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QUALIFICATION OF PURGE AND VENT VALVES

PREPARED FOR:

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2 SITE

VALVE SIZES: 24" AND 30"

VALVE MANUFACTURER: BIF A UNIT OF GENERAL SIGNAL

OPERATOR MANUFACTURER: MILLER AIR PRODUCTS

REPORT DATE: DECEMBER 11, 1983

PREPARED BY: Milon Meyer and Mark Scott

REVIEWED BY: Dennis Armstrong

APPROVED BY: J.E. Rhoads

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QUALIFICATION OF PURGE AND VENT VALVES AT WNP-2

1.0 Introduction

The Nuclear Regulatory Commission is concerned about operability of the WNP-2 purge and vent valves when subjected to a postulated LOCA in combination with seismic plus hydrodynamic conditions. Specifically, their concern is the ability of these valves to close in the time required to prevent discharge of radioactive gases to the outside environment. The valves identified as the containment isolation valves in the purge and vent system are as follows:

Valve Number	Valve Size (in)	Use	Location
CSP-V-1	30	Supply	Outside Containment
CSP-V-2	30	Supply	Outside Containment
CSP-V-3	24	Supply	Outside Containment
CSP-V-4	24	Supply	Outside Containment
CEP-V-1A	30	Exhaust	Outside Containment
CEP-V-2A	30	Exhaust	Outside Containment
CEP-V-3A	24	Exhaust	Outside Containment
CEP-V-4A	24	Exhaust	Outside Containment

2.0 Synopsis

Qualification of WNP-2 purge and vent valves for a postulated LOCA condition superimposed with a seismic/hydrodynamic event is exhibited by analysis utilizing dynamic flow calculations, detailed structural integrity studies, dynamic flow tests and investigation of actual on site configurations.

Operability was addressed by in-situ testing (equivalent static load) of the operator, dynamic flow testing of a similar valve (12") and subsequent calculations to account for dynamic air/steam flow conditions.

Final As-built qualification has been demonstrated on the WNP-2 purge and vent valves by the use of appropriate dynamic torque coefficients for associated installation configurations coupled with a restricted valve opening angle to 70 degress.

3.0 Functional Description and Application

The containment purge and vent valves are butterfly valves manufactured by BIF, a unit of General Signal Corporation and are identified as model numbers A-206765 (24") and model number A-206763 (30"). Both sizes use Miller Air Products air cylinder operators (air to open and spring to close in the fail-safe mode).

CSP-V-1, CSP-V-2 are 30" butterfly valves which are normally closed, and are open only for drywell purge, and drywell inerting. During drywell purge air is supplied by the reactor building ventilation system through these valves into containment. During drywell inerting, nitrogen from the containment inerting system is introduced to the drywell through these valves. Valves fail closed on loss of air or power and close on F,A,Z signal regardless of operating switch position. Figure 1 provides a schematic flow diagram for all eight valves. Also, Attachment L Section 3 provides Flow Diagram M543 with the valve locations identified.

CEP-V-1A, CEP-V-2A are 30" butterfly valves which are normally closed, and are operated only for drywell purge and drywell inerting. During drywell purge or inerting operations, the exhaust gas exits containment through these valves and is routed to either the elevated exhaust stack or to the Standby Gas Treatment System. Used in conjunction with CSP-V-1 and CSP-V-2 these valves fail closed on loss of air or power and close on F,A,Z signal regardless of operating position.

CSP-V-3, CSP-V-4 are 24" butterfly valves which are normally closed, and are opened only for wetwell purge, or wetwell inerting. During wetwell purge, air is supplied by the reactor ventilation system through these valves to the wetwell volume. During wetwell inerting, nitrogen from the containment inerting system is introduced through these valves. Valves used in conjunction with CEP-V-3A and CEP-V-4A fail closed on loss of air or power and close on F,A,Z signal regardless of the operating switch position.

CEP-V-3A, CEP-V-4A are 24" butterfly valves which are normally closed, and are opened only for wetwell purge and wetwell inerting. During wetwell purge or inerting operations, the exhaust gas exits containment through these valves and is routed to either the elevated exhaust stack or to the Standby Gas Treatment System. Used in conjunction with CSP-V-3 and CSP-V-4, these valves fail closed on loss of air or power and close on F,A,Z signal regardless of the operating position.

The purge system is designed to purge either the drywell or the wetwell. Only one entrance and one exhaust line will be open at any given time.

SCHEMATIC FLOW DIAGRAM FOR PURGE AND VENT VALVES

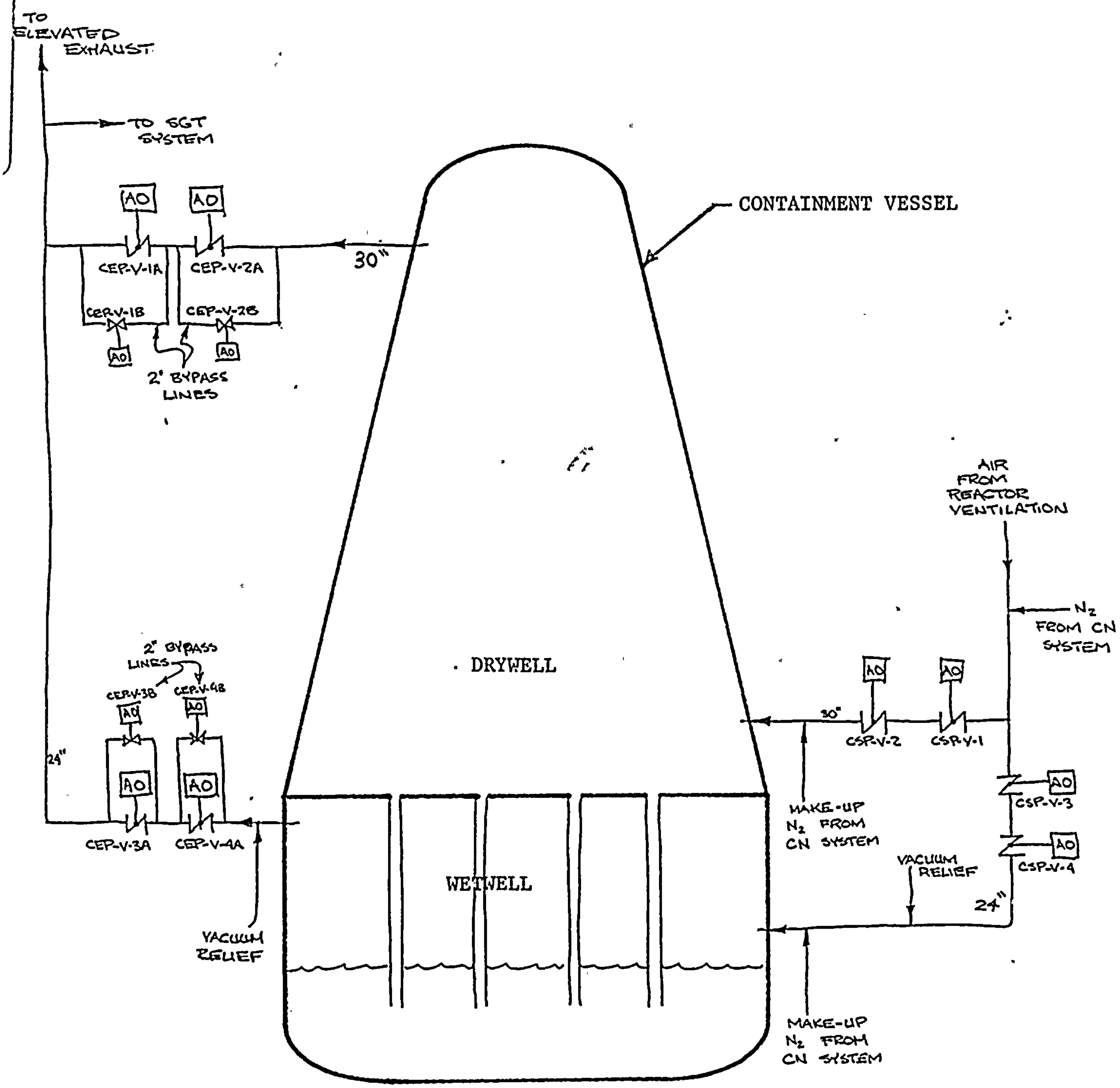


FIGURE 1

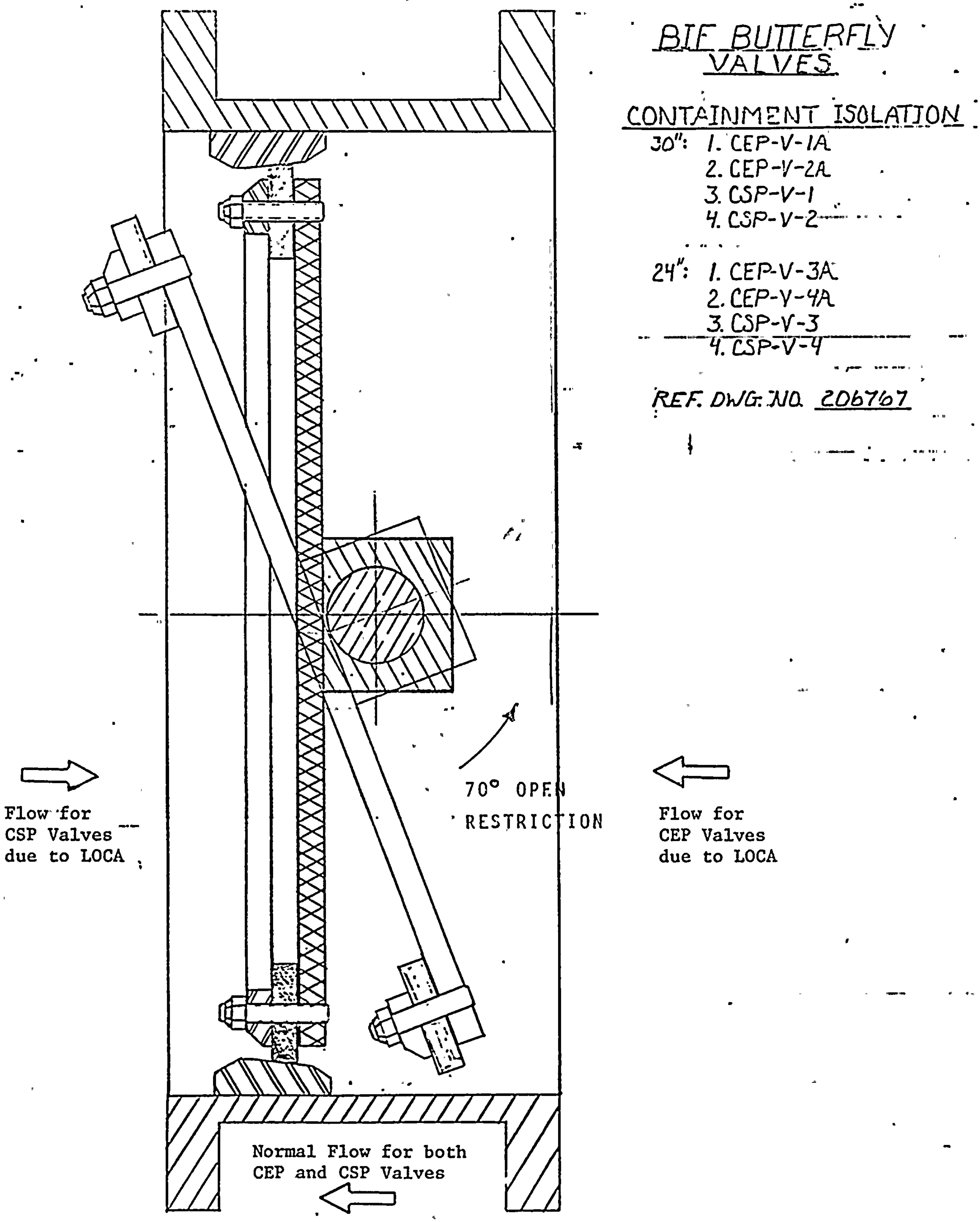

BIF BUTTERFLY VALVES
CONTAINMENT ISOLATION
30": 1. CEP-V-1A
2. CEP-V-2A
3. CSP-V-1
4. CSP-V-2
24": 1. CEP-V-3A
2. CEP-V-4A
3. CSP-V-3
4. CSP-V-4
REF. DWG. NO. 206767
70° OPEN
RESTRICTION
Flow for
CSP Valves
due to LOCA
Flow for
CEP Valves
due to LOCA
Normal Flow for both
CEP and CSP Valves

FIGURE 2

4.0 Limiting Condition for Operation

The Purge and Vent System at WNP-2 for normal operation, is controlled with 2" bypass lines (two pairs) for inerting, de-inerting and pressure control. The large 24" and 30" purge and vent valves will be used only during off-power operation in accordance with the limiting conditions for operation (LCO) as shown below.

Each 24" and 30" purge and exhaust isolation valve shall be normally closed during the time period:

1. Within 24 hours after Thermal Power is greater than 15% of Rated Thermal Power, following start-up to within 24 hours prior to reducing Thermal Power to less than 15% of Rated Thermal Power, preliminary to a scheduled reactor shutdown.

2. The valve opening angle will be limited to 70 degrees and will be implemented prior to 5% Rated Thermal Power.

Each 2" purge valve may be open for purge system operation for inerting, de-inerting and pressure control.

A complete copy of this LCO is provided in Attachment C.

5.0 Response to NRC Concerns (Summary)

5.1 NRC Concern No. 1 - Valve Installations

Detailed valve installation information was not provided for each valve such as:

Item 1. Direction of flow.
Item 2. Disc closure direction.
Item 3. Curved side of disc, upstream or downstream (asymmetric discs).
Item 4. Orientation and distance of elbows, tees, bends, etc. within 20 pipe diameters of valve.
Item 5. Shaft orientation.
Item 6. Distance between valves.

Supply System Response - Valve Installations

Complete details of the valve installations are provided.

Figure 3	CEP-V-1A and CEP-V-2A
Figure 4	CEP-V-3A and CEP-V-4A
Figure 5	CSP-V-1 and CSP-V-2
Figure 6	CSP-V-3 and CSP-V-4

Item 1 - Direction of Flow

For normal flow considerations at WNP-2, the valves are installed in the manufacturer's preferred orientation. Therefore, the exhaust valves (CEP) are installed in the preferred direction of flow for both venting containment and flow which is a result of LOCA. However, the supply valves (CSP) are installed for preferred flow toward containment and will be subjected to non-preferred flow direction during postulated LOCA condition (see figure 2).

These CSP valves are potentially subject to reversed torque due to flow out of containment. To assure that only positive closure torque occurs, all valve openings will be limited to 70° and therefore precluding the negative flow induced torque.

Item 2 - Disc Closure Direction

Disc closure directions are provided in Figures 1 through 4. For installations downstream from an elbow, LOCA induced flow tends to help close the valve.

Item 3 - Curved Side of Disc Installation

The BIF valves used at WNP-2 do not have a curved side and the air foil lifting characteristics associated with this type of configuration will not exist on WNP-2 valves. The location of the seal ring is shown in figures 3 thru 6.

Item 4 - Orientation and Distance of Elbows, Tees, Bends Etc.

Detailed valve installation information for piping configuration is provided in Figures 3 through 6.

Item 5 - Shaft Orientation

Detailed valve installation information for shaft orientations is provided in Figures 3 through 6.

Item 6 - Distance Between Valves

Detailed valve installation information for the distance between valves is provided in Figures 3 through 6.

5.2 NRC Concern No. 2 - Flow Torque vs Seating Torque

The worst case geometry at large angles of valve openings can produce very high torques that would be considerably larger than seating torque. These dynamic torques should be used in the structural analysis instead of seating torques.

Supply System Response No. 2

The qualification analysis used the larger of either seating torque or flow induced dynamic torques.

5.3 NRC Concern No. 3 - Valve Pressure Ratings

Valve pressure ratings and a static pressure analysis are not addressed in the submittals. The applicant is to provide this information for each of the valves.

Supply System Response No. 3

Valve pressure rating of 150 lbs is provided by the Vendor Data Sheets (Attachment L Section 6). Analysis for pressure loading is provided by BIF vendor calculations:

24" Valves - Attachment G, Section 7.0 Sheet B-61

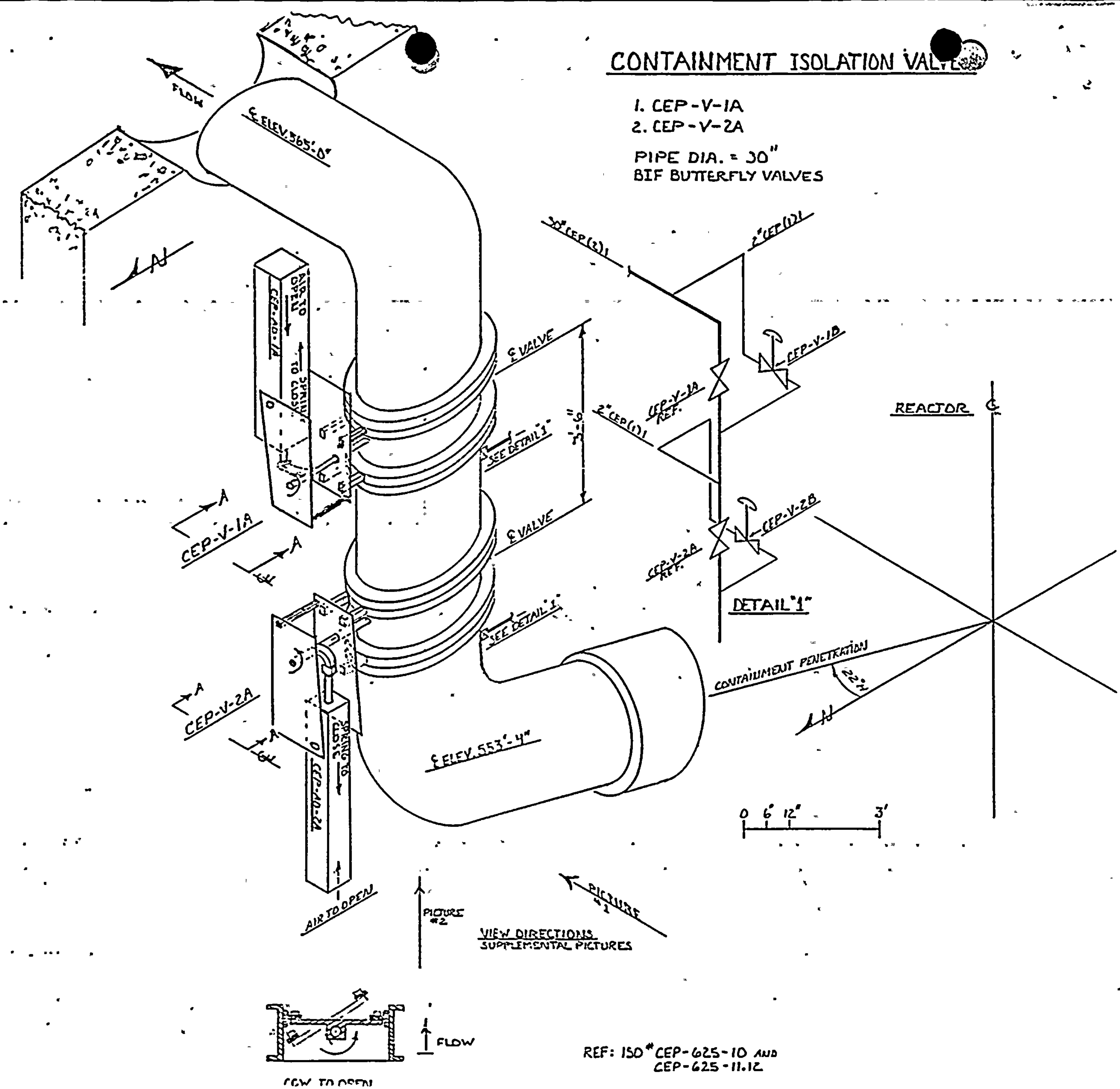
30" Valves - Attachment F, Section 7.4 Sheet 7.4.61

5.4 NRC Concern No. 4 - LOCA Curves

Included were plots of flow rate versus time from LOCA initiation for the 24 inch and 30 inch valves maintained in a full open closure from 90° to 0° which should be deleted. However, the analysis is not affected.

Supply System Response No. 4

The LOCA curves present have two abscissa labels. Supply System agrees that the valve angle information should be deleted and that the analysis is not affected.



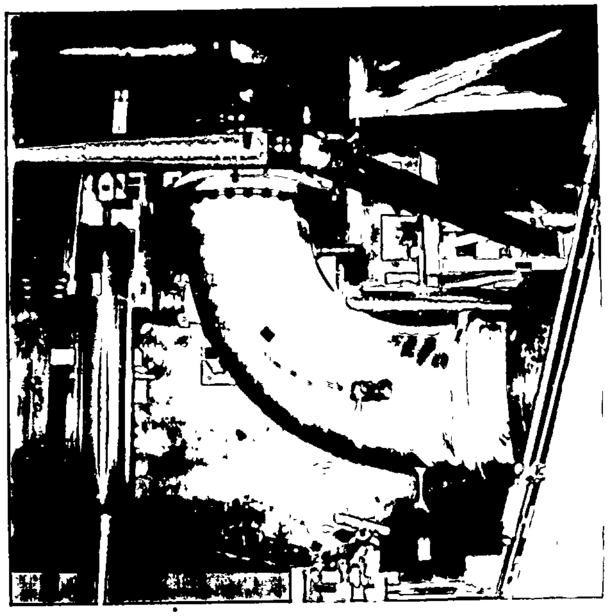
CONTAINMENT ISOLATION VALVES
1. CEP-V-1A
2. CEP-V-2A
PIPE DIA. = 30"
BIF BUTTERFLY VALVES
FLOW
℄ ELEV. 565'-0"
AIR TO OPEN
SPRING TO CLOSE
CEP-AO-1A
℄ VALVE
SEE DETAIL 1
3'-6"
CEP-V-1A
CEP-V-2A
SPRING TO CLOSE
CEP-AO-2A
AIR TO OPEN
℄ ELEV. 553'-4"
30" CEP(2)1
2" CEP(1)1
CEP-V-1B
CEP-V-1A REF.
CEP-V-2B
CEP-V-2A REF.
DETAIL "1"
REACTOR ℄
CONTAINMENT PENETRATION
22°
0 6" 12" 3'
PICTURE #2
PICTURE #1
VIEW DIRECTIONS SUPPLEMENTAL PICTURES
FLOW
CCW TO OPEN
REF: ISO # CEP-625-10 AND CEP-625-11.12

FIGURE 3

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

PURGE AND VENT VALVES

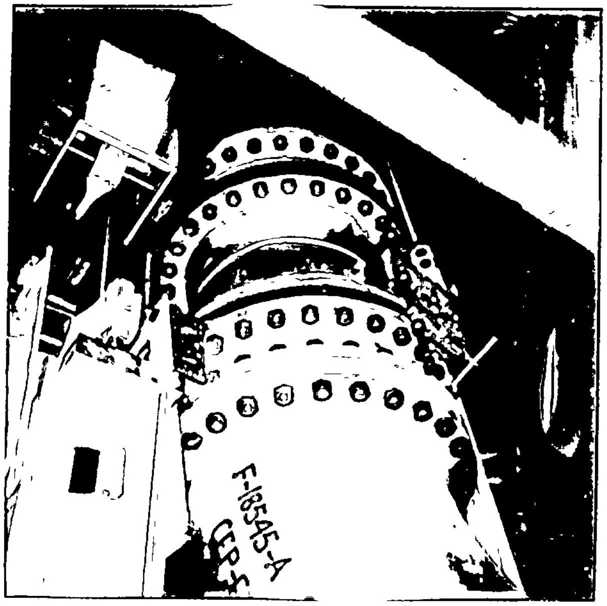


#1

PICTURE NO. 1

CEP-V-2A
ELEV. VIEW LKG. EAST

SHUT, CCW TO OPEN

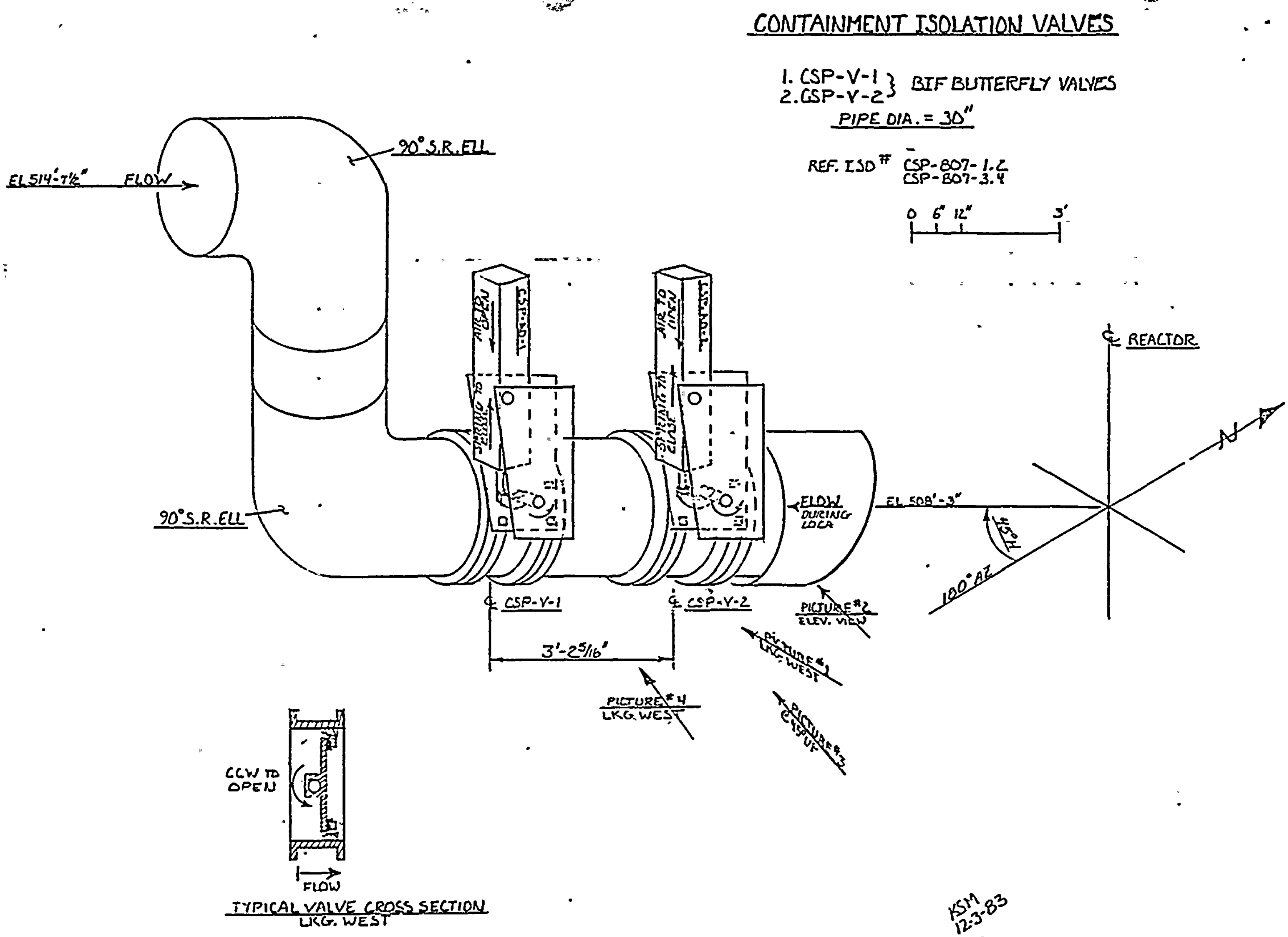


#2

PICTURE NO. 2

CEP-V-1A AND 2A
LKG. UP

SHUT, CCW TO OPEN


CONTAINMENT ISOLATION VALVES
1. CSP-V-1
2. CSP-V-2
BIF BUTTERFLY VALVES
PIPE DIA. = 30"
REF. ISD # CSP-807-1.2
CSP-807-3.4
0 6" 12" 3'
EL 514'-7½" FLOW
90° S.R. ELL
90° S.R. ELL
CSP-AO-1
CSP-AO-2
AIR TO OPEN
FAIL CLOSED
℄ CSP-V-1
℄ CSP-V-2
3'-2 5/16"
FLOW DURING LOCA
EL 508'-3"
℄ REACTOR
N
45°
100° AZ.
PICTURE #2 ELEV. VIEW
PICTURE #1 LKG. WEST
PICTURE #4 LKG. WEST
PICTURE #3 @ 45° UP
CCW TO OPEN
FLOW
TYPICAL VALVE CROSS SECTION
LKG. WEST
KSM
12-3-83

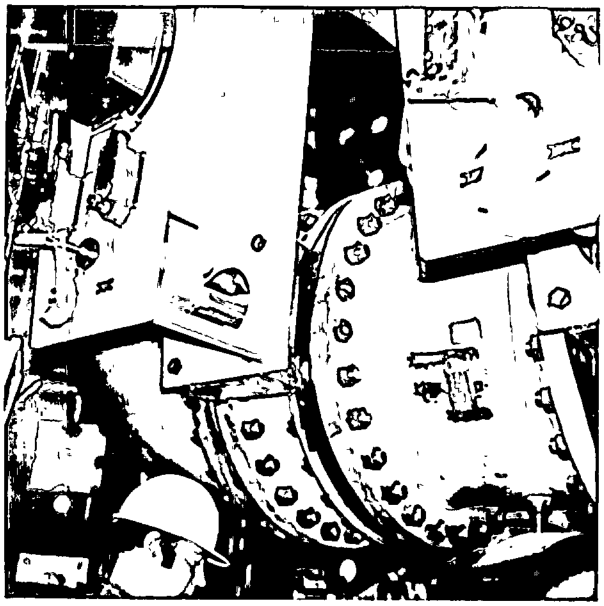
-13

FIGURE 4

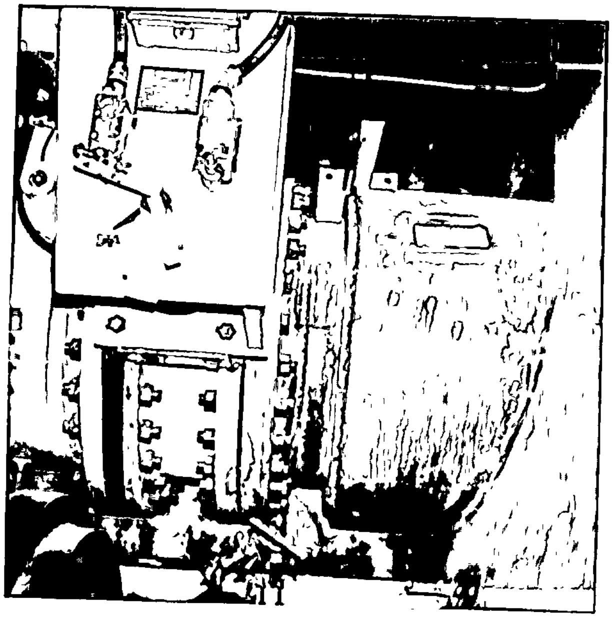
WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

