Attachment 2

ENRICO FERMI ATOMIC POWER PLANT, UNIT 2

ASSESSMENT OF PURGE VALVE

PRESSURE DIFFERENTIAL CAPABILITIES

PREPARED BY

MULTIPLE DYNAMICS CORPORATION
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MDC REPORT NO. DECO-04-2468
REVISION 1

OCTOBER 1984

APPROVED BY D. F. Lehnert
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VICE PRESIDENT

ISSUED BY F. E. Gregor 10/5/84
F. E. GREGOR
PRESIDENT

REVISION CONTROL SHEET

Document No. DECO-04-2468
Rev. 1

Subject: Enrico Fermi Atomic Power Plant, Unit 2
Assessment of Purge Valve Pressure
Differential Capabilities

Name	Title	Initial
Daniel F. Lehnert	Principal Engineer	
Mark A. Hinspeter	Engineer I	

Form MDC-15-145

REVISION CONTROL SHEET

Subject: Enrico Fermi Atomic Power Plant, Unit 2, Assessment of Purge Valve Pressure Differential Capabilities

Document No. DECO-04-2468 Rev. 1

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i	0	MH.	DTL				
1-14	0	MH.	DTL				
App. A	0	MH.	DTL				
iv	1	MH.	DTL				
7, 8	1	MH.	DTL				
14	1	MH	DTL				
App A SC*1 15	1	MH	DTL				
App A SC*2 8	1	MH	DTL				
App A SC*2 9	1	MH	DTL				

Form MDC-15-146

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ATTACHMENT TO:
DECO-04-24GB
SUPP. CALC. NO. 1

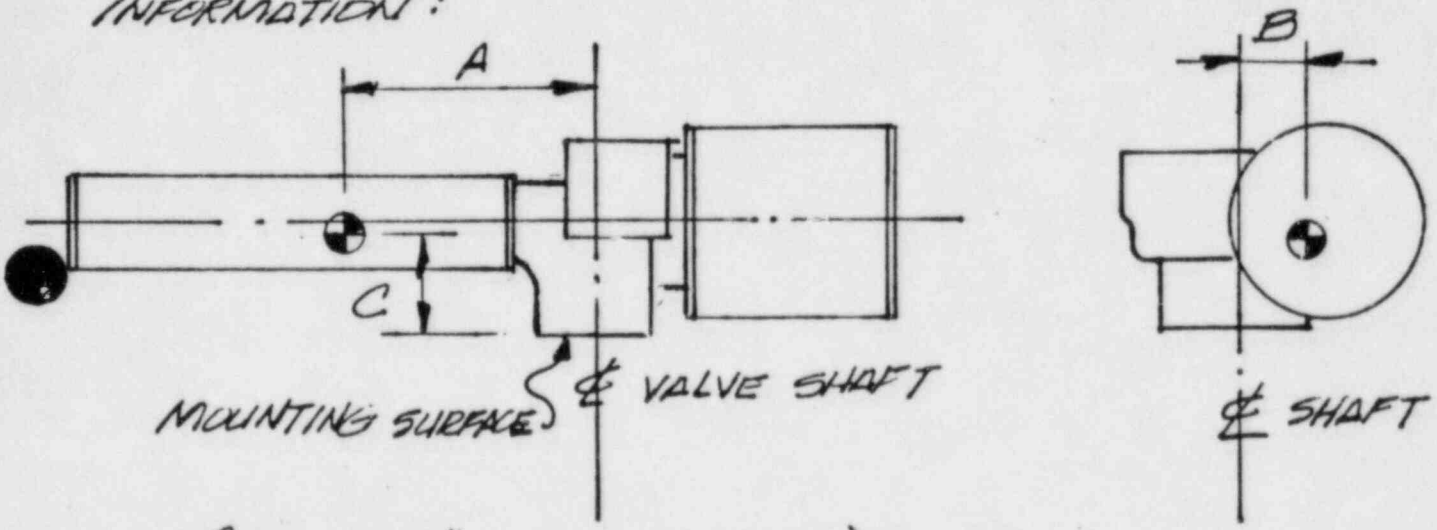
MULTIPLE DYNAMICS CORPORATION

TELECON RECORDS

Date 9/19/84
Project FERMI-2 PURGE VALVE ASSESSMENT
File No. 81-1-B/10
From MARK HINSPETER (MDC)
Time 10:50 AM
To PHIL REED (BETTIS CORP.)
Page 1 of 1

Subject BETTIS VALVE ACTUATOR MODEL T46SR2; CENTER OF GRAVITY LOCATION, WEIGHT

AT MY REQUEST, MR. REED SUPPLIED THE FOLLOWING INFORMATION:



A = 10.7" (OPEN POSITION)
A = 9.6" (CLOSED POSITION-APPROX.)

B = 3.7"
C = 4"

M. Hinspeter

Form MDC-15-151
Revision 1

ATTACHMENT TO:
DECO-04-2468
SUPP. CALC. NO. 1

MULTIPLE DYNAMICS CORPORATION

TELECON RECORDS

Date 9-21-84
Project FERMI 2 PURGE VALVE ASSESSMENT File No. 81-1-B
From MARK HINSPETER (MDC) Time 8:05 A.M.
To BEN ZANNINI (JANESBURY) Page 1 of 1

Subject BRACKET BOLTS ~ 24" WAFER-SPHERE VALVE WITH BETTIS T416-SR2 ACTUATOR.

AT MY REQUEST, MR. ZANNINI PROVIDED THE FOLLOWING INFORMATION:

BOLTS USED TO ATTACH THE T416-SR2 BRACKET TO THE VALVE NECK ARE 3/4" DIA., 10 THREADS PER INCH.

M. Hinspeter

Form MDC-15-151
Revision 1

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DESCRIPTION OF REVISION

Revision 1:

Revision 1 incorporated the editorial changes itemized below.

Page 7 - Net torque value for 24" valve was corrected to reflect the result of Supp. Calc. No. 2.

Page 8 - Error in 10"Ø net torque ratio was corrected.

Page 14 - Note was deleted from Table 2.

Supp. Calc. No. 1 (pg. 15) - Page number was inserted.

Supp. Calc. No. 2 (pg. 8) - Friction coefficient symbol was inserted in equation for friction torque.

Supp. Calc. No. 2 (pg. 9) - The word "closed" was replaced by "full open" in the horizontal axis label.

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1.0 INTRODUCTION

This assessment was performed to determine the differential pressure capability of the primary containment purge valves should they be required to isolate during a LOCA event. The assessment results will establish that the existing Inservice Inspection Program and Technical Specification limits on valve closure time are adequate to ensure valve operability.

In their review of the Fermi 2 purge and vent valve operability demonstration, the Nuclear Regulatory Commission (NRC) indicated (Reference 2) that a maximum allowable stroke time should be established for the 10"Ø and 24"Ø valves for the "inservice test" conditions, i.e., no load stroke timing. The NRC felt that an allowable inservice testing time limit, more restrictive than the Plant Technical Specification, may have to be established to ensure that unacceptable torque loads will not develop on these valves during a LOCA when the primary containment is pressurized.

Detroit Edison requested MDC's assistance in establishing the differential pressure capability of the purge valves and evaluating the need for a more restrictive limit on the closure times measured during inservice inspection (no load condition). Section 2.0 of this report discusses MDC's evaluation approach. The details of the evaluation are presented in Section 3.0. The evaluation results and conclusions are presented in Sections 4.0 and 5.0, respectively. The

The references employed during the assessment are listed in Section 6.0.

2.0 SUMMARY OF THE EVALUATION APPROACH

The approach which was applied in establishing the differential pressure capability of the 10"Ø and 24"Ø Jamesbury butterfly valves is outlined as follows:

(1) The loads and load combinations which were applied in the original Jamesbury stress report (Reference 3) were re-established.

(2) A non-mechanistic, peak dynamic torque value was established corresponding to the primary containment design pressure of 56 psig and the maximum torque coefficient (i.e., CT (90°)).

(3) The new predicted stresses and stress margins for the shaft, bracket, bracket bolts, and body neck were conservatively determined by increasing the total stress values reported in the Jamesbury stress report in proportion to the peak dynamic torque-to-valve breaking torque ratio.

(4) The realistic net torque values that the valve would experience while closing during a postulated DBA event were assessed to establish the conservatism in applying the computed peak dynamic torque.

(5) The results from above evaluation steps were used to confirm that valve closure time measured during testing or no load conditions need not be more restrictive than the Inservice Inspection Program requirements.

3.0 EVALUATION

The original stress reports evaluated the major components of the valves, the results of which are shown in Table 1. These stress levels represent the combined stresses due to seismic loading, valve disc pressure, and valve "breaking" torque (the torque required to either seat or unseat the valve). The breaking torques used in the stress report for the 10"Ø and 24"Ø valves were 730 ft-lbs and 3200 ft-lbs, respectively. The allowable stresses used are those reflecting faulted loading conditions (Level-D allowables) in accordance with the applicable codes and are appropriate for the analysis of LOCA plant conditions.

The original stress report did not include the dynamic torque exerted on the valve by the compressible flow of drywell gases during a LOCA. The dynamic torque on the valve can be determined by the method outlined in the Purge Valve Closure Analysis (Reference 1) which is based on the Fermi 2 drywell LOCA pressure ramp and torque versus closure angle information developed by the manufacturer. As indicated in Reference (2) review of the purge valve operability demonstration,

if for some reason the closure of the 10" and 24" valves is delayed during a LOCA, the NRC is concerned that high drywell pressure would induce net torques on the valves in excess of the torques used in the original stress report. This possibility implies that a time limitation should be placed on these valves during inservice testing to ensure that the differential pressure capability of the valves will not be exceeded.

The intent of the following evaluation is to investigate the stress levels on the 10"Ø and 24"Ø valves resulting from the greatest predictable drywell differential pressure, and determine if those stresses are within allowables and contain sufficient margin to eliminate any need for closure time limitations during inservice testing.

3.1 Stress Levels Resulting from Dynamic Torque

For this analysis, the drywell design pressure of 56 psig is assumed. According to BTP-CSB 6-4, "Containment Purging During Normal Plant Operation" and as reflected in the Fermi 2 Technical Specifications, the maximum allowable purge valve closing time is 5 seconds. Realistically, the requirements of the Inservice Inspection Program will ensure valve closure prior to 5 seconds (see Article 3.3). Using the 5-second interval, the predicted post-LOCA drywell pressure would ramp up to only 50 psig (see Reference 1, Figure 1). Therefore, using the drywell design

pressure as basis for stress level evaluation is a very conservative assumption.

Dynamic torque on the valve is given by the expression,

$$TV = CT(\theta)\ \Delta p\ D^3$$

where TV = dynamic valve torque (ft-lbs)
CT = torque coefficient (a function of valve closure angle θ)
Δp = differential pressure (psi) = 56 psi
D = nominal valve diameter (inches)

Using the Reference (1) torque coefficient curves A and B for the 24 inch and 10 inch valves respectively, at a closure angle of 90 degrees (valve fully open, at which point the maximum dynamic torque is developed for the constant drywell pressure condition assumed in this analysis), the resulting dynamic torques are:

TV (24") = 6600 ft-lbs
TV (10") = 800 ft-lbs

Torque coefficient curves A and B are applicable since Detroit Edison has installed all of the purge valves such that the shaft is in-plane relative to the upstream elbow. The dynamic torques have been compared with the torques used in the original stress report, and applicable ratios computed:

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$$24\text{"}\varnothing \text{ torque ratio} = \frac{6600}{3200} = 2.06$$

$$10\text{"}\varnothing \text{ torque ratio} = \frac{800}{730} = 1.10$$

The original stress levels (σp and τmax) determined in the original stress report are presented in Table 1. These values were then increased by the above factors and compared to the allowables. These results are tabulated in Table 2.

It should be emphasized that this method of comparison results in a very conservative estimate of new stress values resulting from the dynamic torque, because the stresses originally computed were due to seismic loads and disc pressure loads, in addition to the pure torque loads. By amplifying the original stress values by the above factors, the seismic and disc pressure stresses are being amplified as well as the torque stresses. In addition, the disc pressures originally calculated were conservatively, based on drywell pressures greater than 56 psi (62 psi for the 24 inch valve, and 150 psi for the 10 inch valve).

As can be seen from Table 2, the resulting stresses are still well within allowables.

3.2 Net Valve Torque

The pneumatic valve operators consist of a spring-loaded piston linked to the valve shaft. Air on the forward side of the piston compresses the spring and holds the valve open. The valves are closed by the spring when the pressure side of the piston is vented.

In applying a more realistic valve closure analysis, force components due to spring force, piston back pressure, valve friction and dynamic torque all act upon the valve, resulting in a total net torque applied to the shaft. Using the Reference (1) mathematical model, an analysis was done to determine the maximum net torque the valves would experience through a closure cycle during a LOCA event. The Reference (1) drywell post-LOCA pressure versus time and torque coefficient versus valve position response curves were used in the analysis. The results are:

Net Torque (10"Ø valve) = 1,315 ft-lbs
Net Torque (24"Ø valve) = 3,130 ft-lbs ⚠

The net torque in the 24" valve is approximately one-half of the dynamic torque used to evaluate stresses reported in Table 2. It can therefore be concluded that the net torque on the 24" valve throughout the closure cycle will not exceed the peak dynamic torque used in the Section 3.1 assessment, and that the stress levels calculated in Section 3.1 which

represent very conservative maximums, will not be exceeded.

The maximum net torque on the 10" valve exceeds the peak dynamic torque used to evaluate stress levels in Section 3.1. Therefore, a new amplification factor was computed based on the maximum net torque.

$$10"\text{Ø net torque ratio} = \frac{1315}{730} = 1.80$$

The originally computed stress levels were then multiplied by this factor, and are shown in parentheses in Table 2. As can be seen, the resulting stress levels are still well below the allowables. Considering that the original stresses included seismic and conservatively established pressure loads as well as the torsional loads (as discussed in Section 3.1), it is concluded that the components of the 10" valve will not be overstressed during post-LOCA closure.

