CP&L

Carolina Power & Light Company

November 17, 1981

File: NG-3514(B) Serial No.: NO-81-1887

Office of Nuclear Reactor Regulation
ATTN: Mr. T. A. Ippolito, Chief
Operating Reactors Branch No. 2
United States Nuclear Regulatory Commission
Washington, D.C. 20555

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324
LICENSE NOS. DPR-71 AND DPR-62
CONTAINMENT PURGE AND VENT VALVE OPERABILITY

Dear Mr. Ippolito:

SUMMARY

In our letter to you dated December 7, 1979, Carolina Power & Light Company (CP&L) stated our intent to verify the operability of our containment purge and vent valves at the Brunswick Steam Electric Plant by analysis, and in the interim, to limit the travel of all butterfly valves greater than 3 inches nominal diameter to less than 50° open.

DISCUSSION

The valve operability analysis was performed by Posi-Seal International, Inc., manufacturer of the butterfly valves used for our containment purge and vent valves. The analyses supplied by Posi-Seal include both a seismic analysis and an operability analysis. These analyses are attached and are summarized below.

The operability analysis compares the torque requirements of the valves under the maximum differential pressure condition of 47.3 psi to the guaranteed capability of the actuators to close the valves. The effects of the concerns listed under the Operability section of the "Guidelines for Demonstration of Operability of Purge and Vent Valves", Items 1 through 8, are taken into consideration in the analysis. The results demonstrate the capability of the valves to operate under all postulated operating and accident conditions.

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The seismic analysis concentrates on the external seismic loading imposed during a design basis accident (DBA) since this is the only loading beyond normal operating loads added during a DBA. This is based on the fact that the wafer-type butterfly valve body used at Brunswick is always loaded in pure compression, and the transmission of external piping loads is done by the bolting between the piping flanges where the valve is installed. The results establish the adequacy of design for seismic events.

United Engineers and Constructors, our architect-engineer for the Brunswick site, has analyzed the subject valves with regard to sealing integrity after closure and long-term exposure to the containment environment. Since the Brunswick units use water from the suppression pool for containment spray (no chemicals added), radiation, relative humidity, and seal shutoff capability were the primary considerations in seal performance. This analysis concludes that the subject valves will seal and maintain shutoff over the lifetime of the plant and following a design basis accident.

CONCLUSION

In summary, it can be concluded that the containment purge and vent valves in service at Brunswick meet the operability criteria established by the guidelines for valve operability. We will continue to observe the provisions of the interim position while we are awaiting your concurrence to remove the travel limitations on the containment purge and vent valves, and to reenergize those valves that were de-energized due to their inaccessibility for the travel limitation modification. Please advise us of your concurrence so that CP&L may return all the containment purge and vent valves to full operability.

Please contact us should you have any questions regarding this information.

Yours very truly,

E. E. Utley
Executive Vice President
Power Supply and
Engineering & Construction

WRM/lr (7132)

Attachments

ATTACHMENT 1

BRUNSWICK STEAM ELECTRIC PLANT UNIT NOS. 1 AND 2

VALVE SIZING CALCULATIONS FOR CONTAINMENT PURGE AND VENT VALVES

POSI-SEAL INTERNATIONAL, INC.

ENGINEERING CALCULATIONS

Title VALVE SIZING CALCULATION Page 1

Calc. By J. M. Cory Checked By R.C.[illegible] 12/20/79.

POSI · SEAL REFERENCE: 4786

UNITED ENGINEERS & CONSTRUCTORS

CAROLINA POWER & LIGHT CO.
BRUNSWICK STEAM ELECTRIC PLANT
UNITS 1 & 2
UE&C P.O. 9527-01-248-50

ENCLOSURES:

1. POSI-SEAL TECHNICAL BULLETIN NO. 1A DATED MAY 79.
2. CLOSING TORQUES, COMPUTER PRINT OUT DATED 12/18/79.
3. BETTIS ROBOTARM ACTUATOR DATA SHEET.

POSI-SEAL INTERNATIONAL, INC.

ENGINEERING CALCULATIONS

Title ______ Page 2

Calc. By ______ Checked By R. Olamen 12/20/79

ANALYSIS.

AS STATED IN ENCLOSURE 1. THE CLOSING TORQUE IS CALCULATED AS FOLLOWS:

① $T = T_1 + T_2 + T_3(\Delta P)(.5)$

OR

② $T = T_1 + T_3(\Delta P) - T_4(\Delta P)\,G_f$

T = CLOSING TORQUE IN-LB

T_1 = VALVE PACKING TORQUE - IN-LB

T_2 = VALVE SEATING TORQUE - IN-LB

T_3 = VALVE BEARING FRICTION TORQUE - IN-LB

T_4 = VALVE HYDRODYNAMIC TORQUE - IN-LB

NOTE: T_1 EXISTS THROUGHOUT THE 90° VALVE TRAVEL & RESISTS CLOSING MOTION.

T_2 EXISTS ONLY DURING THE LAST 5° OF TRAVEL WHILE SEATING DISC & RESISTS CLOSING MOTION.

T_3 EXISTS THROUGHOUT THE 90° VALVE TRAVEL BUT VARIES WITH ΔP. T_3 RESISTS CLOSING MOTION.

T_4 EXISTS THROUGHOUT THE 90° VALVE TRAVEL BUT VARIES WITH ΔP & VALVE ANGLE. T_4 <u>ASSISTS</u> CLOSING MOTION.

T_4 APPROACHES ZERO (0) AS VALVE APPROACHES SHUT POSITION.

POSI-SEAL INTERN .TIONAL, INC.

ENGINEERING CALCULATIONS

Title ______ Page 4

Calc. By ______ Checked By R Olanson 12/30/79

ITEM	VALVE	ACTUATOR	RATED (1) ACTUATOR TORQUE	REQ'D (2) VALVE TORQUE
1	18"-150	732C-SR80	8200	4132
2	20"-150	732C-SR80	8200	5111
3	20"-150	732C-SR80	8200	5111
4	8"-150	CB520-SR80	1300	1146
5	20"-150	732C-SR80	8200	5111
6	18"-150	732C-SR80	8200	4132
7	24"-150	732C-SR80	8200	7882
8	4"-150	CB415-SR80	700	483
9	4"-150	CB415-SR80	700	483

(1) REFER TO ENCLOSURE 3.

(2) TORQUE IS CALCULATED AT 47.3 PSI ΔP

BETTIS ROBOTARM* VALVE ACTUATORS — SPRING RETURN

TORQUE OUTPUT

ALL PUBLISHED TORQUES ARE GUARANTEED MINIMUM VALUES

CB SERIES
SPRING RETURN

ACTUATOR MODEL	Torque In./Lbs.	OPERATING PRESSURE — LBS./SQ. INCH						
		40	50	60	70	80	90	100
CB-315-SR	ENDING	200	200	300	300	400	400	500
CB-415-SR	ENDING	350	350	500	500	700	700	800
CB-420-SR	ENDING	400	400	600	600	800	800	1000
CB-520-SR	ENDING	600	600	1000	1000	1300	1300	1700
CB-525-SR	ENDING	900	900	1300	1300	1700	1700	2100
CB-725-SR	ENDING	1700	1700	2500	2500	3400	3400	3800

RACK & PINION
SPRING RETURN

		OPERATING PRESSURE — LBS./SQ. INCH												
		40	50	60	70	80	90	100	125	150	175	200	225	250
301D-SR	END	225	420	450	450	515	710	750	1000	1000	1000	1350	1350	2300

HEAVY DUTY — SCOTCH YOKE
SPRING RETURN

		OPERATING PRESSURE — LBS./SQ. INCH												
		40	50	60	70	80	90	100	125	150	175	200	225	250
521C-SR	END	830	830	1250	1250	1660	1660	2080	2600	3130	3130	4170		
721C-SR	END	1710	1710	2570	2570	3420	3420	4280	5350	6420				
722C-SR	END	3150	3150	4750	4750	6300	6300	7900						
732C-SR	END	3500	3500	6150	6150	8200	8200	10300	10[illegible]	15500				

HEAVY DUTY — SCOTCH YOKE
SPRING RETURN
with HYDRAULIC OVERRIDE or SPEED CONTROL

		OPERATING PRESSURE — LBS./SQ. INCH												
		40	50	60	70	80	90	100	125	150	175	200	225	250
522C-SR-H	END	830	830	1250	1250	1660	1660	2080	2600	3130	3130	4170		
722C-SR-H	END	1710	1710	2570	2570	3420	3420	4280	5350	6420				
732C-SR-H	END	—	3500	3500	3500	3500	6150	6150	6150	8200	8200	10300		

T-SERIES
SPRING RETURN

		OPERATING PRESSURE — LBS./SQ. INCH												
		40	50	60	70	80	90	100	125	150	175	200	225	250
T-310A-SR	ENDING		[5] 1.470	[5] 5.170	[5] 5.510	[4] 7.630	[4] 9.570	[4] 9.570	[3] 13.400	[2] 20.200	[2] 20.200	[1] 21.600	[1] [illegible].100	[1] 23.100
T-312A-SR	ENDING	[5] 4.150	[5] 5.510	[4] 9.570	[4] 9.570	[3] 13.400	[3] 13.400	[2] 19.000	[2] 20.200	[1] 27.000	[1] 28.100	[1] 28.100		
T-316A-SR	ENDING	[4] 9.570	[3] 13.400	[2] 17.000	[2] 20.200	[2] 20.200	[1] 24.000	[1] 28.100	[1] 28.100	[1] 28.100				
T-410—SR	ENDING							[5] 13.200	[4] 18.300	[3] 24.500	[3] 29.400	[3] 29.400	[2] 31.800	[2] 41.300
T-412-SR	ENDING				[5] 13.300	[5] 13.300	[4] 19.900	[3] 20.800	[3] 29.400	[3] 29.400	[2] 41.300	[1] 46.300	[1] 55.700	[1] 55.700
T-416-SR	ENDING	[5] 8.800	[5] 13.300	[4] 19.900	[3] 29.400	[3] 29.400	[3] 29.400	[2] 34.000	[1] 46.600	[1] 55.700				
T-420-SR	ENDING	[4] 19.900	[3] 29.400	[3] 29.400	[2] 41.300	[1] 48.500	[1] 55.700	[1] 55.700						
T-516A-SR	ENDING		[5] 26.300	[5] 26.300	[4] 39.900	[3] 48.000	[3] 48.000	[3] 48.000	[2] 66.200	[2] 81.600	[1] 92.500	[1] 111.000	[1] 111.000	[1] 111.000
T-520A-SR	ENDING	[4] 35.100	[3] 48.000	[3] 48.000	[3] 48.000	[2] 69.000	[2] 81.500	[2] 81.500	[1] 111.000	[1] 111.000				
T-616A-SR	ENDING				[5] 59.600	[5] 63.300	[5] 63.300	[5] 63.300	[4] 95.600	[3] 129.000	[3] 129.000	[2] 172.000	[2] 177.000	[2] 177.000
T-820A-SR	ENDING	[5] 43.000	[5] 63.300	[5] 63.300	[4] 85.100	[4] 95.500	[3] 129.000	[3] 129.000	[2] 167.000	[2] 177.000				

*LEGEND [5] NUMBER IN SMALL SQUARE IS SPRING SIZE AND MUST BE SPECIFIED
EXAMPLE T-616-SR5

CONSULT FACTORY FOR SPRING RETURN ACTUATORS CAPABLE OF PRODUCING ENDING TORQUES IN EXCESS OF 177,000 IN./LBS.

POSI-SEAL INTERNATIONAL, INC.

Innovators in Flow Control

TECHNICAL BULLETIN NO. 1A
Operating torque values and Actuator sizing

MAY 79

TORQUE VALUES TO OPEN AND SHUT

The Posi-Seal Trunnion Valve is a low torque valve which normally reaches its highest torque when opening. This torque value will vary with the seat material and stem packing selected in addition to the maximum operating differential pressure (ΔP) across the valve.

Torque values to open and shut for standard Posi-Seal Trunnion Valves are listed in Tables 1, 2 and 3, and are denoted as T_1, T_2, and T_3.

T_1 and T_2 torque values are due to the stem packing and seat material selected and are added together to determine preload torque.

The static pressure torque factor T_3 is the static pressure torque per PSIΔP. This factor (T_3) is multiplied by the maximum operating ΔP or maximum line pressure to obtain the torque value due to pressure.

To obtain the maximum torque to open or shut the T_1, T_2, and T_3 ΔP values are simply added together.

EXAMPLE:

A. Requirement – What is the maximum opening torque of a 12" Class 150 valve with teflon chevron packing, a teflon seal ring with rubber back-up ring and a maximum ΔP of 200 PSI.

B. Solution – From Table 1

T_1 = (B) = 70 in. lbs.

T_2 = (G) = 986 in. lbs.

T_3 = 10.10 in. lbs. per PSIΔP = 10.10 x 200 = 2020 in. lbs.

Total opening torque = T_1 + T_2 + (T_3 x PSIΔP) = 70 + 986 + (10.10 x 200) = 3076 in. lbs.

Although the valve opening torque is normally the highest operating torque used in actuator sizing, it is often necessary with flowing liquids to check for total hydrodynamic torque. Refer to Section II for data on calculating total hydrodynamic torque.