PURGE AND VENT VALVES



#1



#2

PICTURE NO. 1

CSP-V-2

SHUT, CCW TO OPEN

PICTURE NO. 2

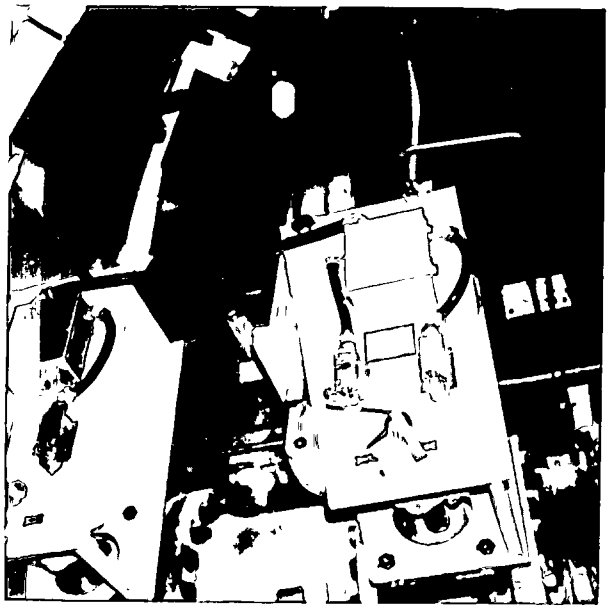
CSP-V-1

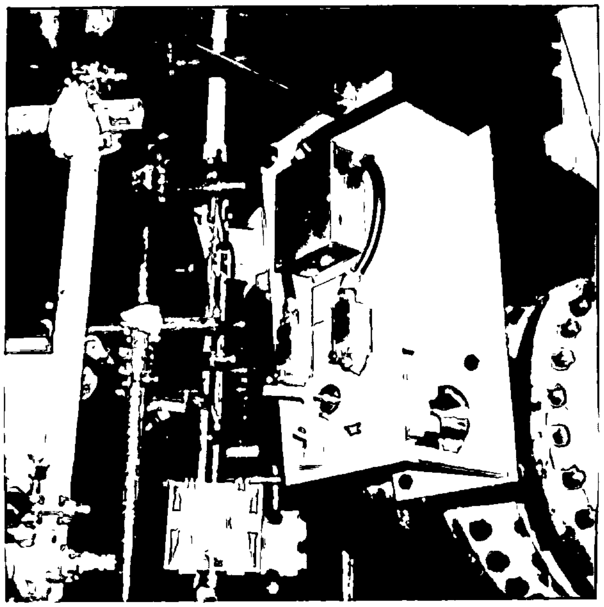
SHUT, CCW TO OPEN

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

PURGE AND VENT VALVES





#3

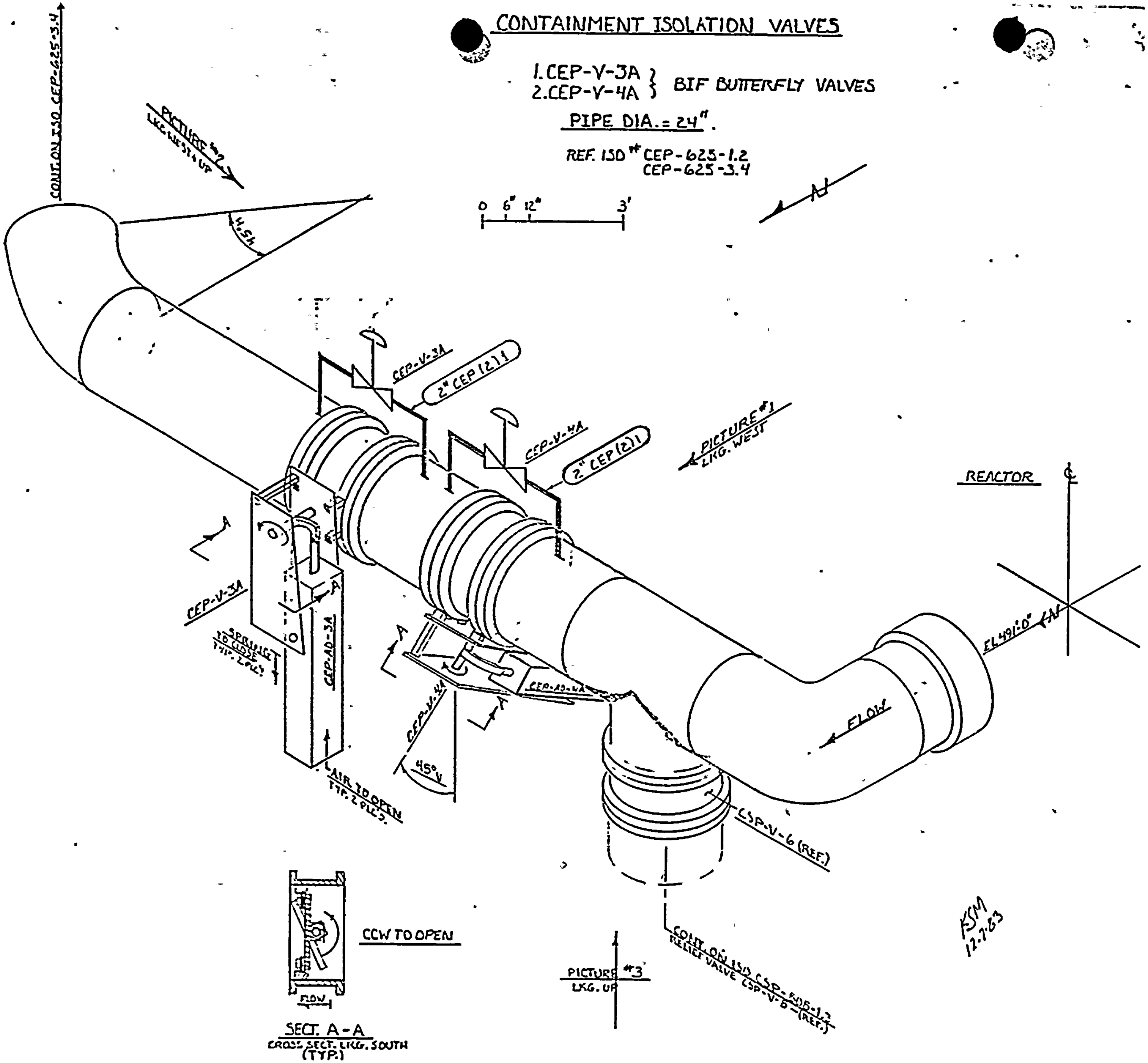
#4

PICTURE NO. 3

CSP-V-1 AND 2
LOOKING UP AT 45°
FROM FLOOR

PICTURE NO. 4

CSP-V-1



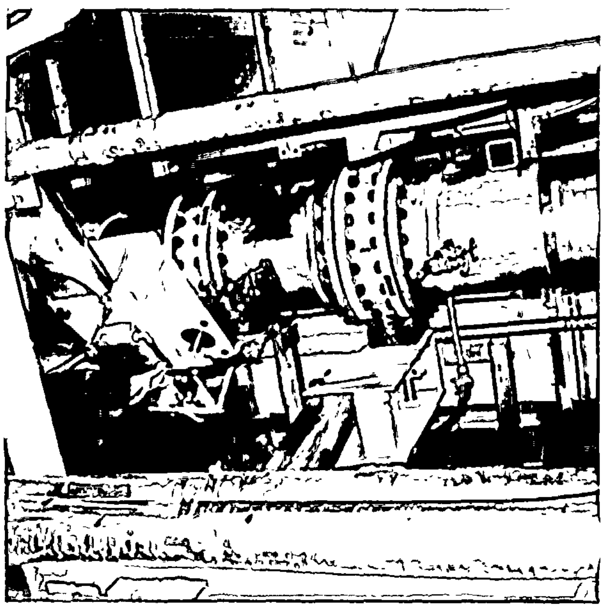
CONTAINMENT ISOLATION VALVES
1. CEP-V-3A
2. CEP-V-4A
BIF BUTTERFLY VALVES
PIPE DIA. = 24".
REF. ISO # CEP-625-1.2
CEP-625-3.4
0 6" 12" 3'
N
CONT. ON ISO CEP-625-3.4
PICTURE #2
LKG. WEST & UP
45°
CEP-V-3A
2" CEP (2) 1
CEP-V-4A
2" CEP (2) 1
PICTURE #1
LKG. WEST
REACTOR
℄
CEP-V-3A
SPRING TO CLOSE TYP. 2 PLCS.
CEP-AO-3A
CEP-AO-4A
CEP-V-4A
45°
AIR TO OPEN TYP. 2 PLCS.
A
A
FLOW
EL 491'-0"
CSP-V-6 (REF.)
CCW TO OPEN
FLOW
SECT. A-A
CROSS SECT. LKG. SOUTH
(TYP.)
PICTURE #3
LKG. UP
CONT. ON ISO CSP-605-1.2
RELIEF VALVE CSP-V-D-(REF.)
KSM
12-7-83

FIGURE 5

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

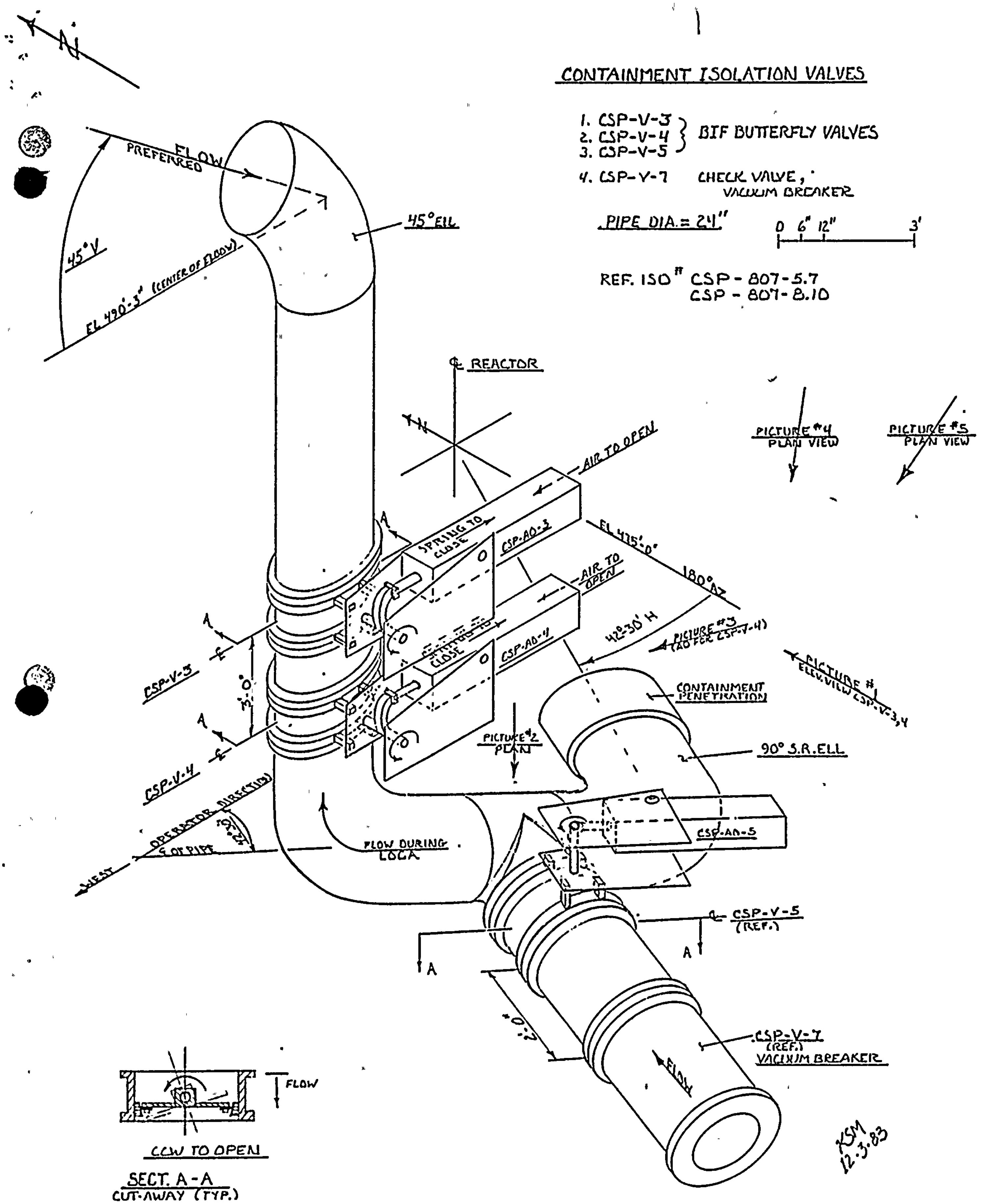
PURGE AND VENT VALVES



PICTURE NO. 1

PICTURE NO. 2

CEP-V-3A AND 4A



SECT. A-A
CUT-AWAY (TYP.)

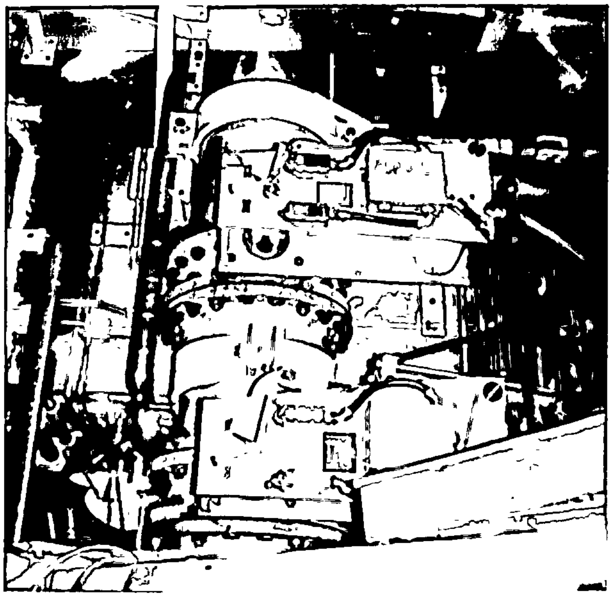
FIGURE 6

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

PURGE AND VENT VALVES

#1

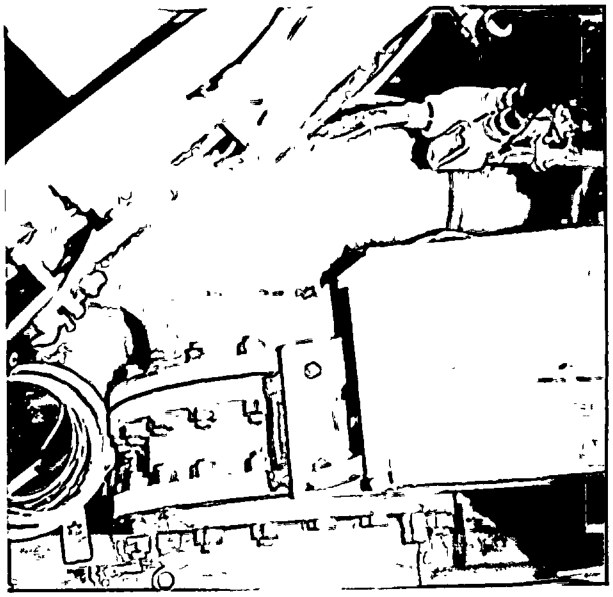


PICTURE NO. 1

CSP-V-3 AND 4

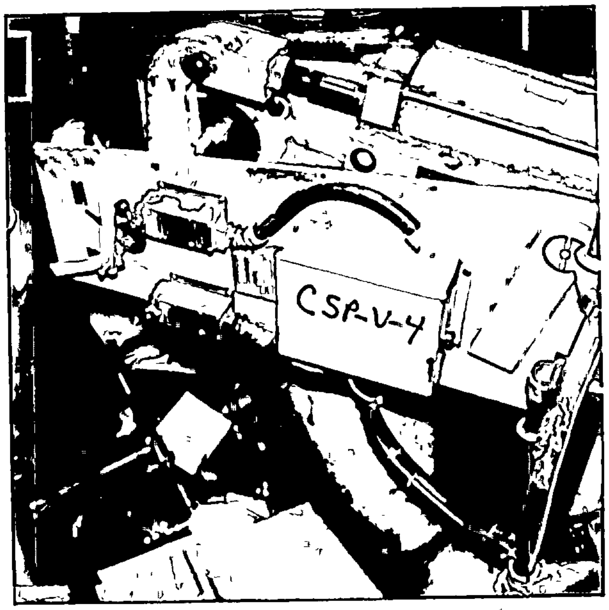
CCW TO OPEN

#2



PICTURE NO. 2

CSP-V-5



#3

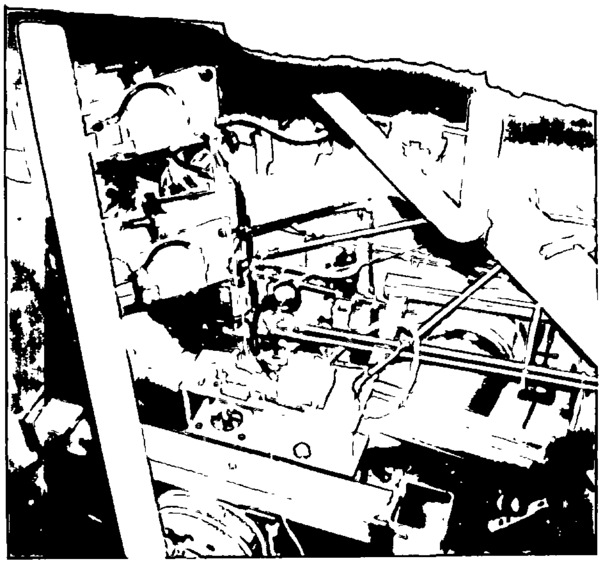
PICTURE NO. 3

CSP-V-4

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

PURGE AND VENT VALVES



PICTURE NO. 4

PICTURE NO. 5

CSP-V-3, 4, 5

6.0 Discussion of Operability

Operator operability was demonstrated by a stress integrity calculation and a static deflection test. The static deflection test consisted of applying a load at the outboard end of the air/spring cylinder equivalent to the SRSS actuator assembly CG acceleration loads. Determined from the piping analysis, in the two axes of the cylinder this load would cause the most adverse operability effect. This acceleration level times the cylinder weight, acting at the cylinder CG, was equated by an equal moments approach to an equivalent force acting at the outboard end of the cylinder assembly. With the load applied, the air supply was removed and the spring loaded cylinder was allowed to move to its fail-safe (de-energized) position. Acceptable operation of the air cylinder was its ability to move from its energized position to the fail-safe position with the load applied at the outboard end.

This static load method of demonstrating operability is deemed very conservative because of the following reasons:

1) Time duration of a peak seismic/hydrodynamic acceleration is very small compared to a steady (static) load.

2) Static friction is greater than dynamic friction.

3) Square root sum of squares of two orthogonal directional accelerations is conservatively applied to the worst case direction.

Conditions and results for the valve stroke tests with and without statically applied loads is provided in Attachment J.

An enveloping test was successfully performed on both the 10" bore cylinder (part of the 30" butterfly valve assembly) and the 8" bore cylinder (part of the 24" butterfly valve assembly).

7.0 Summary of Structural Analysis

Detailed structural analysis was performed on the valve and air/spring actuator. The following is a summary of the analysis performed.

Component Description	QID No.	Attachment
WPPSS Supplemental Calculations (Review of As-built conditions)	--	E
30" BIF Butterfly Valves	361104	F
24" BIF Butterfly Valves	361106	G
30" Valve Vendor (BIF) Calcuations	361104	F Section 7.4
24" Valve Vendor (BIF) Calcuations	361106	G Section 7.0

A summary of critical valve components is provided in Table II for 24" size and Table I for 30" size.

To assure a very high confidence level, normal condition allowables (including 0.4 Sy for shear) were used as criterion for the combined postulated LOCA and seismic/hydrodynamic conditions. Since the valve opening angle will be limited, the operational torques (LOCA) were used in-lue-of the design seating torques, thereby, providing a higher margin of safety on loading deemed less predictable while still maintaining standard margins of safety on design seating loads.

TABLE I

	30" BIF BUTTERFLY CONTAINMENT PURGE/VENT VALVES									
	VALVE SEATING TORQUE + DBE					LOCA FLOW TORQUE + DBE				
	CALC'D STRESS	STRESS ALLOWABLE				CALC'D STRESS	STRESS ALLOWABLE			
		NORMAL		FAULTED			NORMAL		FAULTED	
VALVE/OPERATOR COMPONENT	T = TENSILE S = SHEAR B = BEARING	.6Fy .4Fy .96Fy	MARGIN OF SAFETY	.9Fy .6Fy	MARGIN OF SAFETY	T = TENSILE S = SHEAR B = BEARING	.6Fy .4Fy .96Fy	MARGIN OF SAFETY	.6Fy .4Fy	MARGIN OF SAFETY
TRUNNION PINS	2195 S	12000	5.5	18000	8.2	2195 S	12000	5.5	18000	8.2
TAPERED PINS	8443 S	9300	1.1	13950	1.7	7039 S	9300	1.5	13950	2.0
DRIVE LEVER	11092	24000	2.2	36000	3.2	9340	24000	2.6	36000	3.9
MAIN SHAFT	20527	18000	.88	27000	1.3	14287	18000	1.3	27000	1.9
DRIVE ROD	32845	36000	1.1	54000	1.6	32560	36000	1.1	54000	1.7
EAR BOLTS	8368 (S) 9754 (T)	39938	4.1	–	–	8003 (S) 9518 (T)	40595	5.1	–	–
LEVER KEYWAY	9504	16000	1.7	24000	2.5	7923	16000	2.0	24000	3.0
SHEAR PL WELD	12557	18000	1.4	–	–	12557	18000	1.4	–	–
VALVE EAR WELD	13277	18000	1.4	–	–	12557	18000	1.4	–	–

AISC BOLT TENSILE ALLOWABLE = $55 - 1.8 f_v \leq 44$ KSI FOR A-325

TABLE II

	24" BIF BUTTERFLY CONTAINMENT PURGE/VENT VALVES									
	VALVE SEATING TORQUE + DBE					LOCA FLOW TORQUE + DBE				
	CALC'D STRESS	STRESS ALLOWABLE				CALC'D STRESS	STRESS ALLOWABLE			
		NORMAL		FAULTED			NORMAL		FAULTED	
VALVE/OPERATOR COMPONENT	T = TENSILE S = SHEAR B = BEARING	.6Fy .4Fy .96Fy	MARGIN OF SAFETY	.9Fy .6Fy	MARGIN OF SAFETY	T = TENSILE S = SHEAR B = BEARING	.6Fy .4Fy .96Fy	MARGIN OF SAFETY	.6Fy .4Fy	MARGIN OF SAFETY
TRUNNION PINS	4104 S	12000	2.9	18000	4.4	4104 S	12000	2.9	18000	4.4
TAPERED PINS	8064 S	9300	1.2	13950	1.7	5546 S	9300	1.7	13950	2.5
DRIVE LEVER	8976 T	24000	2.7	36000	4.0	6319 T	24000	3.8	36000	5.7
MAIN SHAFT	17046 T	18000	1.1	27000	1.6	12322 T	18000	1.5	27000	2.2
DRIVE ROD	33230	36000	1.1	54000	1.6	32907	36000	1.1	54000	1.6
EAR BOLTS *	15109 (S) 17244 (T)	27800 T	1.6	—	—	15352 16743	27370 T	1.6	—	—
LEVER KEYWAY	11362 S	16000	1.4	24000	2.1	7814 S	16000	2.0	24000	3.1
SHEAR PL WELD	9637 S	18000	1.9	—	—	9637 S	18000	1.9	—	—
VALVE EAR WELD	10589 S	18000	1.7	—	—	10589 S	18000	1.7	—	—

* AISC BOLT TENSILE ALLOWABLE = $55 - 1.8f_v \leq 44$ KSI FOR A-325

Summary of Dynamic Torques and Available Spring Closure Torques

The purge system valves (CSP-V-1 thru CSP-V-4) are installed with the flat side of the disc upstream. When these valves are in the full open position (90 degrees), the dynamic torque coefficient becomes negative (tends to open the valve). Based on the test results provided in the BIF report (Attachment J Report No. 2) the worst case negative torque coefficient ($C_T = -.34$) is less than the bounding torque coefficient ($C_T = + .56$) used in the BIF calculations. For comparison purposes both the full open valve dynamic torques and the 70° open dynamic torques are compared to the available air operator spring closure torque.

Butterfly Valve with Disc Upstream

Flow at 1 sec. and disc angle 90° - Full Open

Valve Size	Dynamic (1) Torque (Opening)	Actuator Spring Torque Available (Closure)	Margin of Safety
24"	6,830 In. Lb.	11,900 In. Lb.	1.7
30"	13,640 In. Lb.	23,470 In. Lb.	1.7

Flow at 1 sec. and disc angle 70° open

Valve Size	Dynamic Torque (Closure)	Actuator Spring Torque Available (Closure)	Margin of Safety
24"	1,200 In. Lb.	18,600 In. Lb.	Not Applicable Both Loads Provide Closure
30"	2,400 In. Lb.	33,700 In. Lb.	

Figures 7 and 8 show torques for both valve sizes at all angular positions.

(1) Torques conservatively include 1.3 factor for an elbow located directly upstream.

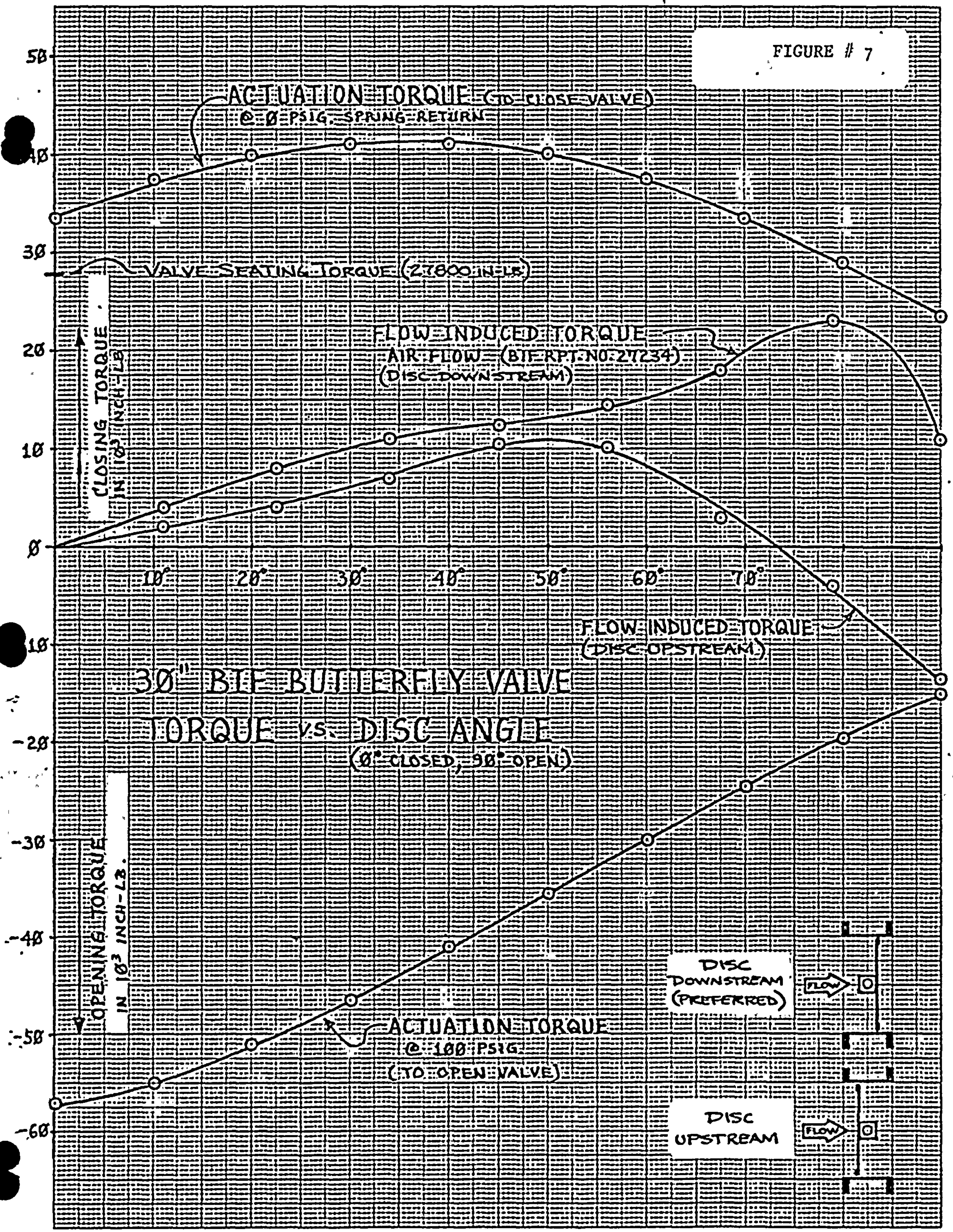


FIGURE # 7
ACTUATION TORQUE (TO CLOSE VALVE)
@ Ø PSIG, SPRING RETURN
VALVE SEATING TORQUE (27800 IN-LB)
FLOW INDUCED TORQUE
AIR FLOW (BIF RPT NO. 27234)
(DISC DOWNSTREAM)
FLOW INDUCED TORQUE
(DISC UPSTREAM)
30" BIF BUTTERFLY VALVE
TORQUE vs. DISC ANGLE
(Ø° CLOSED, 9Ø° OPEN)
CLOSING TORQUE
IN 10³ INCH-LB
OPENING TORQUE
IN 10³ INCH-LB.
ACTUATION TORQUE
@ 1ØØ PSIG
(TO OPEN VALVE)
DISC
DOWNSTREAM
(PREFERRED)
DISC
UPSTREAM
FLOW
FLOW
5Ø
4Ø
3Ø
2Ø
1Ø
Ø
-1Ø
-2Ø
-3Ø
-4Ø
-5Ø
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5Ø°
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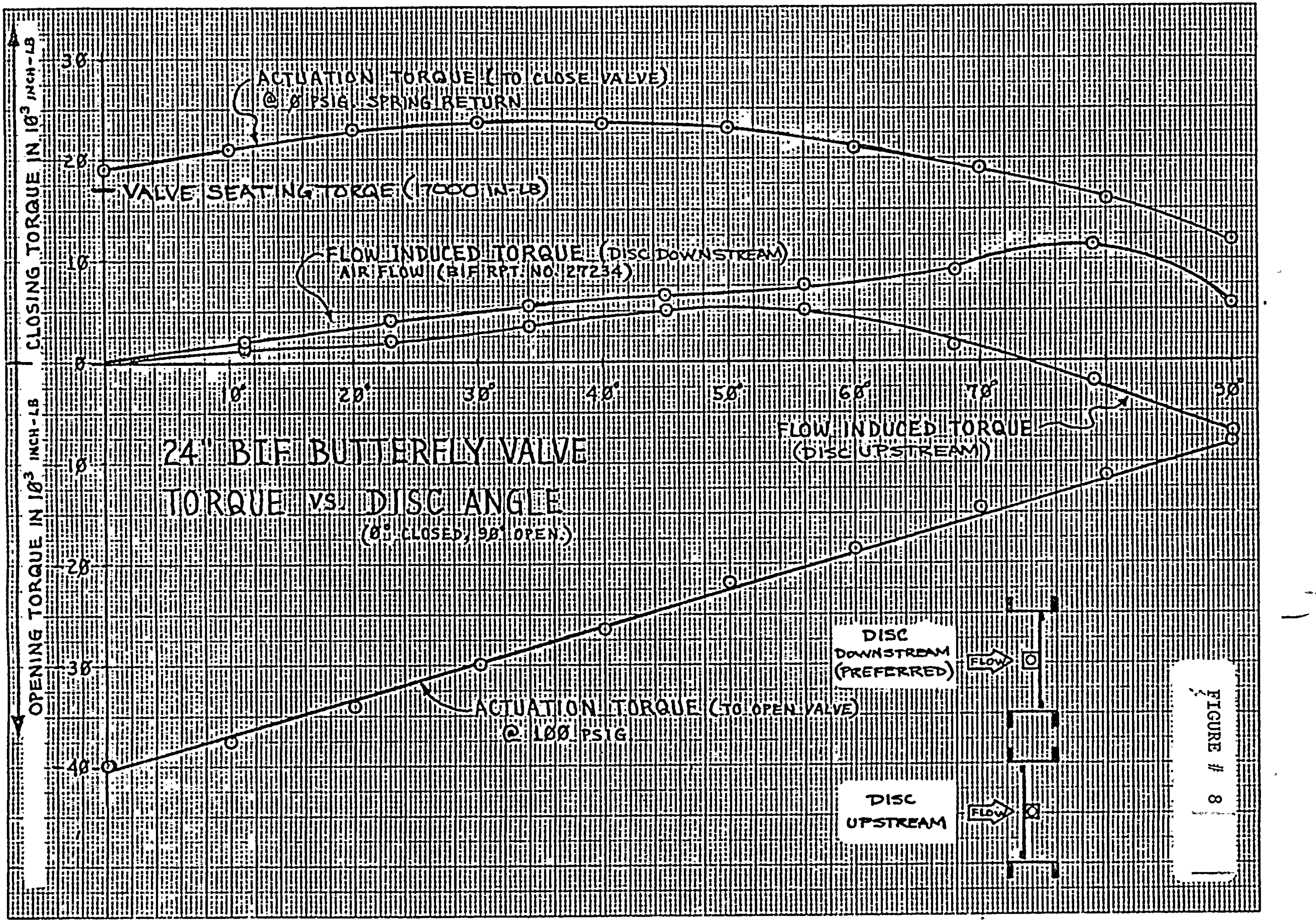

CLOSING TORQUE IN 10^3 INCH-LB
OPENING TORQUE IN 10^3 INCH-LB
ACTUATION TORQUE (TO CLOSE VALVE) @ Ø PSIG SPRING RETURN
VALVE SEATING TORQUE (7000 IN-LB)
FLOW INDUCED TORQUE (DISC DOWNSTREAM) AIR FLOW (BIF RPT. NO. 27234)
FLOW INDUCED TORQUE (DISC UPSTREAM)
ACTUATION TORQUE (TO OPEN VALVE) @ 100 PSIG
24" BIF BUTTERFLY VALVE
TORQUE VS DISC ANGLE
(0° CLOSED, 90° OPEN.)
DISC DOWNSTREAM (PREFERRED)
DISC UPSTREAM
FLOW

FIGURE # 8

8.0 Summary of Flow Calculations

The shortest purge line with the lowest flow resistance was analyzed to determine the Mach number of the fluid flowing through the butterfly isolation valve as a function of valve opening angle. Based on this analysis, it was determined that valve angle positions of 70° or less will assure that the Mach number through both the inner and outer isolation valve remains below Mach number 0.3 following a postulated LOCA.