3.3 Valve Closure Limits

Utilizing the BTP-CSP 6-4, "Containment Purging During Normal Plant Operation", the maximum allowable purge valve closing time would be 5 seconds. However, the inservice test requirements defined by ASME Boiler and Pressure Vessel Code, Section XI, Article IWV-3417 will realistically result in more restrictive closure limits for the Fermi 2 primary containment purge valves.

The as-received full stroke times for these purge valves are well less than 5 seconds. Therefore per Article IWV-3417 of the ASME Code, an increase in stroke time of 50% or more from the previous test will require the test frequency to be increased to once a month until corrective action has been taken.

It is expected that over time, gradual degradation of closure time may result from reductions in cylinder spring force, increase solenoid valve opening times and/or increases in surface friction coefficients. However, if a full 50% degradation in closure time were to occur in any one test, there would still be ample margin between the degraded valve performance condition and the maximum allowable purge valve closing time of 5 seconds. In addition, the required increase in testing frequency will ensure that the valve closing speed is less than the maximum 5 second allowable until corrective action can be instituted.

4.0 RESULTS

Reproportioning the originally computed stresses, based on the dynamic valve torques developed from the drywell design pressure of 56 psig and net torque valves during closure, results in stress levels that are still within allowables, as shown in Table 2 and the preceeding discussions. The margins remaining between the new predicted stress levels and the allowables range from approximately 10 percent to approximately 80 percent of the allowable stresses.

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These margins are more than adequate to overcome any additional stresses caused by normal wear of the moving valve components. In addition, the requirements of the Inservice Inspection program will ensure that any conditions leading to extended closure times are identified and necessary corrective actions instituted.

The results also indicate that the ΔP capability of the valves exceeds the maximum ΔP that would be experienced at any time during a DBA and the valves would be expected to close reliably without damage from overstressing.

The results are reinforced by the conservatisms used in the evaluation, namely:

(1) A non-mechanistically determined drywell differential pressure (56 psig) was assumed to act across the valve throughout closure, when in reality the drywell pressure ramps up from near zero to a peak value of less than 50 psig after 5 seconds, by which time the valve is normally closed.

(2) The original stresses that were amplified in proportion to the maximum dynamic torque were not pure torque-related stresses, but included also seismic loads and conservative disc pressure loads.

(3) The probability of the seismic and LOCA event occurring at the same instant the purge valves were opened for containment inerting or inservice testing would be very low.

(4) The worst case torque coefficient ($CT(\theta)=CT(90^\circ)$, "full open") was applied to determine dynamic torque irrespective of valve position. The torque coefficient actually decreases as the valve closes.

5.0 CONCLUSIONS

The evaluation shows that the differential pressure capability of the 10 inch and 24 inch drywell purge valves are not exceeded during a DBA. Therefore, the Technical Specification maximum allowable closure limit is adequate to ensure valve operability, and no further limitations beyond the requirements of ASME Section XI, Article IWV-3417 need be imposed for measuring closure times during inservice testing.

6.0 REFERENCES

(1) Alden Research Laboratory Worcester Polytechnic Institute Report, "Purge Valve Closure Analysis", October 1981

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(2) NUREG-0798, Supplement No. 3, Article II.E.4.2, "Safety Evaluation Report Related to the Operation of Enrico Fermi Atomic Power Plant, Unit 2", January 1983

(3) John Henry Associates, Inc. Documents, "Seismic Qualification of Valves Covered by Detroit Edison Company Purchase Order No. IE-86782 for Enrico Fermi Atomic Power Plant Unit #2 and Processed Under Jamesbury Order Nos. NC 46261, NC 34252 and JPB 73111", Edison File No. P1-2406

(4) Jamesbury Drawing No. NC-46261-25, "Assembly - 24" Water Sphere Valve Fig. 8922 - Ex Model "A", 150# ANSI Flanged", Revision C, Edison File No. P1-2327

TABLE 1

PURGE VALVE COMBINED LOADING STRESS SUMMARY (1)

Valve	Component	σ	τ	σ_p	τ_{MAX}	σ_{ALL}	τ_{ALL}	Material	
10" Valve (ST880 MS Actuator)	Shaft	29,945	20,718	33,687	23,214	105,000	63,000	17-4 PH	
	Bracket	9,632	6,853	13,192	8,376	40,000	24,000	Duct. Iron	
	Bracket Bolts	12,730	2,819	13,326	6,961	105,000	63,000	SA-193 B7	
	Body Neck	15,202	1,974	15,454	7,853	30,000	18,000	SA-216	
24" Valve (T416SR2 Actuator)	Shaft	9,907	11,396	17,380	12,426	105,000	63,000	LaSalle Stress-Proof Carb. Steel	(2)
	Bracket	-	-	9,650	4,863	30,000	18,000	Carb. Steel	(3)
	Bracket Bolts	-	-	29,330	21,390	105,000	63,000	SA-193 B7	(3)
	Body Neck	4,271	2,596	5,497	3,361	38,000	22,800	SA-515 GR70	

σ = Axial plus bending stress (psi)

τ = Transverse plus torsional shearing, stress (psi)

σ_p = Principal normal stress (combined stress, psi)

τ_{MAX} = Maximum shear stress (psi)

σ_{ALL} = Allowable normal stress = tension yield stress (psi)

τ_{ALL} = Allowable shear stress = shear yield stress = $0.6\,\sigma_{ALL}$ (psi)

(1) Summarized from seismic qualification report JHA-76-34 (P1-2406) (Reference 3)
(2) Properties comparable to 17-4 PH.
(3) From Report No. DECO-04-2468, Supplementary Calculation #1.

TABLE 2

PURGE VALVE COMBINED LOADING STRESSES AMPLIFIED FOR DYNAMIC TORQUE

Valve Size	Component	Stress Amplification Factor	σ_p	τ_{MAX}	σ_{ALL}	τ_{ALL}
10"	Shaft	1.10 (1.80) see note 1	37,100 (60,600)	25,500 (41,800)	105,000	63,000
	Bracket	↓	14,500 (23,700)	9,200 (15,100)	40,000	24,000
	Bracket Bolts	↓	14,500 (24,000)	9,200 (12,500)	105,000	63,000
	Body Neck	↓	17,000 (27,800)	8,600 (14,100)	30,000	18,000
24"	Shaft	2.06	35,800	25,600	105,000	63,000
	Bracket	↓	19,900	10,000	30,000	18,000
	Bracket Bolts	↓	60,400	44,000	105,000	63,000
	Body Neck	↓	11,300	6,900	38,000	22,800

σ_p = Principle Normal Stress (combined stress, psi)

τ_{MAX} = Maximum Shear Stress (psi)

σ_{ALL} = Allowable Normal Yield Stress (psi)

τ_{ALL} = Allowable Shear Stress = 0.6 σ_{ALL} (psi)

(1) Figure in parentheses represent the Purge valve combined loading stresses amplified for the predicted Net Torque during closure, applicable only to the 10" valve as discussed in Section 3.2.

APPENDIX A

TO

MDC REPORT NO. DECO-04-2468

REVISION 1

OCTOBER 1984

SUPPLEMENTARY CALCULATIONS FOR THE ASSESSMENT OF PURGE VALVE PRESSURE DIFFERENTIAL CAPABILITIES

Supplementary Calculation No. 1 - Stress Analysis of Valve Operator Mounting Bracket and Bracket Bolts for Jamesbury 24" Wafer Sphere Valve with Bettis T416-SR2 Operator (27 pages)

Supplementary Calculation No. 2 - Net Torque Assessment During Post-LOCA Closure of 10" and 24" Drywell Purge Valves (16 pages)

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI-2) Client DECO T49.00

Project REPORT NO. DECO-04-2468 SUPP. CALC. #2

SUPPLEMENTARY CALCULATION NO. 2

NET TORQUE ASSESSMENT DURING POST-LOCA CLOSURE OF 10" AND 24" DRYWELL PURGE VALVES.

VALVES :

V4-2040	10" JAMESBURY WAFER-SPHERE WITH ST880 MS ACTUATOR
VR3-3012 & VR3-3023	24" JAMESBURY WAFER-SPHERE WITH BETTIS T416SR2 ACTUATOR

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Prepared By/Date	MH 9-7-84				
Checked By/Date	[illegible]				

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI-2) Client DECO T48.00

Project REPORT DECO-04-2468 SUPP. CALC. NO. 2

CALCULATION SUMMARY

THIS CALCULATION PROVIDES AN ASSESSMENT OF THE NET TORQUE PRODUCED ON THE 10" AND 24" DRYWELL PURGE VALVES DURING A REALISTIC POST-LOCA CLOSURE CYCLE.

THE GENERAL METHOD USED IS TO DETERMINE THE MAGNITUDE OF EACH TORQUE COMPONENT ACTING ON THE VALVE AT VARIOUS CLOSURE ANGLES FROM 90° (FULL OPEN) TO 0° (FULL CLOSED), ADD THESE COMPONENTS ALGEBRAICALLY WITH CLOSING TORQUES POSITIVE AND CLOSURE-RETARDING TORQUES NEGATIVE, AND USE THE RESULTS TO PLOT A NET TORQUE VS. CLOSURE ANGLE CURVE FOR EACH VALVE. (FIGURE 1).

THE METHOD IS DISCUSSED IN DETAIL ON PAGES 4 THROUGH 7, ALONG WITH THE ASSUMPTIONS MADE.

FROM THE RESULTING NET TORQUE VS. CLOSURE ANGLE CURVE (FIGURE 1), THE MAXIMUM NET TORQUES ARE AS FOLLOWS:

MAX. NET TORQUE 10" VALVE = 1315 FT-LBS.
MAX NET TORQUE 24" VALVE = 3130 FT-LBS.

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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-13

Owner DECO (FERMI-2) Client DECO T42.00

Project REPORT DECO-04-2468 SUPP. CALC. NO. 2

NOMENCLATURE

A_p = PROJECTED AREA OF VALVE DISK (IN.^{2})
CT = DYNAMIC TORQUE COEFFICIENT.
D = NOMINAL VALVE DIA. (IN.)
d = VALVE SHAFT DIA. (IN.)
ΔP = DIFFERENTIAL PRESSURE ACROSS VALVE (PSIG.)
T_N = NET CLOSING TORQUE (FT-LBS)
T_A = ACTUATOR TORQUE (FT-LBS)
T_F = FRICTION TORQUE (FT-LBS)
T_D = DYNAMIC TORQUE (FT-LBS.)
t = TIME AFTER LOCA (SEC.)

θ = VALVE CLOSURE ANGLE (DEGREES).
μ = COEFFICIENT OF FRICTION (KINETIC)

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NET TORQUE CALCULATION METHOD

THE NET TORQUE ON THE PURGE VALVES AT ANY POINT OF CLOSURE IS THE ALGEBRAIC SUM OF THE TORQUE THAT ACTS TO CLOSE THE VALVE (PROVIDED BY THE ACTUATOR) AND THE TORQUES THAT TEND TO RETARD CLOSURE (DUE TO FRICTION AND THE DYNAMIC TORQUE PRODUCED BY FLOW ACROSS THE VALVE).

$$T_N = T_A - T_D - T_F$$

WHERE: T_N = NET TORQUE
T_A = ACTUATOR OUTPUT TORQUE
T_D = DYNAMIC TORQUE
T_F = FRICTIONAL TORQUE.

ACTUATOR OUTPUT TORQUE:

ACTUATOR OUTPUT IS A FUNCTION OF VALVE POSITION. THE VALUES USED ARE TAKEN FROM VENDOR OUTPUT CURVES FROM REFERENCE-5. THESE CURVES ARE INCLUDED IN THIS CALC. AS FIGURE 2 AND 3 FOR THE 10" VALVE AND 24" VALVE ACTUATOR RESPECTIVELY.

DYNAMIC TORQUE

THE DYNAMIC TORQUE PRODUCED BY THE POST-LOCA FLOW ACROSS THE VALVE IS DETERMINED BY THE METHOD PRESENTED IN REFERENCE 4.

$$T_D = (CT)\,\Delta P\,D^3 \quad (FT\text{-}LBS.)$$

ΔP = THE DRYWELL POST-LOCA PRESSURE. WHICH IS GIVEN IN FIGURE 4 AS A FUNCTION OF TIME (REPRODUCED FROM REF. 4). (PSIG).

SINCE ΔP IS TIME DEPENDENT, A CLOSURE ANGLE VS. TIME RELATIONSHIP MUST BE ASSUMED. THE RELATIONSHIPS ASSUMED ARE THE CLOSURE TIME CURVES CALCULATED IN REFERENCE 4, INCLUDED HERE AS FIGURE 5 (10" VALVE) AND FIGURE 6 (24" VALVE).

SINCE THE CURVES REPRESENT A SOMEWHAT IDEALIZED CASE, THE CLOSURE TIMES AT EACH CLOSURE ANGLE WERE DOUBLED.

(CT) = DYNAMIC TORQUE COEFFICIENT, A FUNCTION OF VALVE ANGLE. THE VALUES

USED ARE FROM FIGURE 7, CURVES "A" AND "B" (TAKEN FROM REF. 4).

D = THE NOMINAL VALVE DIA. (INCIES)

FRICTION TORQUE

FRICTIONAL TORQUE THAT MUST BE OVERCOME DURING CLOSURE IS CALCULATED PER THE EQUATION FROM REFERENCE-4:

$$T_F = \frac{\left(A_p \ \Delta P \ \mu \ \frac{d}{2}\right)}{12} \quad \text{(FT-LBS)}$$

WHERE: A_p = PROJECTED AREA OF VALVE DISK

$$= \frac{\pi}{4} D^2 \cos\theta$$

D = PORT DIA. OF VALVE
= 22" FOR 24" VALVE (REF. 1)
= 10" FOR 10" VALVE (REF. 2)

θ = CLOSURE ANGLE.

ΔP = DRYWELL PRESSURE (PSIG)

μ = COEFFICIENT OF FRICTION (KINETIC) ASSUMED TO BE APPROX. 0.10.

d = SHAFT DIA. = 2.75" (24" VALVE)
= 1.368" (10" VALVE).

