Sta#4 ⑮
JUL 26 1998

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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 622232

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) TWRS Projects/SST Retrieval	4. Related EDT No.: n/a
5. Proj./Prog./Dept./Div.: D2991 W-320 TWRS/TCPN # ~~D2MA1~~	6. Design Authority/ Design Agent/Cog. Engr.: JW Bailey, NHC	7. Purchase Order No.: n/a
8. Originator Remarks: For approval and release of a new supporting document. This document has been generated to ensure retrievability of the Project W-320 "Piping Calculations, Vol. 4".		9. Equip./Component No.: n/a 10. System/Bldg./Facility: 241-C-106
11. Receiver Remarks: 11A. Design Baseline Document? [X] Yes [] No		12. Major Assm. Dwg. No.: n/a 13. Permit/Permit Application No.: n/a 14. Required Response Date:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-2474	-	0	Project W-320, 241-C-106 Sluicing, Piping Calculations, Vol. 4	NA			-

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
2	1	Design Authority JW Bailey	JW Bailey	7/23/98	S2-48						
		Design Agent MC Davenport		7/23/98							
2	1	Cog.Eng. ~~CE Graves~~	Davenport		S2-48						
2	1	Cog. Mgr JW Bailey	JW Bailey	7/23/98	S2-48						
		QA									
		Safety									
		Env.									

18. MC Davenport ~~CE Graves 3/24/98~~ M Davenport 7/23/98 Signature of EDT Originator Date	19. Authorized Representative for Receiving Organization Date	20. J.W. Bailey ~~3/24/98~~ 7/23/98 Design Authority/ Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

BD-7400-172-1

HNF-2474, Rev. 0

Project W-320, 241-C-106 Sluicing Piping Calculations, Vol. 4

John W. Bailey
Numatec Hanford Co., Richland, WA 99352
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Abstract: This supporting document has been prepared to make the FDNW calculations for Project W-320, readily retrievable.

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15

Release Approval

7/24/98
Date

Release Stamp

Approved for Public Release

Project W-320, 241-C-106 Sluicing Piping Calculations, Vol. 4

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W320-27-015

Support Structural Analysis

ICF KAISER HANFORD COMPANY	CALCULATION IDENTIFICATION AND INDEX	Page i of ii Date 9/13/1996

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27,Piping and Vessels WO/Job No. ER4319 Calculation No. W-320-27-015
Project No. & Name Project W 320 Waste Retrieval for Tank 241-C-106
Calculation Item Support Structural Analysis

These calculations apply to:

Dwg. No. H-2-818548 Shts 1 & 2 of 2 Rev. No. 0
Dwg. No. Rev. No.
Other (Study, CDR)
Rev. No.

The status of these calculations is:

☐ Preliminary Calculations
☒ Final Calculations
☐ Check Calculations (On Calculation Dated)
☐ Void Calculation (Reason Voided)

Incorporated in Final Drawings? ☒ Yes ☐ No
This calculation verified by independent "check" calculation? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	D. L Stone 5/20/94 J. R. Booth 5/31/94	D. L Stone 8/8/95	Diana L Stone 10/13/96
Checked by	M.M. Ahmed 5/20/94	C.D. Jones 8/10/95	10/03/96
Approved by	C.D. Jones 6/3/94	C.D. Jones 8/10/95	10/03/96
Checked Against Approved Vendor Data			

INDEX

FLUOR DANIEL NORTHWEST INC.	**CALCULATION IDENTIFICATION AND INDEX**	Page ia of ii Date 11/24/97

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline: (27) Piping and Vessels WO/Job No.: ER4319 Calculation No.: W320-27-015

Project No. & Name: Project W-320 Waste Retrieval for Tank 241-C-106

Calculation Item: Support Structural Analysis

These calculations apply to:

Dwg. No.: See Calculation Cross Index Rev. No.

Dwg. No.: Rev. No.

Other (Study, CDR): Rev. No.

The status of these calculations is:

- [] Preliminary Calculations
- [X] Final Calculations
- [] Check Calculations (On Calculation Dated)
- [] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [X] Yes [] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

	Rev. 3 Signature/Date	Rev. 4 Signature/Date	Rev. 5 Signature/Date
Originator	Kelly K Hangane 11/24/97		
Checked by	M. Ahmed 3.13.98		
Approved by	J. L. Evans 4/9/98		
Checked Against Approved Vendor Data	M. Ahmed 4.10.98		

INDEX

Design Analysis Page No.	Description
i	Calculation Identification and Index
ii	Calculation Cross Index
1	Objective, Design Inputs, Design Methodology
2	Calculations, References and Conclusions
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Appx A	"POP" Analysis
Appx B	Drawings
	Rev. 3 Incorporates As-Built Conditions. Page ia added. Pages ii, 1, 2, 6, and 16 revised.

CALCULATION CROSS INDEX (Typical)

Subject Calculation No.: W320-27-014

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Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents		Does the output interface calculation/ documents require revision?		Has the output interfacecalculation/ documents been revised?		Discipline manager's signature and date indicating evaluation complete.
		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No	
3	NA	H-2-818532, Sheet 1	01				X		X	X
		H-2-818532, Sheet 2	01							
		H-2-818548, Sheet 1	01	△3						D. L. Evans 7/16/98
		H-2-818548, Sheet 2	01	3.13.98						
		Calc # W320-27-013	3							
		Calc # W320-27-014	3				X		X	X

KEH 1975.00 (12/88)

ICF KAISER
HANFORD COMPANY

DESIGN ANALYSIS

Calc No. W-320-27-015
Revision No. ~~2~~ 3
Page No. 1 of 29

Client WESTINGHOUSE HANFORD COMPANY
Subject SUPPORT STRUCTURAL ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - 200 W. AREA

WO/Job No. ER4319
Date 9 / 13 / 96
Checked 10 / 3 / 96
Revised 11 / 24 / 97

Filename SSA-TEXT. WP
By D.L.STONE
By N.J.JUPLO
By K. Hoyase

CHKD: [illegible]

OBJECTIVE:

The objective of this calculation is to perform the structural analysis of the Pipe Supports designed for Slurry & Supernate transfer pipe lines in order to meet the requirements of Code ASME Code B31.3.

DESIGN INPUTS:

Design Criteria:

1. ASME Code B31.3-93 with B31.3a-93 Addenda.

2. Uniform Building Code, 1991 Edition.

3. Functional Design Criteria WHC-SD-W320-FDC-001, Rev. ~~3~~ 4 3

DESIGN METHODOLOGY:

Support Design Loads:

The pipe support design loads are obtained from the piping stress calculations W320-27-14 (Ref.7) and W320-27-15 (Ref.8). These loads are the total summation of the gravity, pressure, thermal and seismic loads.

Since standard typical designs are used for each type of pipe support such as Y-Stop, Guide and Anchors, each type of support is evaluated for the maximum loads to which this type of supports are subjected. These loads are obtained from the AutoPipe analysis (Ref.7) and used to check the structural adequacy of these supports. These loads are tabulated on Page 3.

Since the intermediate anchor is designed to serve as an anchor for both primary pipe and encasement pipe, it is evaluated for the combined effect of the loads from the primary pipe (AutoPipe analysis) and encasement pipe loads. The only Encasement pipe load this anchor will be subjected to is a thermal axial load. This load is calculated on Page 3. In the event of earth quake, since anchor structure will move in tandem with ground motion, it will not experience any seismic loads.

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DESIGN ANALYSIS

Calc No. W-320-27-015
Revision No. ~~2~~3
Page No. 2 of 29

Client WESTINGHOUSE HANFORD COMPANY
Subject SUPPORT STRUCTURAL ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - 200 W. AREA

WO/Job No. ER4319 Filename SSA-TEXT. WP
Date 9 / 13 / 96 By D.L.STONE
Checked 10 / 3 / 96 By N.J.JUPLO
Revised 11 / 24/ 97 By K. Hayase
CHKD: M. Ahmed
3.3.98

STRUCTURAL ANALYSIS:

The structural analysis (member stresses & weld stresses) is performed using the principles of statics as illustrated in "Design of Welded structures" by Blodgett (Ref.5) & "Formulas for Stress and Strain" by Roark (Ref.6).

The local stresses in the pipe wall due to welded attachments such as trunnions are computed based on Bjilaard principles promulgated in WRC Bulletin 107 (Ref.10). The "POP" computer program (Ref.11), a program based on WRC Bulletin, is used for computing the local stresses for Trunnion attachment. The calculated pipe local stresses are added to corresponding pipe stresses obtained from the AutoPipe analysis in order to satisfy the requirements of Code B31.3.

The base plates are analyzed using the moment of inertia method. The concrete anchors are qualified based on criteria in SDC 4.2, Rev-0, (Ref.14).

CALCULATIONS:

See pages 3 thru 16 for calculations.
See Appendix-A for "POP" program results.

REFERENCES:

1. ASME B31.3-93 Code and ASME B31.3.3a-93 Addenda for "Chemical and Petroleum Refinery".
2. Uniform Building Code, 1991 Edition.
3. Crane Technical Paper No: 410, 22nd Printing-1985.
4. AISC "Steel Construction Manual" 9th Edition.
5. "Design of Welded Structures" by Blodgett, 8th Printing.
6. "Formulas for Stress and Strain" by Roark & Young, 5th Edition.
7. Calculation: W320-27-14, ~~Rev-0~~ "Encasement Pipe Stress Analysis". Rev. 3 △3
8. Calculation: W320-27-13, ~~Rev-0~~ " Process Pipe Stress Analysis". Rev. 3
9. Pipe Support Detail Drawings: H-2-818548 sh 1 & 2 of 2, Rev-0
10. WRC Bulletin no: 107, March 1979 "Local Stresses in Spherical and Cylindrical Shells due to External Loadings" by K.R. Wichman, A.G.Hopper and J.L. Mershon.
11. Computer program "POP" (PIPE ON PIPE) Version-0, Release Date: Feb 12, 1993.
12. W-~~030~~ 320 Project Specs: "WHC-SD-W320-FDC-001, Rev-~~2~~" 4 △3
13. "Hand Book of Engineering Fundamentals" Third Edition by O. W. Eshback and M. Souders.
14. SDC 4.2, Rev-0, "Design & Installation of Expansion Anchors" △3
(Now FDNW Practice # 134.215.1206, Design of Expansion Anchors)

CONCLUSION:

The review of succeeding calculations indicates, pipe supports structures meet ASME Code B31.3 requirements.

Rev. 3 of this calculation verified the analysis against the as-built conditions. △3
and found the changes does not have any adverse impact on analysis

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SLURRY LINE From Autopipe Analysis for Inner Process Pipe (Ref. 8)

(Ref. W320-27-013 Appdx. A)		FORCES (lb)			MOMENTS (ft-lb)		
Anchor	Node	x	y	z	x	y	z
	A39	508	259	688	88	273	362
Guide	Node	x	y	z	x	y	z
	A01	0	514	1218	/	/	/
Incline	Node	x	y	z	x	y	z
	A74		283		/	/	/

SUPERNATE LINE

(Ref. W320-27-013 Appdx. B)		FORCES (lb)			MOMENTS (ft-lb)		
Anchor	Node	x	y	z	x	y	z
	A39	422	259	612	88	227	362
Guide	Node	x	y	z	x	y	z
	A41	670	532	670			
Incline	Node	x	y	z	x	y	z
	A25		286		/	/	/

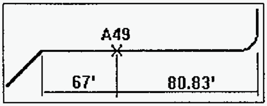
ENCASEMENT PIPE AXIAL LOADS FOR INTERMEDIATE ANCHOR (Ref. 7)

(Ref. W320-27-013 Appdx.)		FORCES (lb)			MOMENTS (ft-lb)		
Thermal Loads	Node	x	y	z	x	y	z
	A49			3844 *			

* Note: Where Encasement Pipe segments on on either side of anchors are equal, axial friction forces at the anchor are equal in magnitude and opposite in direction, resulting in zero axial load on the anchors.
The maximum difference between pipe segment lengths on either side of an anchor occurs at Node A49.

Axial load at A49:

$\Delta L =$	$F =$	$F_z = F \times \Delta L =$
13.82	23.18	3844.1712



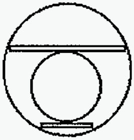
(Ref. 7)

DEAD WEIGHT SUPPORT ANALYSIS (Details 2 and 4 Ref.9)

The purpose of this calculation is to determine a minimum plate thickness required for the Process Pipe Dead Weight Support.

Static bending analysis to determine maximum allowable stress for a minimum plate thickness.

Worst case loadings determined from *Autopipe* analysis. (See Page 3)

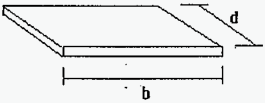


ASTM A36 Plate Material (Ref. 9)

$S_h := 16900 \cdot psi$ Code B31.3 Allowable Stress at 200 deg F (Ref. 1)

$F_y := 286 \cdot lbf$ Worst case loading for Process Pipe Dead Weght Support.

$b := 3.3125 \cdot in$ Design width of support plate. (Ref. 9) (Simple support beam span - conservative)

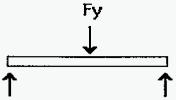


$d := 3 \cdot in$ Plate Length

$M := F_y \cdot \frac{b}{4}$

$M = 236.844 \cdot lbf \cdot in$

Moment at F_y (Ref. 5)



$t := 0.25 \cdot in$ Design thickness of support plate.

$c := \left(\frac{t}{2}\right)$

$c = 0.125 \cdot in$ Distance between centroid and outerfiber. (Ref. 5)

$I := \left(\frac{d \cdot t^3}{12}\right)$

$I = 0.004 \cdot in^4$ Moment of Inertia of the plate

$\sigma_{BpL} := \frac{M \cdot c}{I}$

$\sigma_{BpL} = 7.579 \cdot 10^3 \cdot psi$ Calculated bending stress at F_y

DESIGN ANALYSIS

Client: **WESTINGHOUSE HANFORD COMPANY**
Subject: **PROJECT W-320 WASTE RETRIEVAL**
PIPE SUPPORT STRUCTURAL ANALYSIS
Location: **C TANK FARM - 200 EAST AREA HANFORD**

WO/Job No.: **ER4319**
Date: 9 / 13 / 96 By: **D.L. STONE**
Checked: 10 /03 /96 By: N. J. JUPLO
Revised: By:

$\sigma_{all} := 1.33 \cdot S_h$ (Ref. 1)

$\sigma_{all} = 2.248 \cdot 10^4 \cdot psi$ Allowable stress for ASTM A-36 Plate

$$\left[\frac{M\left(\frac{t}{2}\right)}{\frac{d \cdot t_{min}{}^3}{12}} \right] \text{------->} \frac{6 \cdot M}{d \cdot t_{min}{}^2}$$

Governing Equation (Ref. 5)

$$t_{min} := \sqrt{\frac{6 \cdot M}{d \cdot \sigma_{all}}}$$

$t_{min} = 0.145 \cdot in$ Minimum required plate thickness.

$t = 0.25 \cdot in$ Design Thickness (Ref. 9)

1/4" Plate is adequate for worst case loadings.

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DESIGN ANALYSIS

Calc. No.: W- 320- 27- 015
Revision No.: ~~2~~ 3
Page No.: 6 of 29

Client: WESTINGHOUSE HANFORD COMPANY
Subject: PROJECT W-320 WASTE RETRIEVAL
PIPE SUPPORT STRUCTURAL ANALYSIS
Location: C TANK FARM - 200 EAST AREA HANFORD

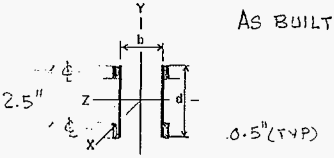
WO/Job No.: ER4319
Date: 9 / 13 / 96 By: D.L. STONE
Checked: 10/03/96 By: N.J. JUPLO
Revised: 11/24/97 By: K. Hayase CHKD: [illegible]
3.13.9

WELD CALCULATIONS FOR JOINT BETWEEN ~~LUGS AND PROGESS PIPE:~~ Plate and Encasement Pipe

3

WELD PROPERTIES: (Ref. 5)

AS BUILT WELD: 1/2" INTERMITTENT GROOVE WELD @ 2½" [illegible]



$b := 3.313 \cdot in$ $d \equiv \cancel{3 \cdot in}$ 1 in

$Cy := \frac{b}{2}$ $Cy = 1.656 \cdot in$

$Cz := \frac{d}{2}$ $Cz = \cancel{1.5 \cdot in}$ 0.5 in

$Aw := 2 \cdot d$ $Aw = \cancel{6 \cdot in}$ 2 in

$Swy := b \cdot d$ $Swy = \cancel{9.939 \cdot in^2}$ 3 in^2

$Swz := \frac{d^2}{3}$ $Swz = \cancel{3 \cdot in^2}$ 0 33 in^2

$\cancel{Jw := \frac{d \cdot (3 \cdot b^2 + d^2)}{6}}$ $\cancel{Jw = 20.964 \cdot in^3}$

JOINT LOADS:

Tensile $Fx := F_y$ = 286 lbs $Fy := 0 \cdot lbf$ $Fz := 0 \cdot lbf$

Moment $Mx := 0 \cdot in \cdot lbf$ $My := M$ = 237 in.lbs $Mz := 0 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = \cancel{71.496} \; 222 \; \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

3

$S_h := 16700 \cdot psi$

1.33×0.8×S_h 17981

$S := \cancel{1.2 \cdot 0.75 \cdot S_h}$ $S = \cancel{1.503 \cdot 10^4} \cdot psi$ Allowable Weld Stress per ASME Code B31.3 (Ref. 1)

$w := \frac{fw}{\cancel{0.707} \cdot S}$ $w = \cancel{0.007 \cdot in}$ 0.013 Minimum ~~Fillet~~ GROOVE Weld Required

$w_{Design} := \left(\frac{1}{8} \cdot in\right)$ Design Fillet Weld Size

$SF_{fw} := \frac{w_{Design}}{w}$ $SF_{fw} = \cancel{18.578}$ 9.6 Design exceeds requirement by a factor of ~~18.578~~ 9.6 - OK

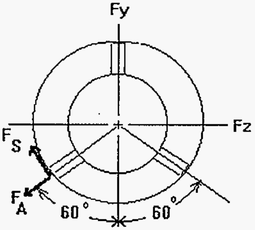
Process Pipe Guide Lug Design

(Detail 3 Ref. 9)

Assumptions: Lugs see Process Pipe Loads, only.

Each lug is subjected to total loading (conservative.) (Ref.8)
Critical Process Pipe Loads located at Nodepoint A41 on Autopipe Model TRAN-SP are determined as critical.

Loads (See Page 3)



$F_x := 0 \cdot lbf$ Longitudinal Force

$F_y := 532 \cdot lbf$ Vertical Force

$F_z := \sqrt{670^2 + 670^2} \cdot lbf$ $F_z - 947.523 \cdot lbf$ Horizontal Force

$F_L := \frac{F_x}{3}$ $F_L - 0 \cdot lbf$ Longitudinal Loading

$F_A := F_y \cdot \cos(60 \cdot deg) + F_z \cdot \sin(60 \cdot deg)$ $F_A - 1.087 \cdot 10^3 \cdot lbf$ Axial Loading

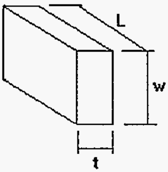
$F_S := F_y \cdot \sin(60 \cdot deg) + F_z \cdot \cos(60 \cdot deg)$ $F_S - 934.487 \cdot lbf$ Shear Loading

Properties

Material: ASTM A240 TP 304L (Ref. 9)

$S_h := 16700 \cdot psi$ Allowable Stress at 200 deg F (Ref.1)

$L := 4 \cdot in$ Lug Length



$w := 0.72 \cdot in$ Lug Width

$t := 0.375 \cdot in$ Lug thickness

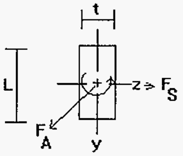
$c_y := \frac{t}{2}$

$c_z := \frac{L}{2}$ (Ref. 5)

$A := L \cdot t$ $A - 1.5 \cdot in^2$ Lug Area

$I_y := \frac{1}{12} \cdot t^3 \cdot L \qquad I_y = 0.018 \cdot in^4$ Moment of Area about y (Ref. 5)

$I_z := \frac{1}{12} \cdot t \cdot L^3 \qquad I_z = 2 \cdot in^4$ Moment of Area about z



$z_y := \frac{I_y}{c_y} \qquad z_y = 0.094 \cdot in^3$ Section Modulus

$z_z := \frac{I_z}{c_z} \qquad z_z = 1 \cdot in^3$ Section Modulus

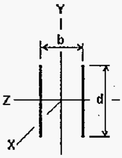
Tension and Bending

$$\sigma_n := \frac{F_A}{A} + \frac{F_S \cdot w}{(z_y)} \qquad \sigma_n = 7.901 \cdot 10^3 \cdot psi$$

$$S_{all} := 1.33 \cdot S_h \qquad S_{all} = 2.221 \cdot 10^4 \cdot psi$$

$$|\sigma_n| = 7.901 \cdot 10^3 \cdot psi \qquad < \qquad S_{all} = 2.221 \cdot 10^4 \cdot psi$$ (Ref. 1)

WELD CALCULATIONS FOR JOINT BETWEEN LUGS AND PROCESS PIPE:



WELD PROPERTIES: (Ref. 5)

$b := 0.375 \cdot in \qquad d \equiv 4 \cdot in$

$Cy := \frac{b}{2} \qquad Cy = 0.187 \cdot in$

$Cz := \frac{d}{2} \qquad Cz = 2 \cdot in$

$Aw := 2 \cdot d \qquad Aw = 8 \cdot in$

$Swy := b \cdot d \qquad Swy = 1.5 \cdot in^2$

$Swz := \frac{d^2}{3} \qquad Swz = 5.333 \cdot in^2$

$Jw := \frac{d \cdot (3 \cdot b^2 + d^2)}{6} \qquad Jw = 10.948 \cdot in^3$

JOINT LOADS:

Tensile	$Fx := F_A$	$Fy := 0 \cdot lbf$	$Fz := 0 \cdot lbf$
Moment	$Mx := 0 \cdot in \cdot lbf$	$My := F_S \cdot w$	$Mz := 0 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 584.376 \cdot \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S_h := 16700 \cdot psi$

$S := 1.2 \cdot 0.75 \cdot S_h \qquad S = 1.503 \cdot 10^4 \cdot psi$ Allowable Weld Stress per ASME Code B31.3 (Ref. 1)

$w := \frac{fw}{0.707 \cdot S} \qquad w = 0.055 \cdot in$ Minimum Fillet Weld Required

$w_{Design} := \left(\frac{3}{16} \cdot in\right)$ Design Fillet Weld Size

$SF_{fw} := \frac{w_{Design}}{w} \qquad SF_{fw} = 3.409$ Design exceeds requirement by a factor of 3.409 - OK

PIPE LOCAL STRESSES DUE TO WELDED LUGS:

As is evident from above, since weld stresses are very low, local stresses in pipe will be insignificant.

DESIGN ANALYSIS

				Calc. No.:	W-320-27-015
				Revision No.:	2
				Page No.:	10 of 29
Client:	WESTINGHOUSE HANFORD COMPANY	WO/Job No.:	ER4319	Filename:	SA-07mcd
Subject:	PROJECT W-320 WASTE RETRIEVAL PIPE SUPPORT STRUCTURAL ANALYSIS	Date:	9 / 13 / 96	By:	D.L. STONE
		Checked:	10 /03 / 96	By:	N. J. JUPLO
Location:	C TANK FARM - 200 EAST AREA HANFORD	Revised:		By:	

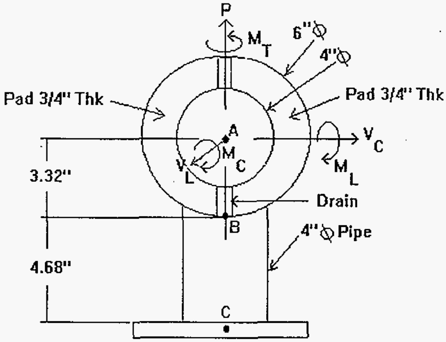
INTERMEDIATE ANCHOR: **(Detail 1 Ref. 9)**

AUTOPIPE Loads for Process Pipe **(See Page 3)**

$F_x := 508 \cdot lbf$ $M_x := 88 \cdot ft \cdot lbf$

$F_y := 259 \cdot lbf$ $M_y := 273 \cdot ft \cdot lbf$

$F_z := 688 \cdot lbf$ $M_z := 362 \cdot ft \cdot lbf$



AUTOPIPE global axes oriented at 45 degree angle to pipe local axes.

PIPE LOADS at A

$P := F_y$ — $P = 259 \cdot lbf$ — **Radial Load**

$V_C := F_z \cdot \cos(45 \cdot deg) + F_x \cdot \cos(45 \cdot deg)$ — $V_C = 845.7 \cdot lbf$ — **Circumferential Shear**

$V_L := F_x \cdot \sin(45 \cdot deg) + F_z \cdot \sin(45 \cdot deg)$ — $V_L = 845.7 \cdot lbf$ — **Longitudinal Shear**

$M_T := M_y$ — $M_T = 3.276 \cdot 10^3 \cdot in \cdot lbf$ — **Torsional Moment**

$M_C := M_x \cdot \cos(45 \cdot deg) + M_z \cdot \cos(45 \cdot deg)$ — $M_C = 3.818 \cdot 10^3 \cdot in \cdot lbf$ — **Circumferential Moment**

$M_L := M_x \cdot \sin(45 \cdot deg) + M_z \cdot \sin(45 \cdot deg)$ — $M_L = 3.818 \cdot 10^3 \cdot in \cdot lbf$ — **Longitudinal Moment**

$F_{AL} := 3844 \cdot lbf$ — **Encased pipe Axial Load (See page 3)**

PIPE LOADS at B **(Checking pipe local stresses and weld between pad and pipes.)**

$P_B := P$ — $P_B = 259 \cdot lbf$

$V_{CB} := V_C$ — $V_{CB} = 845.7 \cdot lbf$

$V_{LB} := V_L + F_{AL}$ — $V_{LB} = 4.69 \cdot 10^3 \cdot lbf$

$M_{TB} := M_T$ — $M_{TB} = 3.276 \cdot 10^3 \cdot in \cdot lbf$

$M_{CB} := M_C + (3.32 \cdot in) \cdot V_C$ — $M_{CB} = 6.626 \cdot 10^3 \cdot in \cdot lbf$

$M_{LB} := M_L + (3.32 \cdot in) \cdot V_{LB}$ — $M_{LB} = 1.939 \cdot 10^4 \cdot in \cdot lbf$

Client: WESTINGHOUSE HANFORD COMPANY
Subject: PROJECT W-320 WASTE RETRIEVAL PIPE SUPPORT STRUCTURAL ANALYSIS
Location: C TANK FARM - 200 EAST AREA HANFORD

WO/Job No.: ER4319
Date: 9 / 13 / 96
Checked: 10 /03 /96
Revised:

Filename: SA-07mcd
By: D.L. STONE
By: J. J. JOFLO
By:

PIPE LOADS at C (Checking base plate and anchor bolts.)

$P_C := P$ $\qquad P_C = 259 \cdot \text{lbf}$

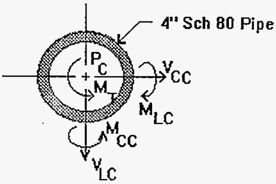
$V_{CC} := V_C$ $\qquad V_{CC} = 845.7 \cdot \text{lbf}$

$V_{LC} := V_L + F_{AL}$ $\qquad V_{LC} = 4.69 \cdot 10^3 \cdot \text{lbf}$

$M_{TC} := M_T$ $\qquad M_{TC} = 3.276 \cdot 10^3 \cdot \text{in} \cdot \text{lbf}$

$M_{CC} := M_C + (8 \cdot \text{in}) \cdot V_C$ $\qquad M_{CC} = 1.058 \cdot 10^4 \cdot \text{in} \cdot \text{lbf}$

$M_{LC} := M_L + (8 \cdot \text{in}) \cdot V_{LC}$ $\qquad M_{LC} = 4.134 \cdot 10^4 \cdot \text{in} \cdot \text{lbf}$



TRUNION STRESSES:

Material: **4" Schedule 80 A 106 GR-B Pipe**

$A := 4.407 \cdot \text{in}^2$ **Area of metal of 4" pipe.**

$z := 4.217 \cdot \text{in}^3$ **Section Modulus**

$$\sigma_n := \frac{P_C}{A} + \frac{M_{CC} + M_{LC}}{z} \qquad \sigma_n = 1.237 \cdot 10^4 \cdot \text{psi}$$

Tension and Bending

$S_h := 20000 \cdot \text{psi}$

$S_{all} := 1.33 \cdot S_h$ **Allowable Stress**

$\sigma_n = 1.237 \cdot 10^4 \cdot \text{psi} \quad < \quad S_{all} = 2.66 \cdot 10^4 \cdot \text{psi}$

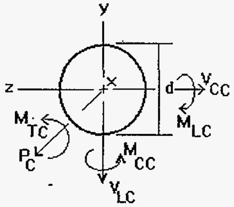
Shear stresses are insignificant.

Client: WESTINGHOUSE HANFORD COMPANY
Subject: PROJECT W-320 WASTE RETRIEVAL
PIPE SUPPORT STRUCTURAL ANALYSIS
Location: C TANK FARM - 200 EAST AREA HANFORD

WO/Job No.: ER4319
Date: 9 / 13 / 96
Checked: 10 / 03 / 96
Revised:

Filename: SA-07.mcd
By: D.L. STONE
By: N.J. JUFLO
By:

WELD CALCULATIONS FOR TRUNION TO BASEPLATE JOINT:



WELD PROPERTIES:

$d := 4.5 \cdot in$ **(Ref. 5)**

$Cy := \frac{d}{2}$ $Cy = 2.25 \cdot in$

$Cz := \frac{d}{2}$ $Cz = 2.25 \cdot in$

$Aw := \pi \cdot d$ $Aw = 14.137 \cdot in$

$Swy := \frac{\pi \cdot d^2}{4}$ $Swy = 15.904 \cdot in^2$

$Swz := Swy$ $Swz = 15.904 \cdot in^2$

$Jw := \frac{\pi \cdot d^3}{4}$ $Jw = 71.569 \cdot in^3$

JOINT LOADS at C:

$Fx := P_C$ $Fy := V_{LC}$ $Fz := V_{CC}$

$Fx = 259 \cdot lbf$ $Fy = 4.69 \cdot 10^3 \cdot lbf$ $Fz = 845.7 \cdot lbf$

$Mx := M_{TC}$ $My := M_{CC}$ $Mz := M_{LC}$

$Mx = 3.276 \cdot 10^3 \cdot in \cdot lbf$ $My = 1.058 \cdot 10^4 \cdot in \cdot lbf$ $Mz = 4.134 \cdot 10^4 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \quad fw = 3.315 \cdot 10^3 \cdot \frac{lbf}{in}$$ **(Ref. 5)**

FILLET WELD SIZE REQUIRED:

$S_h := 17800 \cdot psi$ **ALLOWABLE WELD STRESS PER CODE B31.3 for A36 Plate**

(Ref. 1)

$S := 1.2 \cdot 0.75 \cdot S_h$ $S = 1.602 \cdot 10^4 \cdot psi$

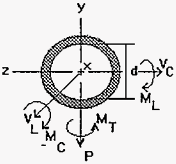
$w := \frac{fw}{0.707 \cdot S}$ $w = 0.293 \cdot in$ **Minimum Fillet Weld Required**

$w_{Design} := \left(\frac{5}{16}\right) \cdot in$ **Design Fillet Weld Size**

$SF_{fw} := \frac{w_{Design}}{w}$ $SF_{fw} = 1.068$ **Design exceeds requirement by a factor of 1.068 - *OK***

WELD CALCULATIONS FOR JOINT BETWEEN PAD AND PIPES:

Note: 1" gaps on top and bottom have been omitted to allow room to weld drain and vent. These gaps are insignificant compared to the total weld length and are, therefore, not considered in the analysis.



WELD PROPERTIES:

$d := 4.5 \cdot in$ **(Ref. 5)**

$Cy := \frac{d}{2}$ $Cy = 2.25 \cdot in$

$Cz := \frac{d}{2}$ $Cz = 2.25 \cdot in$

$Aw := 2 \cdot (\pi \cdot d)$ $Aw = 28.274 \cdot in$

$Swy := 2 \cdot \left(\frac{\pi \cdot d^2}{4}\right)$ $Swy = 31.809 \cdot in^2$

$Swz := Swy$ $Swz = 31.809 \cdot in^2$

$Jw := 2 \cdot \left(\frac{\pi \cdot d^3}{4}\right)$ $Jw = 143.139 \cdot in^3$

JOINT LOADS at B:

$Fx := V_{LB}$	$Fy := P_B$	$Fz := V_{CB}$
$Fx = 4.69 \cdot 10^3 \cdot lbf$	$Fy = 259 \cdot lbf$	$Fz = 845.7 \cdot lbf$
$Mx := M_{CB}$	$My := M_{TB}$	$Mz := M_{LB}$
$Mx = 6.626 \cdot 10^3 \cdot in \cdot lbf$	$My = 3.276 \cdot 10^3 \cdot in \cdot lbf$	$Mz = 1.939 \cdot 10^4 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 895.75 \cdot \frac{lbf}{in}$$

(Ref. 5)

FILLET WELD SIZE REQUIRED:

$S_h \equiv 16700 \cdot psi$ **ALLOWABLE WELD STRESS PER CODE B31.3 for A312 TP306 Pipe** **(Ref. 1)**

$S \equiv 1.2 \cdot 0.75 \cdot S_h$ $S = 1.503 \cdot 10^4 \cdot psi$ **(Ref. 1)**

$w := \frac{fw}{0.707 \cdot S}$ $w = 0.084 \cdot in$ **Minimum Fillet Weld Required**

$w_{Design} := \left(\frac{3}{16}\right) \cdot in$ **Design Fillet Weld Size**

$SF_{fw} := \frac{w_{Design}}{w}$ $SF_{fw} = 2.224$ **Design exceeds requirement by a factor of 2.224 -** *OK*

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HANFORD COMPANY

Calc. No.: W- 320- 27- 015
Revision No.: 2
Page No.: 14 of 29

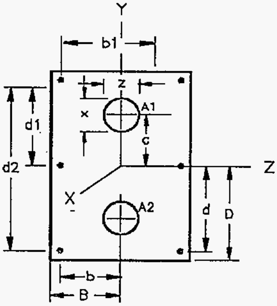
DESIGN ANALYSIS

Client: WESTINGHOUSE HANFORD COMPANY
Subject: PROJECT W-320 WASTE RETRIEVAL
PIPE SUPPORT STRUCTURAL ANALYSIS
Location: C TANK FARM - 200 EAST AREA HANFORD

WO/Job No.: ER4319
Date: 9 / 13 / 96
Checked: 10/03/96
Revised:

Filename: SA-07.mcd
By: D.L. STONE
By: N.J. JUPLO
By:

BASE PLATE ANALYSIS:



DIMENSIONS:

$b := 7.75 \cdot in$ $B := 9 \cdot in$

$d := 11.75 \cdot in$ $D := 13 \cdot in$

$c := 7 \cdot in$ $t := 1 \cdot in$ **Plate Thickness**

$x := 4.5 \cdot in$ $z := 4.5 \cdot in$ **Attachment Diam. (circular)**

$b1 := b + \frac{z}{2} + 2 \cdot t$ $b1 = 12 \cdot in$

$d1 := c + \frac{x}{2} + 2 \cdot t$ $d1 = 11.25 \cdot in$

$d2 := d + d1$ $d2 = 23 \cdot in$

LOADS @ ATTACHMENT "A1" : **(See Page 11)**

$Fx1 := P_C$ $Fy1 := V_{CC}$ $Fz1 := V_{LC}$

$Fx1 = 259 \cdot lbf$ $Fy1 = 845.7 \cdot lbf$ $Fz1 = 4.69 \cdot 10^3 \cdot lbf$

$Mx1 := M_{TC}$ $My1 := M_{LC}$ $Mz1 := M_{CC}$

$Mx1 = 3.276 \cdot 10^3 \cdot in \cdot lbf$ $My1 = 4.134 \cdot 10^4 \cdot in \cdot lbf$ $Mz1 = 1.058 \cdot 10^4 \cdot in \cdot lbf$

LOADS @ ATTACHMENT "A2" :

$Fx2 := P_C$ $Fy2 := V_{CC}$ $Fz2 := V_{LC}$

$Fx2 = 259 \cdot lbf$ $Fy2 = 845.7 \cdot lbf$ $Fz2 = 4.69 \cdot 10^3 \cdot lbf$

$Mx2 := M_{TC}$ $My2 := M_{LC}$ $Mz2 := M_{CC}$

$Mx2 = 3.276 \cdot 10^3 \cdot in \cdot lbf$ $My2 = 4.134 \cdot 10^4 \cdot in \cdot lbf$ $Mz2 = 1.058 \cdot 10^4 \cdot in \cdot lbf$

LOADS @ CENTROID OF BOLT PATTEREN:

$Fx := Fx1 + Fx2$ $Fx = 518 \cdot lbf$

$Fy := Fy1 + Fy2$ $Fy = 1.691 \cdot 10^3 \cdot lbf$

$Fz := Fz1 + Fz2$ $Fz = 9.379 \cdot 10^3 \cdot lbf$

$Mx := Mx1 + Mx2 + c \cdot (Fz1 + Fz2)$ $Mx = 7.221 \cdot 10^4 \cdot in \cdot lbf$

$My := My1 + My2$ $My = 8.267 \cdot 10^4 \cdot in \cdot lbf$

$Mz := Mz1 + Mz2 + c \cdot (Fx1 + Fx2)$ $Mz = 2.479 \cdot 10^4 \cdot in \cdot lbf$

BOLT TENSION & SHEAR:

$$T := \frac{Fx}{6} + \frac{My}{3 \cdot b1} + \frac{Mz}{2 \cdot d1 + 2 \cdot d2} \qquad T = 2.745 \cdot 10^{3} \cdot \text{lbf}$$

$$S := \left[\left[\frac{Fy}{6} + \frac{Mx}{4 \cdot \left(b^2 + d^2\right)^{0.5}} \right]^2 + \left[\frac{Fz}{6} + \frac{Mx}{4 \cdot \left(b^2 + d^2\right)^{0.5}} \right]^2 \right]^{0.5} \qquad S = 3.247 \cdot 10^{3} \cdot \text{lbf}$$

BOLT INTERACTION (I) - BOLT SIZE & EMBEDMENT:

$A_s := 0.462$ **Tensile Stress Area for 7/8 Diam. Bolt** **(Ref. 4)**

$Sh := 13700$ **Allowable Tensile stress for A307 Bolts at 200° F.** **Ref. AISC Pg. 4-3**

$Ta := 1.33 \cdot A_s \cdot Sh$ $Ta = 8.418 \cdot 10^{3}$ **TENSION Allowable**

$Sa := 1.33 \cdot A_s \cdot 0.8 \cdot Sh$ $Sa = 6.734 \cdot 10^{3}$ **SHEAR Allowable**

$I := \frac{T}{Ta} + \frac{S}{Sa}$ $I = 0.808 \cdot \text{lbf} < \mathbf{1.0}$ **BOLTS ARE ACCEPTABLE**

BASE PLATE STRESS:

$Mb := 3 \cdot T \cdot \left(b - \frac{z}{2}\right)$ $Mb = 4.529 \cdot 10^{4} \cdot \text{in} \cdot \text{lbf}$ **Maximum Bending Moment on Plate** **(Ref. 5)**

$Z := \frac{2 \cdot B \cdot t^2}{6}$ $Z = 3 \cdot \text{in}^{3}$

$\sigma b := \frac{Mb}{Z}$ $\sigma b = 1.51 \cdot 10^{4} \cdot \text{psi}$ **Maximum Bending Stress**

$S_h := 17800 \cdot \text{psi}$ **For A36 Plate**

$\sigma_{all} := 1.33 \cdot S_h$ $\sigma_{all} = 2.367 \cdot 10^{4} \cdot \text{psi}$ **Code B31.3 Allowable** **(Ref. 1)**

$\sigma b = 1.51 \cdot 10^{4} \cdot \text{psi} < \sigma_{all} = 2.367 \cdot 10^{4} \cdot \text{psi}$ **MAXIMUM STRESS LEVEL ACCEPTABLE**

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NORTHWEST INC.