TABLE I

CLASS 150 STANDARD RATING

VALVE SIZE	PRELOAD TORQUE = $T_1 + T_2$								STATIC PRESSURE TORQUE PER PSI T_3
	T_1			T_2					
	A	B	C	E	F	G	H	J	
3"	302	28	227	122	73	61	244	280	0.24
4"	338	31	254	218	131	109	436	501	0.50
6"	454	42	340	510	306	255	1020	1173	1.56
8"	529	49	397	902	541	451	1804	2074	3.23
10"	680	63	510	1398	839	699	2796	3215	6.44
12"	756	70	567	1972	1183	986	3944	4535	10.10
14"	832	77	624	2424	1454	1212	4848	5575	13.66
16"	907	84	680	3164	1898	1582	6328	7277	19.44
18"	1058	98	794	3994	2396	1997	7988	9186	28.64
20"	1210	112	907	4914	2948	2457	9828	11302	40.28
24"	1512	140	1134	7564	4538	3782	15128	17397	77.48
30"	1814	168	1361	11982	7189	5991	23964	27558	147.28
36"	2268	210	1701	17426	10456	8713	34852	40080	267.76
42"	2419	672	1814	23795	14277	11897	47590	54728	390.00
48"	2722	756	2041	30864	18518	15432	61728	70987	569.00
54"	2722	756	2041	39849	23909	19924	79698	91653	734.70
60"	3024	840	2268	49280	29568	24640	98561	113345	1010
66"	3326	924	2495	59937	35962	29969	119875	137856	1351
72"	3629	1008	2722	71355	42813	35677	142709	164115	1754

CLASS 150 150PSI RATING

VALVE SIZE	PRELOAD = $T_1 + T_2$								STATIC PRESSURE TORQUE PER PSI T_3
	T_1			T_2					
	A	B	C	E	F	G	H	J	
24"	1210	112	907	7194	4316	3597	14388	16546	58.96
30"	1512	140	1134	12038	7223	6019	24076	27687	123.32
36"	1663	154	1247	17420	10452	8710	34840	40066	196.28
42"	1966	546	1474	23846	14308	11923	47693	54847	317.50
48"	2268	630	1701	31069	18642	15535	62139	71460	477.30
54"	2268	630	1701	39849	23909	19924	79698	91653	612.12
60"	2268	630	1701	49484	29691	24742	98969	113814	760.30
66"	3024	840	2268	59937	35962	29969	119875	137856	1228
72"	3024	840	2268	71661	42997	35830	143322	164820	1468

Valve torque (opening) = $T_1 + T_2 + (T_3 \times PSI\Delta P)$

Valve torque (closing, on-off service) = $T_1 + T_2 + (.5T_3 \times PSI\Delta P)$

Valve torque (closing, modulating service) = $T_1 + T_2 + (T_3 \times PSI\Delta P)$

When the operating ΔP used for actuator selection is less than the maximum line pressure, contact the factory for sizing torque.

NOTES:

T_1 (A) Asbestos jam packing

(B) Teflon Chevron packing

(C) Graphite jam packing

T_2 (E) Urethane seal ring with rubber back-up ring, Metal seal ring with and without rubber back-up ring, Kel-F seal ring without rubber back-up ring

(F) Teflon seal ring with Teflon back-up ring, Tefzel seal ring with rubber back-up ring

(G) Teflon seal ring with rubber back-up ring

(H) Metal seal ring with Teflon insert and rubber back-up ring

(J) Metal seal ring with urethane, Tefzel, or Kel-F insert and rubber back-up ring

TABLE 2
CLASS 300 STD. RATING

VALVE SIZE	PRELOAD TORQUE = $T_1 + T_2$								STATIC PRESSURE TORQUE PER PSI T_3
	T_1			T_2					
	A	B	C	E	F	G	H	J	
......	....	......	....	....	....	....	....	....	....
......	....	......	....	....	....	....	....	....	....
3"	302	28	227	122	73	61	244	280	0.24
4"	338	31	254	218	131	109	436	501	0.50
6"	454	42	340	510	306	255	1020	1173	1.56
8"	756	70	567	750	450	375	1500	1725	3.84
10"	907	84	680	1242	745	621	2484	2857	7.64
12"	1058	98	794	1722	1063	886	3544	4076	12.70
14"	1210	112	907	2160	1296	1080	4321	4968	17.71
16"	1361	126	1021	3164	1898	1582	6328	7277	29.16
18"	1512	140	1134	3602	2161	1801	7204	8285	36.90
20"	1814	168	1361	4534	2720	2267	9068	10428	55.74
24"	2117	196	1588	7564	4538	3782	15128	17397	108.46
30"	2722	252	2041	10764	6458	5382	21528	24757	198.45
36"	3024	280	2268	16278	9767	8139	32556	37439	333.46
42"	3175	294	2381	23402	14041	11701	46804	53825	503.30
48"	4234	392	3175	30383	18230	15192	60766	69881	871.40

Valve torque (opening) = $T_1 + T_2 + (T_3 \times PSI\Delta P)$

Valve torque (closing, on-off service) = $T_1 + T_2 +$ $(.5T_3 \times PSI\Delta P)$

Valve torque (closing, modulating service) = $T_1 + T_2 +$ $(T_3 \times PSI\Delta P)$

When the operating ΔP used for actuator selection is less than the maximum line pressure, contact the factory for sizing torque.

NOTES:

T_1 (A) Asbestos jam packing
(B) Teflon Chevron packing
(C) Graphite jam packing

T_2 (E) Urethane seal ring with rubber back-up ring, Metal seal ring with and without rubber back-up ring, Kel-F seal ring without rubber back-up ring
(F) Teflon seal ring with Teflon back-up ring, Tefzel seal ring with rubber back-up ring
(G) Teflon seal ring with rubber back-up ring
(H) Metal seal ring with Teflon insert and rubber back-up ring
(J) Metal seal ring with urethane, Tefzel, or Kel-F insert and rubber back-up ring

TABLE 3
TORQUE VALUES (In. Lbs.)
Class 600 Posi-Seal Trunnion Valves

VALVE SIZE	PRELOAD TORQUE ($T_1 + T_2$)									STATIC PRESSURE TORQUE PER PSI T_3
	T_1				T_2					
	A	B	C	D	E	F	G	H	J	
3"	342	AVAILABLE ON APPLICATION	257	95	120	72	NOT AVAILABLE IN CLASS 600	AVAILABLE ON APPLICATION	276	0.27
4"	454		340	126	202	121			465	0.63
6"	529		397	147	496	298			1141	1.77
8"	907		680	252	770	462			1771	4.73
10"	1058		794	294	1234	750			2838	8.85
12"	1361		1021	378	1724	1034			3965	15.89
14"	1512		1134	420	2078	1247			4779	21.29
16"	1814		1361	504	2698	1619			6205	33.17
18"	2117		1588	588	3532	2119			8124	50.64
20"	2419		1814	672	4238	2543			9747	69.4
24"	2722		2041	756	6422	3853			14770	118.4

Valve torque (opening) = $T_1 + T_2 + (T_3 \times PSI\Delta P)$

Valve torque (closing, on-off service) = $T_1 + T_2 + (.5T_3 \times PSI\Delta P)$

Valve torque (closing, modulating service) = $T_1 + T_2 + (T_3 \times PSI\Delta P)$

When the operating ΔP used for actuator selection is less than the maximum line pressure, contact the factory for sizing torque.

NOTES:

T_1
- (A) Asbestos jam packing
- (B) Teflon Chevron packing -- available on application
- (C) Graphite jam packing
- (D) Teflon jam packing

T_2
- (E) Metal seal ring with and without rubber back-up ring, Kel-F ring without rubber back-up ring
- (F) Tefzel seal ring with rubber back-up ring
- (G) Not available on Class 600
- (H) Metal seal ring with Teflon insert and rubber back-up ring — available on application
- (J) Metal seal ring with Tefzel, or Kel-F insert and rubber back-up ring (urethane insert available on application)

II. TOTAL VALVE OPERATING HYDRODYNAMIC TORQUE

As previously stated the valve opening torque is normally the highest operating torque used for actuator sizing and selection. However, when flowing liquids, it is often necessary to calculate the total valve operating hydrodynamic torque.

The location of the maximum valve operating torque (total hydrodynamic torque) is a result of the overall system operating parameters in addition to the particular valve disc hydrodynamic torque characteristics.

When the ratio of thru valve ΔP to total system ΔP is high, generally above 25 percent, the maximum valve operating hydrodynamic torque will occur at or about the 70° to 80° disc open position. As this ratio decreases, the maximum valve operating hydrodynamic torque will shift towards the 0° shut position.

To allow for system operating variables it is recommended that the maximum valve operating hydrodynamic torque (TH_T) be calculated at both the 20° and 80° disc open position.

The total valve operating hydrodynamic torque (TH_T) is the summation of three torque components. These components are: stem packing torque (T_1), stem bearing friction torque (static pressure torque per PSIΔP) and the disc hydrodynamic lift and drag torque. Torque values T_1 and T_3 can be found in Tables 1 thru 3.

Extensive flow testing has shown that the disc hydrodynamic lift and drag torque values are dependent upon the direction of flow entering the valve. With liquid flow entering the valve from the stem side, with the seal retaining downstream, the disc hydrodynamic lift and drag torque value (T_4) is positive to the full open position acting to return the disc to the shut position. Liquid flow entering the valve from the opposite direction, seal retaining ring up stream, results in a torque value that remains positive, acting to return the disc to the shut position, until about the 70° to 80° open position. At this point the torque value becomes negative acting to move the disc to the full open position. With liquid flow in this direction the disc hydrodynamic lift and drag torque values are designated as T_5. Also, test results have shown that flowing liquids in this direction results in a positive T_5 value that is lower than the corresponding T_4 value with flow in opposite direction.

By utilizing torque values T_1 and T_3 along with the applicable disc hydrodynamic lift and drag torque values T_4 or T_5 listed in Tables 4 thru 9, the total valve operating hydrodynamic torque TH_T can be calculated as follows:

RETAINING RING DOWNSTREAM

$$TH_T = T_1 + (T_3 \Delta P) + (T_4 \Delta P)\, G_f$$

RETAINING RING UPSTREAM

$$TH_T = T_1 + (T_3 \Delta P) + (T_5 \Delta P)\, G_f$$

TH_T = Total valve operating hydrodynamic torque, in. lbs.

T_1 = Packing torque, in. lbs. Tables 1, 2, and 3.

T_3 = Stem bearing friction torque (static pressure torque per PSIΔP), in. lbs. Tables 1, 2, and 3.

T_4 = Disc hydrodynamic lift and drag torque, in. lbs. Flow into valve with retaining ring downstream.

T_5 = Disc hydrodynamic lift and drag torque, in. lbs. Flow into value with retaining ring upstream.

ΔP = Differential pressure across valve, PSI.

G_f = Specific gravity of liquid at flowing conditions.

$$G_f = \frac{\text{Density of liquid at flowing conditions}}{\text{Density of water at standard conditions}}$$

EXAMPLE:

A. Requirement – What is the total value hydrodynamic torque of a 12" CLASS 150 Valve with teflon chevron packing, flowing water into the valve from the stem side (retaining ring downstream) with a calculated ΔP of 10 PSI at the 70° disc open position.

B. Solution –

$TH_T = T_1 + (T_3 \Delta P) + (T_4 \Delta P)\, G_f$

$TH_T = 70 + [10.10\,(10)] + [692\,(10)]\ 1.0$

$TH_T = 7091$ in. lbs.

Where –

T_1 = 70 in. lbs.

T_3 = 10.10 in. lbs.

T_4 = 692

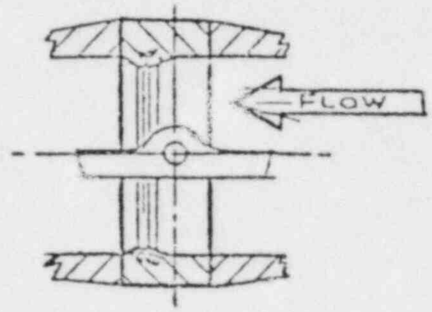
G_f = 1.0

NOTE:

When in doubt about the maximum total value hydrodynamic torque for a specific application, contact Posi-Seal factory for assistance.

