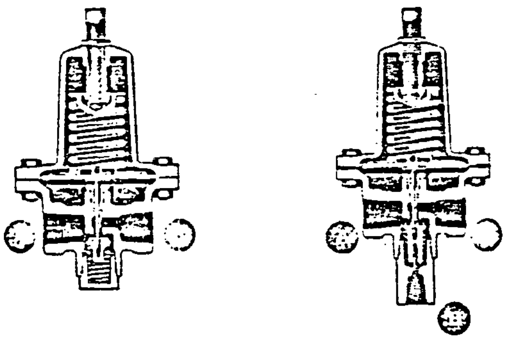
4 **Cam Actuated 2-Way Valve** — Allows pressurization of seal chamber only when butterfly valve disc is in fully closed position.

5 **Flow Control Valve**—A safety feature which delays, for a few seconds, the pressure build-up within the seal chamber upon disc closing.

6 **Flow Control Valve** — Restricts air flow escaping from air actuated 2-way valve upon exhaustion of seal chamber. This allows the seal chamber to become completely exhausted prior to butterfly valve disc opening.

Opposite view of butterfly valve showing double thrust assembly and bracket mounted cam actuated 2-way valve.





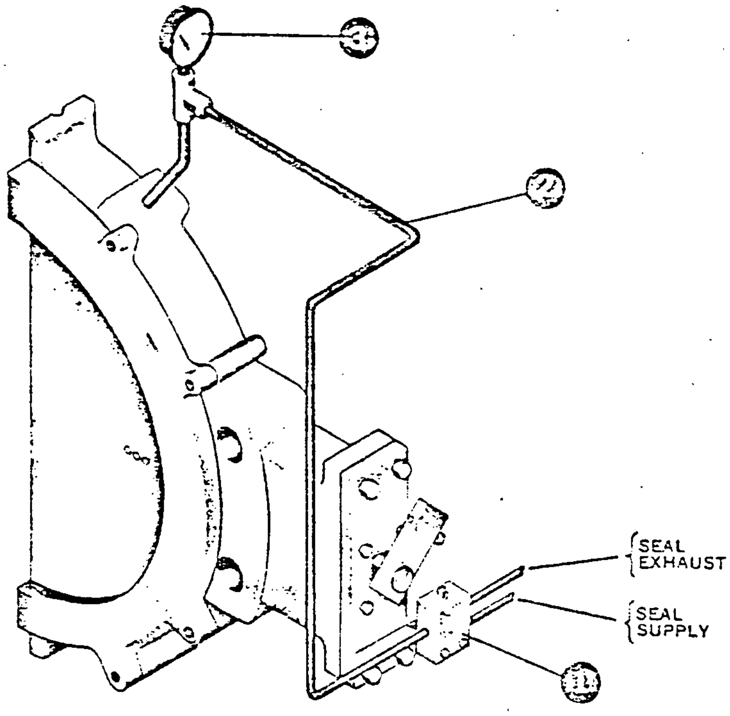
Air Actuated
2-Way Valve

Air Actuated
3-Way Valve

To adjust the air actuated 2-way valve, apply 3 psig pressure to port D. Turn adjusting screw clockwise to limit, then counter clockwise until air flows through A to C in illustration above.

To adjust the air actuated 3-way valve, rotate the butterfly valve disc to closed (0°) position. Set flow control valves in wide open position. Turn the adjusting screw of the air actuated 3-way valve in either direction until seal pressure is applied and no exhaust is felt at exhaust outlet. Now turn the adjusting screw one-half of one revolution beyond this point.

2PC3 AUTOMATIC SEAL SYSTEM



Automatically controlled 2PC3 seal system showing piping arrangement, 3-way valve and pressure gauge installed on T-ring butterfly valve.

DESCRIPTION

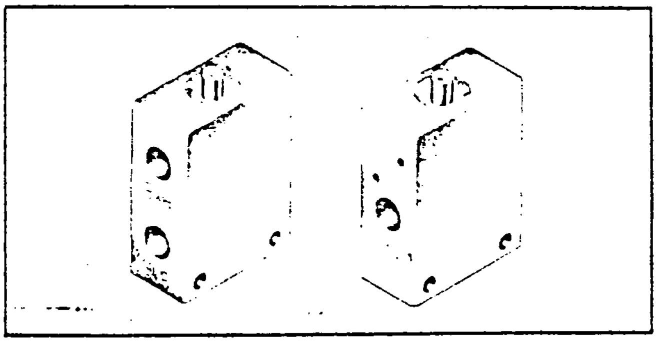
The automatic 2PC3 seal system is designed for use with Continental Types 9000 and 9200 remotely controlled manual or chainwheel actuated T-ring butterfly valves. It consists mainly of a bracket mounted, mechanically operated 3-way valve, piping, actuating lever and pressure gauge. The system utilizes a maximum of 125 psig air, oil or water at a maximum temperature of 180° F.

2 **Piping** — Consists of copper tubing under normal conditions with the necessary fittings. All seal system components and T-ring butterfly valve bodies are threaded to receive ¼" N.P.T. pipe connections.

3 **Pressure Gauge** — Indicates seal chamber pressure. A complete range of gauges is available depending upon the seal pressure used.

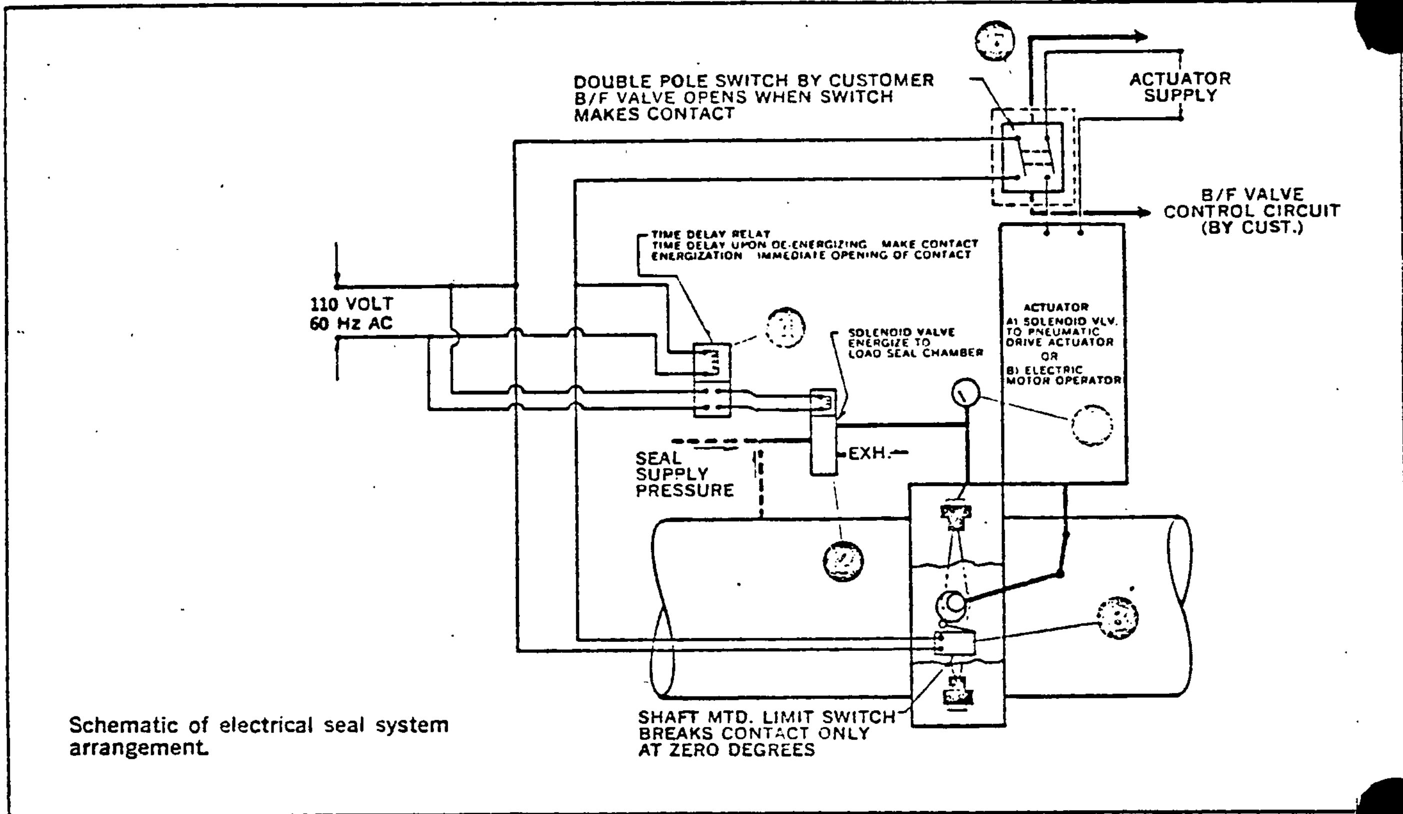
OPERATION

1 **2PC3 Valve**—The lever operated 3-way valve is opened to seal system line pressure through supply and cylinder ports whenever butterfly valve disc is in the closed position. This pressurizes the valve's seal chamber and causes the elastomer T-ring seal to press against the periphery of the closed disc affording bubble-tight shut-off. The 3-way valve, upon opening of the disc, is closed to line pressure and opened to exhaust. This causes the evacuation of pressure in the seal chamber causing the elastomer seal to retract from the disc's periphery.



Two views of 3-way valve showing supply, exhaust and service parts. Notice plunger shaft and snap-ring.

ELECTRICAL SEAL SYSTEM



Schematic of electrical seal system arrangement.

DESCRIPTION

The electrical seal system is used with electrically controlled, diaphragm or piston actuated butterfly valves for on-off service. It may also be used with electric actuator controlled butterfly valves for on-off or throttling service. Standard components are for 110/120 volt 60 Hz AC single phase circuit. Maximum water and oil line pressures are entirely dependent upon the solenoid valve chosen. However, the standard is for 200 psig maximum air pressure and 500 psig maximum water or oil pressure. Minimum seal pressure required is 40 psig. Maximum operating temperature, 150° F.

OPERATION

(51) **Pressure Gauge** — Indicates seal chamber pressure. A complete range of gauges is available depending upon the seal pressure used.

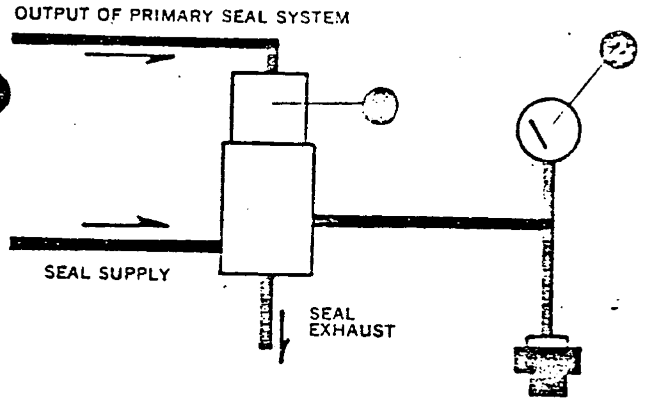
(2) **3-Way Solenoid Valve**—Allows seal chamber to be pressurized and exhausted upon signal from time delay relay switch.

Limit Switch — Butterfly valve shaft mounted switch opens and closes electrical circuit depending upon disc position. As disc opens a few degrees, switch closes and electrical circuit energizes time delay relay regardless of control switch position. Circuit is opened as disc arrives at zero degrees or closed position.

Time Delay Switch — A predetermined delay switch controlling the action of the 3-way solenoid valve. There is a time delay after the time delay relay coil is de-energized, after which the 3-way solenoid valve is energized to allow pressure to the seal chamber. The solenoid valve is immediately de-energized to exhaust the seal pressure when the time delay relay coil is energized.

Double Pole Switch — Furnished and installed by the customer, this switch energizes the time delay relay coil when the butterfly valve disc is to open. This then causes the solenoid valve to exhaust the seal pressure.

NOTE: All components are housed in general pur[pose] enclosures.



Schematic of high pressure supply arrangement showing pilot operated 3-way valve and pressure gauge.

High Pressure Supply Arrangement

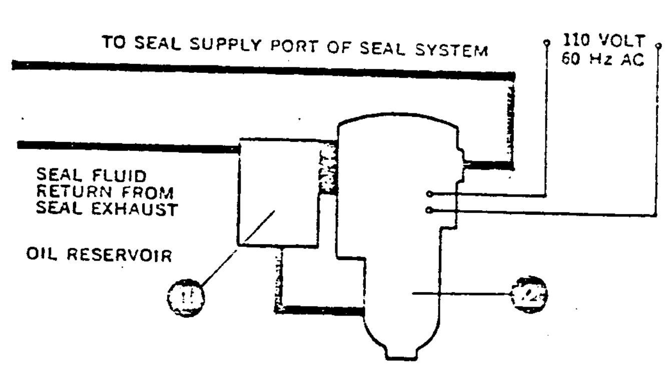
The high pressure supply arrangement is to be used in combination with a primary seal system to give it high pressure capabilities. It will function equally well with either air, oil or water pilot supply and line pressure media. The output of a primary seal system is piped to the pilot port of the 3-way valve rather than to the seal chamber. This output then controls the operation of the 3-way valve, and in turn, the pressure to the seal chamber.

The arrangement requires a minimum primary seal system pressure of 45 psig but not over 125 psig. Maximum pilot supply and line temperature is 180°F. Maximum pilot supply and line pressures are: air—300 psig, water or oil—each 500 psig.

OPERATION

1 **3-Way Valve** — Receives pilot supply pressure from primary seal system at its signal port. This pressure activates the 3-way valve, allowing line pressure to flow through valve to pressurize butterfly valve seal chamber. Seal chamber pressure exhausts through 3-way valve's exhaust port whenever pilot supply pressure is removed.

2 **Pressure Gauge** — Indicates seal chamber pressure. A complete range of gauges is available depending upon the seal pressure used.



Schematic of auxiliary pressure supply source showing oil reservoir and electrical fluid pump arrangement.

345 Auxiliary Pressure Supply Source

The 345 auxiliary pressure supply source provides manual, 2PC3, and electrical seal systems with 150 psig maximum line pressure where otherwise unavailable. The arrangement consists of an oil reservoir, and a Fisher Type 345 electrical fluid pump. It is applicable to seal systems used for butterfly valve tight shut-off requirements. Maximum operating temperature, 150°F.

OPERATION

1 **Oil Reservoir** — Retains ample supply of oil for distribution, by electrical fluid pump, throughout seal system. Reservoir is vented to prevent buildup of vacuum or pressure.

2 **Type 345 Electrical Fluid Pump** — Consists of a continuous 110 volt, 60 Hz, AC motor-pump combination with power supply. Motor is enclosed in an explosion proof housing. Pump output is 15 cubic inches per minute.

Note: The auxiliary pressure supply source provides 150 psig of oil to seal system solenoid or diaphragm valve supply port. Oil from exhausted seal chamber is returned through solenoid or diaphragm exhaust port to oil reservoir.

Hydraulic Fluid Capacity — 2 quarts (Reservoir—1 quart, 345—1 quart).

Hydraulic Fluid Type — Mobil Aereo HFA or Citgo 90151.

SPECIFICATION GUIDE

When ordering specify:

(a) Type of Seal System
(b) Maximum upstream pressure in main pipeline (disc closed)
(c) Maximum downstream pressure in main pipeline (disc closed)
(d) Maximum pressure drop (disc closed)
(e) Minimum and maximum temperature
(f) Type of fluid in main pipeline.
(g) Type and pressure of seal system fluid available
(h) Minimum actuator pressure available
(i) Electrical power available (electrical seal systems)
(j) Type of primary seal system
(k) Output pressure and media of primary seal system

Type 9200

FISHER® Controls

Instruction Manual

Type 9200 T-Ring Butterfly Valve Bodies

Form 2432, March 1974

Introduction

The Type 9200, shown in figure 1, is a heavy-duty butterfly valve body designed for stringent shutoff requirements. An elastomer or TFE T-ring seat is used to obtain shutoff. The available construction variations of the Type 9200 are described below. The method of effecting the T-ring seal varies with the type of construction.

Specification A—The pressure-activated T-ring is contained in the body as shown in figure 2. External sealing pressure forces the T-ring against the disc periphery only when the disc is closed. There is no contact between the disc and T-ring when the disc is opening or closing. Specification A valves are available with elastomer T-rings only.

Specification B-1—The adjustable elastomer T-ring seat is contained between the body and retaining flange as shown in figure 3. The adjusting set screws and compression ring force the T-ring against the disc periphery to provide interference between the T-ring and disc.

Specification B-2—Similar to Specification B-1 except with TFE T-ring

Specification C-1—The adjustable elastomer T-ring seat is contained in the valve disc as shown in figure 4. The adjusting set screws and compression ring force the T-ring against the body bore to provide interference between the T-ring and body bore seating surface.

Specification C-2—Similar to Specification C-1 except with TFE T-ring

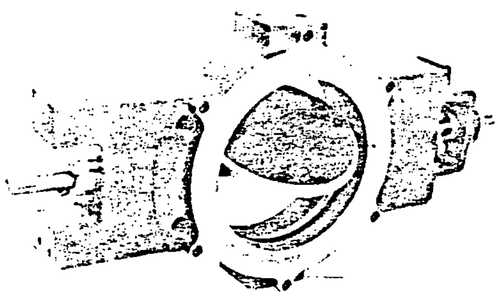


Figure 1. Type 9200 Butterfly Control Valve Body

Installation

WARNING

Do not install the valve in systems where the service conditions exceed those for which the valve was designed, or damage to the valve and personal injury may result.

1. Inspect the valve for shipping damage and be certain that the body cavity is free of foreign materials.

2. Clean out adjoining pipelines to remove all foreign material that could damage the valve seat.

3. In those cases where a flow direction arrow is attached to the valve body, install the body so that the flow through the valve will be in the direction indicated. (Although some seat materials and service conditions require flow in one direction only, the Type 9200 is normally capable of flow in either direction and will have no flow arrow attached.)

4. Be certain that the pipeline flanges are in line with each other and that the disc is fully closed before inserting the valve into the pipeline.

Type 9200

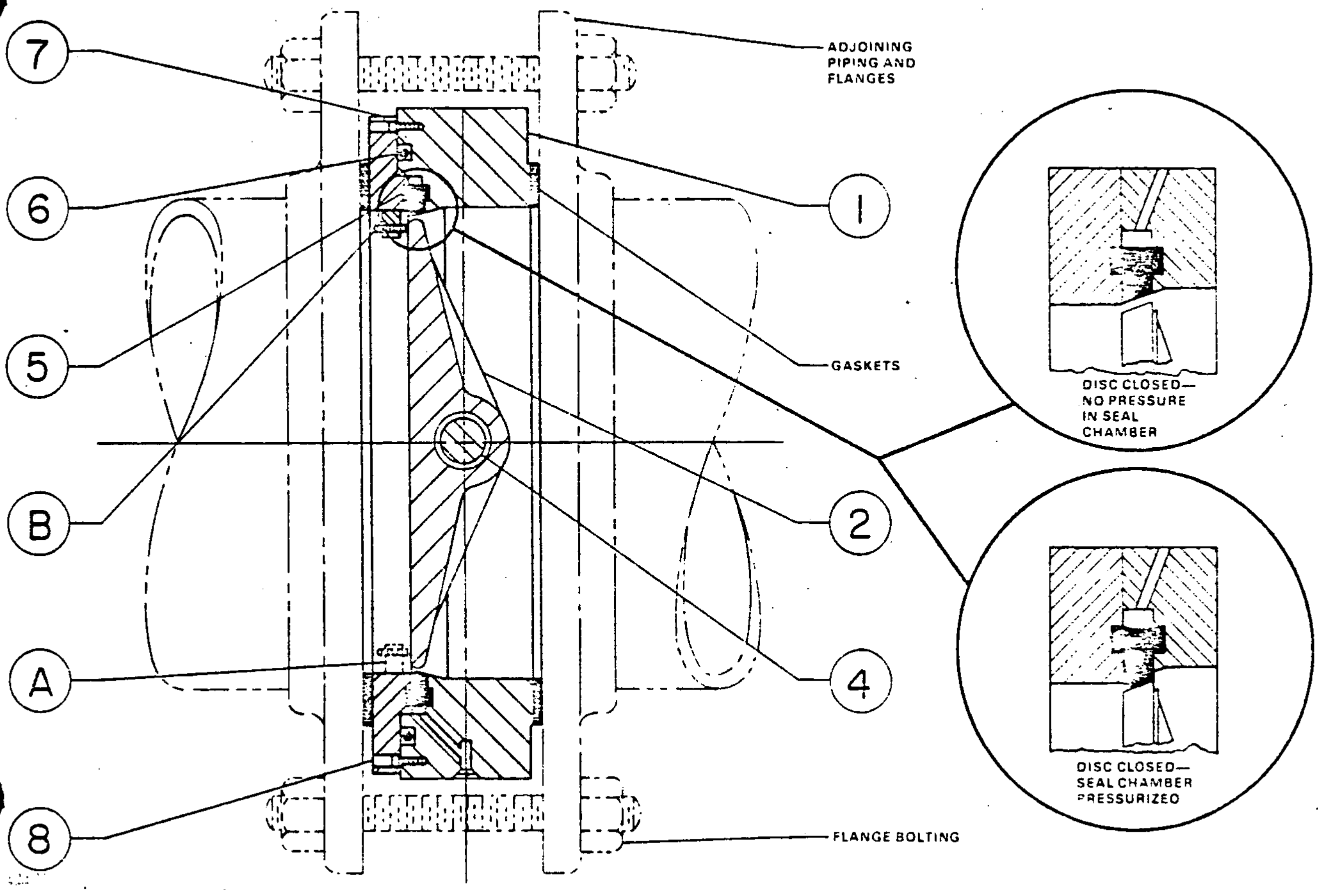


Figure 2. Type 9200 Specification A

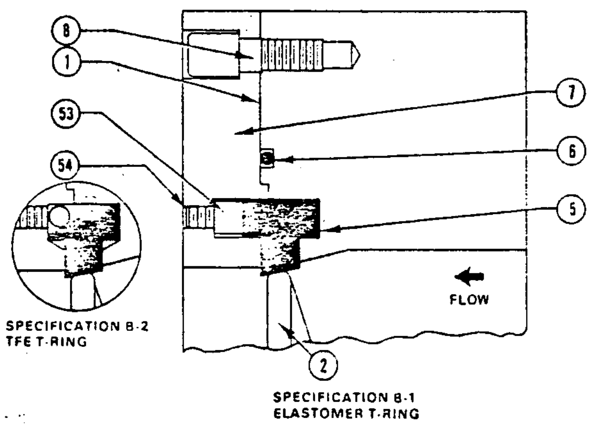


Figure 3. Type 9200 Specifications B-1 and B-2

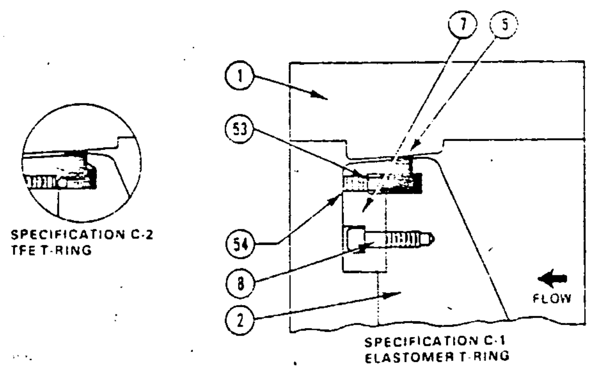


Figure 4. Type 9200 Specifications C-1 and C-2

CAUTION

If the flanges are out of alignment or if the disc is open, difficulties in installation and/or damage to the valve may occur. Be certain that flanges and adjacent piping will not interfere with the opening of the valve disc. Review the dimension drawings to ensure that the inside diameters of the adjacent flanges and piping are large enough to allow disc rotation without interference.