Calc. No.: W320-27-015
Revision: 3
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DESIGN ANALYSIS

Client: Numatec
Subject: Support Structural Analysis
Project W-320 Waste Retrieval for Tank 241-C-106
Location: C Tank Farm 200 East Area

WO/Job No.: ER4319/W-320
Date: 11/24/97 By: K. Hayase
Checked: 3-13-98 By: M. Ahmed
Revised: By:

TOTAL PIPE STRESSES

Includes local pipe stresses due to welded trunion. Assumes the same stress state in the process and encasement pipe due to the trunion.

Process Pipe: (ASTM A312 TP304 L) $S_h = S_c = 16700$ psi

Max Sustained Stress (Autopipe, Ref. 8) 8128 psi
Appdx-A page 103
Local Stress (Sus. + Ther. + Occ.) 7813 psi
(From 'POP', Pg. 6, Appdx A) Total 15941 psi < 16700 psi allowable

Max Displacement Stress (Autopipe, Ref. 8) 16758 psi

Local Stress 7813 psi
Total 24571 psi < 25050 psi allowable
$= [1.25 S_h + 0.25 S_c]$

Max Occasional Stress (Autopipe, Ref. 8) 13427 psi
Appdx-A page 104
Local Stress 7813 psi
Total 21240 psi < 22211 psi allowable $= (1.33 S_h)$

Note: The allowable stress exceeds two-thirds of yield strength at temperature (Ref. B31.3 Para 302.3.6(a) and should be reduced slightly. However, the actual stresses at the intermediate anchor points are significantly less than the max occasional stress used here, therefore this is acceptable.

Encasement Pipe: (ASTM A53 Type-E GR-B) $S_h = 20000$ psi

Max Sustained Stress (STAB, Ref. 7) 1922 psi

Local Stress 7813 psi
Total 9735 psi < 20000 psi allowable (S_h)

Max Displacement Stress (STAB, Ref. 7) 23800 psi
(Page-10 of Ilo Calcs)
Local Stress 7813 psi
Total 31613 psi < 40265 psi allowable

Note: allowable = 1.25(20000 psi + 20000 psi) - 9735 psi = 40265 psi (Ref. B31.3)

Max Occasional Stress (STAB, Ref. 7) 5904 psi

Local Stress 7813 psi
Total 13717 psi < 26600 psi allowable $(1.33 S_h)$

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DESIGN ANALYSIS

Calc. No. W320-27
Revision 0
Page No. 17 of 29

Client WHC
WO/Job No. E5 [illegible] / W-320
Subject Transfer Line - Concrete Base Design
Date 5/20/94 By
Checked 5/20/94 By
Location 200 E
Revised By

Determine the Resteel Required in the Concrete Base for the Transfer Line Pipe Supports

1. Determine if size of footing is adequate to resist movement from forces imposed by the transfer lines.

$F_x = 2(905\ lb) = 1810\ lbs$
$= 1.8\ kips$

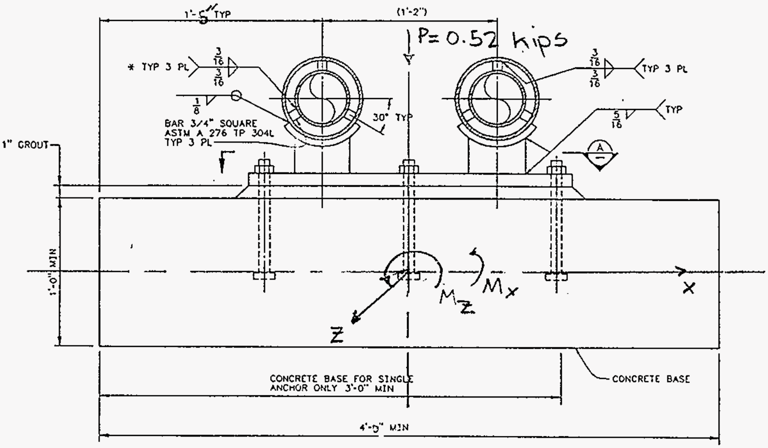
$M_x = 2(79850) = 159700\ in \cdot lb$
$= 159.7\ in \cdot kips$

$F_y = 2(259\ lb) = 518\ lbs$
$= 0.52\ kips$

$M_y = 2(681\ lb) + 2(4752\ lb)(7\ in)$
$= 80160\ in \cdot lb$
$= 80.2\ in \cdot kips$

$F_z = 2(4752) = 9504\ lbs$
$= 9.5\ kips$

$M_z = 2(18298) = 36596\ in \cdot lb$
$= 36.6\ in \cdot kip$



a) $M_z = M_o = 36.6 + 0.57(7 in) = 40.2\ in \cdot kip$ (Overturning Moment)

Determine if eccentricity is greater than Kern ($\frac{W}{6}$).

w = width of footing = 4.17 ft.

Client WHC
WO/Job No. [illegible]
Subject [illegible]
Date [illegible] By [illegible]
Checked 5/20/92 By [illegible]
Location [illegible]
Revised By

a. continued

wt of footing = (1 ft)(3 ft)(4.2 ft)(150 pcf) = 1899 lbs = 1.9 kip

$P = D + L = 1.9 + 0.52 + 5.7 = 8.12$ kip (Ws = wt. of soil = 5.7 kips) $\gamma = 115$ pcf, Table 2 of Shannon & Wilson Report KEH-8008-2

$$e = M/P = \frac{40.2 \text{ in kip}}{8.12 \text{ kip}} = 5.0 \text{ in}$$

$$K = \frac{36 \text{ in}}{6} = 6 \text{ in}$$

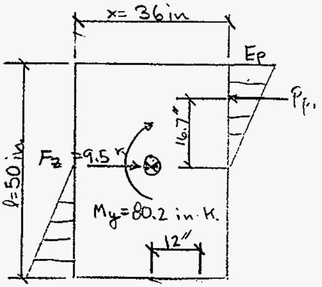
$\therefore$ Since $e < k$ (kern) determine $q_{max} = \frac{P}{BL}\left(1 + \frac{6e}{B}\right)$

P = 8.12 kip
B = 3. ft
L = 4.2 ft
e = 5/12 ft
q_A = 4000 psf

$$q_{max} = \frac{8.12}{(3)(4.2)}\left(1 + \frac{6(5/12)}{3}\right) = 1.18 \text{ ksf} < 4 \text{ ksf}$$ OK

* q_A = 4000 psf from Shannon & Wilson Soil Report, contract# KEH-8008-2

b. Check lateral resistance to sliding & rotation.



PLAN

Allowable Passive earth pressure.

$$E_p = \tfrac{1}{2}(115 \text{ pcf})(4.5 \text{ ft})^2 (4/1.5) = 3105 \text{ lbs/ft}$$

← min depth

Assume My is resisted by the 2 faces of the base.

$$P_{p1} = \left[\frac{E_p \cdot \tfrac{1}{2}}{2}\right] = \left[\frac{3105(4.2/2)}{2}\right] = 3260 \text{ lbs}$$

P_{p1} = 3.3 kip

Note: Ep is total force from soil acting againt the footing at that depth and acts as a triangular distribution from centroid.

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DESIGN ANALYSIS

Calc. No. [illegible]
Revision [illegible]
Page No. 19 of [illegible]

Client W/HC
WO/Job No. ER43[illegible] / W-320
Subject [illegible]
Date 5/2[illegible]/9[illegible] By [illegible]
Checked 5/20/94 By [illegible]
Location [illegible]
Revised By

b. Continued

$M_p \geq M_y$; required to resist torsion.

$M_p = P_p(16.7)z = 110.2$ in·kip

$\therefore M_p > M_y$, <u>OK</u>

Note: For the equation $E_p = \frac{1}{2} \gamma h^2 K_p$, $K_p = 4.0$ from S&W report. S&W recommended S.F. of 1.5. E_p is Total force acting along the base. (lb/ft)

c. Check sliding resistance:

$F_z = 9.5$ kip

$F = \frac{F_r}{F_z} \geq 1.5$, for cohesionless soils.

where

$F_r = R \tan\phi + E_p\, l$

where ϕ = Friction ∡ ($\phi = 37°$, from S&W Report)
$R = W_c + W_s = 7.6$ kip

$W_c = 1.9$ kip

$W_s = 115\,\text{pcf} \times 4.2' \times 3.0' \times 3.92' = 5680$ lbs

$F_r = 7.6(\tan 37°) + 3.1(4.2) = 18.7$ kip

$\frac{F_r}{F_z} = \frac{18.7}{9.5} = 2.0 > 1.5 \quad \therefore$ <u>OK</u>

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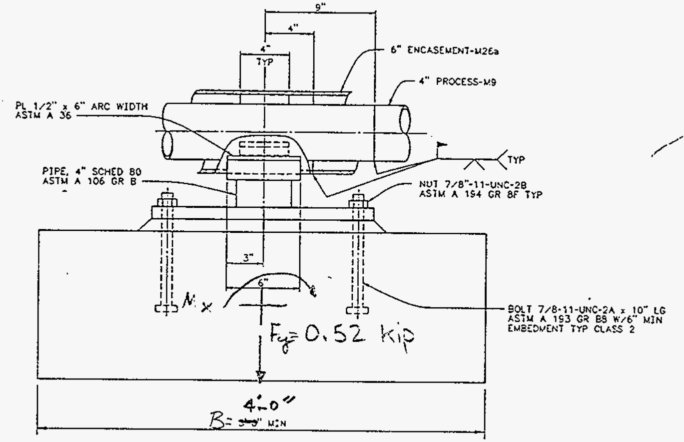
HANFORD

DESIGN ANALYSIS

Calc. No. W320-27-005
Revision 0
Page No. 20 of 27

Client WHC
WO/Job No. ER4319/W-320
Subject Transfer Line - Concrete Base Design
Date 5/20/94 By NK Rosenberg
Checked 5/20/94 By KW Dowling
Location 200E
Revised By

d. Check moment from other view.



$M_o = M_x = 159.7$ in·kip

$P = F_y + W_c + W_s = 8.12$ kips

$e = M/P = \frac{159.7}{8.12 \text{ kip}} = 19.7$ in $\qquad k = \frac{50 \text{ in}}{6} = 8.3$ in

Increase B to 3'-6", which will increase P by 315 lb to P = 8.44 kips

$e = \frac{159.7}{8.44} = 18.9$ in

$q_{ult} = \frac{2P}{3L(B/2 - e)}$, since $e > k$

$q_{ult} = \frac{2(8.44)}{3(4.2)(3.5/2 - 18.9/12)} = 7.7$ ksf N.G

KAISER ENGINEERS
HANFORD

DESIGN ANALYSIS

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Revision 0
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Client WHC
WO/Job No. ER4319 / W-320
Subject Transfer Line - Concrete Base Design
Date 5/24/94 By
Checked By
Location 200 E
Revised By

d. Continued:

Try $B = 4.0'$

P will increase by 315 lb to $P = 8.76$ Kip,

$$e = \frac{159.7}{8.76} = 18.23 \text{ in}$$

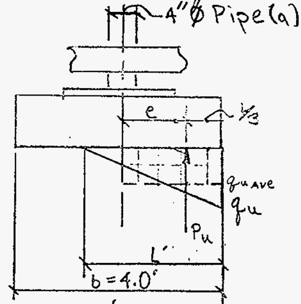
$$q_{u1t} = \frac{2(8.76)}{3(4.0)(4/2 - \frac{18.23}{12})} = 3.0 \text{ ksf} < q_A \quad \text{OK}$$

Note: Stability not a concern since the pipe lines will prevent the footing from overturning.

From a constructibility stand point make concrete pad square (4.0'×4.0')

e. Determine Resteel Required for Slab.

$L' = (\frac{L}{2} - e)3$
$= (\frac{48}{2} - 18.23)3$
$= 17.31$ in
$= 1.44$ ft



$q_{max} = 3.0$ ksF
Use q_A to determine bending for Resteel to take into account the small moment in the other direction.

Ave. the distributed load to be more conserv. and take the moment about the center.

$$q_u = 1.6\, q_A = 1.6(4000 \text{ plf}) = 6400 \text{ plf}$$

Averaging the q_u into $q_{u\,AVE}$.

$$q_{u\,AVE} = \frac{\left(\frac{6.4}{1.44}\right)2}{2} + \left[6.4 - \left(\frac{6.4}{1.44}\right)2\right] = 6.4 \text{ plF}$$

$$M_u = \frac{6.4(2)^2}{2} = 12.8 \text{ Ft} \cdot \text{kip}$$

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DESIGN ANALYSIS

Calc. No. W320-27-015
Revision 0
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Client W/HC		WO/Job No. ER4319 /W-320	
Subject Transfer Line - Concrete Base Design		Date 5/24/94	By Booth
		Checked [illegible]	By [illegible]
Location 200 E		Revised	By

e. Continued:

- Use design proceedure 3 of ACI SP-17(91) vol. 1, "ACI Design Handbook."

$d = 12 - 3 - \frac{0.625}{2} = 8.69'' \quad \phi M_n \geq M_u$

$F = \frac{bd^2}{12000} = \frac{(12)(9)^2}{12000} = 0.081$

$K_n = M_u / F = 12.8 / 0.081 = 158.02$

$K_n < K_{n_{max}}$, select K_n based on $\frac{1}{3}\rho_{max} < \rho < \frac{2}{3}\rho_{max}$

$\therefore K_n = 370$

- Determine Flexural steel required:

$A_s = \frac{12.8}{(9)(4.21)} = 0.35 \text{ in}^2/\text{ft}$

$A_{s_{min}} = 0.0018(12)(12) = 0.26 \text{ in}^2/\text{ft} \qquad \therefore A_s > A_{s_{min}}$

Use $A_s = 0.35 \text{ in}^2/\text{ft}$

- Check Shear: $\phi V_c \geq V_u$ @ d from face of support

$\phi V_c = \phi(2\sqrt{f'_c})b_w d$
$= (0.85)(2)(4000)^{1/2}(12)(9) = 11.16$ kip

$V_u = q_u\left(\frac{b-a}{2} - d\right) = 6.4\left(\frac{4-\frac{1}{3}}{2} - \frac{9}{12}\right) = 7$ kip $\quad \frac{1}{3}'$ is for 4" Ø Pipe support

$\phi V_c > V_u$ OK for shear for one-way shear

Two-Way Shear (Punching): Compute b_o required and compare to b_o (supplied)

$b_o = 2(26+9) + 2(18+9) = 124$ in (Supplied)

e) Continued:

$$\frac{K_{V_6} V_u}{1.02} = 1.72 \qquad \text{for } d = 8'' \text{ conserv.}$$

$q_s = 6.67$ from SP-17, pg-259.

$a_b = 26.6$

$$A_{fv} = (4)^2 - \left(\frac{26+9}{12} \times \frac{18+9}{12}\right) = 9.4\ ft^2$$

$$V_u = A_{fv} \cdot q_s = (9.4\ ft^2)(6.67\ ksf) = 62.7\ kips$$

$$\beta_c = 26/18 = 1.44 \qquad K_{V_6} = 1.0 \text{ for } \beta_c \leq 2.0$$

$$b_o = \frac{(1)(62.7)}{1.72} = 36.5\ in$$

$b_o < b_o$ (supplied)

Bar Selection: Use 5 - #5 bars spaced equally EW w/ 3" clr on bottom and sides or at 10.5 in spacing.

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DESIGN ANALYSIS

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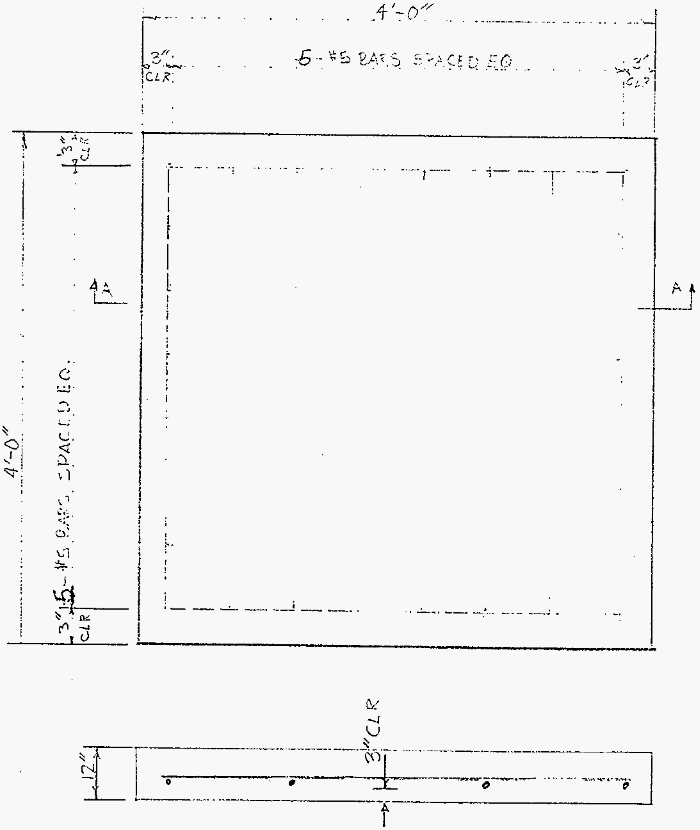
Client W/HC
WO/Job No. ER4319 / W-320
Subject Transfer Line - Concrete Base Design
Date 5/20/94 By R Booth
Checked 5/20/94 By
Location 200E
Revised By

f. Plan View of Slab Dimensions & Reinforcement



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Calc. No. W320-27-015
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DESIGN ANALYSIS

Client W/HC
WO/Job No. ERA319/W-320
Subject Transfer Line - Concrete Base Design
Date 5/20/94 By JR Booth
Checked 5/20/94 By [illegible]
Location 200E
Revised By

g. Check Pull-Out Strength of Anchor Bolts:

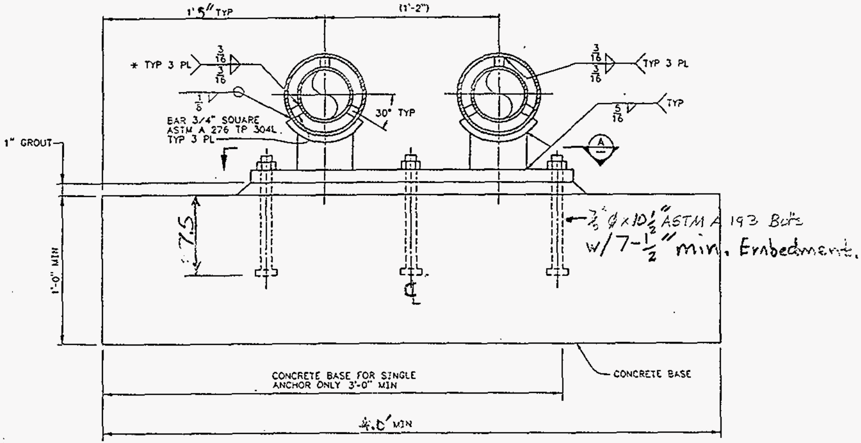
Unfactored loads from pg. 15 of calc.

$T = 2786$ lbs
$S = 3467$ lbs

Adequacy of bolt has already been determined.

Using method presented in A/E STD. # GC-ANCB-01.

Check embedment depth of anchor bolts



SECTION

$L_e = 7$ in
$C = 1.44$ in
$P_u = \pi(L_e^2 + C L_e)(4 \phi_c \sqrt{F'_c}) = 26431$ lb

$A_t = 0.462$ in^2
$\phi_c = 0.65$
$F'_c = 3000$
$F_u = \frac{26431}{0.462} = 57210$ psi

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DESIGN ANALYSIS

Client WHC
WO/Job No. ER 4319 / W-320
Subject Transfer Pipe - Concrete Base Design
Date 5/20/94 By J.R. Booth
Checked 5/20/94 By [illegible]
Location 200E
Revised By

g. Continued:

$$Le = \frac{\sqrt{C^2 + \frac{1.33\, Fu\, A_t}{\pi \phi_c \sqrt{f'_c}}} - C}{2}$$

$$= \frac{\sqrt{(1.44)^2 + \frac{1.3(57210)(0.462)}{\pi(0.65)\sqrt{3000}}} - 1.44\text{in}}{2} = 8.04\text{in}$$

$K_{ns} = 1.0$
$K\phi_c = 0.86$
$Kf'_c = 0.93$

$L_e = Le(K_{ns}\ K_{\phi_c}\ K_{f'_c}) = (8.04)(1.0)(0.86)(0.93) = 6.43$ in

$L'_e > Le$ embedment depth <u>OK</u>.

Edge Distance for Tension Load:

$F_u = 105$ ksi (ASME B31.3, Table A-2, 1993 ED.)
$F_y = 65$ ksi

$D = 7/8$ in
$f_{ult} = 105$ ksi
$f'c = 4000$ psi

$$m_t = D\sqrt{\frac{f_{ult}}{56\sqrt{f'c}}} = (7/8)\sqrt{\frac{105000}{56\sqrt{4000}}} = 4.76\text{ in}$$

m_t is min. edge distance

(m_d) Actual edge distance = 11.75 in <u>OK</u>

$V_D = 223.7\,(m_v)^2 = 223.7\,(13)^2 = 37805$ lbs

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DESIGN ANALYSIS

Calc. No. W320-27-005
Revision 0
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Client WHC
WO/Job No. ER4319 / W-320
Subject Transfer Pipe-Concrete Base Design
Date 5/20/94 By J R Booth
Checked [illegible] By [illegible]
Location 200 E
Revised By

g. Continued:

Edge distance for Shear Load:

$$m_v = D\sqrt{\frac{f_{ult}}{7.5\sqrt{f'c}}} = (7/8)\sqrt{\frac{105000}{7.5\sqrt{4000}}} = 13 \text{ in}$$

$m_d < m_v$, N.G. Going to FIG. 4 $V_c = 4\phi_c\sqrt{f'c}/2\pi m_v^2$
$= 46634$ lbs

$V_D/V_c = 0.8$ $m_d/m_v = 0.9$, zone I <u>OK</u> for shear

Check anchor bolt spacing:

rm' = min. anchor bolt spacing
$= 2\,L_e + C$
$= 2(7) + 1.44 = 15.44$ in > 11.75 <u>NG</u>

Re-evaluate $L'e$ $p = 11.75''$

Note: Increase in min. embedment depth required because anchor bolt spacing less than min. req. w/ 7/8" ϕ bolts.

$\frac{rm - p}{rm} = 0.24$ $K_{le} = 0.93$

$$L'e = \sqrt{\frac{(7)^2}{(0.93)(}} = 7.3 \text{ in},$$

Go to 7/8"-11-UNC-2A x 10.5" LG ASTM A 193 Anchor bolts. (Min. emb. = 7.5")

//

Conclusions:

1) Concrete Base dimensions now 4'-0" x 4'-0" x 1'-0"

2) Resteel - 5 - #5 bars equally spaced w/ 3" clear spacing from sides & bottom.

3) Use 7/8" ϕ anchor bolts now 10½" long.

DESIGN ANALYSIS

Calc. No. W320-27-015
Revision 0
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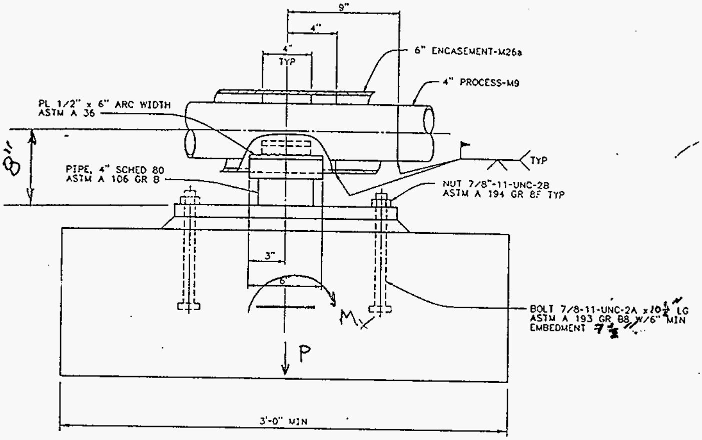
Client WHC
WO/Job No. ER 4319 / W-320
Subject Transfer Line - Concrete Base Design
Date 5/23/94 By A R Booth
Checked 5/26/94 By [illegible]
Location 200E
Revised By

Check Size Required for Concrete Base w/ Only One Pipe

a) Check Worst Case Overturning Moment:



$M_x = 79.85$ in·kip

$P = F_y + W_c + S$
where
$W_c = 150 pcf (1 \times 3 \times 3) = 1350$ lb (Concrete Wt)
$S = 115 pcf (3 \times 3 \times 3.92) = 4057$ lb (Soil Wt)
$F_y = 259$ lbs

$$P = \frac{259 + 1350 + 4057}{1000} = 5.67 \text{ kip}$$

$$e = \frac{79.85 \text{ in·kip}}{5.67} = 14.1 \text{ in} \qquad K = \frac{36 \text{ in}}{6} = 6 \text{ in}$$

$$\text{since } e > K, \quad q_{ult} = \frac{2P}{3L(B/2 - e)} = \frac{2(5.67)}{3(3)(3/2 - 1.18)} = 3.9 \text{ ksf}$$

$q_{ult} < q_A = 4.0$ ksf $\underline{\underline{OK}}$

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DESIGN ANALYSIS

Calc. No. W320-27-03
Revision ~~0~~ ~~1~~ 2
Page No. 29 of 29

Client WHC
WO/Job No. ER4319 / W-320
Subject Transfer Line-Concrete Base Design
Date 5/23/94 By W.L. Booth
Checked 5/24/94 By [illegible]
Location 200E
△1 Revised 8/8/95 By J.R. Booth
△2 10/3/94 K.W. Dowsten

b) For a concrete base supporting only one pipe the twisting action will not be a factor and maintaining approximately the same resteel spacing by inspection will be adequate.

The resteel will have 3" clear from the sides and bottom and be 4-#5 spaced equally in each direction or at 10 inches.

The base will be 3'×3'×1'.

//

Note: The loads used to design the footing were based on preliminary pipe stress information which were greater than the final values calculated by D.L. Stone. Therefore, no changes are necessary in the design of the footing.

RO 8/8/95 △1 | Based upon revised loads presented in revision 1 of pages 1 thru 16, the above conclusion is still valid.

RO △2 10/3/94 | **Based upon the revised loads presented in revision 2 of this calculation, page 14, the conclusion provided in revision 0 is still valid. No further analysis is required.**

P O P
=============

(PIPE ON PIPE)
========================

PIPE WALL LOCAL STRESSES DUE TO WELDED TRUNNION
===

SOURCE:

WELDING RESEARCH COUNCIL BULLETIN NO. 107MARCH 1979 REVISION.LOCAL STRESSES IN SPHERICAL AND CYLINDRICAL SHELL DUE TO EXTERNAL LOADING" BY K.R. WICHMAN A.G. HOPPER AND J.L. MERSHON

PROGRAM AUTHOR: MOHAMMED M. AHMED

FILE NAME: W320POP. mcd

WORK ORDER/ JOB NO: ER4319

INPUT BY: Dianna L. Stone

CHECKED BY:

FF-1

MODEL 7400

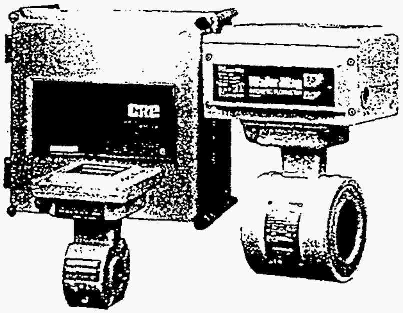
WAFER-MAG™ ELECTROMAGNETIC FLOWMETER

DESCRIPTION

The Brooks® Wafer-Mag electromagnetic flowmeter is a solid state, obstructionless flow rate measuring device which is capable of measuring a wide range of conductive liquids, clear or slurried.

The Wafer-Mag is comprised of two basic parts: a flow transmitter which becomes a part of the pipeline and a signal converter. A magnetic field is generated by compact high density field coils mounted to a short section of straight pipe. As a conductive liquid passes through the pipe section and its magnetic field, a voltage is generated that is directly proportional to the velocity of the conductive liquid. The voltage induced is sensed by electrodes mounted at right angles to the magnetic field and in contact with the conductive liquid or slurry. The electrodes are insulated from the pipe by a non-conductive liner that encapsulates all wetted parts of the pipe. From the electrodes, the voltage is transmitted to a signal conditioner where it is conditioned to the desired output signal(s).

The Brooks Wafer-Mag employs a keyed bi-directional dc magnetic field and digital electronics to establish new criteria in wide rangeability, high accuracy and low power consumption. The Wafer-Mag generates an open collector frequency (proportional to liquid velocity) of 10 kHz at maximum flow rate. Convenient terminal connections are provided to permit local or remote verification of proper meter operation. Optional analog current or factored/ scaled pulse outputs are available for integral or remote mounting.



DESIGN FEATURES

- *Accuracy* of ±0.5% of rate
- *Lay length*: wafer body design for installation between mating flanges of ANSI, DIN or BS bolt pattern, to 300 lb. ANSI rating. Minimum length for maximum ease of installation.
- *Light weight*: the wafer body design minimizes weight to maximize ease of handling.
- *Unobstructed flow*: no restrictions are in the liquid path. Pressure drop is equal to an equivalent length of pipe of the same inside diameter.
- *Stable operation*: flow measurement is unaffected by changes in temperature, pressure, specific gravity, viscosity and/or conductivity above a minimum of 3 micromhos/cm over a wide range of ambient temperatures.
- *DC magnetic field*: bi-directionally driven magnetic field.
- *Automatic zero*: no adjustments required. Signal voltage is dynamically verified each time the coil current reverses up to 75 times per second.
- *Low power consumption*: approximately 15 watts for sizes 0.15" to 8".
- *Interchangeable electronics*: all wafer-mag electronics are interchangeable. No test equipment required.
- *Potted coil housing*: coil housing internals are completely potted for maximum environmental and vibration resistance.
- *Separate sealed wiring compartments*: provide easy customer access for hook-up with maximum protection for electronics.
- *Digital analog span*: analog output has digital span setting for re-ranging without test equipment and no electrical power required for setting.
- *Optional Smart electronics (3580)*: configurable through local or remote operator interface.

Brooks Instrument
FISHER-ROSEMOUNT

Electrical Approvals:

- Flowheads with integral electronics: FM approved Class I, Division 2, Groups A, B, C and D, Class II, Division 1, Groups E, F and G and Class III.
- Flowheads for remote hook-up to 3560, 3570 or 3580 electronics: FM approved Class I, Division 2, Groups A, B, C and D, Class II, Division 1, Groups E, F and G and Class III.
- Optional: FM approved Class I, Division 1, Groups C and D. Flowhead can be used with Brooks remote electronics Models 3560, 3570 and 3580.

SPECIFICATIONS

WARNING: Do not operate this instrument in excess of the specifications listed below. Failure to heed this warning could result in personal injury and/or damage to the equipment.

Capacities

Full Scale Meter Range: 1 to 10 meters/sec or 1 to 10 feet/sec, jumper selectable with no special calibration required (refer to Table 1).

Accuracy

System ±0.5% of the rate from one unit per second to fen units per second. (one unit = one foot or meter) and 0.005 units per second below one unit per second.

Analog output

Add ±0.1% full scale to above accuracy specifications.

Repeatability

0.25% of rate

Pressure Limits

740 psig @ 100°F (40°C) Tefzel and Teflon tubes
285 psig @ 100°F (40°C) Ryton™ tubes (1" and smaller)
150 psig @ 100°F (40°C) Ryton tubes 1-1/2" and 2"

Temperature

Ambient: 0 to 150°F (-18 to 65°C)
Process: Refer to Table 2.

Power Requirements

Selectable by jumper plug -115 Vac or 230 Vac. ±15% 47-63 Hz, 10-30 Vdc

Power Consumption

15 Watts maximum

Table 1 Capacity Table - Velocity-to-Flow Conversion Factors 0.15" to 8" *

Meter Size		Flow in gpm Units = Feet						Flow in gpm Units = Meters							
		1.000 ft/sec		10.00 ft/sec		Low Flow Cut-off [2]		1.000 m/sec		10.000 m/sec		Low Flow Cut-off [2]		Guidelines Flow 6 ft/sec.	
Inches	mm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm
0.15[1]	4	0.055	0.21	0.55	2.1	0.001	0.004	0.18	0.68	1.8	6.8	0.004	0.02	0.33	1.3
0.3[1]	8	0.22	0.83	2.2	8.3	0.005	0.02	0.72	2.7	7.2	27	0.02	0.06	1.3	4.9
1/2	15	0.86	3.3	8.6	33	0.02	0.08	2.8	10.6	28	106	0.06	0.23	5	19
1	25	2.3	8.7	23	87	0.05	0.20	7	28	75	284	0.16	0.6	14	53
1-1/2	40	5.5	21	55	208	0.13	0.48	18	68	180	681	0.41	1.6	36	136
2	50	9.1	34	91	344	0.21	0.79	30	113	300	1,136	0.69	2.6	55	208
3	80	21	80	213	806	0.48	1.8	70	265	700	2,650	1.6	6	128	485
4	100	37	138	365	1,382	0.85	3.2	120	454	1,200	4,542	2.8	10	220	833
6	150	83	314	830	3,142	1.9	7.2	270	1,022	2,700	10,220	6.2	24	495	1,874
8	200	152	575	1,520	5,753	3.5	13	500	1,893	5,000	18,925	11.5	44	915	3,463

* All Values are approximate — actual values will depend on flow tube K-factor

(1) These meter sizes are only offered with Ryton flow tubes, maximum pressure 285 psig at 100°F (40°C)

(2) Low flow cut-off is 2.3% of the selected analog setting adjustable from 23 Hz as listed in the above table through 230 Hz at the MAXIMUM FULL SCALE ANALOG SETTING AT 10 FEET OR 10M PER SECOND.

Table 2 Maximum Working Pressures and Temperatures

Materials (Liner)	Characteristics (Liner)	Available in Meter Sizes	Pressure psig (kPa) 150/300 lb. Flanges			Maximum Allowable Liquid Temperature (1)
			0-100°F (40°C)	200°F (93°C)	300°F (149°C)	
Tefzel	Chemical Resistant	1/2 through 8 inch	740 psig 5202 kPa	675 psig 4745 kPa	655 psig 4605 kPa	300°F (149°C)
Teflon	3A Food Services	1/2 through 6 inch	740 psig 5202 kPa	575 psig 4745 kPa	655 psig 4605 kPa	350°F (149°C)
Ryton	Fractional Sizes	.15 and .30 inch	285 psig 2004 kPa	185 psig 1300 kPa	Not Applicable	200°F (93°C)
Kynar	Consult Factory	Consult Factory	CF	CF	CF	CF

ote (1): Temperature limits may vary depending on liquid being metered.

P O P

INPUT DATA:

1. APPLIED LOADS:

NOTE: THESE ARE THE LOADS ACTING AT PIPE WALL & ATTACHMENT JUNCTURE.

(Ref. File SA-07.mcd, "Pipe Loads at B")

$P \equiv 259$ RADIAL LOAD IN POUNDS

$M_c \equiv 6626$ CIRCUMFERENTIAL MOMENT IN INCH-POUNDS

$M_l \equiv 19390$ LONGITUDINAL MOMENT IN INCH-POUNDS

$M_t \equiv 3276$ TORSIONAL MOMENT IN INCH-POUNDS

$V_c \equiv 846$ SHEAR LOAD ACROSS PIPE LENGTH IN POUNDS

$V_l \equiv 4690$ SHEAR LOAD ALONG PIPE LENGTH IN POUNDS

2. GEOMETRY:

$T \equiv 1.267$ PROC.PIPE 0.237+ENC. PIPE 0.28+PAD 0.75=1.267"

$Rm \equiv 2.68$ (ENC. OD 6.625 - T 1.267)/2

$ro \equiv 2.25$ ATTACHMENT PIPE (TRUNNION) RADIUS IN INCHES

$w \equiv 0.3125$ FILLET WELD SIZE IN INCHES

$r \equiv 0.707 \cdot w$ FILLET WELD RADIUS IN INCHES

$r = 0.221$

3. GEOMETRIC PARAMETERS:

$\Gamma \equiv \frac{Rm}{T}$ PIPE/VESSEL PARAMETER

$\Gamma = 2.115$

$\beta \equiv (0.875) \cdot \frac{ro}{Rm}$ ATTACHMENT PARAMETER

$\beta = 0.735$

4. STRESS CONCENTRATION FACTORS:

$$Kn \equiv 1 + \left(\frac{2 \cdot T}{5.6 \cdot r}\right)^{0.65}$$ TENSILE FACTOR

$Kn = 2.594$

$$Kb \equiv 1 + \left(\frac{2 \cdot T}{9.4 \cdot r}\right)^{0.8}$$ BENDING FACTOR

$Kb = 2.173$

BIJLAARD'S NONDIMENSIONAL CURVES:

THESE CURVES ARE PLOTTED FOR 'β'VERSUS A NONDIMENSIONAL CONSTANTS FOR DIFFERENT VALUES OF 'Γ' AND APPLIED LOADS.THIS PROGRAM ADOPTS A SIMPLE AND CONSERVATIVE APPROACH FOR A SPECIFIC, MOST OFTEN USED RANGE OF VALUES FOR 'β' & 'Γ'. SINCE MOST OF THE PIPE ATTACHMENTS DESIGNED HAVE THE PARAMETERS 'β' & 'Γ' WITHIN THE RANGES LISTED BELOW, THE MOST CRITICAL NONDIMENSIONAL CONSTANTS ARE CHOSEN FROM THE APPLICABLE CURVES AND USED IN COMPUTING STRESSES CONSERVATIVELY. THUS ELIMINATING THE USE OF BIJLAARD CHARTS EACH TIME.

IF VALUE OF "Γ" IS BETWEEN 5 AND 15 $\Gamma = 2.115$

AND "β" = OR > 0.5, $\beta = 0.735$

USE THE CONSTANTS GIVEN BELOW.

(IF Γ & β DO NOT FALL WITHIN ABOVE RANGE, READ CONSTANTS FROM SPECIFIC CURVES AND USE THEM IN PLACE OF CONSTANTS LISTED BELOW.)

SINCE "b

SINCE VALUES ARE OUT OF ABOVE RANGE , APPROPRIATE BJILAARD CONSTANTS ARE USED.