The containment pressure and temperature used as a forcing function for this analysis were obtained from the WNP-2 FSAR (figures 6.2.2 and 6.2.3) for a postulated DBA. Containment pressure obtained from these figures was based on the assumption that there was no fluid leaving containment. If the purge valves were open the containment pressure would be slightly less than that used in this analysis.

Flow calculations are provided in Attachment K.

9.0 Qualification Summary

9.1 The 30" and 24" diameter purge and supply valves are closed for normal plant operation since the small 2" lines will be used for inerting, de-inerting and pressure make-up.

9.2 NRC has recommended the disc opening be limited. Prior to 5% power, WNP-2 will install a mechanical device which limits the opening to 70 degrees. This restriction on valve opening coupled with appropriate dynamic torque coefficients resolves safety and qualification concerns for LOCA conditions.

9.3 Due to the pipe length and associated line loss coefficients; the maximum flow velocity for full open valves was calculated to be 0.33 Mach number, thereby assuring that correlation methods used with compressible fluid calculations as previously presented is valid. With a restriction on valve opening, the Mach number will be less than 0.3 for all conditions:

Additional conservation is introduced because the LOCA pressure and temperature curves did not take credit for flow through these valves during closure time. Also, the pressure excursion assumes a very conservative double ended pipe break.

9.4 As-built configuration of the valves (especially with the 70 degree angle restriction) precludes the possibility of flow induced opening torque. Therefore, the air operator spring and flow will combine to assure valve closure in less than the required 5.0 seconds.

9.5 Structural integrity of these purge and vent valves has been attained by combining two faulted conditions (SSE/Hydrodynamic plus LOCA) using normal allowables. This includes shear allowables of 0.6 Sm for pressure boundary ASME components and 0.4 Sy for AISC components. A table which summarizes the calculated stresses and allowables is provided in Attachment I.

NOTE: Field modifications to strengthen the support brackets and replacement of bolts have been performed. Documentation is provided in Attachment K.

9.6 Since the valves are normally closed, there is a low probability that LOCA conditions will occur with the valves open. Furthermore, a very low probability of all three conditions (valves open, LOCA and seismic/hydrodynamic) will occur simultaneously. Therefore, this very conservative approach of combining all three unlikely conditions and comparing to Normal/Upset condition allowables exhibit large confidence levels.

9.7 Operability was demonstrated by analysis and in-situ (static load) testing.

9.8 In conclusion the purge and vent valves satisfy all the Equipment Qualification criteria implemented at WNP-2 for even 90° (full open) valves. Limiting the disc angle to 70° provides additional margin to address the following NRC concerns. Therefore, our WNP-2 design:

1) Assures dynamic torque due LOCA conditions will always be a positive closure torque.

2) Assures Mach Number will be less than 0.3, and

3) Limits magnitude of dynamic flow induced torque.

10.0 <u>References</u>

10.1 NUREG-0892, WNP-2 SER Outstanding Issue No. 26, "Operability of Purge Valves"

10.2 NRC Standard Review Plan 6.2.4, "Containment Isolation System" Containment Systems Branch (CSB)

10.3 Branch Technical Position CSB 6-4, "Containment Purging During Normal Plant Operations" Supplement to SRP Section 6.2.4

10.4 Letter, A. Schwencer (NRC) to R.L. Ferguson (SS), "Request for Additional Information", dated September 16, 1982, Docket No. 50-39

10.5 WPPSS Letter, February 24, 1983, G.D. Bouchey to A. Schwencer (NRC) with Attachments

10.6 WPPSS Letter, June 22, 1983, G.D. Bouchey to A. Schwencer (NRC) with Attachments

VOLUME II

WPPSS

QUALIFICATION OF PURGE AND VENT VALVES AT WNP-2

ATTACHMENT B - DRAFT COPY OF WNP-2, SER, OUTSTANDING ISSUE NO. 26

ATTACHMENT C - LIMITING CONDITIONS FOR OPERATION (LCO)

ATTACHMENT D - WPPSS LETTER TO NRC

ATTACHMENT E - SUPPLEMENTAL CALCULATION INCLUDING FINAL AS-BUILT REVIEW

WASHINGTON NUCLEAR PROJECT-2
DOCKET NO. 50-397

DEMONSTRATION OF CONTAINMENT PURGE AND VENT VALVE OPERABILITY

DRAFT

1.0 Requirement

Demonstration of operability of the containment purge and vent valves, particularly the ability of these valves to close during a design basis accident, is necessary to assure containment isolation. This demonstration of operability is required by BTP CSB 6-4 and SRP 3.10 for containment purge and vent valves which are not sealed closed during operational conditions 1, 2, 3, and 4.

2.0 Description of Purge and Vent Valves

The valves identified as the containment isolation valves in the purge and vent system are as follows:

DRAFT

Valve Number	Valve Size (inches)	Use	Location
CSP-V-1	30	Vent. Supply	Outside Containment
CSP-V-2	30	Vent. Supply	Outside Containment
CSP-V-3	24	Vent. Supply	Outside Containment
CSP-V-4	24	Vent. Supply	Outside Containment
CEP-V-1A	30	Vent. Exhaust	Outside Containment
CEP-V-2A	30	Vent. Exhaust	Outside Containment
CEP-V-3A	24	Vent. Exhaust	Outside Containment
CEP-V-4A	24	Vent. Exhaust	Outside Containment

The containment purge and vent valves are butterfly valves manufactured by BIF, a unit of General Signal Corporation and are listed as BIF Model Number A-206765 (24" valves) and BIF Model Number A-206763 (30" valves). Miller Air Products Corporation Model A-83 cylinders (air open - spring closed) are used for valve actuation. The 24-inch valves use 8" cylinders and the 30" valves use 10" cylinders.

3.0 Demonstration of Operability.

DRAFT

3.1 Washington Public Power Supply System (WPPSS) has provided operability demonstration information for the containment purge and vent system isolation valves used at their Washington Nuclear Project 2 (WNP 2) in the following submittals:

Reference A

WPPSS letter, February 24, 1983, G. D. Bouchey to A. Schwencer (NRC).

DRAFT

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DRAFT

Reference B

WPPSS letter, June 22, 1983, G. D. Bouchey to A. Schwencer (NRC).

3.2 Determination of dynamic torques during valve closure against the buildup of containment pressure during a LOCA is based on dynamic torque coefficients C_T obtained from BIF tests performed using different types of disc geometry and disc and shaft orientation with respect to direction of flow. The test medium is water and no air testing was performed. One of the test configurations included a directly connected short radius elbow upstream to study the effect of flow non-uniformity on dynamic torque. Several tests were also performed with the valve shaft vertical and horizontal, counter clockwise opening and clockwise opening, with flatside upstream and flatside downstream. From these tests, the most severe case was determined to be a vertical shaft orientation (i.e. perpendicular to the plane of the elbow) with the flatside of the disc downstream and with a clockwise rotation of the disc. This orientation results in an approximately 30% increase in maximum dynamic torque coefficient over the straight pipe inlet configuration. Torque coefficients used to determine dynamic loads for WNP-2 purge and vent valves are based on this worst case configuration.

The differential pressure Δp across the valve is calculated from the data on volumetric flow rate under LOCA conditions, and using the equation:

$$Q = 963\ C_V \sqrt{\frac{P_1^2 - P_2^2}{GT_1}}$$

DRAFT

where Q = Gas flow in SCFH

P_1 = Valve upstream pressure (psia)

P_2 = Valve downstream pressure (psia)

G = Specific gravity

T_1 = Upstream temperature in °Rankine

C_V = Valve coefficient = $\frac{29.9\ D^2}{K_V}$

D = Valve Port diameter (in.)

K_V = Coefficient of flow

No load closure time for the valves ranged from 1 1/2 to 4 seconds based on tests performed at BIF. The maximum no load closure time of 4 seconds is used for the analysis with a one second instrumentation time delay for a total of 5

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seconds from LOCA initiation-to-valve closure. As an additional conservatism, the drywell pressure and temperature rise during a LOCA is used for all valves.

Dynamic torques are calculated for both saturated steam and air as the flow media. The calculations are summarized and shown below in Tables 1, 2, 3, and 4 (Reference B) for both the 24-inch and 30-inch valves and for steam and air flow.

The peak dynamic torques during closure and the seating and bearing friction torques at 0° are compared to the design torques used in the seismic analysis report and indicate positive margins; [redacted]

SUMMARY OF RESULTS

Table 1. 30-Inch Valve, Airflow, (T_{NET} = 22174 in-lb)

Time (s)	Angle α deg.	Dynamic Torque in-lb.
1.0	90 (Full Open)	11020
1.5	78.75	23098
2.0	67.50	18138
2.5	56.25	14747
3.0	45.00	12428
3.5	33.75	10780
4.0	22.50	8014
4.5	11.25	3972
5.0	9.0 (Full closed)	0.0*

DRAFT

*At full closed position, the dynamic torque is zero and the net torque is due to seating and bearing friction.

Note: The design torque used in the Seismic analysis report No. TR-74-8 by McPherson Associates for this valve is 27800 in-lb. [redacted]

DRAFT

SUMMARY OF RESULTS

Table 2. 30-Inch Valve, Steam flow, (T_{NET} = 22174 in-lb)

Time (s)	Angle α deg.	Dynamic Torque in-lb.
1.0	90 (Full Open)	11032
1.5	78.75	23175
2.0	67.50	18142
2.5	56.25	14668
3.0	45.00	12424
3.5	33.75	10580
4.0	22.50	7809
4.5	11.25	3867
5.0	9.0 (Full closed)	0.0*

*At full closed position, the dynamic torque is zero and the net torque is due to seating and bearing friction.

SUMMARY OF RESULTS

Table 3. 24-Inch Valve, Airflow, (T_{NET} = 13808 in-lb)

Time (s)	Angle α deg.	Dynamic Torque in-lb.
1.0	90 (Full Open)	5525
1.5	78.75	11692
2.0	67.50	9095
2.5	56.25	7428
3.0	45.00	6239
3.5	33.75	5430
4.0	22.50	4043
4.5	11.25	2020
5.0	9.0 (Full closed)	0.0*

*At full closed position, the dynamic torque is zero and the net torque is due to seating and bearing friction.

Note: The design torque used in the Seismic analysis report No. TR-74-8 by McPherson Associates for this valve is 17000 in-lb. [redacted]

SUMMARY OF RESULTS

Table 4. 24-Inch Valve, Steamflow, (T_{NET} = 13808 in-lb)

Time (s)	Angle α deg.	Dynamic Torque in-lb.
1.0	90 (Full Open)	5425
1.5	78.75	11394
2.0	67.50	8921
2.5	56.25	7213
3.0	45.00	6109
3.5	33.75	5202
4.0	22.50	3842
4.5	11.25	1902
5.0	9.0 (Full closed)	0.0 *

*At full closed position, the dynamic torque is zero and the net torque is due to seating and bearing friction.

3.3 Demonstration of actuator torque margin is based on the minimum spring force developed which is equal to the spring pre-load.

24-inch valve (8" cylinder)

16,890 in-lbs (preload) > 13,808 in-lbs (seating torque).

30-inch Valve (10-inch cylinder)

32,422 in-lbs (preload) > 22,174 in-lbs (seating torque).

3.4 WPPSS provides a structural analysis for the purge and vent valves and their operators in Reference B. This consists of (3) Seismic/Hydrodynamic Requalification Reports for the 30-inch valves, 24-inch valves, and the operators. The requalification certificates for both the 24" and 30" valves are contingent upon ear bolt modifications and the addition of shear plates.

Acceptance criteria for the structural analysis are taken from Section III of the ASME Boiler and Pressure Vessel Code or the AISC Constructin Manual, whichever is applicable. Loads used in the analysis are the valve operating loads combined with the dynamic loads which would result from seismic and hydrodynamic events as determined by the piping analysis for the plant.

An SRSS analysis was set up in a computer program for each valve assembly in its specific orientation. The SRSS is taken at the maximum stress level due to seismic g-loading. Operating loads due to seating torque force and dead weight are combined with the seismic stress by absolute sum.

Based on the results of the structural analysis, the valves will remain functional through forty years of postulated hydrodynamic events, five operating basis earthquakes, and one safe shutdown earthquake.

4.0 Evaluation

4.1 The determination of dynamic torques for WPPSS purge and vent valves under LOCA conditions is based on the testing by the valve supplier (BIF) of a model valve using water as the test medium. Tests conducted with a short elbow directly upstream, valve shaft at 90° to the plane of the elbow, and flatside of disc downstream indicated a 30% increase in maximum, dynamic torque coefficient for this worst case geometry. Using data from model tests performed by other valve manufacturers with air as the test medium, this worst case geometry produces a 300% increase in maximum dynamic torque coefficient. The large difference (30% water versus 300% air) in maximum dynamic torque coefficient is due to the higher (above Mach .3) velocities at large angles of opening where the dynamic torque coefficients peak. Dynamic torque coefficients from model tests using incompressible fluids correlate reasonably well with data from tests using air if the velocities are below a Mach number of 0.3).

Considering the analysis results tabulated in Table 1 of Reference A, the peak dynamic torque for the 20-inch valve occurred at 78.75° and was 23,098 in-lbs. The design torque is 27,800 in-lbs as noted in the same table. Applying a 300% increase to the 23098 in-lbs peak dynamic torque which already has a 30% worst case configuration factor; the peak dynamic torque using the factor from air tests works out to 48,505 in-lbs, well above the 27,800 in-lbs design torque.

An acceptable approach to the staff instead of the conservative worst case configuration used by the licensee would be the use of appropriate dynamic torque coefficients for each valves installation configuration coupled with a restriction on valve opening.

Detailed valve installation information was not provided for each valve such as:

1. Direction of flow.
2. Disc closure direction.
3. Curved side of disc, upstream or downstream (asymmetric discs).
4. Orientation and distance of elbows, tees, bends, etc. within 20 pipe diameters of valve.
5. Shaft orientation.
6. Distance between valves.

4.2 As demonstrated in 4.1 of this report, the worst case geometry at large angles of valve openings can produce very high torques that would be considerably larger than the seating torque. These dynamic torques should be used in the structural analysis (Reference B) instead of the seating torques.

4.3 Valve pressure ratings and a static pressure analysis are not addressed in the submittals. ~~The applicant is to~~ provide this information for each of the valves.

4.4 Reference A includes plots of flow rate versus time from LOCA initiation for the 24-inch and 30-inch valves maintained in a full open position. The abscissa incorrectly includes valve closure from 90° to 0°, which should be deleted. However, the analysis is not affected.

5.0 Summary

We have completed our review of the information submtted to date, concerning the operability of the 24-inch and 30-inch valves used in the containment purge and vent system for Washington Nuclear Project-2. We find that the information submitted for the 24-inch and 30-inch valves did not demonstrate that these valves have the ability to close against the buildup of pressure in the event of a DBA/LOCA from the full open position. Paragraphs 4.1, 4.2, and are the bases for these findings. For this reason, the 24-inch and 30-inch valves should be sealed closed in accordance with SRP Section 6.2.4 and III.6.f. Furthermore, these valves should be verified to be closed at least once every 31 days.

CONTAINMENT SYSTEMS

DRYWELL AND SUPPRESSION CHAMBER PURGE SYSTEM

LIMITING CONDITION FOR OPERATION

3.6.1.8 The drywell and suppression chamber 2-inch exhaust isolation valves shall be OPERABLE and:

a. Each 24- and 30-inch purge supply and ~~exhaust isolation valve~~ shall be closed during the time period:

   1. Within 24 hours after THERMAL POWER is greater than 15% of RATED THERMAL POWER, following startup, to

   2. Within 24 hours prior to reducing THERMAL POWER to less than 15% of RATED THERMAL POWER, preliminary to a scheduled reactor shutdown.

b. Each 2-inch purge valve may be open for purge system operation for inerting, deinerting and pressure control.

c. Each 24- and 30-inch purge supply and exhaust isolation valve shall be limited to open no more than 70 degrees.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2, and 3.

ACTION:

a. With a 24- and/or 30-inch drywell and suppression chamber purge supply and/or exhaust islation valve(s) not closed, close and/or seal the 24- and 30-inch valve(s) or otherwise isolate the penetration within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours except as provided for in 3.6.1.8.a.

b. With a 2-inch drywell and suppression chamber exhaust isolation valve inoperable or open for other than inerting, deinerting, or pressure control, close the open 2-inch valve(s) or otherwise isolate the penetration(s) within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

c. With a drywell and suppression chamber purge supply and/or exhaust isolation valve(s) with resilient material seals having a measured leakage rate exceeding the limit of Surveillance Requirements 4.5.1.8.2, restore the inoperable valve(s) to OPERABLE status within 24 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.8.1 Each 24- and 30-inch drywell and suppresion chamber purge supply and exhaust isolation valve shall be verified to be closed at least once per 31 days.**

4.6.1.8.2 At least once per 92 days each group shown below of drywell and suppression chamber purge supply and exhaust isolation valve with resilient material seals shall be demonstrated OPERABLE by verifying that the measured leakage rate is less than or equal to .05 L_a when pressurized to P_a.

	Valve Group	Maximum Leakage Rate
a.	CEP-V-1A and 1B CEP-V-2A and 2B	.05 L_a*
b.	CEP-V-3A and 3B CEP-V-4A and 4B	.05 L_a*
c.	CSP-V-1 CSP-V-2	.05 L_a*
d.	CSP-V-3 CSP-V-4	.05 L_a*

4.6.1.8.3 Each 24- and 30-inch purge supply and exhaust isolation valve 70 degree open limiting device shall be functionally tested at least once every 18 months.

* These valves are tested in parallel with the maximum leakage allowed for a single valve applied to the group.

** Valve operation as provided for in 3.6.1.8.a shall be under administrative control only.

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JE Rhoads - 9670	WNP-2 Files	

Docket No. 50-397

December 8, 1983
G02-83-1129

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

Subject: NUCLEAR PROJECT NO. 2
QUALIFICATION AND OPERATION OF
WNP-2 CONTAINMENT VENT & PURGE VALVES

References:
a) Letter, A. Schwencer (NRC) to R. L. Ferguson (SS), "Request for Additional Information", dated September 16, 1982
b) NUREG-0892, WNP-2 Safety Evaluation Report, Outstanding Issue No. 26, "Operability of Purge Valves"
c) Letter, G02-83-170, G. D. Bouchey (SS) to A. Schwencer (NRC), "Vent & Purge Valves", dated February 24, 1983
d) Letter, G02-83-550, G. D. Bouchey (SS) to A. Schwencer (NRC), "Qualification of WNP-2 Containment Vent and Purge Valves", dated June 22, 1983

References a and b contain NRC requests for information regarding the WNP-2 containment vent and purge valves and References c and d are the Supply System's responses to the requests. These concerns have resulted in a proposed Technical Specification Limiting Condition for Operation (LCO), for WNP-2 (Attachment A). This LCO would seriously impact the WNP-2 plant's ability to properly carry out initial power ascension testing and operation.

The purpose of this letter is to bring to the NRC's attention, additional information concerning the Supply Systems action to resolve this issue and to propose an alternate Technical Specification LCO (Attachment B). This LCO is consistent with the LCO that provides for the drywell and suppression chamber atmosphere inerting (Reference Technical Specification 3.6.6.2) and will allow compliance capability.

AUTHOR:	JE Rhoads 12/7/83		FOR SIGNATURE OF:	GC Sorensen	
SECTION					
FOR APPROVAL OF	PL Powell	WW Waddel	LT Harrold	JD Martin	DA Armstrong
APPROVED 12/6/83					
DATE	MR Wuestefeld	12/6/83	12/6/83	12/5/83	12/6/83

The Supply System is aware of NRC concerns which resulted from the staff's review of references c and d. These concerns have been discussed with the Equipment Qualification Branch and their consultant. The result of these discussions is the Supply Systems commitment to limit the valve opening angle to a point that provides a maximum air velocity equal to or below a Mach number of .3. This corresponds to a maximum valve opening of no more than 70 degrees (with full open equal to 90 degrees).

Appropriate valve limiting devices will be installed prior to exceeding 5% power. A revised package detailing the field modification to limit valve opening and demonstrate that the information provided in references c and d is appropriate with this valve opening limit will be provided by December 16, 1983.

Based on the Supply System commitment to limit valve opening, it is understood that the LCO which now requires that they be locked sealed closed may be relaxed. Provided in Attachment B is the Supply System recommendation to a revised LCO that would allow Safe Operation of WNP-2 with the subject valves appropriately modified.

The Supply System's planned December 16 submittal will provide the appropriate data to address the concerns now in place. Should you have any further questions, please contact Mr. P. L. Powell, Manager, WNP-2 Licensing.

Very truly yours,

G C Sorensen

G. C. Sorensen, Manager
Regulatory Programs

JER/tmh
Attachments

cc: R Auluck - NRC
WS Chin - BPA
AD Toth - NRC Site
R Wright - NRC
D Hoffman - NRC
F Eltawila - NRC

ATTACHMENT A

"Current LCO"

CONTAINMENT SYSTEMS

DRYWELL AND SUPPRESSION CHAMBER PURGE SYSTEM

PROOF & REVIEW COPY

LIMITING CONDITION FOR OPERATION

3.6.1.8 The drywell and suppression chamber 2-inch purge supply and exhaust isolation valves shall be OPERABLE and:

a. Each 24- and 30-inch purge supply and exhaust isolation valve shall be sealed closed.

b. Each 2-inch purge valve may be open for purge system operation for inerting, deinerting and pressure control.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2, and 3.

ACTION:

a. With a 24- and/or 30-inch drywell and suppression chamber purge supply and/or exhaust isolation valve(s) open or not sealed closed, close and/or seal the 24- and 30-inch valve(s) or otherwise isolate the penetration within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

b. With a 2-inch drywell and suppression chamber purge supply and/or exhaust isolation valve(s) inoperable or open for other than inerting, deinerting, or pressure control, close the open 2-inch valve(s) or otherwise isolate the penetration(s) within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

c. With a drywell and suppression chamber purge supply and/or exhaust isolation valve(s) with resilient material seals having a measured leakage rate exceeding the limit of Surveillance Requirements 4.6.1.8.3 and/or 4.6.1.8.4, restore the inoperable valve(s) to OPERABLE status within 24 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.8.1 Each 24- and 30-inch drywell and suppression chamber purge supply and exhaust isolation valve shall be verified to be sealed closed at least once per 31 days.

4.6.1.8.2 At least once per 6 months on a STAGGERED TEST BASIS each sealed closed 24- and 30-inch drywell and suppression chamber purge supply and exhaust isolation valve with resilient material seals shall be demonstrated OPERABLE by verifying that the measured leakage rate is less than or equal to 0.05 L_a when pressurized to P_a.

PROOF & REVIEW COPY

SURVEILLANCE REQUIREMENTS (Continued)

4.6.1.8.3 At least once per 92 days each 2-inch drywell and suppression chamber purge supply and exhaust isolation valve with resilient material seals shall be demonstrated OPERABLE by verifying that the measured leakage rate is less than or equal to 0.01 L_a when pressurized to P_a.

ATTACHMENT B

"DRAFT LCO"

CONTAINMENT SYSTEMS

DRYWELL AND SUPPRESSION CHAMBER PURGE SYSTEM

LIMITING CONDITION FOR OPERATION

3.6.1.8 The drywell and suppression chamber 2-inch exhaust isolation valves shall be OPERABLE and:

a. Each 24- and 30-inch purge supply and exhaust isolation valve shall be closed during the time period:

   1. Within 24 hours after THERMAL POWER is greater than 15% of RATED THERMAL POWER, following startup, to

   2. Within 24 hours prior to reducing THERMAL POWER to less than 15% of RATED THERMAL POWER, preliminary to a scheduled reactor shutdown.

b. Each 2-inch purge valve may be open for purge system operation for inerting, deinerting and pressure control.

c. Each 24- and 30-inch purge supply and exhaust isolation valve shall be limited to open no more than 70 degrees.

APPLICABILITY: OPERATIONAL CONDITIONS 1, 2, and 3.

ACTION:

a. With a 24- and/or 30-inch drywell and suppression chamber purge supply and/or exhaust islation valve(s) not closed, close and/or seal the 24- and 30-inch valve(s) or otherwise isolate the penetration within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours except as provided for in 3.6.1.8.a.

b. With a 2-inch drywell and suppression chamber exhaust isolation valve inoperable or open for other than inerting, deinerting, or pressure control, close the open 2-inch valve(s) or otherwise isolate the penetration(s) within 4 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

c. With a drywell and suppression chamber purge supply and/or exhaust isolation valve(s) with resilient material seals having a measured leakage rate exceeding the limit of Surveillance Requirements 4.5.1.8.2, restore the inoperable valve(s) to OPERABLE status within 24 hours or be in at least HOT SHUTDOWN within the next 12 hours and in COLD SHUTDOWN within the following 24 hours.

SURVEILLANCE REQUIREMENTS

4.6.1.8.1 Each 24- and 30-inch drywell and suppresion chamber purge supply and exhaust isolation valve shall be verified to be closed at least once per 31 days.**

4.6.1.8.2 At least once per 92 days each group shown below of drywell and suppression chamber purge supply and exhaust isolation valve with resilient material seals shall be demonstrated OPERABLE by verifying that the measured leakage rate is less than or equal to .05 L_a when pressurized to P_a.

	Valve Group	Maximum Leakage Rate
a.	CEP-V-1A and 1B CEP-V-2A and 2B	.05 L_a*
b.	CEP-V-3A and 3B CEP-V-4A and 4B	.05 L_a*
c.	CSP-V-1 CSP-V-2	.05 L_a*
d.	CSP-V-3 CSP-V-4	.05 L_a*

4.6.1.8.3 Each 24- and 30-inch purge supply and exhaust isolation valve 70 degree open limiting device shall be functionally tested at least once every 18 months.

* These valves are tested in parallel with the maximum leakage allowed for a single valve applied to the group.

** Valve operation as provided for in 3.6.1.8.a shall be under administrative control only.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

REQUALIFICATION CERTIFICATE

WNP- 2

QID 361104

COMPONENT NO: CSP-V-1, CSP-V-2, CEP-V-1A, CEP-V-2A

COMPONENT DESCRIPTION: 30" Cylinder Operated Butterfly Valves

MANUFACTURER: BIF MODEL NO: A-206763

EQUIPMENT CLASSIFICATION: [X] ACTIVE [ ] PASSIVE

SEISMIC QUALIFICATION REPORT REFERENCE:

1. Cygna Energy Services Report No. 05.01.F, "30" Cylinder Operated Butterfly Valves", Rev. 2, dated 6/15/83.
2. WPPSS Supplemental Calculations, EQ-02-83-11, "Final As-built Review of Purge and Vent Valves (BIF)"

ENVIRONMENTAL QUALIFICATION REPORT REFERENCE:

Certificate of qualification is for seismic/hydrodynamic and postulated LOCA conditions.