5. Center the valve between the pipe flanges. Although the valve may be installed in any position, the normal position is with the valve shaft horizontal and the actuator vertical above the valve body.

6. Follow accepted piping practices when installing the valve. Provide suitable flange bolting and flange gaskets.

7. If a power actuator is furnished with the valve body, refer to the appropriate actuator instruction manual for information regarding installation and operation of the actuator.

8. If a sealing system is supplied for Specification A constructions, refer to the seal system instructions for operation information.

Specification A Sealing Pressure

Required sealing pressure for Specification A valves is equal to (a) 50 psig or (b) the valve inlet pressure plus one-half the outlet pressure, whichever is greater. Maximum allowable sealing pressure is equal to (a) the maximum allowable pressure of the sealing system being used or (b) 2.5 times the inlet pressure, whichever is lower.

Operation

Specification A

On power-actuated valves when the disc is in the fully closed position, the seal pressure is applied to the back of the elastomer T-ring, forcing the T-ring against the disc periphery. Immediately upon activation of the actuator to open the valve, the seal pressure is released, allowing the disc to leave the seat without any force being exerted on the elastomer T-ring by the disc. The disc is then positioned at the required angle of operation.

When the disc is brought from its open position to its closed position, there is a delay before seal pressure is applied. The sealing system is tripped just as the disc is entering the seal and allows the disc to close fully (completely in the seat) before the seal pressure is applied. This operation is factory adjusted on each valve; if problems arise, the system can be re-adjusted per the seal system instructions.

On valves without power actuators, the sealing pressure must be released with the manually operated loading valve before the valve is opened and re-applied after the valve is closed.

CAUTION

Never apply pressure to the sealing system unless the valve disc is fully closed, or damage to the T-ring may result.

Specifications B-1, B-2, C-1, and C-2

For Specification B-1 and B-2 valves, the valve disc rotates into contact with the T-ring seat on closing. For Specification C-1 and C-2 valves, the valve disc rotates the T-ring into contact with the body bore seating surface on closing. No sealing pressure is required.

Maintenance

WARNING

To avoid personal injury and damage to the process system, isolate the control valve from all pressure and release pressure from the valve body and actuator before disassembling.

Outboard Roller Bearings

If the valve is equipped with outboard roller bearings, lubricate the bearings periodically with a good quality roller bearing grease.

Packing

Key numbers used in this section are shown in figure 5. For valves with lubricating-type packing boxes, lubricate the packing periodically. The frequency of lubrication required depends upon the severity of service conditions.

Type 9200

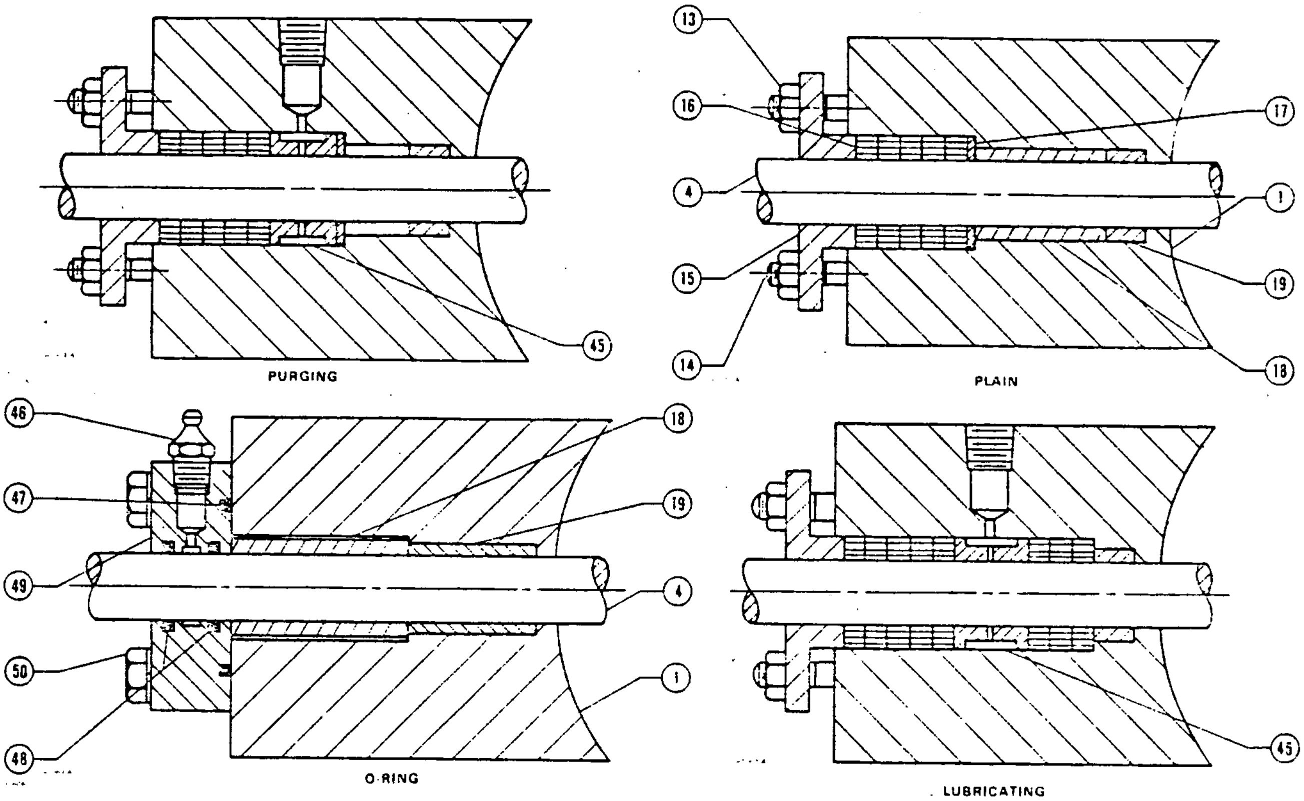


Figure 5. Packing Box Types

It may be necessary to tighten the packing follower nuts (key 13) to stop leakage. If leakage cannot be stopped in this manner, replace the packing per the instructions below.

For split-ring packing, unscrew packing follower nuts (key 13) and slide packing follower (key 15) away from the valve. Remove old packing rings (key 16).

For lubricating packing boxes, remove actuator mounting bracket. Remove lantern ring (key 45) to gain access to the packing rings behind the lantern ring. Place new rings over the valve shaft. When inserting the rings into the packing box, be certain that the split in each ring is positioned 90° from the split in the adjacent ring.

For ring-type packing, remove the actuator and all accessories. Unscrew packing follower nuts (key 13). Remove packing follower and packing rings (keys 15 and 16). For lubricating packing boxes, also remove lantern ring (key 45) to gain access to the packing rings behind the lantern ring. Install new packing rings on the shaft and insert them into the packing box.

For O-ring packing boxes, disassemble the components of the control valve assembly as far as is required to remove the O-ring follower (key 49). Replace O-rings (keys 47 and 48) in the follower as required.

Replacing T-Ring

Specification A

Key numbers used in the following steps are shown in figure 2 except where indicated.

1. Making certain that the valve disc (key 2) is fully closed, remove valve body from pipeline.

2. Note the location of travel stop (key 9, figure 6) on retaining ring (key 7) in respect to the body. This travel stop will be in either location A or B as shown in figure 2 and must be replaced in the same location during reassembly.

3. Unscrew Allen-head cap screws (key 8) and remove retaining ring and T-ring (key 5).

4. Inspect O-ring (key 6). If O-ring requires replacement, remove it from the body.

5. Clean T-ring and O-ring grooves, and coat the new T-ring with a good quality silicone grease.

6. Making certain that the T-ring seat angle matches the disc seat angle (as shown in the inset in figure 2), install the T-ring in the body. Insert the new O-ring if replacement is required.

7. Place retaining ring on the body. Using care to avoid damaging the O-ring (key 6), rotate the retaining ring slightly clockwise and counterclockwise to ensure proper alignment on the T-ring. Be certain the travel stop is positioned in the location noted during disassembly.

8. Replace and tighten Allen-head cap screws (key 8).

9. Replace valve in pipeline per the "Installation" section.

Specifications B-1 and B-2

Key numbers used in the following steps are shown in figure 3 except where indicated.

1. Making certain that the valve disc (key 2) is fully closed, remove valve body from pipeline.

2. Note the location of travel stop (key 9, figure 6) on retaining ring (key 7) in respect to the body. This travel stop will be in either location A or B as shown in figure 2 and must be replaced in the same location during reassembly.

3. Completely loosen adjusting set screws (key 54).

4. Unscrew Allen-head cap screws (key 8) and remove retaining ring, compression ring (key 53), and T-ring (key 5).

5. Inspect O-ring (key 6). If O-ring requires replacement, remove it from the body.

6. Clean T-ring and O-ring grooves. For elastomer T-rings, coat the new T-ring with a good quality silicone grease.

7. Making certain that the T-ring seat angle matches the disc seat angle (as shown in the inset on figure 2), install the T-ring in the body. Insert the new O-ring if replacement is required.

8. Place retaining ring on the body. Using care to avoid damaging O-ring (key 6), rotate the retaining ring slightly clockwise and counterclockwise to ensure proper alignment on the T-ring. Be certain the travel stop is positioned in the location noted during disassembly.

9. Replace and tighten Allen-head cap screws (key 8).

10. Adjust the T-ring per instructions in the "Adjustments" section.

11. Replace valve in pipeline per the "Installation" section.

Specifications C-1 and C-2

Key numbers used in the following steps are shown in figure 4 except where indicated.

1. Making certain that the valve disc (key 2) is fully closed, remove valve body from pipeline.

2. Specification C-1 and C-2 valves may be furnished with a travel stop on the body. This travel stop, if furnished, is not removable.

3. Completely loosen adjusting set screws (key 54).

4. Unscrew Allen-head cap screws (key 8) and remove retaining ring, compression ring, and T-ring (keys 7, 53, and 5).

5. Clean the T-ring groove. For elastomer T-rings, coat the new T-ring with a good quality silicone grease.

6. Making certain that the T-ring seat angle matches the body seat angle, install the T-ring in the disc.

7. Place retaining ring on the disc and rotate the retaining ring slightly clockwise and counterclockwise to ensure proper alignment on the T-ring.

8. Replace and tighten Allen-head cap screws (key 8).

9. Adjust the T-ring per instructions in the "Adjustments" section.

10. Replace valve in pipeline per the "Installation" section.

Replacing Valve Disc

If replacement of the valve disc is required, follow the "Replacing T-Ring" instructions to the point at which the retaining ring and T-ring have been removed. Then proceed with the instructions below. Key numbers used in the following steps are shown in figure 6.

1. Remove actuator, mounting bracket, packing followers (key 15) and packing.

2. If the ends of the taper pins (key 3) are peened, grind off the peened portion. Drive out taper pins.

3. If there is one set of taper pins in the disc, pull shaft (key 4) out of body and remove disc (key 2). Two sets of taper pins indicate that stub shafts are used. Each shaft portion must be pulled out of the body; do not attempt to drive the shaft portions through the disc.

CAUTION

When installing a new disc, also install a new shaft and taper pins. Attempting to use a new disc and old shaft will require drilling new taper pin holes in the shaft, thereby weakening the shaft. The weakened shaft may fail in service. A new shaft may be used with an old disc, using the taper pin holes in the old disc as guides for drilling taper pin holes in the shaft.

4. With inboard bushings (key 19) installed, place valve disc in the body. For large valves, block the body in the horizontal position. Be certain the clearance under the body is equal to at least one-half the disc diameter. With the disc vertical, use a hoist of suitable capacity to place the disc in the body. Be cerain the taper pin holes are on the actuator side of the body.

5. Align the disc shaft hole with the packing box holes in the body.

6. Insert the shaft through the body and disc. Make certain the key seat in the shaft is on the actuator side of the body.

7. Replace bushing retainers and packing box parts (keys 18, 17, 16, 15, and 13).

8. Install taper pins. The disc should be centered in the body bore.

9. Re-install T-ring and retaining ring per instructions in the "Replacing T-Ring" section. For Specifications B-1, B-2, C-1, and C-2, adjust the T-ring per instructions in the "Adjustments" section.

10. Install the valve in the pipeline per instructions in the "Installation" section.

Adjustments

Specifications B-1, B-2, C-1, and C-2 T-Ring

Adjust the T-ring as required to compensate for wear and to retain satisfactory shutoff capability.

1. Rotate valve disc to the fully closed position.

2. Loosen all adjusting set screws (key 54, figure 3 or 4) so that there is clearance between the T-ring and its seating surface at all points around the T-ring.

3. Select one adjusting set screw (key 54) as a starting point and tighten that screw 1/4 turn (clockwise rotation).

4. Moving clockwise around the retaining ring (key 7, figure 3 or 4), tighten each set screw 1/4 turn. Continue until the T-ring contacts its seat at one point.

5. When contact at one point has been made, return to the set screw selected as the starting point. Move around the retaining ring in a clockwise pattern, and wherever there is clearance between the T-ring and its seat, tighten the set screw at that point 1/4 turn. Bypass any screws where the T-ring is in contact with its seat.

6. When contact has been made at all points on the T-ring, tighten each set screw on Specifications B-1 and C-1 an additional 1/4 turn. No further tightening is required on specifications B-2 and C-2.

7. Replace the valve in the pipeline per instructions given in the "Installation" section.

Double-Thrust Bearings

It is unlikely that the thrust bearings will require adjustment. If it does become necessary to adjust the bearings, proceed as follows. Key numbers used in the following steps are shown in figure 6.

1. Making certain the valve disc is in the closed position, remove valve from pipeline.

2. Loosen the screws found in each clamp-type collar (key 27).

3. With the valve disc closed, center the disc in the body bore.

4. With the valve disc centered, position one clamp-type collar against each end of the bearing bracket (key 21) hub. Then, tighten the screw in each collar.

5. For Specifications B-1, B-2, C-1, and C-2 valves, adjust T-ring per the procedure above if the adjustment was disturbed in centering the disc.

6. Replace the valve in the pipeline per the "Installation" section.

Actuator Linkage

Due to the large number of different types of actuators that can be used with the Type 9200, it is not practical to present detailed instructions for the various types. However, to simplify this adjustment and to ensure proper valve disc closure, an internal travel stop is normally furnished with the valve. When checking or adjusting the linkage, the disc may be closed until contact is made with this travel stop. Adjust linkage to close the disc to this point.

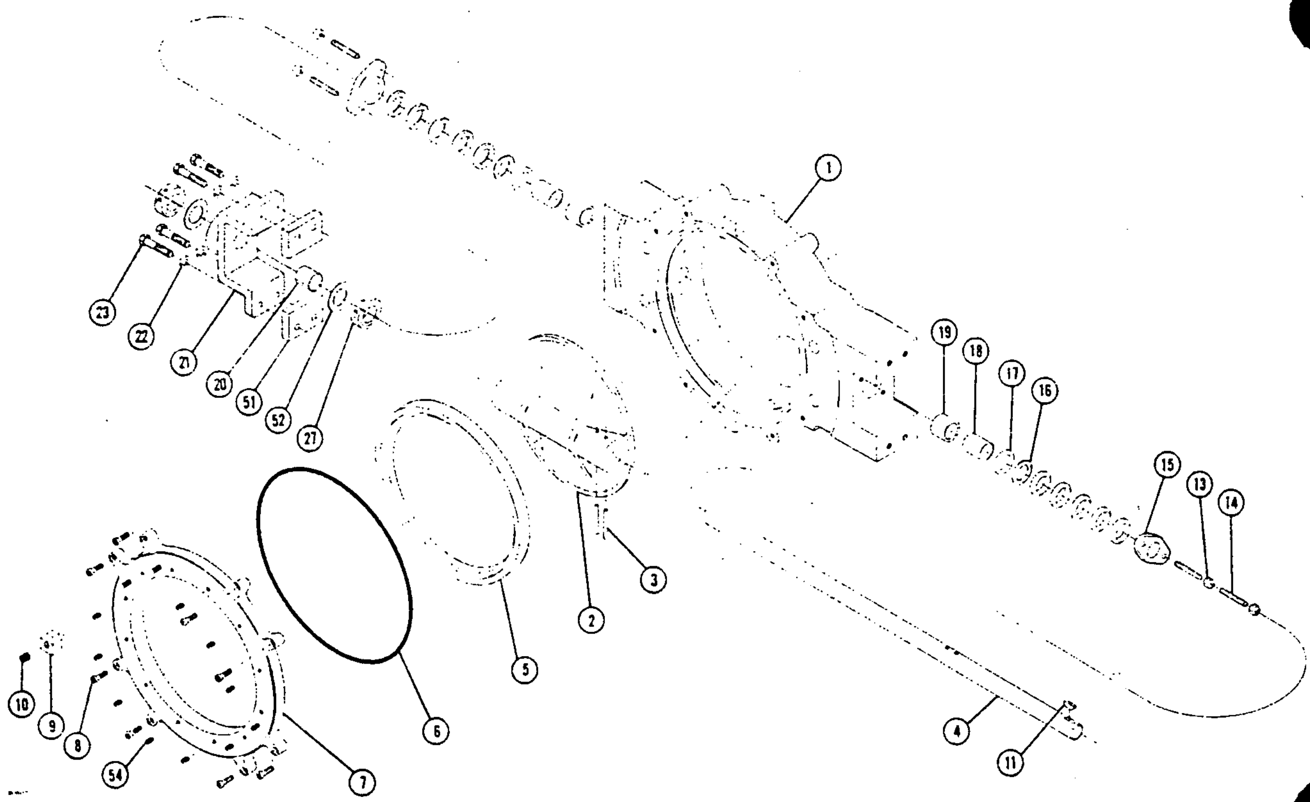


Figure 6. Type 9200

Ordering Replacement Parts

To order replacement parts, specify the key number and name of each part required from the "Parts Reference" section. Also state the original material of the part, if known, the desired quantity, valve type number, size, serial number, and all other pertinent nameplate information. The correct part will be selected based on this information.

In all correspondence with the sales representative, mention the serial number of the valve.

Parts Reference

Key	Part Name
1	Body
2	Valve Disc
3*	Taper Pin
4	Valve Shaft
5*	T-Ring
6*	O-Ring (Specifications A, B-1, and B-2 only)
7	Retaining Ring
8	Allen-Head Cap Screw
9	Travel Stop
10	Set Screw
11*	Key
13	Packing Follower Nut
14	Packing Follower Stud
15	Packing Follower
16*	Packing Ring
17*	Packing Washer
18	Retainer Bushing
19	Inboard Bushing
20	Bushing
21	Bearing Bracket
22	Lock Washer
23	Hex Head Screw
27	Clamp-Type Collar
45	Lantern Ring (Lubricating and purging packing boxes only)
46	Fitting (O-ring packing boxes only)
47*	O-Ring (O-ring packing boxes only)
48*	O-Ring (O-ring packing boxes only)
49	O-Ring Follower (O-ring packing boxes only)
50	Hex Head Bolt (O-ring packing boxes only)
51	Spacer Block
52	Washer
53	Compression Ring (Specifications B-1, B-2, C-1, and C-2 only)
54	Adjusting Set Screw Specifications B-1, B-2, C-1, and C-2 only)

*Recommended Spare Part

Attachment 11: Bulletin and Instruction Manual
for Type 656 Diaphragm Actuator

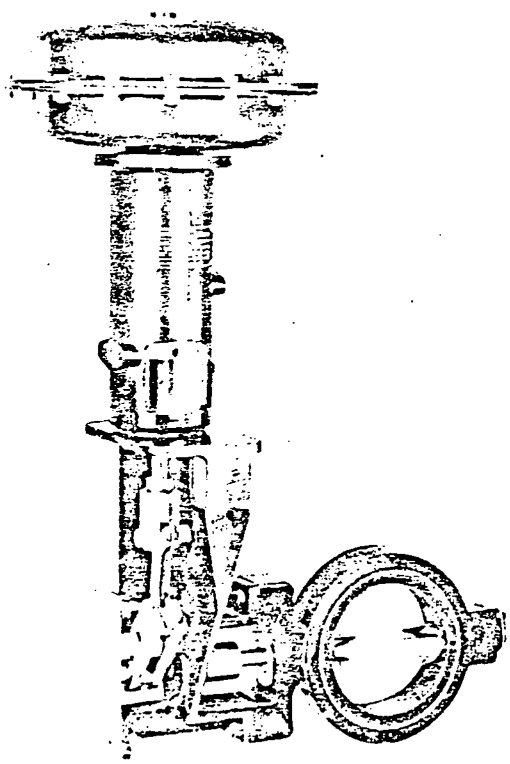
Type 656 Diaphragm Actuator

July 1975 | Bulletin 61.1:656

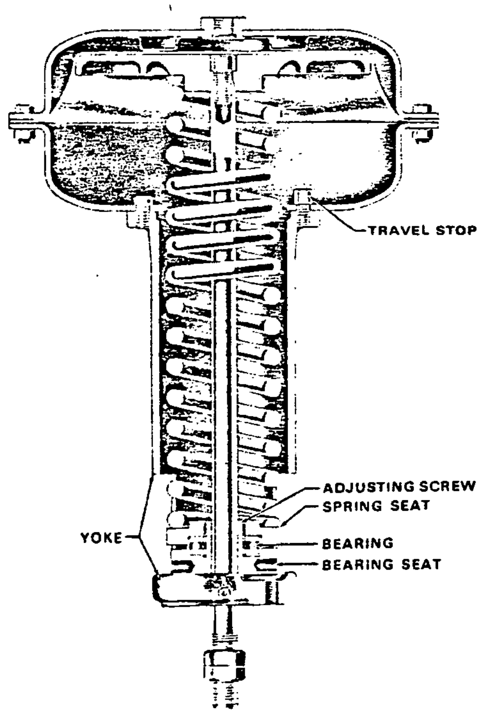
The Type 656 is a yokeless, direct-acting diaphragm actuator for either throttling or on-off service. Principle applications include operation of butterfly and built-in turbine valves, louvers, dampers, and other similar equipment.