CONSTANTS FOR CIRCUMFERENTIAL STRESSES:

Aϕ■0.70	FROM FIG 4C: VALUE OF 'Nϕ/P/Rm' FOR 'P'
Bϕ≡0.04	FROM FIG 2C-1: VALUE OF 'Mϕ/P' FOR 'P'
Cϕ≡0.20	FROM FIG 3A: VALUE OF 'Nϕ/Mc/Rm^2.β' FOR Mc
Dϕ■0.12	FROM FIG 1A: VALUE OF 'Mϕ/Mc/Rm.β' FOR Mc
Eϕ≡0.50	FROM FIG 3B: VALUE OF 'Nϕ/ML/Rm^2.β' FOR ML
Fϕ■0.04	FROM FIG 1B: VALUE OF 'Mϕ/ML/Rm.β' FOR ML

CONSTANTS FOR LONGITUDINAL STRESSESS

Ax≡0.60	FROM FIG 4C: VALUE OF 'Nx/P/Rm' FOR 'P'
Bx≡0.08	FROM FIG 1C-1: VALUE OF 'Nx/P' FOR 'P'
Cx≡0.30	FROM FIG 4A: VALUE OF 'Nx/Mc/Rm^2.β' FOR Mc
Dx≡0.07	FROM FIG 2A: VALUE OF 'Mx/Mc/Rm.β' FOR Mc
Ex≡0.15	FROM FIG 4B: VALUE OF 'Nx/ML/Rm^2.β' FOR ML
Fx≡0.08	FROM FIG 2B: VALUE OF 'Mx/ML/Rm.β' FOR ML

CIRCUMFERENTIAL ($\sigma\phi$) STRESSES:

$$\sigma\phi a \equiv Kn\cdot A\phi\cdot\frac{P}{Rm\cdot T}$$

$\sigma\phi a = 138.48$

$$\sigma\phi b \equiv Kb\cdot B\phi\cdot 6\cdot\frac{P}{T^2}$$

$\sigma\phi b = 84.125$

$$\sigma\phi c \equiv Kn\cdot C\phi\cdot\frac{M_c}{Rm^2\cdot\beta\cdot T}$$

$\sigma\phi c = 514.14$

$$\sigma\phi d \equiv Kb\cdot D\phi\cdot 6\cdot\frac{M_c}{(Rm\cdot\beta)\cdot T^2}$$

$\sigma\phi d = 3.28\cdot 10^3$

$$\sigma\phi e \equiv Kn\cdot E\phi\cdot\frac{M_l}{Rm^2\cdot\beta\cdot T}$$

$\sigma\phi e = 3.761\cdot 10^3$

$$\sigma\phi f \equiv Kb\cdot F\phi\cdot 6\cdot\frac{M_l}{\left(Rm\cdot\beta\cdot T^2\right)}$$

$\sigma\phi f = 3.199\cdot 10^3$

CIRCUMFERENTIAL STRESS ($\sigma\phi$) SUMMATION:

NOTE: USE THE MOST CRITICAL STRESS OF THE FOLLOWING SUMMATIONS.

$$\sigma\phi Cu \equiv \sigma\phi a + \sigma\phi b + \sigma\phi c + \sigma\phi d$$

$\sigma\phi Cu = 4.016\cdot 10^3$

OR

$$\sigma\phi Au \equiv \sigma\phi a + \sigma\phi b + \sigma\phi e + \sigma\phi f$$

$\sigma\phi Au = 7.183\cdot 10^3$

LONGITUDINAL (σx) STRESSES:

$$\sigma xa \equiv Kn \cdot Ax \cdot \frac{P}{Rm \cdot T}$$ $\sigma xa = 118.697$

$$\sigma xb \equiv Kb \cdot Bx \cdot 6 \cdot \frac{P}{T^2}$$ $\sigma xb = 168.25$

$$\sigma xc \equiv Kn \cdot Cx \cdot \frac{M_c}{Rm^2 \cdot \beta \cdot T}$$ $\sigma xc = 771.209$

$$\sigma xd \equiv Kb \cdot Dx \cdot 6 \cdot \frac{M_c}{\left(Rm \cdot \beta \cdot T^2\right)}$$ $\sigma xd = 1.913 \cdot 10^3$

$$\sigma xe \equiv Kn \cdot Ex \cdot \frac{M_1}{Rm^2 \cdot \beta \cdot T}$$ $\sigma xe = 1.128 \cdot 10^3$

$$\sigma xf \equiv Kb \cdot Fx \cdot 6 \cdot \frac{M_1}{\left(Rm \cdot \beta \cdot T^2\right)}$$ $\sigma xf = 6.398 \cdot 10^3$

LONGITUDINAL (σx) STRESS SUMMATION:

NOTE: USE THE MOST CRITICAL OF THE FOLLOWING SUMMATIONS.

$$\sigma xCu \equiv \sigma xa + \sigma xb + \sigma xc + \sigma xd$$ $\sigma xCu = 2.971 \cdot 10^3$

OR

$$\sigma xAu \equiv \sigma xa + \sigma xb + \sigma xe + \sigma xf$$ $\sigma xAu = 7.813 \cdot 10^3$

SHEAR (Γxϕ) STRESSES:

$$\Gamma x\phi 1 \equiv \frac{M_t}{\left(2\cdot\pi\cdot ro^2\cdot T\right)}$$ **SHEAR STRESS DUE TO TORSION 'MT'**

$\Gamma x\phi 1 = 81.287$

$$\Gamma x\phi 2 \equiv \frac{V_c}{\pi\cdot ro\cdot T}$$ **SHEAR STRESS DUE TO SHEAR 'VC'**

$\Gamma x\phi 2 = 94.463$

$$\Gamma x\phi 3 \equiv \frac{V_l}{\pi\cdot ro\cdot T}$$ **SHEAR STRESS DUE TO SHEAR 'VL'**

$\Gamma x\phi 3 = 523.677$

SHEAR STRESS (Γxϕ) SUMMATION:

THE TWO COMPONENTS OF SHEAR STRESSES ARE:

$\Gamma x\phi Au \equiv (\Gamma x\phi 1 + \Gamma x\phi 2)$ $\Gamma x\phi Au = 175.75$

$\Gamma x\phi Du \equiv (\Gamma x\phi 1 + \Gamma x\phi 3)$ $\Gamma x\phi Du = 604.965$

NOTE: WHILE QUALIFYING THE PIPE STRESSES FOR ASME CODES B31.1 AND B31.3, THIS PROGRAM, "POP", SHALL BE RUN TWICE, ONCE FOR THERMAL LOADS AND ONCE FOR SUSTAINED + SEISMIC LOADS. THE HIGHEST OF THE LONGITUDINAL STRESSES (σxAu <u>or</u> σxCu) COMPUTED ON PAGE-6 OF THIS PROGRAM SHALL BE ADDED TO THE "AUTOPIPE" PIPE STRESSES FOR RESPECTIVE LOAD CASE. THE SUMMATION PIPE NORMAL STRESSES (AUTOPIE) AND LOCAL LONGITUDINAL STRESSES (POP) SHALL BE WITHIN THE CODE ALLOWABLES FOR CORROSPONDING LOAD CASES.

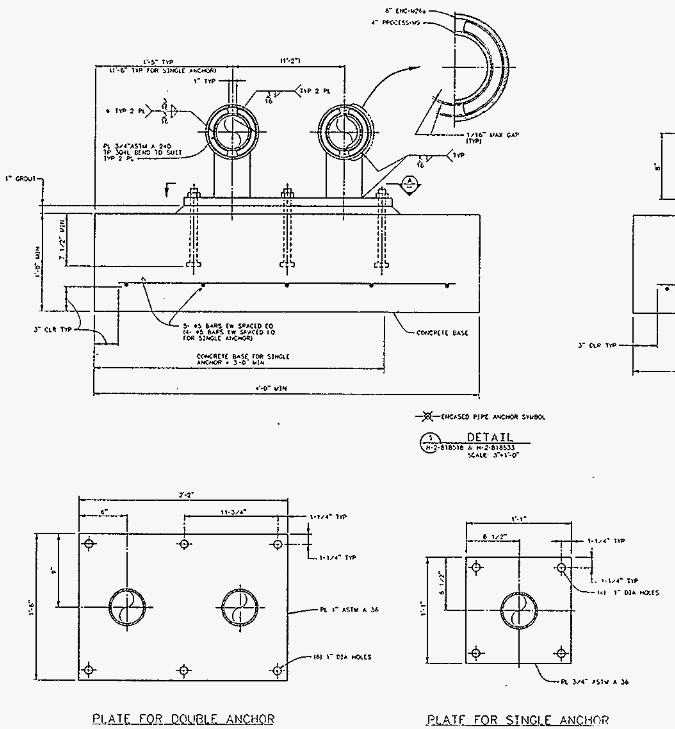
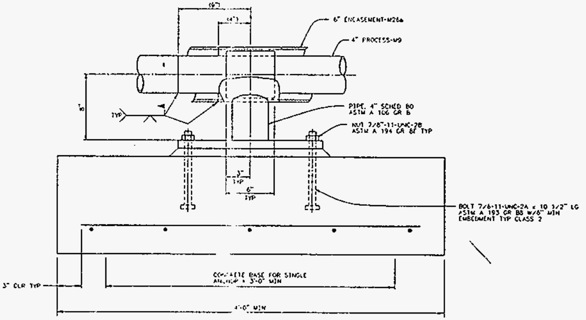


PLATE FOR DOUBLE ANCHOR

PLATE FOR SINGLE ANCHOR

Ⓐ SECTION
SCALE: 3" = 1'-0"



① DETAIL
H-2-818518 & H-2-818533
SCALE: 3"=1'-0"

NOTES:

1. FOR GENERAL NOTES AND LEGEND, SEE DWG H-2-818518 AND H-2-818533
2. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS
3. FOR LOCATION AND/OR SPACING OF SUPPORTS, GUIDES AND ANCHORS, SEE PIPING TRANSFER LINE PLANS.
4. DETAIL 5 ON SHEET 2 TO BE USED AS REQUIRED TO SHIM PIPE CENTER LINE TO ELEVATION REQUIRED

C.D. JONES, PE

PRELIMINARY

BA MEYER
SEE DR/AT FORM
SEE DR/AT FORM
SEE DR/AT FORM

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

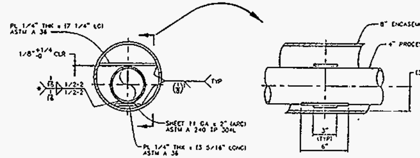
PIPING
SUPPORT DETAILS

W320, TANK 241-C-106 SLUICING

F 2000 0403 H-2-818548 0

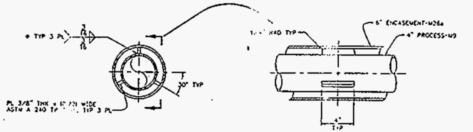
SHOWN ER4319 SHEET 1 OF 2

PLOT SCALE: 1=1 ACMCAD



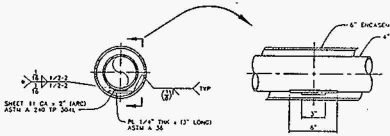
ENCASED PIPE SUPPORT —○— SYMBOL

② DETAIL
H-2-818518 & H-2-818533
SCALE 3"=1'-0"



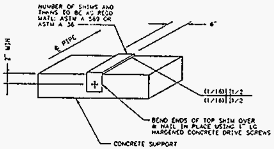
ENCASED PIPE GUIDE —●— SYMBOL

③ DETAIL
H-2-818518 & H-2-818533
SCALE 3"=1'-0"

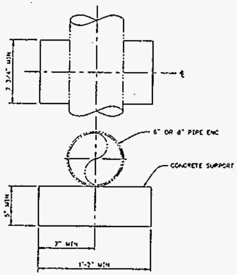


ENCASED PIPE SUPPORT —○— SYMBOL

④ DETAIL
H-2-818518 & H-2-818533
SCALE: 3"= 1'-0"



⑤ DETAIL
SH 1
SCALE: NONE



⑥ DETAIL
H-2-818518 & H-2-818533
SCALE: 3"=1'-0"
LOCATE AT ALL ENCASED PIPE SUPPORTS AND GUIDES (○, ●)

NOTE:

1. FOR NOTES, SEE SHEET 1

C.D. JONES, PE

Ra MEYER	2
SEE OR/AT FORM	PRELIMINARY
SEE OR/AT FORM	U.S. DEPARTMENT OF ENERGY RICHLAND OPERATIONS OFFICE ICF KAISER HANFORD COMPANY
SEE OR/AT FORM	PIPING SUPPORT DETAILS
	W320, TANK 241-C-106 SLUICING
	F | 200-C | H-2-818548 | 0
	2 of 2

2 PLOT SCALE 1=1
KEHCAD

W320-27-016

C Farm Jumper Stress Analysis

ICF KAISER HANFORD COMPANY	CALCULATION IDENTIFICATION AND INDEX	Page i of iii Date 9/11/95

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27,Piping and Vessels WO/Job No. ER4319 Calculation No. W320-27-016

Project No. & Name Project W-320 Waste Retrieval for Tank 241-C-106

Calculation Item C Farm Jumper Stress Analysis

These calculations apply to:

Dwg. No. H-2-818524, H-2-818505, and H-2-818508 Rev. No. ~~0~~ 1

Dwg. No. H-2-818526 and H-2-818515 Rev. No. ~~0~~ 1

Other (Study, CDR)

Rev. No.

The status of these calculations is:

☒ Preliminary Calculations 1/2\

☒ Final Calculations

☐ Check Calculations (On Calculation Dated)

☐ Void Calculation (Reason Voided

Incorporated in Final Drawings? ☑ Yes ☒ No

This calculation verified by independent "check" calculation? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	M. M. Ahmed 9-11-95	M. Ahmed M.M. Ahmed 6/28/96	Kelly K Haynes 11/25/97
Checked by	M. K. Pal 9-11-95	D.L. Stone D.L. Stone 7-1-96	M. Ahmed 3.17.98
Approved by		CD Jones 7/1/96	D.L. Evans 4/9/98
Checked Against			M. Ahmed 4.10.98

RIVISION 1 SUMMARY: Revised pages 1, 5, 6, 7 & 8 , Appendices A & B.
Added page-9.

INDEX

ICF KAISER HANFORD COMPANY	CALCULATION IDENTIFICATION AND INDEX	Page ii of iii Date 9 / 11 /95

Discipline 27,Piping and Vessels WO/Job No._ER4319__ Calculation No. W320-27-016

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	M. M. Ahmed 9-11-95	M.M. Ahmed 6-28-96 M. Ahmed	Kelly Kittayan 11/25/97
Checked by	M. K. Pal 9-11-95	D. L. Stone D.L. Stone 7-1-96	M. Ahmed 3.17.98

INDEX

Design Analysis Page No.	Description
~~Appdx A~~	~~AutoPipe File no:MA=C06A, Stress Isometric & Drawings~~
~~Appdx B~~	~~AutoPipe File~~ MA-C06AS ~~Static & Hydrostatic analysis) || Rev-1~~
~~Appdx C~~	~~AutoPipe File no:Ma-J6A, Isometric & Piping Drawings || REV-1~~
~~Appdx D~~ C	~~Refrence Documentation || Rev-1~~
Appdx A	Autopipe File : MA-C06A, and drawings
Appdx B	Autopipe File : MA-C06AS
Appdx C	Autopipe File : MA-J6A, Isometric, and drawings
Appdx D	Reference Documentation

△2

△2

Rev. 2 - Verify As-Built Conditions.
Page 5a added. Pages i, ii, iii, 1, and 4 revised.

CALCULATION CROSS INDEX (Typical)

Subject Calculation No.: W320-27-016

Page iii of iii

Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents		Does the output interface calculation/ documents require revision?		Has the output interfacecalculation/ documents been revised?		Discipline manager's signature and date indicating evaluation complete.
		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No	
2	NA	H-2-818505, Sheet 1	~~0~~ 1	NA			X		X	X
		H-2-818505, Sheet 2	~~0~~ 1							
		H-2-818508, Sheet 1	~~0~~ 1							D. L. Evans 7/16/98
		H-2-818515, Sheet 1	~~0~~ 1							
		H-2-818524, Sheet 1	~~0~~ 1	2						
		H-2-818524, Sheet 2	~~0~~ 1	Na 3.17.98						
		H-2-818526, Sheet 1	~~0~~ 1							
		H-2-818526, Sheet 2	~~0~~ 1				X		X	

KEH 1975.00 (12/88)

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HANFORD COMPANY

Calc No. W320-27-016
Revision No. ~~0~~ 2
Page No. 1 of 9

DESIGN ANALYSIS

Client WESTINGHOUSE HANFORD COMPANY
Subject AY FARM - JUMPER STRESS ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - 200 W. AREA

WO/Job No. ER4319
Date 9-11-95
Checked 9/11/95
Revised / /

Filename:C06A.WP
By: M.M. Ahmed
By: M.K. Pal
By:

Rev. 2 By: K. Hayase 11/25/97
Chk. By: M. Ahmed 3.17.98

Rev-1: By: M. Ahmed 6-28-96
Chk'd By: D. L Stone 7-1-96

OBJECTIVE:

The objectives of this calculation are:

1. Perform static and dynamic piping stress analysis of the "C- Tank Farm" Jumper Assemblies in order to be in compliance with the Code ASME B31.3 requirements.

2. Qualify the Integral Seal Block (ISB) Jumper connectors for loads exerted by piping in accordance with document WHC-SD-W236A-DA-002, Rev-0

3. Prepare a report on piping loads exerted on pit wall at pipe penetration location.

REV-1:

To incorporate the changes resulting from using a different Booster pump. | Rev-1

Rev-2: Verify As-built conditions | △2

DESIGN CRITERIA:

1. ASME CODE B31.3-93 with Addenda up to 1994.
2. SDC 4.1, REV-12. (Now FDNW Practice #134.215.1217)
3. PROJECT W-320 FDC: WHC-SD-W320-FDC-001, REV. ~~2~~ 4
4. WHC-SD-W236A-DA-002, Rev-0

△2

DESIGN INPUTS:

GENERAL (Applicable to all Jumpers)

Ambient Temperature	40°F	(Ref. 3)
Design Temperature:	180°F	(Ref: 3)
Design Pressure:	325 psig	(Ref: 10)
Hydrostatic Pressure	490 psig	
Pipe Materials:	ASTM A312 TP304L	(Ref: 19)
Pipe Sizes:	3 in. and 4 in. | Rev-1	(Ref: 19)
Pipe Wall	Schedule 40	(Ref: 5 & 19)
Safety Class category:	SC-3	(Ref. 4)
Corrosion Allowance	0.06 inches	(Ref. 7)
B31.3 Code Allowable stress	16700 psi	(Ref: 1)

JUMPER U9-A, B PUMP PIT 241-C-06A (Autopipe Filename: MA-C06A & MA-C06AS ~~C06A-ST)~~ △2

Process Fluid:	241-C-06A SLury	(Ref: 20)
Specific gravity:	1.20	(Ref: 8)
Piping Dimensions:	Dwg: H-2-818505	(Ref: 19)
Flanges	300# ANSI rated	(Ref. 21)
Connector weights	4": 122 lbs 3": 77 lbs 2": 29 lbs	(Ref: 9)
Nozzle weights	4": 11 lbs 3": 6.5 lbs 2": 2.5 lbs	(Ref: 9)
Kickplate weights	4": 16.5 lbs 3": 12 lbs 2": 3.5 lbs	(Ref: 9)
Pressure Element Weight	4": 27 lbs N/A 2": 12 lbs (Appx: C)	(Ref. 18)
Pump	W_{Pump} = 1000 lbs (Appx: C)	(Ref: 17) | Rev-1
Pump Motor	$W_{Pump\ Motor}$ = 2250 lbs (Appx: C)	(Ref: 17) | Rev-1
Blank 2" Connector with Counter Weight	86.98 lbs (Appx: C)	(Ref. 22)

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DESIGN ANALYSIS

Calc No. W320-27-016
Revision No. 0
Page No. 2 of 9

Client WESTINGHOUSE HANFORD COMPANY
Subject AY FARM - JUMPER STRESS ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - 200 W. AREA

WO/Job No. ER4319
Date 9-11-95
Checked 9/11/95
Revised / /

Filename:C06A.WP
By: M.M. Ahmed
By: M.K. Pal
By:

JUMPER U6-A PUMP PIT 241-C-06C (Autopipe Filename: MA-J6A)

Process Fluid:	Tank 241-C-106 Supernate	(Ref: 20)
Specific gravity:	1.12	(Ref: 3)
Piping Dimensions:	Dwg: H-2-818515	(Ref: 19)
Connector weight	122 lbs	(Ref: 9)
Nozzle weight	11 lbs	(Ref: 9)
Kickplate weight	17 lbs	(Ref: 9)
Jumper Flushing Blank Head	71.5 lbs	(Ref: 9)

DESIGN METHODOLOGY:

C Farm Jumper Piping Assemblies include Jumper U9-A that is located in Pump Pit 241-c-06A and Jumper U6-A that is located in Pump Pit 241-C-06C.

The jumper assembly models include connectors and nozzles. The nozzles are considered to be rigidly anchored either to pit walls or cover plate for tanks (H-2-818524 and H-2-818526, Ref:19).

The jumper connectors are specified as Integral Seal Block (ISB) connectors (Ref:9) The document WHC-SD-W236A-DA-002 (Ref:22) provides all the analytical data such as connector stiffness, acceptable piping loads & seating forces for the ISB connectors. These connectors have been modeled in Autopipe as short radius elbows and flexible couplings with specified translation and rotational stiffness. The connector and nozzle weights are imposed at Flexible coupling.

The weights of structural steel assemblies and lifting bails used to connect jumper piping to nozzles during installation are calculated and imposed at appropriate points.

Stress analysis of the jumpers has been performed in accordance with ASME B31.3 for sustained, thermal and seismic loading (Ref. 1) using the computer program "Autopipe" Version-4.6 by "Engineering Design Automation" (EDA) (Ref. 11).

SUSTAINED LOADS:

The "AutoPipe" program checks the sustained stress (the summation of gravity and pressure stresses) against the B31.3 Code Allowable stress "S" for the material specified for each jumper piping.

THERMAL (DISPLACEMENT) STRESS:

The maximum design temperature for the pipe of 180°F and the ambient temperature of 40°F has been used in "AutoPipe" program to qualify the thermal expansion stress to the Code B31.3 allowable for displacement stress, "Sa".

SEISMIC STRESSES:

The jumper piping has been categorized as Safety Class 3. However the pit structure is classified as Safety Class 1 category. In order to perform Safety Class 3/1 analysis for this investigation, dynamic response spectra analysis is performed using Safety class-1, "Fig 3" seismic response spectra (5% Damping) of SDC 4.1, Rev-12 (Ref.2). This response spectra is created in "AutoPipe" as "SC1" and used in this dynamic analysis. Autopipe qualifies seismic stresses as occasional stress with the code allowable 1.33S.

The Jumper Connectors are qualified in accordance with WHC-SD-236A-DA-002, Rev-0 (Ref:22) Table 3.4 Acceptable piping loads. The acceptable axial force is limited to allowable seating forces for 50 ft-lb torque of Table 3.3 assuming all the actual axial loads tend to un-seat connector assembly. This results in conservative analysis. The acceptable loads are not increased by 1/3 as permitted on page-6 of Ref:22, which is conservative. The interaction of loads for critical connector is calculated (See page-6 of this calculations) as specified on page-7 of Ref:22.

HYDROSTATIC PRESSURE:

A hydrostatic pressure analysis is performed for 490 psig (1.5 times of Design pressure) and documented in Appendix-B.

The following describes the modelling and analysis techniques unique to individual jumpers.

JUMPER U9-A

Jumper U9-A includes the piping extending from the Tank C-06 Submersible Pump Assembly nozzle (A) to the Tank C-06 Booster Pump, and from the Booster Pump to the Transfer Line nozzle (U-9). The "Frame" feature of the "Autopipe" program has been used to assimilate the Booster Pump Assembly in order to consider the adequate stiffness of the pump in the system. The weight of the pump and motor is imposed at locations corresponding the centers of gravity of the pump and motor. The seismic stabilizer is represented in the model by two 3-inch schedule 40 pipes that connect to the lifting frame sub-assembly.

A Gravity support (Y-stop) has been modeled directly below the pump assembly (Node point#1) which is seated on concrete pedestal for the Sustained (Static) analysis only (See Appendix-B). The Y-stop is removed from the model for the dynamic analysis (See Appendix-A) in order to retain the linearity of the dynamic analysis and most accurately assimilate the effects of movement of the pump assembly in a Seismic event.

Weight of instrumentation has been applied at the instrument center on the pipe with flanges input as 400# ANSI rated in accordance with the 325 psig design pressure.

PIPING LOADS AT BUILDING PENETRATION ANCHORS

The spreadsheet program, "Excel" (Ref. 12), has been used to summarize Pipe Loading at Building Penetration Anchors and listed on pages 7 & 8.

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HANFORD COMPANY

DESIGN ANALYSIS

Calc No. W320-27-016
Revision No. ~~0~~ 2
Page No. 4 of 9

Client WESTINGHOUSE HANFORD COMPANY
Subject AY FARM - JUMPER STRESS ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - 200 W. AREA

WO/Job No. ER4319
Date 9-11-95
Checked 9/11/95
Revised 11/25/97

Filename:C06A.WP
By: M.M. Ahmed
By: M.K. Pal
By: K. Hayase

CHK'D BY: R. Ahmed
3.17.98

ASSUMPTIONS:

1. Since the "Autopipe" program cannot perform non-linear dynamic analysis, Y-stops (No gap below and an infinite gap above the pipe) is ignored for the dynamic analysis. This results in a conservative analysis.

2. It is assumed that the lifting bail and structural steel assemblies designed to support the jumper piping during installation will be supported by the jumper during operation.

3. Assumed the ISB jumper connectors will be used and torqued to 50 ft-lbs.

4. Building structures and tank nozzles are structurally adequate to withstand pipe loads.

REFERENCES:

1. ASME Code B31.3 and B31.3a-1994 Addenda for "Chemical and Petroleum Refinery."

2. SDC 4.1, Rev. 12, "Standard Architecture & Civil Design Criteria."
(Now FDNW Practice # 134.215.1217, Design Loads for Facilities)

3. WHC-SD-W320-FDC-001, Rev-~~2~~ 4. "Functional Design Criteria for Tank 241-C-106 Waste Retrieval, Project W-320".

2

4. WHC-SD-WM-SEL-033, Rev-1, "Safety Equipment List for 241-C-106 Waste Retrieval Project W-230"

5. Construction specifications W-320-C5, Rev-0 , Section 15493 for piping materials.

6. Construction Specification No: B-131-C1, Section 15415 for piping materials.

7. Calculation No: W-030-011, Rev-1 for "Fouling factor and Corrosion rate."

8. *Data Compendium*, Bruce A. Castaing

9. Jumper Design Fabrication Drawings: H-2-821325, H-2-821326 & H-2-821404.

10. DSI from C.D.Jones dated March 28, 1994 "Design Pressure for Slurry and Sluice Pumps".

11. Computer program "AutoPipe" Version 4.6 by "Engineering Design Automation."

12. Computer Program "EXCEL" Version 4.0, by Microsoft.

13. Crane Technical Paper No: 410, 22nd Printing-1986.

14. Ryerson Stock List and Data Book, 1985-86 Edition, Joseph T. Ryerson & Son, Inc.

Rev-1: By: M. Ahmed 6.28.96
Checked By: D L- 7-1-96

15. PBM Reference Book Sec. II (SP Series) and Sec. IV (MP Series), PBM, Inc.

16. Fax Transmittal Memo from Micro Motion, Inc. Fax dated 6/22/94

17. Fax Transmittal Memo from C.D.Jones of Reliance Dimension Sheet 611740-503 and Goulds Catalog # GPM5, Page 134 for Pump Model 3900 , dated 1/23/95

18. Fax Transmittal Memo from Red Valve Co. Inc., on Series 40 Pressure Sensors.

19. Piping Arrangement and Detail drawings: H-2-818524, H-2-818505, H-2-818508, H-2-818526, and H-2-818515

20. Process Flow Diagrams: H-2-818558 H-2-818559, and H-2-818560

21. ASME/ANSI B16.5

22. WHC-SD-W236A-DA-002, Rev-0 "Stress Analysis of Single Port (ISB) Jumper Connectors for 2-, 3-, and 4-in Sizes".

23. Seismic Design White Paper Project W-320 Tank 241-C-106 Sluicing

CALCULATIONS:

The calculations are documented in this package as shown below.

AutoPipe stress analysis results & Isometric models	Appendices A, B & C	
Jumper Connector load qualification	Page-6	
Pit Wall Anchor Loads	Pages 7 & 8	
Jumper 3D Isometrric Model for AutoPipe	Page-9	I Rev-1

CONCLUSION:

The review of the "AutoPipe" summary results attached as Appendices to this calculation indicates that all pipe stresses are in compliance with the requirements of ASME Code B31.3 requirements.

The Jumper qualification on page-6 indicates that ISB connectors are adequate for piping loads.

The Piping loads on Pit walls at piping penetrations are summarized on pages 7 & 8.

FLUOR DANIEL
NORTHWEST INC.

Calc. No.: W320-27-016
Revision: 2
Page No.: 5a of 9

DESIGN ANALYSIS

Client: Numatec
WO/Job No.: ER4319/W-320
Subject: C Farm Jumper Stress Analysis
Project W-320 Waste Retrieval for Tank 241-C-106
Date: 11/25/97 By: K Hayase
Checked: 3.17.98 By: R. Ahmed
Location: C Tank Farm 200 East Area
Revised: By:

Rev. 2

CONCLUSION (CONTINUED)

Rev. 2 of this calculation verified the analysis against the as-built conditions (~~as of 11/24/97~~). The analysis includes the weights of a flow meter and pressure sensors. These weights are not critical to the results of the analysis. Therefore, any differences between the weights used in the analysis and the approved vendor data are negligible.

AS-BUILT CHANGES ARE INSIGNIFICANT AND WILL NOT HAVE ANY ADVERSE IMPACT ON ANALYSIS.

ICF KAISER
HANFORD COMPANY

DESIGN ANALYSIS

Calc No. W320-27-016
Revision No. 0
Page No. 6 of 9

Client WESTINGHOUSE HANFORD COMPANY
Subject AY FARM - JUMPER STRESS ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - 200 W. AREA

WO/Job No. ER4319
Date 9-11-95
Checked 9/11/95
Revised / /

Filename:C06A.WP
By: M.M. Ahmed
By: M.K. Pal
By:

Rev-1: By: A. Ahmed 6.28.96
Checked By: 7.1.96

ISB JUMPER CONNECTOR LOADS QUALIFICATION

CONNECTOR LOCATION	AUTOPIPE FILE NAME & NODE	SIZE	CONNECTOR ACTUAL LOADS /ALLOWABLE LOADS | Rev-1						REF NO:
			Axial X (lbs)	Shear Y (lbs)	Shear Z (lbs)	Torsion Mx (ft-lb)	Bend My (ft-lb)	Bend Mz (ft-lb)	
Connector-U9 Pump Pit C-06A	MA-C06A A03M	4"	520	276	381	180	197	236	APDX-A
			6310	2220	2220	780	1170	1170	22
Connector A Pump Pit C-06A	MA-C06A A11M	4"	483	149	337	140	365	185	APDX-A
			6310	2220	2220	780	1170	1170	22
Connector B Pump Pit C-06A	MA-C06A B04M	4"	269	258	333	30	100	84	APDX-A
			6310	2220	2220	780	1170	1170	22

SEATING FORCES BETWEEN CONNECTOR & NOZZLES:

The axial allowable load considered in table above are limited to seating forces for 4" Connectors for 50 ft-lb torque as specified in Table 3.3(Ref:22). Since the actual axial forces are less than the allowable seating forces, the connector will not be un-seated from the nozzle.

INTERACTION OF SHEAR, TORSION AND BENDING:

$I = fyz/Fyz + [mx]/Mx + myz/Myz < 1.0$ Ref:22, page-7

Review of actual loads and allowable loads in the table above indicates that the Connector-U9 in the pump pit is more critical for interaction. | Rev-1

fyz = 470 lbs (SRSS of fy=276 & fz=381). Increase Allowable by 1.33 for seismic | Rev-1

myz = 307 ft-lbs (SRSS of my=197 & mz=236) | Rev-1

$I = 470/1.33x2220 + 180/1.33x780 + 307/1.33x1170$ | Rev-1

$I = 0.53 < 1.00$ As such Jumper Connectors are adequate. | Rev-1

ICF KAISER
HANFORD COMPANY

DESIGN ANALYSIS

Calc. No. W-320-27-016
Revision No: 0
Page No. 7 of 9

Client WESTINGHOUSE HANFORD CO.
Subject AY FARM JUMPER STRESS ANALYSIS
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM 200 EAST AREA

WO/Job N ER4319
Date 9/11/95
Checked 9/11/95
Revised

Filename U9.xls:2
By M. M. AHMED
By M. K. PAL
By

REV-1: BY: M. Ahmed 6.28.96
CHECKED BY: D. L Stoss 7-1-96

ANCHOR LOADS AT PIT WALLS

NOTE: THESE ARE THE JUMPER PIPING LOADS EXERTED ON PIT WALL FROM INSIDE THE PIT. DOES NOT INCLUDE THE TRANSFER . PIPE LINE LOADS FROM OUT SIDE THE PIT.

(Inside Pit) JUMPER LOADS		Fx (lbs)	Fy (lbs)	Fz (lbs)	Mx (in-lb)	My (in-lb)	Mz (in-lb)
Identification: Dwg:H-2-818505	(Seismic) (*1)	132	128	295	1548	2352	948
AutoPipe File: MA-C06A Node #: A00 Orientation:	(Thermal) (*2)	23	321	233	3192	24	468
 (*3) ABSOLUTE SUM		155	449	528	4740	2376	1416

Client	WESTINGHOUSE HANFORD CO.	WO/Job N	ER4319	Filename	U9.xls:2
Subject	AY FARM JUMPER STRESS ANALYSIS	Date	9/11/95	By	M. M. AHMED
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106		Checked	9/11/95	By	M. K. PAL
Location	C TANK FARM 200 EAST AREA	Revised		By	

REV:1 BY: M. Ahmed 6-28-96

CHECKED BY: D. L. Stone 7-1-96

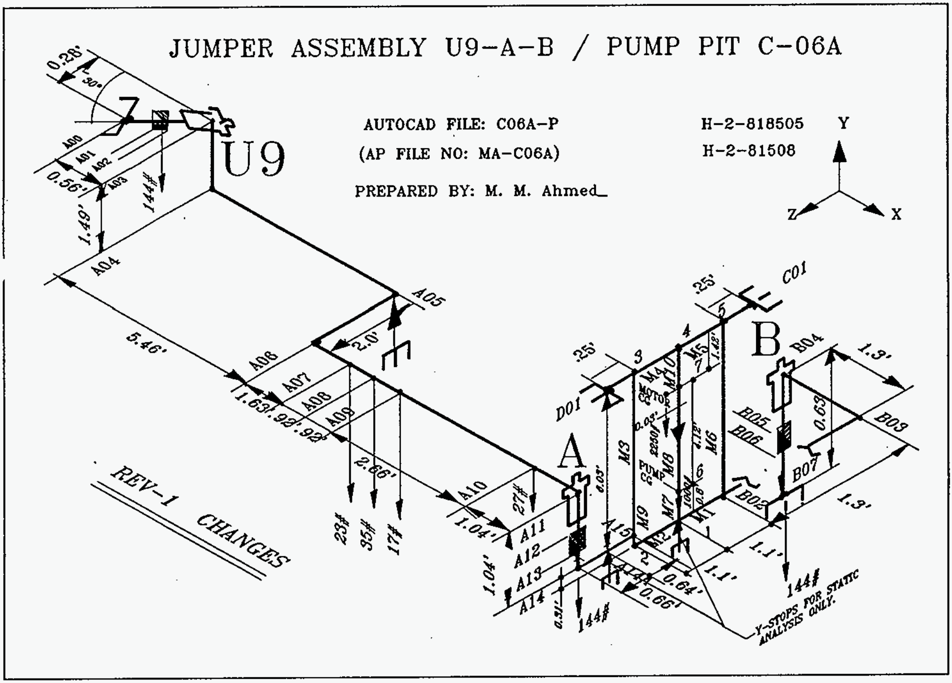
NOTES:

(*1): SEISMIC LOADS COULD BE POSITIVE OR NEGATIVE.

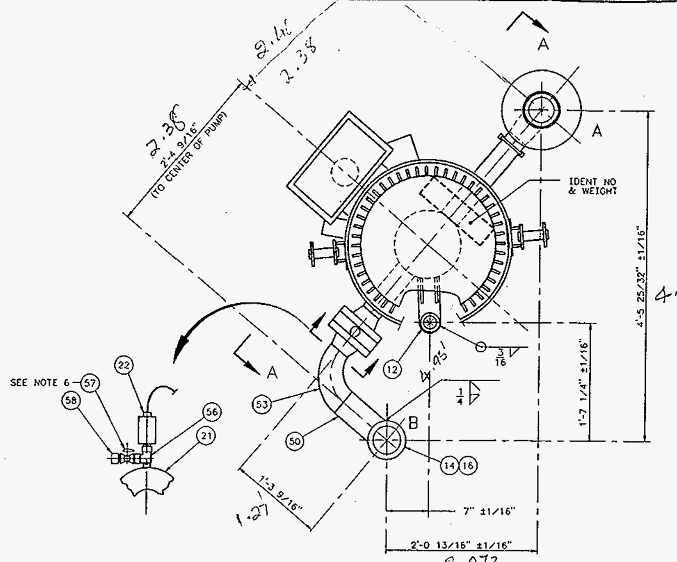
(*2): THERMAL LOADS SPECIFIED ARE THE ALGEBRIC SUM OF GRAVITY AND THERMAL LOADS.

(*3): ABSOLUTE SUM IS THE TOTAL OF THERMAL AND SEISMIC DISREGARDING THE SIGNS.

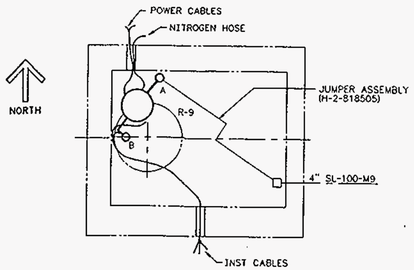
Rev-1: By: M. Ahmed 6-28-96
Checked By: [illegible] 7-1-96



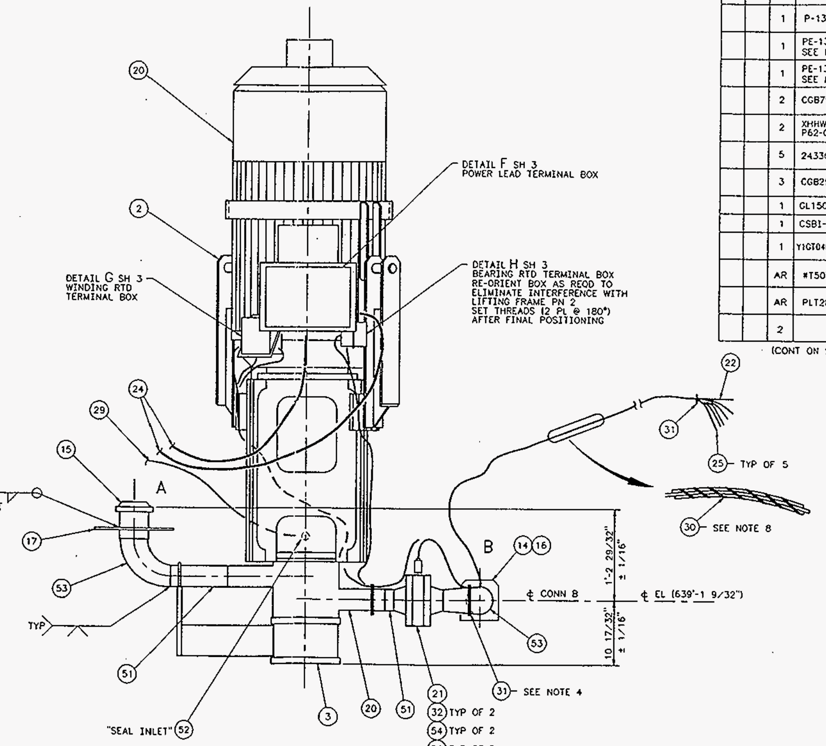
APPDX - A.



