CYGNA

Final Qualification Report

PROJECT: Equipment Seismic and Hydrodynamic Requalification

JOB NO: 82044

CALC NO: OS.01.F

CLIENT: Washington Public Power Supply System

QID NO: 361104

TITLE: Equipment Seismic and Hydrodynamic Requalification of 30" Cylinder Operated Butterfly Valves:

CSP-V-1 and 2
CEP-V-1A and 2A

PREPARED BY:	M.A. Scott	6/15/83 DATE
REVIEWED BY:	L.C. Fernandez	6/15/83 DATE
APPROVED BY:	F. Khanachet	6/15/83 DATE

⚠2 11/4/83 11/7/83 11/7/83

REVISION: 2

QID# 361104

REVISION STATUS LOG

Rev. No.	Date	Prepared by / Reviewed by	Approved by Cygna Energy Services	Approved by WPPSS	Description
0	2/16/83	R. Hsieh H. Abolhoda J. Rakowski / L. Fernandez			Original Issue
1	6/15/83	M. Scott / L. Fernandez			Revised to incorporate addition of shear plates
2	11/4/83	D.Searle / D. BARLOW			Review/comparison of final piping accelerations

1.0 REQUALIFICATION CERTIFICATION

Revision 2 1.1

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

REQUALIFICATION CERTIFICATE

WNP- 2

QID 361104

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

COMPONENT DESCRIPTION: 30" Cylinder Operated Butterfly Valves

MANUFACTURER: BIF **MODEL NO:** A-206763

EQUIPMENT CLASSIFICATION: [X] ACTIVE [ ] PASSIVE

SEISMIC QUALIFICATION REPORT REFERENCE:

Cygna Energy Services, "Equipment Seismic and Hydrodynamic Requalification of 30" Cylinder Operated Butterfly Valves," File No. OS.01.F, QID No. 361104, Revision 1, June, 1983. 1

[redacted]

REQUIRED ACTION: 1) Replace A-307 Ear Bolts with A-325 bolts.
2) Addition of shear plates, see sheets 4.3.30 to 4.3.48 for additional details. 1

THE ABOVE SEISMIC [redacted] QUALIFICATION REPORTS HAVE BEEN REEVALUATED IN ACCORDANCE WITH THE CURRENT NRC SEISMIC [redacted] CRITERIA:

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

This equipment is qualified as a assembly when the air cylinders are completely qualified addressed in QID #018001.

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

PREPARED BY	J.E. Rakowski 1 [signature] 6/14/83 2 [signature] 11/4/83	DATE	3/25/83
REVIEWED BY	[signature] [signature] 6/15/83 [signature] 11-8-83	DATE	5/16/83
APPROVED BY		DATE	

968-12576

2.0 SQRT FORM(S) AND REFERENCES

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

Qualification Summary of Equipment

QID# 361104

Ref. No.

I. PLANT NAME: WNP-2

TYPE

PWR

1. NSSS: GE 2. A/E: Burns & Roe BWR 5, Mark II

II. COMPONENT NAME: 30" Cylinder Operated Butterfly V. COMPONENT NO. CSP-V-1 & 2 CEP-V-1A & 2A (Revision 1)

1. SCOPE: ☐ NSSS ☒ BOP

2. MODEL NUMBER: A-206763 QUANTITY: 2

3. VENDOR: BIF

4. IF THE COMPONENT IS A CABINET OR PANEL, NAME AND MODEL NO. OF THE DEVICES INCLUDED:

N/A

5. PHYSICAL DESCRIPTION: a. APPEARANCE: Butterfly Valve with 10" Cyl Operator

b. DIMENSIONS: 30" Nominal Diameters

c. WEIGHT: 1208 - Valve Assy; 914 - Operator & Bracket

6. LOCATION: BUILDING: Reactor

ELEVATION: 508' (CSP) and 588' (CEP)

7. FIELD MOUNTING CONDITIONS: ☒ BOLT (NO. ______ SIZE ______)

☐ WELD (LENGTH ______)

☐ ______

8. a. SYSTEM IN WHICH LOCATED: Containment Supply Purge Systems (CSP) Containment Exhaust Purge Systems (CEP)

b. FUNCTIONAL DESCRIPTION: Primary Containment isolation, prevention of of the release of radioactive material to the environment.

c. IS THE EQUIPMENT REQUIRED FOR: ☐ HOT STANDBY ☐ COLD SHUTDOWN

☒ BOTH ☐ NEITHER

9. PERTINENT REFERENCE DESIGN SPECIFICATION: WPPSS Spec. 2808-68

III. IS EQUIPMENT AVAILABLE FOR INSPECTION IN THE PLANT: ☒ YES ☐ NO

Qualification Summary of Equipment (Continued)

QID# 361104

Ref. No.

IV. EQUIPMENT QUALIFICATION METHOD:

☐ TEST ☒ ANALYSIS ☐ COMBINATION OF TEST & ANALYSIS

QUALIFICATION REPORT: Equipment Seismic and Hydrodynamic Requalification of 30" Cylinder Operated Butterfly Valve*

(NO., TITLE & DATE): File No. OS.01.F, June, 1983

COMPANY THAT PREPARED REPORT: Cygna Energy Services

COMPANY THAT REVIEWED REPORT: Washington Public Power Supply Systems

*Plus original valve analysis 1

V. VIBRATION INPUT:

1. LOADS CONSIDERED: a. ☐ SEISMIC ONLY

   b. ☐ HYDRODYNAMIC ONLY

   c. ☒ COMBINATON OF (a) AND (b)

2. METHOD OF COMBINING RRS: ☐ ABSOLUTE SUM ☒ SRSS ☐ OTHER (SPECIFY) ____

3. REQUIRED RESPONSE SPECTRA (ATTACH THE GRAPHS): Section 5.1 of QID 361104

4. DAMPING CORRESPONDING TO RSS: ☐ OBE ____ ☒ SSE 3%

5. REQUIRED ACCELERATION IN EACH DIRECTION: ☐ ZPA ☒ OTHER (SPECIFY) Section 5.5

   OBE S/S = Attached F/B = ____ V = ____

   SSE S/S = Attached F/B = ____ V = ____

6. WERE FATIGUE EFFECTS OR OTHER VIBRATION LOADS CONSIDERED?

   ☒ YES ☐ NO

   IF YES, DESCRIBE LOADS CONSIDERED AND HOW THEY WERE TREATED IN OVERALL QUALIFICATION PROGRAM:

   The calculated stress ranges were compared to the AISC allowables, as the structures analyzed were not part of the pressure boundary.

*NOTE: IF MORE THAN ONE REPORT, COMPLETE ITEMS IV THROUGH VII FOR EACH REPORT

Qualification Summary of Equipment (Continued)

QID# 361104

Ref. No.

VI. IF QUALIFICATION BY TEST, THEN COMPLETE*: N/A

1. ☐ SINGLE FREQUENCY ☐ MULTI-FREQUENCY ☐ RANDOM
2. ☐ SINGLE AXIS ☐ MULTI-AXIS ☐ SINE BEAT ☐ ____________

3. NO. OF QUALIFICATION TESTS: OBE ________ SSE ________ OTHER (SPECIFY) ________
4. FREQUENCY RANGE: ____________
5. NATURAL FREQUENCIES IN EACH DIRECTION (SIDE/SIDE, FRONT/BACK, VERTICAL):

   S/S = ____________ F/B = ____________ V = ____________
6. METHOD OF DETERMINING NATURAL FREQUENCIES:

   ☐ LAB TEST ☐ IN SITU TEST ☐ ANALYSIS
7. TRS ENVELOPING RRS USING MULTI-FREQUENCY TEST: ☐ YES (ATTACH TRS & RRS GRAPHS) ☐ NO

8. INPUT g-LEVEL TEST: OBE S/S = ________ F/B = ________ V = ________

   SSE S/S = ________ F/B = ________ V = ________
9. LABORATORY MOUNTING:

   ☐ BOLT (NO.______, SIZE ______) ☐ WELD (LENGTH ______) ☐ ______
10. FUNCTIONAL OPERABILITY VERIFIED: ☐ YES ☐ NO ☐ NOT APPLICABLE
11. TEST REULTS INCLUDING MODIFICATIONS MADE:

    ____

12. OTHER TEST PERFORMED (SUCH AS AGING OR FRAGILITY TEST, INCLUDING RESULTS):

    ____

*NOTE: IF QUALIFICATION BY A COMBINTATION OF TEST AND ANALYSIS, ALSO COMPLETE ITEM VII.

Qualification Summary of Equipment (Continued)

QID# 361104

Ref. No.

II. IF QUALIFICATION BY ANALYSIS, THEN COMPLETE:

1. METHOD OF ANALYSIS:

☐ STATIC ANALYSIS ☒ EQUIVALENT STATIC ANALYSIS

☐ DYNAMIC ANALYSIS ☐ TIME-HISTORY ☐ RESPONSE SPECTRUM

2. NATURAL FREQUENCIES IN EACH DIRECTION (SIDE/SIDE, FRONT/BACK, VERTICAL):

S/S = 13.0 Hz F/B = 11.45 Hz V = >100 Hz

3. MODEL TYPE:

☐ 3D ☐ 2D ☐ 1D ☐ FINITE ELEMENT ☒ BEAM ☐ CLOSED FORM SOLUTION

4. ☐ COMPUTER CODES: ______

FREQUENCY RANGE AND NO. OF MODES CONSIDERED: ______

☒ HAND CALCULATIONS

5. METHOD OF COMBINING DYNAMIC RESPONSES: ☐ ABSOULTE SUM ☐ SRSS ☒ OTHER (SPECIFY) ______

6. DAMPING: OBE ______ SSE ______ BASIS FOR THE DAMPING USED: N/A*

7. SUPPORT CONSIDERATIONS IN THE MODEL: pipe-mounted

8. CRITICAL STRUCTURAL ELEMENTS:

A.

IDENTIFICATION	LOCATION	GOVERNING LOAD OR RESPONSE COMBINATION	SEISMIC STRESS	TOTAL STRESS	STRESS ALLOWABLE
Operator Drive Rod	Cylinder on	Fatigue			
	CSP-V-1	Stress		86,826	90,000
	CSP-V-2	Range		57,526	90,000
Ear Weld	Support Ear	Fatigue			
	CSP-V-1	Stress		26,554	28,000
		Range			

△1

B.

MAX. CRITICAL DEFLECTION	LOCATION	MAXIMUM ALLOWABLE DEFLECTION TO ASSURE FUNCTIONAL OPERABILITY
< 0.01"	Valve disk radial deflection	approx 1/8" radial clearance

NOTE: Calculations based on accelerations for CSP-V-1 and 2 will provide an envelope for CEP-V-1A and 2A. See Table 1.1 of Section 4.3 for relative required accelerations for CSP and CEP valve operators.

* Computed stresses are based on "as-analyzed" g-levels, stresses due to the "as-built accelerations will differ slightly. See discussion Section 4.0 Appendix D1.

△2

Qualification Summary of Equipment (Continued)

QID# 361104

VIII. REFERENCES

1) BIF Drawings

	Drawing #	Rev#	Description
a	A-206763	F	General Arrangement
b	CEP-625-10		From Reactor Nozzle X-3 to SGT-FU-1A, 1B
c	CEP-625-11.12	H	From Reactor Nozzle X-3 to SGT-FU-1A, 1B
d	C-26095		Model A-83B Cylinder
e	A-206767		Valve Assembly
f	DOC-D-220-0310-IR-66	O	Tube errection iso-metric
g	D-207110	F	Valve Data Sheet
h	M-144		General Arrangment plan mis level
k	CSP-807-3.4		Containment purge air supply system

References continued on page 2.6

△2 D. Searle 11/4/83
D. Barlow 11/7/83

Completed By	J E Rakowski △1 6/14/83	Date	3/25/83
Reviewed By	D. E. Searle L. C. Fernandez 6/15/83	Date	5/16/83

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 4/29/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 2.6	

Reference cont'n

2) Formulas for Natural Frequency and Mode Shapes,
Robert D. Blevins
Van Nostrand Reinhold Company
1979 Edition

3) BIF Report TR-27234 and TR-27235, "Dynamic Torque Calculation of Butterfly Valve; Sizes 24 and 30 inch", dated November 10, 1982.

4) Report TR-74-8 by McPherson Assoc., Inc., "Design & Seismic Analysis 30" Cylinder operated Butterfly Valve". (Rev. 1) 12/31/75.

5) WPPSS letter to Cygna Energy Services, GE-02-RWH-018, 12/17/82.

6) WPPSS, WNP-2 SRM Equipment List Summary Sheets dated 2/10/83.

7) Cygna Energy Services, Equipment Qualification Walkdown Verification Form dated 7/14/82 and 7/19/82.

8) Cygna Energy Services, "Project Manual Design Criteria," DC-1, Rev. 1, 10/82.

9) Burns & Roe Revised Piping Analysis Loads for CSP-V-1 and 2 (received 4/13/83) and CEP-V-1A and 1B (dated 11/15/82).

10) Communications Report, R. Ricappito of BIF and J. Rakowski of CES, "BIF Valve Dimensions", 2/11/83

11) Cygna Energy Services, "Equipment Seismic and Hydrodynamic Requalification Calculation No. OS.01.F", QID No. 361104, Revision 1, May, 1983.

Calculation Sheet

Project: WPPSS, WNP-2 Seismic/Hydrodynamic Mechanical Equipment Requalification		Prepared By: L.C.Fernandez	Date: 4/29/83
Subject: 30"Butterfly Valves		Checked By: [signature]	Date: 4/30/83
System: CEP and CSP		Job No: 82044	File No: OS.01.F
Analysis No: 361104	Rev No: 1	Sheet No: 2.7	

△2 D. Searle 11/4/83
D. Barlow 11/7/83

UPSET CONDITION G-LEVELS

EPN	N	V	E
CSP-V-1	0.76	1.36	0.88
CSP-V-2	0.66	1.33	0.79

FAULTED CONDITION G-LEVELS (REQUIRED)*
8 AND 10 INCH AIR CYLINDER OPERATORS

EPN	HYDR LDS	ELEV 'R'	G'S N	G'S V	G'S E
CSP-V-1	Y	508.00	2.26	3.62	2.80
CSP-V-2	Y	508.00	1.44	3.54	1.90
CEP-V-1A	Y	588.00	1.93	2.23	1.85
CEP-V-2A	Y	588.00	0.96	2.11	1.16

* These accelerations represent the "as-analyzed" condition. △2
The required g-levels are tabulated in Section 5.5.
See Section 4 Appendix D1 for discussion of impact on stress levels.

1006 0:

3.0 TABLE OF CONTENTS

EQE / SYGMA

TABLE OF CONTENTS QID# 361104

Revision 1

CYGNA

TABLE OF CONTENTS
CON'T

QID# 361104

*Note: Excerpts from report included in specified section. For complete report see Cygna Energy Services File No. OS.01.F, QID 361104, "Equipment Seismic and Hydrodynamic Requalification of 30" Cylinder Operated Butterfly Valves," Revision 1, June, 1983.

Revision 1

4.0 CALCULATIONS - CYGNA REQUALIFICATION ANALYSIS

CYGNA

Calculation Cover Sheet

Project	Equipment Seismic and Hydrodynamic Requalification	Job No.	82044
		File No.	0S.01.F
Client	Washington Public Power Supply System	Calc. Set No.	1
		No. of Sheets	84

Subject

BIF 30" Cylinder Operated Butterfly Valves,
QID# 361104
EPNS: CSP-V-1, 2
CEP-V-1A, 2A

Statement of Problem

Seismic and Hydrodynamic Requalification of CSP-V-1, CSP-V-2, CEP-V-1A, CEP-V-2A to Burns and Roe Piping Analysis Loads.

Sources of Data

See References pages 4.3.53 and 54.

Sources of Formulae & References

See References pages 4.3.53 and 54.

Remarks The equipment requalification was performed based on calculations using Revised Burns and Roe Piping Analysis Accelerations, April, 1983. (See Section 5.5)
"As analyzed" loads are summarized in table form Sheet 2.7
For discussion of the effects of this discrepency refer to Sheet Appdx. D1

Originators	Checkers	Distribution	Revision No. 2
JE Rakowski	LC Fernandez	Supply System-2	Supersedes Calculation Set No.
H. Abolhoda	MA Scott	Project File-1	Revision 1 6-15-83
R. Hsieh	DE Searle		Approved By: [signature] Date: 6/15/83 11/7/83

1005.00

CYGNA

Calculation Sheet

Project		Prepared By:	Date
Subject		Checked By:	Date
System		Job No.	File No.
Analysis No.	Rev. No.	Sheet No.	

CONTENTS

Calculation Sheet

Project		Prepared By:	Date
Subject		Checked By:	Date
System		Job No.	File No.
Analysis No.	Rev. No.	Sheet No.	

SECTION 4.1

CONCLUSIONS

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification		Prepared By: L.C. Fernandez	Date 6/13/83
Subject: 30" Cylinder Operated Butterfly Valves		Checked By: M.A. Scott	Date 6/13/83
System: CAC & CEP		Job No. 82044	File No. OS.01.F
~~Analysis No.~~ QID 361104	Rev. No. 1	Sheet No. 4.1.1	

4.1 Conclusions

Four 30" BIF butterfly valves with Miller Fluid Power cylinder operators have been analyzed for structural integrity and operability to the seismic and hydrodynamic piping analysis loads. These Burns and Roe piping analysis loads are in the form of operator response g-levels. (see Ref. 9).

All four EPN's, i.e., CSP-v-1, CSP-V-2, CEP-V-1A and CEP-V-2A qualify with the following modifications:

1. Manufacturer supplied A-307 bolts must be replaced with A-325 bolts.

2. Shear plates must be added to reduce the ear weld stress (see sheets 4.3.30 through 4.3.48).

Valve operability was also demonstrated (see p. 4.3.20) while cylinder operability is addressed in QID No. 018001.

Calculation Sheet

Project		Prepared By:	Date
Subject		Checked By:	Date
System		Job No.	File No.
Analysis No.	Rev. No.	Sheet No.	

SECTION 4.2

SUMMARY OF RESULTS

CYGNA

Calculation Sheet

Project WPPSS Mechanical Equipment		Prepared By: J.E. Rakowski	Date 3/25/83
Subject 30" Butterfly Valves		Checked By: [signature]	Date 6/14/83
System CSP & CEP		Job No. 82044	File No. 0S.01.F
Analysis No. 361104	Rev. No. 1	Sheet No. 4.2.1	

SUMMARY OF RESULTS

Parametric data for the four subject valves in this report is given in Table 1.1. Results of the requalification analyses, which include a comparison of calculated stresses to the allowables are given in Table 1.2. Allowable stresses for the various material types are given in Table 1.3.

SUMMARY TABLE 1.1
30" VALVE PARAMETRIC DATA.

EPN	HYDRO LOADS	FUNCTION	ELEV-'R'	PIPE ORIENT	G LOADS FAULTED CONDITION* NORTH	VERT	EAST
CSP-V-1	Y	CONTAINMENT ISOLATION	508	H	1.46	3.67	1.74
CSP-V-2	Y	CONTAINMENT ISOLATION	508	H	1.44	3.57	1.90
CEP-V-1A	Y	DRYWELL EXHAUST	558	V	1.93	2.23	1.85
CEP-V-2A	Y	DRYWELL EXHAUST	558	V	0.96	2.11	1.16

* TRANSMITTED FROM THE FINAL PIPING ANALYSIS, REFER TO SECTION 5.6.5, AT VALVE OPERATOR. (REFER TO SECTION 5.5)

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification
Prepared By: J.E. Rakowski Date: 3/25/83
Subject: 30" Butterfly Valves
Checked By: L.C. Fernandez Date: 4/29/83
System: CSP and CEP
Job No. 82044
File No. OS.01/F
Analysis No. 361104
Rev. No. 1
Sheet No. 4.2.2

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification
Subject: 30" Cylinder Operated Butterfly Valve
System: CSP and CEP
QID 361104
Rev. No. 1
Prepared By: L.C. Fernandez Date 6/15/83
Checked By: M.A. Scott Date 6/15/83
Job No. 82044
File No. OS.01.F
Sheet No. 4.3.3

SUMMARY TABLE 1.2 ~ FAULTED CONDITIONS (STRESS IN PSI)

MEMBER	MATERIAL TYPE	TYPE STRESS	VALVE EPNS CSP-V-1	CSP-V-2	CEP-V-1A[1]	CEP-V-2A[1]	MATERIAL ALLOWABLE
TRUNNION PINS	SA-276	S	4108 MAX				11840
TAPERED PINS	SA-276	S	8985 MAX				11840
DRIVE LEVER	A-395	T	12169 MAX				43200
LEVER KEYWAY	A-395	T	27381 MAX				43200
MAIN SHAFT	SA-479	S	9127 MAX				14500
DRIVE ROD	4140	T	44732 MAX	30082			86400
EAR BOLTS	A-325[2]	T	12150 MAX	8790			66000
		S	9500 MAX	7539			26250
SHEAR ℄ WELD	E60	S	12577				28800
VALVE EAR WELD	E60	S	13277				28800

~ FATIGUE RESULTS (STRESS RANGE IN PSI)

MEMBER	MATERIAL TYPE	TYPE STRESS	CSP-V-1	CSP-V-2	CEP-V-1A	CEP-V-2A	ALLOWABLE STRESS RANGE
TAPER PINS	SA-276	S[3]	35940 MAX				90000
DRIVE ROD	4140	T	86826 MAX	57526			90000
TRUNNION PINS	SA-276	S[3]	16432 MAX				22500
SHEAR ℄ WELD	E60	S	25154				28000
VALVE EAR WELD	E60	S	26554				28000

1 EPNS CEP-V-1A AND CEP-V-2A ENVELOPED BY CSP-V-2 BY A WIDE MARGIN

2 AS INSTALLED BOLTS ARE CURRENTLY A-307 REQUIRE CHANGING TO A-325

3 FATIGUE EVALUATION OF A SHEAR LOAD RESOLVES INTO A TENSILE STRESS RANGE AS FOLLOWS: $\sigma_{MAX} = 2\tau_{MAX}$ $SR = 2\sigma_{MAX} = 4\tau_{MAX}$

2 4 COMPUTED STRESS LEVELS ARE BASED ON ACCELERATION FACTORS THAT VARY SLIGHTLY FROM THE REQUIRED VALUES. SEE DISCUSSION APPENDIX D-1 THIS SECTION.

11/4/83
11/7/83

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Calculation Sheet

Project WPPSS Mechanical Equipment Qualification		Prepared By: J.E. Rakowski	Date 3/25/83
Subject 30" Butterfly Valves		Checked By: L.C. Fernandez	Date 4/29/83
System CSP and CEP		Job No. 82044	File No. OS.01/F
Analysis No. 361104	Rev. No. 1	Sheet No. 4.2.4	

⚠1 [signature] 6/14/83
J.C. Fernandez 6/15/83

THIS SHEET NOT USED

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: J.E. Rakowski	Date: 3/25/83
Subject: 30' Butterfly Valves		Checked By: L. C. Fernandez	Date: 4/29/83
System: CSP & CEP		Job No.: 82044	File No.: OS.01/F
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.2.5	

SUMMARY TABLE 1.3

ALLOWABLE STRESSES

Since operability is required, the stresses for the faulted condition will be kept below yield*. The table below is based on AISC criteria and the yield stresses at temperature (340°F) from PG. 9 of REF. 4 for conservatism.

MATERIAL	YIELD STRS (psi)	LEVEL A & B: .6 Fy BENDING ALLOW.	LEVEL A & B: .4 Fy SHEAR ALLOW.	LEVEL D: 1.6 x .6 Fy = 0.96 Fy BENDING ALLOW.	LEVEL D: 1.6 x .4 Fy 0.64 Fy SHEAR ALLOW.
AISI-4140 HEAT TREATED	90,000	54,000	36,000	86,400	57,600
SA-276, GR 304	18,500	11,100	7,400	17,760	11,840
ASTM A-395-60-45-15	45,000	27,000	18,000	43,200	28,800
SA-307	23,300	13,980	9,320	22,370	14,900
AISI-1018 (MIN YIELD)	35,000	21,000	14,000	33,600	22,400
SA-193, GR B3, 304SS	31,000	18,600	12,400	29,760	19,840
SA-479, 304SS	22,650	13,590	9,060	21,744	14,500
SA-516, GR 60	28,000	16,800	11,200	26,880	17,920

* BRACKET BOLT ALLOWABLES TAKEN FROM AISC, 8TH ED., SEC. 1.5.2.2

SECTION 4.3

ANALYSIS

Project WPPSS Mechanical Equipment Requalification		Prepared By: L.C. Fernandez	Date 6/13/83
Subject 30" Cylinder Operated Butterfly Valves		Checked By: M.A. Scott	Date 6/13/83
System CAC & CEP		Job No. 82044	File No. OS.01.F
~~Analysis No.~~ QID 361104	Rev. No. 1	Sheet No. 4.3.1	

EQUIPMENT REQUALIFICATION FOR QID NO. 361104

BIF 30"CYLINDER OPERATED BUTTERFLY VALVES

4.3.1 Introduction

The four valves in this file are classified according to the parametric data given in Summary Table 1.1.

Since hydrodynamic loads apply (Ref. 7) fatigue analyses were provided for components with the highest stress range.

The analysis method calculates stress from north, vertical and east components of operator response g-levels. These g-levels are the result of the Burns & Roe piping analyses. (Ref. 9)

An SRSS analysis was set up in a computer program for each value 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. Valve ear bending stress components due to any one response g-level component are combined by absolute sum.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E.Rakowski	Date	1/10/83
Subject: 30" Butterfly Valves	Checked By: L. C. Fernández	Date	4/28/83
System: CSP & CEP	Job No. 82044.	File No.	OS.01/F
Analysis No 361104	Rev. No. 1	Sheet No. 4.3.2	

The computer analysis addresses only the more highly stressed components in the valve operator assembly. Separate analysis is given for the remaining components using a simpler approach with upper bound loads. This applies to all valve operator EPN's in QID 361106 (24" Valve/8" cylinders) and QID 361104 (30" valves/10" operators). Hand calculations which check selected portions of computer output is shown in Appendix C.

Appendix B of this section describes the air operator mass/stiffness model which was incorporated in the final piping analysis for calculation of operator response g-levels. The computer program includes an option for using the valve ear forces and moments which are directly output from the piping analysis with the valve/operator model included. This was not finally utilized, however, to qualify the subject equipment.

The equipment locations and elevations were taken from the P&ID's in section 6.0. Natural frequency calculations are given for the air operator assemblies in Section 4.3.2.1.

Preliminary analyses were performed which showed that, for operator response g-levels greater than approximately 3 g's, the air cylinder spring preload force would be exceeded and hence some disk flutter would occur when the valve is in the open position. The calculation in section 4.3.2.2 shows that the magnitude of the valve disk flutter vibration angle due to upper bound g-levels which occur in the hydrodynamic frequency range is approximately 6 degrees. This flutter was evaluated to have no detrimental effect on system safety function as noted in Reference 5.

Valve operability was addressed in the following manner. All valves have a Use Code of 1-3. It is noted that the g-levels pertaining to CSP-V-1 envelope CEP-V-1A and CEP-V-2A.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification		Prepared By: J.E.Rakowski	Date: 1/10/83
Subject: 30' Butterfly Valves		Checked By: L.C. Fernandez	Date: 4/28/83
System: CSP and CEP		Job No. 82044	File No. OS 01/F
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.3	

For valves CSP-V-1 and 2, which must operate from open to fail closed during an event, the following additional evaluations were made:

1) Dynamic flow torques were assessed per Ref. 3 and found to be less than the seating torque which controlled the equipment stresses. Furthermore these flow torques tend to move the valve disk toward the fail-closed position, as noted in the above report.

2) The details of BIF drawing 206 767, parts of which are shown in figures 1.1 and 1.2, allow the following conclusions to be made for valve operability:

   A) Figure 1.1 shows that thrust bearings are part of the shaft bearing design. This design prevents lateral movement of the disk in the direction of the shaft to eliminate interference with the valve body when closing. Further, it is noted on Page 26 of Ref. 3 that frictional torques in the shaft bearing system are [illegible]igible.

   B) Figures 1.1 and 1[illegible] CSP-V-1 [illegible]alve cross section hav[illegible] within which the valve se[illegible]osi- tion. The only me[illegible] af- fect valve closing [illegible]ated is out-of-round di[illegible]ion due to DBE piping l[illegible]ads on the valve.

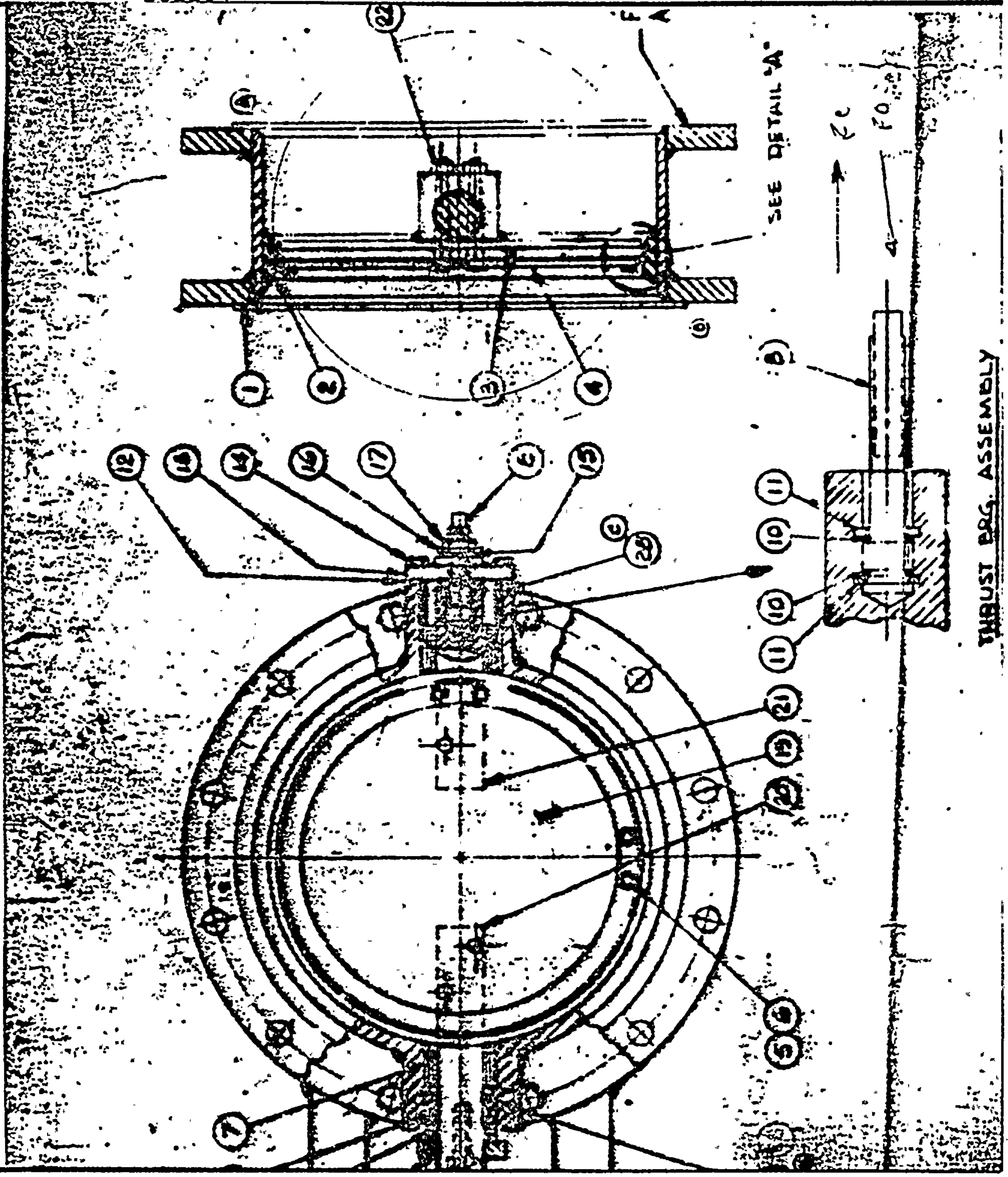
These loads were accounted for in Ref. 4 in the overall valve sizing calculations, where analysis showed that the stress intensity in the 0.5 inch thick valve body remained below 1.2 Sm, or approximately 0.8 of yield. Stress contribution from dynamic loads on the valve and operator were relatively small. Further, as shown in the figures:

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E.Rakowski	Date 1/10/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date 4/28/83	
System: CEP and CSP	Job No. 82044	File No. OS.01.F	
Analysis No. 361104	Rev. No.)	Sheet No. 4.3.4	

FIGURE 1.1 BIF DRAWING 206767



1006 00

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E.Rakowski	Date: 1/10/83	
Subject: 30" Butterfly Valves	Checked By: L. C. Fernandez	Date: 4/27/83	
System: CEP and CSP	Job No.: 82044	File No.: OS.01.F	
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.5	

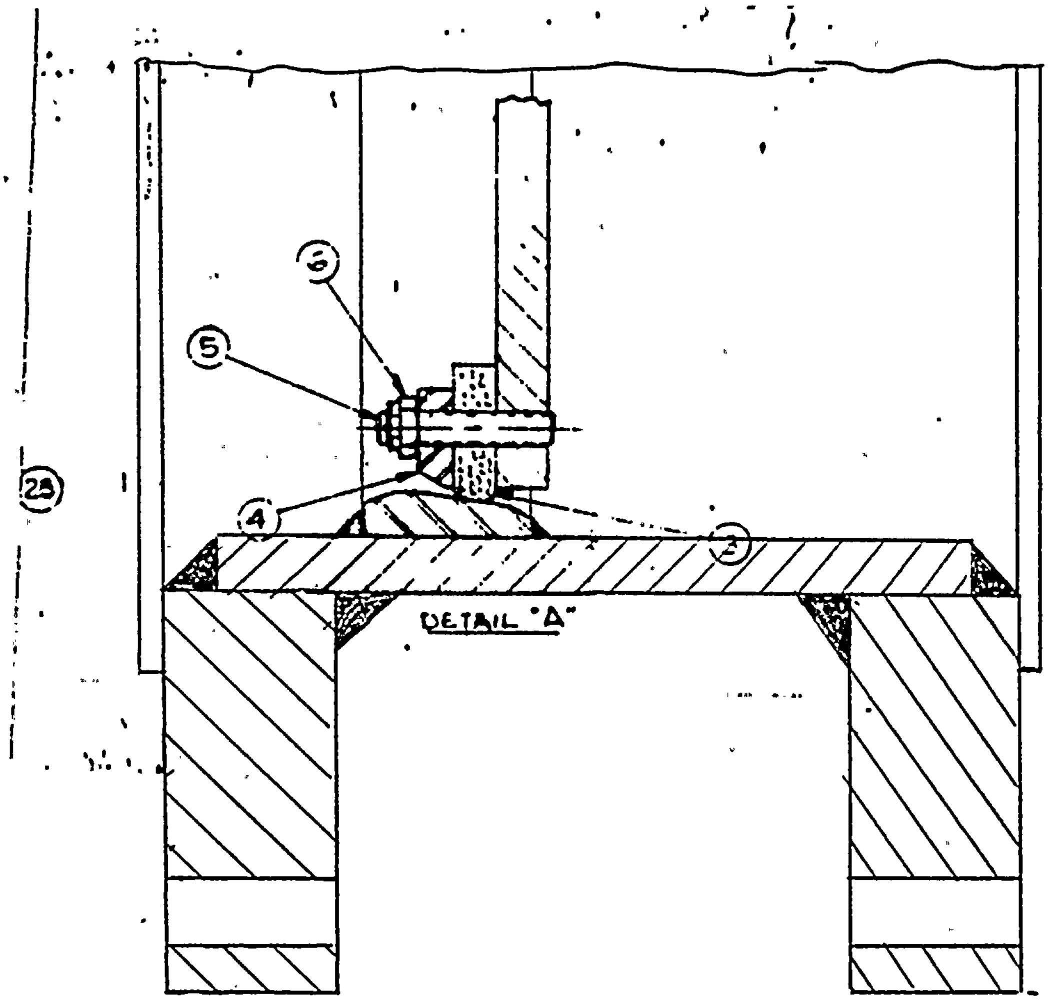


FIGURE 1.2 BIF DRAWING 206767, DETAIL A

1. The valve seat forms a heavily reinforced section made up of the valve body, internal hub and external flanges (including the mating flange of the piping). Hence the stress levels in this section are much lower than in the valve body and hence no distortion of the section could occur to affect seating of the valve. Valve flange dimensions are given below. Note the relatively large internal radial clearance of 1/8 inch.

2. Stress analysis of the valve extended structures are given in this report. Air operator operability is addressed in QID 018001.

   The design data used in the analyses are given in Summary Table 1.1 (pipe-orientations and elevations are taken from the appropriate P&ID's in Section 6.0). Other pertinant data is given below.

   1) Spring preload per communication report in Section 7.0 of QID 018001 are:

      Fail Closed Preload = 2800
      Final = 4800

   2) Cylinder C.G.'s shown on the following sketches represent data received from BIF in the communication report of Section 7.0 of QID 018001.

   3) Closing torque values are taken from Ref. 3.

   4) Valve component dimensions: (Ref. Feb. 10, 11/83 communication report - Section 7)

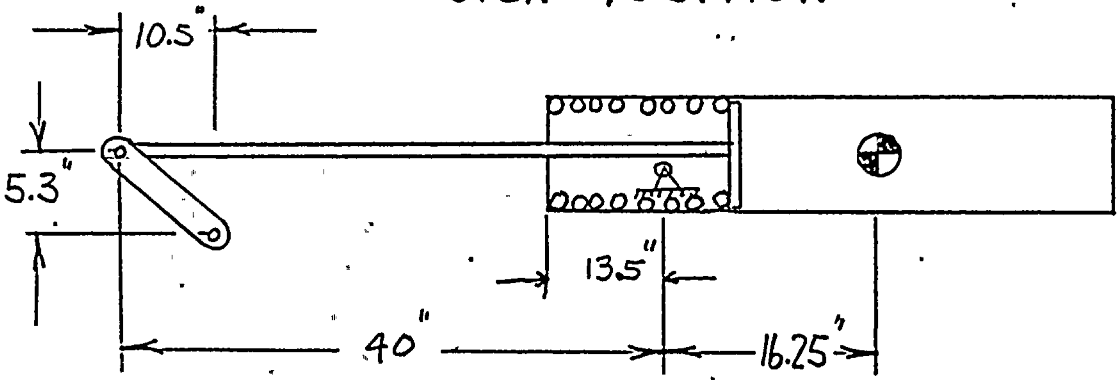
      Flange: width = 3.88", thickness - 2.625"
      Radial Clearance Disk/Seat 1/8"

CYGNA

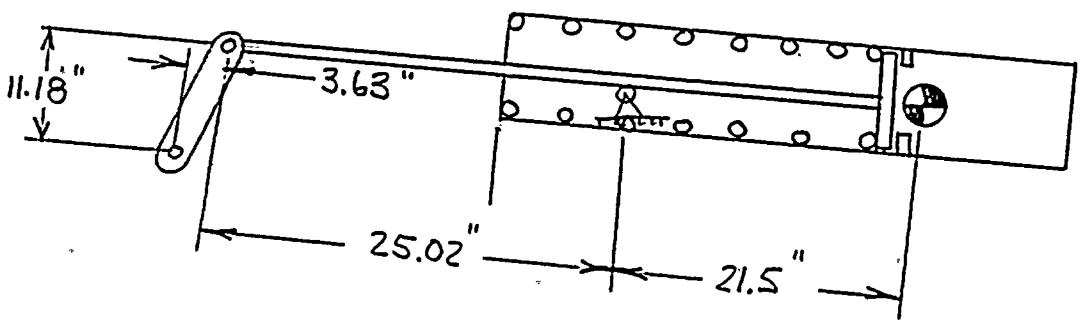
Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 4/28/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No 4.3.7	

OPEN POSITION



CLOSED POSITION



Calculation Sheet

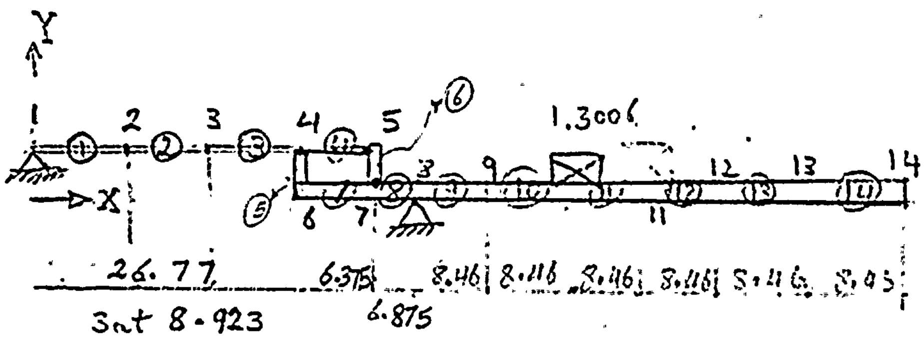
Project: WPPSS Mechanicla Equipment Qualification	Prepared By: H. Abolhoda J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 4/28/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.8	

4.3.2 CALCULATIONS

4.3.2.1 NATURAL FREQUENCY CALCULATIONS

SINCE THE 10" CYLINDERS ARE SIMILAR TO THE 8" CYLINDERS IN QID 361106, THE LOWEST NATURAL FREQUENCY OCCURS WHEN THE CYLINDER IS IN THE OPEN POSITION DUE TO THE GREATER FLEXIBILITY OF THE EXTENDED DRIVE ROD.

A SAP - ANALYSIS WAS PEFORMED TO CALCULATE NATURAL FREQUENCY. THE MODEL IS DESCRIBED BELOW.



IN THE MODEL, NO MOMENT RESISTANCE TAKES PLACE AT NODE 4 (SHAFT PINNED AT NODE 4), AND AT THE PISTON DISK, NODE 8.

PRESENTED BELOW ARE CALCULATIONS FOR THE GEOMETRICAL AND STRUCTURAL PROPERTIES OF THE MODEL ELEMENTS. THE COMPUTER INPUT AND OUTPUT ARE SHOWN ON PAGE 4.3.A6.

ROD AREA $= \pi/4 (D)^2 = \pi/4 (1.75)^2 = 2.405$ IN^2

CYL. AREA $= \pi/4 (D_o^2 - D_i^2) = 3.976$ IN^2

Total length of drive rod = 25.02+(50.75 − 42.625)

= 33.145 inches

mass of Rod per inch $= 2.4055 \times \frac{.286}{386.4} = .0017$

Total mass of Rod = 33.145 x .0017 = .056

mass of cylind per inch $= 3.9761 \times \frac{.286}{386.4} = .0028$

Total mass of cylinder = .0028 x 64 = .1781

Total mass of system $= \frac{593}{386.4} = 1.5347$

c.g. = 34.50" from cylinder end

CYGNA

Calculation Sheet

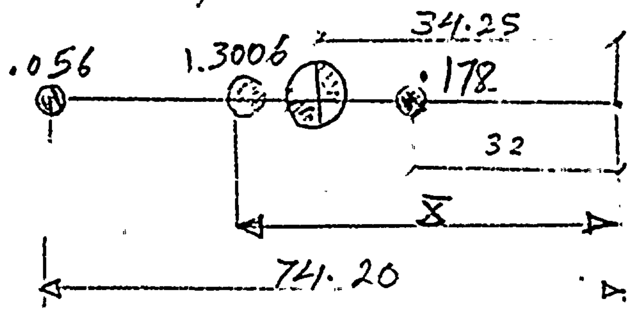
Project: WPPSS Mechanical Equipment Qualification	Prepared By: H. Abolhoda, J.E. Rakowski	Date	3/25/83
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date	4/28/83
System: CSP and CEP	Job No. 82044	File No.	OS.01/F
Analysis No. 361104	Rev. No.	Sheet No.	4.3.10

c.g. of Rod $= \frac{33.145}{2} + (64 - 6.375) = 74.20''$

c.g. of cylinder = 32"

total mass − mass of Rod & cylinder = 1.3006

a concentrated mass should be placed in certain distance (see below) to obtain an equivalent c.g. for total system



$$\bar{X} = \frac{34.25(1.5347) - .178(32) - 74.20(.056)}{1.3006} = 32.84$$

CALCULATION OF STIFFNESS

$I_{ROD} = \frac{\pi * 1.75^4}{64} = .4604 \qquad J_{ROD} = 0.9208$

$I_{CYL} = \frac{\pi}{64}(10.25^4 - 10.0^4) = 50.96\ IN^4 \qquad J_{CYL} = 101.92\ IN^4$

(CYLINDER THICKNESS MODELED AS 0.125")

CYGNA	CALCULATION SHEET	PREPARED BY H. AbolHODA	DATE 7/15/82
	PROJECT Supply System QID 361104	CHECKED BY R. Hsieh	DATE 7/23/82
	SUBJECT 30" Butterfly Valve	JOB NO. 8204	FILE NO. 05.01/F
	SYSTEM CEP/CSP		
	ANALYSIS NO. N/A REV. NO. Ø	SHEET NO. 4.3.11	

Computer Input to SAP RD

Related Info.
UFD = WPSSØS
SAP-INPUT-FILE= BV3Ø OFRS
SAP- OUTPUT-FILE = BV3Ø RS OUT

```
SLIST BV300FRS
CALCULATION OF NATURAL FREQUNCY OF 30 INCHES BUTTERFLY VALVE (OPEN)
 15      1      0      1      3
  1      1      1      1      1      1      0               5.0
  2      0      0      1      1      1      0   8.923       5.0
  4      0      0      1      1      1      0   26.77       5.0                          1
  5      0      0      1      1      1      0   33.145      5.0
  6      0      0      1      1      1      0   26.77       0.0
  7      0      0      1      1      1      0   33.145      0.0
  8      1      1      1      1      1      0   40.02       0.0         0.0
  9      0      0      1      1      1      0   48.48
 14      0      0      1      1      1      0   90.780      0.0         0.0              1
 15      1      1      1      1      1      1    0.0       20.0
  2     14      2             1
 129000000.                   .3      .0007
  1    2.41                                     .921      .4604       .4604
  2    3.98                                   101.92      50.96       50.96

  1      1      2     15      1      1
  4      4      5     15      1      1                                       1        1
  5      4      6      5      1      2                          010001
  6      5      7      4      1      2                                       1
  7      6      7     15      1      2                                                1
 14     13     14     15      1      2
 10      0   1.3006      1.3006

   386.4       386.4       0.0      1
A RESPONSE SPECTRUM WITH CONSTANT ACCLELERATION OF 1 G
  2
    .01        1.0
   100.        1.0
```

$f_{n_1} = 11.45$ Hz (OUTPUT)

09/81 CYGNA

[illegible]

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 4/28/83	
System: CSP and CEP	Job No.: 82044	File No.: OS.01/F	
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.12	

CALCULATION OF f_N PARALLEL TO THE DRIVE ROD AND TRUNNION PINS:

APP. B PG. 4.3.B3

BRACKET STIFFNESS IS: (CANTILEVER BEAM OF EFFECTIVE I_{zz})

$$K = \frac{P}{\delta} = \frac{3EI}{\ell^3} = \frac{3 \times 2.9(10)^7 * 4.22}{(28.5)^3}$$

($2.16\ IN^4$ FOR 8" CYL)
($3.54\ IN^4$ FOR 10" CYL)

$$= 15820\ lb/in$$

$$M = \frac{(\bar{W}_{AO} + \bar{W}_{BR})}{g} = \frac{(593 + 321)}{384.6} = 2.38\ \frac{lb\ sec^2}{in}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{M}} = \frac{1}{6.28}\sqrt{\frac{15820}{2.38}} = 12.98\ Hz$$

B) PARALLEL TO DRIVE ROD

APP. B, PG 4.3.B6

SAME MASS, STIFFNESS = EAR BENDING STIFFNESS

EAR STIFFNESS $= K_{yy} = 48 * 10^6\ lb/in\ (10")$, $= 7.5(10)^6\ \frac{lb}{in}\ (8")$

$$f_n\Big|_{10"} = \frac{10^3}{2\pi}\sqrt{\frac{48}{2.38}} = 715\ Hz$$

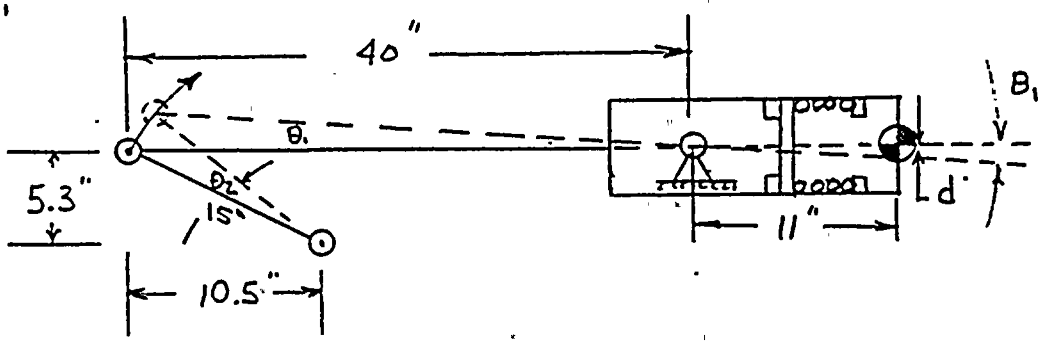
$$f_n\Big|_{8"} = \frac{10^3}{2\pi}\sqrt{\frac{7.5}{1.76}} = 328\ Hz$$

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 4/28/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.13	

4.3.2.2 APPROXIMATE VALVE FLUTTER MAGNITUDE

USING DIMENSIONS FROM FIGURE 1.3 :



CONSERVATIVELY ASSUME THAT THE MAX ACCELERATION COMPONENT OUTPUT FROM THE PIPING ANALYSIS FOR CSP-V-5 : (OPEN / FAIL-OPEN) PRODUCES DISPLACEMENTS OF THE AIR OPERATOR RELATIVE TO THE PIPE IN THE FORM OF

$$d_{max} = \frac{A}{\omega_n^2}, \quad \text{WHERE } A = 9.35 \text{ g's} * 386.4 \text{ "/s}^2 \text{ (TABLE 1.1)}$$

FROM THE SPECTRA IN SECTION 5.1, FOR HYDRODYNAMIC LOADS:

$$\omega_n \Big|_{MIN} = 2\pi \, (15 \text{ Hz}) \, (R/s)$$

$$\theta_1 = \tan^{-1} \frac{d}{11.0} = \tan^{-1}\left(\frac{1}{11} * \frac{9.35*386.4}{(94.2)^2}\right) = \left(\frac{.41}{11}\right) = \tan^{-1}(.04)$$

$$\theta_1 = 2.13^\circ$$

$$\therefore \theta_2 \sim 3 * \theta_1 \sim 6^\circ \quad \text{(SMALL)}$$

CYGNA

Calculation Sheet

Project WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date 1/10/83	
Subject 30" Butterfly Valves	Checked By: L.C. Fernandy	Date 4/28/83	
System CSP and CEP	Job No. 82044	File No. 0S.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.14	

⚠1 6/14/83 L.C. Fernandy 6/15/83

4.3.2.3 STRESS ANALYSIS

The procedures for the analysis of the subject valves are outlined below:

1. Recalculate the valve appurtenance stresses addressed in Ref. 4 using response g-levels from the Burns & Roe piping analysis. Incorporate the current seating torque given in Ref. 3. Compare stresses to the lower yield strengths in Summary Table 1.3.