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-5

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT DECO-04-2468 SUPP. CALC. NO. 2

CALCULATION :

THE PRECEDING TORQUES AND PARAMETERS WERE CALCULATED FOR VARIOUS CLOSURE ANGLES.

THESE VALUES ARE SUMMARIZED IN TABLE 1 AND PLOTTED IN FIGURE 1.

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Checked By/Date					

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT DECO-04-2468 SUPP CALC. NO. 2

TABLE 1

NET TORQUE V.S. CLOSURE ANGLE

θ	t (SEC)	ΔP (PSIG)	A_P (IN^2)	μ	T_F (FT-LB)	CT	D^3 (IN^3)	T_D (FT. LB)	T_A (FT. LB.)	T_N (FT. LB.)
10" VALVE										
90	0.56	18	0	0.10	0	.018	1000	324	1150	826
75	0.84	23	20.33		2.7	.004		92	1275	1180
60	0.96	25	39.27		5.6	.003		75	1350	1269
45	1.08	26	55.54		8.2	.002		52	1375	1315
30	1.16	27	68.02		10.5	.002		54	1300	1235
15	1.24	28	75.86		12.1	.002		56	1100	1032
0	1.30	28.5	78.54		12.8	.0025		71	850	766
24" VALVE										
90	0.84	23	0	0.10	0	.0085	13824	2703	5833	3130
75	1.34	29	98.4		32.7	.004		1604	3917	2280
60	1.60	31.5	190.0		68.6	.003		1306	2917	1542
45	1.80	33.5	268.7		103.1	.002		926	2500	1471
30	1.96	35	329.1		132.0	.002		968	2500	1400
15	2.30	37	367.1		155.6	.002		1023	2750	1570
0	2.50	38	380.1		165.5	.0025		1313	3500	2021

$T_F = (\frac{1}{12})(A_P \Delta P \mu \frac{d}{2})$ $d/2 = 0.684"(10"\phi), 1.375"(24"\phi)$ △1

$T_D = (CT \Delta P D^3)$

T_A = FIGURES 2 & 3

$T_N = T_A - T_F - T_D$.

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Prepared By/Date	[illegible] 9-22-84	TMT 10/4/84	
Checked By/Date	RWH 9/11/84	Dragon 10-4-84	

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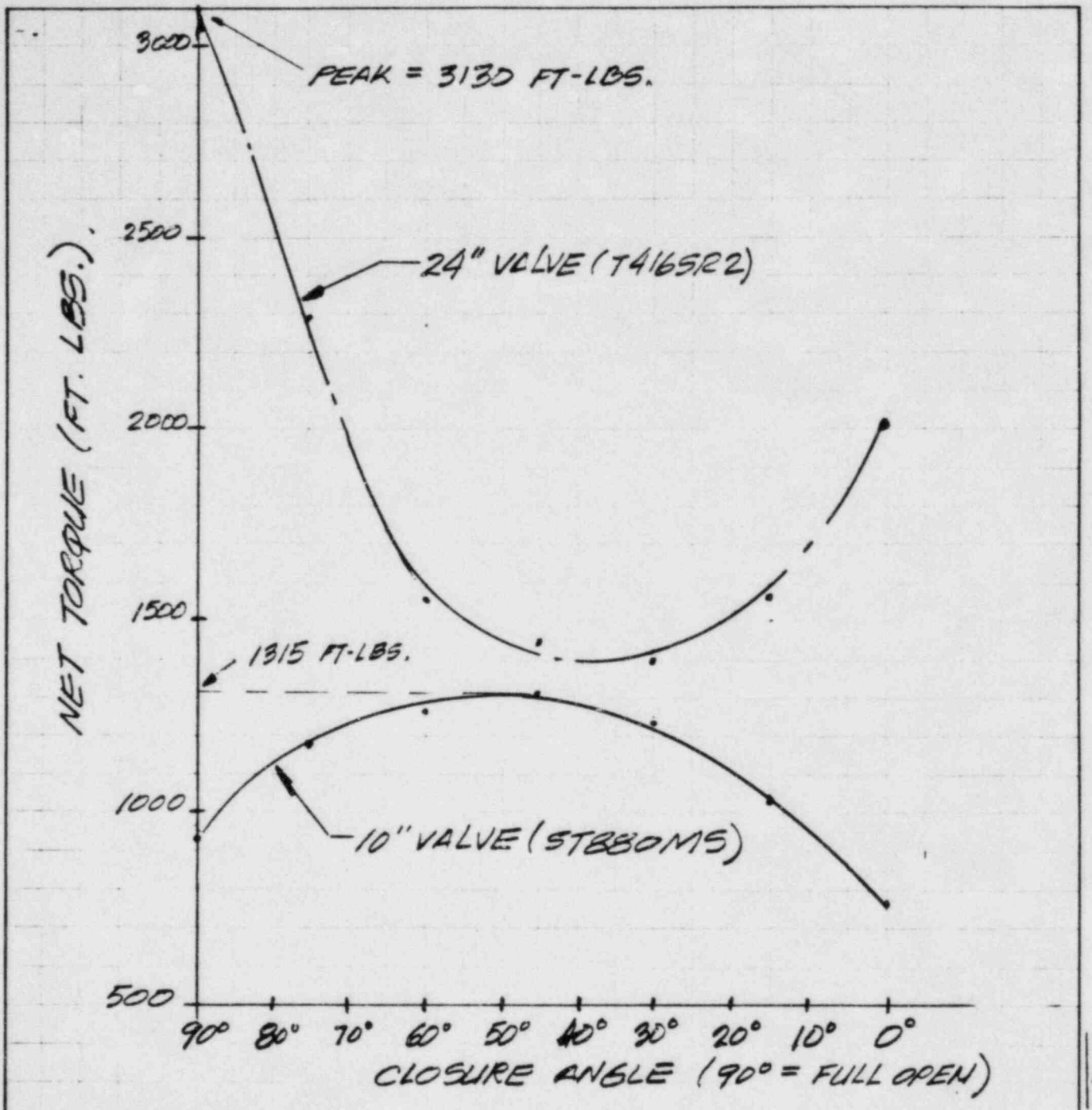
MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT DECO-04-246B SUPP. CALC. NO. 2



NET TORQUE VS. CLOSURE ANGLE

FIGURE 1

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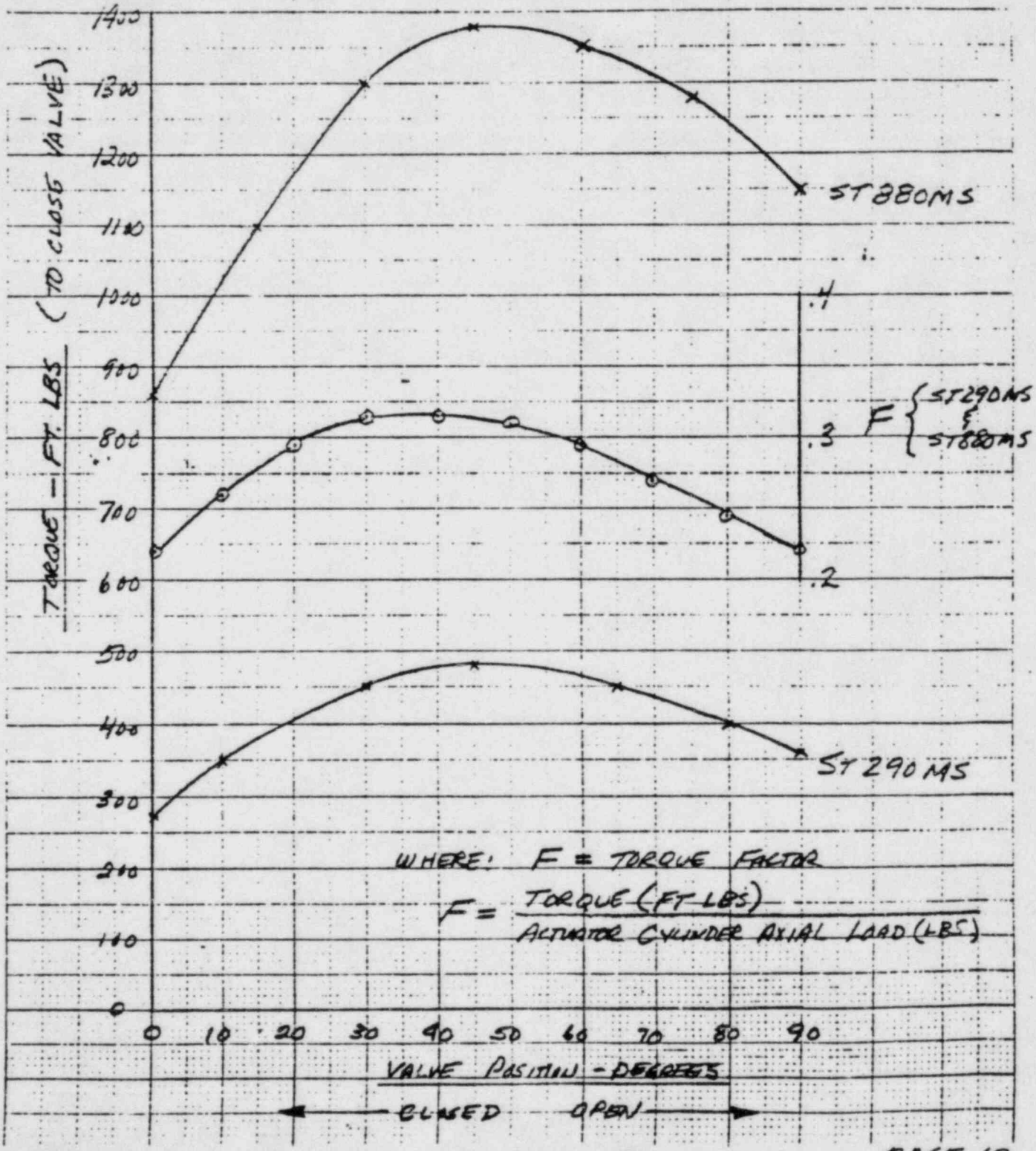
Prepared By/Date	[illegible] 9-27-84	[illegible] 10/4/84			
Checked By/Date	[illegible] 9/28/84	[illegible] 10-4-84			

Attachment 2

JAMESBURY CORP.
TORQUE VS VALVE POSITION
FOR
ST 290 MS & ST 880 MS



WHERE: F = TORQUE FACTOR

$$F = \frac{\text{TORQUE (FT LBS)}}{\text{ACTUATOR CYLINDER AXIAL LOAD (LBS)}}$$

FIGURE-2 (FROM REF. 5)

TORQUE - 1000 IN.-LBS. (T416 SR2)