Features

- **Mounting Versatility**—Four tapped holes in the actuator base permit either bracket or plate mounting.
- **Long Stroke**—Deep casings provide up to 4-1/8 inches of maximum travel (in a Size 60 actuator).
- **Application Versatility**—Wide spring selection is available for nearly any control application. Spring selection procedure is quick and accurate.
- **Severe Service Capability**—Rugged yoke and casings help provide stability and corrosion protection.



MOUNTED ON 9500 SERIES BUTTERFLY VALVE



TYPICAL CONSTRUCTION

Figure 1. Type 656 Actuator

Specifications

MAXIMUM RECOMMENDED CASING OPERATING PRESSURE

35 psig*

SIZES AND MAXIMUM ALLOWABLE CASING PRESSURES

Actuator Size	Maximum Casing Rating (Psig)
30	125
40	65
60	40

NET STEM FORCE OUTPUT

See table 1

TORQUE OUTPUT FOR BUTTERFLY VALVES

See table 2

TRAVEL DATA

ACTUATOR SIZE	MAXIMUM RATED STEM TRAVEL (INCHES)		MAXIMUM STEM RETRACTION ADJUSTMENT (INCHES) WITH OPTIONAL HANDWHEEL
	Standard Travel Stop	Optional Travel Stop	
30	2-1/8	Not available	3/4
40	3-1/2	3	1-1/2
60	4-1/8	3-13/16	2

MAXIMUM OPERATING TEMPERATURE

150°F with standard diaphragm material†

CONSTRUCTION MATERIALS

Part	Material
Diaphragm	Nitrile (standard†)
Diaphragm plate and yoke	Cast iron
Diaphragm casings, spring, spring seats, travel stop, stem, bearing, bearing seat and bearing race	Steel
Adjusting screw	Brass

CASING CONNECTION

1/4" NPT

MOUNTING AND STEM THREAD INFORMATION

See figure 2

WEIGHT DATA

Actuator Size	Approximate Shipping Weight (Pounds)
30	50
40	70
60	160

OPTION

Top-mounted handwheel/adjustable travel stop

*Control and stability may be impaired if this pressure is exceeded.
†Consult your Fisher representative for fluid and temperature capabilities of nonstandard materials.

Table 1. Stem Force Output and Other Actuator Data

ACTUATOR SIZE	TYPICAL SPRINGS[1]			NET STEM FORCE (POUNDS)[2]			EFFECTIVE DIAPHRAGM AREA (SQUARE INCHES)	
	Maximum Range (Psig)	Part Number	Color Code	Stem Fully Retracted[3]	Stem Fully Extended,[4] with Diaphragm Loading as Shown		Stem Fully Retracted[3]	Stem Fully Extended[4]
30	2.5-9.6	1F3616 27032	Aluminum and orange	165	522	20 psig	66	48
	3.0-12.5	1K5098 27032	Aluminum and dark green	211	390			
	4.3-17.6	1N7515 27032	Aluminum and red	297	157			
	3.7-18.4	1F1770 27092	Tan	257	118			
	3.9-23.9	1F1771 27092	Pink	277	382	30 psig		
	3.1-26.1	1F1772 27092	Brown	211	249			
40	3.1-12.7	1L2174 27042	White	330	545	20 psig	100	69
	6.0-27.4	1L2173 27042	Dark green	630	270	30 psig		
	4.3-31.2	1N8440 27082	None[5]	450	367	35 psig		
60	3.7-13.1	1K1627 27082	None	796	1205	20 psig	215	160
	3.5-16.1	1N9373 27082	None	753	750			
	7.1-27.0	1K1628 27082	None[5]	1462	682	30 psig		
	6.9-33.5	1P2702 27042	None[5]	1441	500	35 psig		

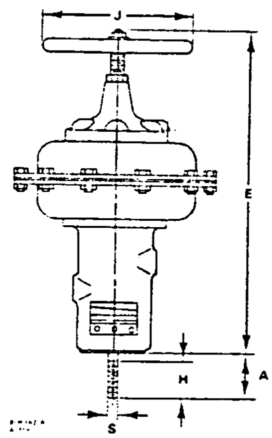
1. Others available; consult your Fisher representative for their characteristics.
2. For maximum rated stem travel with standard travel stop and zero handwheel limitation.
3. Stem force equals initial spring compression with zero loading pressure.
4. Stem force equals: (loading pressure X diaphragm area with stem fully extended) minus force of spring at maximum compression. Higher pressures can be used, but they must not exceed maximum allowable casing pressure or create stem force greater than safe load limit of any control device component.
5. Part number stamped on spring.

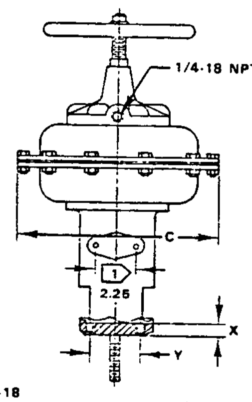
Table 2. Torque Outputs (Inch-Pounds) for Springs Commonly Used with Butterfly Valves*

INPUT SIGNAL								
	WITH POSITIONER		20 PSIG			35 PSIG		
	WITHOUT POSITIONER		3-15 PSIG			6-30 PSIG		
ACTUATOR SIZE			30	40	60	30	40	60
MAXIMUM RATED TRAVEL (INCHES)†			2-1/8	3-1/2	4-1/8	2-1/8	3-1/2	4-1/8
SPRING PART NUMBER			1K5098 27032	1L2174 27042	1K1627 27082	1F1772 20792	1L2173 27042	1K1628 27082
60-Degree Maximum Disc Rotation	Stem Fully Retracted		328	819	2076	328	1638	4152
	Stem Fully Extended	With Positioner	664	1563	4506	836	1754	5773
		Without Positioner	266	621	1931	438	812	3198
90-Degree Maximum Disc Rotation	Stem Fully Retracted		189	472	1197	189	945	2394
	Stem Fully Extended	With Positioner	383	901	2598	482	1011	3329
		Without Positioner	153	358	1113	252	468	1844

*Make sure the lowest torque output of the desired actuator size is sufficient for the valve torque required. †With standard travel stop and zero handwheel limitation.

ACTUATOR SIZE	DIMENSION									
	A	C	E		H	J	S (Stem Thread)	X	Y (4 Holes)	
			Without Handwheel	With Handwheel					Bolt Circle Diameter	Thread
30	2.62	11.38	12.38	19.31	2.12	6.75	1/2-20	.75	2.88	3/8-16 UNC
40	3.12	13.12	17.88	28.38	2.25	8.75	3/4-16	.75	2.88	3/8-16 UNC
60	3.12	18.62	27.25	39.06	2.50	8.75	3/4-16	1.25	3.88	1/2-13 UNC





1 DUPLICATED ON OPPOSITE SIDE. EACH HOLE 5/16-18 UNC-28 AND TAPPED 0.50 DEEP

Figure 2. Dimensions, Inches

Installation

The Type 656 may be installed in any position. Dimensions are shown in figure 2.

Ordering Information

When ordering, specify:

1. Type number and size

2. Desired spring from table 1 or 2

3. Handwheel and/or optional travel stop, if desired (see **Specifications**)

4. Magnitude and type of loading pressure (for instance: 3-15 psig, controller output signal)

Instruction Manual

Type 650 & 656 Diaphragm Actuators

Form 5504, September 1974

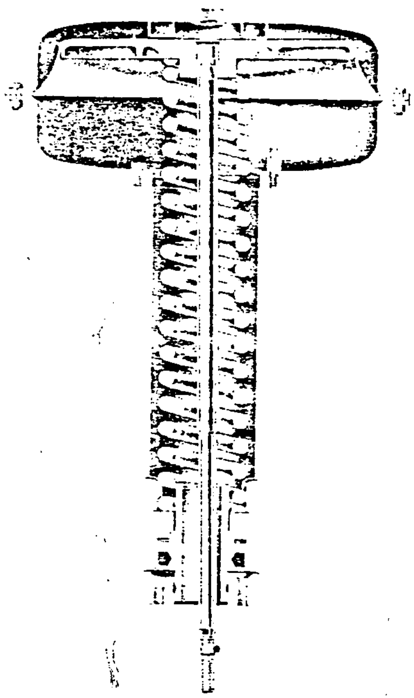


Figure 1. Type 650 Diaphragm Actuator

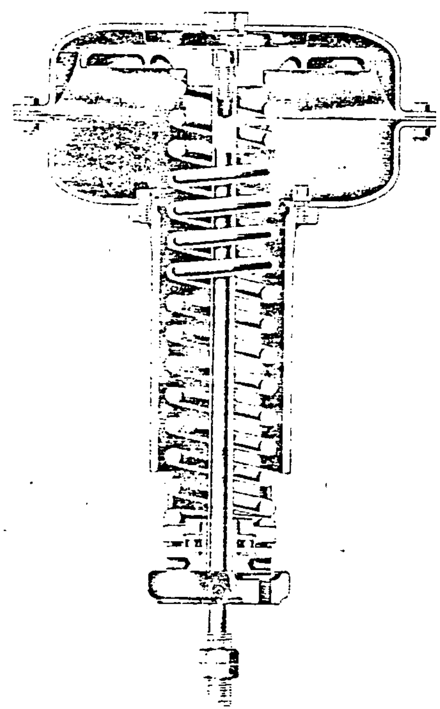


Figure 2. Type 656 Diaphragm Actuator

Application

The Fisher Types 650 and 656 are long stroke, spring opposed, direct acting diaphragm actuators. They operate Vee-Ball® valves, butterfly valves, built-in turbine valves, louvers, dampers, and similar equipment. They are suitable for either "push-down-to-open" or "push-down-to-close" applications and are available in sizes 30, 40 and 60 to provide 2-1/8", 3-1/2" and 4-1/8" travel respectively.

In a direct acting diaphragm actuator, increasing loading pressure moves the actuator stem downward, compressing the spring. When the diaphragm pressure is decreased, the spring moves the actuator stem upward. In the event of failure of the loading pressure or the operating medium pressure to the controller, the actuator stem moves to the extreme upward position.

Installation

If the actuator is mounted on a valve body, follow the specific valve body instruction sheet when installing the control valve in the pipeline. For actuators that are shipped separately, four holes are tapped in the yoke boss to provide a method of securing it to a mounting plate or bracket (factory will supply mounting plate or bracket when specified). See the appropriate assembly procedure A or B in the "Maintenance" section of this manual for making the stem connection. Standard actuator sizes 30 and 40 have mounting holes tapped 3/8" UNC, while the size 60 mounting holes are tapped 1/2" UNC.

A 1/4" NPT loading pressure connection is located in the top of the upper diaphragm case. Using either pipe or tubing, connect either the loading pressure connection or valve positioner input connection (if a valve positioner is furnished, the loading pressure connection to the actuator will be made at the factory) to the output pressure connection on the controller. Keep the length of the pipe or tubing as short as possible to avoid transmission lag in the control signal.

Adjustment

When the actuator is completely installed and connected to the controller, it should be checked for correct travel, freedom from friction, and correct action "push-down-to-open" or "push-down-to-close".

The actuator spring and diaphragm have been selected to meet the requirements of the application. It should be noted that the actuator spring has a constant rate of compression, and that adjustment of the spring compression merely shifts the initial spring set point up or down to make the actuator travel within the initial spring set point and the maximum diaphragm pressure indicated on the actuator nameplate.

In some instances, however, such as high friction butterfly and ball valves, the actuator will fully stroke with less diaphragm pressure than indicated on the nameplate. To increase the pressure required to initiate actuator stem movement, turn the lower bearing seat (key 14) up, toward the spring case. To decrease the pressure at which movement begins, turn the lower bearing seat down, away from the spring case.

Maintenance

Disassembly

The following procedure describes how the actuator can be completely disassembled.

1. If the actuator is installed on a control valve, isolate or bypass the control valve.
2. Shut off the diaphragm loading pressure, and remove the pipe or tubing from the loading pressure connection in the top of the diaphragm case.
3. Turn the lower bearing seat (key 14) down, away from the spring case to relieve all spring compression.
4. If the entire actuator is to be removed from its mounting, disconnect the actuator stem (key 10) from the stem connector, clevis, etc., and remove the jam nuts (key 3). Loosen the cap screws that hold the yoke (key 9) to its mounting plate or bracket, and lift the entire actuator from its mounting.
5. Remove the diaphragm case cap screws and nuts (keys 19 and 20), and lift the upper diaphragm case (key 1) off the actuator. Remove the diaphragm (key 2).
6. Lift out diaphragm plate (key 4) and stem (key 10). They may be separated by removing cap screw (key 3).
7. Take out the actuator spring (key 6).
8. The lower diaphragm case (key 5) can be removed from the yoke, if required, by loosening the travel stops and cap screws (keys 7 and 8).
9. Remove lower spring seat (key 11), and thrust bearing (key 13). Also remove thrust bearing race (key 15) on Type 650. Unscrew the lower bearing seat (key 14) from the adjusting screw (key 12).
10. Remove set screw (key 22) and screw out adjusting screw (key 12) to complete disassembly.

Assembly

1. Apply Lubriplate No. 130AA lubricant or equivalent to the adjusting screw threads (key 12) and screw this into the yoke (key 9). Replace set screw (key 22).
2. Screw the lower bearing seat (key 14) all the way onto the adjusting screw with the eared portion up.
3. Apply Lubriplate No. 130AA lubricant or equivalent to thrust bearing (key 13) and position it on lower bearing seat (key 14). (Place a thrust bearing race [key 15] on each side of thrust bearing [key 13] on the Type 650 before positioning on lower bearing seat [key 14]). Now lay the lower spring seat (key 11) on top of the thrust bearing assembly.
4. Mount the lower diaphragm case (key 5) to the top of the yoke (key 9) using the travel stops and cap screws (keys 7 and 8). Alternate screws and travel stops on the sizes 30 and 40. See figure 3 for the correct orientation on the size 60.

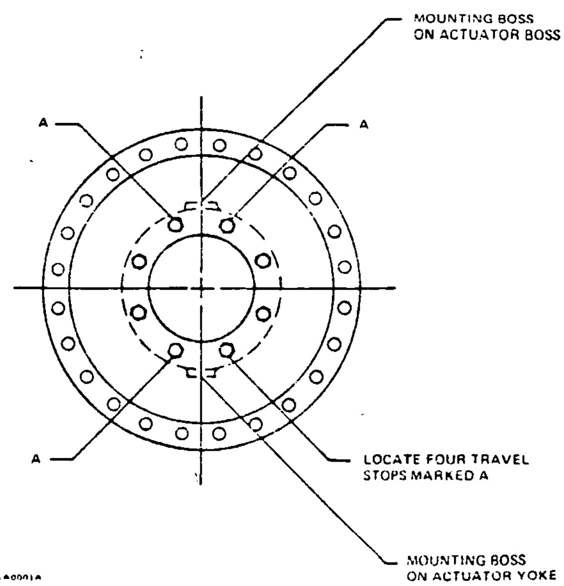


Figure 3. Travel Stop Orientation for Types 650 & 656, Size 60

5. Position the actuator spring (key 6) on the lower spring seat.
6. Attach the diaphragm plate (key 4) to the actuator stem (key 10) with the cap screw (key 3). On Type 656, apply Lubriplate No. 130AA lubricant or equivalent to the stem (key 10). Place this assembly, actuator stem first, into the yoke with the actuator stem through the spring adjustor (key 12).
7. Position the diaphragm (key 2) on the diaphragm plate (key 4) and align the holes with the lower diaphragm casing (key 5). Attach the upper diaphragm case (key 1) to the lower diaphragm casing (key 5) using the cap screws and nuts (keys 19 and 20). Tighten evenly, using a criss-cross pattern to ensure a proper seal.
8. If the actuator has been removed from its mounting, position it on its mounting plate or bracket, and secure with cap screws.
9. Attach the pressure pipe or tubing to the loading pressure connection on top of the upper diaphragm case.
10. Attach the actuator stem to the stem connector or clevis and adjust the travel by following one of the two procedures below:

A. For "Push Down to Open" applications:

1. Set the controlled element (valve plug, louver, damper, etc.) in the closed position.
2. Turn the lower bearing seat (key 14) up, toward the spring case far enough to ensure that the actuator stem is at the top of its stroke.
3. Make the actuator stem connection, making sure that there is full engagement of the actuator stem threads. Tighten slightly.
4. Apply loading pressure to the diaphragm case to move the controlled element toward its wide open position. Screw the controlled element linkage into the actuator stem connection far enough to move the controlled element toward its closed position 1/8", and tighten the stem connection securely. This adjustment ensures that the controlled element will close before the actuator stem travels to the top of its stroke. The travel stops (key 7) in the lower diaphragm case ensure correct travel of the controlled element in the open direction.
5. If travel starts at a lower or higher pressure than is required for proper operation, turn the lower bearing seat (key 14) up or down respectively, as described in the "Adjustment" section.

B. For "Push Down To Close" Applications:

1. Set the controlled element (valve plug, louver, damper, etc.) in the open position.
2. Turn the lower bearing seat (key 14) up, toward the spring case far enough to ensure that the actuator stem is at the top of its stroke.
3. Tighten the actuator stem connection slightly, making sure that there is full engagement of the actuator stem threads.
4. Apply loading pressure to the diaphragm case and observe the travel of the controlled element to make sure that it closes completely. If the travel is not correct, it can be changed by screwing the controlled element linkage in or out of the stem connection. When the travel is set correctly, tighten the stem connection securely, and lock the jam nuts (key 23).
5. If travel starts at a lower or higher pressure than is required for proper operation turn the lower bearing seat (key 14) in or out respectively, as described in the "Adjustment" section.

Serial Number

When corresponding with the sales representative about this equipment, state the serial number of the unit. When ordering replacement parts, also specify the complete eleven-character part number of each part required.