TABLE 4

CLASS 150 STD RATING



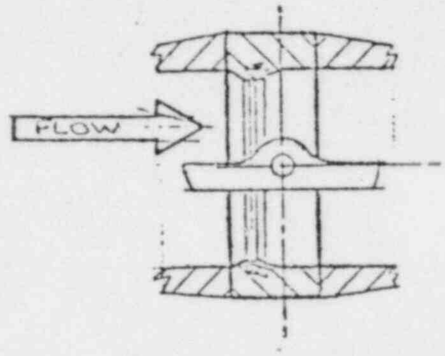
Seal Retaining Ring Downstream
Disc Hydrodynamic Lift & Drag Torque – T_4

VALVE SIZE	T_4 VS. OPEN POSITION								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
......	....	....	....	....	....	....	....	....	....
......	....	....	....	....	....	....	....	....	....
3"	0	0	0	0	1	2	5	6	5
4"	0	0	1	1	3	6	12	16	13
6"	1	2	4	8	13	27	51	68	56
8"	4	10	16	30	49	100	185	247	204
10"	6	16	26	49	79	161	300	399	330
12"	15	38	60	114	182	372	692	920	761
14"	23	59	94	177	283	579	1075	1430	1182
16"	41	102	164	307	492	1005	1876	2482	2052
18"	64	162	259	486	778	1590	2953	3927	3245
20"	99	248	397	746	1193	2437	4526	6019	4974
24"	214	536	858	1610	2576	5259	9768	12988	10734
30"	462	1156	1850	3469	5551	11334	21049	27988	23131
36"	1884	4710	7537	14132	22611	46164	85734	113998	94213
42"	2281	5704	9127	17114	27383	55908	103829	138058	114098
48"	3265	8164	13063	24494	39191	80016	148602	197592	163299
54"	7388	18471	29554	55414	88662	181020	336180	447008	369428
60"	11165	27913	44661	83740	133984	273552	508026	675506	558270
66"	14942	37355	59768	112066	179306	366084	679972	904005	747112
72"	22995	57488	91981	172465	275945	563388	1046293	1391225	1149773
CLASS 150 150 PSI RATING									
24"	255	637	1020	1913	3061	6251	11609	15437	12758
30"	857	2144	3431	6433	10293	21016	39030	51897	42890
36"	1792	4480	7168	13441	21505	43907	81542	108424	89607
42"	3202	8007	12811	24021	38434	78469	145729	193772	160142
48"	5412	13530	21648	40591	64946	132598	246254	327437	270609
54"	7336	18341	29346	55025	88040	179749	333820	443871	366835
60"	14428	36072	57715	108216	173146	353506	656512	872945	721442
66"	14942	37355	59768	112066	179306	366084	679872	904005	747112
72"	30124	75310	120496	225931	361490	738044	1370653	1822516	1506212

1. T_4 values = in. lbs. per PSIΔP.
2. All T_4 values are positive acting to shut valve.
3. 0 T_4 values $\cong <1$.

TABLE 5

CLASS 150 STD. RATING



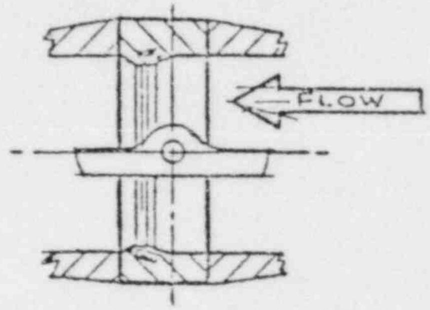
Seal Retaining Ring Upstream
Disc Hydrodynamic Lift & Drag Torque – T_5

VALVE SIZE	T_5 VS. DISC OPEN POSITION								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
3"	0	0	0	0	0	1	1	0	–5
4"	0	0	0	0	1	3	4	0	–13
6"	0	1	2	2	5	13	19	–1	–56
8"	2	4	8	10	18	46	69	–4	–204
10"	3	6	13	16	29	75	112	–6	–330
12"	7	15	30	38	68	175	258	–15	–761
14"	11	23	47	59	106	271	402	–23	–1182
16"	20	41	82	102	184	471	697	–41	–2052
18"	32	64	129	162	292	746	1103	–64	–3245
20"	49	99	198	248	447	1144	1691	–99	–4974
24"	107	214	429	536	966	2468	3649	–214	–10734
30"	231	462	925	1156	2081	5320	7864	–462	–23131
36"	942	1884	3768	4710	8479	21669	32032	–1884	–94213
42"	1140	2281	4563	5704	10268	26242	38793	–2281	–114098
48"	1632	3265	6531	8164	14696	37558	55521	–3265	–163299
54"	3694	7388	14777	18471	33248	84968	125605	–7388	–369428
60"	5583	11165	22330	27913	50244	128402	189812	–11165	–558270
66"	7471	14942	29884	37355	67240	171835	254018	–14942	–747112
72"	11497	22995	45990	57488	103479	264447	390922	–22995	–1149773
CLASS 150 150 PSI RATING									
24"	127	255	510	637	1148	2934	4337	–255	–12758
30"	428	857	1715	2144	3860	9864	14582	–857	–42890
36"	896	1792	3584	4480	8064	20609	30466	–1792	–89607
42"	1601	3202	6405	8007	14412	36832	54448	–3202	–160142
48"	2706	5412	10824	13530	24354	62240	92007	–5412	–270609
54"	3668	7336	14673	18341	33015	84372	124724	–7336	–366835
60"	7214	14428	28857	36072	64929	165931	245290	–14428	–721442
66"	7471	14942	29884	37355	67240	171835	254018	–14942	–747112
72"	15062	30124	60248	75310	135559	346428	512112	–30124	–1506212

1. T_5 values = in. lbs. per PSIΔP.
2. Except as noted, T. values are positive acting to shut valve.
3. Negative (–) T_5 values act to move the disc to the full open (90°) position.
4. 0 T_5 values ≅ < 1.

TABLE 6

CLASS 300 STD RATING



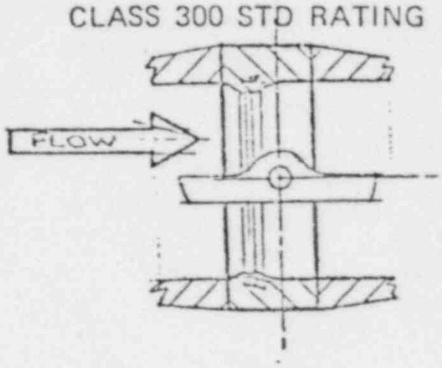
Seal Retaining Ring Downstream
Disc Hydrodynamic Lift & Drag Torque – T_4

VALVE SIZE	T_4 VS. DISC OPEN POSITION								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
......	......	....	....	....	....	....	....	....	....
......	......	....	....	....	....	....	....	....	....
3"	0	0	0	0	1	2	5	6	5
4"	0	0	1	1	3	6	12	16	13
6"	1	2	4	8	13	27	51	68	56
8"	1	4	7	11	21	34	57	81	68
10"	3	9	17	27	51	81	136	192	162
12"	7	21	39	60	113	179	298	422	355
14"	9	29	54	84	158	250	416	590	495
16"	12	37	68	105	198	313	520	737	620
18"	28	86	158	244	460	726	1208	1711	1438
20"	30	92	169	261	493	778	1294	1833	1540
24"	41	125	229	355	668	1054	1754	2485	2088
30"	143	429	788	1218	2292	3618	6019	8526	7165
36"	287	861	1579	2441	4596	7253	12065	17092	14363
42"	686	2058	3773	5381	10976	17321	28812	40817	34300
48"	429	1287	2359	3646	6864	10832	18018	25526	21451

1. T_4 values = in. lbs. per PSIΔP.
2. All T_4 values are positive acting to shut valve.
3. 0 T_4 values $\cong <$ 1.

TABLE 7

CLASS 300 STD RATING



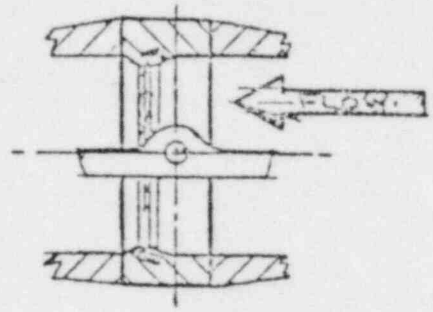
Seal Retaining Ring Upstream
Disc Hydrodynamic Lift & Drag Torque – T_5

VALVE SIZE	T_5 VS. DISC OPEN POSITION								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
......	......	......	......	....	....	....	....	....	....
......	......	......	......	....	....	....	....	....	....
3"	0	0	0	0	0	1	1	0	–5
4"	0	0	0	0	1	3	4	0	–13
6"	0	1	2	2	5	13	19	–1	–56
8"	0	1	2	6	8	10	4	–22	–68
10"	1	3	6	14	21	24	11	–53	–162
12"	3	7	14	31	46	53	24	–117	–355
14"	4	9	19	44	64	74	34	–163	–495
16"	6	12	24	55	80	93	43	–204	–620
18"	14	28	57	129	187	215	100	–474	–1438
20"	15	30	61	138	200	231	107	–508	–1540
24"	20	41	83	187	271	313	146	–689	–2088
30"	71	143	286	644	931	1074	501	–2364	–7165
36"	143	287	574	1292	1867	2154	1005	–4739	–14363
42"	343	686	1372	3087	4459	5145	2401	–11319	–34300
48"	214	429	858	1930	2788	3217	1501	–7078	–21451

1. T_5 values = in. lbs. per PSIΔP.
2. Except as noted, T_5 values are positive acting to shut valve.
3. Minus T_5 values are negative and act to move the disc to the full open (90°) position.
4. 0 T_5 values $\cong <$ 1.

TABLE 8

CLASS 600 STD RATING



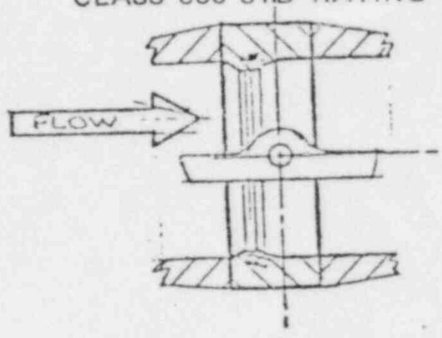
Seal Retaining Ring Downstream
Disc Hydrodynamic Lift & Drag Torque – T_4

VALVE SIZE	T_4 VS. DISC OPEN POSITION								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
3"	0	0	0	0	0	0	0	0	0
4"	0	0	0	0	0	0	0	0	0
6"	0	1	3	3	6	8	13	14	13
8"	0	5	10	12	19	27	44	46	43
10"	1	13	26	29	48	67	107	112	105
12"	1	20	38	43	71	99	158	165	154
14"	2	27	52	58	96	133	213	223	208
16"	2	36	69	78	128	178	284	298	279
18"	3	43	83	93	153	214	341	358	334
20"	3	41	79	88	146	203	324	340	317
24"	12	166	319	357	587	818	1303	1367	1278

1. T_4 values = in. lbs. per PSIΔP.
2. All T_4 values are positive acting to shut valve.
3. 0 T_4 values $\cong < 1$.

TABLE 9

CLASS 600 STD RATING



Seal Retaining Ring Upstream
Disc Hydrodynamic Lift & Drag Torque – T_5

VALVE SIZE	T_5 VS. DISC OPEN POSITION								
	10°	20°	30°	40°	50°	60°	70°	80°	90°
3"	0	0	0	0	0	0	0	0	0
4"	0	0	0	0	0	0	0	0	0
6"	0	0	1	2	3	2	0	–6	–13
8"	0	2	3	8	9	9	–2	–22	–43
10"	1	5	9	21	24	22	–6	–55	–105
12"	1	7	13	30	35	32	–9	–82	–154
14"	2	10	18	41	48	43	–12	–110	–208
16"	2	13	25	55	64	58	–16	–147	–279
18"	3	16	30	66	76	70	–20	–177	–334
20"	3	15	28	63	73	66	–19	–168	–317
24"	12	63	115	255	293	268	–76	–677	–1278

1. T_5 values = in. lbs. per PSIΔP.
2. Except as noted, T_5 values are positive acting to shut valve.
3. Negative (–) T_5 values act to move the disc to the full open (90°) position.
4. 0 T_5 values $\cong < 1$.

III. AERODYNAMIC TORQUE

Aerodynamic torque resulting from gaseous flow is negligible compared to Hydrodynamic torque. However, when in doubt concerning a specific application (such as applications where flow is sonic) consult the factory.

IV. ACTUATOR SELECTION

Published torque values for Posi-Seal Trunnion Valves include adequate safety factors and do not require additional safety factors. However, when sizing actuators for specific valve torque requirements, decrease the published actuator torques by at least 10% to allow for a realistic safety factor in actuator selection. When selecting fail safe actuators, the torque output at the end of the actuator spring stroke (ending torque) should be used as the basis for actuator selection. When the operating ΔP used for actuator selection is less than maximum line pressure, contact the factory for sizing torque.

