Florida Power
CORPORATION

INTEROFFICE CORRESPONDENCE

Office	MAC	Telephone
Nuclear Engineering Design (NED)	NA1E	3582

SUBJECT: Crystal River Unit 3
Quality Document Transmittal - Analysis/Calculation

TO: Records Management - NR2A

The following analysis/calculation package is submitted as the QA Record copy:

DOCNO (FPC DOCUMENT IDENTIFICATION NUMBER)	REV	SYSTEM(S)	TOTAL PAGES TRANSMITTED
S96-0130	0	MS	21

TITLE

Qualification of Pipe Supports MSH-13B and MSH-27B

KWDS (IDENTIFY KEYWORDS FOR LATER RETRIEVAL)

Hangers, Pipe Supports

DXREF (REFERENCES OR FILES - LIST PRIMARY FILE FIRST)

Problem Report 96-0180

M75-0012

M75-0013

VEND (VENDOR NAME)	VENDOR DOCUMENT NUMBER (DXREF)	SUPERSEDED DOCUMENTS (DXREF)
n/a	n/a	n/a

TAG

	MSH-13B	
	MSH-27B	

PART NO

COMMENTS (USAGE RESTRICTIONS, PROPRIETARY, ETC.)

NOTE:
Use Tag number only for valid tag numbers (i.e., RCV-8, SWV-34, DCH-99), otherwise; use Part number field (i.e., CSC14599, AC1459). If more space is required, write "See Attachment" and list on separate sheet.

DESIGN ENGINEER	DATE	VERIFICATION ENGINEER	DATE	SUPERVISOR, NUCLEAR ENG.	DATE
[signature]	8/1/96	[signature]	8/1/96	[signature]	8/1/96

cc: MAR Office (If MAR Related) ☐ Yes ☒ No
Mgr. Nucl. Config. Mgt.
Mgr., Nucl. Eng. Design
(Original) w/attach

Plant Document Updates Required ☐ Yes ☒ No (If Yes, send copy of the Calculation Review form to Nuclear Licensing and a copy of the Calculation to the Responsible Organization(s) identified in Part III on the Calculation Review form.)

A/E ______________ ☐ Yes ☒ No
(If yes, Transmit w/attach)

RET: Life of Plant RESP: Nuclear Engineering

Florida Power Corporation

ANALYSIS/CALCULATION SUMMARY

DOCUMENT IDENTIFICATION NUMBER	DISCIPLINE	CONTROL NO	REVISION LEVEL
	S	96-0130	0

TITLE

Qualification of Pipe Supports MSH-13B and MSH-27B

CLASSIFICATION (CHECK ONE)

- [x] Safety Related
- [ ] Non Safety Related

MAR/SP/CGWR/PEERE NUMBER: n/a

VENDOR DOCUMENT NUMBER: n/a

	REVISION APPROVALS	ITEMS REVISED
Design Engineer	C. Glenn Pugh (signature)	Original Issue
Date	8/1/96	
Verification Engineer	D. Backwood (signature)	
Date/Method*	8/1/96 R	
Supervisor	(signature)	
Date	8/1/96	

***VERIFICATION METHODS:** R - Design Review; A - Alternate Calculation; T - Qualification Testing

DESCRIBE BELOW IF METHOD OF VERIFICATION WAS OTHER THAN DESIGN REVIEW

PURPOSE SUMMARY

The purpose of this calculation is to provide detailed qualification calculations for pipe supports MSH-13B and MSH-27B.

RESULTS SUMMARY

Pipe supports are qualified to the piping analysis loads.

SECTION I PURPOSE:

The purpose of this calculation is to provide technical qualification of two Main Steam Pipe Supports MSH-13B and MSH-27B. This specific calculation is to supplement calculations sent to FPC by Parsons Power Group, Inc.. A copy of these calculations is included as Attachment 5 for reference.

SECTION II DESIGN INPUTS:

This calculation uses the following items as design inputs. The design loads are taken from the "Analysis of Record" for the appropriate piping system.

MSH-13B:

This hanger is located on Drawing 305-753 (Reference 1). It is part of analysis CR-6. This analysis is filed under FPC Calculation Number M75-0013 (Reference 3). The pipe support load summary sheets for this hanger list the following loads:

Deadweight:	-7208 lbs.
Thermal:	-2323 lbs.
Seismic:	+/- 6796 lbs.

MSH-27B:

This hanger is located on Drawing 305-752 (Reference 2). It is part of analysis CR-5. This analysis is filed under FPC Calculation Number M75-0012 (Reference 4). The pipe support load summary sheets for this hanger list the following loads:

Deadweight:	-6070 lbs.
Thermal:	-2597 lbs.
Seismic:	+/- 9892 lbs.

SECTION III ASSUMPTIONS:

Any assumptions used in this calculation will be stated in the body of the calculation. Any assumptions made will not require further action.

SECTION IV REFERENCES:

1. Drawing 305-753, Revision 1

2. Drawing 305-752, Revision 2

3. Analysis Calculation M75-0013, Revision 0

4. Analysis Calculation M75-0012, Revision 0

5. Pipe Support Drawing for MSH-13B, Revision 1

6. Pipe Support Drawing for MSH-27B, Revision 1

7. "Pipe Hangers and Supports," by Power Piping Company, Catalog 90.

8. "Manual of Steel Construction," by American Institute of Steel Construction, Seventh Edition

9. Drawing 521-212, Revision 11

10. DCN 96-217

11. "Load Capacity Data Sheets for Component Standard Supports," by Power Piping Company.

SECTION V DETAILED CALCULATIONS:

Section V.1 Design Loads:

From Section II, use the following for analysis loads:

MSH-13B:
Deadweight: -7208 lbs.
Thermal: -2323 lbs.
Seismic: +/- 6796 lbs.

Or, use 7208 + 2323 + 6796 = 16327 lbs. acting downward (applying tension load to rods). In an seismic event, the vertical seismic uplift (6796 lbs.) will not exceed the dead load on the pipe. Therefore, no uplift considerations for this hanger.

MSH-27B:
Deadweight: -6070 lbs.
Thermal: -2597 lbs.
Seismic: +/- 9892 lbs.

Or, use 6070 + 2597 + 9892 = 18559 lbs. acting downward (applying tension load to rods). In an seismic event, the vertical seismic uplift (9892 lbs.) will exceed the dead loads on the pipe by 9892 - 6070 = 3822 lbs. Therefore, this rod must be designed for uplift considerations.

For the design verification of these supports, use 19000 lbs (Faulted) as a tension load. Use 4000 lbs. (Faulted) as a compression load.

SECTION V DETAILED CALCULATIONS (Continued):

Section V.2 Hanger Component Qualification:

Both hangers have some hanger components in common. This section of the calculation will qualify the Power Piping Components. Allowable loads are taken from Reference 7. The below comparison is conservative since it compares the Normal/Upset allowable loads to the Faulted applied loads.

2" Diameter Rods:

The straight rods and the eye rods are considered to have the same allowable loads. The Power Piping Catalog lists the Normal/Upset allowable load of 20690 pounds > 19000 pounds.

Therefore, acceptable

Hanger Attachment, Figure 203:

The hanger attachment, Figure 203, has a published allowable load of 22000 pounds (using a 2" diameter bolt) > 19000 pounds.

Therefore, acceptable

Clevis

Per the Power Piping Catalog, clevises are designed to develop the full strength of the hanger rod with that used. Therefore, the Normal/Upset allowable load is 20690 pounds > 19000 pounds.

Therefore, acceptable

Turnbuckle:

The hanger drawing refers to a turnbuckle with a 12" opening. This corresponds to a Power Piping Figure 166 for 2" diameter rod. The catalog lists a Normal/Upset allowable loads of 37,200 pounds > 19000 pounds.

Therefore, acceptable

SECTION V DETAILED CALCULATIONS (Continued):

Section V.2 Hanger Component Qualification (Continued):

Pipe Clamp:

Support MSH-13B references a Power Piping Figure 224 pipe clamp. Support MSH-27B references a Power Piping Figure 225 pipe clamp.

The allowable Normal/Upset load for the Figure 224 is 16200 pounds. This is greater than the applied Normal/Upset load. The allowable faulted load is 30450 pounds. This is greater than the faulted load of 16327 for MSH-13B.

The allowable Normal/Upset load for the Figure 225 (MSH-27B) is 20600 pounds > 19000 pounds.

Therefore, acceptable

SECTION V DETAILED CALCULATIONS (Continued):

Section V.3 Weld Qualification:

Both Hanger Drawings reference a Figure 203 beam attachment. Power Piping Catalog shows this to be flat plate, 3/4" thick x 6" long.

Faulted Loads:

$Fx := 19000 \cdot lbf$

$Fy := Fx \cdot \sin(4 \cdot deg)$

$Fy = 1325.373 \cdot lbf$

$Fz := Fx \cdot \sin(4 \cdot deg)$

$Fz = 1325.373 \cdot lbf$

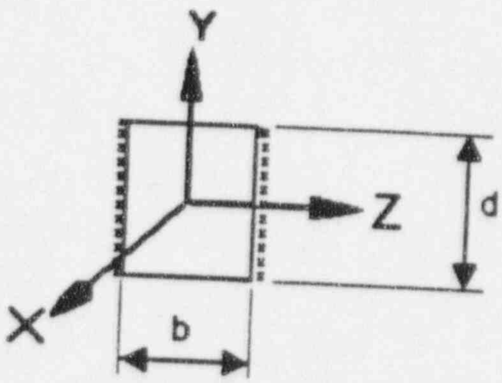
$Mx := 0 \cdot lbf \cdot in$

$My := Fz \cdot 3.5 \cdot in$

$My = 4638.806 \cdot lbf \cdot in$

$Mz := Fy \cdot 3.5 \cdot in$

$Mz = 4638.806 \cdot lbf \cdot in$



Weld Properties:

$d := 6 \cdot in$ $\quad b := .75 \cdot in$

$Aw := d \cdot 2 \cdot 1 \cdot in$ $\quad Aw = 12 \cdot in^2$ $\quad Cy := \frac{b}{2}$

$Sy := d \cdot b \cdot 1 \cdot in$ $\quad Sy = 4.5 \cdot in^3$ $\quad Cz := \frac{d}{2}$

$Sz := \frac{d^2}{3} \cdot 1 \cdot in$ $\quad Sz = 12 \cdot in^3$ $\quad Cy = 0.375 \cdot in$

$Jwx := \frac{d}{6} \cdot \left(3 \cdot b^2 + d^2\right) \cdot 1 \cdot in$ $\quad Jwx = 37.688 \cdot in^4$ $\quad Cz = 3 \cdot in$

General Weld Equation:

$$fw := \sqrt{\left(\frac{Fx}{Aw} + \frac{My}{Sy} + \frac{Mz}{Sz}\right)^2 + \left(\frac{Fy}{Aw} + Mx \cdot \frac{Cy}{Jwx}\right)^2 + \left(\frac{Fz}{Aw} + Mx \cdot \frac{Cz}{Jwx}\right)^2}$$

$$fw = 3004.809 \cdot \frac{lbf}{in^2}$$

SECTION V DETAILED CALCULATIONS (Continued):

Section V.3 Weld Qualification (Continued):

For general A-36 type material and E60 electrodes (assumed for older hangers), the controlling allowable stress will be the shear in the weld material.

$$tw := \frac{fw \cdot (1 \cdot in)}{1.33 \cdot 0.3 \cdot 0.707 \cdot 60000 \cdot psi} \qquad tw = 0.178 \cdot in$$

Weld symbol shown on drawings indicate a partial penetration weld with 1/8" and 1/4" prep shown. Field walkdowns show the attachments to have a fillet weld cap. The existing fillet weld with the assumed partial penetration weld exceeds the "tw" above.

Normal / Upset Loads:

$Fx := 9531 \cdot lbf$

$Fy := Fx \cdot \sin(4 \cdot deg)$

$Fy = 664.849 \cdot lbf$

$Fz := Fx \cdot \sin(4 \cdot deg)$

$Fz = 664.849 \cdot lbf$

$Mx := 0 \cdot lbf \cdot in$

$My := Fz \cdot 3.5 \cdot in$

$My = 2326.971 \cdot lbf \cdot in$

$Mz := Fy \cdot 3.5 \cdot in$

$Mz = 2326.971 \cdot lbf \cdot in$

General Weld Equation:

$$fw := \sqrt{\left(\frac{Fx}{Aw} + \frac{My}{Sy} + \frac{Mz}{Sz}\right)^2 + \left(\frac{Fy}{Aw} + Mx \cdot \frac{Cy}{Jwx}\right)^2 + \left(\frac{Fz}{Aw} + Mx \cdot \frac{Cz}{Jwx}\right)^2}$$

$$fw = 1507.307 \cdot \frac{lbf}{in^2}$$

$$tw := \frac{fw \cdot (1 \cdot in)}{0.30 \cdot 0.707 \cdot 60000 \cdot psi} \qquad tw = 0.118 \cdot in$$

Acceptable by comparison

SECTION V DETAILED CALCULATIONS (Continued):

Section V.4 Uplift (Compression) Check:

To check the support for the compression load, need to find the pin-to-pin length of the rod. The drawing shows a dimension of 10'-0 1/4" from centerline of pipe to bottom of beam. The hanger attachment has a 3.5" dimension from bottom of beam to bolt. From the pipe centerline to the top bolt of the clamp is 21 3/4". Therefore, use a rod length of 10'- 0 1/4" - 3 1/2" - 21 3/4" = 95". (MSH-27B)

Reference 8 gives the properties of the round rod as:

Moment of Inertia: $I = \frac{\pi\cdot(2\cdot in)^4}{64}$ $I = 0.785\cdot in^4$

Cross-sectional Area: $A = \frac{\pi\cdot(2\cdot in)^2}{4}$ $A = 3.142\cdot in^2$

Radius of Gyration: $r = \frac{2\cdot in}{4}$ $r = 0.5\cdot in$

Modulus of Elasticity: $E = 29000000\cdot psi$

Length Factor: $K = 1$

Length: $L = 95\cdot in$

Euler Buckling load is defined as:

$$P = \frac{I\cdot\pi^2\cdot E}{(K\cdot L)^2} \qquad P = 24908.089\cdot lbf$$

Greater than 4000# assumed compression load

Allowable Compressive stress as defined by AISC is:

$$\frac{K\cdot L}{r} = 190$$

$$Fa = \frac{12\cdot\pi^2\cdot E}{23\cdot\left(\frac{K\cdot L}{r}\right)^2} \qquad Fa = 4136.604\cdot psi$$

$$P = Fa\cdot A \qquad P = 12995.525\cdot lbf$$

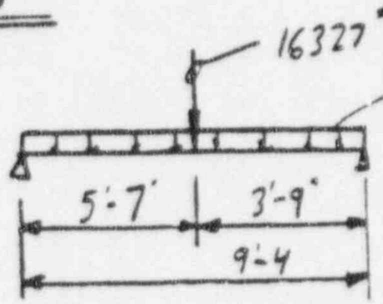
Greater than 4000# assumed compression load

SECTION V DETAILED CALCULATIONS (Continued):

Section V.5 Building Steel Check:

The hanger drawing for MSH-27B shows an existing 24WF68. However, Drawing 521-212 shows this beam to be a 24WF76. This does not affect this calculation. However, this discrepancy is being resolved by DCN 96-217. Hanger MSH-13B attaches to an 12WF31. Recent walkdowns show miscellaneous conduits and smallbore pipe also attach to these structural members.

MSH-13B:



w = 31#/ft (W12x31)
+ 100#/ft to account for conduit support
131

R = 7171 R = 10378

Mmax = 37998 #-ft From AISC, 7th Edition, page 2-97, w/ L_b = 9½' Mmax = 72 K-ft

∴ OKAY

MSH-27B:

ACCEPTABLE BY COMPARISON

SECTION VI RESULTS/CONCLUSIONS:

The detailed calculations show the pipe supports, MSH-13B and MSH-27B, to be qualified to the design loads.

SECTION VII ATTACHMENTS:

Attachment 1: Copy of Pipe Support Drawing MSH-13B for reference, one page.

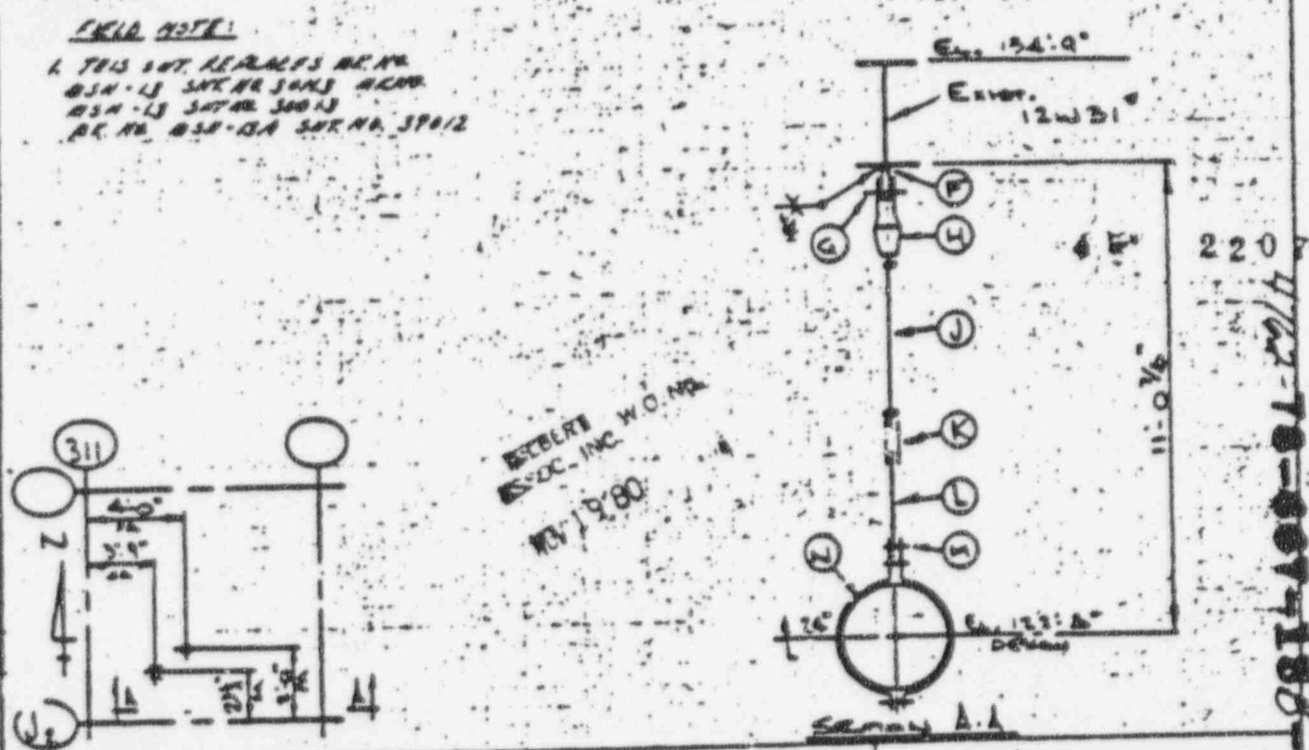
Attachment 2: Copy of Pipe Support Drawing MSH-27B for reference, one page.

Attachment 3: Copy of pipe support load summary sheet from M75-0012 for MSH-27B, one page.

Attachment 4: Copy of pipe support load summary sheet from M75-0013 for MSH-13B, one page.

Attachment 5: Copy of existing calculations of MSH-13B and MSH-27B as found by Parson Power Group, Inc., five pages.

POWER PIPING COMPANY PITTSBURGH, PA. 15233	FLORIDA POWER CORPORATION CRYSTAL RIVER - UNIT #3 P.O. PR3-1403

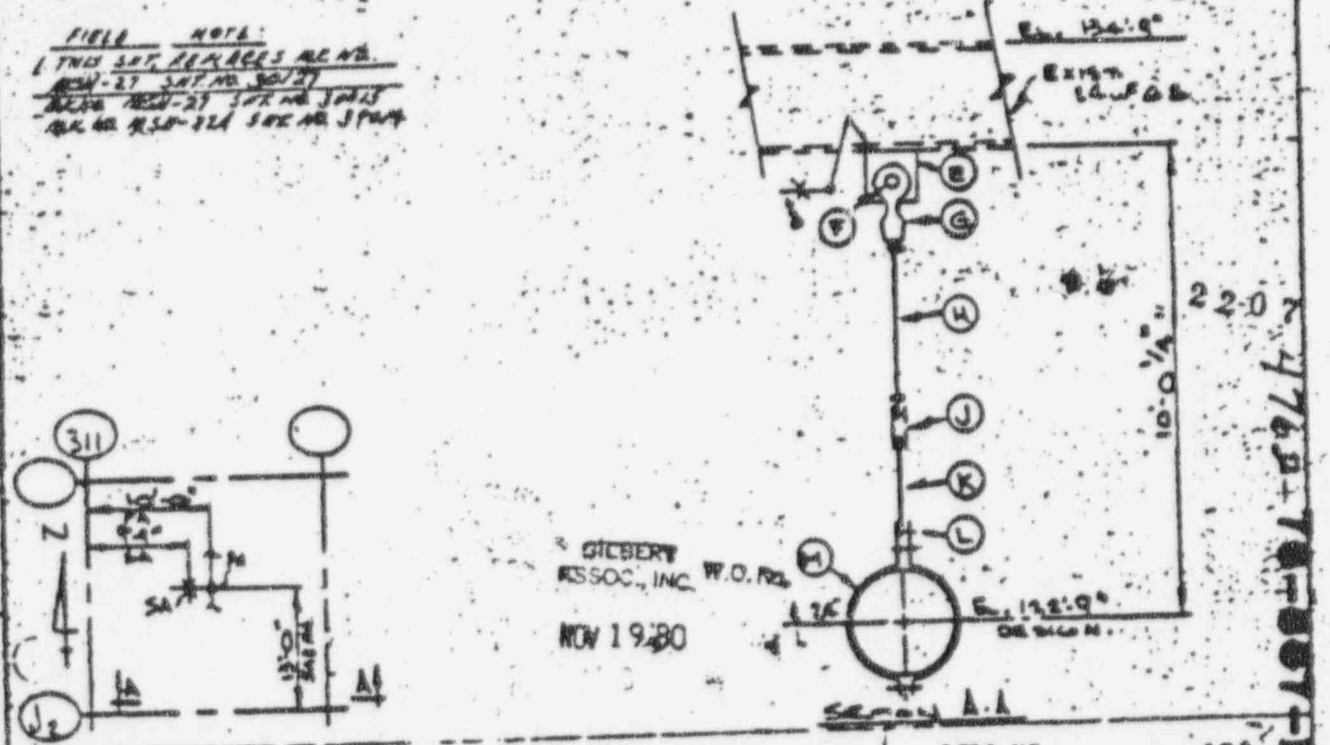


		Main Steam			REQD. MK MSH-13B
○	QUAN.	[X] INSPECTION [ ] HOT & COLD DWG. [ ] SPECIAL PAINT	ASTM	MPS	
F	1	2" Hor. Attach. Pl. Fig. 28A - Drill 2 1/16" ϕ	575		
G	1	2" ϕ x 8 1/2" Lg. Alloy Stud w/ (2) Hex. & 3 7/8" Thd. Ea. End	193/194		
H	1	#5 Clevis Tap. 2" Pinhole - 2 1/16" ϕ Grip - 1 1/4"			
J	1	2" ϕ Rod x 4'-9" Lg. w/ 1 1/2" Thd. & Hex Ea. End	575		
K	1	2" Turnbuckle x 12" Opening			
L	1	2" ϕ Eyerod x 3'-0" Lg. w/ 1 1/2" L.H. Thd. Drill 2 1/16" ϕ	575		
M	2	2" ϕ x 10 1/2" Lg. Alloy Stud w/ (2) Hex. & 3 1/2" Thd. Ea. End	193/194		
N	1	24" Special Pipe Clamp Fig. 224 (Less Top			
		Bolt & Drill Top Bolt Hole 2 1/16" ϕ wt. 222#			
	1	Drawing			
	1	Assembly			

=========================
Attachment 1
Analysis/Calculation
S96-0130, Rev. 0
Page 1 of 1
=========================

REF. DWG. HD-306-013 Rel. 2	D SGAT	R RL	C KSM	ISSUE
REVISIONS 1. AS BUILT PER MAR 791271	REL. DATE OCT 03 1975			AUTH 3926-N
	PROJ. ENGR. LENCZEWSKI			SHEET 39036 REV. 1

POWER PIPING COMPANY PITTSBURGH, PA. 15233	FLORIDA POWER CORPORATION CRYSTAL RIVER - UNIT #3 P. O. PR3-1403



REQD. MK MSH-27B

MK	QUAN.	MAIN STEAM — X INSPECTION ☐ HOT & COLD ☐ SPECIAL PAINT	ASTM	MRS
E	1	2" Hgr. Attach. Fig. 808 - Drill 2 1/16" ϕ	575	
F	1	2"ϕ x 8 1/2" Lg. Alloy Stud w/Hvy. Hx. & 3 1/4" Thd. Ea. End	193/194	WT-34
G	1	#5 Clevis Tap - 2" Pinhole - 2 1/16"ϕ Grip 1 1/4"		
H	1	2"ϕ Rod x 3'-11" Lg. w/ 12" Thd. & Hx. Ea. End	575	
J	1	2" Turnbuckle x 12" Opening		
K	1	2"ϕ x 3'-0" Lg. Eyerod w/12" L.H. Thd. Drill 2 5/16"ϕ	575	
L	1	1 5/8"ϕ x 8" Lg. Alloy Stud w/Hvy. Hx. & 3 1/4" Thd. Ea. End	193/194	WT-74
M	1	24" Special Rgr. Clamp Fig. 225 (Less Top Bolt & Drill Top Bolt Hole 2 5/16"ϕ Wt. = 300#		

Drawing
Assembly

REF. DWG. HO-306-027 Rev. 2
REVISIONS REV. 1 AS BUILT PER NAR 78-12-71

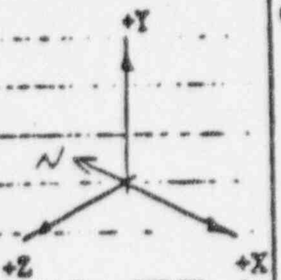
REL. DATE OCT 03 1975
DRWN. CHKR. LEWCZEWSKI
AUTH. 3926-W
SHEET 39037
REV. 1

ES

Attachment 2
Analysis/Calculation
S96-0130, Rev. 0
Page 1 of 1

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT Florida Power Corporation	Page 7 of 17
	PROJECT Crystal River Unit #3	W.O. 04-4203-C71
SYSTEM MS		ORIGINATOR [illegible] DATE 5-2-74
CALCULATION FOR CR - 5A Pipe Supports		REVIEWER S. Ferrandle DATE 1/7/75

Note: All loads act on pipe.
Positive directions are shown here.



ANALYSIS/CALCULATION
DOC ID M-75-0017 ATT [illegible]
REV 0 SHEET 20 OF 27

Comments

Attachment 3
Analysis/Calculation
S96-0130, Rev. 0
Page 1 of 1

Mk. No.	analysis	Mx	My	Mz	Fx	Fy	Fz
MSH-27	deadload					3070	
Sheet No.	seismic					9802	
26127	thermal					2597	
Type	calc. load (+)					15559	
[illegible]	allow. load (+)						
Analysis	calc. load (-)					-[illegible]	
point HO	allow. load (-)						

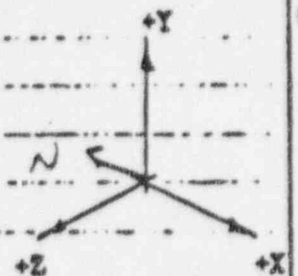
Mk. No.	analysis	Mx	My	Mz	Fx	Fy	Fz
[illegible]	deadload					0	0
Sheet No.	seismic					2174	5302
261121	thermal					0	0
Type	calc. load (+)					2174	5302
[illegible]	allow. load (+)						
Analysis	calc. load (-)					-2174	-5302
point (HP) PP	allow. load (-)						

Mk. No.	analysis	Mx	My	Mz	Fx	Fy	Fz
MSH-21?	deadload					18616	
Sheet No.	seismic					5240	
	thermal					-1569	
Type	calc. load (+)					25856	
Rigid	allow. load (+)						
Analysis	calc. load (-)						
point HO	allow. load (-)						

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT Florida Power Corporation	Page 7 of 16
	PROJECT Crystal River Unit #3	W.O. 04-4203-C71
SYSTEM MS		ORIGINATOR [illegible] DATE 4/2/74
CALCULATION FOR CR - 6B Pipe Supports		REVIEWER S Ferrarello DATE 1/4/75

Comments

Note: All loads act on pipe.
Positive directions are shown here.



~~ANALYSIS/CALCULATION~~
~~DOC ID M-75-[illegible] ATT~~
~~REV 0 SHEET 19 OF [illegible]~~

Mk. No.	analysis	Mx	My	Mz	Fx	Fy	Fz
MSH-12	deadload					3549	
Sheet No.	seismic					22	
3-117	thermal					0	
Type	calc. load (+)					3571	
Spring	allow. load (+)						
Analysis	calc. load (-)					—	
point HQ	allow. load (-)						

Mk. No.	analysis	Mx	My	Mz	Fx	Fy	Fz
[illegible]-227	deadload				0		
Sheet No.	seismic				10262		
	thermal				0		
Type	calc. load (+)				10262		
Hydraulic	allow. load (+)						
Analysis	calc. load (-)				-10262		
point HP	allow. load (-)						

Mk. No.	analysis	Mx	My	Mz	Fx	Fy	Fz
MSH-13	deadload					7208	
Sheet No.	seismic					6796	
	thermal					2323	
Type	calc. load (+)					16327	
Rigid	allow. load (+)						
Analysis	calc. load (-)					—	
point HS	allow. load (-)						

Attachment 4
Analysis/Calculation
S96-0130, Rev. 0
Page 1 of 1

GAI 353 REV. 10-72

Gilbert/Commonwealth ENGINEERS/CONSULTANTS CALCULATION	SUBJECT PIT/CR#3 POTENTIAL EFFECTS OF OTSG OVERFILL		IDENTIFIER 5500-035-MS-13		PAGE 1 OF 3 PAGES
	REV.	0	1	2	3
	MICROFILMED				
	ORIGINATOR	T. BYRNE			
	DATE	6-26-85			

NUCLEAR SAFETY RELATED

MK. NO. W.O. 04-5300-035
MSH-013B

1.0) OBJECTIVE
EVALUATE PIPE SUPPORT FOR EFFECTS FROM OTSG OVERFILL

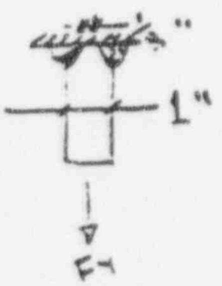
2.0) DESIGN LOAD (ANALYSIS CR-6)
OWT = +0/- 24911 # THER. = +0/- 2323 #
TOTAL = +0/- 27234 #
USE FAULTED ALLOWABLES.