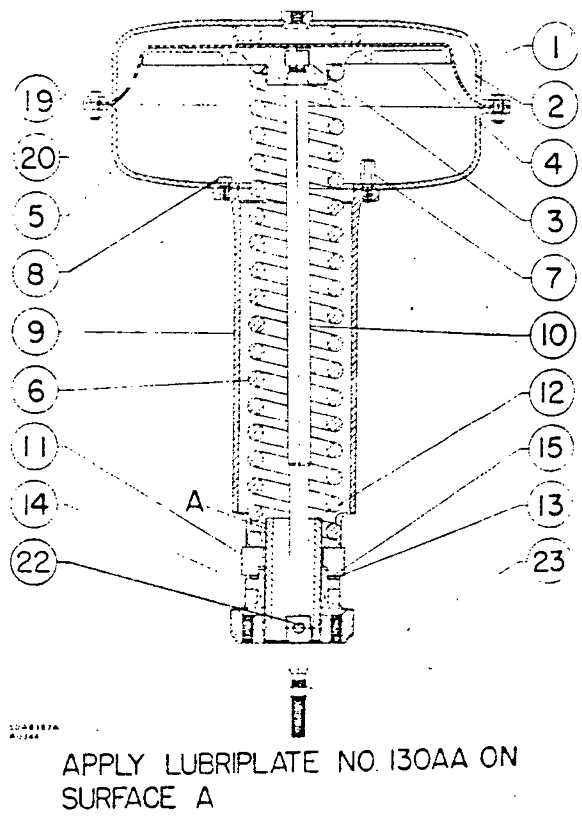


Figure 4. Type 650

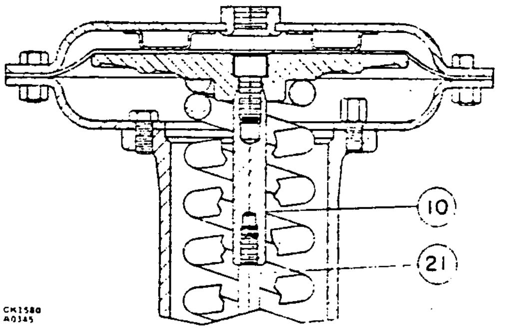
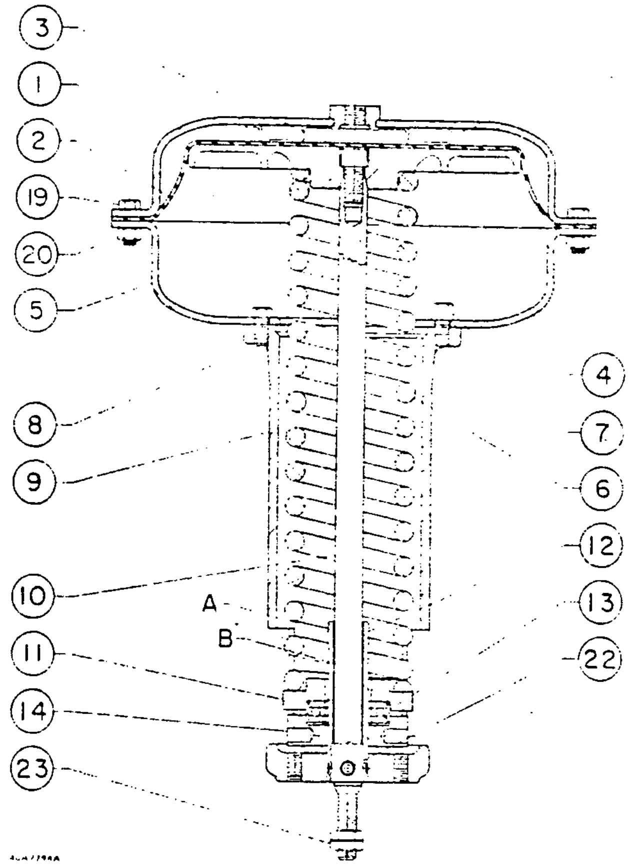


Figure 5. Type 656 (Size 30)



APPLY LUBRIPLATE NO. 130AA ON SURFACES A & B

Figure 6. Type 656 (Sizes 40 & 60)

Parts Reference

Types 650 & 656

Key	Description	Part Number
1	Diaphrgm Case Assembly, steel	
	Standard	
	Size 30	2J7138 28992
	Size 40	2L4418 28992
	Size 60	30A005 5X012
	For top-mounted handjack	
	Size 30	2E7922 25062
	Size 40	2E8063 25062
	Size 60	2E8474 25062
2*	Diaphragm	
	Size 30	2E7919 02202
	Size 40	2E6700 02202
	Size 60	2E8597 02022
3	Cap Screw, steel	
	Sizes 30 & 40	1E7604 32992
	Size 60	1E7754 32982
4	Diaphragm Plate, cast iron	
	Size 30	2F6493 19042
	Size 40	2V9399 19042
	Size 60	20A133 6X012
5	Lower Diaphragm Case, steel	
	Size 30	2E7922 25062
	Size 40	2E8063 25062
	Size 60	2E8474 25062
6	Actuator Spring	
	Steel	See following table
7	Down Travel Stop, steel	
	Size 30 (3 req'd)	1F8429 24092
	Size 40 (3 req'd)	1F8428 24092
	Size 60 (4 req'd)	1E7979 24092
8	Cap Screw, steel	
	Sizes 30 & 40 (3 req'd), 60 (4 req'd)	
	All sizes	1A3684 24052
9	Yoke, cast iron	
	Type 650	
	Size 30	20A518 2X012
	Size 40	30A463 7X012
	Size 60	40A005 0X012
	Type 656	
	Size 30	2F9986 19042
	Size 40	3L4404 19042
	Size 60	4L9191 19042
10	Actuator Stem, steel	
	Type 650	
	Size 30	20A518 1X012
	Size 40	20A463 8X012
	Size 60	20A133 5X012

Key	Description	Part Number
10	Actuator Stem (Continued)	
	Type 656	
	Size 30	1F9994 24102
	Size 40	1L4502 24102
	Size 60	2L9192 24102
11	Lower Spring Seat, steel	
	Type 650	
	Size 30	10A517 8X012
	Size 40	10A464 0X012
	Size 60	10A005 2X012
	Type 656	
	Size 30	1F9990 24102
	Size 40	10A702 1X012
	Size 60	1L9193 24272
12	Adjusting Screw, brass	
	Type 650	
	Size 30	10A518 0X012
	Size 40	10A463 9X012
	Size 60	10A005 3X012
	Type 656	
	Size 30	1J9924 14012
	Size 40	1L4501 14012
	Size 60	1L9194 14012
13	Thrust Bearing, steel	
	Type 650	
	Sizes 30 & 40	10A463 6X012
	Size 60	1N8887 99012
	Type 656 (ball bearing)	
	Sizes 30 & 40	1F9992 28992
	Size 60	1L9195 28992

Key	Description	Part Number
14	Lower Bearing Seat, steel	
	Type 650	
	Size 30	10A517 9X012
	Size 40	10A464 1X012
	Size 60	10A005 4X012
	Type 656	
	Sizes 30 & 40	1F9991 24012
	Size 60	1L9196 24272
15	Thrust Bearing Race, steel	
	Type 650 Only (2 req'd all sizes)	
	Sizes 30 & 40	10A463 5X012
	Size 60	1N8888 99012
17	Nameplate, SST	
	Standard	
	Size 30	1H9038 38992
	Sizes 40 & 60	1U9615 38982
	Butterfly valves	1U6136 38982
18	Drive Screw, SST	
	(4 req'd)	1A3682 28982
19	Cap Screw, steel	
	Size 30 (12 req'd)	1E7603 24052
	Size 40 (16 req'd)	1E7603 24052
	Size 60 (24 req'd)	1A6751 24052
20	Hex Nut, steel	
	Size 30 (12 req'd)	1A3465 24122
	Size 40 (16 req'd)	1A3465 24122
	Size 60 (24 req'd)	1A3465 24122

*Recommended Spare Part

Key	Description	Part Number
	...e Stem, 316 SST	
	...ype 656	
	(Size 30 only)	1J9925 35162
	Set Screw, steel	
	Type 650	
	Sizes 30 & 40	1C3451 28992
	Size 60	1H1999 28992
	Type 656	
	(All sizes)	1H1999 28992
	Hex Nut, steel	
	Type 650	
	Size 30	1A9463 24122
	Size 40	1A3537 24122
	Size 60	1A3540 24122
	Type 656 (2 req'd)	
	Size 30	1A3537 24122
	Sizes 40 & 60	1A3511 24122

...andjack

Key	Description	Part Number
...1	Handwheel, cast iron	
	Size 30	1F1438 19042
	Size 40	1F1181 19042
	Size 60	1F1185 19042
	Jam Nut, steel	1A3537 24122
...3	Stem, brass	
	Size 30	1K9495 14042
	Size 40	1N1689 14042
	Size 60	12A403 5X012
...4	Washer, steel	1A5189 25072
...5	...her Plate Assembly, steel	
	...s 30 & 40	1F1179 99012
	...e 60	1F1183 99012
...7	Jam Nut, steel	
	Sizes 30 & 40	1A3511 24122
	Size 60	1F1187 24122
...8*	O-Ring, nitrile	
	Sizes 30 & 40	1D2375 06992
	Size 60	1B8855 06992
...9*	O-Ring, nitrile	
	Sizes 30 & 40	1D2673 06992
	Size 60	1D5471 06992
...0	Groove Pin, steel	
	Sizes 30 & 40	1F1180 28992
	Size 60	1B6270 35072
...1	Cap Screw, steel	
	Sizes 30 & 40	
	(6 req'd)	1A3684 24052
	Size 60 (8 req'd)	1A3684 24052
	Handjack Body, cast iron	
	Size 30	2K9496 19012
	Size 40	2N1687 19012
	Size 60	2K9494 19012
...4	Body Extension, steel	
	Size 30	(not req'd)
	Size 40	1N1688 24092
	Size 60	12A403 7X012
	Groove Pin, steel	
	Size 30	(not req'd)
	Size 40	1A9532 28982
	Size 60	1F1180 28992
	Spacer, 416 SST	
	Size 60 only	
	(...t shown)	10A005 7X012

Key 6 Actuator Spring, steel

Actuator Size	Spring Rate (Lb/In)	Spring Color Code	Part Number
30	125	Aluminum & Orange	1F3616 27032
	170	Aluminum & Dark Green	1K5098 27032
	238	Aluminum & Red	1N7515 27032
	275	Tan	1F1770 27092
	370	Brown	1F1771 27092
	460	Pink	1F1772 27092
40	145	White	1L2174 27042
	205	Yellow	1P6371 27082
	335	Dark Green	1L2173 27042
	455	None†	1N8440 27082
60	280	None†	1K1627 27082
	400	None†	1N9373 27082
	610	None†	1K1628 27082
	860	None†	1P2702 27042
Type 656 Only			
30	40	Aluminum & Lt. Blue	1H8262 27032
	80	Aluminum & Purple	1H8261 27032

† These springs have part numbers stamped on the side of the tapered spring ends.

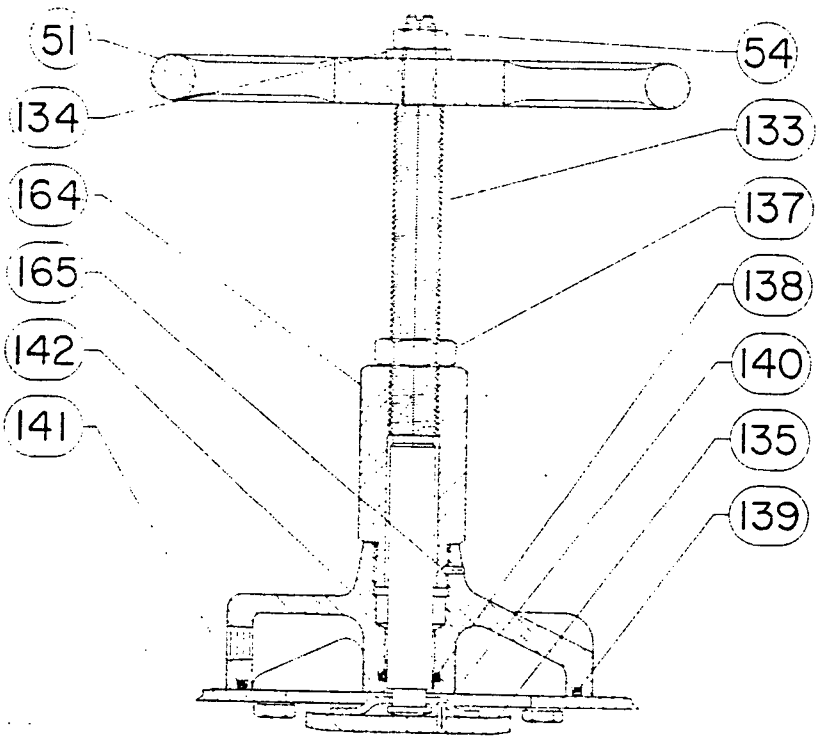


Figure 7. Typical Top Mounted Handjack for Diaphragm Actuator

* Recommended Spare Part

Cast Actuator-Mounting Bracket with Adjustable Linkage

The cast actuator-mounting bracket with adjustable linkage, shown in figure 1, is used to mount power actuators with linear-motion output on Fisher butterfly valves having keyed valve shafts. The bracket assembly consists of a cast iron mounting bracket and an adjustable lever. The lever converts linear motion of the actuator stem to rotary motion of the actuator-mounting bracket shaft. The bracket shaft is directly coupled to the butterfly valve shaft and is supported by TFE-lined steel bushings in the bracket hub and in the bushing plate.

This mounting bracket is normally used with a Fisher Type 320, 480-15, 481-15, 656, or 657 actuator for actuator travel to 4-1/8 inches and valve shaft diameters to 1-1/2 inches.

Features

- **High Torque Capabilities**—The cast actuator bracket assembly is capable of transmitting high torque to the valve shaft due to heavy-duty bracket construction; bushings located on both sides of lever resist bending of bracket and valve shafts under high torque

- **Field-Reversible Valve Action**—Valve action can be easily changed in the field from push-down-to-open to push-down-to-close or vice versa without additional parts by changing the position of the valve shaft coupling on the valve shaft

- **Field-Changeable Disc Rotation**—For many sizes, disc rotation can be changed from 0-60 degrees to 0-90 degrees or vice versa in the same manner. The valve shaft coupling is furnished with multiple keyways for these purposes, and with removal of only one bolt, minor adjustments to lever length, and consequently to disc rotation, can be made using the adjusting screw in the lever

- **Easy Maintenance**—Individual components, such as the power actuator, auxiliary manual handwheel actuator, and lever, can be removed and replaced without complete disassembly of the bracket assembly

- **Personnel Safety**—Optional mounting bracket of fabricated steel with zippered canvas linkage cover is available to reduce possibility of accidental contact with moving linkage and to protect linkage from dirt and other airborne particles

- **Variety of Accessories Available**—Bracket is designed to allow addition of auxiliary manual handwheel actuator, disc rotation indicator, travel stop, or limit switches

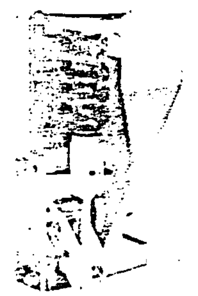


Figure 1. Cast Actuator-Mounting Bracket with Type 480-15 Actuator and 7600 Series Valve

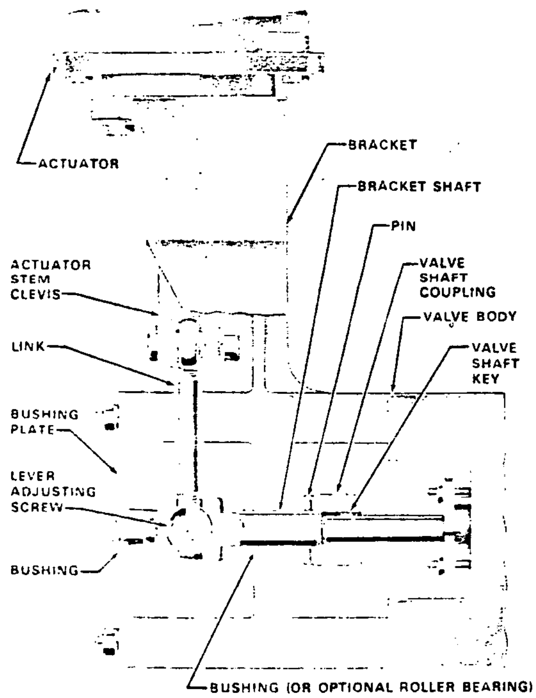


Figure 2. Partial Sectional of Bracket Assembly

Specifications

ACCEPTABLE VALVE SHAFT DIAMETERS	■ 3/8 and 1/2, ■ 5/8 to 1, and ■ 1-1/4 and 1-1/2 inch butterfly valve shaft diameters
MAXIMUM LINEAR ACTUATOR TRAVEL	4-1/8 inches
VALVE DISC ROTATION	**Actuator Travel Through 2-1/2 Inches:** 0 to 60 degrees or 0 to 90 degrees of valve disc rotation (interchangeable by changing position of coupling on valve shaft) **Actuator Travel Greater than 2-1/2 Inches:** ■ 0 to 60 degrees or ■ 0 to 90 degrees of valve disc rotation (different bracket required for each)
ROTATION ADJUSTABILITY*	**Actuator Travel Through 2-1/2 Inches** ***0 to 60 Degree Operation:*** 60 to 75 degrees ***0 to 90 Degree Operation:*** 75 to 90 degrees **Actuator Travel Greater than 2-1/2 Inches** ***0 to 60 Degree Operation:*** 60 to 68 degrees ***0 to 90 Degree Operation:*** 82 to 90 degrees
CONSTRUCTION MATERIALS	**Bracket:** Cast iron (A126 Cl B) **Bracket Shaft:** 17-4PH stainless steel **Valve Shaft Coupling:** Stainless steel **Bracket Shaft Bushings:** TFE-lined steel **Lever:** Ductile Iron **Lever Adjusting Screw:** Steel **Link:** Steel **Actuator Stem Clevis:** Cadmium-plated steel **Lever Key:** Alloy steel **Bushing Plate:** Steel **Coupling Pin:** Alloy Steel **Adaptor Plate:** Steel **Short, Open Extension:** Ductile iron (A536-45-12) **Yoke Adaptor Stud (For Yoke-Type Actuators):** Cast iron **Push Rod (For Yoke-Type Actuators):** Stainless steel
LEVER LENGTH	See table 1

ACTUATOR MOUNTING	■ Perpendicular to pipeline (standard) or ■ parallel with pipeline as shown in figure 4; mounting adaptor plate required for all parallel-mounted actuators; short, open extension required for parallel mounting of some diaphragm actuator sizes (see figure 5 and table 2) With perpendicular mounting, actuator can extend ■ above or ■ below pipeline; with parallel mounting, actuator can extend ■ upstream or ■ downstream; see figure 4 Actuator can be mounted on ■ right (right-hand mounting) or ■ left (left-hand mounting) of valve (when viewed from valve inlet) as shown in figure 4
ACTUATOR-VALVE ACTION	Field reversible between ■ push-down-to-open (extending actuator stem opens valve) and ■ push-down-to-close (extending actuator stem closes valve) by changing position of coupling on valve shaft
APPROXIMATE WEIGHT (BRACKET AND LINKAGE ONLY)	**3/8 and 1/2-Inch Valve Shaft Diameters:** 25 pounds **5/8-Inch Valve Shaft Diameter:** 28 pounds **3/4 and 1-Inch Valve Shaft Diameters:** 30 pounds **1-1/4 and 1-1/2 Inch Valve Shaft Diameters:** 60 pounds
OPTIONS	**Type 304 Valve Position Switch:** Mounting parts can be furnished to mount Type 304 switch and to couple actuator bracket shaft to Type 304 switch cam rod **Limit Switches:** A maximum of four limit switches can be furnished; use of limit switches requires mounting adaptor plate and short, open extension between valve body and actuator bracket **Rotation Indicator:** Steel indicator pin and dial to indicate valve disc rotation between 0 and 90 degrees. Dial is attached to bracket, and pin is attached to a collar on the valve shaft coupling

*Using adjusting screw in lever.

Specifications (Continued)

Roller Bearing: Special bracket with grease fitting and roller bearing replacing the bushing that supports the bracket shaft; for use where dry service conditions require a lubricated bearing

Valve Positioner and Transmitter Mounting: Includes parts required for mounting Type 3582 pneumatic or Type 3590 electro-pneumatic valve positioner or Type 3583 pneumatic motion transmitter on Type 656 and 657 actuators

Auxiliary Manual Handwheel Actuator: Type 1074 manual handwheel actuator can be mounted on cast actuator bracket to provide manual operation of valve when power actuator is not in use

Travel Stop: Steel travel stop as shown in figure 6 can be used to provide easy disc rotation adjustment in response to changes in service conditions, where it is not desirable to use an auxiliary manual actuator or top-mounted diaphragm actuator handwheel as a travel stop, or where internal actuator travel stops are not available

Table 1. Lever Length

Maximum Angle of Valve Disc Opening (Degrees)	Actual Lever Length (Inches)*	Effective Lever Length (Inches)†
60	1.00 x Actuator Travel	0.867 x Actuator Travel
65	0.93 x Actuator Travel	0.785 x Actuator Travel
70	0.87 x Actuator Travel	0.714 x Actuator Travel
75	0.822 x Actuator Travel	0.652 x Actuator Travel
80	0.778 X Actuator Travel	0.596 x Actuator Travel
85	0.739 x Actuator Travel	0.545 x Actuator Travel
90	0.707 x Actuator Travel	0.50 x Actuator Travel

* Distance between lever/link pivot point and centerline of actuator bracket shaft

† Lever length to be used when determining actuator output torque. Effective lever length is the perpendicular distance between the direction of force in the link and the centerline of actuator bracket shaft (see figure 3) when valve disc is at 0 degrees of disc rotation and again when the valve disc is at the maximum angle of disc rotation listed at the left of the above table.

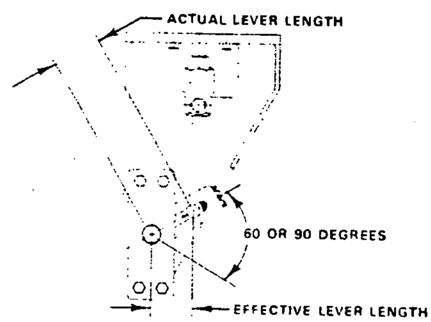


Figure 3. Lever Lengths

Table 2. Actuator-Valve Combinations Requiring Short, Open Extension for Mounting Power Actuator Parallel with Pipeli

Valve Shaft Diameter (Inches)	3/8 and 1/2			5/8, 3/4, and 1
Actuator Type and Size	Type 656, Size 60	Type 657, Size 45	Type 657, Sizes 602* and 604*	Type 656, Size 60 and Type 657, Sizes 602* and 604*
Valve Series and Sizes Requiring Extension	7600 Series—2"-3" 7800 Series—2"-6"	7800 Series—2"-3" 9500 Series—2"	7600 Series—2"-3" 7800 Series—2"-6"	9500 Series—3"-8"

*Size 602 is a size 60 actuator with standard 2-inch travel; size 604 is a size 60 actuator with 4-inch travel.