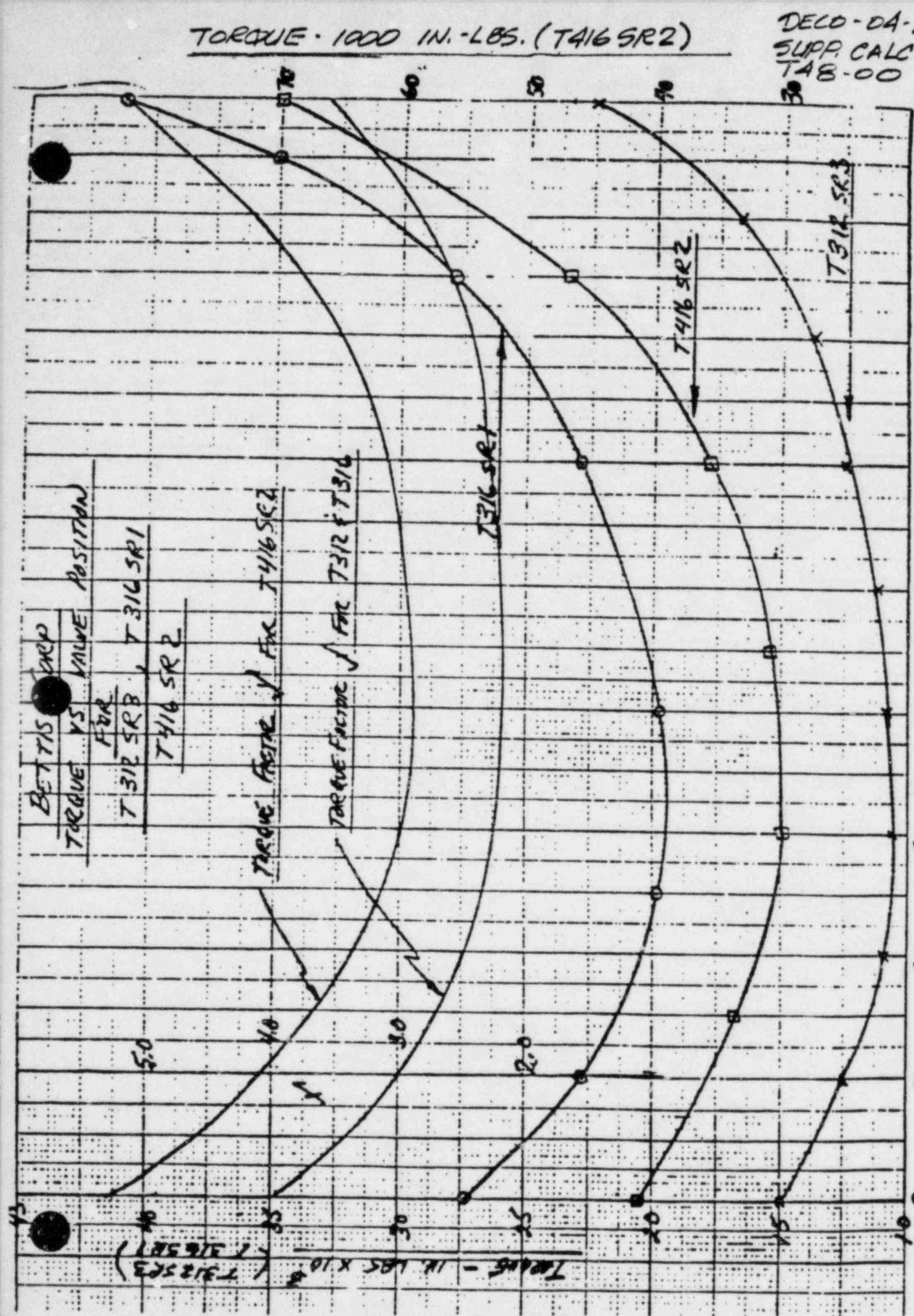
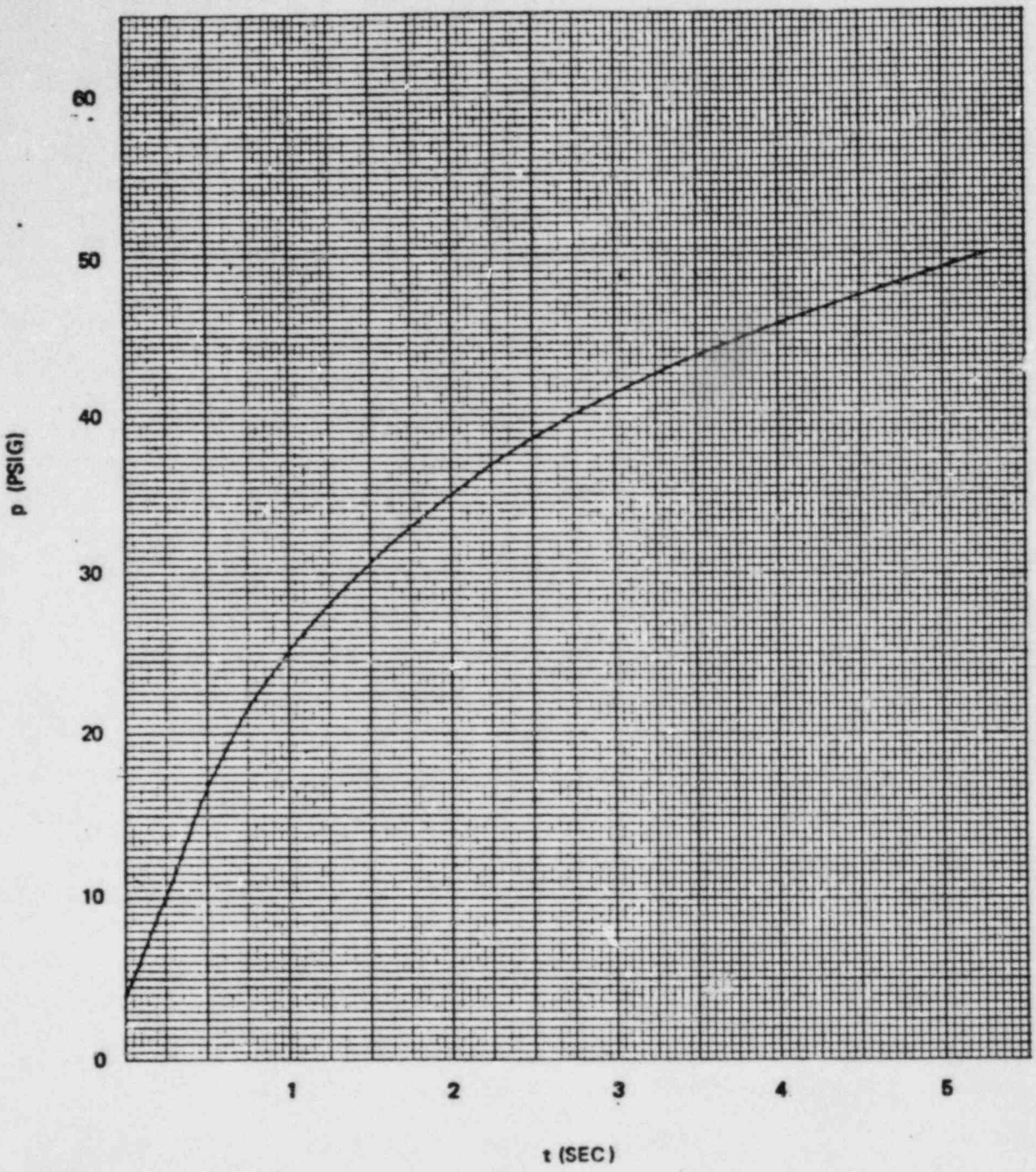


FIGURE - 3 (FROM REF. 5)

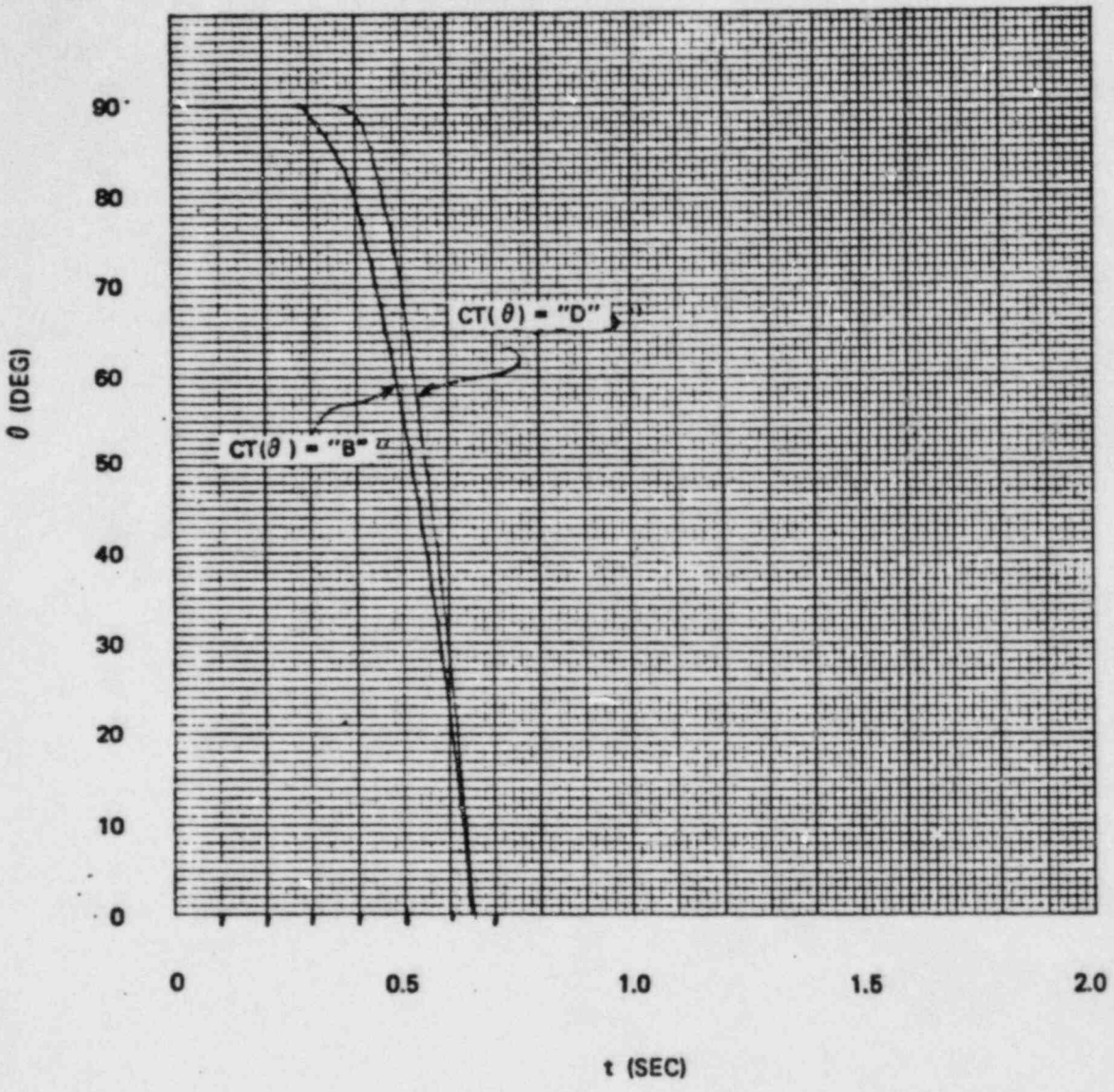
DELO-04-2468
SUPP. CALC. 2
T48-00



FERMI-2 DRYWELL LOCA PRESSURE RAMP
(FROM REFERENCE 4)

FIGURE 4 (FROM REF. 4)

DECO-04-246B
SUPP. CALC. NO. 2
T48-00

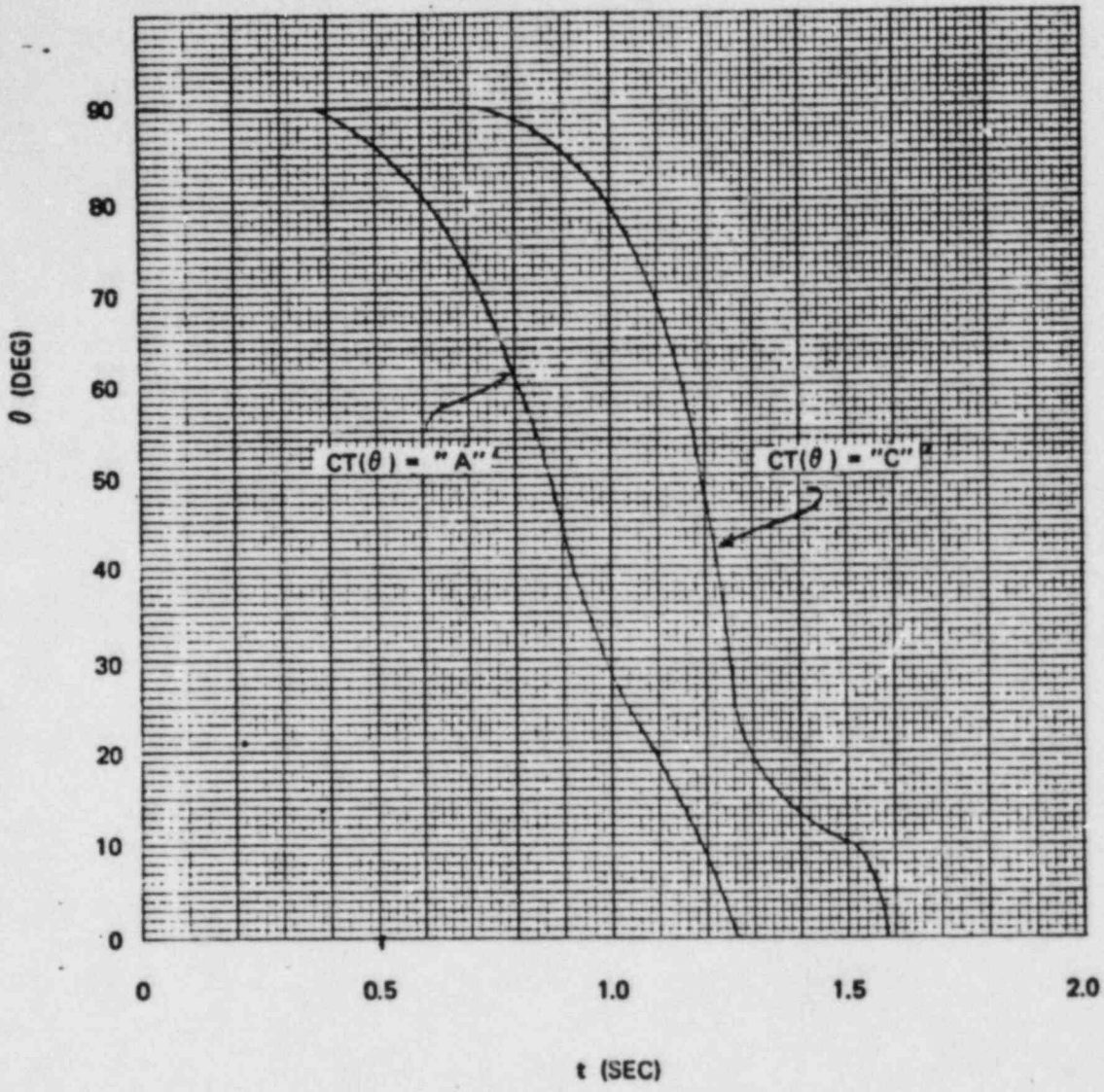


CLOSURE OF 10 INCH VALVE FOR TORQUE COEFFICIENT CURVES B AND D

NOTE ~ TIMES USED IN CALCULATION ARE THOSE FROM CURVE-B X 2.