3.0) COMPONENTS

COMPONENTS	ACTUAL	≤	ALLOW.**
_" HGR. ATTACH R (203)	27234	≤	44000#
#5 CLEVIS (161)	27234	≤	41260#
2" Φ ROD (51)	27234	≤	41260#
2" TURNBUCKLE	27234	≤	41260#
2" Φ EYEROD	27234	≤	41260#
24" PIPE CLAMP (224)	27234	≤	30450#

** USE FAULTED ALLOW. FROM POWER PIPING NF CATALOG

4.0) WELD (PART 203)



$F_Y = 27234\#$
$A_W = 14"$
$W = .875"$

$$f = \frac{F_Y}{A_W} = 1945 \#/IN$$

$$\sigma = \frac{f}{.707W} = \frac{1945}{.707(.875)} = 3145 \text{ PSI}$$

∴ OK

========================
Attachment 5
Analysis/Calculation
S96-0130, Rev. 0
Page 1 of 5
========================

Gilbert/Commonwealth ENGINEERS/CONSULTANTS CALCULATION	SUBJECT FPC/CR#3 POTENTIAL EFFECTS OF OTSG OVERFILL	IDENTIFIER S500-035-MS-13	PAGE 2 OF 3 PAGES
	REV. 0	1	2	3
	MICROFILMED			
	ORIGINATOR T. BYRNE			
	DATE 7-3-85			

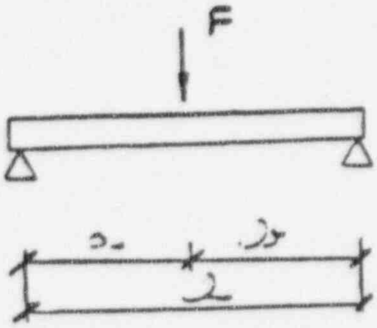
NUCLEAR SAFETY RELATED

MK. No
MSH-013B

W.O. 09-S500-035

5.0) SPRING CONSTANT

W12 × 31

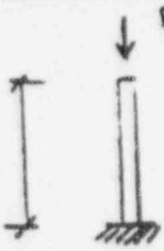


$a = 67.25''$
$b = 45.5''$
$l = 112.75''$

PROPERTIES
FOR B&W ... STRUCTURAL ... = S-521-212
$E = 27.7 \times 10^6$ PSI
$I = 238.$ IN^4
$S = 39.5$ IN^3

$$K_1 = \frac{3EIl}{a^2 b^2} = \frac{3(27.7\times10^6)(238)112.75}{67.25^2 (45.5)^2} = 239170 \text{ LBS/IN}$$

2" Φ ROD



$l = 122''$
$A = \pi r^2 = \pi 1^2 = 3.14$ IN^2
$E = 27.7 \times 10^6$ PSI

$$K_2 = \frac{AE}{l} = \frac{3.14(27.7\times10^6)}{122} = 712934 \text{ LBS/IN}$$

COMBINE K'S

$$K = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2}} = \frac{1}{\frac{1}{239170} + \frac{1}{712934}} = 1.8 \times 10^5 \text{ LBS/IN}$$

=========================
Attachment 5
Analysis/Calculation
S96-0130, Rev. 0
Page 2 of 5
=========================

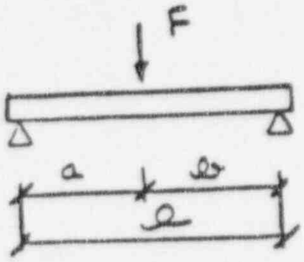
Gilbert/Commonwealth ENGINEERS/CONSULTANTS CALCULATION	SUBJECT FPC/CR#3 POTENTIAL EFFECTS OF OTSG OVERFILL			IDENTIFIER 5500-035-MS-13		PAGE 3 OF 3 PAGES
	REV.	0	1	2	3	
	MICROFILMED					
	ORIGINATOR	T. BYRNE				
	DATE	7-8-85				

NUCLEAR SAFETY RELATED

MK. NO.
MSH-013B

W.O. 04-5500-035

6.0) <u>W12×31</u>



F: 27234#
a = 67.25"
b = 45.5"
l = 112.75"

<u>PROPERTIES</u>
$I = 239.\ IN^4$
$S = 39.5\ IN^3$

$$M_{MAX} = \frac{Fab}{l} = \frac{27234(67.25)(45.5)}{112.75} = 739092 \text{ \#IN}$$

$$\sigma = \frac{M}{S} = \frac{739092}{39.5} = 18711 \text{ PSI} \leq 21600 \text{ PSI}$$

∴ OK

7.0) <u>CONCLUSION</u>
SUPPORT OK FOR OTSG OVERFILL.

Attachment 5
Analysis/Calculation
S96-0130, Rev. 0
Page 3 of 5

Gilbert/Commonwealth ENGINEERS/CONSULTANTS CALCULATION	SUBJECT FPT./CR#3 POTENTIAL EFFECTS OF OTSG OVERFILL	IDENTIFIER 5520-CSS-MS-27	PAGE 1 OF 1 PAGES
	REV. 0 / 1 / 2 / 3		
	MICROFILMED		
	ORIGINATOR T. BYRNE		
	DATE 6-25-85		

NUCLEAR SAFETY RELATED

MK. No: MSH-027B

W.O. 64-5520-0?

1.0) OBJECTIVE

EVALUATE PIPE SUPPORT FOR EFFECTS FROM OTSG OVERFILL

2.0) DESIGN LOAD (ANALYSIS CC-2)

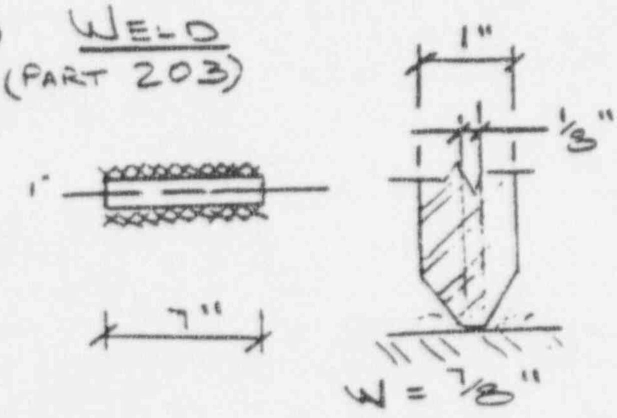
DWT + THER. = -26081 #

USE FAULTED ALLOWABLES FROM POWER PIPING'S NF CATALOG

3.0) COMPONENTS

	ACTUAL	≤	ALLOW.
2" HGR. ATTACH. R (203)	26081	≤	44000#
#5 CLEVIS (161)	26081	≤	41260#
2" ϕ ROD (81)	26081	≤	41260#
2" ϕ TURNBUCKLE	26081	≤	41260#
2" ϕ EYEROD	26081	≤	41260#
24" ϕ PIPE CLAMP (223)	26081	≤	38730#

4.0) WELD (PART 203)



$F_Y = 26081$ #

$A_W = 14"$

$f = \frac{F_Y}{A_W} = 1863$ #/IN

$\sigma = \frac{f}{.707 w} = \frac{1863}{.707(.875)} =$

$= 3011$ PSI

5.0) CONCLUSION

SUPPORT OK USING NORMAL ALLOWABLES.

Attachment 5
Analysis/Calculation
S96-0130, Rev. 0
Page 4 of 5

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT / PROJECT: ~~FLORIDA POWER CORPORATION~~ CRYSTAL RIVER UNIT #3	FILING CODE: 3?-MSH-2?
		W.O. 4263 / PAGE 1 of 1

SYSTEM: Main Steam

CALCULATION FOR: MSH-27

ORIGINATOR:

DATE:

REVIEWER: B. Stevens

DATE 6-19-74

RESULTS

RIGID ROD WITH COMPRESIVE LOAD

ROD IS 10 FT LONG $d = 2"$

$$P_{CR} = \frac{\pi^2 EI}{L^2}$$

$$I = \frac{\pi d^4}{64} = .049 d^4 = .784$$

$$P_{CR} = \frac{(3.1416)^2(29,000,000)(.784)}{122^2}$$

$$P_{CR} = \frac{(9.8596)(29,000,000)(.784)}{14,884} = 15,060.995^{\#}$$

TENSION

$$S = \frac{P}{A} =$$

$$9000 = \frac{P}{3.1416}$$

$$P = 28,274.4^{\#}$$

USE 2" DIA ROD

Attachment 5
Analysis/Calculation
S96-0130, Rev. 0

Pipe Stress Analysis Specification

Basic Guideline for the design of piping has been the Code for Pressure Piping B31.1.0-1967 and those portions of Code Case N7. In accordance with this code, Deadweight/Pressure, Thermal, Seismic and any additional transient type of loading must be considered.

The original design methodology used GAI Topical Report No. 1729, "Dynamic Analysis of Vital Piping Systems Subjected to Seismic Motion" as a guideline. A copy of this guideline is attached to this document. For all new or revised piping analyses completed today, Piping Analysis Design Guide MDG-1 is followed as a guideline.

Design Basis Loading Conditions for Main Steam System

Requirement Outline - R.O. 2891 and Enhanced Design Basis Document (EDBD) - Section 6/10

Design Pressure = 1050 psi
Operating Temperature= 590 degrees F

Seismic Input - Reference: Environmental and Seismic Qualification Program Manual (ESQPM) - Section 5

The response spectra used in the analysis was Curve CRW2. This curve is a response spectra that was developed for analysis of piping supported by the Reactor Building Shell at Elevation 123.00. Response spectra, CRW2, was used since a significant portion of the mass of this system, in particular the relief valves, will be directly accelerated by the Reactor Building Shell and it was felt that it was a more conservative response spectra curve than the ground response curve due to the two peaks which occur at 4 to 5 Hz and 14 to 18 Hz.

While this curve is not contained in the ESQPM, it was developed using the same methodology as the original curves. Response curve CRW2 utilized lower margins to envelop the derived response spectra in peak regions of amplifications when compared to the base curve, CR-R2, which is contained in the ESQPM as Figure 2.

Seismic response spectra were developed using the response spectrum method. The inherent conservatism of the response spectrum method is discussed in FSAR Section 5.4.5.1 and demonstrated in FSAR Figure 5-29 and 5-30.

Design Basis Loading Conditions for Main Steam System (cont'd)

As documented in the FSAR, period domain broading of the response spectra was implemented on the analytical derived curves to establish "design envelope" values. Conservatively, additional acceleration value enveloping was applied in the regions of amplified response. The magnitude of margin between the analytical derived peak acceleration and the "design envelope" value was established at the judgement of the senior engineer tasked with development of the response curves. Specific margin amplification percentage varies from building to building and level to level within a given structure. The implied basis for this variable was to provide additional conservatism to the CR3 design, since typically seismic design conditions did not govern CR3 design.

Based upon review of original design documentation, Curve CRW2 was established specifically for the piping analysis of containment anchored piping in the intermediate building. The period domain broading of CRW2 is identical to the basic design envelop, CRR2. The acceleration amplitude margin was reduced to a minimum of 5% above the analytical derived acceleration value

Analysis Criteria and Methodology

During the original design of CR3, those piping systems which required computer analyses were analyzed on main frame program - "Pipe Stress Analysis - M003".

Various computer analyses were completed on safety related systems. For the Main Steam system, a deadweight, thermal, seismic, safety valve discharge loading were all computer analyzed. For steam hammer, a simplified, conservative, manual calculation was performed to document this loading condition.

The deadweight/longitudinal pressure analysis was completed with the supports placed at specified locations based on field information. This analysis checked the deadweight/pressure stress and this value was compared to the B31.1 Code allowable of Sh.

Using the same field supplied support information, the thermal analysis was completed to insure that all code allowables were met. The thermal stress value was compared to the B31.1 Code Allowable of Sa. Where required, the Maximum Seismic Anchor Movement Stress was included with the thermal stress.

Analysis Criteria and Methodology (cont'd)

Upon completion of successful deadweight and thermal analyses, the seismic (and transient loadings, if any) analysis was performed to insure code allowables were not exceeded. Snubbers and other necessary restraints were added to the system to control the seismic loadings. The combined primary stresses produced by the MHE (0.10g horizontal ground acceleration) are maintained at less than or equal to 120% of the code allowable stresses from ANSI B31.1.0-1967, plus code case N-7 for duration up to 1% of the operating period.

To obtain the Operating Basis Earthquake (OBE) stress levels and support loadings, the seismic analysis involved choosing the appropriate response spectrum curve and analyzing a two dimensional earthquake (i.e. x-y quake and a y-z quake). The loadings and stresses from this analysis were then doubled to obtain the Safe Shutdown Earthquake (SSE) values. The results of these two separate earthquakes were reviewed and the largest values (stresses and support loads) were documented. The seismic stresses were then combined with the deadweight/pressure stresses and compared a code allowable of 1.2 Sh. This is a very conservative allowable whereas, methodology that is used for a plant in a comparable time frame compares the OBE stress levels to 1.2 Sh and the SSE stress levels to 1.8 Sh (Reference ASME Section III, Subsection NC, 1971 through Winter 1973 Addenda). Upon successful completion of the seismic analysis, the deadweight and thermal analyses were again analyzed if seismic restraints, other than snubbers were added to the system.

It should be noted, piping analysis CR-5 modeled a significant portion of the non-safety, Seismic Class S-III main piping run from the class break to the Turbine connection. This was done for overlap purposes to determine the effects the non-safety piping had on the safety related piping. Regulatory Guide 1.29, Section C.3 states the following:

> "Seismic Category I design requirements should extend to the first seismic restraint beyond the defined boundaries. Those portions of structures, systems, or components that form interfaces between Seismic Category and non-Seismic Category I features should be designed to Seismic Category I requirements."

Analysis Criteria and Methodology (cont'd)

The non-safety supports after the class break have been designed accounting for the seismic loadings. Therefore, the intent of Regulatory Guide 1.29 has been met. Various flow transients were required to be analyzed to account for any other type of dynamic loading in nature. For the Main Steam Line those analyses included Relief (Safety) Valve Discharge and Steam Hammer.

Relief Valve Discharge forces were originally documented by manual calculations and were then subsequently backed-up by computer generated results. The stress results of this analysis were combined with the deadweight/pressure and SSE stress levels and compared to 1.2 Sh. A copy of the manual calculations has been included with this document.

Also as a part of the safety valve analyses, the movements of the Main Steam Safety Valves relative to the discharge piping were calculated to assist in the design of the flexonic connections at the valve/piping interface. A copy of the manual calculations documenting these movements is included with this document.

The steam hammer analysis for this piping system was a simplified, conservative, manual calculation that provided the necessary documentation that when valve closure did occur, the system would be capable of withstanding any unbalanced forces that was created by the pressure wave traveling through the pipe. During this calculation, the seismic restraints (snubbers/rigid supports) were considered the main restraints in the piping system. Rod supports were only considered active in the vertical downward direction. A copy of the Steam Hammer Analysis by MZ Lee dated 11/2/73 is attached to this document.

The final phase of the design for the Main Steam piping system was visual observation during functional testing and during Initial Operation. For the Main Steam system one of the most critical loading conditions was the observation of a Turbine Trip. The final results of the steam hammer visual inspection was quite favorable. A few supports did require minor modifications; however, in general the system responded favorably and was capable of withstanding all loadings. A copy of the Report entitled "Main Steam and Feedwater - Steam Hammer Observations and Instrumentation" dated May 31, 1977 covering the observations and instrumentation has been attached to this document.

Qualification Criteria and Methodology on Rod Hangers

The ability of an item of pipe support hardware to resist forces due to static and dynamic events is a function of the physical properties and installation details specified for the hardware.

For static dead weight evaluations, all hardware capable of resisting vertical forces are modeled as active. For analysis of dynamic transients, only hardware which can resist load reversals without undergoing non linear or non elastic deflections is considered effective. In the seismic analyses where the spring constants were inserted into the analysis, the seismic loading was minimal when compared to the deadweight loading. Since the seismic loading never exceeded the deadweight loading, the supports remained within the elastic range and thus would be acceptable for the minimal seismic loading that has occurr... Generalities regarding the applicability of a hardware component are not used to classify the resistance capability of hardware. Specific installation parameters are evaluated to establish the load resistance capability of individual hardware items.

Installation parameters evaluated to establish the resistance capability of hardware include:

- Physical strength of the hardware component to resist tension forces and compression force. Buckling criteria governs this review and is based upon the components length and cross sectional properties. AISC and SSRC (Structural Stability Research Council) criteria for limiting slenderness ratios, kl/r, to 200 governs component members.

- Hardware fit up can not permit a gap movement or unrestrained deflection beyond the industry standard of 1/8" under a load reversal.

- The supported piping system must be of sufficient physical size to provide inherent lateral support to potential compression members which form "pinned" columns.

A rod hanger supported by a spring can would not be effective for dynamic events if the upper working range of the spring can is exceeded and the spring has no downward deflection since the rod bearing plate can uplift from the spring coil resulting in gap movement.

Qualification Criteria and Methodology on Rod Hangers (cont'd)

A larger diameter rod with attachment hardware at the pipe and structural attachment point which preclude gap movement is effective for dynamic loads if the stability slenderness ratio criteria is complied with. Behavior of large diameter rods meeting the stability fit up criteria and rigid struts are identical from a piping analysis standpoint.

MOVEMENTS OF MAIN STEAM
SAFETY VALVES RELATIVE TO DISCHARGE
PIPING

MOVEMENTS OF MAIN STEAM
SAFETY VALVES RELATIVE TO DISCHARGE
PIPING

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FPC
PROJECT	CR UNIT 3
FILING CODE	
W.O.	4103-07
PAGE	1 OF 2
SYSTEM	Notes for Calculations of Safety
CALCULATION FOR	Valve Movements
ORIGINATOR	A. ECKENRODE
DATE	12/5/73
REVIEWER	M. Z. Lee
DATE	12/5/73

RESULTS

① Safety Valves may be closed or open. Therefore both conditions are considered.

② Data from the seismic analysis is the sum of X and Y or Y and Z movement.

③ Seismic movement may be positive or negative. Therefore both conditions are considered.

④ Axial and lateral movement are calculated separately so that the worst condition is found in each case. For examples a positive seismic value may be used to calculate axial movement while the negative value is used to calculate lateral movement.

⑤ The largest possible lateral movement in the XY plane not including stack movement is calculated. The smallest

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 2 OF 2
SYSTEM		ORIGINATOR DATE	
CALCULATION FOR		REVIEWER DATE	

possible is also calculated. This figure is used to calculate the maximum lateral movement off the XY plane including stack movement.

RESULTS

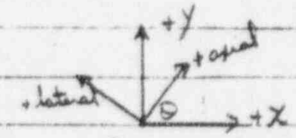
FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC	FILING CODE	
	PROJECT CR UNIT 3	W.O. 4203-027	PAGE 1 OF 6
SYSTEM CR - 3		ORIGINATOR A. ECKENROTH	
CALCULATION FOR Movement on Safety Valve MSV - 46F		DATE 11/30/73	
		REVIEWER M. Z. Lee	
		DATE 12/5/73	

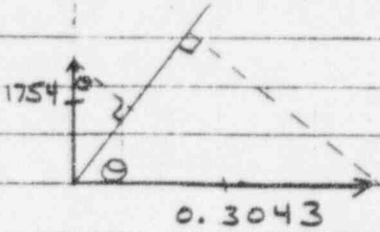
RESULTS

Thermal (original run) movements @ Pt HO-51

ΔX = +.3043"
ΔY = +.1754"
ΔZ = +.8246"



θ = 53°
Facing East



Axial Mov't = (0.1754) Sin θ + (0.3043) Cos θ
0.1401 + 0.1831 =
+0.3232"

Lateral Mov't in XY Plane =
(0.1754) Cos θ − (0.3043) Sin θ
.1056 − .2430 =
−0.1374

Lateral Mov't off XY Plane (ΔZ = 0.8246")

$$\text{Absolute Lateral Mov't} = \sqrt{(0.8246)^2 + (\text{Lateral Mov't in XY})^2}$$

$$\sqrt{(0.8246)^2 + (0.1374)^2} =$$

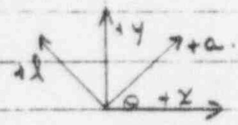
0.8359"

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 2 OF 6
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER M. Z. Lee	
		DATE 12/5/73	

RESULTS

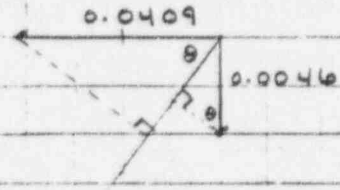
Safety Valve Loads (case No. 2) mov't @ Pt. HO-51

$\Delta X = -0.0409''$
$\Delta Y = -0.0046''$
$\Delta Z = +0.0614''$



θ = 53°

Facing East



Axial Mov't = $(-0.0046)\sin\theta + (-0.0409)\cos\theta$
$(-0.0037) + (-0.0246) =$
$-0.0283''$ or 0"

Lateral Mov't in XY Plane =
$(-.0046)\cos\theta - (-.0409)\sin\theta$
$(-.0028) - (-.0327) =$
$+.0299''$ or 0"

Lateral Mov't off XY Plane ($\Delta Z = +.0614''$)

Absolute Lateral Mov't = $\sqrt{(0.0614)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(0.0614)^2 + (0.0299)^2} =$

$0.0683''$ or 0"

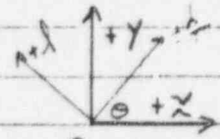
FILING

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 3 OF 6
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER M. Z. Lee / DATE 12/5/73

RESULTS

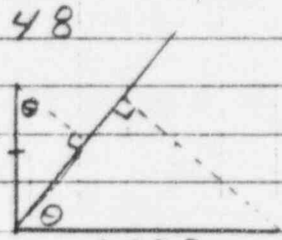
Seismic Mov't. @ Pt MP-48

$\Delta X = \pm 0.0078''$
$\Delta Y = \pm 0.0037''$
$\Delta Z = \pm 0.0278''$



$\theta = 53°$

Facing East



Axial Mov't = $(.0037)\sin\theta + (.0078)\cos\theta$
$.0030 + .0047 =$
$+ .0077''$

Lateral Mov't in XY Plane =
$(\pm .0037)\cos\theta - (\pm .0078)\sin\theta$
$(\pm .0022) - (\pm .0062) =$
$\pm .0040''$

Lateral Mov't off XY Plane ($\Delta Z = \pm .0278''$)

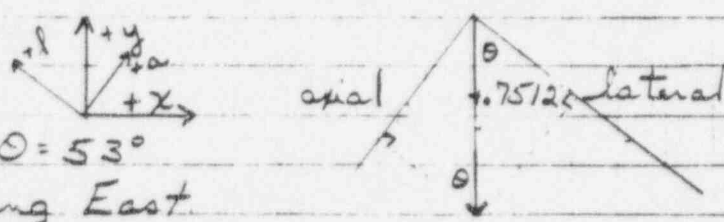
Absolute Lateral Mov't = $\sqrt{(.0278)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(.0278)^2 + (.0040)^2} =$

0.0280

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 4 OF 6
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER M. Z. Lee	
		DATE 12/5/73	

	RESULTS
Stack Mov't due to Thermal Expansion:	
ELEV. of anchor in roof = 149'-0"	
ELEV. of safety valve = 128'-3"	
Length of stack = 20'-9"	
*Expansion of A106-GR. B steel @ 500°F = .0362 in. / ft. of pipe	
20.75 ft × .0362 in/ft = 0.7512 in	
	
θ = 53° Facing East	
Axial Mov't = (-0.7512) Sin θ =	-.5999" (compressive)
Lateral Mov't in XY Plane = (-0.7512) Cos θ =	-.4521"
* Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines.	

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 5 OF 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER M. Z. Lee	
		DATE 12/5/73	

	RESULTS
Total Mov't @ Pt 40-51 =	
Thermal + Safety Valve + Seismic Mov't.	
Axial Mov't = (+.3232) + (-.0283) + (+.0077) =	+.3026"
	OR
When Safety Valve is Closed = (+.3232) + (+.0077) =	+.3309" (compressive)
Lateral Mov't in XY Plane = (-.1374) + (+.0299) + (+.0040) =	-.1035"
	OR
When Safety Valve is Closed = (-.1374) + (-.0040) =	-.1414"
Mov't in Z Direction = (+.8246) + (+.0614) + (+.0278) =	+.9138"
	OR
When Safety Valve is Closed = (+.8246) + (+.0278) =	+.8524"
Lateral Mov't off XY Plane =	
$\sqrt{(.9138)^2 + (.1414)^2}$ =	.9247"
Total Movement	
Axial Mov't = (.3309) + (.5999) =	.9308"
Lateral Mov't in XY Plane = (-.4521) - (-.1035) =	-.3486"
Lateral Mov't off XY Plane =	
$\sqrt{(.9138)^2 + (.3486)^2}$ =	.9780"

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER M. Z. Lee

DATE 12/5/73

RESULTS

MSV-46F Summary
MSEJ-4

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	RESULTS
AXIAL	.3309"	.9308"	Compression
X-Y	-.1414"	-.3486"	
Z	+.9138"	+.9138"	
LATERAL	.9247"	.9780"	

Design Conditions

Axial = .85" Compression max

Lateral = .81"

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC	FILING CODE	
	PROJECT CR UNIT 3	W.O.	PAGE 1 OF 6

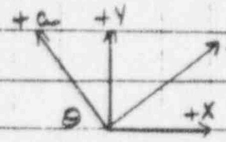
SYSTEM CR-3	ORIGINATOR A. ECKENROTH
CALCULATION FOR Movement of Safety Valve MSV-42	DATE 12/6/73
	REVIEWER M. Z. Lee
	DATE 12/08/73
	RESULTS

Thermal (original run) movements @ Pt HP-58

$\Delta X = -.0328"$

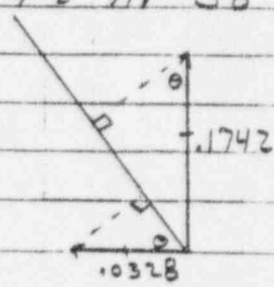
$\Delta Y = +.1742"$

$\Delta Z = +.9852"$



$\theta = 53°$

Facing East



Axial mov't $= (+.1742)\sin\theta - (-.0328)\cos\theta$

$(+.1391) - (-.0197) =$

$+.1588"$

Lateral Mov't in XY Plane =

$(+.1742)\cos\theta + (-.0328)\sin\theta =$

$(+.1048) + (-.0262) =$

$+.0786"$

Lateral Mov't off XY Plane $(\Delta Z = +.9852")$

Absolute Lateral Mov't $= \sqrt{(.9852)^2 + (\text{Lat Mov't in XY})^2} =$

$\sqrt{(.9852)^2 + (.0786)^2} =$

$.9883"$

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 2 of 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE
		REVIEWER
		DATE

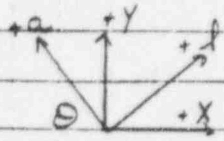
RESULTS

Safety Valve Loads (case No. 2) mov't @ Pt. HP-58

$\Delta X = -.0138''$

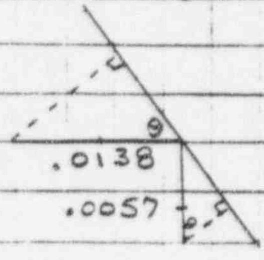
$\Delta Y = -.0057''$

$\Delta Z = +.0197''$



$\Theta = 53°$

Facing East



Axial Mov't = $(-.0057)\sin\Theta - (-.0138)\cos\Theta =$

$(-.0046) - (-.0083) =$

$+.0037''$ or $0''$

Lateral Mov't in XY Plane =

$(-.0057)\cos\Theta + (-.0138)\sin\Theta =$

$(-.0034) + (-.0110) =$

$-.0144''$ or $0''$

Lateral Mov't off XY Plane ($\Delta Z = +.0197$)

Absolute Lateral Mov't = $\sqrt{(.0197)^2 + (\text{Lateral Mov't in XY})^2}$

$= \sqrt{(.0197)^2 + (.0144)^2} =$

$.0244''$

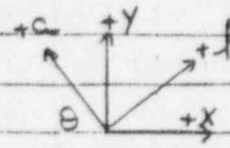
FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O.	PAGE 3 OF 6
SYSTEM		ORIGINATOR DATE	
CALCULATION FOR		REVIEWER DATE	

RESULTS

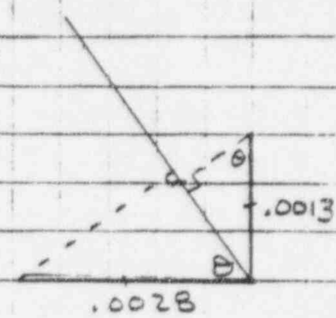
Seismic Mov't @ Pt. MR-55

$\Delta X = \pm .0028''$
$\Delta Y = \pm .0013''$
$\Delta Z = \pm .0291''$



θ = 53°

Facing East



Axial Mov't = $(\pm .0013) \sin\theta - (\pm .0028) \cos\theta =$
$(\pm .0010) - (\pm .0017) =$
$\pm .0027''$

Lateral Mov't in XY Plane =
$(\pm .0013) \cos\theta + (\pm .0028) \sin\theta =$
$(\pm .0008) + (\pm .0022) =$
$\pm .0030''$

Lateral Mov't off XY Plane = $(\Delta z = \pm .0291'')$

Absolute Lateral Mov't $= \sqrt{(.0291)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(.0291)^2 + (.0030)^2} =$

$.0293''$

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 4 OF 6
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER	
		DATE	

Stack Mov't due to Thermal Expansion:

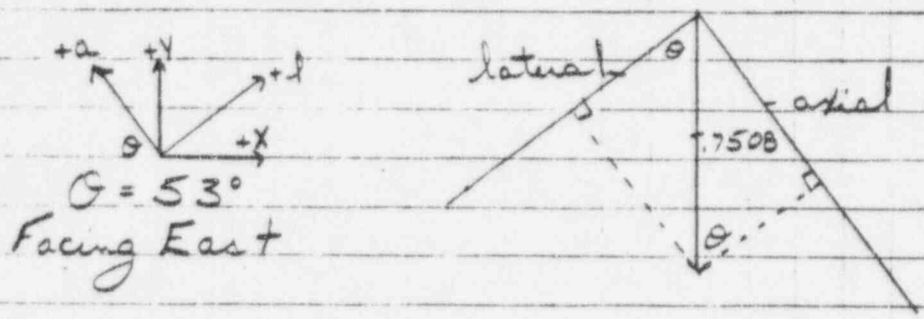
ELEV of anchor in roof = 149'-0"

ELEV of safety valve = 128'-3 1/8"

Length of stack = 20'-8 7/8"

* Expansion of A106-GR B steel @ 500°F = .0326 in/ft. of pipe

20.7396 ft x .0362 in/ft = .7508 ins.