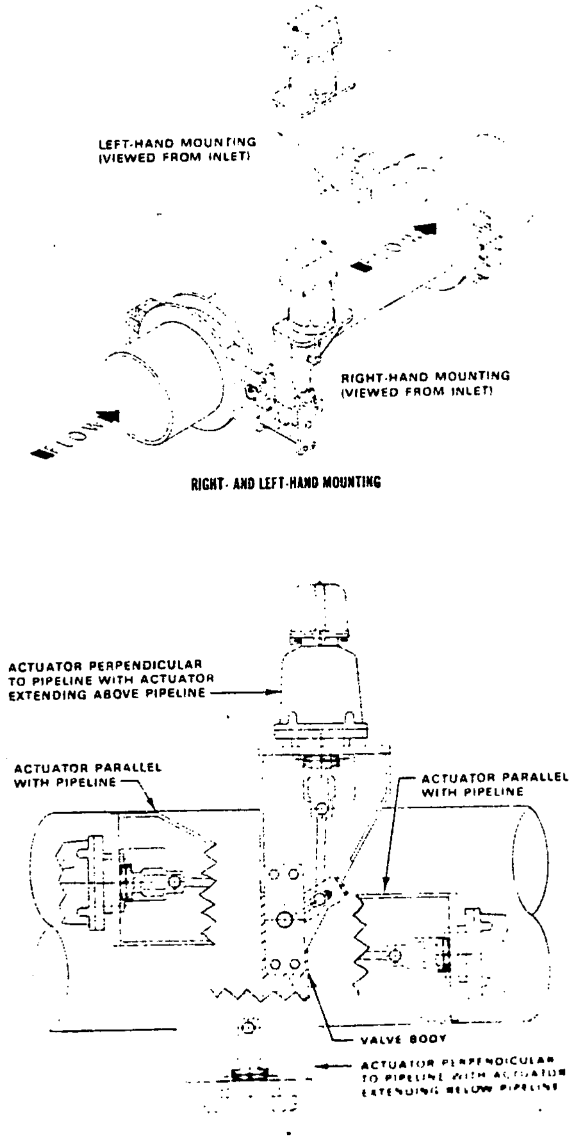
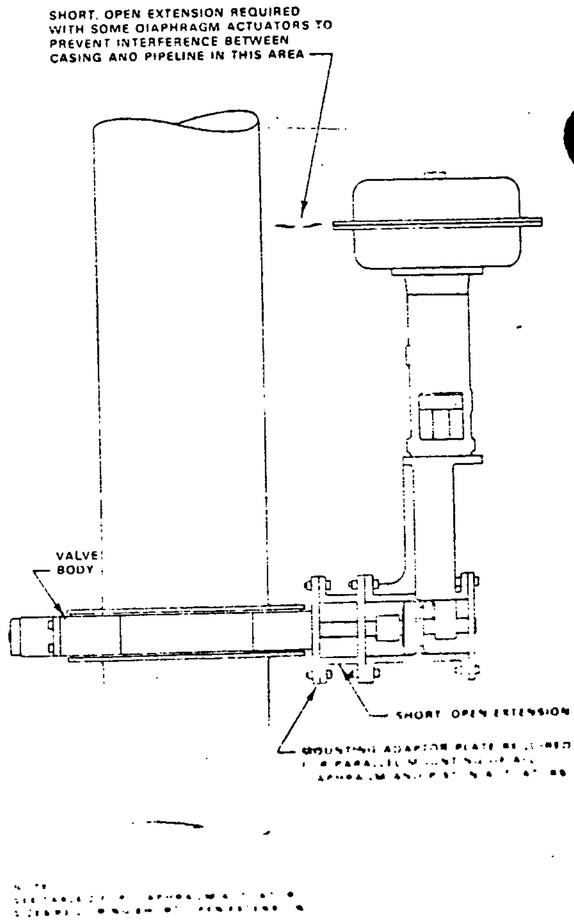


Figure 4. Actuator Mounting



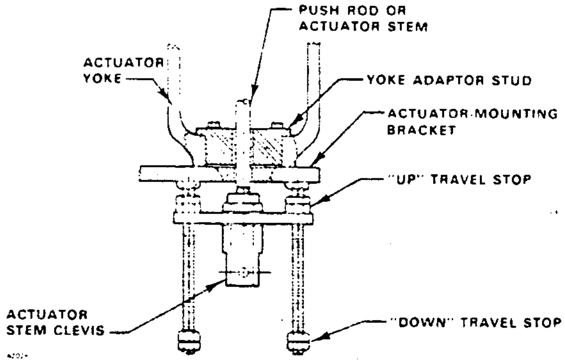


Figure 6. Typical Travel Stop—Yoke-Type Actuator Shown

Installation

The cast actuator-mounting bracket will be attached to the valve in the positions specified from figure 4.

For valve discs that require a specific flow direction (such as **Fishtail** ® discs), install the control valve assembly only in the position specified when the unit is ordered.

For valve discs that do not require a specific flow direction, the position of the control valve assembly in the pipeline may be changed if desired. This is, the control valve assembly may be turned around in the line to change from left-hand mounting to right-hand mounting, from "actuator vertical above pipeline" to "actuator vertical below pipeline", or from "actuator extending upstream" to "actuator extending downstream."

VALVE SHAFT DIAMETER	EE (MAX)	STANDARD		WITH SHORT, OPEN EXTENSION†		P-BRACKET SHAFT DIA-METER	T	
		L	M	L	M		One or Two BZE6-2RQ2 Limit Switches	One‡ EXAR or OPAR Limit Switch
3/8 & 1/2	11.00	4.50*	5.88*	8.25	9.63	1/2	4.50	4.62
5/8, 3/4, & 1	11.00	5.50*	7.25*	9.25	11.00	1	4.50	4.62
1-1/4 & 1-1/2	11.50	7.88*	9.88*	12.25	14.25	1-1/2	4.62	4.87

*Includes adaptor plate used for mounting power actuator parallel with pipeline. For perpendicular mounting, subtract 0.25 inches for 3/8 and 1/2-inch valve shaft diameters or 0.38 inches for 5/8-inch through 1-1/2 inch valve shaft diameters.

†Short, open extension required for mounting power actuator parallel with pipeline for types and sizes listed in table 2 and for mounting limit switches on all sizes.

‡Double the "T" dimension for two EXAR or OPAR switches.

MAXIMUM VALVE DISC ROTATION (DEGREES)	DD					
	Power Actuator Type and Size*					
	480 Series			Type 656		
	20	30, 40, & 60	80	30	40	60
60	1.38	3.75	3.75	1.38	3.25	3.75
90	1.50	2.50	2.00	1.38	2.12	2.44

*For types and sizes not shown, contact the Fisher sales representative.

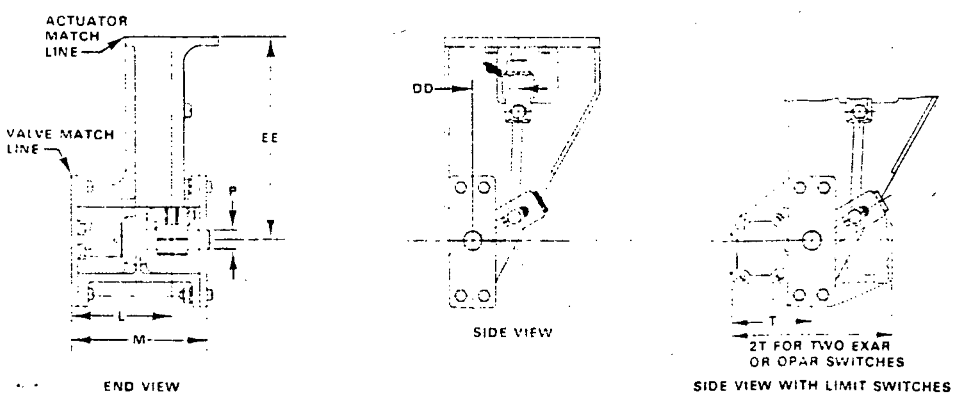


Figure 7. Dimensions (Inches)

Ordering Information

When ordering, specify:

1. Valve type, size, shaft diameter and maximum valve disc rotation
2. Actuator type and size
3. Refer to the specifications table on page 2. Review the description to the right of each specification and in the referenced figures; indicate the desired choice wherever there is a selection to be made. When specifying mounting positions from figure 4,

a) State position of pipeline (such as "horizontal," "vertical", "inclined 20 degrees from horizontal", etc.)

b) State direction of flow through pipeline (such as "left to right," "right to left," "up," "down," or, for inclined pipelines, "down to the left," "up to the right," etc.). When determining flow direction, always view pipeline from actuator-mounting bracket side

c) State whether perpendicular or parallel mounting and right-hand or left-hand mounting is desired; also state mounting position (such as "actuator extending upstream" or "actuator extending above pipeline")

4. If ordering optional limit switches, state disc rotation at which switching is to occur
5. Refer to separate bulletins for ordering information for the control valve body, actuator, and accessories

Attachment 13: Replacement T-Ring Certification
Dated 4/24/81 and 4/28/81

CERTIFICATION

April 28, 1981

TO: Fisher Controls Company
Continental Division
200 Main Street
Coraopolis, Pennsylvania 15108

ATTENTION: QUALITY CONTROL MANAGER

We hereby certify that the materials and/or parts shipped on your order number #013366 and comprised of

one piece 18" T Ring, EPDM

List code numbers, quantities, lot numbers, number packages, etc.

comply in full with the following specifications, standards, blueprints and/or drawings.

Drawing #G12846

Compound #C-3929-EP

Cure Date: April 27, 1981 Shelf Life: 10 years

Test reports and/or control data verifying the above are on file and available upon request.

Company Colonial Rubber Company

by William J. Kirkpatrick
William J. Kirkpatrick

Title Quality Assurance Manager

"IMPORTANT"

Certification must accompany shipment. Include one copy with packing list.

FORM 143 REV. 1

CERTIFICATION

April 24, 1981

TO: Fisher Controls Company
Continental Division
200 Main Street
Coraopolis, Pennsylvania 15108

ATTENTION: QUALITY CONTROL MANAGER

We hereby certify that the materials and/or parts shipped on your order number #013106 and comprised of

2 pieces 20" EPDM T-Rings

7 pcs. 18" EPDM T-Rings

List code numbers, quantities, lot numbers, number packages, etc.

comply in full with the following specifications, standards, blueprints and/or drawings.

Dwg. #G12847 (20") Dwg. #G12846 (18")

Compound #C-3929-EP

Cure Date: 4/15/81 Shelf Life: 10 years

Test reports and/or control data verifying the above are on file and available upon request.

Company Colonial Rubber Company

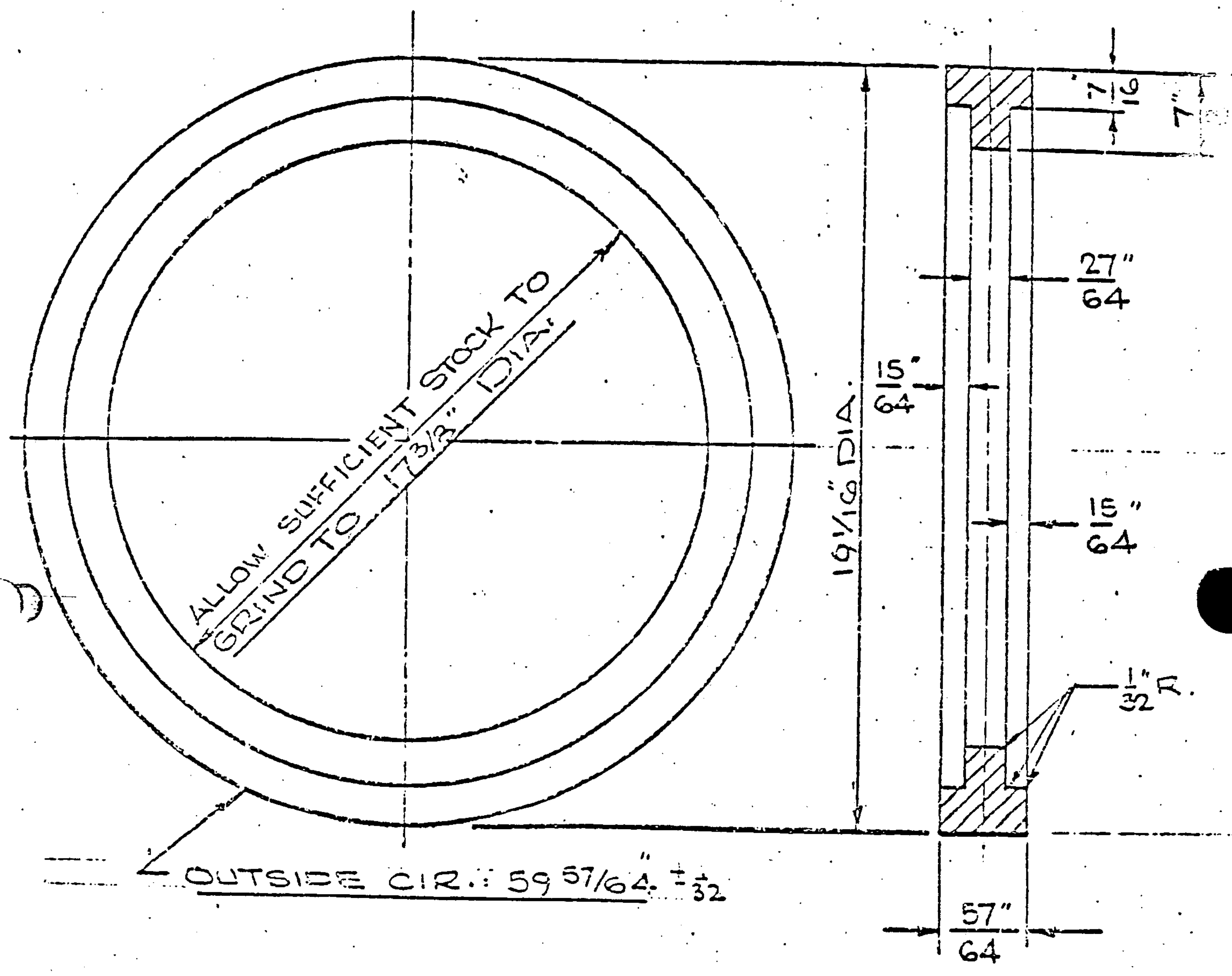
by William J. Kirkpatrick
William J. Kirkpatrick

Title Quality Assurance Manager

"IMPORTANT"

Certification must accompany shipment. Include one copy with packing list.

FORM 548 REV. 1



MAT'L. AS REQ'D.

ENGINEERING CO. TR
IN MARSHALLTOWN

SUPERSEDES DWG. F-20395 -18"

DISTRIBUTION
K

TEE RING SEAT
18" PRESSURE SEAL VALVE

DWN.	DAT. 6/
CKD.	
LAYOUT NO.	SCALE
DWG. NO. G-12846	B

PROPERTY OF
CONTINENTAL EQUIPMENT COMPANY

Attachment 14: Materials Properties Data for Ethylene-Propylene Elastomers

a. Comparative Properties of DuPont Elastomers and Natural Rubber

b. Letter: Fisher Controls Co. (Dan Button) to NSP (John Windschill) dated 5-14-80, with Related Attachments

COMPARATIVE PROPERTIES of the Du Pont elastomers and natural rubber

Properties	Natural Rubber	ADIPRENE* polyurethane	HYPALON* chloro-sulfonated poly-ethylene	HYTREL* polyester elastomer				KALREZ* perfluoroelastomer	Neoprene chloroprene	NORDEL* ethylene-propylene-diene polymer	VAMAC* ethylene/acrylic elastomer	VITON* co-polymer of vinylidene fluoride and hexafluoro-propylene
HARDNESS RANGE (durometer A&D)	30-90A	60-99+A (up to 80D)	40-95A	92A	55D	63D	72D	65-95A	40-95A	40-90A	40-95A	55-95A
TENSILE STRENGTH, MPa(psi) Pure gum	Over 20.7 (3,000)	Over 27.6 (4,000)	Over 17.2 (2,500)	40.7 (5,900)	44.1 (6,400)	40.0 (5,800)	40.0 (5,800)	N.A.	Over 20.7 (3,000)	—	—	Over 12.4 (1,800)
Black loaded stocks	Over 20.7 (3,000)	—	Over 20.7 (3,000)	—	—	—	—	Over 13.8 (2,000)	Over 20.7 (3,000)	Over 20.7 (3,000)	Over 17.2 (2,500)	Over 13.8 (2,000)
SPECIFIC GRAVITY (Base Material)	0.93	1.06	1.12-1.26	1.17	1.20	1.22	1.25	2.01	1.23	0.86	1.08-1.12	1.85
VULCANIZING PROPERTIES	Excellent	Excellent	Excellent	Unnecessary to vulcanize				N.A.	Excellent	Excellent	Good to Excellent	Good
ADHESION TO METALS	Excellent	Excellent	Excellent	Good	Good	Good	Good	Fair	Excellent	Good to Excel.	V.G. to Excellent	Good
ADHESION TO FABRICS	Excellent	Excellent	Good	Good	Good	Good	Good	Good	Excellent	Good	Good	Good to Excel.
TEAR RESISTANCE	Good	Excellent	Fair	Excel.	Outstng.	Outstng.	Outstng.	Fair	Good	Good	Good	Fair
ABRASION RESISTANCE	Excellent	Outstanding	Excellent	Outstng.	Very Outstng.	Very Outstng.	Very Outstng.	Good	Excellent	Excellent	Good	Good
COMPRESSION SET	Good	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair to Good	Good	Good	Fair to Good
REBOUND Cold	Excellent	Poor at V.L. temp.	Good	V. Good	Good	Fair	Fair	N.A.	Very Good	Very Good	Poor	Good
Hot	Excellent	Good at R.T.	Good	Excel.	V. Good	Good	Good	N.A.	Very Good	Very Good	Fair	Excellent
DIELECTRIC STRENGTH	Excellent	Excellent	Excellent	Fair to Good	Fair to Good	Fair to Good	Good	Excellent	Good	Excellent	Good	Good
ELECTRICAL INSULATION	Good to Excellent	Fair to Good	Good	Fair to Good*	Fair to Good	Fair to Good	Good	Excellent	Fair to Good	Excellent	Fair to Good	Fair to Good
PERMEABILITY TO GASES	Fair	Fair	Low - V.L.	Fair	Fair	Fair	Good	Fair	Low	Fair	Very Low	Very Low
ACID RESISTANCE Dilute	Fair to Good	Fair	Excellent	Fair	Fair	Fair	Fair	Excellent	Excellent	Excellent	Good	Excellent
Concentrated	Fair to Good	Poor	Very Good	Poor	Poor	Poor	Poor	Excellent	Good	Excellent	Poor	Excellent
SOLVENT RESISTANCE Aliphatic hydrocarbons	Poor	Excellent	Good	Excel.	Excel.	Excel.	Excel.	Excellent	Good	Poor	Good	Excellent
Aromatic hydrocarbons	Poor	Fair to Good	Fair	Good	Good	Good	Good	Excellent	Fair	Poor	Fair	Excellent
Oxygenated (ketones, etc.)	Fair to Good	Poor	Poor	Fair	Good	Good	Good	Excellent	Poor	Good	Poor	Poor
Lacquer solvents	Poor	Poor	Poor	Fair	Fair to Good	Good	Good	Excellent	Poor	Poor	Poor	Poor
RESISTANCE TO: Swelling in lubricating oil	Poor	Excellent	Good to Excel.	Good	Excel.	Excel.	Excel.	Excellent	Good	Poor	Good	Excellent
Oil and gasoline	Poor	Excellent	Good	Very Good	Excel.	Excel.	Excel.	Excellent	Good	Poor	Good	Excellent
Animal and vegetable oils	Poor to Good	Excellent	Good	Very Good	Excel.	Excel.	Excel.	Excellent	Good	Good	Good	Excellent
Water absorption	Very Good	Good at R.T. Poor at 100°C (212°F.)	Very Good	V. Good up to 100°C (212°F.)	V. Good up to 100°C (212°F.)	V. Good up to 100°C (212°F.)	V. Good up to 100°C (212°F.)	Very Good	Good	Very Good	Very Good up to 100°C (212°F.)	Very Good
Oxidation	Good	Excellent	Excellent	Excel.	Excel.	Excel.	Excel.	Outstanding	Excellent	Excellent	Outstanding	Outstanding
Ozone	Fair	Excellent	Outstanding	Excel.	Excel.	Excel.	Excel.	Outstanding	Excellent	Outstanding	Outstanding	Outstanding
Sunlight aging	Poor	Good	Outstanding	Very Good***	Very Good***	Very Good***	Very Good***	Outstanding	Very Good	Outstanding	Outstanding	Outstanding
Heat aging (upper limit cont. service)	85°C (185°F.)	85°C (185°F.)	135°C (275°F.)	100°C (212°F.)	110°C (230°F.)	110°C (230°F.)	110°C (230°F.)	290°C (554°F.)	95°C (203°F.)	145°C (293°F.)	165°C (329°F.)	205°C (401°F.)
Flame**	Poor	Fair (will melt)	Good		Good*** (will melt)			Excellen[illegible]	Very Good	Poor	Poor	Excellent
Heat	Good	Good	Excellent	V. Good	Excel.	Excel.	Excel.	Very Out[illegible]	Very Good	Excellent	Excellent	Outstanding
Cold	Excellent	Excellent	Good	Excel.	Excel.	Excel.	Excel.	Good	Good	Excellent	Good	Good

Measuring Performa[nce]
Characteristics.
Test methods have been e[...]
Society for Testing Materia[...]
of Automotive Engineers (S[...]
and chemical properties of
elastomers. Properly used [...]
provide an excellent basis f[...]
supplier the performance c[...]
in a rubber product. A comp[...]
procedures is contained in [...]
Standards on Rubber Prod[...]
1916 Race Street, Philadel[...]

*Reg. U.S. Pat. & Tm. Off.

**These evalua[...] alitative and comparat[...] recommenda[...]ic compounding is [...] choice shoul[...] upon a practical consid[...] involved in ea[...]al case and, if applicab[...]

***With additives

FISHER CONTROLS COMPANY

MARSHALLTOWN, IOWA 50158

AUTOMATIC CONTROL EQUIPMENT
SINCE 1880

Reply to: FISHER CONTROLS COMPANY, R. A. Engel Technical Center, P.O. Box 11, Marshalltown, Iowa 50158

May 14, 1980

Northern State Power Company
Monticello Nuclear Plant
Monticello, Minnesota 55362

Attention: Mr. John Windschill

Dear Mr. Windschill:

The purpose of this letter is to respond to the question which you posed to Mr. Charles A. Loudin of Colonial Rubber Company concerning the radiation capability of EPDM material (seal ring material used in Fisher Control's Type 9200 butterfly valves). The response presented below is based on material supplier's conclusions drawn from irradiating test coupons, and, Fisher Control's limited experience gained in actual type-tests of 9200 butterfly valves.

MATERIAL SUPPLIER'S TEST RESULTS

After your request to the Colonial Rubber Company, Mr. Loudin contacted DuPont (the base polymer used by Colonial Rubber Co. is DuPont's "Nordel") and received the following reply:

> "Based on tests conducted by DuPont on EPDM compound used in Fisher Control's EPDM valve liners, the following results may be experienced." Parts should be unaffected to 6×10^7 rads of gamma radiation. Parts should be useful up to 5×10^8 rads of gamma radiation.

The radiation capability of test coupons at the levels referenced above is also claimmed in the vendor literature which is attached to this letter.

Attachments to this letter also include an article from "Power Engineering", (Dec. 1977) entitled "Selecting Elastomeric Seals for Nuclear Service". This article, as a result of compression set experienced during radiation tests, states that "...no elastomer known today should be considered for applications where 10^7 rads dosage will be exceeded between scheduled overhauls". While this article seems to be addressing only "normal" environment radiation, and therefore, sounds very inflexible in regards to the "magic" figure of 10^7 rads, it does correlate closely with what Fisher Controls has experienced during an actual irradiation type-test of a 9200 butterfly valve.