FIGURE 5 (FROM REF 4)

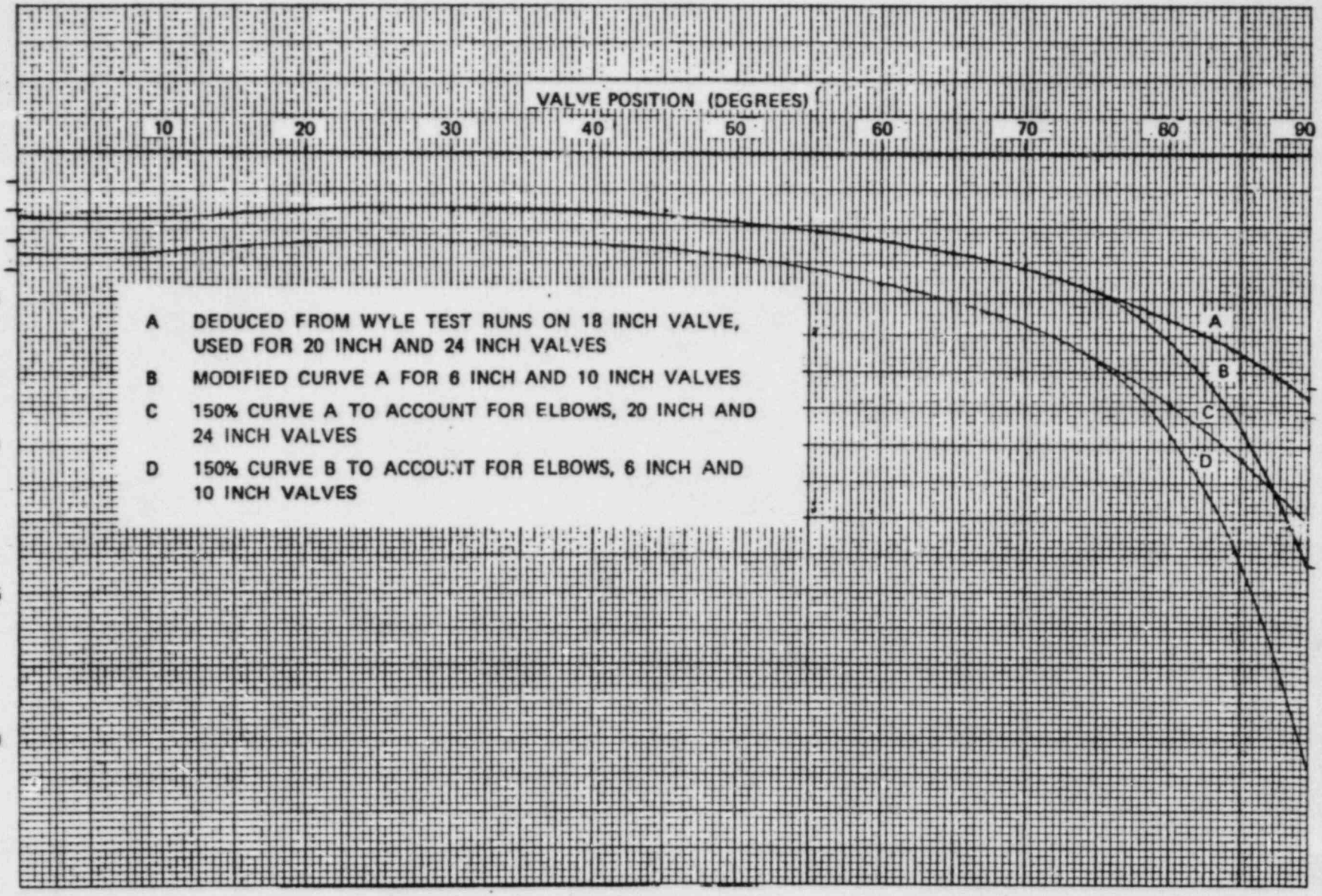
DECO-04-246B
SUPP. CALC. NO. 2
T48-00



CLOSURE OF 24 INCH VALVE FOR TORQUE COEFFICIENT CURVES A AND B

NOTE: TIMES USED IN ANALYSIS ARE THOSE FROM CURVE "A" X 2.
CURVE IS FROM REF. 4.

FIGURE-6



TORQUE COEFFICIENT VS. VALVE POSITION – COMPRESSIBLE FLOW

FIGURE - 7 (FROM REF 4) PAGE 15 OF 16

DECO-04-2468
SUPP. CALC. NO. 2
TAB-00

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT DECO-04-2468 SUPP. CALC. NO. 2.

REFERENCES - SUPPLEMENTARY CALC NO. 2

1) JAMESBURY CORPORATION DWG. NC-46261-25, REV. C, 24" WAFER SPHERE VALVE WITH BETTIS T416-SR2 ACTUATOR.

2) JAMESBURY CORP. DWG. NC-46261-21, REV. D, 10" WAFER SPHERE VALVE WITH JAMESBURY ST-880MS ACTUATOR.

3) "SEISMIC QUALIFICATION OF VALVES COVERED BY DETROIT EDISON PURCHASE ORDER NO. IE-86782 FOR THE ENRICO FERMI ATOMIC POWER PLANT UNIT NO. 2 AND PROCESSED UNDER JAMESBURY ORDER NO'S NC-46261, NC-34252, AND JPB-73111," EDISON FILE NO. PI-2327.

4) "PURGE VALVE CLOSURE ANALYSIS", BY WILLIAM W. DURGIN, ALDEN RESEARCH LABORATORY, WORCESTER POLYTECHNIC INSTITUTE, HOLDEN, MASSACHUSETTS, OCTOBER, 1981.

5) ACTUATOR SIZING CALCULATIONS PREPARED BY JAMESBURY CORP. FOR DETROIT EDISON UNDER P.O. NO. IE-86782, CHANGE ORDER NO. 22, T48-00-F, EDISON FILE NO. PI-2421

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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI 2) Client DECO T48-00

Project REPORT DECO-04-246B SUPP. CALC. NO. 1

REPORT NO. DECO-04-246B
SUPPLEMENTARY CALCULATION NO. 1

STRESS ANALYSIS OF VALVE OPERATOR MOUNTING BRACKET AND BRACKET BOLTS FOR JAMESBURY 24" WAFER-SPHERE VALVE WITH EETTIS T 416-SR2 OPERATOR

APPLICABLE TO DRYWELL PURGE VALVES VR3-3012 & VR3-3023.

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BACKGROUND INFORMATION

THE VALVE NECK, ACTUATOR MOUNTING BRACKET, AND BRACKET BOLTS OF THE 24" VALVES WERE QUALIFIED IN THE ORIGINAL VENDOR STRESS REPORT (REFERENCE 1) BY COMPARISON TO A SIMILAR 20" VALVE WITH SIMILAR COMPONENTS. IT WAS NOTED THAT THE STRESSES ON THE 20" VALVE COMPONENTS WERE WITHIN ALLOWABLES AND THAT THE ANALOGOUS COMPONENTS ON THE 24" VALVE WERE STRONGER, AND THAT THE 24" VALVE OPERATOR WEIGHS LESS THAN THE 20" VALVE OPERATOR

IT WAS THEREFORE CONCLUDED THE STRESS LEVELS ON THE 24" VALVE COMPONENTS WOULD BE LESS THAN THOSE FOR THE 20" VALVE COMPONENTS, AND NO FURTHER QUANTITATIVE ANALYSIS WAS PERFORMED.

THE ORIGINAL STRESS REPORT CONSIDERED LOADS DUE TO SEISMIC EXCITATION, STATIC PRESSURE ON THE VALVE DISK, AND THE VALVE BREAKING (SEATING) TORQUE.

AS DISCUSSED IN MDC REPORT NO. DECO-04-2468, IT IS NECESSARY TO DETERMINE THE COMPONENT STRESSES DUE TO HIGHER

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

Owner DECO (FERMI-2) Client DECO T4800

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1

TORQUES ON THE 24" VALVE THAN WERE CONSIDERED IN THE ORIGINAL STRESS REPORT.

THEREFORE, A MORE ACCURATE ASSESSMENT OF THE 24" VALVE COMPONENT STRESSES IS NEEDED.

THIS CALCULATION ESTABLISHES THE STRESSES IN THE ACTUATOR MOUNTING BRACKET AND BRACKET BOLTS FOR THE 24" VALVES WITH BETTIS MODEL T416-SR2 ACTUATOR FOR THE LOADS CONSIDERED IN THE ORIGINAL VENDOR STRESS REPORT.

SEISMIC STRESSES ARE CALCULATED BASED ON EQUIVALENT STATIC LOADS FOR THE FOLLOWING ACCELERATIONS (PER REFERENCE 1)

HORIZONTAL = 5g
VERTICAL = 3g

VALVE TORQUE = 3200 FT-LBS.
DISC PRESSURE = 62 PSIG
(PER REFERENCE 1)

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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-3

Owner DECO (FERMI-2) Client DECO T48.00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1

SUMMARY OF RESULTS

COMPONENT STRESSES (PSI)

	BRACKET	BRACKET BOLTS
σ_p (SEISMIC)	1,566	23,060
σ_p (TORQUE)	8,084	6,270
σ_p (TOTAL)	9,650	29,330
σ_p (ALLOW.)	30,000	105,000
τ_{MAX} (SEISMIC)	821	15,120
τ_{MAX} (TORQUE)	4,042	6,270
τ_{MAX} (TOTAL)	4,863	21,390
τ_{MAX} (ALLOW.)	18,000	63,000

σ_p = PRINCIPLE NORMAL STRESS
τ_{MAX} = MAXIMUM SHEAR STRESS

NOTES:

1) ALLOWABLES ARE FROM REFERENCE 1.
2) DISC PRESSURE WAS DETERMINED TO HAVE A NEGLIGIBLE AFFECT ON THE BRACKET AND BRACKET BOLTS.

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SEISMIC ANALYSIS OF BRACKET

SEISMIC FORCES

PER REFERENCE 1 (PAGE-2) THE BRACKET WILL BE ANALYZED FOR THE FOLLOWING EQUIVALENT STATIC LOADS:

5g HORIZONTAL
3g VERTICAL.

THE LOADS WILL BE APPLIED SIMULTANEOUSLY.

ACTUATOR INFORMATION

CENTER OF GRAVITY IS LOCATED AS GIVEN IN REFERENCE 4.

ACTUATOR WEIGHT = 586 LB. (REF. 1, PG. 25)

BRACKET INFORMATION

THE BRACKET DETAIL IS SHOWN IN FIGURE 1.

VALVES VR3-3012 AND VR3-3023 ARE ORIENTED AS SHOWN IN FIGURE 2. THE LOADING CASES USED IN THE FOLLOWING CALCULATION CORRESPOND WITH THESE ORIENTATIONS, WHICH REPRESENT THE WORST LOADING CONDITION ON THE BRACKET (I.E., GREATEST SHEAR & BENDING/TENSILE STRESSES).

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-3

Owner DECO (FERMI-2) Client DECO T-B-00

Project REPORT NO. DECO-04-246B SUPP. CALC NO. 1

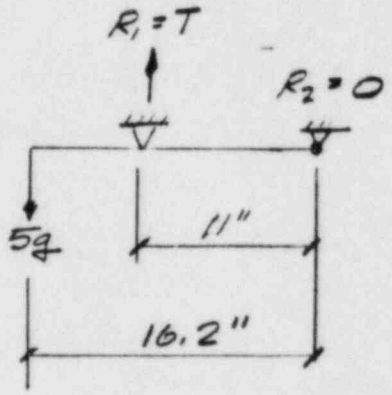
CASE #1

CORRESPONDS TO ORIENTATION OF VALVE VR3-3012 EXCEPT VALVE SHAFT IS HORIZONTAL TO MAXIMIZE EFFECTS OF VERTICAL FORCE. SEE FIGURE 3.

σ_T = TENSILE LOADING STRESS
σ_b = BENDING STRESS
τ = SHEAR LOADING STRESS.

TENSILE STRESS

CONSIDER OPERATOR AS A BEAM SUPPORTED BY THE BRACKET LEGS.

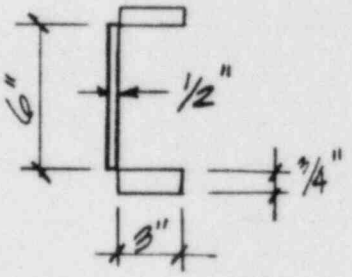


R = REACTION FORCE
T = TENSILE FORCE

$$T = (5 \times 580) \times \frac{16.2}{11} = 4{,}315 \text{ LBS.}$$

A = CROSS-SECTIONAL AREA OF LEG
= 2×3×0.75 + 6×0.5
= 7.5 IN.^{2}

$$\sigma_T = T/A = 575 \text{ PSI}$$



LEG X-SECTION

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(CASE #1 CONT'D)

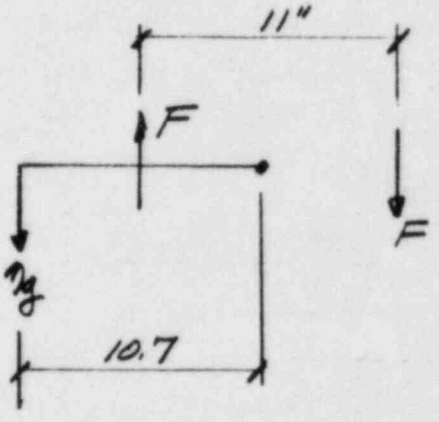
SHEAR STRESS

SHEAR STRESSES IN THE LEGS AT THE CRITICAL SECTION WILL BE DUE TO TWO DIFFERENT LOADING ASPECTS.

τ_1 = STRESS DUE TO VERTICAL 3g LOAD

τ_2 = STRESS DUE TO TORSION OF 3g VERTICAL LOAD ABOUT THE Z-AXIS.

τ_2 WILL BE APPROXIMATED BY RESOLVING THE TORSIONAL MOMENT INTO AN EQUIVALENT COUPLE WITH FORCES ACTING THROUGH THE LEGS.



$(3 \times 586)(10.7) = 11(F)$

$F = 1710$ LBS.

$\therefore \tau_2 = \frac{F}{A} = \frac{1710}{7.5} = \underline{228 \text{ PSI}}$

τ_1 WILL BE DISTRIBUTED EQUALLY TO THE LEGS.

$\tau_1 = \frac{1}{2} \times (3 \times 586) / 7.5 \text{ IN}^2 = \underline{117.2 \text{ PSI}}$

$\tau \text{ (TOTAL)} = \tau_1 + \tau_2 = \underline{345 \text{ PSI}}$

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MULTIPLE DYNAMICS CORPORATION

Job No. EN-1-5

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1

(CASE #1 CONT'D)

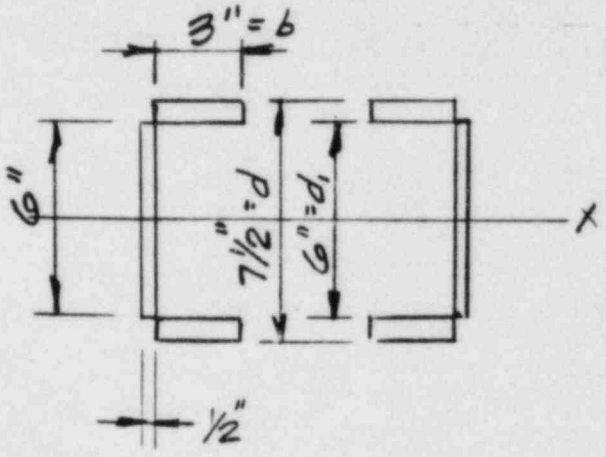
BENDING STRESSES

M ≡ MOMENTS ABOUT X-AXIS

$M = (3g)(11.25) + 5g(3.7)$

$= (3\times586)(11.25) + (5\times586)(3.7) = 30,618$ IN-LB.