Axial Mov't = (-.7508) Sin θ = -.5996" (compressive)

Lateral Mov't in XY Plane = (-.7508) Cos θ = -.4518"

* Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines.

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 5 OF 6
SYSTEM		ORIGINATOR DATE	
CALCULATION FOR		REVIEWER DATE	

	RESULTS
Total Mov't @ Pt. HP-58 =	
Thermal + Safety Valve + Seismic Mov't	
Axial Mov't = (+.1588)+(+.0037)+(+.0027) =	+.1652"
	or
When Safety Valve is Closed = (+.1588)+(+.0027) =	+.1615" (compressive)
Lateral Mov't in XY Plane = (+.0786)+(-.0144)+(-.0030) =	+.0612"
	or
When Safety Valve is Closed = (+.0786)+(+.0030) =	+.0816"
Mov't in Z Direction = (+.9852)+(+.0197)+(+.0291) =	+1.0340"
When Safety Valve is Closed = (+.9852)+(+.0291) =	+1.0143"
Lateral Mov't off XY Plane = $\sqrt{(1.0340)^2+(.0816)^2}$ =	1.0372"
Total Movement	
Axial Mov't = (.5996)+(.1652) =	.7648"
Lateral Mov't in XY Plane = (-.4518) − (+.0816) =	-.5334"
Lateral Mov't off XY Plane = $\sqrt{(1.0340)^2+(.5334)^2}$ =	1.1635"

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

MSV-42F Summary
MSEJ-3

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	
AXIAL	.1652"	.7648"	Compression
XY	+.0816"	-.5334"	
Z	+1.0340"	+1.0340"	
LATERAL	1.0372"	1.1635"	

Design Conditions

Axial = 0.84"

Lateral = 0.73"

FILING

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT: FPC	FILING CODE	
	PROJECT: CR UNIT 3	W.O. 4203-007	PAGE 1 OF 6
SYSTEM: CR-4		ORIGINATOR: A ECKENRODE	DATE 12/5/73
CALCULATION FOR: Movement on Safety Valve MSV-40 F		REVIEWER: M. Z. Lee	DATE 12/5/73

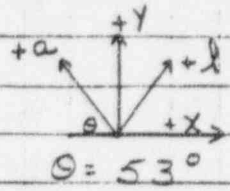
RESULTS

Thermal (Revision #1) mov't @ Pt. DH-572

$\Delta X = +.0848''$

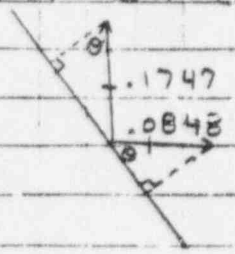
$\Delta Y = +.1747''$

$\Delta Z = +1.2388''$



$\theta = 53°$

Facing East



Axial Mov't = $(+.1747)\sin\theta - (+.0848)\cos\theta =$
$(+.1395) - (+.0510) =$
$+.0885''$

Lateral Mov't in XY Plane =
$(+.1747)\cos\theta + (+.0848)\sin\theta =$
$(+.1051) + (+.0677) =$
$+.1728''$

Lateral Mov't off XY Plane

Absolute Lateral Mov't =

$$\sqrt{(1.2388)^2 + (\text{Lateral Mov't in XY})^2}$$

$$\sqrt{(1.2388)^2 + (.1728)^2} =$$

$$1.2508''$$

FILING

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 2 of 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

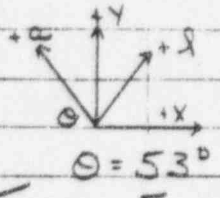
RESULTS

Safety Valve Loads (case #3) mov't @ Pt DH-572

$\Delta X = +.0608''$

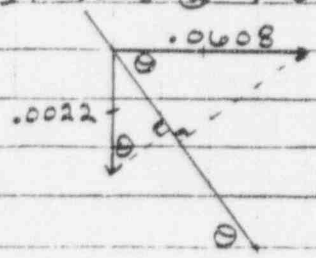
$\Delta Y = -.0022''$

$\Delta Z = +.0127''$



$\theta = 53^\circ$

Facing East



Axial Mov't = $(-.0022)\sin\theta - (+.0608)\cos\theta =$

$(-.0018) - (+.0366) =$

$-.0384''$ or $0''$

Lateral Mov't in XY Plane =

$(-.0022)\cos\theta + (+.0608)\sin\theta =$

$(-.0013) + (+.0486) =$

$+.0473''$ or $0''$

Lateral Mov't off XY Plane

Absolute Lateral Mov't =

$$\sqrt{(.0127)^2 + (\text{Lateral Mov't in XY})^2}$$

$$\sqrt{(.0127)^2 + (.0473)^2} =$$

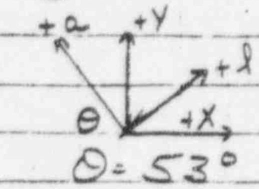
$.0490''$ or $0''$

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 3 OF 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	
		RESULTS	

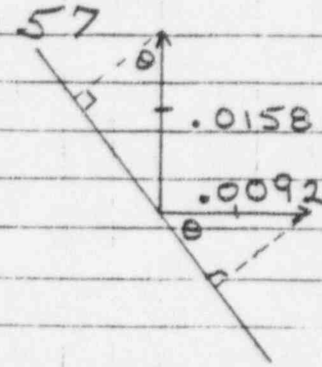
Seismic Mov't @ Pt. MV-57

$\Delta X = \pm .0092"$
$\Delta Y = \pm .0158"$
$\Delta Z = \pm .0123"$



$\theta = 53°$

Facing East



Axial Mov't = $(+.0158) \sin\theta - (+.0092) \cos\theta =$
$(+.0126) - (+.0055) =$
$+.0071"$

Lateral Mov't in XY Plane =
$= (\pm.0158) \cos\theta + (\pm.0092) \sin\theta =$
$(\pm.0095) + (\pm.0073) =$
$\pm .0168"$

Lateral Mov't off XY Plane =

$\sqrt{(.0123)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(.0123)^2 + (.0168)^2} =$

$.0208"$

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 4 OF 6
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER	
		DATE	

Stack Mov't due to Thermal Expansion -

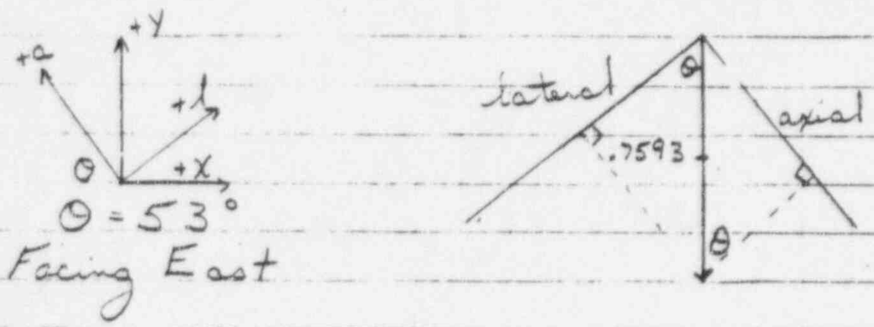
ELEV of anchor in roof = 149'-0"

ELEV of safety valve = 128'-0 5/16"

Length of stack = 20'-11 11/16"

* Expansion of A106 GR. B steel @ 500°F = .0362 in / ft. of pipe

20.9740 ft x .0362 in/ft. = .7593"



	RESULTS
Axial Mov't = (-.7593) Sin Θ =	-.6064" (compressive)
Lateral Mov't in XY Plane = (-.7593) Cos Θ =	-.4570"

* Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines.

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 5 OF 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE / REVIEWER / DATE

	RESULTS
Total Mov't @ Pt. DH-572 =	
Thermal + Safety Valve + Seismic Mov't	
Axial Mov't = (+.0885) + (-.0384) + (+.0071) =	+.0572"
	OR
When Safety Valve is closed = (+.0885) + (+.0071) =	+.0956" (compressive)
Lateral Mov't in XY Plane = (+.1728) + (+.0473) + (+.0168) =	+.2369"
	OR
When Safety Valve is closed = (+.1728) + (-.0168)	+.1560"
Mov't in Z Direction = (+1.2388) + (+.0127) + (+.0123) =	+1.2638"
	OR
When Safety Valve is closed = (+1.2388) + (+.0123) =	+1.2511"
Lateral Mov't off XY Plane = $\sqrt{(1.2638)^2 + (.2369)^2}$ =	1.2858"
Total Movement	
Axial Mov't = (.0956) + (.6064) =	.7020"
Lateral Mov't in XY Plane = (-.4570) − (+.1560) =	-.6130"
Lateral Mov't off XY Plane = $\sqrt{(1.2638)^2 + (.6130)^2}$ =	.9864"

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

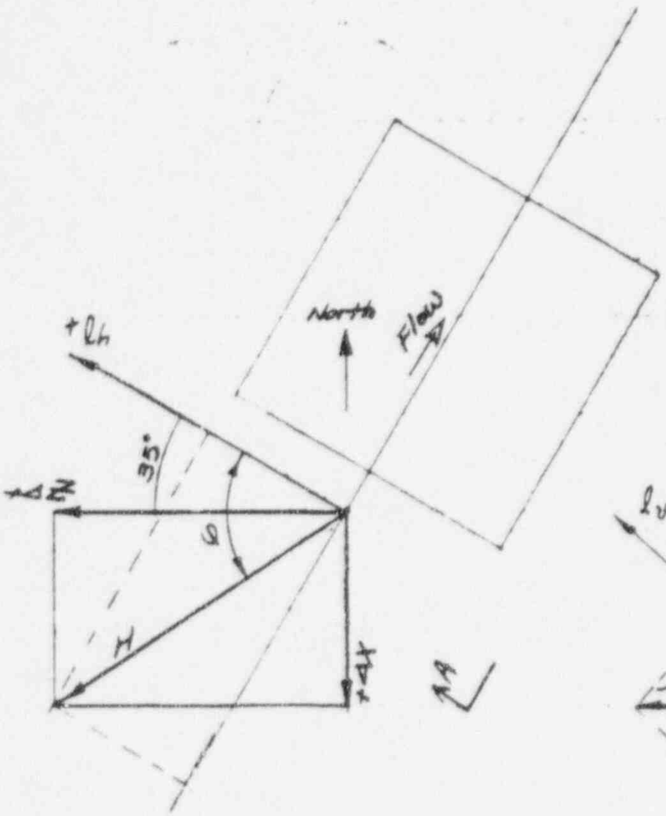
MSV-40F Summary
MSEJ-9

DIRECTION	WITHOUT STACK MOVEMENTS	WITH STACK MOVEMENTS
AXIAL	.0956"	.7020"
XY	+.2369"	-.6130"
Z	+1.2638"	+1.2638"
LATERAL	1.2858"	.9864"

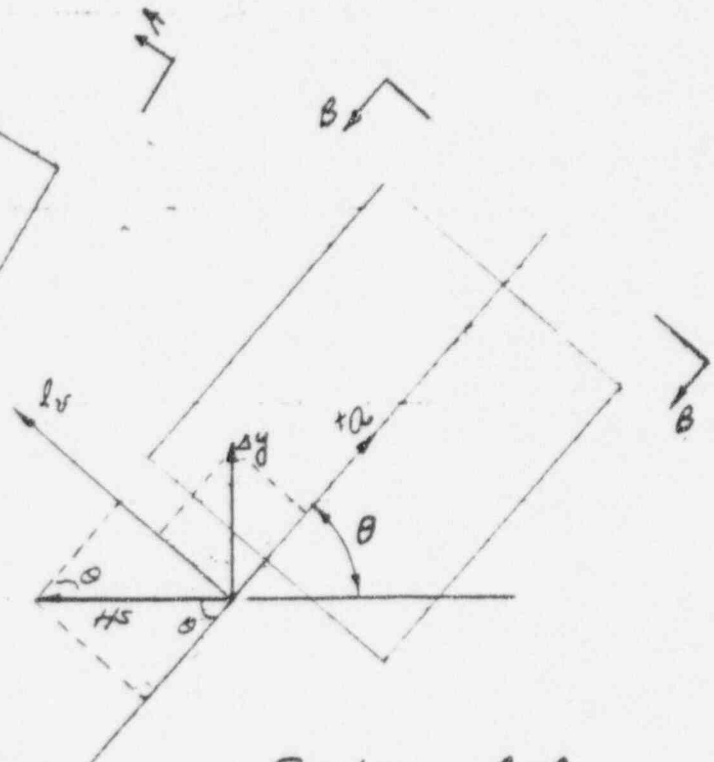
Design Conditions
Axial = .84"
Lateral = 1.14"

FILING CODE

Florida Power Corp.	MADE 12/4/73	GILBERT ASSOCIATES, INC.
Crystal River #3	CHK'D.	ENGINEERS AND CONSULTANTS
MSEJ-7 Flexonic Joint on MSV-38	SQ. CF.	READING, PENNA.
Movements Calculation	CF. DFN.	4203-27
	ENG. M. Z. Lee	WORK ORDER / SIZE / DRAWING / REV
	REV. CH. APP. DATE	



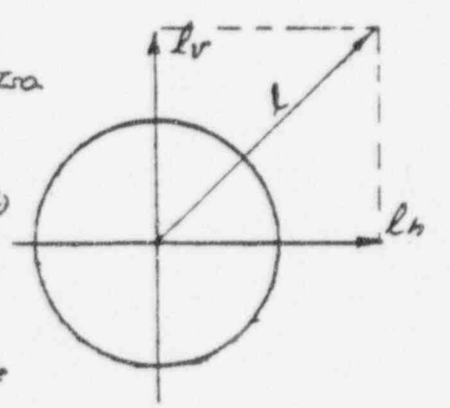
PLAN



Section A-A

Notes:

1. X-Y-Z matches with Iso.
2. a = axial movement
   l = lateral movement (⊥ axis of Flexonics)
   l_v = lateral movement in vertical plane
   l_h = lateral movement in horizontal plane



Section B-B

$\vec{H} = \vec{\Delta Z} + \vec{\Delta X}$

$|H| = \sqrt{(\Delta Z)^2 + (\Delta X)^2}$

$\varphi = \tan^{-1}\frac{\Delta X}{\Delta Z} + 35°$

$Hs = |H| \cdot \sin\varphi$

$l_h = |H| \cdot \cos\varphi$

$l_v = HS \cdot \sin\theta + \vec{\Delta y}\cos\theta$

$|l| = \sqrt{l_v^2 + l_h^2}$

$a = \vec{y} \cdot \sin\theta - HS \cdot \cos\theta$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC	FILING CODE
	PROJECT CR - UNIT 3	W.O. / PAGE 1 OF 9
SYSTEM CR - 4		ORIGINATOR A ECKENROTH DATE 12/5/73
CALCULATION FOR Movement of Safety Valve MSV-38		REVIEWER M.Z. Lee DATE 12/6/73

Thermal (Revision #1) Mov't @ Pt. FH-662

RESULTS

$\Delta X = -.1676''$
$\Delta Y = +.1735''$
$\Delta Z = +.8552''$

$$\vec{H} = \vec{\Delta Z} + \vec{\Delta X}$$

$$|H| = \sqrt{(.8552)^2 + (.1676)^2} = .8715''$$

$$\varphi = \tan^{-1}\frac{\Delta X}{\Delta Z} + 35^\circ =$$

$$\tan^{-1}(-.19598) + 35^\circ = -11^\circ + 35^\circ = 24^\circ$$

$$HS = |H| \cdot \sin\varphi = (.8715)\sin\varphi = .3545''$$

$$a = \vec{y}\sin\Theta - HS\cos\Theta$$

$$= (+.1735)\sin\Theta - (+.3545)\cos\Theta =$$
$$(+.1386) - (+.2133) = -.0747''$$

Axial Mov't = $-.0747''$

$l_h = |H| \cdot \cos 6$

$= (.8715) \cos 6 = +.7962$

$l_v = HS \cdot \sin \theta + \bar{\Delta y} \cos \theta =$

$(+.3545) \sin \theta + (+.1735) \cos \theta =$
$.2831 + .1044 = .3875$

$|l| = \sqrt{l_v^2 + l_h^2} =$

$\sqrt{(.3875)^2 + (.7962)^2} = .8855"$

Lateral Mov't = .8855"

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FILING CODE
PROJECT	W.O. / PAGE 3 OF 9
SYSTEM	ORIGINATOR
CALCULATION FOR	DATE / REVIEWER / DATE

RESULTS

Safety Valve (Case #3) Mov't @ Pt. FH-662

$\Delta X = +.0286''$
$\Delta Y = +.0122''$
$\Delta Z = +.0046''$

$$\vec{H} = \vec{\Delta Z} + \vec{\Delta X}$$

$$|H| = \sqrt{(+.0046)^2 + (.0286)^2} = .0290''$$

$$\phi = \tan^{-1}\frac{\Delta X}{\Delta Z} + 35° =$$

$$\tan^{-1}(+6.2174) + 35° =$$

$$81° + 35° = 116°$$

$$HS = |H| \cdot \sin\phi =$$

$$(.0290)\sin\phi = +.0261''$$

$$a = \vec{y}\sin\theta - HS\cos\theta$$

$$= (+.0122)\sin\theta - (+.0261)\cos\theta =$$
$$(+.0097) - (+.0157) = -.0060''$$

Axial Mov't = −.0060"

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FILING CODE
PROJECT	W.O. / PAGE 4 OF 9
SYSTEM	ORIGINATOR / DATE
CALCULATION FOR	REVIEWER / DATE

RESULTS

$lh = |H| \cdot \cos \varphi$

$= (.0290) \cos \varphi = -.0127''$

$lv = HS \cdot \sin \theta + \vec{\Delta Y} \cos \theta =$

$(+.0261) \sin \theta + (+.0122) \cos \theta =$
$(+.0208) + (+.0073) = +.0281''$

$|l| = \sqrt{lv^2 + lh^2} =$

$\sqrt{(.0281)^2 + (.0127)^2} = .0308''$

Lateral Mov't = .0308"

FILING

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 5 OF 9
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

RESULTS

Seismic Mov't @ Pt MZ-66

$\Delta X = \pm .0009''$
$\Delta Y = \pm .0116''$
$\Delta Z = \pm .0088''$

$$\vec{H} = \overrightarrow{\Delta Z} + \overrightarrow{\Delta X}$$

$$|H| = \sqrt{(.0088)^2 + (.0009)^2} = .0092''$$

$$\phi = \tan^{-1} \frac{\Delta X}{\Delta Z} + 35° =$$

$$\tan^{-1}(\pm .1023) + 35° =$$

$$\pm 6° + 35° = 29° \text{ or } 42°$$

$$HS = |H| \sin \phi =$$

$$(.0092) \sin \phi = .0045 \text{ or } .0062$$

$$a = \vec{y} \sin \theta - HS \cos \theta =$$

$$(\pm .0116) \sin \theta - (\pm .0045) \cos \theta =$$

$$(\pm .0093) - (\pm .0027) = \pm .0066''$$

Axial Mov't = ±.0066"

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FILING CODE
PROJECT	W.O. / PAGE 6 OF 9
SYSTEM	ORIGINATOR / DATE
CALCULATION FOR	REVIEWER / DATE
	RESULTS

$l_h = |H| \cdot \cos 6 =$

$(.0092) \cos 6 = .0080''$

$l_v = HS \sin \Theta + \vec{A_y} \cos \Theta =$

$(+.0062) \sin \Theta + (+.0116) \cos \Theta =$

$(+.0050) + (+.0070) = .0120''$

$|l| = \sqrt{l_v^2 + l_h^2} =$

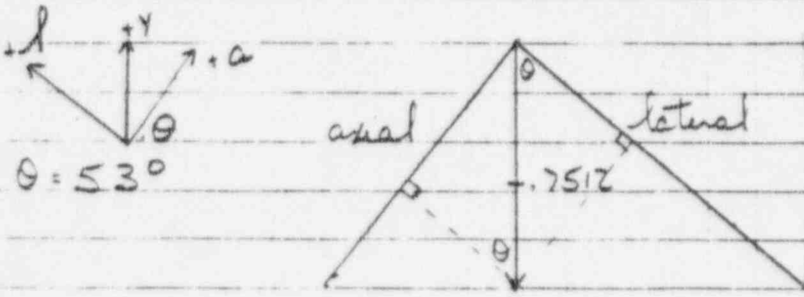
$\sqrt{(.0120)^2 + (.0080)^2} = .0144''$

Lateral Mov't = .0144"

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE	
		W.O.	PAGE 7 OF 9
SYSTEM		ORIGINATOR DATE	
CALCULATION FOR		REVIEWER DATE	

	RESULTS
Mov't on stack	
ELEV of anchor in roof = 149'-0"	
ELEV of safety valve = 128'-3"	
Length of stack = 20'-9"	
Expansion of A106-GR. B. steel @ 500°F = .0362 in/ft of pipe	
20.75 ft x .0362" in/ft = .7512 in	



θ = 53°

Axial Mov't = (-.7512) Sin θ =	-.5999"
(lw) Lateral Mov't = (-.7512) Cos θ =	-.4521"

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 8 OF 9
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

	RESULTS
<u>Total Mov't @ Pt. FH-662</u>	
Thermal + Safety Valve + Seismic Mov't	
Axial Mov't = (-.0747) + (-.0060) + (-.0066) =	-.0873"
	or
When Safety Valve is closed = (-.0747) + (+.0066) =	-.0681" (elongation)
Lateral Mov't l_v = (+.3875) + (+.0281) + (+.0120) =	+.4276"
	or
When Safety Valve is closed = (+.3875) + (+.0120) =	+.3995"
Lateral Mov't l_h = (+.7962) + (-.0127) + (+.0080) =	+.7915"
	or
When Safety Valve is closed = (+.7962) + (+.0080) =	+.8042"
Absolute Lateral Mov't = $\sqrt{(.4276)^2 + (.8042)^2}$ =	.9108"
<u>Total Movement</u>	
Axial Mov't = (+.5999) + (-.0873) =	+0.5126 ~~-.6872"~~
Lateral Mov't l_v = (-.4521) - (+.4276) =	-.8797"
Absolute Lateral Mov't = $\sqrt{(.8797)^2 + (.8042)^2}$ =	1.1909"

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

MSV-38 Summary
MSEJ-7

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT
AXIAL	-.0873"	~~-.6872"~~ + 0.5126 (COMPRESSION)
lv	+.4276"	-.8797"
lh	+.8042"	+.8042"
LATERAL |l|	.9108"	1.1909"

Elongation (WITHOUT STACK MOV)

Design Conditions

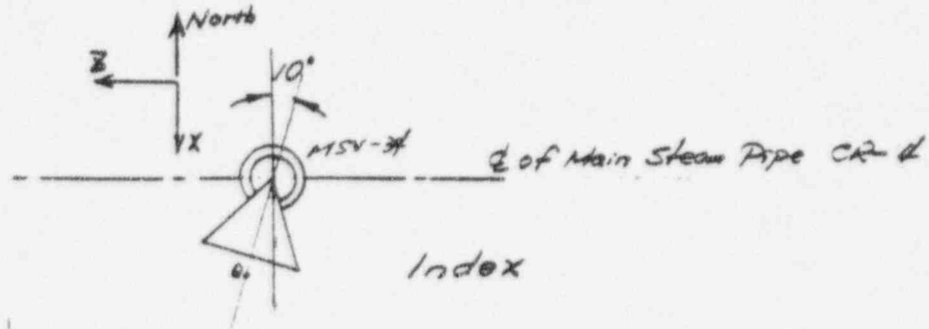
Axial = 0.84" Compression

Lateral = 0.77"

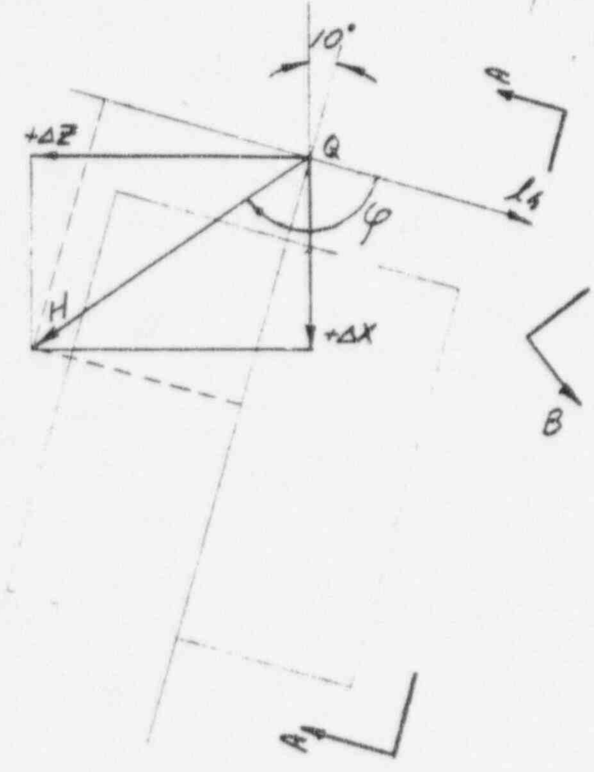
FILING CODE

GAI 350 REV. 10-72

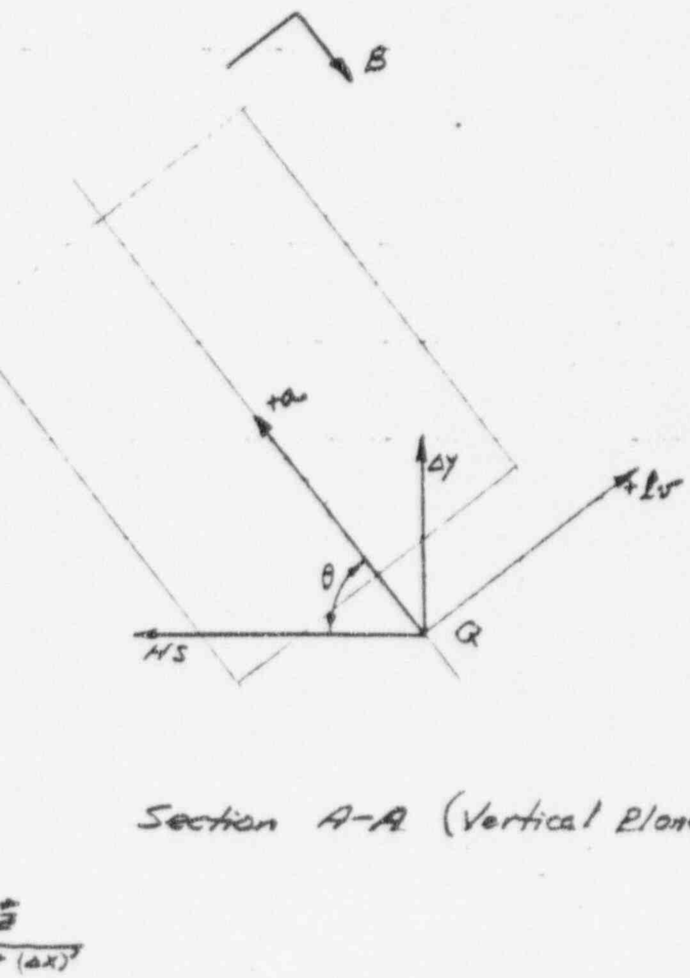
Florida Power Corp	MADE 12/6/73	GILBERT ASSOCIATES, INC.
	CHK'D.	ENGINEERS AND CONSULTANTS
	SO. CF.	READING, PENNA.
Crystal River #3	CF. DFM.	4203-027
MSEJ - 6 Flexonic Joint on MSV-34	ENG. M. Z. Lee	WORK ORDER · SIZE · DRAWING · REV.
Movement Calculation	REV. CK. APP. DATE	



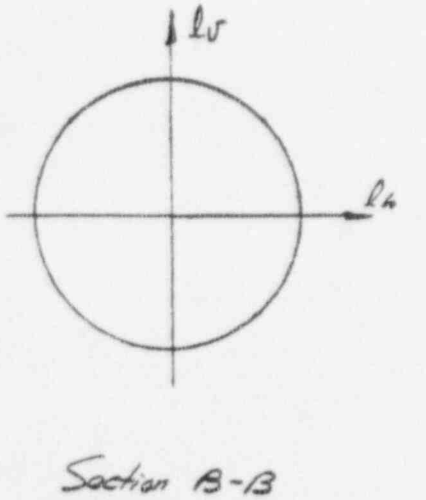
Index



Plan



Section A-A (Vertical Plane



Section B-B

$$\vec{H} = \vec{\Delta X} + \vec{\Delta Z}$$

$$|H| = \sqrt{(\Delta Z)^2 + (\Delta X)^2}$$

$$\varphi = \tan^{-1}\left(\frac{\Delta Z}{\Delta X}\right) + 80^\circ$$

$$H_S = |H| \cdot \sin\varphi$$

$$l_h = |H| \cdot \cos\varphi$$

$$l_v = \Delta y \cos\theta - H_S \cdot \sin\theta$$

$$|l| = \sqrt{l_v^2 + l_h^2}$$

$$a = y \cdot \sin\theta + H_S \cos\theta$$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC	FILING CODE	
	PROJECT CR UNIT 3	W.O.	PAGE 1 OF 9
SYSTEM CR-4		ORIGINATOR A. ECKENROTH DATE 12/6/73	
CALCULATION FOR Movement of Safety Valve MSV-34		REVIEWER H.Z. Lee DATE 12/08/73	