FISHER CONTROLS TYPE TEST RESULTS

During aging tests on a 20", Type 9200 Butterfly Valve (with adjustable "T" ring seal), Fisher exposed the valve to 1 x 10^7 Rads (γ). After radiation, the test valve permitted slight leakage (greater than pre-radiation but less than defined allowable) while subjected to 60 psi differential across the disk. It was determined that this leakage resulted from a small amount of compression set that had taken place in the adjustable "T" ring seal. Supplemental information obtained by Fisher indicates that the material not only undergoes additional compression set, but could also experience a great deal of hardening during radiation exposure of 10^7 to 10^8 rads, and therefore, become ineffective with respect to the sealing requirements of the subject valves.

CONCLUSION

Due to the results of the limited amount of tests performed by Fisher, we do not presently claim seal integrity at radiation dosages (normal plus accident) greater than 1 x 10^7 rads.

Many factors could affect this "allowable" radiation level, such as, increased acceptable leakage rates under accident conditions, seal design (inflatible seal ring vs the tested adjustable "T" ring seal - it is assummed that the inflatible seal ring would perform at least as well as the adjustable "T" ring after radiation exposure), pressure differential, etc.; however, these effects could only be addressed by actual type-tests. If your radiation requirements exceed the allowable dosage recommended by Fisher, and you would like to pursue the possibility of Fisher performing additional tests under contract, your request should be directed to:

J. Bovee
Manager, Contracts Administration
Fisher Controls Company
205 S. Center Street
Marshalltown, Iowa 50159
Telephone; (515) 754-2079

If there are questions concerning any of the above discussion, please contact the writer at (515) 754-3338.

Sincerely,

Dan G. Button

Dan G. Button
Engineer, Nuclear Program

DGB/kkc
cc: L. E. Fleetwood
F. D. Jury
D. Cerny
A. Gentile - Cont. Div.

Enc.

F1-1006 REV. 12-76

E. I. du Pont de Nemours & Company
Incorporated
4330 Allen Road
Stow, Ohio ~~42223~~ 44224

Elastomer Chemicals Department

October 7, 1977

Mr. D. Howells
Fisher Controls
Continental Division
200 Main Street
Coraopolis, PA. 15108

Dear Mr. Howells:

Effects of beta radiation and of gamma radiation on various elastomers are described in the attached data.

The standard method of test for absorbed gamma radiation dose in the Fricke dosimeter is described in Part 37 of ASTM Standards D1671-71 and standard recommended practice for exposure of polymeric materials to high energy radiation is described in the same part D1672-66.

We hope that this information helps you in the project that you have undertaken.

Sincerely,

Jack P. Leonhard

J. P. Leonhard
Akron Laboratory

JPL:dlw

Attachment

EFFECT OF BETA RADIATION*

Percent Change In Properties

POLYMER	COMMENTS	100% MODULUS	200% MODULUS	TENSILE	ELONGATION	HARDNESS
NORDEL®	Peroxide Cured	+52	+68	-27	-43	+2
NORDEL®	Sulfur Cure	+32	+60	-23	-43	+2
HYPALON®	Litharge Cure	+100	-	-20	-64	+6
HYPALON®	Aged 1 year	+127	-	+3	-46	+4
NORDEL®	Blend	+57	-	-12	-42	+3
SBR	SBR-1500	+110	+98	+6	-31	+7
NATURAL RUBBER	Smoke Sheet	+56	+52	-27	-39	+7
ADIPRENE®	L-100	+18	+20	-28	-20	-1
ADIPRENE®	L-167	+22	+8	-24	-42	-6
NEOPRENE	Wax Added	+119	+115	-56	-51	+8
NEOPRENE	NA-22 Cure	+140	-	-43	-64	+7

*The exposure consisted of 300 seconds of Beta radiation, of 0.2 megareps per second intensity, and a distance of 300 cms. giving a total of 60 megareps intensity.

"57 Mreps

EFFECT OF GAMMA RADIATION* ON PHYSICAL PROPERTIES

	PVC	High Density PE	Black XLPE	Un-filled XLPE	SBR	EPDM	EPM	Butyl	Silicone	Neoprene	HYPALON®	Chlorinated PE
Original Properties												
200% Modulus, psi	2415	2000	1767	1260	580	1033	730	520	859	930	884	626
Tensile Strength, psi	2601	2213	2045	2272	1520	1443	872	798	1191	2544	2113	2170
Elongation at Break, %	250	640	270	480	460	470	300	450	290	550	560	670
200% Modulus, % Retention after Irradiation, Rads												
5×10^5	81	95	125	96	106	100	116	103	75	107	116	103
5×10^6	95	98	115	102	121	94	127	69	112	103	156	152
5×10^7	+	+	+	108	150	120	+	++	98	160	203	+
1×10^8	-	+	+	+	+	+	+	++	+++	-	-	-
Tensile Strength, % Retention after Irradiation, Rads												
5×10^5	80	96	122	102	98	104	101	96	76	104	106	112
5×10^6	88	98	112	97	100	97	106	58	100	98	113	98
5×10^7	61	123	101	70	82	93	119	++	100	77	124	135
1×10^8	-	118	95	59	40	79	90	++	+++	-	-	-
Elongation, % Retention after Irradiation, Rads												
5×10^5	100	103	104	90	93	111	96	93	107	96	89	99
5×10^6	80	103	96	96	96	102	81	87	90	93	86	63
5×10^7	40	-	48	58	70	47	41	++	34	46	59	18
1×10^8	-	2	37	25	33	32	26	++	+++	-	-	-

---

* Radiation Source - For exposures of 5×10^5, 5×10^6, and 5×10^7, Cobalt 60 Source was used (gamma = 1.17 to 1.332 meV and Beta = 0.31 meV, at a dose rate of 5×10^5 rads/hr.
For exposure of 1×10^8, Esso Research and Engineering Company's radiation core in air and water was used, with the same dose rate as above.

+ Elongated less than 200%
++ Degraded (low strength due to chain scissions)
+++ [illegible]
- No value reported

Selecting elastomeric seals for nuclear service

Compression set tests have proved more reliable than tensile tests in the selection of elastomer compounds for use as seals in a nuclear environment

By ROBERT BARBARIN, Parker Hannifin Corp./Seal Group

In the early 1960s, the primary test used in selecting elastomers for reactor seals was a tensile test conducted on unstressed slabs of the compounds after they had been subjected to irradiation. These standard tests had the unfortunate ability to make compounds look very appealing to the nuclear engineer while completely failing the primary requirements of seal engineers. Today, a test has been developed which promises to satisfy the demands of both engineers. This is a test to determine the compression set of seals which are simultaneously squeezed (as they would be when installed) and irradiated (as they may be when in service) over prolonged periods. The new data provide criteria by which compounds may be selected for long life, normally requiring replacement only during conservatively scheduled five-year reactor overhauls.

Typical applications for elastomeric seals in and around nuclear reactors include the static seals in pressurized conduits containing radioactive fluids, and the dynamic seals in structural hydraulic snubbers.

Compression set

Compression set may be defined as the percent by which a seal fails to return to its original dimension after compression, expressed as a percent of its deflection. This loss of dimensional memory is due to changes in the elastomer's arrangement and density of molecular cross-links. As the change in cross-linking progresses, the seal will gradually take on the shape of the confining groove and relax the force that it exerts on the confining surfaces.

Since this normally occurs before tensile property changes, the tensile tests are frequently omitted as contemporary criteria for nuclear seal compound selection.

Of the three major types of radiation from nuclear fission, only gamma rays are normally considered a hazard to elastomer seals that are completely enclosed in conventional metal grooves. Alpha and beta rays are effectively stopped by thin metal barriers. Gamma rays, however, easily penetrate the typical elastomeric seal glands and cause cumulative changes in the compounds (see Table 1).

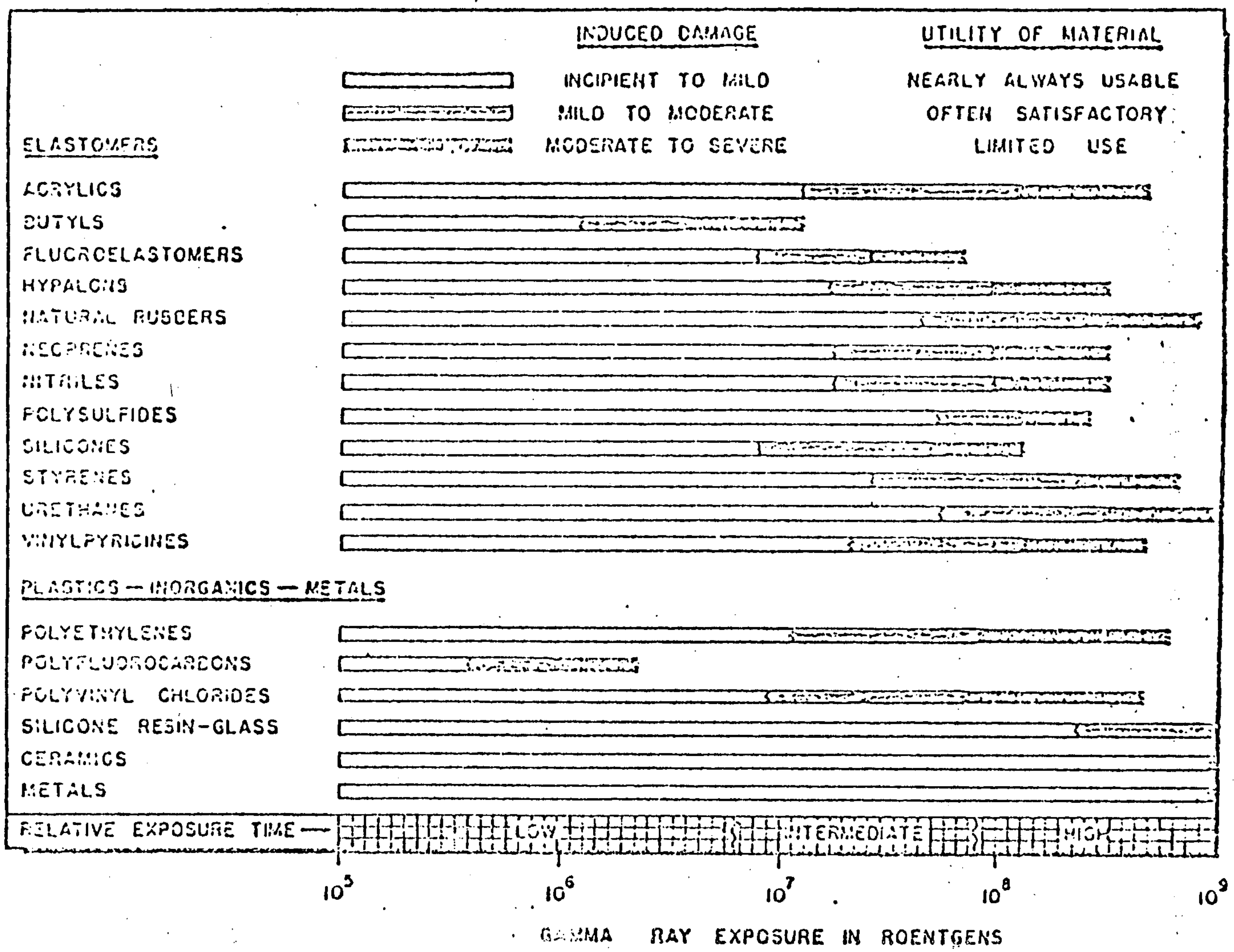
All elastomers tested to date have shown excessive compression set at 10^8 rads, yet a number of compounds showed acceptable compression set at 10^7 rads of gamma radiation dosage.

Therefore, no elastomer known today should be considered for

Table 1. Effects of gamma radiation on the principal properties of elastomeric compounds most often considered for seals in and around nuclear reactors. Compression set tests were conducted at room temperature and 25% deflection, for the number of days noted, while under radiation from cobalt strips in air.

Generic or Base Polymer (Compound No.)	Radiation Dosage in Rads	Hardness in Pts on Shore "A" Scale (Pts Change)	Tensile Strength in Psi @ Break (% Change)	Elongation in % @ Break (% Change)	Modulus in Psi @ 100% Stretch (% Change)	Tear Strength in lb/in. (% Change)	Compression Set Test: Days Deflected	Compression Set Test: CS in % of Original Deflection
Silicone (S455-70)	Original	69	807	117	668	63	93	7.6
	10^7	72 (+3)	733 (-9)	89 (-24)	—	63 (0)	93	31.4
	10^8	85 (+16)	—	—	—	—	93	90.5
Silicone (S604-70)	Original	66	1010	149	695	70	93	3.8
	10^7	69 (+3)	1020 (+1)	129 (-13)	833 (+25)	62 (-11)	93	20.0
	10^8	85 (+19)	939 (-7)	31 (-79)	—	29 (-59)	93	92.4
Ethylene Propylene (E515-80)	Original	78	1450	213	689	164	93	16.2
	10^7	78 (0)	1220 (-16)	176 (-17)	740 (+7)	148 (-10)	93	46.6
	10^8	84 (+6)	1030 (-29)	79 (-63)	—	71 (-57)	93	96.2
Ethylene Propylene (E740-70)	Original	70	2080	233	554	174	93	6.7
	10^7	73 (+3)	2140 (+3)	194 (-17)	808 (+46)	163 (-6)	93	28.6
	10^8	79 (+9)	1700 (-18)	96 (-59)	—	70 (-60)	93	90.5
Fluorocarbon (V747-75)	Original	75	1510	190	634	128	93	14.7
	10^7	76 (+1)	1580 (+5)	130 (-32)	1120 (+77)	87 (-32)	93	66.7
	10^8	88 (+15)	1180 (-22)	29 (-85)	—	82 (-36)	93	93.3
Polyurethane (P642-70)	Original	66	3560	582	342	306	56	17.1
	10^7	67 (+1)	3570 (0)	491 (-16)	444 (+30)	374 (+22)	56	55.2
	10^8	66 (0)	1420 (-60)	201 (-65)	—	146 (-52)	56	91.4
Fluoro-silicone (L677-70)	Original	68	1050	180	520	72	128	13.3
	10^7	72 (+4)	668 (-36)	97 (-46)	—	—	128	67.6
	10^8	84 (+16)	—	—	—	—	128	97.1

UNCLASSIFIED



UNCLASSIFIED

RELATIVE RADIATION RESISTANCE OF ELASTOMERS AND OTHER MATERIALS applications where 10^7 rads dosage will be exceeded between scheduled overhauls.

Table 1 documents several compounds frequently considered for nuclear seals, showing their original properties and those same properties after exposure to 10^7 rads. At this dosage, two silicones, two nitriles and one ethylene propylene compound exhibit acceptable compression set. A second ethylene propylene compound, as well as polyurethane, polyacrylate, fluorocarbon, and fluorosilicone, would not be recommended because they all tested out at marginal or excessive compression set. The results for polyurethane are particularly revealing; the tensile, tear and modulus tests were either unchanged or actually improved by 10^7 rads, but the compression set rose from approximately 17% to over 55%.

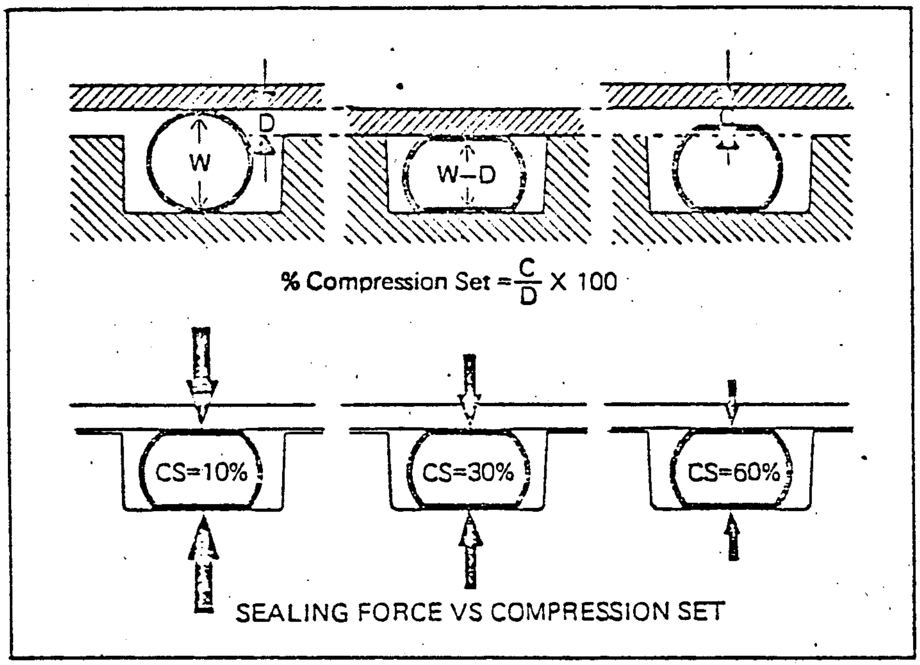


Figure 1. Compression set (the percentage of initial deflection which is unrecovered when a seal is released) directly affects the force that a compression seal can maintain on its sealing lines. This factor, which is increased by radiation, is a prime criterion for the selection of seals for reactors.

Temperatures and fluids

Service temperatures and/or fluids often degrade an elastomer faster and more severely than gamma radiation. This is illustrated clearly by comparisons between Tables 1 and 2. While Table 1 shows the effects of gamma radiation without fluid or temperature influences, Table 2 shows the effects of fluids and temperatures frequently encountered in nuclear reactor environments but without the gamma radiation. It is interesting to note that the polyurethane degradation documented in Table 2 was the result of temperature, but that it would doubtless have been attributed to radiation if it had occurred in a reactor.

The combined effects of radiation, temperature and fluid are seldom a simple addition of their individual effects, but are synergistic. However, knowledge of all three characteristics for each compound can help in the selection of the best compounds for testing.

Table 2. Effects of fluid immersion in principal reactor fluids on polyurethane and ethylene propylene elastomers considered for seals in and around nuclear reactors. Note severe effects of temperature excursions on properties of polyurethane compounds compared to the properties of most ethylene propylenes.

Generic or Base Polymer (Compound No.)	Immersion Test Fluid immersed 3 hrs @ 340F + 3 hrs @ 320F + 18 hrs @ 250F	Hardness in Pts on Shore "A" Scale (Pts Change)	Tensile Strength in Psi @ Break (% Change)	Elongation in % @ Break (% Change)	Modulus in Psi @ 100% Stretch (% Change)	Volume Change in %	Compression Set in % of Original Deflection
Polyurethane (P4611)	Original properties	95	7240	470	1590		
	GE SF 96 Silicone (200 c/s)	89 (-6)	4250 (-41)	537 (+14)	1370 (-14)	-0.8	119.2
	GE SF1154 Silicone	89 (-6)	3650 (-50)	550 (+17)	1400 (-12)	-0.3	cancelled
	Water	89 (-6)	4680 (-35)	576 (+23)	1180 (-26)	+2.3	96.5
Polyurethane (P642-70)	Original properties	66	3780	699	350		
	GE SF 96 Silicone (200 c/s)	Deteriorated				-1.7	cancelled
	GE SF1154 Silicone	Deteriorated				-2.2	cancelled
	Water	Deteriorated					
Ethylene Propylene (E740-75)	Original properties	73	2390	177	991		
	GE SF 96 Silicone (200 c/s)	73 (0)	2800 (+17)	207 (+17)	865 (-13)	-1.5	19.9
	GE SF1154 Silicone	70 (-3)	2660 (+11)	198 (+12)	800 (-19)	+3.0	17.8
	Water	74 (+1)	2600 (+9)	182 (+3)	873 (-12)	0.0	14.4
Ethylene Propylene (E652-90)	Original properties	88	2330	146	1230		
	GE SF 96 Silicone (200 c/s)	91 (+3)	2330 (0)	146 (0)	1500 (+22)	-2.5	44.9
	GE SF1154 Silicone	89 (+1)	2430 (+4)	143 (-2)	1490 (+21)	+0.4	cancelled
	Water	90 (+2)	2450 (+5)	145 (-1)	1430 (+16)	-1.0	42.0
Ethylene Propylene (E529-65)	Original properties	61	1450	273	279		
	GE SF 96 Silicone (200 c/s)	61 (0)	1680 (+16)	317 (+16)	296 (+6)	-4.5	29.6
	GE SF1154 Silicone	60 (-1)	1520 (+5)	279 (+2)	290 (+4)	-2.1	28.4
	Water	61 (0)	1590 (+10)	298 (+9)	276 (-1)	-0.1	29.8
Ethylene Propylene (E692-75)	Original properties	74	1610	239	563		
	GE SF 96 Silicone (200 c/s)	72 (-2)	1350 (-16)	209 (-13)	578 (+3)	-3.4	25.4
	GE SF1154 Silicone	72 (-2)	1620 (+1)	219 (-8)	549 (-2)	+0.8	30.5
	Water	73 (-1)	1100 (-32)	171 (-28)	545 (-3)	+0.2	16.7

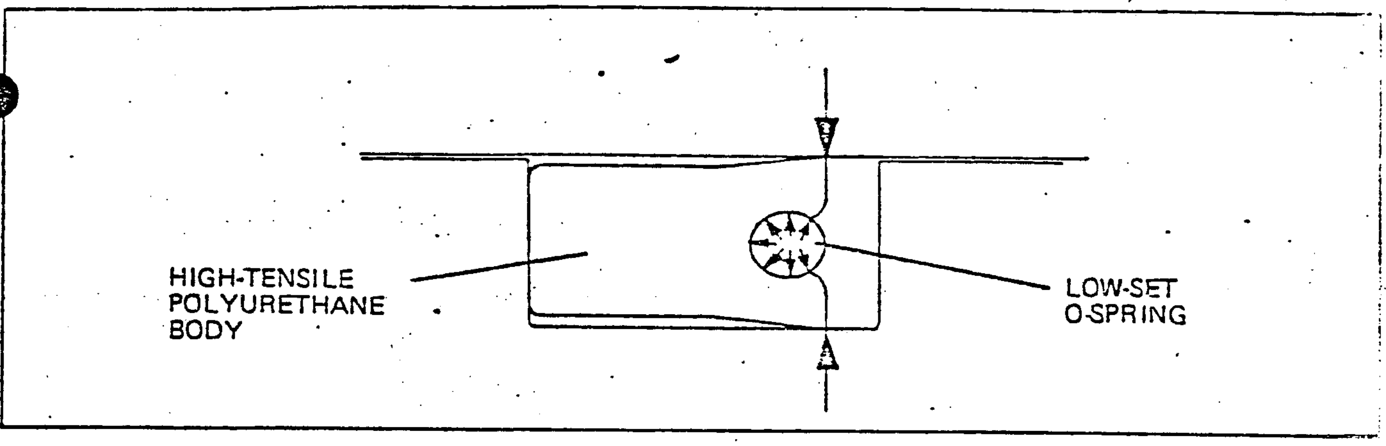


Figure 2. Excellent tensile, tear and modulus properties of polyurethane under radiation may be preserved by a design which compensates for poor compression set under radiation. An O-ring with superior compression set can be used as a spring to energize a polyurethane seal body with superior tensile properties.