S_x ≡ SECTION MODULUS OF BRACKET ABOUT X-AXIS @ CRITICAL SECTION.



$$S_x = 2\times\frac{bd^2}{6} + \frac{2b(d^3 - d_1^3)}{6d}$$

$$= \frac{0.5\times6^2}{3} + \frac{2\times3(7.5^3 - 6^3)}{6\times7.5}$$

$$= 6.00 + 27.45 = 33.45 \text{ IN.}^3$$

$$\sigma_b = \frac{M}{S_x} = \frac{30,618}{33.45} = \underline{915 \text{ PSI}}$$

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MULTIPLE DYNAMICS CORPORATION

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Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1

(CASE #1 CONT'D).

COMBINED STRESSES

$\sigma = \sigma_T + \sigma_b = 575 + 915 = 1490$ PSI.

$\tau = 343$ PSI.

USING THE MOHR'S CIRCLE EQUATIONS, THE PRINCIPLE NORMAL STRESS (σ_p) AND MAXIMUM SHEAR STRESS (τ_{MAX}) CAN BE DETERMINED.

$$\sigma_p = \frac{\sigma}{2} + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} = 1566 \text{ PSI}$$

$$\tau_{MAX} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} = 821 \text{ PSI}$$

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CASE #2

CORRESPONDS TO ORIENTATION OF VALVE VR3-3023, SEE FIGURE 4.

PROCEEDING SIMILARLY AS CASE #1:

σ_T = TENSILE STRESS
σ_b = BENDING STRESS
τ = SHEAR STRESS

AREA OF LEG = 7.5 IN^2
ACTUATOR WT. = 586 LB.

$$\sigma_T = \frac{(5 \times 586) \times \left(\frac{5.5 + 3.7}{11}\right)}{7.5 \text{ IN}^2} = 327 \text{ PSI.}$$

τ (TOTAL) = $\tau_1 + \tau_2$

τ_1 = DIRECT SHEAR
τ_2 = TORSIONAL SHEAR

$$\tau_1 = \left(\frac{3 \times 586}{7.5}\right) \times 1/2 = 117 \text{ PSI.}$$

$$\tau_2 = \left(\frac{3 \times 586 \times 10.7}{11}\right)\left(\frac{1}{7.5}\right) = 228 \text{ PSI.}$$

τ (TOTAL) = 345 PSI

$$\sigma_b = M_y / S_y$$

$$M_y = (3 \times 586)(11.25) + (5 \times 586)(3.7) = 30,618 \text{ IN-LB.}$$

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-3

Owner DECO (FERMI-2) Client DECO T+B-00

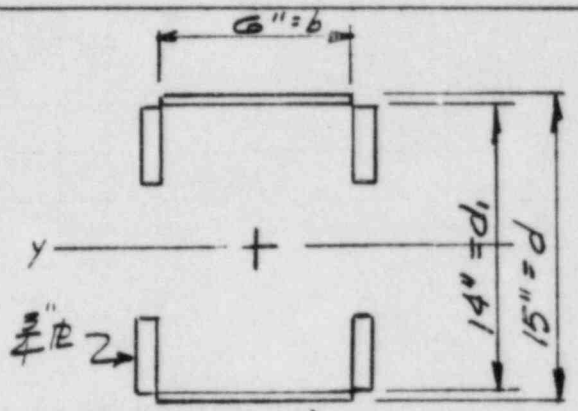
Project REPLT 110. EI.10-04-2468 SUPP. CALC. I.D.

(CASE #2 CONT'D)

$$S_y = \frac{b(d^3 - d_1^3)}{6d}$$

$$= \frac{6(15^3 - 14^3)}{6 \times 15}$$

$$= 42.07 \text{ IN.}^3$$



(NEGLECT 3/4" RATES ~ CONSERVATIVE)

$\therefore \sigma_b = 30618 / 42.07 = 728$ PSI.

TOTAL STRESSES:

$\sigma = \sigma_T + \sigma_b = 327 + 728 = 1055$ PSI

$\tau = 345$ PSI.

USING MOHR'S CIRCLE EQUATIONS

$$\sigma_P = \frac{\sigma}{2} + \sqrt{(\sigma/2)^2 + \tau^2} = \underline{1160 \text{ PSI}}$$

$$\tau_{MAX} = \sqrt{(\sigma/2)^2 + \tau^2} = \underline{690 \text{ PSI}}$$

NOTE: CASE #1 IS A WORSE LOADING CONDITION.

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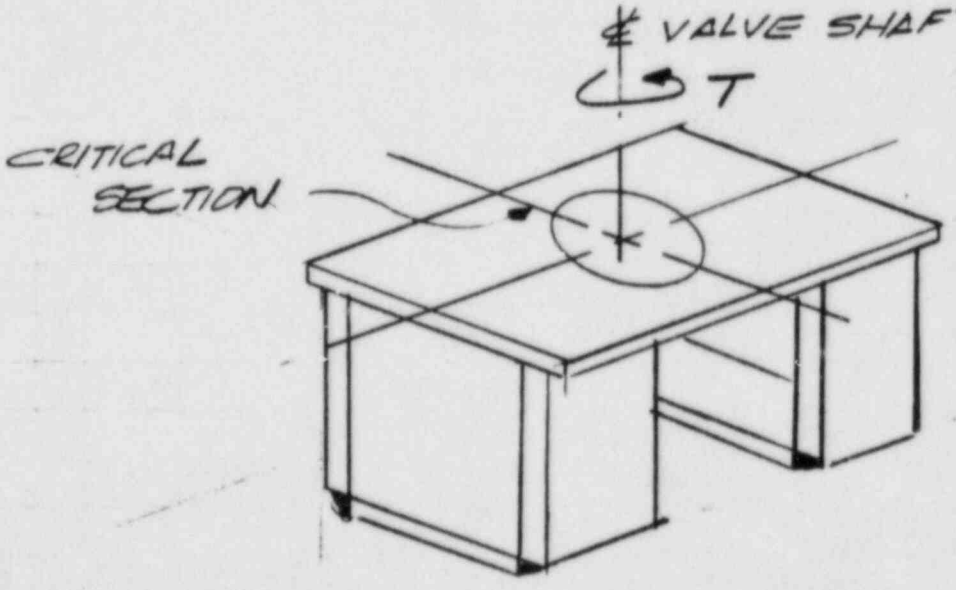
BRACKET ANALYSIS (CONT'D)

STRESSES FROM VALVE TORQUE & DISC PRESSURE

THE STRESSES DUE TO A VALVE TORQUE OF 3200 FT-LBS WILL BE DETERMINED (THE SAME TORQUE USED TO ORIGINALLY ASSESS THE 24" VALVES IN REFERENCE 1).

PRESSURE ON THE VALVE DISK INDUCES SHEAR LOADS ON THE SHAFT. (THIS IS A STATIC PRESSURE, AS THE VALVE WOULD SEE WHEN SEATED.) THESE SHEARS ARE TRANSFERRED TO THE VALVE BODY AND NECK THROUGH THE BEARINGS, AND DO NOT AFFECT THE BRACKET. THEREFORE, NEGLECT DISK PRESSURE.

ASSUME THAT THE ENTIRE TORQUE (3200 FT-LBS) IS TAKEN BY THE BRACKET.



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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-B

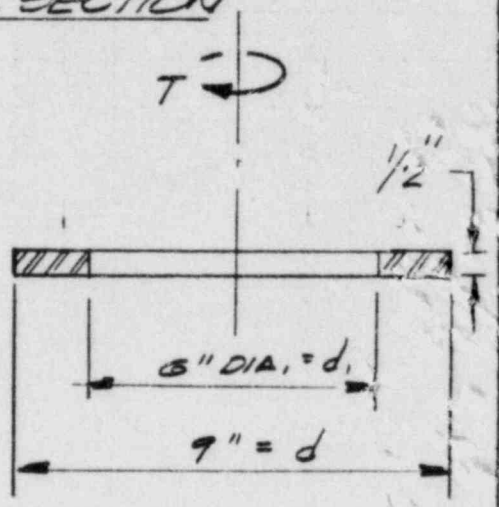
Owner DECO (FERMI 2) Client DECO T48-00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO 1

(VALVE TORQUE STRESSES CONT'D)

CHECK TOP PLATE @ CRITICAL SECTION

BENDING ABOUT SHAFT ℄ :



$M = T = 3200 \times 12 = 38400$ IN-LB.

$S = b(d^3 - d_1^3)/6d$

$= 0.5(9^3 - 6^3)/(6 \times 9)$

$= 4.75$ IN.^{3}

$\sigma_b = M/S =$ **8,084 PSI**

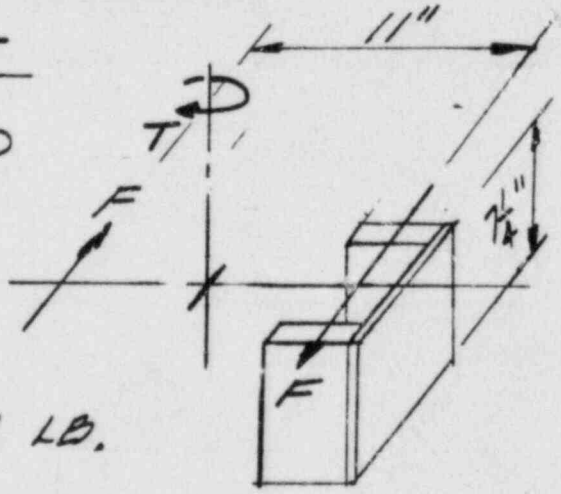
USING MOHR'S CIRCLE EQUATIONS :

$\sigma_P = \frac{\sigma}{2} + \sqrt{(\frac{\sigma}{2})^2 + \tau^2} =$ **8084 PSI**

$\tau_{MAX} = \sqrt{(\frac{\sigma}{2})^2 + \tau^2} =$ **4042 PSI**

CHECK LEGS OF BRACKET

ASSUME TORQUE IS TRANSMITTED TO LEGS AS AN EQUIVALENT COUPLE.



F = FORCE PER LEG.

$F = \frac{T}{11"} = \frac{38400 \text{ IN-LB}}{11 \text{ IN.}} = 3490$ LB.

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MULTIPLE DYNAMICS CORPORATION

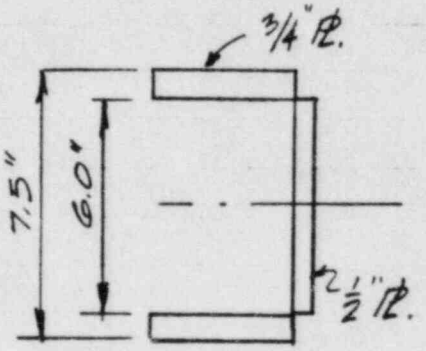
Job No. 81-1-13

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-246B SUPP. CALC. NO. 1

FORCE F PRODUCES BENDING AND SHEAR ON LEG.

M = MOMENT @ BASE
= 3490 x 7.25" = 23,300 IN-LB.



$$S = \frac{3(7.5^3 - 6^3)}{6 \times 7.5} + \frac{\frac{1}{2} \times 6^2}{6}$$

$$= 13.75 + 3.0$$
$$= 16.75\ IN^3$$

$$\sigma_b = \frac{M}{S} = \underline{1390\ PSI}$$

$$\tau = \frac{F}{A} = \frac{3490\ LB}{7.5\ IN^2} = \underline{465\ PSI.}$$

USING MOHR'S CIRCLE EQUATIONS:

$$\sigma_p = \frac{\sigma}{2} + \sqrt{(\sigma/2)^2 + \tau^2} = \underline{1530\ PSI}$$

$$\tau_{MAX} = \sqrt{(\sigma/2)^2 + \tau^2} = \underline{836\ PSI}$$

∴ TOP PLATE IS THE CRITICAL COMPONENT. 3200 FT-LBS TORQUE RESULTS IN:

$$\sigma_p = 8084\ PSI$$

$$\tau_{MAX} = 4042\ PSI$$

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BRACKET BOLT ANALYSIS

THE WORST LOADING CASE FOR THE BRACKET BOLTS IS WHEN THE VALVE SHAFT IS HORIZONTAL, (SEE HAND CALCULATIONS INCLUDED IN REFERENCE 5), WHICH IS APPROPRIATE FOR THE ORIENTATION OF VALVES VR3-3012 AND VR3-3023. (FIG. 2)

4 BOLTS ARE USED TO ATTACH THE BRACKET TO THE VALVE NECK. 6 BOLTS ATTACH THE ACTUATOR TO THE BRACKET, AND THESE ARE CLOSER TO THE ACTUATOR C.G. THAN THE 4 BOLTS, SO THE GREATEST FORCES ARE DEVELOPED IN THE 4 BRACKET-TO-VALVE NECK BOLTS.

BOLTS WILL BE ANALYZED FOR SEISMIC AND VALVE TORQUE LOADS. DISC PRESSURE LOADS DO NOT AFFECT THESE BOLTS (SEE PAGE 12). ⚠1

SEISMIC LOADS: 5g HORIZONTAL
3g VERTICAL

WT. ACTUATOR = 586 LB.

VALVE TORQUE: 3200 FT-LBS.
= 38400 IN-LBS.

BOLTS: 3/4" DIAMETER, 10-PITCH. (REF. 6)
ROOT DIAMETER = 0.620"
A = ROOT AREA = 0.302 SQ. IN.