THE ABOVE SEISMIC AND ENVIRONMENTAL QUALIFICATION REPORTS HAVE BEEN REEVALUATED IN ACCORDANCE WITH THE CURRENT NRC SEISMIC AND ENVIRONMENTAL CRITERIA:

1. IEEE STANDARDS 344 (1975)
2. USNRC REGULATORY GUIDES 1.92, 1.100
3. STANDARD REVIEW PLANS 3.9.2, 3.10, 3.11
4. NUREG-0588

THE ABOVE COMPONENT HAS BEEN FOUND ACCEPTABLE FOR PERFORMING ITS INTENDED SAFETY RELATED FUNCTION WHEN SUBJECTED TO THE PLANT SPECIFIC VIBRATORY AND ENVIRONMENTAL LOADS.

PREPARED BY	Mark Scott [signature]	DATE 12/14/83
REVIEWED BY	Milon Meyer [signature]	DATE 12/14/83
APPROVED BY	Dennis Armstrong [signature]	DATE 12/14/83

965-12576

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

REQUALIFICATION CERTIFICATE

WNP- 2

QID 361106

COMPONENT NO: CSP-V-3, CSP-V-4, CSP-V-5, CSP-V-6, CSP-V-9, CEP-V-3A, CEP-V-4A

COMPONENT DESCRIPTION: 24" Cylinder Operated Butterfly Valves

MANUFACTURER: BIF MODEL NO: A-206765

EQUIPMENT CLASSIFICATION: [X] ACTIVE [ ] PASSIVE

SEISMIC QUALIFICATION REPORT REFERENCE:

1. Cygna Energy Services Report No. OT.01.F, "24" Cylinder Operated Butterfly Valves", Rev. 4, dated 11/11/83.
2. WPPSS Supplemental Calculations EQ-02-83-11, "Final As-built Review of Purge and Vent Valves (BIF)"

ENVIRONMENTAL QUALIFICATION REPORT REFERENCE:

Certificate of qualification is for seismic/hydrodynamic and postulated LOCA conditions.

THE ABOVE SEISMIC AND ENVIRONMENTAL QUALIFICATION REPORTS HAVE BEEN REEVALUATED IN ACCORDANCE WITH THE CURRENT NRC SEISMIC AND ENVIRONMENTAL CRITERIA:

1. IEEE STANDARDS 344 (1975)
2. USNRC REGULATORY GUIDES 1.92, 1.100
3. STANDARD REVIEW PLANS 3.9.2, 3.10, 3.11
4. NUREG-0588

THE ABOVE COMPONENT HAS BEEN FOUND ACCEPTABLE FOR PERFORMING ITS INTENDED SAFETY RELATED FUNCTION WHEN SUBJECTED TO THE PLANT SPECIFIC VIBRATORY AND ENVIRONMENTAL LOADS.

PREPARED BY	Mark Scott	DATE 12/14/83
REVIEWED BY	Milon Meyer	DATE 12/14/83
APPROVED BY	Dennis Armstrong	DATE 12/14/83

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

CALCULATION COVER SHEET

SHEET ____ OF ____

PROJECT	DISCIPLINE	CALC. NO.
WNP-2	EQUIPMENT QUALIFICATION	EQ-02-83-11
CONTRACT	**SPECIFICATION**	**QUALITY CLASS**
68	2808-68	I
SYSTEM NO.	**EQUIPMENT PIECE NO.**	
CEP & CSP	CEP-V-1A,2A,3A,4B, CSP-V-1,2,3,4,5,6,9,	

SUBJECT

CONTAINMENT PURGE/VENT VALVES
STRESS REVIEW AND SUMMARY
FINAL ASBUILT LOAD REVIEW

ACTION REQUIRED

☐ SAR CHANGE ☐ SPEC. CHANGE ☐ OTHER (IDENTIFY BELOW)

REVIEW FINAL LOADS FOR ACCEPTABILITY AND MAKE A COMPARISON OF STRESSES TO THE NRC REQUIREMENTS FOR CONTAINMENT PURGE/VENT VALVES.

ATTACHMENTS

☒ COMPUTER PRINTOUT ☐ VERIFICATION CHECKLIST

OTHER (IDENTIFY)

VERIFICATION REQUIREMENT	YES	NO	REASON	APPROVED/DATE
	☐	☒	TDP-3.32	

TYPE OF CALCULATION	REMARKS	SUPERSEDES / SUPERSEDED BY
☐ PRELIMINARY ☒ FINAL		SUPERSEDES: SUPERSEDED BY:

REV. NO.	REVISION DESCRIPTION	CALCULATION BY	DATE	CHECKED	DATE	APPROVED	DATE
0	ORIGINAL	[signature]	12/16/83	[signature]	12/16/83	[signature]	12/16/83

WP-809 R4

Calculation Sheet

Project WPPSS		Prepared By: [signature]	Date 12/15/83
Subject SUPPLEMENTAL CALCS		Checked By: Milton Meyer	Date 12-16-83
System CONTAINMENT PURGE & VENT VALVES		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No.	Sheet No. E-1	

"SUPPLEMENTAL CALCULATIONS"

24" AND 30" BIF BUTTERFLY VALVES

TABLE OF CONTENTS

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/16/83
Subject: VALVE ACTUATION TORQUES		Checked By: Milon Meyer	Date: 12-16-83
System: CONTAINMENT VENT/PURGE VALVES		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.	Sheet No.: E-2	

SUMMARY

THE CONTAINMENT VENT AND PURGE VALVE QUALIFICATION REPORTS, (REF 1 & 7) WERE REVIEWED FOR THEIR COMPLIANCE WITH THE NRC QUESTIONS REGARDING CONTAINMENT VENT AND PURGE VALVES. THE STRESS CALCULATIONS WERE REVIEWED AND MODIFIED IN THE FOLLOWING ANALYSIS TO BOTH REMOVE EXCESS CONSERVATISM AND EVALUATE FINAL ASBUILT LOADING ACCELERATIONS. THE RESULTING STRESSES WERE THEN COMPARED WITH THE REQUIRED NRC ALLOWABLE STRESSES.

CONCLUSION

THE RESULTING STRESSES DUE TO THE VALVE SEATING TORQUES PLUS DBE LOADING MEET THE ALLOWABLE STRESS LEVELS FOR FAULTED CONDITIONS. THE RESULTING STRESSES DUE TO THE LOCA FLOW INDUCED TORQUES PLUS DBE LOADING MEET THE REQUIRED ALLOWBLE STRESS LEVELS FOR NORMAL CONDITIONS AS IMPOSED BY THE NRC REQUIREMENTS.

Calculation Sheet

Project: WPPSS - WNP-2		Prepared By: [signature]	Date: 12/13/85
Subject: VALVE ACTUATION TORQUE		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E3	

REF. 1 "DESIGN AND SEISMIC ANALYSIS OF 24" CYLINDER OPERATED BUTTERFLY VALVE FOR WPPSS & B&R," BIF REPORT # TR-74-7, MCPHERSON ASSOCIATES, INC.

REF 2 "DYNAMIC TORQUE CALCULATION OF BUTTERFLY VALVE, BIF REPORT # TR-27234 AND TR-27235, DEBENDRA K. DAS.

REF 3 "EQUIPMENT SEISMIC AND HYDRODYNAMIC REQUALIFICATION OF 24" CYLINDER OPERATED BUTTERFLY VALVES FOR CSP-V-3, 4, 5, 6 & 9 AND CEP-V-3A & 4A, REPORT # OT.01.F, QID #361106, CYGNA ENERGY SERVICES.

REF 4 FINAL ASBUILT ACCELERATIONS SECTION 5.5 OF REF 1 AND REF 7

REF 5 BIF TEST REPORT "DYNAMIC TORQUE AND HEAD LOSS TESTS OF CAST IRON STREAMLINE DISC VERSUS FABRICATED FLAT PLATE DISC."

REF 6 BIF REPORT NO. TR-0650-43 DATED 2-24-82 "HYDRODYNAMIC AND HEADLOSS TEST OF 12"- 150B BUTTERFLY VALVE WITH DIRECTLY CONNECTED SHORT RADIUS ELBOW UPSTREAM."

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/85
Subject VALVE ACTUATION TORQUE		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-4	

REF 7. "DESIGN AND SEISMIC ANALYSIS OF 30" CYLINDER OPERATED BUTTERFLY VALVE FOR WPPSS & B&R," BIF REPORT # TR-74-7, McPHERSON ASSOCIATES, INC.

REF 8. "EQUIPMENT SEISMIC AND HYDRODYNAMIC REQUALIFICATION OF 30" CYLINDER OPERATED BUTTERFLY VALVES FOR CSP-V-1 & 2 AND CEP-V-1A & 2A" REPORT # 05.01.F, QID # 361104, CYGNA ENERGY SERVICES.

VALVE/OPERATOR COMPONENT	24" BIF BUTTERFLY CONTAINMENT PURGE/VENT VALVES									
	VALVE SEATING TORQUE + DBE					LOCA FLOW TORQUE + DBE				
	CALC'D STRESS	STRESS ALLOWABLE				CALC'D STRESS	STRESS ALLOWABLE			
		NORMAL		FAULTED			NORMAL		FAULTED	
	T = TENSILE S = SHEAR B = BEARING	.6Fy .4Fy .96Fy	MARGIN OF SAFETY	.9Fy .6Fy	MARGIN OF SAFETY	T = TENSILE S = SHEAR B = BEARING	.6Fy .4Fy .96Fy	MARGIN OF SAFETY	.6Fy .4Fy	MARGIN OF SAFETY
TRUNNION PINS	4104 S	12000	2.9	18000	4.4	4104 S	12000	2.9	18000	4.4
TAPERED PINS	8064 S	9300	1.2	13950	1.7	5546 S	9300	1.7	13950	2.5
DRIVE LEVER	8976 T	24000	2.7	36000	4.0	6319 T	24000	3.8	36000	5.7
MAIN SHAFT	17046 T	18000	1.1	27000	1.6	12322 T	18000	1.5	27000	2.2
DRIVE ROD	33230	36000	1.1	54000	1.6	32907	36000	1.1	54000	1.6
EAR BOLTS *	15109 (S) 17244 (T)	27800 T	1.6	—	—	15352 16743	27370 T	1.6	—	—
LEVER KEYWAY	11362 S	16000	1.4	24000	2.1	7814 S	16000	2.0	24000	3.1
SHEAR PL WELD	9637 S	18000	1.9	—	—	9637 S	18000	1.9	—	—
VALVE EAR WELD	10589 S	18000	1.7	—	—	10589 S	18000	1.7	—	—

* AISC BOLT TENSILE ALLOWABLE = 55 − 1.8fv ≤ 44 KSI FOR A-325

Calculation Sheet

Project: WPPSS WNP-?
Subject: VALVE ACTUATION TORQUE STRESSES
System: CONTAINMENT ISOLATION VALVES CEP, CSP
Analysis No.: EQ-02-83-11
Rev. No.: 0
Job No.:
Sheet No.: E-5
File No.:
Prepared By: [signature] Date: 12/13/83
Checked By: Milon Meyer Date: 12-15-83

	30" B/F Butterfly Containment Purge/Vent Valves									
	Valve Seating Torque + DBE					LOCA Flow Torque + DBE				
	Calc'd Stress	Stress Allowable Normal		Faulted		Calc'd Stress	Stress Allowable Normal		Faulted	
Valve/Operator Component	T = Tensile S = Shear B = Bearing	.6Fy .4Fy .96Fy	Margin of Safety	.9Fy .6Fy	Margin of Safety	T = Tensile S = Shear B = Bearing	.6Fy .4Fy .96Fy	Margin of Safety	.6Fy .4Fy	Margin of Safety
Trunnion Pins	2195 S	12000	5.5	18000	8.2	2195 S	12000	5.5	18000	8.2
Tapered Pins	8443 S	9300	1.1	13950	1.7	7039 S	9300	1.5	13950	2.0
Drive Lever	11092	24000	2.2	36000	3.2	9340	24000	2.6	36000	3.9
Main Shaft	20527	18000	.88	27000	1.3	14287	18000	1.3	27000	1.9
Drive Rod	32845	36000	1.1	54000	1.6	32560	36000	1.1	54000	1.7
Ear Bolts	8368 (S) 9754 (T)	39938	4.1	–	–	8003 (S) 9518 (T)	40595	5.1	–	–
Lever Keyway	9504	16000	1.7	24000	2.5	7923	16000	2.0	24000	3.0
Shear PL Weld	12557	18000	1.4	–		12557	18000	1.4	–	
Valve Ear Weld	13277	18000	1.4	–		13277	18000	1.4	–	

AISC Bolt Tensile Allowable = $55 - 1.8 f_v \leq 44$ ksi for A-325

Calculation Sheet

Project: WPPSS WNP-2
Subject: Valve Actuation Torque Stresses
System: Containment Isolation Valves CEP & CSP
Analysis No.: EQ-02-83-11
Rev. No.: 0
Sheet No.: E-6
Prepared By: [signature] Date: 12/13/83
Checked By: Milton Meyer Date: 12-16-83
Job No.:
File No.:

Calculation Sheet

Project: WPPSS WNP-2 | Prepared By: [signature] | Date: 12/13/83

Subject: Valve Actuation Torque | Checked By: Milon Meyer | Date: 12-15-83

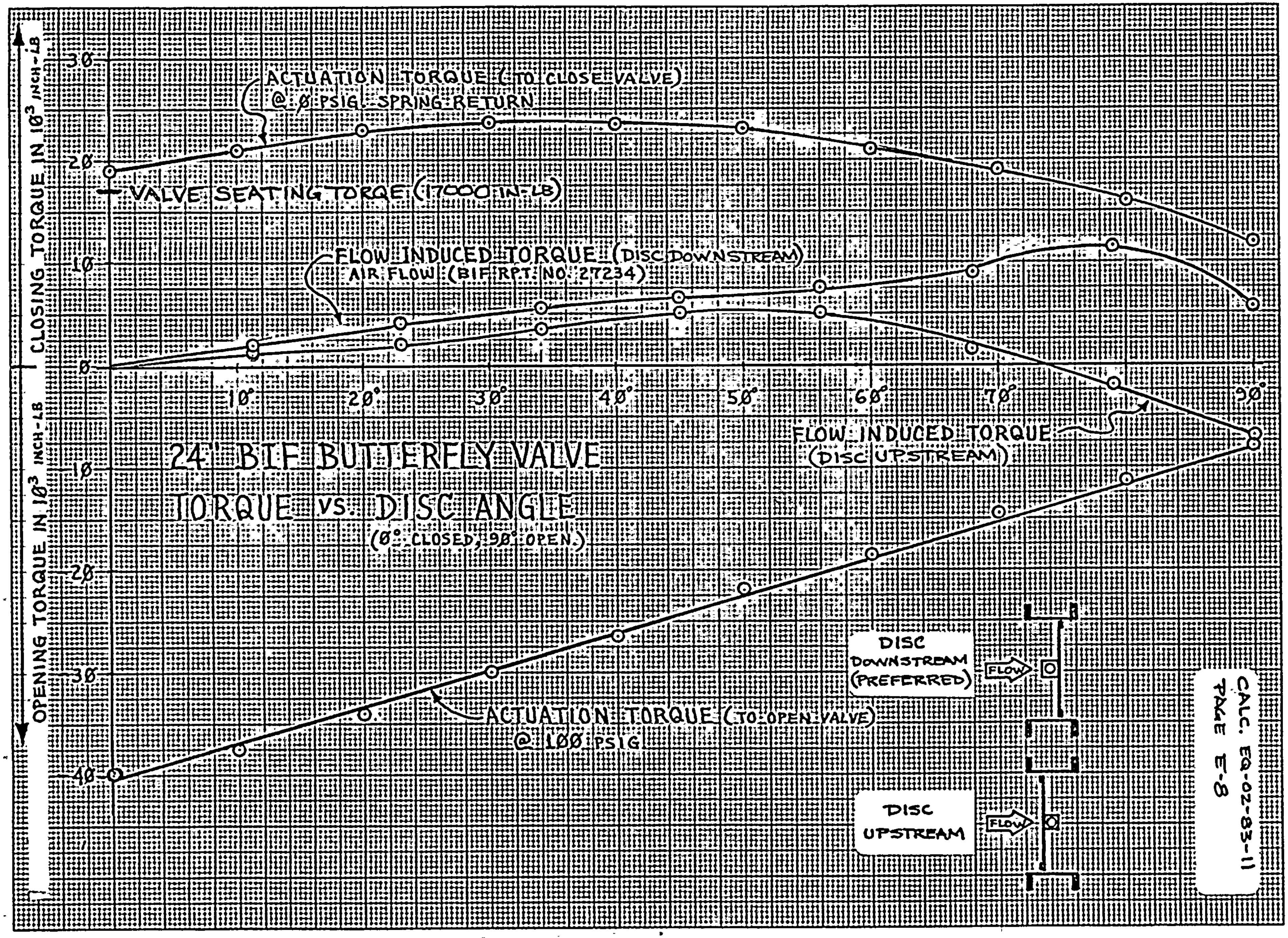
System: Containment Isolation Valves CEP; CSP | Job No. | File No.

Analysis No. EQ-02-83-11 | Rev. No. 0 | Sheet No. E-7

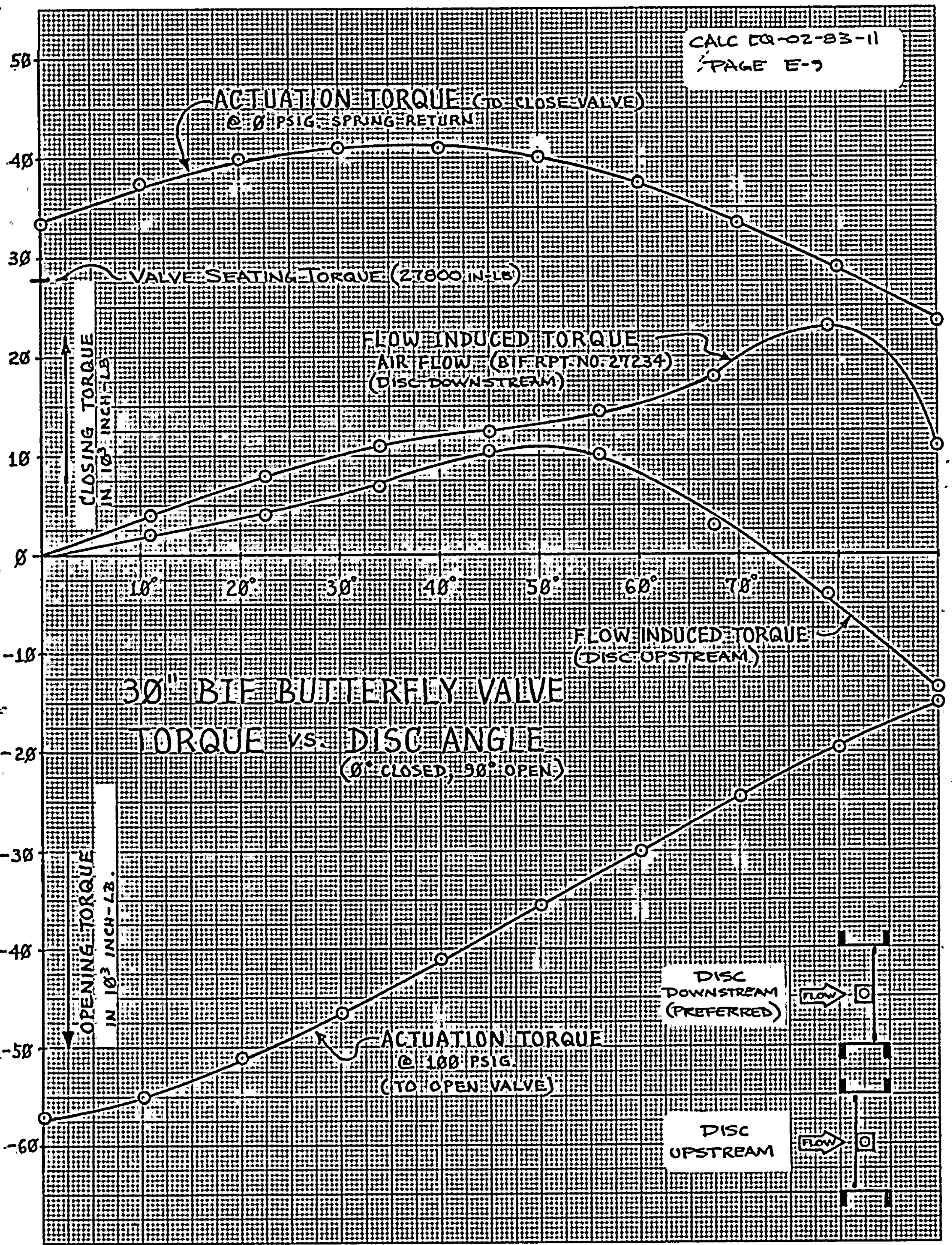
ALLOWABLE MATERIAL STRESSES

COMPONENTS	MAT'L	Sy	Su	.4 Sy	.6 Sy	.9 Sy	TEMP
TRUNNION PINS	A-276 GR 304 (SA479-304)	30,000	75000	12,000	18000	27000	R.T
TAPERED PINS*	A-276 (GR-304) (SA479-304)	21,780 (23,250)	65400 (67500)	8,710 (9300)	13068 (13950)	19602 (20925)	350° 270°
DRIVE LEVER	A395	40,000	60,000	16000	24000	36000	R.T
MAIN SHAFT *	SA479	30,000 (23,250)	75000 (67500)	12000 (9300)	18000 (13950)	27000 (20925)	R.T @ 270°F
DRIVE ROD	4140	90,000	110000	36000	54000	81000	RT
EARBOLTS	A-325	81000	105000	32400	48600	72900	RT
LEVER KEY	A-395	40,000	60,000	16000	24000	36000	RT
SHEAR PL WELD	E-60XX		60000	.3 Fu 18000			RT
VALVE EAR WELD	E-60XX		60000	18000			RT

*TEMP = 340°F
(TEMP = 270°F)



CLOSING TORQUE IN 10^3 INCH-LB
OPENING TORQUE IN 10^3 INCH-LB
30
20
10
0
10
20
30
40
10°
20°
30°
40°
50°
60°
70°
90°
ACTUATION TORQUE (TO CLOSE VALVE) @ Ø PSIG SPRING RETURN
VALVE SEATING TORQE (17000 IN-LB)
FLOW INDUCED TORQUE (DISC DOWNSTREAM) AIR FLOW (BIF RPT NO. 27234)
FLOW INDUCED TORQUE (DISC UPSTREAM)
24" BIF BUTTERFLY VALVE
TORQUE VS. DISC ANGLE
(Ø° CLOSED, 9Ø° OPEN.)
ACTUATION TORQUE (TO OPEN VALVE) @ 1ØØ PSIG
DISC DOWNSTREAM (PREFERRED)
FLOW
DISC UPSTREAM
FLOW
CALC. EQ-02-83-11
PAGE E-8


CALC EQ-02-83-11
PAGE E-9
ACTUATION TORQUE (TO CLOSE VALVE)
@ Ø PSIG SPRING RETURN
VALVE SEATING TORQUE (27800 IN-LB)
FLOW INDUCED TORQUE
AIR FLOW (BIF RPT NO. 27234)
(DISC DOWNSTREAM)
FLOW INDUCED TORQUE
(DISC UPSTREAM)
CLOSING TORQUE IN 10³ INCH-LB
OPENING TORQUE IN 10³ INCH-LB.
30" BIF BUTTERFLY VALVE
TORQUE vs. DISC ANGLE
(Ø° CLOSED, 90° OPEN)
ACTUATION TORQUE
@ 100 PSIG
(TO OPEN VALVE)
DISC DOWNSTREAM (PREFERRED)
DISC UPSTREAM
FLOW
50
40
30
20
10
Ø
-10
-20
-30
-40
-50
-60
10°
20°
30°
40°
50°
60°
70°

Calculation Sheet

Project: WPPSS WNP-2	Prepared By: [signature]	Date: 12/15/83	
Subject: VALVE COMPONENT STRESSES	Checked By: Milan Meyer	Date: 12-16-83	
System: CONTAINMENT ISOLATION VALVES CEP & CSP	Job No.	File No.	
Analysis No. EQ-02-83-11	Rev. No.	Sheet No. E-10	

SEVERAL VALVE COMPONENTS ARE STRESSED AS A FUNCTION OF VALVE OPERATIONAL TORQUE. THE STRESSES ARE CALCULATED FOR THE 24" AND 30" VALVES WITH THE FOLLOWING LOAD CONDITIONS.

LOAD CONDITION #1

SEATING TORQUE + DBE LOADING

	24"	30"
SEATING TORQUE	17000 IN-LB (REF 1)	27800 IN-LB (REF 7)

LOAD CONDITION #2

FLOW INDUCED TORQUE + DBE LOADING

	24"	30"
FLOW TORQUE	11692 IN-LB (REF 2)	23175 IN-LB (REF 2)

THE STRESSES RESULTING FROM THESE TWO LOAD CASES ARE PRESENTED IN A SUMMARY TABLE ON PAGES E5 & E6 AND COMPARED TO THEIR RESPECTIVE ALLOWBLES.

24" BIF BUTTERFLY VALVES

"STRESS CALCULATIONS"

(30" VALVES ON PAGE E30)

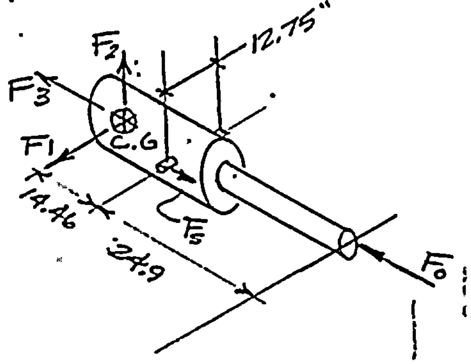
Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject VALVE COMPONENT STRESSES		Checked By: Milan Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP; CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-11	

THE FOLLOWING COMPONENTS ARE STRESSED BY THE APPLIED TORQUE DURING LOCA CONDITIONS. THE RESULTING STRESSES ARE CALCULATED BELOW.

TRUNNION PINS

FROM ALL OF THE DIRECTIONAL ACCELERATIONS PICK THE WORST THREE ACCELERATIONS. OF BOTH BRACKET AND CYLINDER MASSES



X = 11.39g HORIZ
Y = 3.52g VERT
Z = 5.85g HORIZ

(REF 4)

THE TOTAL SHEAR LOAD ON THE TRUNNION IS

$$F_S = \left[\left(\frac{14.46\,F_1}{12.75} + \frac{F_3}{2} + \frac{F_0}{2}\right)^2 + \left(\frac{(14.46+24.9)}{24.9}\,\frac{F_2}{2}\right)^2\right]^{1/2}$$

$$F_S = \left[(1.13\,F_1 + .5F_3 + .5F_0)^2 + (.79F_2)^2\right]^{1/2}$$

ORIENTING THE WORST HORIZONTAL COMBINATION TO THE F_1 DIRECTION MAXIMIZES THE FORCE ON THE TRUNNION. FORCES APPLIED IN THE F_2 DIRECTION THOUGH GREATER THAN THE F_3 WILL BE OUT OF PHASE WITH THE OTHERS.

USE $F_1 = W_T (11.39^2 + 5.85^2)^{1/2} = 399(12.80) = 5109^{\#}$

$F_2 = 0$

$F_3 = W_T (3.52 + 1) = 399(4.52) = 1803^{\#}$

$F_0 = \frac{T_{SEATING}}{r} = \frac{17000}{11.75} = 1447$ LB (REF 1)

$P = 1.134(5109) + .5(1803) + .5(1447)$

$= 7419^{\#}$

THE MAXIMUM SHEAR STRESS IS THEN

$\tau = \frac{4}{3}\left(\frac{7419}{2.41}\right) = 4104$ PSI

CLEVIS PIN

THE STRESS CALCULATED ON PAGE 361106-43-24 OF REF 3 IS CONSERVATIVE AND WILL BE USED.

$\tau = 2717$ PSI

DRIVE LEVER

THE MAXIMUM FORCE ON THE DRIVE LEVER IS DUE TO THE SEATING TORQUE AND REACTION OF THE DRIVE ROD TO DYNAMIC LOADING OF THE CYLINDER.

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/15/83
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E13	

THE MAXIMUM LOAD DUE TO THE SEATING TORQUE PRODUCES A FORCE NEARLY PERPENDICULAR TO THE AXIS OF THE DRIVE LEVER. THE DYNAMIC LOAD PRODUCES A FORCE NEARLY PARRALLEL TO THE AXIS OF THE DRIVE LEVER.

$$F_{\perp} = \frac{17000}{11.75} = 1447^{\#} \qquad F_{\parallel} = (11.39^2 + 5.85^2)^{1/2}\, 399\, \frac{(14.46)}{24.87}$$

$$= 2970^{\#}$$

THE RESULTING STRESS USING THE SECTION PROPERTIES FROM PG. 35 OF REF 1

$$\sigma_{TENSILE} = \frac{Mc}{I} + \frac{F_{\parallel}}{A}$$

$$= \frac{1447(11.75)1.44}{2.99} + \frac{2970}{4.32}$$

$$= 8188 + 788 = 8976 \text{ PSI}$$

$$\tau_{AVE} = \frac{V}{A} = \frac{1447}{4.32} = 335 \text{ PSI}$$

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/15/83
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E-14	

FOR LOCA LOADS THE FLOW INDUCED TORQUE IS

$T = 11692$ IN-LB (REF 2)

$$\therefore F_{\perp} = \frac{11692}{11.75} = 995^{\#}$$

$$F_{\parallel} = 2970^{\#} \quad \text{(PREVIOUS PAGE)}$$

$$\sigma_{TENSILE} = \frac{Mc}{I} + \frac{F_{\parallel}}{A} = \frac{995(11.75)(1.44)}{2.99} + \frac{2970}{4.32}$$

$$= 5631 + 688$$

$$= 6319 \text{ PSI}$$

Calculation Sheet

Project: WPPSS WNP-2	Prepared By: [signature]	Date: 12/15/83	
Subject: Valve Component Stresses	Checked By: Milon Meyer	Date: 12-15-83	
System: Containment Isolation Valves CEP/CSP	Job No.	File No.	
Analysis No.: EQ-02-83-11	Rev. No.	Sheet No.: E-15	

Lever Keyway

FOR KEYWAYS THE AVERAGE SHEAR STRESS IS CALCULATED FOR THE SECTION OF CONCERN. THE FORCE AT THE SHEAR SURFACE BETWEEN THE DRIVE LEVER AND MAIN VALVE SHAFT IS:

$$F = \frac{T\,2}{d} = \frac{17000(2)}{2.25} = 15111\ \#$$

THE RESULTING BEARING STRESS USING THE AREA VALUES FROM PG. 36 OF REF 1

$$f_b = \frac{15111}{.448} = 33730$$

THE ALLOWABLE BEARING STRESS IS YIELD, WHICH IS:

$$F_Y = 40000$$

THE RESULTING AVERAGE SHEAR STRESS IS:

$$\tau = \frac{15111}{1.33} = 11362.\ \text{PSI}$$

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/83
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-16	

BASED ON THE MAXIMUM FLOW INDUCED TORQUE OF 11692 IN-LB (REF 2)

$$f_b = 33730\left(\frac{11692}{17000}\right) = 23198 \text{ psi}$$

$$\tau = 11362\left(\frac{11692}{17000}\right) = 7814 \text{ psi}$$

MAIN SHAFT

FOLLOWING THE FORMAT OF REF 3 PAGE 4.3-27 THE SHEAR STRESS DUE TO OPERATING TORQUE IS:

$$\tau_T = \frac{T r}{J} \qquad r = 1.125''$$

$$J = 2\frac{\pi D^4}{64} = 2.5161$$

$$= \frac{17000(1.125)}{2.5161} = 7601 \text{ psi}$$

THE SHEAR STRESS DUE TO THE THRUST OF THE DRIVE LEVER

$$\tau = \frac{(1447^2 + 2970^2)^{1/2}}{3.976} = 831 \text{ psi}$$

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/85
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-17	

THE BENDING STRESS CALCULATION FOLLOWS THE PROCEDURE ESTABLISHED ON PAGE 48 & 49 OF REFERENCE 1.

$$M = F_{COMBINED} \frac{a\,b}{L} = \frac{(1447^2 + 2970^2)^{1/2}(6.005)(10.31)}{16.315}$$

$$= 3304(3.795) = 12537 \text{ IN-LB}$$

$$\sigma_b = \frac{Mc}{I} = \frac{12537}{\pi \frac{2.25^3}{32}} = 11211 \text{ PSI}$$

(1.1183)

THE RESULTING COMBINED STRESS EVALUATED SIMILARLY TO THAT ON PAGE 50 OF REF 1

$a = 1 \quad b = \sigma_b = 11211 \quad c = (-\tau_T^2 - \tau^2)$

$$= (7601^2 - 831^2)$$
$$= -58,465,762.$$

$$x = \frac{-11211 \pm \sqrt{11211^2 - 4(1)(-58465762)}}{2(1)}$$

$$= \frac{-11211 \pm 18962}{2}$$

$= 3875$ PSI

$= -15086$ PSI

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/83
Subject: Valve Component Stresses		Checked By: Milton Meyer	Date: 12-15-83
System: Containment Isolation Valves CEP-CSP		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E-18	

THE RESULTING STRESS INTENSITY IS THEN

$$S_t = x_1 - x_2 = 3875 - (-15086)$$

$$= 18961 \cdot \text{PSI}$$

THE ALLOWABLE STRESS INENSITY FOR NORMAL LOADING @ ROOM TEMPERATURE,

$$S_{allow\ normal} = .6 S_y = 18000 \text{ PSI}$$

FOR FAULTED LOADING THE ALLOWABLE STRESS LEVEL IS:

$$S_{allow\ fault} = 1.5(.6 S_y) = 27000 \text{ PSI}$$

THESE STRESS LEVELS CAN BE REDUCED BY REMOVING SOME OF THE CONSERVATISM IN THE APPLIED LOADING. TO ACHIEVE THIS USE THE FINAL AS BUILT ACCELERATIONS APPLICABLE TO THE CYLINDER. AND USE THE APPLIED FLOW INDUCED TORQUE.