RESULTS

Thermal (Revision #1) Mov't @ Pt GH-722

$\Delta X = -.0458"$
$\Delta Y = +.1745"$
$\Delta Z = +.7156"$

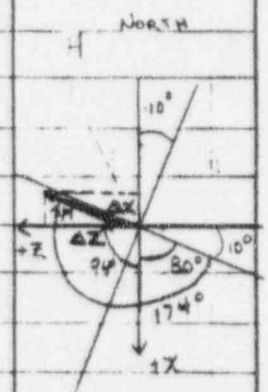
$$\vec{H} = \vec{\Delta X} + \vec{\Delta Z}$$

$$|H| = \sqrt{(.0458)^2 + (.7156)^2} = .7171"$$

$$\phi = \tan^{-1}\left(\frac{\Delta Z}{\Delta X}\right) + 80° =$$

$$\tan^{-1}(-15.6245) + 80° =$$

$$-94° + 80° = 174°$$



$$HS = |H| \sin\phi =$$

$$(.7171) \sin\phi = +.0750"$$

$$a = \vec{y} \sin\Theta + HS \cos\Theta =$$

$$(+.1745) \sin\Theta + (+.0750) \cos\Theta =$$

$$(+.1394) + (+.0451) = +.1845"$$

Axial Mov't = +.1845"

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FILING CODE
PROJECT	W.O. / PAGE 2 OF 9
SYSTEM	ORIGINATOR / DATE
CALCULATION FOR	REVIEWER / DATE

RESULTS

$lh = |H| \cdot \cos \phi$

$= (.7171) \cos \phi = -.7132$

$lv = \Delta y \cos \theta - HS \sin \theta =$

$(+.1745) \cos \theta - (+.0750) \sin \theta =$

$(+.1050) - (+.0599) =$

$+.0451''$

$|l| = \sqrt{lv^2 + lh^2} =$

$\sqrt{(.0451)^2 + (.7132)^2} = .7146''$

Lateral Mov't = .7146"

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 3 OF 9
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

RESULTS

Safety Valve (case #3) Mov't @ Pt. GH-722

$\Delta X = +.0167"$
$\Delta Y = -.0160"$
$\Delta Z = -.0007"$

$$\vec{H} = \vec{\Delta X} + \vec{\Delta Z}$$

$$|H| = \sqrt{(.0167)^2 + (.0007)^2} = .0167"$$

$$\phi = \tan^{-1}\left(\frac{\Delta Z}{\Delta X}\right) + 80° =$$

$$\tan^{-1}(-.0419) + 80° =$$

$$-2° + 80° = 78°$$

$$HS = |H| \sin \phi =$$

$$(.0167) \sin \phi = +.0163"$$

$$a = \vec{y} \cdot \sin\Theta + HS \cos\Theta =$$

$$(-.0160)\sin\Theta + (+.0163)\cos\Theta =$$
$$(-.0128) + (+.0098) =$$
$$-.0030"$$

Axial Mov't = $-.0030"$

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 4 OF 9
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER	
		DATE	

RESULTS

$lh = |H| \cdot \cos 6 =$

$(.0167) \cos 6 = +.0035"$

$lv = \Delta y \cos \Theta - H.S \cdot \sin \Theta =$

$(-.0160) \cos \Theta - (+.0163) \sin \Theta =$

$(-.0096) - (+.0130) =$

$-.0226"$

$|l| = \sqrt{lv^2 + lh^2} =$

$\sqrt{(.0226)^2 + (.0035)^2} = .0229"$

Lateral Movt = .0229"

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

Seismic Mov't @ Pt. NB-72

$\Delta X = \pm .0028''$

$\Delta Y = \pm .0085''$

$\Delta Z = \pm .0085''$

$$\vec{H} = \vec{\Delta x} + \vec{\Delta z}$$

$$|H| = \sqrt{(.0028)^2 + (.0085)^2} = .0089''$$

$$\phi = \tan^{-1}\left(\frac{\Delta z}{\Delta x}\right) + 80° =$$

$$\tan^{-1}(\pm 3.0357) + 80° =$$

$$\pm 72° + 80° = 8° \text{ or } 152°$$

$$HS = |H| \cdot \sin\phi =$$

$$(.0089) \sin\phi = +.0012'' \text{ or } +.0042''$$

$$a = \vec{y} \sin\theta \;\; HS \cos\theta =$$

$$(+.0085) \sin\theta + (+.0042)\cos\theta =$$

$$(+.0068) + (+.0025) = +.0093''$$

Axial Mov't = +.0093"

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 6 OF 9
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

RESULTS

$lh = |H| \cos 6 =$

$(.0089) \cos 6 = +.0088"$ or $-.0079"$

$lv = \Delta Y \cos\theta - HS \sin\theta =$

$(\pm.0085)\cos\theta - (+.0042)\sin\theta =$

$(\pm.0051) - (+.0034) =$

$-.0085"$ or $+.0017"$

$|l| = \sqrt{lv^2 + lh^2} =$

$\sqrt{(.0085)^2 + (.0088)^2} =$

$.0122"$

Lateral Mov t = .0122"

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FILING CODE
PROJECT	W.O. / PAGE 7 OF 9
SYSTEM	ORIGINATOR
CALCULATION FOR	DATE / REVIEWER / DATE

Mov't on stack

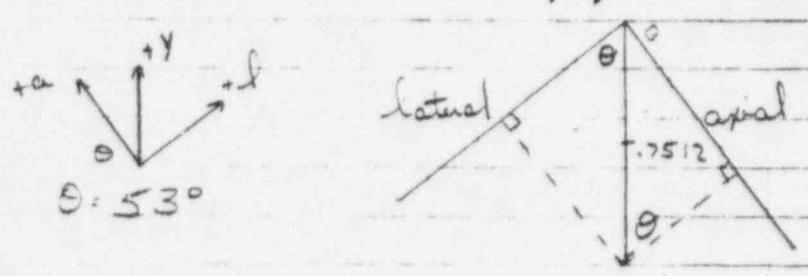
ELEV of anchor in roof = 149'-0"

ELEV of safety valve = 128'-3"

Length of stack = 20'-9"

Expansion of A106-GR B steel @ 500°F = .0362 in/ft. of pipe

20.75 ft x .0362 in/ft = .7512 in



	RESULTS
Axial Mov't = (-.7512) Sin θ =	-.5999" (compression)
(-l) Lateral Mov't = (-.7512) Cos θ =	-.4521"

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 8 OF 9
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE / REVIEWER / DATE	

RESULTS

Total Mov't @ Pt GH-722

Thermal + Safety Valve + Seismic Mov't

Axial Mov't = (+.1845) + (-.0030) + (+.0093) = +.1908"

or

When Safety Valve is closed = (+.1845) + (+.0093) = +.1938" (compression)

Lateral Mov't lv = (+.0451) + (-.0226) + (-.0085) = +.0140"

or

When Safety Valve is closed (+.0451) + (+.0017) +.0468"

Lateral Mov't lh = (-.7132) + (+.0035) + (+.0088) = -.7009"

or

When Safety Valve is closed (-.7132) + (-.0079) = -.7211"

Absolute Lateral Mov't |l| =

$$\sqrt{(.0468)^2 + (.7211)^2} = .7226"$$

Total Movement

Axial Mov't = (.5999) + (.1938) = .7937"

Lateral Mov't lv = (-.4521) − (+.0468) = -.4989"

Absolute Lateral Mov't |l| =

$$\sqrt{(.4989)^2 + (.7211)^2} = .8769"$$

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

MSV - 34 Summary
MSEJ - 6

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	RESULTS
AXIAL	.1938"	.7937"	compression
lv	+.0468"	-.4989"	
lh	-.7211"	-.7211"	
LATERAL lll	.7226"	.8769"	

Design Conditions

Axial = 0.84" compression

Lateral = 0.66"

FILING

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC	FILING CODE	
	PROJECT CR Unit 3	W.O. 4203-027	PAGE 1 of 6
SYSTEM CR-5		ORIGINATOR A. ECKENROTH DATE 12/3/73	
CALCULATION FOR Movement on Safety Valve MSV-48F		REVIEWER M.Z. Lee DATE 12/5/73	

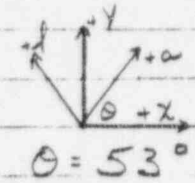
RESULTS

Thermal (Revision #1) movements @ Pt. EH-652

$\Delta X = +.1907''$

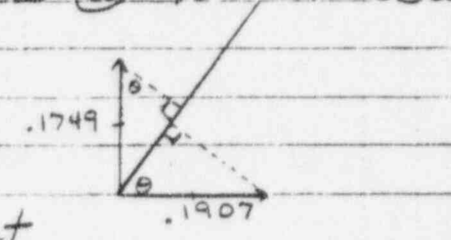
$\Delta Y = +.1749''$

$\Delta Z = +1.1043''$



$\theta = 53°$

Facing East



Axial Mov't = $(+.1749)\sin\theta + (+.1907)\cos\theta =$

$(+.1397) + (+.1148) =$

$+.2545''$

Lateral Mov't in XY Plane =

$(+.1749)\cos\theta - (+.1907)\sin\theta =$

$(+.1053) - (+.1523) =$

$-.0470$

Lateral Mov't off XY Plane ($\Delta Z = +1.1043$)

Absolute Lateral Mov't = $\sqrt{(1.1043)^2 + (\text{Lateral Mov't in XY})^2} =$

$\sqrt{(1.1043)^2 + (.0470)^2} =$

1.1053

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

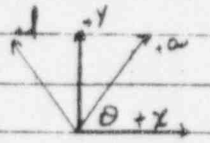
REVIEWER M. Z. Loo

DATE 10/5/73

RESULTS

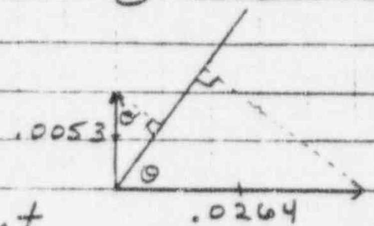
Safety Valve Loads (case # 2) mov't @ Pt EH-652

ΔX = +.0264"
ΔY = +.0053"
ΔZ = -.0128"



θ = 53°

Facing East



Axial Mov't = (+.0053) Sin θ + (+.0264) Cos θ -
(+.0042) + (+.0159) =
+.0201" or 0"

Lateral Mov't in XY Plane =
(+.0053) Cos θ − (+.0264) Sin θ
(+.0032) − (+.0211) =
−.0179" or 0"

Lateral Mov't off XY Plane = (ΔZ = −.0128")

Absolute Lateral Mov't = $\sqrt{(.0128)^2 + (\text{Lateral Mov't in XY})^2}$ =

$\sqrt{(.0128)^2 + (.0179)^2}$ =

.0220"

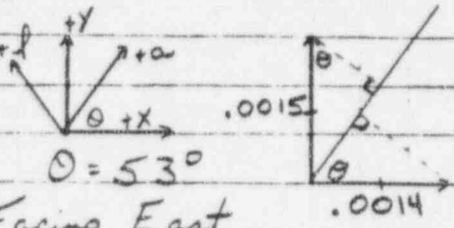
FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. / PAGE 3 OF 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE REVIEWER M. Z. Lee DATE 12/5/73
		RESULTS

Seismic Mov't @ Pt. MW-65

$\Delta X = \pm .0014"$
$\Delta Y = \pm .0015"$
$\Delta Z = \pm .0018"$ $\quad \theta = 53°$



Facing East

Axial Mov't = $(\pm.0015)\sin\theta + (\pm.0014)\cos\theta$
$(\pm.0012) + (\pm.0008) =$
$\pm.0020"$

Lateral Mov't in XY Plane =

$(\pm.0015)\cos\theta - (\pm.0014)\sin\theta$
$(\pm.0009) - (\pm.0011) =$
$\pm.0002"$

Lateral Mov't off XY Plane =

Absolute Lateral Mov't = $\sqrt{(.0018)^2 + (\text{Lateral Mov't in XY})^2} =$

$\sqrt{(.0018)^2 + (.0002)^2} =$

$.0018"$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 4 of 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE
		REVIEWER M. Z. Lee
		DATE 12/5/73

RESULTS

Stack Mov't due to Thermal Expansion

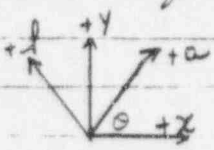
ELEV of anchor in roof = 149'-0"

ELEV of safety valve = 128'-0 7/16"

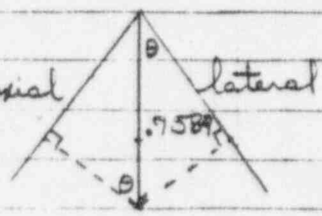
Length of stack = 20'-11 9/16"

* Expansion of A106 GR.B steel @ 500°F = .0362 in./ft. of pipe

20.9635 ft x .0362 in/ft = .7589 in



θ = 53°
Facing East



Axial Mov't = (-.7589) Sin θ = -.6061" (compressive)

Lateral Mov't in XY Plane = (-.7589) Cos θ = -.4567"

* Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines

FILING

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 5 OF 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE
		REVIEWER M.Z. Lee DATE 12/5/73

	RESULTS
Total Mov't @ Pt EH-652	
Thermal + Safety Valve + Seismic Mov't	
Axial Mov't = (+.2545) + (+.0201) + (+.0020) =	+.2766"
	OR
When Safety Valve is closed = (+.2545) + (+.0020) =	+.2565" (compressive)
Lateral Mov't in XY Plane = (-.0470) + (-.0179) + (-.0002) =	-.0651"
	OR
When Safety Valve is closed = (-.0470) + (+.0002) =	-.0468"
Mov't in Z Direction = (+1.1043) + (-.0128) + (+.0018) =	+1.0933"
When Safety Valve is closed = (+1.1043) + (+.0018) =	+1.1061"
Lateral Mov't off XY Plane = $\sqrt{(1.1061)^2 + (.0651)^2}$ =	1.1080"
Total Movement	
Axial Mov't = (.2766) + (.6061) =	.8827"
Lateral Mov't in XY Plane = (-.4567) - (-.0468) =	-.4099"
Lateral Mov't off XY Plane = $\sqrt{(1.1061)^2 + (.4099)^2}$ =	1.1796"

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 6 of 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER M. Z. Lee	DATE 12/5/73
		RESULTS	

MSV - 48 F Summary
MSEJ - 14

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT
AXIAL	.2766"	.8827"
XY	-.0651"	-.4099"
Z	+1.1061"	+1.1061"
LATERAL	1.1080"	1.1796"

Design Conditions

Axial = .84"

Lateral = 1.42"

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

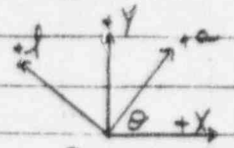
CLIENT: FPC
PROJECT: CR Unit 3
SYSTEM: CR-5
CALCULATION FOR: Movement of Safety Valve MSV-36

FILING CODE:
W.O.:

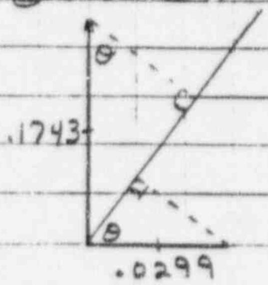
ORIGINATOR: A. Eckenroth
DATE 12/6/73
REVIEWER: H. Z. Lee
DATE 12/8/73
RESULTS

Thermal (Revision #1) movements @ Pt. IH-782

$\Delta X = +.0299''$
$\Delta Y = +.1743''$
$\Delta Z = +.8079''$ $\theta = 53°$



Facing East



Axial Mov't = $(+.1743)\sin\theta + (+.0299)\cos\theta$ =
$(+.1392) + (+.0180) =$
$+.1572''$

Lateral Mov't in XY Plane =
$(+.1743)\cos\theta - (+.0299)\sin\theta =$
$(+.1049) - (+.0239) =$
$+.0810''$

Lateral Mov't off XY Plane ($\Delta Z = +.8079''$)

Absolute Lateral Mov't $= \sqrt{(.8079)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(.8079)^2 + (.0810)^2} =$

$.8120''$

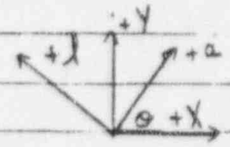
FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 2 OF 6
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER	
		DATE	

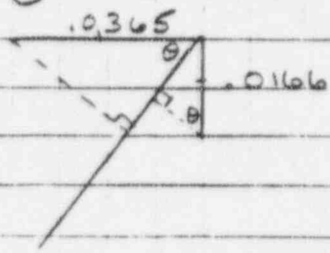
RESULTS

Safety Valve Loads (case #2) mov't @ Pt. IH-782

ΔX = -.0365"
ΔY = -.0166"
ΔZ = -.0162"



θ = 53°
Facing East



Axial Mov't = (-.0166) Sin θ + (-.0365) Cos θ =
(-.0133) + (-.0220) =
-.0353" or 0"

Lateral Mov't in XY Plane =
(-.0166) Cos θ - (-.0365) Sin θ =
(-.0100) - (-.0292) =
+.0192" or 0"

Lateral Mov't off XY Plane (ΔZ = -.0162")

Absolute Lateral Mov't = $\sqrt{(.0162)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(.0162)^2 + (.0192)^2}$ =

.0251"

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 3 OF 6
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

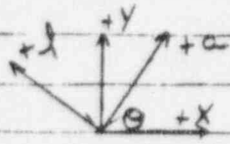
RESULTS

Seismic Mov't @ Pt. NC-78

$\Delta X = \pm .0010''$

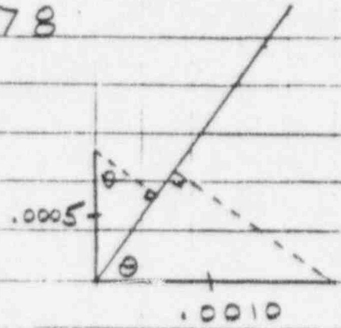
$\Delta Y = \pm .0005''$

$\Delta Z = \pm .0007''$



$\theta = 53°$

Facing East



Axial Mov't = $(\pm .0005)\sin\theta + (\pm .0010)\cos\theta$ =

$(\pm .0004) + (\pm .0006) =$

$\pm .0010''$

Lateral Mov't in XY Plane =

$(\pm .0005)\cos\theta - (\pm .0010)\sin\theta =$

$(\pm .0003) - (\pm .0008) =$

$\pm .0011''$

Lateral Mov't off XY Plane ($\Delta Z = \pm .0007''$)

Absolute Lateral Mov't = $\sqrt{(.0007)^2 + (\text{Lateral Mov't in XY})^2}$ =

$\sqrt{(.0007)^2 + (.0011)^2} =$

$.0013''$

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 4 OF 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE / REVIEWER / DATE

RESULTS

Stack Mov't due to Thermal Expansion

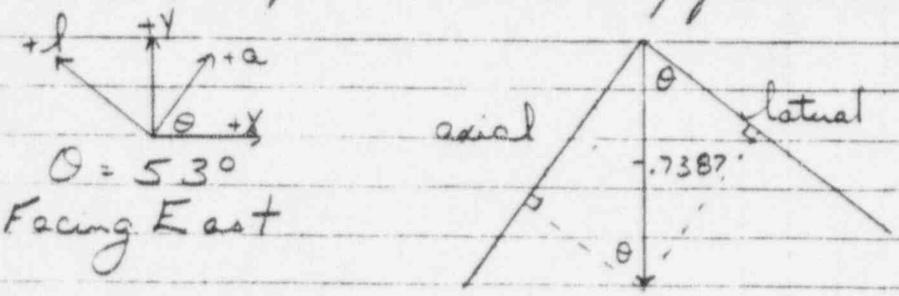
ELEV of anchor in roof = 149'-0"

ELEV of safety valve = 128'-7 1/8"

Length of stack = 20'-4 7/8"

* Expansion of A106 GR B steel @ 500°F = .0362 in / ft. of pipe

20.4063 ft x .0362 in/ft = .7387 in



θ = 53°
Facing East

Axial Mov't = (-.7387) Sin θ = -.5900" (compressive)

Lateral Mov't in XY Plane = (-.7387) Cos θ = -.4446"

*Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 5 of 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE / REVIEWER / DATE

	RESULTS
<u>Total Mov't @ Pt IH-782</u>	
Thermal + Safety Valve + Seismic Mov't	
Axial Mov't = (+.1572)+(−.0353)+(+.0010) =	+.1229"
When Safety Valve is closed = (+.1572)+(+.0010) =	or +.1582" (compressive)
Lateral Mov't in XY Plane = (+.0810)+(+.0192)+(+.0011) =	+.1013"
When Safety Valve is closed = (+.0810)+(−.0011) =	+.0799"
Mov't in Z Direction = (+.8079)+(−.0162)+(+.0007) =	+.7924"
When Safety Valve is closed = (+.8079)+(+.0007)	+.8086"
Lateral Mov't off XY Plane = $\sqrt{(.8086)^2 + (.1013)^2}$ =	.8149"
<u>Total Movement</u>	
Axial Mov't = (.5900) + (.1582) =	.7482"
Lateral Mov't in XY Plane = (−.4446) − (+.1013) =	−.5459"
Lateral Mov't off XY Plane = $\sqrt{(.8086)^2 + (.5459)^2}$ =	.9756"

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

MSV-36 Summary
MSEJ-11

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	
AXIAL	.1582"	.7482"	Compression
XY	+.1013"	-.5459"	
Z	+.8086"	+.8086"	
LATERAL	.8149"	.9756"	

Design Conditions

Axial = 0.9" compression

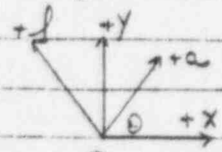
Lateral = 0.84"

FILING CODE

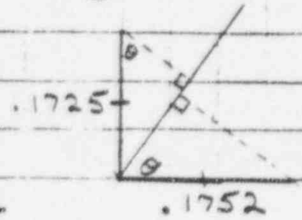
GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC	FILING CODE	
	PROJECT CR UNIT #3	W.O. 4203-027	PAGE 1 OF 6
SYSTEM CR-6A		ORIGINATOR A ECKENROTH	
CALCULATION FOR Movement on Safety Valve MSV-47F		DATE 12/3/73	
		REVIEWER M. Z. Lee	
		DATE 12/5/73	
		RESULTS	

Thermal (Revision #1) movements @ Pt ID-723

ΔX = +.1752"
ΔY = +.1725"
ΔZ = +.9191"



θ = 53°
Facing East



Axial Mov't = (+.1725) Sin θ + (+.1752) Cos θ =
(+.1378) + (+.1054) =
+.2432"

Lateral Mov't in XY Plane =
(+.1725) Cos θ − (.1752) Sin θ =
(+.1038) − (+.1399) =
−.0361"

Lateral Mov't off XY Plane =

Absolute Lateral Mov't = $\sqrt{(.9191)^2 + (\text{Lateral Mov't in XY})^2}$ =

$\sqrt{(.9191)^2 + (.0361)^2}$ =

.9198"

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. PAGE 2 OF 6
SYSTEM		ORIGINATOR DATE
CALCULATION FOR		REVIEWER DATE

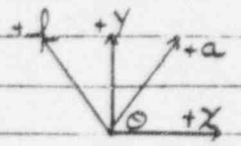
RESULTS

Safety Valve Loads (case #1) mov't @ Pt. IO-723

$\Delta X = -.0230''$

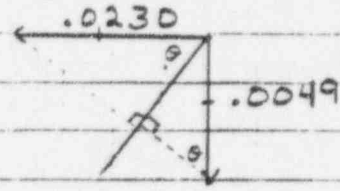
$\Delta Y = -.0049''$

$\Delta Z = +.0103''$



$\theta = 53°$

Facing East



Axial Mov't = $(-.0049)\sin\theta + (-.0230)\cos\theta =$

$(-.0039) + (-.0138) =$

$-.0177''$ or $0''$

Lateral Mov't in XY Plane =

$(-.0049)\cos\theta - (-.0230)\sin\theta$

$(-.0029) - (-.0184) =$

$+.0155''$ or $0''$

Lateral Mov't off XY Plane =

Absolute Lateral Mov't = $\sqrt{(.0103)^2 + (\text{Lateral Mov't in XY})^2} =$

$\sqrt{(.0103)^2 + (.0155)^2} =$

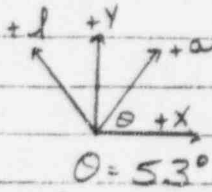
$.0186''$

FILING CODE

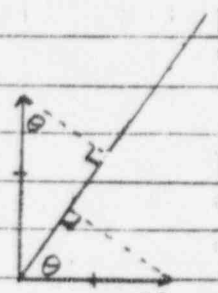
GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O.	PAGE 3 OF 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE
		REVIEWER
		DATE
		RESULTS

Seismic Mov't @ Pt. NA-72

$\Delta X = \pm .0089"$
$\Delta Y = \pm .0231"$
$\Delta Z = \pm .0088"$



θ = 53°
Facing East



Axial Mov't = $(\pm.0231)\sin\theta + (\pm.0089)\cos\theta$
$(\pm.0184) + (\pm.0054) =$
$\pm .0238"$

Lateral Mov't in XY Plane =
$(\pm.0231)\cos\theta - (\pm.0089)\sin\theta$
$(\pm.0139) - (\pm.0071) =$
$\pm .0068"$

Lateral Mov't off XY Plane

Absolute Lateral Mov't = $\sqrt{(.0088)^2 + (\text{Lateral Mov't in XY})^2} =$

$\sqrt{(.0088)^2 + (.0068)^2} =$

$.0111"$

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 4 OF 6
SYSTEM		ORIGINATOR
CALCULATION FOR		DATE / REVIEWER / DATE

RESULTS

Stack Mov't due to Thermal Expansion

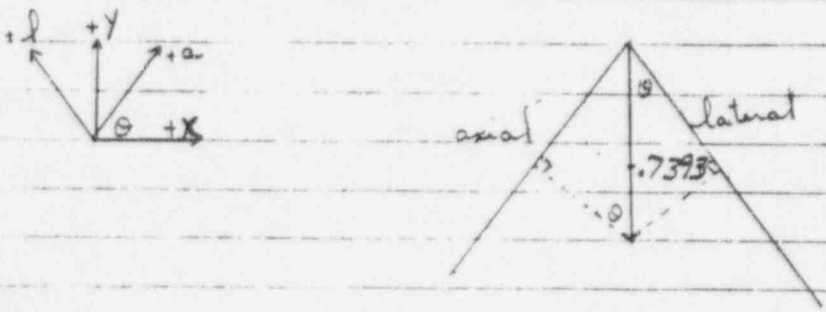
ELEV. of anchor in roof = 149'-0"

ELEV of safety valve = 128'-6 15/16"

Length of stack = 20'-5 1/16"

* Expansion of A106-GR B steel @ 500°F = .0362 in /ft. of pipe

20.4219 ft x .0362 in/ft = .7393 in



Axial Mov't = (-.7393) Sin θ = | -.5904" (compressive)

Lateral Mov't in XY Plane = (-.7393) Cos θ = | -.4449"

* Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines.

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 5 OF 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

	RESULTS
Total Mov't @ Pt. ID-723 =	
Thermal + Safety Valve + Seismic Mov't	
Axial Mov't = (+.2432) + (-.0177) + (+.0238) =	+.2493"
	OR
When Safety Valve is closed = (+.2432) + (+.0238) =	+.2670" (compressive)
Lateral Mov't in XY Plane = (-.0361) + (+.0155) + (+.0068) =	-.0138"
	OR
When Safety Valve is closed = (-.0361) + (-.0068) =	-.0429"
Mov't in Z Direction = (+.9191) + (+.0103) + (+.0088) =	+.9382"
	OR
When Safety Valve is closed = (+.9191) + (+.0088) =	+.9279"
Lateral Mov't off XY Plane = $\sqrt{(.9382)^2 + (.0429)^2}$ =	.9392"
Total Movement	
Axial Mov't = (.2493) + (.5904) =	.8397"
Lateral Mov't in XY Plane = (-.4449) - (-.0138) =	-.4311"
Lateral Mov't off XY Plane = $\sqrt{(.9382)^2 + (.4311)^2}$	1.0325"

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

MSV-47F Summary
MSEJ-18

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT
AXIAL	.2670"	.8397"
XY	-.0429"	-.4311"
Z	+.9382"	+.9382"
LATERAL	.9392"	1.0325"

Design Conditions
Axial = .84"
Lateral = 1.32"

FILING CODE

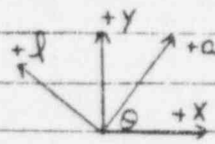
GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT: FPC	FILING CODE	
	PROJECT	W.O.	PAGE 1 OF 6
SYSTEM: CR-6A		ORIGINATOR: A. ECKENROTH DATE 12/6/73	
CALCULATION FOR: Movement on Safety Valve MSV-35		REVIEWER: M. Z. Lee DATE 12/08/73	
		RESULTS	

Thermal (Revision #1) movements @ Pt IG-853

$\Delta X = +.0783''$

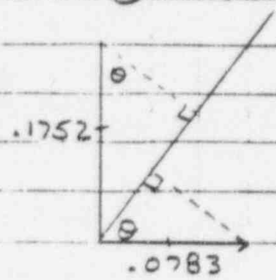
$\Delta Y = +.1752''$

$\Delta Z = +.6318''$



$\Theta = 53°$

Facing East



Axial Mov't = $(+.1752)\sin\Theta + (+.0783)\cos\Theta$ =
$(+.1399) + (+.0471) =$
$+.1870''$

Lateral Mov't in XY Plane =
$(+.1752)\cos\Theta - (.0783)\sin\Theta$
$(+.1054) - (+.0625) =$
$+.0429''$

Lateral Mov't off XY Plane ($\Delta Z = +.6318''$)

Absolute Lateral Mov't = $\sqrt{(.6318)^2 + (\text{Lateral Mov't in XY})^2}$ =

$\sqrt{(.6318)^2 + (.0429)^2} =$

$.6333''$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 2 OF 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

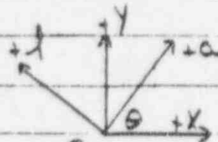
RESULTS

Safety Valve Loads (case #1) mov't @ Pt. IG-853

$\Delta X = -.0172"$

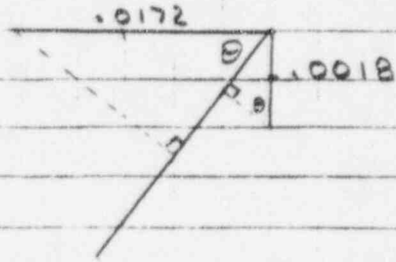
$\Delta Y = -.0018"$

$\Delta Z = -.0013"$



$\theta = 53°$

Facing East



Axial Mov't = $(-.0018)\sin\theta + (-.0172)\cos\theta =$

$(-.0014) + (-.0104) =$

$-.0118"$ or $0"$

Lateral Mov't in XY Plane =

$(-.0018)\cos\theta - (-.0172)\sin\theta =$

$(-.0010) - (-.0137) =$

$+.0127"$ or 0

Lateral Mov't off XY Plane ($\Delta Z = +.0013$)

Absolute Lateral Mov't = $\sqrt{(.0013)^2 + (\text{Lateral Mov't in XY})^2} =$

$\sqrt{(.0013)^2 + (.0127)^2} =$

$.0128"$

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. / PAGE 3 of 6
SYSTEM		ORIGINATOR DATE
CALCULATION FOR		REVIEWER DATE

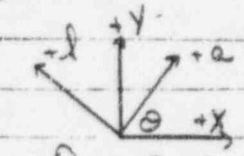
RESULTS

Seismic Mov't @ Pt. NG-85

$\Delta X = \pm .0062''$

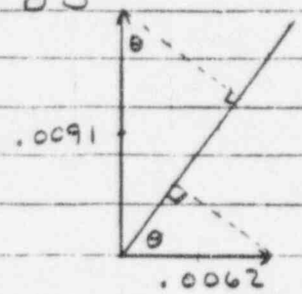
$\Delta Y = \pm .0091''$

$\Delta Z = \pm .0160''$



$\theta = 53°$

Facing East



Axial Mov't = $(\pm .0091) \sin\theta + (\pm .0062) \cos\theta =$

$(\pm .0073) + (\pm .0037) =$

$\pm .0110''$

Lateral Mov't in XY Plane =

$(\pm .0091) \cos\theta - (\pm .0062) \sin\theta$

$(\pm .0055) - (\pm .0050) =$

$\pm .0105''$

Lateral Mov't off XY Plane ($\Delta Z = \pm .0160''$)

Absolute Lateral Mov't $= \sqrt{(.0160)^2 + (\text{Lateral Mov't in XY})^2}$

$\sqrt{(.0160)^2 + (.0105)^2} =$

$.0191''$

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O.	PAGE 4 OF 6
SYSTEM		ORIGINATOR DATE	
CALCULATION FOR		REVIEWER DATE	

Stack Mov't due to Thermal Expansion

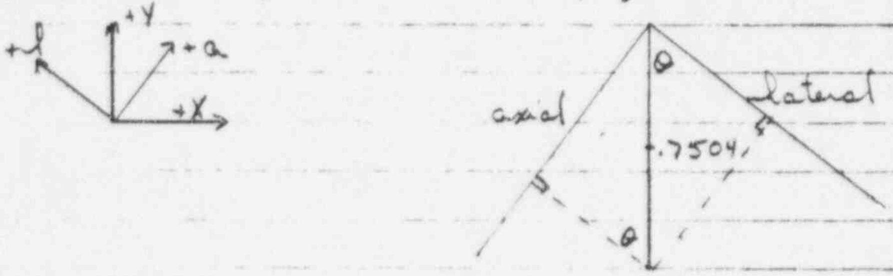
ELEV of anchor in roof = 149'-0"

ELEV of safety valve = 128'-3 1/4"

Length of stack = 20'-8 3/4"

* Expansion of A106 GR B steel @ 500°F = .0362 in/ft of pipe

20.7292 ft x .0362 in/ft = .7504 in.