USI-SEAL VALVE TORQUES

ITEM — CLOSING TORQUE

1. VALVE SIZE=18 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING
1.75	16.654	47.3	3

T1= 1,058.4 T2= 2,396.3 T3= 677.2 TOTAL TORQUE= 4,132.0

2. VALVE SIZE=20 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING
2	18.474	47.3	3

T1= 1,209.6 T2= 2,948.7 T3= 952.4 TOTAL TORQUE= 5,110.7

3. VALVE SIZE=20 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING
2	18.474	47.3	3

T1= 1,209.6 T2= 2,948.7 T3= 952.4 TOTAL TORQUE= 5,110.7

4. VALVE SIZE=8 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING
.875	7.912	47.3	3

T1= 529.2 T2= 540.8 T3= 76.4 TOTAL TORQUE= 1,146.4

5. VALVE SIZE=20 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING
2	18.474	47.3	3

T1= 1,209.6 T2= 2,948.7 T3= 952.4 TOTAL TORQUE= 5,110.7

6. VALVE SIZE=18 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING
1.75	16.654	47.3	3

T1= 1,058.4 T2= 2,396.3 T3= 677.2 TOTAL TORQUE= 4.132.0

12/20/75

SEAL 2 BEARING 1

LB

SEAL 2 BEARING 1

LB

SEAL 2 BEARING 1

LB

SEAL 2 BEARING 1

LB

SEAL 2 BEARING 1

LB

SEAL 2 BEARING 1

LB

7. VALVE SIZE=24 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING	SEAL	BEARING
2.5	22.918	47.3	3	2	1

T1= 1,512.0 T2= 4,538.0 T3= 1,832.2 TOTAL TORQUE= 7,882.2 IN-LB

8. VALVE SIZE=4 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING	SEAL	BEARING
.562	3.896	47.3	3	2	1

T1= 339.8 T2= 131.1 T3= 11.9 TOTAL TORQUE= 482.9 IN-LB

9. VALVE SIZE=4 VALVE CLASS=150

STEM DIA.	DISC DIA.	PRESSURE	PACKING	SEAL	BEARING
.562	3.896	47.3	3	2	1

T1= 339.8 T2= 131.1 T3= 11.9 TOTAL TORQUE= 482.9 IN-LB

PACKING CODE : 3 ASBESTOS

SEAL CODE : 2 TEFZEL

BEARING CODE : 1 TYPE 316 S.S. WITH MICROSEAL

ATTACHMENT 2

BRUNSWICK STEAM ELECTRIC PLANT UNIT NOS. 1 AND 2

SEISMIC CALCULATIONS FOR CONTAINMENT PURGE AND VENT VALVES

8/28/72

SEISMIC LOADS ON VALVES

JOB NO: 4

CALCULATED BY: John McCoy

2/28/72

SEISMIC LOADS ON VALVES

REFERENCES: (a) DWG SK 6339, 18"-150LB 275 WOG

(b) DWG SK6340, 18"-150 LB 275 WOG

(c) DWG SK 6341, 20"-150 LB 275 WOG

(d) DWG SK 6342, 20"-150LB 275 WOG

(e) DWG SK 6344, 24"-150 LB 275 WOG

(f) DWG SK 6343, 20"-150 LB 275 WOG

(g) DWG SK 6322, 4"-150 LB ANSI

(h) DWG SK 6323, 4"-150 LB ANSI

(i) DWG SK 6338, 8"-150 LB ANSI

8/25/72

FROM A PREVIOUS ANALYSIS ON DWG SK 6015 IT IS OBVIOUS THAT THE NATURAL FREQUENCY OF THE CANTILEVERED OPERATOR FOR THESE VALVES IS WELL ABOVE 25 CPS.

THEREFORE, A STATIC ANALYSIS CAN BE USED TO DETERMINE THE STRESS VALUES IN THE VALVES OF REF. (a)-(i).

SEISMIC LOADS FOR A STATIC ANALYSIS ARE FOUND USING 3 g HORIZONTAL AND 2 g VERTICAL.

FOR THESE CALCULATIONS IT SHALL BE ASSUMED THAT THE HORIZONTAL FORCES IN BOTH ORTHOGONAL DIRECTIONS AND THE VERTICAL FORCES ACT SIMULTANEOUS

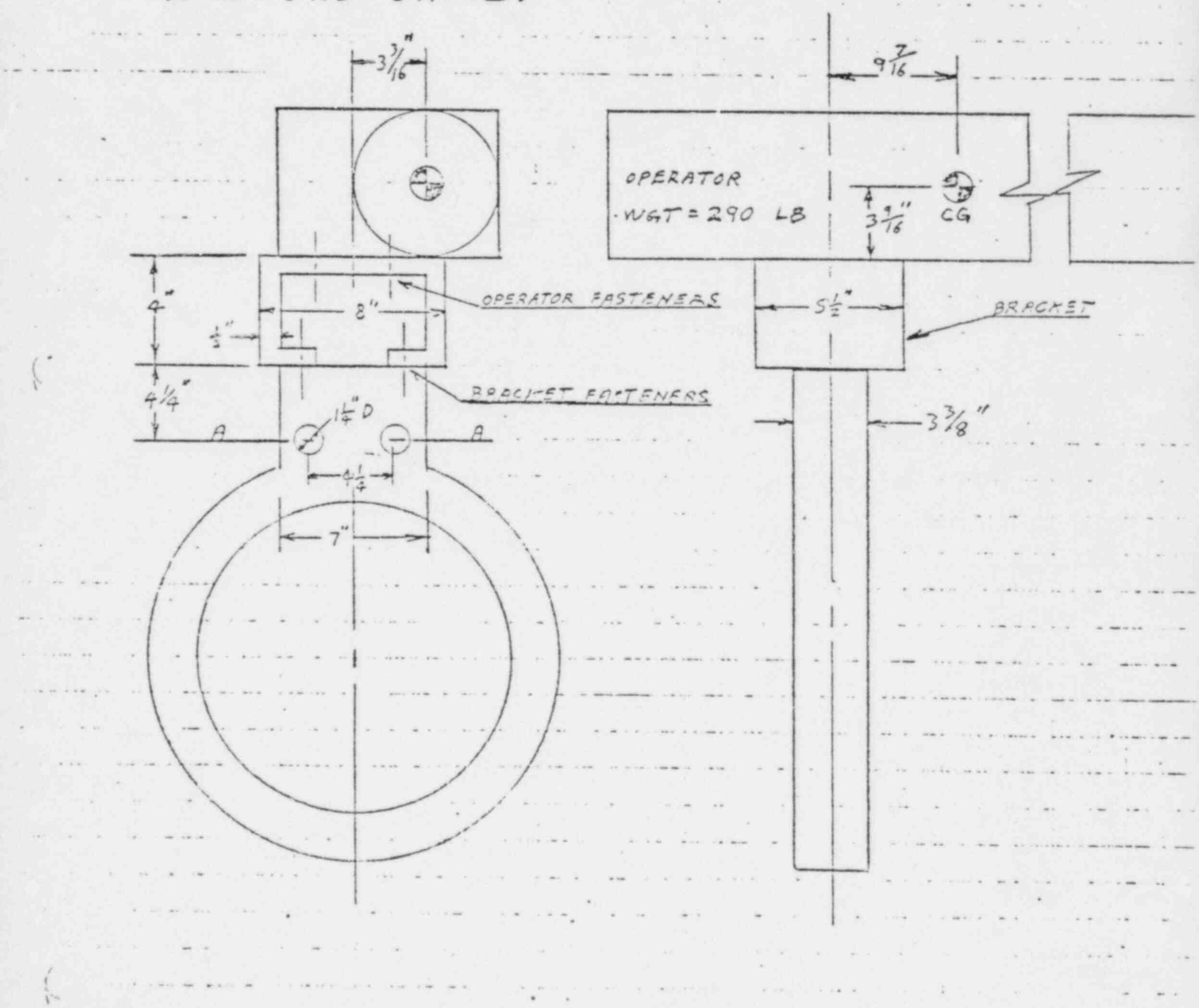
ANALYSIS OF DRAWINGS

SK 6339, SK 6340, SK 6341.

SK 6342 AND SK 6344

STRESS ANALYSIS OF VALVES SK 6339, SK 6340, 6341, 6342, AND 6344.

NOTE:
ANALYSIS IS THE SAME FOR ALL DRAWINGS SINCE OPERATORS, BOLTING, AND BRACKETS ARE THE SAME.



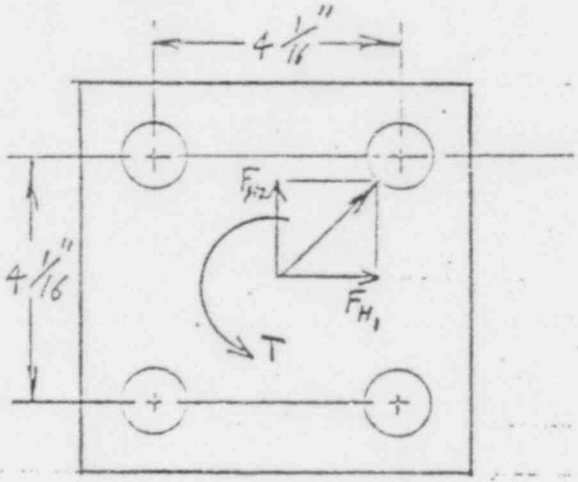
SEISMIC LOADS FROM OPERATOR:

HORIZONTAL: 3(290) = 870 LB AT CG

VERTICAL: 2(290) = 580 LB AT CG

BOLT PATTERN OF OPERATOR FASTENERS

4 BOLTS 3/4" - 10 UNC 1" DEEP THREADED HOLES.



F_{H1} = HORIZONTAL FORCE (870 ...
F_{H2} = HORIZONTAL FORCE (870 ...
T = TWIST DUE TO HORIZ. FORCES ACTING AT CG OF OPERATOR:

$$T = 870(3.1875) + 870(9.4375) = 10{,}975 \text{ IN-LB}$$

$$F_{HR} = \sqrt{F_{H1}^2 + F_{H2}^2} = \sqrt{870^2 + 870^2} = 1230 \text{ LB}$$

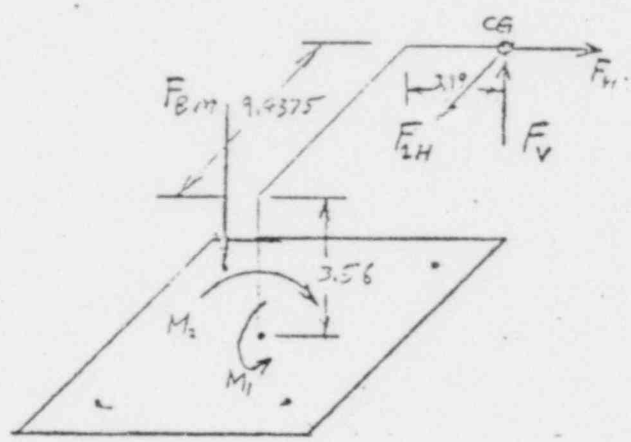
∴ MAX SHEAR FORCE ON A BOLT IS

$$\frac{F_{HR}}{4} + \frac{T \cos 45^\circ}{2.031(4)} = \frac{1230}{4} + \frac{10975(.707)}{(4)2.031} = 1263$$

STRESS AREA OF BOLT = .334 IN^2

SHEAR STRESS = $\frac{1263}{.334}$ = 3790 PSI

MAX BOLT TENSILE STRESS IN BOLT!



$M_2 = F_{H1}(3.56) - F_V(3.19) = 870(3.56) - 580(3.19)$

M_2 = 1250 IN-LB

$M_1 = F_{H2}(3.56) + F_V(9.438) = 870(3.55) + 580(9.438)$

M_1 = 8570 IN-LB

$F_{BMAX} = \frac{M_2}{4.0625(2)} + \frac{M_1}{4.0625(2)} + \frac{F_V}{4}$ = 1354 LB

TENSILE STRESS = $\frac{F_{B\,MAX}}{.334} = \frac{1354}{.334}$ = 4060 PS

COMBINED STRESS:

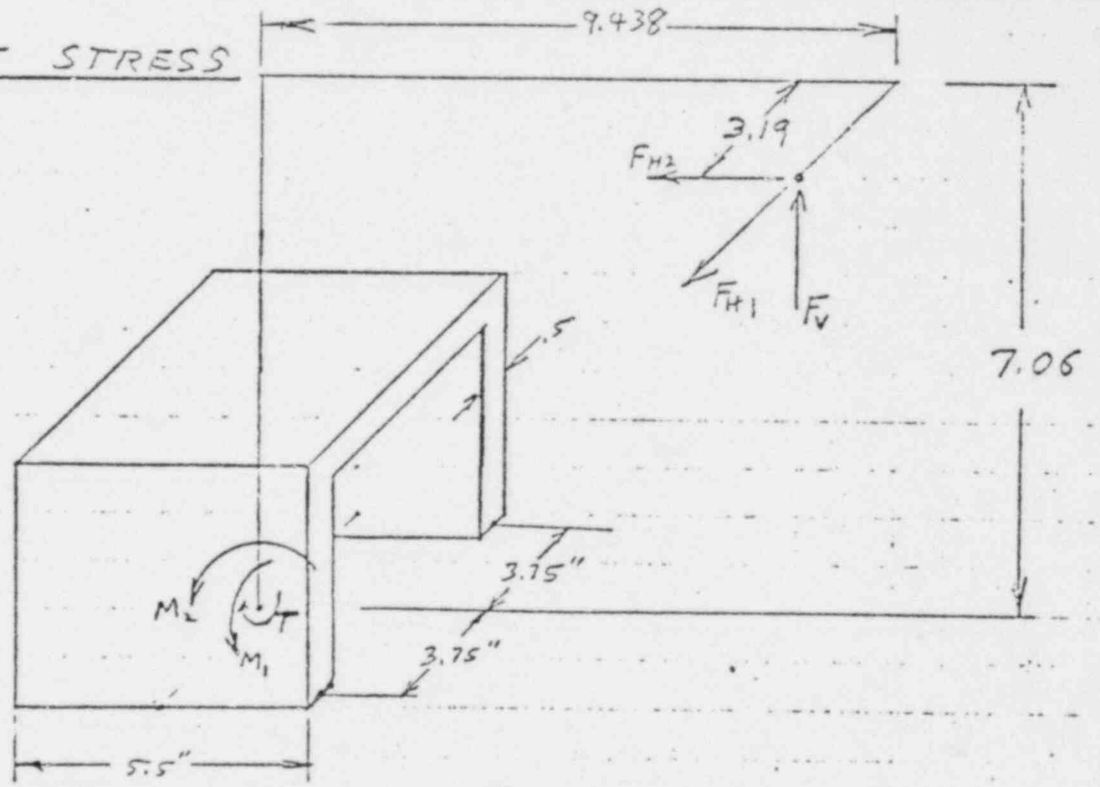
MAX SHEAR THEORY $\tau_{max} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$

$$\tau_m = \sqrt{\left(\frac{4060}{2}\right)^2 + (3790)^2} = 4280 \text{ PSI SHEAR}$$