THE MAXIMUM GLOBAL ACCELERATIONS ARE

$$aX = 4.57g \quad \text{HORIZ (CEP-V-3A)}$$

$$aY = 3.52g \quad \text{VERT (CSP-V-5)}$$

$$aZ = 5.85g \quad \text{HORIZ (CSP-V-6)}$$

COMBINING THE TWO HORIZONTAL ACCELERATIONS BY SRSS

$$a_{horiz} = 7.42\ g$$

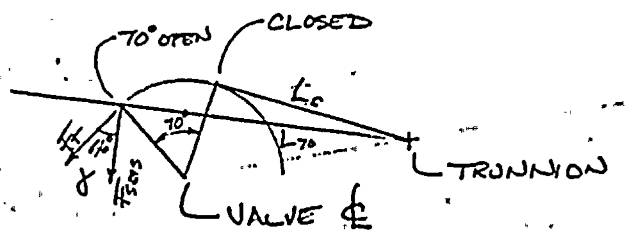
Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP; CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-19	

MAXIMUM FLOW INDUCED TORQUE
T = 11692 IN-LB (FLOW INDUCED TORQUE)

$F_T = \frac{11692'}{11.75''} = 995$ LB TANGENTIAL FORCE

THE LOAD DUE TO THE SEISMIC ACCELERATION PARALLEL TO THE DRIVE LEVER AXIS AND PERPENDICULAR TO THE TANGENTIAL FLOW INDUCED FORCE



$L_{cg} = 14.46$
$L_c = 24.87$
$L_{70} = 37.03$
} PAGE E-46 OF THIS REPT.

$F_{SEIS} = a(W_T)\frac{L_{cg}}{L_i}$

IN THE CLOSED POSITION T = 17000 IN-LB $F_T = 1447$ LB

$F_{SEIS} = 7.42(399)\frac{14.46}{24.87} = 1721$ LB

IN THE 70° OPEN POSITION CONSERVATIVELY USE T = 11692 IN-LB
$F_T = 995$

$F_{SEIS} = 7.42(399)\frac{14.46}{37.03} = 1156$ LB

CONSERVATIVELY ADD THE COMPONENTS OF THE SEISMIC FORCE TO F_T

$F_T' = F_T + \cos 56° F_{SEIS} = 995 + (.56)1156 = 1641$ LB

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/15/83
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP	Job No. CSP	File No.	
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-20	

THE AXIAL LOAD ON THE DRIVE LEVER IS THEN

$$F_{AX} = \sin 56^\circ F_{SOTS} = (.829)(1156)$$

$$= 958\#$$

DETERMINE THE TORSIONAL SHEAR STRESS

$$\tau_T = \frac{Tr}{J} = \frac{11692(1.125)}{2.5161} = 5228 \text{ PSI}$$

DETERMINE THE SHEAR STRESS DUE TO THRUST LOADS ON THE DRIVE LEVER.

$$\tau = \frac{(1641^2 + 958^2)^{1/2}}{3.9761} = 478 \text{ PSI}$$

THE BENDING STRESS ON THE SHAFT IS THEN

$$M = F_{COMB} \frac{ab}{L} = \frac{(1641^2 + 958^2)^{1/2}\, 6.005(10.31)}{16.315}$$

$$= 7211 \text{ IN-LB}$$

$$\sigma_b = \frac{M}{S} = \frac{7211.}{\frac{\pi\, 2.25^3}{32}} = \frac{7211}{1.1183} = 6448 \text{ PSI}$$

$$\frac{\pi\, 2.25^3}{32} = 1.1183$$

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/83
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP/CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-21	

THE RESULTING COMBINED STRESS EVALUATED SIMILARLY TO THAT ON PAGE 50 OF REF. 1.

$a = 1 \quad b = \sigma_b = 6448 \text{ PSI} \quad c = (-\tau_T^2 - \tau^2)$

$= (-5228^2 - 478^2)$

$= -27,560,468$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-6448 \pm \sqrt{6448^2 - 4(-27,560,468)}}{2(1)}$$

$$= \frac{-6448 \pm 12321}{2}$$

$\sigma_1 = +2937$ PSI
$\sigma_2 = -9385$ PSI

THE RESULTING STRESS INTENSITY IS THEN

$S_t = 12322$ PSI

THE ALLOWABLE STRESSES ARE GIVEN ON PAGE E7 OF THIS REPORT.

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/93
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-93
System: CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-22	

IN THE CLOSED POSITION WITH THE ACTUAL CYLINDER ACCELERATIONS AND A SEATING TORQUE VALUE OF 17000 IN LB THE SHAFT STRESS BECOMES

$F_T = 1447 \quad F_{SEIS} = 1721$ LB (MUTUALLY PERPENDICULAR IN CLOSED POSITION)

$$F_{TOTAL} = (1447^2 + 1721^2)^{1/2} = 2248$$

$$\tau_T = \frac{Tr}{J} = \frac{17000(1.125)}{2.5161} = 7601$$

$$\tau = \frac{F_{TOTAL}}{A} = \frac{2248}{3.9761} = 565 \text{ PSI}$$

$$\sigma_b = \frac{M}{S} = \frac{\frac{2248(6.005)(10.31)}{16.315}}{1.1183} = 7628 \text{ PSI}$$

$$\sigma = \frac{-7628 \pm \sqrt{7628^2 - 4(-7601^2 - 565^2)}}{2(1)}$$

$$= \frac{-7628 \pm 17046}{2}$$

$\sigma_1 = 4709$
$\sigma_2 = -12337$

$$\sigma_{MAX} = 4709 - (-12337) = 17046 \text{ PSI}$$

1006.00

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/15/93
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-93
System: CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-93-11	Rev. No. 0	Sheet No. E-23	

TAPER PINS

BASED ON THE SHEAR AREAS DETERMINED ON PAGES 52 & 53 OF REF 1 DETERMINE THE AVERAGE SHEAR STRESS IN THE TAPER PIN.

THE SHEAR AREA IS

$$A_s = .937 \, IN^2$$

THE SEATING TORQUE OF 17000 IN-LB PRODUCES A SHEAR STRESS OF

$$\tau = \frac{T}{rA} = \frac{17000/2\text{PINS}}{1.125(.937)} = 8064 \text{ PSI}$$

THE FLOW INDUCED TORQUE OF 11394 IN-LB PRODUCES A SHEAR STRESS OF

$$\tau = \frac{11697}{17000}(8064) = 5546 \text{ PSI}$$

THE ALLOWABLE SHEAR STRESS FOR NORMAL LOADING IS:

$$\tau_{\substack{ALLOW \\ NORM}} = .4F_y = 9300 \text{ PSI} \quad \left(\begin{array}{c} A276\text{-}304 \\ @270°F \end{array}\right)$$

THE FAULTED ALLOWABLE IS:

$$\tau_{\substack{ALLOW \\ FAULT}} = .6F_y = 13950 \text{ PSI}$$

CYGNA

Calculation Sheet

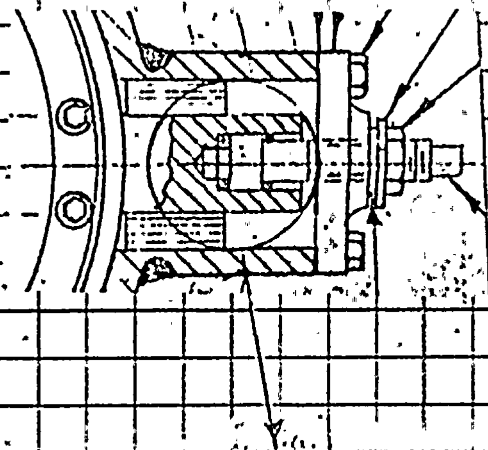
Project: WPPSS WNP-2	Prepared By: Milon Meyer — Date: 12-15-83
Subject: Valve Component Stresses	Checked By: [signature] — Date: 12/15/83
System: Containment Isolation Valves CEP & CSP	Job No. — File No.
Analysis No. EQ-02-83-11 — Rev. No. 0	Sheet No. E-24

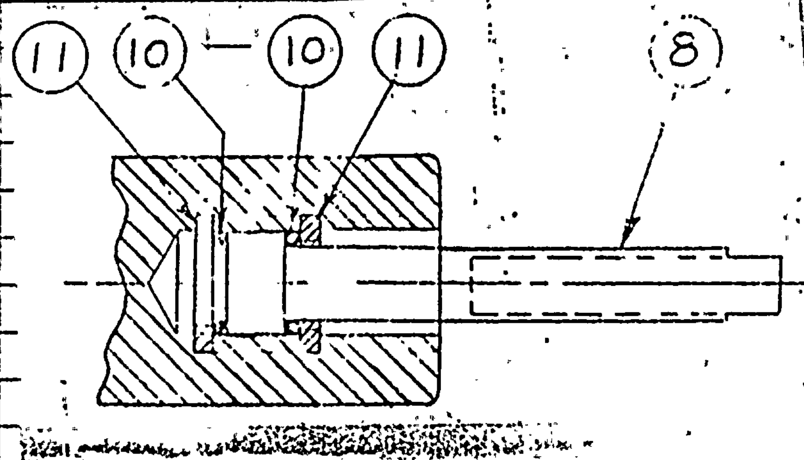
Thrust Bearing Load Evaluation

Ref: BJF Drawing No A-206761

Material Description / Size 18", 24" and 30"

WPPSS CVI-02-68-00-30 (Instruction Manual No 11)





THRUST BRG. ASSEMBLY

1006.00

Calculation Sheet

Project: WPPSS WNP-2 | Prepared By: Milon Meyer | Date: 12-15-83

Subject: Valve Component Stresses | Checked By: [signature] | Date: 12/15/83

System: Containment Isolation Valves CEP & CSP | Job No. | File No.

Analysis No.: EQ-02-83-11 | Rev. No. 0 | Sheet No. E-25

The thrust load is supported by (11) Retaining Ring with Material Description AMCO PH 15-7 Mo

Applied loads are summarized as follows.

Valve Size	Wt. of Disc and Shaft	"g's"	Load	Shaft Size
24"	224 LB △	7.42	1,662 LB	2 1/4"
30"	389	5.05	1,990 LB	2 1/2"

The allowable load for retaining rings is estimated from IRR Catalog (Vendor files 8378-2551)

Allowable Thrust load = 2900 LB for groove dia = 1.047" worse case light wt. gauge

Conclusion: Retaining ring is structurally adequate and all other components are adequate by comparison

△ Ref BJF Report page

△ Ref. 11. BJF Report page 47 24" valve

1006.00

4773201 INDUSTRIAL RETAINING RING 30C 00129 D T-71-23

CATALOG A-4-B
ENGINEERING SPECIFICATIONS

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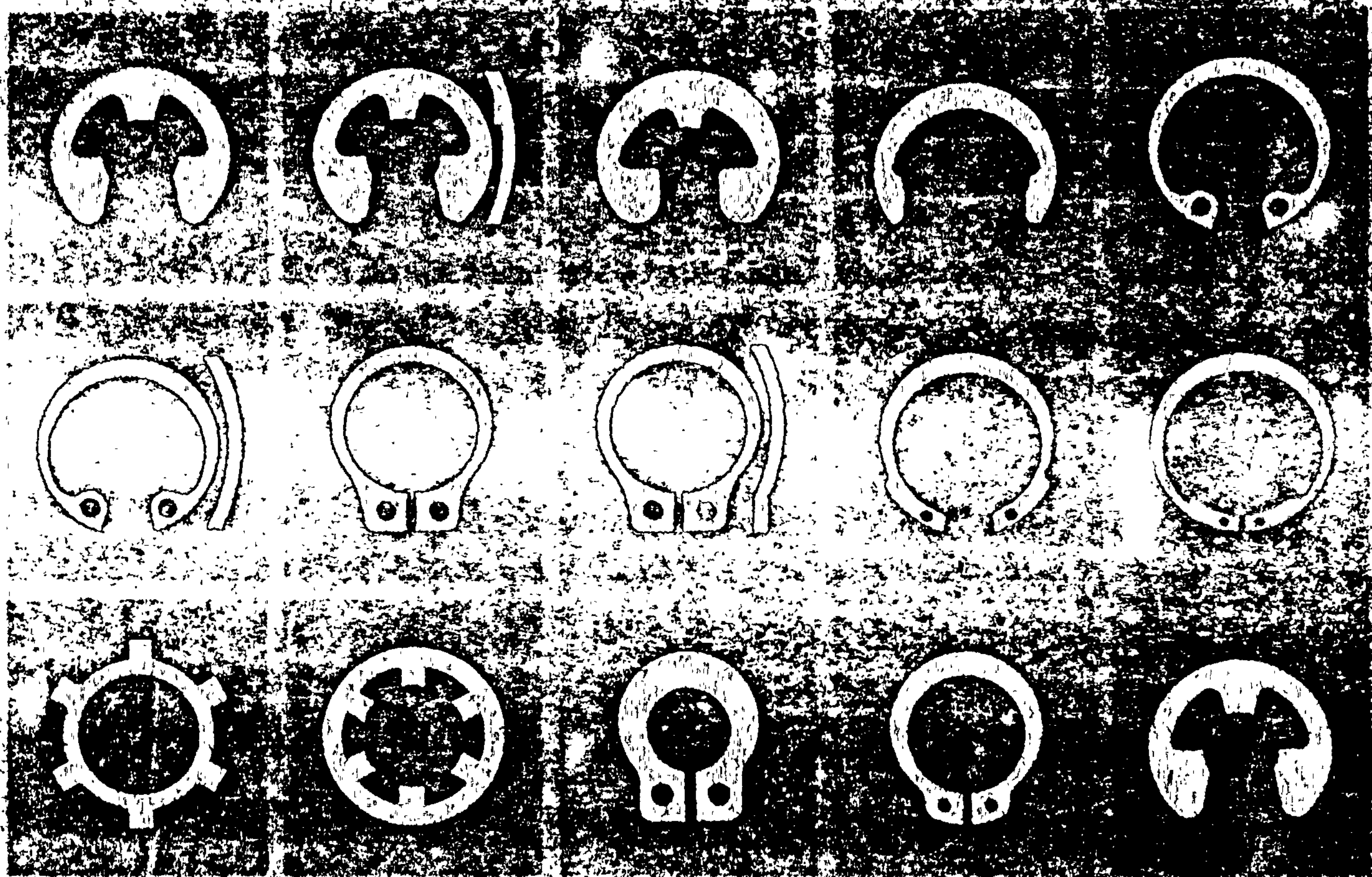
IRR

(Vendor Catalog Ref 8378-2551)

INDUSTRIAL RETAINING RINGS



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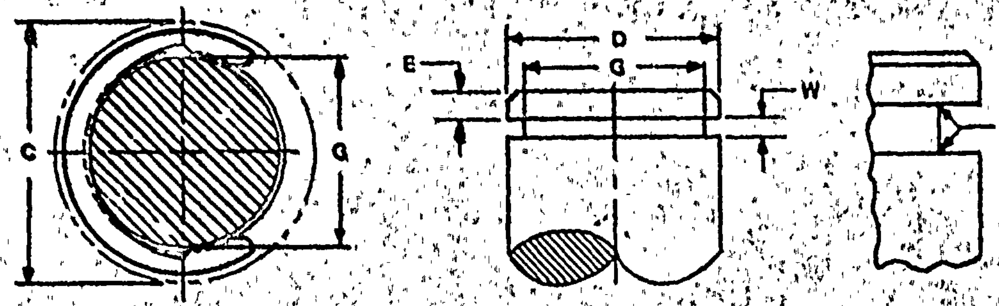
4773201 INDUSTRIAL RETAINING RING 30C 00143 0 D-11-83

RETAINING RING SERIES 2000



GROOVE DETAIL
Maximum Bottom Radii:
.005 for 2000-12 through -43
.010 for 2000-46 through -100
.015 for 2000-112 through -200

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PAGE-E-27

APPROX. WEIGHT PER 1000 RINGS (Lbs.)	ROCKWELL HARDNESS OF RING (Standard Material)	THRUST LOAD (Lbs.) Sharp Corner Abutment — RING — Safety Factor 4	GROOVE† — Safety Factor 2	RING CLEARANCE** C	GROOVE DIMENSIONS — DIAMETER G	DIAMETER TOL.	WIDTH W	WIDTH TOL.	EDGE MARGIN E	INDUSTRIAL RING NO.
.03	15N 86.0-88.0	85	40	.18	.106		.018	+.002	.020	2000-12
.04	15N 86.0-88.0	110	55	.22	.135	±.0015	.018	−.000	.020	2000-15
.07	15N 86.0-88.0	130	70	.26	.165		.018		.022	[illegible]
.13	30N 68.5-72.0	260	100	.29	.193		.029		.026	2000-21
.15	30N 68.5-72.0	280	115	.31	.203		.029		.028	[illegible]
.16	30N 68.5-72.0	295	130	.33	.220		.029		.030	[illegible]
.20	30N 68.5-72.0	330	170	.36	.247	±.002	.029		.034	[illegible]
.23	30N 68.5-72.0	370	200	.39	.276		.029		.036	[illegible]
.30	30N 68.5-72.0	440	265	.47	.335		.029		.040	[illegible]
.35	30N 68.5-72.0	480	300	.50	.364		.029		.042	[illegible]
.36	30N 68.5-72.0	515	340	.53	.393		.029		.044	[illegible]
.68	30N 67.5-71.0	825	440	.60	.450		.039	+.003	.050	2000-50
.75	30N 67.5-71.0	930	550	.67	.507		.039	−.000	.056	[illegible]
.94	30N 67.5-71.0	1030	690	.74	.563		.039		.062	2000-62
1.35	30N 67.5-71.0	1700	820	.80	.619		.046		.068	2000-68
1.60	30N 67.5-71.0	1850	985	.87	.676	±.003	.046		.074	2000-75
1.75	30N 67.5-71.0	2010	1150	.94	.732		.046		.080	2000-81
2.00	C 48-52	2165	1320	1.01	.789		.046		.086	2000-87
2.50	C 48-52	2320	1550	1.08	.843		.046		.094	2000-93
2.75	C 48-52	2480	1770	1.15	.900		.046		.100	2000-100
4.00	C 48-52	3300	2200	1.30	1.013		.056		.112	2000-112
4.75	C 48-52	3500	2300	1.36	1.047		.056		.140	2000-X118
5.25	C 48-52	3600	2700	1.44	1.123	±.004	.056	+.004	.124	2000-125
6.25	C 48-52	4000	3300	1.59	1.237		.056	−.000	.138	2000-137
7.75	C 48-52	4400	4000	1.73	1.380		.056		.150	2000-150
13.00	C 48-52	6400	5300	2.02	1.570	±.005	.068		.174	2000-175
16.75	C 48-52	7300	7000	2.30	1.830		.068		.200	[illegible]

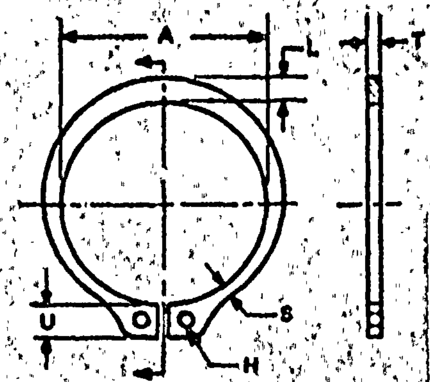
2566

**C = Ring clearance diameter after ring is applied into groove.

†Groove wall thrust loads shown are for grooves machined in cold-rolled steel with a tensile yield strength of 45,000 psi. For shaft material with greater or lesser yield strength, groove wall thrust load increases or decreases proportionally.

[illegible]

INDUSTRIAL EXTERNAL



CALC No
EQ-02-83-11
PAGE E-28

INDUSTRIAL RING NO.	SHAFT DIAMETER			RING DIMENSIONS											
	FRAC.	DEC.	MM.	FREE DIAMETER		THICKNESS†		LARGE SECTION		SMALL SECTION		LUG		HOLE DIAMETER	
	D	D	D	A	TOL.	T	TOL.	L	TOL.	S	TOL.	U	TOL.	H	TOL.
3100-100	1	1.000	25.40	.925	+.005	.042		.116	±.005	.085	±.005	.167		.078	
3100-102	—	1.023	26.00	.948	−.010	.042		.118		.086		.160		.078	
3100-103	1 1/16	1.062	26.99	.982		.050		.122		.069		.181		.078	
3100-112	1 1/8	1.125	28.58	1.041		.050		.128		.071		.182		.078	
3100-118	1 3/16	1.188	30.16	1.098		.050	±.002	.132		.072		.182		.078	
3100-125	1 1/4	1.250	31.75	1.156	+.010	.050		.140		.076		.183		.078	
3100-131	1 5/16	1.312	33.34	1.214	−.015	.050		.146		.076		.183		.078	
3100-137	1 3/8	1.375	34.93	1.272		.050		.152		.082		.184		.078	
3100-143	1 7/16	1.438	36.51	1.333		.050		.160		.086		.184		.078	
3100-150	1 1/2	1.500	38.10	1.387		.050		.168		.091		.214	±.004	.120	
3100-156	1 9/16	1.562	39.69	1.446		.062		.172	±.006	.093	±.006	.235		.125	
3100-162	1 5/8	1.625	41.28	1.503		.062		.180		.097		.235		.125	
3100-168	1 11/16	1.687	42.86	1.560		.062		.184		.099		.235		.125	
3100-175	1 3/4	1.750	44.45	1.618	+.013	.062		.188		.101		.237		.125	
3100-177	—	1.772	45.00	1.637	−.020	.062		.190		.102		.237		.125	
3100-181	1 13/16	1.812	46.04	1.675		.062		.192		.102		.238		.125	+.015
3100-187	1 7/8	1.875	47.63	1.735		.062		.198		.104		.239		.125	−.002
3100-193	1 31/32	1.969	50.00	1.819		.062		.200		.106		.245		.125	
3100-200	2	2.000	50.80	1.850		.062		.204		.108		.239		.125	
3100-206	2 1/16	2.062	52.39	1.908		.078		.208		.111		.266		.125	
3100-212	2 1/8	2.125	53.98	1.964		.078		.212		.113		.266		.125	
3100-215	2 5/32	2.156	54.77	1.993		.078	±.003	.212		.113		.266		.125	
3100-225	2 1/4	2.250	57.15	2.081	+.015	.078		.220		.116		.267		.125	
3100-231	2 5/16	2.312	58.74	2.139	−.025	.078		.222		.118		.267		.125	
3100-237	2 3/8	2.375	60.33	2.197		.078		.224		.119		.267		.125	
3100-243	2 7/16	2.438	61.91	2.255		.078		.228	±.007	.120	±.007	.268	±.005	.125	
3100-250	2 1/2	2.500	63.50	2.313		.078		.232		.122		.268		.125	
3100-255	—	2.559	65.00	2.377		.078		.238		.125		.268		.125	
3100-262	2 5/8	2.625	66.68	2.428		.078		.242		.127		.268		.125	
3100-268	2 11/16	2.688	68.26	2.485	+.020	.078		.246		.129		.268		.125	
3100-275	2 3/4	2.750	69.85	2.543	−.030	.093		.248		.131		.310		.125	
3100-287	2 7/8	2.875	73.03	2.659		.093		.256		.133		.308		.125	

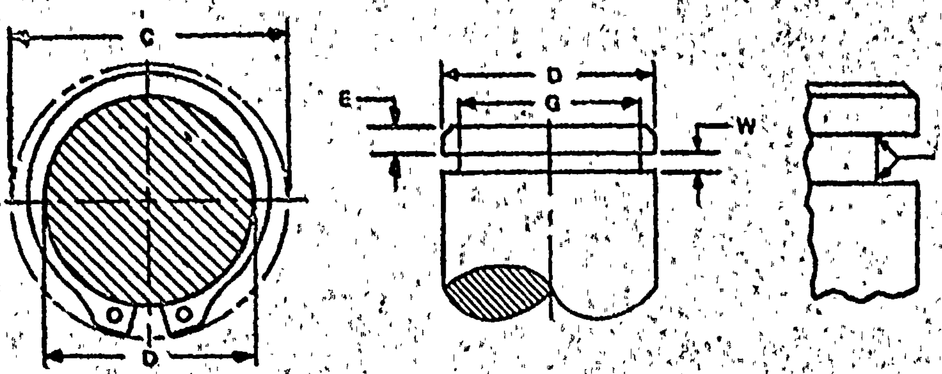
Standard Material: Carbon spring steel (SAE 1060-1090)
Standard Finish: Oil-dipped
Bulk-packed only

†Indicated thickness (T) is for unplated rings.
For plated, phosphate-coated, and stainless steel rings 3100-100 and -102, the maximum ring thickness will not exceed the minimum groove width (W) minus .0002". For 3100-103 through -237, the maximum ring thickness may be exceeded by .002".

See page 61 for Industrial Pliers

4773201 INDUSTRIAL RETAINING RING 30C 00159 D J-11-03

RETAINING RING SERIES 3100



GROOVE DETAIL
Maximum Bottom Radii:
.005 for 3100-100
.010 for 3100-102 through -287

CALC NO
EQ-02-83-11
PAGE E-29

APPROX. WEIGHT PER 1000 RINGS (Lbs.)	ROCKWELL HARDNESS OF RING (Standard Material)	THRUST LOAD (Lbs.) Sharp Corner Abutment: RING, Safety Factor 4	GROOVE†, Safety Factor 2	RING CLEARANCE** C	GROOVE DIMENSIONS: DIAMETER G	DIAMETER TOL.	WIDTH W	WIDTH TOL.	EDGE MARGIN E	INDUSTRIAL RING NO.
3.55	C 49-53	4900	2100	1.41	.940	±.003	.046	+.003	.090	3100-100
3.76	C 49-53	5000	2200	1.43	.961		.046	−.000	.093	3100-102
4.65	C 48-52	6200	2400	1.49	.983		.056		.096	3100-103
5.12	C 48-52	6600	2600	1.56	1.030		.056		.099	3100-112
5.55	C 48-52	6900	2900	1.62	1.118		.056		.105	3100-118
6.10	C 48-52	7300	3200	1.69	1.176	±.004	.056		.111	3100-125
6.65	C 48-52	7700	3700	1.75	1.232		.056		.120	3100-131
7.15	C 48-52	8000	4000	1.81	1.291		.056		.126	3100-137
7.66	C 48-52	8400	4400	1.88	1.350		.056		.132	3100-143
8.81	C 48-52	8800	4900	2.00	1.406		.056	+.004	.141	3100-150
11.9	C 48-52	11400	5100	2.10	1.468		.068	−.000	.141	3100-156
13.0	C 48-52	11800	5500	2.17	1.529		.068		.144	3100-162
14.1	C 48-52	12000	5800	2.23	1.589		.068		.147	3100-168
14.9	C 48-52	12700	6100	2.31	1.650		.068		.150	3100-175
15.1	C 48-52	12900	6300	2.34	1.669	±.005	.068		.153	3100-177
15.7	C 48-52	13200	6800	2.38	1.709		.068		.156	3100-181
16.5	C 48-52	13600	7000	2.44	1.769		.068		.159	3100-187
17.3	C 48-52	14300	7700	2.55	1.857		.068		.168	3100-196
18.5	C 48-52	14600	8000	2.57	1.886		.068		.171	3100-200
24.0	C 48-52	16900	8400	2.63	1.946		.086		.174	3100-206
25.0	C 48-52	18500	9100	2.72	2.003		.086		.183	3100-212
25.5	C 48-52	19800	9400	2.75	2.032		.086		.186	3100-215
26.5	C 48-52	20600	10300	2.86	2.120		.086		.195	3100-225
27.5	C 48-52	21300	10900	2.95	2.178		.086		.201	3100-231
28.5	C 48-52	21600	11400	3.01	2.239		.086		.204	3100-237
29.0	C 48-52	22400	11800	3.07	2.299	±.006	.086	+.005	.207	3100-243
30.0	C 48-52	22800	12300	3.13	2.360		.086	−.000	.210	3100-250
32.8	C 48-52	23500	12600	3.19	2.410		.086		.210	3100-256
34.0	C 48-52	24100	13300	3.25	2.481		.086		.216	3100-262
35.0	C 48-52	24700	13800	3.32	2.541		.086		.219	3100-268
46.0	C 48-52	30100	14300	3.47	2.602		.103		.222	[illegible]
47.0	C 48-52	31400	15600	3.59	2.721		.103		.231	3100-287

2582

**C = Ring clearance diameter when ring is expanded over shaft before insertion into groove

†Groove wall thrust loads shown are for grooves machined in cold-rolled steel with a tensile yield strength of 45,000 psi. For shaft material with greater or lesser yield strength, groove wall thrust load increases or decreases proportionally.