2. If faulted condition stresses exceed the upset condition allowable stresses, repeat the analysis for the affected components using upset accelerations from the piping analysis.

3. Perform a fatigue analysis on significantly stressed components. Determine allowable alternating stress ranges from AISC 8th Edition, Appendix B, noting commentary.

The fatigue analysis is to be performed only for those EPN's subject to hydrodynamic loads. The number of respective load cycles is given below.

LOAD COMBINATIONS & STRESS CYCLES

The following table lists the load combinations and the nubmer of expected stress cycles for each combination. (From the design criteria)

	Combination	Cycles
1.	SRV Alone	3(4500)=13500
2.	OBE+SRV	50
3.	OBE+SRV+Chugging	2000
4.	SSE+SRV+Chugging/ SSE+ΔP	10

⚠1

Note: Load combination #4 with 15560 cycles can be used to conservatively bound all combinations.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 4/28/83	
System: CSP and CEP	Job No.: 82044	File No.: OS.01/F	
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.15	

STRESS ANALYSIS OF VALVE AND AIR OPERATOR COMPONENTS NOT COVERED IN QID 018001

1) TRUNNION PINS

TRUNNION PINS WERE ANALYZED AND THE SHEAR STRESS WAS FOUND TO BE PRIMARILY DEPENDENT ON OVERTURNING IN THE 3-AXIS DIRECTION. WHEN ANALYZED WITH AN ACCELERATION IN THIS DIRECTION OF 13.9 g's, THE SHEAR STRESS WAS ONLY 35 PERCENT OF THE ALLOWABLE. THEREFORE THE PINS ARE SUFFICIENT FOR ALL EPN'S.

THIS CALCULATION FOLLOWS:
[10" A/O ENVELOPED BELOW]

L_{ROD} = 25" (CLOSED) L_{CG} = 14.46"

	8"	10"
L_{CG}	14.46	21.50"
X	12.75	13.38"
A_{TP}	2.41 IN^2	2.41 IN^2

$M_1 = \bar{W}_{AO}\, g_3 L_{CG} = (399)(13.9)(14.46) = 80{,}139$ IN#

$F_{23} = \frac{M_1}{X} = \frac{80139}{12.75} = 6285$ # (CONTROLS STRESS, ENVELOPES 10" A/O G's BY WIDE MARGIN)

$F_{11} = \frac{(L_{ROD}+L_{CG})}{L_{ROD}} \frac{\bar{W}_{AO}}{2} g_1 = \frac{39.46}{25*2}(399)(1.04) = 327$ #

$F_{22} = \frac{\bar{W}_{AO}}{2} g_2 = \frac{399(1.66)}{2} = 332$ #

$F_{ST2} = \frac{1201^{\#}}{2} = 601$ #

$F_{WEIGHT(2)} = \frac{399}{2} = 200$ #

(801# FIXED)

$F'_{ST2} = \frac{\text{SEAT TRQUE}}{11.75"} \times \cos 11.82°$

FOR 8" $= \frac{13808''\#}{} \times .66 = 1150$ #

FOR 10" $= \frac{22{,}174''\#}{} \times .86 = 1847$ #

SEE BIF RPT & MCPHERSON RPT

CONSERVATIVE COMBINATION

$$\tau = \frac{1}{.75(2.41)}\left\{\left[\left(F_{23}+F_{22}\right)^2 + F_{11}^2\right]^{\frac{1}{2}} + F_{FIXED}\right\} = 4108 \text{ PSI} < 11{,}840 \text{ PSI}$$

(OK)

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski Date: 3/25/83
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez Date: 4/28/83
System: CSP and CEP	Job No. 82044 File No. OS.01/F
Analysis No. 361104 Rev. No.	Sheet No. 4.3.16

CLEVIS

4, 32 THE TOTAL LOAD ON THE CLEVIS IS THE VECTOR SUM OF $F_C \rightarrow$ AND $F_{ST} \downarrow$.

	8"	10"
F_{STZ}	1201# (MAX)	1847#
CLEVIS AREA	2.44"^{2}	2.44 IN^2

$$F_{CLEVIS} = \left[F_C^2 + F_{STZ}^2 \right]^{\frac{1}{2}}$$

ASSUME UPPER LIMIT OF $g_1 = 15g$'s JUST FOR

4, 33 THIS MEMBER, $F_{STZ} = 1847$#, $W_{AO} = 539$ # (10"), $L_{CG} = 21.5$"

$$F_{CLEVIS} = \left[1847^2 + 6953^2\right]^{\frac{1}{2}} = 7194 \#$$

$$\tau_{CLEVIS} = 7194\# / 2.44" = 2949 \text{ PSI} < 28{,}800 \text{ (OK)}$$

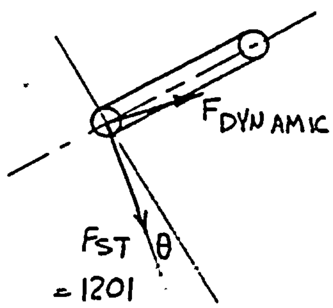
CLEVIS PIN $\tau = 7194\# / 3.53 \text{ IN}^2 * \frac{4}{3} = 2717 \text{ PSI} < 11{,}840 \text{ (OK)}$

4, 32 ∴ CLEVIS & PIN ARE GOOD FOR ALL 8" & 10" A/O EPN'S.

DRIVE LEVER

IMPOSE THE SEATING TORQUE LOAD AND DYNAMIC REACTION FORCE ON THE DRIVE LEVER IN THEIR RESPECTIVE DIRECTIONS:

$\theta = 6.5°$ MAX



REF 4, Pg 35 LOAD F_C WILL INCREASE THE AXIAL FORCE IN THE DRIVE LEVER, HOWEVER, THE MAXIMUM TORQUE ON THE LEVER IS THE SEATING TORQUE. THE AIR OPERATOR TRUNNIONS AND INTERNAL SPRING HOLD THE VALVE STABLE IN THE CLOSED POSITION.

1006 00

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 4/28/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No 361104	Rev. No. 1	Sheet No. 4.3.17	

MAX NORMAL FORCE ON DRIVE LEVER:

$F_{ST} \cos\theta + F_C \sin\theta = 2524$ LB (ENVELOPE)

$1847 * .99 + 6953 * .10 =$

MAX AXIAL FORCE ON DRIVE LEVER:

$F_{ST} \sin\theta + F_C \cos\theta = 7068$ LB (ENVELOPE)

$1847 \quad .10 \quad 6953 \quad .99$

REF 4, Pg. 34 — MINIMUM DRIVE LEVER AREA A = 1.875 IN^2, CONSIDERING FAILURE MODES.

AXIAL STRESS:

MAX BENDING MOMENT = 22,174 IN-LB (CONSERVATIVE FOR USE ON MIN. AREA OUT NEAR CLEVIS PIN)

$$\sigma_{AXIAL} = \frac{Mc}{I} + \frac{F_{AX}}{A}$$

REF 4, PG 35

$$\sigma_{AXIAL} = 22{,}174 * \frac{1.625}{4.29} + \frac{7068}{1.875} = 12{,}169 \text{ PSI}$$

12,169 < 43,200 PSI OK

SHEAR STRESS:

$$\tau = \frac{2524}{1.875} = 1346 \text{ PSI} < 28{,}800 \text{ PSI OK}$$

DRIVE LEVER SUFFICIENT ON BOTH 8" & 10" A/O's.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 4/28/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.13	

KEY WAY BEARING STRESS – DUE TO SEATING TORQUE

30" VALVE PARAMETERS:

REF 4, PG 36 — $A_B = 0.448\ IN^2$ — $A_B = .675\ IN^2$

REF 3, PG 3 — $M = 13{,}800$ IN-LB — $M = 22{,}174$ IN-LB

REF 4, PG 36 — $\frac{D_{MIN}}{2} = 1.125$ IN — $\frac{D_{MIN}}{2} = 1.25$ IN

$F_{BRG} = \frac{M * 2}{D_{MIN}} = 12{,}267$ LB (17,739)

$\sigma_{BRG} = \frac{F_{BRG}}{A_B} = 27{,}381$ PSI (26,280) ∴ 24" VALVE CONTROLS

27,381 < 43,200 PSI

OK MARGIN = 58%

REF 4, PG 37 — SHEAR AREA OF KEY = $1.33\ IN^2$.

THEREFORE – BEARING STRESS CONTROLS.

MAIN SHAFT:

PRELIMINARY ANALYSIS SHOWS THIS IS NOT A HIGHLY STRESSED COMPONENT, ∴ ANALYZE FOR ENVELOPE LOADS.

STRESS = STRESS DUE TO SEATING TORQUE +
STRESS DUE TO SHEAR OF F_{STZ} +
STRESS DUE TO BENDING OF F_{STZ}.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date 4/28/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.19	

	8"	10"
r =	1.1248"	1.25"
$J = 2I$ =	2.514 IN^4	3.83 IN^4
ℓ_5 =	6.005"	6.32"
ℓ_6 =	10.31"	11.18"
I_s =	1.257	1.916
T_s	13,808"#	22,174"#

REF 4, PG 49

① $\tau_T = \frac{T_s r}{J} = \frac{13{,}868\,(1.1248)}{2.514} = 6174$ PSI $\left\{ \frac{22174(1.25)}{3.83} = 7237\,PSI > 6174\,PSI \right\}$

② $\tau_{AVE} = \frac{F_{COMB.}}{A}$ FROM FIG. ON PAGE 4.3.16 & PG 4.3.17:

$F_{COMB} = [2524^2 + 7068^2]^{\frac{1}{2}} = 7505$ LB

$\tau_{AVE} = \frac{7505}{3.97} = 1890$ PSI

③ $M = \frac{1847\,(6.32)(11.18)}{16.315 = (\ell_6 + \ell_5)} = 7999$ IN-LB

$\sigma = \frac{Mc}{I} = \frac{7999 \times (1.1248)}{1.257} = 7158$ PSI

CONSERVATIVELY ADDING SHEAR STRESSES

	$\tau = 7237 + 1890 = 9127$ PSI < 14,500 OK
&	$\sigma = 7158$ PSI < 21744 OK

RESULT GOOD FOR BOTH 24" & 30" VALVES

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification		Prepared By: J.E. Rakowski	Date: 1/10/83
Subject: 30" Butterfly Valves		Checked By: L.C. Fernandez	Date: 4/29/83
System: CSP and CEP		Job No. 82044	File No. 0.S.01/F
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.20	

Disc

The stresses in the disc were shown on page 51 of Ref. 4 to be due almost entirely to the pressure load. Since the stress found in Ref. 4 of 4540 PSI will not change significantly for the new accelerations, the disc is acceptable.

Taper Pins

The stress in these pins is due only to the seating torque. The stress in Ref. 4, page 53, is 11265 PSI and is therefore acceptable. For the new, lower seating torque, the stress becomes 8985 PSI.

Analysis for: Drive Rod, cylinder bushing pressure, valve ears and valve ear bolts.

Method I: Use element forces and moments output from the piping analysis (Summary Table 1.1) and the absolute sum of stresses. The conservatism of SRSS summing of the component stresses cannot be assured because the independence of the six element forces (/moments) cannot be determined without analysis of modal participation.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification		Prepared By: J.E. Rakowski	Date: 1/10/83
Subject: 30' Butterfly Valves		Checked By: L.C. Ferrande	Date: 4/29/83
System: CSP and CEP		Job No.: 82044	File No.: OS.01/F
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.21	

Method II: Use the north, east and vertical operator accelerations output from the piping analysis. Absolute sum for stresses with each component then SRSS over results for N,E and V.

Note 1: Analysis of the distribution of stress on 4 valve ears to predict the maximum tensile stress cannot confirm a maximum value lower than the absolute sum of the elemental tensil stresses due to the six forces (from one acceleration direction, N,E or V). Therefore the absolute sum will be used at this level.

Note 2: Add stress due to the vector sum of deadweight plus seating torque force after above SRSS combinations are performed. (ABS)

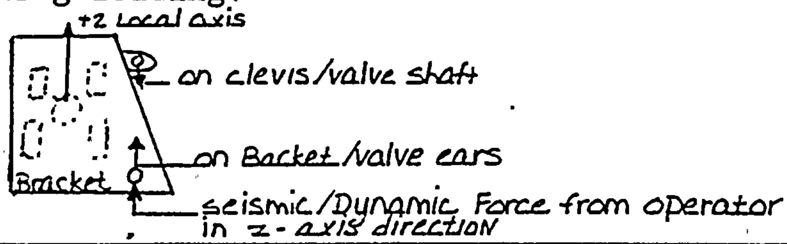
Note 3: 10" A/O parameters are shown for use in QID 361104.

<u>Analysis of Seating Torque Forces</u>

1) Seating Torque loads control the stress in the valve lever arm, keyway, shaft and taper pins. These stresses were less than allowables for the valves of seating torque given in Ref. 3, for all valves.

2) For valve EPN's which are Fail-Open with Use-Code 2, no seating torque forces are applied during the faulted and upset conditions (CSP-V-5,6).

3) For the Fail-Closed valves, the forces at the trunnion pins are shown below, along the cylinder axis, for +2-axis g-loading:



CYGNA

Calculation Sheet

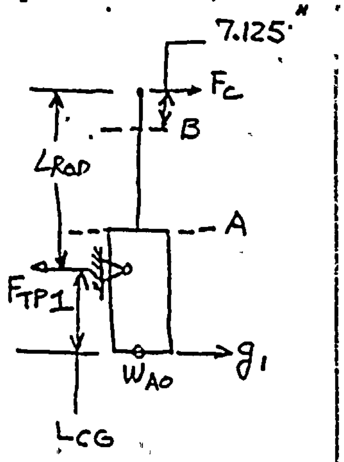
Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 1/10/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 4/29/83	
System: CSP and CEP	Job No.: 82044	File No.: OS .01/F	
Analysis No.: 36110.4	Rev. No.: 1	Sheet No.: 4.3.22	

As the bracket deflects in +2, under dynamic loads, the seating torque force is releived. The extent of relief depends on the relative stiffness of the bracket and valve ears relative to the valve seat. Since the steel backets and ears are very stiff in this direction, little relief can be expected. Hence seating torque forces will be added as an ABS sum to the valve ears. However, seating torque. force will oppose operator weight when the brackets hangs downward from horizontal pipes.

Operator Drive Rod

Drive rod dyanmic stress is due only to g_1 because g_3 and g_2 forces are taken out by trunnion pins. Add seating torque stresses.

$$F_c = \frac{L_{CG}}{L_{ROD}} W_{AO} g_1$$



TWO POINTS ARE CRITICAL, PT A AT THE BUSHING AND PT B AT THE REDUCED THREAD DIAMETER

$$M_A = F_c (L_{ROD} - 13.5")$$

$$\boxed{\sigma_A = \frac{M_A C_A}{I_A}}$$

$$M_B = 7.125 \; F_c$$

$$\boxed{\sigma_B = \frac{M_B C_B}{I_B}}$$

	8"	10"
I_A	.4604 IN^4	↑
C_A	.875 IN	Same
I_B	.1383 IN^4	Same
C_B	.6478 IN	Shaft
A_B	1.405 IN^2	↓
A_A	2.41 IN^2	2.41 IN^2

1006 00

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski — Date 3/25/83
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández — Date 4/29/83
System: CSP and CEP	Job No. 82044 — File No. OS.01/F
Analysis No. 361104 — Rev. No. 1	Sheet No. 4.3.23

FINALLY:

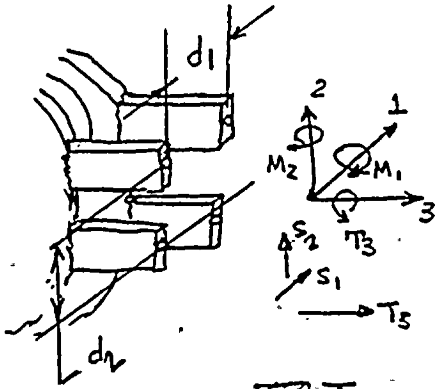
$$\sigma_A\Big)_{OPERATING} = \frac{F_{STZ}}{A_A} + \frac{M_A c}{I_A}\Big)_{DW}$$

$$\sigma_B\Big)_{OPERATING} = \frac{F_{STZ}}{A_B} + \frac{M_B c}{I_B}\Big)_{DW}$$

} ADD AS ABS SUM AFTER SRSS OF DYNAMIC COMPONENTS

SEISMIC / DYNAMIC FORCES ON VALVE EARS

A SAP-TYPE* MASS/STIFFNESS MODEL WAS PREPARED FOR THE PIPING MODEL TO CALCULATE A/O RESPONSE G-LEVELS (SEE ATTACHMENT). THE VALVE-EAR SYSTEM BENDING AND TORSIONAL FLEXIBILITY WAS INCLUDED IN THE MODEL AND SRSS FORCES AND MOMENTS WILL ALSO BE OUTPUT FOR CONVERSION INTO VALVE EAR STRESSES. THE EQUATIONS ARE:

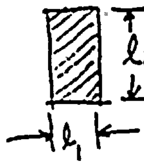


Tension due to M_1 & T_3:
(SEE LOCAL COORD. DEF'N – NEXT PG)

$2Pd_1 = M_1$

$\sigma_{M_1} = \frac{P}{A} = \frac{M_1}{2d_2 A}$ $A = l_1 l_2$

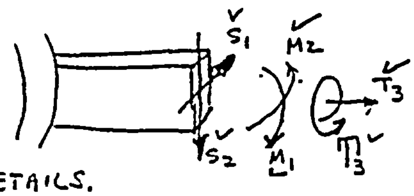
	8"	10"
l_2 =	2.5"	3"
l_1 =	1.5	1.75
d_1 =	7.5"	9.5"
d_2 =	10.0"	10.5"



① $\sigma_{T_3} = \frac{P}{4A} = \frac{T_3}{4 l_1 l_2}$ (tension due to T_3) + WHEN T_3 = +

② $\sigma_{3\,tension} = \frac{M_1}{2 d_2 l_1 l_2}$ due to M_1

SAP-MODEL:
(SEE ATTCHMNT)
(APPENDIX B)



TOP IN TENSION (+) WHEN M_1 IS +

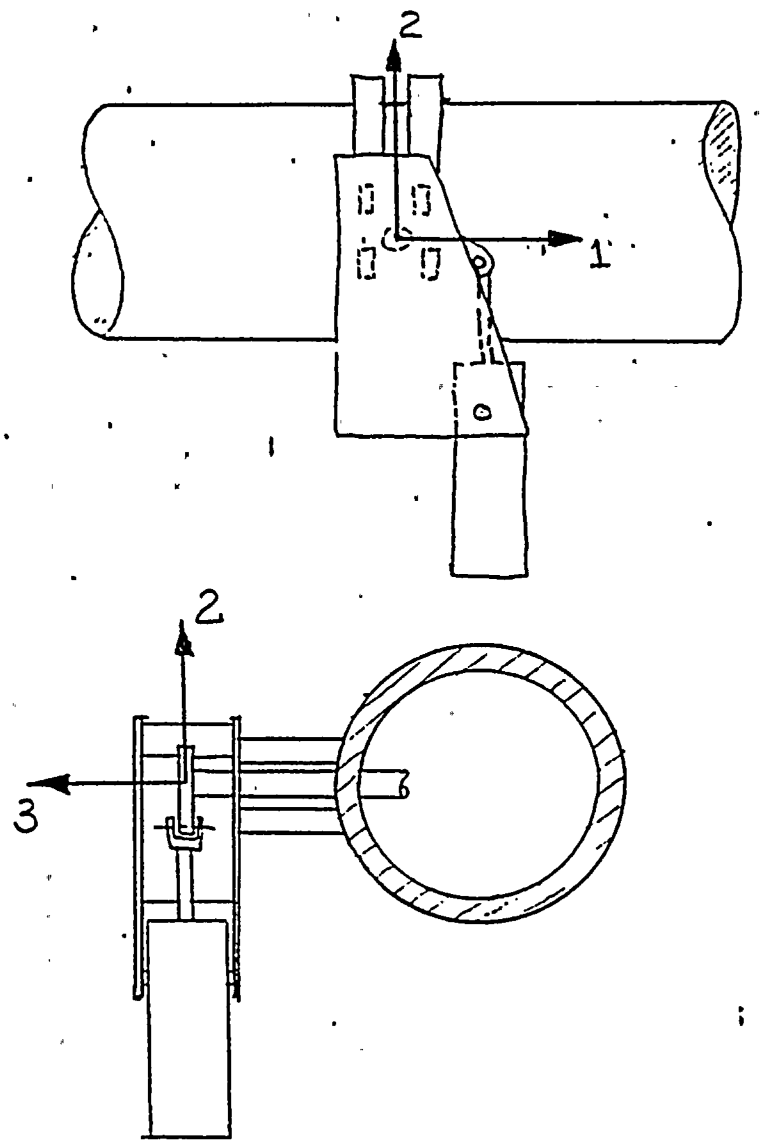
* STRUTURAL ANALYSIS PROGRAM. SEE APPENDIX A FOR ADDITIONAL DETAILS.

1006 00

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski Date: 3/25/83
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez Date: 4/29/83
System: CSP and CEP	Job No.: 82044 File No.: OS.01/F
Analysis No.: 361104 Rev. No.: 1	Sheet No.: 4.3.24

COORDINATE SYSTEM (LOCAL)



CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment		Prepared By: J.E. Rakowski	Date: 3/25/83
Subject: 30" Butterfly Valves		Checked By: L.C. Fernández	Date: 6/15/83
System: CSP and CEP		Job No.: 82044	File No.: OS.01/F
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.25	

⚠1 [signature] 6/14/83 LC Fernandez 6/15/83

BOLTS HOLDING BRACKETS TO EARS:

BOLT TENSION IS DUE TO M_1, M_2, T_3

BOLT SHEAR IS DUE TO S_1, S_2, T_3

AREA

	8"	10"
$A_B = \frac{\pi D^2}{4}$	$0.31 IN^2$	$.43 IN^2$
D	.6273"	.7387"

Tension (ABS SUM):

$$\sigma_{T3} = \frac{T_3}{4 A_B}$$

$$\sigma_T)_{M1} = \frac{M_1}{2 d_2 A_B}$$

$$\sigma_T)_{M2} = \frac{M_2}{2 d_1 A_B}$$

Shear:

$$F_{11}/bolt = F_c * AF_x$$
$$F_{22}/bolt = F_c * AF_y$$

(PREVIOUS PAGES 4.3.26, 27)

$$\tau_1 = \frac{F_{11}}{A_B} = \frac{F_c * AF_x}{A_B} \rightarrow \quad (1)$$

$$\tau_2 = \frac{F_{22}}{A_B} = \frac{F_c * AF_y}{A_B} \downarrow \quad (2)$$

Similarly: $$\tau_{S1} = \frac{S_1}{4 A_B} \rightarrow \quad (3)$$

$$\tau_{S2} = \frac{S_2}{4 A_B} \downarrow \quad (4)$$

COMBINE IN SAME MANNER AS ON PREVIOUS PAGE, FOR EARS BUT SUBSTITUTE A_B FOR $\ell_1 * \ell_2$

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 6/15/83	
System: CSP and CEP	Job No.: 82044	File No.: OS.01/F	
Analysis No.: 361104	Rev. No.: 1	Sheet No: 4.3.26	

METHOD II – THE PREVIOUS EQUATIONS FOR STRESS BY METHOD I ARE APPLICABLE. HOWEVER,

1) EXPRESSIONS FOR THE SIX FORCES/MOMENTS ARE DERIVED BELOW IN TERMS OF g-level COMPONENTS IN THE LOCAL AXIS SYSTEM (SUBSEQUENTLY DIRECTION COSINES WILL BE USED TO CONVERT THE N, E & V ACCELERATION VECTORS, IN TURN, IN TO LOCAL AXES). (SEE SECTION 5.4)

2) THESE EQUATIONS ARE TO BE USED TO FIND THE FORCES AND MOMENTS ON THE EARS DUE TO THE DEADWEIGHT AND SEATING TORQUE FORCES, FOR CALCULATION OF OPERATING STRESSES, FOR USE IN EITHER METHOD 1 & 2.

SEE FORCES & BRACKET ORIENTATION IN LOCAL COORDINATES, NEXT PAGE:

1: T_3 = TORSION ABOUT LOCAL AXIS # 3

$$T_3 = \Sigma M_{SHAFT} (+) = F_{TR1} e_3 + F_{BR1} e_4 + F_{AO2} e_2 + F_{BR2} e_1$$

$$= F_{TR1} e_3 + \bar{W}_{BR} g_1 e_4 + \bar{W}_{AO} g_2 e_2 + \bar{W}_{BR} g_2 e_1$$

$T_3 = (+)$	$= F_{TR1} e_3 + \bar{W}_{BR} g_1 e_4 + g_2 (\bar{W}_{AO} e_2 + \bar{W}_{BR} e_1)$
$T_{3\,FIXED} = (+)$	$= W_{ATR1} e_3 + (W_{AO2} + F_{ST2}) e_2 + W_{BR1} e_4 + W_{BR2} e_1$

1006 00

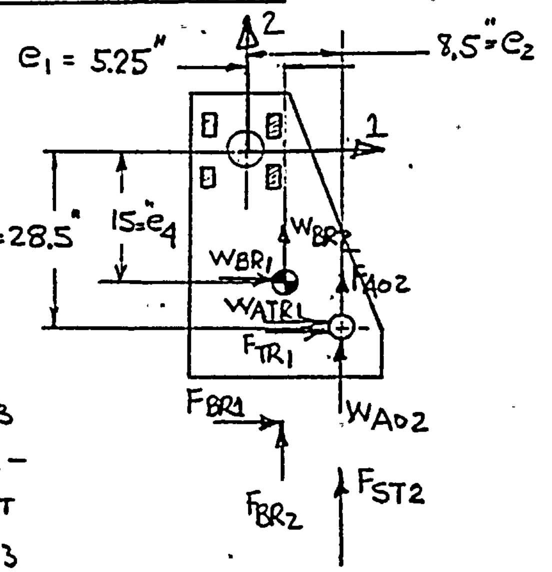
CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 6/15/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.27	

FORCES ON SUPPORT EARS DUE TO LOCAL-AXIS ACCELERATIONS g_1, g_2, g_3

FORCES IN THE LOCAL COORDINATE SYSTEM:



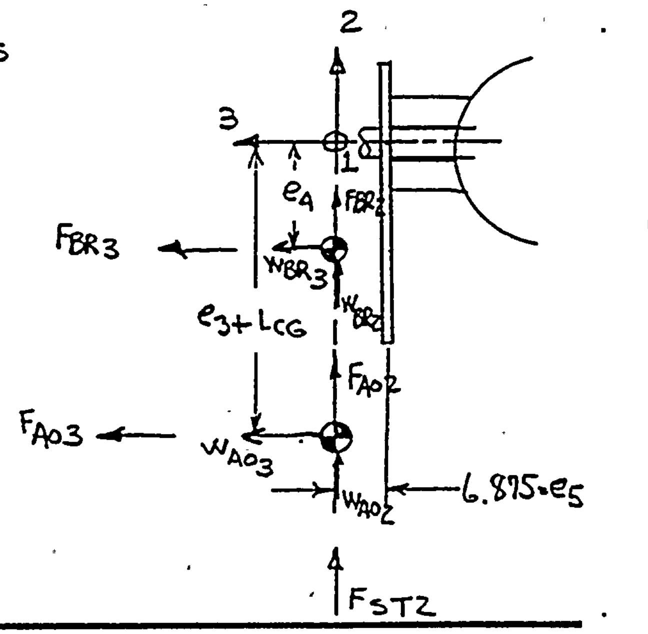
ELEVEN FORCES ACT IN THE LOCAL 1,2,3 A/O AXIS SYSTEM:

DYNAMIC:

- $F_{AO\,2,3} = \bar{W}_{AO} * g_{2,3}$
- $F_{TR\,1}$ = 1-AXIS COMPONENT OF DYNAMIC FORCE AT TRUNNION
- $F_{BR\,1,2,3}$ - 1,2,3 AXIS COMPONENTS OF BRACKET INERTIA $= \bar{W}_{BR} * g_{1,2,3}$

STATIC:

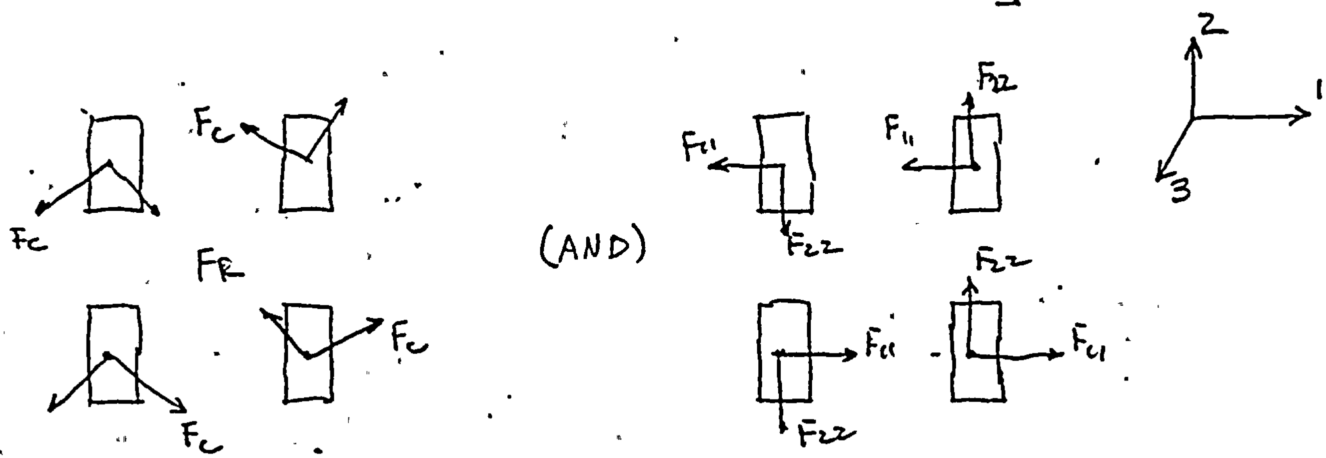
- W_{ATR1} = FORCE AT TRUNNION IN 1-AXIS <u>DUE TO</u> A/O WEIGHT
- $W_{AO\,2,3}$ = WEIGHT OF A/O IN AXES 1,2,3
- $W_{BR\,1,2,3}$ = WEIGHT OF BRACKET IN THE 1,2 & 3-AXIS DIRECTIONS
- $F_{ST\,2}$ = SEATING TORQUE FORCE, IS ALWAYS ALONG 2-AXIS.



Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification		Prepared By: J.E. Rakowski	Date: 3/25/83
Subject: 30" Butterfly Valves		Checked By: L.C. Fernandez	Date: 6/15/83
System: CSP and CEP		Job No.: 82044	File No.: OS.01/F
Analysis No: 361104	Rev. No.: 1	Sheet No.: 4.3.28	

FORCE ORIENTATIONS ON EARS: IF (+ T_3)



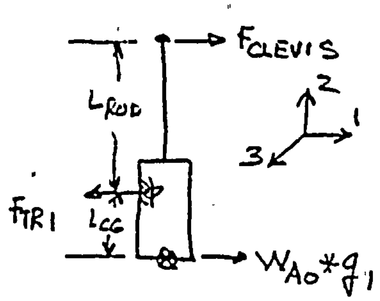
$$S_1 = F_{TR1} + F_{BR1} = \overrightarrow{F_{TR1} + \bar{W}_{BR}\, g_1}^{+}$$

$$S_{1\,FIXED} = \qquad = \overrightarrow{W_{BR1} + W_{ATR1}}^{+}$$

FROM A FORCE BALANCE OF THE OPERATOR:

$$F_{TR1} = + \frac{(L_{ROD} + L_{CG})}{L_{ROD}} * \bar{W}_{AO} * g_1 \quad (+\text{ FORCE ON BRKT})$$

$$W_{ATR1} = + \frac{(L_{ROD} + L_{CG})}{L_{ROD}} W_{AO1}$$



	LENGTH 8"		10"	
	OPEN	CLOSED	OPEN	CLOSED
LROD	40"	25"	40"	25"
LCG	10.96"	14.46	16.25"	21.5"

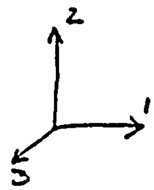
CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L. C. Fernandez	Date: 6/15/83	
System: CSP and CEP	Job No.: 82044	File No.: OS.01/F	
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.29	

$$S_2 = F_{AO2} + F_{BR2} = (\bar{w}_{AO} + \bar{w}_{BR}) g_2 \quad +\uparrow$$

$$S_{2\,FIXED} = w_{BR2} + w_{AO2} + F_{ST2} \quad +\uparrow$$

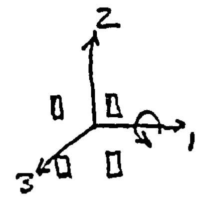


FOR OUT OF PLANE BENDING:

$$M_1 = (+) = -F_{AO2} e_5 - F_{BR2} e_5 - F_{AO3}(e_3 + L_{CG}) + F_{BR3} e_4$$

$$M_1 = -(\bar{w}_{AO} + \bar{w}_{BR}) g_2 e_5 - \bar{w}_{AO} g_3 (e_3 + L_{CG}) + \bar{w}_{BR} g_3 e_4$$

$$M_{1\,FIXED} = (w_{AO2} + w_{BR2} + F_{ST2}) e_5 - w_{AO3}(e_3 + L_{CG}) - w_{BR3} e_4$$

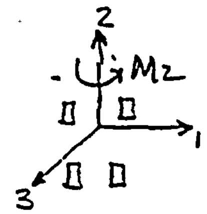


+ = TOP EARS IN TENSION

$$M_2 = (+) = +F_{TR1} e_5 + F_{BR1} e_5 - F_{AO3} e_2 - F_{BR3} e_1$$

$$M_2 = +(F_{TR1} + \bar{w}_{BR} g_1) e_5 - (\bar{w}_{AO} e_2 + \bar{w}_{BR} e_1) g_3$$

$$M_{2\,FIXED} = +(w_{ATR1} + w_{BR1}) e_5 - w_{AO3} e_2 - w_{BR3} e_1$$



+ = LEFT EARS IN TENSION

$T_3 = +\swarrow$ (+3 AXIS) $= (\bar{w}_{AO} + \bar{w}_{BR}) g_3$	$T_{3\,FIXED} = w_{AO3} + w_{BR3}$

T_3, M_1, M_2, S_1, S_2, & T_3 COMPLETE

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott		Date: 6/15/83
Subject: 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez		Date: 6/15/83
System: CSP and CEP	Job No.: 82044	File No.: OS.01.F	
~~Analysis No:~~ QID 361104	Rev. No.: 1	Sheet No.: 4.3.30	

Section 4.3.4 - Ear Support Weld Stress

Comparison of a similar file (QID No. 361106) to this file noted the unconservative assumption of considering the bracket support ears to be a guided cantilever (fixed-fixed). The resulting ear weld stresses exceeded the allowable stresses. The ear weld stresses can be lowered by the addition of shear plates to stiffen the whole assembly. The resulting weld stresses (both existing and modified) are to be kept within the fatigue allowable stress, i.e., ½ stress range. The allowable fatigue stress range from AISC for fillet welds in shear with less than 20000 cycles of loading is:

$$SR = (1.5)(15000) = 22500 \text{ PSI}$$

This includes the 50% increase due to fewer than 20000 cycles. The weld stresses are calculated using faulted loads. These loads produce less than one percent of the total 15560 cycles of faulted/hydrodynamic loading. Since the upset and emergency conditions are considerably lower in magnitude, small margins of overstress in fatigue will be tolerated for faulted stress levels. The following allowables will be adhered to in the ear weld stress calculations.

Allowable stress for welds for faulted conditions:

$$\sigma_{allow} = 1.6(0.3)Fu = 28800 \text{ PSI}$$

Allowable stress for welds subject to fatigue. This is ½ the allowable stress range of AISC Appendix B:

$$\sigma_{allow_{fat}} = \frac{1.25(1.5)(15)}{2} = 14 \text{ KSI}$$

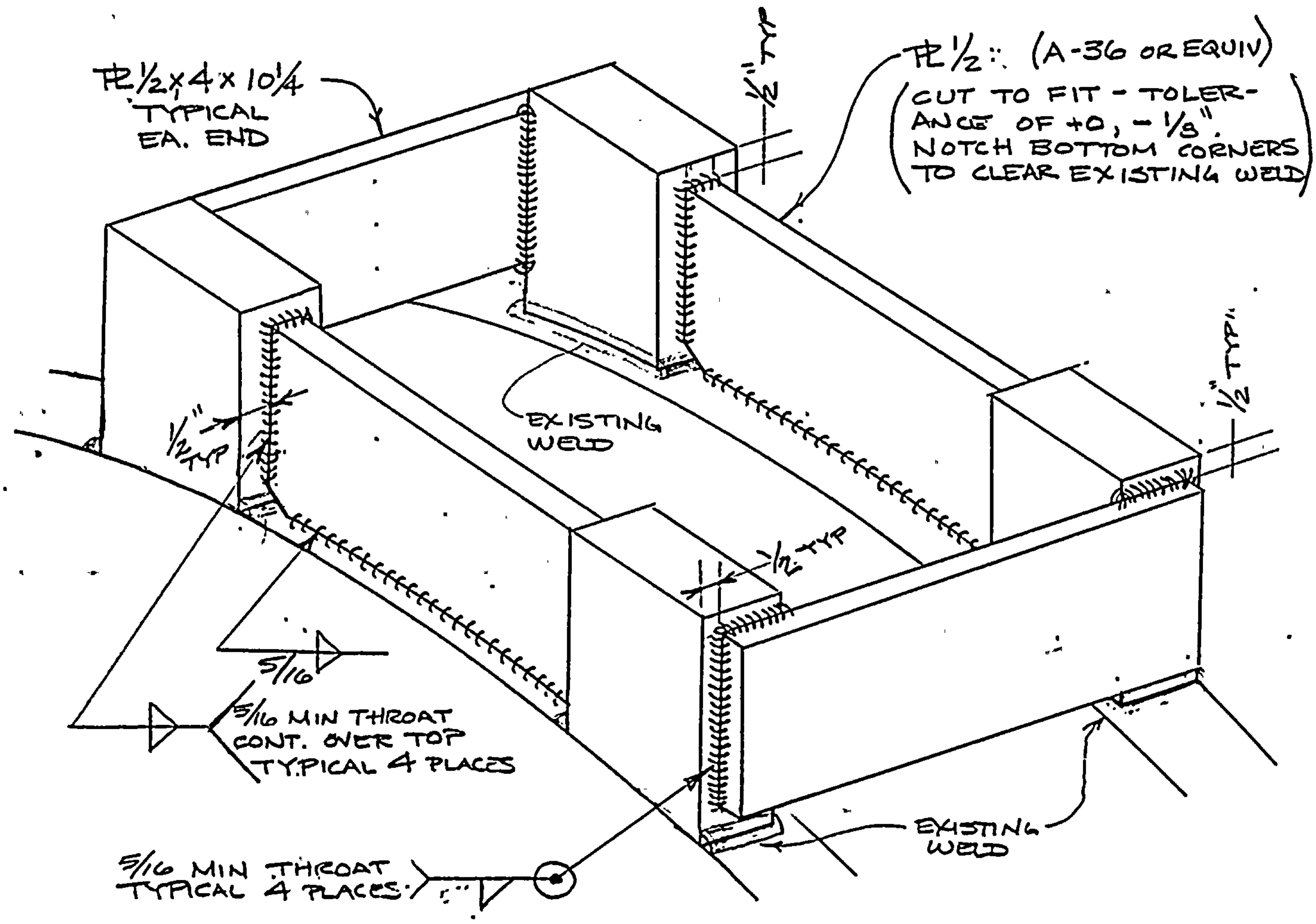
1.25 = 25% increase due to previous comments

1.5 = 50% increase due to AISC commentary

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott Date 6/15/83
Subject: 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez Date 6/15/83
System: CSP and CEP	Job No. 82044 File No. OS.01.F
~~Analysis No.~~ QID 361104 Rev. No. 1	Sheet No. 4.3.31



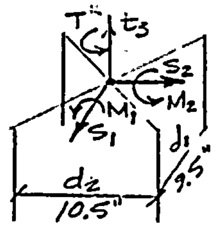
ALL WELD METAL E7018
PREHEAT 200°F MIN
3/4" MAX FILLET
EXEMPTED FOR POST WELD HEAT TREATMENT PER ASME III NC-4622.7.

TO BE REPAIRED UNDER SECTION 11 GUIDELINES

Calculation Sheet

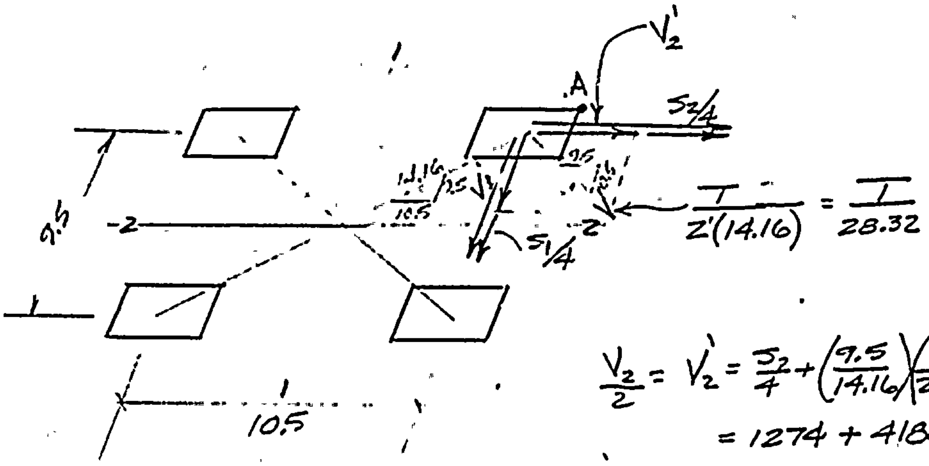
Project: WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott		Date: 6/15/83
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez		Date: 6/15/83
System: CSP and CEP	Job No. 82044		File No. OS.01.F
~~Analysis No.~~ OID 361104	Rev. No. 1	Sheet No. 4.3.32	

CSP-V-1



APPLIED LOADS @ TOP OF SUPPORT EARS

	S_1	S_2	t_3	M_1	M_2	T
OPERATING	0	2761	0	21398	0	22425
DYNAMIC	5094	3309	3270	148924	142329	154015
COMBINED	5094	6070	3270	170322	142329	176438



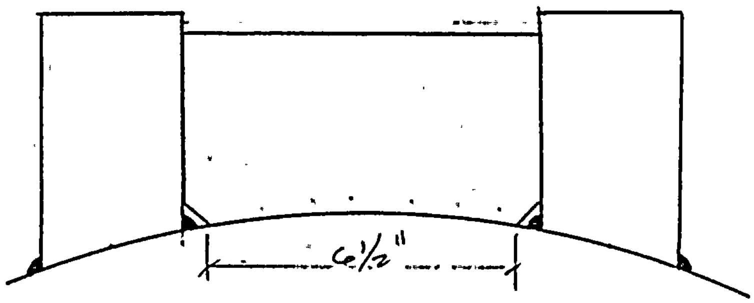
$$\frac{V_2}{2} = V_2' = \frac{S_2}{4} + \left(\frac{9.5}{14.16}\right)\left(\frac{T}{28.32}\right)$$

$$= 1274 + 4180 = 5454^{\#}$$

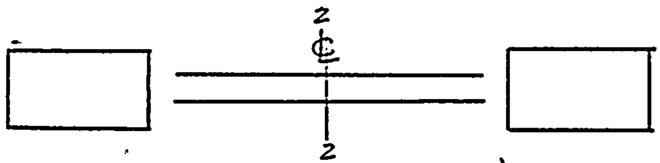
$$\frac{V_1}{2} = V_1' = \frac{S_1}{4} + \left(\frac{10.5}{14.16}\right)\left(\frac{T}{28.32}\right)$$

$$= 1518 + 4620 = 6138^{\#}$$

FOR THE 10½" SIDE, DUE TO THE RELATIVE STIFFNESS OF THE EARS TO THE PLATE ATTACH THE SHEAR PL TO THE FLANGE OF THE VALVE.



THE RESULTING WELD PROPERTIES @ THE FLANGE ARE THEN



$$A = \left(2\left[(3+1.75)2\right] + 2(6\tfrac{1}{2})\right)t_w =$$

$$= (19.0 + 13.0)\,t_w = 32\,t_w \ \text{IN}^2$$

$$I_2 = \left(2\left[\frac{3(1.75)^2}{2} + \frac{3^3}{6}\right] + \frac{6.5^3}{6} + 2\left(19.0(5.25)^2\right)\right)t_w$$

I EAR WELDS — I PL WELD — $A\,l^2$

$$= t_w\left[18.188 + 45.771 + 1047.375\right] = 1111.33\,t_w \ \text{IN}^4$$

[illegible]

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott	Date: 6/15/83	
Subject: 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez	Date: 6/15/83	
System: CSP and CEP	Job No.: 82044	File No.: OS.01.F	
~~Analysis No.:~~ QID 361104	Rev. No.: 1	Sheet No.: 4.3.34	

THE RESULTING SECTION MODULUS IS THEN

$$S = \frac{1{,}111.33\, t_w}{(5.25+1.5)} = 164.6\, t_w \ \text{IN}^3$$

THE SECTION PROPERTIES OF THE WELDMENT OF THE EARS ABOUT THE 1-1 AXIS WILL IGNORE THE CONTRIBUTION OF THE SHEAR PL WELDMENT. SINCE THE STRESS CALCULATIONS WILL ONLY USE THE INDIVIDUAL EAR THE PROPERTIES WILL BE CALCULATED THUS.

$$A_{EAR\,WELD} = t_w(3+1.75)2 = 9.5\, t_w \ \text{IN}^2$$

$$S_{1\,EAR} = \left[3(1.75) + \frac{1.75^2}{3}\right] = 6.271\, t_w \ \text{IN}^2$$

CYGNA

Calculation Sheet

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THE STRESSES ON THE WELDMENT ABOUT THE 1-1 AXIS IS DUE TO THE FOLLOWING LOAD

MOMENT @ WELDMENT

$$M_{11} = 170322 + 2(5454)(5") = 224862 \text{ IN-LB}$$

54540

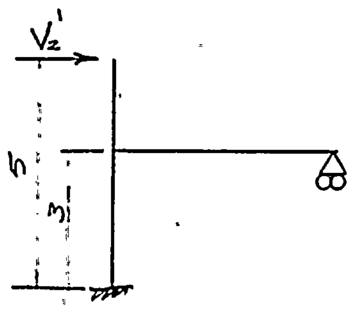
$$V_1 = 2(5454) = 10908 \text{ LB}$$

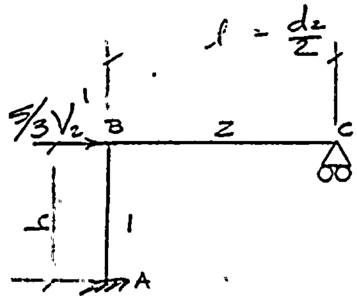
THE RESULTING WELD LOAD IS THEN:

$$f_{b_A} = M/S = 224862/164.6 = 1366 \text{ LB/IN}$$

$$f_{VH_A} = V/A = 10908/32 = 341 \text{ LB/IN}$$

THE V_2 SHEAR AND THE M_1 MOMENT APPLICATION TO THE EAR GROUP IS TREATED AS FOLLOWS





CYGNA

Calculation Sheet

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IN REVIEWING THE PROPORTIONS OF THE MEMBERS, THE BENDING DEFLECTIONS WILL BE NEGLIGABLE IN COMPARISON TO SHEAR. THE RESULTING RESPONSE OF BENDING OF THE EAR IN COMPARISON TO THE HORIZONTAL SHEAR DEFLECTION OF THE PLATE

$$\delta_b = \frac{Pl^3}{3EI} = \frac{6138(5)^3}{3(30E^6)\left(\frac{3(1.75)^3}{12}\right)} = .00636$$

ASSUMING THE 1/2" PL AND THE EARS ARE EFFECTIVE IN SHEAR

$$A_s = 2(3)(1.75) + 7.75(.5) = 14.375$$

$$\delta_s = \frac{PL}{AE_s} = \frac{2(6138)(5.0)}{14.375(12E^6)} = .000356$$

$$\frac{\delta_b}{\delta_s} = 17.88$$

⇒ SHEAR STIFFNESS IS ABOUT 18 TIMES AS STIFF AS BENDING

∴ ASSUME ~~THAT~~ THE RESULTING LOAD GOES PRIMARILY TO AXIAL AND SHEAR ON THE WELDMENT.