EQUIVALENT TENSILE STRESS = 2(4280)

= **8560 PSI** → FOR OPERATOR BOLT

BRACKET STRESS



$$M_1 = F_{H1}(7.06) - F_V(3.19) = 870(7.06) - 580(3.19)$$

$$M_1 = 4330 \text{ IN-LB}$$

$M_2 = F_{H2}(7.06) + F_V(9.939) = 870\ (7.06) + 590\ (9.93$

$M_2 = 11{,}530$ IN-LB

$T = F_{H1}(9.438) + F_{H2}(3.19) = 870\ (9.438) + 870\ (3.19$

$T = 10{,}975$ IN-LB

STRESSES

DUE TO M_1: $S_1 = \frac{M_1}{7.5(.5)(5.5)} = \frac{4330}{7.5(.5)(5.5)} = \underline{210.}$ P

DUE TO M_2: $S_2 = \frac{M_2}{Z}$ $Z = \frac{bh^2}{6} = \frac{2(.5)(5.5)^2}{6} = 5.04$ IN

$S_2 = \frac{11530}{5.04} = \underline{2290}$ PSI

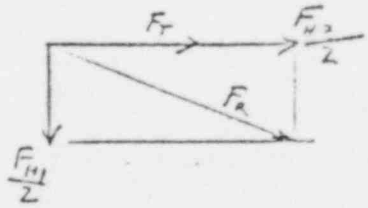
DUE TO F_V: $S_V = \frac{F_V}{2(.5)(5.5)} = \underline{105.5}$ PSI

COMBINED TENSILE STRESS:

$S_C = S_1 + S_2 + S_V = 210 + 2290 + 105.5 = \underline{2605.5\text{ PSI}}$

SHEAR STRESS:

FORCES: $F_T = \frac{T}{7.5} = \frac{10975}{7.5} = 1465$ LB



$F_R = \sqrt{\left(F_T + \frac{F_{H2}}{2}\right)^2 + \frac{F_{H1}}{2}^2}$

ONE SIDE

$$F_R = \sqrt{\left(1465 + \frac{270}{2}\right)^2 + \frac{270}{2}^2} = 380 \text{ LB}$$

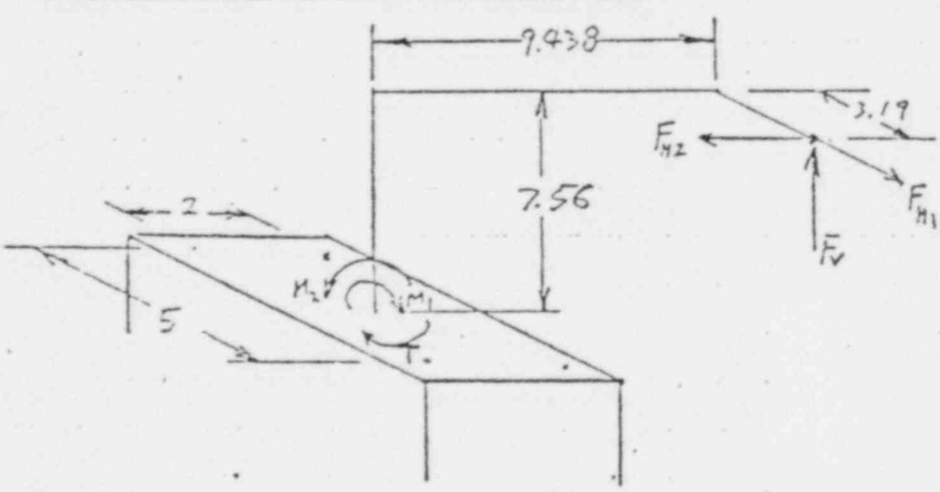
$$S_S = \frac{F_R}{.5(5.5)} = \underline{138} \text{ PSI}$$

COMBINED TENSILE AND SHEAR STRESS:

$$\tau_m = \sqrt{\left(\frac{2606}{2}\right)^2 + (138)^2} = 1310 \text{ PSI}$$

EQUIVALENT MAX TENSILE STRESS IN BRACKET:
$S_{eq} = 2(1310) = \underline{2620 \text{ PSI}}$

BRACKET FASTENER



3/4 -10 UNC

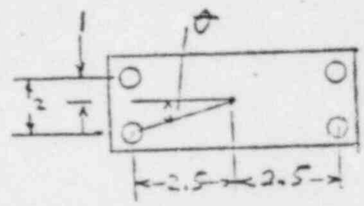
STRESS AREA = .334 IN²

$$M_1 = (870)(7.56) - (580)(3.19) = 4720 \text{ IN-LB}$$

$$M_2 = (870)(7.56) + (580)(9.438) = 12050 \text{ IN-LB}$$

$$T = (870)(3.19) + (870)(9.438) = 10,975 \text{ IN-LB}$$

$$F_{m1} = \frac{M_1}{2(5)} = 472 \text{ LB}$$



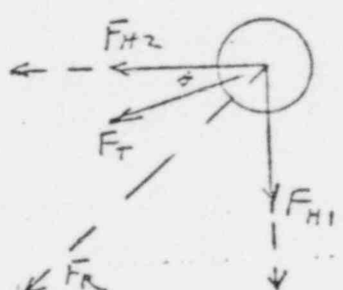
$$F_{m2} = \frac{M_2}{2(2)} = 3012 \text{ LB}$$

$$F_{FV} = \frac{F_V}{4} = 145 \text{ LB}$$

$$Tan\ \theta = \frac{1}{2.5} = .4$$
$$\theta = 21.8^\circ$$

SHEAR FORCE:

$$F_T = \frac{T \cos\theta}{(2.5)\,4} = \frac{10975(.93)}{(2.5)\,4} = 1020 \text{ LB per b}$$



$$F_R = \sqrt{(F_{H2} + F_T \cos\theta)^2 + (F_{H1} + F_T \sin\theta)^2}$$

$$F_R = \sqrt{[870 + (1020)(.93)]^2 + [870 + (1020)(.371)]^2} = 2210$$

BOLT STRESS:

TENSILE:

$$S_T = \frac{F_{m_1} + F_{m_2} + F_{FV}}{.334} = \frac{472 + 3012 + 145}{.334}$$

$$S_T = 10850 \text{ PSI}$$

SHEAR:

$$S_S = \frac{F_R}{.334} = \frac{2210}{.334} = \underline{6620 \text{ PSI}}$$

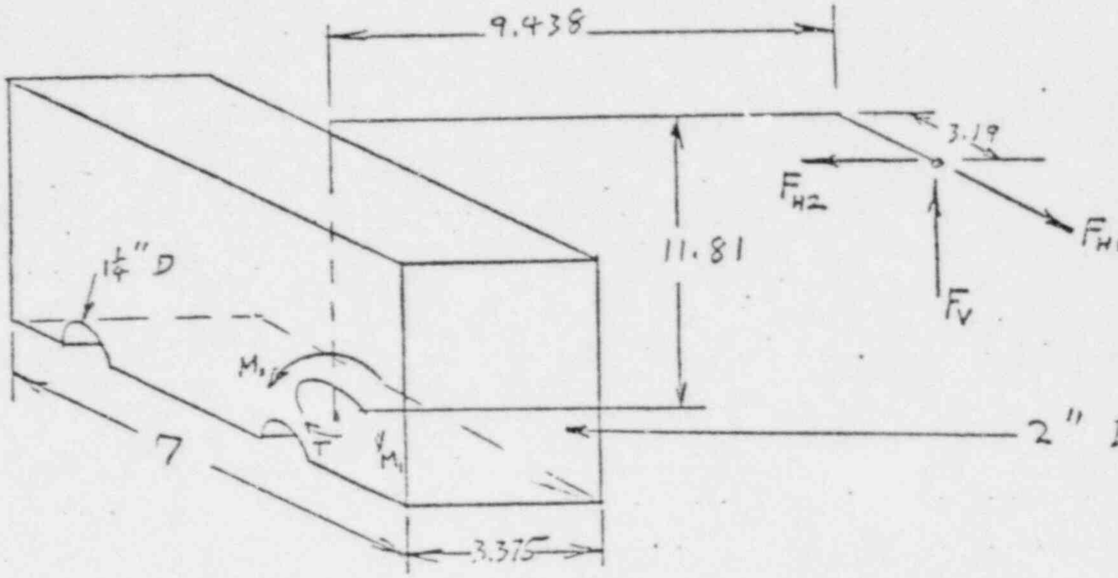
COMBINED STRESS

$$\tau_m = \sqrt{\left(\frac{10850}{2}\right)^2 + (6620)^2} = 8560 \text{ PSI}$$

EQUIVALENT TENSILE STRESS (MAX)

$$S_{eq} = 2(8560) = \underline{17120 \text{ PSI}}$$

SECTION A-A



$$M_1 = (870)(11.81) - (580)(3.19) = 8450 \text{ IN-LB}$$

$$M_2 = (870)(11.81) + (580)(9.438) = 15770 \text{ IN-LB}$$

$$T = (870)(3.19) + (870)(9.438) = 10975 \text{ IN-LB}$$

$$A = 3.375(7.0) - 2.5(3.375) - \frac{\pi}{4}(2)^2 = 12.0 \text{ IN}^2$$

$$Z_1 = \left[\frac{3.375(7.0)^3}{12} - \frac{3.375(5.5)^3}{12} + \frac{3.375(3)^3}{12} - \frac{\pi}{64}(2)^4\right]\frac{1}{3.5} = 16.2 \quad \text{I.}$$

$$Z_2 = \left[\frac{4.5(3.375)^3}{12} - \frac{\pi}{64}(2)^4\right]\frac{1}{1.6875} = 8.13 \text{ IN}^3$$

TENSILE STRESS:

$$S_T = \frac{M_1}{Z_1} + \frac{M_2}{Z_2} + \frac{F_V}{A} = \frac{8450}{16.2} + \frac{15770}{8.13} + \frac{580}{12.0}$$

$$S_T = 2509 \text{ PSI}$$

ANALYSIS OF DRAWING

SK6343

DRAWING SK 6343

THE ANALYSIS OF THIS DRAWING IS IDENTICAL TO THE PREVIOUS ANALYSIS EXCEPT THAT THE OPERATOR WEIGHT IS ONLY 48 LB IN LIEU OF 285 LB.

SINCE THE OPERATOR IS LIGHTER THE RESPECTIVE LOADS AND STRESSES WILL BE LOWER.

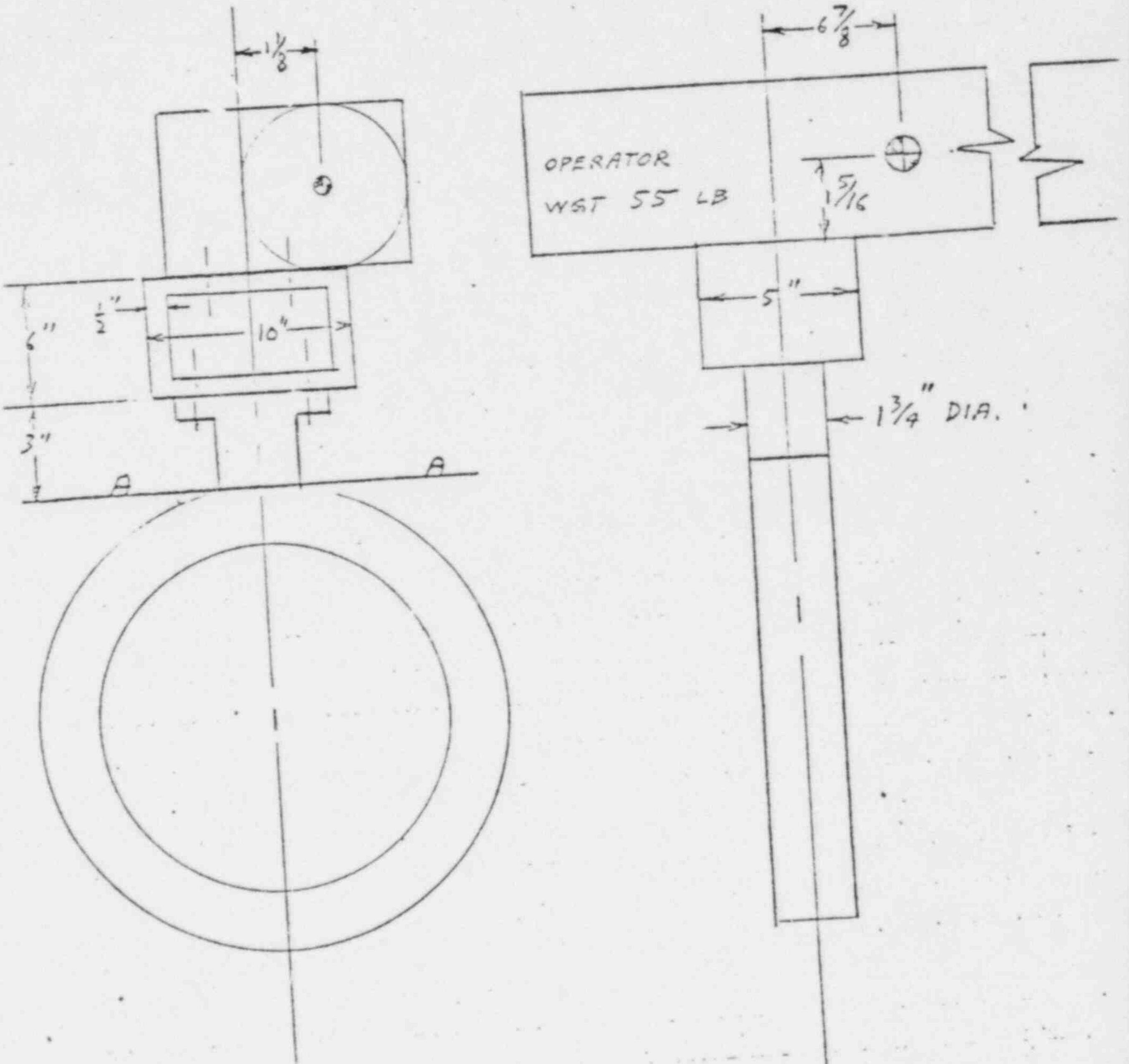
THEREFORE, BY INSPECTION THIS ASSEMBLY IS SATISFACTORY.