[illegible]

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-16-83
System CONTAINMENT ISOLATION VALVES		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-30	

30" BIF BUTTERFLY VALVES

STRESS CALCULATIONS

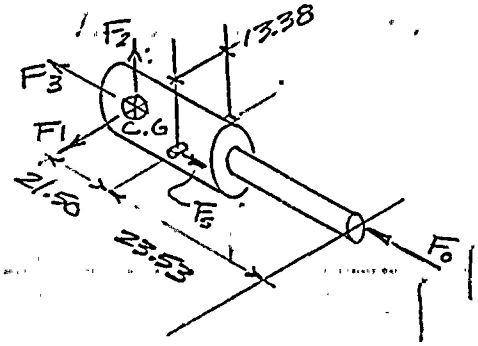
Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject: Valve Component Stresses		Checked By: Milon Meyer	Date 12-15-83
System: Containment Isolation Valves CEP;CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-31	

THE FOLLOWING COMPONENTS ARE STRESSED BY THE APPLIED TORQUE DURING LOCA + DBE CONDITIONS. THE RESULTING STRESSES ARE CALCULATED BELOW. AND COMPARED TO SEATING LOADS + DBE.

TRUNNION PINS

FROM ALL OF THE DIRECTIONAL ACCELERATIONS PICK THE WORST THREE ACCELERATIONS. OF BOTH BRACKET AND CYLINDER MASSES



X = 11.93 g HORIZ
Y = 3.67 g VERT
Z = 1.90 g HORIZ

(REF 4)

THE TOTAL SHEAR LOAD ON THE TRUNNION IS

$$F_5 = \left[\left(\frac{21.50\,F_1}{13.38} + \frac{F_3}{2} + \frac{F_0}{2}\right)^2 + \left(\frac{(21.50+23.53)}{23.53}\,\frac{F_2}{2}\right)^2\right]^{1/2}$$

$$F_5 = \left[\left(1.607\,F_1 + .5F_3 + .5F_0\right)^2 + \left(1.91\,F_2\right)^2\right]^{1/2}$$

ORIENTING THE WORST ACCELERATION COMBINATION TO THE F_2 DIRECTION MAXIMIZES THE FORCE ON THE TRUNNION. THE ORIENTATION OF THE THIRD ACCELERATION MAXIMIZES THE FORCE WHEN ORIENTED IN THE F_2 DIRECTION

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/95
Subject: Valve Component Stresses		Checked By: Milon Meyer	Date: 12-15-83
System: Containment Isolation Valves CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-32	

USE $F_1 = W_T(1.93^2 + 1.90^2)^{1/2} = 593^{\#}(2.71) = 1607^{\#}$

$F_2 = (3.67g + 1g)\,W_t = 4.67(593^{\#}) = 2769^{\#}$

$F_3 = 0$

$F_0 = \dfrac{T_{SEATING}}{r} = \dfrac{27800}{11.75} = 2366 \text{ LB}$ (REF 7)

$P = 1.6069(1607) + .5(0) + .5(2769)$

$= 3967^{\#}$

THE MAXIMUM SHEAR STRESS IS THEN

$\tau = \dfrac{4}{3}\left(\dfrac{3967}{2.41}\right) = 2195 \text{ PSI}$

CLEVIS PIN

THE STRESS CALCULATED ON PAGE 361106-43-24 OF REF 3 IS CONSERVATIVE AND WILL BE USED.

$\tau = 2717 \text{ PSI}$

DRIVE LEVER

THE MAXIMUM FORCE ON THE DRIVE LEVER IS DUE TO THE SEATING TORQUE AND REACTION OF THE DRIVE ROD TO DYNAMIC LOADING OF THE CYLINDER.

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/83
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP; CSP		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E53	

THE MAXIMUM LOAD DUE TO THE SEATING TORQUE PRODUCES A FORCE NEARLY PERPENDICULAR TO THE AXIS OF THE DRIVE LEVER. THE DYNAMIC LOAD PRODUCES A FORCE NEARLY PARALLEL TO THE AXIS OF THE DRIVE LEVER.

$$F_{\perp} = \frac{27800}{11.75} = 2366^{\#} \qquad F_{\parallel} = \left((3.67+1)^2 + 1.93^2\right)^{1/2} .593 \frac{(21.50)}{23.53}$$

$$= 2738^{\#}$$

THE RESULTING STRESS USING THE SECTION PROPERTIES FROM PG. 35 OF REF 7

$$\sigma_{TENSILE} = \frac{Mc}{I} + \frac{F_{\parallel}}{A}$$

$$= \frac{27800\,(1.625)}{4.29} + \frac{2738}{4.875}$$

$$= 10530 + 562 = 11092 \text{ PSI}$$

$$\tau_{AVE} = \frac{V}{A} = \frac{2366}{4.875} = 742 \text{ PSI}$$

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/15/83
Subject VALVES COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-34	

FOR LOCA LOADS THE FLOW INDUCED TORQUE IS

$$T = 23175.\ \text{IN-LB} \qquad \text{(REF 2)}$$

$$F_{\perp} = \frac{23175}{11.75} = 1972^{\#}$$

$$F_{\parallel} = 2738^{\#} \qquad \text{(PREVIOUS PAGE)}$$

$$\sigma_{TENSILE} = \frac{Mc}{I} + \frac{F_{\parallel}}{A} = \frac{23175\,(1.625)}{4.29} + \frac{2738}{4.875}$$

$$= 8778 + 562$$

$$= 9340\ \text{PSI}$$

Calculation Sheet

Project WPPSS WNP-2	Prepared By: [signature] Date 12/15/83
Subject VALVE COMPONENT STRESSES	Checked By: Milon Meyer Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP; CSP Job No.	File No.
Analysis No. EQ-02-83-11 Rev. No.	Sheet No. E-35

LEVER KEYWAY

FOR KEYWAYS THE AVERAGE SHEAR STRESS IS CALCULATED FOR THE SECTION OF CONCERN. THE FORCE AT THE SHEAR SURFACE BETWEEN THE DRIVE LEVER AND MAIN VALVE SHAFT IS:

$$P = \frac{T\,2}{d} = \frac{27800(2)}{2.50} = 22240\ \#$$

THE RESULTING BEARING STRESS USING THE AREA VALUES FROM PG. 36 OF REF 1

$$f_b = \frac{22240}{.675} = 32948$$

THE ALLOWABLE BEARING STRESS IS YIELD, WHICH IS:

$$F_Y = 40000$$

THE RESULTING AVERAGE SHEAR STRESS IS:

$$\tau = \frac{22240}{2.34} = 9504 \text{ PSI}$$

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/93
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-93
System CONTAINMENT ISOLATION VALVES CEP, CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-36	

BASED ON THE MAXIMUM FLOW INDUCED TORQUE OF 23175 IN-LB (REF 2)

$$f_b = 32948\left(\frac{23175}{27800}\right) = 27467 \text{ psi}$$

$$\tau = 9504\left(\frac{23175}{27800}\right) = 7923 \text{ psi}$$

MAIN SHAFT

FOLLOWING THE FORMAT OF REF 3 PAGE 4.3-27 THE SHEAR STRESS DUE TO OPERATING TORQUE IS:

$$\tau_T = \frac{T\,r}{J} \qquad r = 1.25 \text{ (RADIUS OF SHAFT)}$$

$$J = 2\,\frac{\pi D^4}{64} = 3.835$$

$$= \frac{27800\,(1.25)}{3.835} = 9061 \text{ psi}$$

THE SHEAR STRESS DUE TO THE THRUST OF THE DRIVE LEVER

$$\tau = \frac{(2366^2 + 2738^2)^{1/2}}{4.91} = 737$$

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/85
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP; CSP		Job No. CSP	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-37	

THE BENDING STRESS CALCULATION FOLLOWS THE PROCEDURE ESTABLISHED ON PAGE 48 & 49 OF REFERENCE 7.

$$M = F_{COMBINED}\frac{ab}{L} = \frac{(2366^2+2738^2)^{1/2}(6.32)(11.18)}{17.5}$$

$$= 3619(4.0376) = 14611 \text{ IN-LB}$$

$$\sigma_b = \frac{M}{S} = \frac{14611}{\frac{\pi(2.5)^3}{32}} = \frac{14611}{1.534} = 9525 \text{ PSI}$$

THE RESULTING COMBINED STRESS EVALUATED SIMILARLY TO THAT ON PAGE 50 OF REF 1

$a = 1 \quad b = \sigma_b = 9525 \quad c = (-\tau_T^2 - \tau^2)$

$$= (-9061^2 - 737^2)$$
$$= -82,644,890$$

$$X = \frac{-9525 \pm \sqrt{9525^2 - 4(1)(-82,644,890)}}{2(1)}$$

$$= \frac{-9525 \pm 20526}{2}$$

$\sigma_1 = 5501$ PSI

$\sigma_2 = -15026$ PSI

Calculation Sheet

Project: WPPSS WNP-2	Prepared By: [signature]	Date: 12/13/83	
Subject: VALVE COMPONENT STRESSES	Checked By: Milton Meyer	Date: 12-15-83	
System: CONTAINMENT ISOLATION VALVES CEP; CSP	Job No.	File No.	
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E-38	

THE RESULTING STRESS INTENSITY IS THEN

$$S_t = x_1 - x_2 = 5501 - (-15026)$$

$$= 20527 \text{ PSI}$$

THE ALLOWABLE STRESS INTENSITY FOR NORMAL LOADING AT ROOM TEMPERATURE

$$S_{allow_{NORMAL}} = .6S_y = 18000 \text{ PSI}$$

FOR FAULTED LOADING THE ALLOWABLE STRESS LEVEL IS:

$$S_{ALLOW_{FAULT}} = 1.5(.6S_y) = 27000 \text{ PSI}$$

Calculation Sheet

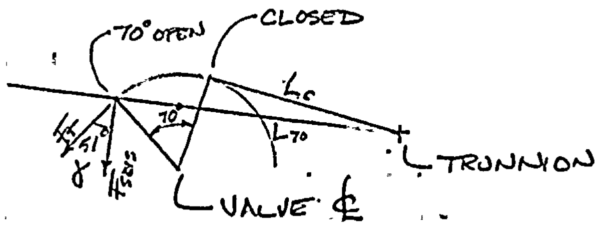
Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date 12-15-83
System CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-39	

MAXIMUM FLOW INDUCED TORQUE @ 70°

T = 20,000 IN-LB (FLOW INDUCED TORQUE)

$F_T = \frac{20000}{11.75''} = 1702$ LB TANGENTIAL FORCE

THE LOAD DUE TO THE SEISMIC ACCELERATION, PARALLEL TO THE DRIVE LEVER AXIS AND PERPENDICULAR TO THE TANGENTIAL FLOW INDUCED FORCE



$L_{cg} = 21.50$

$L_c = 23.53$ } PAGE E47 OF THIS REPT.

$L_{70} = 36.21$

$F_{SEIS} = a(W_T)\frac{L_{cg}}{L_i}$

THE RESULTING SEISMIC INDUCED FORCE @ THE LEVER:

$$F_{SEIS} = \frac{((3.67+1)^2 + 1.93^2)^{1/2}\, 593(21.50)}{36.21}$$

$= 1779$

THE TANGENTIAL COMPONENT OF THIS FORCE WILL NOT INCREASE THE EXISTING COMPONENT FROM THE FLOW TORQUE BECAUSE OF THE FREEDOM OF THE DISC TO ROTATE. ONLY THE FORCE COMPONENT ALONG THE AXIS OF THE LEVER IS APPLICABLE.

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/83
Subject: VALVE COMPONANT STRESSES		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP; CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-40	

THE AXIAL LOAD ON THE DRIVE LEVER IS THEN

$$F_{AX} = \sin 51^\circ F_{SETS} = (.777)1779$$

$$= 1383^{\#}$$

DETERMINE THE TORSIONAL SHEAR STRESS

$$\tau_T = \frac{Tr}{J} = \frac{20000(1.25)}{3.835} = 6519 \text{ PSI}$$

DETERMINE THE SHEAR STRESS DUE TO THRUST LOADS ON THE DRIVE LEVER.

$$\tau = \frac{(1702^2 + 1383^2)^{1/2}}{4.91} = 447 \text{ PSI}$$

THE BENDING STRESS ON THE SHAFT IS THEN

$$M = F_{COMB} \frac{ab}{L} = \frac{(1702^2 + 1383^2)^{1/2} 6.32(11.18)}{17.5}$$

$$= 18854 \text{ IN-LB}$$

$$\sigma_b = \frac{M}{S} = \frac{8854}{\frac{\pi 2.5^3}{32}} = \frac{18854}{1.534} = 5772 \text{ PSI}$$

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/85
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-83
System: CONTAINMENT ISOLATION VALVES CEP/CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-41	

THE RESULTING COMBINED STRESS EVALUATED SIMILARLY TO THAT ON PAGE 50 OF REFERENCE 7.

$a = 1 \quad b = \sigma_b = 5772 \text{ PSI} \quad c = (-\tau_T^2 - \tau^2)$

$= (-6519^2 - 447^2)$

$= -42,697,170$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-5772 \pm \sqrt{5772^2 - 4(-42697170)}}{2(1)}$$

$$= \frac{-5772 \pm 14287}{2}$$

$\sigma_1 = 4257$ PSI

$\sigma_2 = -10029$ PSI

THE RESULTING STRESS INTENSITY IS THEN

$S_I = 14287$ PSI

THE ALLOWABLE STRESSES ARE GIVEN ON PAGE E7 OF THIS REPORT.

Calculation Sheet

Project: WPPSS WNP-2		Prepared By: [signature]	Date: 12/13/93
Subject: VALVE COMPONENT STRESSES		Checked By: Milon Meyer	Date: 12-15-93
System: CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-93-11	Rev. No. 0	Sheet No. E-42	

TAPER PINS

BASED ON THE SHEAR AREAS DETERMINED ON PAGES 52 & 53 OF REF 1 DETERMINE THE AVERAGE SHEAR STRESS IN THE TAPER PIN.

THE SHEAR AREA IS

$$A_s = 1.317 \ IN^2$$

THE SEATING TORQUE OF 17000 IN-LB PRODUCES A SHEAR STRESS OF

$$\tau = \frac{T}{r A_s} = \frac{27800 / 2 \text{ PINS}}{1.25(1.317)} = 8443 \text{ PSI}$$

THE FLOW INDUCED TORQUE OF 23175 IN-LB PRODUCES A SHEAR STRESS OF

$$\tau = \frac{23175}{27800}(8443) = 7039 \text{ PSI}$$

THE ALLOWABLE SHEAR STRESS FOR NORMAL LOADING IS:

$$\tau_{\substack{ALLOW \\ NORM}} = .4 F_y = 9300 \text{ PSI} \quad (A276\text{-}304 \ @ \ 270°F)$$

THE FAULTED ALLOWABLE IS:

$$\tau_{\substack{ALLOW \\ FAULT}} = .6 F_y = 13950 \text{ PSI}$$

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject VALVE ACTUATION TORQUES		Checked By: Milon Meyer	Date 12-11-83
System CONTAINMENT ISOLATION VALVES CEP & CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-43	

OPERATIONAL TORQUE VALUES

THE FOLLOWING PAGES SHOW THE CALCULATIONS FOR DETERMINING THE OPERATIONAL TORQUES DUE TO THE AIR PRESSURE ACTUATION FORCE AND SPRING RETURN FORCE FOR THE VALVES. ALSO, THE FLOW INDUCED TORQUES ON THE VALVE DISC DUE TO REVERSE FLOW (ON THE CSP VALVES) CHARACTERISTICS NOT CALCULATED BY BIF IN THEIR PREVIOUS ANALYSES.

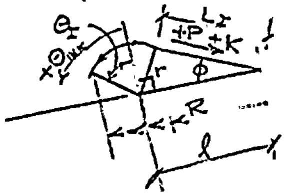
Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/13/83
Subject VALVE ACTUATION TORQUE		Checked By: Milon Meyer	Date 10-16-83
System CONTAINMENT ISOLATION VALVES CEP & CSP	Job No.	File No.	
Analysis No. EQ-02-83-11	Rev. No.	Sheet No. E-44	

BIF//BUTTERFLY VALVE

OPERATING TORQUE VS VALVE POSITION

PROGRAM FOR HP-15C



STORE REGISTER		DESCRIPTION
0	ℓ	= ℄ VALVE SHAFT TO OPERATOR PIVOT (DISTANCE)
1	r	= LENGTH OF ACTUATOR ARM
2	R	= VARIABLE DISTANCE FROM OPER PIVOT TO CYLINDER ROD/ACTUATOR CONNECTION
3	Θ_I	= INITIAL ACTUATOR ANGLE TO GLOBAL
4	Θ	= ACTUATOR ANGLE
5	Θ_{INCR}	= ACTUATOR ANGLE INCREMENT
~~6~~	~~P~~	~~= PRESSURE FORCE~~
7	ϕ	= ANGLE OF OPERATOR THRUST TO GLOBAL
8	P_I	= INITIAL PRELOAD
9	K	= SPRING RATE
0.	L_I	= INITIAL CYLINDAR/ROD LENGTH
1.	L	= CYLINDER/ROD LENGTH
2.	γ	= ANGLE BETWEEN CYLINDER THRUST (P_S) AND TANGENTIAL ACTUATOR FORCE (F_T)

INITIAL VALUES UNDERLINED

$R = \ell + r(\sin\Theta)$	SEE ABOVE
$\phi = \arctan\left(\frac{r\cos\Theta}{R}\right)$	SEE ABOVE
$\gamma = \Theta + \phi$	SEE ABOVE
$F_T = \cos\gamma\,(F_O)$	TANGENTIAL ACTUATOR FORCE
$F_O = P_I - K(L_A - L_I)$	OPERATOR FORCE
$L_I = R/\cos\phi$	CYLINDER LENGTH
$T = F_T(R)$	OPERATING TORQUE
$P = pA =$	FORCE DUE TO ACTUATION PRESSURE

Calculation Sheet

Project	WPPSS WNP-2	Prepared By: [signature]	Date 12/13/83
Subject	VALVE ACTUATION TORQUE	Checked By: Milon Meyer	Date 12-16-83
System	CONTAINMENT ISOLATION VALVES CEP; CSP	Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E45	

STEP	FUNCTION	DEF	STEP	FUNCTION	DEF
1	f(lbl)D		32	PSE	L
2	DEG		33	RCL 3	
3	RCL4		34	RCL4	
4	PSE	θ	35	g TEST 5	(X=Y)
5	SIN		36	GSB 1	
6	RCL1		37	RCL .1	
7	X		38	RCL .0	
8	RCL0		39	−	
9	+		40	RCL 9	
10	STO2		41	X	
11	PSE	R	42	RCL8	
12	PSE		43	−	
13	1/x		44	RCL6	
14	RCL1		45	PSE	P
15	X		46	+	
16	RCL4		47	CHS	
17	COS		48	PSE	F_o
18	X		49	RCL .2	
19	TAN^{-1}		50	COS	
20	STO 7		51	X	
21	PSE	φ	52	PSE	F_T
22	RCL 4		53	RCL1	
23	+		54	X	
24	STO .2		55	R/S	T
25	PSE	γ	56	RCL5	
26	RCL 7		57	STO +4	
27	COS		58	GTO D	
28	1/x		59	f LBL 1	
29	RCL2		60	RCL .1	
30	X		61	STO .0	L_I
31	STO .1		62	RTN	

Calculation Sheet

Project: WPPSS - WNP-2		Prepared By: [signature]	Date: 12/13/83
Subject: Valve Actuation Torque		Checked By: Milton Meyer	Date: 12-16-83
System: Containment Isolation Valves CEP & CSP		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E-46	

24" BIF Butterfly Valve

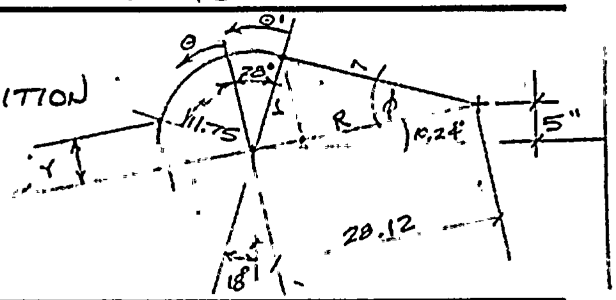
Operating Torque vs. Valve Position

$P_F = 100(\pi \frac{8^2}{4}) = 5030$

$l = 28.12$ $\theta_{INC} = -10°$

$r = 11.75$ $P_I = 3000$

$\theta_I = 62°$ $K = -100$ #/IN



	θ'	θ	R	φ	Y	L	P_F	F_o	F_T	T
OPEN	90°	62°	38.49	8.15	70.15	38.89	0	3000	1018	11967
	80	52	37.38	11.0	62.95	38.07	0	2918	1327	15593
	70	42	35.98	13.6	55.64	37.03	0	2814	1588	18660
	60	32	34.34	16.2	48.18	35.76	0	2687	1792	21057
	50	22	32.52	18.5	40.52	34.30	0	2541	1932	22696
	40	12	30.56	20.6	32.60	32.65	0	2376	2001	23522
	30	2	28.53	22.4	24.37	30.85	0	2196	2000	23508
	20	-8	26.48	23.7	15.72	28.92	0	2004	1929	22666
	10	-18	24.49	24.5	6.53	26.92	0	1803	1791	21048
CLOSE	0	-28	22.60	24.7	-3.35	24.87	0	1598	1595	18748
OPEN	90°	62°	38.49	8.15	70.15	38.89	5030	-2030	-689	-8097
	80	52	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	↓	-2112	-960	-11282
	70	42						-2216	-1251	-14696
	60	32						-2343	-1562	-18354
	50	22						-2489	-1892	-22232
	40	12						-2654	-2235	-26264
	30	2						-2834	-2581	-30327
	20	-8						-3026	-2913	-34226
	10	-18						-3227	-3206	-37671
CLOSE	0	-28	22.60	24.7	-3.35	24.87		-3432	-3426	-40254

Calculation Sheet

Project: WPPSS · WNP-2 | Prepared By: [signature] | Date: 12/13/83

Subject: Valve Acuation Torque | Checked By: Milton Meyer | Date: 12-16-83

System: Containment Isolation Valves CEP & CSP | Job No. | File No.

Analysis No.: EQ-02-83-11 | Rev. No.: 0 | Sheet No.: E-47

30 inch B/F Butterfly Valve Operating Torque vs Valve Position

$\ell = 29.74"$

$r = 11.75$

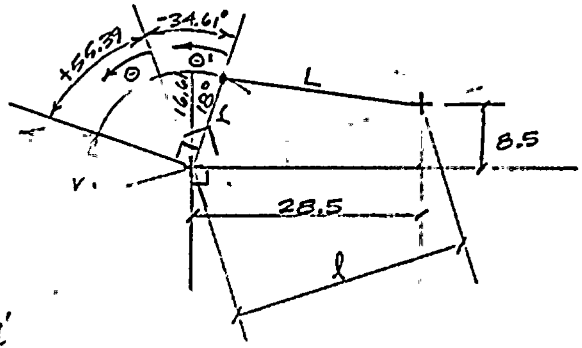
$\theta = 55.39$

$\theta_{INC} = -10°$

$P_I = 4800$

$K = -126.67$

$P = 100(\pi \frac{10^2}{4}) = 7854$



	θ'	θ	R	φ	γ	L	P	F_o	F_T	T
OPEN	90	55.4	37.79	10.02	65.41	38.38	0.0	4800	1998	23474
	80	45.4	36.48	12.74	58.13	37.41	0.0	4677	2469	29014
	70	35.4	34.92	15.34	50.73	36.21	0.0	4526	2865	33666
	60	25.4	33.16	17.75	43.14	34.82	0.0	4349	3173	37287
	50	15.4	31.24	19.93	35.32	33.23	0.0	4148	3384	39767
	40	5.4	29.22	21.82	27.21	31.48	0.0	3926	3492	41031
	30	-4.6	27.18	23.31	18.70	29.59	0.0	3657	3493	41039
	20	-14.6	25.16	24.32	9.71	27.61	0.0	3436	3387	39793
	10	-24.6	23.23	24.70	.09	25.57	0.0	3177	3177	37335
CLOSE	0	-34.6	21.45	24.27	-10.34	23.53	0.0	2919	2872	33742
OPEN	90°	55.4	37.77	10.02	65.41	38.38	7854	-3054	-1271	-14935
	SAME AS ABOVE		SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	↓	-3177	-1677	-19706
								-3328	-2106	-24751
								-3505	-2557	-30049
								-3706	-3024	-35528
								-3928	-3493	-41044
								-4167	-3946	-46371
								-4418	-4355	-51168
								-4677	-4677	-54949
CLOSE	-0	-34.6	21.45	24.27	-10.34	38.38	7854	-4935	-4855	-57044

Calculation Sheet

Project: WNP-2		Prepared By: Milon Meyer	Date: 12-12-83
Subject: BIF Butterfly Valves		Checked By: [signature]	Date: 12/15/83
System: Containment Isolation Valves CEP, CSP		Job No.	File No.
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E-48	

Purpose:

Calculations provided by BIF for the WNP-2 butterfly valves did not address the CSP valve installation direction. Specifically, the supply valves (CSP) have reversed flow during a postulated LOCA event. The dynamic torques are bounded by previous BIF analysis, however, the potential torque reversal was not evaluated.

Analysis utilizes curves provided by BIF test report [Ref 5 and 6] and the flow calculations in BIF report [Ref 2].

Note: The flow tests by BIF were performed for a cast iron valve and a fabricated valve of 12" diameter. A comparison of (C_T) dynamic torque coefficients is shown on the following sheets. The BIF valves at WNP-2 are bounded by these two configurations. (Magnitude of torque - cast iron and torque reversal - fab)

Calculation Sheet

Project: Equipment Qualification	Prepared By: Milon Meyer	Date: 12-13-83	
Subject: Purge and Vent Valves	Checked By: [signature]	Date: 12/15/83	
System: CEP / CSP	Job No.	File No.	
Analysis No.: EQ-02-83-11	Rev. No.: 0	Sheet No.: E-49	

Dynamic Torque for 24" Valves Air flow (Worse Case)

Time	Angle	Dynamic Torque IN·LB *	$(C_T)_D$ *	$(C_T)_U$ **	Disc Mounted Upstream Torque IN·LB *
1.0	90°	5,525	.275	-.34	-6,830.
1.5	78.75	11,692	.56	-.1	-2,090.
2.0	67.5	9,095	.35	+.06	1,560.
2.5	56.25	7,428	.175	+.12	5,090.
3.0	45.0	6,239	.09	+.076	5,268.
3.5	33.75	5,430	.045	+.03	3,620.
4.0	22.5	4,013	.02	+.01	2,021.
4.5	11.25	2,020	.01	+.005	1,010.
5.0	0.0	0	0	0	0

$(C_T)_D$: * Cast iron disc Page 42 Ref. 2

$(C_T)_U$: Fabricated Disc **

$$\text{New Torque} = \text{Old Torque} \left[\frac{C_T \text{ upstream}}{C_T \text{ Downstream}} \right]$$

* Includes Elbow effects

Calculation Sheet

Project: Equipment Qualification | Prepared By: Milon Meyer | Date: 12-12-83
Subject: Purge and Vent Valves | Checked By: [signature] | Date: 12/15/83
System: CEP / CSP | Job No. | File No.
Analysis No.: EQ-02-83-11 | Rev. No.: 0 | Sheet No.: E-50

Dynamic Torque for 30" Valves Δ Steamflow

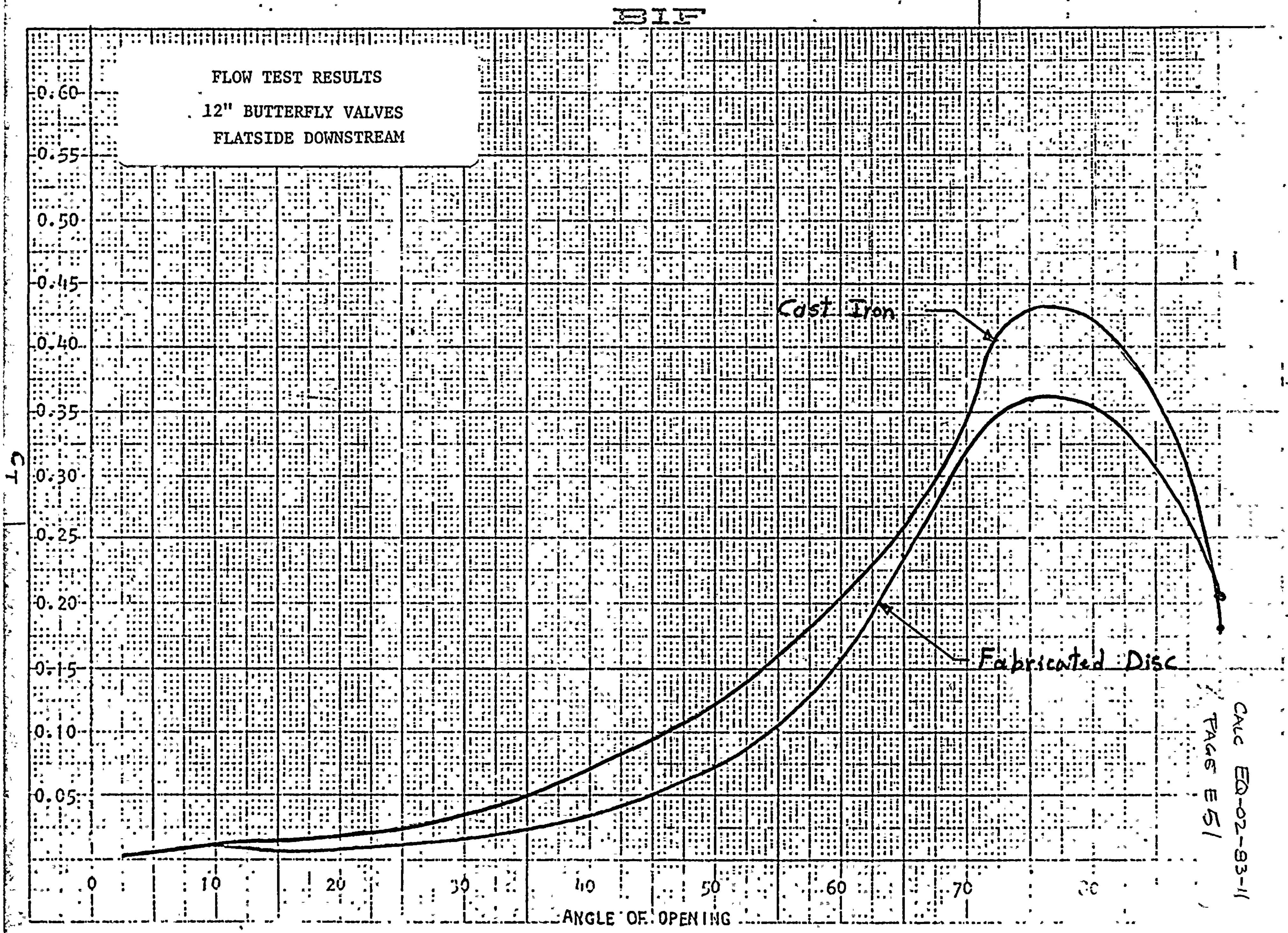
Time	Angle	Dynamic Torque IN-LB	$(C_T)_D$	$(C_T)_U$	Disc Mounted Upstream Torque IN-LB
1.0	90°	11,032	.275	-.34	-13,640
1.5	78.75	23,175	.56	-.10	-4,138
2.0	67.50	18,142	.35	+.06	+3,110
2.5	56.25	14,668	.175	+.12	+10,060
3.0	45.00	12,424	.09	+.076	+10,490
3.5	33.75	10,580	.045	+.030	+7,050
4.0	22.5	7,809	.02	+.010	+3,905
4.5	11.25	3,967	.01	+.005	+1,984
5.0	0.0	0	0	0	0