Calculation Sheet

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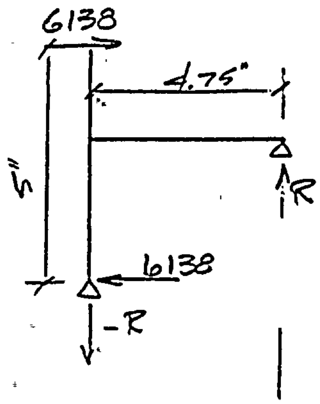

$$R = \frac{6138(5)}{4.75} = 6461\#$$

THE VERTICAL LOAD ON THE WELD DUE TO SHEAR AND BENDING MOMENT IS

$$f_{axial} = \frac{P}{A} + \frac{M_z}{d_z A_g} = \frac{6461}{9.5} + \frac{142329/9.51}{32}$$

$$= .680 + 468 = 1148 \ \#/IN$$

THE HORIZONTAL LOAD PRODUCES THE FOLLOWING SHEAR LOAD ON THE WELD.

$$f_{shear} = \frac{V_z}{A_s} = \frac{6138}{9.5} = 646 \ \#/IN$$

SINCE THE BENDING DOES CONTRIBUTE TO THE WELD STRESS CONSERVITIVELY ASSUME THE BENDING TO BE 10% EFFECTIVE OF TOTAL BENDING NEGLECTING SHEAR STIFFNESS.

Calculation Sheet

CYGNA

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FROM KLEINLOGEL'S "RIGID FRAME FORMULAS" FOR FRAME 5

$$I_1 = \frac{3(1.75)^3}{12} = 1.34 \text{ IN}^4$$

$$I_2 = \frac{.5(4)^3}{12} = 2.67 \text{ IN}^4$$

$l_1 = 3 \text{ IN}$

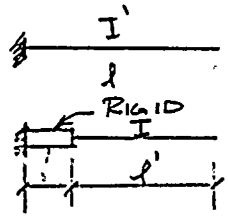
$l_2 = 9.5/2 = 4.75 \text{ IN}$

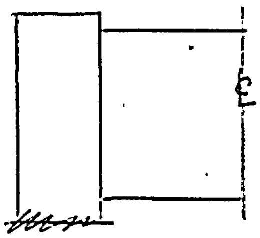
SINCE A PORTION OF THE SHEAR PLATE IS PART OF THE EAR MODIFY THE STIFFNESS (I) TO COMPENSATE FOR THE "RIGID" PORTION

$$\frac{I_2}{l'^3} = \frac{I_2'}{l^3}$$

$$I_2' = \frac{I_2 l^3}{l'^3} \cdot \frac{(2.67)(4.75)^3}{(4.75 - 1.75/2)^3}$$

$= 4.917$





FROM KLEINLOGEL

$$k = \frac{I_2'}{I_1} \cdot \frac{h}{l} = \frac{4.917\,(3.0)}{1.34\,(4.75)} = 2.318$$

$N = 3K + 1 = 7.954$

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott	Date	6/15/83
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$$M_B = \frac{3Phk}{2N} = \frac{3(5/3)(6138)(3.0)(2.318)}{2(7.954)} = 13415 \text{ IN LB}$$

$$M_A = -Ph + M_B = -(5/3)(6138)(3.0) + 13415$$

$$= -30690 + 13415 = -17274$$

THE AXIAL VERTICAL REACTION @ EITHER A OR C DUE TO HORIZONTAL SHEAR

$$V_C = -V_A = \frac{M_B}{l} = \frac{13415}{4.75} = 2824 \text{ LB}$$

THE RESULTING LOAD IN THE WELD IN THE EAR: AXIAL DIRECTION DUE TO BENDING IS THEN

$$f_b = \frac{M}{S} = \frac{17274}{6.271} = 2755$$

TEN PERCENT OF THIS VALUE IS THEN

$$f_b' = 2755(.10) = 276 \text{ \#/IN}$$

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott	Date 6/15/83	
Subject: 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez	Date 6/15/83	
System: CSP and CEP	Job No. 82044	File No. OS.01.F	
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TOTAL COMBINED LOAD

THE AXIAL LOAD t_3 WHEN APPLIED TO THE TOTAL AREA OF ATTACHMENT TO THE FLANGES PRODUCES THE FOLLOWING AXIAL LOAD ON THE WELD

$$f_a = \frac{t_3}{2A} = \frac{3270}{2(32)} = 51.1 \text{ LB/IN}$$

THE TOTAL COMBINED LOAD ON THE WELD IS THEN

$$f_{tot} = \left[(1366 + 1148 + 276 + 51)^2 + (341^2 + 666^2)\right]^{1/2}$$

$$= 2933 \text{ LB/IN}$$

THE RESULTING WELD STRESS IS THEN

$$\tau_{WELD} = \frac{2933}{(.707)(.3125)} = 13277 \text{ PSI} \leq 14000$$

* THIS STRESS LEVEL IS SOMEWHAT GREATER THAN THE ALLOWABLE STRESS FOR FATIGUE BUT CONTAINS THE OPERATING LOADS WHICH WOULD BRING THE ACTUAL ALTERNATING STRESS RANGE WITHIN ACCEPTABLE LIMITS.

CYGNA

Calculation Sheet

Project WPPSS Mechanical Equipment Requalification	Prepared By: M.A. Scott	Date 6/15/83	
Subject 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez	Date 6/15/83	
System CSP and CEP	Job No. 82044	File No. OS.01.F	
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THE STRESS LEVEL IN THE CORNER WELD DUE TO OPERATING LOADS IS

BENDING ABOUT THE 1-1 AXIS

$$V_2' = \frac{S_2}{4} + \left(\frac{9.5}{14.16}\right)\left(\frac{T}{28.32}\right)$$

$$V_2' = 690.3 + 531.5 = 1222 \text{ LB}$$

$$V_2 = 2V_2' = 2444$$

$$M_{11} = 21398 + 2444(5) = 33618$$

$$f_{b_{11}} = \frac{M_{11}}{S_{11}} = \frac{33618}{164.6} = 204 \text{ \#/IN}$$

SHEAR ALONG THE 22 AXIS

$$f_{v_{22}} = \frac{V_2'}{A} = \frac{1222}{32} = 38 \text{ \#/IN}$$

LOAD DUE TO SHEAR IN 1-1 DIRECTION

$$V_1' = \left(\frac{10.5}{14.16}\right)\left(\frac{T}{28.32}\right) = 587 \text{ \#}$$

THE ~~SHEAR~~ ALONG THE 1-1 AXIS IS THEN!

$$f_{v_{11}} = \frac{587}{9.5} = 62 \text{ \#/IN}$$

CYGNA

Calculation Sheet

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Subject: 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez	Date	6/15/83
System: CSP and CEP	Job No. 82044	File No.	OS.01.F
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THE AXIAL LOAD ON THE WELD IS THEN

$$f_a = \frac{587(5)}{(4.75)9.5} \doteq 65. \#/in$$

THE 10 PERCENT CONTRIBUTION FROM BENDING IS THEN

$$f_b = 276\left(\frac{587}{6138}\right) = 26 \#/in$$

THE COMBINED LOAD FOR OPERATING IS THEN

$$f_t = \left[(204 + 65 + 26)^2 + (38^2 + 62^2)\right]^{1/2}$$

$$= 303.8 \#/in$$

THE RESULTING STRESS LEVEL IS THEN

$$\sigma_{weld} = \frac{303.8}{.707(.3125)} = 1375 \text{ PSI}$$

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Calculation Sheet

CYGNA

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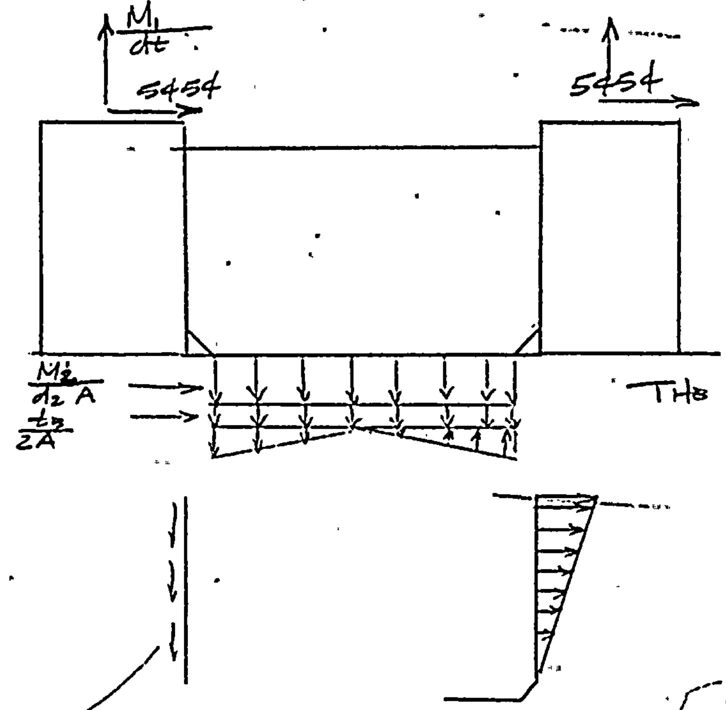
Subject: 30" Cylinder Operated Butterfly Valves		Checked By: L.C. Fernandez	Date: 6/15/83
System: CSP and CEP		Job No.: 82044	File No.: OS.01.F
~~Analysis No.~~ QID 361104	Rev. No. 1	Sheet No. 4.3.43	

THE WELD STRESS ON THE STIFFENING PL OF THE 10.5" DIRECTION IS CALCULATED AS FOLLOWS. CONSERVATIVELY COMBINE WORST CASE TENSILE AND SHEAR STRESS.



THE AREA OF WELD MENT OF PL TO FLANGE

$A_F = 2(6\frac{1}{2}") = 13 \text{ in}$

GROSS PL & EAR PROP

$Q@_{WELD} = (5.25)(5.75) = 30.2$

$I_g = \frac{3(13.5)^3}{12} - \frac{2.5(7.5)^3}{12} = 527.2$

TO GET PEAK STRESS @ END

$$\frac{M_2}{d_2 A}\frac{(13\frac{1}{2})}{4_{IN}} + \frac{t_3}{2A}\frac{(13\frac{1}{2})}{4_{IN}} + \frac{VQ}{I}(2)$$

$$= \frac{468(6.5)}{4} + \frac{(51.1)6.5}{4} + \frac{2(5454)\cdot 30.2(\cdot 2)}{527.2}$$

$$= 761 + 83 + 1250 = 2094 \text{ LB/IN}$$

WELD SHEAR LOAD

CYGNA

Calculation Sheet

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Subject: 30" Cylinder Operated Butterfly Valves	Checked By: L.C. Fernandez	Date: 6/15/83	
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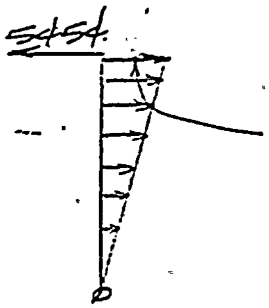
~~Analysis No.~~ QID 361104	Rev. No.: 1	Sheet No.: 4.3.44	

THE MAXIMUMUM TENSILE LOAD IS THEN



ASSUMING PINED @ THE BOTTOM AND EQUATING MOMENTS.

$$5454\,l = \frac{wl}{2}\,\frac{2l}{3}$$

$$w = \frac{5454(3)}{l} = 4091 \ \#/\text{IN}$$

COMBINE THE TENSILE AND THE SHEAR TO COME UP WITH THE REQUIRED WELD SIZE

$$f_{tot} = \left(4091^2 + 2094^2\right)^{1/2} = 4596 \text{ LB/IN}$$

TO STAY BELOW THE STRESS VALUE OF 11500 PSI FOR FATIGUE AND USING 2 WELDS ALONG THE LENGTH

$$t_w = \frac{4596}{(11{,}500)(.707)(2)} = .283 \text{ IN}$$

$\Rightarrow$ USE 5/16 FILLET EA SIDE.

FOR THE WELDMENT @ THE BOTTOM OF THE SHEAR PLATE THE LOADS AND RESULTING STRESSES ARE AS FOLLOWS.

Calculation Sheet

Project: WPPSS Mechanical Equipment Requalification		Prepared By: M.A. Scott [initials]	Date: 6/15/83
Subject: 30" Cylinder Operated Butterfly Valves		Checked By: L.C. Fernandez [initials]	Date: 6/15/83
System: CSP and CEP		Job No.: 82044	File No.: OS.01.F
~~Analysis No.~~ QID 361104	Rev. No.: 1	Sheet No.: 4.3.45	

THE SHEAR LOAD PER LENGTH IS

$$f_v = \frac{(5454)(2)([illegible]}{32} = 341 \text{ LB/IN}$$

THE AXIAL LOAD DUE TO AXIAL OVERTURNING AND MOMENT LOADS IS THEN:

$$f_a = \frac{M_1}{d_2 A} + \frac{t_3}{2A} + \frac{Mc'}{I} =$$

$$= 560 + 51.1 + \frac{196869(6.5/2)}{1111.33}$$

$$= 560 + 51.1 + 575.7 = 1187 \text{ \#/IN}$$

THE TOTAL COMBINED LOAD

$$f_T = (1187^2 + 341^2)^{1/2} = 1235 \text{ \#/IN}$$

ASSUMING A 5/16" WELD ON EACH SIDE OF THE PLATE THE RESULTING WELD STRESS IS THEN

$$\tau_{WELD} = \frac{1235}{(.707)(.3125)\,2} = 2795 \text{ PSI} \leq 14000$$

CYGNA

Calculation Sheet

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System: CSP and CEP		Job No.: 82044	File No.: OS.01.F
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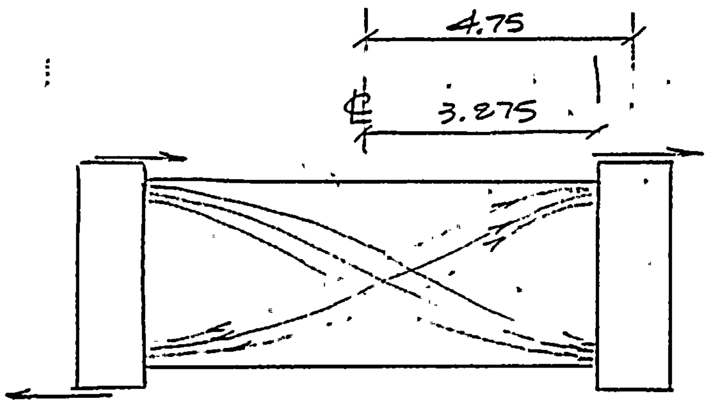
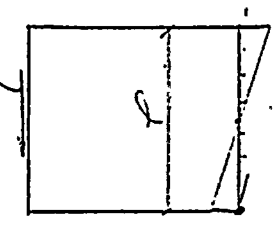
THE MAXIMUM LOADS ON THE WELD OF THE OTHER PLATE ARE AS FOLLOWS. SINCE THE BASIC RESISTANCE TO DEFLECTION IS BY SHEAR RESISTANCE OF THE PLATE THE PLATE IS BASICALLY ACTING LIKE A DIAGONAL MEMBER AS SHOWN BELOW.





FROM THE ORIGINAL FREEBODY THE ℄ SHEAR WAS 6461 # AND THE MOMENT WOULD BE $6461(3.875) = 25036$ IN LB. $S = \frac{t_w (4)^2}{6} = 2.67$

CYGNA

Calculation Sheet

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Subject: 30" Cylinder Operated Butterfly Valves		Checked By: L.C. Fernandez	Date: 6/15/83
System: CSP and CEP		Job No. 82044	File No. OS.01.F
~~Analysis No.~~ QID 361104	Rev. No. 1	Sheet No. 4.3.47	

THE RESULTING LOAD FROM THIS APPROACH

$$f_b = \frac{M}{S} = \frac{25036}{2.67} = 9377 \ \#/\text{IN}$$

THE RESULTING SHEAR LOAD WOULD BE

$$f_v = \frac{V}{A} = \frac{6461}{4} = 1615 \ \#/\text{IN}$$

THE COMBINED LOAD WOULD BE

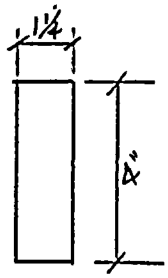
$$f_t = \left(9377^2 + 1615^2\right)^{1/2} = 9515$$

FOR A 5/16 WELDMENT ON EITHER SIDE THE RESULTING WELD STRESS WOULD THEN BE

$$\sigma_{WELD} = \frac{9515}{(.707)(.3125)(2)} = 21533 \ \text{LB/IN}^2$$

TOO HIGH

IF THIS WERE CHANGED TO A PL ON THE OUTSIDE OF THE EARS WITH A WELDMENT WITH THE FOLLOWING PROPORTIONS



$$A = 2(4 + 1.25) = 10.5 \ \text{IN}$$

$$J = \frac{(b+d)^3}{6} = \frac{(4+1.25)^3}{6} = 24.1$$

THE MOMENT WOULD BE

$$6461\left(3.875+\left(1.25/2\right)\right)=(4.5)(6461)=29075$$

THE HORIZONTAL SHEAR LOAD @ THE TOP WOULD BE

$$f_h=\frac{Mc_v}{J}=\frac{29075\,(2'')}{24.1}=2413\ \#/\text{IN}$$

THE VERTICAL SHEAR LOAD @ THE TOP WOULD BE

$$f_v=\frac{Mc_h}{J}+\frac{V}{A}=\frac{29075(.625)}{24.1}+\frac{6461}{10.5}$$

$$=754+615=1369\ \#/\text{IN}$$

THE TOTAL LOAD ON THE WELD IS THEN

$$f_{tot}=\left(2413^2+1369^2\right)^{1/2}=2774$$

THE RESULTING WELD STRESS IS THEN

$$\sigma_{WELD}=\frac{2774}{.707(.3125)}=12557\ \text{PSI}\ \leq\ 14000^{*}$$

* THIS LOAD IS SOMEWHAT HIGH BUT CONTAINS THE OPERATING LOADS SO THE ACTUAL FATIGUE RANGE IS LOWER. AND IS SO ACCEPTABLE

Section 4.3.5 - Fatigue Analysis

Discussion

The operator and bracket assembly are not part of the pressure boundary, therefore, the fatigue analysis will be performed in accordance with Appendix B of the AISC Manual for Steel Construction. The following assumptions apply to the fatigue analysis.

1) Faulted stresses (based on piping-analysis accelerations) will be used. This is necessary to insure operability after a design basis event.

2) The actual stresses used will be the ones calculated in Section 4.3.

3) If the alternating portion of the stress has been calculated separately only this part will be used. If the operating loads (i.e. seating torque effects) are already included in the stress analysis it will be conservative to use the calculated stress value. As long as no failures occur, the operating stress does not need to be extracted.

4) The allowable stress will be based on Table B3 of Appendix B in the AISC Manual of Steel Construction.

5) A factor of 1.5 will be applied to the allowable because of the low number of cycles. (Per Section 1.7 of the Commentary on the AISC Manual).

6) The actual stress range is taken as 2 times the maximum stress for components subject to alternating tension and compression.

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E.Rakowski	Date: 1/10/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 4/29/83	
System: CSP and CEP	Job No.: 82044	File No.: OS.01/F	
Analysis No.: 361104	Rev. No.: 1	Sheet No.: 4.3.50	

7) Bracket bolting is assumed to be properly tightened and will not be considered for fatigue per Section B3.1 of the AISC Manual.

The table on the following page gives the calculated stress range, stress category, and allowable for the critical components. The following page gives excerpts from Appendix B of the AISC Manual showing the descriptions of the relevent stress categories.

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 1/10/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernandez	Date: 4/29/83	
System: CSP and CEP	Job No. 82044	File No. O.S.01/F	
Analysis No. 36110 4	Rev. No. 1	Sheet No. 4.3.51	

Fatigue Analysis (cont.)

ITEM	STRESS TYPE	STRESS (PSI)	STRESS RANGE (PSI)	STRESS CATEGORY	1.5 x ALLOW (FROM AISC)
TRUNNION PIN	τ	4108	8216	F (1)	22500
DRIVE ROD (MAX)	σ	- SEE TABLE 1.2 -		A	90000
SUPPORT EARS	σ	- SEE TABLE 1.2 -		A	90000
MAIN SHAFT	τ σ	9127 7158	18254 14316	A A	90000 90000

NOTES:

(1) Assume shear stress on nominal area of a stud type shear connection.

Note that this comparison includes all of the load combinations in one conservative comparison using the maximum stress and the total number of cycles (3 x 4500 + 2000 + 60 = 15560).

Calculation Sheet

Prepared By: [signature]	Date 11/19/82
Checked By: L Pomer	Date 11/19/82
Job No. 82044	File No. 05.01/F
Sheet No. 4.3.52	

Project SUPPLY SYSTEM
Subject 30" BUTTERFLY VALVE
System CSP & CEP
Analysis No. 361104 Rev. No. 1

FATIGUE ANALYSIS (CONT.)

THE TABLE BELOW HAS BEEN CONDENSED FROM APPENDIX B OF THE AISC MANUAL OF STEEL CONSTRUCTION. THE CASES USED ARE MARKED WITH AN ARROW.

General Condition	Situation	Kind of Stress*	Stress Category. (See Table B3)	
Plain material	Base metal with rolled or cleaned surfaces.	T or Rev.	A	⟵ (90,000)
Built-up members	Base metal and weld metal in members, without attachments, built-up of plates or shapes connected by continuous full- or partial-penetration groove welds or continuous fillet welds parallel to the direction of applied stress.	T or Rev.	B	
	Calculated flexural stress, f_b, in base metal at toe of welds on girder webs or flanges adjacent to welded transverse stiffeners.	T or Rev.	C	
	Base metal at end of partial-length welded cover plates having square or tapered ends, with or without welds across the ends.	T or Rev.	E	
Mechanically fastened connections	Base metal at gross section of high-strength-bolted friction-type connections, except connections subject to stress reversal and axially loaded joints which induce out-of-plane bending in connected material.	T or Rev.	B	
	Base metal at net section of other mechanically fastened joints.	T or Rev.	D	
	Base metal at net section of high-strength bolted bearing connections.	T or Rev.	B	
Attachments	Shear stress on nominal area of stud-type shear connectors.	S	F	⟸ (22,500)

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski Date: 3/25/83
Subject: 30" Butterfly Valve	Checked By: L.C. Fernandez Date: 4/29/83
System: CSP and CEP	Job No. 82044 File No. OS.01/F
Analysis No. 361104 Rev. No. 1	Sheet No. 4.3.53

4.4 REFERENCES

1) BIF Drawings

	Drawing #	Rev#	Description
a	A-206763	F	General Arrangement
b	CEP-625-10		From Reactor Nozzle X-3 to SGT-FU-1A, 1B
c	CEP-625-11.12	H	From Reactor Nozzle X-3 to SGT-FU-1A, 1B
d	C-26095		Model A-83B Cylinder
e	A-206767		Valve Assembly
f	DOC-D-220-0310-IR-66	O	Tube errection iso-metric
g	D-207110	F	Valve Data Sheet
h	M-144		General Arrangment plan mis level
k	CSP-807-3.4		Containment purge air supply system

CYGNA

Calculation Sheet

Project: WPPSS Mechanical Equipment Qualification	Prepared By: J.E. Rakowski	Date: 3/25/83	
Subject: 30" Butterfly Valves	Checked By: L.C. Fernández	Date: 4/29/83	
System: CSP and CEP	Job No. 82044	File No. OS.01/F	
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.54	

Reference cont'n

2) Formulas for Natural Frequency and Mode Shapes,
Robert D. Blevins
Van Nostrand Reinhold Company
1979 Edition

3) BIF Report TR-27234 and TR-27235, "Dynamic Torque Calculation of Butterfly Valve; Sizes 24 and 30 inch", dated November 10, 1982.

4) Report TR-74-8 by McPherson Assoc., Inc., "Design & Seismic Analysis 30" Cylinder operated Butterfly Valve". (Rev. 1) 12/31/75.

5) WPPSS letter to Cygna Energy Services, GE-02-RWH-018, 12/17/82.

6) WPPSS, WNP-2 SRM Equipment List Summary Sheets dated 2/10/83.

7) Cygna Energy Services, Equipment Qualification Walkdown Verification Form dated 7/14/82 and 7/19/82.

8) Cygna Energy Services, "Project Manual Design Criteria," DC-1, Rev. 1, 10/82.

9) Burns and Roe Revised Piping Analysis Loads for CSP-V-1 and 2 (dated 4/12/83) and CEP-V-1A and 1B (dated 11/15/82).

10) Communications Report, R. Ricappito of BIF and J. Rakowski of CES, "BIF Valve Dimensions", 2/11/83

APPENDIX A

COMPILED PROGRAMS AND RESULTS FOR

CSP-V-1

CSP-V-2

```
sbasic csp12
      tm
S-BASIC Compiler Version 5.4b

REM***** BIF VALVE AND AIR OPERATOR SEISMIC STRESS *****
REM*************** CSP-V/AO-1/2 ************************
REM*************** 10 INCH AO PARAMETERS ***************
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
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 9.5, 10.5, .88, 3.94, 1.50,1.34
2   data 25,21.50,.488,48.,4.85,.627,1.75,3.0
3   data 1847.,.875,.46,.648,.138,2.41,1.4
4   data 593.,321.,5.25,8.5,28.5,15.,7.75
5   data 40.,16.25,26.5,43.,2.075
6   data 135.,90.,135.,90.,180.,90.
7   data 45.,90.,135.,90.,0.,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
read  a(1,3),a(2,3),a(3,3),av(1),av(2),av(3)
text 0,& INPUT GLOBAL ACCELERATIONS &
input b(1),b(2),b(3)
print
text 0,& INPUT DATA &
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)
```

CYGNA
ATTACHM. 'T'
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.A2

```
0059:00 print "EAST VECTOR ANGLES    = ";a(1,3),a(2,3),a(3,3)
0060:00 print "WEIGHT VECTOR ANGLES  = ";av(1),av(2),av(3)
0061:00 print
0062:00 for i=1 to 3
0063:01 for j=1 to 3
0064:02   a(j,i)=a(j,i)*2.*3.1416/360.
0065:02   glc(j,i)=b(i)*cos(a(j,i))
0066:02 next j
0067:01 next i
0068:00 for j=1 to 3
0069:01 av(j)=av(j)*2.*3.1416/360.
0070:01 next j
0071:00 print
0072:00 text 0,& LOCAL G-LEVELS &
0073:00 print
0074:00 print glc(1,1),glc(1,2),glc(1,3)
0075:00 print glc(2,1),glc(2,2),glc(2,3)
0076:00 print glc(3,1),glc(3,2),glc(3,3)
0077:00 REM WEIGHT COMPONENTS
0078:00 for j=1 to 3
0079:01 wa(j)=wao*cos(av(j))
0080:01 wb(j)=wbr*cos(av(j))
0081:01 next j
0082:00 phi=phi*2.*3.1416/360.
0083:00 la=lave/2
0084:00 ci12=c1/i2
0085:00 ci21=c2/i1
0086:00 aear=l1*l2
0087:00 REM CALCULATE EAR FORCES USE B&R LOADS AS OPTION LATER
0088:00 REM FIXED COMPONENTS ARE ALWAYS THERE
0089:00 lbr=lrod+lcg
0090:00 watr1=lbr*wa(1)/lrod
0091:00 s1f=wb(1)+watr1
0092:00 wtot=wao+wbr
0093:00 s2f=wb(2)+wa(2)+fst2
0094:00 t3f=wa(3)+wb(3)
0095:00 m1f=-(wa(2)+wb(2)+fst2)*e5-wa(3)*(e3+lcg)-wb(3)*e4
0096:00 m2f=(watr1+wb(1))*e5-wa(3)*e2-wb(3)*e1
0097:00 tt3f=watr1*e3+(wa(2)+fst2)*e2+wb(1)*e4+wb(2)*e1
0098:00 fcdrf=lcg*wa(1)/lrod
0099:00 maf=fcdrf*(lrod-13.5)
0100:00 mbf=fcdrf*7.125
0101:00 sdraf=fst2/aa+abs(maf*ca/ia)
0102:00 sdrbf=fst2/ab+abs(mbf*cb/ib)
0103:00 fcof=lcgo*wa(1)/lrodo
0104:00 pbushf=fcof*(ldr+d)/(d*abush)
0105:00 REM STRESSES FROM FIXED COMPONENTS
0106:00 dear=(d1*d1+d2*d2)**.5
0107:00 set3f=abs(t3f/(4*aear))
0108:00 sem1f=abs(m1f/(2*d2*aear))
0109:00 sem2f=abs(m2f/(2*d1*aear))
0110:00 fcearf=tt3f/(2*dear)
0111:00 frf=x*fcearf
0112:00 f11f=-(fcearf*sin(phi)-frf*cos(phi))
0113:00 f22f=fcearf*cos(phi)+frf*sin(phi)
0114:00 stt3f=abs(f11f*la*ci12)+abs(f22f*la*ci21)
0115:00 ses1f=abs(s1f*ci12*la/4.)
0116:00 ses2f=abs(s2f*ci21*la/4.)
0117:00 srf=set3f+sem1f+sem2f+ses1f+ses2f+stt3f
0118:00 REM EAR SHEAR
0119:00 tau11f=abs(s1f/(4*aear))+abs(f11f/aear)
0120:00 tau22f=abs(s2f/(4*aear))+abs(f22f/aear)
0121:00 taurf=(tau11f*tau11f+tau22f*tau22f)**.5
0122:00 taubf=taurf*aear/ablt
0123:00 REM EARBOLT TENSION
0124:00 btf=(set3f+sem1f+sem2f)*aear/ablt
0125:00 print
```

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 43.43

```
0126:00 print"OPERATING CYLINDER BRG PRESSURE ";pbush+
0127:00 print"OPERATING VALVE EAR TENSILE STR ";srf
0128:00 print"OPERATING VALVE EAR SHEAR STRES ";taurf
0129:00 print"OPERATING EAR BOLT SHEAR STRESS ";taubf
0130:00 print"OPERATING EAR BOLT TENSILE  STR ";btf
0131:00 print
0132:00 REM
0133:00 REM CALCULATE VARIABLE COMPONENTS
0134:00 REM
0135:00 dsr=0.
0136:00 dtaur=0.
0137:00 dtaub=0.
0138:00 dbten=0.
0139:00 dsa=0.
0140:00 dsb=0.
0141:00 dpb=0.
0142:00 for j=1 to 3
0143:01 fco=lcgo*wao*glc(1,j)/lrodo
0144:01 pbush=fco*(ldr+d)/(d*abush)
0145:01 ftr1=lbr*wao*glc(1,j)/lrod
0146:01 s1=ftr1+wbr*glc(1,j)
0147:01 s2=wtot*glc(2,j)
0148:01 t3=wtot*glc(3,j)
0149:01 m1=-wtot*glc(2,j)*e5-wao*glc(3,j)*(e3+lcg)-wbr*glc(3,j)*e4
0150:01 m2=(ftr1+wbr*glc(1,j))*e5-(wao*e2+wbr*e1)*glc(3,j)
0151:01 tt3=ftr1*e3+wbr*glc(1,j)*e4+glc(2,j)*(wao*e2+wbr*e1)
0152:01 fcdr=lcg*wao*glc(1,j)/lrod
0153:01 ma=fcdr*(lrod-13.5)
0154:01 mb=fcdr*7.125
0155:01 siga=ma*ca/ia
0156:01 sigb=mb*cb/ib
0157:01 REM CALCULATE EAR TENSION
0158:01 set3=abs(t3/(4*aear))
0159:01 sem1=abs(m1/(2*d2*aear))
0160:01 sem2=abs(m2/(2*d1*aear))
0161:01 fcear=tt3/(2*dear)
0162:01 fr=x*fcear
0163:01 f11=-(fcear*sin(phi)-fr*cos(phi))
0164:01 f22=fcear*cos(phi)+fr*sin(phi)
0165:01 stt3=abs(f11*la*ci12)+abs(f22*la*ci21)
0166:01 ses1=abs(s1*ci12*la/4.)
0167:01 ses2=abs(s2*ci21*la/4.)
0168:01 sr=set3+sem1+sem2+ses1+ses2+stt3
0169:01 REM EAR SHEAR
0170:01 tau11=abs(s1/(4.*aear))+abs(f11/aear)
0171:01 tau22=abs(s2/(4.*aear))+abs(f22/aear)
0172:01 tauear=(tau11*tau11+tau22*tau22)**.5
0173:01 taublt=tauear*aear/ablt
0174:01 REM EARBOLT TENSION
0175:01 btens=(set3+sem1+sem2)*aear/ablt
0176:01 dsa=dsa+siga*siga
0177:01 dsb=dsb+sigb*sigb
0178:01 dpb=dpb+pbush*pbush
0179:01 dsr=dsr+sr*sr
0180:01 dtaur=dtaur+tauear*tauear
0181:01 dtaub=dtaub+taublt*taublt
0182:01 dbten=dbten+btens*btens
0183:01 next j
0184:00 REM COMBINE STRESSES
0185:00 dsa=dsa**.5
0186:00 dsb=dsb**.5
0187:00 dpb=dpb**.5
0188:00 dsr=dsr**.5
0189:00 dtaur=dtaur**.5
0190:00 dtaub=dtaub**.5
0191:00 dbten=dbten**.5
```

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.A4

```
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
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)
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
end

            ****** End of program ******
```

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.A5

csp(1)..
INPUT GLOBAL ACCELERATIONS
? 2.26,3.62,2.8

INPUT DATA

GLOBAL G-LEVELS	=	2.26	3.62	2.8
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

-1.59807	-1.38092E-5	1.97989
-8.62121E-6	-3.62	-1.06811E-5
-1.59807	-1.38092E-5	-1.97991

OPERATING DRIVE ROD STRESS AT A 766.432
OPERATING DRIVE ROD STRESS AT B 1319.35
OPERATING CYLINDER BRG PRESSURE -7.15824E-4
OPERATING VALVE EAR TENSILE STR 2111.01
OPERATING VALVE EAR SHEAR STRES 293.896
OPERATING EAR BOLT SHEAR STRESS 2460.85
OPERATING EAR BOLT TENSILE STR 1625.1

DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A 28384.4
DRIVE ROD TENSILE STRESS AT B 43412.2 ← reduced cross section due to thread at clevis
BUSHING PRESSURE 477.447
~~VALVE EAR TENSILE STRESS 8282.34~~ *SEE SHEETS 4.3.30 - 4.3.48 (1)
~~VALVE EAR SHEAR STRESS 840.657~~
EAR BOLT SHEAR STRESS 7039
EAR BOLT TENSILE STRESS 10524.9

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A 29150.9
DRIVE ROD TENSILE STRESS AT B 44731.6
PUSHING PRESSURE 477.448
~~VALVE EAR TENSILE STRESS 10393.3~~ *
~~VALVE EAR SHEAR STRESS 1134.55~~
EAR BOLT SHEAR STRESS 9499.86
EAR BOLT TENSILE STRESS 12150

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.A6

csp(1)2

INPUT GLOBAL ACCELERATIONS

? 26,3.62,2.8

INPUT DATA

GLOBAL G-LEVELS	=	2.26	3.62	2.8
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

-1.59807	-1.38092E-5	1.97989
-8.62121E-6	-3.62	-1.06811E-5
-1.59807	-1.38092E-5	-1.97991

OPERATING DRIVE ROD STRESS AT A	766.432
OPERATING DRIVE ROD STRESS AT B	1319.35
OPERATING CYLINDER BRG PRESSURE	-7.15824E-4
OPERATING EAR WELD TENSILE STR	3090.43
OPERATING EAR WELD SHEAR STRES	735.124
OPERATING EAR BOLT SHEAR STRESS	2460.86
OPERATING EAR BOLT TENSILE STR	1625.1

MIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	28384.4
DRIVE ROD TENSILE STRESS AT B	43412.2
BUSHING PRESSURE	477.447
~~EAR WELD TENSILE STRESS~~	~~12091.7~~ * SEE SHEETS 4.3.30 – 4.3.48 △1
~~EAR WELD SHEAR STRESS~~	~~2102.74~~
EAR BOLT SHEAR STRESS	7039
EAR BOLT TENSILE STRESS	10524.9

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	29150.9
DRIVE ROD TENSILE STRESS AT B	44731.6
BUSHING PRESSURE	477.448
~~EAR WELD TENSILE STRESS~~	~~15182.1~~ *
~~EAR WELD SHEAR STRESS~~	~~2837.86~~
EAR BOLT SHEAR STRESS	9499.86
EAR BOLT TENSILE STRESS	12150

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.A7

csp ②

INPUT GLOBAL ACCELERATIONS
? 1.44,3.54,1.9

INPUT DATA

GLOBAL G-LEVELS	=	1.44	3.54	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	-1.3504E-5	1.3435
-5.49316E-6	-3.54	-7.24792E-6
-1.01824	-1.3504E-5	-1.34351

OPERATING DRIVE ROD STRESS AT A	766.432
OPERATING DRIVE ROD STRESS AT B	1319.35
OPERATING CYLINDER BRG PRESSURE	-7.15824E-4
OPERATING VALVE EAR TENSILE STR	2111.01
OPERATING VALVE EAR SHEAR STRES	293.896
OPERATING EAR BOLT SHEAR STRESS	2460.85
OPERATING EAR BOLT TENSILE STR	1625.1

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~~	~~5755.57~~
~~VALVE EAR SHEAR STRESS~~	~~606.452~~
EAR BOLT SHEAR STRESS	5077.94
EAR BOLT TENSILE STRESS	7164.63

* SEE SHEETS 4.3.30 - 4.3.48 ⚠

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	19572.5
DRIVE ROD TENSILE STRESS AT B	30082.1
PUSHING PRESSURE	316.333
~~VALVE EAR TENSILE STRESS~~	~~7866.59~~ *
~~VALVE EAR SHEAR STRESS~~	~~900.348~~
EAR BOLT SHEAR STRESS	7538.79
EAR BOLT TENSILE STRESS	8789.72

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.A8

csp1 (2)

INPUT GLOBAL ACCELERATIONS

[illegible]44,3.54,1.9

INPUT DATA

GLOBAL G-LEVELS	=	1.44	3.54	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	-1.3504E-5	1.3435
-5.49316E-6	-3.54	-7.24792E-6
-1.01824	-1.3504E-5	-1.34351

OPERATING DRIVE ROD STRESS AT A	766.432
OPERATING DRIVE ROD STRESS AT B	1319.35
OPERATING CYLINDER BRG PRESSURE	-7.15824E-4
OPERATING EAR WELD TENSILE STR	3090.43
OPERATING EAR WELD SHEAR STRES	735.124
OPERATING EAR BOLT SHEAR STRESS	2460.86
OPERATING EAR BOLT TENSILE STR	1625.1

[illegible]MIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	18806	
DRIVE ROD TENSILE STRESS AT B	28762.8	
BUSHING PRESSURE	316.332	
~~EAR WELD TENSILE STRESS~~	~~8415.88~~	* SEE SHEETS 4.3.30 - 4.3.48 △1
~~EAR WELD SHEAR STRESS~~	~~1516.92~~	
EAR BOLT SHEAR STRESS	5077.96	
EAR BOLT TENSILE STRESS	7164.63	

FIXED PLUS DYNAMIC COMPONENTS

DRIVE ROD TENSILE STRESS AT A	19572.5	
DRIVE ROD TENSILE STRESS AT B	30082.1	
BUSHING PRESSURE	316.333	
~~EAR WELD TENSILE STRESS~~	~~11506.3~~	*
~~EAR WELD SHEAR STRESS~~	~~2252.04~~	
EAR BOLT SHEAR STRESS	7538.81	
EAR BOLT TENSILE STRESS	8789.72	

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.49

APPENDIX B

VALVE/AIR OPERATOR MODEL FOR FINAL PIPING RESPONSE G-LEVEL CALCULATION.

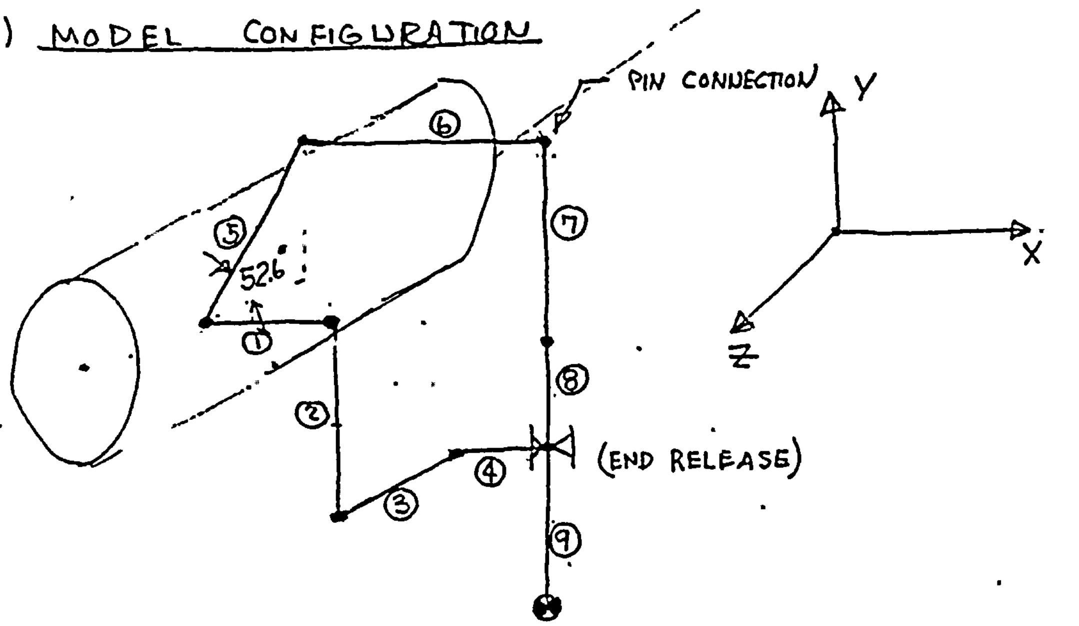
CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 4.3.B1

Calculation Sheet

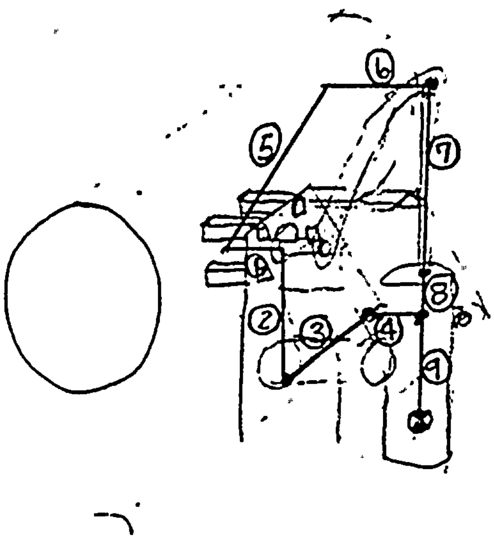
Project: WPPSS EQ		Prepared By: J E R [signature]	Date 1/3/83
Subject: BIF VALVE / ACTUATOR MODEL SUMMARY		Checked By: W. E. Searle	Date 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 36110.4 +106	Rev. No. 1	Sheet No. 4.3.B2	

SUMMARY

A) MODEL CONFIGURATION



B) ACTUAL STRUCTURE



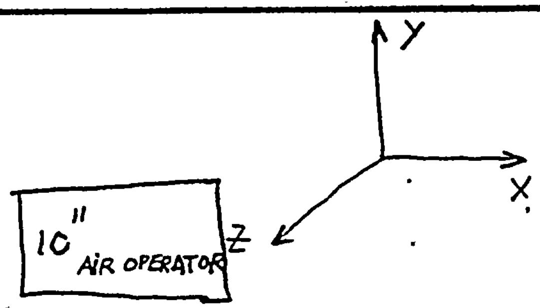
STRUCTURAL MEMBER DIRECTIONS

①	+X
②	−Y
③	−Z
④	+X
⑤	YZ-PLANE
⑥	+X
⑦	+Y
⑧	+Y
⑨	−Y

CYGNA

Calculation Sheet

Project: WPPSS		Prepared By: J E Kokowski	Date: 1/3/83
Subject: BIF VALVE/ACTUATOR MODEL SUMMARY		Checked By: W. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No.: 82044	File No.: OT.01/F & OS.01/F
Analysis No.: 361104 & 361106	Rev. No.: 1	Sheet No.: 4.3.B3	



① VALVE EARS

8" CYL (24" VALVE)

		10" AIR OPERATOR
$A_x = A_y = A_z$	$= 15\ IN^2$	21
I_{xx}	$= 106\ IN^4$	657
I_{yy}	$= 11.2$ "	21.4
I_{zz}	$= 31.2$ "	63
C_y	$= 5.60$	5.25
C_z	$= 3.75$	4.75
$E = 28 \times 10^6$ PSI, $E_s = 11.6 \times 10^6$ PSI		✓
ℓ	$= 7.125$"	4.85"

② BRACKET

(Put e = 0 & add 277# 15" down) 321#

$A_x = A_y = A_z$	$= 6.84\ IN^2$	8.5
I_{xx}	$= 102\ IN^4$	255
I_{yy}	$= 1000\ IN^4$	$1000\ IN^4$
I_{zz}	$= 2.16\ IN^4$	$4.22\ IN^4$
C_x	$= .25$ IN	.313
C_z	$= 6.84$ IN	8.5
$E = 28 \times 10^6$ PSI, $E_s = 11.6 \times 10^6$ PSI		✓
$\ell = 28.5$" (15" down to CG)		

③ & ④ BRACKET OFFSETS $L_3 = 8.8$" (8.5") $L_4 = 6.875$ (8.0")

③ MASSLESS, RIGID LINK, 8.8" LONG (8.5)

④ " " , 6.875" " (8.0)

(END RELEASE FOR ROTATION θ_{xx} ON ④)

CYGNA

Calculation Sheet

Project	WPPSS EQ	Prepared By: [signature]	Date 1/3/83
Subject	BIF VALVE/ACTIVATOR MODEL - SUMMARY	Checked By: [signature]	Date 3/24/83
System	CSP and CEP	Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361106 + 361104	Rev. No. 1	Sheet No. 4.3.B4	

⑤ SHAFT OFFSET

RIGID LINK 14.48" LONG (14.30)
AT 52.6° ↑ AS SHOWN

⑥ SHAFT

$A_x = A_y = A_z =$	$3.98\ IN^2$	4.91
$I_{xx} =$	$2.52\ IN^4$	3.04
$I_{yy} =$	4 "	5.75
$I_{zz} =$	1.26 "	1.92
$C_y =$	1.125	1.25
$C_z =$	1.125	1.25
$E = 29 \times 10^6$ PSI	$E_S = 11.6 \times 10^6$ PSI	
$\ell =$	14 in.	12.85"

⑦ DRIVE ROD

$A_x = 2.41$ $A_y = 2.41$ $A_z =$	$2.41\ IN^2$	$2.41\ IN^2$
$I_{xx} = I_{zz} =$	$.46\ IN^4$	$.46\ IN^4$
$I_{yy} =$	$.92\ IN^4$	$.92\ IN^4$
$C_x = C_z =$	.875 IN	.875 IN
HIGH STREN. ☆ $E = 30 \times 10^6$ PSI	$E_S = 12 \times 10^6$ PSI	

⑧ & ⑨ CYLINDER
(PUT ρ=0 + ADD 399# AT END.) ⟶ 593#

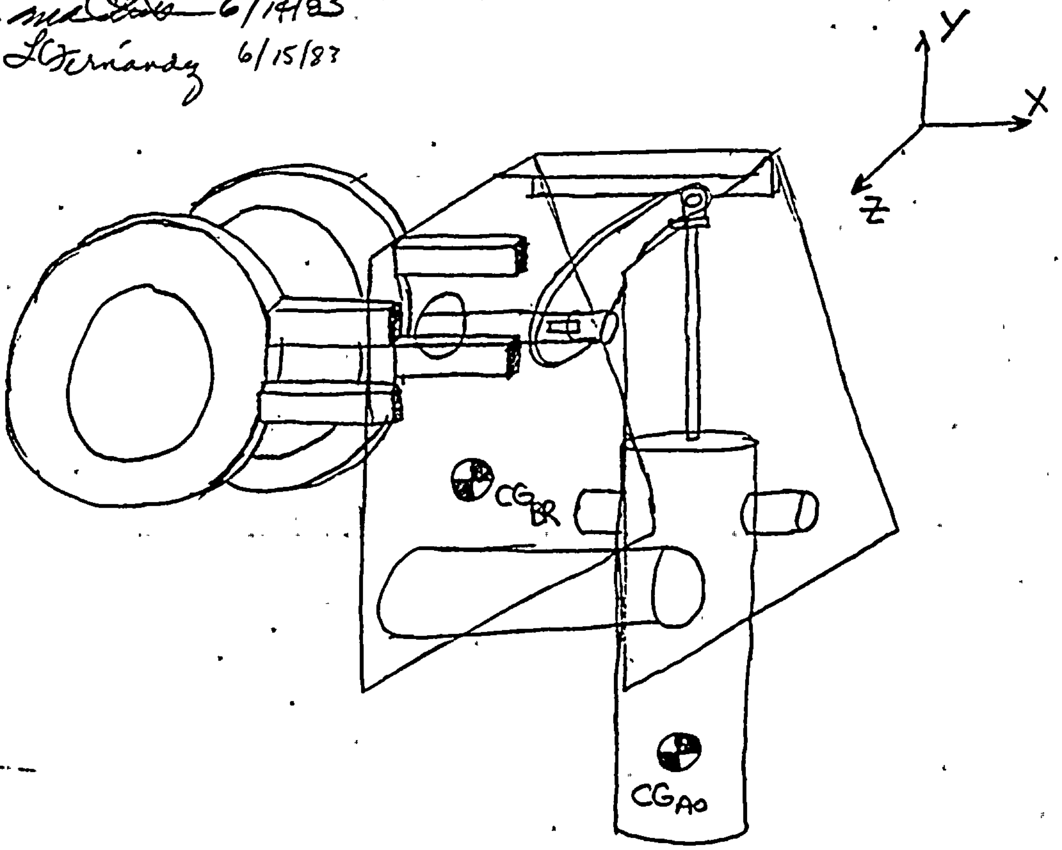
$L_{⑧} =$	13.5"	13.5"
$L_{⑨} =$	14.0"	19"
$I_{yy} =$	$74\ IN^4$	$180\ IN^4$
$I_{xx} = I_{zz} =$	$52\ IN^4$	$127\ IN^4$
$A_x = A_y = A_z =$	$50\ IN^2$	$78\ IN^2$
$C_x = C_z =$	4"	5 IN