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MULTIPLE DYNAMICS CORPORATION

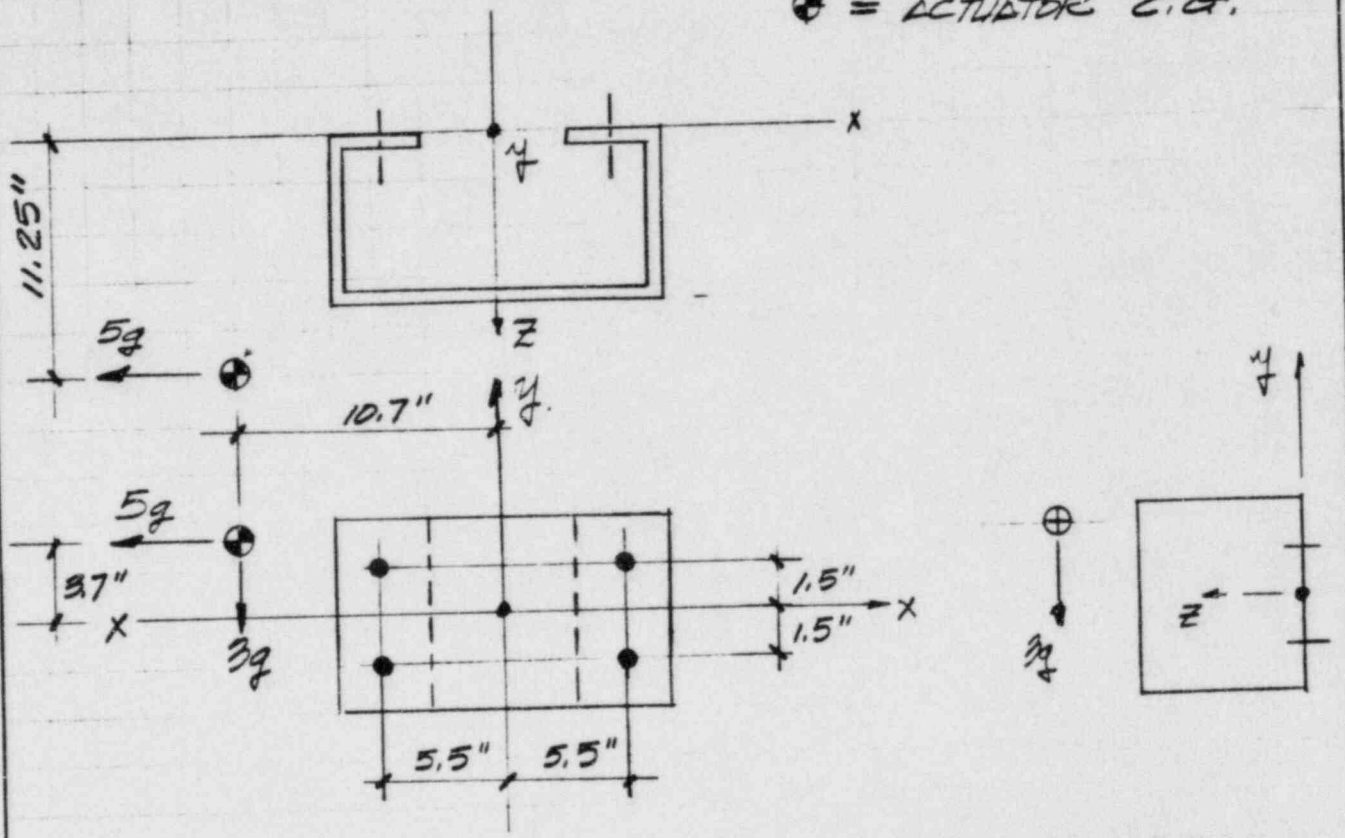
Job No. 31-3

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1

BRACKET BOLTS - SEISMIC FORCES

⊕ = ACTUATOR C.G.



RESOLVING FORCES ABOUT ORIGIN OF COORDINATE AXES:

$M_z = (5 \times 586 \times 3.7) + (3 \times 586 \times 10.7) = 29,652$ IN-LB.

$M_y = 5 \times 586 \times 11.25 = 32,962$ IN-LB.

$M_x = 3 \times 586 \times 11.25 = 19,778$ IN-LB.

$F_x = 5 \times 586 = 2930$ LB.

$F_y = 3 \times 586 = 1758$ LB.

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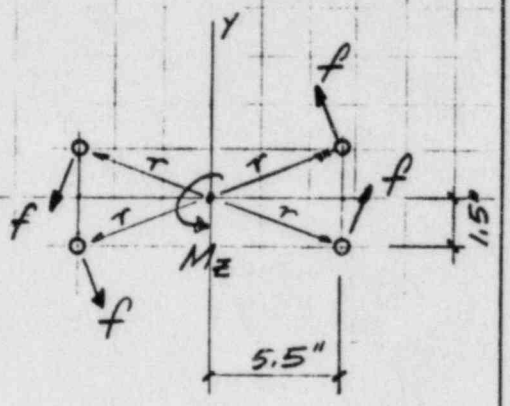
(SEISMIC CONT'D)

SHEAR FORCE (M_z, F_x, F_y)



$M_z = \Sigma rf = 4rf_s$

f_s = FORCE PER BOLT (SEISMIC)

$r = \sqrt{1.5^2 + 5.5^2} = 5.70"$

$\therefore f_s = M_z / 4r$

$= 29{,}652 / 4 \times 5.70 = 1300$ LB.

$f_{sx} = 1300 \times (5.5/5.70) = 1254$ LB.

$f_{sy} = 1300 \times (1.5/5.70) = 342$ LB.

$\Sigma f_{sx} = 1254 + 2930 = 3272$ LB.

$\Sigma f_{sy} = 342 + 1758 = 2100$ LB.

RESULTANT $f_{s_R} = (\Sigma f_x^2 + \Sigma f_y^2)^{1/2} = \underline{3888 \text{ LB.}}$

TENSILE FORCE (M_x, M_y)

F_s = TENSILE FORCE PER BOLT (SEISMIC)

$F_s = \frac{1}{2}\left(\frac{M_y}{11}\right) + \frac{1}{2}\left(\frac{M_x}{3}\right)$

$= 32962/22 + 19778/6$

$= \underline{4{,}795 \text{ LBS.}}$

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MULTIPLE DYNAMICS CORPORATION

Job No. 31-1-B

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-2468 SUPP. CALC NO. 1

BOLT STRESSES ~ SEISMIC

τ = 3888 / 0.302 IN^2 = 12870 PSI.

σ = 4795 / 0.302 = 15,878 PSI

USING MOHR'S CIRCLE EQUATIONS:

$\sigma_p = \sigma/2 + \sqrt{(\sigma/2)^2 + \tau^2}$ = 23,060 PSI

$\tau_{MAX} = \sqrt{(\sigma/2)^2 + \tau^2}$ = 15,120 PSI

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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-3

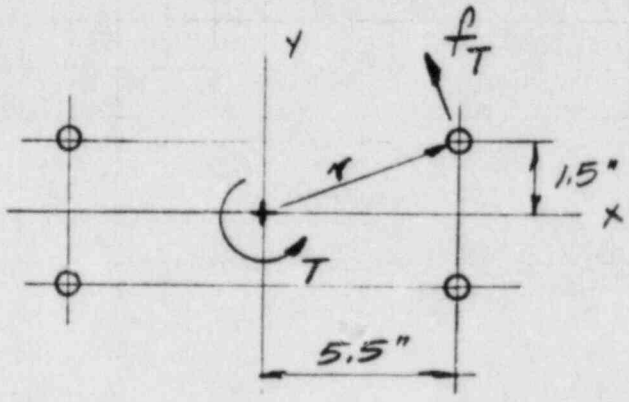
Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1

BRACKET BOLTS ~ VALVE TORQUE FORCES

T = VALVE TORQUE
= 38,400 IN-LB.

f_T = FORCE PER BOLT DUE TO VALVE TORQUE



$J = 4r f_T$ $r = 5.07"$

$$f_T = \frac{38400}{4 \times 5.07} = 1,890 \text{ LBS.}$$

BOLT STRESSES ~ VALVE TORQUE.

$\tau = 1890/0.302 = 6,270$ PSI.

$\sigma = \phi$

FROM MOHR'S CIRCLE

$$\tau_{MAX} = \sqrt{(\sigma/2)^2 + \tau^2} = \underline{6270 \text{ PSI}}$$

$$\sigma_p = \frac{\sigma}{2} + \sqrt{(\sigma/2)^2 + \tau^2} = \underline{6270 \text{ PSI.}}$$

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MULTIPLE DYNAMICS CORPORATION

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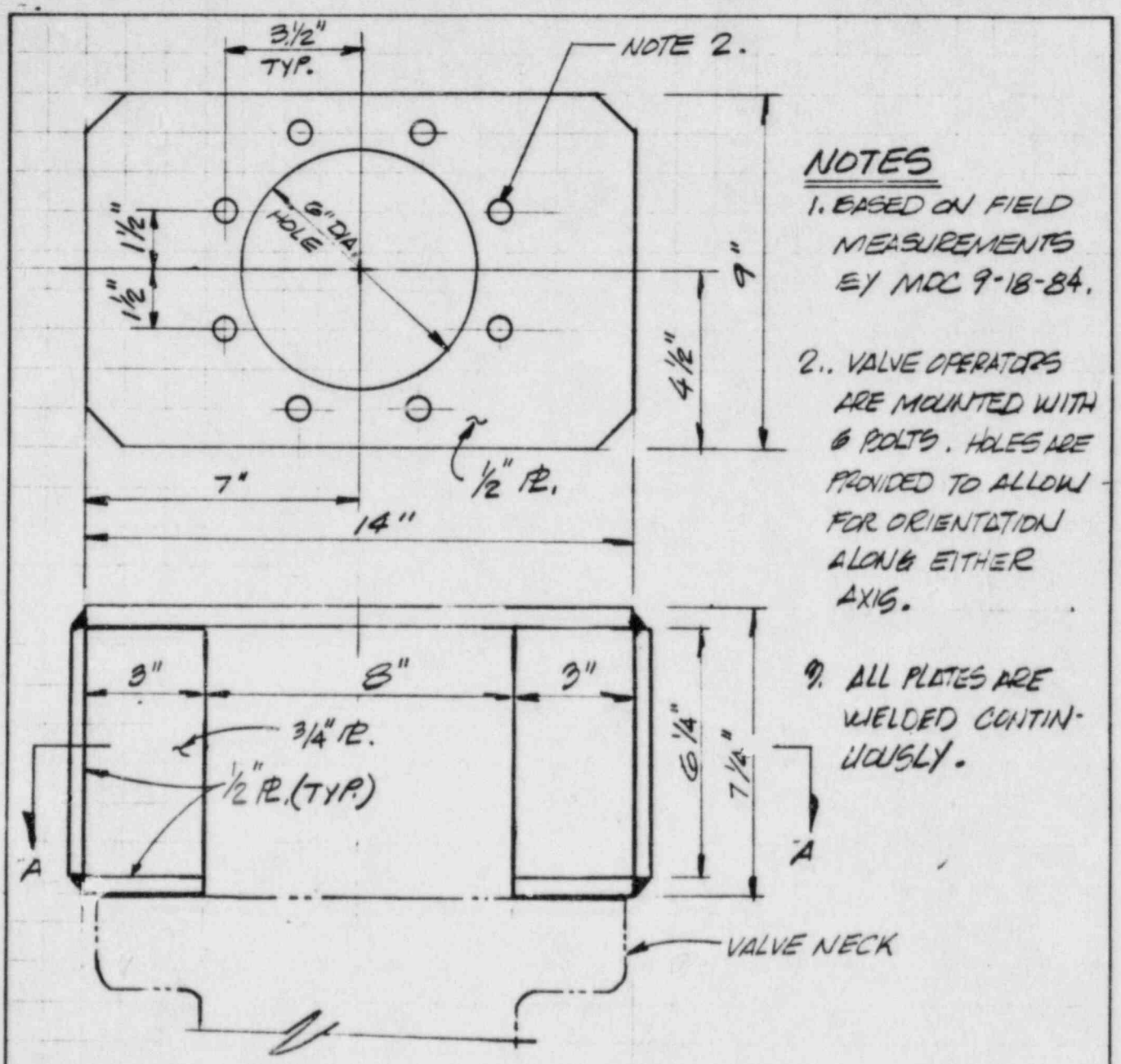

NOTES

1. BASED ON FIELD MEASUREMENTS BY MDC 9-18-84.
2. VALVE OPERATORS ARE MOUNTED WITH 6 BOLTS. HOLES ARE PROVIDED TO ALLOW FOR ORIENTATION ALONG EITHER AXIS.
3. ALL PLATES ARE WELDED CONTINUOUSLY.