Axial Mov't = (-.7504) Sin θ = -.5993" (compressive)

Lateral Mov't = (-.7504) Cos θ = -.4516"

* Temperature is found in pipe specifications (page 65) for Safety Valve Relief Lines

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 5 OF 6
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

RESULTS

Total Mov't @ Pt IG-853

Thermal + Safety Valve + Seismic Mov't

Axial Mov't = (+.1870) + (-.0118) + (+.0110) = +.1862"
or
When Safety Valve is closed = (+.1870) + (+.0110) +.1980 (compressive)

Lateral Mov't in XY Plane =
(+.0429) + (+.0127) + (+.0105) = +.0661"
or
When Safety Valve is closed (+.0429) + (-.0105) = +.0324"

Mov't in Z Direction =
(+.6318) + (-.0013) + (+.0160) = +.6465"
or
When Safety Valve is closed (+.6318) + (+.0160) = +.6478"

Lateral Mov't off XY Plane =

$$\sqrt{(.6478)^2 + (.0661)^2} = .6512"$$

Total Movement

Axial Mov't = (.5993) + (.1980) = .7973"

Lateral Mov't in XY Plane = (-.4516) - (+.0661) = -.5177"

Lateral Mov't off XY Plane =

$$\sqrt{(.6478)^2 + (.5177)^2} = .8293"$$

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

SYSTEM

ORIGINATOR

CALCULATION FOR

DATE

REVIEWER

DATE

RESULTS

MSV-35F Summary
MSEJ-15

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	RESULTS
AXIAL	.1980"	.7973"	Compression
XY	+.0661"	-.5177"	
Z	+.6478"	+.6478"	
LATERAL	.6512"	.8293"	

Design Conditions

Axial = 0.84"

Lateral = 0.76"

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE OF
SYSTEM CR-3		ORIGINATOR G. ARAUZ DATE 1-3-73	
CALCULATION FOR Movement on Safety Valve MSV-46V		REVIEWER DATE	

RESULTS

Stack Mov't due to Thermal Expansion

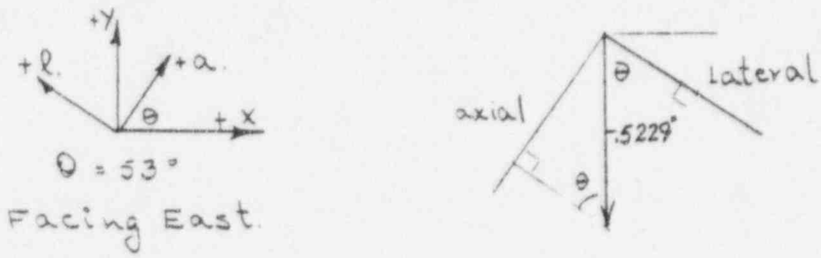
ELEV of anchor in roof = 149'-0"

ELEV. of safety valve = 128'-3"

Length of stack = 20'-9"

Expansion of A106-GR. B steel @ 380°F = .0252 in/ft. of pipe.

20.75 ft x .0252 in/ft = 0.5229 in



Axial Mov't = (-0.5229) sin. θ = -.4176" (compressive)

Lateral Mov't in XY Plane = (-0.5229) cos. θ = -.3147"

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE OF
SYSTEM		ORIGINATOR G. ARAUZ DATE 1-3-74	
CALCULATION FOR		REVIEWER DATE	

RESULTS

Total Mov't @ Pt. HO-51

Thermal + Safety Valve + Seismic Mov't

Axial Mov't = (+.3232) + (-.0283) + (+.0077) = +.3026"

OR

When Safety Valve is Closed = (+.3232) + (+.0077) = +.3309" (compressive)

Lateral Mov't in XY Plane =
(-.1374) + (+.0299) + (+.0040) = -.1035"

OR

When Safety Valve is Closed = (-.1374) + (-.0040) = -.1414"

Mov't in Z direction =
(+.8246) + (+.0614) + (+.0278) = +.9138"

OR

When safety Valve is closed = (+.8246) + (+.0278) = +.8524

Lateral Mov't off XY Plane =

$$\sqrt{(.9138)^2 + (.1414)^2} = .9247"$$

Total Movement

Axial Mov't = (.3309) + (.4176) = .7485

Lateral Mov't in XY Plane = (-.3147) - (-.1035) = -.2112"

Lateral Mov't off XY Plane =

$$\sqrt{(.9138)^2 + (.2112)^2} = .9379"$$

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. PAGE OF
SYSTEM		ORIGINATOR G. ARAUZ DATE 1-3-74
CALCULATION FOR		REVIEWER DATE

MSV-46F SUMMARY
MSEJ-4

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	RESULTS
AXIAL	.3309"	.7485"	Compression
X - Y	-.1414"	-.2112"	
Z	+.9138"	+.9138"	
LATERAL	.9247"	.9379"	

Design Conditions

Axial = .85" Compression max

Lateral = .81"

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FPC. PROJECT CR #3	FILING CODE	W.O.	PAGE OF
SYSTEM CR - 3		ORIGINATOR G. ARAUZ DATE 1-3-74		
CALCULATION FOR Movement of Safety Valve MSV-42		REVIEWER DATE		

RESULTS

STACK MOV'T DUE TO THERMAL EXPANSION

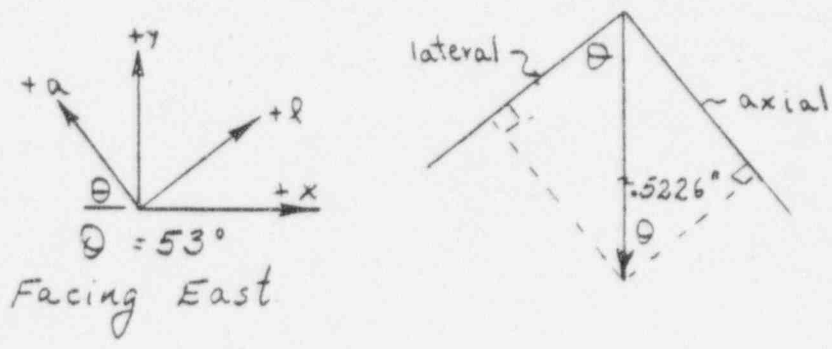
ELEV of ANCHOR IN ROOF = 149'-0"

ELEV. OF SAFETY VALVE = 128'-3 1/8"

LENGTH OF STACK = 20'-8 7/8"

Expansion of A106-GR-B steel @ 380°F = .0252 in/ft. of pipe

20.7396 ft × .0252 in/ft = 0.5226 in



Axial Mov't = (-.5226) sin θ = -.4174" (Compressive)

Lateral Mov't in XY Plane = (-.5226) cos θ = -.3145"

GAI 350 REV. 10-72

FILING

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE OF
SYSTEM		ORIGINATOR G. ARAUZ DATE 1-3-74	
CALCULATION FOR		REVIEWER DATE	

TOTAL MOV'T @ Pt. HP-58 =

Thermal + Safety Valve + Seismic Mov't

	RESULTS
Axial Mov't = (+.1588) + (+.0037) + (+.0027) =	+.1652" OR
When Safety Valve is closed = (+.1588) + (+.0027) =	+.1615" (compressive)
Lateral Mov't in xy Plane = (+.0786) + (-.0144) + (-.0030) =	+.0612" OR
When Safety is closed = (+.0786) + (+.0030) =	+.0816"
Mov't in Z Direction = (+.9852) + (+.0197) + (+.0291) =	+1.0340"
When Safety Valve is closed = (+.9852) + (+.0291) =	+1.0143"
Lateral Mov't off XY Plane = $\sqrt{(1.0340)^2 + (.0816)^2}$ =	1.0372"
Total Movement.	
Axial Mov't = (.4174) + (.1652) =	.5826"
Lateral Mov't in XY Plane = (-.3145) - (+.0816) =	-.3961"
Lateral Mov't off XY Plane = $\sqrt{(1.0340)^2 + (.3961)^2}$ =	1.1073"

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O. | PAGE OF

SYSTEM

CALCULATION FOR

ORIGINATOR G. ARAUZ
DATE 1-3-74
REVIEWER
DATE
RESULTS

MSY-42F SUMMARY
MSEJ-3

DIRECTION	WITHOUT STACK MOVEMENT	WITH STACK MOVEMENT	
AXIAL	.1652"	.5826"	Compressive
XY	+.0816"	-.3961"	
Z	+1.0340"	1.0340"	
LATERAL	1.0372"	1.1073	

Design Conditions

Axial = 0.84"

Lateral = 0.73"

FILING CODE

GAI 350 REV. 10-72

File

CR #3 II-21

CRYSTAL RIVER #3

Main Steam Pipe

Steam Hammer Analysis

S4203MS02A0

For final steam-
hammer restraints
Please see
Restraints ...
at the back of this
report

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203M502A0
	PROJECT Crystal River #3	W.O. 4203-027 PAGE 1 OF
SYSTEM Main Steam Ping		ORIGINATOR M.Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER
		DATE
		RESULTS

Assumptions

1. Turbine emergency stop valves are energized to close when the turbine is operating at max load.

2. No steam is extracted or released from the main steam piping when the valve is closing and sometime thereafter.

3. Turbine emergency stop valves close according to the time history shown in Fig. 1.

4. Net travelling time of value is 0.15 Sec.

FILING CODE

GAI 350 REV. 10-73

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203 MS02 A0
	PROJECT Crystal River #3	W.O. / PAGE 2 OF
SYSTEM Main Steam Ping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER / DATE

RESULTS

DATA

Operating Conditions

Steam Pressure	1065.0 psia
Steam Temperature	600° F
Flow Rate	2,784,350. #/hr
Ratio of Specific Heat, C_p/C_v	1.27
Pipe I.D.	22.064 in

Calculated Initial Conditions

Steam Velocity	137.8 ft/sec
Acoustic Velocity	1,722.5 ft/sec
Pressure Drop in Valve	5.344 psi
Density	0.065644 $lb\text{-}sec^2/ft^4$
Entropy	1.4329 BTU/lb °R
Specific Weight	2.1137 lbs/ft^3

Valve Closing Time

Information obtained from Westinghouse

Total closing time	0.25 Sec
Valve travelling time	0.15 Sec

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT Crystol River #3	FILING CODE S4203M502A0 W.O. / PAGE 3 OF
SYSTEM	Main Steam Piping	ORIGINATOR M.Z. Lee DATE 11/2/73
CALCULATION FOR	Steam Hammer	REVIEWER DATE

RESULTS

Unbalanced Force

Maximum pressure increase due to stop valve closure computed by GAI Computer Program M015 is

$$\Delta p_{max} = 113.27 \text{ psi}$$

$\Delta p(\tau)$ is plotted in Fig. 1 along with $A(\tau)$ for dimensionless time τ.

Maximum slope of pressure increase curve is

$$\left.\frac{dp}{d\tau}\right|_{max} = \frac{\Delta p(0.7) - \Delta p(0.4)}{0.3} = \frac{58}{0.3} = 193 \text{ psi/wave length}$$

Unbalanced Force

$$F_{max} = \Delta p_{max} \cdot A = 113.27 \cdot \frac{\pi}{4}(22.064)^2 = 43309^{lb} = 43.3 \text{ Kips}$$

$$\left.\frac{dF}{d\tau}\right|_{max} = \left.\frac{d\Delta p}{d\tau}\right|_{max} A = 193 \times \frac{\pi}{4}(22.063)^2 = 73.7 \text{ Kips/wave length}$$

It is easily seen that the maximum axial thrust on i-th section of pipe with length l_i can be approximated by

$$U_i \leq \min\left[F_{max}, \frac{l_i}{\lambda}\left.\frac{dF}{d\tau}\right|_{max}\right]$$

where λ = length of pressure wave

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203M502A0
	PROJECT Crystal River #3	W.O. / PAGE 4 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee
CALCULATION FOR Steam Hammer		DATE 11/2/73
		REVIEWER
		DATE

RESULTS

For valve closing time $t_c = 0.15$ sec, the wave length is

$$\lambda = V_a t_c = 1722.5 \times 0.15 = 258 \text{ ft}$$

where V_a = acoustic velocity = 1722.5 ft/sec

Pressure gradient and unbalanced force gradient

$$\frac{dp'}{d\ell}\Big|_{max} = \frac{193}{258} = 0.75 \text{ psi/ft of pipe}$$

$$\frac{dF}{d\ell}\Big|_{max} = \frac{73.7}{258} = 0.286 \text{ Kips/ft of pipe}$$

FILING CODE

S 4203 M502A0 p5

	MADE 11/2/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
	CHK'D.	
	DG. CF.	
Crystal River #3	CF. DFN.	4203-027
Main Steam Steam Hammer	ENG. M.Z. Lee	WORK ORDER / SIZE / DRAWING / REV.
	REV. CK. APP. DATE	

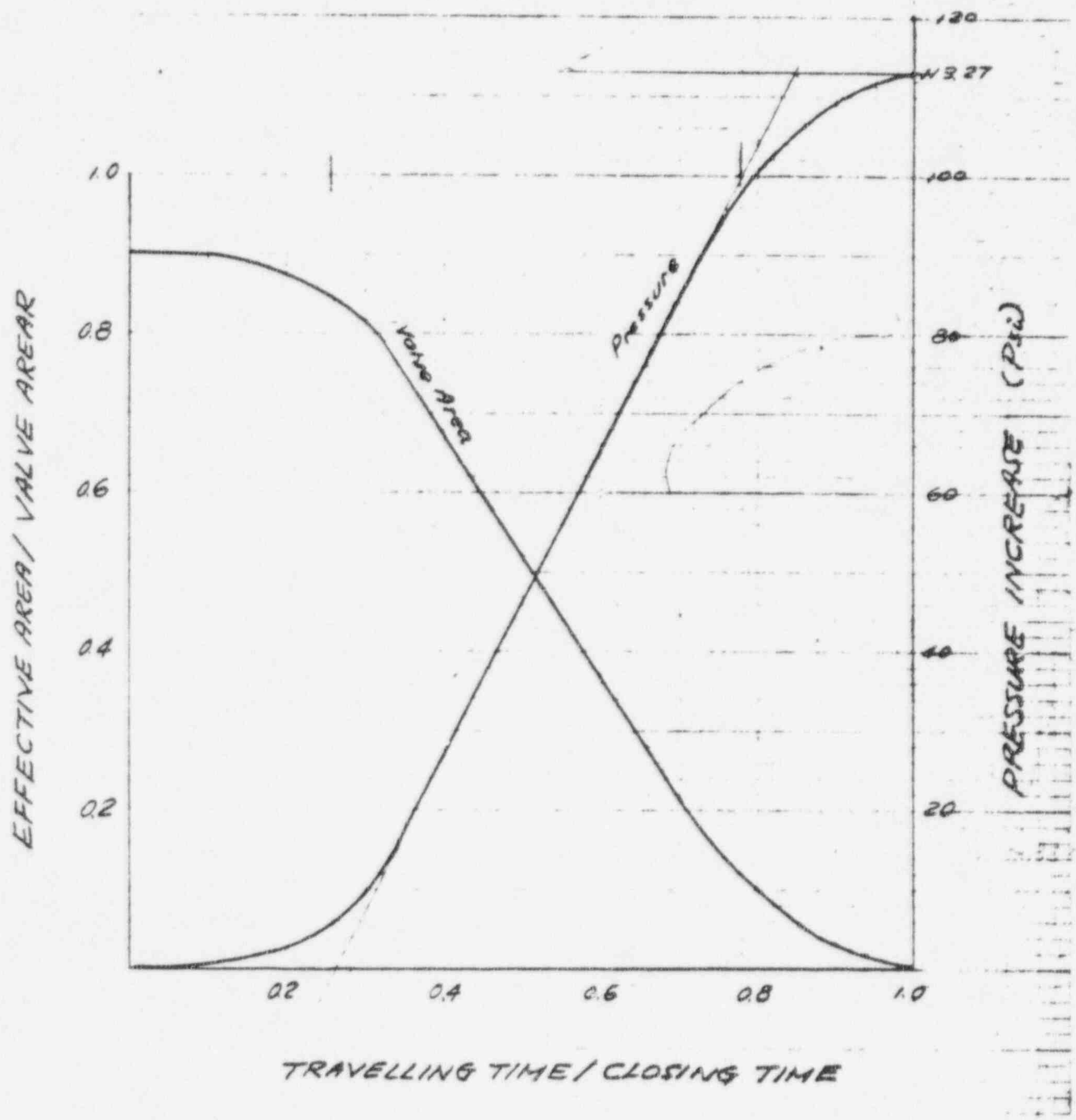


Fig. 1.

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT Crystol River #3

FILING CODE S4203 MS02A0

W.O.

PAGE 6 OF

SYSTEM Main Steom Piping

ORIGINATOR M. Z. Lee

DATE 11/2/73

CALCULATION FOR Steam Hammer

REVIEWER

DATE

RESULTS

Line CR-3A & Line CR-13A (Fig. 2)

Sec. No. i	Length l_i	Force U_i	Existing Snubber Capcity	Additional Snubber	Notes	Results
1	27.552	7.85	0 Kips		Connected to Turbine Stop valve	
2	29.438	8.4	49.5			MSH-237
3	67.25	19.2	49.5			-238
4	12.73	3.6	49.5			-239
5	23.75	6.6	49.5			-240
6	21.406	6.0	0		Restrained by Penetr. Anchor	
7	21.469	6.0	0		"	
8	16.88	4.7	0		"	
9	19.6	5.5	0	49.5 Kip		MSH-162
10	22.99	6.3	0	49.5		
11	9.67	2.7	0	30		
12	23.672	6.7	0		Connected to Steam Gen.	

FILING CODE

Crystal River #3	MADE 11/2/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
Main Steam Piping	CHK'D.	
Steam Hammer	SQ. CF.	
	CF. DFN.	4203-027
	ENG. M. Z. Lee	WORK ORDER / SIZE / DRAWING / REV.
	REV. CK. APP. DATE	

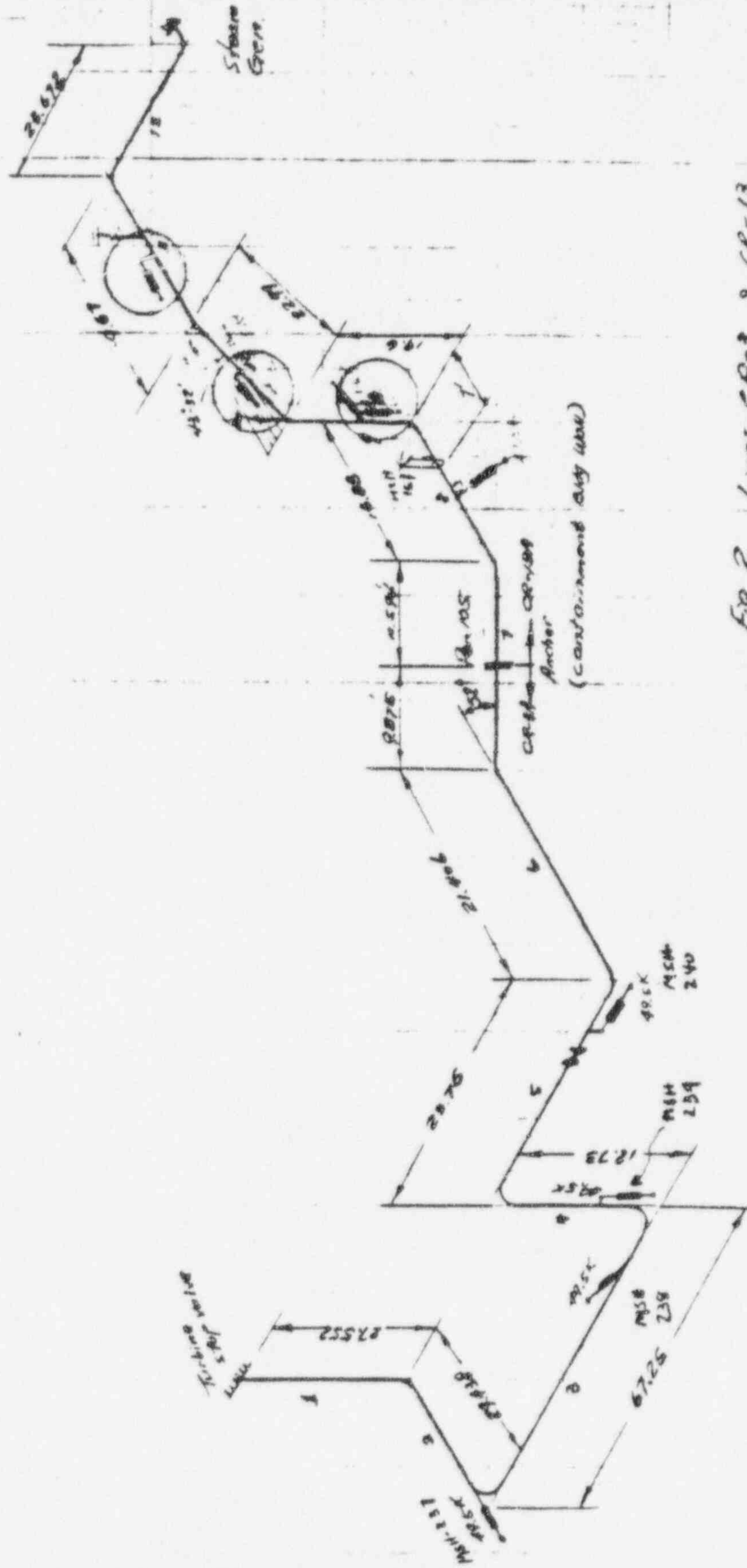


Fig. 2 Lines CR-3 & CR-13

Line CR-3 Outside Containment Bldg.

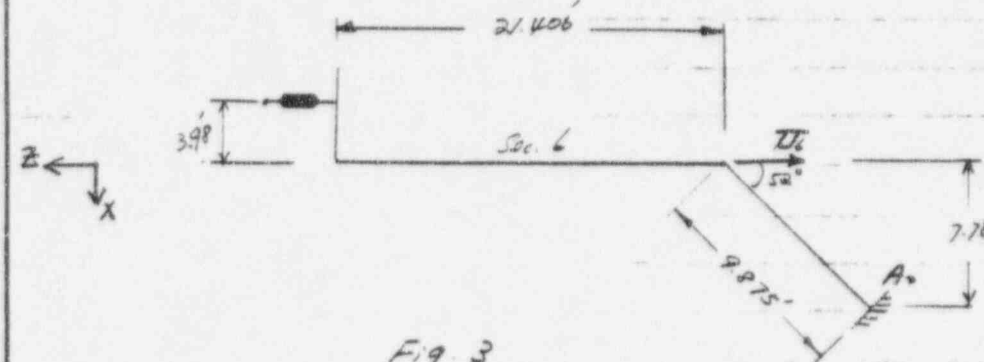


Fig. 3

Stresses at A_2 from Piping Stress Program

Vibration (Y-Z)	853 psi	
S.V. Discharge	761	
Pressure $(\frac{PD}{4t})$	6500	Stress Program gives 2x the stress = 4.81

Allowable Stress $= 1.2 S_h = 18,000$ psi

Bending Stress at A_2 due to Steam Hammer.

$M = T_6 \sin 52° \times l$

$= T_6 \times (9.875 \times 12) \sin 52° = 93.4\, T_6$ lb-in

$S_b = \frac{M}{Z} = \frac{93.4}{388} T_6 = \frac{1}{4.16} T_6$

Let $S_b = 18,000 - 853 \times 2^{DLF} - 761 \times 1.5^{DLF} - 6500$

$= 8,650$ psi

Then $T_6 = 4.16 \times 8,650 = 36,000^{lb} = 36$ Kips

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE 54203 M502A0
	PROJECT Crystal River #3	W.O. / PAGE 9 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER DATE

RESULTS

If the pressure wave has a form of Fig 1 the max unbalanced force on Sec 6 is 6 Kips

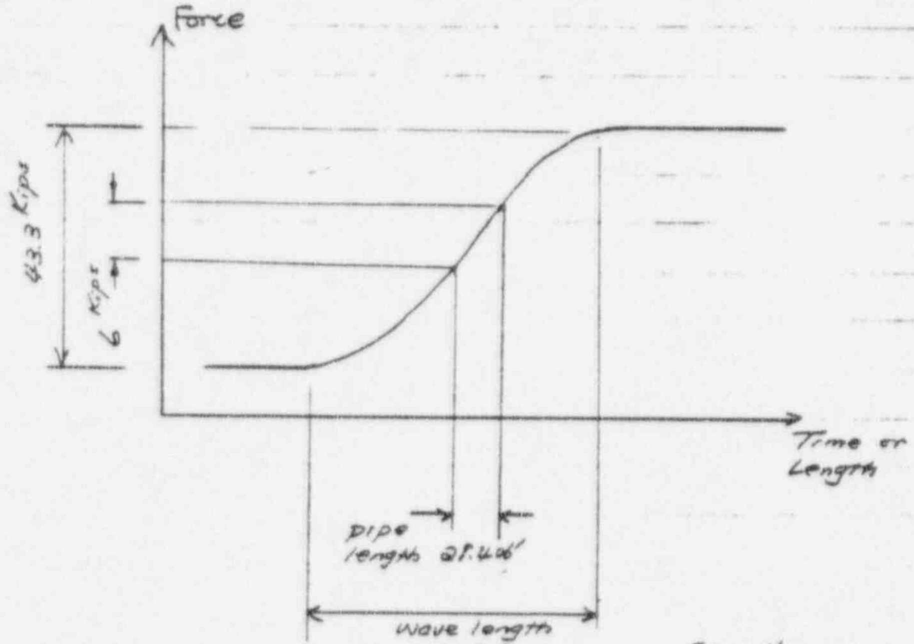


Fig. 4

Though the form of pressure wave may deviate from Fig 1 and results in steeper slope consequently larger unbalanced force, it is unlikely that the unbalanced force will reach say 20 Kips in the section of pipe 21' long when the normal wave length is 258 ft

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203 M502 A0
	PROJECT Crystal River #3	W.O. / PAGE 10 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR		REVIEWER / DATE

RESULTS

Line CR-13 Inside Pen. 105 (Ref. Fig. 2)

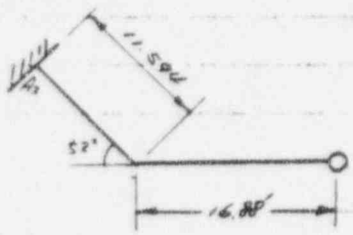


Fig. 5

Stresses at A_2 from Piping Stress Program

Vibration (x-Y) 516 psi
Pressure 6,500

Bending stress allowed for steam Hammer

$S_b = 18,000 - 516 \times 2 - 6500 = 10,468$ psi

$M = U_8 \times (11.594 \times 12) \sin 52° = 109.2\ U_8$

Let $\frac{M}{Z} = S_b = 10,468$

$U_8 = \frac{388}{109.2} \times 10,468 = 37,000^{lbs} = 37^{Kips}$

Calculated U_8 for max $\frac{dp}{dt}$ is 4.7 Kips.

No additional support is recommended.

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE 54203 M502 A0
	PROJECT Crystal River #3	W.O. / PAGE 11 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER DATE

RESULTS

Line CR-13A at EL 142'-10¾" Near Steam Gen.