ANALYSIS OF DRAWING

SK 6338

STRESS ANALYSIS OF VALVES SK6338

NOTE: THIS ANALYSIS IS SIMILAR TO THE PRECEDING ONE WITH DIFFERENT DIMENSIONS.



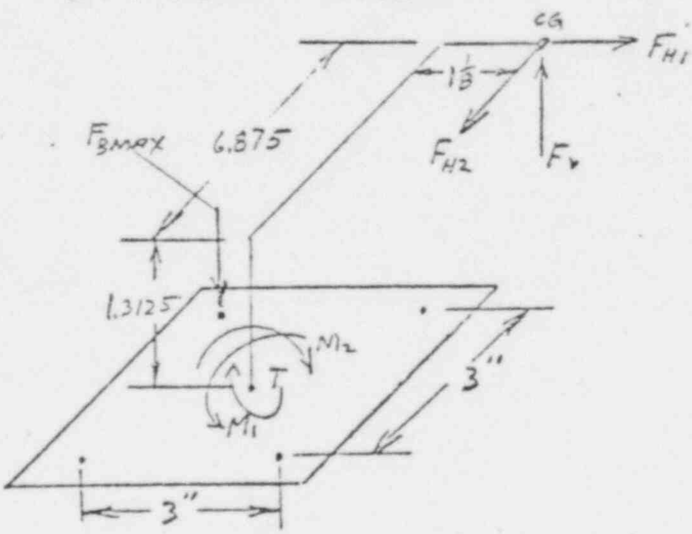
SEISMIC LOADS FROM OPERATOR:

HORIZONTAL : 3(55) = 165 LB F_{H1} & F_{H2}

VERTICAL : 2(55) = 110 LB F_V

LOADING OF OPERATOR FASTENERS:

4 BOLTS 3/8 - 16 UNC
STRESS AREA = .0773 IN²



$M_1 = (165)(1.3125) + (110)(6.875) = 972$ IN-LB

$M_2 = (165)(1.3125) - (110)(1.125) = 92$ IN-LB

$T = (165)(1.125) + (165)(6.875) = 1320$ IN-LB

$$F_{B\,MAX} = \frac{M_2}{2(3)} + \frac{M_1}{2(3.0)} + \frac{F_V}{4} = 204.9 \text{ LB}$$

$$\text{TENSILE STRESS} = \frac{204.9}{.0773} = \underline{2650 \text{ PSI}}$$

SHEAR:

$$\text{SHEAR LOAD} = \frac{T \cos 45}{(1.5)\,4} + \frac{\sqrt{F_{H1}^2 + F_{H2}^2}}{4}$$

$$\text{SHEAR LOAD} = \frac{(1320)(.707)}{(1.5)\,4} + \frac{\sqrt{(165)^2 + (165)^2}}{4}$$

$$= 213 \text{ LB}$$

$$\text{SHEAR STRESS} = \frac{213}{.0773} = 2760 \text{ PSI}$$

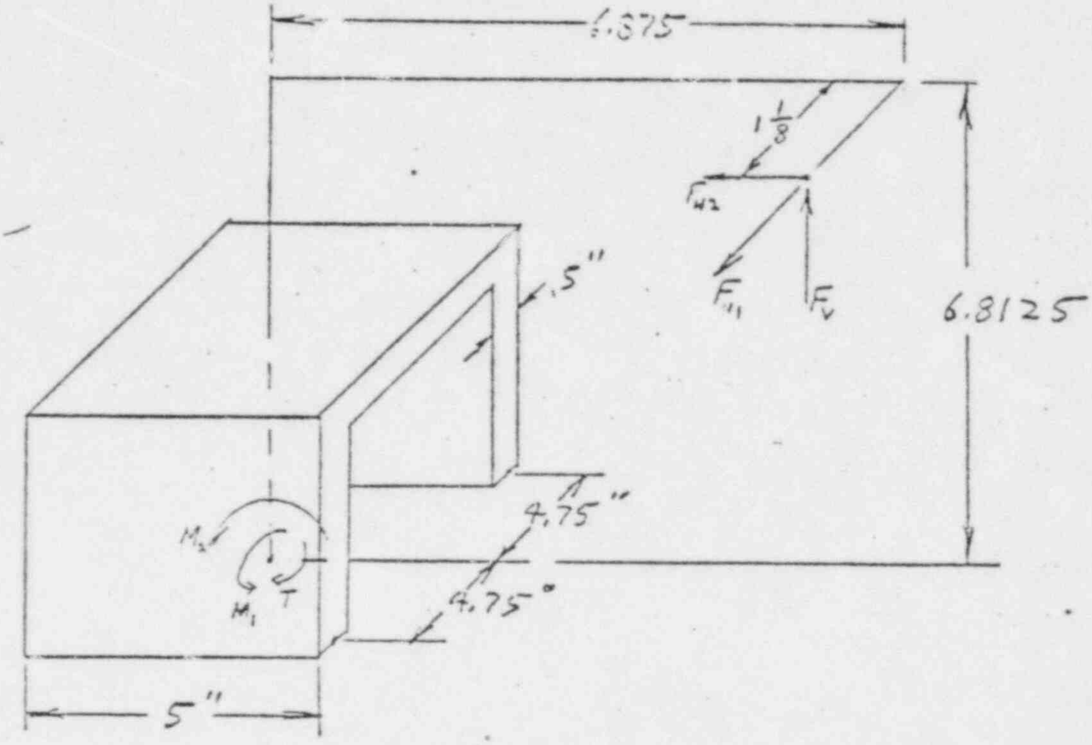
COMBINED STRESS (MAX):

$$\tau = \sqrt{\left(\frac{2650}{2}\right)^2 + (2760)^2} = 3060 \text{ PSI}$$

EQUIVALENT TENSILE STRESS:

$$S_{eq} = 2(3060) = 6120 \text{ PSI}$$

BRACKET STRESS



THE LOWER SECTION OF THE BRACKET IS ANALYZED SINCE IT YIELDS THE LONGEST MOMENT ARMS FROM THE CG, THEREFORE IT RESULTS IN THE HEIGHEST BRACKET STRESSES.

$$M_1 = (165)(6.8125) - (110)(1.125)$$

$$M_1 = 1001 \text{ IN-LB}$$

$M_2 = F_{H2}(6.8125) + F_V(6.875) = 165(6.8125) + 110(6.87$

$M_2 = 1880$ IN-LB

$T = F_{H1}(1.125) + F_{H2}(6.875) = 165(1.125) + 165(6.875$

$T = 1320$ IN-LB

STRESSES

DUE TO M_1: $S_1 = \frac{M_1}{9.5(.5)(5.0)} = \frac{1001}{9.5(.5)(5.0)} = \underline{42.1}$

DUE TO M_2: $S_2 = \frac{M_2}{Z}$ $Z = \frac{bh^2}{6} = \frac{2(.5)(5.0)^2}{6} = 4.17$

$S_2 = \frac{1880}{4.17} = \underline{452}$ PSI

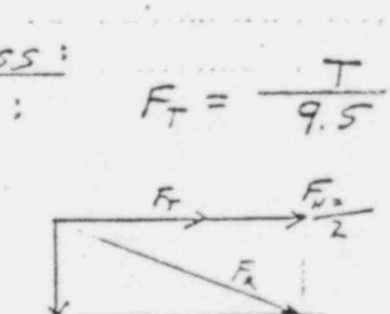
DUE TO F_V: $S_V = \frac{F_V}{2(.5)(5.0)} = \underline{22.0}$ PSI

COMBINED TENSILE STRESS:

$S_c = S_1 + S_2 + S_V = 42 + 452 + 22 = \underline{516 \text{ PSI}}$

SHEAR STRESS:

FORCES: $F_T = \frac{T}{9.5} = \frac{1320}{9.5} = 139$ LB



$F_R = \sqrt{\left(F_T + \frac{F_{H2}}{2}\right)^2 + \left(\frac{F_{H1}}{2}\right)^2}$

ONE SIDE

$$F_R = \sqrt{\left(139 + \frac{165}{2}\right)^2 + \left(\frac{165}{2}\right)^2} = 236 \text{ LB}$$

$$S_s = \frac{F_R}{.5(5)} = \underline{94.5} \text{ PSI}$$

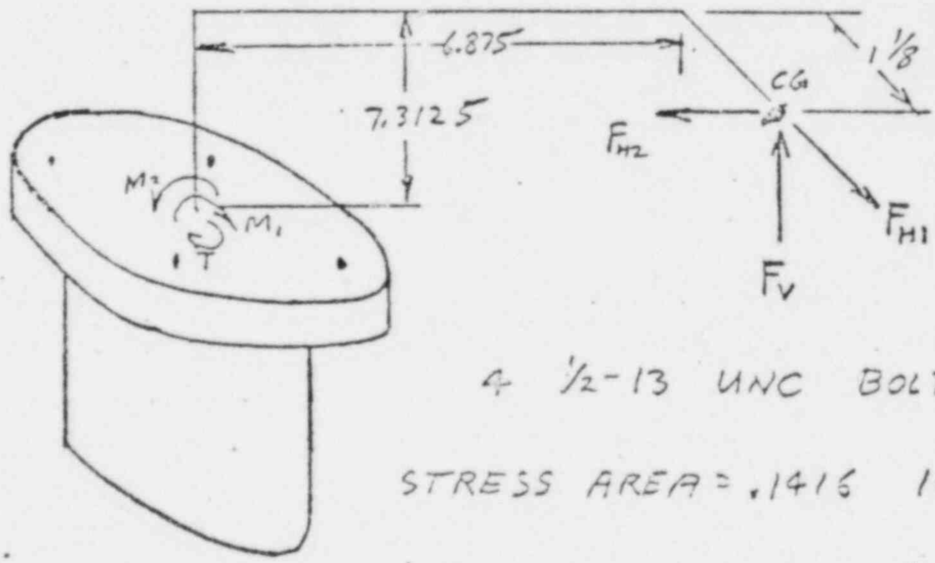
COMBINED TENSILE AND SHEAR STRESS:

$$\tau_m = \sqrt{\left(\frac{516}{2}\right)^2 + (94.5)^2} = 275 \text{ PSI}$$

EQUIVALENT MAX. TENSILE STRESS IN BRACKET:

$$S_{eq} = 2(275) = \underline{550 \text{ PSI}}$$

BRACKET FASTENERS



4 ½-13 UNC BOLTS 4½" DBC

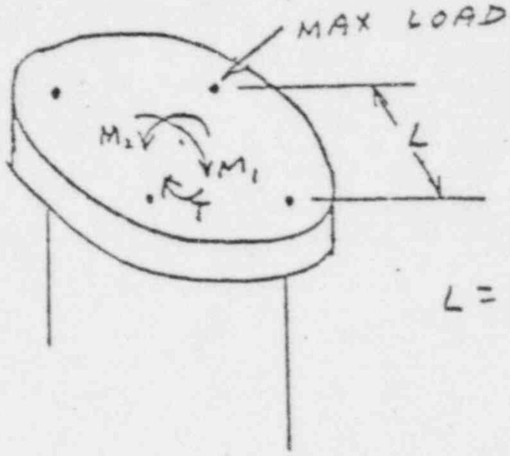
STRESS AREA = .1416 IN^2

$$M_1 = (165)(7.3125) - (110)(1.125) = 1081 \text{ IN-LB}$$

$$M_2 = (165)(7.3125) + (110)(6.875) = 1960 \text{ IN-LB}$$

$$T = (165)(1.125) + (165)(6.875) = 1320 \text{ IN-LB}$$

TENSILE BOLT STRESS (MAX)