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: E Rolgowski	Date: 1/3/83
Subject: SAP MODEL - BIF VALVE / AO		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.OF/01 & OS.01/F
Analysis No. 361104 & 361106	Rev. No. 1	Sheet No. 4.3.B5	

⚠ * [initials] 6/14/83
L Fernández 6/15/83



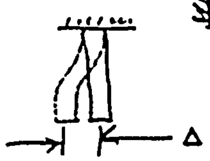
DESCRIPTION OF AO MODEL INCLUDING 4 VALVE EARS:

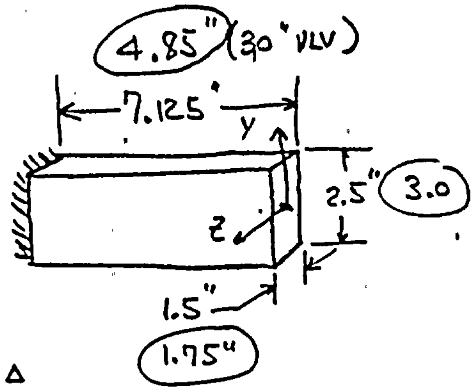
8" AO

① Derive Ear Model

K_{zz} = 4 * ~~stiffness~~ of 1 ear
= 4 * F_z / Δ_z

Use Roark, Pg 96, # 1b.:





*. THIS ASSUMPTION ERROR IS CORRECTED ON PAGE 4.3-30 TO 4.3-48 OF 361104 Rev 1

1006 00

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: [signature]	Date: 1/3/83
Subject: BIF VALVE/ACTUATOR MODEL SUMMARY		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 106	Rev. No. 1	Sheet No. 4.3.B6	

⚠1 * [signature] 6/14/83 / Fernandez 6/15/83

* THIS ASSUMPTION ERROR IS CORRECTED ON PAGES 4.3-30 – 4.3-40

$M_A = \frac{W(l-a)^2}{2l}$ $\theta_A = 0$

$y_A = \frac{-W}{12EI}(l-a)^2(l+2a) = \frac{-W}{12EI} l^3$

$\therefore \frac{F_z}{\Delta z} = \frac{12EI}{(l)^3} \quad (a=0) =$

$E_{ear} \cong 29 \times 10^6$ PSI

$l = 7.125''$ (4.85")

I_{min} (for z-axis) $= 0.70 \text{ in}^4$

$\frac{1}{12} \cdot 3 \cdot 1.75^3 = 1.34$

I_{max} (for y-axis) $= 1.95 \text{ in}^4$

$\frac{1}{12} \cdot 1.75 \cdot 3^3 = 13.94$

$= \frac{12 \times 29 \times 10^6 \times 0.7}{(7.125)^3} = .693 \times 10^6 \frac{lb}{in}$ (1.34; 4.08)

$(7.125)^3 = 361.7$

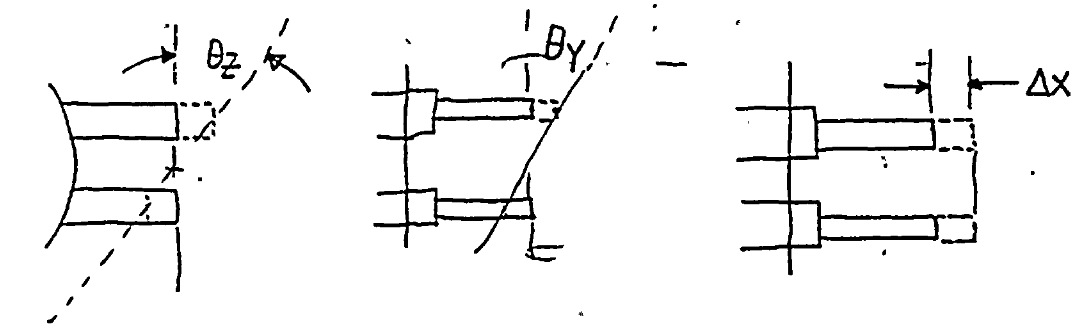
$(4.85)^3 = 114.08$

(units: $\frac{F}{L^2} \cdot \frac{L^4}{L^3} = \frac{F}{L}$ (OK))

$K_{zz} = 4 \times \frac{F_z}{\Delta z} = 2.694 \times 10^6 \frac{lb}{in}$ (16.34)

$K_{xx} = 4 \times \frac{F_x}{\Delta x} = \frac{4 \times 12 EI_{max}}{l^3} = K_{zz} \times \frac{1.95}{.7} = 7.50 \frac{lb}{in} \times 10^6$ (3.94/1.34 = 48)

θ:

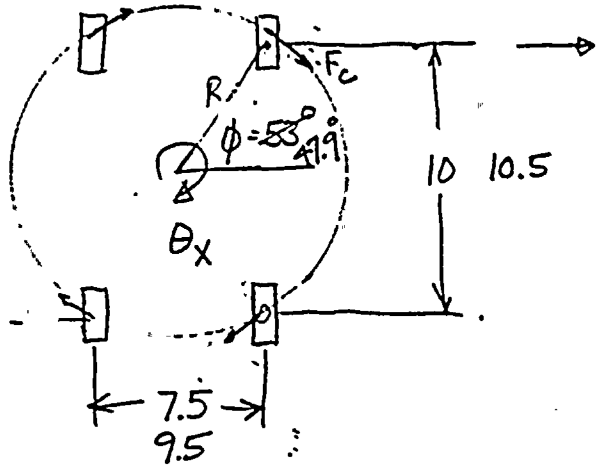


CONSIDER THE EAR-SYSTEM STIFFNESS IN THESE MODES VERY LARGE, BECAUSE OPERATOR BRACKET BENDING WILL CONTROL

CYGNA

Calculation Sheet

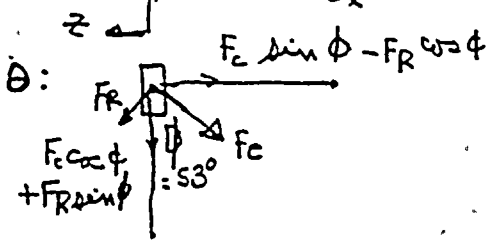
Project: WPPSS EQ		Prepared By: J E Pobanski	Date: 1/3/83
Subject: BIF VALVE/ACTUATOR MODEL SUMMARY		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No.: 82044	File No.: OT.01/F & OS.01/F
Analysis No.: 361104 & 106	Rev. No.: 1	Sheet No.: 4.3.B7	



The attached plate forces the ears to deflect tangent to the circle. The force on each ear is:

$$4 F_c R = T \quad , \quad R = \left[3.75^2 + 25\right]^{\frac{1}{2}} = 6.25''$$
$$4.75^2 + 5.25^2 = 7.08$$

$$\text{Stiffness} = \frac{T}{\Delta\theta_X} = \frac{4 F_c \,(\cancel{6.25})\ 7.08}{\Delta\theta_X}$$



There is a restraint force which acts through the plate keeping the ear deflection on the circle. This must be a radially-directed force: F_R (no torque contribution)

$$\text{Deflection:} \quad \Delta Y = -\left(F_c \cos\phi + F_R \sin\phi\right)\left[\frac{l^3}{12 E I_{max}} + \frac{l}{(k=1.5)A(G=.4E)}\right]$$

$l^3 \ll 12 I_{max}$, $1.5 \times .4 \, l A^2$ — $1.5 \times .4 \, l A$E

$$\Delta Z = -\left(F_c \sin\phi - F_R \cos\phi\right)\frac{l^3}{12 E I_{min}}$$

$12 I_{max} = 23.4$
$1.5 \times .4 \, l^2 A = 14.22$
∴ Shear not sig.

1006 00

CYGNA Calculation Sheet

Project: WPPSS EQ		Prepared By: [signature]	Date: 1/3/83
Subject: BIF VALVE/ACTUATOR MODEL SUMMARY		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 106	Rev. No. 1	Sheet No. 4.3.B8	

$$\tan\phi = \frac{-\Delta Z}{-\Delta Y} = \frac{\Delta Z}{\Delta Y} = \frac{I_{max}}{I_{min}} \frac{(F_C \sin\phi - F_R \cos\phi)}{(F_C \cos\phi + F_R \sin\phi)} = 1.327 \quad 1.105$$

$$\frac{I_{max}}{I_{min}} = \frac{\cancel{1.95}\ 3.94}{.70\ \ 1.34} = 2.786\ \ 2.94, \quad \sin\phi = .799 \quad .742, \quad \cos\phi = .602 \quad .671$$

$$\therefore \frac{1.327\ \ 1.105}{2.786\ \ 2.94} = \frac{F_C\ .799\ (.742) - .602\ (.671)\ F_R}{.602\ (.671)\ F_C + .799\ (.742)\ F_R} = .476 \quad .376$$

$$.799\ (.742)\ F_C - .602\ (.671)\ F_R = .278\ (.252)\ F_C + .380\ (.279)\ F_R$$

$$.521\ (.464)\ F_C = .982\ (.950)\ F_R$$

$$\boxed{F_R = .531\ F_C} \quad .488$$

NOTE: Another force FR acts on valve ears – include in stress analysis.

2 ☆ SIGN CHANGES FOR F_R ON ALTERNATE EARS.

To find θ:

$$\Delta\theta = \frac{\Delta C}{R} = \frac{-\Delta Y}{R\cos\phi} = \frac{+(F_C \cos\phi + F_R \sin\phi)\dfrac{l^3}{12EI_{max}}}{R\cos\phi}$$

$$= \frac{l^3}{12EI_{max}}\left(\frac{F_C}{R} + \frac{.531\ (.488)\ F_C}{R}\tan\phi\right), \quad \tan\phi = 1.327 \quad 1.105$$

$$\Delta\theta_x = \frac{l^3}{12REI_{max}} F_C \begin{pmatrix}1.704\\1.540\end{pmatrix} = \frac{F_C}{51.362\ (14.64)\ REI_{max}}$$

$$K_{\theta_x\theta_x} = \frac{T}{\Delta\theta_x} = \frac{4F_C R}{\dfrac{51.362\ F_C}{REI_{max}}} = \frac{4}{51.362\ (14.64)} R^2 EI_{max}$$

$$\frac{F}{L^2} L^2 \frac{L^4}{(L^3)} = FL \quad (OK)$$

CYGNA

Calculation Sheet

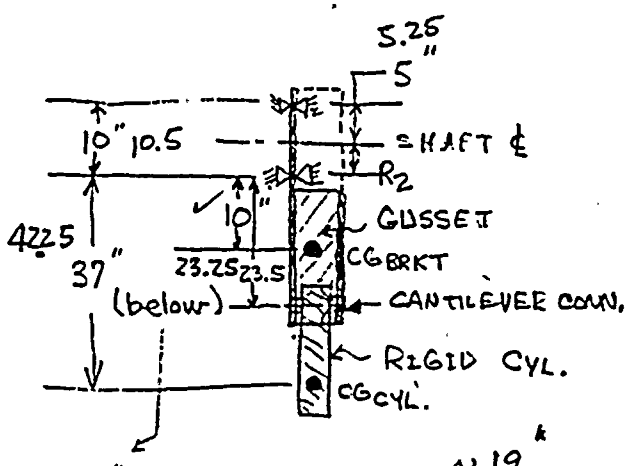
Project WPPSS EQ		Prepared By: J.E. Rakowski	Date 1/3/83
Subject BIF Valve/Actuator Model Summary		Checked By: D.E. Searle	Date 3/24/83
System CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 361106	Rev. No. 1	Sheet No. 4.3.B9	

$$K_{\theta\theta} = \frac{.078(6.25)^2(29)(10)^6(1.95)}{(7.08)(3.94)} = \frac{172(10)^6}{1565} \text{ in lb/rad}$$

$$K_{\theta\theta} = 1.72(10)^8 \text{ in lb/rad}$$

$$1.565(10)^9 \text{ "}$$

SUPPORT BRACKET PLATE BENDING



28.5" shaft → tr. pin + ~13.5" to CG ~19"
= 42" − 5" = 37"

FOR CALCULATION OF BRACKET FLEXIBILITY, THE FOLLOWING MEASUREMENTS WERE TAKEN ON CSP-AO-5 & 3. DATA IS APPROXIMATE.

DEFLECTION AT END OF CYL (IN): .125, .125, .150
FORCE AT END OF CYL (LB): 85, 150, 100

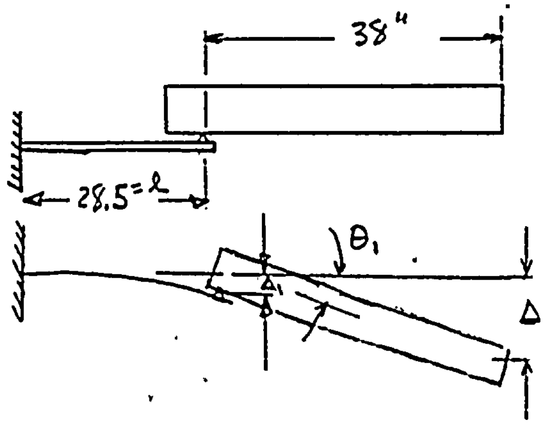
CYGNA

Calculation Sheet

Project	WPPSS EQ	Prepared By: J.E. Rakowski	Date 1/3/83
Subject	BIF Valve/Actuator Model Summary	Checked By: D. E. Searle	Date 3/24/83
System	CSP and CEP	Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 361106	Rev. No. 1	Sheet No. 4.3.B10	

AVERAGE FLEXIBILITY = $1.27(10)^{-3}$ in/lb

CALCULATE EFFECTIVE MOMENT OF INERTIA OF A CANTILEVER BEAM USED TO REPRESENT THE BRACKET. USE THE FOLLOWING DIMENSIONS



$\Delta = \Delta_1 + 38\theta_1 = 150^{\#} * .00127\ in/\# = 0.190$ (use $150^{\#}$ as = F)

$$\Delta_1 = \frac{F\ell^3}{3EI} + \frac{(38F)\ell^2}{2EI} = \frac{F\ell^2}{EI}\left(\frac{\ell}{3} + 19\right) = \frac{F\ell^2}{EI}\left(\frac{28.5}{3} + 19\right)$$

$$\frac{F\ell^2}{EI} = \frac{150 * (28.5)^2}{2.9(10)^7 I_{zz}} = \frac{4.2(10)^4 (10)^{-7}}{I_{zz}} = \frac{.0042}{I_{zz}}$$

$$\Delta_1 = \frac{.0042}{I_{zz}} * \left(\frac{28.5}{3} + 19\right) = \frac{.120}{I_{zz}}\ in$$

$$\Delta = \frac{.120}{I_{zz}} + 38\theta_1$$

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: J.E. Rakowski	Date: 1/3/83
Subject: BIF Valve/Actuator Model Summary		Checked By: D.E. Searle	Date: 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 361106	Rev No. 1	Sheet No. 4.3.B11	

$\theta_1 = \theta_1$ due to $F + \theta_1$ due to $M = 38F$

$$= \frac{F\ell^2}{2EI} + \frac{(38F)\,\ell}{EI} = \frac{F\ell}{EI_{zz}}\left(\frac{\ell}{2} + 38\right)$$

$$\theta_1 = \frac{150\,(28.5)}{2.9(10)^7\,I_{zz}}\left(\frac{28.5}{2} + 38\right) = \frac{7.7(10)^4 * 10^{-7}}{I_{zz}} = \frac{7.7(10)^{-3}}{I_{zz}}$$

$$38\,\theta_1 = \frac{.293}{I_{zz}}$$

$$\therefore\ \Delta = \frac{.122}{I_{zz}} + \frac{.293}{I_{zz}} = .19$$

$$\frac{.415}{I_{zz}} = .19$$

$$\boxed{I_{zz} = 2.16\ \text{IN}^4}\quad 8''\ \text{A/O}$$

FOR THE 10" CYLINDER, RATIO OF INERTIA, I.E.

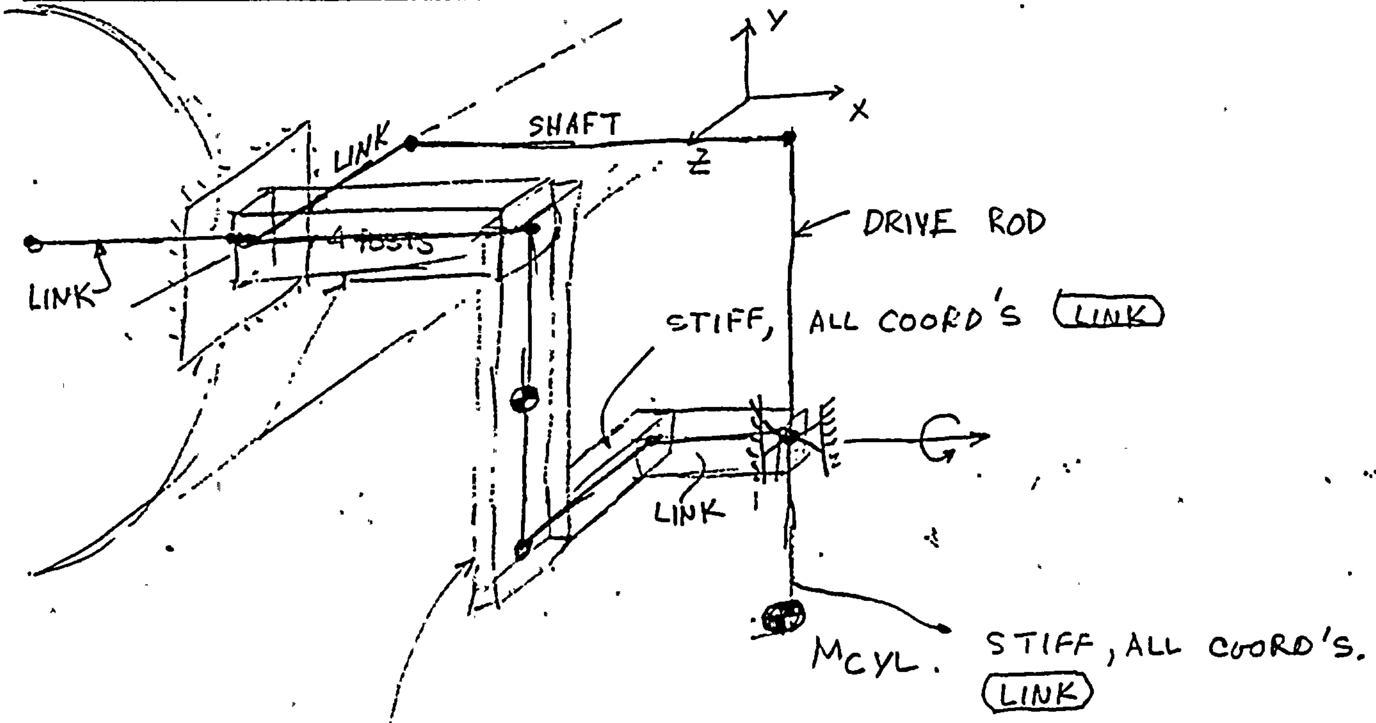
$$I_{zz}\big|_{10} = I_{zz}\big|_8 * \frac{(5/8)^3}{(1/2)^3} = I_{zz}\big|_8 * 1.95$$

$$\boxed{I_{zz}\big|_{10''} = 4.22\ \text{IN}^4}$$

BRACKET TORSIONAL RESISTANCE : SET TO A HIGH VALUE SINCE BENDING + TORSION BOTH REPRESENTED IN ABOVE FLEXIBILITY. ($1000\ \text{IN}^4$)

Calculation Sheet

Project WPPSS - EQ		Prepared By: D E Rabrowski	Date 1/3/83
Subject BIF VALVE/ACTUATOR MODEL SUMMARY		Checked By: D E Searle	Date 3/24/83
System CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 106	Rev. No. 1	Sheet No. 4.3.B12	



ZZ Bending, Flex calc.'d.
XX - Stiff
I_{yy} - TORSIONAL STIFFNESS

Pick I's & A's for proper STIFFNESSES, THEN DO OTHERS.

GO TO 4-EARS

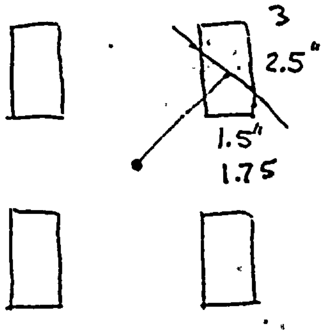
[illegible]

CYGNA

Calculation Sheet

Project: WPPSS - EQ		Prepared By: D. E. Pikowski	Date: 1/3/83
Subject: BIF VALVE/ACTUATOR MODEL SUMMARY		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 106	Rev. No. 1	Sheet No. 4.3.B13	

① EARS:



$A_x = 1.5 \times 2.5 \times 4 = 15$ (21) IN^2

$A_Y = A_Z = \frac{15}{1.5} = 10$ (crossed out) IN^2

R = 19.83

INERTIAS:

$I_{xx} = J$

Define I_{xx} for proper $\phi = \frac{T l}{G I_x}$

$I_{xx} = \frac{T l}{\phi G}$ — from page 5:

$K_{\theta_x \theta_x} = 1.72(10)^8$ ($1.565(10)^9$) $\frac{in\#}{rad} = \frac{T}{\phi}$

$\therefore I_{xx} = \frac{l}{G} K_{\theta_x\theta_x} = \frac{7.125 \; (4.85)}{.4(10)^6 * 29} * 1.72(10)^8$ ($1.565(10)^9$, $15.65(10)^8$)

UNITS: $\frac{F \times L \times L}{-\frac{F}{L^2}} = L^4$ OK

$I_{xx} = 1.06 * 10^2 \; in^4 = \underline{106 \; IN^4}$

$106 * \frac{15.65}{1.72} * \frac{4.85}{7.125} = \underline{\underline{657 \; IN^4}}$

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: J E Rakowski	Date: 1/3/83
Subject: BIF VALVE / ACTUATOR MODEL SUMMARY		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No. 82044	File No. OT.01/F & OS.01/F
Analysis No. 361104 & 106	Rev. No. 1	Sheet No. 4.3.B14	

⚠1 [signature] 6/14/83
[signature] 6/15/83

$I_z = 4 * I_{MAX}$ (1.95) 3.94

$I_z = 7.80\ in^4$ $15.76\ IN^4$

$I_y : 4\ I_{min}$ (0.70) 1.34 $= 2.80\ IN^4$ $5.36\ IN^4$

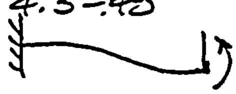
$c_z = 5\ IN$ (5.25), $c_y = 3.75\ IN$ (4.75)

$E = 29 * 10^6\ PSI$, $G = E_s = 11.6 * 10^6\ PSI$

BECAUSE OF BENDING OF EARS IN MODE BELOW, ADJUST I_y & I_z TO ACCOUNT. (THIS WAS DONE IN ANALYSIS FOR $K_{\theta x}\theta_x$):

* THIS ASSUMPTION ~~BREAK~~ IS CORRECTED ON PAGE 4.3-30 TO 4.3-43

$Y_{max} = \frac{-w}{12EI} \ell^3$ FOR EARS:



$Y_{max} = -\frac{w}{6EI}(2\ell^3)$ for

$\therefore Y_{max\text{-}ear} = \frac{1}{4} Y_{max}$ (model beam)

Since $Y_{max} \propto \frac{1}{I}$, multiply $I_{model\ beam}$ by 4.

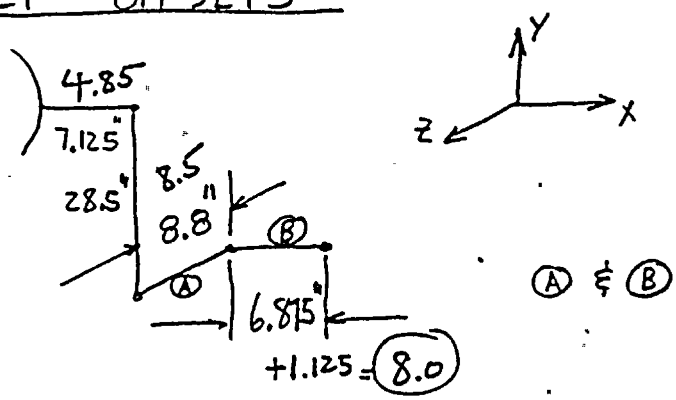
I_z =	7.8 (15.76)	* 4	=	31.2 IN^4 (63)
I_y :	2.8 (5.36)	* 4	=	11.2 IN^4 (21.4)

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: E Rakowski	Date: 1/3/83
Subject: BIF VALVE / ACTUATOR MODEL SUMMARY		Checked By: D. E. Searle	Date: 3/24/83
System: CSP and CEP		Job No.: 82044	File No.: OT.01/F & OS.01/F
Analysis No.: 361104 & 106	Rev. No.: 1	Sheet No.: 4.3.B15	

BRACKET OFFSETS



Ⓐ & Ⓑ ARE MASSLESS, RIGID LINKS

SHAFT

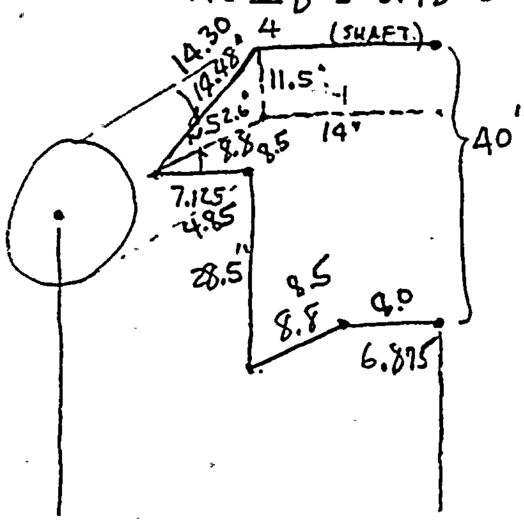
DIA = 2.50 7.25" (from McPherson, (30") 24" valve):

C = 1.125" 1.25

I = 1.26 IN^4 = I_{yy} 1.92

$I_{xx} = \sqrt{2}\, I_{yy}$ = 1.78 IN^4 2.72

A = $\frac{\pi D^2}{4}$ = 3.98 IN^2 4.91



L = 4.85 7.125 + 8 6.875 = 12.85" 14"

SHAFT TO BE SOFT FOR Y-DEFLECTION & STIFF FOR Z-DEFECTION (L NOT IMPORTANT.) (NO STRESS)
THEREFORE; SINCE SHAFT IS MODELED HERE OF GREATER THAN ACTUAL LENGTH, USE:

I_{XX} = 1.78 IN^4 2.72

I_{YY} = 3 * I_{ZZ} ≈ 4 IN^4 5.75

I_{ZZ} = 1.26 IN^4 1.92

CYGNA

Calculation Sheet

Project: WPPSS EQ		Prepared By: J.E. Rakowski	Date: 1/3/83
Subject: BIF Valve/Actuator Model Summary		Checked By: D.E. Searle	Date: 3/24/83
System: CSP and CEP		Job No.: 82044	File No.: OT.01/F & OS.01/F
Analysis No.: 361104 & 361106	Rev. No.: 1	Sheet No.: 4.3.B16	

FOR THE BRACKET ELEMENT:

(MAKE $e = 0$ & PUT 277# 15" DOWN) (321#)

LENGTH	= 28.5 (15 + 13.5)	✓28.5
WEIGHT	= 277 LB	321 #
$A_x = A_y = A_z$	= 6.84 IN^2	10.6 IN^2
C_z	= 6.84 IN	8.5 IN
C_x	= .25 IN	.313 IN
I_{xx}	= 102 IN^4 (BELOW)	255 IN^4
I_{yy}	= 1000 IN^4 (PAGE __)	1000 IN^4
I_{zz}	= 2.16 IN^4 (PAGE __)	4.22 IN^4

IN PLANE BENDING INERTIA OF BRACKET PLATE:

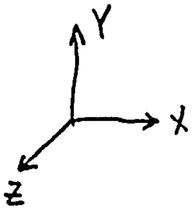
$$I_{xx} = \frac{1}{12} b h^3 = \frac{1}{12} (0.5)(13.5)^3 = 102 \text{ IN}^4$$

(revised: .625, 17; 255)

CYGNA — Calculation Sheet

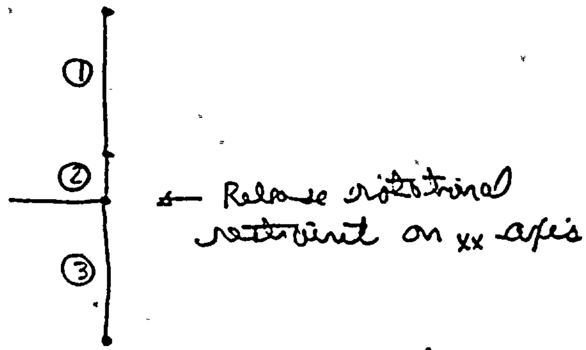
Project: WPPSS EQ	Prepared By: [signature] Date: 1/3/83
Subject: BIF VALVE/ACTUATOR MODEL SUMMARY	Checked By: D. E. Searle Date: 3/24/83
System: CSP and CEP	Job No. 82044 File No. OT.01/F & OS.01/F
Analysis No. 361104 & 106 Rev. No. 1	Sheet No. 4.3.B17

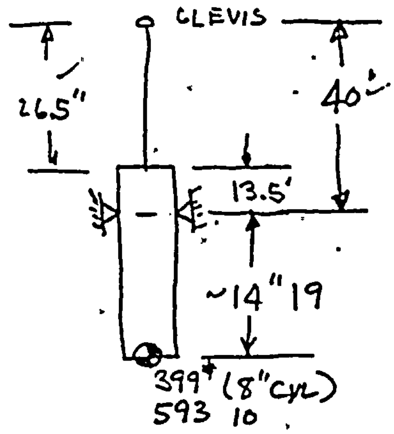
DRIVE ROD & CYLINDER:



IMPORTANT DISTANCES ARE:

MODEL:





①: DRIVE ROD:

$L = 26.5''$ ✓

$A = \pi/4\ D^2 = 2.41\ IN^2$ ✓

$C = .875''$ ✓

$I = .46\ IN^4 = I_{xx} = I_{zz}$ ✓

$I_{yy} = \sqrt{2} * I_{xx} = .65\ IN^4$ ✓

② ③ 8" CYL: (10) (Say $\rho = 0$ AND PUT 399# (593#) AT CG)

$L_② = 13.5$ ✓

$L_③ = 14.0$ 19

$I_{yy} = \quad = 74\ IN^4$ 180

$I_{xx} = I_{zz_2} = 52.2\ IN^4$ (large) ÷ $(1.25)^4$ = 127

$A = \pi/4\ 8^2 = 50.3\ IN^2$ 78

$C = 4''$ 5

APPENDIX C

SAMPLE HAND CALCULATIONS
TO CHECK PROGRAM
CEP-V-3A

nbif CEP-V- 3A
INPUT GLOBAL ACCELERATIONS
? 13.89,1.66,1.04
.INPUT ANGLES OF NORTH VECTOR
? 90,90,0
INPUT ANGLES OF VERTICAL VECTOR
? 90,0,90
INPUT ANGLES OF EAST VECTOR
? 0,90,90

Calculation Sheet

Prepared By: J.E. Rakowski	Date 1/10/83		
Checked By: D.E. Searle	Date 3/24/83		
Job No. 82044	File No. OS.01/F	Sheet No: 4.3.C2	

INPUT DATA

GLOBAL G-LEVELS	=	13.89	1.66	1.04
NORTH VECTOR ANGLES	=	90	90	0
VERTICAL VECTOR ANGLES	=	90	0	90
EAST VECTOR ANGLES	=	0	90	90

INPUT ANGLES OF WEIGHT VECTOR
? 90,180,90

LOCAL G-LEVELS

-5.29861E-5	-6.33239E-6	1.04
-5.29861E-5	1.66	-3.96728E-6
13.89	-6.33239E-6	-3.96728E-6

OPERATING DRIVE ROD STRESS AT A	477.198
OPERATING DRIVE ROD STRESS AT B	821.458
OPERATING CYLINDER BRG PRESSURE	-3.75613E-4
OPERATING VALVE EAR TENSILE STR	1136.52
OPERATING VALVE EAR SHEAR STRES	89.1706
OPERATING EAR BOLT SHEAR STRESS	1078.68
OPERATING EAR BOLT TENSILE STR	5251.595

glc(1,j)= j=-5.29861E-5 ✓ 1
fcdr= -1.22282E-2
siga= -.267492
sigb= -.409114
Fc due to T3=-5.71181E-2
f11= 2.73638E-2
f22=-5.85968E-2
dsa= .071552
dsr= 3.3257E+7
dbten= 4.86604E+9
glc(1,j)= j=-6.33239E-6 2
fcdr= -1.4614E-3
siga= -3.19681E-2
sigb= -4.88934E-2
Fc due to T3= 321.752
f11=-154.143
f22= 330.082 (NEXT PAGE)
dsa= .072574
dsr= 3.7607E+7
dbten= 4.86759E+9
glc(1,j)= j= 1.04 3
fcdr= 240.013
siga= 5250.28
sigb= 8029.99
Fc due to T3= 919.516
f11=-440.516
f22= 943.322
dsa= 2.75454E+7

SAMPLE CHECK CALC'S.

EAR TENSILE STRESS

$T_{3F} = (F_{ST} - W_{AO}) * 8.5 - 277 * 5.25$

$= (1150 - 399) * 8.5 - 277 * 5.25$

$T_{3F} = 4939$, $F_c = \frac{4939}{25} = 198\#$

$F_{11} = -.48 * T_{3F} = -95$

$F_{22} = +1.03 * T_{3F} = 203$

$S_{tt1F} = \left|-95 * \frac{7.125}{2} * \frac{.75}{.70}\right| + \left|203 * \frac{7.125}{2} * \frac{1.25}{1.95}\right|$

— NOTE BELOW —

$= 826$ PSI

M_1 due to dwd bending $= (W_{AO} + W_{BR} - F_{ST2}) * e_5$

$\tau_{M1} = M_1 / 2 d_2 * l_1 l_2 = \frac{3259}{2 * 10 * 1.5 * 2.5} = 44$ PSI

τ due to dwd shear $= \frac{(W_{AO} + W_{BR} - F_{ST2})}{4} * \frac{c_2}{z_1} * \frac{l_{aw}}{2}$

τ due to Shear $= \frac{+474}{4} * \frac{1.25}{1.95} * \frac{7.125}{2} = 271$ PSI

TOTAL DWD EAR TENSILE STRESS =
$826 + 44 + 271 = 1141$ VS ~ 1137 (OK)

CHECK F_c:

$F_{TR1} = \frac{(25 + 14.46)}{25} * 399 * 1.04 = 655\#$

$T_3 = (655 * 28.5 + 277 * 1.04 * 15) / 25 = 919.25$ (OK)

ERROR IN EAR STRESS CALCULATION CORRECTED ON PAGES 4.3-30 TO 4.3-48 ⚠ [signature] 6/14/83
[signature] 6/15/83

1006.00

CYGNA

Calculation Sheet

Project WPPSS Mechanical Equipment Qualification		Prepared By: J.E. Rakowski	Date 1/10/83
Subject 30" Butterfly Valves		Checked By: D.E. Searle	Date 3/24/83
System CSP and CEP		Job No. 82044	File No. OS.01/F
Analysis No. 361104	Rev. No. 1	Sheet No. 4.3.C3	

CHECK EAR TENSILE STRESS CALCS:

$\frac{f_{11}}{f_c} = \frac{-154}{322} = -.48$ ✓ $\frac{+330}{322} = +1.03$ ✓ (OK)

SIGNS (OK)

$T_3 = 2D\ F_c = 2 * 12.5 * 322 = 8050$ "#

CHECK:

$T_3 = F_{TL1} * 28.5 + \bar{W}_{BR} * g_1 * 15 + W_{AO} * g_2 * 8.5 + \bar{W}_{BR} * g_2 * 5.25$

$= \sim 0$ (i.e. $g_{1,2} \approx 0$) $+ 399 * 1.66 * 8.5 + 277 * 1.66 * 5.25$

$T_3 = 8044$ "# vs 8050 "# (OK)

CONCLUSIONS OF CHECK CASE CEP-V-3A:

1. FIXED STRESSES ON EARS CHECK
2. NEW VALVE EAR BENDING STRESS COMPONENTS CHECK
3. BEARING PRESSURE CHECKS (NOT SHOWN)
4. DRIVE ROD STRESS CHECKS (NOT SHOWN)
5. BOLT TENSION CHECKS (NOT SHOWN)

CYGNA

Calculation Sheet

Project WPPSS-WNP#2		Prepared By:	Date 11/4/83
Subject EQUIPMENT SEISMIC/HYDRO REQUALIFICATION		Checked By:	Date 11/7/83
System CSP/CEP		Job No. 82044	File No. 05.01.F
Analysis No. QID 361104	Rev. No. 2	Sheet No. SECTION 4	

APPENDIX D-1

ACCELERATION COMPARISON
ANALYSIS VS. FINAL-AS-BUILT

COMPARE SEISMIC ACCELERATION (ANALYZED WITH LATEST) TO DETERMINE IF MAGNITUDE OF THE ACCELERATION HAS INCREASED. AND IF SO WILL THE INCREASE INVALIDATE STRESS ANALYSIS. (NOTE: THERE WAS NO REVISED LOADING ISSUED FOR VALVES CEP-V-1A,2A)

REFERENCE SHEET 2.7 (ANALYZED LOADS).
REFERENCE SHEETS 5.5.1 → 5.5.6 (AS-BUILT LOADS)

INCREASED VALUES FOR GLOBAL "Y" ACCELERATION ONLY

CSP-V-1 – 3.67
3.62
.05 → 1.4% INCREASE

CSP-V-2 – 3.57
3.54
.03 → 0.85% INCREASE

WITHOUT CONSIDERATION FOR THE COMPENSATING DECREASE IN ACCELERATION IN THE OTHER AXIS, THE FAULTED CONDITION STRESSES SUMMARIZED SHEET 4.3.3 CAN BE READILY FACTORED UP BY 1% WITHOUT EXCEEDING ALLOWABLE. BECAUSE OF THIS RELATIVELY SMALL INCREASE AND SUFFICIENT MARGIN OF SAFETY RECOMPUTATION IS NOT NECESSARY.

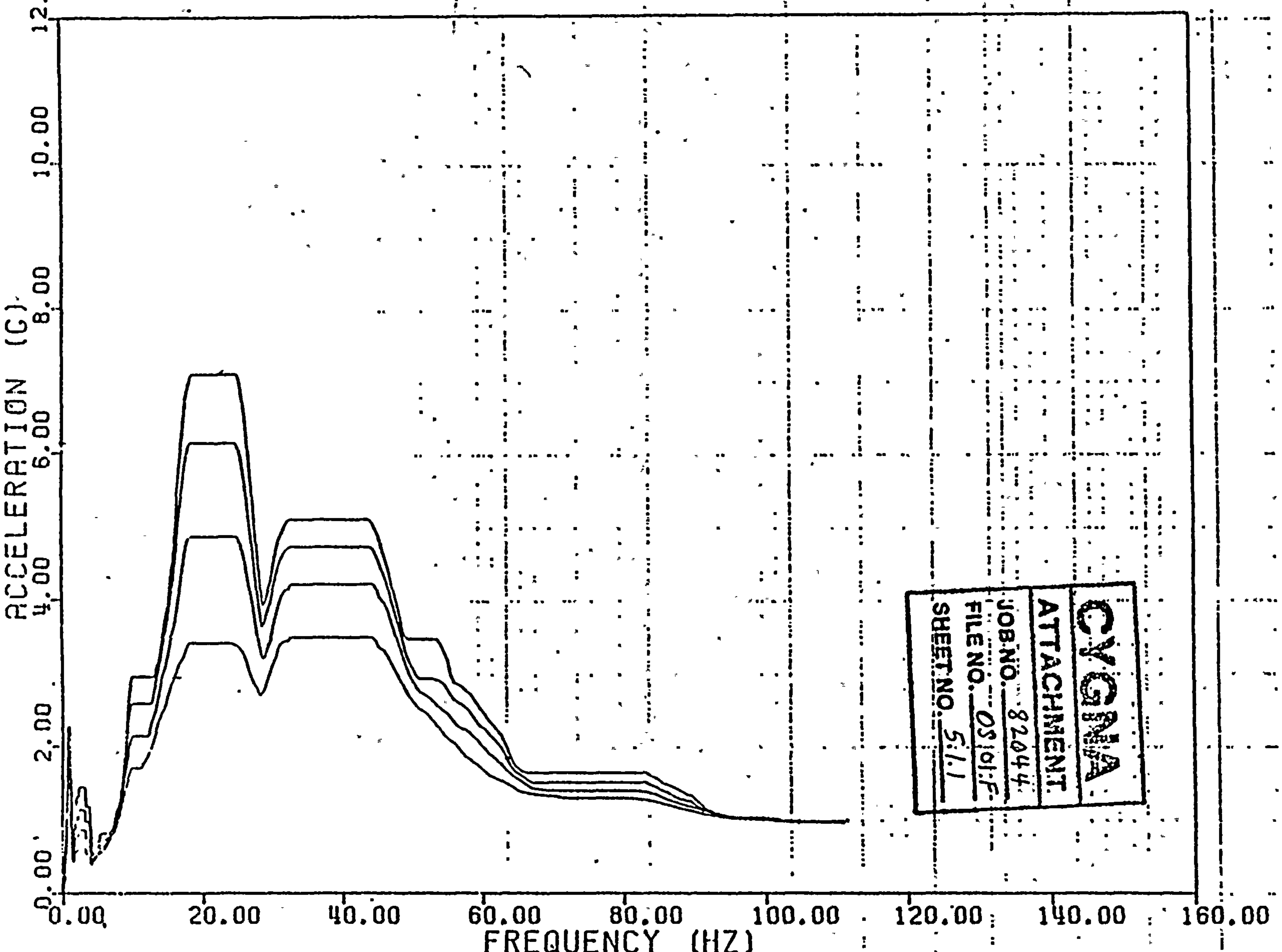
5.0 APPENDICES TO REQUALIFICATION ANALYSES

SECTION 5.0

APPENDICES

CONTENTS

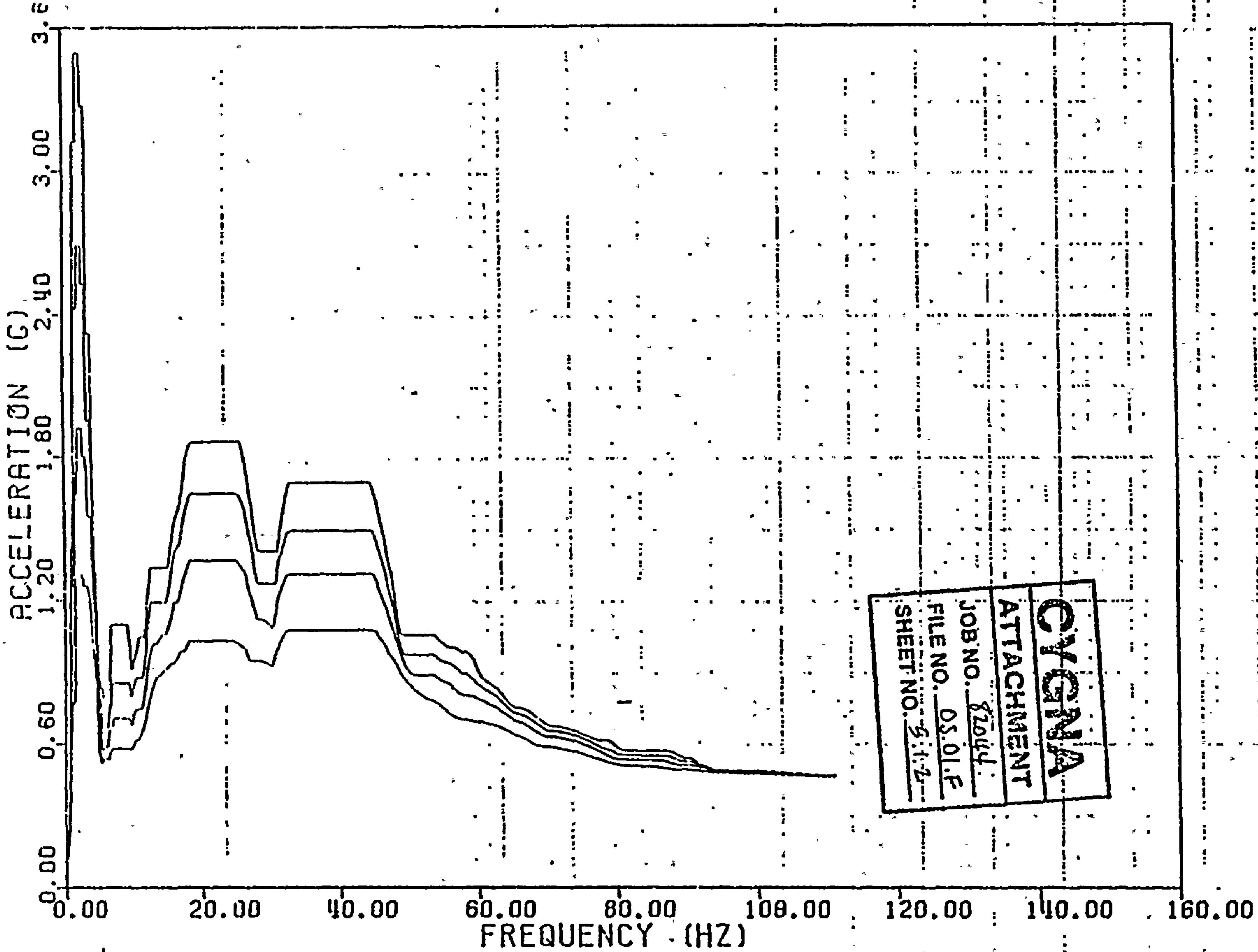
5.1 RESPONSE SPECTRA



WPPSS REACTOR BLDG. SRSS OF SRV SSE AP/CHUG.

MASS NO. 182 EL. 500 FT. HORIZ. TRANSLATION

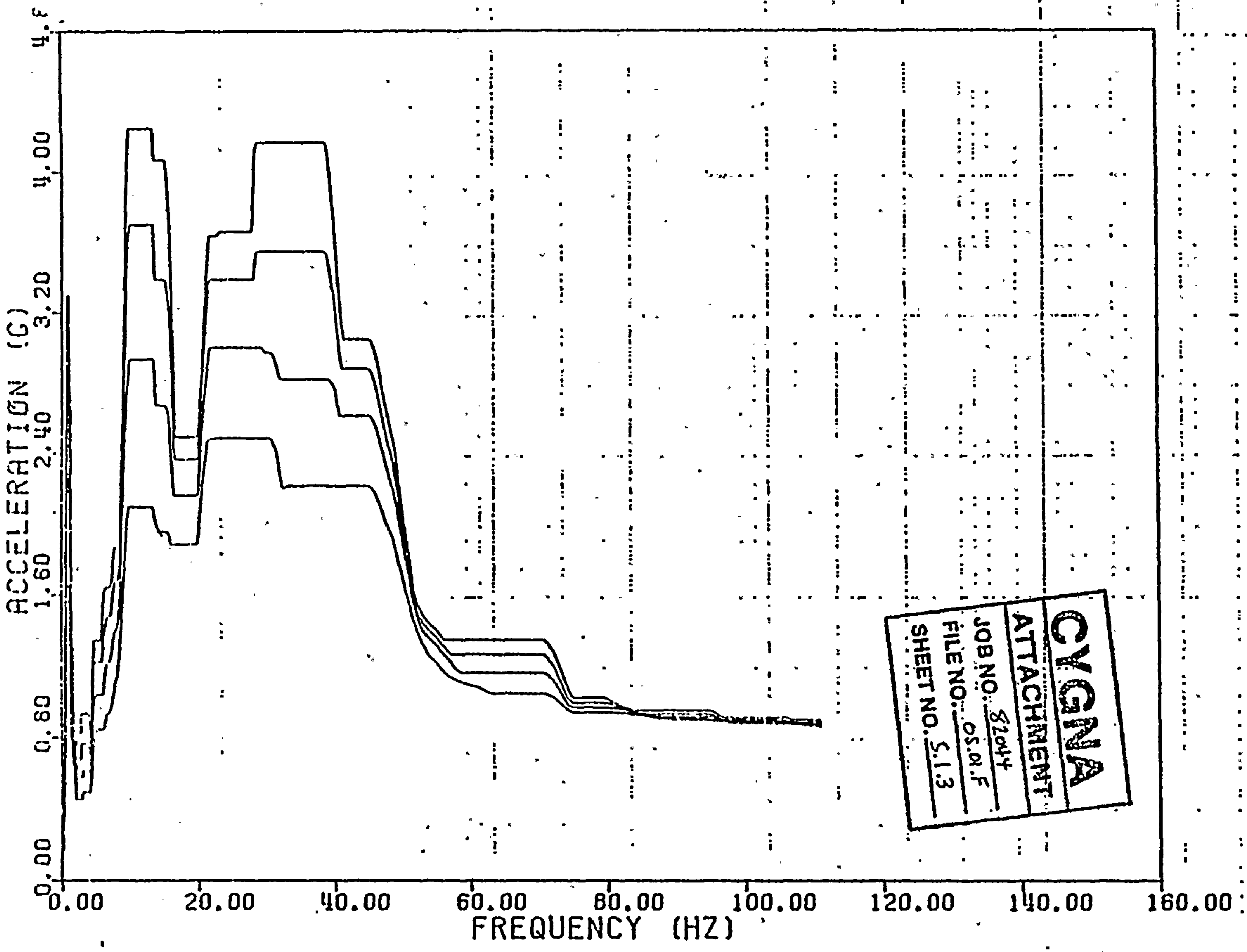
CONTAINMENT VESSEL DAMPING= .005,.01,.02,.04



WPPSS REACTOR BLDG. SRSS OF SRV SSE AP/CHUG.