Base polymers vs variations

It can be very misleading to ascribe either fluid, temperature or radiation resistant properties to a generic class of elastomers. Variations in compounding within the generic class can cause wide differences in properties. Early tests of nitriles, for example, discouraged their use in reactor environments for many years. However, later tests of other nitrile formulations showed that their compression set properties were among the best when subjected to gamma radiation.

Ethylene propylene is a case in point. The standard Parker E515-80 compound (see Tables 1 and 2) developed nearly twice the compression set and lost significantly more tensile and tear strength than E740-75—another ethylene propylene compound. The E740-75 material has compression set characteristics similar to the silicones and nitriles tested and also has much better resistance than the latter to water and silicone fluids commonly used in reactors.

Silicones are deceptive in that they show excellent compression set characteristics under radiation, but show poor resistance to water and the silicone fluids. This severely limits their usefulness in reactors.

Fluoroelastomers (fluorocarbons and fluorosilicones) have long been equated by many engineers with "the best available" primarily because of their outstanding temperature range. Not only do test results contradict this optimism, with neither recommended for more than 10^6 rads, but fluoroelastomers tend to degrade rapidly in water or steam. Also, some reactor specifications forbid the use of any materials containing fluorine or chlorine. Even if the fluid is compatible, and the radiation tolerance can be accepted at 10^6 rads, such specifications as the AEC's RDT M11-IT may prohibit their use.

Polyurethane takes a rather high compression set in radiation even though its unstressed physical properties hold up well at room temperature after 10^7 rads. It would not be a preferred material for O-rings or other compression type seals. It probably would serve well in an O-ring energized lip seal, however, if the O-ring is radiation-resistant (see Figure 2), or in lip type seals that are activated entirely by *continuous* fluid pressure.

While polyurethane compounds are not generally recommended for use in water fluids, it should be pointed out that the rapid deterioration of the P4611 and P642-70 compounds reported in Table 2 was due primarily to temperature.

Nitrile compounds' resistance to gamma radiation varies greatly, depending on the specific formulation. Thus far, N674-70 and N741-75 are unique in their ability to tolerate 10^7 rads with little compression set. These two formulations, therefore, may become quite useful in some nuclear applications. Even these formulations, however, could not be recommended for long-term use if the sealed fluid were not air or other critical fluid/temperature combinations.

Polyacrylates are like polyurethanes in that they have a low tolerance for water, especially at higher temperatures, while being quite compatible with silicone fluids up to 350 F. Their compression set properties under radiation usually would suggest switching to the E740-75 ethylene propylene for reactor service.

Work to overhaul periods

Compounds that are recommended for service as seals in reactor environments should have ample remaining life at regularly scheduled overhaul intervals to permit routine replacement without stretching their projected life. Many engineers who inquire about seals ask for 20 to 40 years of service even though shutdown and overhaul is scheduled at 5- or 10-year intervals.

Designers working with elastomeric seals must learn to work to the overhaul periods and not to the reactor life. Even then, it is important to test elastomers under the combined degradation factors anticipated for each application to earn a high confidence factor.

No blanket recommendation can logically be made for the one best seal compound for nuclear reactors or non-nuclear applications. While the E740-75 ethylene propylene compound exhibits the best combination of radiation, fluid and temperature tolerance of all the known contenders for reactor seals, even this excellent compound should be evaluated under the combined conditions for the specific application. Tensile tests alone cannot predict elastomer's response to radiation environments. This may not only lead away from the optimum material, but may lead to a compound that develops excessive compression set early in its exposure to gamma radiation. **END**

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April 30, 1980

Fisher Controls Company
Continental Division
200 Main Street
Coraopolis, Pennsylvania 15108

Attention: Mr. Al Gentile, Sales Engineer

Dear Mr. Gentile:

Our Chief Lab Technician, Mr. Charles A. Loudin received a phone call on April 28, 1980 from a Mr. John Windschill, Northern State Power Company, Monticello Nuclear Plant in Monticello, Minnesota. Mr. Windschill asked if we would send a letter stating the effect of radiation to Continental Valve Liners, lined with EPDM material. The base polymer we use is DuPont's Nordel. Mr. Loudin contacted DuPont, asking the above question and received the following reply.

"Based on tests conducted by DuPont on EPDM compound used in Fisher Control 's EPDM Valve Liners, the following results may be experienced." Parts should be unaffected to $6 \times 10_7$ rads of gamma radiation. Parts should be useful up to $5 \times 10_8$ rads of gamma radiation.

The thought occured to us that this was an unusual request from a customer we have never dealt with. In view of these facts, I spoke with your Mr. Gary Wadding and he recommended that I send the above information to your attention. We will not reply to Mr. Windschill. We will expect you to reply with or without the above information.

Please let us know if we can be of more help to you. Thanks for your cooperation.

Very truly yours,

James C. Moore
Sales Manager

JCM/lk

cc: Mr. Wayne Slack
Mr. Gary Wadding, Fisher Controls Company

Director of NRR
June 15, 1984
Attachment (3)

ADDITIONAL RESPONSE TO QUESTION (3)

APR 19 1982

nutech ENGINEERS 303 EAST WACKER DRIVE • CHICAGO, ILLINOIS 60601 • (312) 565-2900

April 9, 1982
NSP-64-003

Mr. R. L. Goranson
Northern States Power Company
Monticello Nuclear Generating Station
P.O. Box 600
Monticello, MN 55362

COPY OF ATTACHMENT (1)
INFORMALLY SENT TO
H. NICOLARAS, NRC PROJ MGR,
ON 4/19/82
DMM

Subject: Review of Fisher's Purge and Vent Valve Engineering Response/NRC Questions

References:

1. Letter, Fisher Controls (L. R. Waite) to Northern States Power (R. L. Goranson) dated 3/19/81;
   Subject: 18" Type 9200 Containment Isolation Valves

2. Letter, Fisher Controls (J. Dresser) to Northern States Power (R. L. Goranson) dated 12/4/81;
   Subject: Engineering Response/NRC Questions

Dear Dick:

We have completed our review of Reference 2, and have just one comment on the material prepared by Fisher Controls. The responses to questions 1 and 21 state that the maximum temperature condition (180°F) was used during the evaluation. For certain portions of the evaluation it would be appropriate to use 180°F, however, it may not be conservative to use this temperature throughout the analysis since peak containment atmosphere temperature during a design basis event will be approximately 300°F. Three separate phases of the evaluation should be considered:

1. Thermal-hydraulics calculations: It is conservative to use 180°F in the thermal-hydraulics calculations.

2. Stress calculations: Material allowable stresses for the materials used, including the replacement shaft, are constant in the 100 to 300°F range so using the peak containment temperature should have no impact.

3. Seal material qualification: Using a maximum temperature of 180°F for seal material qualification may not be conservative. Fisher and NSP should review the response to question 21.

In addition to reviewing the responses prepared by Fisher, NUTECH has prepared a complete response to question 3. The response to question 3 has been included with this letter as Attachment 1. Allis-Chalmers test data for in-plane and out-of-plane upstream elbow conditions can be found in Attachment 2 and Figures 1 through 6.

If you have any questions, please call me or John Kin.

Yours very truly,

John M. Clauss

John M. Clauss, P.E.
Project Engineer

JMC/amc

Attachments

cc: D. A. Gerber - w/attachments
J. W. Kin - w/attachments
File: 30.2364.0003 - w/o attachments
30.2364.0011 - w/attachments
JMC-82-055

Attachment 1

April 9, 1982
NSP-64-003

Question 3

"Were installation effects accounted for in the determination of dynamic torques developed? Dynamic torques are known to be affected, for example, by flow direction through valves with off-set discs, by downstream piping backpressure, by shaft orientation relative to elbows, etc. What was the basis (test data or other) used to predict dynamic torques for the particular valve installation?"

Response

Geometrical piping system considerations are summarized in Table 1.

All Fisher sizing procedures are based on a pressure drop across the valve that is supplied by our customer; if downstream piping produces a backpressure, and if the customer wants to take credit for this effect, the existence of the backpressure should be reflected in the sizing ΔP provided. As stated previously for the subject accident conditions, the sizing ΔP across the valve is taken to be equal to the peak accident containment pressure for all angles of disc opening. This approach is conservative if backpressure actually does exist because the maximum ΔP will produce the maximum operator torque.

In the development of the dynamic torque coefficients, flow direction has been considered. In the case of flow into the hub, a factor of 1.5 is used (when selecting torque coefficients) as compared to flow into the flat side of the disc; this is done in the interests of convenience and conservatism because the Fisher model tests indicate torque values are 1 to 1.5 times higher when flowing into the hub side.

All Fisher sizing data is based on dynamic torque determination tests which were performed with uniform flow profiles and on valve discs with representative geometries. The effects of a non-uniform flow profile, due to piping elbows, "T"-connections, etc., upstream, are discussed below.

A. Valve Shaft and Elbow In-plane

If it has been determined that plant layout is such that the valve shaft is oriented to be in-plane with the upstream elbows, the non-uniform fluid profile is not expected to produce an additional torque on the valve disc since both "wings" of the disc (as split by the shaft) will be subjected to the same flow with respect to time.

B. Valve Shaft and Elbow Out-of-Plane

Valves AO-2378, AO-2386, and AO-2387 are installed in an out-of-plane arrangement. These three installations can be shown to be acceptable based on the qualification work performed using a uniform flow profile and the following information:

1. Each of the installations in question is oriented such that flow is into the flat rather than into the hub. Peak operator torque occurs when flow is into the hub and the valves are qualified for this situation. Since these valves have flow into the flat the peak torque they will experience is equal to 0.66 times the calculated maximum torque (Reference 1).

2. The off-set disc butterfly valves installed at Monticello are similar to the Allis-Chalmers valves tested at NASA's Langley Research Center. The test data (Attachment 2) for the Allis-Chalmers valves indicates that the peak operator torque for the "out-of-plane" elbow case (where shaft rotation is limited to 40° open) is less than the peak operator torque when the upstream elbow is "in-plane". The Allis-Chalmers test data has been plotted in Figures 1 through 6 to facilitate data comparison.

In conclusion, the uniform flow case is the governing case for qualification of the subject valves. The out-of-plane upstream elbow case will not produce maximum operator torque. The following information is a comparison of the Fisher valves installed out-of-plane at Monticello and the Allis-Chalmers test valve.

Parameter	Fisher Valve	Allis-Chalmers Valve
General Description	Off-set disc, butterfly	Off-set disc, butterfly
t/D	.20	.17
Range of Opening	0 to 40° (pinned)	0 to 90°
Flow into	Flat	Flat
Uniform Flow Test Data	See Reference 1	Test 29 See Attachment 2 and Figures 1 through 6
Non-Uniform Flow Test Data	——	Test 32 See Attachment 2 and Figures 1 through 6

TABLE 1

	Valve Number	Upstream Elbows?	Distance, Elbow to Valve (ft.)	Valve Shaft and Elbow In-Plane	Valve Shaft and Elbow Out-of-Plane	Flow Into	Out-of-Plane Effect on Valve Closure
1.5	AO-2377	Yes	5'-8½"	X		Flat	NA
3.0	AO-2378	Yes	1'-8"		X	Flat	Assist Closure
1.5	AO-2381	Yes	5'-6¼"	X		Flat	NA
1.5(1.5)	AO-2383	Yes	1'-3½"	X		Hub	NA
3.0	AO-2386	Yes	3'-4"		X	Flat	Assist Closure
3.0	AO-2387	Yes	5'-1"		X	Flat	Assist Closure
1.5(1.5)	AO-2896	Yes	4'-1½"	X		Hub	NA

Attachment 2

April 7, 1982
NSP-64-003

Test 29 $P_T = 15$ PSI

°Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	5.0	2.5	2.5	0.2	0.6	6.4
80	5.0	2.5	2.5	1.6	5.1	6.4
70	7.0	2.0	5.0	3.9	6.2	7.8
60	9.0	1.5	7.5	3.1	3.3	9.8
50	10.5	1.0	9.5	1.2	1.0	11.8
40	12.0	0.5	11.5	-0.8	-0.6	11.8
30	12.0	0	12.0	-1.6	-1.1	12.5
20	12.0	0	12.0	-2.0	-1.3	13.2
10	12.5	0	12.5	-2.8	-1.8	13.8
0	12.5	0	12.5	-3.1	-2.0	13.8

Test 29 20 PSI

90	7	3.0	4.0	-5.0	-10.0	2.4
80	9	3.0	6.0	-3.0	-4.0	3.7
70	10	3.0	7.0	8.0	9.2	5.1
60	14	2.5	11.5	6.0	4.2	8.4
50	17	2.0	15.0	2.0	1.1	11.1
40	18	1.0	17.0	-5.0	-2.4	11.8
30	18	0.5	17.5	-6.0	-2.7	13.2
20	19	0	19.0	-8.0	-3.4	13.8
10	19	0	19.0	-10.0	-4.2	15.2
0	19	0	19.0	-13.0	-5.5	15.2

Extracted from: "Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves.

Attachment 2

April 7, 1982
NSP-64-003

Test 29 30 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	12	7	5	-5.9	-9.44	3.7
80	18	7	11	-3.15	-2.3	5.1
70	20	7	13	0	0	7.8
60	22.5	5	17.5	0	0	9.1
50	25	2.5	22.5	-1.57	-.558	11.8
40	27.5	1.5	26	-3.93	-1.2	13.8
30	28	0	28	-3.93	-1.12	16.5
20	29	0	29	-3.93	-1.08	18.5
10	30	0	30	-5.9	-1.57	18.5
0	30	0	30	-7.87	-1.57	18.5

Test 29 40 PSIG

90	20	10	10	-7.86	-6.29	9.8
80	20	10	10	-4.68	-3.74	10.5
70	25	10	15	-3.74	-1.99	11.8
60	30	7.5	22.5	-1.87	-.66	17.2
50	35	5	30	-3.92	-1.05	20.6
40	37.5	2.5	35	-5.97	-1.36	22.6
30	38	0	38	-4.68	-.985	23.9
20	39	0	39	-5.61	-1.15	24.6
10	39.5	0	39.5	-5.97	-1.21	25.3
0	40	0	40	-7.86	-1.56	25.3

Extracted from: "Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves

Test 29 50 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25	15	10	-8.88	-7.10	15.8
80	25	15	10	-5.14	-4.11	17.2
70	32.5	15	17.5	-2.81	-1.28	20.6
60	37.5	10	27.5	-2.25	-.65	25.3
50	42.5	7.5	35	-5.14	-1.17	28.6
40	45	2.5	42.5	-7.86	-1.48	30.7
30	46	2	44	-7.48	-1.36	32.8
20	47.5	1	46.5	-7.86	-1.35	33.3
10	48	1	47	-7.48	-1.27	34.0
0	49	0	49	-10.61	-1.73	34.7

Test 29 60 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	30	15.5	14.5	7.87	-4.34	28.0
80	32.5	15.5	17	5.15	-2.42	28.6
70	40	15.5	24.5	3.93	-1.28	32.0
60	47.5	13.5	34	3.93	-.93	34.7
50	52	10	42	6.56	-1.25	40.1
40	55	5	50	9.82	-1.57	42.8
30	57	2.5	54.5	9.82	-1.44	44.1
20	58	2.5	55.5	9.82	-1.42	44.8
10	59	2	57	8.42	-1.18	45.5
0	60	0	60	11.79	-1.57	45.5

Extracted from: "Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves

Test 32 P_{T_1} = 20 PSI

° Open	P_1	$*P_2$	ΔP	T_D	C_T	Temp °F
90	7	3	4	-5.9	-11.8	58.9
80	8	3	5	-3.1	-5.0	58.9
70	11	3	8	3.9	3.9	56.2
60	14	3	11	4.7	3.4	52.9
50	17	2	15	2.0	1.1	50.8
40	18	1	17	-0.8	-0.4	49.5
30	18	1	17	-1.2	-0.6	48.8
20	19	0	19	-1.6	-0.7	47.5
10	19	0	19	-3.1	-1.3	46.1
0	19	0	19	-3.9	-1.6	45.5

Test 32 P_{T_1} = 15 PSI

90	5	3	2	-2.4	-9.6	56.2
80	5	2	3	0	0	56.2
70	7	2	5	4.7	7.5	55.6
60	8	2	6	3.9	5.2	52.9
50	10	1	9	2.4	2.1	52.2
40	12	1	11	0.8	0.6	50.2
30	12	0	12	0	0	49.5
20	13	0	13	-1.6	-1.0	48.8
10	13	0	13	-2.0	-1.2	48.8
0	13	0	13	-3.1	-1.9	48.8

Extracted from: "Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves

Test 32 P_{T_1} = 40 PSIG

DA	P_{T_5}	P_{T_6}	ΔP	T_D	C_T	Temp °F
90	18	12	6	-15.7	-21	48.8
80	21	11	10	- 6.9	5.5	46.8
70	26	7	19	1.2	.51	45.5
60	33	5	28	2	.57	40.1
50	35	2	33	- .8	-.195	37.4
40	37	1	36	- 4.03	-.9	34.7
30	38	0	38	- 2.8	-.59	33.3
20	38	0	38	- 4.03	-.85	32.7
10	38.5	0	38.5	- 4.8	-1.0	0

Test 32 P_{T_1} = 30 PSIG

90	12	8.5	3.5	-11.7	-26.7	56.2
80	14	8	6	- 4.8	-6.4	25.6
70	18	7	11	2	1.5	52.2
60	22	5	17	3.2	1.5	48.8
50	26	2	24	.8	.27	46.1
40	27	1	26	-1.6	-.5	45.5
30	28	0	28	-1.2	-.34	43.4
20	28	0	28	-2.4	-.69	42.8
10	28.5	0	28.5	-4.03	-1.13	42.8

Extracted from: "Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves

Attachment 2

April 7, 1982
NSP-64-003

Test 32 $P_{T_1} = 60$ PSI

° Open	P_1	$^*P_2$	ΔP	T_D	C_T	Temp °F
90	31	16	15	-15.7	-8.4	33.3
80	34	16	18	- 7.1	-3.2	34.7
70	40	17	23	0	0	36.7
60	45	13	32	3.1	0.8	38.7
50	51	8	43	-1.6	-0.3	44.8
40	54	5	49	-4.7	-0.8	45.5
30	55	3	52	-3.9	-0.6	45.5
20	55	2	53	-5.9	-0.9	46.1
10	56	1	55	-5.9	-0.9	47.5
0	56	0	56	-9.4	-1.3	48.2

Test 32 $P_{T_1} = 50$ PSI

° Open	P_1	$^*P_2$	ΔP	T_D	C_T	Temp °F
90	.24	14	10	-17.7	-14.1	25.3
80	25	14	11	-9.8	-7.1	26.6
70	35	13	22	0	0	33.3
60	39	11	28	2.0	0.6	35.4
50	43	7	36	-1.6	-0.4	38.7
40	45	3	42	-4.3	-0.8	40.1
30	46	2	44	-3.9	-0.7	41.4
20	46	2	44	-4.7	-0.9	42.1
10	47	1	46	-4.7	-0.8	42.1
0	47	0	47	-9.4	-1.6	42.8

Extracted from: "Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves

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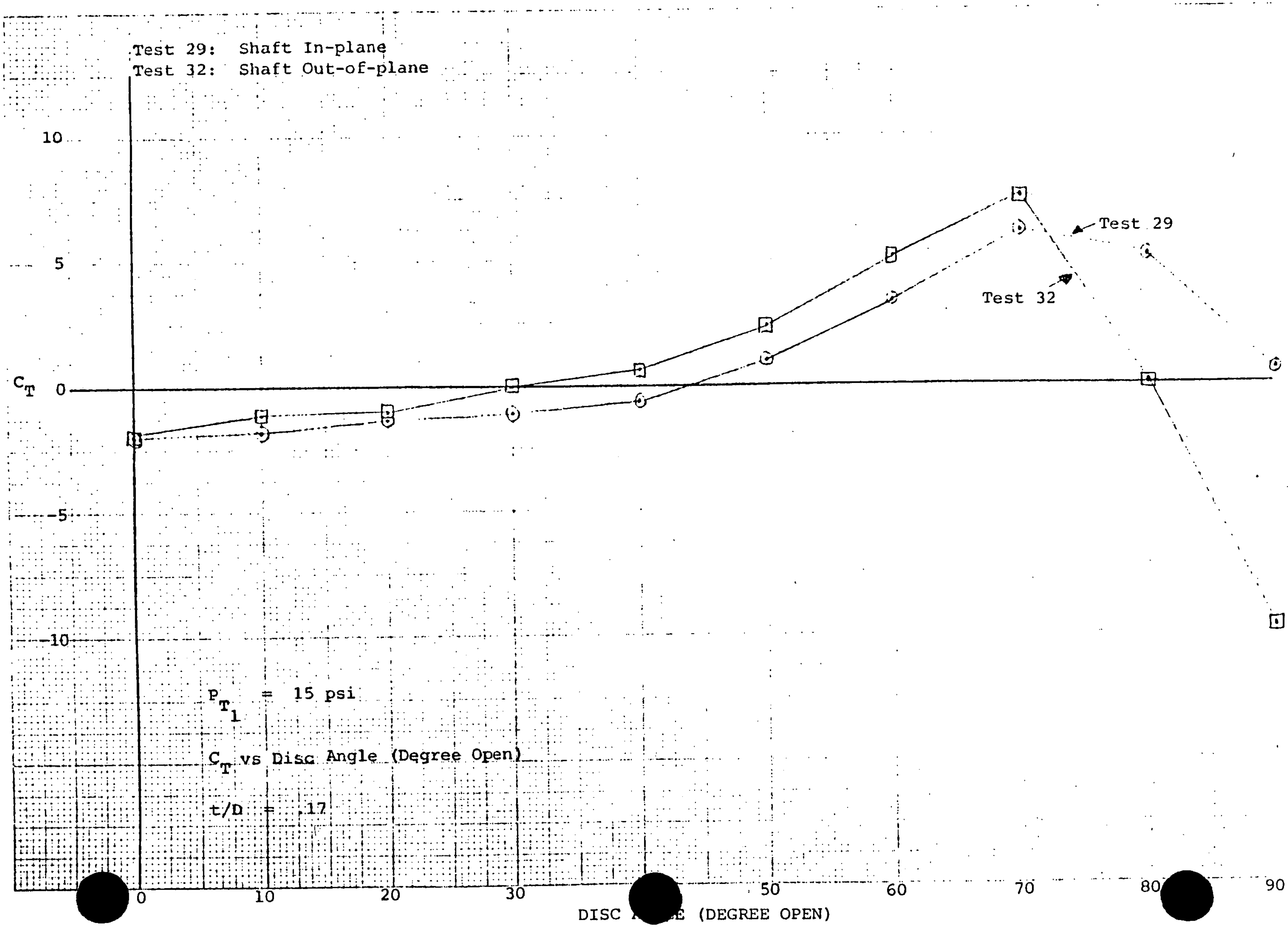