$$L = \left[\frac{4.5}{2} \cos 45^\circ\right] 2 = 3.18''$$

$$F_{M_1} = \frac{M_1}{2(3.18)} = \frac{1081}{2(3.18)} = 170. \text{ LB}$$

$$F_{M_2} = \frac{M_2}{2(3.18)} = \frac{1960}{2(3.18)} = 308 \text{ LB}$$

$$F_{F_V} = \frac{F_V}{4} = \frac{110}{4} = 27.5 \text{ LB}$$

$$\text{TENSILE STRESS} = \frac{F_{M_1} + F_{M_2} + F_{FV}}{.1416}$$

$$= \frac{170 + 308 + 28}{.1416} = \underline{3580 \text{ PSI}}$$

SHEAR:

$$\text{SHEAR LOAD} = \frac{T}{(2.25)} + \frac{\sqrt{F_{H1}^2 + F_{H2}^2}}{4}$$

$$\text{SHEAR LOAD} = \frac{(1320)}{(2.25)\,4} + \frac{\sqrt{(165)^2 + (165)^2}}{4}$$

$$= 205 \text{ LB PER BOLT}$$

$$\text{SHEAR STRESS} = \frac{205}{.1416} = \underline{1450 \text{ PSI}}$$

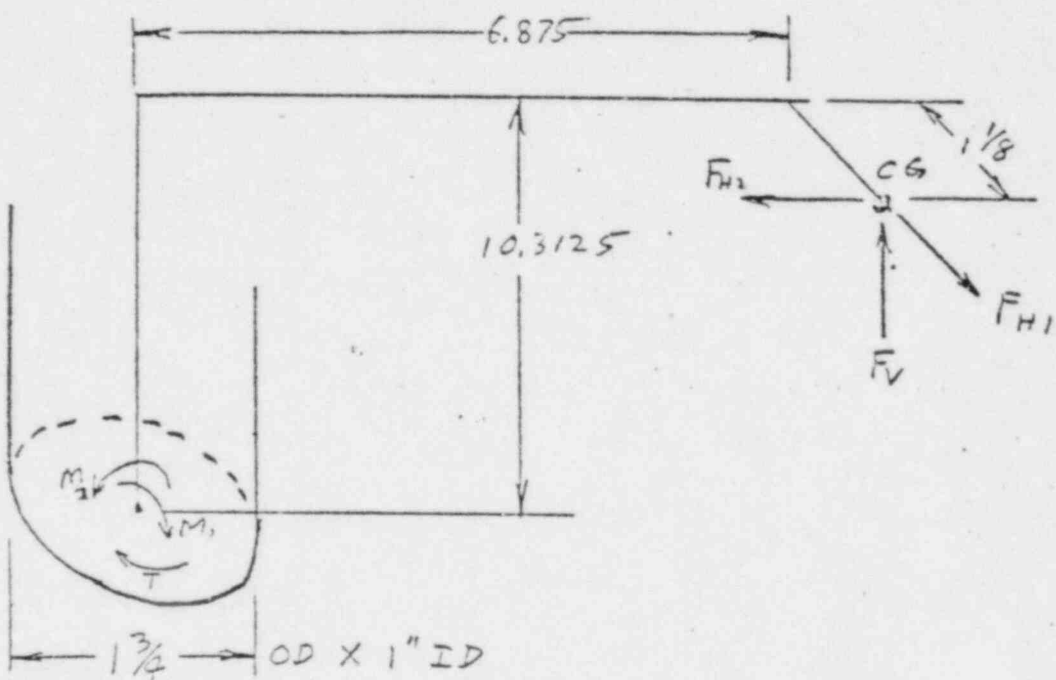
COMBINED STRESS (MAX):

$$\tau = \sqrt{\left(\frac{3580}{2}\right)^2 + (1450)^2} = 2300 \text{ PSI}$$

EQUIVALENT TENSILE STRESS:

$$S_{eq} = 2(2300) = \underline{4600 \text{ PSI}}$$

STRESS AT SECTION A-A



$M_1 = (165)(10.3125) - (110)(1.125) = 1576$ IN-LB

$M_2 = (165)(10.3125) + (110)(6.875) = 2455$ IN-LB

$T = (165)(1.125) + (165)(6.875) = 1320$ IN-LB

$A = \pi/4\,(1.75^2 - 1^2) = 1.15$ IN^2

$$Z = \frac{\pi/64\,(1.75^4 - 1^4)}{.875} = .471 \text{ IN}^3$$

$$\text{TENSILE STRESS} = \frac{\sqrt{M_1^2 + M_2^2}}{Z} + \frac{F_V}{A} = \frac{\sqrt{(1576)^2 + (2455)^2}}{.471} + \frac{110}{1.15}$$

$= \underline{6296}$ PSI

SHEAR STRESS

$$S_s = \frac{T}{Z_J}$$

$$Z_J = \frac{\frac{\pi}{32}\left(1.75^4 - 1^4\right)}{.875} = .942 \text{ IN}^3$$

$$S_s = \frac{1320}{.942} = \underline{1400 \text{ PSI}}$$

COMBINED STRESS:

$$\tau = \sqrt{\left(\frac{62.96}{2}\right)^2 + (1400)^2} = 3440 \text{ PSI}$$

SHEAR

EQUIVALENT TENSILE STRESS

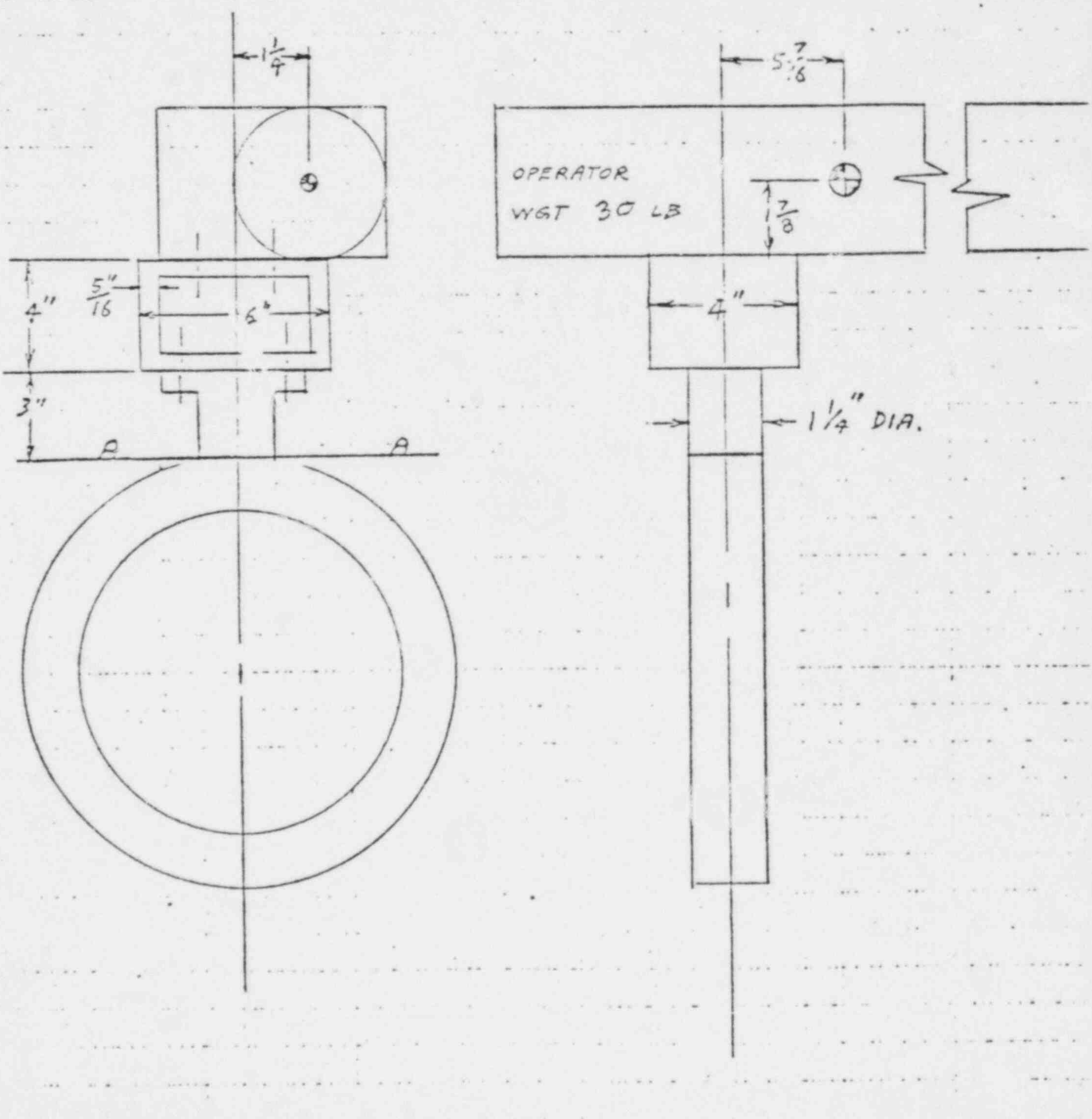
$$S_{eq} = 2(3440) = \underline{6880 \text{ PSI}}$$

ANALYSIS OF DRAWINGS

SK 6322 & SK 6323

STRESS ANALYSIS OF VALVES SK6322 & 6323

NOTE: THIS ANALYSIS IS SIMILAR TO THE PRECEDING ONE WITH DIFFERENT DIMENSIONS.



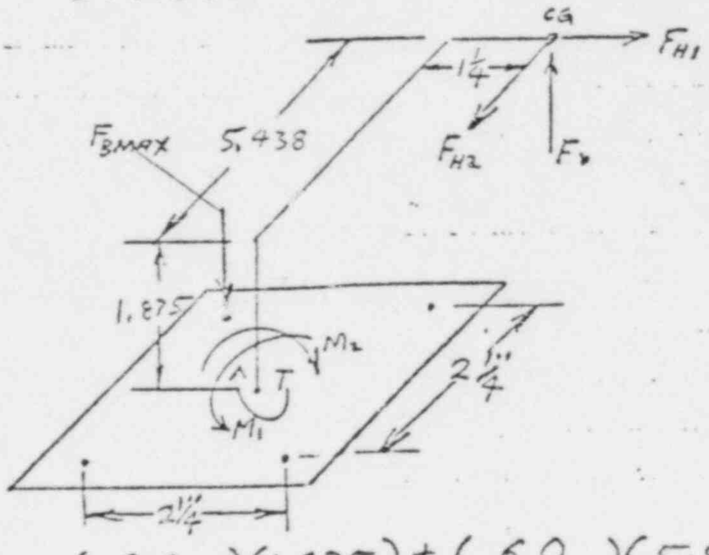
SEISMIC LOADS FROM OPERATOR:

HORIZONTAL: 3(30) = 90 LB F_{H1} & F_{H2}

VERTICAL : 2(30) = 60 LB F_V

LOADING OF OPERATOR FASTENERS:

4 BOLTS 5/16 - 18 UNC
STRESS AREA = .0522 IN^2



$$M_1 = (90)(1.875) + (60)(5.438) = 495 \text{ IN-LB}$$

$$M_2 = (90)(1.875) - (60)(1.25) = 93.5 \text{ IN-LB}$$

$$T = (90)(1.25) + (90)(5.438) = 603 \text{ IN-LB}$$

$$F_{B\,MAX} = \frac{M_2}{2(2.25)} + \frac{M_1}{2(2.25)} + \frac{F_V}{4} = 146 \text{ LB}$$

$$\text{TENSILE STRESS} = \frac{146}{.0522} = \underline{2800 \text{ PSI}}$$

SHEAR:

$$\text{SHEAR LOAD} = \frac{T \cos 45}{(1.125)\,4} + \frac{\sqrt{F_{H1}^2 + F_{H2}^2}}{4}$$

$$\text{SHEAR LOAD} = \frac{(603)(.707)}{(1.125)\,4} + \frac{\sqrt{(90.0)^2 + (90.0)^2}}{4}$$