PLAN
(HOSES & WIRES NOT SHOWN FOR CLARITY)



241-C-06A
PUMP PIT
KEY PLAN
SCALE: NONE



ELEVATION A-A

① ASSEMBLY
SCALE: 1 1/2"= 1'-0"

PARTS/MATERIAL LIST

QUANTITY REQUIRED			PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
		☒	-010	ASSEMBLY			1
	☒	1	-020	LIFTING FRAME SUB-ASSY		2	2
☒		1	-030	PUMP BASE SUB-ASSY		2	3
							4
							5
	4		-001	PLATE, 3/8" THK	ASTM A 36	3	6
	4		-002	PLATE, 3/8" THK	ASTM A 36	3	7
2			-003	PLATE, 3/8" THK	ASTM A 36	3	8
1			-004	PLATE, 1/2" THK	ASTM A 36	3	9
2			-005	PLATE, 1" THK x 11 5/8" DIA	ASTM A 276 304L	3	10
[illegible]			[illegible]	[illegible]	[illegible]	3	11
		1	-007	PLATE, 3/8" THK	ASTM A 36	3	12
							13
		1	H-2-32440-2	CONN, VERT 4"			14
		1	H-2-90187-2	NOZZLE, MALE 4"			15
		1	H-2-3997-8	GASKET 4" TYPE III			16
		1	H-2-3194-4	KICK-OFF PL, 4" STD ROUND			17
							18
		1	RB350-250	CONDUIT RED BUSHING, 3 1/2" x 2 1/2"	APPLETON ELECTRIC		19
		1	P-1362	PUMP, IN-LINE 3" INLET & 3" OUTLET	PROCUREMENT SPEC W-320-P17		20
		1	PE-1363 SEE NOTE 6 & 9	PRESSURE SENSOR, 3"	RED VALVE CO, INC		21
		1	PE-1363 SEE NOTE 7	PRESSURE TRANSDUCER, (PE) 1/4" NPT	CONSTR SPEC W-320-C5		22
		2	CGB791	CABLE FITTING, 2 1/2" MNPT x 1.375/1.625 DIA	CROUSE-HINDS		23
		2	XHHW P62-0404	CABLE, 3C, 4/0 AWG W/ GROUND, RATED FOR 90°C, 30' L	ROCKBESTOS FIREWALL III		24
		5	2433C	CABLE, 3C, #16 AWG W/ OVERALL SHIELD x 25' L	ALPHA		25
		3	CGB293	CABLE FITTING, 3/4" MNPT x .250/.375 DIA	CROUSE-HINDS		26
		1	CL150	CABINET ADAPTER, 1 1/2"	O-Z/GEDNEY		27
		1	CSBI-150P-1	CONDUIT SEALING BUSHING, 1 1/2"	O-Z/GEDNEY		28
		1	Y1GT0404MC04MC-300	HOSE ASSY 1/4" ID FLEX x 25' L	IMPERIAL EASTMAN		29
		AR	#T50T	CABLE TEFLON SPRIAL WRAPPING x L AS REQD	PANDUIT		30
		AR	PLT2H-	CABLE TIE, NYLON HVY CROSS SECTION x L AS REQD	PANDUIT		31
		2		GASKET, 3" FLANGE, 1/8" THK	COMPRESSED FIBER GARLOCK BLUE GARD		32

(CONT ON SHEET 2)

NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH HANFORD SPECIFICATION HS-BS-0084, REV B.
2. HYDROSTATIC TEST AT 480 PSIG.
3. JUMPER WEIGHT IS 3750 LB APPROX.
4. ROUTE CABLES APPROXIMATELY AS SHOWN AND SECURE TO SUPPORT STEEL W/PN 31, AVOID IMPACT WRENCH AND LIFTING BAIL AREAS.
5. USE (1) COAT OF AMERLOCK 400 IN PLACE OF AMERCOAT 187 PRIMER AND AMERCOAT 33, WHERE REQUIRED BY JUMPER FABRICATION SPECIFICATION.
6. SEE CONSTRUCTION SPEC W-320-C5, SECTION 13440 FOR FILLING INSTRUCTION AFTER ASSEMBLY. AFTER FILLING, REMOVE HANDLE FROM BALL VALVE (PN 57).
7. TRIM CABLES FURNISHED WITH PN 22 TO 25' LONG PRIOR TO INSTALLATION.
8. TIE EACH END OF TEFLON SPIRAL WRAPPING (PN 30) WITH NYLON CABLE TIES (PN 31).
9. PRESSURE SENSOR (PN 21) SHALL BE SERIES 40, FOR CLASS 300 FLANGES, 316 SST, EPDM SLEEVES, WITH 1/4" NPT PRESSURE TAP. FURNISH WITH 100ML OF SILICONE OIL IN A SEPERATE CONTAINER.

CARROLL D. JONES
11633
EXPIRES 5-3-96

NUMBER	TITLE

DRAWING TRACEABILITY LIST

NUMBER	TITLE
H-2-818423 SH 7	DRAWING LIST

REFERENCES
NEXT USED ON H-2-818524

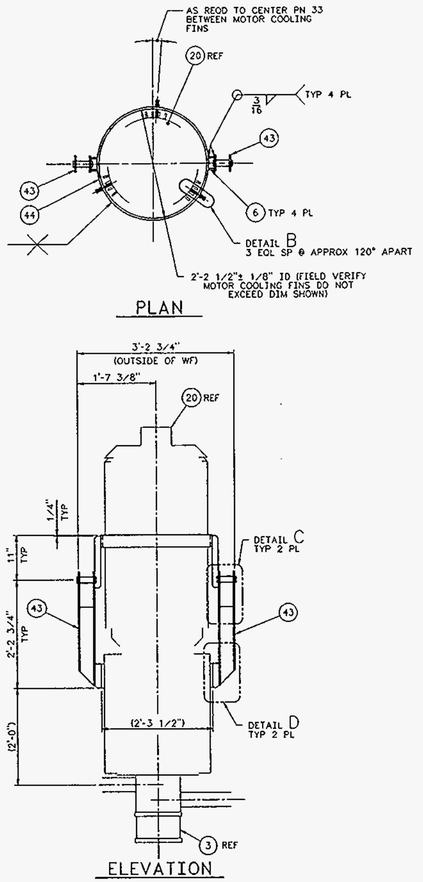
REVISIONS
CAD FILE 8508AR1
CAD CODE 2B:IBM:ACD2:12.0:NN

DESIGNED Ba MEYER sr
SAFETY SEE DR/AT FORM
ENVIR SEE DR/AT FORM
QUAL ENGR SEE DR/AT FORM
REVIEW NO. 11 6-13 1996
APPROVED FOR IMPLEMENTATION
BY WHC
USE CONSTRUCTION
SAFETY CLASS 3

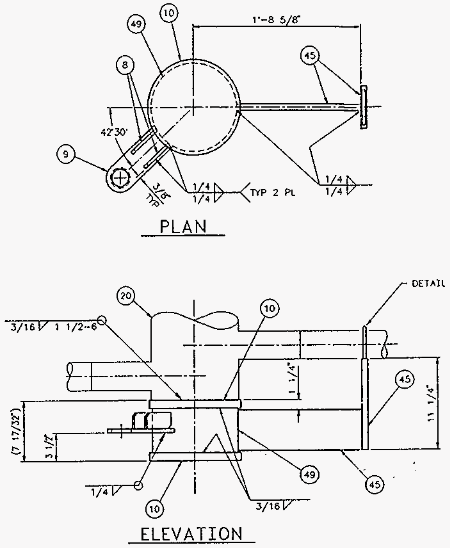
U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

JUMPER ASSEMBLY
PUMP PIT
C-06A-B-(A)

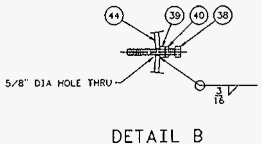
PROJECT W-320 TANK 241-C-106 SLUICING
SIZE F BLDG NO. 241-C INDEX NO. 8405 DWG NO. B508AR1 REV NO. 1
SCALE SHOWN JOB NO. ER4319 SHEET 1 OF 3
PLOT SCALE: 1=8
KEHCAD



2 LIFTING FRAME SUB-ASSY
SCALE: 1"= 1'-0"

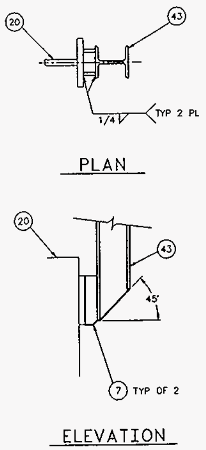


3 PUMP BASE SUB-ASSY
SCALE: 2"= 1'-0"

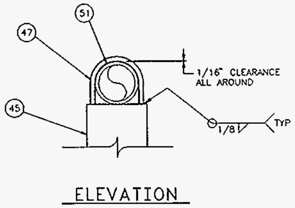


DETAIL B
SCALE: 3"=1'-0"

QUANTITY REQUIRED			PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
				(CONT FROM SHEET 1)			
		☒		ASSEMBLY		1	1
	☒			LIFTING FRAME SUB-ASSY			2
☒				PUMP BASE SUB-ASSY			3
							33
		~~4~~		~~NUT, HVY HEX, 3/4"-10 UNC-2B~~	~~ASTM A 194, GR 8F 303~~		34
		~~8~~		~~STUD BOLT, 5/8"-11 UNC-2A x 5 1/2"L~~	~~ASTM A 193, GR B8 304~~		35
		8		STUD BOLT, 3/4"-10 UNC-2A x 7 1/2"L	ASTM A 193, GR B8 304		36
		32		NUT, HVY HEX, 3/4"-10 UNC-2B	ASTM A 194, GR 8F 303		37
		3		MACHINE SCREW, 1/2"-13 UNC-2A x 4 1/2"L	SAE J429 GR. 5		38
		3		NUT, HVY HEX, 1/2"-13 UNC-2B	ASTM A 563, GR B		39
		3		NUT, JAM, 1/2"-13 UNC-2B	ASTM A 563, GR A		40
							41
							42
	AR			W4 x 13	ASTM A 36		43
	AR			FLAT BAR, 3" x 1/2"	ASTM A 36		44
AR				FLAT BAR, 5" x 3/4"	ASTM A 36		45
	2			BAR, 1 1/2" DIA x 4 7/8" L	ASTM A 36		45
AR				BAR, 3/8" DIA	ASTM A 36		47
							48
AR				PIPE, 10" SCHED 40S	ASTM A 312 GR TP 304L		49
		AR		PIPE, 4" SCHED 40S	ASTM A 312 GR TP 304L		50
		AR		PIPE, 3" SCHED 40S	ASTM A 312 GR TP 304L		51
		1	SS-8-RB-4	RED BUSHING, 1/2" NPT x 1/4" NPT	CAJON		52
		2		RDCR ELB 90° LR, 4" x 3", SCHED 40S BW	ASTM A 403 WP-S 304L		53
		2		FLANGE 3", 300# RF WN	ASTM A 182 GR F 304L		54
		1		PLUG, 3/8" NPT	ASTM A 126 GCI		55
		1	SS-4-ST	STREET TEE, 1/4" NPT	CAJON		56
		1	SS-43M4	BALL VALVE, 1/4" NPT	WHITEY		57
		1	SS-4-CP	PIPE CAP, 1/4" NPT	CAJON		58



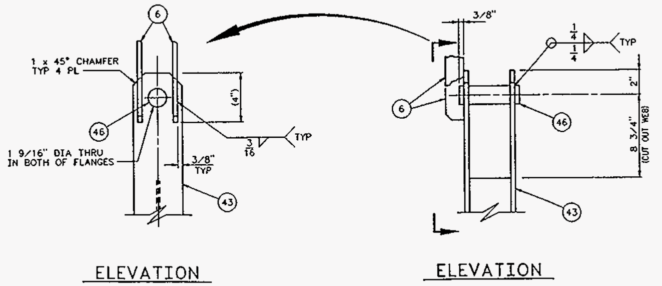
DETAIL D
SCALE: 2"=1'-0"



DETAIL E
SCALE: 3"=1'-0"

NOTE:

1. FOR NOTES, SEE SHEET 1



DETAIL C
SCALE: 3"=1'-0"

11633
EXPIRES 5-3-96

DESIGNED Ba MEYER sr
SAFETY SEE DR/AT FORM
ENVIR SEE DR/AT FORM
QUAL ENGR SEE DR/AT FORM
REVIEW NO. 12 6-13 1996
APPROVED FOR IMPLEMENTATION
FOR WHC
USE CONSTRUCTION
SAFETY CLASS 3

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

JUMPER ASSEMBLY
PUMP PIT
C-06A-B-(A)

PROJECT W-320 TANK 241-C-106 SLUICING
SIZE F BLDG NO. 241-C INDEX NO. 8405 DWG NO. B508BR1 REV NO. 1
SCALE SHOWN JOB NO. EP4319 SHEET 2 OF 3
CAD FILE B508BR1 CAD CODE 2B:IBM:ACD2:12.0:NN
PLOT SCALE: 1=12 KEHCAD

```
------------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A             ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                  AutoPIPE+4.60 MODEL  PAGE   3
------------------------------------------------------------------------------------


                    P O I N T   D A T A   L I S T I N G

POINT         -----OFFSETS (ft )-----
NAME  TYPE     X       Y       Z    PIPE ID  DESCRIPTION
----- ---- ------- ------- ------- -------- --------------------------------
*** SEGMENT A
A00   Run       0       0       0 4PIPE
A01   Flex   0.22       0   -0.11           Wt= 144 lb , Ar= 3.2 sq.in
                                            Axial= 23300000 Tors=    304.0
                                            Y-Shear= RIGID    Bend=   2080.0
                                            Z-Shear= RIGID    Bend=   2080.0

A02   Run    0.04       0   -0.02
A03   Bend   0.30       0   -0.15           Short Elbow, Radius = 4.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 2.56, Out = 2.13
                                            Flex = 7.908

A04   Bend      0   -1.49       0           Long  Elbow, Radius = 6.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272

A05   Bend   5.46       0       0           Long  Elbow, Radius = 6.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272

A06   Bend      0       0    2.00           Long  Elbow, Radius = 6.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272

A07   Run    1.63       0       0
A08   Run    0.92       0       0
A09   Run    0.92       0       0
A10   Run    2.66       0       0
A11   Bend   1.04       0       0           Short Elbow, Radius = 4.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 2.56, Out = 2.13
                                            Flex = 7.908

A12   Flex      0   -0.40       0           Wt= 144 lb , Ar= 3.2 sq.in
                                            Axial= 23300000 Tors=    304.0
                                            Y-Shear= RIGID    Bend=   2080.0
                                            Z-Shear= RIGID    Bend=   2080.0

A13   Run       0   -0.04       0
A14   Bend      0   -0.60       0           Long  Elbow, Radius = 6.00 inch
```

```
------------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A             ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                  AutoPIPE+4.60 MODEL  PAGE   4
------------------------------------------------------------------------------------


                    P O I N T   D A T A   L I S T I N G

POINT         -----OFFSETS (ft )-----
NAME  TYPE     X       Y       Z    PIPE ID  DESCRIPTION
----- ---- ------- ------- ------- -------- --------------------------------
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272

A14 F Far                           3PIPE
A14A  Run       0       0   -0.66
A15   Run       0       0   -0.64

*** SEGMENT B
B02   Run   13.19   -2.84   -1.78 3PIPE
B03   Bend      0       0   -1.30           Long  Elbow, Radius = 4.50 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.78, Out = 1.48
                                            Flex = 4.577

B03 F Far                           4PIPE
B04   Bend  -1.30       0       0           Short Elbow, Radius = 4.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 2.56, Out = 2.13
                                            Flex = 7.908

B05   Flex      0   -0.40       0           Wt= 144 lb , Ar= 3.2 sq.in
                                            Axial= 23300000 Tors=    304.0
                                            Y-Shear= RIGID    Bend=   2080.0
                                            Z-Shear= RIGID    Bend=   2080.0

B06   Run       0   -0.04       0
B07   Run       0   -0.19       0

*** SEGMENT C
5     Run   13.19    3.50   -1.78 3.5PIPE
C01   Run       0       0   -0.25

*** SEGMENT D
3     Run   13.19    3.50    0.42 3.5PIPE
D01   Run       0       0    0.25

 Total weight of empty pipes : 254 lb
```

```
                    C O M P O N E N T   D A T A   L I S T I N G

POINT  ---COORDINATE(ft  )---  DATA
NAME     X       Y       Z     TYPE  DESCRIPTION
----- ------- ------- ------- ------ -----------------------------------------
*** SEGMENT A
A00      0.00    0.00    0.00 ANCHOR Rigid
                                     Thermal movements : None
A01      0.22    0.00   -0.11
A02      0.26    0.00   -0.13
A03 N    0.26    0.00   -0.13
A03      0.56    0.00   -0.28 TI
A03 M    0.47   -0.10   -0.24
A03 F    0.56   -0.33   -0.28
A04 N    0.56   -0.99   -0.28
A04      0.56   -1.49   -0.28 TI
A04 M    0.71   -1.34   -0.28
A04 F    1.06   -1.49   -0.28
A05 N    5.52   -1.49   -0.28
A05      6.02   -1.49   -0.28 TI
A05 M    5.87   -1.49   -0.13
A05 F    6.02   -1.49    0.22
A06 N    6.02   -1.49    1.22
A06      6.02   -1.49    1.72 TI
A06 M    6.17   -1.49    1.57
A06 F    6.52   -1.49    1.72
A07      7.65   -1.49    1.72 WEIGHT 23 lb    ,  No offsets
A08      8.57   -1.49    1.72 WEIGHT 35 lb    ,  No offsets
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
A09      9.49   -1.49    1.72 WEIGHT 17 lb    ,  No offsets
A10     12.15   -1.49    1.72 WEIGHT 27 lb    ,  No offsets
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
A11 N   12.86   -1.49    1.72
A11     13.19   -1.49    1.72 TI
A11 M   13.09   -1.59    1.72
A11 F   13.19   -1.82    1.72
A12     13.19   -1.89    1.72
A13     13.19   -1.93    1.72
A14 N   13.19   -2.03    1.72
A14     13.19   -2.53    1.72 TI
A14 M   13.19   -2.38    1.57
A14 F   13.19   -2.53    1.22
A14A    13.19   -2.53    1.06
A15     13.19   -2.53    0.42

*** SEGMENT B
B02     13.19   -2.84   -1.78
B03 N   13.19   -2.84   -2.70
```

```
                    C O M P O N E N T   D A T A   L I S T I N G

POINT  ---COORDINATE(ft  )---  DATA
NAME     X       Y       Z     TYPE  DESCRIPTION
----- ------- ------- ------- ------ -----------------------------------------
B03     13.19   -2.84   -3.08 TI
B03 M   13.08   -2.84   -2.97
B03 F   12.81   -2.84   -3.08
B04 N   12.22   -2.84   -3.08
B04     11.89   -2.84   -3.08 TI
B04 M   11.99   -2.94   -3.08
B04 F   11.89   -3.17   -3.08
B05     11.89   -3.24   -3.08
B06     11.89   -3.28   -3.08
B07     11.89   -3.47   -3.08 ANCHOR Rigid
                                     Thermal movements : None

*** SEGMENT C
5       13.19    3.50   -1.78 ANCHOR Translational stiffness lb/in
                                     X= FREE      Y= FREE      Z= FREE
                                     Rotational stiffness ft-lb/deg
                                     X= RIGID     Y= RIGID     Z= RIGID
                                     Thermal movements : None
C01     13.19    3.50   -2.03 ANCHOR Rigid
                                     Thermal movements : None

*** SEGMENT D
3       13.19    3.50    0.42 ANCHOR Translational stiffness lb/in
                                     X= FREE      Y= FREE      Z= FREE
                                     Rotational stiffness ft-lb/deg
                                     X= RIGID     Y= RIGID     Z= RIGID
                                     Thermal movements : None
D01     13.19    3.50    0.67 ANCHOR Rigid
                                     Thermal movements : None

Number of points in the system : 51
```

IC14PRINT

```
                    P I P E   D A T A   L I S T I N G

Pipe ID/     Nom/  O.D.  -----Thickness(inch)-----  Spec   Weight(lb/ft )
Material     Sch   inch  W.Th. Corr Mill Insu Ling  Grav  Pipe  Other Total
------------ ----  ----- ----- ---- ---- ---- ----  ----  -----  ----- -----
4PIPE           4  4.500 0.237 0.06 0.03    0    0  1.20  11.04      0 17.66
AU            STD

3.5PIPE     3.500  4.000 0.226 0.06 0.03    0    0     0   9.32      0  9.32
AU            STD

3PIPE       3.000  3.500 0.216 0.06 0.03    0    0  1.20   7.75      0 11.60
AU            STD
```

```
               M A T E R I A L   D A T A   L I S T I N G

 Material               Density  Pois. Temper. Modulus  Expans.    Allow.
   Name       Pipe ID   lb/cu.ft Ratio deg F   E6 psi   in/100ft   psi
------------ --------  --------- ----- ------ -------- --------  --------
AU           4PIPE        501.0  0.30    40.0    28.42            16700.0
                                        180.0             1.5442  16700.0

AU           3PIPE        501.0  0.30    40.0    28.42            16700.0
                                        180.0             1.5442  16700.0

AU           3.5PIPE      501.0  0.30    40.0    28.42            16700.0
                                        180.0             1.5442  16700.0
```

```
                        FRAME POINT DATA LISTING

POINT   ---COORDINATE(ft  )---  DATA
NAME      X       Y       Z     TYPE  DESCRIPTION
-----  -------  ------  ------ ------ ----------------------------------------
A15     13.19   -2.53    0.42
1       13.19   -2.84   -0.68
B02     13.19   -2.84   -1.78
5       13.19    3.50   -1.78 ANCHOR Translational stiffness lb/in
                                      X= FREE       Y= FREE       Z= FREE
                                      Rotational stiffness ft-lb/deg
                                      X= RIGID      Y= RIGID      Z= RIGID
                                      Thermal movements : None
4       13.19    3.50   -0.68
3       13.19    3.50    0.42
6       13.19   -2.04   -0.68 WEIGHT 1000 lb      , No offsets
2       13.19   -2.84    0.42
7       13.19    2.08   -0.68 WEIGHT 2250 lb      , Offsets in ft
                                      DX = 0.00, DY = 0.00, DZ = 0.03
```

```
                             BEAM DATA LISTING

BEAM          POINT  LENGTH  SECTION ID/         BETA     RIGID      RELEASE
 ID           NAME   (ft  )  MATERIAL ID         ANGLE    END(ft)  Ax  Y-Y Z-Z
----          -----  ------  ---------------     ------   ------   --- --- ---
M2     From   2        1.10  W4X13                0.00     0.00    N   N   N
       To     1              A36                           0.00    N   N   N

M9     From   2        0.31  W4X13                0.00     0.00    N   N   N
       To     A15            A36                           0.00    N   N   N

M1     From   1        1.10  W4X13                0.00     0.00    N   N   N
       To     B02            A36                           0.00    N   N   N

M6     From   5        6.34  W4X13                0.00     0.00    N   N   N
       To     B02            A36                           0.00    N   N   N

M3     From   A15      6.03  W4X13                0.00     0.00    N   N   N
       To     3              A36                           0.00    N   N   N

M4     From   3        1.10  W4X13                0.00     0.00    N   N   N
       To     4              A36                           0.00    N   N   N

M5     From   4        1.10  W4X13                0.00     0.00    N   N   N
       To     5              A36                           0.00    N   N   N

M7     From   1        0.80  XS12                 0.00     0.00    N   N   N
       To     6              A36                           0.00    N   N   N

M8     From   6        4.12  XS12                 0.00     0.00    N   N   N
       To     7              A36                           0.00    N   N   N

M10    From   4        1.42  XS12                 0.00     0.00    N   N   N
       To     7              A36                           0.00    N   N   N
```

```
                          CROSS SECTION LISTING

Section ID                        Area(sq.in  )             Inertia (in**4  )
ID                         Axial   Y-Shear  Z-Shear    Torsion    Y-Y Bend   Z-Z Bend
----------------          -------  -------  -------    --------   --------   --------
W4X13                        3.83     1.16     1.86         0.2        3.9       11.3
XS12                        19.20     9.60     9.60       724.0      362.0      362.0
```

```
                              BEAM MATERIAL LISTING

                        Elastic                Yield                               Ultimate
                        modulus    Poissons    Stress     Density      Expansion    stress
MATERIAL ID             E6 psi      ratio      psi        lb/cu.ft      E-6 /F      psi
----------------        --------   --------   --------   ----------   ----------   --------
A36                       29.000      0.250      36000       490.00      6.50000      58000
```

```
--------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A               ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                    AutoPIPE+4.60 MODEL  PAGE  13
--------------------------------------------------------------------------------


                        TEMPERATURE AND PRESSURE DATA
      -----C A S E  1------  -----C A S E  2------  -----C A S E  3------
POINT PRESS. TEMPER  EXPAN.   PRESS. TEMPER  EXPAN.   PRESS. TEMPER  EXPAN.
NAME  psi    deg F  in/100ft  psi    deg F  in/100ft  psi    deg F  in/100ft
----- ------ ------ --------  ------ ------ --------  ------ ------ --------

*** SEGMENT A
A00      325    180    1.544
A14 F    325    180    1.544
A15      325    180    1.544

*** SEGMENT B
B02      325    180    1.544
B03 F    325    180    1.544
B07      325    180    1.544

*** SEGMENT C
5        490    180    1.544
C01      490    180    1.544

*** SEGMENT D
3        490    180    1.544
D01      490    180    1.544
```

```
--------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A               ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                    AutoPIPE+4.60 RESULT PAGE   1
--------------------------------------------------------------------------------


                        A N A L Y S I S   S U M M A R Y

  Current model revision number : 24

    Static - Date and Time of analysis ............. Jun 26, 1996   11:08 AM
             Model Revision Number ................. 23 ***
             Number of load cases .................. 2
             Load cases analyzed ................... GR T1
             Gaps/Friction/Yielding considered ..... No
             Hanger design run ..................... No
             Cut short included .................... No
             Weight of contents included ........... Yes
             Pressure stiffening case .............. 0
             Water elevation for buoyancy loads .... Not considered

     Modal - Date and Time of analysis ............. Jun 26, 1996   11:09 AM
             Model Revision Number ................. 24
             Number of modes ....................... 6
             Cutoff frequency (Hz) ................. 33.0
             Weight of contents included ........... Yes
             Pressure stiffening case .............. 0
             Water elevation for buoyancy loads .... Not considered

  Response - Date and Time of analysis ............. Jun 26, 1996   11:09 AM
             Model Revision Number ................. 24
             Number of load cases .................. 3
             Load cases analyzed ................... R1 R2 R3
             Date and time of modal analysis ....... Jun 26, 1996   11:09 AM
             Number of modes ....................... 6
             Cutoff frequency (Hz) ................. 33.0
             Model revision of modal analysis ...... 24
             Weight of contents included ........... Yes
             Pressure stiffening case .............. 0
             Water elevation for buoyancy loads .... Not considered


  *** W A R N I N G

  Current model revision does not match analysis
```

```
                    CODE COMPLIANCE COMBINATIONS

 Combination  Category   Method    Load      Factor Allowable  Remarks
 -----------  ---------- -------- ---------- ------ ---------  -------
 GR + Max P   Sustain    Sum      Gravity     1.00  Automatic  Default
                                  Max Long    1.00

 Cold to T1   Expansion  Sum      Thermal 1   1.00  Automatic  Default

 Sus. + R1    Occasion   Abs sum  Response 1  1.00  Automatic  Default
                                  Max Sus     1.00

 Sus. + R2    Occasion   Abs sum  Response 2  1.00  Automatic  Default
                                  Max Sus     1.00

 Sus. + R3    Occasion   Abs sum  Response 3  1.00  Automatic  Default
                                  Max Sus     1.00

 Max P        Hoop                Max Hoop    1.00  Automatic  Default

 SRSS         Occasion   SRSS     Response 1  1.00  Automatic  User
                                  Response 2  1.00
                                  Response 3  1.00



             OTHER USER COMBINATIONS

 Combination  Method      Load     Factor  Remarks
 -----------  --------  ---------- ------  -------
 GR           Sum       Gravity     1.00   Default

 T1           Sum       Thermal 1   1.00   Default

 R1           Sum       Response 1  1.00   Default

 R2           Sum       Response 2  1.00   Default

 R3           Sum       Response 3  1.00   Default

 GR+T1        Sum       Gravity     1.00   User
                        Thermal 1   1.00

 RESPONSE     SRSS      Response 1  1.00   User
                        Response 2  1.00
                        Response 3  1.00

 TOTAL        Abs sum   GR+T1       1.00   User
                        RESPONSE    1.00


CODE COMPLIANCE
```

```
 Y - Factor ............................ 0.40
 Weld efficiency factor ................ 1.00
 Range reduction factor ................ 1.00
 Design Pressure Factor ................ 1.00
 Minimum stress ratio used in reports... 0.00
 Include corrosion in stress calcs. .... Y
 Include torsion in code stress ........ N
 Include axial force in code stress .... N
 Longitudinal pressure calculation ..... PD/4t
 Include rigorous pressure ............. Not analyzed
```

```
   RESPONSE SPECTRUM LOAD CASES :
   -----------------------------

   Number of load cases analysed :  3

   Load case 1  -  R1

   Missing mass : Yes
   ZPA          : No

   Combination method : SRSS

   X- Spectrum : SC1
   Multiplier  :    1.00

   SC1

 Freq(Hz)  Grav(        )  Freq(Hz)  Grav(        )  Freq(Hz)  Grav(        )
 --------  -------------   --------  -------------   --------  -------------
   0.100             0.01    0.160             0.03    0.250             0.06
   0.400             0.10    0.600             0.16    1.100             0.28
   1.640             0.42    8.000             0.42   12.000             0.34
  20.000             0.26   33.000             0.20  100.000             0.20
```

```
   Load case 2  -  R2

   Missing mass : Yes
   ZPA          : No

   Combination method : SRSS

   Y- Spectrum : SC1
   Multiplier  :    1.00

   SC1

 Freq(Hz)  Grav(        )  Freq(Hz)  Grav(        )  Freq(Hz)  Grav(        )
 --------  -------------   --------  -------------   --------  -------------
   0.100             0.01    0.160             0.03    0.250             0.06
   0.400             0.10    0.600             0.16    1.100             0.28
   1.640             0.42    8.000             0.42   12.000             0.34
  20.000             0.26   33.000             0.20  100.000             0.20
```

```
Load case 3  -  R3

Missing mass : Yes
ZPA          : No

Combination method : SRSS

Z- Spectrum : SC1
Multiplier  :   1.00

SC1

Freq(Hz)  Grav(        )  Freq(Hz)  Grav(        )  Freq(Hz)  Grav(        )
--------  -------------   --------  -------------   --------  -------------
  0.100          0.01       0.160          0.03       0.250          0.06
  0.400          0.10       0.600          0.16       1.100          0.28
  1.640          0.42       8.000          0.42      12.000          0.34
 20.000          0.26      33.000          0.20     100.000          0.20
```

```
                          D I S P L A C E M E N T S

Point    Load          TRANSLATIONS (in  )           ROTATIONS (deg  )
name     combination    X       Y       Z             X       Y       Z
------   -----------  ------  ------  ------        ------  ------  ------

*** Segment A  begin ***

A00      GR            0.000   0.000   0.000         0.000   0.000   0.000
         T1            0.000   0.000   0.000         0.000   0.000   0.000
         GR+T1         0.000   0.000   0.000         0.000   0.000   0.000
         RESPONSE      0.000   0.000   0.000         0.000   0.000   0.000
         TOTAL         0.000   0.000   0.000         0.000   0.000   0.000

A01      GR            0.000   0.000   0.000         0.000   0.000  -0.002
         T1            0.003   0.000  -0.002         0.000   0.000  -0.001
         GR+T1         0.003   0.000  -0.002         0.000   0.000  -0.002
         RESPONSE      0.000   0.000   0.000         0.001   0.002   0.001
         TOTAL         0.003   0.000   0.002         0.001   0.002   0.004

A02      GR            0.000   0.000   0.000         0.153  -0.015  -0.124
         T1            0.003   0.000  -0.002         0.058   0.000  -0.076
         GR+T1         0.003  -0.001  -0.002         0.210  -0.015  -0.200
         RESPONSE      0.000   0.000   0.000         0.161   0.078   0.097
         TOTAL         0.004   0.001   0.002         0.371   0.093   0.297

A03 N    GR            0.000   0.000   0.000         0.153  -0.015  -0.124
         T1            0.003   0.000  -0.002         0.058   0.000  -0.076
         GR+T1         0.003  -0.001  -0.002         0.210  -0.015  -0.200
         RESPONSE      0.000   0.000   0.000         0.161   0.078   0.097
         TOTAL         0.004   0.001   0.002         0.371   0.093   0.297

A03 M    GR           -0.002  -0.003  -0.002         0.151  -0.015  -0.128
         T1            0.005  -0.004  -0.004         0.055  -0.002  -0.082
         GR+T1         0.003  -0.007  -0.007         0.206  -0.017  -0.211
         RESPONSE      0.003   0.004   0.006         0.164   0.088   0.102
         TOTAL         0.006   0.010   0.013         0.370   0.105   0.313

A03 F    GR           -0.009  -0.004  -0.010         0.154  -0.014  -0.132
         T1            0.002  -0.009  -0.008         0.051  -0.003  -0.085
         GR+T1        -0.006  -0.012  -0.017         0.205  -0.018  -0.217
         RESPONSE      0.008   0.005   0.015         0.167   0.091   0.106
         TOTAL         0.014   0.018   0.032         0.373   0.108   0.323

A04 N    GR           -0.027  -0.004  -0.031         0.156  -0.015  -0.134
         T1           -0.010  -0.019  -0.015         0.050  -0.005  -0.083
         GR+T1        -0.036  -0.022  -0.046         0.206  -0.020  -0.217
         RESPONSE      0.022   0.005   0.037         0.168   0.095   0.105
         TOTAL         0.058   0.028   0.083         0.373   0.115   0.321
```

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--------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A                 ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                      AutoPIPE+4.60 RESULT PAGE   8
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                        D I S P L A C E M E N T S

Point    Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name    combination     X       Y       Z          X       Y       Z
------  -----------   ------  ------  ------     ------  ------  ------
A04 M   GR            -0.037  -0.008  -0.042      0.159  -0.014  -0.142
        T1            -0.013  -0.026  -0.018      0.045  -0.008  -0.063
        GR+T1         -0.050  -0.034  -0.060      0.204  -0.023  -0.205
        RESPONSE       0.029   0.008   0.051      0.166   0.097   0.097
        TOTAL          0.079   0.042   0.111      0.370   0.119   0.302

A04 F   GR            -0.041  -0.019  -0.046      0.161  -0.014  -0.147
        T1            -0.009  -0.032  -0.019      0.041  -0.014  -0.037
        GR+T1         -0.050  -0.051  -0.064      0.202  -0.029  -0.184
        RESPONSE       0.032   0.014   0.060      0.165   0.101   0.091
        TOTAL          0.083   0.065   0.124      0.367   0.130   0.275

A05 N   GR            -0.041  -0.139  -0.032      0.175  -0.013  -0.093
        T1             0.060  -0.046   0.005      0.025  -0.041   0.004
        GR+T1          0.018  -0.185  -0.027      0.200  -0.054  -0.089
        RESPONSE       0.032   0.087   0.131      0.158   0.083   0.060
        TOTAL          0.051   0.272   0.158      0.358   0.137   0.150

A05 M   GR            -0.042  -0.150  -0.032      0.165  -0.011  -0.052
        T1             0.063  -0.046   0.011      0.020  -0.058   0.015
        GR+T1          0.022  -0.196  -0.021      0.185  -0.069  -0.036
        RESPONSE       0.033   0.092   0.135      0.153   0.069   0.038
        TOTAL          0.055   0.288   0.155      0.338   0.138   0.075

A05 F   GR            -0.042  -0.163  -0.031      0.155  -0.010  -0.033
        T1             0.061  -0.046   0.018      0.013  -0.070   0.021
        GR+T1          0.018  -0.209  -0.013      0.169  -0.080  -0.012
        RESPONSE       0.036   0.099   0.136      0.147   0.067   0.030
        TOTAL          0.055   0.308   0.149      0.316   0.147   0.043

A06 N   GR            -0.045  -0.196  -0.031      0.154  -0.011  -0.001
        T1             0.046  -0.049   0.034      0.012  -0.068   0.027
        GR+T1          0.001  -0.244   0.003      0.166  -0.079   0.027
        RESPONSE       0.048   0.118   0.136      0.145   0.065   0.021
        TOTAL          0.049   0.363   0.138      0.311   0.144   0.048

A06 M   GR            -0.046  -0.206  -0.031      0.137  -0.016   0.020
        T1             0.044  -0.049   0.041      0.009  -0.047   0.032
        GR+T1         -0.002  -0.255   0.010      0.146  -0.063   0.052
        RESPONSE       0.052   0.125   0.135      0.135   0.057   0.024
        TOTAL          0.053   0.380   0.145      0.281   0.120   0.077
```

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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                 ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                      AutoPIPE+4.60 RESULT PAGE   9
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                        D I S P L A C E M E N T S

Point    Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name    combination     X       Y       Z          X       Y       Z
------  -----------   ------  ------  ------     ------  ------  ------
A06 F   GR            -0.046  -0.207  -0.029      0.122  -0.023   0.068
        T1             0.048  -0.046   0.046      0.007  -0.020   0.040
        GR+T1          0.002  -0.253   0.016      0.129  -0.043   0.108
        RESPONSE       0.053   0.126   0.132      0.128   0.062   0.045
        TOTAL          0.055   0.380   0.149      0.257   0.105   0.153

A07     GR            -0.046  -0.187  -0.024      0.117  -0.026   0.098
        T1             0.066  -0.036   0.049      0.007  -0.006   0.044
        GR+T1          0.019  -0.224   0.025      0.124  -0.032   0.142
        RESPONSE       0.053   0.114   0.118      0.123   0.073   0.061
        TOTAL          0.072   0.338   0.143      0.247   0.105   0.203

A08     GR            -0.046  -0.166  -0.018      0.113  -0.028   0.124
        T1             0.080  -0.028   0.049      0.007   0.004   0.046
        GR+T1          0.034  -0.194   0.031      0.120  -0.024   0.170
        RESPONSE       0.053   0.101   0.104      0.119   0.084   0.075
        TOTAL          0.086   0.295   0.135      0.239   0.108   0.245

A09     GR            -0.046  -0.140  -0.013      0.109  -0.030   0.147
        T1             0.094  -0.019   0.047      0.007   0.013   0.047
        GR+T1          0.048  -0.158   0.035      0.116  -0.017   0.194
        RESPONSE       0.053   0.086   0.088      0.115   0.095   0.088
        TOTAL          0.101   0.244   0.122      0.231   0.112   0.282

A10     GR            -0.046  -0.044   0.005      0.097  -0.034   0.186
        T1             0.135   0.007   0.034      0.008   0.033   0.042
        GR+T1          0.089  -0.038   0.039      0.105  -0.001   0.228
        RESPONSE       0.053   0.030   0.033      0.103   0.115   0.108
        TOTAL          0.142   0.068   0.072      0.208   0.116   0.335

A11 N   GR            -0.046  -0.017   0.010      0.094  -0.035   0.186
        T1             0.146   0.013   0.029      0.008   0.037   0.039
        GR+T1          0.100  -0.004   0.039      0.102   0.002   0.225
        RESPONSE       0.053   0.015   0.022      0.101   0.116   0.107
        TOTAL          0.153   0.019   0.061      0.202   0.118   0.332

A11 M   GR            -0.042  -0.008   0.010      0.091  -0.038   0.176
        T1             0.150   0.013   0.026      0.011   0.046   0.029
        GR+T1          0.108   0.005   0.037      0.102   0.007   0.205
        RESPONSE       0.052   0.010   0.019      0.098   0.117   0.102
        TOTAL          0.159   0.015   0.056      0.200   0.124   0.307
```

```
--------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  10
--------------------------------------------------------------------------------

                      D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )         ROTATIONS (deg  )
name      combination     X       Y       Z           X       Y       Z
------    -----------   ------  ------  ------      ------  ------  ------
A11 F     GR            -0.034  -0.004   0.007       0.085  -0.040   0.160
          T1             0.153   0.010   0.025       0.013   0.049   0.023
          GR+T1          0.119   0.005   0.032       0.098   0.008   0.183
          RESPONSE       0.050   0.008   0.016       0.093   0.118   0.094
          TOTAL          0.169   0.014   0.048       0.191   0.126   0.277

A12       GR            -0.032  -0.004   0.006       0.085  -0.040   0.160
          T1             0.153   0.009   0.025       0.013   0.049   0.023
          GR+T1          0.121   0.004   0.030       0.098   0.008   0.182
          RESPONSE       0.049   0.008   0.015       0.092   0.118   0.094
          TOTAL          0.171   0.013   0.046       0.190   0.126   0.276

A13       GR            -0.031  -0.004   0.005       0.046  -0.096   0.058
          T1             0.153   0.009   0.025       0.009   0.418   0.016
          GR+T1          0.122   0.004   0.030       0.054   0.323   0.074
          RESPONSE       0.049   0.008   0.015       0.053   0.134   0.043
          TOTAL          0.172   0.013   0.045       0.107   0.457   0.117

A14 N     GR            -0.030  -0.004   0.004       0.045  -0.096   0.057
          T1             0.153   0.007   0.024       0.008   0.419   0.016
          GR+T1          0.124   0.003   0.028       0.054   0.323   0.073
          RESPONSE       0.049   0.008   0.014       0.053   0.135   0.043
          TOTAL          0.173   0.011   0.043       0.106   0.458   0.116

A14 M     GR            -0.023  -0.003   0.001       0.037  -0.092   0.041
          T1             0.142   0.002   0.022       0.007   0.420   0.020
          GR+T1          0.119  -0.001   0.023       0.044   0.329   0.061
          RESPONSE       0.046   0.007   0.013       0.044   0.134   0.036
          TOTAL          0.164   0.008   0.036       0.087   0.462   0.097

A14 F     GR            -0.015  -0.001   0.000       0.018  -0.087   0.033
          T1             0.111   0.000   0.016       0.003   0.419   0.024
          GR+T1          0.096  -0.001   0.016       0.022   0.332   0.057
          RESPONSE       0.038   0.004   0.013       0.030   0.132   0.034
          TOTAL          0.134   0.005   0.029       0.052   0.464   0.091

A14A      GR            -0.013   0.000   0.000       0.013  -0.086   0.028
          T1             0.097   0.000   0.013       0.003   0.418   0.027
          GR+T1          0.085   0.000   0.013       0.016   0.331   0.055
          RESPONSE       0.034   0.003   0.013       0.027   0.132   0.032
          TOTAL          0.119   0.003   0.027       0.043   0.463   0.087
```