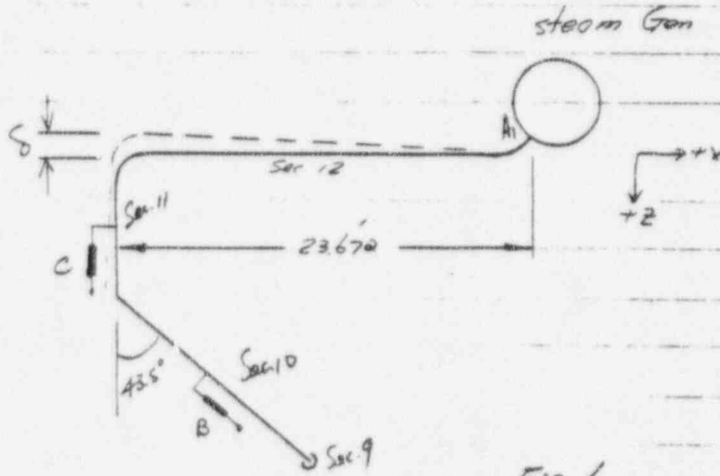


Fig. 6

Consider sec. 12 as a cantilever fixed at Gen. Then

$$\delta = \frac{Pl^3}{3EI}, \quad \sigma = \frac{M}{Z} = \frac{Pl\,d/2}{I}$$

$$\therefore \delta = \frac{2}{3}\frac{\sigma}{E}\frac{l^2}{d} \quad \text{or} \quad \sigma = \frac{3}{2}\frac{Ed}{l^2}\delta$$

$$\sigma = \frac{3}{2}\frac{30\times10^6\times24}{(23.672\times12)^2}\delta = 13600\,\delta$$

Assume the snubber lock up at $\delta = \frac{1}{4}$", then

$$\sigma = 13,600 \times \frac{1}{4} = 3,400 \text{ psi}$$

Computer Piping stress program gives the following stresses

Vibration (x-Y)	1309 psi
Dead Load	824
Pressure (hand calculation)	6,500
Expansion	4,579

Combined Occasional stress

$$S_b = \underset{Vib}{1309} + \underset{D.L.}{824} + \underset{Pr}{6,500} + \underset{St\ Hammer}{3,400} = 12033\ psi$$

$$< 1.2\,S_h = 18,000\ psi$$

∴ A snubber can protect point A_1 from overstressing.

Snubber Capacity

Snubber	A	59.5 Kips	Sec. 9
	B	59.5 Kips	Sec. 10
	C	80.0 Kips	Sec. 11

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT Crystal River #3

FILING CODE S 4203 M502 A0
W.O.
PAGE 13 OF

SYSTEM Main Steam Piping

ORIGINATOR M. Z. Lee
DATE 11/2/73

CALCULATION FOR Steam Hammer

REVIEWER
DATE
RESULTS

Line CR-4 & Line CR-14A

Sec. No i	Length l_i	Force U_i	Existing Axial Snubber	Additional Axial Snubber	
1	27.552	7.9	0 Kips		Restrained by Turbine
2	35.94	10.3	49.5		
3	86.05	24.4	49.5		
4	12.58	3.6	49.5		
5	32.12	9.2	49.5		
6	20.646	5.9			Restrained by Pen. 106
7	21.355	6.1			Anchored at Pen. 106
8	14.479	4.2			Restrained by Pen. 106
9	31.578	9.1		49.5 Kips	
10	26.7	7.7	49.5		
11	26.513	7.6		30 Kips	
12	11.87	3.4		49.5 Kips	
13	20.125	5.8			Restrained by Steam Gen.

FILING CODE

GAI 350 REV. 10-72

S4203 M502 A0 p.14

Crystal River #3	MADE 11/2/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
	CHK'D.	
Main Steam Piping	DS. CF.	
	CF. DFN.	4203-027
Steam Hammer Analysis	ENG. M.Z. Lee	WORK ORDER / SIZE / DRAWING / REV.
	REV. CH. APP. DATE	

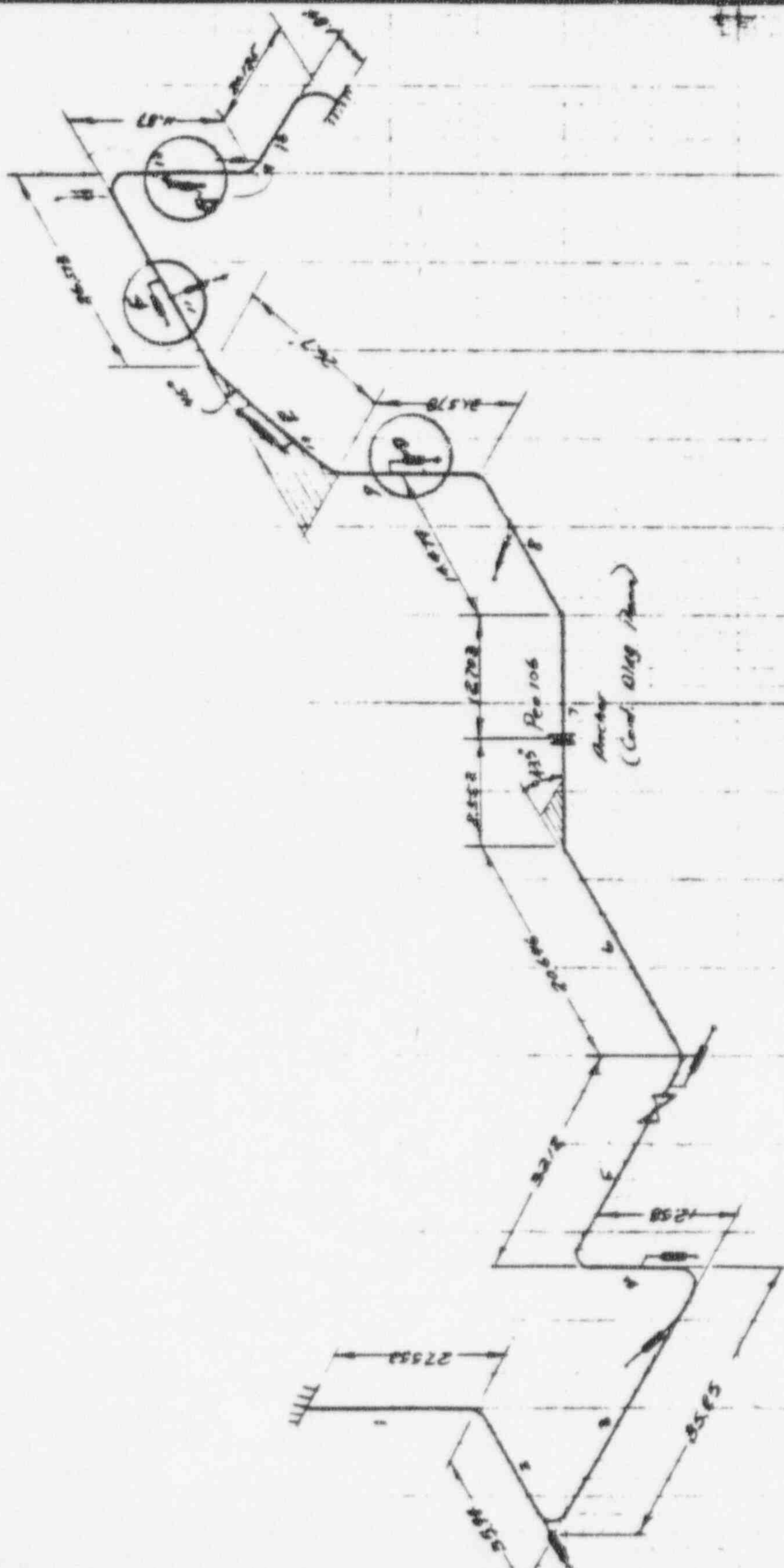


Fig. 7 Lines CR-4 & CR-14

RESULTS

Stresses at Penetration 106

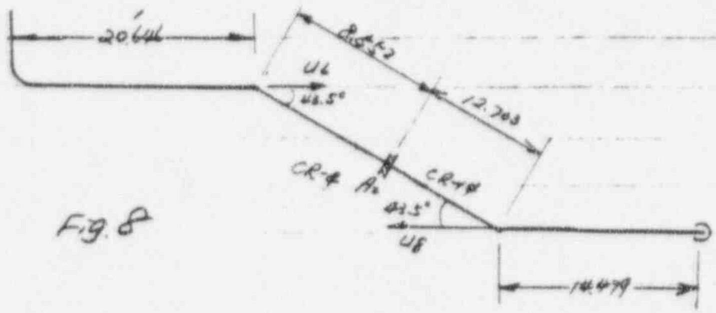


Fig. 8

Outside Pen. 106

Stresses from Piping Stress Program

Dead Load & Press.	4026 psi use	6,500
Seismic		857
S. V. Disch.		357

Allowable Stress for steam Hammer

$$S_b = 18{,}000 - 6500 - 857 \times \overset{DLF}{2} - 357 \times \overset{DLF}{1.5} = 9{,}250$$

$$M = U_6 \times (8.552 \times 12) \sin 43.5^\circ = 70.7\, U_6 = S_b \cdot Z$$

$$U_6 = \frac{Z}{70.7} S_b = \frac{388}{70.7} \times 9250 = 50{,}700^{lb} > 43.3^{Kips}$$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203MS02A0
	PROJECT Crystal River #3	W.O. / PAGE 16 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER / DATE

RESULTS

Inside Pen. 106

Stresses from Piping Stress Program

Dead Load	349
Pressure	6,500
Seismic	1,126

Allowable Stress for Steam Hammer

$S_b = 18,000 - 349 - 6500 - 1,126 \times 2 = 9,101$

$M = U_8 \times (12.703 \times 12) \sin 43.5° = 105\, U_8 = S_b Z$

$U_8 = \frac{Z S_b}{105} = \frac{388}{105} \times 9,101 = 33,700^{lbs} = 33.7^{Kips}$

Calculated U_8 from max $\frac{dp}{dt}$ = 4.2 Kips.

Snubber Capacity

D	Sec. 9	49.5 Kps
E	Sec. 10	(49.5) Existing
F	Sec 11	30 Kips
G	Sec. 12	49.5 Kips.

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE 54203 MS02A0
	PROJECT Crystal River #3	W.O. PAGE 17 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER DATE

RESULTS

Line CR-5 & Line CR-15

Section i	Length l_i	Force u_i	Existing axial Snubber	Additional Axial Snubber	Notes
1	6.052	1.2 kips	kips		Restrained by Turb.
2	30.94	8.8	49.5		
3	67.0	19.	49.5		
4	28.0	8.0	49.5		
5	9.29	2.7	0	49.5 kip	No Y-Snubber on neighboring sections.
6	81.06	23.	49.5		
7	91.5	26			Anchored at Pen. 107
8	25.4	7.2		49.5 kip	
9	31.84	9.0		49.5	
10	26.87	7.6		/	Restrained by Snubbers on Secs 9 & 11
11	14.07	4.0		49.5	
12	8.32	2.4		30	Y-direction
13	16.26	4.6			

Crystal River #3	MADE 11/2/73	GILBERT ASSOCIATES, INC.
	CHK'D.	ENGINEERS AND CONSULTANTS
	DG. CP.	READING, PENNA.
Main Steam Piping	CP. BFN.	4203-027
Steam Hammer Analysis	ENG. M. Z. Lee	WORK ORDER / SIZE / DRAWING / REV.
	REV. CK. APP. DATE	

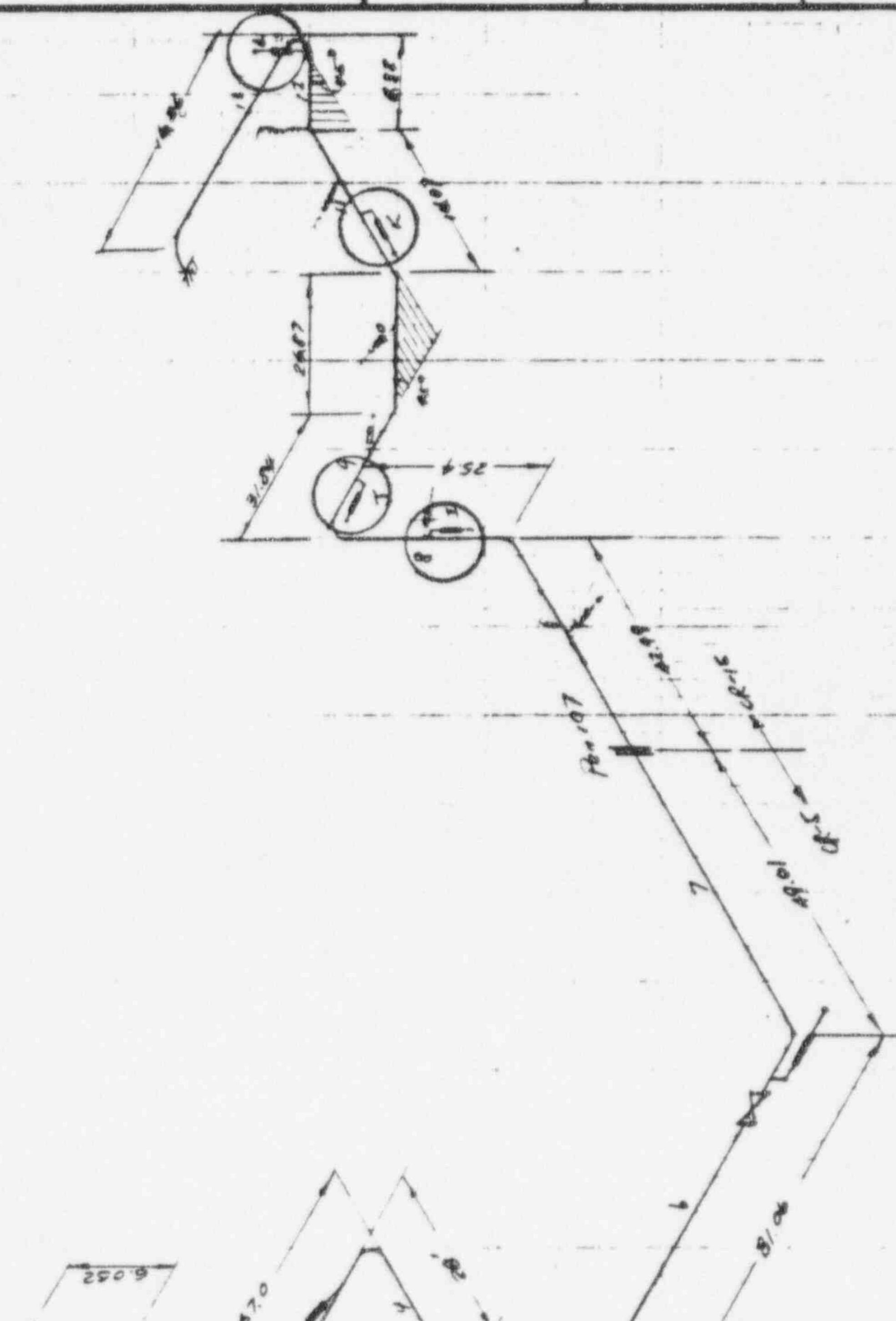


Fig. 9 Lines CR-5 & CR-15

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203 MS02A0
	PROJECT Crystal River #3	W.O. / PAGE 19 OF
SYSTEM	Main Steam Piping	ORIGINATOR M. Z. Lee
CALCULATION FOR	Steam Hammer	DATE 11/2/73
		REVIEWER
		DATE
		RESULTS

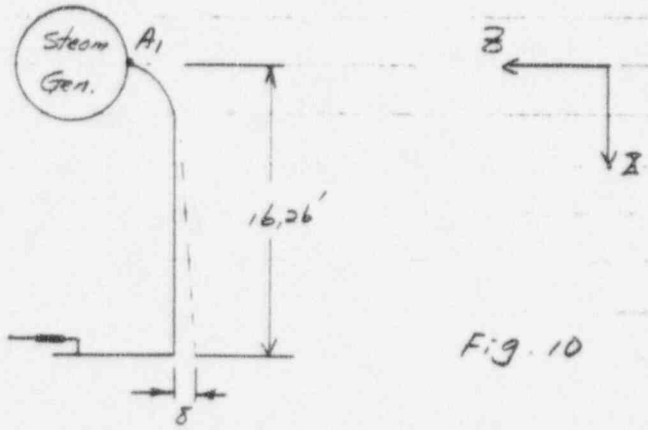


Fig. 10

$$\sigma = \frac{3}{2}\frac{Ed}{l^2}\delta = \frac{3}{2}\frac{30\times10^6\times24}{(16.26\times12)^2}\delta = 28,400\,\delta$$

Stresses at connection A_1 are

Vibration (Y-Z)	±104	psi
Dead Load	1058	psi
Pressure	6500	
Total	12,662	

If snubber lock up at $\frac{3}{16}$" displacement

$$\sigma = 28,400 \times \frac{3}{16}" = \pm 5310 \text{ psi}$$

Max stress at A_1

$$S_{max} = 12,662 + 5310 = 17,972 \text{ psi}$$

$$< 1.2\, S_h = 18,000 \text{ psi}$$

Snubber limits δ for both vibration and steam hammer as a result the stresses will be lower.

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE 5?203 MS02 A0	
	PROJECT Crystal River #3	W.O.	PAGE 20 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee	
		DATE 11/2/73	
CALCULATION FOR Steam Hammer		REVIEWER	
		DATE	

be protected from overstress by using snubber

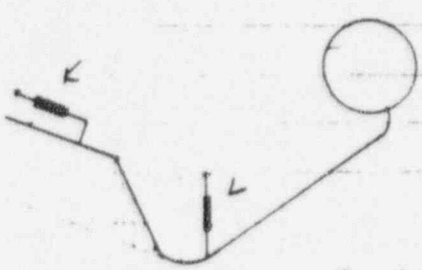


Fig. 11

Capacity of snubber in Y-direction

$$43.3 \sin 45^\circ = 30.6 \text{ Kips}$$

From

$$P = \frac{3EI}{\ell^3}\delta = \frac{3\times 30\times 10^6 \times 4653}{(16.26\times 12)^3}\delta$$

$$= 56800\,\delta$$

For $\delta = 1/8''$ $\quad P = 56.8 \times \frac{1}{8} = 7.1$ Kips

Snubber Capacity $= 30.6 - 7.1 = 23.5$ Kips

Snubber Capacity

H	Sec. 5	49.5 Kips
I	Sec. 8	49.5
J	Sec. 9	49.5
K	Sec. 11	49.5
L	Sec. 12	80

RESULTS

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203 MS02A0
	PROJECT Crystal River #3	W.O. / PAGE 21 OF
SYSTEM	Main Steam Piping	ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR	Steam Hammer	REVIEWER DATE

RESULTS

Line CR-6 & Line CR-16

Section i	Length li	Force Ui	Existing Axial Snubber	Additional Axial Snubber	Notes
1	6.052	1.7			Restrained by Turb.
2	36.938	10.6	49.5		
3	79.0	22.8	49.5		
4	28.0	8.0	49.5		
5	9.51	2.7	0	49.5	
6	98.568	28.2	49.5		
7	44.323	12.7			Restrained by Pen 108
8	33.078	9.5			Anchored at Pen 108
9	20.38	5.9			Restrained by Pen 108
10	19.474	5.6		49.5	
11	28.919	8.3		49.5	
12	16.615	7.6		30	Z-direction
13	17.026	4.9			

✓

FILING CODE

S4203 MS02 A0 p.22

Crystal River #3	MADE 11/2/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.	
Main Steam Piping	CHK'D. / SQ. CF. / CF. DFN.	4203-027	
Steam Hammer Analysis	ENG. M. Z. Lee	WORK ORDER	SIZE / DRAWING / REV.
	REV. CH. APP. DATE		

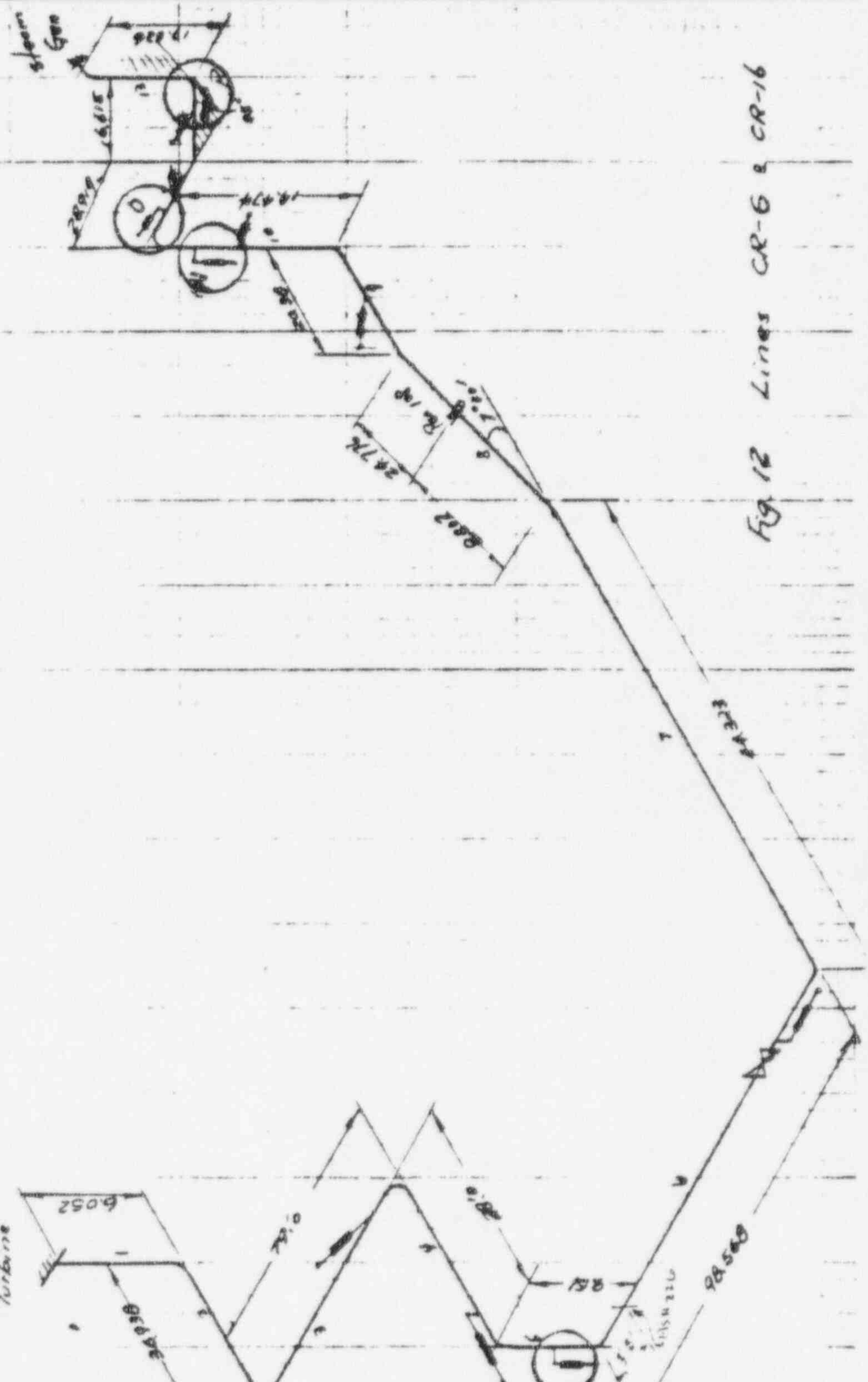


Fig. 12 Lines CR-6 & CR-16

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE 54203 M502A0
	PROJECT Crystal River #3	W.O. / PAGE 23 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee DATE 11/2/73
CALCULATION FOR Steam Hammer		REVIEWER DATE

RESULTS

Summary

Max. Pressure Rise	113.27 psi
Max. Unbalanced Force	43.3 Kips
Wave Length for 0.15 Sec Valve Closing Time	258 ft/sec
Max Pressure Gradient	0.36 psi/ft pipe
Max Unbalance Force Gradient	0.286 Kips/ft pipe

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE 54203 14502A0
	PROJECT Crystal River #3	W.O. / PAGE 24 OF
SYSTEM	Main Steam Piping	ORIGINATOR M. Z. Lee
CALCULATION FOR	Steam Hammer	DATE 11/2/73
		REVIEWER
		DATE

RESULTS

Recommendations

Add 15 Snubbers as follows

Line No	Sec. No.	Capacity Kips	Orientation	Notes
3	9	49.5	Axial	
	10	49.5	Axial	
	11	30	Axial	
4	9	49.5	"	
	11	30	"	
	12	49.5	"	
5	5	49.5	"	
	8	49.5	"	
	9	49.5	"	} As close to Sec. 10 as is possible
	11	49.5	"	
	12 n 13	30	Vertical	End of Sec. No 12 Near Sec. 13
6	5	49.5	Axial	
	10	49.5	"	
	11	49.5	"	Close to Sec. 12
	13	80	Z-dir.	Lower end of Sec. 13

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. 4203-027 PAGE 25 OF
SYSTEM		ORIGINATOR M. Z. Lee DATE 11/21/73
CALCULATION FOR		REVIEWER DATE

Steam Hammer Restraints on Branch Lines.

Pressure wave created by turbine trip may travell along all branches connected to the main steam pipes. As a result, steam hammer may hit those branches in the same way as it hits on the main lines. Therefore, it is necessary to provide proper restraints on the branch lines. The branches to be considered are

10" turbine by-pass to condender — 2 lines.

6" main steam to moisture separator — 4 lines

6" main steam to emergency F.W. pump turbine — 2 Lines

Maximum unbalanced forces corresponds to pressure rise of 113.27 psi are calculated and restraints are located on sketches on the following pages.

RESULTS

FILING CODE

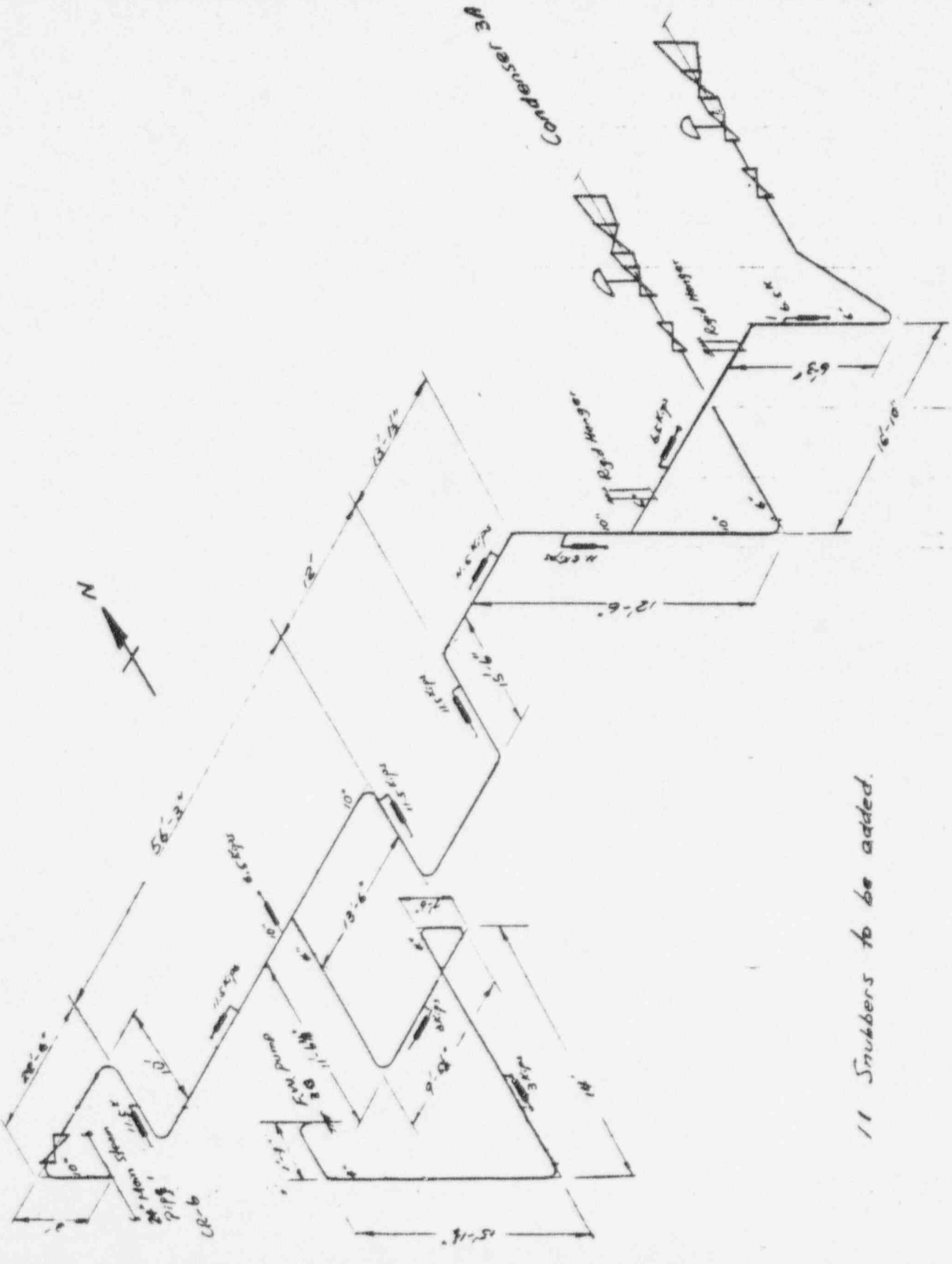
GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. 4203-027 PAGE 26 OF
SYSTEM		ORIGINATOR M. Z. Lee DATE 11/21/73
CALCULATION FOR		REVIEWER DATE
		RESULTS

	10" SCH 60	6" SCH 40	4" SCH 40	
Flow Area A_f (in²)	74.7	28.9	12.73	
Max Unbalance Force $F = \Delta p_{max} \times A_f \div 1000$ (kip)	8.47	3.28	1.45	
$\frac{dF}{d\ell}\Big\vert_{max}$ (lbs/ft)	56	22	11	

Calculated Unbalanced Force in Pipe Section with length ℓ		10" SCH 60	6" SCH 40	4" SCH 40	
	ℓ = 10 ft	560 lb	220	110	
	ℓ = 20 ft	1,120	440	220	
	ℓ = 30 ft	1,680	660	330	
	ℓ = 40 ft	2,240	880	440	
	ℓ = 50 ft	2,800	1,100	550	