Cast iron disc Ref 2 Page 42 (→ $(C_T)_D$)

Fabricated Disc (→ $(C_T)_U$)

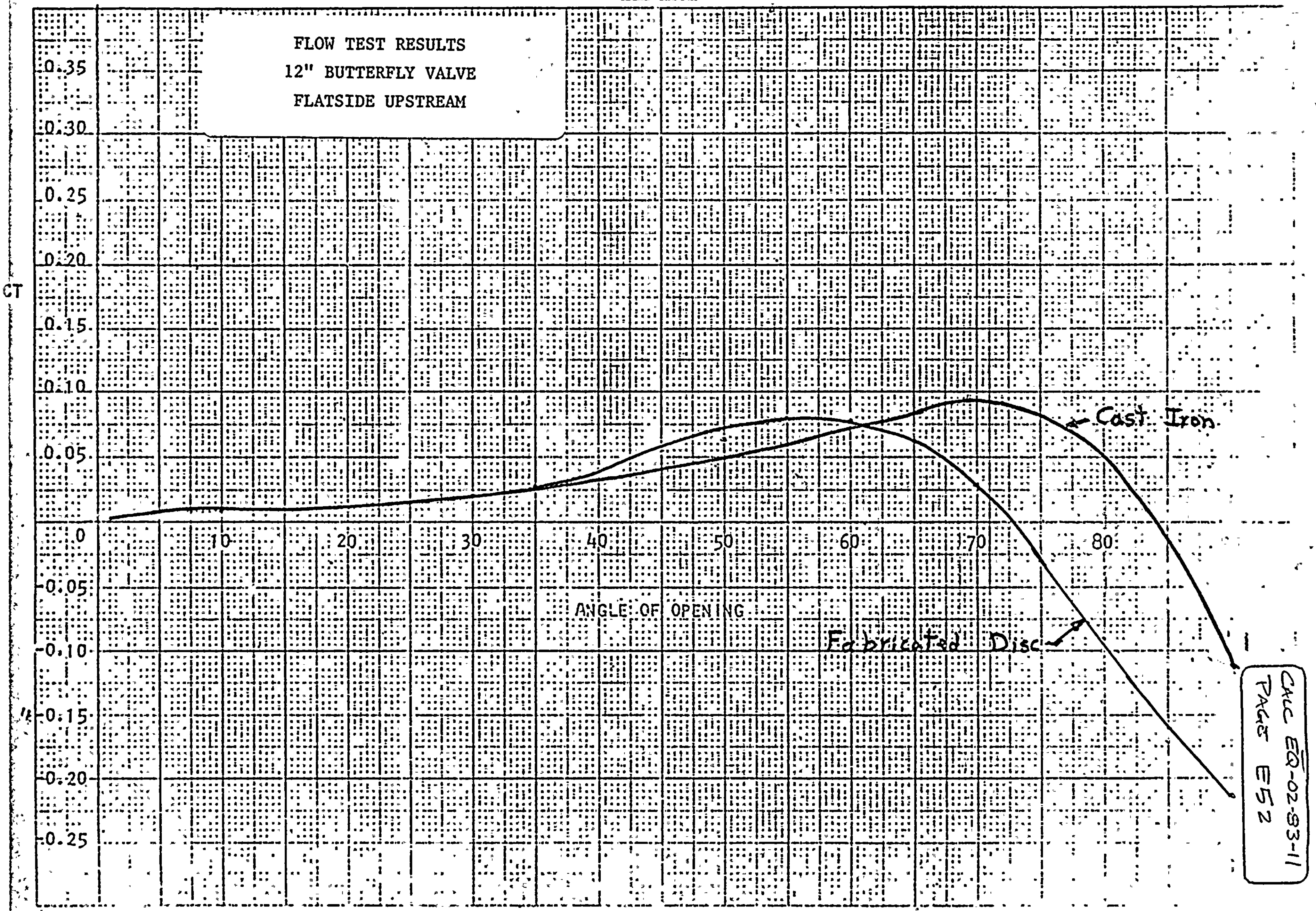
$$\text{New Torque} = \text{Old Torque}\left[\frac{C_T\ \text{upstream}}{C_T\ \text{Downstream}}\right]$$

1006.00

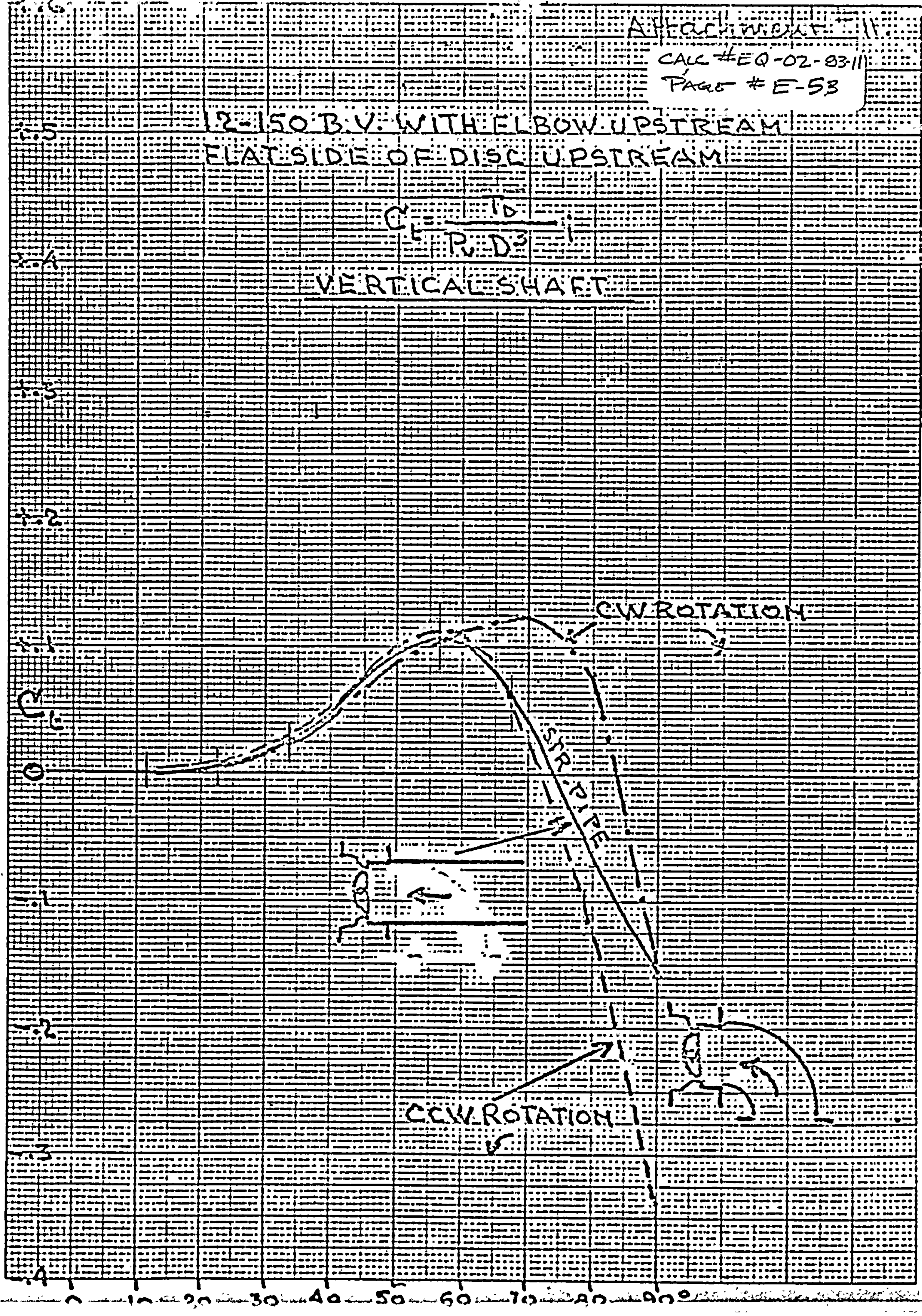


CALC EQ-02-83-11
PAGE E51

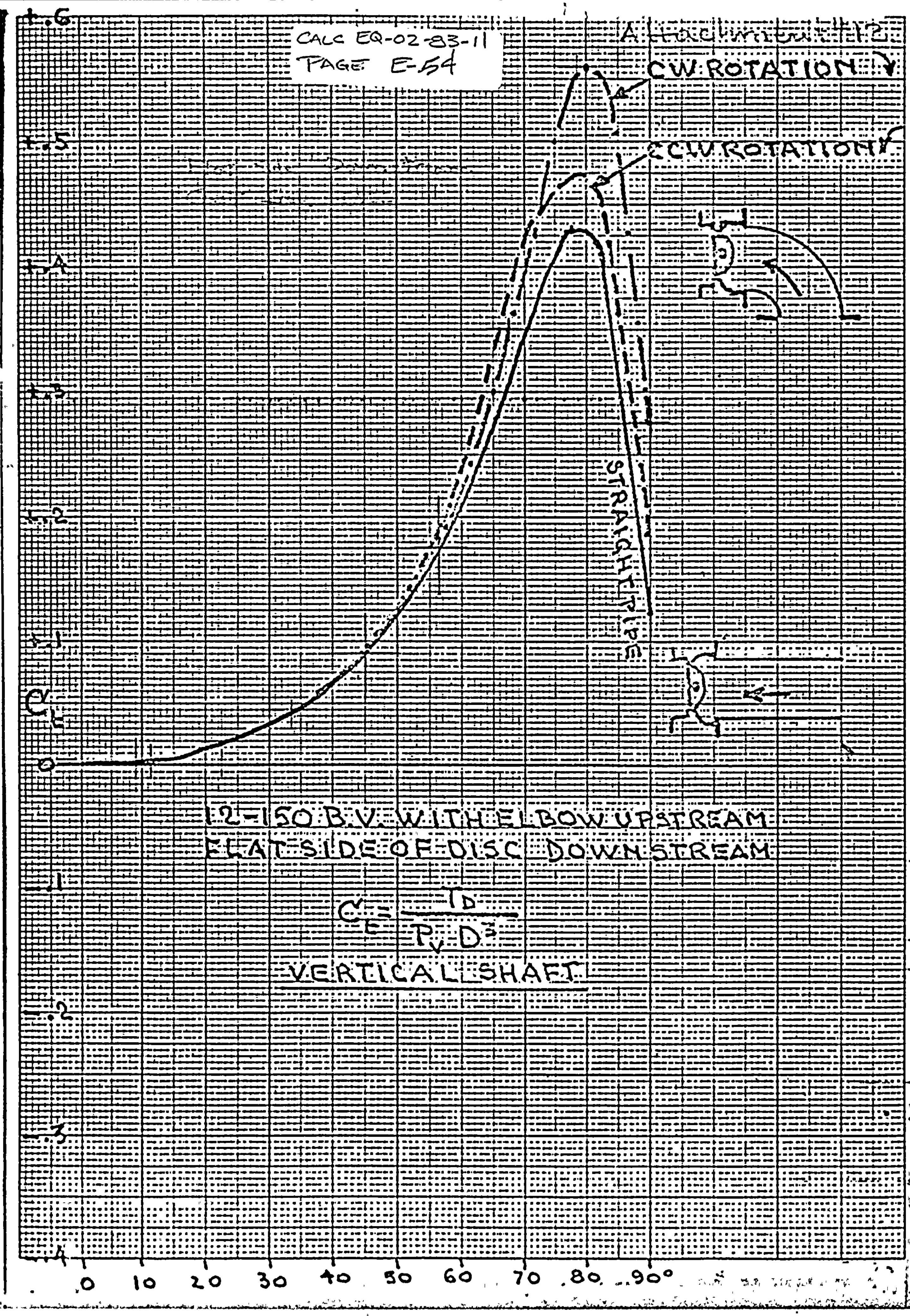
BIF


FLOW TEST RESULTS
12" BUTTERFLY VALVE
FLATSIDE UPSTREAM
CT
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
-0.05
-0.10
-0.15
-0.20
-0.25
10
20
30
40
50
60
70
80
ANGLE OF OPENING
Cast Iron
Fabricated Disc
CALC EQ-02-83-11
PAGE E52

GRAPH #5



Attachment 11
CALC #EQ-02-83-11
PAGE #E-53
12-150 B.V. WITH ELBOW UPSTREAM
FLAT SIDE OF DISC UPSTREAM
$C_t = \frac{T_D}{P_v D^3}$
VERTICAL SHAFT
CW ROTATION
STR. PIPE
CCW ROTATION
C_t
.6
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
0
10
20
30
40
50
60
70
80
90°



CALC EQ-02-83-11
PAGE E-54
Attachment 12
CW ROTATION
CCW ROTATION
STRAIGHT PIPE
Ct
12-150 B.V. WITH ELBOW UPSTREAM
FLAT SIDE OF DISC DOWNSTREAM
Ct = TD / Pv D3
VERTICAL SHAFT
+.6
+.5
+.4
+.3
+.2
+.1
0
-.1
-.2
-.3
-.4
0
10
20
30
40
50
60
70
80
90°

Calculation Sheet

Project WPPSS WNP-2		Prepared By: [signature]	Date 12/15/83
Subject VALVE COMPONENT STRESSES		Checked By: Mike Meyer	Date 12-16-83
System CONTAINMENT ISOLATION VALVES CEP/CSP		Job No.	File No.
Analysis No. EQ-02-83-11	Rev. No. 0	Sheet No. E-55	

THE FOLLOWING COMPUTER PRINTOUTS FOR THE VARIOUS VALVES WERE PERFORMED WITH THE ASBUILT PIPING ACCELERATIONS. THE ORIGINAL COMPUTER ANALYSIS AND PROCEDURE ARE DEFINED IN REFERENCES 3 & 8. THE INPUT WAS SLIGHTLY MODIFIED TO ACCEPT DIFFERENT OPERATING TORQUE FORCES. THE RESULTING STRESSES WERE THEN CALCULATED WITH THE MAXIMUM FLOW INDUCED TORQUE FORCE PLUS DBE LOADING AND SECONDLY WITH THE MAXIMUM SEATING TORQUE FORCE PLUS DBE. A LISTING WITH THE MODIFIED CHANGES UNDERLINED IS FOLLOWING THE VARIOUS VALVE PRINTOUTS.

EQ-02-83-11

E-56

CEP3A
CEP-V/AO-3A WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

INPUT GLOBAL ACCELERATIONS
? 4.57, 1.26, 0.90

INPUT DATA

INPUT OPERATOR FORCE (TORQUE) FLOW TORQUE
? 995.

GLOBAL G-LEVELS	=	4.57	1.26	.9
NORTH VECTOR ANGLES	=	90	90	0
VERTICAL VECTOR ANGLES	=	90	0	90
EAST VECTOR ANGLES	=	180	90	90
WEIGHT VECTOR ANGLES	=	90	180	90

LOCAL G-LEVELS

-1.74332E-5	-4.80652E-6	-.9
-1.74332E-5	1.26	-3.43323E-6
4.57	-4.80652E-6	-3.43323E-6

OPERATING DRIVE ROD STRESS AT A 412.882
OPERATING DRIVE ROD STRESS AT B 710.744
OPERATING CYLINDER BRG PRESSURE -3.75613E-4
OPERATING VALVE EAR TENSILE STR 1240.79
OPERATING VALVE EAR SHEAR STRES 63.5285
OPERATING EAR BOLT SHEAR STRESS 768.49
OPERATING EAR BOLT TENSILE STR 353.72

s1f=-3.4591E-3
s2f= 319
t3f=-2.57873E-3
m1f=-2193.04
m2f=-5.29623E-3
tt3f= 3611.67

CEP3A 995

E-57

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	4543.51
DRIVE ROD TENSILE STRESS AT B	6949.04
BUSHING PRESSURE	88.6181
VALVE EAR TENSILE STRESS	7118.23
VALVE EAR SHEAR STRESS	296.639
EAR BOLT SHEAR STRESS	3588.37
EAR BOLT TENSILE STRESS	23002.1

s1d= 816.102
s2d= 851.76
t3d= 3089.31
m1d= 97498.6
m2d= 22844.9
tt3d= 20809.2

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	4956.39
DRIVE ROD TENSILE STRESS AT B	7659.78
PUSHING PRESSURE	88.6185
VALVE EAR TENSILE STRESS	8359.01
VALVE EAR SHEAR STRESS	360.167
EAR BOLT SHEAR STRESS	4356.86
EAR BOLT TENSILE STRESS	23355.8

s1t= 816.106
s2t= 1170.76
t3t= 3089.32
m1t= 99691.6
m2t= 22844.9
tt3t= 24420.9

CEP3A
CEP-V/AO-3A WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E-58

INPUT GLOBAL ACCELERATIONS
? 4.57, 1.26, 0.90

INPUT DATA

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

GLOBAL G-LEVELS	=	4.57	1.26	.9
NORTH VECTOR ANGLES	=	90	90	0
VERTICAL VECTOR ANGLES	=	90	0	90
EAST VECTOR ANGLES	=	180	90	90
WEIGHT VECTOR ANGLES	=	90	180	90

LOCAL G-LEVELS

-1.74332E-5	-4.80652E-6	-.9
-1.74332E-5	1.26	-3.43323E-6
4.57	-4.80652E-6	-3.43323E-6

OPERATING DRIVE ROD STRESS AT A	600.434
OPERATING DRIVE ROD STRESS AT B	1033.6
OPERATING CYLINDER BRG PRESSURE	-3.75613E-4
OPERATING VALVE EAR TENSILE STR	2670.32
OPERATING VALVE EAR SHEAR STRES	138.312
OPERATING EAR BOLT SHEAR STRESS	1673.13
OPERATING EAR BOLT TENSILE STR	854.929

s1f=-3.4591E-3
s2f= 771
t3f=-2.57873E-3
m1f=-5300.54
m2f=-5.29623E-3
tt3f= 7453.67

CEP3A 1447

E59

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	4543.51
DRIVE ROD TENSILE STRESS AT B	6949.04
BUSHING PRESSURE	88.6181
VALVE EAR TENSILE STRESS	7118.23
VALVE EAR SHEAR STRESS	296.639
EAR BOLT SHEAR STRESS	3588.37
EAR BOLT TENSILE STRESS	23002.1

s1d= 816.102
s2d= 851.76
t3d= 3089.31
m1d= 97498.6
m2d= 22844.9
tt3d= 20809.2

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	5143.94
DRIVE ROD TENSILE STRESS AT B	7982.64
PUSHING PRESSURE	88.6185
VALVE EAR TENSILE STRESS	9788.55
VALVE EAR SHEAR STRESS	434.951
EAR BOLT SHEAR STRESS	5261.5
EAR BOLT TENSILE STRESS	23857.1

s1t= 816.106
s2t= 1622.76
t3t= 3089.32
m1t= 1.02799E+5
m2t= 22844.9
tt3t= 28262.9

CEP4A
CEP-V/AO-4A WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E60

INPUT GLOBAL ACCELERATIONS
? 3.71, 1.34, 0.89

INPUT OPERATOR FORCE (TORQUE) FLOW TORQUE
? 995.

INPUT DATA

GLOBAL G-LEVELS	=	3.71	1.34	.89
NORTH VECTOR ANGLES	=	90	-38	52
VERTICAL VECTOR ANGLES	=	90	52	142
EAST VECTOR ANGLES	=	180	90	90
WEIGHT VECTOR ANGLES	=	90	-128	-38

LOCAL G-LEVELS

-1.41525E-5	-5.11169E-6	-.89
2.92352	.824984	-3.39508E-6
2.2841	-1.05594	-3.39508E-6

OPERATING DRIVE ROD STRESS AT A	412.882
OPERATING DRIVE ROD STRESS AT B	710.744
OPERATING CYLINDER BRG PRESSURE	-3.75613E-4
OPERATING VALVE EAR TENSILE STR	2300.51
OPERATING VALVE EAR SHEAR STRES	102.384
OPERATING EAR BOLT SHEAR STRESS	1238.52
OPERATING EAR BOLT TENSILE STR	4599.3

s1f=-3.4591E-3
s2f= 578.81
t3f= 532.695
m1f=-20760.8
m2f=-3818.52
tt3f= 5474.06

CEP4A 995

E61

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	4493.02
DRIVE ROD TENSILE STRESS AT B	6871.83
BUSHING PRESSURE	87.6336
VALVE EAR TENSILE STRESS	9303.24
VALVE EAR SHEAR STRESS	405.714
EAR BOLT SHEAR STRESS	4907.83
EAR BOLT TENSILE STRESS	14492.5

s1d= 807.034
s2d= 2053.47
t3d= 1701.06
m1d= 64964.6
m2d= 13396.7
tt3d= 24569.7

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	4905.9
DRIVE ROD TENSILE STRESS AT B	7582.57
PUSHING PRESSURE	87.6339
VALVE EAR TENSILE STRESS	11603.7
VALVE EAR SHEAR STRESS	508.099
EAR BOLT SHEAR STRESS	6146.36
EAR BOLT TENSILE STRESS	19091.8

s1t= 807.038
s2t= 2632.28
t3t= 2233.76
m1t= 85725.4
m2t= 17215.2
tt3t= 30043.7

CEP4A
CEP-V/AO-4A WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E62

INPUT GLOBAL ACCELERATIONS
? 3.71, 1.34, 0.89

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

INPUT DATA

GLOBAL G-LEVELS	=	3.71	1.34	.89
NORTH VECTOR ANGLES	=	90	-38	52
VERTICAL VECTOR ANGLES	=	90	52	142
EAST VECTOR ANGLES	=	180	90	90
WEIGHT VECTOR ANGLES	=	90	-128	-38

LOCAL G-LEVELS

-1.41525E-5	-5.11169E-6	-.89
2.92352	.824984	-3.39508E-6
2.2841	-1.05594	-3.39508E-6

OPERATING DRIVE ROD STRESS AT A 600.434
OPERATING DRIVE ROD STRESS AT B 1033.6
OPERATING CYLINDER BRG PRESSURE -3.75613E-4
OPERATING VALVE EAR TENSILE STR 3730.04
OPERATING VALVE EAR SHEAR STRES 177.18
OPERATING EAR BOLT SHEAR STRESS 2143.31
OPERATING EAR BOLT TENSILE STR 5100.51

s1f=-3.4591E-3
s2f= 1030.81
t3f= 532.695
m1f=-23868.3
m2f=-3818.52
tt3f= 9316.05

CEP4A 1447

'E65

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	4493.02
DRIVE ROD TENSILE STRESS AT B	6871.83
BUSHING PRESSURE	87.6336
VALVE EAR TENSILE STRESS	9303.24
VALVE EAR SHEAR STRESS	405.714
EAR BOLT SHEAR STRESS	4907.83
EAR BOLT TENSILE STRESS	14492.5

s1d= 807.034
s2d= 2053.47
t3d= 1701.06
m1d= 64964.6
m2d= 13396.7
tt3d= 24569.7

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	5093.46
DRIVE ROD TENSILE STRESS AT B	7905.43
PUSHING PRESSURE	87.6339
VALVE EAR TENSILE STRESS	13033.3
VALVE EAR SHEAR STRESS	582.894
EAR BOLT SHEAR STRESS	7051.14
EAR BOLT TENSILE STRESS	19593

s1t= 807.038
s2t= 3084.29
t3t= 2233.76
m1t= 88833
m2t= 17215.2
tt3t= 33885.7

CSP1Ø
CSP-V/AO-1/Ø WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

l.5 E64

INPUT GLOBAL ACCELERATIONS
? 1.46, 3.67, 2.13

INPUT OPERATOR FORCE (TORQUE) FLOW TORQUE
? 1966.

INPUT DATA

GLOBAL G-LEVELS	=	1.46	3.67	2.13
NORTH VECTOR ANGLES	=	135	90	135
VERTICAL VECTOR ANGLES	=	90	180	90
EAST VECTOR ANGLES	=	45	90	135
WEIGHT VECTOR ANGLES	=	90	0	90

LOCAL G-LEVELS

-1.03238	-1.39999E-5	1.50613
-5.56945E-6	-3.67	-8.1253E-6
-1.03238	-1.39999E-5	-1.50614

OPERATING DRIVE ROD STRESS AT A	815.81
OPERATING DRIVE ROD STRESS AT B	1404.35
OPERATING CYLINDER BRG PRESSURE	-7.15824E-4
OPERATING VALVE EAR TENSILE STR	4206.68
OPERATING VALVE EAR SHEAR STRES	306.895
OPERATING EAR BOLT SHEAR STRESS	2569.7
OPERATING EAR BOLT TENSILE STR	1695.14

s1f=-5.43205E-3
s2f= 2880
t3f=-3.48663E-3
m1f=-22319.9
m2f=-1.64417E-2
tt3f= 23436.6

CSP1 1966

E65

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	20370.4
DRIVE ROD TENSILE STRESS AT B	31155.3
BUSHING PRESSURE	342.645
VALVE EAR TENSILE STRESS	11484.3
VALVE EAR SHEAR STRESS	648.873
EAR BOLT SHEAR STRESS	5433.14
EAR BOLT TENSILE STRESS	7823.03

s1d= 2600.18
s2d= 3354.38
t3d= 1668.96
m1d= 68091.2
m2d= 27118.9
tt3d= 70644.8

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	21186.2
DRIVE ROD TENSILE STRESS AT B	32559.7
PUSHING PRESSURE	342.646
VALVE EAR TENSILE STRESS	15691
VALVE EAR SHEAR STRESS	955.768
EAR BOLT SHEAR STRESS	8002.83
EAR BOLT TENSILE STRESS	9518.17

s1t= 2600.18
s2t= 6234.38
t3t= 1668.97
m1t= 90411.1
m2t= 27119
tt3t= 94081.4

CSP1Ø
CSP-V/AO-1/Ø WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E66

INPUT GLOBAL ACCELERATIONS
? 1.46, 3.67, 2.13

INPUT OPERATOR FORCE (TORQUE)
? 2366.

INPUT DATA

GLOBAL G-LEVELS	=	1.46	3.67	2.13
NORTH VECTOR ANGLES	=	135	90	135
VERTICAL VECTOR ANGLES	=	90	180	90
EAST VECTOR ANGLES	=	45	90	135
WEIGHT VECTOR ANGLES	=	90	0	90

LOCAL G-LEVELS

-1.03238	-1.39999E-5	1.50613
-5.56945E-6	-3.67	-8.1253E-6
-1.03238	-1.39999E-5	-1.50614

OPERATING DRIVE ROD STRESS AT A	981.785
OPERATING DRIVE ROD STRESS AT B	1690.06
OPERATING CYLINDER BRG PRESSURE	-7.15824E-4
OPERATING VALVE EAR TENSILE STR	4807.48
OPERATING VALVE EAR SHEAR STRES	350.589
OPERATING EAR BOLT SHEAR STRESS	2935.55
OPERATING EAR BOLT TENSILE STR	1930.58

s1f=-5.43205E-3
s2f= 3280
t3f=-3.48663E-3
m1f=-25419.9
m2f=-1.64417E-2
tt3f= 26836.6

CSP1 2366

E67

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	20370.4
DRIVE ROD TENSILE STRESS AT B	31155.3
BUSHING PRESSURE	342.645
VALVE EAR TENSILE STRESS	11484.3
VALVE EAR SHEAR STRESS	648.873
EAR BOLT SHEAR STRESS	5433.14
EAR BOLT TENSILE STRESS	7823.03

s1d= 2600.18
s2d= 3354.38
t3d= 1668.96
m1d= 68091.2
m2d= 27118.9
tt3d= 70644.8

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	21352.2
DRIVE ROD TENSILE STRESS AT B	32845.4
PUSHING PRESSURE	342.646
VALVE EAR TENSILE STRESS	16291.8
VALVE EAR SHEAR STRESS	999.462
EAR BOLT SHEAR STRESS	8368.69
EAR BOLT TENSILE STRESS	9753.61

s1t= 2600.18
s2t= 6634.38
t3t= 1668.97
m1t= 93511.1
m2t= 27119
tt3t= 97481.4

```
CSP02
 CSP-V/AO-0/2 WITH TORQUE MODIFICATION
 REVISED 12-10-83  MAS/TBGM/CYGNA                         E68

 INPUT GLOBAL ACCELERATIONS
? 1.44, 3.57, 1.90

 INPUT OPERATOR FORCE (TORQUE)
? 1966.

 INPUT DATA

GLOBAL G-LEVELS        =  1.44              3.57          1.9
NORTH VECTOR ANGLES    =  135               90            135
VERTICAL VECTOR ANGLES=   90                180           90
EAST VECTOR ANGLES     =  45                90            135
WEIGHT VECTOR ANGLES   =  90               0              90

 LOCAL G-LEVELS

-1.01824      -1.36185E-5     1.3435
-5.49316E-6   -3.57          -7.24792E-6
-1.01824      -1.36185E-5    -1.34351

OPERATING DRIVE ROD STRESS AT A  815.81
OPERATING DRIVE ROD STRESS AT B  1404.35
OPERATING CYLINDER BRG PRESSURE -7.15824E-4
OPERATING VALVE EAR TENSILE STR  4206.68
OPERATING VALVE EAR SHEAR STRES  306.895
OPERATING EAR BOLT SHEAR STRESS  2569.7
OPERATING EAR BOLT TENSILE  STR  1695.14

 s1f=-5.43205E-3
 s2f= 2880
 t3f=-3.48663E-3
 m1f=-22319.9
 m2f=-1.64417E-2
 tt3f= 23436.6
```

CSP2 1966

E69

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	18806
DRIVE ROD TENSILE STRESS AT B	28762.8
BUSHING PRESSURE	316.332
VALVE EAR TENSILE STRESS	10686.5
VALVE EAR SHEAR STRESS	607.944
EAR BOLT SHEAR STRESS	5090.43
EAR BOLT TENSILE STRESS	7168.94

s1d= 2400.49
s2d= 3262.98
t3d= 1540.79
m1d= 63365
m2d= 24262.9
tt3d= 65656.8

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	19621.9
DRIVE ROD TENSILE STRESS AT B	30167.1
PUSHING PRESSURE	316.333
VALVE EAR TENSILE STRESS	14893.1
VALVE EAR SHEAR STRESS	914.838
EAR BOLT SHEAR STRESS	7660.13
EAR BOLT TENSILE STRESS	8864.08

s1t= 2400.5
s2t= 6142.98
t3t= 1540.8
m1t= 85684.9
m2t= 24263
tt3t= 89093.4

CSPØ2
CSP-V/AO-Ø/2 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

LE70

INPUT GLOBAL ACCELERATIONS
? 1.44, 3.57, 1.90

INPUT OPERATOR FORCE (TORQUE)
? 2366.