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MA-C06A   JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  11
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                      D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )         ROTATIONS (deg  )
name      combination     X       Y       Z           X       Y       Z
------    -----------   ------  ------  ------      ------  ------  ------
A15       GR            -0.001   0.000   0.000       0.000  -0.084   0.008
          T1             0.042   0.000   0.004      -0.001   0.407   0.040
          GR+T1          0.041   0.000   0.004      -0.001   0.323   0.049
          RESPONSE       0.025   0.001   0.013       0.011   0.129   0.029
          TOTAL          0.065   0.001   0.017       0.012   0.452   0.078

*** Segment A  end   ***

*** Segment B  begin ***

B02       GR             0.000   0.000   0.000      -0.001   0.000   0.000
          T1             0.033   0.000   0.004       0.003   0.029   0.028
          GR+T1          0.033   0.000   0.004       0.002   0.029   0.028
          RESPONSE       0.016   0.001   0.013       0.003   0.048   0.016
          TOTAL          0.049   0.001   0.017       0.005   0.077   0.044

B03 N     GR             0.000   0.000   0.000      -0.001   0.000   0.000
          T1             0.026   0.002  -0.011       0.011   0.040   0.003
          GR+T1          0.026   0.002  -0.011       0.010   0.040   0.003
          RESPONSE       0.005   0.001   0.013       0.001   0.058   0.012
          TOTAL          0.031   0.003   0.024       0.012   0.098   0.015

B03 M     GR             0.000   0.000   0.000      -0.001   0.000  -0.001
          T1             0.022   0.003  -0.014       0.015   0.054  -0.007
          GR+T1          0.022   0.002  -0.014       0.015   0.054  -0.008
          RESPONSE       0.002   0.001   0.012       0.004   0.053   0.009
          TOTAL          0.024   0.003   0.026       0.018   0.107   0.017

B03 F     GR             0.000   0.000   0.000      -0.001   0.000  -0.001
          T1             0.016   0.004  -0.012       0.017   0.066  -0.024
          GR+T1          0.017   0.004  -0.012       0.017   0.065  -0.025
          RESPONSE       0.001   0.001   0.010       0.007   0.049   0.004
          TOTAL          0.018   0.004   0.021       0.024   0.115   0.029

B04 N     GR             0.000   0.000   0.000      -0.001   0.000  -0.001
          T1             0.007   0.007  -0.004       0.015   0.067  -0.026
          GR+T1          0.007   0.007  -0.004       0.015   0.067  -0.027
          RESPONSE       0.001   0.000   0.004       0.008   0.049   0.003
          TOTAL          0.008   0.008   0.007       0.023   0.116   0.030

B04 M     GR             0.000   0.000   0.000      -0.001   0.000  -0.002
          T1             0.003   0.007  -0.001       0.014   0.068  -0.026
          GR+T1          0.003   0.007  -0.001       0.013   0.068  -0.027
          RESPONSE       0.001   0.000   0.001       0.010   0.049   0.008
          TOTAL          0.004   0.007   0.002       0.023   0.117   0.035
```

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                           D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )            ROTATIONS (deg  )
name    combination      X       Y       Z             X       Y       Z
------  -----------   ------  ------  ------        ------  ------  ------
B04 F   GR             0.000   0.000   0.000         0.000   0.000  -0.001
        T1             0.000   0.004   0.000         0.011   0.069  -0.023
        GR+T1          0.000   0.004   0.000         0.011   0.069  -0.024
        RESPONSE       0.000   0.000   0.000         0.011   0.048   0.011
        TOTAL          0.001   0.004   0.000         0.021   0.117   0.035

B05     GR             0.000   0.000   0.000         0.000   0.000  -0.001
        T1             0.000   0.003   0.000         0.011   0.069  -0.022
        GR+T1          0.000   0.003   0.000         0.011   0.068  -0.024
        RESPONSE       0.000   0.000   0.000         0.011   0.048   0.011
        TOTAL          0.000   0.003   0.000         0.021   0.117   0.035

B06     GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.003   0.000         0.000   0.000   0.000
        GR+T1          0.000   0.003   0.000         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.003   0.000         0.000   0.000   0.001

B07     GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.000   0.000         0.000   0.000   0.000
        GR+T1          0.000   0.000   0.000         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.000   0.000         0.000   0.000   0.000

*** Segment B  end   ***

*** Segment C  begin ***

5       GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.000   0.003         0.000   0.000   0.000
        GR+T1          0.000   0.000   0.003         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.000   0.003         0.000   0.000   0.000

C01     GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.000   0.000         0.000   0.000   0.000
        GR+T1          0.000   0.000   0.000         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.000   0.000         0.000   0.000   0.000

*** Segment C  end   ***

 ** Segment D  begin ***
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                           D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )            ROTATIONS (deg  )
name    combination      X       Y       Z             X       Y       Z
------  -----------   ------  ------  ------        ------  ------  ------
3       GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.000  -0.003         0.000   0.000   0.000
        GR+T1          0.000   0.000  -0.003         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.000   0.003         0.000   0.000   0.000

D01     GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.000   0.000         0.000   0.000   0.000
        GR+T1          0.000   0.000   0.000         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.000   0.000         0.000   0.000   0.000

*** Segment D  end   ***

A15     GR            -0.001   0.000   0.000         0.000  -0.084   0.008
        T1             0.042   0.000   0.004        -0.001   0.407   0.040
        GR+T1          0.041   0.000   0.004        -0.001   0.323   0.049
        RESPONSE       0.025   0.001   0.013         0.011   0.129   0.029
        TOTAL          0.065   0.001   0.017         0.012   0.452   0.078

1       GR             0.000   0.000   0.000         0.000  -0.001   0.000
        T1             0.038   0.000   0.004        -0.002   0.013   0.029
        GR+T1          0.038   0.000   0.004        -0.003   0.012   0.029
        RESPONSE       0.024   0.000   0.013         0.009   0.012   0.017
        TOTAL          0.062   0.000   0.017         0.011   0.025   0.046

B02     GR             0.000   0.000   0.000        -0.001   0.000   0.000
        T1             0.033   0.000   0.004         0.003   0.029   0.028
        GR+T1          0.033   0.000   0.004         0.002   0.029   0.028
        RESPONSE       0.016   0.001   0.013         0.003   0.048   0.016
        TOTAL          0.049   0.001   0.017         0.005   0.077   0.044

5       GR             0.000   0.000   0.000         0.000   0.000   0.000
        T1             0.000   0.000   0.003         0.000   0.000   0.000
        GR+T1          0.000   0.000   0.003         0.000   0.000   0.000
        RESPONSE       0.000   0.000   0.000         0.000   0.000   0.000
        TOTAL          0.000   0.000   0.003         0.000   0.000   0.000

4       GR             0.000   0.000   0.000         0.000  -0.001   0.000
        T1             0.000   0.000   0.000        -0.002   0.009   0.029
        GR+T1          0.000   0.000   0.000        -0.002   0.008   0.029
        RESPONSE       0.000   0.000   0.000         0.009   0.008   0.018
        TOTAL          0.000   0.001   0.000         0.011   0.017   0.047
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                  ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                       AutoPIPE+4.60 RESULT PAGE  14
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                         D I S P L A C E M E N T S

Point      Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name     combination      X       Y       Z          X       Y       Z
------   -----------   ------  ------  ------     ------  ------  ------
3        GR             0.000   0.000   0.000      0.000   0.000   0.000
         T1             0.000   0.000  -0.003      0.000   0.000   0.000
         GR+T1          0.000   0.000  -0.003      0.000   0.000   0.000
         RESPONSE       0.000   0.000   0.000      0.000   0.000   0.000
         TOTAL          0.000   0.000   0.003      0.000   0.000   0.000

6        GR             0.000   0.000   0.000      0.000  -0.001   0.000
         T1             0.033   0.000   0.003     -0.003   0.013   0.029
         GR+T1          0.033   0.000   0.003     -0.003   0.012   0.029
         RESPONSE       0.021   0.001   0.012      0.009   0.012   0.017
         TOTAL          0.054   0.001   0.015      0.012   0.024   0.046

2        GR            -0.001   0.000   0.000     -0.001  -0.005   0.008
         T1             0.044   0.000   0.004     -0.001   0.039   0.040
         GR+T1          0.044   0.000   0.004     -0.001   0.034   0.049
         RESPONSE       0.026   0.001   0.013      0.005   0.016   0.029
         TOTAL          0.070   0.001   0.017      0.007   0.051   0.077

7        GR             0.000   0.000   0.000      0.000  -0.001   0.000
         T1             0.009   0.000   0.001     -0.003   0.010   0.029
         GR+T1          0.009   0.000   0.001     -0.003   0.009   0.029
         RESPONSE       0.006   0.001   0.003      0.010   0.009   0.018
         TOTAL          0.014   0.001   0.004      0.013   0.019   0.047
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                  ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                       AutoPIPE+4.60 RESULT PAGE  15
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                         S U P P O R T   F O R C E S

 Point/  Connect/    Load             L O C A L                G L O B A L
Supp. ID   Type   Combination  Dirn  Force    Deform     Dirn   Force    Deform
-------- -------- -----------  ----  -------- --------   ----  --------  --------


***  End of system , no supports  encountered.  ***
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 MA-C06A   JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
 06/26/96  PIPE STRESS ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  16
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                     R E S T R A I N T   R E A C T I O N S

 Point    Load              FORCES (lb     )              MOMENTS (ft-lb  )
 name   combination   X      Y      Z    Result    X       Y       Z     Result
 ------ ----------- ------ ------ ------ ------ ------- ------- ------- -------

 A00      Anchor
          GR            57   -358      9    362     -28     -39    -186     193
          T1          -290     37    -32    294     -11      41     -80      91
          GR+T1       -233   -321    -23    397     -39       2    -266     269
          RESPONSE     295    128    132    347      79     196     129     248
          TOTAL        528    449    155    710     118     198     395     458

 B07      Anchor
          GR             5   -167      2    167      -1       0      -4       4
          T1             8   -197   -103    222       1      21     -48      52
          GR+T1         13   -363   -102    378       1      21     -52      56
          RESPONSE     326     86    169    377      56      15      90     107
          TOTAL        339    450    270    625      56      35     142     156

 5        Anchor
          GR             0      0      0      0      50       4       2      50
          T1             0      0      0      0      -4     -72     284     293
          GR+T1          0      0      0      0      46     -69     286     298
          RESPONSE       0      0      0      0      94      60     123     166
          TOTAL          0      0      0      0     140     129     409     451

 C01      Anchor
          GR            22   -231     -6    232      29       3       0      29
          T1          -279    -14 -24319  24321       2     -35       0      35
          GR+T1       -257   -245 -24325  24328      31     -32       0      44
          RESPONSE     281   1062    314   1142     133      35       0     137
          TOTAL        538   1307  24639  24680     163      67       0     177

 3        Anchor
          GR             0      0      0      0     -80      13    -134     156
          T1             0      0      0      0     -41    -167     748     767
          GR+T1          0      0      0      0    -121    -155     614     645
          RESPONSE       0      0      0      0     200     240     397     506
          TOTAL          0      0      0      0     321     395    1011    1132

 D01      Anchor
          GR           -84    154     -5    175      19      10       0      22
          T1           561    262  24455  24463      33     -70       0      77
          GR+T1        477    416  24450  24458      52     -60       0      79
          RESPONSE     560   1180    316   1344     148      70       0     163
          TOTAL       1037   1596  24766  24839     200     130       0     238
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 MA-C06A   JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
 06/26/96  PIPE STRESS ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  17
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                     R E S T R A I N T   R E A C T I O N S

 Point    Load              FORCES (lb     )              MOMENTS (ft-lb  )
 name   combination   X      Y      Z    Result    X       Y       Z     Result
 ------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
 5        Anchor
          GR             0      0      0      0      50       4       2      50
          T1             0      0      0      0      -4     -72     284     293
          GR+T1          0      0      0      0      46     -69     286     298
          RESPONSE       0      0      0      0      94      60     123     166
          TOTAL          0      0      0      0     140     129     409     451
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MA-C06A    JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/26/96   PIPE STRESS ANALYSIS                     AutoPIPE+4.60 RESULT PAGE  18
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              G L O B A L   F O R C E S   &   M O M E N T S

Point      Load              FORCES (lb    )             MOMENTS (ft-lb  )
name    combination   X       Y      Z    Result    X       Y       Z    Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------

*** Segment A  begin ***

A00      GR            -57    358     -9    362      28      39     186     193
         T1            290    -37     32    294      11     -41      80      91
         GR+T1         233    321     23    397      39      -2     266     269
         RESPONSE      295    128    131    347      79     196     129     248
         TOTAL         528    448    155    710     118     198     395     458

A01      GR            -57    209     -9    217     -11      31     108     113
         T1            290    -37     32    294      15      -2      88      89
         GR+T1         233    172     23    291       4      29     196     198
         RESPONSE      290    115    121    335      75     161     118     213
         TOTAL         523    288    145    614      80     190     314     376

A02      GR            -57    209     -9    217     -16      29      97     103
         T1            290    -37     32    294      16       5      90      91
         GR+T1         233    172     23    291      -1      34     186     190
         RESPONSE      287    109    117    329      75     155     117     208
         TOTAL         520    281    140    608      76     190     303     366

A03 N    GR            -57    209     -9    217     -17      29      97     102
         T1            290    -37     32    294      16       5      90      91
         GR+T1         233    172     23    291      -1      35     186     189
         RESPONSE      287    109    117    329      75     155     117     208
         TOTAL         520    281    140    608      76     190     303     365

A03 M    GR            -57    205     -9    212     -39      21      58      74
         T1            290    -37     32    294      23      43      69      84
         GR+T1         233    168     23    288     -17      64     128     144
         RESPONSE      287    108    117    328      68     133      96     177
         TOTAL         520    276    140    605      85     197     223     309

A03 F    GR            -57    200     -9    208     -50      18      54      76
         T1            290    -37     32    294      32      58       4      67
         GR+T1         233    163     23    286     -18      76      58      98
         RESPONSE      287    108    116    327      62     128      76     161
         TOTAL         520    271    139    602      80     204     134     257

A04 N    GR            -57    188     -9    197     -56      18      91     109
         T1            290    -37     32    294      53      58    -186     202
         GR+T1         233    151     23    279      -3      76     -95     122
         RESPONSE      285    108    114    325      96     128     213     266
         TOTAL         518    259    137    595      99     204     308     383
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MA-C06A    JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/26/96   PIPE STRESS ANALYSIS                     AutoPIPE+4.60 RESULT PAGE  19
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              G L O B A L   F O R C E S   &   M O M E N T S

Point      Load              FORCES (lb    )             MOMENTS (ft-lb  )
name    combination   X       Y      Z    Result    X       Y       Z    Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A04 M    GR            -57    181     -9    190     -60      17      84     105
         T1            290    -37     32    294      65      63    -283     297
         GR+T1         233    145     23    275       5      80    -199     215
         RESPONSE      284    107    111    323     129     118     298     346
         TOTAL         517    252    135    591     135     197     498     552

A04 F    GR            -57    174     -9    184     -61      14      30      69
         T1            290    -37     32    294      70      74    -313     329
         GR+T1         233    138     23    272       9      88    -283     297
         RESPONSE      276    104    100    312     144     101     314     360
         TOTAL         509    242    123    577     153     189     598     645

A05 N    GR            -57     96     -9    112     -61     -27    -573     577
         T1            290    -37     32    294      70     219    -148     273
         GR+T1         233     59     23    242       9     192    -721     746
         RESPONSE      268     83     73    290     144     417     354     565
         TOTAL         502    141     96    530     153     609    1075    1245

A05 M    GR            -57     89     -9    106     -48     -22    -605     608
         T1            290    -37     32    294      64     188    -135     240
         GR+T1         233     52     23    240      17     166    -741     759
         RESPONSE      267     80     68    287     135     417     371     574
         TOTAL         500    132     92    526     152     583    1112    1265

A05 F    GR            -57     82     -9    100     -17      -3    -618     618
         T1            290    -37     32    294      51      90    -130     166
         GR+T1         233     45     23    239      34      87    -748     754
         RESPONSE      264     77     61    282     117     377     378     547
         TOTAL         498    122     84    519     151     464    1126    1227

A06 N    GR            -57     64     -9     86      56      54    -618     623
         T1            290    -37     32    294      14    -200    -130     239
         GR+T1         233     27     23    236      70    -146    -748     765
         RESPONSE      260     70     54    274      98     354     378     527
         TOTAL         493     98     78    508     168     500    1126    1244

A06 M    GR            -57     57     -9     81      77      72    -627     636
         T1            290    -37     32    294       1    -297    -124     322
         GR+T1         233     20     23    235      78    -225    -751     788
         RESPONSE      257     66     51    270     104     392     383     558
         TOTAL         490     86     74    503     182     617    1134    1304
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                    ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                         AutoPIPE+4.60 RESULT PAGE  20
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             G L O B A L   F O R C E S   &   M O M E N T S

Point    Load          FORCES (lb    )                 MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result     X       Y       Z     Result
------ ----------- ------ ------ ------ ------  ------- ------- ------- -------
A06 F   GR           -57     50     -9     76       85      77    -646     656
        T1           290    -37     32    294       -4    -328    -111     347
        GR+T1        233     13     23    235       81    -251    -757     802
        RESPONSE     250     58     45    261      107     414     393     581
        TOTAL        484     71     68    494      188     665    1150    1342

A07  -  GR           -57     30     -9     65       85      67    -691     700
        T1           290    -37     32    294       -4    -292     -70     300
        GR+T1        233     -7     23    235       81    -225    -761     798
        RESPONSE     250     58     45    261      107     419     420     603
        TOTAL        484     65     68    493      188     644    1181    1358

A07  +  GR           -57      7     -9     58       85      67    -691     700
        T1           290    -37     32    294       -4    -292     -70     300
        GR+T1        233    -30     23    236       81    -225    -761     798
        RESPONSE     232     42     38    239      107     419     420     603
        TOTAL        465     71     61    475      188     644    1181    1358

A08  -  GR           -57     -9     -9     58       85      59    -691     698
        T1           290    -37     32    294       -4    -262     -36     264
        GR+T1        233    -46     23    239       81    -203    -726     758
        RESPONSE     232     42     38    239      107     407     420     595
        TOTAL        465     88     61    477      188     610    1146    1312

A08  +  GR           -57   -114     -9    128       85      59    -691     698
        T1           290    -37     32    294       -4    -262     -36     264
        GR+T1        233   -151     23    279       81    -203    -726     758
        RESPONSE     179     83     76    212      107     407     420     595
        TOTAL        412    234    100    484      188     610    1146    1312

A09  -  GR           -57   -130     -9    142       85      50    -578     587
        T1           290    -37     32    294       -4    -232      -2     232
        GR+T1        233   -167     23    288       81    -182    -580     613
        RESPONSE     179     83     76    212      107     339     347     497
        TOTAL        412    250    100    492      188     520     927    1080

A09  +  GR           -57   -147     -9    158       85      50    -578     587
        T1           290    -37     32    294       -4    -232      -2     232
        GR+T1        233   -184     23    298       81    -182    -580     613
        RESPONSE     158    109     97    216      107     339     347     497
        TOTAL        392    294    120    504      188     520     927    1080
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                    ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                         AutoPIPE+4.60 RESULT PAGE  21
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             G L O B A L   F O R C E S   &   M O M E N T S

Point    Load          FORCES (lb    )                 MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result     X       Y       Z     Result
------ ----------- ------ ------ ------ ------  ------- ------- ------- -------
A10  -  GR           -57   -194     -9    202       85      26    -124     153
        T1           290    -37     32    294       -4    -146      96     175
        GR+T1        233   -231     23    329       81    -120     -28     147
        RESPONSE     158    109     97    216      107      92      88     166
        TOTAL        392    340    120    533      188     211     116     306

A10  +  GR           -57   -291     -9    297       85      26    -124     153
        T1           290    -37     32    294       -4    -146      96     175
        GR+T1        233   -328     23    403       81    -120     -28     147
        RESPONSE     108    136    124    213      107      92      88     166
        TOTAL        342    464    147    595      188     211     116     306

A11 N   GR           -57   -304     -9    309       85      20      86     122
        T1           290    -37     32    294       -4    -123     123     174
        GR+T1        233   -341     23    413       81    -103     208     246
        RESPONSE     105    137    125    214      107      30      78     136
        TOTAL        339    478    148    604      188     133     287     368

A11 M   GR           -57   -308     -9    314       84      18     163     185
        T1           290    -37     32    294       -1    -115     103     155
 Ⓐ      GR+T1        233   -345     23    417       83     -98     266     296
        RESPONSE     104    138    126    213      101      42      99     148
        TOTAL        337    483    149    607      185     140     365     432

A11 F   GR           -57   -313     -9    318       82      17     207     223
        T1           290    -37     32    294        7    -112      38     119
        GR+T1        233   -350     23    421       89     -96     245     278
        RESPONSE     103    138    126    213       93      51     115     156
        TOTAL        336    488    149    611      181     147     360     429

A12     GR           -57   -458     -9    462       82      17     211     227
        T1           290    -37     32    294        9    -112      19     114
        GR+T1        233   -495     23    548       90     -96     230     265
        RESPONSE      63    154    148    223       92      51     117     157
        TOTAL        296    649    172    733      182     147     347     418

A13     GR           -57   -458     -9    462       81      17     213     229
        T1           290    -37     32    294       10    -112       7     113
        GR+T1        233   -495     23    548       91     -96     220     257
        RESPONSE      92    176    178    267       92      51     119     159
        TOTAL        325    671    201    772      183     147     339     412
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                 G L O B A L   F O R C E S   &   M O M E N T S

Point     Load              FORCES (lb     )               MOMENTS (ft-lb  )
name   combination    X      Y      Z    Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A14 N   GR            -57   -460     -9    463      80      17     219     234
        T1            290    -37     32    294      13    -112     -22     115
        GR+T1         233   -497     23    549      93     -96     197     238
        RESPONSE       94    176    179    268      95      51     124     164
        TOTAL         327    673    202    775     189     147     321     400

A14 M   GR            -57   -467     -9    470     145       9     239     279
        T1            290    -37     32    294      30     -70    -124     146
        GR+T1         233   -504     23    556     175     -61     115     218
        RESPONSE       96    177    180    270     143      40     144     207
        TOTAL         329    681    204    783     318     101     258     422

A14 F   GR            -57   -474     -9    477     310     -12     247     397
        T1            290    -37     32    294      48      33    -167     176
        GR+T1         233   -511     23    562     358      21      80     367
        RESPONSE       97    178    181    272     204      23     154     256
        TOTAL         330    688    204    790     562      44     234     610

A14A    GR            -57    549     -9    552     386     -21     247     459
        T1            290     -2     32    292      54      79    -167     192
        GR+T1         233    546     23    594     440      58      80     451
        RESPONSE       98    178    182    273     226      29     154     275
        TOTAL         331    725    205    823     666      87     234     711

A15     GR            -57    541     -9    544      37     -57     247     256
        T1            290     -2     32    292      55     265    -167     317
        GR+T1         233    539     23    588      93     208      80     241
        RESPONSE       98    178    182    273     326      83     154     370
        TOTAL         331    717    205    816     419     291     234     561

*** Segment A  end   ***

*** Segment B  begin ***

B02     GR              5     19      2     20      13      -5       4      15
        T1              8   -197   -103    222    -189    -124     213     311
        GR+T1          13   -178   -102    205    -176    -129     217     308
        RESPONSE      319     59    154    359      45     259      39     266
        TOTAL         332    237    255    481     221     388     256     515

B03 N   GR              5      8      2     10       1       0       4       4
        T1              8   -197   -103    222      -7    -117     213     243
        GR+T1          13   -188   -102    214      -7    -117     217     246
        RESPONSE      319     59    154    359      28     113      39     122
        TOTAL         332    247    256    487      35     229     256     345
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                 G L O B A L   F O R C E S   &   M O M E N T S

Point     Load              FORCES (lb     )               MOMENTS (ft-lb  )
name   combination    X      Y      Z    Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
B03 M   GR              5      5      2      7      -1       1       5       5
        T1              8   -197   -103    222      45    -103     192     222
        GR+T1          13   -192   -102    217      43    -102     196     225
        RESPONSE      319     59    155    360      39     154      44     165
        TOTAL         332    251    257    489      83     256     241     361

B03 F   GR              5      2      2      5      -2       1       5       6
        T1              8   -197   -103    222      66     -75     139     172
        GR+T1          13   -195   -102    220      65     -73     145     175
        RESPONSE      319     59    156    360      45     142      59     161
        TOTAL         332    254    257    491     109     216     204     316

B04 N   GR              5     -9      2     10      -2       0       3       4
        T1              8   -197   -103    222      66     -14      23      71
        GR+T1          13   -206   -102    230      65     -13      26      71
        RESPONSE      319     59    156    360      45      52      93     115
        TOTAL         333    264    258    497     109      65     119     174

B04 M   GR              5    -13      2     14      -1       0       0       1
        T1              8   -197   -103    222      56      11     -24      62
        GR+T1          13   -210   -102    234      55      11     -24      61
Ⓑ       RESPONSE      319     59    156    360      29      19      76      83
        TOTAL         333    269    258    500      84      30     100     134
                      (X)    (Y)    (Z)
B04 F   GR              5    -18      2     19      -1       0      -2       3
        T1              8   -197   -103    222      32      21     -45      59
        GR+T1          13   -215   -102    238      31      21     -48      60
        RESPONSE      319     59    156    360       8      15       7      18
        TOTAL         333    274    258    502      39      35      55      76

B05     GR              5   -163      2    163      -1       0      -3       3
        T1              8   -197   -103    222      25      21     -46      56
        GR+T1          13   -360   -102    374      24      21     -49      58
        RESPONSE      321     67    160    365      18      15      16      28
        TOTAL         334    427    262    602      42      35      65      85

B06     GR              5   -163      2    163      -1       0      -3       3
        T1              8   -197   -103    222      21      21     -46      55
        GR+T1          13   -360   -102    374      20      21     -49      57
        RESPONSE      326     86    168    377      25      15      29      40
        TOTAL         339    446    270    622      44      35      78      96
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A               ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                    AutoPIPE+4.60 RESULT PAGE  24
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                 G L O B A L   F O R C E S   &   M O M E N T S

Point    Load              FORCES (lb    )               MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result     X       Y       Z    Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
B07      GR            5   -167      2    167      -1       0      -4       4
         T1            8   -197   -103    222       1      21     -48      52
         GR+T1        13   -363   -102    378       1      21     -52      56
         RESPONSE    326     86    168    377      56      15      90     107
         TOTAL       339    449    270    624      56      35     142     156

*** Segment B  end   ***

*** Segment C  begin ***

5        GR           22   -229     -6    230     -29      -3       0      29
         T1         -279    -14 -24319  24321      -2      35       0      35
         GR+T1      -257   -243 -24325  24328     -30      32       0      44
         RESPONSE    281   1062    314   1142     133      35       0     137
         TOTAL       538   1304  24639  24679     163      67       0     176

C01      GR           22   -231     -6    232      29       3       0      29
         T1         -279    -14 -24319  24321       2     -35       0      35
         GR+T1      -257   -245 -24325  24328      31     -32       0      44
         RESPONSE    281   1062    314   1142     133      35       0     137
         TOTAL       538   1307  24639  24679     163      67       0     177

*** Segment C  end   ***

*** Segment D  begin ***

3        GR          -84    156     -5    177     -19     -10       0      22
         T1          561    262  24455  24463     -33      70       0      77
         GR+T1       477    418  24450  24458     -52      60       0      79
         RESPONSE    560   1180    316   1344     148      70       0     163
         TOTAL      1037   1598  24766  24839     200     130       0     238

D01      GR          -84    154     -5    175      19      10       0      22
         T1          561    262  24455  24463      33     -70       0      77
         GR+T1       477    416  24450  24458      52     -60       0      79
         RESPONSE    560   1180    316   1344     148      70       0     163
         TOTAL      1037   1596  24766  24839     200     130       0     238

*** Segment D  end   ***
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                     AutoPIPE+4.60 RESULT PAGE  25
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                         ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )            (Stress in psi      )
Point     Load      In-Pl. Out-Pl. Torsion  S.I.F     Eq. Load   Code   Code
name   combination  Moment  Moment  Moment  In  Out   no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----  ------ ------

*** Segment A  begin ***

A00    Max P                                         (3a) HOOP    4844  16700
       GR + Max P      179      39          1.00 1.00 (18) SUST    2947  16700
       Cold to T1       76      41       26 1.00 1.00 (17) DISP     338  25050
       SRSS            141     196          1.00 1.00 (18)  OCC    1162  22211

A01    Max P                                         (3a) HOOP    4844  16700
       GR + Max P       92      31          1.00 1.00 (18) SUST    2531  16700
       Cold to T1       85       2       26 1.00 1.00 (17) DISP     334  25050
       SRSS            130     161          1.00 1.00 (18)  OCC     992  22211

A02    Max P                                         (3a) HOOP    4844  16700
       GR + Max P       79      29          1.00 1.00 (18) SUST    2472  16700
       Cold to T1       87       5       26 1.00 1.00 (17) DISP     340  25050
       SRSS            128     155          1.00 1.00 (18)  OCC     967  22211

A03 N- Max P                                         (3a) HOOP    4844  16700
       GR + Max P       79      29          1.00 1.00 (18) SUST    2470  16700
       Cold to T1       87       5       26 1.00 1.00 (17) DISP     340  25050
       SRSS            128     155          1.00 1.00 (18)  OCC     966  22211

A03 N+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P       79      29          2.56 2.13 (18) SUST    3080  16700
       Cold to T1       87       5       26 2.56 2.13 (17) DISP     839  25050
       SRSS            128     155          2.56 2.13 (18)  OCC    2235  22211

A03 M  Max P                                         (3a) HOOP    4844  16700
       GR + Max P       35      28          2.56 2.13 (18) SUST    2580  16700
       Cold to T1       72      23       38 2.56 2.13 (17) DISP     725  25050
       SRSS            108      99          2.56 2.13 (18)  OCC    1674  22211

A03 F- Max P                                         (3a) HOOP    4844  16700
       GR + Max P       26      69          2.56 2.13 (18) SUST    2842  16700
       Cold to T1       18      27       58 2.56 2.13 (17) DISP     349  25050
       SRSS             79      57          2.56 2.13 (18)  OCC    1136  22211

A03 F+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P       50      54          1.00 1.00 (18) SUST    2420  16700
       Cold to T1       32       4       58 1.00 1.00 (17) DISP     248  25050
       SRSS             62      76          1.00 1.00 (18)  OCC     469  22211
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                   ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                        AutoPIPE+4.60 RESULT PAGE  26
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                    ASME B31.3c (1992)  CODE COMPLIANCE
                      (Moments in ft-lb  )          (Stress in psi      )
Point      Load     In-Pl. Out-Pl. Torsion   S.I.F    Eq. Load   Code   Code
name   combination  Moment  Moment  Moment  In  Out   no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----  ------ ------
A04 N- Max P                                         (3a) HOOP    4844  16700
       GR + Max P        56      91          1.00 1.00 (18) SUST    2580  16700
       Cold to T1        53     186       58 1.00 1.00 (17) DISP     755  25050
       SRSS              96     213          1.00 1.00 (18)  OCC    1121  22211

A04 N+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P        91      56          1.95 1.63 (18) SUST    3027  16700
       Cold to T1       186      53       58 1.95 1.63 (17) DISP    1413  25050
       SRSS             213      96          1.95 1.63 (18)  OCC    2132  22211

A04 M  Max P                                         (3a) HOOP    4844  16700
       GR + Max P        84      30          1.95 1.63 (18) SUST    2890  16700
       Cold to T1       283      90        1 1.95 1.63 (17) DISP    2137  25050
       SRSS             298      93          1.95 1.63 (18)  OCC    2889  22211

A04 F- Max P                                         (3a) HOOP    4844  16700
       GR + Max P        30      14          1.95 1.63 (18) SUST    2364  16700
       Cold to T1       313      74       70 1.95 1.63 (17) DISP    2339  25050
       SRSS             314     101          1.95 1.63 (18)  OCC    3050  22211

A04 F+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P        30      14          1.00 1.00 (18) SUST    2223  16700
       Cold to T1       313      74       70 1.00 1.00 (17) DISP    1228  25050
       SRSS             314     101          1.00 1.00 (18)  OCC    1585  22211

A05 N- Max P                                         (3a) HOOP    4844  16700
       GR + Max P       573      27          1.00 1.00 (18) SUST    4818  16700
       Cold to T1       148     219       70 1.00 1.00 (17) DISP    1020  25050
       SRSS             354     417          1.00 1.00 (18)  OCC    2624  22211

A05 N+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P        27     573          1.95 1.63 (18) SUST    6546  16700
       Cold to T1       219     148       70 1.95 1.63 (17) DISP    1850  25050
       SRSS             417     354          1.95 1.63 (18)  OCC    4783  22211

A05 M  Max P                                         (3a) HOOP    4844  16700
       GR + Max P        22     395          1.95 1.63 (18) SUST    5153  16700
       Cold to T1       188     141       50 1.95 1.63 (17) DISP    1626  25050
       SRSS             417     254          1.95 1.63 (18)  OCC    4381  22211

A05 F- Max P                                         (3a) HOOP    4844  16700
       GR + Max P         3      17          1.95 1.63 (18) SUST    2205  16700
       Cold to T1        90      51      130 1.95 1.63 (17) DISP     873  25050
       SRSS             377     117          1.95 1.63 (18)  OCC    3650  22211
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MA-C06A   JUMPER ASSEMBLY C-06A-9-A                   ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                        AutoPIPE+4.60 RESULT PAGE  27
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                    ASME B31.3c (1992)  CODE COMPLIANCE
                      (Moments in ft-lb  )          (Stress in psi      )
Point      Load     In-Pl. Out-Pl. Torsion   S.I.F    Eq. Load   Code   Code
name   combination  Moment  Moment  Moment  In  Out   no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----  ------ ------
A05 F+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P        17       3          1.00 1.00 (18) SUST    2151  16700
       Cold to T1        51      90      130 1.00 1.00 (17) DISP     620  25050
       SRSS             117     377          1.00 1.00 (18)  OCC    1895  22211

A06 N- Max P                                         (3a) HOOP    4844  16700
       GR + Max P        56      54          1.00 1.00 (18) SUST    2436  16700
       Cold to T1        14     200      130 1.00 1.00 (17) DISP     891  25050
       SRSS              98     354          1.00 1.00 (18)  OCC    1763  22211

A06 N+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P        54      56          1.95 1.63 (18) SUST    2729  16700
       Cold to T1       200      14      130 1.95 1.63 (17) DISP    1537  25050
       SRSS             354      98          1.95 1.63 (18)  OCC    3405  22211

A06 M  Max P                                         (3a) HOOP    4844  16700
       GR + Max P        72     498          1.95 1.63 (18) SUST    6011  16700
       Cold to T1       297      89       87 1.95 1.63 (17) DISP    2258  25050
       SRSS             392     300          1.95 1.63 (18)  OCC    4355  22211

A06 F- Max P                                         (3a) HOOP    4844  16700
       GR + Max P        77     646          1.95 1.63 (18) SUST    7161  16700
       Cold to T1       328     111        4 1.95 1.63 (17) DISP    2488  25050
       SRSS             414     393          1.95 1.63 (18)  OCC    4946  22211

A06 F+ Max P                                         (3a) HOOP    4844  16700
       GR + Max P       646      77          1.00 1.00 (18) SUST    5187  16700
       Cold to T1       111     328        4 1.00 1.00 (17) DISP    1295  25050
       SRSS             393     414          1.00 1.00 (18)  OCC    2740  22211

A07    Max P                                         (3a) HOOP    4844  16700
       GR + Max P       691      67          1.00 1.00 (18) SUST    5400  16700
       Cold to T1        70     292        4 1.00 1.00 (17) DISP    1120  25050
       SRSS             420     419          1.00 1.00 (18)  OCC    2850  22211

A08    Max P                                         (3a) HOOP    4844  16700
       GR + Max P       691      59          1.00 1.00 (18) SUST    5393  16700
       Cold to T1        36     262        4 1.00 1.00 (17) DISP     987  25050
       SRSS             420     407          1.00 1.00 (18)  OCC    2807  22211

A09    Max P                                         (3a) HOOP    4844  16700
       GR + Max P       578      50          1.00 1.00 (18) SUST    4852  16700
       Cold to T1         2     232        4 1.00 1.00 (17) DISP     867  25050
       SRSS             347     339          1.00 1.00 (18)  OCC    2327  22211
```

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-------------------------------------------------------------------------------
 MA-C06A   JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
 06/26/96  PIPE STRESS ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  28
-------------------------------------------------------------------------------


                          ASME B31.3c (1992)  CODE COMPLIANCE
                            (Moments in ft-lb  )            (Stress in psi     )
Point      Load        In-Pl. Out-Pl. Torsion   S.I.F      Eq.  Load   Code   Code
name    combination    Moment  Moment  Moment   In   Out   no.  type  Stress Allow.
------  -----------    ------- ------- -------  ---- ----  ---- ----  ------ ------
A10     Max P                                              (3a) HOOP    4844  16700
        GR + Max P        124      26          1.00 1.00  (18) SUST    2676  16700
        Cold to T1         96     146        4 1.00 1.00  (17) DISP     654  25050
        SRSS               88      92          1.00 1.00  (18)  OCC     609  22211