FILING CODE

CRYSTAL RIVER #3	MADE 11/30/73	GILBERT ASSOCIATES, INC.
	CHK'D.	ENGINEERS AND CONSULTANTS
	DG. CP.	READING, PENNA.
Main Steam By-Pass to Condenser #3A	CP. DFN.	
Main steam to Feedwater Pump Turbine #3B	ENG. M. Z. Lee	4203-027
		WORK ORDER · SIZE · DRAWING · REV.
STEAM HAMMER RESTRAINTS	REV. CK. APP. DATE	



CRYSTAL RIVER #3

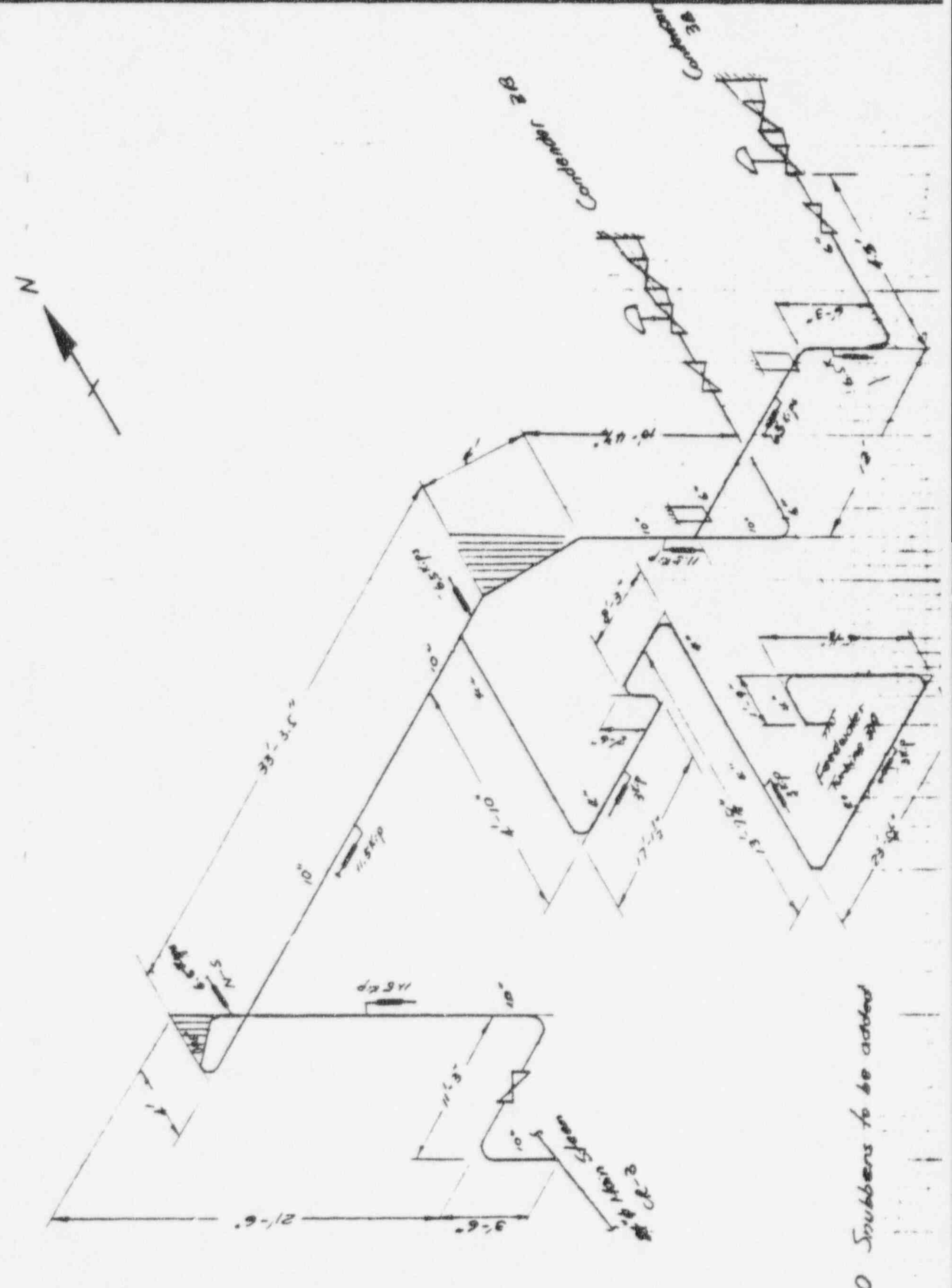
Main Steam By-Pass to Condenser 3B

Main Steam to Emergency Feedwater Pump Turbine 3A STEAM HAMMER RESTRAINTS

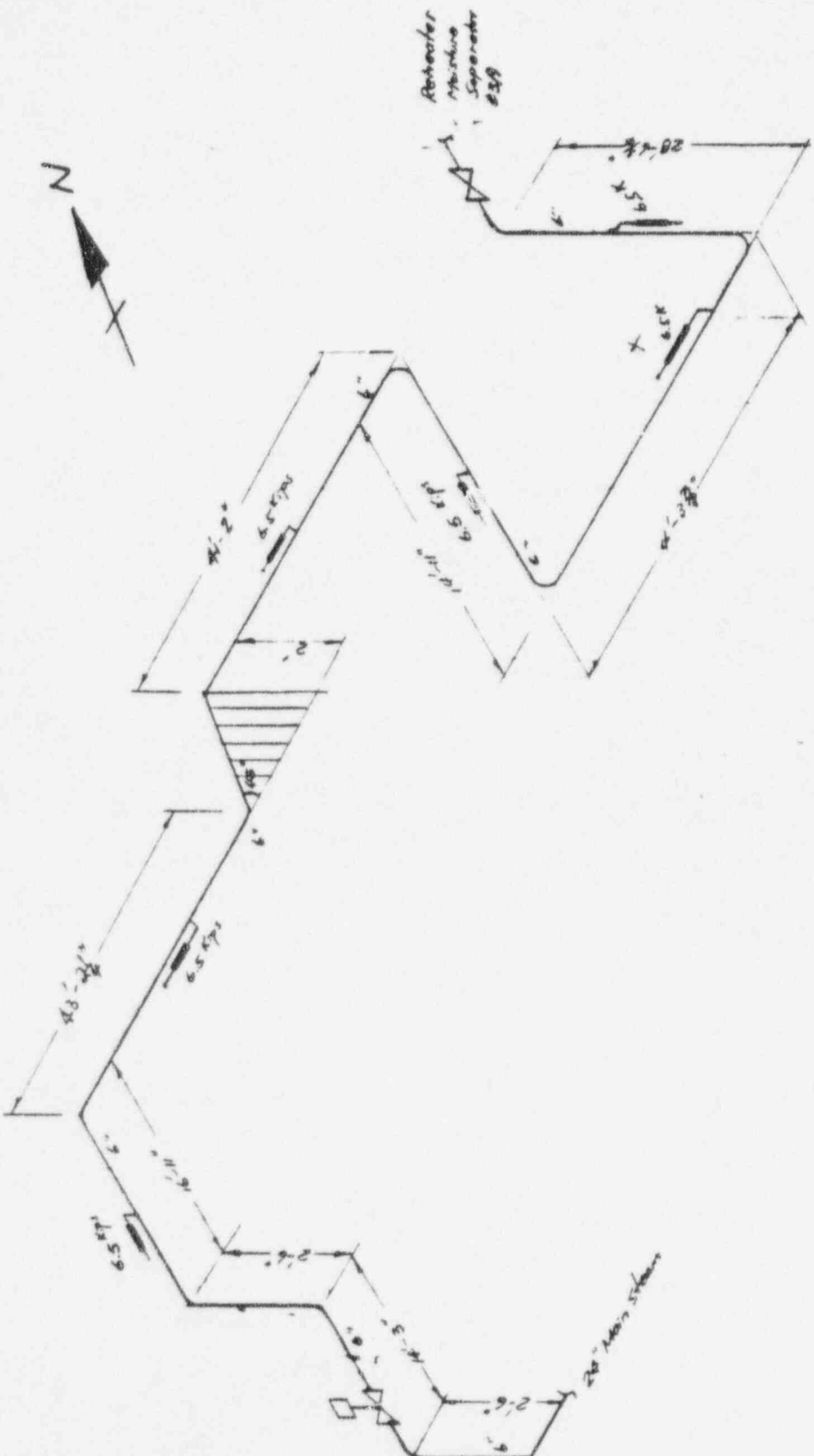
MADE 11/20/73
CHK'D.
DG. CF.
CF. DFN.
ENG. M. Z. Lee
REV. CH. APP. DATE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PENNA.

WORK ORDER	SIZE	DRAWING	REV
4203-027			

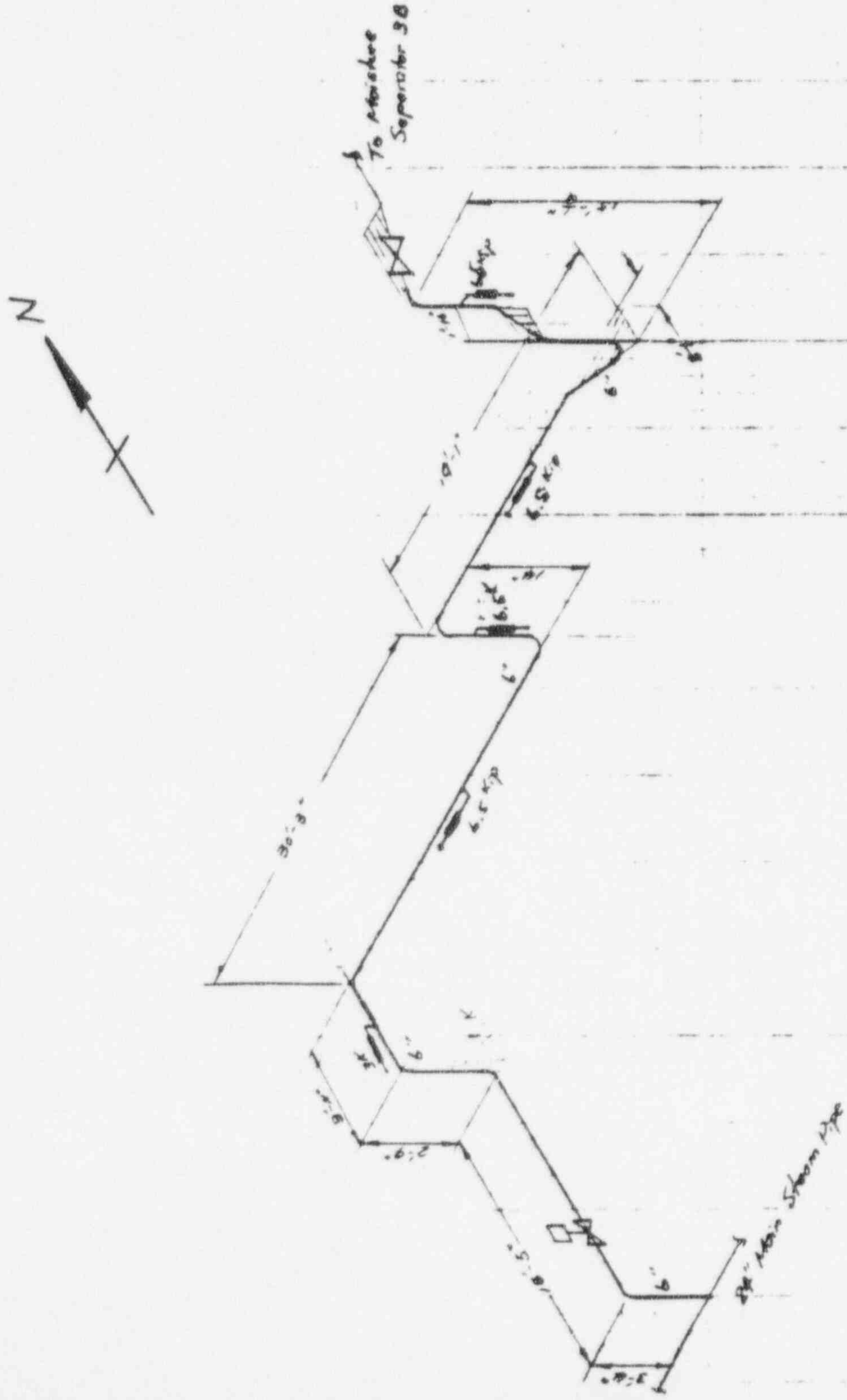


CRYSTAL RIVER #3	MADE 11/21/73 CHK'D. SQ. CF.	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
Main Steam Piping to #3A Moisture Separator Reheater Steam Hammer Restraints	CF. DFN. ENG. M. Z. Lee REV. CH. APP. DATE	#203-027 WORK ORDER / SIZE / DRAWING / REV.



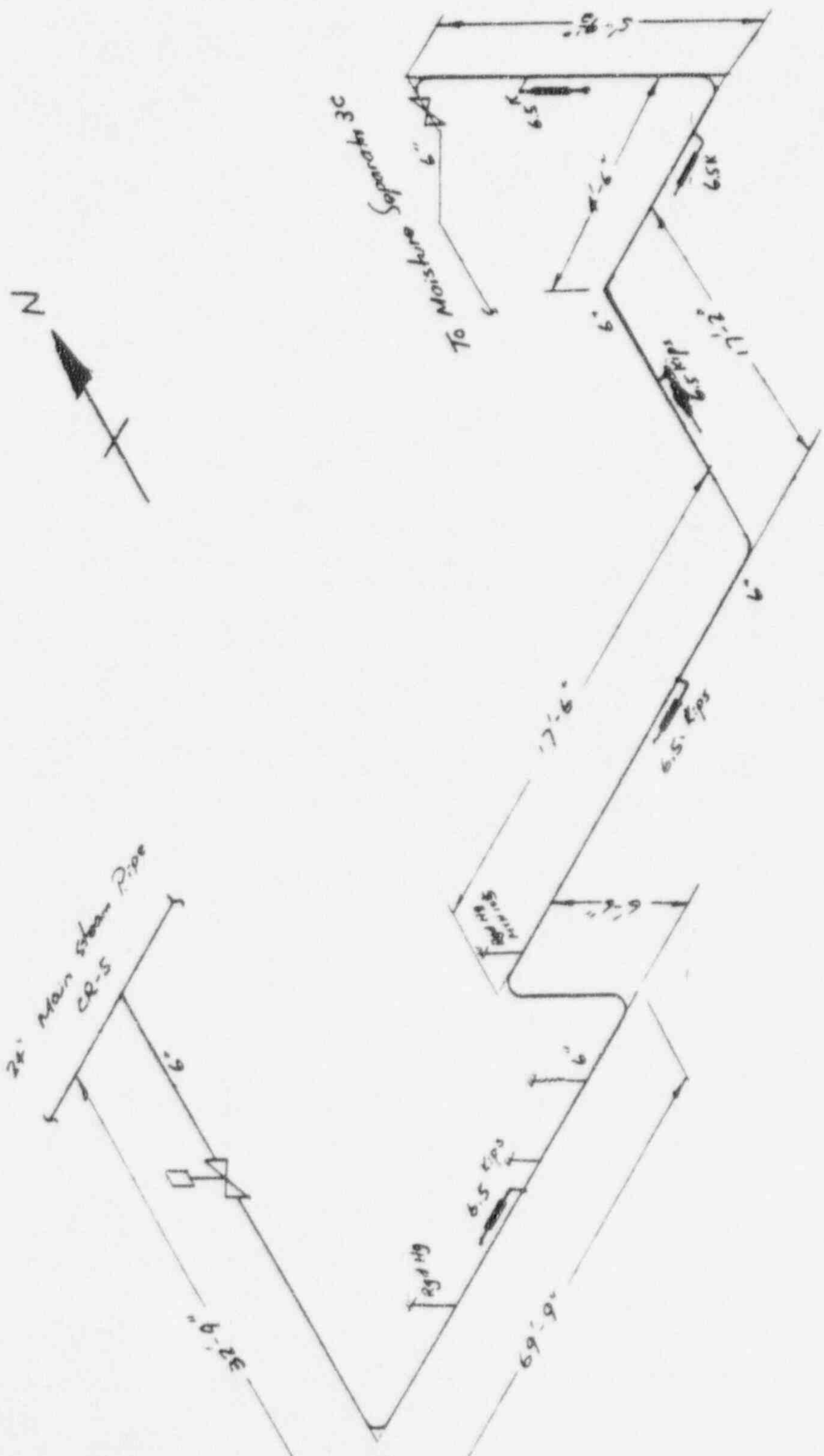
6 Snubbers to be added

CRYSTAL RIVER #3	MADE 11/20/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
	CHK'D.	
	GR. CP.	
Main Steam Piping to Moisture Separator	CP. DFM.	4203-027
Reheater #3B Steam Hammer Restraints	ENG. M. Z. Lee	WORK ORDER / SIZE / DRAWING / REV.
	REV. CK. APP. DATE	



5 Snubbers to be added

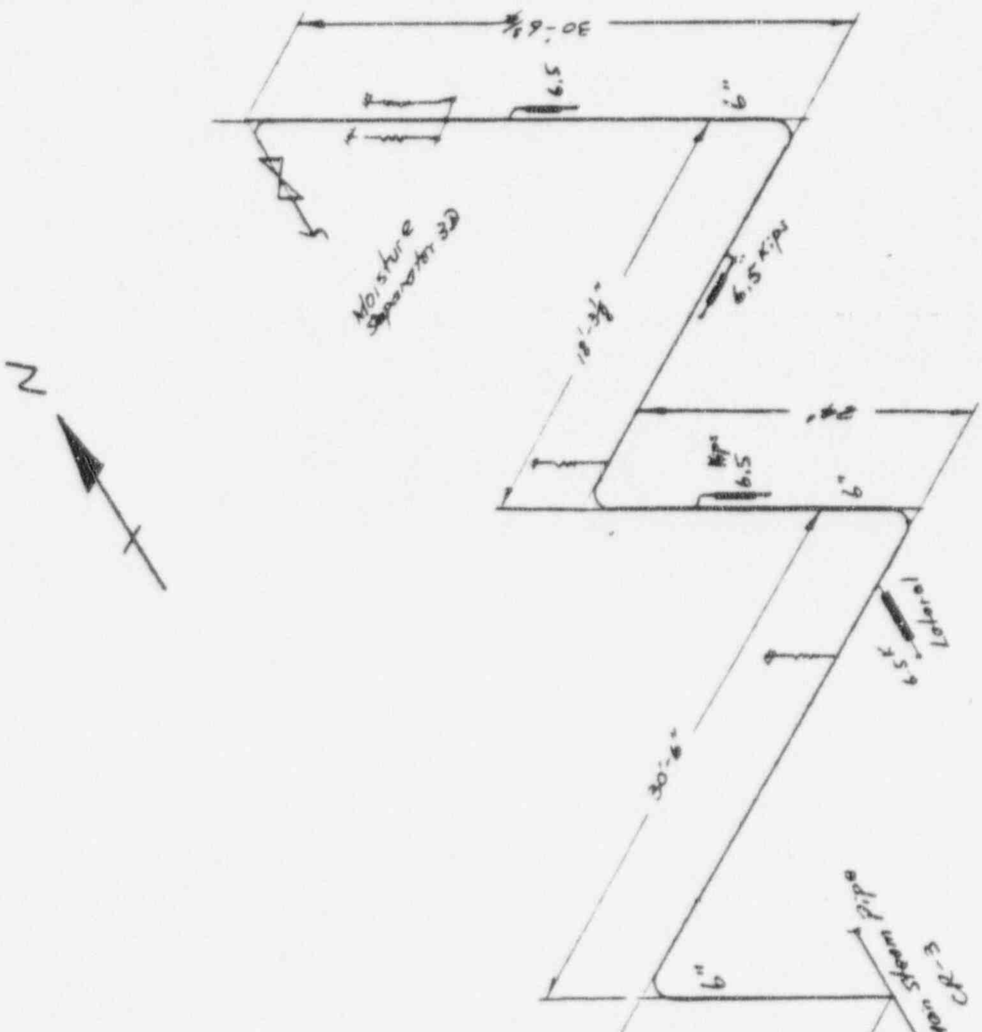
CRYSTAL RIVER #3	MADE 11/21/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
Main Steam Piping to Moisture	CHK'D.	
Separator Reheater #3C	DG. CF.	
Steam Hammer Restraints	CF. DFN.	4203-027 WORK ORDER / SIZE / DRAWING / REV.
	ENG. M. Z. Lee	
	REV. CK. APP. DATE	



Note: For illustration only. Dimensions given are approximate values.

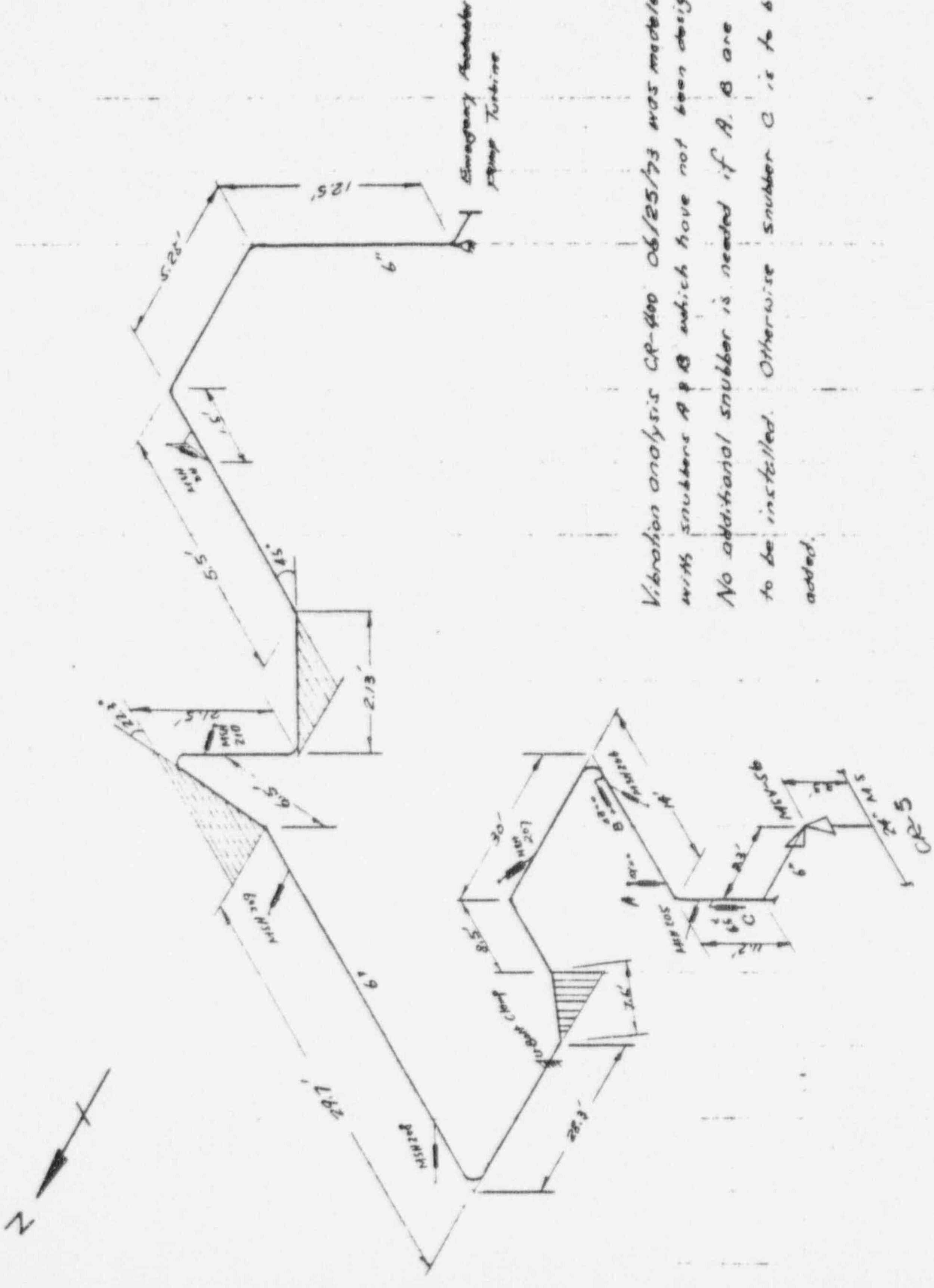
5 Snubbers to be added

CRYSTAL RIVER #3	MADE 11/20/73	GILBERT ASSOCIATES, INC.
	CHK'D.	ENGINEERS AND CONSULTANTS
	SQ. CF.	READING, PENNA.
Main Steam Piping to #3D Moisture	CF. DFN.	4203-027
Separator Reheater Steam Hammer	ENG. MZ Lee	WORK ORDER / SIZE / DRAWING / REV.
Restraints	REV. CK. APP. DATE	



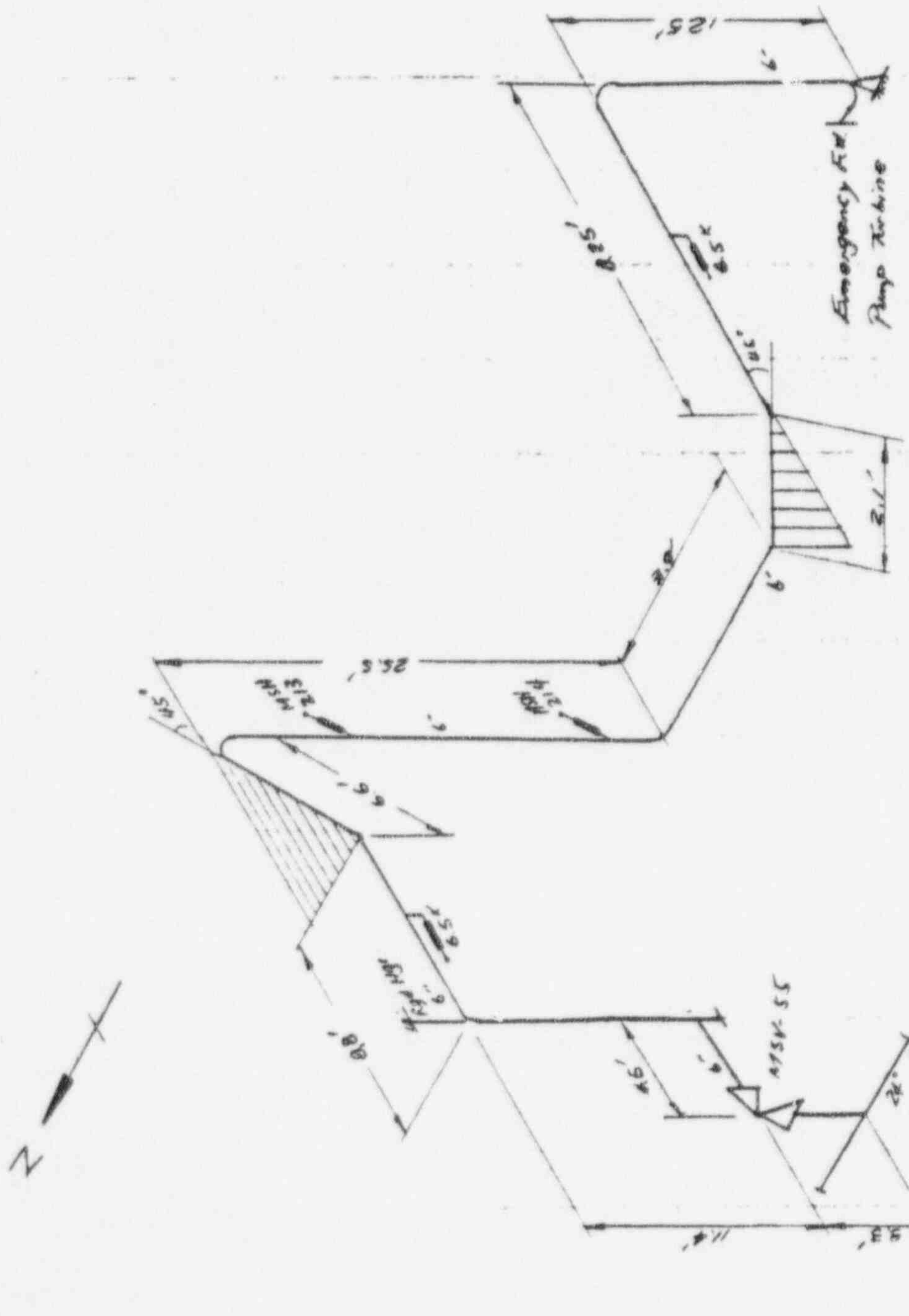
4 Snubbers to be added

CRYSTAL RIVER #3	MADE 11/21/73	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
	CHK'D.	
	BID. CF.	
Main Steam Piping to Emergency F.W.	CF. DFR.	4203-027
Pump Turbine Steam Hammer Restraints	ENG. M. Z. Lee	WORK ORDER / SIZE / DRAWING / REV.
	REV. CH. APP. DATE	



Vibration analysis CR-800 06/25/73 was modeled with snubbers A & B which have not been designed. No additional snubber is needed if A, B are to be installed. Otherwise snubber C is to be added.

CRYSTAL RIVER #3	MADE 11/21/73 CHK'D. SQ. CF.	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
Main Steam Piping to Emergency F. W.	CF. DFN.	4203-027
Pump Turbine Steam Hammer Restraint	ENG. M. Z. Lee	WORK ORDER / SIZE / DRAWING / REV
	REV. CH. APP. DATE	



2 Snubbers to be added

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE S4203MS02 A0
	PROJECT Crystal River #3	W.O. / PAGE 35 OF
SYSTEM Main Steam Piping		ORIGINATOR M. Z. Lee
CALCULATION FOR Steam Hammer		DATE 11/2/73
		REVIEWER
		DATE
		RESULTS

References

[1] Coccio, C. L. Steam Hammer in Turbine Piping Systems. Combustion, Feb. 1967

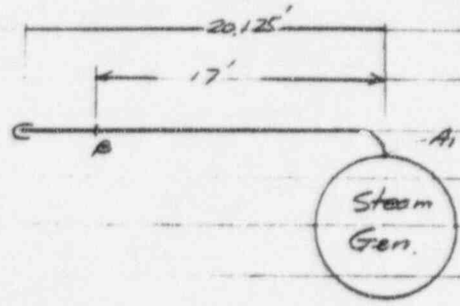
[2] Piping Stress Analysis File

CR-3	CR-13
CR-4	CR-14
CR-5	CR-15
CR 6	CR-16

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE OF
SYSTEM		ORIGINATOR M. Z. Lee DATE 11/21/73
CALCULATION FOR		REVIEWER
		DATE
		RESULTS

Line CR-14 Section 13



Stress at A1 from computer output

Dead Load	824	psi
X-Y Quake	1309	
Y-Z Quake	461	

Pressure

$\frac{PD}{4t} = \frac{1100 \times 24}{4 \times 0.968} =$ 6,820

Total 9,414

Provide a vertical snubber at B

$\delta = \frac{Pl^3}{3EI}, \quad \sigma = \frac{M}{z} = \frac{MD}{2I}$

$\therefore \sigma = \frac{3}{2}\frac{ED}{l^2}\delta = \frac{90 \times 10^6 \times 24}{2 \times (17 \times 12)^2}\delta = 26,000\ \delta$

Suppose snubber locks up at $\frac{1}{4}$" movement

$\sigma = 26,000 \times \frac{1}{4} = 6,500$

$9,414 + 6,500 = 15,914 < 18,000$

$\therefore$ Snubber can be placed at B

FILE ________

GILBERT ASSOCIATES, INC.