MASS NO. 182 EL. 500 FT. VERT. TRANSLATION

CONTAINMENT VESSEL DAMPING= .005, .01, .02, .04



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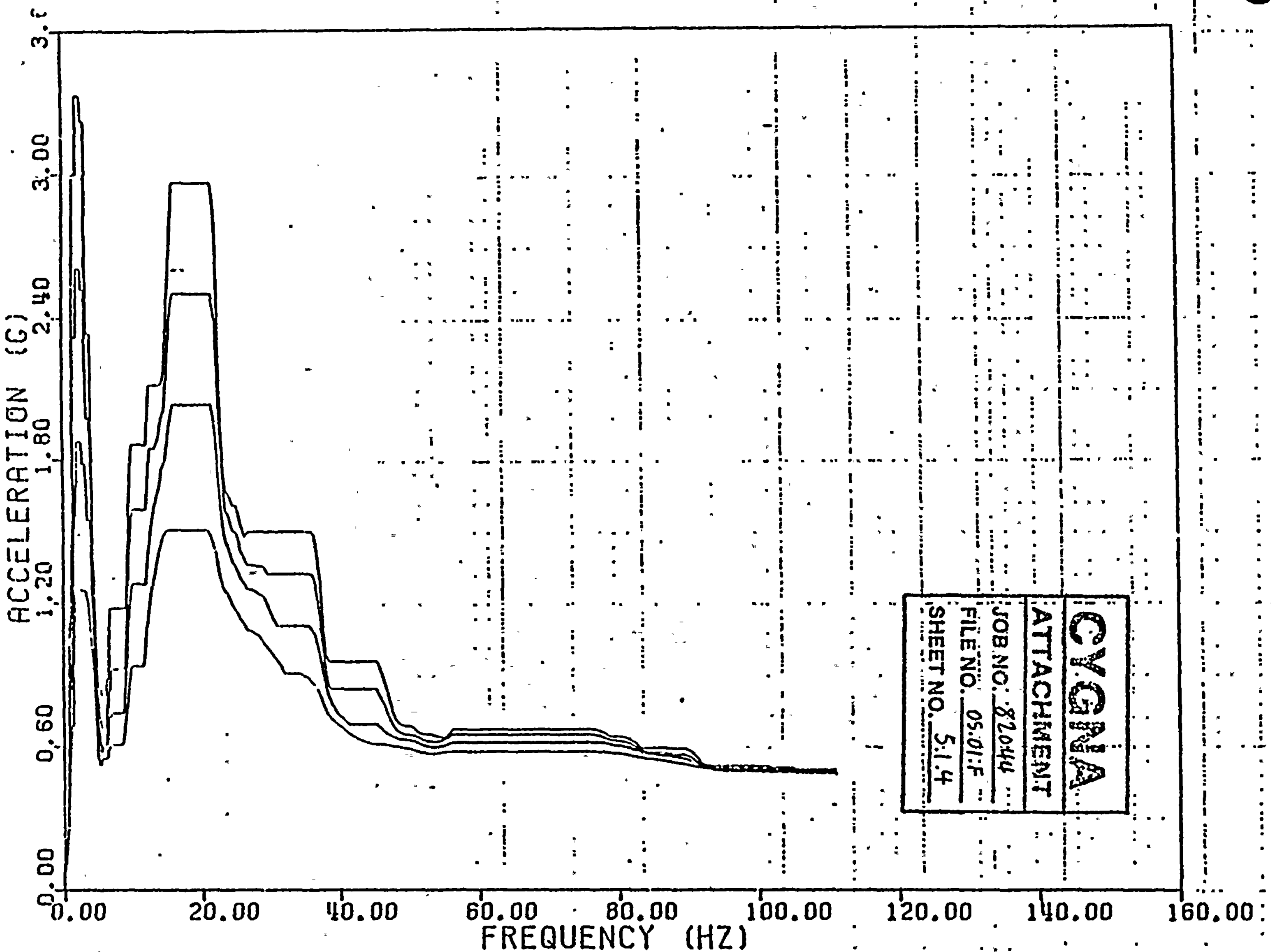
MASS NO. 187 EL. 558 FT. HORIZ. TRANSLATION
CONTAINMENT VESSEL DAMPING= .005,.01,.02,.04



WPPSS REACTOR BLDG. SRSS OF SRV SSE AP/CHUG.
MASS NO. 186 EL. 541 FT. VERT. TRANSLATION
CONTAINMENT VESSEL DAMPING= .005,.01,.02,.04

5.2 WALKDOWN SHEETS

△

EQUIPMENT QUALIFICATION WALKDOWN VERIFICATION FORM

EPN# CSP-V-1

QID# 361104

BLDG R   FLOOR EL 501   COORDS M.5/7.6

MFR BIF   COMPONENT EL 508   DSCRP 30" BFLY

MOD# A206763   SERIAL# ____   MAT'L ____

____ PSI @ ____ °F   LBS ____ SIZE ____

ASME CLASS ____

YOKE ORIENTATION

⊥ TO AXIS OF PIPE ( )

// TO AXIS OF PIPE ( )

YOKE LENGTH ____
(FLANGE TO FLANGE)

MOUNTING CONDITION

NO OF BOLTS ____

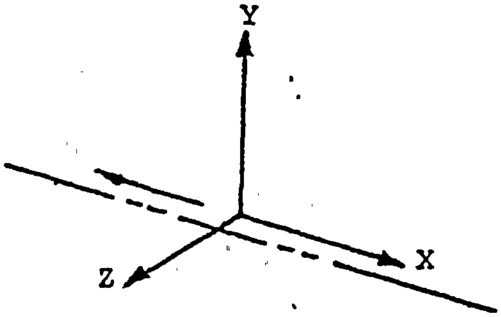
BOLT TYPE ____ BOLT Ø ____

WELD TYPE & SIZE ____

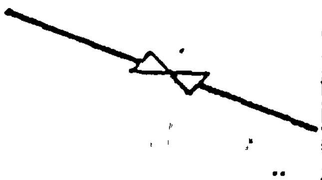
PIPE MOUNTED YES( ) NO ( )

PERMANENT OBSTRUCTION (WITHIN 2") YES( ) NO( )

FULL(6WAY) ANCHOR BETWEEN COMPONENT & PRI CONT YES( ) NO( )



GLOBAL CO-ORDINATE SYSTEM



CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.2.1

VALVE STEM ORIENTATION

OPERATOR EPN ____   MANUFACTURER ____

MODEL NO ____   SERIAL NO ____

TYPE ____ SIZE ____   ORDER NO ____

MOTOR EPN ____   MANUFACTURER ____

MODEL NO ____   SERIAL NO ____

ID NO ____ INS CLASS ____   1-PHASE ( ) 3-PHASE ( ) AC ____ DC ____

COMMENTS: Definition (N/F = Not Found)

Component not installed as of 7/19/82

SEE SHEET 2 OF 2.

△ VISUAL INSPECTION PERFORMED 12/22/82 IT WAS NOTED VALVE INSTALLED

PREPARED BY [signature] DATE 7/19/82 REVIEWED BY William Cunha DATE 7/19/82
(SIGNATURE) (SIGNATURE)

Doug True   WILLIAM CUNHA

△ [illegible] 1/5/83

CYGNA

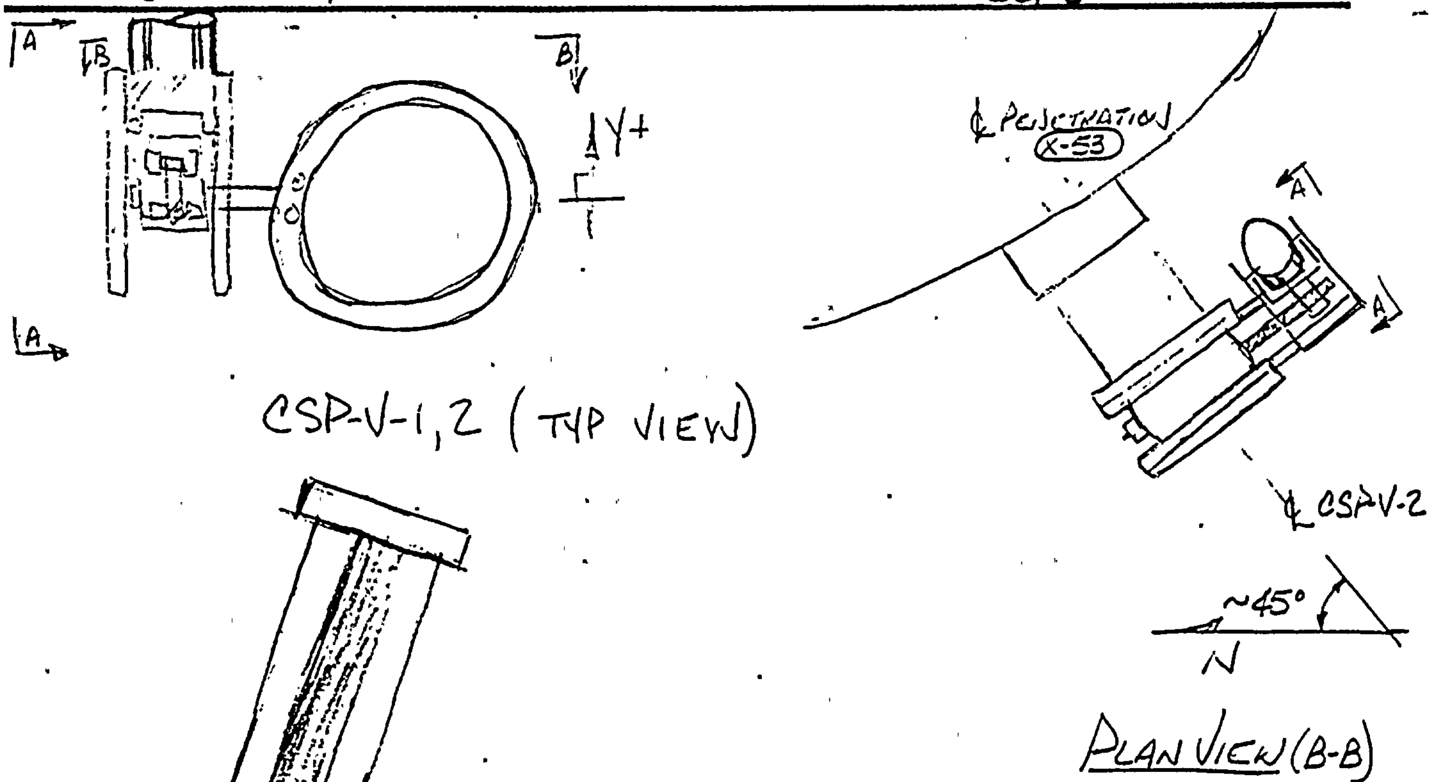
Calculation Sheet

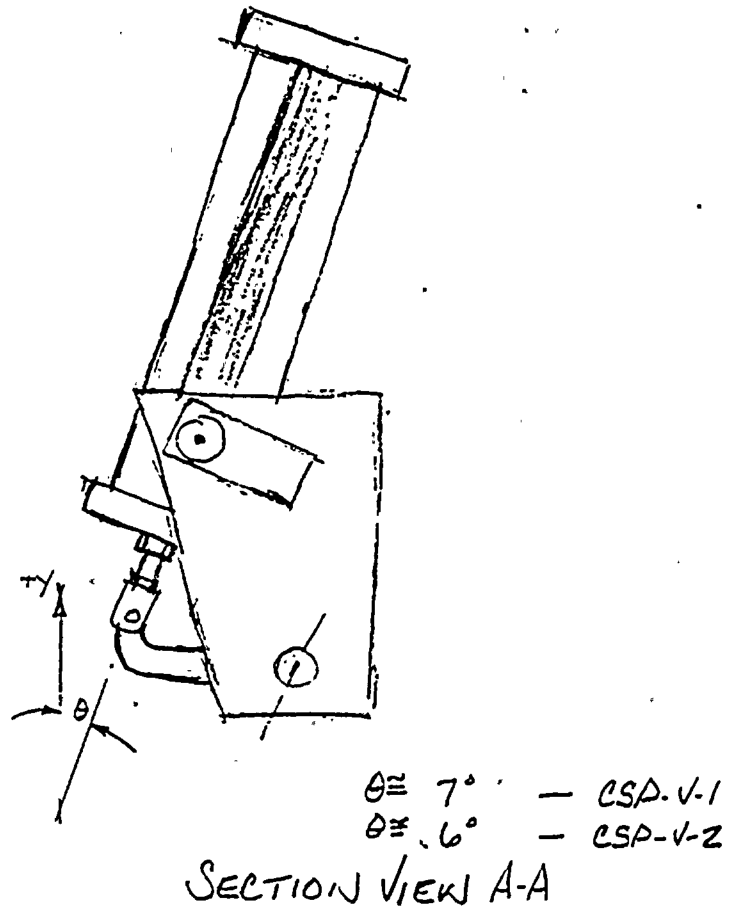
Project WNP #2 | Prepared By: [signature] | Date 12/22/82

Subject EQUIP. QUALIFICATION | Checked By: E Kalinowski | Date 1/4/83

System | Job No. 82044 | File No.

Analysis No. OID 361104 | Rev. No. | Sheet No. 2 OF 2





CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. S.2.2

FIELD SKETCH (FOR THE PURPOSE OF DEPICTING OPERATOR ORIENTATION, ONLY)

CYGNA

EQUIPMENT QUALIFICATION WALKDOWN VERIFICATION FORM

EPN# - CSS-V-2

QID# 361104

BLDG R   FLOOR EL 501   COORDS M.5/7.4

MFR BIF   COMPONENT EL 508   DSCRP 30" BFLY

MOD# A-206763   SERIAL# ____   MAT'L ____

____ PSI @ ____ °F   LBS ____ SIZE ____

ASME CLASS ____

YOKE ORIENTATION

⊥ TO AXIS OF PIPE ( )

// TO AXIS OF PIPE ( )

YOKE LENGTH ____ (FLANGE TO FLANGE)

MOUNTING CONDITION

NO OF BOLTS ____

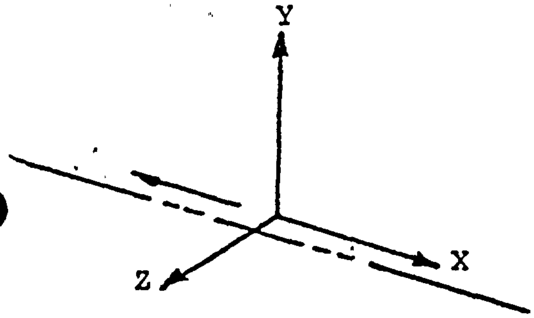
BOLT TYPE ____ BOLT Ø ____

WELD TYPE & SIZE ____

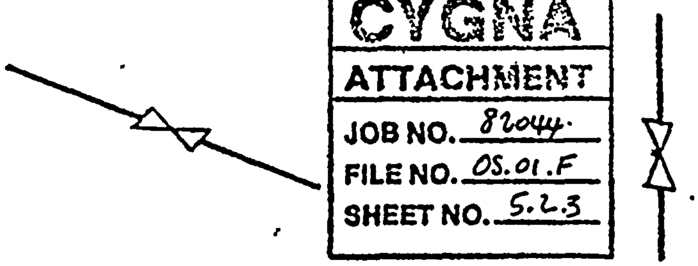
PIPE MOUNTED YES( ) NO ( )

PERMANENT OBSTRUCTION (WITHIN 2") YES( ) NO( )

FULL(6WAY) ANCHOR BETWEEN COMPONENT & PRI CONT YES( ) NO( )



GLOBAL CO-ORDINATE SYSTEM



CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.2.3

VALVE STEM ORIENTATION

OPERATOR EPN ____   MANUFACTURER ____

MODEL NO ____   SERIAL NO ____

TYPE ____ SIZE ____   ORDER NO ____

MOTOR EPN ____   MANUFACTURER ____

MODEL NO ____   SERIAL NO ____

ID NO ____ INS CLASS ____   1-PHASE ( ) 3-PHASE ( ) AC ____ DC ____

COMMENTS: Definition (N/F = Not Found)   Limit Switch

⚠ VISUAL INSPECTION PERFORMED 12/22/82 + IT WAS NOTED VALVE INSTALLED SEE SHEET 2 OF 2

Note: Not installed as of 7/19/82

PREPARED BY [signature] (SIGNATURE)   DATE 7/19/82   REVIEWED BY [signature] (SIGNATURE)   DATE 7/19/82

Doug True   William Cinelli

⚠ [signature] 1/5/83

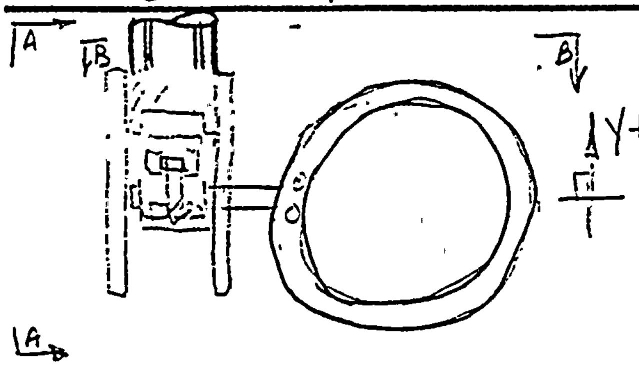
1

0.10

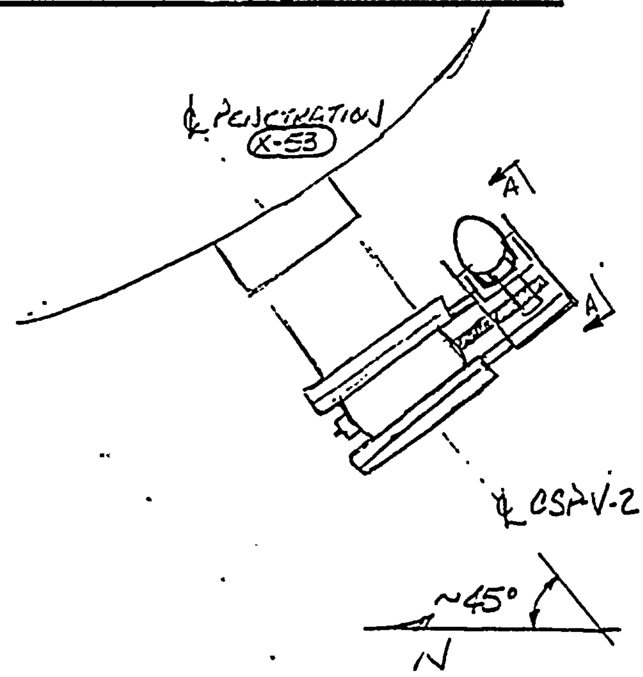
CYGNA

Calculation Sheet

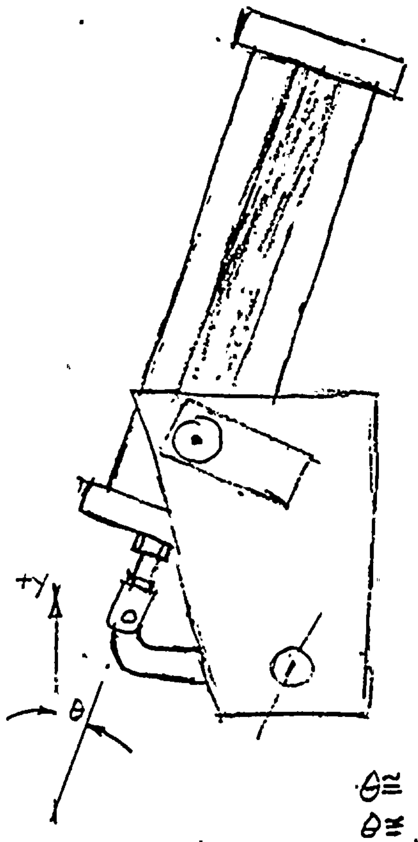
Project: WNP #2		Prepared By: [signature]	Date: 12/22/82
Subject: EQUIP. QUALIFICATION		Checked By: E Rabowski	Date: 1/4/83
System:		Job No.: 82044	File No.:
Analysis No.: QID#361104	Rev. No.:	Sheet No.: 2 OF 2	



CSP-V-1,2 (TYP VIEW)



PLAN VIEW (B-B)



θ≅ 7° — CSP-V-1
θ≅ 6° — CSP-V-2

SECTION VIEW A-A

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.2.4

FIELD SKETCH (FOR THE PURPOSE OF DEPICTING OPERATOR ORIENTATION, ONLY)

EQUIPMENT QUALIFICATION WALKDOWN VERIFICATION FORM

EPN# CEP-V-1A

QID# 361104

BLDG R FLOOR EL 548 COORDS J4/5.4

MFR BIF COMPONENT EL 558 DSCRP 30" Butterfly

MOD# A-206763 SERIAL# 27234-3 MAT'L SA-516-GR70

45 PSI @ 340 °F LBS N/F SIZE 30'

ASME CLASS 2

YOKE ORIENTATION

⊥ TO AXIS OF PIPE ( )

// TO AXIS OF PIPE ( ) N/A

YOKE LENGTH N/A
(FLANGE TO FLANGE)

MOUNTING CONDITION

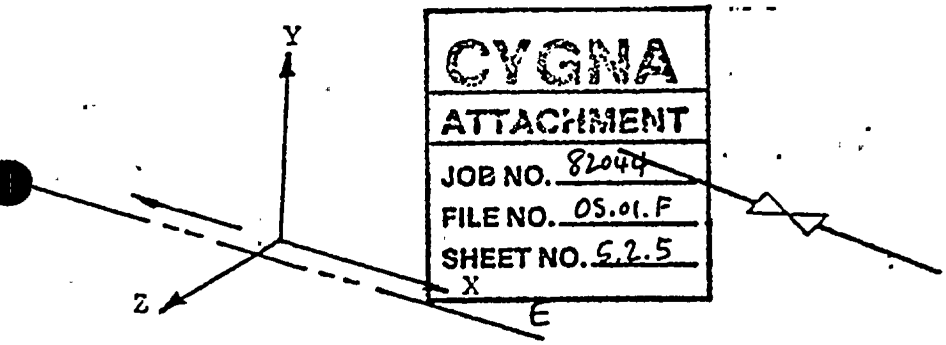
NO OF BOLTS N/A

BOLT TYPE N/A BOLT Ø N/A

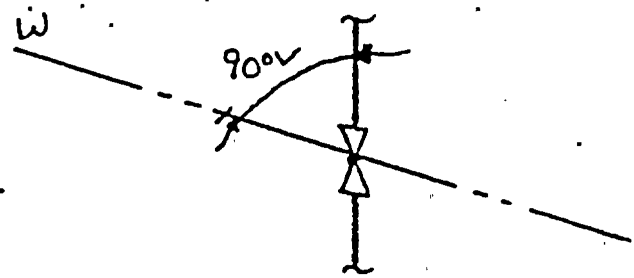
WELD TYPE & SIZE N/A

PIPE MOUNTED YES (✓) NO ( ) bolted flanges

PERMANENT OBSTRUCTION (WITHIN 2") YES ( ) NO (✓)
IS COMP BETWEEN CONT & 1ST ANC. (FULL 6 WAY ANC) YES (✓) NO ( )
DO MULTIPLE SUPPORTS EXIST BETWEEN CONT & COMP YES ( ) NO (✓)



CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 6.2.5



GLOBAL CO-ORDINATE SYSTEM

VALVE STEM ORIENTATION

OPERATOR EPN N/A MANUFACTURER

MODEL NO SERIAL NO

TYPE SIZE ORDER NO

MOTOR EPN N/A MANUFACTURER

MODEL NO SERIAL NO

ID NO INS CLASS 1-PHASE ( ) 3-PHASE ( ) AC DC

COMMENTS: 2 Limit Switches Found EPN's: not known
Model: 1703100 Manufacturer: Namco Controls
EA74080100

PREPARED BY [signature] DATE 7/14/82 REVIEWED BY William Cunha DATE 7/14/82
(SIGNATURE) (SIGNATURE)
David Tran WILLIAM CUNHA

CYGNA

EQUIPMENT QUALIFICATION WALKDOWN VERIFICATION FORM

EPN# CEP-V-2A

QID# 361104

BLDG R | FLOOR EL 548 | COORDS J.4 / 5.4

MFR BIF | COMPONENT EL 558 | DSCRP 30" Butterfly

MOD# 0657 | SERIAL# 27234-4 | MAT'L SA-516-GR 70

45 PSI @ 340 °F | LBS N/F SIZE 30"

ASME CLASS 2

YOKE ORIENTATION

⊥ TO AXIS OF PIPE ( )

// TO AXIS OF PIPE ( ) N/A

YOKE LENGTH N/A
(FLANGE TO FLANGE)

MOUNTING CONDITION

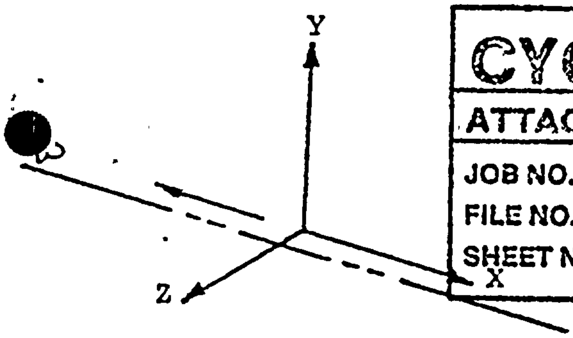
NO OF BOLTS N/A

BOLT TYPE N/A BOLT Ø N/A

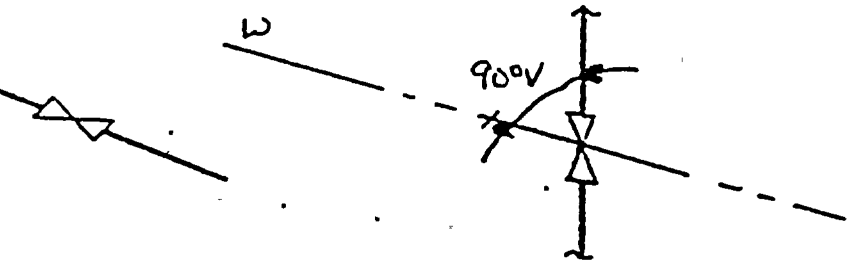
WELD TYPE & SIZE N/A

PIPE MOUNTED YES (✓) NO ( ) bolted flanges

PERMANENT OBSTRUCTION (WITHIN 2") YES ( ) NO (✓)
IS COMP BETWEEN CONT & 1ST ANC. (FULL 6 WAY ANC) YES (✓) NO ( )
DO MULTIPLE SUPPORTS EXIST BETWEEN CONT & COMP YES ( ) NO (✓)



CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.2.6



GLOBAL CO-ORDINATE SYSTEM

VALVE STEM ORIENTATION

OPERATOR EPN N/A	MANUFACTURER
MODEL NO N/A	SERIAL NO
TYPE ___ SIZE ___	ORDER NO

MOTOR EPN N/A	MANUFACTURER
MODEL NO	SERIAL NO
ID NO ___ INS CLASS ___	1-PHASE ( ) 3-PHASE ( ) AC ___ DC ___

COMMENTS: 2 Limit Switches found Manufacturer: Namco Controls
Model #: 1703100 EPN: CEP-LMS-2A
#: EA 74080100

PREPARED BY Doug ... for Dave Doyel (SIGNATURE) DATE 7/14/82 REVIEWED BY William ... (SIGNATURE) DATE 7/14/82

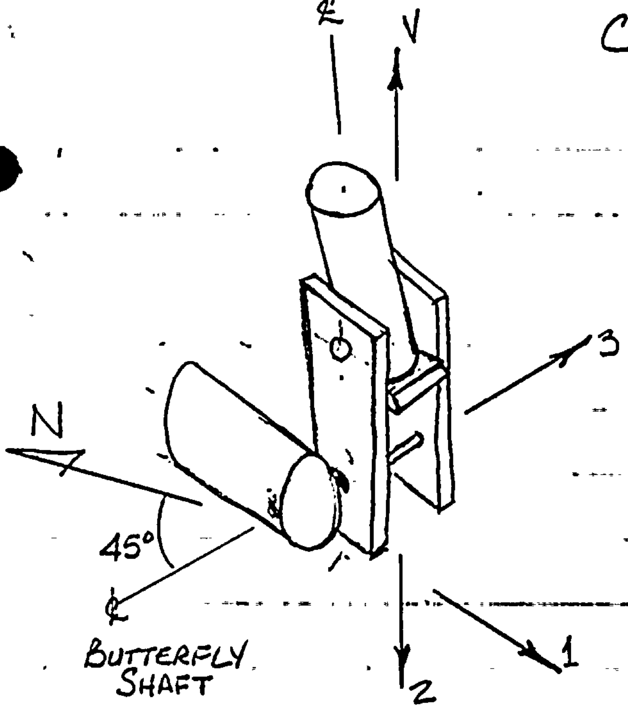
5.3 Valve Local Coordinate Systems

CSP-V-1

CSP-V-2

CSP-V-1,2

REFERENCE: CSP-V-1,2 FIELD WALKDOWN SHEETS



PREPARED BY [signature] 2/11/83

REVIEWED BY: [signature] 2/11/83

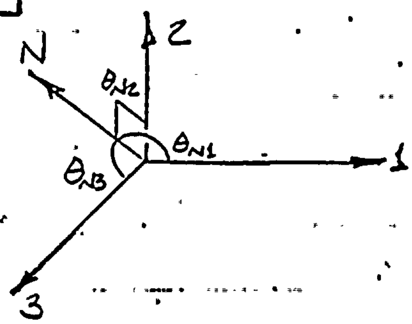
CYGNA

ATTACHMENT

JOB NO. 82044

FILE NO. 05.01.F

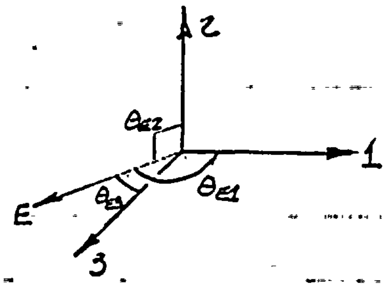
SHEET NO. 5.3.1



$\theta_{N1} = 135°$ $\cos\theta_{N1} = -0.707$

$\theta_{N2} = 90°$ $\cos\theta_{N2} = 0$

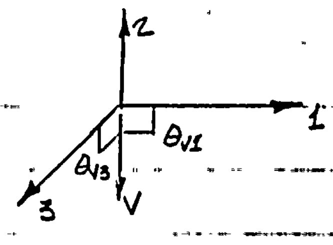
$\theta_{N3} = 135°$ $\cos\theta_{N3} = -0.707$



$\theta_{E1} = 45°$ $\cos\theta_{E1} = 0.707$

$\theta_{E2} = 90°$ $\cos\theta_{E2} = 0$

$\theta_{E3} = 135°$ $\cos\theta_{E3} = -0.707$



$\theta_{V1} = 90°$ $\cos\theta_{V1} = 0$

$\theta_{V2} = 180°$ $\cos\theta_{V2} = -1$

$\theta_{V3} = 90°$ $\cos\theta_{V3} = 0$

5.4 SUMMARY SHEETS

user number 43

function FIN

date/time 02/10/83 09:06

-SRM MASTER EQUIPMENT LIST-

EPN	COMPOSITE EPN
2-CSP-V-1	2-CSP-V-1+

CONTRACT	MFG	MODEL	SERIAL NUMBER
68	B250	A-206763	

DESCRIPTION

30" BFLY CONTAINMENT ISOL VALVE

A.S 5/16/83

LEVEL	EC	USE	HOURS	SAFETY FUNCTION	ACCURACY
2	A	~~2 2~~ 1 3	4320	B1, F	

A/E DRAWING	AE ZONE	BLDG	ELEV	DETAIL	ZONE	ROOM
M543	D5	R	508	M. 5/7. 6	R43	

HL	SEIS. TEST	QUAL ANL	F/O	C	ENV. AGING	QUAL DBE	C	QUAL SEIS	STATUS ENV	TM	FREQ	QID
~~N~~ Y		01		0				~~C~~ A		P	07	361104

MESSAGE

CYGNA

PROJECT WPPSS WNP-2

TITLE Summary Sheets

PREPARED BY: L.C. Fernandez

DATE 4/28/83

CHECKED BY: D.E. Stark

DATE 5/16/83

JOB NO. 82044

FILE NO. 05.01.F

SHEET NO. 5.4.1

user number 43 date/time 02/10/83 09:07

function NEX -SRM MASTER EQUIPMENT LIST-

EPN	COMPOSITE EPN
2-CSP-V-2	2-CSP-V-2+

CONTRACT	MFG	MODEL	SERIAL NUMBER
68	B250	A-206763	

DESCRIPTION

30" BFLY CONTAINMENT ISOL VALVE

D.S. 5/16/83

LEVEL	EC	USE	HOURS	SAFETY FUNCTION	ACCURACY
2	A	~~2 3~~ 1 3	4320	B1,F	

A/E DRAWING	AE ZONE	BLDG	ELEV	DETAIL	ZONE	ROOM
M543	D6	R	508	M.5/7.4	R43	

HL	SEIS. QUAL TEST	ANL	F/D	C	ENV. AGING	QUAL DBE	C	QUAL SEIS	STATUS ENV	TM	FREQ	QID
~~N~~ Y		01		0				~~C~~ A		P	07	361104

MESSAGE

CYGNA

PROJECT WPPSS WNP-2

TITLE Summary Sheets

PREPARED BY: L.C Fernandez

DATE 4/28/83

CHECKED BY: D.E. Leaule

DATE 5/16/83

JOB NO. 82044

FILE NO. 05.01.F

SHEET NO. 5.4.2

user number 43 date/time 02/10/83 09:13

function FIN -SRM MASTER EQUIPMENT LIST-

EPN	COMPOSITE EPN
2-CEP-V-1A	2-CEP-V-1A+

CONTRACT	MFG	MODEL	SERIAL NUMBER
2	B250	DWG A-206763	27234-3

DESCRIPTION

30.0" BFLY(AO) DRYWELL EXHAUST

LEVEL	EC	USE	HOURS	SAFETY FUNCTION	ACCURACY
2	A	1 3	4320	B1,F	

A/E DRAWING	AE ZONE	BLDG	ELEV	DETAIL	ZONE	ROOM
M543	J13	R	558	J.4/5.4	R62	

	SEIS. QUAL				ENV.	QUAL		QUAL STATUS		TM	FREQ	QID
HL	TEST	ANL	F/O	C	AGING	DBE	C	SEIS	ENV			
Y		01		O				A		P	07	361104

MESSAGE

CYGNA
PROJECT WPPSS-WNP-2
TITLE Summary Sheets
PREPARED BY: L.C. Fernandez
DATE 4/28/83
CHECKED BY: D.E. Searle
DATE 5/16/83
JOB NO. 82044
FILE NO. 03.01.F
SHEET NO. 5.4.3

user number 43 date/time 02/10/83 09:13

function FIN -SRM MASTER EQUIPMENT LIST-

EPN	COMPOSITE EPN
2-CEP-V-2A	2-CEP-V-2A+

CONTRACT	MFG	MODEL	SERIAL NUMBER
2	B250	DWG A-206763	27234-4

DESCRIPTION
30" AO BLFY DRYWELL EXHAUST

LEVEL	EC	USE	HOURS	SAFETY FUNCTION	ACCURACY
2	A	1 3	4320	B1,F	

A/E DRAWING	AE ZONE	BLDG	ELEV	DETAIL	ZONE	ROOM
M543	J13	R	558	J. 4/5. 4	R62	

HL	SEIS. QUAL TEST	ANL	F/O	C	ENV. AGING	QUAL DBE	C	QUAL STATUS SEIS	ENV	TM	FREQ	QID
Y				~~Y~~ O				A		P	07	361104

MESSAGE

CYGNA
PROJECT WPPSS, WNP-2
TITLE Summary Sheets
PREPARED BY: L.C. Fernandez
DATE 4/28/83
CHECKED BY: D.C. Seagle
DATE 5/16/83
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.4.4

5.5 REVISED BURNS & ROE PIPING ANALYSIS ACCELERATIONS

Tracy

MAY 11 1983

RECEIVED

MAY 31 1983

CYGNA-RICHLAND

Subject: W. O. 3900/4000
Washington Public Power Supply System
WNP-2
Qualification of Mechanical Pipe
Mounted Equipment; Forwarding of
Information

April 29, 1983
BRWP-83-078

Mr. L. T. Harrold
Assistant Director
Washington Public Power Supply System
3000 George Washington Way
Richland, Washington 99352

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.5.1

Attention: Mr. B. A. Holmberg

References: (a) WPBR-83-17, dated 3/16/83.
(b) WPBR-83-28, dated 4/12/83.
(c) WPBR-83-29, dated 4/12/83.
(d) Telecopy, B. A. Holmberg to J. J. Verderber, dated 4/4/83.

Gentlemen:

In response to the request of references (a), (b), (c) and (d), this letter is forwarding refined valve accelerations. The valve acceleration sheets for the five (5) CSP valves represent the second iteration of the refinement task. Valve sheets for the other four (4) valves represent the first iteration of the refinement task. Please inform the Woodbury Office if efforts should be made to reduce accelerations further.

Very truly yours,

ORIGINAL SIGNED BY J. J. VERDERBER

John J. Verderber
Project Engineering Manager

JJV/BPM/es
Att.

CC: Mr. W. S. Chin - BPA - 1 w/1
Mr. J. E. Rhodes - WPPSS - 1 w/1
Mr. P. Buck - WPPSS - 1 w/1 Mail Drop 575.

ATTACHMENT

Data forwarded with BRWP-83-078, dated April 29, 1983

Valve #	Anchor Group	Calc. No.
CSP-V-1	125	8.14.129
CSP-V-2	125	8.14.129
CSP-V-3	125	8.14.129
CSP-V-4	125	8.14.129
CSP-V-5	125	8.14.129
RCIC-V-31	107	8.14.112A
RHR-V-17B	31	8.14.121
RHR-V-53A	29	8.14.62C
RHR-V-53B	31	8.14.121B

CYGNA
ATTACHMENT
JOB NO. 82049
FILE NO. 05.01.F
SHEET NO. 5.5.2

Burns and Roe, Inc.

W.O. No. 3900-10 Date 4/12/83 Book No. 8,14,129 Page No. ___ Sheet ___ of ___

Drawing No. M200 Sh. 172 Rev 3A Calc. No. 8,14,129

By T.S. Checked ___ Approved ___

Title WNP-2 Status As-Built Verification of Piping Calculation

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 553

CSP-V-1 Valve Qualification

B&R File No. Dwg. 68-00-0008 Operation I.D. No. ______

B&R M200 Iso No. 172 Anchor Group 125

VALVE ACCELERATIONS

Location	Nodal Pt. No.	Mass Wt. (lb.)	Condition	Accelerations (g) X	Y	Z	Comments
Valve Operator (Bracket)	25	321	Upset	0.65	1.27	0.65	
			Emergency	0.88	1.58	1.87	
			Faulted	1.31	2.69	2.13	
Valve Operator (Cylinder)	33	593	Upset	0.76	1.41	0.88	
			Emergency	1.07	2.95	1.40	
			Faulted	1.46	3.67	1.74	

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.54

CSP-V-2 Valve Qualification

B&R File No. Dwg. 68-00-0008 Operation I.D. No. ______

B&R M200 Iso No. 172 Anchor Group 125

VALVE ACCELERATIONS

Location	Nodal Pt. No.	Mass Wt. (lb.)	Condition	Accelerations (g) X	Accelerations (g) Y	Accelerations (g) Z	Comments
Valve Operator (Bracket)	8	321	Upset	0.61	1.27	0.64	
			Emergency	0.81	1.51	1.56	
			Faulted	1.26	2.65	1.86	
Valve Operator (Cylinder)	17	593	Upset	0.66	1.33	0.79	
			Emergency	1.06	2.82	1.61	
			Faulted	1.44	3.57	1.90	

BURNS AND ROE, INC.
W.O. No. 3900-10 Date 4/12/83 Book No. 8.14.129 Page No. Sheet of
Drawing No. M200 Sh. 172 Rev 2A Calc. No. 8.14.129
By P.S. Checked Approved
Title WNP-2 Status As-Built Verification of Piping Calculation

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 5.5.5

B&R File No. 68-00-0308
B&R N200 Iso No. 171 REV 2A

Operation I.D. No. CEP-V-1A
Anchor Group 123
Calc. No. 8.14.125

W.O. No. 2-3900-10 Date 11/15/1982 Book No. 8.14.125 Page No.
Drawing No. [illegible]-CO-SII-171/REV 2A Calc No.
By R.N. Checked RP Approved Sheet Cont on Sheet
Title STRESS ANALYSIS [illegible] SII-171/REV. 2A

Valve Acceleration

CEP-V-1A

Location	Nodal Pt. No.	Mass Wt. M (lb.)	Conditions	Loads (lb.) FX	FY	FZ	Acceleration (g) Horizontal $\frac{(FX^2+FZ^2)^{1/2}}{M}$	Vertical $\frac{FY}{M}$	Comments
Valve Body	53	1876	Upset	1970	3018	2040	1.51	1.61	
			Emergency	1975	3027	2044	1.52	1.62	
			Faulted	2383 1.27	3322 1.77	2313 1.23	1.77	1.77	SLSS=2.50
Valve Operator	555	1352	Upset	2148	2752	2019	2.28	2.04	
			Emergency	2157	2759	2229	2.3	2.04	
			Faulted	2613 1.93	3009 2.25	2494 1.85	2.67	2.23	SLSS=2.48

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 556

B&R File No. 68-00-0008

B&R N200 Iso No. 171 REV 2A

Operation I.D. No. CEP-V-2A

Anchor Group 123

Calc. No. 8.14.125

Valve Acceleration

CEP-V-2A

Location	Nodal Pt. No.	Mass Wt. M (lb.)	Conditions		Loads (lb.) FX	FY	FZ	Acceleration (g) Horizontal $\frac{(FX^2+FZ^2)^{1/2}}{M}$	Vertical $\frac{FY}{M}$	Comments
Valve Body	661	1870	Upset		1246	3012	1588	1.08	1.61	
			Emergency		1277	3020	1623	1.1	1.61	
			Faulted		1464 / 0.78	3315 / 1.77	1918 / 1.02	1.29	1.77	SRSS = 2.19
Valve Operator	664	1352	Upset		1112	2600	1282	1.26	1.92	
			Emergency		1176	2608	1361	1.33	1.93	
			Faulted		1300 / 0.96	2856 / 2.11	1562 / 1.16	1.50	2.11	SRSS = 2.59

W.O. No. ... Drawing No. N200-SIT-171-2A Date 11/15/1982 Book No. 8.14.125
By J.M. Chkd RR Calc. No. 8.14.125 Approval Sheet Cont. on Sheet Page No.
Title STRESS ANALYSIS OF ISO N200-SIT-171 REV 2A

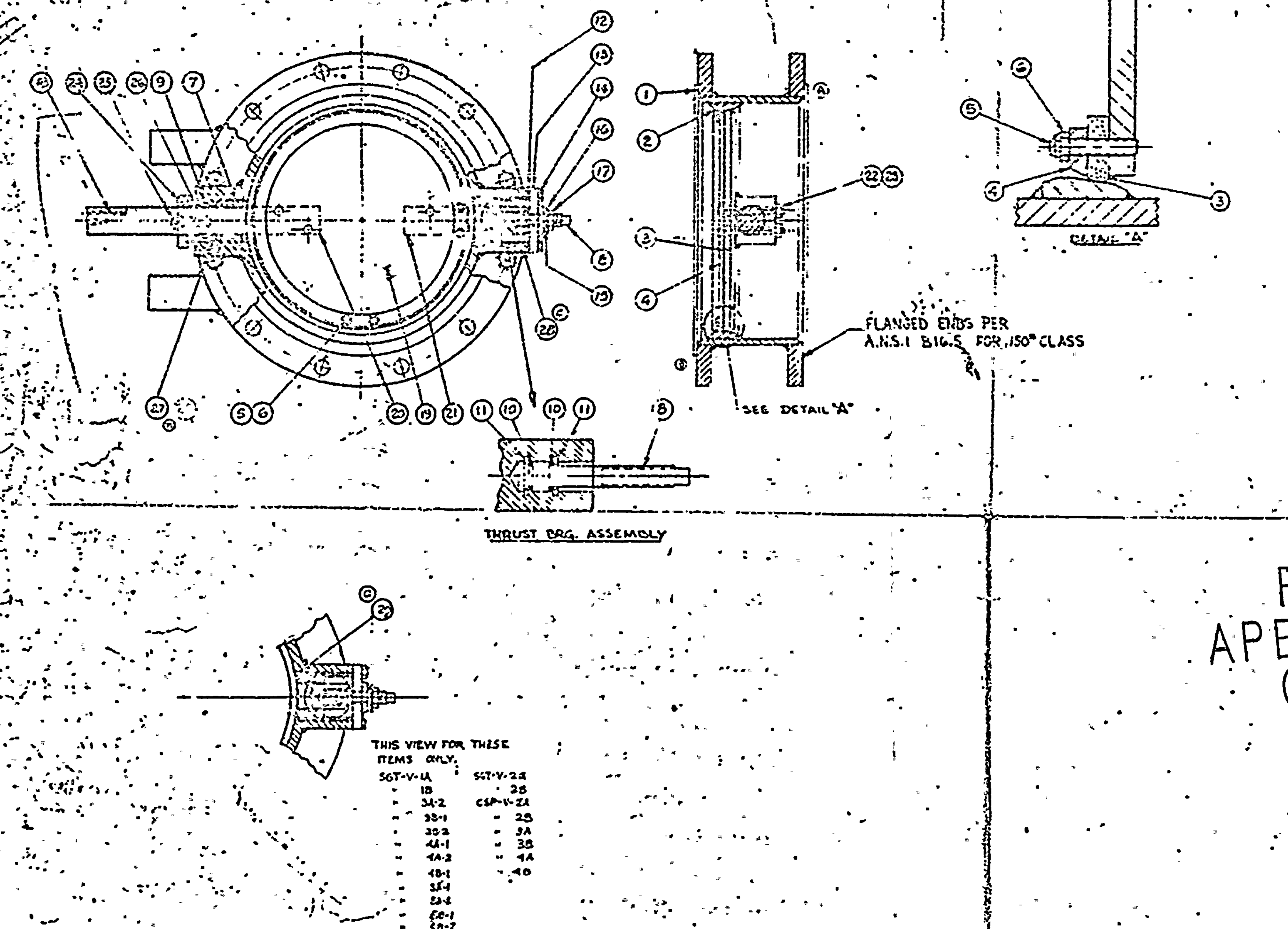
6.0 DRAWINGS USED FOR REQUALIFICATION

6.0 Drawings

QID# 361104

DRAWINGS SUBMITTED TO SUPPLY SYSTEM
IN ORIGINAL PACKAGE

A-206763	Rev	F
A-206767	"	C
D-220-0310-IR-66	Rev	0
C-26095	"	-
D-207110-F	"	-
CEP-625-10	"	2
CEP-625-11.12	Rev	5
CSP-807-3.4	Rev	4



ITEM	DESCRIPTION	MATERIAL	
1	VALVE BODY	[illegible]	
2	[illegible] BODY SEAT	[illegible]	
3	RUBBER SEAT	[illegible]	
4	CLAMPING RING	[illegible]	
5	CLAMPING RING STUD	18-8 STN. [illegible]	
6	CLAMP. RING LOCKNUT	[illegible]	
7	SHAFT BEARING	[illegible]	
8	THRUST ADJ. SCREW	STN. STL. [illegible]	
9	[illegible] PACKING	CRANE [illegible]	
10	THRUST BEARING	BRONZE ASTM B-[illegible]	
11	RETAINING PINS	[illegible]	
12	GASKET	COMPRESSED ASBESTOS [illegible]	
13	THRUST BEARING COVER	STL. SA 516 GR. [illegible]	
14	HEX HD CAP SCREW	STL. SA 193 GR. B7	
15	"O" RING	[illegible]	
16	PLAIN WASHER	BRASS	
17	HEX NUT	18-8 STN. STL. SA-194 GR. 8	
18	KEY	STL. A.I.S.I. 1018	
19	VALVE DISC	STL. SA 516 GR. 60	
20	VALVE SHAFT, FRONT	STN. STL. SA479 GR. 304	
21	STUB SHAFT	STN. STL. SA479 GR. 304	
22	DISC PIN	STN. STL. ASTM A276 GR. 304	
23	HEX NUT	18-8 STN. STL. SA-194 GR. 8	
24	GLAND FOLLOWER	STN. STL. SA 240 GR. 304	
25	HEX HD CAP SCREW	STN. STL. SA 193 GR. B8	
26	STUFFING BOX GLAND	STN. STL. SA479 GR. 304	
27	STUFFING BOX FLANGE	STN. STL. SA240 GR. 304	
28	SPACER	STN. STL. ASTM A240 TP. 304	
29	SPACER	STN. STL. ASTM A240 TP304	

PRC APERTURE CARD

THIS PRINT RELEASED FOR
CUSTOMER APPROVAL
CUSTOMER RECORD
PROCUREMENT

NUCLEAR

SIZE	VALVE		
30"	CSP-V-1, CSP-V-2, CSP-V-1A, CSP-V-2A	(4) REQ'D	PRIMARY CONTAINMENT BUTTERFLY [illegible]
24"	CSP-V-5, CSP-V-6, CSP-V-9	(3) REQ'D	[illegible] CONTAINMENT VACUUM [illegible] VALVES
24"	CSP-V-3, CSP-V-4, CSP-V-3A, CSP-V-4A	(4) REQ'D	[illegible] CONTAINMENT BUTTERFLY
18"	SGT-V-2A, SGT-V-2B	(2) REQ'D	[illegible] VALVES
18"	[illegible] SGT-V-3A1, SGT-V-3A2 (14) REQ'D [illegible]		STANDBY GAS TREATMENT SYSTEM BUTTERFLY VALVES

2. ALL VALVE MATERIAL IS SUITABLE FOR ACCIDENT AMBIENT CONDITIONS AS PER TABLE 7 OF SPEC.

1. VALVES TO BE MANUFACTURED IN STRICT ACCORDANCE WITH ASME BOILER/PRESSURE VESSEL CODE, SECTION III CLASS 2, [illegible]

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL DESCRIPTION

SIZE 18", 24" & 30"

WPPSS NUCLEAR PROJECT NO. 2
WASHINGTON PUBLIC POWER SUPPLY SYSTEM, CONTRACT [illegible]
68 00 0006

8312300159-01

7.0 PRIOR CALCULATIONS USED FOR REQUALIFICATION

CYGNA

7.0 TRANSMITTAL, PRIOR CALCULATIONS AND REPORTS

CONTENTS

*Note: Excerpts from report included in specified section. For complete report, see Cygna Energy Services File No. OS.01.F, QID 361104, "Equipment Seismic and Hydrodynamic Requalification of 30" Cylinder Operated Butterfly Valves," Revision 1, June, 1983.