INPUT DATA

GLOBAL G-LEVELS	=	1.44	3.57	1.9
NORTH VECTOR ANGLES	=	135	90	135
VERTICAL VECTOR ANGLES	=	90	180	90
EAST VECTOR ANGLES	=	45	90	135
WEIGHT VECTOR ANGLES	=	90	0	90

LOCAL G-LEVELS

-1.01824	-1.36185E-5	1.3435
-5.49316E-6	-3.57	-7.24792E-6
-1.01824	-1.36185E-5	-1.34351

OPERATING DRIVE ROD STRESS AT A	981.785
OPERATING DRIVE ROD STRESS AT B	1690.06
OPERATING CYLINDER BRG PRESSURE	-7.15824E-4
OPERATING VALVE EAR TENSILE STR	4807.48
OPERATING VALVE EAR SHEAR STRES	350.589
OPERATING EAR BOLT SHEAR STRESS	2935.55
OPERATING EAR BOLT TENSILE STR	1930.58

s1f=-5.43205E-3
s2f= 3280
t3f=-3.48663E-3
m1f=-25419.9
m2f=-1.64417E-2
tt3f= 26836.6

CSPZ 2366

E71

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	18806
DRIVE ROD TENSILE STRESS AT B	28762.8
BUSHING PRESSURE	316.332
VALVE EAR TENSILE STRESS	10686.5
VALVE EAR SHEAR STRESS	607.944
EAR BOLT SHEAR STRESS	5090.43
EAR BOLT TENSILE STRESS	7168.94

s1d= 2400.49
s2d= 3262.98
t3d= 1540.79
m1d= 63365
m2d= 24262.9
tt3d= 65656.8

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	19787.8
DRIVE ROD TENSILE STRESS AT B	30452.8
PUSHING PRESSURE	316.333
VALVE EAR TENSILE STRESS	15493.9
VALVE EAR SHEAR STRESS	958.532
EAR BOLT SHEAR STRESS	8025.98
EAR BOLT TENSILE STRESS	9099.52

s1t= 2400.5
s2t= 6542.98
t3t= 1540.8
m1t= 88784.9
m2t= 24263
tt3t= 92493.4

CSP30
CSP-V/AO-3/40 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

- E72

INPUT GLOBAL ACCELERATIONS
? 2.66, 3.17, 3.76

INPUT OPERATOR FORCE (TORQUE) FLOW TORQUE
? 995.

INPUT DATA

GLOBAL G-LEVELS =	2.66	3.17	3.76
NORTH VECTOR ANGLES =	90	90	180
VERTICAL VECTOR ANGLES=	0 90	90	
EAST VECTOR ANGLES =	90	180	90
WEIGHT VECTOR ANGLES =	180	90	90

LOCAL G-LEVELS

-1.01471E-5	3.17	-1.43433E-5
-1.01471E-5	-1.20926E-5	-3.76
-2.66	-1.20926E-5	-1.43433E-5

OPERATING DRIVE ROD STRESS AT A	5461.21
OPERATING DRIVE ROD STRESS AT B	8431.86
OPERATING CYLINDER BRG PRESSURE	-98.4646
OPERATING VALVE EAR TENSILE STR	5930.22
OPERATING VALVE EAR SHEAR STRES	251.91
OPERATING EAR BOLT SHEAR STRESS	3047.3
OPERATING EAR BOLT TENSILE STR	2443.98

s1f=-906.782
s2f= 994.997
t3f=-2.57873E-3
m1f=-6840.52
m2f=-6234.1
tt3f=-13646.3

CSP3 995

E73

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	16003.2
DRIVE ROD TENSILE STRESS AT B	24476
BUSHING PRESSURE	312.133
VALVE EAR TENSILE STRESS	23769.1
VALVE EAR SHEAR STRESS	1017.24
EAR BOLT SHEAR STRESS	12305.3
EAR BOLT TENSILE STRESS	14299.1

s1d= 2874.49
s2d= 2541.76
t3d= 1798.16
m1d= 59281.6
m2d= 23594.3
tt3d= 72399

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	21464.4
DRIVE ROD TENSILE STRESS AT B	32907.9
PUSHING PRESSURE	410.597
VALVE EAR TENSILE STRESS	29699.3
VALVE EAR SHEAR STRESS	1269.15
EAR BOLT SHEAR STRESS	15352.6
EAR BOLT TENSILE STRESS	16743.1

s1t= 3781.28
s2t= 3536.76
t3t= 1798.16
m1t= 66122.1
m2t= 29828.4
tt3t= 86045.3

CSP34
CSP-V/AO-3/4 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E 74

INPUT GLOBAL ACCELERATIONS
? 2.66, 3.17, 3.76

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

INPUT DATA

GLOBAL G-LEVELS =	2.66	3.17	3.76
NORTH VECTOR ANGLES =	90	90	180
VERTICAL VECTOR ANGLES=	0 90	90	
EAST VECTOR ANGLES =	90	180	90
WEIGHT VECTOR ANGLES =	180	90	90

LOCAL G-LEVELS

-1.01471E-5	3.17	-1.43433E-5
-1.01471E-5	-1.20926E-5	-3.76
-2.66	-1.20926E-5	-1.43433E-5

OPERATING DRIVE ROD STRESS AT A	5648.76
OPERATING DRIVE ROD STRESS AT B	8754.72
OPERATING CYLINDER BRG PRESSURE	-98.4646
OPERATING VALVE EAR TENSILE STR	5380.35
OPERATING VALVE EAR SHEAR STRES	231.813
OPERATING EAR BOLT SHEAR STRESS	2804.19
OPERATING EAR BOLT TENSILE STR	2945.19

s1f=-906.782
s2f= 1447
t3f=-2.57873E-3
m1f=-9948.02
m2f=-6234.1
tt3f=-9804.29

CSP3 1447

LE 75

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	16003.2
DRIVE ROD TENSILE STRESS AT B	24476
BUSHING PRESSURE	312.133
VALVE EAR TENSILE STRESS	23769.1
VALVE EAR SHEAR STRESS	1017.24
EAR BOLT SHEAR STRESS	12305.3
EAR BOLT TENSILE STRESS	14299.1

s1d= 2874.49
s2d= 2541.76
t3d= 1798.16
m1d= 59281.6
m2d= 23594.3
tt3d= 72399

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	21652
DRIVE ROD TENSILE STRESS AT B	33230.7
PUSHING PRESSURE	410.597
VALVE EAR TENSILE STRESS	29149.4
VALVE EAR SHEAR STRESS	1249.05
EAR BOLT SHEAR STRESS	15109.5
EAR BOLT TENSILE STRESS	17244.3

s1t= 3781.28
s2t= 3988.76
t3t= 1798.16
m1t= 69229.6
m2t= 29828.4
tt3t= 82203.3

CSP04
CSP-V/AO-0/4 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E 76

INPUT GLOBAL ACCELERATIONS
? 3.25, 2.94, 4.19

INPUT OPERATOR FORCE (TORQUE) FLOW TORQUE
? 995.

INPUT DATA

GLOBAL G-LEVELS =	3.25	2.94	4.19
NORTH VECTOR ANGLES =	90	90	180
VERTICAL VECTOR ANGLES= 0	90	90	
EAST VECTOR ANGLES =	90	180	90
WEIGHT VECTOR ANGLES =	180	90	90

LOCAL G-LEVELS

-1.23978E-5	2.94	-1.59836E-5
-1.23978E-5	-1.12152E-5	-4.19
-3.25	-1.12152E-5	-1.59836E-5

OPERATING DRIVE ROD STRESS AT A	5461.21
OPERATING DRIVE ROD STRESS AT B	8431.86
OPERATING CYLINDER BRG PRESSURE	-98.4646
OPERATING VALVE EAR TENSILE STR	5930.22
OPERATING VALVE EAR SHEAR STRES	251.91
OPERATING EAR BOLT SHEAR STRESS	3047.3
OPERATING EAR BOLT TENSILE STR	2443.98

s1f=-906.782
s2f= 994.997
t3f=-2.57873E-3
m1f=-6840.52
m2f=-6234.1
tt3f=-13646.3

CSr4 995

E77

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	14842.1
DRIVE ROD TENSILE STRESS AT B	22700.2
BUSHING PRESSURE	289.486
VALVE EAR TENSILE STRESS	22501.9
VALVE EAR SHEAR STRESS	972.261
EAR BOLT SHEAR STRESS	11761.2
EAR BOLT TENSILE STRESS	17082.2

s1d= 2665.94
s2d= 2832.44
t3d= 2197
m1d= 71899.2
m2d= 24165
tt3d= 68083

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	20303.3
DRIVE ROD TENSILE STRESS AT B	31132
PUSHING PRESSURE	387.951
VALVE EAR TENSILE STRESS	28432.1
VALVE EAR SHEAR STRESS	1224.17
EAR BOLT SHEAR STRESS	14808.5
EAR BOLT TENSILE STRESS	19526.2

s1t= 3572.72
s2t= 3827.44
t3t= 2197
m1t= 78739.7
m2t= 30399.1
tt3t= 81729.3

CSP04

E78

CSP-V/AO-0/4 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

INPUT GLOBAL ACCELERATIONS
? 3.25, 2.94, 4.19

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

INPUT DATA

GLOBAL G-LEVELS =	3.25	2.94	4.19
NORTH VECTOR ANGLES =	90	90	180
VERTICAL VECTOR ANGLES=	0 90	90	
EAST VECTOR ANGLES =	90	180	90
WEIGHT VECTOR ANGLES =	180	90	90

LOCAL G-LEVELS

-1.23978E-5	2.94	-1.59836E-5
-1.23978E-5	-1.12152E-5	-4.19
-3.25	-1.12152E-5	-1.59836E-5

OPERATING DRIVE ROD STRESS AT A 5648.76
OPERATING DRIVE ROD STRESS AT B 8754.72
OPERATING CYLINDER BRG PRESSURE -98.4646
OPERATING VALVE EAR TENSILE STR 5380.35
OPERATING VALVE EAR SHEAR STRES 231.813
OPERATING EAR BOLT SHEAR STRESS 2804.19
OPERATING EAR BOLT TENSILE STR 2945.19

s1f=-906.782
s2f= 1447
t3f=-2.57873E-3
m1f=-9948.02
m2f=-6234.1
tt3f=-9804.29

CSP4 1447

E79

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	14842.1
DRIVE ROD TENSILE STRESS AT B	22700.2
BUSHING PRESSURE	289.486
VALVE EAR TENSILE STRESS	22501.9
VALVE EAR SHEAR STRESS	972.261
EAR BOLT SHEAR STRESS	11761.2
EAR BOLT TENSILE STRESS	17082.2

s1d= 2665.94
s2d= 2832.44
t3d= 2197
m1d= 71899.2
m2d= 24165
tt3d= 68083

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	20490.9
DRIVE ROD TENSILE STRESS AT B	31454.9
PUSHING PRESSURE	387.951
VALVE EAR TENSILE STRESS	27882.2
VALVE EAR SHEAR STRESS	1204.07
EAR BOLT SHEAR STRESS	14565.4
EAR BOLT TENSILE STRESS	20027.4

s1t= 3572.72
s2t= 4279.44
t3t= 2197
m1t= 81847.2
m2t= 30399.1
tt3t= 77887.2

CSP5
CSP-V/AO-5 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E80

INPUT GLOBAL ACCELERATIONS
? 2.96, 3.52, 5.42

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

INPUT DATA

GLOBAL G-LEVELS	=	2.96	3.52	5.42
NORTH VECTOR ANGLES	=	42.5	47.5	90
VERTICAL VECTOR ANGLES	=	90	90	0
EAST VECTOR ANGLES	=	47.5	137.5	90
WEIGHT VECTOR ANGLES	=	180	90	90

LOCAL G-LEVELS

2.18234	-1.34277E-5	3.66169
1.99974	-1.34277E-5	-3.99606
-1.12915E-5	3.52	-2.06756E-5

OPERATING DRIVE ROD STRESS AT A	5648.76
OPERATING DRIVE ROD STRESS AT B	8754.72
OPERATING CYLINDER BRG PRESSURE	-98.4646
OPERATING VALVE EAR TENSILE STR	5380.35
OPERATING VALVE EAR SHEAR STRES	231.813
OPERATING EAR BOLT SHEAR STRESS	2804.19
OPERATING EAR BOLT TENSILE STR	2945.19

s1f=-906.782
s2f= 1447
t3f=-2.57873E-3
m1f=-9948.02
m2f=-6234.1
tt3f=-9804.29

CSP5 1447

E81

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	21519.6
DRIVE ROD TENSILE STRESS AT B	32912.8
BUSHING PRESSURE	419.724
VALVE EAR TENSILE STRESS	30726.9
VALVE EAR SHEAR STRESS	1312.91
EAR BOLT SHEAR STRESS	15882
EAR BOLT TENSILE STRESS	19863.7

s1d= 3865.34
s2d= 3020.7
t3d= 2379.52
m1d= 77785.5
m2d= 31577.4
tt3d= 84539.5

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	27168.3
DRIVE ROD TENSILE STRESS AT B	41667.5
PUSHING PRESSURE	518.189
VALVE EAR TENSILE STRESS	36107.2
VALVE EAR SHEAR STRESS	1544.73
EAR BOLT SHEAR STRESS	18686.2
EAR BOLT TENSILE STRESS	22808.9

s1t= 4772.12
s2t= 4467.7
t3t= 2379.52
m1t= 87733.5
m2t= 37811.5
tt3t= 94343.8

CSP6
CSP-V/AO-6 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E82

INPUT GLOBAL ACCELERATIONS
? 2.55, 3.33, 5.85

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

INPUT DATA

GLOBAL G-LEVELS	=	2.55	3.33	5.85
NORTH VECTOR ANGLES	=	90	90	0
VERTICAL VECTOR ANGLES	=	0 90	90	
EAST VECTOR ANGLES	=	90	0	90

LOCAL G-LEVELS

-9.72747E-6	3.33	-2.2316E-5
-9.72747E-6	-1.27029E-5	5.85
2.55	-1.27029E-5	-2.2316E-5

OPERATING DRIVE ROD STRESS AT A	5648.76
OPERATING DRIVE ROD STRESS AT B	8754.72
OPERATING CYLINDER BRG PRESSURE	-98.4646
OPERATING VALVE EAR TENSILE STR	5380.35
OPERATING VALVE EAR SHEAR STRES	231.813
OPERATING EAR BOLT SHEAR STRESS	2804.19
OPERATING EAR BOLT TENSILE STR	2945.19

s1f=-906.782
s2f= 1447
t3f=-2.57873E-3
m1f=-9948.02
m2f=-6234.1
tt3f=-9804.29

CSPG 1447

E83

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	16811
DRIVE ROD TENSILE STRESS AT B	25711.4
BUSHING PRESSURE	327.887
VALVE EAR TENSILE STRESS	26284.3
VALVE EAR SHEAR STRESS	1154.32
EAR BOLT SHEAR STRESS	13963.6
EAR BOLT TENSILE STRESS	14253.5

s1d= 3019.58
s2d= 3954.6
t3d= 1723.8
m1d= 60730.3
m2d= 24158.8
tt3d= 78875.3

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	22459.8
DRIVE ROD TENSILE STRESS AT B	34466.1
PUSHING PRESSURE	426.352
VALVE EAR TENSILE STRESS	31664.6
VALVE EAR SHEAR STRESS	1386.13
EAR BOLT SHEAR STRESS	16767.8
EAR BOLT TENSILE STRESS	17198.7

s1t= 3926.36
s2t= 5401.6
t3t= 1723.8
m1t= 70678.3
m2t= 30393
tt3t= 88679.5

CSPG'

CSP-V/AO-6 WITH TORQUE MODIFICATION
REVISED 12-10-83 MAS/TBGM/CYGNA

E84

INPUT GLOBAL ACCELERATIONS
? 11.39, 3.33, 5.85

INPUT OPERATOR FORCE (TORQUE) OLD SEATING TORQUE
? 1447.

INPUT DATA

GLOBAL G-LEVELS =	11.39	3.33	5.85
NORTH VECTOR ANGLES =	90	90	0
VERTICAL VECTOR ANGLES=	0	90	90
EAST VECTOR ANGLES =	90	0	90

LOCAL G-LEVELS

-4.34494E-5	3.33	-2.2316E-5
-4.34494E-5	-1.27029E-5	5.85
11.39	-1.27029E-5	-2.2316E-5

OPERATING DRIVE ROD STRESS AT A 5648.76
OPERATING DRIVE ROD STRESS AT B 8754.72
OPERATING CYLINDER BRG PRESSURE -98.4646
OPERATING VALVE EAR TENSILE STR 5380.35
OPERATING VALVE EAR SHEAR STRES 231.813
OPERATING EAR BOLT SHEAR STRESS 2804.19
OPERATING EAR BOLT TENSILE STR 2945.19

s1f=-906.782
s2f= 1447
t3f=-2.57873E-3
m1f=-9948.02
m2f=-6234.1
tt3f=-9804.29

CSPG' 1447

E85

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	16811
DRIVE ROD TENSILE STRESS AT B	25711.4
BUSHING PRESSURE	327.887
VALVE EAR TENSILE STRESS	26685.4
VALVE EAR SHEAR STRESS	1154.32
EAR BOLT SHEAR STRESS	13963.6
EAR BOLT TENSILE STRESS	57543

s1d= 3019.58
s2d= 3954.6
t3d= 7699.63
m1d= 2.44083E+5
m2d= 58968.3
tt3d= 78875.3

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	22459.8
DRIVE ROD TENSILE STRESS AT B	34466.1
PUSHING PRESSURE	426.352
VALVE EAR TENSILE STRESS	32065.7
VALVE EAR SHEAR STRESS	1386.13
EAR BOLT SHEAR STRESS	16767.8
EAR BOLT TENSILE STRESS	60488.2

s1t= 3926.36
s2t= 5401.6
t3t= 7699.64
m1t= 2.54031E+5
m2t= 65202.4
tt3t= 88679.5

E 86

```
REM***** BIF VALVE AND AIR OPERATOR SEISMIC STRESS *****
REM*****     CEP-V/AO-3A WITH TORQUE MODIFICATION ******
REM***** REVISED 12-10-83  MA SCOTT / TBG MARVIN / CYGNA
REM
var i,j,K = integer
var lrod,lcg,x,phi,lave,ablt,l1,l2,e1,e2,e3,e4,e5 = real
var fst2, ca,ia,cb,ib,aa,ab,d1,d2,c1,i1,c2,i2=real
var lrodo,lcgo,ldr,d, abush, pbush=real
var fcof, fco, ma,mb, siga, sigb, fcdr, fcdrf,maf, mbf=real
var dear, fcear,fr, f11,f22,la, ci12,ci21,stt3,sem1=real
var sem2,set3,ses1,ses2,sr,tau11,tau22,tauear,aear=real
var btens, taublt, set3f,sem1f,sem2f,fcearf, frf,f11f=real
var f22f,stt3f,ses1f,ses2f,srf,tau1f,tau2f,taurf=real
var taubf,btf, dsr,dtaur,dtaub,dbten,dsa,dsb,dpb=real
var sdraf,sdrbf,pbushf,tau11f,tau22f=real
var wao,wbr,ftr1,watr1,s1,s1f,s2,s2f,m1,m1f,m2=real
var m2f,t3,t3f,tt3,tt3f,lbr,wtot=real
var bs1,bs2,bt3,bm1,bm2,btt3=real

var fs1,fs2,ft3,fm1,fm2,ftt3,s1d,s2d,t3d        =real
var m1d,m2d,tt3d,s1t,s2t,t3t,m1t,m2t,tt3t       =real
dim real av(3)
dim real wa(3)
dim real wb(3)
REM
REM *** BURNS 7 ROE EAR FORCES ARE bs1 etc TURN ON WITH K=1***
REM
REM
dim real a(3,3)
dim real b(3)
dim real glc(3,3)
1   data 7.5, 10, .75, 1.95, 1.25, .7
2   data 25,14.46,.531,53.,5.5,.31,1.5,2.5
3   data 1150.,.875,.46,.648,.138,2.41,1.4
4   data 399,277,5.25,8.5,28.5,15.,6.875
5   data 40.,10.96,26.5,30.5,2.075
6   data 90.,90.,0.,90.,0.,90.
7   data 180.,90.,90.,90.,180.,90.
REM DATA 6&7 FOR VALVE/GLOBAL-G ORIENTATIONS AND WEIGHT VECTOR
restore
read d1,d2,c1,i1,c2,i2
restore 2
read lrod,lcg,x,phi,lave,ablt,l1,l2
restore 3
read fst2,ca,ia,cb,ib,aa,ab
restore 4
read wao,wbr,e1,e2,e3,e4,e5
restore 5
read lrodo,lcgo,ldr,d,abush
restore 6
read  a(1,1),a(2,1),a(3,1),a(1,2),a(2,2),a(3,2)
restore 7
```

E87

```
read  a(1,3),a(2,3),a(3,3),av(1),av(2),av(3)
text 0,& CEP-V/AO-3A WITH TORQUE MODIFICATION &
text 0,& REVISED 12-10-83  MAS/TBGM/CYGNA &
print
text 0,& INPUT GLOBAL ACCELERATIONS &
input b(1),b(2),b(3)
print
text 0,& INPUT DATA &
print
text 0,& INPUT OPERATOR FORCE (TORQUE) &
input fst2
print
print "GLOBAL G-LEVELS         = ";b(1),b(2),b(3)
print "NORTH VECTOR ANGLES     = ";a(1,1),a(2,1),a(3,1)
print "VERTICAL VECTOR ANGLES= ";a(1,2),a(2,2),a(3,2)
print "EAST VECTOR ANGLES      = ";a(1,3),a(2,3),a(3,3)
print "WEIGHT VECTOR ANGLES    = ";av(1),av(2),av(3)
print
for i=1 to 3
for j=1 to 3
  a(j,i)=a(j,i)*2.*3.1416/360.
  glc(j,i)=b(i)*cos(a(j,i))
next j
next i
for j=1 to 3
av(j)=av(j)*2.*3.1416/360.
next j
print
text 0,& LOCAL G-LEVELS &
print
print glc(1,1),glc(1,2),glc(1,3)
print glc(2,1),glc(2,2),glc(2,3)
print glc(3,1),glc(3,2),glc(3,3)
REM WEIGHT COMPONENTS
for j=1 to 3
wa(j)=wao*cos(av(j))
wb(j)=wbr*cos(av(j))
next j
phi=phi*2.*3.1416/360.
la=lave
ci12=c1/i2
ci21=c2/i1
aear=l1*l2
REM CALCULATE EAR FORCES USE B&R LOADS AS OPTION LATER
REM FIXED COMPONENTS ARE ALWAYS THERE
lbr=lrod+lcg
watr1=lbr*wa(1)/lrod
s1f=wb(1)+watr1
wtot=wao+wbr
s2f=wb(2)+wa(2)+fst2
t3f=wa(3)+wb(3)
m1f=-(wa(2)+wb(2)+fst2)*e5-wa(3)*(e3+lcg)-wb(3)*e4
```

E88

```
m2f=(watr1+wb(1))*e5-wa(3)*e2-wb(3)*e1
tt3f=watr1*e3+(wa(2)+fst2)*e2+wb(1)*e4+wb(2)*e1
fcdrf=lcg*wa(1)/lrod
maf=fcdrf*(lrod-13.5)
mbf=fcdrf*7.125
sdraf=fst2/aa+abs(maf*ca/ia)
sdrbf=fst2/ab+abs(mbf*cb/ib)
fcof=lcgo*wa(1)/lrodo
pbushf=fcof*(ldr+d)/(d*abush)
REM STRESSES FROM FIXED COMPONENTS
dear=(d1*d1+d2*d2)**.5
set3f=abs(t3f/(4*aear))
sem1f=abs(m1f/(2*d2*aear))
sem2f=abs(m2f/(2*d1*aear))
fcearf=tt3f/(2*dear)
frf=x*fcearf
f11f=-(fcearf*sin(phi)-frf*cos(phi))
f22f=fcearf*cos(phi)+frf*sin(phi)
stt3f=abs(f11f*la*ci12)+abs(f22f*la*ci21)
ses1f=abs(s1f*ci12*la/4.)
ses2f=abs(s2f*ci21*la/4.)
srf=set3f+sem1f+sem2f+ses1f+ses2f+stt3f
REM EAR SHEAR
tau11f=abs(s1f/(4*aear))+abs(f11f/aear)
tau22f=abs(s2f/(4*aear))+abs(f22f/aear)
taurf=(tau11f*tau11f+tau22f*tau22f)**.5
taubf=taurf*aear/ablt
REM EARBOLT TENSION
btf=(set3f+sem1f+sem2f)*aear/ablt
print
print"OPERATING DRIVE ROD STRESS AT A ";sdraf
print"OPERATING DRIVE ROD STRESS AT B ";sdrbf
print"OPERATING CYLINDER BRG PRESSURE ";pbushf
print"OPERATING VALVE EAR TENSILE STR ";srf
print"OPERATING VALVE EAR SHEAR STRES ";taurf
print"OPERATING EAR BOLT SHEAR STRESS ";taubf
print"OPERATING EAR BOLT TENSILE  STR ";btf
print

print
print "s1f=";s1f
print "s2f=";s2f
print "t3f=";t3f
print "m1f=";m1f
print "m2f=";m2f
print "tt3f=";tt3f
print
REM
REM CALCULATE VARIABLE COMPONENTS
REM
dsr=0.
dtaur=0.
```

E89

```
dtaub=0.
dbten=0.
dsa=0.
dsb=0.
dpb=0.

fs1=0.
fs2=0.
ft3=0.
fm1=0.
fm2=0.
ftt3=0.
for j=1 to 3
fco=lcgo*wao*glc(1,j)/lrodo
pbush=fco*(ldr+d)/(d*abush)
ftr1=lbr*wao*glc(1,j)/lrod
s1=ftr1+wbr*glc(1,j)
s2=wtot*glc(2,j)
t3=wtot*glc(3,j)
m1=-wtot*glc(2,j)*e5-wao*glc(3,j)*(e3+lcg)-wbr*glc(3,j)*e4
m2=(ftr1+wbr*glc(1,j))*e5-(wao*e2+wbr*e1)*glc(3,j)
tt3=ftr1*e3+wbr*glc(1,j)*e4+glc(2,j)*(wao*e2+wbr*e1)
fcdr=lcg*wao*glc(1,j)/lrod
ma=fcdr*(lrod-13.5)
mb=fcdr*7.125
siga=ma*ca/ia
sigb=mb*cb/ib
REM CALCULATE EAR TENSION
set3=abs(t3/(4*aear))
sem1=abs(m1/(2*d2*aear))
sem2=abs(m2/(2*d1*aear))
fcear=tt3/(2*dear)
fr=x*fcear
f11=-(fcear*sin(phi)-fr*cos(phi))
f22=fcear*cos(phi)+fr*sin(phi)
stt3=abs(f11*la*ci12)+abs(f22*la*ci21)
ses1=abs(s1*ci12*la/4.)
ses2=abs(s2*ci21*la/4.)
sr=set3+sem1+sem2+ses1+ses2+stt3
REM EAR SHEAR
tau11=abs(s1/(4.*aear))+abs(f11/aear)
tau22=abs(s2/(4.*aear))+abs(f22/aear)
tauear=(tau11*tau11+tau22*tau22)**.5
taublt=tauear*aear/ablt
REM EARBOLT TENSION
btens=(set3+sem1+sem2)*aear/ablt
dsa=dsa+siga*siga
dsb=dsb+sigb*sigb
dpb=dpb+pbush*pbush
dsr=dsr+sr*sr
dtaur=dtaur+tauear*tauear
dtaub=dtaub+taublt*taublt
```

E90

```
dbten=dbten+btens*btens

fs1=fs1+s1*s1
fs2=fs2+s2*s2
ft3=ft3+t3*t3
fm1=fm1+m1*m1
fm2=fm2+m2*m2
ftt3=ftt3+tt3*tt3
next j
REM COMBINE STRESSES
dsa=dsa**.5
dsb=dsb**.5
dpb=dpb**.5
dsr=dsr**.5
dtaur=dtaur**.5
dtaub=dtaub**.5
dbten=dbten**.5

fs1=fs1**.5
fs2=fs2**.5
ft3=ft3**.5
fm1=fm1**.5
fm2=fm2**.5
ftt3=ftt3**.5
print
text 0,& DYNAMIC COMPONENTS &
print
print "DRIVE ROD TENSILE STRESS AT A";dsa
print "DRIVE ROD TENSILE STRESS AT B";dsb
print "BUSHING PRESSURE               ";dpb
print "VALVE EAR TENSILE STRESS       ";dsr
print "VALVE EAR SHEAR STRESS         ";dtaur
print "EAR BOLT SHEAR STRESS          ";dtaub
print "EAR BOLT TENSILE STRESS        ";dbten

print
print "s1d=";fs1
print "s2d=";fs2
print "t3d=";ft3
print "m1d=";fm1
print "m2d=";fm2
print "tt3d=";ftt3
print
dsa=dsa+abs(sdraf)
dsb=dsb+abs(sdrbf)
dpb=dpb+abs(pbushf)
dsr=dsr+abs(srf)
dtaur=dtaur+abs(taurf)
dtaub=dtaub+abs(taubf)
dbten=dbten+abs(btf)

fs1=fs1+abs(s1f)
```

E91

```
fs2=fs2+abs(s2f)
ft3=ft3+abs(t3f)
fm1=fm1+abs(m1f)
fm2=fm2+abs(m2f)
ftt3=ftt3+abs(tt3f)
print
text 0,& FIXED PLUS DYNAMIC COMPONENTS &
print
print "DRIVE ROD TENSILE STRESS AT A";dsa
print "DRIVE ROD TENSILE STRESS AT B";dsb
print "PUSHING PRESSURE              ";dpb
print "VALVE EAR TENSILE STRESS      ";dsr
print "VALVE EAR SHEAR STRESS        ";dtaur
print "EAR BOLT SHEAR STRESS         ";dtaub
print "EAR BOLT TENSILE STRESS       ";dbten

print
print "s1t=";fs1
print "s2t=";fs2
print "t3t=";ft3
print "m1t=";fm1
print "m2t=";fm2
print "tt3t=";ftt3
print
end
```

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

SUPPLIER TRANSMITTAL FORM

(AREA WITHIN HEAVY BORDER TO BE COMPLETED BY SUPPLIER)

TO THE ATTENTION OF: Dennis Armstrong
(COGNIZANT PURCHASE AGENT/BUYER/CONTRACT ADMIN.)
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SUBJECT: Equip. Seismic/Hydrodynamic Requal.
FROM: Cygna Energy Services
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