Test 29: Shaft In-plane
Test 32: Shaft Out-of-plane
10
5
C_T 0
-5
-10
Test 29
Test 32
P_{T_1} = 15 psi
C_T vs Disc Angle (Degree Open)
t/D = .17
0
10
20
30
50
60
70
80
90
DISC A[illegible]E (DEGREE OPEN)

Figure 1

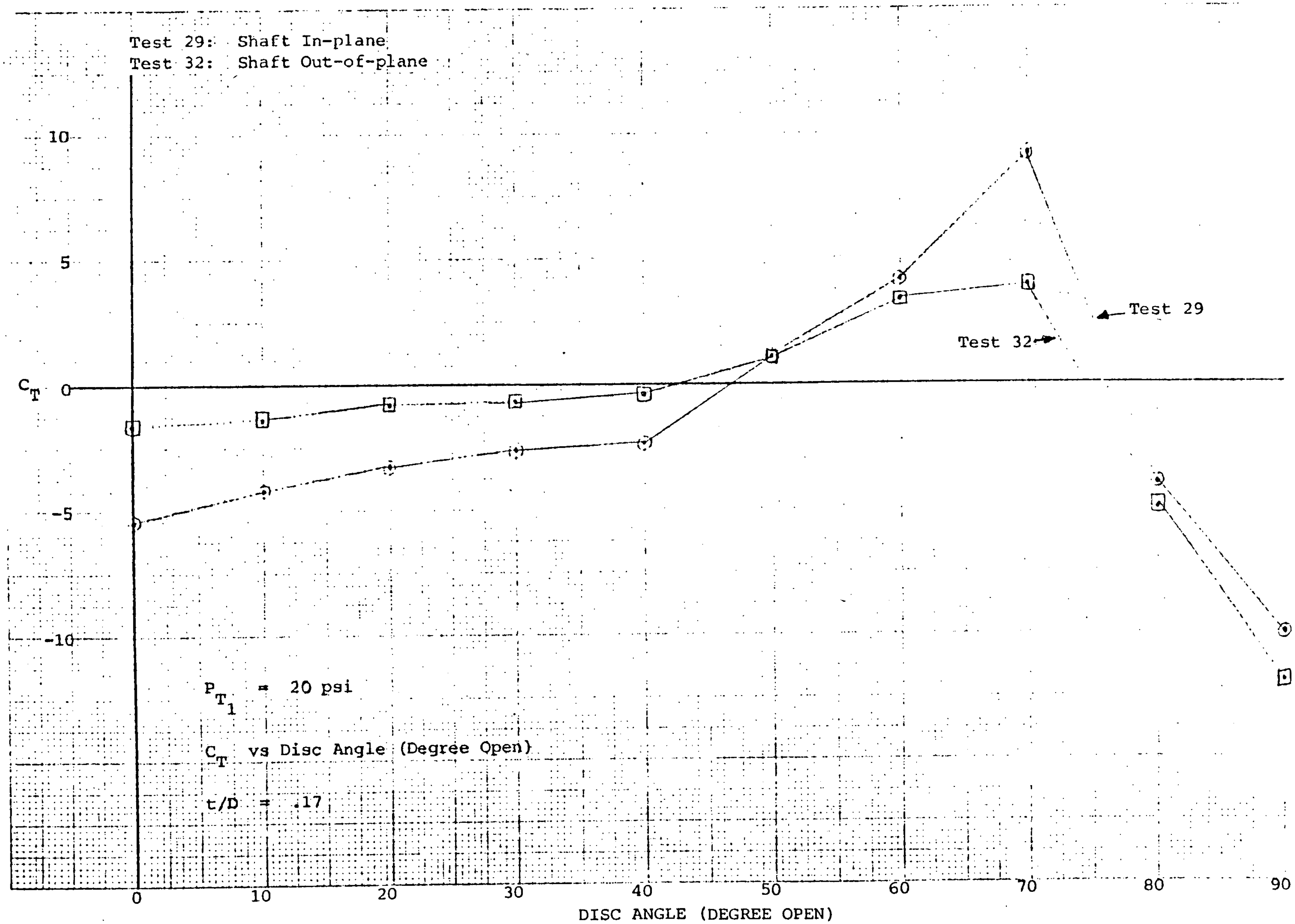
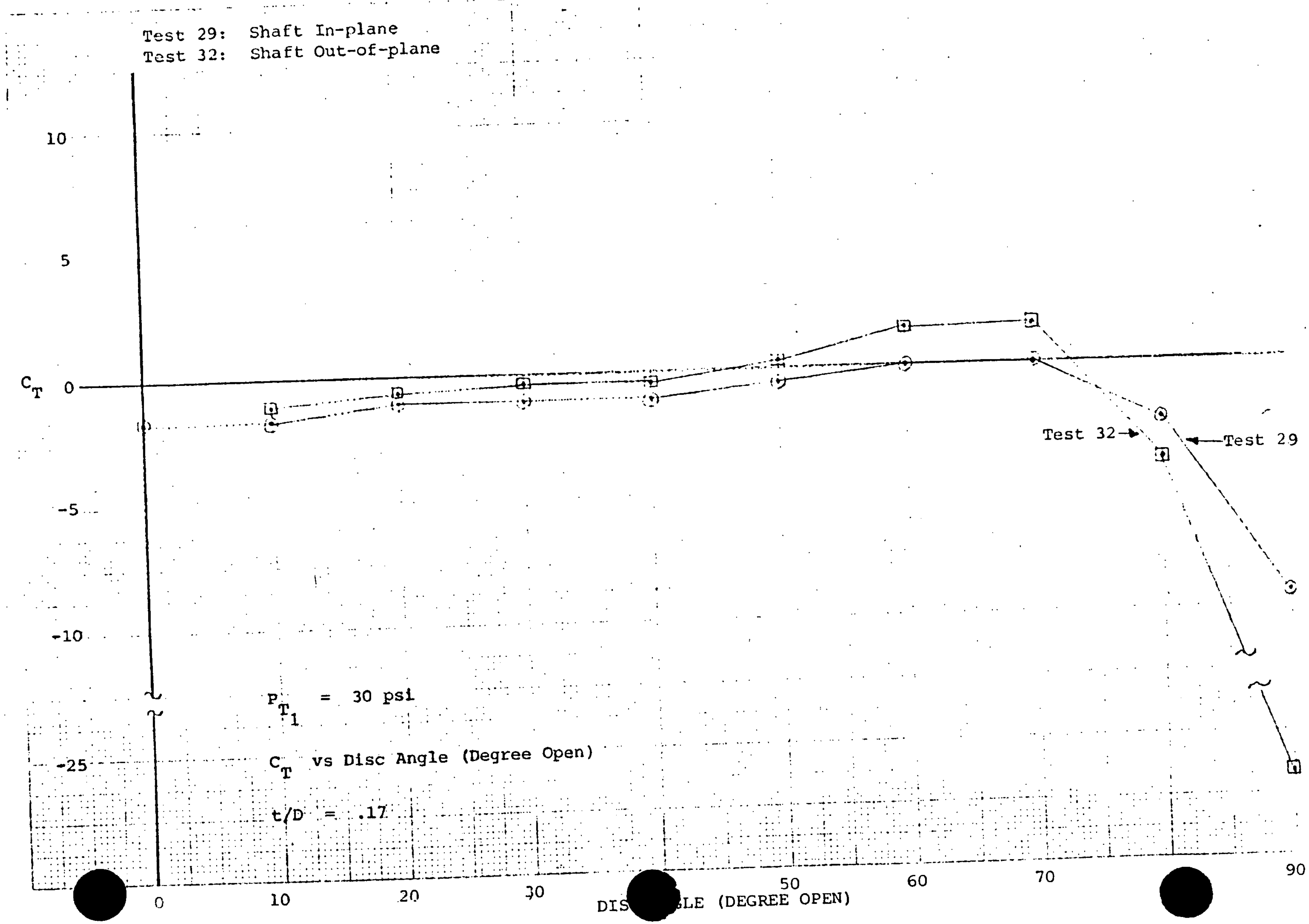
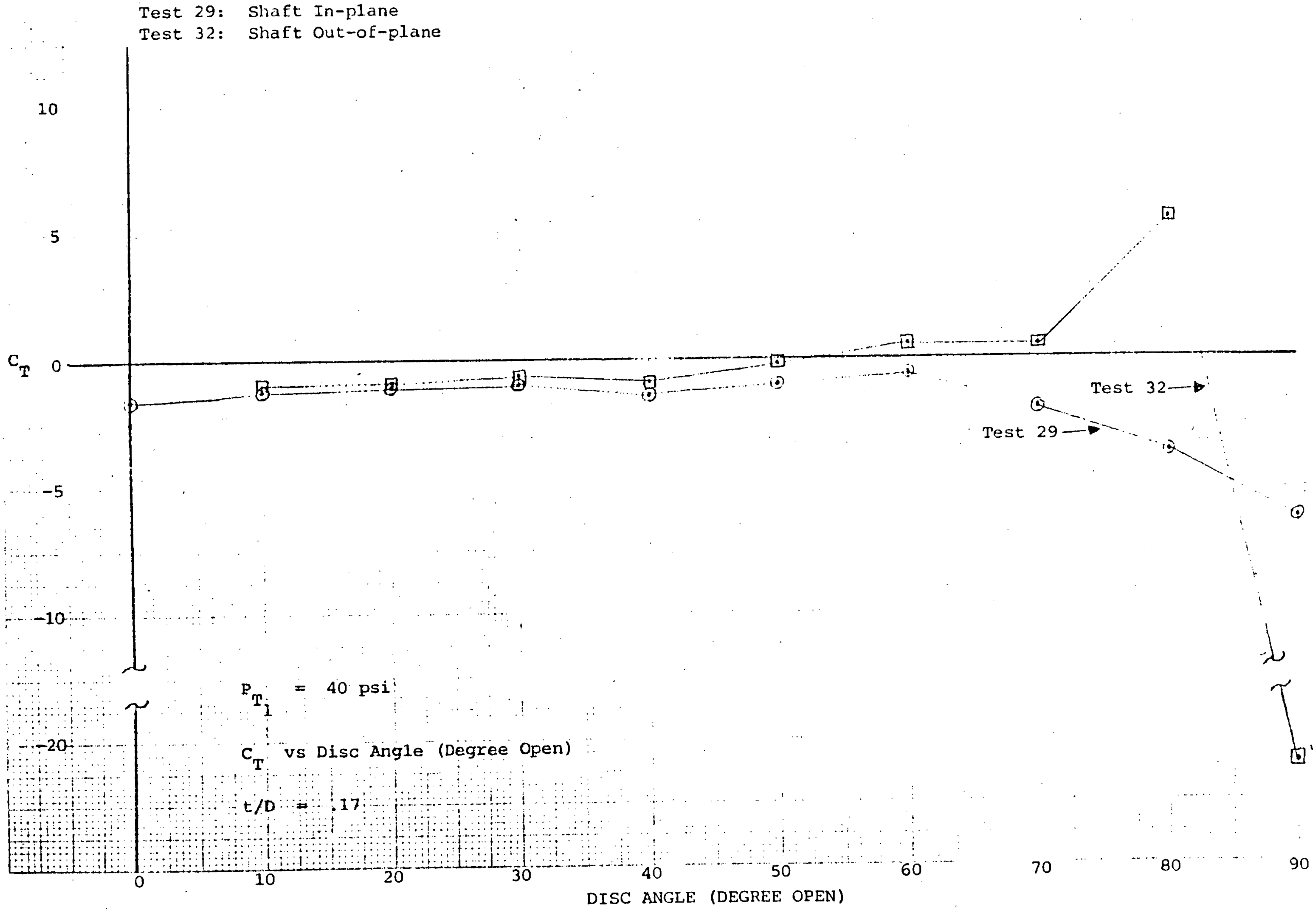

Test 29: Shaft In-plane
Test 32: Shaft Out-of-plane
10
5
C_T 0
-5
-10
Test 29
Test 32
P_{T_1} = 20 psi
C_T vs Disc Angle (Degree Open)
t/D = .17
0
10
20
30
40
50
60
70
80
90
DISC ANGLE (DEGREE OPEN)

Figure 2



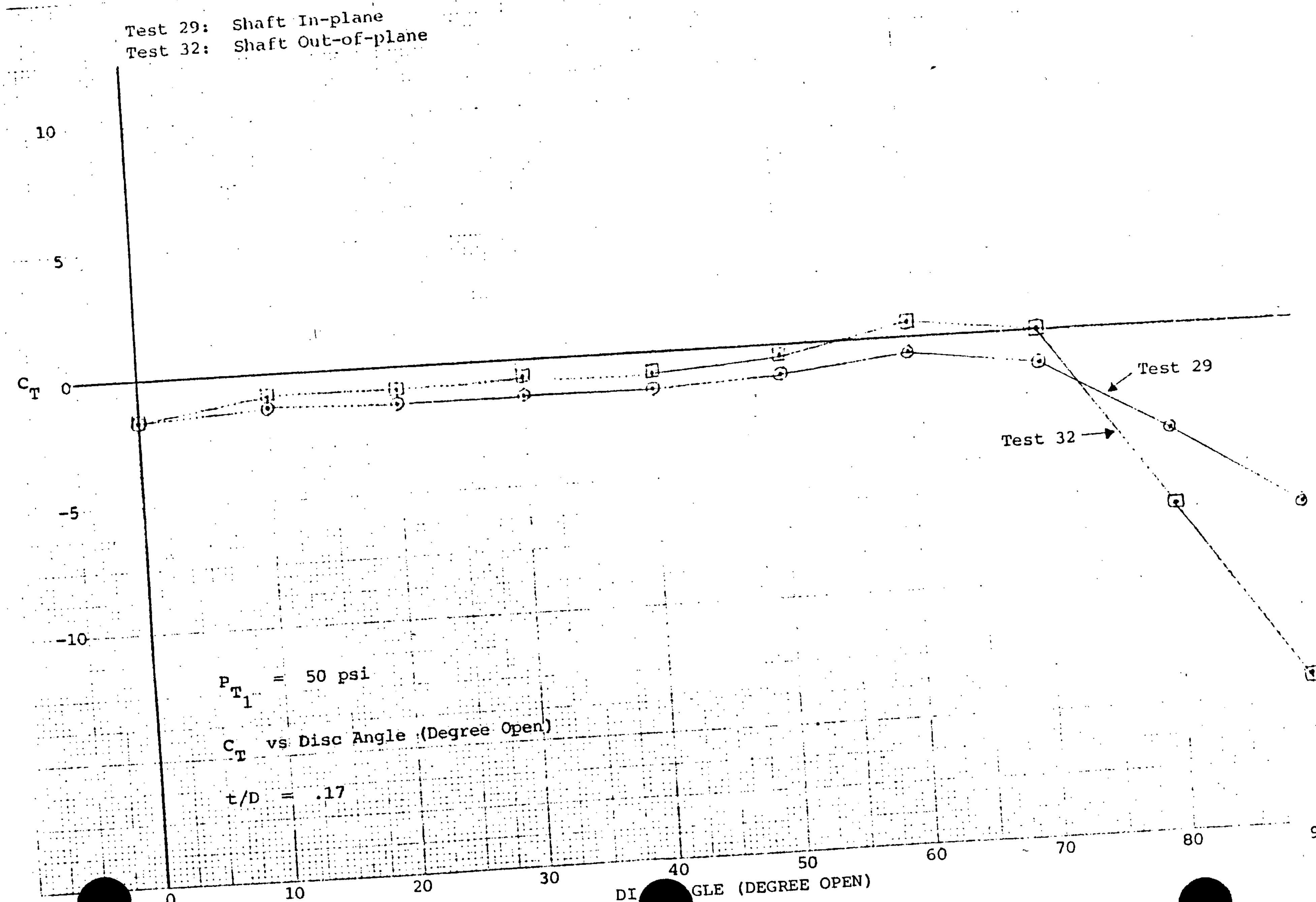
Test 29: Shaft In-plane
Test 32: Shaft Out-of-plane
10
5
C_T 0
-5
-10
-25
Test 32
Test 29
P_{T_1} = 30 psi
C_T vs Disc Angle (Degree Open)
t/D = .17
0
10
20
30
50
60
70
90
DIS LE (DEGREE OPEN)

Figure 3



Test 29: Shaft In-plane
Test 32: Shaft Out-of-plane
10
5
C_T 0
-5
-10
-20
Test 32
Test 29
P_{T_1} = 40 psi
C_T vs Disc Angle (Degree Open)
t/D = .17
0
10
20
30
40
50
60
70
80
90
DISC ANGLE (DEGREE OPEN)

Figure 4



Test 29: Shaft In-plane
Test 32: Shaft Out-of-plane
10
5
0
-5
-10
C T
Test 29
Test 32
P T 1 = 50 psi
C T vs Disc Angle (Degree Open)
t/D = .17
0
10
20
30
40
50
60
70
80
90
(DEGREE OPEN)

Figure 5

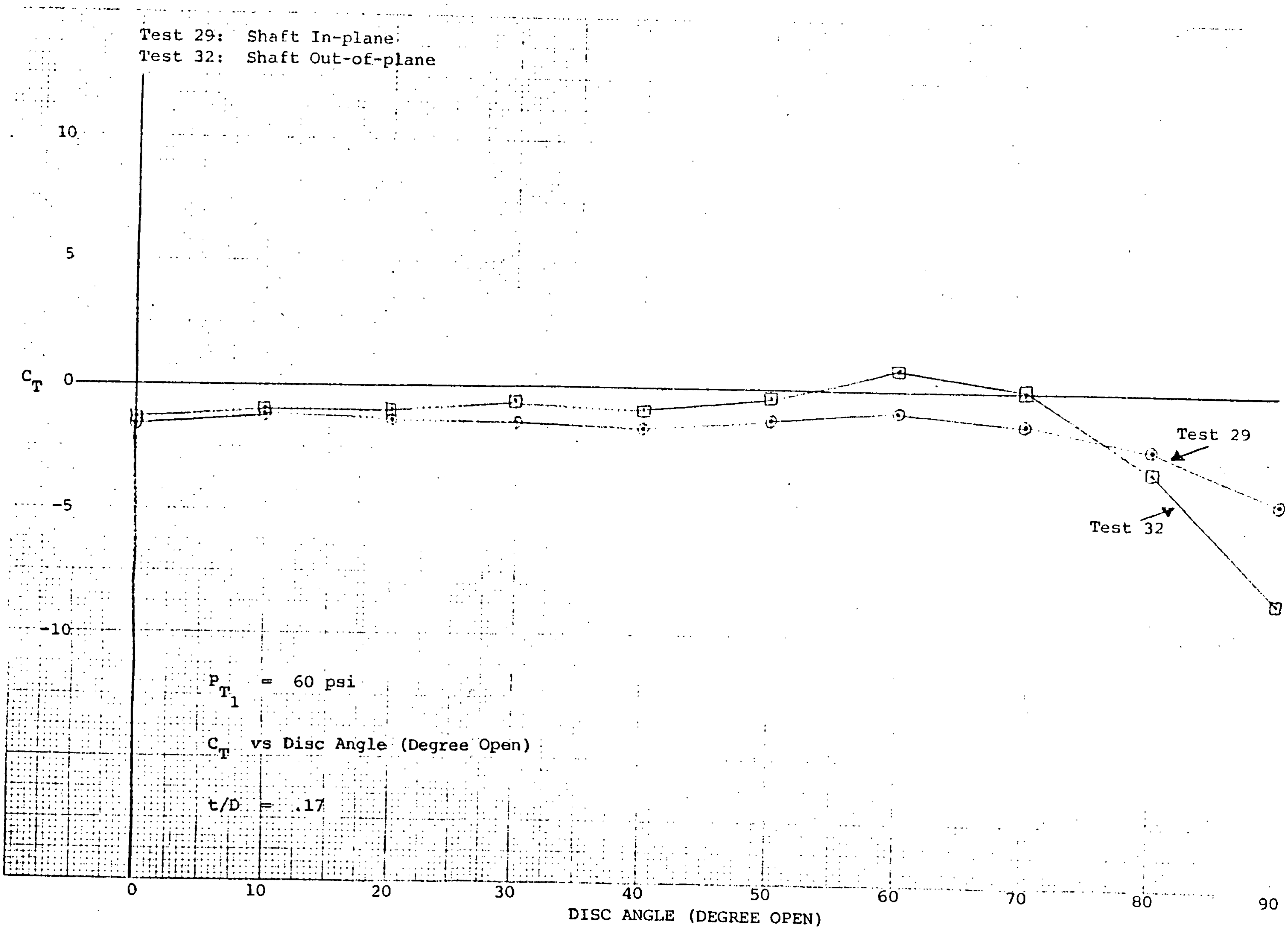

Test 29: Shaft In-plane
Test 32: Shaft Out-of-plane
10
5
C_T 0
-5
-10
Test 29
Test 32
P_{T_1} = 60 psi
C_T vs Disc Angle (Degree Open)
t/D = .17
0
10
20
30
40
50
60
70
80
90
DISC ANGLE (DEGREE OPEN)

Figure 6