CYGNA

7.1 COMMUNICATION REPORTS

CYGNA

Memorandum

Project Memo No. 14B

To: W. Schlafer

Date: November 15, 1982

From: P. Guglielmino/J. M. Foley

Job No: 83015

Subject: [redacted]

Copies: T. Wittig

RECEIVED
NOV 17 1982
CYGNA-RICHLAND

The above QID's have been revised to include the effects of the following:

1) Dynamic Torque due to Containment Backpressure Effect (TCB)

2) Dynamic Loads 5g, 5g and 3'g, two horizontal and vertical.

3) Seismic Loads.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.1.1

The results and recommendations are outlined below.

A. QID No. 361106 - 24" Primary Containment Butterfly Isolation Valves.

EPN's:	CSP-V-3, 4	Fail Close
	CEP-V-3A, 4A	Fail Close
	CSP-V-5, 6, 9	Fail Open

1) Maximum Dynamic Torque result from BIF Report No. TR-27234 is 11,691 in-lbs. for the air flow analysis and 11,379 in-lbs. for the steam flow analysis. These valves are lower than the design seating torque value of 17,000 in-lbs used in the original McPherson Associates analysis report No. TR-74-7.

2) Stresses due to Seismic and Dynamic Loads are within the material allowables and satisfy the requirements of the AISC Code, Appendix B, for fatigue evaluation. (Fatigue evaluation applies only to EPN CSP-V-9 which is subjected to Hydrodynamic loads.)

3) Results of the stability analysis for both the fail close and fail open valves are as follows:

a) Fail Open Valves (CSP-V-5; 6; and 9).

The current fail open design using a 100#/in spring with 350# preload will not be stable in the open position. The spring preload should be increased to provide stability for the open position.

However, if the preload is increased enough to stabilize the open position when subjected to seismic and dynamic torque conditions, the corresponding final spring load will be too great to allow proper seating with the 70 PSI air supplied to the operator. It is recommended that the spring preload be increased to approximately 1650# and that the supplied air pressure be increased to 95 PSI.

b) Fail Close Valves (CSP-V-3; 4 and CEP-V-3A, 4A)

The current fail closed design using a 100#/in spring with a 1500# preload will not be stable in the open position. This occurs because almost all of the load exerted by the 70 PSI cylinder operating pressure is required to compress the spring to its final load of 3000#. The additional axial load of 1244 lbs. due to seismic and dynamic torque will cause the valve disc to flutter. However, the full 1500# preload is required to seat the valve closed, the spring load cannot be reduced. Therefore, we recommend the air pressure be increased to 85 PSI to stabilize the disc in the open position when subjected to seismic and dynamic torque loads.

B. QID No. 361104

30" Primary Containment Butterfly Isolation Valves (Fail Close)

EPN's CSP-V-1; 2
CEP-V-1A; 2A

1) Maximum Dynamic Torque result from BIF Report No. TR-27234 is 23,099 in-lbs. for the air flow analysis and 23,171 in-lbs. for the steam flow analysis. These valves are lower than the design seating torque valve of 27,800 in-lbs. used in the original Dynatech analysis report No. 1351, Rev. 1.

2) Seismic Stresses were found to be acceptable. Fatigue analysis was not required since the valves are not subjected to hydrodynamic loads.

3) Stability analysis for the fail close position showed that theses valves experienced the same stability problems as the 24" fail close valves. (See discussion above)

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.1.2

The above results and recommendations are based on the assumption that stability is defined as no motion of the disc in either the open or closed position due to seismic, hydro and dynamic torque loads.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.1.3

Washington Public Power Supply System
P.O. Box 968 3000 George Washington Way Richland, Washington 99352 (509) 372-5000

December 17, 1982
GE-02-RWH-82-018

Cygna Energy Services
141 Battery Street
Suite 400
San Francisco, CA 94111

Attention: Mr. T. Wittig, Project Manager

Subject: NUCLEAR PROJECT 2
CONTRACT C-0892

Investigation of the CSB and CEB systems shows that during a dynamic event the systems are not degraded in any way by the butterfly valves fluttering. Therefore, all work on Work Release Nos. 14 and 17 which address valve stability should be terminated.

RWHickman

R. W. Hickman - 575
Senior Engineer,
Equipment Qualification

RWH/sms

cc: F. Khanachet, Cygna Richland

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.1.4

RECEIVED

DEC 22 1982

CYGNA-RICHLAND

CYGNA

Communications Report

Company: CES	☒ Telecon		☐ Conference Report
Project: WPPSS EQ		Job No.	
		Date:	Below
Subject: BIF VALVE DIMENSIONS		Time:	Below
		Place:	RBO

Participants:		of
	Jim Foley	CES - BAO
	Rick Riccappito 401-885-1000	BIF
	Jim Rokowski	CES - RBO

Item	Comments	Req'd Action By
	2/10/83 - J. Foley / J. Rokowski	
	BIF VALVE FLANGE DIMENSIONS	
	24": thickness 1.78" 30": 2.125"	
	i.d. 25" 31"	
	o.d. 32" 38.75"	
	BOLTS: 1 3/8" (20) 1 3/8" (28)	
	2/11/83 - Rick Riccappito / J. Rokowski	
	Radial Clearance of 24" & 30" valves.	
	— approx 1/8 inch —	

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.1.5

Signed: Page of

Distribution:

1020.00

Communications Report

Company: CES	☒ Telecon	☐ Conference Report
Project: WNP-2 Equipment Qualification		Job No. 82044
		Date: 4/28/83
Subject: Weld size at Valve Flange/Ear Interface		Time: 2:00 p.m.
		Place: Richland

Participants:

Don Searle	of CES/RBO
Rick Ricappito	of BIF 401-885-1000
	of

Item	Comments	Req'd Action By
	Requested and received information concerning the attachment of the rectangular shaped "ears" to the valve body flanges.	
	Rick informed me that all of these items were affixed to the valve flange by means of welding.	
	a) 0.31" fillet weld three sides	
	b) 0.31" "J"/Groove weld on side flush with flange face	
	Reference: BIF Order No: PN27234, PN27235	
	BIF Assembly Drawing: A-206767	

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.1.6

Signed: D. Searle

Page 1 of 1

Distribution: T. Wittig, F. Khanachet, D. Armstrong, M. Scott, R. Hickman, Project File, D. Searle, Office File

1070 (X

7.2 Original Requalification and SQRT Forms

WPPSS NUCLEAR PLANT
UNIT 2

361104

SEISMIC AND HYDRODYNAMIC LOADS

REQUALIFICATION CERTIFICATION

JOB NO. 2808

EQUIPMENT NAME: 30" Cylinder Operated Butterfly Valve

SPEC. NO: 68

EQUIPMENT NO: CSP-V-1,2; CEP-V-1A, 2A

LOCATION: Reactor Bldg. Elevs. 508'0", 508'0", 562'0", 558'0"

EQUIPMENT CLASSIFICATION: ☒ ACTIVE ☐ PASSIVE

SEISMIC QUALIFICATION REPORT REFERENCE:

1. Seismic analysis of 30" cylinder operated butterfly valve. Report No. TR-74-8 (Rev. 1) dated 12/31/75 by McPherson Assoc./BIF
2. Dynatech project No. BIF-14 deflection analysis of butterfly valves by Dynatech R/D Co. 4/12/76 Trans.13B

THE ABOVE SEISMIC QUALIFICATION REPORT(S) HAVE BEEN REEVALUATED AND REQUALIFIED WHERE NECESSARY TO SHOW THAT THE ABOVE-MENTIONED COMPONENT IS CAPABLE OF PERFORMING ITS INTENDED SAFETY FUNCTION UNDER ALL THE APPLICABLE LOADING COMBINATIONS INCLUDING THE POOL DYNAMIC LOADS.

PREPARED: ____________________

APPROVED: ____________________

DATE: ____________________

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.2.1

nutech
San Jose, California

Project WNP-2 File No.
Owner Washington Public Power Supply System
Client Washington Public Power Supply System

Tag No. CSP-V-1
CSP-V-2
CEP-V-1A
CEP-V-2A
Class I, Active

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F.
SHEET NO. 7.2.2

30" Cylinder Operated Butterfly Valve

I. Original qualification method

A. Equivalent static analyis

II. Reevaluation

A. The natural frequencies were not calculated.

B. Valve operability was verified by deflection calculation.

C. Calculated stress margins are within allowables.

D. RRS not used, but seismic coefficients used in the analysis envelops the interim SQRT criteria.

E. Loads combined by SRSS method.

III. Conclusion

A. The 30" cylinder operated butterfly valve does not comply with interim SQRT requirements.

1. The natural frequencies were not calculated.

IV. Recommendations

A. Analyze valve to SQRT requirements.

V. Comments on original analysis

A. The horizontal acceleration used were for SSE 3g in orthogonal direction and vertical, combined using SRSS.

B. The natural frequencies were not calculated.

C. Maximum critical deflection was 0.104 in. vs. 0.50 in. allowable.

Revision	0					Page 1
Prepared By/Date	BRJ 8/4/81					of 1
Checked By/Date	FEP 8/6/81					

Tag no. CSP-V-1
CSP-V-2
CEP-V-1A
CEP-V-2A

Qualification Summary of Equipment

I. Plant Name: WNP-2 — Type:

1. Utility: Washington Public Power Supply System — PWR
2. NSSS: GE 3. A/E: Burns & Roe — BWR 5, Mark II

II. Component Name 30" Cylinder Operated Butterfly Valve

1. Scope: [ ] NSSS [X] BOP
2. Model Number: A-206-763 Quantity: 4
3. Vendor: McPherson/BIF
4. If the component is a cabinet or panel, name and model No. of the devices included: N/A
5. Physical Description a. Appearance Valve
   b. Dimensions
   c. Weight 321 lbs.
6. Location: Building: Reactor
   Elevation: 508'0", 508'0", 562'0", 558'0"
7. Field Mounting Conditions [ ] Bolt (No.____, Size____)
   [ ] Weld (Length____)
   [ ] ____
8. a. System in which located: Containment Supply Purge System Containment Exhaust Purge System
   b. Functional Description: Drywell Exhaust, Containment Isolation
   c. Is the equipment required for [ ] Hot Standby [ ] Cold Shutdown
   [ ] Both [ ] Neither
9. Pertinent Reference Design Specifications: 2808-68

Prepared by: BRH 8/9/81
Checked by: PPP 8/10/81

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.2.3

3/81

III. Is Equipment Available for Inspection in the Plant: [.] Yes [ ] No

IV. Equipment Qualification Method:

[ ] Test [x] Analysis [ ] Combination of Test and Analysis

Qualification Report*: Contract 68, Transmittal 24

(No., Title and Date) Report No. TR-74-8 (Rev. 1) 12/31/75, Seismic Analysis of 30" Cylinder Operated Butterfly Valve

Company that Prepared Report: McPherson Assoc/BIF

Company that Reviewed Report: Burns & Roe/NUTECH

V. Vibration Input:

1. Loads considered: a. [x] Seismic only

   b. [ ] Hydrodynamic only

   c. [ ] Combination of (a) and (b)

2. Method of Combining RRS: [ ] Absolute Sum [ ] SRSS [x] N/A (other, specify)

3. Required Response Spectra (attach the graphs): Attached

4. Damping Corresponding to RRS: OBE ______ SSE ½%

5. Required Acceleration in Each Direction: [ ] ZPA [X] Other Attachment1 (specify)

OBE	S/S =	F/B =	V =
SSE	S/S = 1.36g	F/B = 1.36g	V = 2.00g
	E-W	N-S	

*NOTE: If more than one report complete items IV thru VII for each report.

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.2.4

VI. If Qualification by Test, then Complete*: N/A

1. [ ] Single Frequency [ ] Multi-Frequency: [ ] random [ ] sine beat [ ] ________

2. [ ] Single Axis [ ] Multi-Axis

3. No. of Qualification Tests: OBE ________ SSE ________ Other ________ (specify)

4. Frequency Range: ________________________

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = ____________ F/B = ____________ V = ____________

6. Method of Determining Natural Frequencies

[ ] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test [ ] Yes (Attach TRS & RRS graphs)
[ ] No

8. Input g-level Test: OBE S/S = ________ F/B = ________ V = ________

SSE S/S = ________ F/B = ________ V = ________

9. Laboratory Mounting:

1. [ ] Bolt (No.____, Size____) [ ] Weld (Length____) [ ] ____

10. Functional operability verified: [ ] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: ________________________

____

12. Other test performed (such as aging or fragility test, including results):

____

____

*Note: If qualification by a combination of test and analysis also complete Item VII.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.2.5

12/80

VII. If Qualification by Analysis, then complete:

1. Method of Analysis:

[ ] Static Analysis [X] Equivalent Static Analysis $g_h=3g$, $g_v=2g$

[ ] Dynamic Analysis: [ ] Time-History [ ] Response Spectrum

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = ______________ F/B = ______________ V = ______________

3. Model Type: [ ] 3D [ ] 2D [ ] 1D

[ ] Finite Element [ ] Beam [X] Closed Form Solution

4. [ ] Computer Codes: None

Frequency Range and No. of modes considered: ______________

[ ] Hand Calculations

5. Method of Combining Dynamic Responses: [ ] Absolute Sum [ ] SRSS
[ ] Other: ______________ (specify)

6. Damping: OBE N/A SSE N/A Basis for the damping used: ______________

7. Support Considerations in the model: ______________

8. Critical Structural Elements:

A.

Identification	Location	Governing Load or Response Combination	Seismic Stress	Total Stress	Stress Allowable
Valve Body				17,796 psi	18,000 psi

B.

Max. Critical Deflection	Location	Maximum Allowable Deflection to Assure Functional Operability
0.104 in.	Disk	0.500 in.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.2.6

Attachment 1

Static Seismic "G" calculations (Stick Model)
OBE Level, 1/2% Critical Damping, frequency cut-off * and above
SSE Value = 2 x OBE Value

Building	Area Elevation (Ft.)	Horizontal OBE, g	Horizontal SSE, g	Vertical OBE, g	Vertic SSE, g
Reactor Building	653**	1.25	2.50	1.00	2.00
	567	.58	1.16	1.00	2.00
*8 Hz	547	.57	1.14	.95	1.90
	521	.57	1.14	.87	1.74
	500	.68	1.36	.68	1.36
	470	.80	1.60	.60	1.20
	443	.87	1.74	.60	1.20
	434**	1.00	2.00	.40	.80
Diesel Gen.	414**	1.00	2.00	.40	.80
*10 Hz/15 Hz	472	3.5/.60	7.0/1.2	2.6/1.6	5.2/3.
	454	3.2/.70	6.4/1.4	2.5/1.0	5.0/2.
	437	2.2/.90	4.4/1.8	2.4/1.1	4.8/2.
Radwaste *8 Hz/10 Hz	541	1.5/1.5	3.0/3.0	2.0/1.1	4.0/2.
	524	1.1/1.1	2.2/2.2	1.7/.3	3.4/1.
	500	1.0/.65	2.0/1.3	1.8/.65	3.6/1.
	466	1.1/.60	2.2/1.3	1.7/.60	3.4/1.

Building	Area Elevation (Ft.)	Horizontal OBE, g	Horizontal SSE, g N/S	Horizontal SSE, g E/W	Vertical OBE, g	Vertic SSE, g
Reactor Building Primary Cont. *8 Hz	492'-11 5/8"		3.2	3.2		1.3
	480'-4"		3.2	3.0		1.3
	467'-3"		3.0	2.8		1.3
	455'-3"		4.0	3.0		1.3

**From RRS at additional elevations (by NuTech)

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.2.1

CYGNA

7.3 BIF REPORT: DYNAMIC TORQUE CALCULATIONS OF BUTTERFLY VALVE

B I F A UNIT OF GENERAL SIGNAL
1600 DIVISION ROAD
WEST WARWICK, R.I. 02893

QUALIFICATION OF PRIMARY CONTAINMENT BUTTERFLY ISOLATION VALVES UNDER LOCA CONDITION.

DYNAMIC TORQUE CALCULATION OF BUTTERFLY VALVE

PREPARED FOR:

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

VALVE SIZES 30", and 24"
WPPSS CONTRACT NO. 68
BIF ORDER NO.: PN27234 & PN27235
WPPSS IDENTIFICATION NO. CSP-V-1 & 2, and
CSP-V-3 & 4

Prepared by: Debendra K. Das *Debendra K. Das*
Date: Nov. 10, 1982
Checked by: Dezso Szilagyi *Dezso Szilagyi*
Date: Nov. 10. 1982

REPORT NO. TR-27234 And
TR-27235

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.1

TABLE OF CONTENTS

SUMMARY

This report contains the dynamic torque analysis of two butterfly valves of sizes 30, and 24 inch. The analysis is performed for LOCA (loss of Coolant Accident) per WPPSS Specification, reference 1 on page six of this report. The analytical procedure and the assumptions are outlined in the section beginning on page seven. Dynamic torque calculations have been performed for two media, namely, air and saturated steam for various angles of opening of these valves.

The results of the analysis tabulated on page two through five of the report indicate that the dynamic torques developed under the specified flow conditions are less than the design torques used in the original Seismic and Stress analysis of these valves. Therefore the valves are safe against the action of dynamic torque in the event of a LOCA.

SUMMARY OF RESULTS

Table - 1, 30 Inch Valve, airflow

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 *

$T_{Net} = 22174$ in-lb

* 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. Therefore the design is safe.

SUMMARY OF RESULTS

Table - 2, 30 Inch Valve Steam flow

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 *

T_{Net} = 22174 in-lb

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

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.5

SUMMARY OF RESULTS

Table - 3, 24 Inch Valve, Air flow

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 *

T_{Net} = 13808 in-lb

* 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-74-7 by McPherson Associate for this valve is 17000 in-lb. Therefore the deisgn is safe.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.6

SUMMARY OF RESULTS

Table - 4, 24 Inch Valve, Steam flow

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 *

T_{Net} = 13808 in-lb

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

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.7

6

REFERENCES

1. WPPSS Specification 2808-68, Calc. No. ME-02-83-08-0, Sheets 1 thru 9, dated 10/8/82.

   LOCA Temperature Curve Fig. 6.2-2.
   LOCA Pressure Curve Fig. 6.2-3.

2. ANSI/AWWA C504-80, AWWA Standard for Rubber-Seated Butterfly Valves. American Water Works ASsociation,Colo.

3. Beard,C., Final Control Elements, Valves and Actuators, First Edition, Rimbach Publications, 1969.

4. Hutchison, J. W., ISA Handbook of Control Valves, 2nd Edition.

5. Torque and Sizing Calculation for BIF Butterfly Valves, No. D-214590, dated 1/9/75 for WPPSS Contract #68.

6. B I F Test Report for Dynamic Torque and Head Loss Tests of Cast Iron Streamline Disc versus Fabricated Flat Plate Disc dated May 13, 1974.

7. B I F Test Report #TR-0650-43, Hydrodynamic and Headloss Test of 12" - 150 Lb. Butterfly Valve with directly connected short radius elbow upstream, dated 2/24/82.

8. B I F Drawings: 30 inch Valve General Arrangement Drawing A-206763
   24 inch Valve General Arrangement Drawing A-206764

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.8

CYGNA

7.4 McPHERSON ASSOCIATES REPORT:

DESIGN AND SEISMIC ANALYSIS OF 24" CYLINDER-OPERATED BUTTERFLY VALVE

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.1

BIF A UNIT OF GENERAL SIGNAL
1600 DIVISION ROAD
WEST WARWICK, R.I. 02893

DESIGN AND SEISMIC ANALYSIS OF 30" CYLINDER OPERATED BUTTERFLY VALVE FOR WASHINGTON PUBLIC POWER SUPPLY SYSTEM AND BURNS AND ROE

CUSTOMER P.O. CONTRACT 68

BIF SHOP ORDER NO. PN27234-U-0608

BIF SERIAL NO'S. PN27234-1 thru 4.

REPORT NO. TR-74-8

PREPARED BY McPHERSON ASSOCIATES, INC.

NUCLEAR

APPROVED ~~BY~~ [signature] 3/7/74

REVISION 1 REAPPROVED 1/5/76

By: John P Cunningham

NUMBER 68 00 0049

DESIGN AND
SEISMIC ANALYSIS
OF
30" CYLINDER OPERATED
BUTTERFLY VALVE
A-206763

NUCLEAR

22 February 1974

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.2

Prepared For:

BIF
A Unit of General Signal Corporation

Prepared By:

Thomas M. Riley
John R. Henry

BIF
A Unit of General Signal Corporation
Purchase Order No. 84908-63

McPherson Associates, Inc.
Report No. TR-74-8 REV 1 12/31/75

McPherson Associates, Inc.
400 Totten Pond Road
Waltham, Massachusetts 02154

McPherson Associates Inc.
400 TOTTEN POND ROAD • WALTHAM, MASSACHUSETTS 02154

SEISMIC ANALYSIS
OF
30" CYLINDER OPERATED
BUTTERFLY VALVE
A-206763

BIF
A Unit of General Signal Corporation
Purchase Order No. 84908-63

McPherson Associates, Inc.
Report No. TR-74-8
REV. 1 12/31/75

FOR 30" VALVES

BIF Contract No.	BIF S.O. No.	Valve Tag No's
68	N 27234-F	CSP-V-1 CSP-V-2 CEP-V-1A CEP-V-2A

REVISION RECORD

NUS REPORT NO. TR-74-8

REVISION 1 12/31/75

Page 3
a) Material was ASTM A-126 & A-48
b) Allowable stress values corrected

Page 5
a) Drive lever was B-208217-17
b) Clevis was D-146578-1

Page 9
a) Mat'l was ASTM A-126, Class C
b) Corrected yield stress allowable
c) Deleted ASTM A-48

Pages 28 & 30
a) Mat'l was ASTM A-48
b) Corrected allowable stress

Page 32
a) Ref. Dwgs. were B-208217-17 & D-146578-1

Pages 33, 35, 36 & 37
a) Mat'l was ASTM A-126 C. C
b) Corrected allowables

TABLE OF CONTENTS

Certification

McPherson Associates, Inc. certifies that the 30" Butterfly Valve, A-206763, as shown on the customer drawings was analyzed in accordance with Washington Public Power Supply System Specification No. 2808-68 and to the best of our knowledge and belief, meets the requirements of Paragraphs 3.2, 3.3, and 3.5.2.4 of this document and Reference 3 of Section 4.0 of this report.

NUCLEAR

John R. Henry
Registered Professional Engineer
Mass. Registration No. 25929

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.6

Section 1.0

INTRODUCTION

The purpose of this report is to determine the structural adequacy of a 30" Butterfly Valve Assembly when subjected to seismic accelerations as described in Reference 1 and to insure the valve design is in accordance with Reference 3 of this report.

The seismic plus operating analysis is performed in accordance with Washington Public Power Supply System Specification No. 2808-68, Reference 1, and all applicable information as described in Section 4.0 of this report.

Section 2.0

SUMMARY OF RESULTS

JHC DATE 2-21-74	SUBJECT 30" B.F.V.	SHEET NO. 2.01 OF
BY JH DATE 2-21-74	- SUMMARY -	JOB NO.

COMPONENT	PAGE	STRESS COMPARISON (PSI) & MATERIAL
JUNION PINS	19	$\tau = 2729 < .6\ S_y = 11100$ (SA-276, 304)
IL. OPERATOR DRIVE ROD	22	$\tau = 48017 < S_y = 90000$ (AISI-4140)
YL. SUPPORT BRACKET	28	$\tau = 1733 < .S_y = 36,000$ (ASTM A36) ①
CLEVIS	33	$T = 1865 < 0.6 S_y = 36000$ (ASTM A395) ②
CLEVIS PIN	33	$\tau = 1719 < .6 S_y = 11100$ (SA-276, 304)
DRIVE LEVER	37	$\tau = 39690 < < S_y = 45000$ (ASTM A395) ①
VALVE BODY "EARS"	42	$\tau = 26587 < S_y = 28000$ (SA-516, GC 60)
HARDWARE	45	$\tau = 16772 < S_y = 23300$ (SA-307)
SHAFT	50	$S.I. = 21818 < 1.8\ S_m = 27180$ (SA-479, 304)
DISC	51	$S.I. = 4540 < S_m = 15000$ (SA-516, GC 60)
TAPER PINS	53	$\tau_{max} = 11265 < .8\ S_m = 12000$ (SA-276, 304)
VALVE BODY	63	$S.I. = 17796 < 1.2\ S_m = 18000$ (SA-516, GC 60)
GLAND FOLLOWER	65	THICKNESS CHECK ONLY
THRUST BEARING COVER	67	THICKNESS CHECK ONLY

THE TERM "S.I." REFERS TO STRESS INTENSITY

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.9

Section 3.0

CONCLUSIONS

McPherson Associates, Inc. concludes that all components for the 30" Butterfly Valve, as analyzed in this report, meet the requirements of all governing specifications for seismic plus operating considerations as defined in References 1, and 3 of this report.

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JOB NO. 82044
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SHEET NO. 7.4.10

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JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 74.11

Section 4.0

REFERENCES

1. Washington Public Power Supply System Specification No. 2808-68.

2. BIF Drawings

Drawing No.	Revision	Description
A-206763	B	30" Butterfly Valve-General Arrangement
A-900501	-	Body, Fabricated
A-900502	-	Body, Machining
A-900499	-	Disc, Fabricated
A-900500	-	Disc, Machined
A-208195	-	Cylinder Support Bracket
B-900514, B-900515	-	Operator Shafts
(1) B 211829	-	Drive Lever
D 211832-2	-	Clevis
D-184100	A	Miller Cylinder

3. Section III, Nuclear Power Plant Components, ASME Boiler and Pressure Vessel Code, 1971 with Addenda.

4. Virgil Moring Faires, Design of Machine Elements, 4th Edition, The MacMillan Co., N.Y., 1965.

5. Raymond J. Roark, Formulas for Stress and Strain, 4th Edition, McGraw Hill Book Co., 1965.

6. Laddish Catalog No. 55.

7. Grinnel, Piping and Engineering, 3rd Edition, 1971.

8. 1963 Supplement to Screw Thread Standards for Federal Services.

9. Baumeister & Marks, Standard Handbook for Mechanical Engineers, 7th Edition, McGraw Hill Book Co.

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10. Kent, Mechanical Engineers Handbook.

11. A.S.T.M. Standards - Part 2

12. A.S.M. Metals Handbook

13. Timoshenko and Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Book Co., 1970.

14. Seely and Smith, Advanced Mechanics of Materials, 2nd Edition, John Wiley & Son, Inc., 1966.

15. Machinery's Handbook, 17th Edition, The Industrial Press, 1964.

16. Section VIII, Pressure Vessels, Division 2, Alternative Rules, A.S.M.E. Boiler and Pressure Vessel Code, 1971.

17. Chemical Rubber Publishing Co., Standard Mathematics Tables, Twelfth Edition.

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CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.12

7.3 BIF REPORT: DYNAMIC TORQUE CALCULATIONS OF BUTTERFLY VALVE

B I F A UNIT OF GENERAL SIGNAL
1600 DIVISION ROAD
WEST WARWICK, R.I. 02893

QUALIFICATION OF PRIMARY CONTAINMENT BUTTERFLY ISOLATION VALVES UNDER LOCA CONDITION.

DYNAMIC TORQUE CALCULATION OF BUTTERFLY VALVE

PREPARED FOR:

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

VALVE SIZES 30", and 24"
WPPSS CONTRACT NO. 68
BIF ORDER NO.: PN27234 & PN27235
WPPSS IDENTIFICATION NO. CSP-V-1 & 2, and
CSP-V-3 & 4

Prepared by: Debendra K. Das Debendra K. Das
Date: Nov. 10, 1982
Checked by: Dezso Szilagyi Dezso Szilagyi
Date: Nov. 10. 1982

REPORT NO. TR-27234 And
TR-27235

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.1

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CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.2

SUMMARY

This report contains the dynamic torque analysis of two butterfly valves of sizes 30, and 24 inch. The analysis is performed for LOCA (loss of Coolant Accident) per WPPSS Specification, reference 1 on page six of this report. The analytical procedure and the assumptions are outlined in the section beginning on page seven. Dynamic torque calculations have been performed for two media, namely, air and saturated steam for various angles of opening of these valves.

The results of the analysis tabulated on page two through five of the report indicate that the dynamic torques developed under the specified flow conditions are less than the design torques used in the original Seismic and Stress analysis of these valves. Therefore the valves are safe against the action of dynamic torque in the event of a LOCA.

SUMMARY OF RESULTS

Table - 1, 30 Inch Valve, airflow

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 *

T_{Net} = 22174 in-lb

* 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. Therefore the design is safe.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.4

SUMMARY OF RESULTS

Table - 2, 30 Inch Valve Steam flow

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 *

T_{Net} = 22174 in-lb

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

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.5

SUMMARY OF RESULTS

Table - 3, 24 Inch Valve, Air flow

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 *

T_{Net} = 13808 in-lb

* 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-74-7 by McPherson Associate for this valve is 17000 in-lb. Therefore the deisgn is safe.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.6

SUMMARY OF RESULTS

Table - 4, 24 Inch Valve, Steam flow

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 *

T_{Net} = 13808 in-lb

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

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.7

REFERENCES

1. WPPSS Specification 2808-68, Calc. No. ME-02-83-08-0, Sheets 1 thru 9, dated 10/8/82.

   LOCA Temperature Curve Fig. 6.2-2.
   LOCA Pressure Curve Fig. 6.2-3.

2. ANSI/AWWA C504-80, AWWA Standard for Rubber-Seated Butterfly Valves. American Water Works ASsociation,Colo.

3. Beard,C., Final Control Elements, Valves and Actuators, First Edition, Rimbach Publications, 1969.

4. Hutchison, J. W., ISA Handbook of Control Valves, 2nd Edition.

5. Torque and Sizing Calculation for BIF Butterfly Valves, No. D-214590, dated 1/9/75 for WPPSS Contract #68.

6. B I F Test Report for Dynamic Torque and Head Loss Tests of Cast Iron Streamline Disc versus Fabricated Flat Plate Disc dated May 13, 1974.

7. B I F Test Report #TR-0650-43, Hydrodynamic and Headloss Test of 12" - 150 Lb. Butterfly Valve with directly connected short radius elbow upstream, dated 2/24/82.

8. B I F Drawings: 30 inch Valve General Arrangement Drawing A-206763
   24 inch Valve General Arrangement Drawing A-206764

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. OS.01.F
SHEET NO. 7.3.8

SEE QID 361106 FOR BODY
OF REPORT

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.3.9

CYGNA

7.4 McPHERSON ASSOCIATES REPORT:

DESIGN AND SEISMIC ANALYSIS OF 24" CYLINDER-OPERATED BUTTERFLY VALVE

BIF A UNIT OF GENERAL SIGNAL
1600 DIVISION ROAD
WEST WARWICK, R.I. 02893

DESIGN AND SEISMIC ANALYSIS OF 30" CYLINDER OPERATED BUTTERFLY VALVE FOR WASHINGTON PUBLIC POWER SUPPLY SYSTEM AND BURNS AND ROE

NUCLEAR

CUSTOMER P.O. CONTRACT 68

BIF SHOP ORDER NO. PN27234-U-0608

BIF SERIAL NO'S. PN27234-1 thru 4.

REPORT NO. TR-74-8
PREPARED BY McPHERSON ASSOCIATES, INC.

APPROVED BY: [signature] 3/7/74
REVISION 1 REAPPROVED 1/5/76
BY: John P Cunningham

NUMBER 68 00 0049

DESIGN AND
SEISMIC ANALYSIS
OF
30" CYLINDER OPERATED
BUTTERFLY VALVE
A-206763

NUCLEAR

22 February 1974

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.2

Prepared For:

BIF
A Unit of General Signal Corporation

Prepared By:

Thomas M. Riley
John R. Henry

BIF
A Unit of General Signal Corporation
Purchase Order No. 84908-63

McPherson Associates, Inc.
Report No. TR-74-8 REV 1 12/31/75

McPherson Associates, Inc.
400 Totten Pond Road
Waltham, Massachusetts 02154

McPherson Associates Inc.
400 TOTTEN POND ROAD • WALTHAM, MASSACHUSETTS 02154

SEISMIC ANALYSIS
OF
30" CYLINDER OPERATED
BUTTERFLY VALVE
A-206763

BIF
A Unit of General Signal Corporation
Purchase Order No. 84908-63

McPherson Associates, Inc.
Report No. TR-74-8
REV. 1 12/31/75

FOR 30" VALVES

BIF Contract No.	BIF S.O. No.	Valve Tag No's
68	N 27234-F	CSP-V-1 CSP-V-2 CEP-V-1A CEP-V-2A

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.4

REVISION RECORD

NUS REPORT NO. TR-74-8

REVISION 1 12/31/75

Page 3
a) Material was ASTM A-126 & A-48
b) Allowable stress values corrected

Page 5
a) Drive lever was B-208217-17
b) Clevis was D-146578-1

Page 9
a) Mat'l was ASTM A-126, Class C
b) Corrected yield stress allowable
c) Deleted ASTM A-48

Pages 28 & 30
a) Mat'l was ASTM A-48
b) Corrected allowable stress

Page 32
a) Ref. Dwgs. were B-208217-17 & D-146578-1

Pages 33, 35, 36 & 37
a) Mat'l was ASTM A-126 C C
b) Corrected allowables

NUCLEAR

TABLE OF CONTENTS

Certification

McPherson Associates, Inc. certifies that the 30" Butterfly Valve, A-206763, as shown on the customer drawings was analyzed in accordance with Washington Public Power Supply System Specification No. 2808-68 and to the best of our knowledge and belief, meets the requirements of Paragraphs 3.2, 3.3, and 3.5.2.4 of this document and Reference 3 of Section 4.0 of this report.

NUCLEAR

John R. Henry
Registered Professional Engineer
Mass. Registration No. 25929

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.6

Section 1.0

INTRODUCTION

The purpose of this report is to determine the structural adequacy of a 30" Butterfly Valve Assembly when subjected to seismic accelerations as described in Reference 1 and to insure the valve design is in accordance with Reference 3 of this report.

The seismic plus operating analysis is performed in accordance with Washington Public Power Supply System Specification No. 2808-68, Reference 1, and all applicable information as described in Section 4.0 of this report.

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ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.7

Section 2.0

SUMMARY OF RESULTS

BY THE DATE 2-21-74	SUBJECT 30" B.F.V.	SHEET NO. 2.01 OF
CHKD. BY JH DATE 2-21-74	– SUMMARY –	JOB NO.

COMPONENT	PAGE	STRESS COMPARISON (PSI) & MATERIAL
TRUNNION PINS	19	$\tau = 2729 < .6\ S_y = 11100$ (SA-276, 304)
CYL. OPERATOR DRIVE ROD	22	$\sigma = 48017 < S_y = 90000$ (AISI-4140)
CYL. SUPPORT BRACKET	28	$\sigma = 1733 < S_y = 36,000$ (ASTM A36) ①
CLEVIS	33	$\tau = 1965 < 0.6\ S_y = 36000$ (ASTM A395) ②
CLEVIS PIN	33	$\tau = 1719 < .6\ S_y = 11100$ (SA-276, 304)
DRIVE LEVER	37	$\sigma = 39690 < S_y = 45000$ (ASTM A395) ①
VALVE BODY "EARS"	42	$\sigma = 26587 < S_y = 28000$ (SA-516, GR 60)
HARDWARE	45	$\sigma = 16772 < S_y = 23300$ (SA-307)
SHAFT	50	S.I. = 21818 < 1.8 S_m = 27180 (SA-479, 304)
DISC	51	S.I. = 4540 < S_m = 15000 (SA-516, GR 60)
TAPER PINS	53	τ_{max} = 11265 < .8 S_m = 12000 (SA-276, 304)
VALVE BODY	63	S.I. = 17796 < 1.2 S_m = 18000 (SA-516, GR 60)
GLAND FOLLOWER	65	THICKNESS CHECK ONLY
THRUST BEARING COVER	67	THICKNESS CHECK ONLY

THE TERM "S.I." REFERS TO STRESS INTENSITY

Section 3.0

CONCLUSIONS

McPherson Associates, Inc. concludes that all components for the 30" Butterfly Valve, as analyzed in this report, meet the requirements of all governing specifications for seismic plus operating considerations as defined in References 1, and 3 of this report.

CYGNA
ATTACHMENT
JOB NO. 81044
FILE NO. 05.01.F
SHEET NO. 7.4.11

Section 4.0

REFERENCES

1. Washington Public Power Supply System Specification No. 2808-68.

2. BIF Drawings

Drawing No.	Revision	Description
A-206763	B	30" Butterfly Valve-General Arrangement
A-900501	-	Body, Fabricated
A-900502	-	Body, Machining
A-900499	-	Disc, Fabricated
A-900500	-	Disc, Machined
A-208195	-	Cylinder Support Bracket
B-900514, B-900515	-	Operator Shafts
① B 211829	-	Drive Lever
D 211832-2	-	Clevis
D-184100	A	Miller Cylinder

3. Section III, Nuclear Power Plant Components, ASME Boiler and Pressure Vessel Code, 1971 with Addenda.

4. Virgil Moring Faires, Design of Machine Elements, 4th Edition, The MacMillan Co., N.Y., 1965.

5. Raymond J. Roark, Formulas for Stress and Strain, 4th Edition, McGraw Hill Book Co., 1965.

6. Laddish Catalog No. 55.

7. Grinnel, Piping and Engineering, 3rd Edition, 1971.

8. 1963 Supplement to Screw Thread Standards for Federal Services.

9. Baumeister & Marks, Standard Handbook for Mechanical Engineers, 7th Edition, McGraw Hill Book Co.

NUCLEAR

10. Kent, Mechanical Engineers Handbook.

11. A.S.T.M. Standards - Part 2

12. A.S.M. Metals Handbook

13. Timoshenko and Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Book Co., 1970.

14. Seely and Smith, Advanced Mechanics of Materials, 2nd Edition, John Wiley & Son, Inc., 1966.

15. MacHinery's Handbook, 17th Edition, The Industrial Press, 1964.

16. Section VIII, Pressure Vessels, Division 2, Alternative Rules, A.S.M.E. Boiler and Pressure Vessel Code, 1971.

17. Chemical Rubber Publishing Co., Standard Mathematics Tables, Twelfth Edition.

D. BY______ DATE______ JOB NO.______

SECTION 5.0

DESIGN DATA

IN GENERAL:

IN THIS REPORT, TENSILE AND BENDING ALLOWABLES, DUCTILE MATERIALS OUTSIDE THE VALVE PRESSURE BOUNDARY = BASED ON YIELD STRESS; SHEAR ALLOWABLES FOR SUCH MATERIAL ARE HELD TO (.6) × (YIELD STRESS)

WHEN BRITTLE MATERIALS ARE ENCOUNTERED OUTSIDE THE VALVE PRESSURE BOUNDARY ALLOWABLE STRESSES ARE BASED ON ULTIMATE STRESS.

FOR MATERIALS WITHIN THE PRESSURE BOUNDARY ALLOWABLE STRESSES AS DEFINED IN REFERENCES 3 AND OF THIS REPORT ARE EMPLOYED.

ON THE FOLLOWING PAGE IS PRESENTED A TABLE OF STRESS ALLOWABLES FOR THE VARIOUS MATERIALS USED IN THE VALVE.

IN THE CASE OF "ALLOWABLE STRESS" VALUES, THE STRESS ALLOWABLES AS PRESENTED ARE BASE NUMBERS AND ARE ADJUSTED IN VALUE DEPENDING ON THE STRESS COMPARISON [e.g. EARTHQUAKE → (1.2) (S_m)]

:D. BY JH DATE 2-21-74 30" B.F.V. SHEET NO. OF

JOB NO.

Max. Temperature, Process Air = 340 °F

MAX PRESSURE (ΔP) = 45 PSI

MATERIAL	†YIELD STRESS (PSI)
AISI-4140, HEAT TREATED	90000
SA-276, GR 304	18500
ASTM A395-60-45-15	45000
SA-276, GR 304	* 15000
SA 516, GR 60	* 15000
SA-307	23300
AISI 1018	*** 35000
SA-479, 304 S.S.	* 15100
SA-193, GR B-8, 304 S.S.	31000

① ①

† UNLESS NOTED (@ TEMP)

* ALLOWABLE STRESS @ TEMPERATURE

①

*** MINIMUM YIELD

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CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.15

SECTION 6.0

ANALYSIS

BY: [illegible] DATE 2-21-74 SUBJECT: DISCUSSION
— ANALYSIS —
SHEET NO. OF
JOB NO.

THE APPROACH TAKEN IN DETERMINING SEISMIC LOADS [A]ND STRESSES IS TO ANALYZE ON A "WORST CASE" BASIS WHENEVER [P]OSSIBLE.

THE ORDER OF ANALYSIS AS PRESENTED ON THE FOLLOWING PAGES CONSISTS IN FIRST DEFINING WHAT ORIENTATIONS AND ACCELERATIONS PRODUCE "WORST CASE" CONDITIONS AND THEN ESTABLISHING STRESSES FOR THE VARIOUS COMPONENTS ON THIS BASIS.

IN GENERAL, LOADS ACTING AT A POINT ARE ADDED DIRECTLY REGARDLESS OF LINE OF ACTION,

MAXIMUM ACCELERATIONS ARE USED AS OPPOSED TO LESSER "REAL" ACCELERATIONS WHENEVER POSSIBLE.

SEISMIC ACCELERATIONS ARE ASSUMED TO OCCUR WHEN MAXIMUM NORMAL/ABNORMAL OPERATING STRESSES EXIST ON THE APPARATUS.

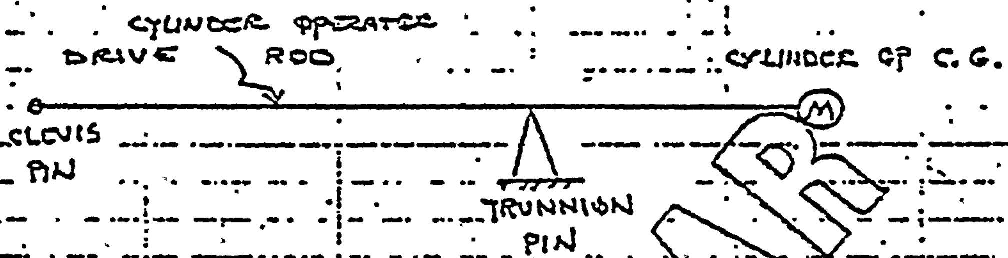
VALVE SIZING AND COMBINED OPERATING PLUS SEISMIC STRESS ANALYSIS IS PROVIDED IN THE LATTER SECTIONS OF THE REPORT.

NO LONGER

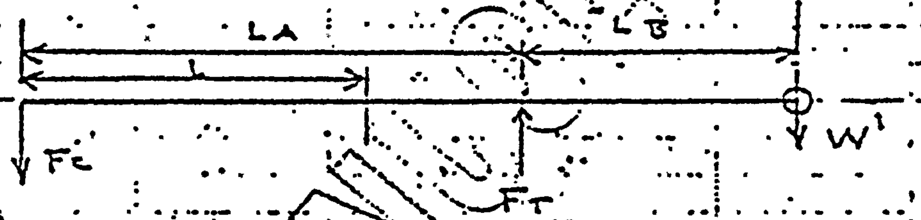
CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 14.17

GENERAL EXPRESSIONS FOR FULCRUM & CLEVIS REACTIONS TREATING CYLINDER OPERATOR AS A BEAM WITH A TIP MASS.

THE FOLLOWING MODEL IS REPRESENTATIVE OF THE CYLINDER OPERATOR AND ITS SUSPENSION: (LATERAL ACCELERATION ONLY)



BECAUSE OF THE NATURE OF THE SUPPORTS THE FREE BODY DIAGRAM IS:



$\sum M_{\text{TRUNNION PIN}} = 0 \quad ; \quad F_C (L_A) = W' L_B$

$$F_C = \left(\frac{L_B}{L_A}\right) W'$$

AS "L_B", THE DISTANCE BETWEEN THE CYL. OP. C.G. & THE TRUNNION PIN IS ROUGHLY FIXED, "F_C" IS MAXIMIZED WHEN "L_A" IS MINIMUM. (MIN. EXTENSION OF CYL. OP.)

OVER →

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 03.01.F
SHEET NO. 14.19

$$\Sigma \overset{\curvearrowleft}{M}_{\text{CLEVIS PIN}} = 0 \; ; \quad (F_T)(L_A) = (W^1)(L_A + L_B)$$

$$F_T = \left(\frac{L_A}{L_A} + \frac{L_B}{L_A} \right) W^1$$

"F_T" IS MAXIMIZED WHEN "L_A" APPROACHES "L_B" (CYLINDER OPERATOR AT MINIMUM EXTENSION)

W^1, AS PRESENTED ABOVE, IS A FUNCTION OF BOTH THE DEAD WEIGHT AND SEISMIC ACCELERATION. PER REF. __ THE MAXIMUM HORIZONTAL ACCELERATION PRODUCES A SEISMIC LOAD OF 3.0 W; THE MAXIMUM VERTICAL ACCELERATION PRODUCES A SEISMIC LOAD OF 2.0 W. + 1.0 G DEAD WT.

THE RESULTING LATERAL (HORIZONTAL) & VERTICAL ACCELERATIONS ARE 3G & 3G.

DEPENDING ON THE ANALYSIS BEING PERFORMED W^1 MAY BE CONSIDERED TO FALL BETWEEN (3)(W) & $\sqrt{(3)^2 + (3)^2}\,(W) = (4.24)(W)$.

THE MINIMUM EXTENSION OF THE CYLINDER OPERATOR DRIVE ROD IS DEFINED AS THE FREE LENGTH OF THE DRIVE ROD PLUS APPLICABLE CLEVIS LENGTH IN THE TRUE "VALVE CLOSED" POSITION.

WHEN EVER POSSIBLE; CONSERVATIVE SEISMIC LOADS WILL BE DETERMINED. SHOULD THESE LOADS PROVE EXCESSIVE, ACTUAL LOADS WILL BE DETERMINED.

BY [illegible] DATE [illegible] SUBJECT [illegible] SHEET NO. [illegible] OF [illegible]
CHKD. BY ______ DATE ______ — ORDER OF ANALYSIS — JOB NO. ______

SECTION 6.1

CYLINDER OPERATOR ASSEMBLY:

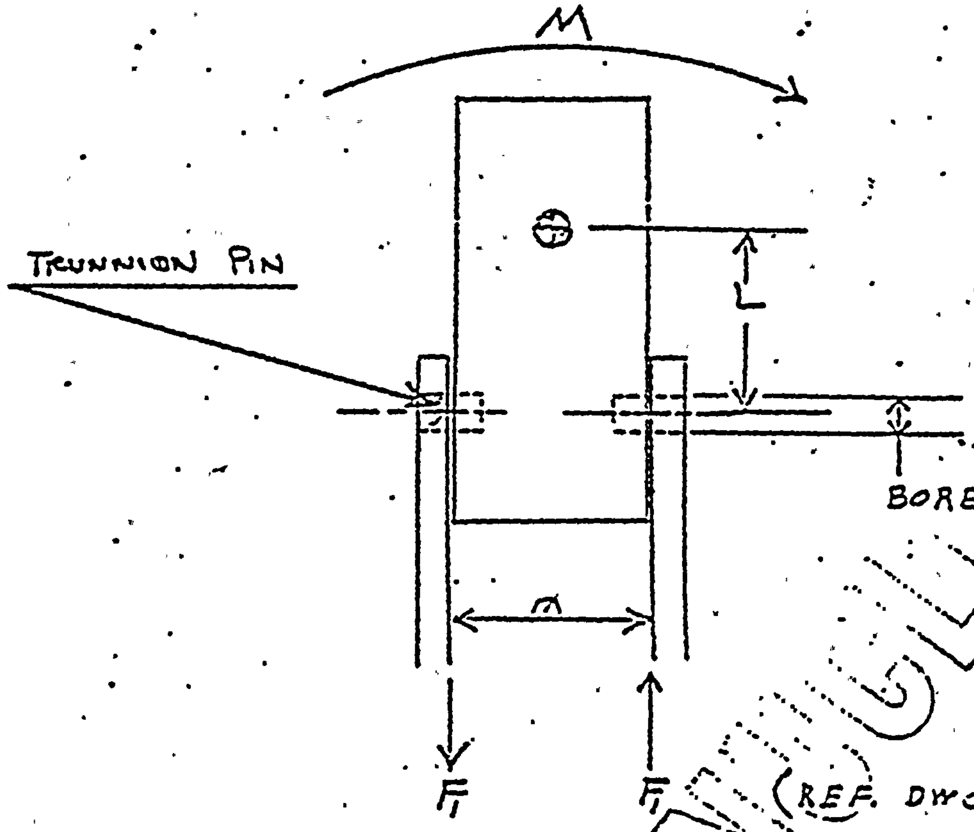
a) TRUNNION PINS

b) TRUNNION PIN LUGS

c) CYLINDER OPERATOR DRIVE LEVER

TRUNNION PIN

THE TRUNNION PINS ARE IN SINGLE SHEAR AND ARE ASSUMED TO HAVE THE SAME O.D. AS THE RECEIVER BORE I.D. THE PINS ARE MOST SEVERELY LOADED WHEN THE CYLINDER OPERATOR IS OVERTURNED SUCH THAT THE PINS RESIST OVERTURNING VIA COUPLE ACTION.



(REF. DWGS. A-208195, D-184100)

$$M = W\,g\,L$$
$$= 593\,(3)(21.25)$$
$$= 37{,}804 \text{ IN.-LB.}$$

$F_1 = \frac{M}{X}$

$= 37,804 / 13.39$

$= 2,825$ LBS.