A11 N-  Max P                                              (3a) HOOP    4844  16700
        GR + Max P         86      20          1.00 1.00  (18) SUST    2488  16700
        Cold to T1        123     123        4 1.00 1.00  (17) DISP     649  25050
        SRSS               78      30          1.00 1.00  (18)  OCC     403  22211

A11 N+  Max P                                              (3a) HOOP    4844  16700
        GR + Max P         86      20          2.56 2.13  (18) SUST    3138  16700
        Cold to T1        123     123        4 2.56 2.13  (17) DISP    1527  25050
        SRSS               78      30          2.56 2.13  (18)  OCC    1010  22211

A11 M   Max P                                              (3a) HOOP    4844  16700
        GR + Max P        163      72          2.56 2.13  (18) SUST    4203  16700
        Cold to T1        103      82       81 2.56 2.13  (17) DISP    1220  25050
        SRSS               99      69          2.56 2.13  (18)  OCC    1402  22211

A11 F-  Max P                                              (3a) HOOP    4844  16700
        GR + Max P        207      82          2.56 2.13  (18) SUST    4742  16700
        Cold to T1         38       7      112 2.56 2.13  (17) DISP     558  25050
        SRSS              115      93          2.56 2.13  (18)  OCC    1699  22211

A11 F+  Max P                                              (3a) HOOP    4844  16700
        GR + Max P         82     207          1.00 1.00  (18) SUST    3134  16700
        Cold to T1          7      38      112 1.00 1.00  (17) DISP     444  25050
        SRSS               93     115          1.00 1.00  (18)  OCC     708  22211

A12     Max P                                              (3a) HOOP    4844  16700
        GR + Max P         82     211          1.00 1.00  (18) SUST    3150  16700
        Cold to T1          9      19      112 1.00 1.00  (17) DISP     426  25050
        SRSS               92     117          1.00 1.00  (18)  OCC     714  22211

A13     Max P                                              (3a) HOOP    4844  16700
        GR + Max P         81     213          1.00 1.00  (18) SUST    3160  16700
        Cold to T1         10       7      112 1.00 1.00  (17) DISP     422  25050
        SRSS               92     119          1.00 1.00  (18)  OCC     721  22211

A14 N-  Max P                                              (3a) HOOP    4844  16700
        GR + Max P         80     219          1.00 1.00  (18) SUST    3184  16700
        Cold to T1         13      22      112 1.00 1.00  (17) DISP     430  25050
        SRSS               95     124          1.00 1.00  (18)  OCC     748  22211
```

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-------------------------------------------------------------------------------
 MA-C06A   JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
 06/26/96  PIPE STRESS ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  29
-------------------------------------------------------------------------------


                          ASME B31.3c (1992)  CODE COMPLIANCE
                            (Moments in ft-lb  )            (Stress in psi     )
Point      Load        In-Pl. Out-Pl. Torsion   S.I.F      Eq.  Load   Code   Code
name    combination    Moment  Moment  Moment   In   Out   no.  type  Stress Allow.
------  -----------    ------- ------- -------  ---- ----  ---- ----  ------ ------
A14 N+  Max P                                              (3a) HOOP    4844  16700
        GR + Max P         80     219          1.95 1.63  (18) SUST    3932  16700
        Cold to T1         13      22      112 1.95 1.63  (17) DISP     450  25050
        SRSS               95     124          1.95 1.63  (18)  OCC    1314  22211

A14 M   Max P                                              (3a) HOOP    4844  16700
        GR + Max P        145     163          1.95 1.63  (18) SUST    3927  16700
        Cold to T1         30      38      137 1.95 1.63  (17) DISP     604  25050
        SRSS              143      93          1.95 1.63  (18)  OCC    1521  22211

A14 F-  Max P                                              (3a) HOOP    4844  16700
        GR + Max P        310      12          1.95 1.63  (18) SUST    4972  16700
        Cold to T1         48      33      167 1.95 1.63  (17) DISP     740  25050
        SRSS              204      23          1.95 1.63  (18)  OCC    1919  22211

A14 F+  Max P                                              (3a) HOOP    4279  16700
        GR + Max P        310      12          1.00 1.00  (18) SUST    4661  16700
        Cold to T1         48      33      167 1.00 1.00  (17) DISP    1228  25050
        SRSS              204      23          1.00 1.00  (18)  OCC    1876  22211

A14A    Max P                                              (3a) HOOP    4279  16700
        GR + Max P        386      21          1.00 1.00  (18) SUST    5358  16700
        Cold to T1         54      79      167 1.00 1.00  (17) DISP    1337  25050
        SRSS              226      29          1.00 1.00  (18)  OCC    2087  22211

A15     Max P                                              (3a) HOOP    4279  16700
        GR + Max P         37      57          1.00 1.00  (18) SUST    2444  16700
        Cold to T1         55     265      167 1.00 1.00  (17) DISP    2210  25050
        SRSS              326      83          1.00 1.00  (18)  OCC    3078  22211

*** Segment A  end   ***

*** Segment B  begin ***

B02     Max P                                              (3a) HOOP    4279  16700
        GR + Max P         13       5          1.00 1.00  (18) SUST    1952  16700
        Cold to T1        189     124      213 1.00 1.00  (17) DISP    2166  25050
        SRSS               45     259          1.00 1.00  (18)  OCC    2407  22211

B03 N-  Max P                                              (3a) HOOP    4279  16700
        GR + Max P          1       0          1.00 1.00  (18) SUST    1828  16700
        Cold to T1          7     117      213 1.00 1.00  (17) DISP    1692  25050
        SRSS               28     113          1.00 1.00  (18)  OCC    1063  22211
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---------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A                 ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                      AutoPIPE+4.60 RESULT PAGE  30
---------------------------------------------------------------------------------

                       ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )              (Stress in psi      )
Point      Load       In-Pl. Out-Pl. Torsion   S.I.F    Eq.  Load   Code    Code
name    combination   Moment  Moment  Moment  In   Out  no.  type  Stress  Allow.
------  -----------  ------- ------- ------- ---- ---- ----  ----  ------  ------
B03 N+ Max P                                            (3a) HOOP    4279   16700
       GR + Max P          0       1         1.78 1.48 (18) SUST    1831   16700
       Cold to T1        117       7     213 1.78 1.48 (17) DISP    2071   25050
       SRSS              113      28         1.78 1.48 (18)  OCC    1871   22211

B03 M  Max P                                            (3a) HOOP    4279   16700
       GR + Max P          1       4         1.78 1.48 (18) SUST    1881   16700
       Cold to T1        103     104     167 1.78 1.48 (17) DISP    2031   25050
       SRSS              154      51         1.78 1.48 (18)  OCC    2594   22211

B03 F- Max P                                            (3a) HOOP    4279   16700
       GR + Max P          1       5         1.78 1.48 (18) SUST    1899   16700
       Cold to T1         75     139      66 1.78 1.48 (17) DISP    1770   25050
       SRSS              142      59         1.78 1.48 (18)  OCC    2450   22211

B03 F+ Max P                                            (3a) HOOP    4844   16700
       GR + Max P          5       1         1.00 1.00 (18) SUST    2092   16700
       Cold to T1        139      75      66 1.00 1.00 (17) DISP     640   25050
       SRSS               59     142         1.00 1.00 (18)  OCC     740   22211

B04 N- Max P                                            (3a) HOOP    4844   16700
       GR + Max P          3       0         1.00 1.00 (18) SUST    2081   16700
       Cold to T1         23      14      66 1.00 1.00 (17) DISP     267   25050
       SRSS               93      52         1.00 1.00 (18)  OCC     511   22211

B04 N+ Max P                                            (3a) HOOP    4844   16700
       GR + Max P          3       0         2.56 2.13 (18) SUST    2106   16700
       Cold to T1         23      14      66 2.56 2.13 (17) DISP     349   25050
       SRSS               93      52         2.56 2.13 (18)  OCC    1259   22211

B04 M  Max P                                            (3a) HOOP    4844   16700
       GR + Max P          0       1         2.56 2.13 (18) SUST    2077   16700
       Cold to T1         24      32      47 2.56 2.13 (17) DISP     387   25050
       SRSS               76      31         2.56 2.13 (18)  OCC     980   22211

B04 F- Max P                                            (3a) HOOP    4844   16700
       GR + Max P          2       1         2.56 2.13 (18) SUST    2098   16700
       Cold to T1         45      32      21 2.56 2.13 (17) DISP     507   25050
       SRSS                7       8         2.56 2.13 (18)  OCC     123   22211

B04 F+ Max P                                            (3a) HOOP    4844   16700
       GR + Max P          1       2         1.00 1.00 (18) SUST    2079   16700
       Cold to T1         32      45      21 1.00 1.00 (17) DISP     221   25050
       SRSS                8       7         1.00 1.00 (18)  OCC      53   22211
```

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---------------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A                 ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                      AutoPIPE+4.60 RESULT PAGE  31
---------------------------------------------------------------------------------

                       ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )              (Stress in psi      )
Point      Load       In-Pl. Out-Pl. Torsion   S.I.F    Eq.  Load   Code    Code
name    combination   Moment  Moment  Moment  In   Out  no.  type  Stress  Allow.
------  -----------  ------- ------- ------- ---- ---- ----  ----  ------  ------
B05    Max P                                            (3a) HOOP    4844   16700
       GR + Max P          1       3         1.00 1.00 (18) SUST    2080   16700
       Cold to T1         25      46      21 1.00 1.00 (17) DISP     210   25050
       SRSS               18      16         1.00 1.00 (18)  OCC     117   22211

B06    Max P                                            (3a) HOOP    4844   16700
       GR + Max P          1       3         1.00 1.00 (18) SUST    2081   16700
       Cold to T1         21      46      21 1.00 1.00 (17) DISP     204   25050
       SRSS               25      29         1.00 1.00 (18)  OCC     181   22211

B07    Max P                                            (3a) HOOP    4844   16700
       GR + Max P          1       4         1.00 1.00 (18) SUST    2085   16700
       Cold to T1          1      48      21 1.00 1.00 (17) DISP     194   25050
       SRSS               56      90         1.00 1.00 (18)  OCC     508   22211

*** Segment B  end   ***

*** Segment C  begin ***

5      Max P                                            (3a) HOOP    6905   16700
       GR + Max P         29       3         1.00 1.00 (18) SUST    3140   16700
       Cold to T1          2      35       0 1.00 1.00 (17) DISP     175   25050
       SRSS              133      35         1.00 1.00 (18)  OCC     895   22211

C01    Max P                                            (3a) HOOP    6905   16700
       GR + Max P         29       3         1.00 1.00 (18) SUST    3140   16700
       Cold to T1          2      35       0 1.00 1.00 (17) DISP     175   25050
       SRSS              133      35         1.00 1.00 (18)  OCC     895   22211

*** Segment C  end   ***

*** Segment D  begin ***

3      Max P                                            (3a) HOOP    6905   16700
       GR + Max P         19      10         1.00 1.00 (18) SUST    3096   16700
       Cold to T1         33      70       0 1.00 1.00 (17) DISP     388   25050
       SRSS              148      70         1.00 1.00 (18)  OCC    1065   22211

D01    Max P                                            (3a) HOOP    6905   16700
       GR + Max P         19      10         1.00 1.00 (18) SUST    3095   16700
       Cold to T1         33      70       0 1.00 1.00 (17) DISP     388   25050
       SRSS              148      70         1.00 1.00 (18)  OCC    1065   22211

*** Segment D  end   ***
```

```
----------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                     AutoPIPE+4.60 RESULT PAGE  32
----------------------------------------------------------------------------


                         S Y S T E M   S U M M A R Y
                         ---------------------------


Maximum displacements (in)
-------------------------

        Maximum X :     0.173      Point : A14 N       Load Comb.: TOTAL
        Maximum Y :     0.380      Point : A06 M       Load Comb.: TOTAL
        Maximum Z :     0.158      Point : A05 N       Load Comb.: TOTAL
        Max. total:     0.411      Point : A06 F       Load Comb.: TOTAL

Maximum rotations (deg)
----------------------

        Maximum X :     0.373      Point : A04 N       Load Comb.: TOTAL
        Maximum Y :     0.464      Point : A14 F       Load Comb.: TOTAL
        Maximum Z :     0.335      Point : A10         Load Comb.: TOTAL
        Max. total:     0.506      Point : A04 N       Load Comb.: TOTAL



Maximum restraint forces(lb)
-------------------------

        Maximum X :      1037      Point : D01         Load Comb.: TOTAL
        Maximum Y :      1596      Point : D01         Load Comb.: TOTAL
        Maximum Z :     24766      Point : D01         Load Comb.: TOTAL
        Max. total:     24839      Point : D01         Load Comb.: TOTAL

Maximum restraint moments(ft-lb)
-----------------------------

        Maximum X :       321      Point : 3           Load Comb.: TOTAL
        Maximum Y :       395      Point : 3           Load Comb.: TOTAL
        Maximum Z :      1011      Point : 3           Load Comb.: TOTAL
        Max. total:      1132      Point : 3           Load Comb.: TOTAL
```

```
----------------------------------------------------------------------------
MA-C06A   JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/26/96  PIPE STRESS ANALYSIS                     AutoPIPE+4.60 RESULT PAGE  33
----------------------------------------------------------------------------


                         S Y S T E M   S U M M A R Y
                         ---------------------------


Maximum pipe forces (lb)
-------------------------

        Maximum X :      1037      Point : 3           Load Comb.: TOTAL
        Maximum Y :      1598      Point : 3           Load Comb.: TOTAL
        Maximum Z :     24766      Point : 3           Load Comb.: TOTAL
        Max. total:     24839      Point : 3           Load Comb.: TOTAL

Maximum pipe moments (ft-lb)
----------------------------

        Maximum X :       666      Point : A14A        Load Comb.: TOTAL
        Maximum Y :       665      Point : A06 F       Load Comb.: TOTAL
        Maximum Z :      1181      Point : A07         Load Comb.: TOTAL
        Max. total:      1358      Point : A07         Load Comb.: TOTAL
```

```
                  S Y S T E M    S U M M A R Y
                  ----------------------------

  Maximum sustained stress

                          Point            : A06 F
                          Stress     psi   : 7161
                          Allowable psi    : 16700
                          Ratio            : 0.43
                          Load combination : GR + Max P

  Maximum displacement stress

                          Point            : A06 F
                          Stress     psi   : 2488
                          Allowable psi    : 25050
                          Ratio            : 0.10
                          Load combination : Cold to T1

  Maximum occasional stress

                          Point            : A06 F
                          Stress     psi   : 4946
                          Allowable psi    : 22211
                          Ratio            : 0.22
                          Load combination : SRSS

  Maximum hoop stress

                          Point            : 5
                          Stress     psi   : 6905
                          Allowable psi    : 16700
                          Ratio            : 0.41
                          Load combination : Max P

  Maximum sustained stress ratio

                          Point            : A06 F
                          Stress     psi   : 7161
                          Allowable psi    : 16700
                          Ratio            : 0.43
                          Load combination : GR + Max P

  Maximum displacement stress ratio

                          Point            : A06 F
                          Stress     psi   : 2488
                          Allowable psi    : 25050
                          Ratio            : 0.10
                          Load combination : Cold to T1
```

```
                  S Y S T E M    S U M M A R Y
                  ----------------------------

  Maximum occasional stress ratio

                          Point            : A06 F
                          Stress     psi   : 4946
                          Allowable psi    : 22211
                          Ratio            : 0.22
                          Load combination : SRSS

  Maximum hoop stress ratio

                          Point            : 5
                          Stress     psi   : 6905
                          Allowable psi    : 16700
                          Ratio            : 0.41
                          Load combination : Max P


  * * * The system satisfies ASME B31.3 code requirements * * *
  * * * for the selected options                          * * *
```

APPDX - B

```
                  P O I N T   D A T A   L I S T I N G

POINT        -----OFFSETS (ft )-----
NAME  TYPE     X       Y       Z     PIPE ID  DESCRIPTION
----- ---- ------- ------- ------- -------- ---------------------------------
*** SEGMENT A
A00   Run        0       0       0 4PIPE
A01   Flex    0.22       0   -0.11          Wt= 144 lb , Ar= 3.2 sq.in
                                            Axial= 23300000 Tors=    304.0
                                            Y-Shear= RIGID    Bend=   2080.0
                                            Z-Shear= RIGID    Bend=   2080.0

A02   Run     0.04       0   -0.02
A03   Bend    0.30       0   -0.15          Short Elbow, Radius = 4.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 2.56, Out = 2.13
                                            Flex = 7.908
A04   Bend       0   -1.49       0          Long  Elbow, Radius = 6.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272
A05   Bend    5.46       0       0          Long  Elbow, Radius = 6.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272
A06   Bend       0       0    2.00          Long  Elbow, Radius = 6.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272
A07   Run     1.63       0       0
A08   Run     0.92       0       0
A09   Run     0.92       0       0
A10   Run     2.66       0       0
A11   Bend    1.04       0       0          Short Elbow, Radius = 4.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 2.56, Out = 2.13
                                            Flex = 7.908
A12   Flex       0   -0.40       0          Wt= 144 lb , Ar= 3.2 sq.in
                                            Axial= 23300000 Tors=    304.0
                                            Y-Shear= RIGID    Bend=   2080.0
                                            Z-Shear= RIGID    Bend=   2080.0

A13   Run        0   -0.04       0
A14   Bend       0   -0.60       0          Long  Elbow, Radius = 6.00 inch
```

```
                  P O I N T   D A T A   L I S T I N G

POINT        -----OFFSETS (ft )-----
NAME  TYPE     X       Y       Z     PIPE ID  DESCRIPTION
----- ---- ------- ------- ------- -------- ---------------------------------
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.95, Out = 1.63
                                            Flex = 5.272

A14 F Far                              3PIPE
A14A  Run        0       0   -0.66
A15   Run        0       0   -0.64

*** SEGMENT B
B02   Run    13.19   -2.84   -1.78 3PIPE
B03   Bend       0       0   -1.30          Long  Elbow, Radius = 4.50 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 1.78, Out = 1.48
                                            Flex = 4.577

B03 F Far                              4PIPE
B04   Bend   -1.30       0       0          Short Elbow, Radius = 4.00 inch
                                            Bend angle change = 90.00 deg
                                            Mid point at 50.00 percent
                                            SIF - In 2.56, Out = 2.13
                                            Flex = 7.908

B05   Flex       0   -0.40       0          Wt= 144 lb , Ar= 3.2 sq.in
                                            Axial= 23300000 Tors=    304.0
                                            Y-Shear= RIGID    Bend=   2080.0
                                            Z-Shear= RIGID    Bend=   2080.0

B06   Run        0   -0.04       0
B07   Run        0   -0.19       0

*** SEGMENT C
5     Run    13.19    3.50   -1.78 3.5PIPE
C01   Run        0       0   -0.25

*** SEGMENT D
3     Run    13.19    3.50    0.42 3.5PIPE
D01   Run        0       0    0.25

 Total weight of empty pipes : 254 lb
```

```
                COMPONENT  DATA  LISTING

POINT   ---COORDINATE(ft  )---  DATA
NAME      X       Y       Z     TYPE  DESCRIPTION
----- ------- ------- ------- ------ ------------------------------------------
*** SEGMENT A
A00      0.00    0.00    0.00 ANCHOR Rigid
                                     Thermal movements : None
A01      0.22    0.00   -0.11
A02      0.26    0.00   -0.13
A03 N    0.26    0.00   -0.13
A03      0.56    0.00   -0.28 TI
A03 M    0.47   -0.10   -0.24
A03 F    0.56   -0.33   -0.28
A04 N    0.56   -0.99   -0.28
A04      0.56   -1.49   -0.28 TI
A04 M    0.71   -1.34   -0.28
A04 F    1.06   -1.49   -0.28
A05 N    5.52   -1.49   -0.28
A05      6.02   -1.49   -0.28 TI
A05 M    5.87   -1.49   -0.13
A05 F    6.02   -1.49    0.22
A06 N    6.02   -1.49    1.22
A06      6.02   -1.49    1.72 TI
A06 M    6.17   -1.49    1.57
A06 F    6.52   -1.49    1.72
A07      7.65   -1.49    1.72 WEIGHT 23 lb     ,  No offsets
A08      8.57   -1.49    1.72 WEIGHT 35 lb     ,  No offsets
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
A09      9.49   -1.49    1.72 WEIGHT 17 lb     ,  No offsets
A10     12.15   -1.49    1.72 WEIGHT 27 lb     ,  No offsets
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
                              FLANGE Weld neck          SIF = 1.00
                                     Rating = 400, Weight = 35 lb
A11 N   12.86   -1.49    1.72
A11     13.19   -1.49    1.72 TI
A11 M   13.09   -1.59    1.72
A11 F   13.19   -1.82    1.72
A12     13.19   -1.89    1.72
A13     13.19   -1.93    1.72
A14 N   13.19   -2.03    1.72
A14     13.19   -2.53    1.72 TI
A14 M   13.19   -2.38    1.57
A14 F   13.19   -2.53    1.22
A14A    13.19   -2.53    1.06 Y-STOP ID : A14A 1, Connected to Ground
                                     Gap-Below = 0.00, Above = 1.00 inch
                                     Friction = 0.00
                                     Gaps set Weightless

A15     13.19   -2.53    0.42
```

```
                COMPONENT  DATA  LISTING

POINT   ---COORDINATE(ft  )---  DATA
NAME      X       Y       Z     TYPE  DESCRIPTION
----- ------- ------- ------- ------ ------------------------------------------
*** SEGMENT B
B02     13.19   -2.84   -1.78
B03 N   13.19   -2.84   -2.70
B03     13.19   -2.84   -3.08 TI
B03 M   13.08   -2.84   -2.97
B03 F   12.81   -2.84   -3.08
B04 N   12.22   -2.84   -3.08
B04     11.89   -2.84   -3.08 TI
B04 M   11.99   -2.94   -3.08
B04 F   11.89   -3.17   -3.08
B05     11.89   -3.24   -3.08
B06     11.89   -3.28   -3.08
B07     11.89   -3.47   -3.08 ANCHOR Rigid
                                     Thermal movements : None

*** SEGMENT C
5       13.19    3.50   -1.78 ANCHOR Translational stiffness lb/in
                                     X= FREE       Y= FREE       Z= FREE
                                     Rotational stiffness ft-lb/deg
                                     X= RIGID      Y= RIGID      Z= RIGID
                                     Thermal movements : None
C01     13.19    3.50   -2.03 ANCHOR Rigid
                                     Thermal movements : None

*** SEGMENT D
3       13.19    3.50    0.42 ANCHOR Translational stiffness lb/in
                                     X= FREE       Y= FREE       Z= FREE
                                     Rotational stiffness ft-lb/deg
                                     X= RIGID      Y= RIGID      Z= RIGID
                                     Thermal movements : None
D01     13.19    3.50    0.67 ANCHOR Rigid
                                     Thermal movements : None


Number of points in the system : 51
```

```
-------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
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                      P I P E   D A T A   L I S T I N G

Pipe ID/      Nom/  O.D.  -----Thickness(inch)-----  Spec   Weight(lb/ft )
Material      Sch   inch  W.Th. Corr Mill Insu Ling  Grav  Pipe  Other Total
------------  ----  ----- ----- ---- ---- ---- ----  ----  ----- ----- -----
4PIPE            4  4.500 0.237 0.06 0.03    0    0  1.20  11.04     0 17.66
AU             STD

3.5PIPE      3.500  4.000 0.226 0.06 0.03    0    0     0   9.32     0  9.32
AU             STD

3PIPE        3.000  3.500 0.216 0.06 0.03    0    0  1.20   7.75     0 11.60
AU             STD
```

```
-------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
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-------------------------------------------------------------------------------


                M A T E R I A L   D A T A   L I S T I N G

 Material             Density  Pois. Temper. Modulus  Expans.   Allow.
   Name      Pipe ID  lb/cu.ft Ratio deg F   E6 psi   in/100ft  psi
------------ -------- -------- ----- ------- -------- --------  --------
AU           4PIPE       501.0  0.30    40.0    28.42            16700.0
                                        70.0             0.3088  16700.0

AU           3PIPE       501.0  0.30    40.0    28.42            16700.0
                                        70.0             0.3088  16700.0

AU           3.5PIPE     501.0  0.30    40.0    28.42            16700.0
                                        70.0             0.3088  16700.0
```

```
                            FRAME POINT DATA LISTING

POINT   ---COORDINATE(ft  )---   DATA
NAME      X       Y       Z      TYPE   DESCRIPTION
-----  ------- ------- -------  ------  -------------------------------------------
A15      13.19   -2.53    0.42
1        13.19   -2.84   -0.68  Y-STOP  ID : 1      1, Connected to Ground
                                        Gap-Below = 0.00, Above = 1.00 inch
                                        Friction = 0.00
                                        Gaps set Weightless
B02      13.19   -2.84   -1.78
5        13.19    3.50   -1.78  ANCHOR  Translational stiffness lb/in
                                        X= FREE       Y= FREE       Z= FREE
                                        Rotational stiffness ft-lb/deg
                                        X= RIGID      Y= RIGID      Z= RIGID
                                        Thermal movements : None
4        13.19    3.50   -0.68
3        13.19    3.50    0.42
6        13.19   -2.04   -0.68  WEIGHT  1000 lb      ,  No offsets
2        13.19   -2.84    0.42
7        13.19    2.08   -0.68  WEIGHT  2250 lb      ,  Offsets in ft
                                        DX = 0.00, DY = 0.00, DZ = 0.03
```

```
                               BEAM DATA LISTING

BEAM             POINT   LENGTH   SECTION ID/          BETA     RIGID      RELEASE
 ID              NAME    (ft  )   MATERIAL ID          ANGLE    END(ft)  Ax  Y-Y Z-Z
----             -----   ------   ---------------      ------   ------   --- --- ---
M2        From   2         1.10   W4X13                 0.00     0.00     N   N   N
          To     1                A36                            0.00     N   N   N

M9        From   2         0.31   W4X13                 0.00     0.00     N   N   N
          To     A15              A36                            0.00     N   N   N

M1        From   1         1.10   W4X13                 0.00     0.00     N   N   N
          To     B02              A36                            0.00     N   N   N

M6        From   5         6.34   W4X13                 0.00     0.00     N   N   N
          To     B02              A36                            0.00     N   N   N

M3        From   A15       6.03   W4X13                 0.00     0.00     N   N   N
          To     3                A36                            0.00     N   N   N

M4        From   3         1.10   W4X13                 0.00     0.00     N   N   N
          To     4                A36                            0.00     N   N   N

M5        From   4         1.10   W4X13                 0.00     0.00     N   N   N
          To     5                A36                            0.00     N   N   N

M7        From   1         0.80   XS12                  0.00     0.00     N   N   N
          To     6                A36                            0.00     N   N   N

M8        From   6         4.12   XS12                  0.00     0.00     N   N   N
          To     7                A36                            0.00     N   N   N

M10       From   4         1.42   XS12                  0.00     0.00     N   N   N
          To     7                A36                            0.00     N   N   N
```

```
------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
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------------------------------------------------------------------------------


                      CROSS SECTION LISTING

Section ID                   Area(sq.in  )           Inertia (in**4  )
ID                     Axial   Y-Shear  Z-Shear   Torsion   Y-Y Bend  Z-Z Bend
----------------      -------  -------  -------  ---------  --------  --------
W4X13                   3.83     1.16     1.86       0.2       3.9      11.3
XS12                   19.20     9.60     9.60     724.0     362.0     362.0
```

```
------------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                   ICF KAISER HANFORD CO
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------------------------------------------------------------------------------------


                           BEAM MATERIAL LISTING

                  Elastic               Yield                              Ultimate
                  modulus   Poissons    Stress    Density    Expansion     stress
MATERIAL ID       E6 psi     ratio      psi       lb/cu.ft   E-6 /F        psi
----------------  --------  --------   --------  ----------  ----------   ---------
A36                 29.000     0.250      36000      490.00     6.50000       58000
```

```
                          TEMPERATURE AND PRESSURE DATA
      -----C A S E  1------  -----C A S E  2------  -----C A S E  3------
POINT PRESS. TEMPER  EXPAN.   PRESS. TEMPER  EXPAN.   PRESS. TEMPER  EXPAN.
NAME  psi    deg F  in/100ft  psi    deg F  in/100ft  psi    deg F  in/100ft
----- ------ ------ --------  ------ ------ --------  ------ ------ --------

*** SEGMENT A
A00        490  70.00    0.309
A14 F      490  70.00    0.309
A15        490  70.00    0.309

*** SEGMENT B
B02        490  70.00    0.309
B03 F      490  70.00    0.309
B07        490  70.00    0.309

*** SEGMENT C
5          490  70.00    0.309
C01        490  70.00    0.309

*** SEGMENT D
3          490  70.00    0.309
D01        490  70.00    0.309
```

```
                   A N A L Y S I S   S U M M A R Y

 Current model revision number : 3

   Static - Date and Time of analysis ............. Jun 28, 1996   11:05 AM
            Model Revision Number ................. 3
            Number of load cases .................. 3
            Load cases analyzed ................... GR T1 P1
            Gaps/Friction/Yielding considered ..... No
            Hanger design run ..................... No
            Cut short included .................... No
            Weight of contents included ........... Yes
            Pressure stiffening case .............. 0
            Water elevation for buoyancy loads .... Not considered
```

```
--------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
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--------------------------------------------------------------------------------


                      CODE COMPLIANCE COMBINATIONS

   Combination  Category   Method    Load      Factor Allowable  Remarks
   -----------  ---------  -------  ---------  ------ ---------  -------
   GR + Max P   Sustain    Sum      Gravity     1.00  Automatic  Default
                                    Max Long    1.00

   Cold to T1   Expansion  Sum      Thermal 1   1.00  Automatic  Default

   Max P        Hoop                Max Hoop    1.00  Automatic  Default



                 OTHER USER COMBINATIONS

   Combination  Method    Load       Factor  Remarks
   -----------  -------  ---------   ------  -------
   GR           Sum      Gravity      1.00   Default

   T1           Sum      Thermal 1    1.00   Default

   P1           Sum      Press 1      1.00   Default


  CODE COMPLIANCE

  Y - Factor ............................ 0.40
  Weld efficiency factor ................ 1.00
  Range reduction factor ................ 1.00
  Design Pressure Factor ................ 1.00
  Minimum stress ratio used in reports... 0.00
  Include corrosion in stress calcs. .... Y
  Include torsion in code stress ........ N
  Include axial force in code stress .... N
  Longitudinal pressure calculation ..... PD/4t
  Include rigorous pressure ............. Y
```

```
--------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A              ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                    AutoPIPE+4.60 RESULT PAGE   3
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                       D I S P L A C E M E N T S

Point      Load         TRANSLATIONS (in  )          ROTATIONS (deg  )
name    combination      X       Y       Z          X       Y       Z
------  -----------    ------  ------  ------     ------  ------  ------

*** Segment A  begin ***

A00        GR           0.000   0.000   0.000      0.000   0.000   0.000
           T1           0.000   0.000   0.000      0.000   0.000   0.000
           P1           0.000   0.000   0.000      0.000   0.000   0.000

A01        GR           0.000   0.000   0.000      0.000   0.000  -0.002
           T1           0.001   0.000   0.000      0.000   0.000   0.000
           P1           0.000   0.000   0.000      0.000   0.000   0.000

A02        GR           0.000   0.000   0.000      0.153  -0.015  -0.124
           T1           0.001   0.000   0.000      0.012   0.000  -0.015
           P1           0.000   0.000   0.000      0.001   0.000  -0.002

A03 N      GR           0.000   0.000   0.000      0.153  -0.015  -0.124
           T1           0.001   0.000   0.000      0.012   0.000  -0.015
           P1           0.000   0.000   0.000      0.001   0.000  -0.002

A03 M      GR          -0.002  -0.003  -0.002      0.151  -0.015  -0.128
           T1           0.001  -0.001  -0.001      0.011   0.000  -0.016
           P1           0.000   0.000   0.000      0.001   0.000  -0.002

A03 F      GR          -0.009  -0.004  -0.010      0.154  -0.014  -0.132
           T1           0.000  -0.002  -0.002      0.010  -0.001  -0.017
           P1           0.000   0.000   0.000      0.001   0.000  -0.002

A04 N      GR          -0.027  -0.004  -0.031      0.156  -0.015  -0.134
           T1          -0.002  -0.004  -0.003      0.010  -0.001  -0.017
           P1           0.000   0.000   0.000      0.001   0.000  -0.002

A04 M      GR          -0.037  -0.008  -0.042      0.159  -0.014  -0.142
           T1          -0.003  -0.005  -0.004      0.009  -0.002  -0.013
           P1           0.000  -0.001   0.000      0.001   0.000  -0.001

A04 F      GR          -0.041  -0.019  -0.046      0.161  -0.014  -0.147
           T1          -0.002  -0.006  -0.004      0.008  -0.003  -0.007
           P1           0.000  -0.001   0.000      0.001   0.000  -0.001

A05 N      GR          -0.041  -0.139  -0.032      0.175  -0.013  -0.093
           T1           0.012  -0.009   0.001      0.005  -0.008   0.001
           P1           0.001  -0.001   0.000      0.000  -0.001   0.000

A05 M      GR          -0.042  -0.150  -0.032      0.165  -0.011  -0.052
           T1           0.013  -0.009   0.002      0.004  -0.012   0.003
           P1           0.001  -0.001   0.000      0.000  -0.001   0.000
```

```
--------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                      AutoPIPE+4.60 RESULT PAGE   4
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                         D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name      combination    X       Y       Z            X       Y       Z
------    -----------  ------  ------  ------       ------  ------  ------
A05 F     GR           -0.042  -0.163  -0.031        0.155  -0.010  -0.033
          T1            0.012  -0.009   0.004        0.003  -0.014   0.004
          P1            0.001  -0.001   0.000        0.000  -0.001   0.000

A06 N     GR           -0.045  -0.196  -0.031        0.154  -0.011  -0.001
          T1            0.009  -0.010   0.007        0.002  -0.014   0.005
          P1            0.001  -0.001   0.001        0.000  -0.001   0.001

A06 M     GR           -0.046  -0.206  -0.031        0.137  -0.016   0.020
          T1            0.009  -0.010   0.008        0.002  -0.009   0.006
          P1            0.001  -0.001   0.001        0.000  -0.001   0.001

A06 F     GR           -0.046  -0.207  -0.029        0.122  -0.023   0.068
          T1            0.010  -0.009   0.009        0.001  -0.004   0.008
          P1            0.001  -0.001   0.001        0.000   0.000   0.001

A07       GR           -0.046  -0.187  -0.024        0.117  -0.026   0.098
          T1            0.013  -0.007   0.010        0.001  -0.001   0.009
          P1            0.001  -0.001   0.001        0.000   0.000   0.001

A08       GR           -0.046  -0.166  -0.018        0.113  -0.028   0.124
          T1            0.016  -0.006   0.010        0.001   0.001   0.009
          P1            0.002  -0.001   0.001        0.000   0.000   0.001

A09       GR           -0.046  -0.140  -0.013        0.109  -0.030   0.147
          T1            0.019  -0.004   0.009        0.001   0.003   0.009
          P1            0.002   0.000   0.001        0.000   0.000   0.001

A10       GR           -0.046  -0.044   0.005        0.097  -0.034   0.186
          T1            0.027   0.001   0.007        0.002   0.007   0.008
          P1            0.003   0.000   0.001        0.000   0.001   0.001

A11 N     GR           -0.046  -0.017   0.010        0.094  -0.035   0.186
          T1            0.029   0.003   0.006        0.002   0.007   0.008
          P1            0.003   0.000   0.001        0.000   0.001   0.001

A11 M     GR           -0.042  -0.008   0.010        0.091  -0.038   0.176
          T1            0.030   0.003   0.005        0.002   0.009   0.006
          P1            0.003   0.000   0.001        0.000   0.001   0.001

A11 F     GR           -0.034  -0.004   0.007        0.085  -0.040   0.160
          T1            0.031   0.002   0.005        0.003   0.010   0.005
          P1            0.003   0.000   0.000        0.000   0.001   0.001

A12       GR           -0.032  -0.004   0.006        0.085  -0.040   0.160
          T1            0.031   0.002   0.005        0.003   0.010   0.005
          P1            0.003   0.000   0.000        0.000   0.001   0.001
```

```
--------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
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--------------------------------------------------------------------------------


                         D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name      combination    X       Y       Z            X       Y       Z
------    -----------  ------  ------  ------       ------  ------  ------
A13       GR           -0.031  -0.004   0.005        0.046  -0.096   0.058
          T1            0.031   0.002   0.005        0.002   0.084   0.003
          P1            0.003   0.000   0.000        0.000   0.009   0.000

A14 N     GR           -0.030  -0.004   0.004        0.045  -0.096   0.057
          T1            0.031   0.001   0.005        0.002   0.084   0.003
          P1            0.003   0.000   0.000        0.000   0.009   0.000

A14 M     GR           -0.023  -0.003   0.001        0.037  -0.092   0.041
          T1            0.028   0.000   0.004        0.001   0.084   0.004
          P1            0.003   0.000   0.000        0.000   0.009   0.000

A14 F     GR           -0.015  -0.001   0.000        0.018  -0.087   0.033
          T1            0.022   0.000   0.003        0.001   0.084   0.005
          P1            0.002   0.000   0.000        0.000   0.009   0.000

A14A      GR           -0.013   0.000   0.000        0.013  -0.086   0.028
          T1            0.019   0.000   0.003        0.001   0.084   0.005
          P1            0.002   0.000   0.000        0.000   0.009   0.001

A15       GR           -0.001   0.000   0.000        0.000  -0.084   0.008
          T1            0.008   0.000   0.001        0.000   0.081   0.008
          P1            0.001   0.000   0.000        0.000   0.008   0.001

*** Segment A  end   ***

*** Segment B  begin ***

B02       GR            0.000   0.000   0.000       -0.001   0.000   0.000
          T1            0.007   0.000   0.001        0.001   0.006   0.006
          P1            0.001   0.000   0.000        0.000   0.001   0.001

B03 N     GR            0.000   0.000   0.000       -0.001   0.000   0.000
          T1            0.005   0.000  -0.002        0.002   0.008   0.001
          P1            0.001   0.000   0.000        0.000   0.001   0.000

B03 M     GR            0.000   0.000   0.000       -0.001   0.000  -0.001
          T1            0.004   0.001  -0.003        0.003   0.011  -0.001
          P1            0.000   0.000   0.000        0.000   0.001   0.000

B03 F     GR            0.000   0.000   0.000       -0.001   0.000  -0.001
          T1            0.003   0.001  -0.002        0.003   0.013  -0.005
          P1            0.000   0.000   0.000        0.000   0.001  -0.001

B04 N     GR            0.000   0.000   0.000       -0.001   0.000  -0.001
          T1            0.001   0.001  -0.001        0.003   0.013  -0.005
          P1            0.000   0.000   0.000        0.000   0.001  -0.001
```

```
                         D I S P L A C E M E N T S

Point      Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name    combination      X       Y       Z          X       Y       Z
------  -----------    ------  ------  ------     ------  ------  ------
B04 M   GR              0.000   0.000   0.000     -0.001   0.000  -0.002
        T1              0.001   0.001   0.000      0.003   0.014  -0.005
        P1              0.000   0.000   0.000      0.000   0.001  -0.001

B04 F   GR              0.000   0.000   0.000      0.000   0.000  -0.001
        T1              0.000   0.001   0.000      0.002   0.014  -0.005
        P1              0.000   0.000   0.000      0.000   0.001  -0.001

B05     GR              0.000   0.000   0.000      0.000   0.000  -0.001
        T1              0.000   0.001   0.000      0.002   0.014  -0.004
        P1              0.000   0.000   0.000      0.000   0.001  -0.001

B06     GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.001   0.000      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

B07     GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000   0.000      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

*** Segment B  end    ***

*** Segment C  begin ***

5       GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000   0.001      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

C01     GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000   0.000      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