OPERATOR BRACKET FOR VB-3012 & 3023

FIGURE 1 SHT. 1 OF 2

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MULTIPLE DYNAMICS CORPORATION

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Owner DECO (FERMI-2) Client DECO T48-00

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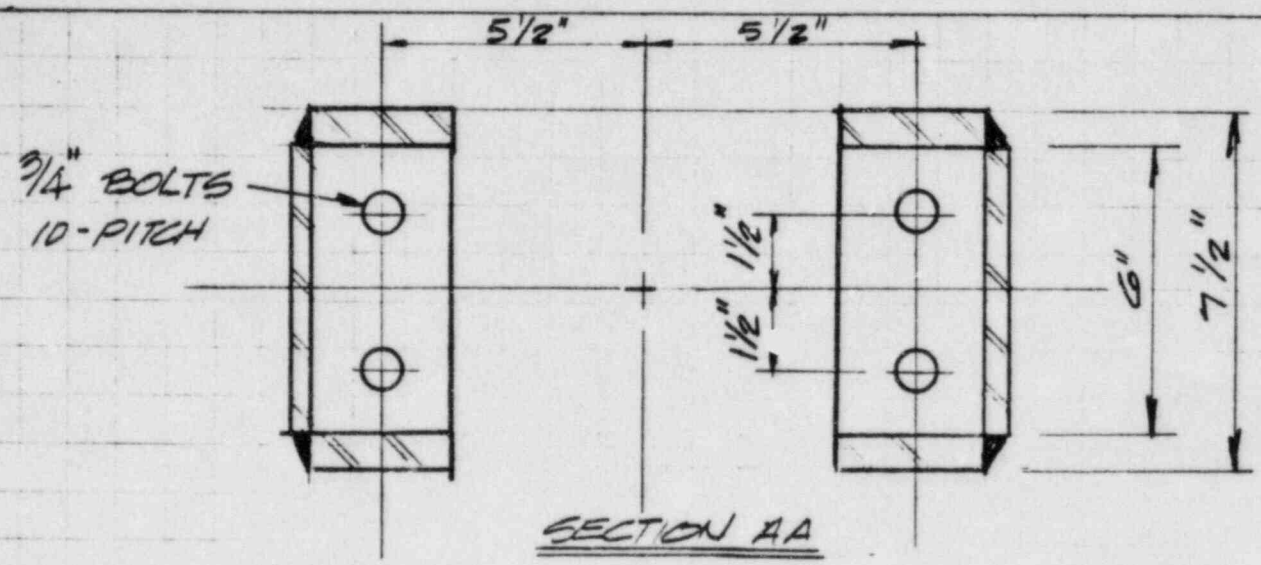

SECTION AA

OPERATOR BRACKET FOR VR3-3012 & 3023

FIGURE 1 SHT. 2 of 2

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MULTIPLE DYNAMICS CORPORATION

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Owner DECO (FERMI-2) Client DECO T48-00

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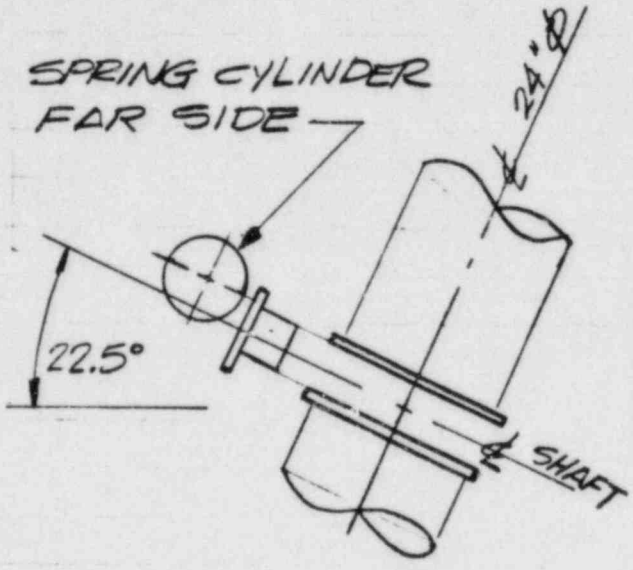
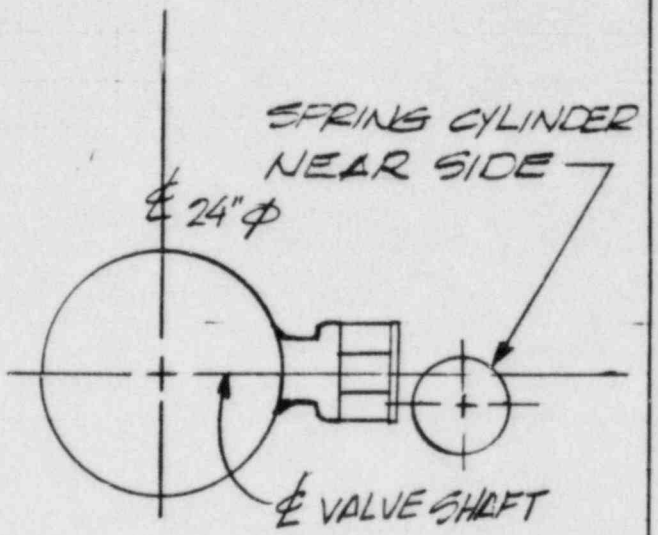


ELEVATION

VR3-3012



ELEVATION

VR3-3023

(REFERENCE : EDISON DWG. GM721-4304, REV. K
FIELD VERIFIED BY MDC 9-18-84.)

24" PURGE VALVE ORIENTATION

FIGURE 2

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MULTIPLE DYNAMICS CORPORATION

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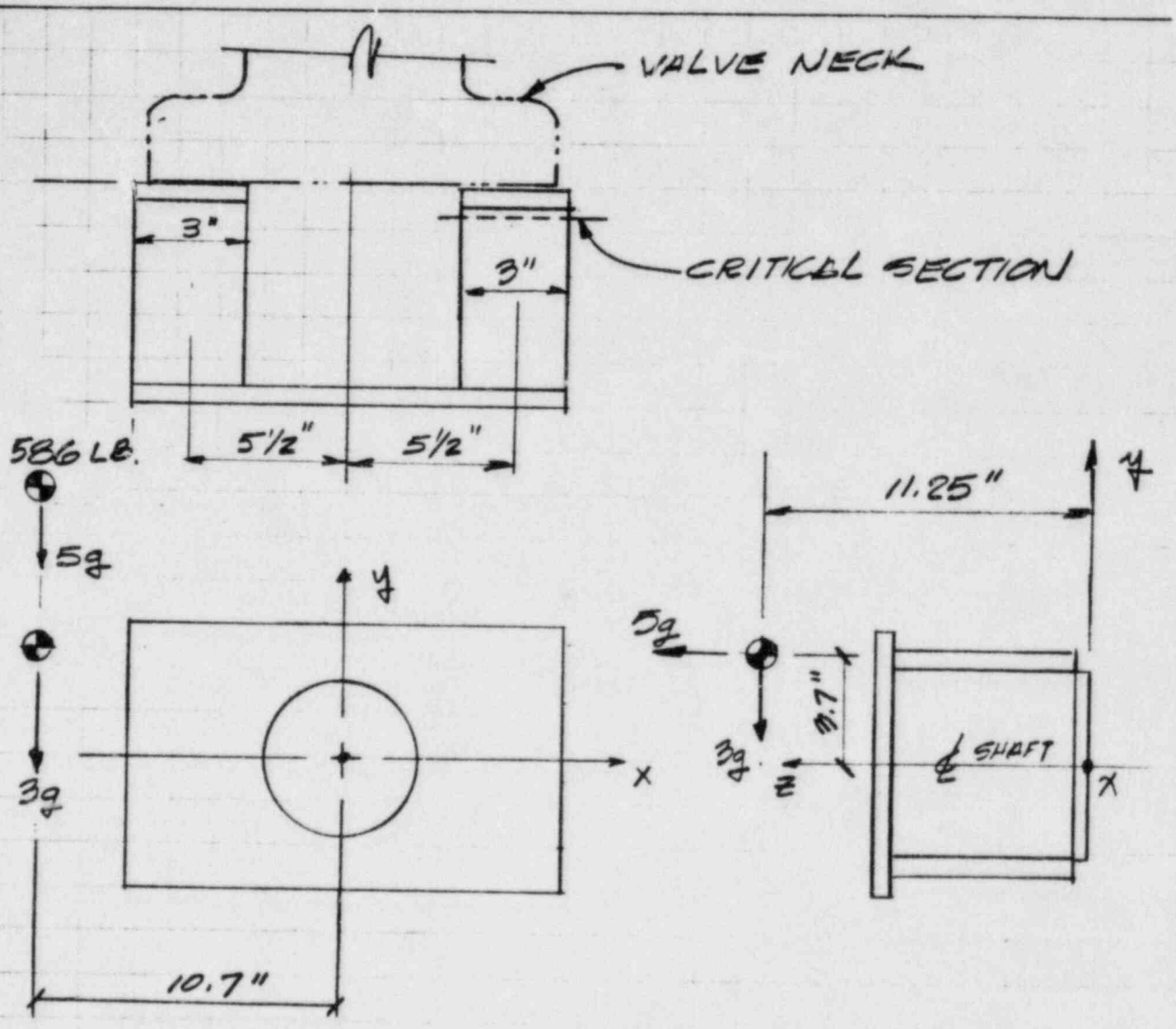
Owner DECO (FERMI-2) Client DECO T4B-00

Project REPORT NO. DECO-04-2468 SUPP. CALC. NO. 1



SEISMIC LOAD CASE #1

FIGURE 3

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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-5

Owner DECO (FERMI-2) Client DECO T48-00

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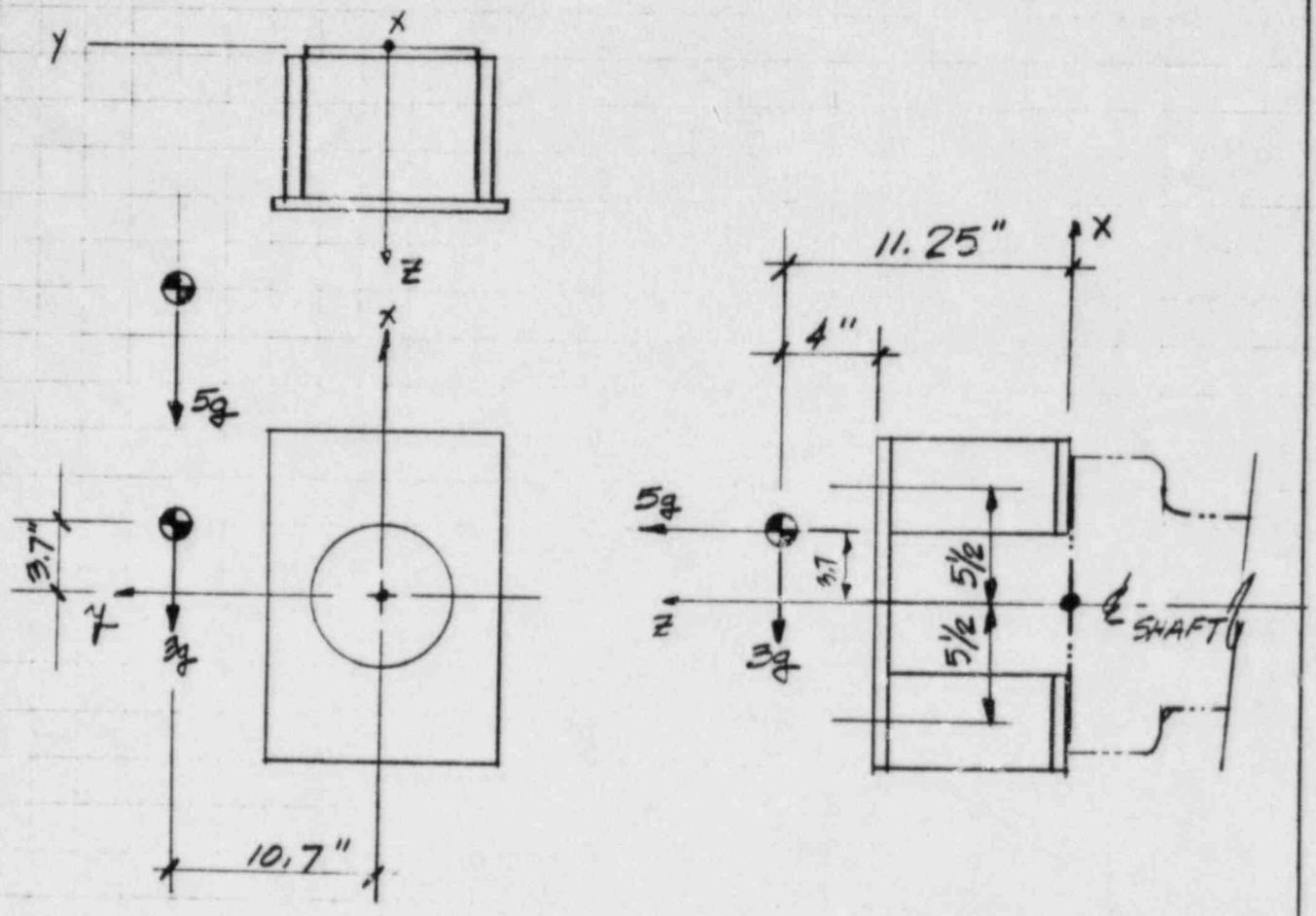

SEISMIC LOAD CASE #2

FIGURE 4

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NOMENCLATURE

A = CROSS-SECTIONAL AREA (IN^2)
g = GRAVITATIONAL CONSTANT
F = FORCE (LBS.)
M = BENDING MOMENT (IN-LB.)
S = SECTION MODULUS ($IN.^3$)
T = TORQUE (IN-LB. OR FT-LB.)

σ = NORMAL STRESS (BENDING OR AXIAL) (PSI)
τ = SHEAR STRESS (PSI)

σ_p = THE MAXIMUM PRINCIPLE STRESS PER MOHR'S CIRCLE (PSI)

τ_{MAX} = THE MAXIMUM SHEAR STRESS PER MOHR'S CIRCLE (PSI).

MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-3

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-84-2468 SUPP. CALC. NO. 1

REFERENCES

1) JOHN HENRY ASSOCIATES REPORT NO. JHA-76-34, "SEISMIC QUALIFICATION OF VALVES COVERED BY DETROIT EDISON PURCHASE ORDER IE-86782 FOR THE ENRICO FERMI ATOMIC POWER PLANT UNIT NO. 2, PROCESSED UNDER JAMESBURY ORDER NO.'S NC-46261, NC-34252, AND JPB 73111," DATED AUGUST 31, 1981, EDISON FILE NO. P1-2406.

2) JAMESBURY DWG. NO. NC-46261-25, REV. C, 24" WAFER-SPHERE VALVE & BETTIS T416SR2 ACTUATOR (VALVES VRD-3012 & 3023), EDISON FILE NO. P1-2327.

3) DETROIT EDISON DWG. 6M721-4704, REV. K, DRYWELL PURGE SYSTEM PIPING ISOMETRIC.

4) TELECON BETWEEN M. HINSPETER (MDC) & PHIL REED (GH-BETTIS CORPORATION) OF 9-19-84 (ATTACHED).

5) JOHN HENRY ASSOCIATES DOCUMENTS, "SEISMIC QUALIFICATION OF VALVES COVERED BY DETROIT EDISON PURCHASE ORDER NO. IE-86782 FOR ENRICO FERMI ATOMIC POWER PLANT UNIT 2 AND PROCESSED UNDER JAMESBURY ORDER NO'S. NC-46261, NC-34252, JPB-73111", EDISON FILE # P1-2406.

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MULTIPLE DYNAMICS CORPORATION

Job No. 81-1-3

Owner DECO (FERMI-2) Client DECO T48-00

Project REPORT NO. DECO-04-246B SUPP. CALC. NO. 1

REFERENCES (CONT'D)

6) TELECON MEMO OF 9-21-84, M. HINSPETER (MDC) AND BEN ZANNINI (JAMESBURY COPORATION) (ATTACHED).

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