ACTING SIMULTANEOUSLY IS THE VERTICAL SEISMIC EFFECT OF (2 g + 1 g DEAD WT.) = 3 g

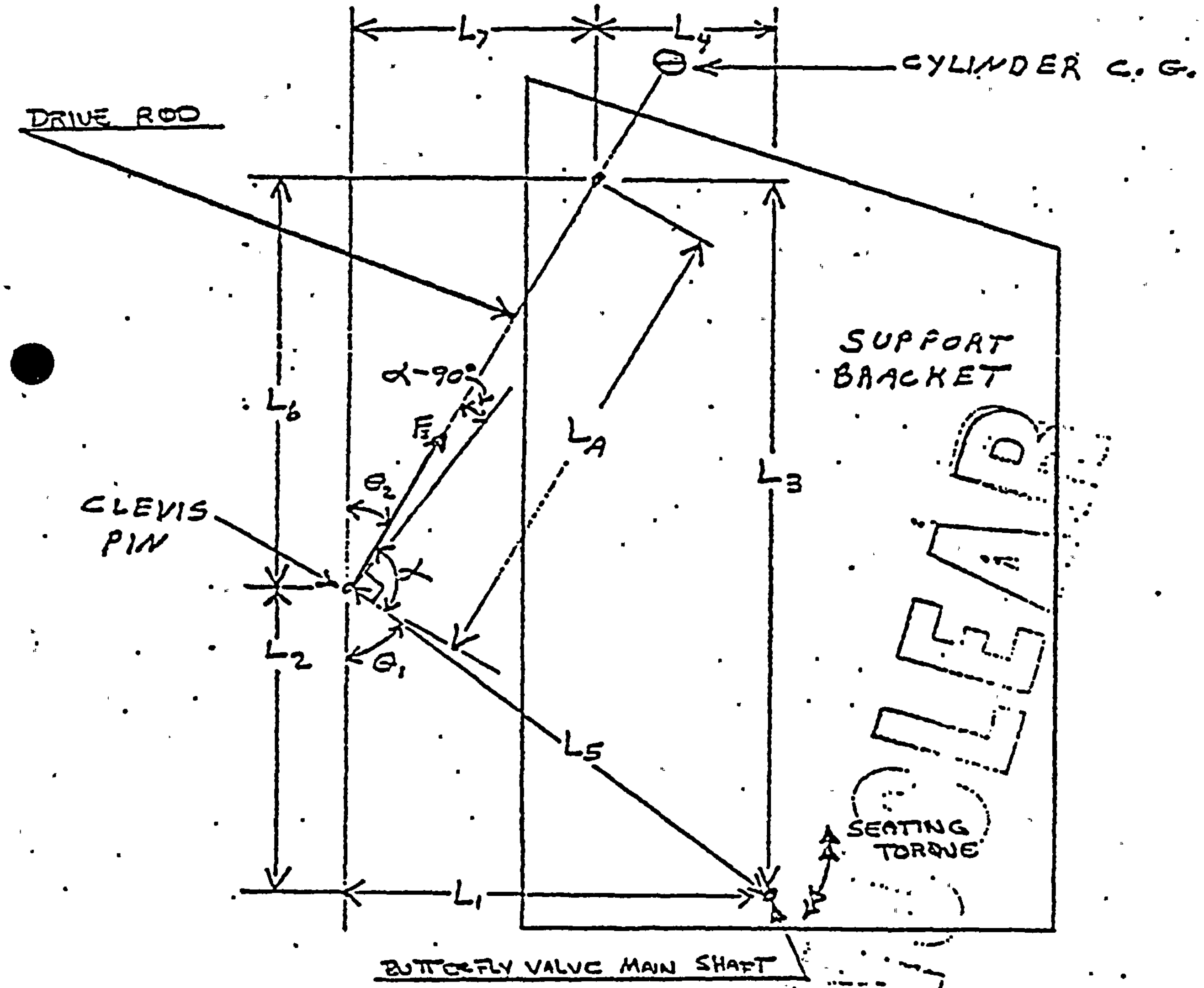
$F_2 = 3 \ (W)$

$= 1,779$ LB

$= 890$ LB./PIN

SEE NEXT PAGE FOR THE CALCULATIONS TO DETERMINE THE FORCE ON THE TRUNNION PINS DUE TO SEATING TORQUE

LOADING DETERMINATION USED FOR CALCULATION OF TRUNNION PIN REACTION DUE TO SEATING TORQUE ("VALVE CLOSED" POSITION)



$$F_3 = \frac{(\text{SEATING TORQUE})}{L_5}\left[\cos(\alpha - 90)\right]$$

CKD. BY THR DATE 7-7-79 OPERATING TORQUE EFFECT JOB NO.

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.24

$L_1 = 11.18 \quad L_2 = 3.625 \quad L_3 = 28.5 \quad L_4 = 8.5$

$L_5 = (L_1^2 + L_2^2)^{1/2} = (11.18^2 + 3.625^2)^{1/2}$

$= 11.753$

$L_6 = L_3 - L_2 = 28.5 - 3.625$

$= 24.875$

$L_7 = L_1 - L_4 = 11.18 - 8.5$

$= 2.68$

$\theta_1 = TAN^{-1} L_1/L_2 = TAN^{-1} 11.18/3.625$

$= TAN^{-1} 3.084$

$= 72.035°$

$\theta_2 = TAN^{-1} L_7/L_6 = TAN^{-1} 2.68/24.875$

$= TAN^{-1} .1077$

$= 6.149°$

$\alpha = 180° - \theta_1 - \theta_2 = 180° - 72.035 - 6.149°$

$= 101.816°$

$\alpha - 90° = 11.816°$

$F_3 = \frac{27,800}{11.753} \cos 11.816°$

$= 2,416$ LBS.

$= 1,208$ LBS./PIN

NUCLEAR

THE TOTAL LOAD PER PIN $= \sum_{1}^{3} F_i$

$= 2,825 + 890 + 1,208$

$= 4,923$ LB.

THE MAXIMUM SHEAR STRESS FOR SOLID CIRCULAR CROSS SECTIONS IS DEFINED AS

$$\tau = \frac{4}{3}\frac{V}{A}$$

$$= \frac{4}{3}\frac{(4,923)}{\frac{\pi(1.75)^2}{4}}$$

$= 2,729$ PSI. $< .6\ S_y = 11100$ psi
(SA-275, 304 S.S 340°F)

CYLINDER OPERATOR DRIVE ROD

THE DRIVE ROD IS ANALYZED FOR COMBINED SEISMIC PLUS DEAD WT. PLUS OPERATING STRESS

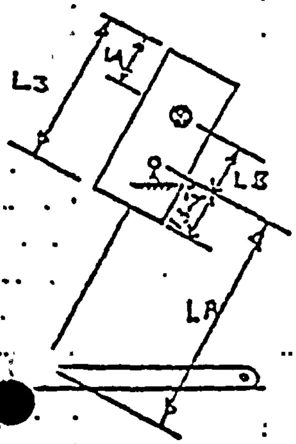
...ADED CYL. OPERATOR
...VE ROD

FOR CONSERVATISM THE LATERAL ACCELERATION (...ORIZONTAL) IS COMBINED WITH THE VERTICAL ACCELERATION TO PROVIDE THE LARGEST POSSIBLE ACCELERATION INDUCING ...ENDING.

$\overrightarrow{3.0\,G} + (2.0\,G + 1.0\,G)\downarrow = 4.24\,G$

FROM PG 12 THE MAXIMUM CLEVIS REACTION

$F_C = \frac{L_B}{L_A} W'$ WHERE $W' = (4.24)W$



(REF DWNGS D-184100, D-146579)

$L_B = L_3 - (L_4 + 13.5)$ $L_3 = 64$ $L_4 = 29.25$

$L_B = 21.25$

FROM PG 17 $L_A = L_6 / \cos \theta_2$

$L_6 = 24.875$

$\theta_2 = 6.15°$

$\therefore L_A = 25.02$ IN.

$F_c = \frac{21.25}{25.02}(4.24)(593)$ $F_c = 2,135$ lbs

CALCULATING MOMENT @ POINT WHERE DRIVE ROD ENTERS CYLINDER:

$M = F_c\,(L_A - 13.5") = 2,135(25.02 - 13.5)$

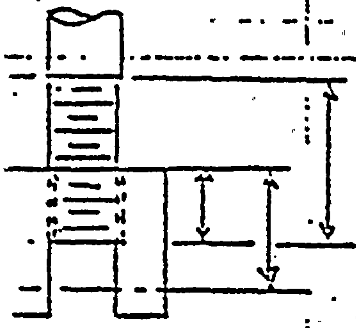
$= 24,595$ IN-lbs

$\sigma = \frac{Mc}{I}$ $c = D/2 = 1.75/2 = .875$ IN.

$I = .46$ IN^4

$\sigma = 46,745 < S_y$ (90000 psi)
(AISI 4140)

FOR THE THD'D REGION OF THE DRIVE ROD:



$L = (4.625 - 2.25) + (4.375)$

$L = 6.75$ IN.

* (DRIVE ROD ASSUMED TO OCCUPY ALL OF THREADED CLEVIS)

$M = (F_c)(L) = 2,135(6.75)$

$= 14,411$ IN-lbs

FOR THE THREADED REGION THE MINOR DIA. OR A $1\frac{3}{4}$-5 THREAD IS:

$D_{MINOR} = 1.5046$ IN. REF 8

$C = D/2 = .7523$ IN.

$I = .252$ IN.^{4}

$$\sigma = \frac{Mc}{I} = \frac{74,411(.7523)}{.252}$$

$= 43,096$ psi

FROM PG 18 THE OPERATING CONDITION LOAD DUE TO VALVE SEATING TORQUE IS:

$F_3 = 2,416$

TENSILE/COMPRESSIVE STRESS $\sigma = \frac{F_3}{A}$

A = TENSILE STRESS AREA = 1.9 REF 8

$\therefore \sigma = 1,272$ psi

THE COMBINED BENDING + AXIAL STRESS IS:
(COMBINED TO MAXIMIZE TOTAL STRESS)

48,017 psi < S_y = 90000 psi
(AISI-4140)

BY TMK DATE 2-20-74 SUBJECT "30" B.F.V. SHEET NO. 6.2.1 OF
CHKD. BY DATE — SCOPE OF ANALYSIS — JOB NO.

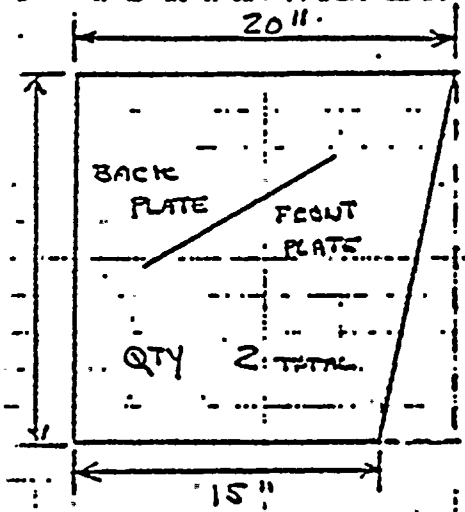
SECTION 6.2

a) CYLINDER SUPPORT BRACKET

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.29

DETERMINATION OF APPROXIMATE WEIGHT OF CYLINDER OPERATOR BRACKET

DWNG A-208195



TOTAL AREA = $A_1 - A_2$

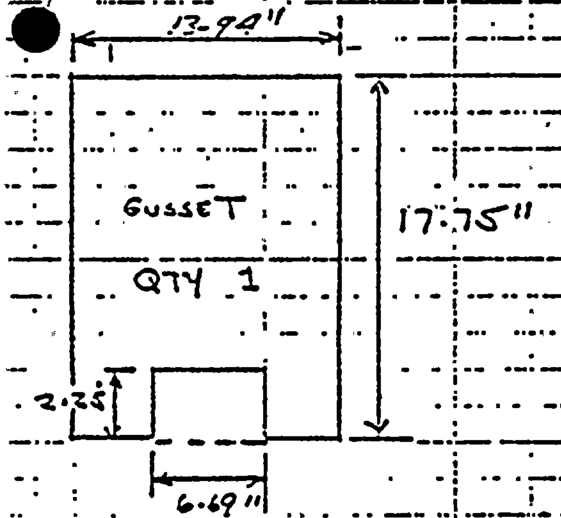
$A_1 = 20 \times 37.5 = 750 \text{ in}^2$

$A_2 = 1/2 \times 5 \times 37.5 = 93.75 \text{ in}^2$

A_{TOTAL} PER PLATE $= 656.25 \text{ in}^2$

TOTAL VOLUME PER PLATE $= A_T \times t$

$= 656.25 \times .62 = 406.88 \text{ in}^3$



TOTAL AREA = $A_1 - A_2$

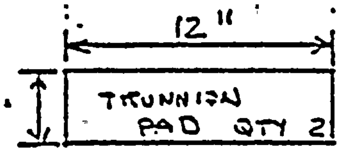
$A_1 = 13.94 \times 17.75 = 247.44 \text{ in}^2$

$A_2 = 2.25 \times 6.69 = 15.05 \text{ in}^2$

$A_{TOTAL} = 232.38 \text{ in}^2$

TOTAL VOLUME $= A_T \times t$

$= 232.38 \times .62 = 144.08 \text{ in}^3$



$A_{TOTAL} = 3 \times 12$
$= 36 \text{ in}^2$

TOTAL VOLUME $= A_T \times t$
$= 36 \times .75 = 27 \text{ in}^3$

8" SCH 20 S̄ PIPE

13.94"

QTY 1

WEIGHT = 22.36 lb/FT
GEINUEL (Ref.) P 188

TOTAL PIPE WT = $\frac{13.94}{12}$ × 22.36 = 25.97 lb.

3" × 3"

PAD
QTY 4

A TOTAL = 3 × 3 = 9 IN²
V TOTAL = 9 × .38 = 3.42 IN³

4" × 4"

MAIN
SHAFT
PAD
QTY - 1

AT = 4 × 4 = 16 IN²
VT = 16 × .62 = 9.92 IN³

13.94"

ANGLE S̄ QTY 1

WT = 1.92 lb/FT

TOTAL WT = $\frac{13.94}{12}$ × 1.92 = 2.23 lb

ITEM 9 DWNG A-208195 IS IGNORED WRTO WEIGHT.
NO WEIGHT ALLOWANCE FOR THRU-HOLES IS PROVIDED,
THUS THE TOTAL APPROXIMATED WT IS CONSERVATIVELY
HIGH.

TOTAL APPROXIMATED WT IS CALCULATED AS:

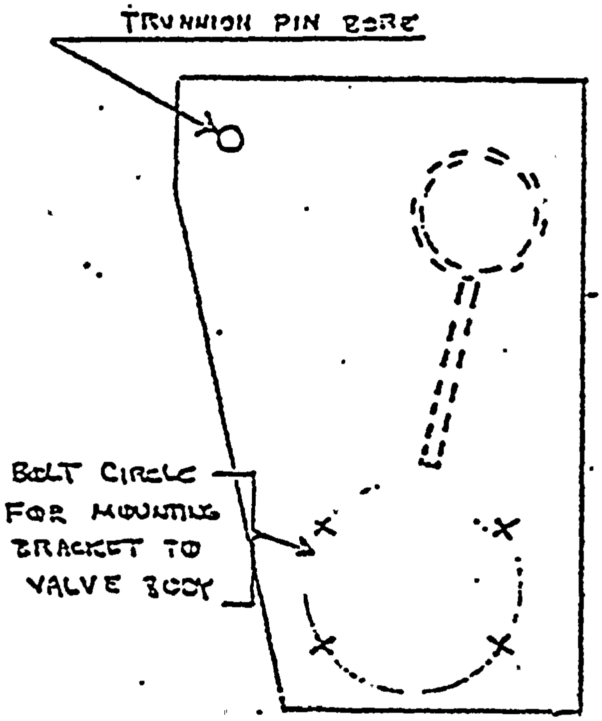
$V_{TOTAL} \times \rho$ WHERE $\rho \equiv .283$ lb/in^3

$$W_{TOTAL} = \left\{ (.283)\left[(2)(406.88) + (1)(144.08) + (2)(27) + (4)(3.42) + (1)(9.92)\right] + 25.97 \text{ lb} + 2.23 \text{ lb} \right.$$

W_{TOTAL} (APPROXIMATE) = 321. lb

NOTE: THIS WT. WILL BE ARBITRARILY APPLIED IN SUCH A WAY AS TO MAXIMIZE SEISMIC STRESS EFFECTS AS OPPOSED TO JUST CONSIDERING THIS WT. @ THE TRUE C.G. OF THE CYLINDER OPERATOR BRACKET.

CYLINDER SUPPORT BRACKET



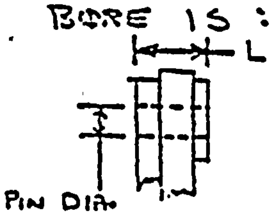
GENERAL ARRANGEMENT
CYL. OPERATOR SUPPORT BRACKET

THE CYLINDER OPERATOR SUPPORT BRACKET IS ANALYZED FOR BEARING AT THE TRUNNION BORE & SHEAR & BENDING EFFECTS ACROSS THE "MINIMUM" SECTION OF THE BRACKET.

FROM PG 19, THE COMBINED SEISMIC PLUS OPERATING CONDITION LOAD ON A GIVEN TRUNNION PIN IS:

$$F_{TOTAL} = 4923 \text{ lbs}$$

THE BEARING AREA PRESENTED BY THE TRUNNION BORE IS:



$A_B = L\,D$ WHERE D = TRUNNION PIN DIA.

(REF DWNGS A-208195 & D-184100)

L = 1.62 IN. D = 1.75 IN

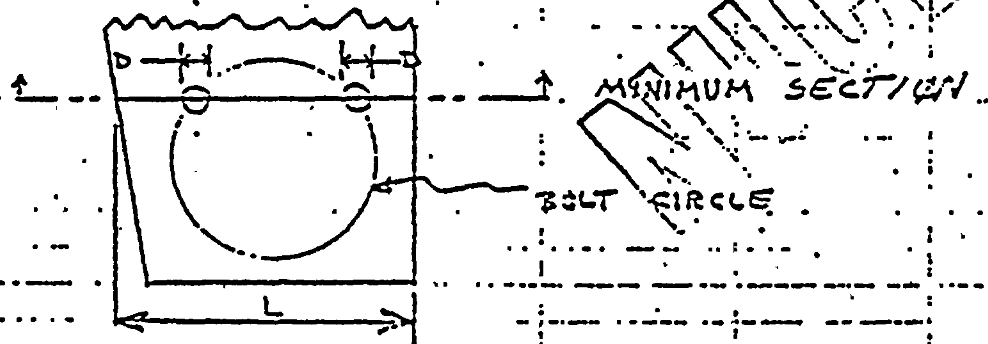
$A_B = 2.84$ IN^2

BEARING STRESS = σ_{BRNG} = F_{TOTAL} / A_B

σ = 1733 psi

1733 psi < S_y = 36000 psi ①
① (ASTM A36)

THE "MINIMUM" SECTION OF THE BRACKET IS DEFINED BY A LINE DRAWN THROUGH THE UPPER TWO MOUNTING HARDWARE BOLT HOLES. THE RESULTING SECTION IS CONSIDERED TO CARRY SEISMIC + OPERATING LOADS BASED ON THE ASSUMPTION THAT THE BRACKET IS SECURELY BOLTED TO THE VALVE BODY.



THE BENDING EFFECT CAUSED BY SEISMIC OVERTURNING OF THE CYLINDER OPERATOR IS CARRIED AS A COUPLE AT THE MINIMUM SECTION ; ALSO THE ACCELERATED BRACKET WT. TOO, IS CARRIED AS A COUPLE AT THE MIN. SECTION

FOR CONSERVATISM THE MAGNITUDE OF THE FORCE IN THE RESULTING COUPLE IS EQUAL TO "F_{TOTAL}" CALCULATED PREVIOUSLY PLUS $\frac{(4.24)(\text{BRACKET WT})(L_{MAX})}{W}$

(WHERE L_{MAX} IS CONSERVATIVELY CHOSEN AS $(L_3 - L_6)$ -BELOW- AND "W" IS THE WIDTH BETWEEN BRACKET PLATES —BELOW—)

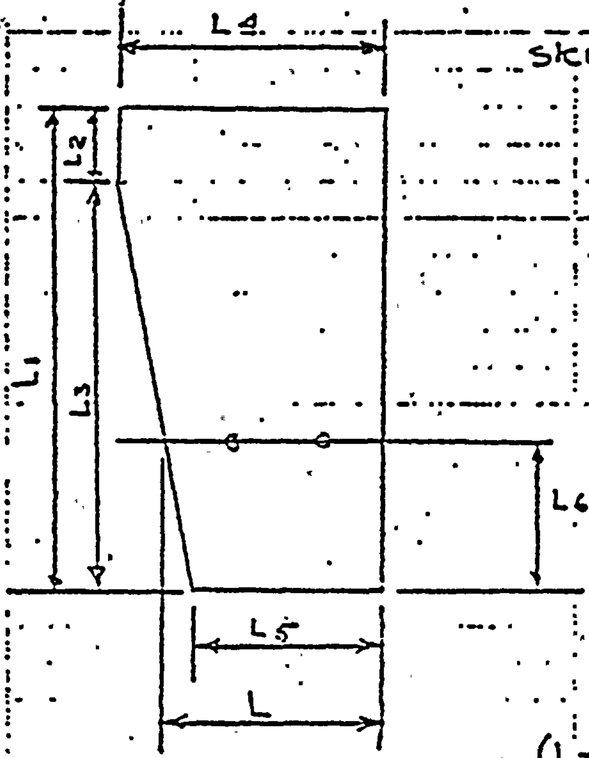
THE TENSILE AREA @ THE MINIMUM SECTION (ONE SIDE OF BRACKET) IS:

$(L - 2D)t$ WHERE t = PLATE THICKNESS

D = THRU-HOLE DIA.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.35

IN DETERMINING "L" & "L_{MAX}" THE ACCOMPANYING SKETCH IS USED.



$L_1 = 37.5$ IN. $L_2 = 0$ IN.

$L_3 = (L_1 - L_2) = 37.5$ IN.

$L_4 = 20.0$ IN. $L_5 = 15.0$ IN.

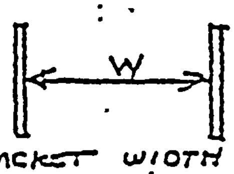
$L_6 = 12.25$ IN. $W = 13.88$ IN.

FROM SIMILAR TRIANGLES

$$\frac{L_3}{(L_4 - L_5)} = \frac{L_6}{(L - L_5)}$$

$$(L - L_5) = \frac{(L_6)(L_4 - L_5)}{L_3} = 1.63$$

$$L = (1.63) + L_5$$



BRACKET WIDTH

$L = 16.63$ IN. $L_{MAX} = 25.25$

TENSILE AREA = (16.63 − 1.88)(0.62)

$A_T = 9.15 \text{ IN}^2$

AXIAL STRESS = $\sigma_A = \left[4923 + \frac{(4.24)(321)(25.25)}{(13.88)}\right] / A_T$

$\sigma_A = 809$ psi

809 psi < Sy = 36000 psi ① (ASTM A36) ①

THE LARGEST VALUE OF SHEAR LOAD IS CONSERVATIVELY CALCULATED AS $V = 4.24 (W_1 + W_2)$

W_1 (CYLINDER WT) = 399 lbf W_2 (BRACKET WT) = 321 lbf

∴ V = 3053 lbf

THE SHEAR AREA IS TWICE THE CALCULATED TENSILE AREA IN THIS CASE THUS

$$\tau = \frac{V}{A} = \frac{V}{2A_T} = \frac{3053}{2(9.15)}$$

$\tau = 167$ psi

167 psi ≪ 0.6 Sy = 21,6000 psi ① (ASTM A36) ①

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.436

BY TMR DATE 2-20-74 SUBJECT 30" B.F.V. SHEET NO. 6.3.1 OF
CHKD. BY ____ DATE ____ —ORDER OF ANALYSIS— JOB NO. ____

SECTION 6.3

CLEVIS ASSEMBLY AND DRIVE LEVER :

a) CLEVIS PIN

b) CLEVIS

c) DRIVE LEVER

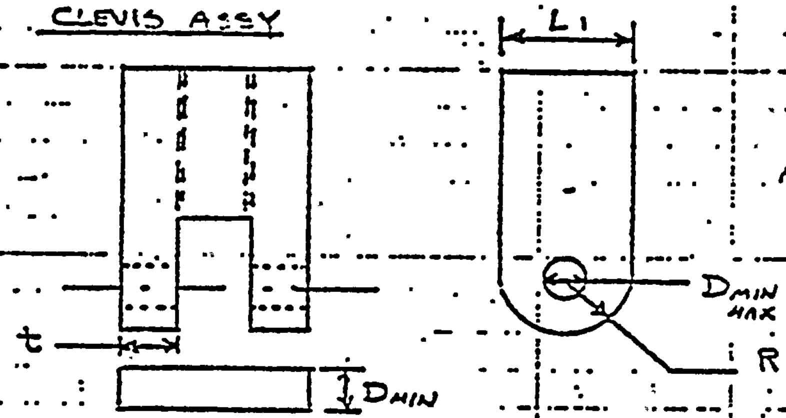
d) KEY

CHKD. BY PHW DATE 2/3/79 SEISMIC + OPERATING STRESS JOB NO.

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.38

CLEVIS ASSY. AND DRIVE LEVER

(REF DWNGS B211829 & D211832-2 ①



THE CLEVIS PIN IS ASSUMED TO HAVE THE SAME Φ.D. AS THE MINIMUM I.D. CLEVIS BORE

THE CLEVIS PIN IS IN DOUBLE SHEAR AND PRESENTS A TOTAL SHEAR AREA OF:

$$A_s = 2\left(\frac{\pi D^2}{4}\right) \qquad D = 1.5 \text{ IN}$$

$$A_s = 3.53 \text{ IN}^2$$

THE TOTAL SEISMIC PLUS OPERATING CONDITION LOAD ON THE CLEVIS PIN IS CONSERVATIVELY CHOSEN AS THE ALGEBRAIC SUM OF CLEVIS SEISMIC REACTION AND SEATING TORQUE REACTION

CLEVIS SEISMIC LOAD (PG 21) = 2135 lbf

CLEVIS (TRUNNION PIN) SEATING TORQUE LOAD (PG 18) = 2416 lbf.

F_{TOTAL} = 4551 lbf

THE RESULTING MAXIMUM SHEAR STRESS IN THE CLEVIS PIN IS:

$$\tau = \frac{4}{3}\frac{V}{A} = \frac{4}{3}\frac{4551}{3.53}$$

$$\tau = 1719 \text{ psi} < .6 S_y = 11100 \text{ psi}$$

(SA 276, 304 S.S) @ 340

THE CLEVIS ITSELF CAN FAIL IN ONE OF SEVERAL MODES:

TENSILE FAILURE: $A_{TENSILE} = 2(L_1 - D_{MAX})(t)$

$L_1 = 3.0$ in $D_{MAX} = 1.5$ in. $t = .813$ in.

$A_T = 2.44 \text{ in}^2$

BEARING FAILURE: $A_{BRNG} = 2(D_{MIN})(t)$

$A_{BRNG} = 2.44 \text{ in}^2$

PUNCH SHEAR: $A_S = 4(R - D_{MAX}/2)(t)$

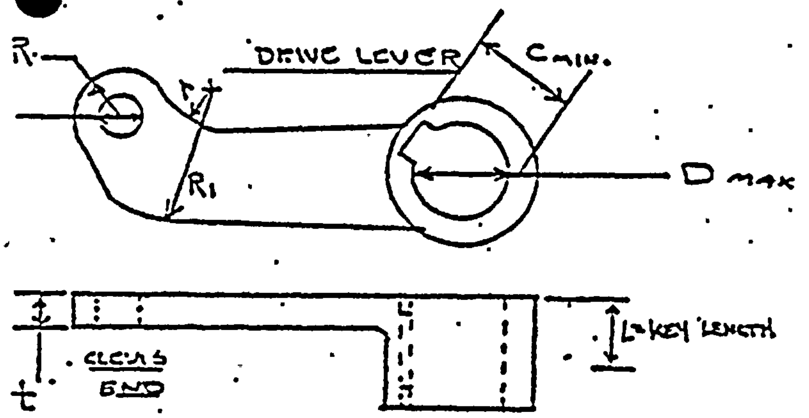
$A_S = 2.44 \text{ in}^2$

THE TOTAL LOAD ON THE CLEVIS IS F_{TOTAL} AS CALCULATED ON THE PREVIOUS PAGE.

THE GOVERNING STRESS IS: $\frac{4551}{2.44} = 1865$ psi

1865 psi < .6 S_y = 27,000 psi ①
33
(ASTM A285)

BY DATE 5/18/79 SUBJECT W B.F.V. SHEET NO. 6.4.7 OF
CHK. BY DATE 2/22/79 SEISMIC + OPERATING STRESS JOB NO.



THE DRIVE LEVER IS ANALYZED FOR GOVERNING STRESS CONDITIONS AT THE "CLEVIS END"; IS ANALYZED FOR COMBINED TENSILE PLUS BENDING AT THAT SECTION DEFINED AS $(R_1 - r)$ AND IS ANALYZED FOR BEARING STRESS AT THE KEYWAY ON THE "MAINSHAFT END".

FROM PG 32, THE MAXIMUM CLEVIS REACTION (TRUNNION PIN REACTION) IS

$$F_{TRIAL.} = 4551 \text{ lbf}$$

AT THE CLEVIS END, SEVERAL MODES OF FAILURE EXIST:

TENSILE FAILURE: $A_T = (2R - d)t$ $R = 1.5$ IN, $d = 1.75$ IN, $t = 1.5$ IN

$A_T = 1.875 \text{ IN}^2$

BEARING FAILURE: $A_{BRNG} = (\text{CLEVIS PIN DIA.})(t)$ $D_{c.p.} = 1.5$ IN.

$A_{BRNG} = 2.25 \text{ IN}^2$

PUNCH SHEAR: $A_S = 2(R - d/2)(t)$

$A_S = 1.875 \text{ IN}^2$

THE GOVERNING STRESS IS:

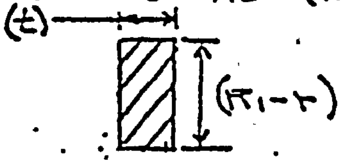
$$= \frac{F_{TOTAL}}{A_S} = \frac{4551}{1.875}$$

$$T = 2427 \text{ psi} < .6 S_y = 22{,}000 \text{ psi} \quad (1)$$

(ASTM A395) (1)

TENSILE + BENDING STRESS.

FOR THE SECTION DESCRIBED AS $(R_1 - r)$ THE MOMENT OF INERTIA IS:



$$I = \frac{bh^3}{12}$$

$b = t = 1.5$ IN. $R_1 = 4.75$ $r = 1.5$

$h = (R_1 - r) = 3.25$ IN.

$$I = 4.29 \text{ IN}^4$$

THE LARGEST MOMENT THE DRIVE LEVER CAN GENERATE IS EQUAL TO THE SEATING TORQUE. (ABOVE THIS TORQUE LEVEL THE VALVE UNSEATS)

$$\sigma_B = \frac{Mc}{I}$$

WHERE $M = 27800$ IN-lbs

$c = (R_1 - r)/2 = 1.625$ IN.

$$\sigma_B = 10530 \text{ psi}$$

$\frac{27800 \cdot 1.625}{4.29} = 10530 \times \frac{22174}{27800} = 8399$

IN ADDITION TO THE BENDING STRESS AN AXIAL STRESS CAN EXIST. FOR CONSERVATISM THE FORCE PRODUCING THIS STRESS IS F_{TOTAL} AS DEFINED ABOVE.

THE MINIMUM AREA CARRYING THIS TENSILE LOAD IS $A_T = (R_1 - r)(t) = 3.25(1.5) = 4.875$

THE AXIAL STRESS $\sigma_A = \frac{F_{TOTAL}}{A_T} = 934$ psi

THE TOTAL BENDING + TENSILE STRESS IS:

$\sigma_A + \sigma_B = 11,464$ psi $<$ $S_y = 45000$ psi (ASTM A395) ①

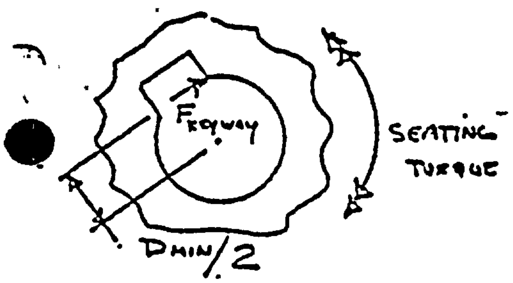
KEYWAY BEARING STRESS

THE MINIMUM BEARING AREA PRESENTED BY THE KEYWAY IS, FROM THE SKETCH ON PG 34:

$A_B = (C - D) \cdot (L)$ WHERE $C = 2.68$ IN.
$D = 2.5$ IN.
$L = 3.75$ IN. (LENGTH OF KEY)

$A_B = 0.675$ IN.^{2}

THE COMBINED FORCE ACTING ON THE KEYWAY IS CONSERVATIVELY ASSUMED TO BE THE COMBINATION OF SEATING TORQUE REACTION PLUS THE MAXIMUM CLEVIS REACTION LOAD



$(F_{KEYWAY})(D_{MIN}/2) = M$

$\frac{D_{MIN}}{2} = 1.25$ IN.

$M = 27800$ IN-lbf

∴ F_{keyway} = 22240 lbf & FROM PREVIOUS PG.:

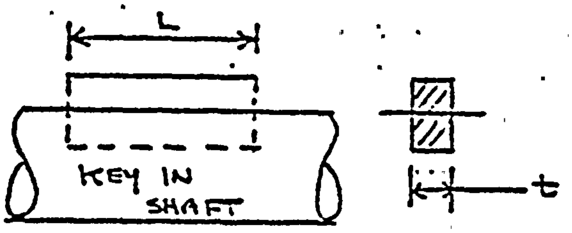
F_{TOTAL} = 4551 lbf

THE COMBINED FORCE = $F_{keyway} + F_{TOTAL}$ = 26791 lbf

BEARING STRESS = $\sigma_{BRNG} = \frac{F_{COMBINED}}{A_B} = \frac{26791}{.675}$

σ_{BRNG} = 39690 psi < S_y = 45000 psi (1)
(ASTM A395) (1)

THE COMBINED FORCE AS CALCULATED ABOVE IS APPLIED TO THE KEY AS A SHEAR LOAD.



THE SHEAR AREA OF THE KEY IS:

$A_S = Lt$ WHERE L = 3.75 IN t = .625 IN

A_S = 2.34 IN^2

$\tau = \frac{F_{COMBINED}}{A_S} = \frac{26791}{2.34}$

τ = 11449 psi < .6 S_y = 27000 psi
(AISI-1018)

JMK DATE 2-20-79 SUBJECT [illegible] SHEET NO. [illegible] OF
CHD. BY DATE — ORDER OF ANALYSIS — JOB NO.

SECTION 6.4

VALVE BODY SUPPORT "EARS" AND ASSOCIATED HARDWARE:

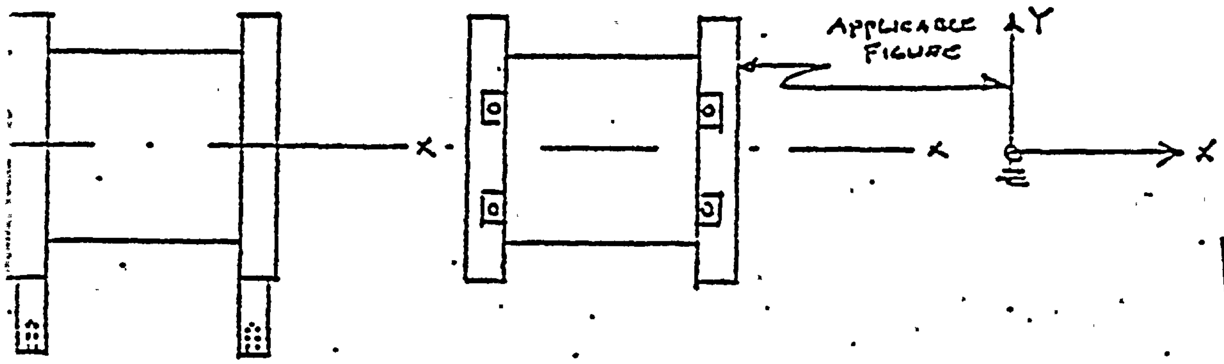
a) "EARS"

b) BOLTING HARDWARE

DATE ______ SUBJECT ______ SHEET NO. ______
TMF DATE 2-13-74 SEISMIC PLUS OPERATING STRESS JOB NO. ______

VALVE BODY SUPPORT "EARS"

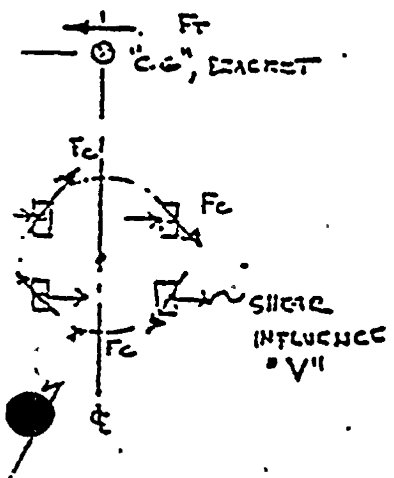
AND CYL. OPERATOR BRACKET TO BODY HARDWARE



THE "EARS" OF THE VALVE BODY SUPPORT THE CYLINDER [illegible]RATOR / BRACKET ASSY. AND ARE ANALYZED HERE FOR [illegible] [illegible], BENDING AND SHEAR EFFECTS.

TORSIONAL EFFECT

WHEN CYL. OPERATOR & BRACKET TEND TO OVERTURN [illegible] THE Z AXIS THE VALVE "EARS" REACT OUT THE TORQUE [illegible]ECT IN COUPLE ACTION.



THE SEISMIC PORTION OF THE TRUNNION REACTION IS:
$F_{T_S} = \left(\frac{L_A}{L_A} + \frac{L_B}{L_A}\right) W'$ (PG 13) ; THE SEATING TORQUE EFFECT IS "F3" (PG 18) ; $W' = 4.24\,(W_{cyl})$
$L_A = 25.02$ IN.
$L_B = 21.25$ IN.

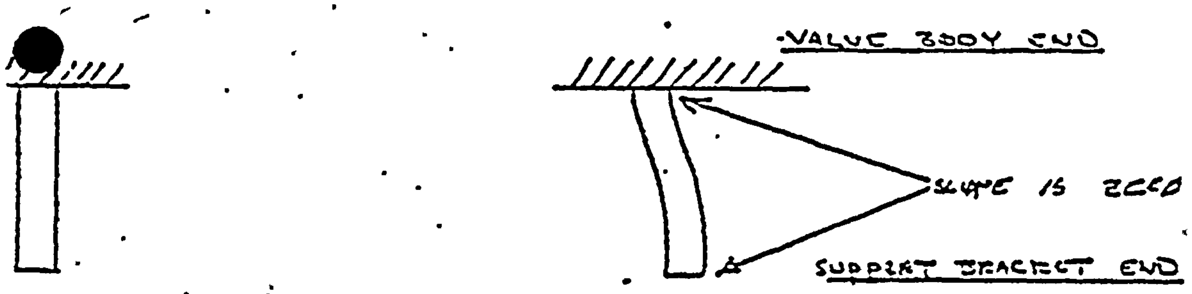
$F_T = F_{T_S} + F_3 = 7{,}066$ lbf

BRACKET WT = 321 lbf (PG 26)

IT IS ASSUMED THE BRACKET C.G. IS LOCATED AS SHOWN IN FIGURE SUPPLIED AND THAT L REPRESENTS LENGTH FROM TRUNNION BORE TO MAINSHAFT ℄
L = 28.5 IN.

CIRCLE

DATE 2-12-74 SUBJECT 30" B.F.V. SHEET NO. C-4.3 OF
DATE 2/22/79 SEISMIC PLUS OPERATING STRESS JOB NO.



EFFECT COUPLE ACTION EAR IN COUPLE ACTION (RESTRAINED)

ABOVE CONDITION EXISTS DUE TO THE FACT THAT BOTH THE BODY & THE SUPPORT BRACKET ARE CONSIDERED ...ECTLY RIGID.

THE TOTAL TORQUE RESISTED BY THE VALVE "EARS" IS:

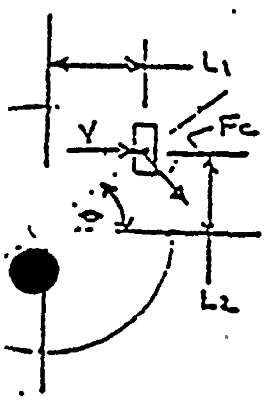
$$T = (F_T)(L) + (4.24)(W)(L) \quad (W = \text{BRACKET WT.})$$

RESULTING VALUE OF Fc IS:

$$2F_c = T / \text{DIA BOLT CIRCLE} \quad \text{WHERE } D_{IA} = 14.16 \text{ IN}$$
(BOLT CIRCLE)

$T = 240{,}165$ IN-lbf $\therefore$ $F_c = 8{,}480$ lbf

BENDING OF THE VALVE BODY EARS ABOUT THE Y-AXIS AS ...N ON THE PREVIOUS PAGE, IS THE WEAKEST PLANE OF BENDING



(REF DWNG A-208195)

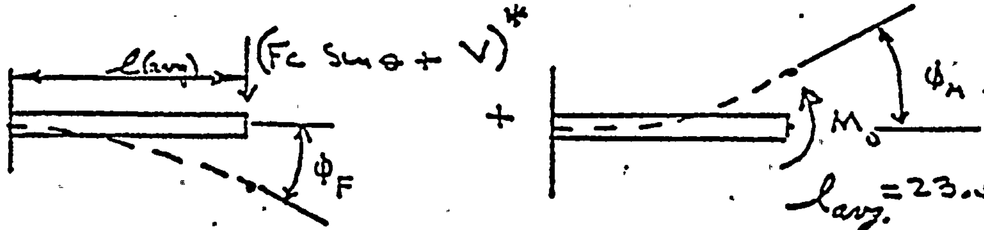
$L_1 = 4.75$ IN.

$L_2 = 5.25$ IN.

$\theta = \tan^{-1} L_2/L_1 = 47.86°$

$V + F_c \sin\theta$ = FORCE PRODUCING BENDING ABOUT Y-AXIS

IN ORDER TO MAINTAIN A ZERO SLOPE @ BRACKET END OF "EMR"
A MOMENT IS INDUCED SUCH THAT:



$l_{avg} = 23.5 - \sqrt{\left(\frac{32.75}{2}\right)^2 - 5.25^2}$
$= 4.85$

$$\phi_F + \phi_M = 0$$

FROM REF 5 PG's 104 & 106:

FOR AN END LOAD OF Fc Sin θ + V:

$$\phi_F = \frac{1}{2}\frac{W l^2}{EI}$$

FOR AN END MOMENT (M_o):

$$\phi_M = \frac{M_o l}{EI}$$

$$\frac{1}{2}\frac{W l^2}{EI} + \frac{M_o l}{EI} = 0$$

SOLVING FOR Mo:

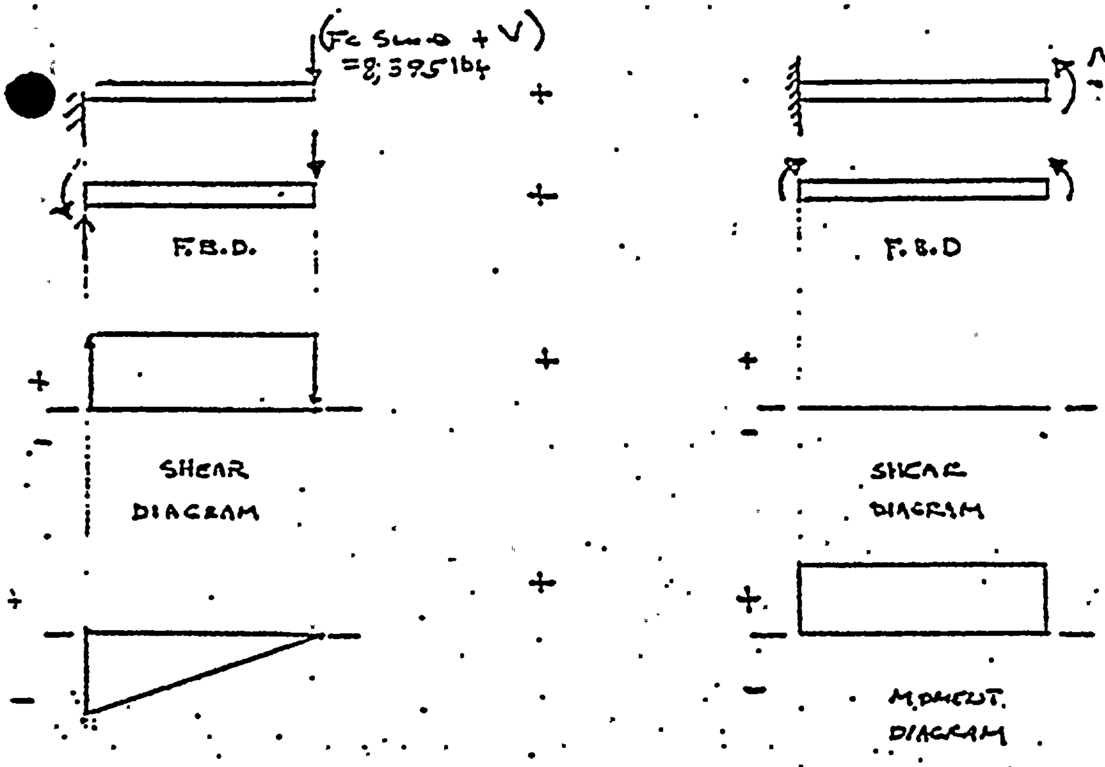
$$M_o = -\left(\frac{W l^2}{2}\right)\left(\frac{1}{l}\right)$$

$$M_o = -\frac{W l}{2} = -(F_c \sin\theta + V)\frac{l}{2}$$

* V IS THE SHEAR EFFECT = $(F_T + 4.24 W_2) / 4$

W_2 (BRACKET) = 321 lbs

V = 2,107 lbs

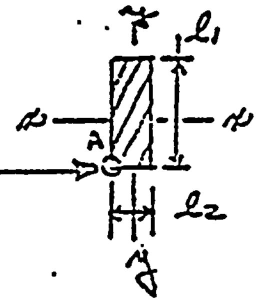


THE MAXIMUM MOMENT OCCURS AT THE CANTILEVERED END AND EQUALS:

$$M = (F_c \sin\theta + V)(l_{ag}) - M_o$$
$$= 20,358 \text{ IN-lbs}$$

THE RESULTING BENDING STRESS PER EAR IS:

$$\sigma_B = \frac{M c}{I}$$



...DING ...SS CALCULATED HERE (PT. A)

$c = l_2/2$

$$I_{yy} = \frac{bh^3}{12} = \frac{l_1 \, l_2^{\,3}}{12}$$

$l_1 = 3$ IN.

$l_2 = 1.75$ IN.

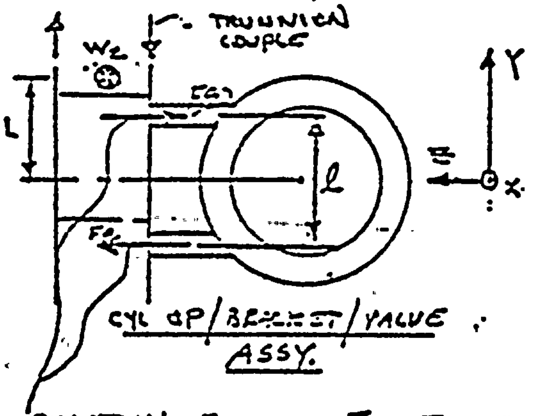
$$\sigma_B = \frac{(20,358)(.875)}{(1.34)} = 13,293 \text{ psi}$$

...ERVATIVELY ASSUMING σ_B EXISTS IN BOTH y-y & x-x AXES @ A:

σ_B TOTAL (CONSERVATIVE) $= 2\sigma_B = 26,587$ psi $<$ $S_y = 28000$ psi (SA-516, GR 60 @ 340 °F)

BENDING EFFECT

WHEN THE CYLINDER OPERATOR IS "OVERTURNED" INTO THE VALVE BODY AS IN SECTION 6.1, THE COMBINED MOMENT EFFECT OF CYLINDER OPERATOR & BRACKET IS TAKEN OUT IN THE "EARS" AS AXIAL TENSION/COMPRESSION



L = 29.5" (SEE PG 39)

TRUNNION COUPLE = 37,30? IN-lbf (SEE PG 15)

BRACKET WT = W_2 = 321 lbf (SEE PG 26)

CYL. OP. WT = W_1 = 593 lbf (SEE PG 15)

REACTION FORCES, F_B, TO BENDING EFFECT

THE TOTAL SEISMIC + OPERATING MOMENT IS:

M = TRUNNION COUPLE + $(4.24)(W_2)(L)$

$M = 76,594$ IN - lbf

$\therefore \quad F_B = \dfrac{M}{l}$ WHERE $l = 10.5$ IN.

$F_B = 7,295$ lbf ; THE STRAIGHT WT EFFECT IS $4.24(W_1 + W_2) = F_A = 3,875$ LB. (CYL. WT, BRACKET WT)

AS TWO "EARS" ARE IN TENSION:

$\sigma_{TOTAL} = \dfrac{.5 F_B + .25 F_A}{A_T}$ WHERE $A_T = (l_1)(l_2)$ (REFER PREVIOUS PG)

$\sigma_{TOTAL} = 879$ psi $\ll S_y = 28000$ psi (SA-516, GR60 @ 340°F)

KD. BY [illegible] DATE 2/27/74 SEISMIC PLUS OPERATING STRESS JOB NO.