TELEPHONE AND CONFERENCE MEMORANDUM

DATE 10/30/?? 10:30 AM

BY: M. Z. Lee WORK ORDER NO. 4203-027

TELEPHONE CALL [X] CONFERENCE [ ]

WITH: Khemlani 595-3936 (Crystal River Project System Engineer)

COMPANY: Westinghouse, Lester Office

SUBJECT:

NOTES: Request information on Main Steam Turbine Emergency stop value Closing Time for Crystal River Unit #3.

Ans.

Total closing Time = 250 milisec ✓

Includes signal etc.

Value Travelling Time = 150 milisec ✓

Copies To:

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT Crystal River #3	W.O. 4203-027 PAGE OF
SYSTEM Main Steam Piping Inside Containment Bldg.		ORIGINATOR M. Z Lee DATE 12/21/73
CALCULATION FOR		REVIEWER DATE

RESULTS

Steam Hammer Restraints (Revised)

Line CR-13

1. Add one axial snubber on Sec. 10 (Ref. Fig. 2 of original Report) Capacity 30 Kips
2. Modify MSH-151 to take 20 Kips upward force (Insert a saddle support between 24" pipe and 21WF62 above the pipe)

Line CR-14

1. Add a rigid vertical support near elbow of the vertical drop section upstream of MSH-152.

   Design Load 42 Kips downward

   35 Kips upward

Line CR-15

1. Add one vertical snubber near the the elbow between Sec. 12 & 13. Capacity 30 Kips.
2. Modify MSH-142 to take

   44 Kips downward load

   20 Kips upward load

   Desirable to move MSH-142 closer to elbow

Line CR-16

1. Add a 30 Kips axial snubber on Sec 12
2. Modify MSH-137 as recommended for MSH-142

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT Crystal River #3

FILING CODE

W.O. 4203-027 | PAGE 1 OF

SYSTEM Main Steam Piping Inside Containment Bldg

ORIGINATOR M. Z. Lee

DATE 12/21/73

CALCULATION FOR

REVIEWER

DATE

RESULTS

	No. of Snubber to be added	No. of Rigid Support to be Modified
CR-13	1	1
CR-14		1
CR-15	1	1
CR-16	1	1
Total	3	4

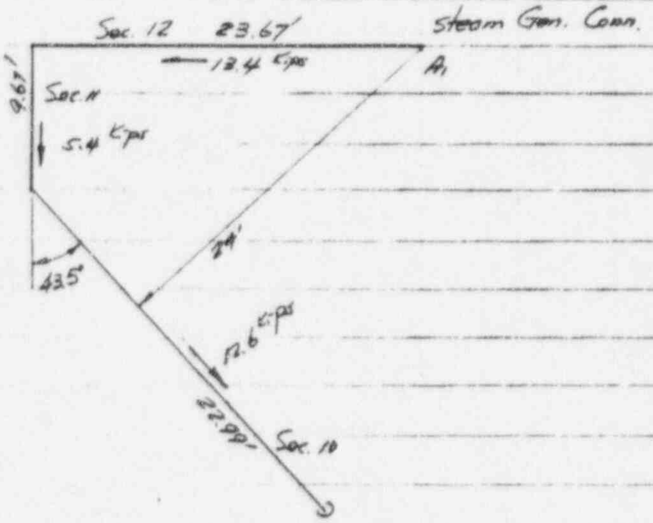
FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. PAGE 2 OF
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE
		RESULTS

CR-13

Sections Near Steam Gen



$M_{A_1} = 5.4^{Kips} \times 23.67' + 12.6^{Kip} \times 24 = 430^{Kip\text{-}ft}$

Bending stress at A_1

$S_b = \frac{M_{A_1}}{Z} = \frac{430 \times 12}{388} = 13.3^{Ksi} = 13,300^{psi}$

Combined Stress at A_1 (p.10)

Vibration	1,309×2 2,618	(from Piping Stress output)
Dead Load	824	
Pressure	6,500	
Steam Hammer	13,800	
Total	22,242	> 18,000 = 1.2 S_h N.G

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

PAGE 3 OF

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

Suppose an axial snubber is installed on Sec. 10

Assume the snubber lock up at movement $\delta_{10} = \frac{1}{4}$"

Then $\delta_{11} = \frac{1}{4} \cdot \frac{1}{\cos 43.5°} = 0.344$"

Bending stress at A_1 corresponding to δ_{11} is

$\sigma = 13,600\ \delta_{11} = 13,600 \cdot 0.344 = 4,680$ psi
(p.11)

Combined Stress at A_1

Vibration	2,618
Dead Load	824
Pressure	6,500
Steam Hammer	4,680
Total	14,622 < 18,000 O.K

Since $\sigma = 4680$ (with snubber) $\ll S_b = 13,300$ (without Snubber)

and deflection $\propto$ stress

Without snubber sec. 10 may move axially

$\frac{1}{4} \times \frac{13,300}{4680} = 0.71$"

Therefore the snubber will be effective.

GAI 350 REV 10-72

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 4 OF
SYSTEM		ORIGINATOR
		DATE
CALCULATION FOR		REVIEWER
		DATE

RESULTS

Capacity of snubber on Sec. 10

$$12.6 + 5.4 \frac{1}{\cos 33.5^\circ} = 12.6 + 6.5 = 19.1^{\text{Kips}}$$

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

PAGE 5 OF

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

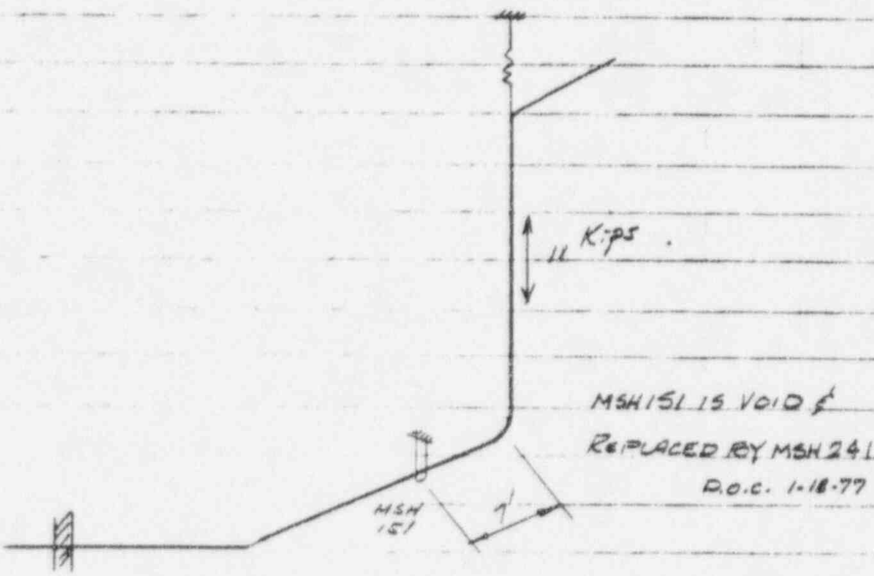
REVIEWER

DATE

RESULTS

CR-13

Vertical Drop to Penetration Anchor



MSH 151 operation load 31,300 lbs
Structure Design Load 32,000 lbs

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 6 OF
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

RESULTS

The effects of 11 Kips force on vertical drop section are obtained by Thermal Program

1. MSH-151 will be subject to 16,000 Kips additional downward force

Combined loads of MSH-151

Seismic	2.045	Kips x 2 DLF
Dead wt	4.9	Kips
Steam Hammer	16.006	
Total	24.0	Kips
	< 31.3	Kips hanger design load

∴ MSH-151 can take downward steam hammer load.

∴ MSH-151 must be modified to take 20 Kip upward load.

From stress summary of CR-14 (without steam hammer load)

$S_{max} = 10,817$ psi

Max stress due to steam hammer = 1,801 psi

$\therefore S'_{max} = 10,817 + 1,801 = 12,618$ psi

$< 18,000 = 1.2 S_h$

FILING CODE

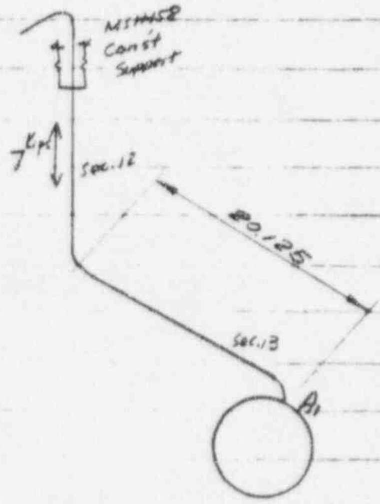
CR-13 Conclusion

1. Add one axial snubber on Sec 10
   Capacity 19.1 Kips min. use 30 Kip

2. Modify MSH-151 to take 20 Kips upward force
   (Insert saddle support between 24" pipe and 21WF62 above the pipe)

GR-14

Sec. 12 & Sec. 13 Near Steam Gen.



Bending stress at A_1 due to 7 Kip steam hammer load acting on sec. 12

$$S_b = \frac{7000 \times 20.125 \times 12}{388} = 4{,}360 \text{ psi}$$

$$\delta = \frac{Pl^3}{3EI} = \frac{7000 \cdot (20.125 \times 12)^3}{90 \times 10^6 \times 4653} = 0.23''$$

Combined Stress at A_1

Dead Weight		925
Seismic	1305 × 2	2,610
Pressure		6,500
Steam Hammer		4,360
Total		14,395 $< 18{,}000 = 1.2 S_h$

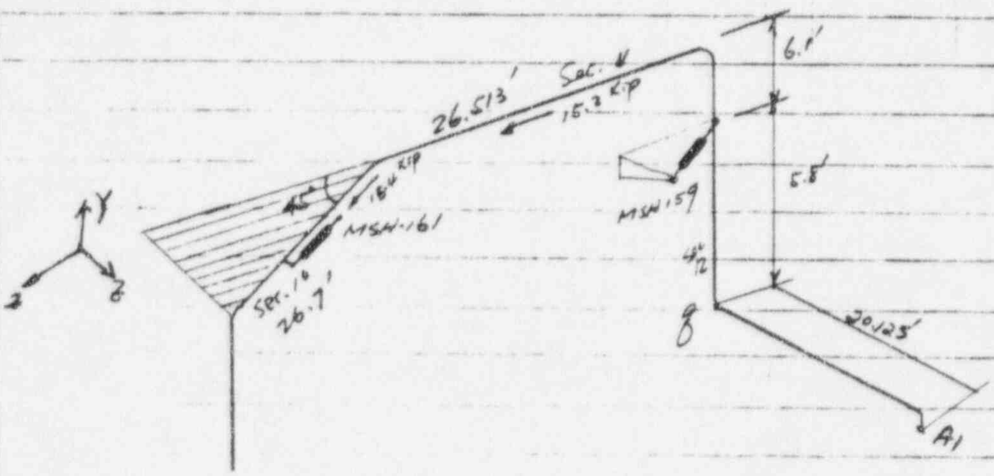
No additional restraint is needed.

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 9 OF
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

RESULTS

CR-14

Sec. 10 & Sec. 11



Restrain Capacity of MSH-161 = 49.5 Kips

Axial Thrust along Sec. 10

$= 15.2 \times \frac{1}{\cos 45°} + 15.4 = 21.5 + 15.4 = 37^{\text{Kips}}$
< 49.5

Assume movement of Sec. 10 is 1/4" axial, Then

Axial movement of Sec. 11 $= \frac{1}{4} \frac{1}{\cos 45°} = 0.354$

Movement at 8 with MSH-159 acting as support:

Assume MSH-159 lock up at movement $\frac{3}{16}$"

Then movement of 8 is

$(0.354 - \frac{3}{16}) \times \frac{5.8}{6.1} = 0.168$"

FILING CODE

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

PAGE 10 OF

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

Stress imposed on A_1 due to movement of δ is

$$\sigma = \frac{3}{2}\frac{Ed}{\ell^2}\delta = \frac{90\times10^6\times24}{2\times(20.125\times12)^2}\delta = 18{,}300\,\delta$$

$= 18{,}300 \times 0.168 = 3{,}080$ psi

Combined stress at A_1 (See Sec. 12)

$14{,}395 + 3080 = 17{,}475$ psi $< 18{,}000$ psi

No additional support is required.

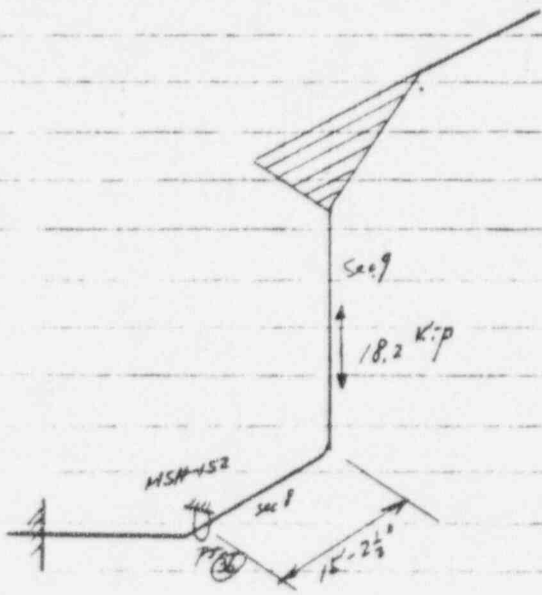
GAI 350 REV. 10-72

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 11 OF
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE	
		REVIEWER	
		DATE	

RESULTS

CR-14



Case 1

Put 18.2 Kip downward force on Sec. 9 (Steam Hammer stress Prog. Case 1)

stress at pt (36) = 8,074 psi

Combined stress at 26

Seismic	1,614 × 2	= 3,228	10,052	
D.W		324		
Pressure		6,500		
steam Hammer		8,074		
Total		18,126	> 18,000 = 1.2 S_h	N.G

Loads on MSH-152

DW.		6.5 Kips	
Seismic	10.05 × 2 = 20.1		
S. H		58,278	
		84.9 Kip	
Str. Design load		15.450 lbs	N.G

FILING CODE

Movement of Sec. 9 ≐ 0.43"

Need a snubber on Sec. 9

Case 2

Suppose Sec. 9 moves 1/4" axially (Steam Hammer Load Case #2)

max S.H. stress = 4727 psi at pt 36

Combined S_{max} = 10,052 + 4727 = 14,780 psi
< 18,000 = 1.2 S_h

Loads on MSH-152

DW	6.5	
Seismic + S.H	34.9	(with snubber on Sec. 9)
Total	41.4 Kips down	

35 Kps up

Case 4 A Better Design

1. Add another support between MSH142 & elbow. Without snubber on vertical sec max. stress is
   2,258 psi at pt 32 (New position of MSH-152)

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O. | PAGE 13 OF

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

REVIEWER

DATE

RESULTS

Load on Support at New Location

Steam Hammer Load	= 23.3 K.P	
D.L.	6.5	estimated
Seismic	15	from MSH-142
Thermo (negative)	—	
Total	42 K.P downward	
	35 K.P upward	

FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

PAGE 14 OF

SYSTEM

ORIGINATOR

DATE

CALCULATION FOR

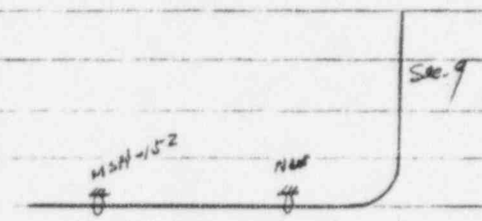
REVIEWER

DATE

RESULTS

CR-14 Conclusion

1. Add a rigid support near elbow



Design Load 42 Kips tension
35 Kips compr.

FILING CODE

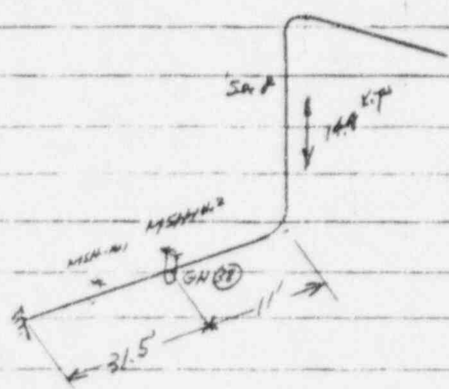
GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O.	PAGE 15 OF
SYSTEM		ORIGINATOR	
CALCULATION FOR		DATE REVIEWER DATE	

RESULTS

CR-15

Sec. 7 & Sec. 8 (vertical drop)



Applied 14.4 Kips on Sec. 8

max stress = 4,036 at pt 38

Fy = 20.2 Kips at MSH142

ΔY = +0.05" at MSH141

Pipe stress at pt (38)

Seismic	1332 × 2	= 2,664
D.W.		884
Pressure		6,500
Steam Hammer		4,036
Total		13,684 < 18,000 = 1.2 Sh

Pipe is O.K

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. | PAGE 16 OF
SYSTEM		ORIGINATOR DATE
CALCULATION FOR		REVIEWER DATE
		RESULTS

Support MSH-142 Loading

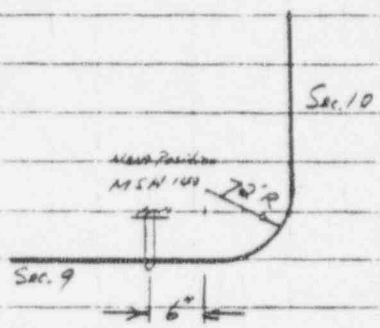
Seismic 5.65 × 2	= 11.3 Kips	
Dead Load	7.414	
Thermal (dd)	4.666	
Steam Hammer	20.2	
Total	43.58	downward

upward load

$20.2 + 11.3 - 7.4 - 4.6 \doteq 20$ Kip upward

Case 2.

Suppose MSH-142 is located at 6" from the elbow



Load on MSH-142

Seismic	11.3
Dead Load	7.414
Thermal	4.666
Steam Hammer	17.38
Total	40.86

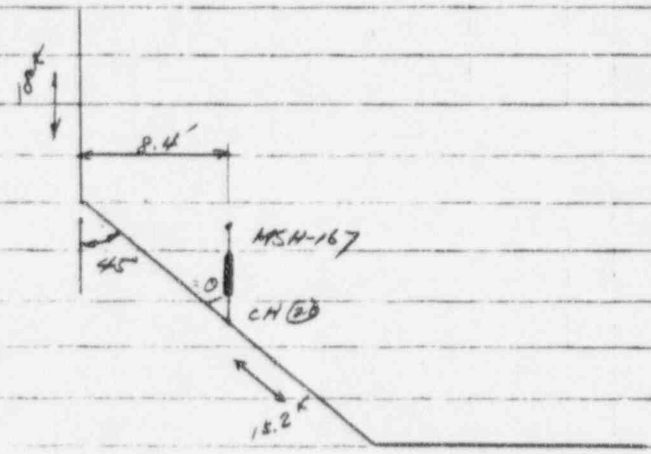
Piping Stress due to steam hammer decreased to 2955 from 4036 psi

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. / PAGE 17 OF
SYSTEM		ORIGINATOR DATE
CALCULATION FOR		REVIEWER DATE

RESULTS

CR-15

Secs 9 & 10



Load on MSH-167

$\cong \frac{15.2}{\cos 45°} + 18 = 21.5 + 18 = 40$ Kips

Existing Seismic Snubber 49.5 Kips

Bending stress in pipe at CH (23)

$S_b = \frac{18{,}000 \times (8.4 \times 12)}{388} = 4{,}680$ psi

Seismic stress 875×2 = 1,750

Pressure 6,500

Dead Load (–)

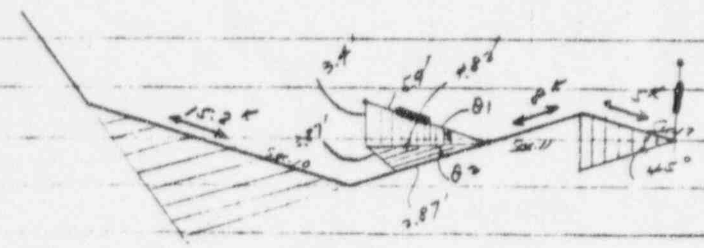
Total 12,930 < 18,000 = 1.2 S_h

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT PROJECT	FILING CODE W.O. PAGE 18 OF
SYSTEM		ORIGINATOR DATE
CALCULATION FOR		REVIEWER DATE

RESULTS

CR-15

Sec. 11



Axial Thrust on Sec. 11

$F = 8 + 5 \times 0.707 + 15.2 \times 0.707 = 22.3^{Kips}$

$\cos\theta_1 = 0.817 \qquad \cos\theta_2 = 0.595$

Load on Snubber

$\doteq \frac{F}{\cos\theta_1 \cos\theta_2} = \frac{22.3}{0.817 \times 0.595} = 46^{Kips}$

Existing Snubber MSH-166 is sized to 49.5 Kips

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT

PROJECT

FILING CODE

W.O.

PAGE 19 OF

SYSTEM

ORIGINATOR

CALCULATION FOR

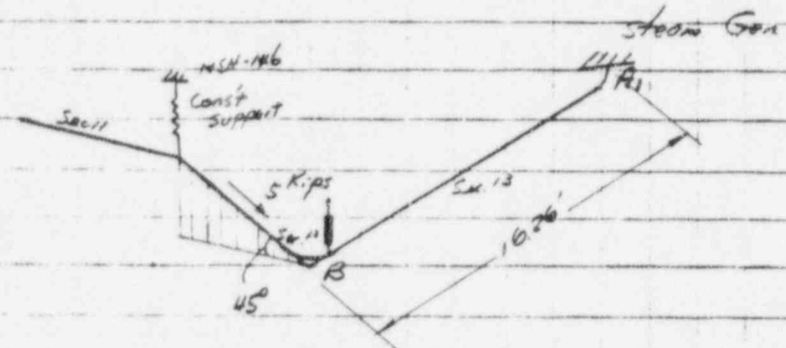
DATE

REVIEWER

DATE

RESULTS

CR-15



Vertical Component of 5 kip thrust on sec 12

$F_v = 5 \times 0.707 = 3.5$ Kips.

Bending Stress at A_1 due to F_v

$$S_b = \frac{F_v \times (16.25 \times 12)}{Z} = \frac{3,500 \times 16.25 \times 12}{388}$$

$= 1,760$

Combined Stress at A_1

Seismic	5104 × 2	= 10,208
Dead Wt		1,110
Pressure		6,500
Steam Hammer		1,760
Total		19,578 > 18,000 = 1.2 Sh

N.G.

Need additional restraint

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 20 OF
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

CR-15

If a vertical snubber is placed at B and locks up at "1/4", then

$$\sigma = \frac{3}{2}\frac{Ed}{\ell^2}\delta = \frac{3}{2}\frac{30\times10^6\times24}{(16.26\times12)^2}\delta = 28{,}400\,\delta$$

$$= 28{,}400 \times \frac{1}{4} = 7{,}100 \text{ psi}$$

Combined stress at A_1 is

Dead wt	1,110
Pressure	6,500
Steam Hammer & Seismic (1/4" snubber movement)	7,100
Total	14,710 < 18,000 = 1.2 S_h

Load Capacity of snubber

Assume: Seismic stress at A_1 is caused by a concentrated load at B (F_s)

$$F_s = \frac{S_b \cdot Z}{\ell} = \frac{5104 \times 388}{16.25\times12} = 10{,}200 \text{ lbs}$$

$$F_s + F_v = 10.2 + 3.5 \approx 14 \text{ Kips (min)}$$

RESULTS

FILING

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT	FILING CODE
PROJECT	W.O. — PAGE 21 OF
SYSTEM	ORIGINATOR
CALCULATION FOR	DATE
	REVIEWER
	DATE
	RESULTS

CR-15

Conclusion

1. Add one vertical snubber near the elbow between Sec 12 & 13.
   Capacity 30 Kips

2. Modify MSH-4:
   44 Kip downward load
   20 Kip upward "

   Both pipe stress & support load will be decreased by moving MSH+42 closer to elbow.

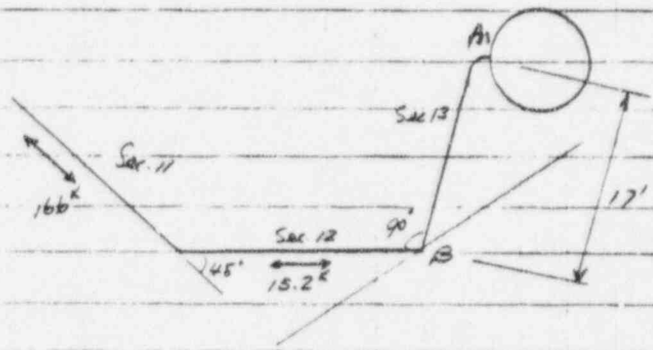
FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 22 OF
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

CR-16

Sec 12 & Sec 13 Near Steam Gen



Stresses at A1 (Piping stress program)

Seismic	1.132 × 2	= 2264
Pressure		6500
D. L.		405
Total		9,170

Axial force on Sec. 12

$P = 15.2 + 16.6 \cos 45° = 26.9$

Deflection at B

$$\delta = \frac{P l^3}{3EI} = \frac{26{,}900 \times (17 \times 12)^3}{3 \times 30 \times 10^6 \times 4653} = 0.545''$$

$$\sigma = \frac{Pl}{Z} = \frac{26{,}900 \times (17 \times 12)}{388} = 14{,}100 \text{ psi}$$

RESULTS

GAI 350 REV. 10-72

CR-16

Combined Stress at A_1

$$S_{max} = 14,100 + 9,170 = 23,270$$
$$> 18,000 = 1.2 S_h$$

Need restraint on Sec. 12

Snubber Capacity = 20 Kips

Suppose the snubber stops movement of B within 1/4"

$$\sigma = \frac{3}{2}\frac{Ed}{l^2}\delta = \frac{3}{2}\frac{30\times10^6\times24}{(17\times12)^2}\delta = 23,100\,\delta$$

$$= 23,100 \times \frac{1}{4} = 5,780 \text{ psi at } A_1$$

Combined stress at A_1 is

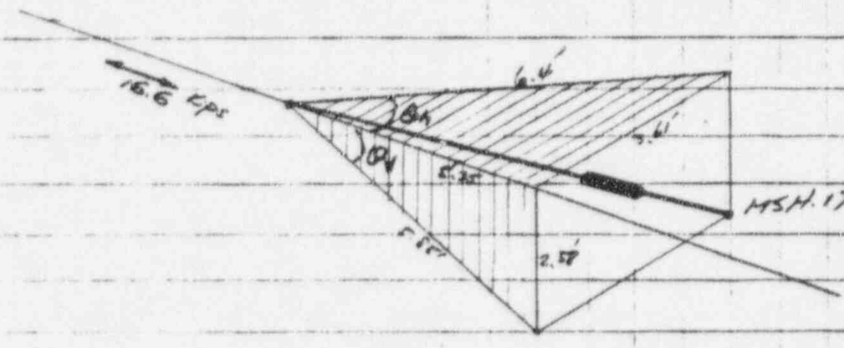
$$S_{max} = 5,780 + 9,170 = 14,950$$
$$< 18,000 = 1.2 S_h$$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 24 OF
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

RESULTS

CR-16

Sec. 11



$$\cos\theta_h = \frac{5.25}{6.4} = 0.821 \qquad \cos\theta_v = \frac{5.25}{5.85} = 0.9$$

$F_x = 16.6$ Kips

Load on MSH-170 due to Fx

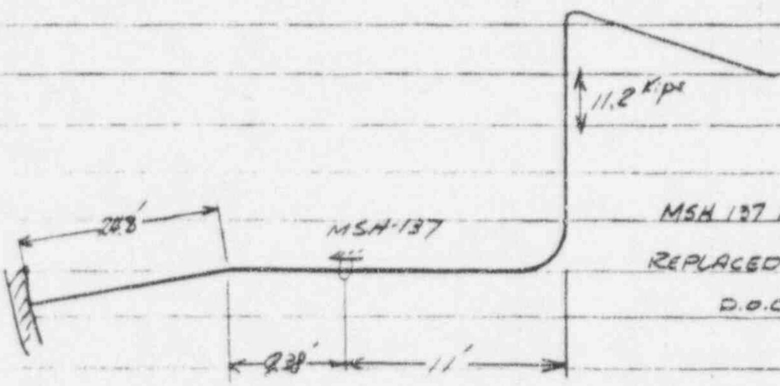
$$= F_x \frac{1}{\cos\theta_h \cos\theta_v} = 16.6 \frac{1}{0.821 \times 0.9} = 22.4^{Kips}$$

Existing Capacity $49.5^{Kips} > 22.4^{Kips}$

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE	
	PROJECT	W.O.	PAGE 25 OF
SYSTEM		ORIGINATOR	
		DATE	
CALCULATION FOR		REVIEWER	
		DATE	
		RESULTS	

CR-16

Sec. 10 (vertical drop)



MSH 137 IS VOID &
REPLACED BY MSH 247
D.O.C. 1-18-77

Since the layout is close to that of CR-15 and with smaller axial thrust on the vertical section, the modification of MSH-142 on CR-15 can be applied to MSH137.

FILING CODE

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	FILING CODE
	PROJECT	W.O. / PAGE 26 OF
SYSTEM		ORIGINATOR / DATE
CALCULATION FOR		REVIEWER / DATE

CR-16

Conclusion

1. Add one snubber on Sec. 12 (30 kips)

2. Modify MSH-137 as recommended for MSH-142 of CR-15

RESULTS

FILING CODE

GAI 350 REV. 10-72