$$= 127 \text{ LB}$$

$$\text{SHEAR STRESS} = \frac{127}{.0522} = \underline{2440 \text{ PSI}}$$

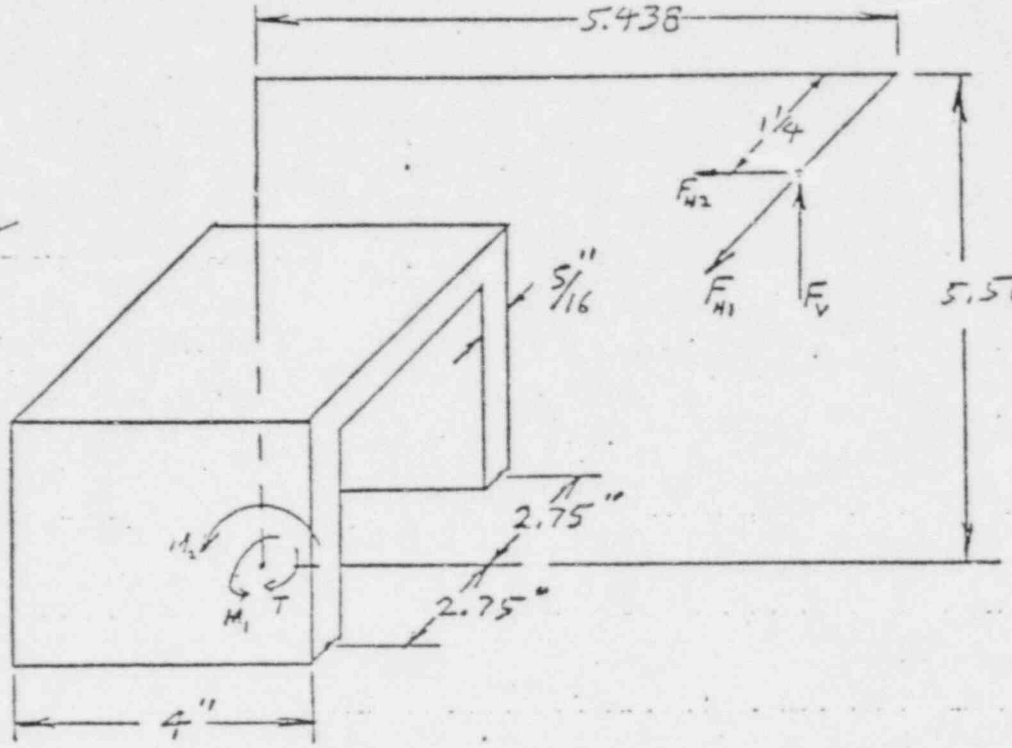
COMBINED STRESS (MAX):

$$\tau = \sqrt{\left(\frac{2800}{2}\right)^2 + (2440)^2} = 2810 \text{ PSI}$$

EQUIVALENT TENSILE STRESS:

$$S_{eq} = 2\,(2810) = \underline{5620 \text{ PSI}}$$

BRACKET STRESS



THE LOWER SECTION OF THE BRACKET IS ANALYZED SINCE IT Y.ELDS THE LONGEST MOMENT ARMS FROM THE CG, THEREFORE IT RESULTS IN THE HEIGHEST BRACKET STRESSES.

$$M_1 = (90.0)(5.562) - (60.0)(1.25)$$

$$M_1 = 425 \text{ IN-LB}$$

$M_2 = F_{H2}(5.512) + F_V(5.438) = 90.0\ (5.512) + 60.0(5.438)$

$M_2 = 826$ IN-LB

$T = F_{H1}(1.25) + F_{H2}(5.438) = 90.0\ (1.25) + 90.0(5.438)$

$T = 603$ IN-LB

STRESSES

DUE TO M_1: $S_1 = \frac{M_1}{5.5(\frac{5}{16})(4.0)} = \frac{425}{5.5(\frac{5}{16})(4.0)} = \underline{61.7}$ P.

DUE TO M_2: $S_2 = \frac{M_2}{Z}$ $Z = \frac{bh^2}{6} = \frac{2(\frac{5}{16})(4.0)^2}{6} = 1.67$ IN

$S_2 = \frac{826}{1.67} = \underline{495}$ PSI

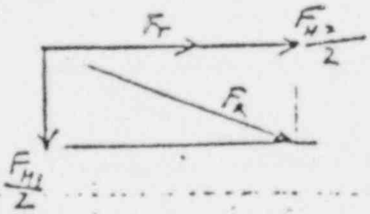
DUE TO F_V: $S_V = \frac{F_V}{2(4)(5/16)} = \underline{24.0}$ PSI

COMBINED TENSILE STRESS:

$S_C = S_1 + S_2 + S_V = 62 + 495 + 24 = \underline{581\ PSI}$

SHEAR STRESS:

FORCES: $F_T = \frac{T}{5.5} = \frac{603}{5.5} = 110$ LB



$F_R = \sqrt{\left(F_T + \frac{F_{H2}}{2}\right)^2 + \left(\frac{F_{H1}}{2}\right)^2}$

ONE SIDE

$$F_R = \sqrt{\left(110 + \frac{90}{2}\right)^2 + \left(\frac{90}{2}\right)^2} = 161$$

$$S_s = \frac{F_R}{\frac{5}{16}(4)} = \underline{129} \text{ PSI}$$

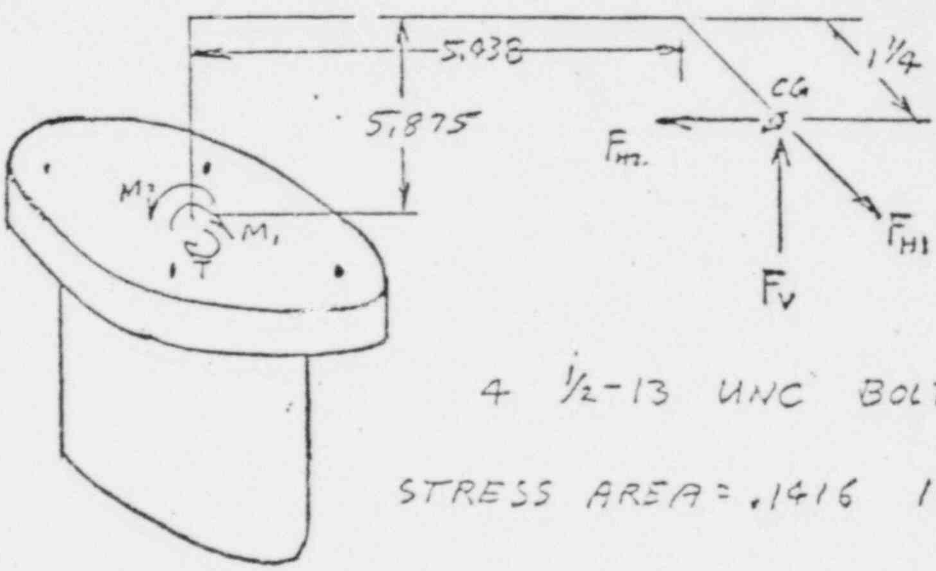
COMBINED TENSILE AND SHEAR STRESS:

$$\tau_m = \sqrt{\left(\frac{581}{2}\right)^2 + (129)^2} = 316 \text{ PSI}$$

EQUIVALENT MAX. TENSILE STRESS IN BRACKET:

$$S_{eq} = 2(316) = \underline{632 \text{ PSI}}$$

BRACKET FASTENERS



4 1/2-13 UNC BOLTS 3 1/2" DI

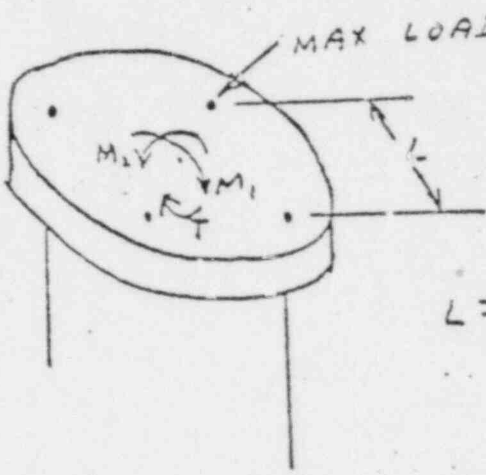
STRESS AREA = .1416 IN^2

$M_1 = (90.0)(5.875) - (60.0)(1.25) = 453$ IN-LB

$M_2 = (90.0)(5.875) + (60.0)(5.438) = 854$ IN-LB

$T = (90.0)(1.25) + (90.0)(5.438) = 603$ IN-LB

TENSILE BOLT STRESS (MAX)



$$L = \left[\frac{3.5}{2} \cos 45^\circ\right] 2 = 2.48''$$

$$F_{M_1} = \frac{M_1}{2(2.48)} = \frac{453}{2(2.48)} = 91.5 \text{ LB}$$

$$F_{M_2} = \frac{M_2}{2(2.48)} = \frac{854}{2(2.48)} = 172 \text{ LB}$$

$$F_{F_v} = \frac{F_v}{4} = \frac{60.0}{4} = 15.0 \text{ LB}$$

$$\text{TENSILE STRESS} = \frac{F_{M_1} + F_{M_2} + F_{F_V}}{.1416}$$

$$= \frac{91.5 + 172 + 15}{.1416} = \underline{1970 \text{ PSI}}$$

SHEAR:

$$\text{SHEAR LOAD} = \frac{T}{(1.75)\,4} + \frac{\sqrt{F_{H1}^2 + F_{H2}^2}}{4}$$

$$\text{SHEAR LOAD} = \frac{(603)}{(1.75)\,4} + \frac{\sqrt{(90.0)^2 + (90.0)^2}}{4}$$

$$= 118 \text{ LB PER BOLT}$$

$$\text{SHEAR STRESS} = \frac{118}{.1416} = 835 \text{ PSI}$$

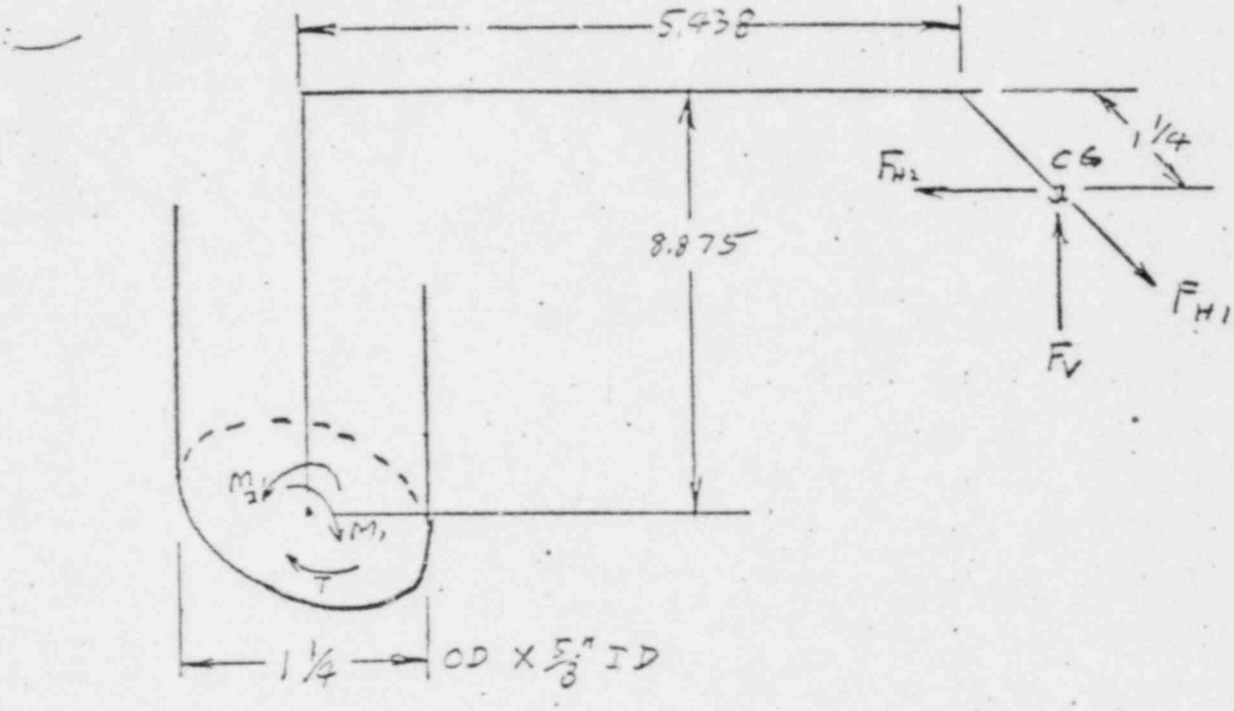
COMBINED STRESS (MAX):

$$\Upsilon = \sqrt{\left(\frac{1970}{2}\right)^2 + (835)^2} = 1290 \text{ PSI}$$

EQUIVALENT TENSILE STRESS:

$$S_{eq} = 2(1290) = 2580 \text{ PSI}$$

STRESS AT SECTION A-A



$M_1 = (90.0)(8.875) - (60.0)(1.25) = 723$ IN-LB

$M_2 = (90.0)(8.875) + (60.0)(5.438) = 1124$ IN-LB

$T = (90.0)(1.25) + (90.0)(5.438) = 603$ IN-LB

$A = \pi/4\,(1.25^2 - .625^2) = 0.92$ IN^2

$Z = \dfrac{\pi/64\,(1.25^4 - .625^4)}{.625} = 0.18$ IN^3

TENSILE STRESS $= \dfrac{\sqrt{M_1^2 + M_2^2}}{Z} + \dfrac{F_V}{A} = \dfrac{\sqrt{(723)^2 + (1124)^2}}{0.18} + \dfrac{60}{.9}$

$= \underline{7465}$ PSI

SHEAR STRESS

$$S_s = \frac{T}{Z_J}$$

$$Z_J = \frac{\frac{\pi}{32}\left(1.25^4 - .625^4\right)}{.625} = .36 \ IN^3$$

$$S_s = \frac{603}{.360} = 1680 \ PSI$$

COMBINED STRESS:

$$\tau = \sqrt{\left(\frac{7465}{2}\right)^2 + \left(1680\right)^2} = 4090 \ PSI$$

SHEAR

EQUIVALENT TENSILE STRESS

$$S_{eq} = 2(4090) = 8180 \ PSI$$