SHEAR LOADING

THE COMBINED SEISMIC EFFECT OF CYLINDER OPERATOR WT. & BRACKET WT. IS:

$F_s = 4.24 (W_1 + W_2)$ W_1 (CYL) = 593 lbf.
W_2 (BRACKET) = 321 lbf.

FROM PG 18 THE TRUNNION REACTION AS A RESULT OF OPERATING TORQUE IS:

$F_3 = 2,416$ lbf

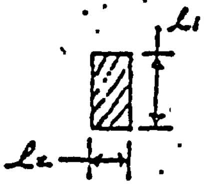
CONSERVATIVELY SUMMING FOR A TOTAL SHEAR LOAD:

$V = F_s + F_3 = (3,875) + (2,416)$

$V = 6,291$ lbf

V IS ASSUMED TO BE SHARED EQUALLY BY EACH OF THE FOUR "EARS".

$\therefore \tau = \dfrac{V}{A_s}$



$A_s = (4)(l_1)(l_2)$

$A_s = 21$ in^2

$\tau = \dfrac{(6,291)}{(21)} = 300$ psi $\ll \frac{2}{3} S_y = 16800$ psi (SA 515, GR 60 @ 340°F)

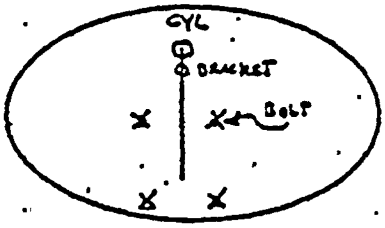
COMBINING σ_{TOTAL} (PREVIOUS PG) PLUS τ (ABOVE):

MAX STRESS (CONSERVATIVE) $= \dfrac{\sigma_T}{2} + \sqrt{\left(\dfrac{\sigma_T}{2}\right)^2 + (\tau)^2}$ 44

OVER →

MAX. STRESS = 972 psi << S_y = 28000 psi
(SA-516-GR60 @ 390°F)

BRACKET HARDWARE (REALISTICALLY REVIEWING LOADS)



(A) SHEAR DUE TO CYL. & BRACKET
$= \frac{(4.24)}{4} (W_{cyl} + W_{bracket})$
= 969 lbf.

(B) TORQUE DUE TO CYLINDER
$= (4.24)\left(1 + \frac{21.25}{2592}\right)(573)(28.5)$
= 132519. in-lbf

∴ Fc DUE TO CYL. = $\frac{132519}{(2)(14.16)}$ = 4679 lbf

SHEAR DUE TO (A) & (B) IS 5615 lbf

(C) THE TRUE BRACKET C.G. LOCATION IS APPROX. 22" ABOVE BOLT CIRCLE ℄.

TORQUE INFLUENCE = $\frac{(22)(573)(3)}{(2)(14.16)}$ = 1382 lbf

TOTAL SHEAR; (A)+(B)+(C) = 6997 lbf

$\tau_{avg} = \frac{6997}{A_s}$ WHERE $A_s = \frac{\pi D_{min}^2}{4}$

BOLT SIZE = 7/8"-9 ∴ D_{min} = .7387 IN (REF 8)

τ_{avg} = 16326 psi & FROM PG 43;

$\sigma_{tensile}$ = 879 psi

$\tau_{max} = \frac{879}{2} + \sqrt{\left(\frac{879}{2}\right)^2 + (16326)^2}$ = 16772 psi < S_y = 23300 psi
(SA-307 @ 212°F)

BY TMR DATE 2-20-74 SUBJECT 30" B.F.V. — ORDER OF ANALYSIS — SHEET NO. C.5.1 OF

CHKD. BY DATE JOB NO.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 03.01.F
SHEET NO. 7.4.57

SECTION 6.5

SHAFT AND DISC ASSEMBLY :

a) FRONT SHAFT

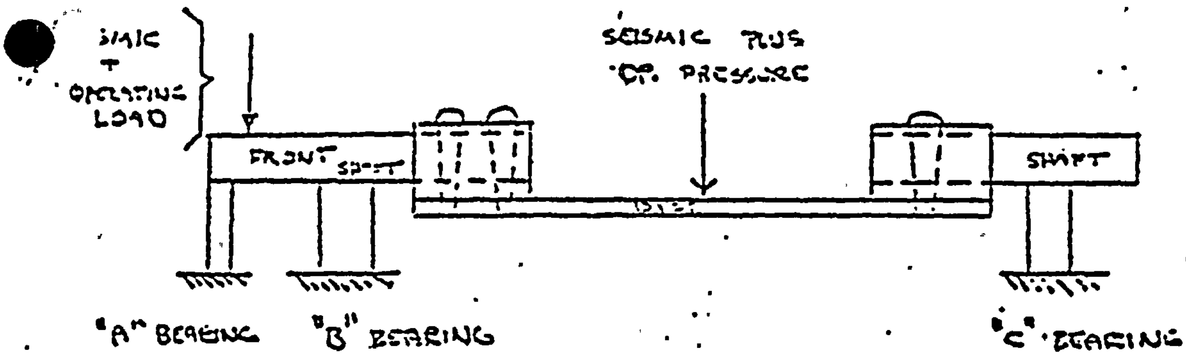
b) DISC

c) TAPER PINS

d) BOLTING HARDWARE

NUCLEAR

BY TMR DATE 2-19-79 SUBJECT 30" B.F.V. SHEET NO. 6.5.2 OF
CHKD. BY [illegible] DATE 2/23/79 SEISMIC PLUS OPERATING STRESS JOB NO.



SHAFT AND DISC ASSEMBLY

FROM PG 21, THE MAXIMUM SEISMIC CLEVIS/DRIVE LEVER LOAD IS F_C = 2135 lbf.

FROM PG 18, THE SEATING TORQUE LOAD ON THE CLEVIS/DRIVE LEVER IS F_{OT} = 2416 lbf.

$F_C + F_{OT}$ = COMBINED SEISMIC + OPERATING EFFECT = 4551 lbf. (CONSERVATIVE)

FROM BIF THE SEATING TORQUE IS 27800 IN-lbf.

FROM BIF THE COMBINED WEIGHTS OF THE SHAFTS AND DISC ARE $W_{COMBINED}$ = 384 lbf.

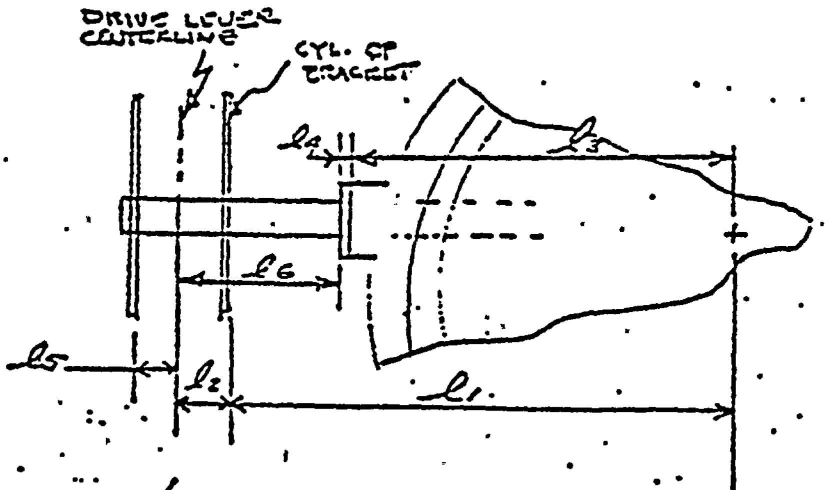
THE MAXIMUM SEISMIC INFLUENCE ON THE DISC IS

$4.24(W_c) = 4.24(384) = 1628$ lbf.

BASED ON THE TRUE SHAFT/DISC SUSPENSION SYSTEM, THE FRONT SHAFT IS ASSUMED SIMPLY SUPPORTED FROM THE FRONT FACE OF THE GLAND FOLLOWER AND THE FREE END OUTER SHAFT BEARING

BY THR DATE 2-9-74 SUBJECT 30" B.F.V. — SEISMIC PLUS OPERATING STRESS SHEET NO. ___ OF ___
CHKD. BY RKC DATE 2/22/74 JOB NO. ___

- SEISMIC & OPERATING FORCES ARE CONSIDERED TO ACT ON THE FRONT SHAFT @ THE INTERSECTION OF FRONT SHAFT & CENTERLINE OF THE DRIVE LEVER.



(DWNGS: GEN'L ARRANGEMENT, A-206763 ; BODY, FABRICATED, A-900501 ; GLAND FOLLOWER, B-900517 .. CYL. SUPPT BRACKET A-208195)

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.54

- ℓ_6 = FREE SPAN LENGTH $= (\ell_1 + \ell_2) - (\ell_3 + \ell_4)$

$\ell_1 = 23.5$ IN; $\ell_2 = 7.75$ IN; $\ell_3 = 19.44$ in; $\ell_4 = .63$ IN.

$\ell_5 \cong 6.32$ IN; $\therefore \ell_6 = 11.18$ IN.

FROM THE PREVIOUS PG, THE MAXIMUM SEISMIC + OPERATING LOAD ON THE CLEVIS IS $F_C + F_{OIT} = F_{combined} = 4551$ lbf (CONSERVATIVE)

FROM REF. 5 PG 106, CASE 12:

THE MAXIMUM BENDING MOMENT IS $M = W\frac{ab}{L}$ @ LOAD POINT

$a = \ell_5$, $b \equiv \ell_6$, $L \equiv \ell_6 + \ell_5$, $W = F_{combined}$

$\therefore M = \frac{(4551)(6.32)(11.18)}{(17.5)}$; $M = 18375$ IN-lbf

- MIN. SHAFT DIA. = $D_{MIN} = 2.4995$ IN $\therefore C = \frac{D_{MIN}}{2} = 1.25$ IN. $I = \frac{\pi D_{MIN}^4}{64} = 1.916$ IN

BENDING STRESS $= \sigma_B = \frac{Mc}{I} = 11988$ psi

IN-ADDITION TO BENDING, $F_{COMBINED}$ PRODUCES AN AVERAGE SHEAR STRESS ACROSS THE SHAFT EQUAL TO:

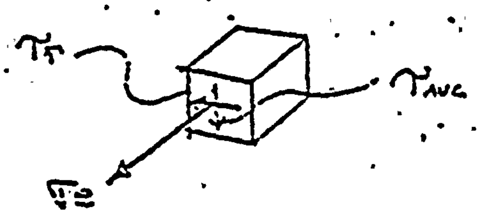
$$\tau_{AVG} = \frac{F_{COMBINED}}{A} \quad \text{WHERE } A = \frac{\pi D_{MIN}^2}{4} = 4.907 \text{ IN}^2$$

$$\tau_{AVG} = 927 \text{ psi}$$

THE OPERATING TORQUE PRODUCES A TORSIONAL SHEAR OF:

$$\tau_T = \frac{T\rho}{J}; \quad \rho = c = 1.25 \text{ IN}; \quad J = 2I = 3.832 \text{ IN}^4$$

$$\tau_T = 9068 \text{ psi}$$



THE RESULTING STRESS CUBE IS VIEWED AS TRIAXIAL IN STRESS STATE. (CONSERVATIVE)

FROM REF 5 Pg 95, CASE 7:

GENERAL TRIAXIAL STRESS CASE

$$S^3 - (S_1+S_2+S_3)S^2 + (S_1S_2 + S_2S_3 + S_1S_3 - S_{s_1}^2 - S_{s_2}^2 - S_{s_3}^2)S - (S_1S_2S_3 + 2S_{s_1}S_{s_2}S_{s_3} - S_1S_{s_1}^2 - S_2S_{s_2}^2 - S_3S_{s_3}^2) = 0$$

$S_1 = \sigma_B$, $S_2 = 0$, $S_3 = 0$

$S_{s1} = 0$, $S_{s2} = \tau_T$, $S_{s3} = \tau_{AVG}$

$\therefore$

$$S^3 - (S_1)S^2 + (-S_{s2}^2 - S_{s3}^2)S = 0$$

OR $S^2 - S_1 S + (-S_{s2}^2 - S_{s3}^2) = 0$ THIS SIMPLIFIED EQTN IS OF THE FORM $ax^2 + bx + c = 0$

BY: TAR DATE 2-19-74 SUBJECT 30" B.F.V. SHEET NO. OF
CHKD. BY RAW DATE 2/25/74 SEISMIC PLUS OPERATING STRESS JOB NO.

THE SOLUTION OF THIS QUADRATIC IS

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

$a = 1, \quad b = \sigma_8, \quad c = (-S_{s_2}^2 - S_{s_3}^2)$ WHERE

$\therefore c = -83051273$ $\quad S_{s_2} = \tau_T = 9068$ psi

$S_{s_3} = \tau_{avg} = 907$ psi

$$\sigma = \frac{-(11988) \pm \sqrt{(11983)^2 - 4(1)(-83051273)}}{2(1)}$$

$$\sigma = -\frac{(11988) \pm (21819)}{2(1)}$$

$$= +\frac{9831}{2}, \quad = -\frac{33807}{2}$$

$\sigma = +4916$

$= -16903$

$= 0$

MAX. STRESS INTENSITY = 20724 psi

21818 psi < (1.2)(1.5)(S_m) = 27180 psi
(SA-479, 304 @ 340° F)

BY. JMG DATE SUBJECT
CHKD. BY. Pittal DATE 2/22/78 SEISMIC PLUS OPERATING STRESS JOB NO.

THE DISC ITSELF UNDERGOES BENDING DUE TO THE COMBINED EFFECT OF SEISMIC & OPERATING LOADS.

THE DISC IS ASSUMED TO BE SIMPLY SUPPORTED @ IT'S EDGES & CARRYING A UNIFORM LOAD ACROSS ITS FACE.

FROM REF 5 PG 216 CASE 1.

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.57

STRESSES ARE MAX @ CENTER:

MAX Sr (RADIAL STRESS) = MAX St (TANGENTIAL STRESS)

$$= \frac{3W}{8\pi m t^2}(3m+1)$$

WHERE $m = \frac{1}{.3} = 3.33$

t = DISC THICKNESS = 1.625 IN.

$W = 4.24\,(W_{DISC} + W_{SHAFTS}) + P\pi a^2$; $P = 45$ psi

DISC RADIUS = a = 14.27 IN.
(SEALED) SEE 82044 MACHINING DWNG A-900502

W = 30432 lbs.

$$S_r = S_t = \frac{(3)(30432)}{8\pi(3.33)(1.625)^2}\left[(3)(3.33)+1\right]$$

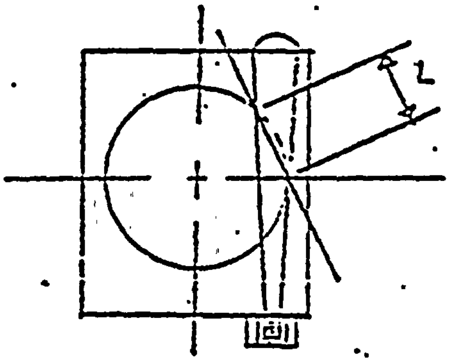
S_{r-0} = STRESS INTENSITY = 4540 psi < S_m = 15000 psi
(SA-516, GR 60 @ 340°F)

NUCLEAR

TAPER PINS

FOR ALL INTENSIVE PURPOSES THE TAPER PINS ONLY CARRY THE VALVE SEATING TORQUE IN SHEAR.

∴ IN SHEAR, 50% OF THE TOTAL TORQUE IS ASSUMED CARRIED BY THE FIRST PIN.

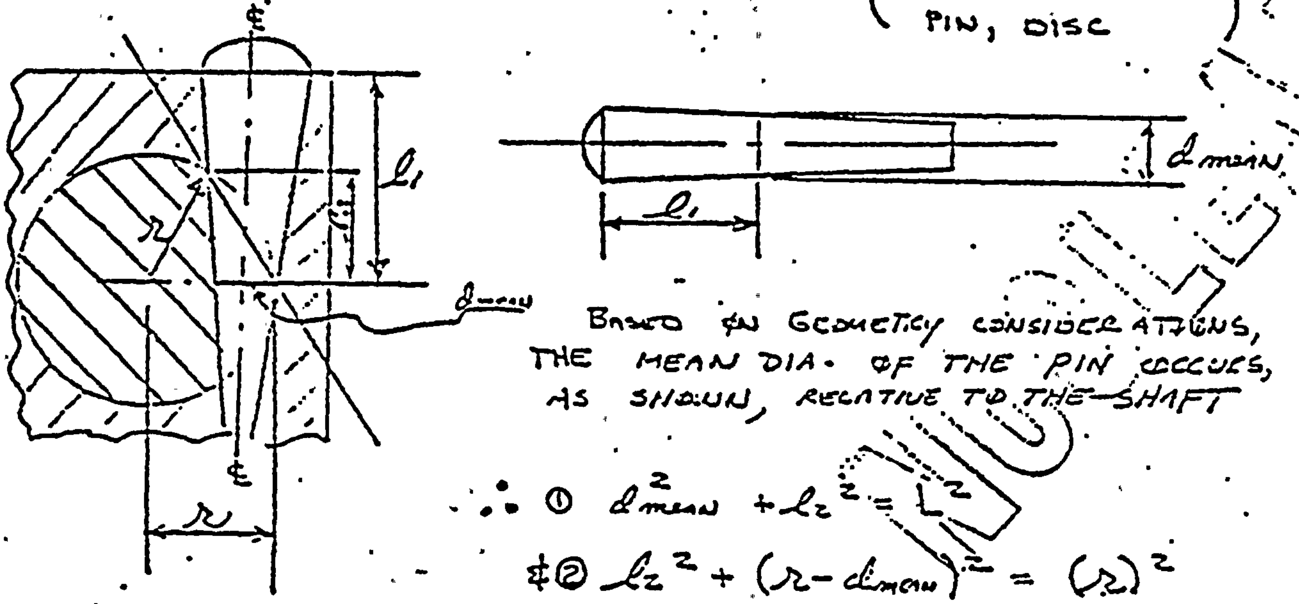


TAPER PIN, SHAFT & HUB

IN SHEAR, THE SHAFT TENDS TO ROTATE THROUGH THE PIN ALONG A PATH WHICH IS DEFINED BY "L".

THE TAPER PIN IS DEFINED BY A RT. CIRCULAR PIN OF AVERAGE DIA.

d_{mean} = TAPER PIN MEAN DIA. = .655 IN. (DWNG B-900516 PIN, DISC)

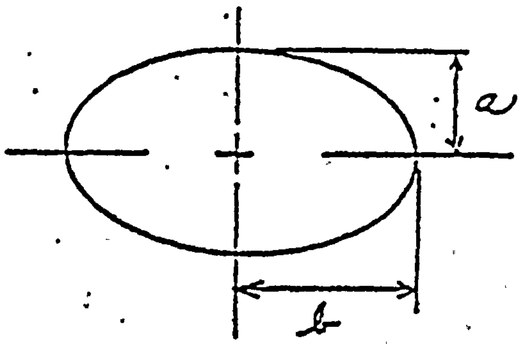


BASED ON GEOMETRY CONSIDERATIONS, THE MEAN DIA. OF THE PIN OCCURS, AS SHOWN, RELATIVE TO THE SHAFT

$$\therefore \text{①} \quad d_{mean}^2 + l_2^2 = L^2$$

$$\text{\& ②} \quad l_2^2 + (r - d_{mean})^2 = (r)^2$$

CHKD. BY BAL DATE 2/27/79 SEISMIC PLUS OPERATING STRESS JOB NO.



AREA OF ELLIPSE IS :

$A_s = \pi a b$ REF 4: Pg 399

WHERE $a = \frac{d_{mean}}{2}$

$b = \frac{L}{2}$

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.59

$\therefore$ ③ $A_s = \pi \frac{d_{mean}}{2} \frac{L}{2}$

COMBINING EQUATIONS ① + ③ :

$L = \sqrt{(2r)(d_{mean})} = \sqrt{(D_{SHAFT})(d_{mean})}$

SUBSTITUTING INTO EQTN. ③ :
(REF BIF)

$A_s = (2)\pi \frac{d_{mean}}{4} \sqrt{(D_s)(d_m)}$ = SHEAR AREA CARRYING 50% OF TOTAL TORQUE

$A_s = 1.317 \ in^2$

THE SHEAR LOAD IS → $V = \left(\frac{TORQUE}{D_s/2}\right)(.5) = 11122$ lbs

$\tau_{max} = \frac{4}{3}\frac{V}{A_s} = \frac{4}{3}\frac{(11122)}{(1.317)}$

$\tau_{MAX} = 11265$ psi < .8 S_m = 12000 psi
53 (SA-276 304 @ 340°F)

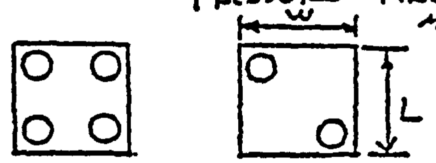
NUCLEAR

THRUST BEARING COVER & STUFFING BOX GLAND FOLLOWER HARDWARE

THIS ANALYSIS IS PERFORMED CONSIDERING THE THE VALVE PRESSURE EFFECT ON THRUST BEARING COVER AND STUFFING BOX HARDWARE.

THE MAX. PRESSURE AREA FOR EITHER COVER IS DETERMINED & THE RESULTING PRESSURE FORCE IS APPLIED TO (2) BOLTS OF THE SMALLEST TENSILE AREA OF EITHER STUFFING BOX OR THRUST BEARING HARDWARE.

$$\text{PRESSURE AREA}_{MAX} = (L)(W) = (5)^2 = 25 \text{ IN}^2$$



THRUST COVER   GLAND FOLLOWER

MINIMUM BOLT SIZE = $\frac{1}{2}$-13 UNC ;

$\therefore A_{TENSILE} = .1419 \text{ IN}^2$ (REF 8)

$$\text{TENSILE STRESS} = \sigma_T = \frac{(A_{PRESSURE})(P)}{(2)(A_T)} \quad P = 45 \text{ PSI}$$

$$\sigma_T = 3964 \text{ PSI} < S_m = 25000 \text{ PSI}$$

SECTION 6.6

VALVE SIZING AND STRESS ANALYSIS CONSIDERING COMBINED OPERATING AND SEISMIC CONDITIONS

PRESENTLY, FOR AIR PURGE VALVES OF BUTTERFLY DESIGN, IN SIZES IN EXCESS OF 24 INCHES, THE A.S.M.E WORKING GROUP ON VALVES HAS NOT DEFINED* THE MANNER IN WHICH THESE VALVES WILL BE DESIGNED.

TO THIS END BASIC SHELL THICKNESS IS DETERMINED USING PARAGRAPH NB-3324 OF REF. 3.

IN ADDITION TO BASIC SIZING, THE EFFECTS OF OPERATING CONDITIONS, SEISMIC ACCELERATION, AND PIPE LOAD INFLUENCE ARE EXAMINED IN THIS SECTION.

$t = \frac{PR}{S_m - .5P}$; $P = 45$ psi

$R = 15$ IN.

$\therefore$ t ≡ THICKNESS $S_m = 15000$ psi (SA-516, GR.60 @ 340 °F)

$\therefore t = .045$ IN. (ABSOLUTE MINIMUM/PRESSURE ONLY)

CORROSION ALLOWANCE = .0625 IN.

t + CORROSION ALLOWANCE = .1076 IN. $< t_{ACTUAL} = .500$ IN.

* BY "DEFINED" IS MEANT THAT NO APPROVED DOCUMENT EXISTS, SUCH AS ANSI-B16.5, FOR LARGE VALVES SUCH THAT VALVES OF LOW OPERATING PRESSURE CAN BE SIZED WITHOUT THE RESULT OF EXCESSIVE SHELL THICKNESS BEING REQUIRED.

CHKD. BY [illegible] DATE 7/22/[illegible] JOB NO. [illegible]

$$\vec{F_Y} + \vec{F_Z} = \sqrt{(75\,\Xi)^2 + (75\,\Xi)^2}$$

$$= F_{SHEAR} = 106.1\,\Xi\ \text{lb} \qquad = F_S$$

$$\vec{M_Y} + \vec{M_Z} = \sqrt{(750\,\Xi)^2 + (750\,\Xi)^2}$$

$$= M_{BENDING} = 1060.72\,\Xi\ \text{ft-lb} \quad = M_B$$

$F_X = F_{TENSION/COMPRESSION}$

$$F_{T/C} = 75\,\Xi\ \text{lb} \qquad = F_{T/C}$$

$M_X = M_{TORSION}$

$$M_{TORSION} = 750\,\Xi\ \text{ft-lb} \qquad = M_T$$

AS ALL VALUES ARE SHORT IN LENGTH RELATIVE TO THEIR DIAMETER IT IS ASSUMED THAT MOMENTS AND FORCES ARE CONSTANT ALONG THE VALVE BODY LENGTH.

FOR THE VALVE BODY, $I = \frac{\pi}{64}\left[D_o^4 - D_i^4\right]$

$$C = \frac{D_o}{2}$$

LOAD DETERMINATION

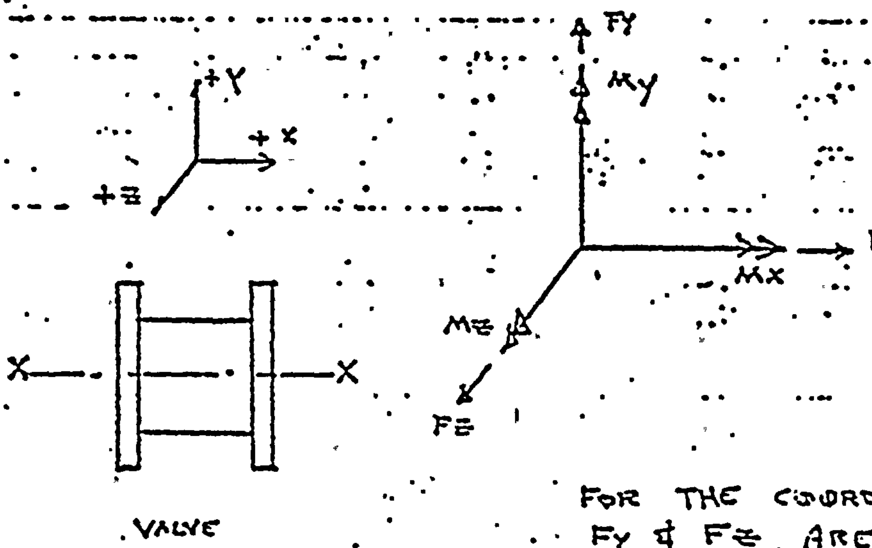
FROM THE APPLICABLE SPECIFICATION (REF 1), PIPE LOADS, AS APPLIED TO THE BUTTERFLY VALVE, ARE DETERMINED AS FOLLOWS:

FROM PG 15A-5, REF 1

TYPE LOAD	VALUE
BENDING MOMENT	750 Z ft-lb.
TORSIONAL MOMENT	750 Z ft-lb.
FORCE	75 Z lb

WHERE Z = SECTION MODULUS (IN^3)

AS ALL MOMENTS AND FORCES ARE APPLIED SIMULTANEOUSLY IN EACH OF (3) ORTHOGONAL DIRECTIONS, LOADING APPEARS AS SHOWN:



NOTE: LOADS ARE APPLIED AT VALVE FLANGES.

FOR THE COORDINATE SYSTEM SHOWN, FY & FZ ARE SHEARING LOADS ON THE VALVE BODY & MAY BE COMBINED

FOR THE COORDINATE SYSTEM SHOWN MY & MZ ARE ALSO COMBINED

OVER →

VALVE SIZE	D_o IN.	D_i IN.	$I = \frac{\pi}{64}(D_o^4 - D_i^4)$ IN.^{4}	$C = D_o/2$ IN.	$Z = I/C$ IN.^{3}	$F_{T/L} = 75Z$ LB.	$F_S = 106.1Z$ LB.	$M_B = 1060.7Z$ FT.-LB.	$M_T = 750Z$ FT.-LB.
24"	25.	24.	2,887.	12.5	231.1	17,332.	24,520.	245,127.	173,324.
30"	31.	30.	5,572.	15.5	357.5	26,763.	38,144.	381,335.	267,634.

59

BY DKG DATE 1-25-79
CHKD. BY [illegible] DATE 2/12/79
SUBJECT PIPE LOAD EFFECT 30" B.F.V.
SHEET NO. 6.6.5 OF
JOB NO.

NUCLEAR

CYGNA
ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.65

BY TMR DATE 1/23/74 SUBJECT Pipe Load Effect SHEET NO 66 OF
CHKD. BY ? DATE ? 30" B.F.V. JOB NO.

30"

$$\sigma_{T/C} = \frac{F_{T/C}}{A} \quad \text{WHERE } A = \frac{\pi}{4}\left(D_o^2 - D_i^2\right)$$

$$= \frac{26,963}{\frac{\pi}{4}(31^2 - 30^2)}$$

$$= 563.\ psi$$

$$\tau_s = \frac{4}{3}\frac{V}{A}\left[1 + \frac{D_o D_i}{D_o^2 + D_i^2}\right]$$

$$= \frac{4}{3}\left(\frac{38,144}{\frac{\pi}{4}(31^2 - 30^2)}\right)\left[1 + \frac{31(30)}{31^2 + 30^2}\right]$$

$$= 1,592.\ psi$$

$$\sigma_B = \frac{Mc}{I}$$

$$= \frac{381,335\ (15.5)(12)}{5,572}$$

$$= 12732.\ psi$$

$$\tau_T = \frac{T_c}{J}$$

$$= \frac{269,634\ (15.5)(12)}{5,572\ (2)}$$

$$= 4500\ psi$$

BY JMF DATE 2-21-79 SUBJECT 30" C.F.V. SHEET NO. 6.67 OF

CHKD. BY [illegible] DATE 2/22/79 — VALVE BODY / COMBINED STRESS — JOB NO.

THE VALVE BODY IS TREATED AS A THIN WALLED CYLINDER

PRESSURE STRESSES :

HOOP STRESS = $\frac{PR}{t}$; LONGITUDINAL STRESS = $\frac{PR}{2t}$

TRANSVERSE STRESS = $\frac{-P}{2}$

P = 45 psi

R = 15.25 IN.

t = .5 IN.

CYGNA ATTACHMENT

JOB NO. 82044

FILE NO. 05.01.F

SHEET NO. 7.4.67

∴ Hoop Stress, σ_H = 1373 psi

LONG. STRESS, σ_L = 686 psi

TRANS. STRESS σ_T = 23 psi

IN ADDITION TO PRESSURE STRESSES, PIPE LOAD STRESSES AS CALCULATED ON THE PRECEEDING PAGE EXIST AS WELL AS A SEISMIC SHEAR STRESS (THE VALVE BEHAVES AS A RING IN SEISMIC "DEAD" WEIGHT)

NUCLEAR

BY TAR DATE 2-21-74 SUBJECT 30" B.F.V. SHEET NO 6.6.8 OF
CHKD. BY RCL DATE 2/22/79 — VALVE BODY / COMBINED STRESS — JOB NO.

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.68

FROM PG 60, THE STRESSES DUE TO PIPE LOADS ARE:

$\sigma_{T/C}$ = 563 psi

σ_B = 12732 psi

τ_S = 1592 psi

τ_T = 4500 psi

THE SEISMIC SHEAR STRESS IS:

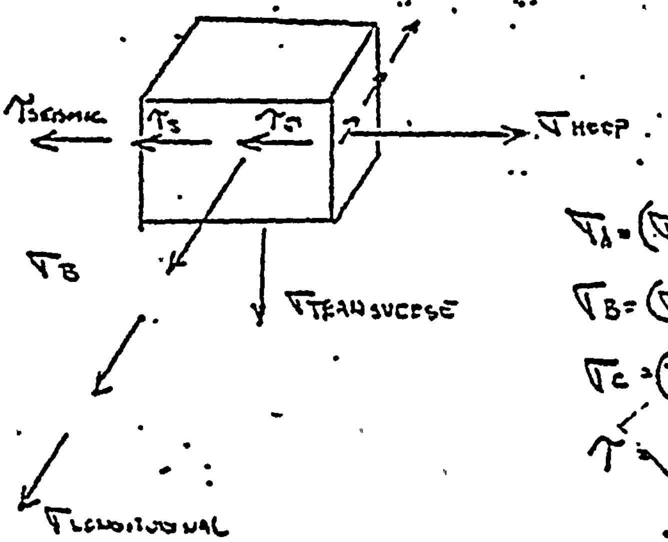
$(4.24)(W_{assy})/A_S$ WHERE W_{assy} = 2122 lbs (REF BIF)

$A_S = \dfrac{\pi(D_o^2 - D_i^2)}{4}$, D_o = 31 IN, D_i = 30 IN.

$\therefore A_S$ = 47.9 IN^2

$\tau_{\text{seismic shear}}$ = 188 psi

CONSERVATIVELY COMBINING PRESSURE, PIPE AND SEISMIC STRESSES:



$\sigma_A = (\sigma_L + \sigma_{T/C} + \sigma_B)$ = 13981 psi

$\sigma_B = (\sigma_H)$ = 1373 psi

$\sigma_C = (\sigma_T)$ = 23 psi

$\tau = (\tau_{seismic} + \tau_S + \tau_T)$ = 6280 psi

(CIRCUMFERENTIAL) 62

BY. TME DATE 2-21-74 SUBJECT 30" B.F.V. SHEET NO. 669 OF

CHKD. BY. [illegible] DATE 2/22/79 —VALVE BODY / COMBINED STRESS— JOB NO.

$$\sigma_{\frac{1}{2}} = \frac{\sigma_A + \sigma_B}{2} \pm \sqrt{\left(\frac{\sigma_A - \sigma_B}{2}\right)^2 + \tau^2}$$

$\sigma_3 = \sigma_C = \sigma_{\text{TRANSVERSE}} =$ 23 psi

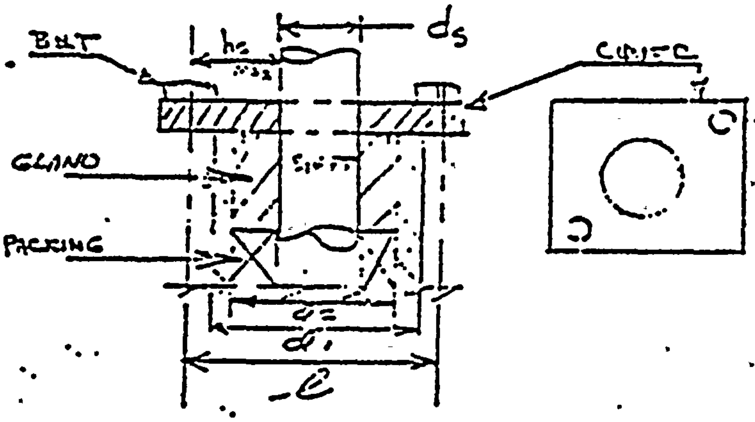
$\sigma_{\frac{1}{2}} = 7677 \pm (\ 8898\ )$; $\sigma_1 = 16575$ psi

$\sigma_2 = -1221$ psi

STRESS INTENSITY = 17796 psi $< (1.2) S_{\text{ALLOWABLE}} =$ 18000 psi
(SA-516, GR 60 @ 340°F)

BY: JMW DATE: 3/1/74 SUBJECT: ______ SHEET NO. ____ OF ____
CHKD. BY: TMP DATE: 3/1/74 JOB NO. ______

GLAND FOLLOWER COVER



(FOLLOWER IS SQUARE)

THE PACKING IS CRANE TYPE 187-I (FIBRE) AND THE COVER ARRANGEMENT IS CONSERVATIVELY MODELED AS CASE (k) OF FIG. UG-34 SECTION VIII DIV. 1.

t = COVER (GLAND FOLLOWER) THICKNESS

$$t = d\sqrt{\frac{Z\,C\,P}{S} + \frac{6\,W\,h_G}{S\,L\,d^2}}$$

REFER TO TABLE UA-49.1 SECTION VIII, DIV. 1

FOR THE GLAND FOLLOWER:

$d \cong d_2 = 3.06$ IN, $Z = 2.5_{max}$; $C = 0.3$; $S = S_m = 15000$ PSI (SA-240, 304 @ 340°F)

$h_G = 1.125$ IN, $P = 45$ PSI; $L = 4D = 13.44$ IN

W EQUALS THE LARGER OF EQTNS 3, 4; PG 220, SEC. VIII, DIV. 1.

EQ. 3: $W_{m1} = .785\,G^2 P + (2b\,\pi\,G\,m\,P)$

$G \simeq d_2 = 3.06$ IN.

$b = \frac{W}{8}$ & $W = \frac{d_2 - d_s}{2} = 0.28$ IN. $\therefore b_o \le 1/4$ IN

$\therefore b = b_o = 0.035$ IN. $m = 1.75$

$\therefore W_{m1} = 384$ lbf

CHKD. BY TJL DATE 3/1/74 JOB NO.

$$W = \frac{(A_m + A_b)\, S_a}{2}$$

$A_{m_1} = \frac{W_{m_1}}{S_b} = 0.0295\ in^2$

$A_b = 0.284\ in^2$

$A_{m_2} = \frac{W_{m_2}}{S_a} = 0.0247\ in^2$

$S_b = 13000$ psi (SA-193 @ 390°F)

$S_a = 15000$ psi (SA-193 @ 70°F)

$W_{m_2} = \pi b G y$ where $y = 1100$ psi (Pg 215 Sec. VIII, Div. 1)

$\doteq 370$

$\therefore\ W = 2351$ lbf

$\therefore\ W_{max} = 2351$ lbs

$$\therefore\ t = (3.06)\sqrt{\frac{(2.5)(0.3)(45)}{(15000)} + \frac{(6)(2351)(1.125)}{(15000)(13.49)(3.06)^2}}$$

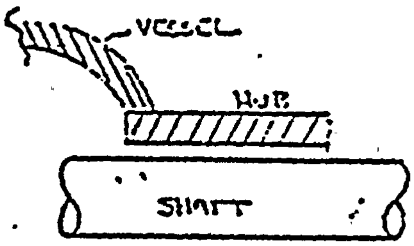
$t_{required} = 0.316$ in $< t_{actual} = 0.63$ in.

BY JMR DATE 3/5/79 SUBJECT SU ...

CHKD. BY MWC DATE 3/6/79

JOB NO.

HUB REINFORCEMENT



FROM SEC VIII, DIV 1 WITH APPLICABLE PAGES DESCRIBED:

t_r = REQD NOZZLE THICKNESS = $\frac{PR}{SE - .6P}$; P = 45 psi; R = (15 + .0625); S = 15000 psi; E = 1 (PG 11)

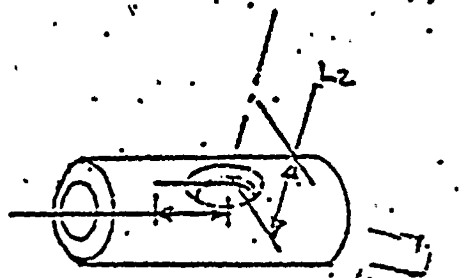
∴ t_r = .045 IN.

REQUIRED CROSS-SECTIONAL AREA OF REINFORCEMENT, VESSEL:

A = (d)(t_r)(F); d = (3.7507 + .125); F = 1 (PG 27)

∴ A = .174 IN^2.

LIMITS OF REINFORCEMENT:



L_1 = d = 3.876 IN. (PG 29) (LONGITUDINAL)

L_2 = 2.5 (.5 − .0625) = 1.094 IN. < HUB HEIGHT (RADIAL)

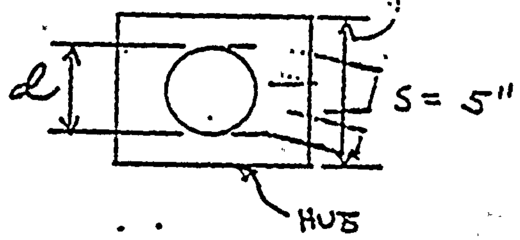
ALSO 2d = 7.75" > $\sqrt{2 \cdot 25}$ = 7.07"

AVAILABLE METAL/VESSEL WALL:

A_1 = (E_1 t − F t_r) d; E_1 = 1, t = (.5 − .0625); F = 1, (PG 29)

A_1 = 1.52 IN^2 > A = .174 IN^2 ∴ VESSEL O.K.

AS A_1 > A THERE IS SUFFICIENT REINFORCING

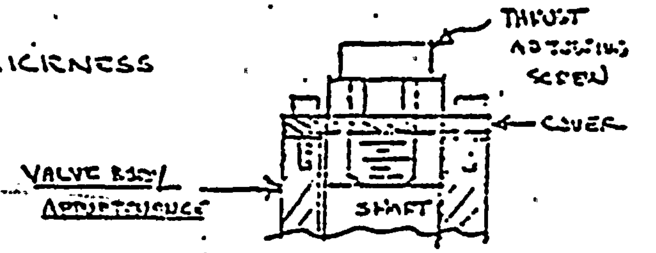


THRUST BEARING COVER

DUE TO THE MANNER IN WHICH THE THRUST BEARING COVER IS SECURED TO THE VALVE BODY IT IS CONSIDERED TO BE SIMILAR IN MOUNTING TO CASE (P), FIG UG-34 SECTION VIII, DIV. 1

t = THRUST BEARING COVER THICKNESS

$t = d\sqrt{\dfrac{ZCP}{S}}$



$d = 3.36$ IN, $Z = 2.5_{MAX.}$; $C = 0.25$;

$S = S_m = 15000$ psi; $P = P_{EQUIVALENT} = f$ (PRESSURE & SEISMIC LOAD)
(SA-240, 304 @ 340 °F)

$P = 45 \text{ psi} + \dfrac{4.24 \text{ (DISC + SHAFT WEIGHT)}}{\frac{\pi D_e^2}{4}}$

WHERE D_e EQUALS AN EQUIVALENT DIA. (INSCRIBED CIRCLE WHOSE DIAMETER IS CONSERVATIVELY CHOSEN AS THE SAME DIAMETER AS THE SHAFT)

DISC + SHAFT WT = 384.0 lbf

$D_e = 2.4995$ IN.

∴ P = 377 psi

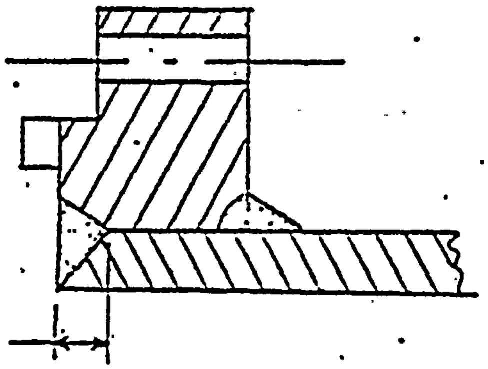
& $t_{REQUIRED} = 0.42$ IN. < $t_{ACTUAL\,(MINIMUM)} \cong 0.6$ IN.
(including counter-sink effect & SPOTFACE OF 1/32" ASSUMED)

BY: TMR DATE: ______ SUBJECT: 30" BFV — FLANGE ANALYSIS — SHEET NO. ____ OF ____
CHKD. BY: JCM DATE: 3/5/74 JOB NO. ______

FROM SEC. VIII DIV. 1 :

PG 214

OPTIONAL FLANGE (8b) IS COMPARABLE TO 30" FLANGE TYPE.



AS ALLOWED BY PARAGRAPH UA-48 (3) & FIG. UA-48 THE FOLLOWING ANALYSIS IS BASED ON TREATING THE FLANGE AS A LOOSE TYPE FLANGE.

ASSUMPTIONS USED IN DESIGN:

THE GASKET SIZE IS ASSUMED TO BE 3/4" WIDE.

PER DISCUSSION WITH BIF, FLANGE BOLTS ARE ASSUMED TO BE SA-307 ; FLANGE GASKET IS ASSUMED TO BE 1/16" THICK ASBESTOS. THE MATING FLANGE IS ASSUMED SIMILAR IN GEOMETRY.

EQ (1), PG 219:

$$W_{m1} = H + H_p = 0.785\, G^2 P + (2b\pi G m P)$$

$P = 45$ psi , $m = 2.75$ (PG 215, TABLE UA-49.1)

$$b_o = \frac{.75''}{2} = .375'' \quad \therefore \quad b = \frac{\sqrt{b_o}}{2} = .306''$$

G = FLANGE FACE DIA. − 2b

$$G = (33.75) - (2)(.306) = 33.14''$$

$\therefore W_{m1} =$ 46681 lbs. = REQD. BOLT LOAD, OPERATING CONDITIONS

BY TMR DATE ______ SUBJECT 30" B.F.V. SHEET NO. ____ OF ____
CHKD. BY JCM DATE 3/5/74 JOB NO. ______

FROM EQTN (2), PG 220:

$W_{m2} = \pi b G y$ WHERE "y" = 3700 (PG 215, TABLE UA-49.1) AND "b" & "G" HAVE BEEN DEFINED

$\therefore W_{m2} = 117876$ lbf ≡ MINIMUM INITIAL BOLT LOAD

$A_{m1} = \frac{W_{m1}}{S_b}$ WHERE S_b = 7000 psi (SA-307 @ 340°F)

$\therefore A_{m1} = 6.67$ IN²

$A_{m2} = \frac{W_{m2}}{S_a}$ WHERE S_a = 7000 psi (SA-307, @ 70°F)

$\therefore A_{m2} = 16.84$ IN²

} UA-49 (3)(C)

FOR OPERATING CONDITIONS:

$W = W_{m2}$ (AS $W_{m2} > W_{m1}$ — PARAGRAPH UA-49-(b)(2))

FLANGE MOMENTS (OPERATING) = $M_D + M_T + M_G = M_o$

$M_D = H_D h_D = (.785 B^2 P)\left(\frac{C-B}{2}\right)$ (FIG UA-43(2))

B = 31."; C = 36";
P = 45 psi

$\therefore M_D = 84868$ IN-lbf

$M_T = H_T h_T$; $H_T = (H - H_D) = (.785 P)(G^2 - B^2)$

h_T (FIG UA-48 (5b)) $= \frac{h_D + h_G}{2} = \frac{(2.5) + (1.43)}{2} = 1.965$

WHERE 33.75" = O.D OF RAISED FACE ; C = 36" ; B = 31"

.75" = GASKET WIDTH ; G = 33.14"

$\therefore M_T = 9527$ IN-lbf

$M_G = H_G h_G$; $H_G = W - H = (117876) - (.785 G^2 P)$

$h_G = \frac{C - G}{2}$

$\therefore M_G = 113084$ IN-lbf

$\therefore M_\phi = M_D + M_T + M_G = 207479$ IN-lbf

FOR OPERATING CONDITIONS THE TANGENTIAL STRESS FOR A LOOSE TYPE RING FLANGE IS :

$S_T = \frac{Y M_\phi}{t^2 B}$; Y IS A FUNCTION OF A/B WHERE

$A = 33.75"$; $B = 31"$

$A/B = 1.25$; $\therefore Y = 9$ (FIG UA-51.1)

$t = 2.06"$

$\therefore S_T = 14195$ psi $<$ $S_{\bar{s}} = 15000$ psi (SA-516, GR 60 @ 340°F)

FOR GASKET SEATING :

$$W = \left(\frac{A_m + A_b}{2}\right) S_a \quad \text{WHERE } S_a = 7000 \text{ psi} \quad \begin{pmatrix}\text{SA-307} \\ @ \ 70°F\end{pmatrix} \quad \begin{pmatrix}\text{EQN 4} \\ \text{PG 220}\end{pmatrix}$$

$$A_b = \frac{\pi D_{MIN}^2}{4} \quad (28 \text{ BOLTS})$$

D_{MIN} FOR 1¼" UNC BOLTS IS 1.0747" REF 8.

$A_b = 25.4 \text{ IN}^2$, $A_m = A_{m2} = 16.84 \text{ IN}^2$

$\therefore W = 147840$ lbf

$$M_\phi = W\left(\frac{C - G}{2}\right) \quad \begin{pmatrix}\text{EQTN (5)} \\ \text{PG 220}\end{pmatrix}$$

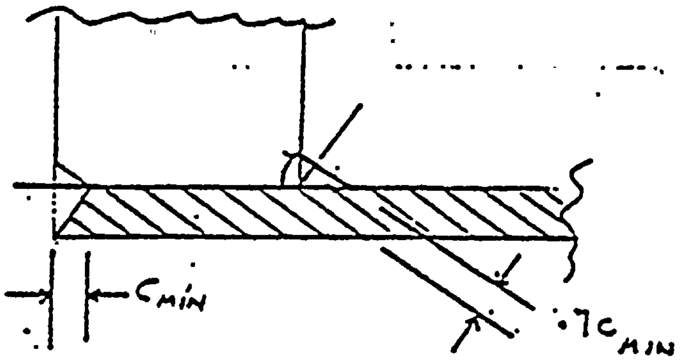
$\therefore M_\phi = 211411$ in-lbf

$$S_T = \frac{Y M_\phi}{t^2 B} = \frac{(9)(211411)}{(2.06)^2 (31)} = 14464 \text{ psi}$$

$14464 \text{ psi} < S_f = 15000 \text{ psi}$

ALSO $\frac{14464}{2} = 7232 < S_f = 15000$ psi

WELD SHEAR STRESS



* THIS ANALYSIS IS BASED ON ABSOLUTE MINIMUM SHEAR AREA AS OPPOSED TO REAL SHEAR AREA WHICH IS LARGER THAN $A_{SHEAR\ MIN.\ TOTAL}$

$C_{MIN} = t_n$ WHERE $t_n = 1/4''$ (FROM "t_x" CONSIDERATION)

CALCULATING A MINIMUM WELD SHEAR AREA:

$$A_{SHEAR\ MIN.\ TOTAL} = \pi B\, C_{MIN} + \pi B\, (.7\, C_{MIN})$$

$$B = 31''$$

$$\therefore A_{S\ MIN.\ TOTAL} = 41.4\ in^2$$

TOTAL SHEAR LOAD EQUAL GREATER OF H_p OR W_{m2}

$$H_p < W_{m2} = 117876\ lbs \equiv V \quad \text{(CONSECUTIVE)}$$

$$\therefore \tau = \frac{V}{A_s} = 2848\ psi < .8\,S_m = 12000\ psi$$

(SA-516, GR 60 @ 340°F)

CYGNA ATTACHMENT
JOB NO. 82044
FILE NO. 05.01.F
SHEET NO. 7.4.78