*** Segment C  end    ***

*** Segment D  begin ***

3       GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000  -0.001      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

D01     GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000   0.000      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

*** Segment D  end    ***

A15     GR             -0.001   0.000   0.000      0.000  -0.084   0.008
        T1              0.008   0.000   0.001      0.000   0.081   0.008
        P1              0.001   0.000   0.000      0.000   0.008   0.001
```

```
                         D I S P L A C E M E N T S

Point      Load          TRANSLATIONS (in  )          ROTATIONS (deg  )
name    combination      X       Y       Z          X       Y       Z
------  -----------    ------  ------  ------     ------  ------  ------
1       GR              0.000   0.000   0.000      0.000  -0.001   0.000
        T1              0.008   0.000   0.001      0.000   0.003   0.006
        P1              0.001   0.000   0.000      0.000   0.000   0.001

B02     GR              0.000   0.000   0.000     -0.001   0.000   0.000
        T1              0.007   0.000   0.001      0.001   0.006   0.006
        P1              0.001   0.000   0.000      0.000   0.001   0.001

5       GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000   0.001      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

4       GR              0.000   0.000   0.000      0.000  -0.001   0.000
        T1              0.000   0.000   0.000      0.000   0.002   0.006
        P1              0.000   0.000   0.000      0.000   0.000   0.001

3       GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000  -0.001      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000

6       GR              0.000   0.000   0.000      0.000  -0.001   0.000
        T1              0.007   0.000   0.001     -0.001   0.003   0.006
        P1              0.001   0.000   0.000      0.000   0.000   0.001

2       GR             -0.001   0.000   0.000     -0.001  -0.005   0.008
        T1              0.009   0.000   0.001      0.000   0.008   0.008
        P1              0.001   0.000   0.000      0.000   0.001   0.001

7       GR              0.000   0.000   0.000      0.000  -0.001   0.000
        T1              0.002   0.000   0.000     -0.001   0.002   0.006
        P1              0.000   0.000   0.000      0.000   0.000   0.001
```

```
                           S U P P O R T   F O R C E S

 Point/   Connect/   Load               L O C A L              G L O B A L
Supp. ID   Type    Combination  Dirn  Force    Deform     Dirn   Force   Deform
--------  -------- -----------  ----  -------- --------   ----  -------- --------

A14A                GR          down     1024   0.000      X               -0.013
A14A 1    Y - Stop                                         Y        -1024   0.000
Stiff    :RIGID                                            Z                0.000

                    T1          down        7   0.000      X                0.019
                                                           Y           -7   0.000
                                                           Z                0.003

                    P1          down        1   0.000      X                0.002
                                                           Y           -1   0.000
                                                           Z                0.000

1                   GR          down     3293   0.000      X                0.000
1     1   Y - Stop                                         Y        -3293   0.000
Stiff    :RIGID                                            Z                0.000

                    T1          down       11   0.000      X                0.008
                                                           Y          -11   0.000
                                                           Z                0.001

                    P1          down        1   0.000      X                0.001
                                                           Y           -1   0.000
                                                           Z                0.000
```

```
                         R E S T R A I N T   R E A C T I O N S

Point    Load            FORCES (lb    )                   MOMENTS (ft-lb  )
name   combination   X       Y       Z    Result     X       Y       Z    Result
------ -----------  ------ ------ ------ ------   ------- ------- ------- -------

A00      Anchor
         GR           57    -358      9     362     -28     -39    -186     193
         T1          -58       7     -6      59      -2       8     -16      18
         P1           -6       1     -1       6       0       1      -2       2

A14A     Y - Stop
         GR            0   -1024      0    1024       0       0       0       0
         T1            0      -7      0       7       0       0       0       0
         P1            0      -1      0       1       0       0       0       0

B07      Anchor
         GR            5    -167      2     167      -1       0      -4       4
         T1            2     -39    -21      44       0       4     -10      10
         P1            0      -5     -2       5       0       0      -1       1

5        Anchor
         GR            0       0      0       0      50       4       2      50
         T1            0       0      0       0      -1     -14      57      59
         P1            0       0      0       0       0      -1       6       6

C01      Anchor
         GR           22    -231     -6     232      29       3       0      29
         T1          -56      -3  -4864    4864       0      -7       0       7
         P1           -5       2   -435     435       0      -1       0       1

3        Anchor
         GR            0       0      0       0     -80      13    -134     156
         T1            0       0      0       0      -8     -33     150     153
         P1            0       0      0       0      -1      -3      15      16

D01      Anchor
         GR          -84     154     -5     175      19      10       0      22
         T1          112      52   4891    4892       7     -14       0      15
         P1           11       5    437     438       1      -1       0       2

1        Y - Stop
         GR            0   -3293      0    3293       0       0       0       0
         T1            0     -11      0      11       0       0       0       0
         P1            0      -1      0       1       0       0       0       0

5        Anchor
         GR            0       0      0       0      50       4       2      50
         T1            0       0      0       0      -1     -14      57      59
         P1            0       0      0       0       0      -1       6       6
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                 ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                       AutoPIPE+4.60 RESULT PAGE  10
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              G L O B A L   F O R C E S   &   M O M E N T S

Point     Load            FORCES (lb    )             MOMENTS (ft-lb  )
name   combination   X      Y      Z   Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------

*** Segment A  begin ***

A00     GR           -57    358     -9    362      28      39     186     193
        T1            58     -7      6     59       2      -8      16      18
        P1             6     -1      1      6       0      -1       2       2

A01     GR           -57    209     -9    217     -11      31     108     113
        T1            58     -7      6     59       3       0      18      18
        P1             6     -1      1      6       0       0       2       2

A02     GR           -57    209     -9    217     -16      29      97     103
        T1            58     -7      6     59       3       1      18      18
        P1             6     -1      1      6       0       0       2       2

A03 N   GR           -57    209     -9    217     -17      29      97     102
        T1            58     -7      6     59       3       1      18      18
        P1             6     -1      1      6       0       0       2       2

A03 M   GR           -57    205     -9    212     -39      21      58      74
        T1            58     -7      6     59       5       9      14      17
        P1             6     -1      1      6       0       1       1       2

A03 F   GR           -57    200     -9    208     -50      18      54      76
        T1            58     -7      6     59       6      12       1      13
        P1             6     -1      1      6       1       1       0       1

A04 N   GR           -57    188     -9    197     -56      18      91     109
        T1            58     -7      6     59      11      12     -37      40
        P1             6     -1      1      6       1       1      -4       4

A04 M   GR           -57    181     -9    190     -60      17      84     105
        T1            58     -7      6     59      13      13     -57      59
        P1             6     -1      1      6       1       1      -6       6

A04 F   GR           -57    174     -9    184     -61      14      30      69
        T1            58     -7      6     59      14      15     -63      66
        P1             6     -1      1      6       1       2      -7       7

A05 N   GR           -57     96     -9    112     -61     -27    -573     577
        T1            58     -7      6     59      14      44     -30      55
        P1             6     -1      1      6       1       5      -3       6

A05 M   GR           -57     89     -9    106     -48     -22    -605     608
        T1            58     -7      6     59      13      38     -27      48
        P1             6     -1      1      6       1       4      -3       5
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                 ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                       AutoPIPE+4.60 RESULT PAGE  11
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              G L O B A L   F O R C E S   &   M O M E N T S

Point     Load            FORCES (lb    )             MOMENTS (ft-lb  )
name   combination   X      Y      Z   Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A05 F   GR           -57     82     -9    100     -17      -3    -618     618
        T1            58     -7      6     59      10      18     -26      33
        P1             6     -1      1      6       1       2      -3       3

A06 N   GR           -57     64     -9     86      56      54    -618     623
        T1            58     -7      6     59       3     -40     -26      48
        P1             6     -1      1      6       0      -4      -3       5

A06 M   GR           -57     57     -9     81      77      72    -627     636
        T1            58     -7      6     59       0     -59     -25      64
        P1             6     -1      1      6       0      -6      -3       7

A06 F   GR           -57     50     -9     76      85      77    -646     656
        T1            58     -7      6     59      -1     -66     -22      69
        P1             6     -1      1      6       0      -7      -2       7

A07  -  GR           -57     30     -9     65      85      67    -691     700
        T1            58     -7      6     59      -1     -58     -14      60
        P1             6     -1      1      6       0      -6      -1       6

A07  +  GR           -57      7     -9     58      85      67    -691     700
        T1            58     -7      6     59      -1     -58     -14      60
        P1             6     -1      1      6       0      -6      -1       6

A08  -  GR           -57     -9     -9     58      85      59    -691     698
        T1            58     -7      6     59      -1     -52      -7      53
        P1             6     -1      1      6       0      -5      -1       5

A08  +  GR           -57   -114     -9    128      85      59    -691     698
        T1            58     -7      6     59      -1     -52      -7      53
        P1             6     -1      1      6       0      -5      -1       5

A09  -  GR           -57   -130     -9    142      85      50    -578     587
        T1            58     -7      6     59      -1     -46       0      46
        P1             6     -1      1      6       0      -5       0       5

A09  +  GR           -57   -147     -9    158      85      50    -578     587
        T1            58     -7      6     59      -1     -46       0      46
        P1             6     -1      1      6       0      -5       0       5

A10  -  GR           -57   -194     -9    202      85      26    -124     153
        T1            58     -7      6     59      -1     -29      19      35
        P1             6     -1      1      6       0      -3       2       4

A10  +  GR           -57   -291     -9    297      85      26    -124     153
        T1            58     -7      6     59      -1     -29      19      35
        P1             6     -1      1      6       0      -3       2       4
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                   ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                        AutoPIPE+4.60 RESULT PAGE  12
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              G L O B A L   F O R C E S   &   M O M E N T S

Point    Load            FORCES (lb     )              MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result     X       Y       Z     Result
------ --------- ------ ------ ------ ------ ------- ------- ------- -------
A11 N   GR          -57   -304     -9    309      85      20      86     122
        T1           58     -7      6     59      -1     -25      25      35
        P1            6     -1      1      6       0      -3       3       4

A11 M   GR          -57   -308     -9    314      84      18     163     185
        T1           58     -7      6     59       0     -23      21      31
        P1            6     -1      1      6       0      -2       2       3

A11 F   GR          -57   -313     -9    318      82      17     207     223
        T1           58     -7      6     59       1     -22       8      24
        P1            6     -1      1      6       0      -2       1       2

A12     GR          -57   -458     -9    462      82      17     211     227
        T1           58     -7      6     59       2     -22       4      23
        P1            6     -1      1      6       0      -2       0       2

A13     GR          -57   -458     -9    462      81      17     213     229
        T1           58     -7      6     59       2     -22       1      23
        P1            6     -1      1      6       0      -2       0       2

A14 N   GR          -57   -460     -9    463      80      17     219     234
        T1           58     -7      6     59       3     -22      -4      23
        P1            6     -1      1      6       0      -2       0       2

A14 M   GR          -57   -467     -9    470     145       9     239     279
        T1           58     -7      6     59       6     -14     -25      29
        P1            6     -1      1      6       1      -1      -3       3

A14 F   GR          -57   -474     -9    477     310     -12     247     397
        T1           58     -7      6     59      10       7     -33      35
        P1            6     -1      1      6       1       1      -3       4

A14A -  GR          -57   -476     -9    479     386     -21     247     459
        T1           58     -7      6     59      11      16     -33      38
        P1            6     -1      1      6       1       2      -3       4

A14A +  GR          -57    549     -9    552     386     -21     247     459
        T1           58      0      6     58      11      16     -33      38
        P1            6      0      1      6       1       2      -3       4

A15     GR          -57    541     -9    544      37     -57     247     256
        T1           58      0      6     58      11      53     -33      63
        P1            6      0      1      6       1       6      -3       7

*** Segment A  end   ***

*** Segment B  begin ***
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                   ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                        AutoPIPE+4.60 RESULT PAGE  13
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              G L O B A L   F O R C E S   &   M O M E N T S

Point    Load            FORCES (lb     )              MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result     X       Y       Z     Result
------ --------- ------ ------ ------ ------ ------- ------- ------- -------
B02     GR            5     19      2     20      13      -5       4      15
        T1            2    -39    -21     44     -38     -25      43      62
        P1            0     -5     -2      5      -5      -2       5       7

B03 N   GR            5      8      2     10       1       0       4       4
        T1            2    -39    -21     44      -1     -23      43      49
        P1            0     -5     -2      5       0      -2       5       6

B03 M   GR            5      5      2      7      -1       1       5       5
        T1            2    -39    -21     44       9     -21      38      44
        P1            0     -5     -2      5       1      -2       5       5

B03 F   GR            5      2      2      5      -2       1       5       6
        T1            2    -39    -21     44      13     -15      28      34
        P1            0     -5     -2      5       1      -1       3       4

B04 N   GR            5     -9      2     10      -2       0       3       4
        T1            2    -39    -21     44      13      -3       5      14
        P1            0     -5     -2      5       1       0       0       2

B04 M   GR            5    -13      2     14      -1       0       0       1
        T1            2    -39    -21     44      11       2      -5      12
        P1            0     -5     -2      5       1       0      -1       2

B04 F   GR            5    -18      2     19      -1       0      -2       3
        T1            2    -39    -21     44       6       4      -9      12
        P1            0     -5     -2      5       1       0      -1       2

B05     GR            5   -163      2    163      -1       0      -3       3
        T1            2    -39    -21     44       5       4      -9      11
        P1            0     -5     -2      5       1       0      -1       2

B06     GR            5   -163      2    163      -1       0      -3       3
        T1            2    -39    -21     44       4       4      -9      11
        P1            0     -5     -2      5       1       0      -1       2

B07     GR            5   -167      2    167      -1       0      -4       4
        T1            2    -39    -21     44       0       4     -10      10
        P1            0     -5     -2      5       0       0      -1       1

*** Segment B  end   ***

*** Segment C  begin ***

5       GR           22   -229     -6    230     -29      -3       0      29
        T1          -56     -3  -4864   4864       0       7       0       7
        P1           -5      2   -435    435       0       1       0       1
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                    ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                          AutoPIPE+4.60 RESULT PAGE  14
--------------------------------------------------------------------------------


                 G L O B A L   F O R C E S   &   M O M E N T S

Point      Load             FORCES (lb      )             MOMENTS (ft-lb  )
name    combination    X      Y      Z   Result     X       Y       Z    Result
------  ----------- ------ ------ ------ ------ ------- ------- ------- -------
C01       GR           22   -231     -6    232      29       3       0      29
          T1          -56     -3  -4864   4864       0      -7       0       7
          P1           -5      2   -435    435       0      -1       0       1

*** Segment C  end   ***

*** Segment D  begin ***

3         GR          -84    156     -5    177     -19     -10       0      22
          T1          112     52   4891   4892      -7      14       0      15
          P1           11      5    437    438      -1       1       0       2

D01       GR          -84    154     -5    175      19      10       0      22
          T1          112     52   4891   4892       7     -14       0      15
          P1           11      5    437    438       1      -1       0       2

*** Segment D  end   ***
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                    ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                          AutoPIPE+4.60 RESULT PAGE  15
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                       ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )                  (Stress in psi     )
Point     Load       In-Pl. Out-Pl. Torsion   S.I.F     Eq.  Load   Code   Code
name   combination   Moment  Moment  Moment  In   Out   no.  type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----  ------ ------

*** Segment A  begin ***

A00     Max P                                          (3a) HOOP    7304  16700
        GR + Max P     181      38           1.00 1.00 (18) SUST    4000  16700
        Cold to T1      15       8         5 1.00 1.00 (17) DISP      68  25050

A01     Max P                                          (3a) HOOP    7304  16700
        GR + Max P      94      31           1.00 1.00 (18) SUST    3586  16700
        Cold to T1      17       0         5 1.00 1.00 (17) DISP      67  25050

A02     Max P                                          (3a) HOOP    7304  16700
        GR + Max P      81      29           1.00 1.00 (18) SUST    3527  16700
        Cold to T1      17       1         5 1.00 1.00 (17) DISP      68  25050

A03 N-  Max P                                          (3a) HOOP    7304  16700
        GR + Max P      81      29           1.00 1.00 (18) SUST    3525  16700
        Cold to T1      17       1         5 1.00 1.00 (17) DISP      68  25050

A03 N+  Max P                                          (3a) HOOP    7304  16700
        GR + Max P      81      29           2.56 2.13 (18) SUST    4148  16700
        Cold to T1      17       1         5 2.56 2.13 (17) DISP     168  25050

A03 M   Max P                                          (3a) HOOP    7304  16700
        GR + Max P      36      28           2.56 2.13 (18) SUST    3639  16700
        Cold to T1      14       5         8 2.56 2.13 (17) DISP     145  25050

A03 F-  Max P                                          (3a) HOOP    7304  16700
        GR + Max P      26      69           2.56 2.13 (18) SUST    3887  16700
        Cold to T1       4       5        12 2.56 2.13 (17) DISP      70  25050

A03 F+  Max P                                          (3a) HOOP    7304  16700
        GR + Max P      50      54           1.00 1.00 (18) SUST    3467  16700
        Cold to T1       6       1        12 1.00 1.00 (17) DISP      50  25050

A04 N-  Max P                                          (3a) HOOP    7304  16700
        GR + Max P      55      87           1.00 1.00 (18) SUST    3610  16700
        Cold to T1      11      37        12 1.00 1.00 (17) DISP     151  25050

A04 N+  Max P                                          (3a) HOOP    7304  16700
        GR + Max P      87      55           1.95 1.63 (18) SUST    4039  16700
        Cold to T1      37      11        12 1.95 1.63 (17) DISP     283  25050

A04 M   Max P                                          (3a) HOOP    7304  16700
        GR + Max P      78      28           1.95 1.63 (18) SUST    3880  16700
        Cold to T1      57      18         0 1.95 1.63 (17) DISP     427  25050
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MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                  ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  16
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                   ASME B31.3c (1992)  CODE COMPLIANCE
                     (Moments in ft-lb  )                (Stress in psi     )
Point     Load      In-Pl. Out-Pl. Torsion   S.I.F    Eq. Load   Code   Code
name   combination Moment   Moment  Moment  In  Out   no. type Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ---- ------ ------
A04 F- Max P                                         (3a) HOOP   7304  16700
       GR + Max P       23      15         1.95 1.63 (18) SUST   3360  16700
       Cold to T1       63      15      14 1.95 1.63 (17) DISP    468  25050

A04 F+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P       23      15         1.00 1.00 (18) SUST   3245  16700
       Cold to T1       63      15      14 1.00 1.00 (17) DISP    246  25050

A05 N- Max P                                         (3a) HOOP   7304  16700
       GR + Max P      576      22         1.00 1.00 (18) SUST   5878  16700
       Cold to T1       30      44      14 1.00 1.00 (17) DISP    204  25050

A05 N+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P       22     576         1.95 1.63 (18) SUST   7614  16700
       Cold to T1       44      30      14 1.95 1.63 (17) DISP    370  25050

A05 M  Max P                                         (3a) HOOP   7304  16700
       GR + Max P       18     397         1.95 1.63 (18) SUST   6221  16700
       Cold to T1       38      28      10 1.95 1.63 (17) DISP    325  25050

A05 F- Max P                                         (3a) HOOP   7304  16700
       GR + Max P        1      16         1.95 1.63 (18) SUST   3242  16700
       Cold to T1       18      10      26 1.95 1.63 (17) DISP    175  25050

A05 F+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P       16       1         1.00 1.00 (18) SUST   3193  16700
       Cold to T1       10      18      26 1.00 1.00 (17) DISP    124  25050

A06 N- Max P                                         (3a) HOOP   7304  16700
       GR + Max P       56      49         1.00 1.00 (18) SUST   3472  16700
       Cold to T1        3      40      26 1.00 1.00 (17) DISP    178  25050

A06 N+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P       49      56         1.95 1.63 (18) SUST   3750  16700
       Cold to T1       40       3      26 1.95 1.63 (17) DISP    307  25050

A06 M  Max P                                         (3a) HOOP   7304  16700
       GR + Max P       66     500         1.95 1.63 (18) SUST   7063  16700
       Cold to T1       59      18      17 1.95 1.63 (17) DISP    451  25050

A06 F- Max P                                         (3a) HOOP   7304  16700
       GR + Max P       70     648         1.95 1.63 (18) SUST   8216  16700
       Cold to T1       66      22       1 1.95 1.63 (17) DISP    497  25050

A06 F+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P      648      70         1.00 1.00 (18) SUST   6241  16700
       Cold to T1       22      66       1 1.00 1.00 (17) DISP    259  25050
```

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----------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                  ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                   AutoPIPE+4.60 RESULT PAGE  17
----------------------------------------------------------------------------


                   ASME B31.3c (1992)  CODE COMPLIANCE
                     (Moments in ft-lb  )                (Stress in psi     )
Point     Load      In-Pl. Out-Pl. Torsion   S.I.F    Eq. Load   Code   Code
name   combination Moment   Moment  Moment  In  Out   no. type Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ---- ------ ------
A07    Max P                                         (3a) HOOP   7304  16700
       GR + Max P      693      61         1.00 1.00 (18) SUST   6450  16700
       Cold to T1       14      58       1 1.00 1.00 (17) DISP    224  25050

A08    Max P                                         (3a) HOOP   7304  16700
       GR + Max P      691      53         1.00 1.00 (18) SUST   6440  16700
       Cold to T1        7      52       1 1.00 1.00 (17) DISP    197  25050

A09    Max P                                         (3a) HOOP   7304  16700
       GR + Max P      578      46         1.00 1.00 (18) SUST   5896  16700
       Cold to T1        0      46       1 1.00 1.00 (17) DISP    173  25050

A10    Max P                                         (3a) HOOP   7304  16700
       GR + Max P      122      23         1.00 1.00 (18) SUST   3710  16700
       Cold to T1       19      29       1 1.00 1.00 (17) DISP    131  25050

A11 N- Max P                                         (3a) HOOP   7304  16700
       GR + Max P       88      17         1.00 1.00 (18) SUST   3544  16700
       Cold to T1       25      25       1 1.00 1.00 (17) DISP    130  25050

A11 N+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P       88      17         2.56 2.13 (18) SUST   4211  16700
       Cold to T1       25      25       1 2.56 2.13 (17) DISP    305  25050

A11 M  Max P                                         (3a) HOOP   7304  16700
       GR + Max P      166      70         2.56 2.13 (18) SUST   5269  16700
       Cold to T1       21      16      16 2.56 2.13 (17) DISP    244  25050

A11 F- Max P                                         (3a) HOOP   7304  16700
       GR + Max P      208      82         2.56 2.13 (18) SUST   5801  16700
       Cold to T1        8       1      22 2.56 2.13 (17) DISP    112  25050

A11 F+ Max P                                         (3a) HOOP   7304  16700
       GR + Max P       82     208         1.00 1.00 (18) SUST   4187  16700
       Cold to T1        1       8      22 1.00 1.00 (17) DISP     89  25050

A12    Max P                                         (3a) HOOP   7304  16700
       GR + Max P       82     211         1.00 1.00 (18) SUST   4201  16700
       Cold to T1        2       4      22 1.00 1.00 (17) DISP     85  25050

A13    Max P                                         (3a) HOOP   7304  16700
       GR + Max P       81     213         1.00 1.00 (18) SUST   4209  16700
       Cold to T1        2       1      22 1.00 1.00 (17) DISP     84  25050

A14 N- Max P                                         (3a) HOOP   7304  16700
       GR + Max P       80     218         1.00 1.00 (18) SUST   4231  16700
       Cold to T1        3       4      22 1.00 1.00 (17) DISP     86  25050
```

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---------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                      AutoPIPE+4.60 RESULT PAGE  18
---------------------------------------------------------------------------------


                      ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )              (Stress  in psi      )
Point       Load      In-Pl. Out-Pl. Torsion   S.I.F     Eq. Load    Code    Code
name    combination   Moment  Moment  Moment  In  Out    no. type   Stress  Allow.
------  -----------  ------- ------- ------- ---- ----  ---- ----   ------  ------

A14 N+ Max P                                            (3a) HOOP     7304   16700
       GR + Max P        80     218          1.95 1.63  (18) SUST     4978   16700
       Cold to T1         3       4       22 1.95 1.63  (17) DISP       90   25050

A14 M  Max P                                            (3a) HOOP     7304   16700
       GR + Max P       146     162          1.95 1.63  (18) SUST     4975   16700
       Cold to T1         6       8       27 1.95 1.63  (17) DISP      121   25050

A14 F- Max P                                            (3a) HOOP     7304   16700
       GR + Max P       311      11          1.95 1.63  (18) SUST     6030   16700
       Cold to T1        10       7       33 1.95 1.63  (17) DISP      148   25050

A14 F+ Max P                                            (3a) HOOP     6451   16700
       GR + Max P       311      11          1.00 1.00  (18) SUST     5595   16700
       Cold to T1        10       7       33 1.00 1.00  (17) DISP      246   25050

A14A   Max P                                            (3a) HOOP     6451   16700
       GR + Max P       387      19          1.00 1.00  (18) SUST     6294   16700
       Cold to T1        11      16       33 1.00 1.00  (17) DISP      267   25050

A15    Max P                                            (3a) HOOP     6451   16700
       GR + Max P        38      51          1.00 1.00  (18) SUST     3334   16700
       Cold to T1        11      53       33 1.00 1.00  (17) DISP      442   25050

*** Segment A   end    ***

*** Segment B   begin ***

B02    Max P                                            (3a) HOOP     6451   16700
       GR + Max P         8       7          1.00 1.00  (18) SUST     2844   16700
       Cold to T1        38      25       43 1.00 1.00  (17) DISP      433   25050

B03 N- Max P                                            (3a) HOOP     6451   16700
       GR + Max P         0       2          1.00 1.00  (18) SUST     2765   16700
       Cold to T1         1      23       43 1.00 1.00  (17) DISP      338   25050

B03 N+ Max P                                            (3a) HOOP     6451   16700
       GR + Max P         2       0          1.78 1.48  (18) SUST     2779   16700
       Cold to T1        23       1       43 1.78 1.48  (17) DISP      414   25050

B03 M  Max P                                            (3a) HOOP     6451   16700
       GR + Max P         1       7          1.78 1.48  (18) SUST     2839   16700
       Cold to T1        21      21       33 1.78 1.48  (17) DISP      406   25050

B03 F- Max P                                            (3a) HOOP     6451   16700
       GR + Max P.        0       9          1.78 1.48  (18) SUST     2866   16700
       Cold to T1        15      28       13 1.78 1.48  (17) DISP      354   25050
```

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---------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                      AutoPIPE+4.60 RESULT PAGE  19
---------------------------------------------------------------------------------


                      ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )              (Stress  in psi      )
Point       Load      In-Pl. Out-Pl. Torsion   S.I.F     Eq. Load    Code    Code
name    combination   Moment  Moment  Moment  In  Out    no. type   Stress  Allow.
------  -----------  ------- ------- ------- ---- ----  ---- ----   ------  ------

B03 F+ Max P                                            (3a) HOOP     7304   16700
       GR + Max P         9       0          1.00 1.00  (18) SUST     3156   16700
       Cold to T1        28      15       13 1.00 1.00  (17) DISP      128   25050

B04 N- Max P                                            (3a) HOOP     7304   16700
       GR + Max P         4       0          1.00 1.00  (18) SUST     3132   16700
       Cold to T1         5       3       13 1.00 1.00  (17) DISP       53   25050

B04 N+ Max P                                            (3a) HOOP     7304   16700
       GR + Max P         4       0          2.56 2.13  (18) SUST     3159   16700
       Cold to T1         5       3       13 2.56 2.13  (17) DISP       70   25050

B04 M  Max P                                            (3a) HOOP     7304   16700
       GR + Max P         1       0          2.56 2.13  (18) SUST     3122   16700
       Cold to T1         5       6        9 2.56 2.13  (17) DISP       77   25050

B04 F- Max P                                            (3a) HOOP     7304   16700
       GR + Max P         4       0          2.56 2.13  (18) SUST     3159   16700
       Cold to T1         9       6        4 2.56 2.13  (17) DISP      101   25050

B04 F+ Max P                                            (3a) HOOP     7304   16700
       GR + Max P         0       4          1.00 1.00  (18) SUST     3131   16700
       Cold to T1         6       9        4 1.00 1.00  (17) DISP       44   25050

B05    Max P                                            (3a) HOOP     7304   16700
       GR + Max P         0       4          1.00 1.00  (18) SUST     3132   16700
       Cold to T1         5       9        4 1.00 1.00  (17) DISP       42   25050

B06    Max P                                            (3a) HOOP     7304   16700
       GR + Max P         0       4          1.00 1.00  (18) SUST     3133   16700
       Cold to T1         4       9        4 1.00 1.00  (17) DISP       41   25050

B07    Max P                                            (3a) HOOP     7304   16700
       GR + Max P         0       5          1.00 1.00  (18) SUST     3138   16700
       Cold to T1         0      10        4 1.00 1.00  (17) DISP       39   25050

*** Segment B   end    ***

*** Segment C   begin ***

5      Max P                                            (3a) HOOP     6905   16700
       GR + Max P        28       2          1.00 1.00  (18) SUST     2920   16700
       Cold to T1         0       7        0 1.00 1.00  (17) DISP       35   25050

C01    Max P                                            (3a) HOOP     6905   16700
       GR + Max P        29       2          1.00 1.00  (18) SUST     2921   16700
       Cold to T1         0       7        0 1.00 1.00  (17) DISP       35   25050

*** Segment C   end    ***
```

```
--------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                      AutoPIPE+4.60 RESULT PAGE  20
--------------------------------------------------------------------------------


                        ASME B31.3c (1992)  CODE COMPLIANCE
                          (Moments in ft-lb  )             (Stress in psi      )
Point      Load       In-Pl. Out-Pl. Torsion   S.I.F     Eq. Load   Code   Code
name   combination    Moment  Moment  Moment  In  Out    no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----  ------ ------

*** Segment D  begin ***

3       Max P                                          (3a) HOOP    6905  16700
        GR + Max P       20       9         1.00 1.00 (18) SUST    2876  16700
        Cold to T1        7      14       0 1.00 1.00 (17) DISP      78  25050

D01     Max P                                          (3a) HOOP    6905  16700
        GR + Max P       20       9         1.00 1.00 (18) SUST    2876  16700
        Cold to T1        7      14       0 1.00 1.00 (17) DISP      78  25050

*** Segment D  end   ***
```

```
--------------------------------------------------------------------------------
MA-C06AS  JUMPER ASSEMBLY C-06A-9-A                ICF KAISER HANFORD CO
06/28/96  HYDRO-TEST ANALYSIS                      AutoPIPE+4.60 RESULT PAGE  21
--------------------------------------------------------------------------------


                              S Y S T E M   S U M M A R Y
                              ---------------------------


Maximum displacements (in)
--------------------------

         Maximum X :     -0.046     Point : A06 F       Load Comb.: GR
         Maximum Y :     -0.207     Point : A06 F       Load Comb.: GR
         Maximum Z :     -0.046     Point : A04 F       Load Comb.: GR
         Max. total:      0.214     Point : A06 F       Load Comb.: GR

Maximum rotations (deg)
-----------------------

         Maximum X :      0.175     Point : A05 N       Load Comb.: GR
         Maximum Y :     -0.096     Point : A14 N       Load Comb.: GR
         Maximum Z :      0.186     Point : A11 N       Load Comb.: GR
         Max. total:      0.218     Point : A04 F       Load Comb.: GR


Maximum restraint forces(lb)
--------------------------

         Maximum X :        112     Point : D01         Load Comb.: T1
         Maximum Y :      -3293     Point : 1           Load Comb.: GR
         Maximum Z :       4891     Point : D01         Load Comb.: T1
         Max. total:       4892     Point : D01         Load Comb.: T1

Maximum restraint moments(ft-lb)
--------------------------------

         Maximum X :        -80     Point : 3           Load Comb.: GR
         Maximum Y :        -39     Point : A00         Load Comb.: GR
         Maximum Z :       -186     Point : A00         Load Comb.: GR
         Max. total:        193     Point : A00         Load Comb.: GR
```

```
                     S Y S T E M   S U M M A R Y
                     ---------------------------


Maximum pipe forces (lb)
------------------------

         Maximum X :       112     Point : 3          Load Comb.: T1
         Maximum Y :       549     Point : A14A       Load Comb.: GR
         Maximum Z :      4891     Point : 3          Load Comb.: T1
         Max. total:      4892     Point : 3          Load Comb.: T1

Maximum pipe moments (ft-lb)
----------------------------

         Maximum X :       386     Point : A14A       Load Comb.: GR
         Maximum Y :        77     Point : A06 F      Load Comb.: GR
         Maximum Z :      -691     Point : A07        Load Comb.: GR
         Max. total:       700     Point : A07        Load Comb.: GR
```

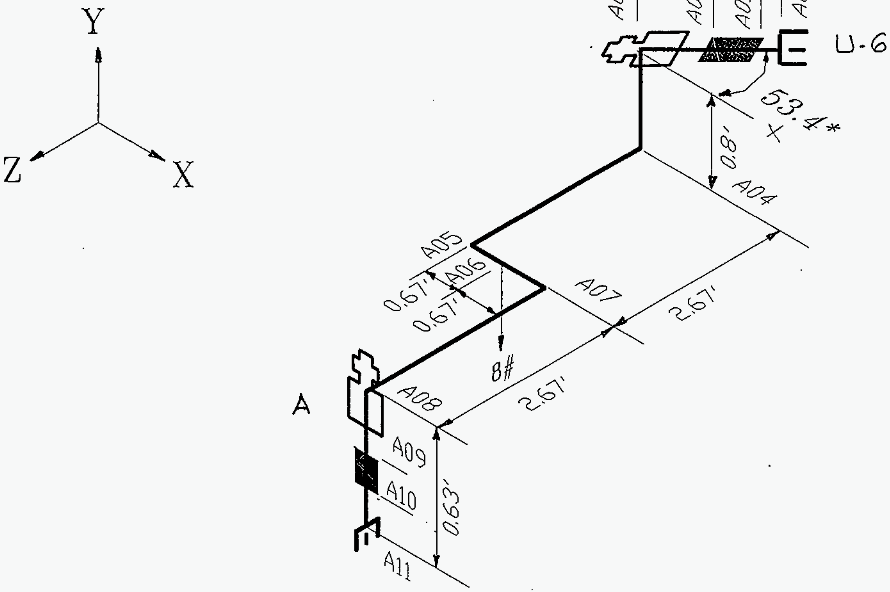
```
                     S Y S T E M   S U M M A R Y
                     ---------------------------


    Maximum sustained stress

                               Point            : A06 F
                               Stress     psi   : 8216
                               Allowable psi    : 16700
                               Ratio            : 0.49
                               Load combination : GR + Max P

    Maximum displacement stress

                               Point            : A06 F
                               Stress     psi   : 497
                               Allowable psi    : 25050
                               Ratio            : 0.02
                               Load combination : Cold to T1

    Maximum hoop stress

                               Point            : A00
                               Stress     psi   : 7304
                               Allowable psi    : 16700
                               Ratio            : 0.44
                               Load combination : Max P

    Maximum sustained stress ratio

                               Point            : A06 F
                               Stress     psi   : 8216
                               Allowable psi    : 16700
                               Ratio            : 0.49
                               Load combination : GR + Max P

    Maximum displacement stress ratio

                               Point            : A06 F
                               Stress     psi   : 497
                               Allowable psi    : 25050
                               Ratio            : 0.02
                               Load combination : Cold to T1

    Maximum hoop stress ratio

                               Point            : A00
                               Stress     psi   : 7304
                               Allowable psi    : 16700
                               Ratio            : 0.44
                               Load combination : Max P
```

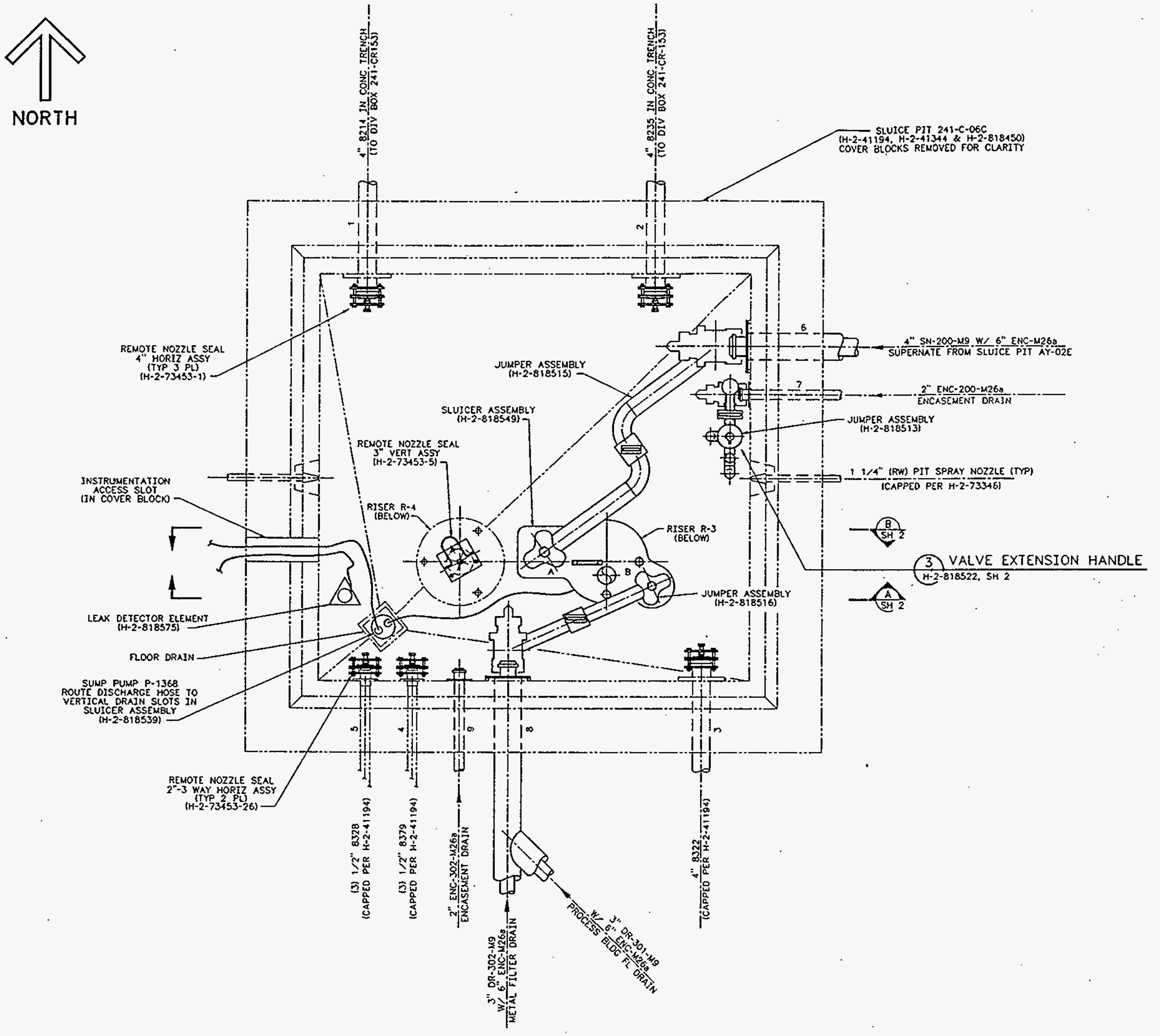
APPDX - C

JUMPER ASSEMBLY U6-A / SLUICE PIT C-06C

DRAWING: H-2-818515 FILE NAME: J6A-S AP FILE NAME: MA-J6A

PREPARED BY: M. M. AHMED





PLAN
SLUICE PIT
241-C-06C

NOTES:

1. FOR GENERAL NOTES, LEGEND AND KEY PLAN SEE H-2-818518.

EXPIRES 3-3-96

H-2-818423 SH 7	DRAWING LIST	

B818526A
2B:IBM:ACD2:12.0:NN
N

DESIGNER R W SCHROEDER
SEE DR/AT FORM
SEE DR/AT FORM
SEE DR/AT FORM
11
WHC

3
CONSTRUCTION

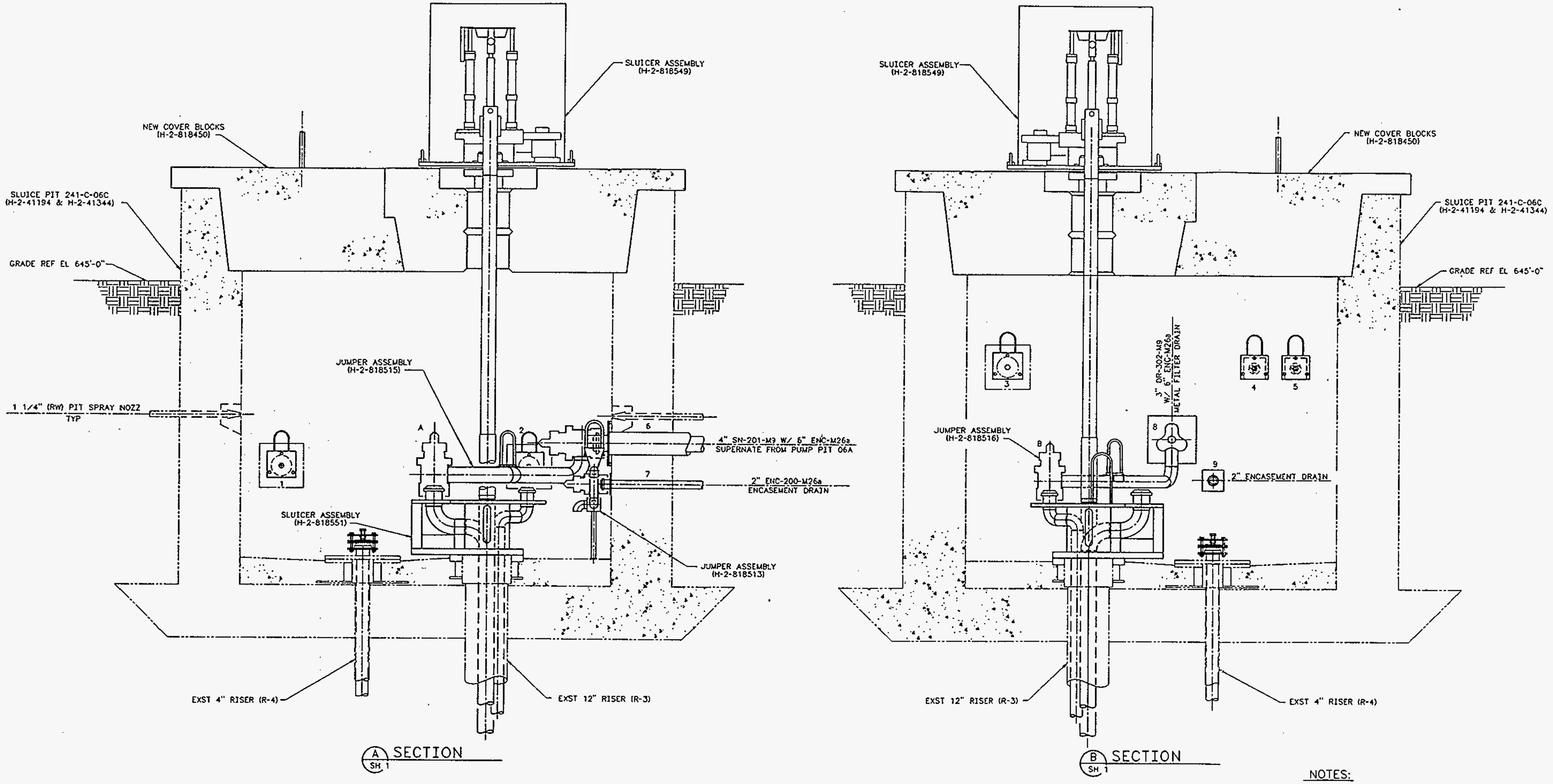
U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

PIPING
JUMPER ARRANGEMENT
SLUICE PIT 241-C-06C

W-320 TANK 241-C-106 SLUICING

F
241-C
8404
H-2-818526
0
1"=1'-0"
ER4319
1 of 2

PLOT SCALE: 1=12
KEHCAD



NOTES:

1. FOR NOTES, SEE SHEET 1.

CARROLL D. JONES
11633
EXPIRES 5-3-96

CONSTRUCTION

DESIGNED R W SCHROEDER
SAFETY CLASS 3
SAFETY SEE DR/AT FORM
SEE DR/AT FORM
SEE DR/AT FORM
REVIEW NO. 10

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

PIPING
JUMPER ARRANGEMENT
SLUICE PIT 241-C-06C

PROJECT W-320 TANK 241-C-106 SLUICING

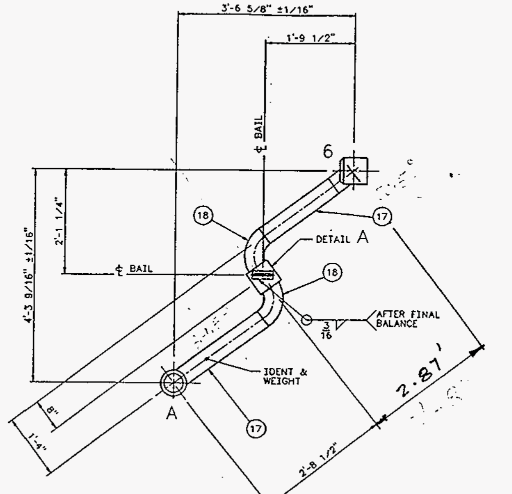
SIZE	BLDG NO.	INDEX NO.	DWG NO.	REV NO
F	241-C	8404	H-2-818526	0

SCALE 1"=1'-0" JOB NO. ER4319 SHEET 2 OF 2

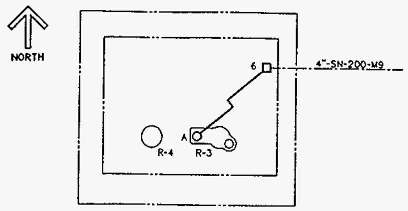
FOR WHC

CAD FILE B818526B
CAD CODE 2B:18M:ACD2:12.0:NN

2 PLOT SCALE: 1=12 KEHCAD 1

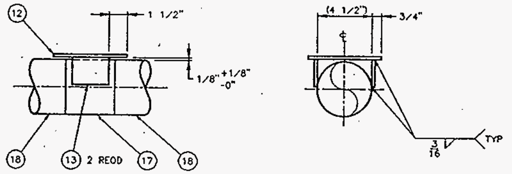


PLAN

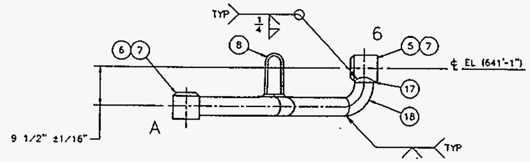


241-C-06C
SLUICE PIT
KEY PLAN
SCALE: NONE

PARTS/MATERIAL LIST					
QTY REQD	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
☒	-010	ASSEMBLY			1
					2
					3
					4
1	H-2-32440-1	CONN, HORIZ 4"			5
1	H-2-32440-2	CONN, VERT, 4"			6
2	H-2-3997-8	GASKET 4" TYPE III			7
1	H-2-90161-3	LIFTING BAIL			8
					9
					10
					11
1		PLATE 1/4" THK x 6" x 6"	ASTM A 36		12
2		BAR 1/4" THK x 2 1/4" x 3"	ASTM A 240 304L		13
					14
					15
					16
AR		PIPE, 4" SCHED 40S	ASTM A 312 GR TP 304L		17
3		ELBOW, 90° LR 4" SCHED 40S BW	ASTM A 403 WP-S 304L		18
					19
					20



DETAIL A
SCALE: 3"= 1'-0"



ELEVATION

① ASSEMBLY
SCALE: 1"= 1'-0"

NOTE:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH HANFORD SPECIFICATION HS-BS-0084 REV B.
2. HYDROSTATIC TEST AT 480 PSIG.
3. JUMPER WEIGHT IS 325 LB APPROX.
4. USE (1) COAT OF AMERLOCK 400 IN PLACE OF AMERCOAT 187 PRIMER AND AMERCOAT 33, WHERE REQUIRED BY JUMPER FABRICATION SPECIFICATION.

CARROLL D. JONES
11633
EXPIRES 5-3-96

H-2-818423 SH 7	DRAWING LIST
NUMBER	TITLE
REFERENCES	
NEXT USED ON H-2-818526	
CAD FILE B818515A	CAD CODE 2B:IBM:ACD2:12.0:NN

DESIGNED Ba MEYER sr
SAFETY SEE DR/AT FORM
DWSE SEE DR/AT FORM
QUAL ENGR SEE DR/AT FORM
REVIEW NO. 3
APPROVED FOR IMPLEMENTATION
FOR WHC
SAFETY CLASS 3
USE CONSTRUCTION

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY

JUMPER ASSEMBLY
SLUICE PIT
C-06C-6-A

PROJECT W-320 TANK 241-C-106 SLUICING
SIZE F | BLDG NO. 241-C | INDEX NO. 8405 | DWG NO. H-2-818515 | REV NO 0
SCALE SHOWN | JOB NO. ER4319 | SHEET 1 OF 1

2 PLOT SCALE: 1=12 | KEHCAD 1

```
------------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS     ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                         AutoPIPE+4.60 MODEL  PAGE   3
------------------------------------------------------------------------------


                    P O I N T   D A T A   L I S T I N G

POINT        -----OFFSETS (ft )-----
NAME  TYPE     X        Y       Z    PIPE ID  DESCRIPTION
----- ----  ------- ------- -------  -------  ---------------------------------
*** SEGMENT A
A00   Run        0        0       0  4PIPE
A01   Flex   -0.11        0    0.15           Wt= 144 lb , Ar= 3.2 sq.in
                                              Axial= 23300000 Tors=    304.0
                                              Y-Shear= RIGID    Bend=   2080.0
                                              Z-Shear= RIGID    Bend=   2080.0

A02   Run    -0.02        0    0.03
A03   Bend   -0.22        0    0.33           Short Elbow, Radius = 4.00 inch
                                              Bend angle change = 90.00 deg
                                              Mid point at 50.00 percent
                                              SIF - In 2.56, Out = 2.13
                                              Flex = 7.908

A04   Bend       0    -0.84       0           Long  Elbow, Radius = 6.00 inch
                                              Bend angle change = 90.00 deg
                                              Mid point at 50.00 percent
                                              SIF - In 1.95, Out = 1.63
                                              Flex = 5.272

A05   Bend       0        0    2.67           Long  Elbow, Radius = 6.00 inch
                                              Bend angle change = 90.00 deg
                                              Mid point at 50.00 percent
                                              SIF - In 1.95, Out = 1.63
                                              Flex = 5.272

A06   Run     0.67        0       0
A07   Bend    0.67        0       0           Long  Elbow, Radius = 6.00 inch
                                              Bend angle change = 90.00 deg
                                              Mid point at 50.00 percent
                                              SIF - In 1.95, Out = 1.63
                                              Flex = 5.272

A08   Bend       0        0    2.67           Short Elbow, Radius = 4.00 inch
                                              Bend angle change = 90.00 deg
                                              Mid point at 50.00 percent
                                              SIF - In 2.56, Out = 2.13
                                              Flex = 7.908

A09   Flex       0    -0.40       0           Wt= 144 lb , Ar= 3.2 sq.in
                                              Axial= 23300000 Tors=    304.0
                                              Y-Shear= RIGID    Bend=   2080.0
                                              Z-Shear= RIGID    Bend=   2080.0

A10   Run        0    -0.04       0
A11   Run        0    -0.19       0

 Total weight of empty pipes : 104 lb
```

```
------------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS     ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                         AutoPIPE+4.60 MODEL  PAGE   4
------------------------------------------------------------------------------


                C O M P O N E N T   D A T A   L I S T I N G

POINT   ---COORDINATE(ft  )---  DATA
NAME      X       Y       Z     TYPE  DESCRIPTION
----- ------- ------- ------- ------ -----------------------------------------
*** SEGMENT A
A00      0.00    0.00    0.00 ANCHOR Rigid
                                     Thermal movements : None
A01     -0.11    0.00    0.15
A02     -0.13    0.00    0.18
A03 N   -0.17    0.00    0.23
A03     -0.35    0.00    0.51 TI
A03 M   -0.30   -0.10    0.43
A03 F   -0.35   -0.33    0.51
A04 N   -0.35   -0.34    0.51
A04     -0.35   -0.84    0.51 TI
A04 M   -0.35   -0.69    0.66
A04 F   -0.35   -0.84    1.01
A05 N   -0.35   -0.84    2.68
A05     -0.35   -0.84    3.18 TI
A05 M   -0.21   -0.84    3.04
A05 F    0.15   -0.84    3.18
A06      0.32   -0.84    3.18 WEIGHT 8 lb    ,  No offsets
A07 N    0.49   -0.84    3.18
A07      0.99   -0.84    3.18 TI
A07 M    0.84   -0.84    3.33
A07 F    0.99   -0.84    3.68
A08 N    0.99   -0.84    5.52
A08      0.99   -0.84    5.85 TI
A08 M    0.99   -0.94    5.75
A08 F    0.99   -1.17    5.85
A09      0.99   -1.24    5.85
A10      0.99   -1.28    5.85
A11      0.99   -1.47    5.85 ANCHOR Rigid
                                     Thermal movements : None


Number of points in the system : 27
```

```
                   P I P E   D A T A   L I S T I N G

Pipe ID/     Nom/ O.D.  -----Thickness(inch)-----  Spec  Weight(lb/ft )
Material     Sch  inch  W.Th. Corr Mill Insu Ling  Grav  Pipe  Other Total
------------ ---- ----- ----- ---- ---- ---- ----  ----  ----- ----- -----
4PIPE           4 4.500 0.237 0.06 0.03    0    0  1.12  11.04     0 17.22
AU           STD
```

```
                 M A T E R I A L   D A T A   L I S T I N G

 Material                Density  Pois. Temper. Modulus  Expans.   Allow.
   Name      Pipe ID   lb/cu.ft Ratio deg F   E6 psi   in/100ft  psi
------------ -------- -------- ----- ------- --------- -------- --------
AU           4PIPE       501.0  0.30    40.0     28.42           16700.0
                                       180.0              1.5442 16700.0
```

```
---------------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS      ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                          AutoPIPE+4.60 MODEL  PAGE   7
---------------------------------------------------------------------------------


                         TEMPERATURE AND PRESSURE DATA
      -----C A S E   1------   -----C A S E   2------   -----C A S E   3------
POINT PRESS. TEMPER  EXPAN.    PRESS. TEMPER  EXPAN.    PRESS. TEMPER  EXPAN.
NAME  psi    deg F  in/100ft   psi    deg F  in/100ft   psi    deg F  in/100ft
----- ------ ------ --------   ------ ------ --------   ------ ------ --------

*** SEGMENT A
A00      325    180    1.544
A11      325    180    1.544
```

```
---------------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS      ICF KAISER HANFORD COMPANY
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---------------------------------------------------------------------------------


                         A N A L Y S I S   S U M M A R Y


   Current model revision number : 1

     Static - Date and Time of analysis ............. Sep 11, 1995   12:54 PM
              Model Revision Number ................. 1
              Number of load cases .................. 2
              Load cases analyzed ................... GR T1
              Gaps/Friction/Yielding considered ..... No
              Hanger design run ..................... No
              Cut short included .................... No
              Weight of contents included ........... Yes
              Pressure stiffening case .............. 0
              Water elevation for buoyancy loads .... Not considered

      Modal - Date and Time of analysis ............. Sep 11, 1995   12:54 PM
              Model Revision Number ................. 1
              Number of modes ....................... 1
              Cutoff frequency (Hz) ................. 33.0
              Weight of contents included ........... Yes
              Pressure stiffening case .............. 0
              Water elevation for buoyancy loads .... Not considered

   Response - Date and Time of analysis ............. Sep 11, 1995   12:55 PM
              Model Revision Number ................. 1
              Number of load cases .................. 3
              Load cases analyzed ................... R1 R2 R3
              Date and time of modal analysis ....... Sep 11, 1995   12:54 PM
              Number of modes ....................... 1
              Cutoff frequency (Hz) ................. 33.0
              Model revision of modal analysis ...... 1
              Weight of contents included ........... Yes
              Pressure stiffening case .............. 0
              Water elevation for buoyancy loads .... Not considered
```

```
                    CODE COMPLIANCE COMBINATIONS

   Combination  Category   Method     Load     Factor Allowable  Remarks
   -----------  ---------- --------  ---------- ------ ---------  -------
   GR + Max P   Sustain    Sum       Gravity     1.00 Automatic  Default
                                     Max Long    1.00

   Cold to T1   Expansion  Sum       Thermal 1   1.00 Automatic  Default

   Sus. + R1    Occasion   Abs sum   Response 1  1.00 Automatic  Default
                                     Max Sus     1.00

   Sus. + R2    Occasion   Abs sum   Response 2  1.00 Automatic  Default
                                     Max Sus     1.00

   Sus. + R3    Occasion   Abs sum   Response 3  1.00 Automatic  Default
                                     Max Sus     1.00

   Max P        Hoop                 Max Hoop    1.00 Automatic  Default



            OTHER USER COMBINATIONS

   Combination Method     Load     Factor  Remarks
   ----------- -------- ---------- ------  -------
   GR          Sum      Gravity     1.00   Default

   T1          Sum      Thermal 1   1.00   Default

   R1          Sum      Response 1  1.00   Default

   R2          Sum      Response 2  1.00   Default

   R3          Sum      Response 3  1.00   Default

   GR+T1       Sum      Gravity     1.00   User
                        Thermal 1   1.00

   SEIS        Abs sum  Response 1  1.00   User
                        Response 2  1.00
                        Response 3  1.00

   TOTAL       Abs sum  GR+T1       1.00   User
                        SEIS        1.00



  CODE COMPLIANCE

  Y - Factor ............................ 0.40
  Weld efficiency factor ................ 1.00
  Range reduction factor ................ 1.00
```

```
  Design Pressure Factor ................ 1.00
  Minimum stress ratio used in reports... 0.00
  Include corrosion in stress calcs. .... Y
  Include torsion in code stress ........ N
  Include axial force in code stress .... N
  Longitudinal pressure calculation ..... PD/4t
  Include rigorous pressure ............. Not analyzed
```

```
RESPONSE SPECTRUM LOAD CASES :
-----------------------------

Number of load cases analysed :  3

Load case 1  -  R1

Missing mass : No
ZPA          : No

Combination method : SRSS

X- Spectrum : SC1
Multiplier  :   1.00

SC1

Freq(Hz)  Grav(        )   Freq(Hz)  Grav(        )   Freq(Hz)  Grav(        )
--------  -------------    --------  -------------    --------  -------------
  0.100          0.01        0.160           0.03       0.250           0.06
  0.400          0.10        0.600           0.16       1.100           0.28
  1.640          0.42        8.000           0.42      12.000           0.34
 20.000          0.26       33.000           0.20     100.000           0.20
```

```
Load case 2  -  R2

Missing mass : No
ZPA          : No

Combination method : SRSS

Y- Spectrum : SC1
Multiplier  :   1.00

SC1

Freq(Hz)  Grav(        )   Freq(Hz)  Grav(        )   Freq(Hz)  Grav(        )
--------  -------------    --------  -------------    --------  -------------
  0.100          0.01        0.160           0.03       0.250           0.06
  0.400          0.10        0.600           0.16       1.100           0.28
  1.640          0.42        8.000           0.42      12.000           0.34
 20.000          0.26       33.000           0.20     100.000           0.20
```

```
    Load case 3  -  R3

    Missing mass : No
    ZPA          : No

    Combination method : SRSS

    Z- Spectrum : SC1
    Multiplier  :   1.00

    SC1

  Freq(Hz)  Grav(        )    Freq(Hz)  Grav(        )    Freq(Hz)  Grav(        )
  --------  ------------      --------  ------------      --------  ------------
    0.100          0.01         0.160          0.03         0.250          0.06
    0.400          0.10         0.600          0.16         1.100          0.28
    1.640          0.42         8.000          0.42        12.000          0.34
   20.000          0.26        33.000          0.20       100.000          0.20
```

```
                  F R E Q U E N C I E S

Mode      Frequency   Frequency    Period       Participation factors
Number   (Rads/sec)   (Hertz)      (Sec)        X         Y         Z
------   ----------   ---------    ------    --------  --------  --------

   1       207.2037     32.9775    0.030       0.497    -0.054     0.000
```

```
                         M O D E   S H A P E S

Point                                  TRANSLATIONS              ROTATIONS (deg     )
name    Mode  Frequency         X         Y         Z         X         Y         Z
------  ----  ---------   -------   -------   -------   -------   -------   -------

*** Segment A  begin ***

A00       1    32.9775     0.000     0.000     0.000     0.000     0.000     0.000

A01       1    32.9775     0.001    -0.001     0.001     0.030     0.040     0.030

A02       1    32.9775     0.009    -0.011     0.005     0.601     2.387     3.813

A03 N     1    32.9775     0.036    -0.046     0.023     0.610     2.399     3.823

A03 M     1    32.9775     0.224    -0.186     0.076     0.882     2.703     4.130

A03 F     1    32.9775     0.482    -0.250     0.059     1.009     2.796     4.305

A04 N     1    32.9775     0.488    -0.250     0.057     1.009     2.797     4.305

A04 M     1    32.9775     0.895    -0.281    -0.019     0.955     2.835     4.238

A04 F     1    32.9775     1.234    -0.344    -0.047     0.711     2.763     4.118

A05 N     1    32.9775     2.147    -0.555    -0.049     0.503     2.289     3.703

A05 M     1    32.9775     2.280    -0.475    -0.098     0.416     1.164     3.597

A05 F     1    32.9775     2.303    -0.233    -0.135     0.451    -0.177     3.259

A06       1    32.9775     2.303    -0.117    -0.127     0.433    -0.303     3.220

A07 N     1    32.9775     2.302    -0.003    -0.115     0.415    -0.437     3.178

A07 M     1    32.9775     2.253     0.202    -0.023     0.489    -2.227     2.738

A07 F     1    32.9775     2.015     0.245     0.065     0.533    -4.064     2.539

A08 N     1    32.9775     0.227     0.044     0.063     0.550    -4.927     1.838

A08 M     1    32.9775     0.013     0.014     0.050     0.668    -5.135     1.651

A08 F     1    32.9775    -0.022     0.000     0.014     0.689    -5.226     1.328

A09       1    32.9775    -0.004     0.000     0.004     0.686    -5.220     1.319

A10       1    32.9775     0.001     0.000     0.001     0.018    -0.016     0.011

A11       1    32.9775     0.000     0.000     0.000     0.000     0.000     0.000

*** Segment A  end   ***
```

```
                         D I S P L A C E M E N T S

Point     Load           TRANSLATIONS (in  )         ROTATIONS (deg  )
name    combination      X       Y       Z            X       Y       Z
------  -----------   ------  ------  ------       ------  ------  ------

*** Segment A  begin ***

A00     GR             0.000   0.000   0.000        0.000   0.000   0.000
        T1             0.000   0.000   0.000        0.000   0.000   0.000
        R1             0.000   0.000   0.000        0.000   0.000   0.000
        R2             0.000   0.000   0.000        0.000   0.000   0.000
        R3             0.000   0.000   0.000        0.000   0.000   0.000
        GR+T1          0.000   0.000   0.000        0.000   0.000   0.000
        SEIS           0.000   0.000   0.000        0.000   0.000   0.000
        TOTAL          0.000   0.000   0.000        0.000   0.000   0.000

A01     GR             0.000   0.000   0.000        0.000   0.000   0.000
        T1            -0.002   0.000   0.002        0.001  -0.003   0.000
        R1             0.000   0.000   0.000        0.000   0.000   0.000
        R2             0.000   0.000   0.000        0.000   0.000   0.000
        R3             0.000   0.000   0.000        0.000   0.000   0.000
        GR+T1         -0.002   0.000   0.002        0.001  -0.003   0.000
        SEIS           0.000   0.000   0.000        0.000   0.000   0.000
        TOTAL          0.002   0.000   0.002        0.001   0.003   0.000

A02     GR             0.000   0.000   0.000        0.011   0.001   0.004
        T1            -0.002   0.000   0.002        0.209  -0.128  -0.211
        R1             0.000   0.000   0.000        0.001   0.002   0.003
        R2             0.000   0.000   0.000        0.000   0.000   0.000
        R3             0.000   0.000   0.000        0.000   0.000   0.000
        GR+T1         -0.002   0.000   0.002        0.220  -0.127  -0.206
        SEIS           0.000   0.000   0.000        0.001   0.002   0.004
        TOTAL          0.002   0.000   0.002        0.221   0.129   0.210

A03 N   GR             0.000   0.000   0.000        0.011   0.001   0.004
        T1            -0.004  -0.001   0.002        0.210  -0.129  -0.211
        R1             0.000   0.000   0.000        0.001   0.002   0.003
        R2             0.000   0.000   0.000        0.000   0.000   0.000
        R3             0.000   0.000   0.000        0.000   0.000   0.000
        GR+T1         -0.004  -0.001   0.002        0.220  -0.127  -0.206
        SEIS           0.000   0.000   0.000        0.001   0.002   0.004
        TOTAL          0.004   0.001   0.002        0.221   0.130   0.210

A03 M   GR             0.000  -0.001   0.000        0.011   0.001   0.005
        T1            -0.016  -0.006  -0.004        0.220  -0.126  -0.202
        R1             0.000   0.000   0.000        0.001   0.002   0.004
        R2             0.000   0.000   0.000        0.000   0.000   0.000
        R3             0.000   0.000   0.000        0.000   0.000   0.000
        GR+T1         -0.016  -0.006  -0.004        0.231  -0.125  -0.198
        SEIS           0.000   0.000   0.000        0.001   0.003   0.004
        TOTAL          0.016   0.007   0.004        0.232   0.128   0.202
```

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----------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS     ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                         AutoPIPE+4.60 RESULT PAGE  10
----------------------------------------------------------------------------


                       D I S P L A C E M E N T S

Point   Load           TRANSLATIONS (in  )        ROTATIONS (deg  )
name    combination     X       Y       Z          X       Y       Z
------  -----------   ------  ------  ------     ------  ------  ------
A03 F   GR             0.000  -0.001  -0.001      0.011   0.001   0.004
        T1            -0.029  -0.011  -0.015      0.205  -0.115  -0.183
        R1             0.000   0.000   0.000      0.001   0.003   0.004
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.028  -0.012  -0.015      0.216  -0.114  -0.179
        SEIS           0.000   0.000   0.000      0.001   0.003   0.004
        TOTAL          0.029   0.012   0.015      0.217   0.116   0.184

A04 N   GR             0.000  -0.001  -0.001      0.011   0.001   0.004
        T1            -0.029  -0.011  -0.015      0.205  -0.114  -0.183
        R1             0.000   0.000   0.000      0.001   0.003   0.004
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.028  -0.012  -0.016      0.216  -0.113  -0.179
        SEIS           0.000   0.000   0.000      0.001   0.003   0.004
        TOTAL          0.029   0.012   0.016      0.217   0.116   0.184

A04 M   GR             0.001  -0.001  -0.002      0.012   0.001   0.003
        T1            -0.045  -0.022  -0.026      0.141  -0.095  -0.153
        R1             0.001   0.000   0.000      0.001   0.003   0.004
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.044  -0.023  -0.028      0.152  -0.094  -0.149
        SEIS           0.001   0.000   0.000      0.001   0.003   0.004
        TOTAL          0.045   0.023   0.028      0.153   0.097   0.153

A04 F   GR             0.001  -0.002  -0.002      0.012   0.000   0.003
        T1            -0.055  -0.030  -0.024      0.041  -0.049  -0.129
        R1             0.001   0.000   0.000      0.001   0.002   0.004
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.054  -0.033  -0.026      0.053  -0.049  -0.126
        SEIS           0.001   0.000   0.000      0.001   0.003   0.004
        TOTAL          0.055   0.033   0.026      0.053   0.052   0.130

A05 N   GR             0.001  -0.006  -0.002      0.009  -0.001   0.002
        T1            -0.063  -0.033   0.001     -0.017   0.015  -0.088
        R1             0.002   0.000   0.000      0.000   0.002   0.003
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.062  -0.039  -0.001     -0.009   0.014  -0.086
        SEIS           0.002   0.001   0.000      0.000   0.002   0.004
        TOTAL          0.064   0.039   0.001      0.009   0.017   0.090
```

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----------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS     ICF KAISER HANFORD COMPANY
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----------------------------------------------------------------------------


                       D I S P L A C E M E N T S

Point   Load           TRANSLATIONS (in  )        ROTATIONS (deg  )
name    combination     X       Y       Z          X       Y       Z
------  -----------   ------  ------  ------     ------  ------  ------
A05 M   GR             0.001  -0.006  -0.002      0.003  -0.003   0.003
        T1            -0.055  -0.032   0.004     -0.057   0.125  -0.066
        R1             0.002   0.000   0.000      0.000   0.001   0.003
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.055  -0.039   0.002     -0.054   0.122  -0.063
        SEIS           0.002   0.000   0.000      0.000   0.001   0.004
        TOTAL          0.057   0.039   0.002      0.054   0.124   0.067

A05 F   GR             0.000  -0.006  -0.002      0.001  -0.004   0.004
        T1            -0.045  -0.034  -0.007     -0.075   0.199  -0.036
        R1             0.002   0.000   0.000      0.000   0.000   0.003
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.044  -0.040  -0.009     -0.074   0.196  -0.032
        SEIS           0.002   0.000   0.000      0.000   0.000   0.003
        TOTAL          0.047   0.040   0.009      0.074   0.196   0.035

A06     GR             0.000  -0.006  -0.001      0.000  -0.004   0.004
        T1            -0.042  -0.035  -0.015     -0.077   0.202  -0.035
        R1             0.002   0.000   0.000      0.000   0.000   0.003
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.042  -0.041  -0.016     -0.077   0.198  -0.030
        SEIS           0.002   0.000   0.000      0.000   0.000   0.003
        TOTAL          0.044   0.041   0.016      0.077   0.198   0.034

A07 N   GR             0.000  -0.006  -0.001      0.000  -0.004   0.004
        T1            -0.040  -0.036  -0.022     -0.080   0.202  -0.034
        R1             0.002   0.000   0.000      0.000   0.000   0.003
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.039  -0.042  -0.023     -0.080   0.198  -0.029
        SEIS           0.002   0.000   0.000      0.000   0.000   0.003
        TOTAL          0.041   0.042   0.023      0.081   0.198   0.033

A07 M   GR             0.000  -0.005  -0.001     -0.003  -0.003   0.006
        T1            -0.029  -0.036  -0.034     -0.089   0.158  -0.026
        R1             0.002   0.000   0.000      0.000   0.002   0.002
        R2             0.000   0.000   0.000      0.000   0.000   0.000
        R3             0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1         -0.028  -0.041  -0.035     -0.092   0.154  -0.020
        SEIS           0.002   0.000   0.000      0.000   0.002   0.003
        TOTAL          0.030   0.041   0.035      0.092   0.157   0.023
```

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                          D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )       ROTATIONS (deg  )
name   combination     X       Y       Z        X       Y       Z
------ -----------   ------  ------  ------   ------  ------  ------
A07 F  GR             0.000  -0.005  -0.001   -0.008  -0.002   0.007
       T1            -0.018  -0.029  -0.033   -0.099   0.078  -0.025
       R1             0.002   0.000   0.000    0.000   0.004   0.002
       R2             0.000   0.000   0.000    0.000   0.000   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1         -0.018  -0.034  -0.034   -0.107   0.076  -0.018
       SEIS           0.002   0.000   0.000    0.000   0.004   0.003
       TOTAL          0.020   0.034   0.034    0.107   0.080   0.020

A08 N  GR             0.000  -0.001  -0.001   -0.011  -0.001   0.006
       T1             0.002   0.007  -0.005   -0.076   0.036  -0.035
       R1             0.000   0.000   0.000    0.000   0.004   0.002
       R2             0.000   0.000   0.000    0.000   0.000   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1          0.001   0.006  -0.006   -0.087   0.035  -0.029
       SEIS           0.000   0.000   0.000    0.000   0.005   0.002
       TOTAL          0.002   0.006   0.006    0.088   0.040   0.031

A08 M  GR             0.000   0.000  -0.001   -0.012  -0.001   0.006
       T1             0.002   0.008   0.000   -0.019   0.027  -0.039
       R1             0.000   0.000   0.000    0.001   0.005   0.001
       R2             0.000   0.000   0.000    0.000   0.001   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1          0.002   0.007  -0.001   -0.031   0.025  -0.033
       SEIS           0.000   0.000   0.000    0.001   0.005   0.002
       TOTAL          0.002   0.007   0.001    0.031   0.030   0.035

A08 F  GR             0.000   0.000   0.000   -0.010  -0.002   0.005
       T1             0.001   0.004   0.001    0.014   0.025  -0.040
       R1             0.000   0.000   0.000    0.001   0.005   0.001
       R2             0.000   0.000   0.000    0.000   0.001   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1          0.001   0.004   0.000    0.003   0.024  -0.035
       SEIS           0.000   0.000   0.000    0.001   0.005   0.001
       TOTAL          0.001   0.004   0.000    0.004   0.029   0.036

A09    GR             0.000   0.000   0.000   -0.010  -0.002   0.005
       T1             0.000   0.003   0.000    0.014   0.025  -0.040
       R1             0.000   0.000   0.000    0.001   0.005   0.001
       R2             0.000   0.000   0.000    0.000   0.001   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1          0.000   0.003   0.000    0.004   0.024  -0.035
       SEIS           0.000   0.000   0.000    0.001   0.005   0.001
       TOTAL          0.000   0.003   0.000    0.004   0.029   0.036
```

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                          D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )       ROTATIONS (deg  )
name   combination     X       Y       Z        X       Y       Z
------ -----------   ------  ------  ------   ------  ------  ------
A10    GR             0.000   0.000   0.000    0.000   0.000   0.000
       T1             0.000   0.003   0.000    0.002   0.000  -0.001
       R1             0.000   0.000   0.000    0.000   0.000   0.000
       R2             0.000   0.000   0.000    0.000   0.000   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1          0.000   0.003   0.000    0.002   0.000  -0.001
       SEIS           0.000   0.000   0.000    0.000   0.000   0.000
       TOTAL          0.000   0.003   0.000    0.002   0.000   0.001

A11    GR             0.000   0.000   0.000    0.000   0.000   0.000
       T1             0.000   0.000   0.000    0.000   0.000   0.000
       R1             0.000   0.000   0.000    0.000   0.000   0.000
       R2             0.000   0.000   0.000    0.000   0.000   0.000
       R3             0.000   0.000   0.000    0.000   0.000   0.000
       GR+T1          0.000   0.000   0.000    0.000   0.000   0.000
       SEIS           0.000   0.000   0.000    0.000   0.000   0.000
       TOTAL          0.000   0.000   0.000    0.000   0.000   0.000

*** Segment A   end    ***
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                       S U P P O R T   F O R C E S

 Point/  Connect/   Load               L O C A L              G L O B A L
Supp. ID   Type   Combination  Dirn  Force    Deform    Dirn   Force   Deform
-------- -------- ----------- ---- -------- --------    ---- -------- --------


*** End of system , no supports  encountered.  ***
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                        R E S T R A I N T   R E A C T I O N S

Point     Load          FORCES (lb    )                MOMENTS (ft-lb  )
name   combination   X      Y      Z   Result    X       Y       Z   Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------

A00     Anchor
        GR            6   -222     29    224      55       7      38      67
        T1         -447    427  -2062   2153      76    -588     -60     596
        R1            9      1      7     12       4       5       3       7
        R2            1      0      1      1       0       1       0       1
        R3            0      0      0      0       0       0       0       0
        GR+T1      -441    205  -2034   2091     131    -581     -22     596
        SEIS         10      1      8     13       4       6       4       8
        TOTAL       451    206   2042   2101     135     586      26     602

A11     Anchor
        GR           -6   -208    -29    210     -27       0      12      30
        T1          447   -427   2062   2153     458       8    -175     491
        R1           10      1      7     12       3       1       0       3
        R2            1      0      1      1       0       0       0       0
        R3            0      0      0      0       0       0       0       0
        GR+T1       441   -635   2034   2175     431       7    -163     461
        SEIS         11      1      8     14       3       2       0       3
        TOTAL       452    636   2042   2186     434       9     164     464
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                G L O B A L   F O R C E S   &   M O M E N T S

Point    Load              FORCES (lb   )                  MOMENTS (ft-lb  )
name   combination     X      Y      Z   Result      X       Y       Z    Result
------ ----------- ------ ------ ------ ------  ------- ------- ------- -------

*** Segment A  begin ***

A00      GR           -6    222    -29    224      -55      -7     -38      67
         T1          447   -427   2062   2153      -76     588      60     596
         R1            9      1      7     12        4       5       3       7
         R2            1      0      1      1        0       1       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -205   2034   2091     -131     581      22     596
         SEIS         10      1      8     13        4       6       4       8
         TOTAL       451    206   2042   2101      135     586      26     602

A01      GR           -6     75    -29     80      -21      -3     -13      25
         T1          447   -427   2062   2153     -141     287      12     320
         R1            9      1      7     12        4       4       3       7
         R2            1      0      1      1        0       0       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -352   2034   2110     -162     284      -1     327
         SEIS         10      1      8     13        4       5       4       7
         TOTAL       451    353   2042   2120      166     289       5     333

A02      GR           -6     75    -29     80      -17      -2     -10      20
         T1          447   -427   2062   2153     -154     232       4     279
         R1            9      1      7     12        4       4       3       6
         R2            1      0      1      1        0       0       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -352   2034   2110     -171     230      -7     286
         SEIS         10      1      8     13        4       5       4       7
         TOTAL       451    353   2042   2120      175     235      10     293

A03 N    GR           -6     73    -29     79      -13      -1      -8      15
         T1          447   -427   2062   2153     -176     136     -11     223
         R1            9      1      7     12        4       4       3       6
         R2            1      0      1      1        0       0       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -353   2034   2111     -189     135     -19     233
         SEIS         10      1      8     13        4       5       4       7
         TOTAL       451    354   2042   2121      193     140      23     239

A03 M    GR           -6     69    -29     75       -2       4       2       5
         T1          447   -427   2062   2153      -59    -221    -111     254
         R1            9      1      7     12        3       3       2       5
         R2            1      0      1      1        0       0       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -358   2034   2111      -60    -217    -109     250
         SEIS         10      1      8     13        3       4       3       5
         TOTAL       451    359   2042   2121       63     221     111     255
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                G L O B A L   F O R C E S   &   M O M E N T S

Point    Load              FORCES (lb   )                  MOMENTS (ft-lb  )
name   combination     X      Y      Z   Result      X       Y       Z    Result
------ ----------- ------ ------ ------ ------  ------- ------- ------- -------
A03 F    GR           -6     64    -29     71       -3       6       7      10
         T1          447   -427   2062   2153      393    -369    -239     590
         R1            9      1      7     12        1       3       0       3
         R2            1      0      1      1        0       0       0       0
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -362   2034   2112      390    -363    -232     581
         SEIS         10      1      8     13        1       3       0       3
         TOTAL       451    363   2042   2122      391     366     232     584

A04 N    GR           -6     64    -29     71       -3       6       7      10
         T1          447   -427   2062   2153      407    -369    -242     600
         R1            9      0      7     12        1       3       0       3
         R2            1      0      1      1        0       0       0       0
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -362   2034   2112      403    -363    -235     591
         SEIS         10      1      8     13        1       3       0       3
         TOTAL       451    363   2042   2122      404     366     235     594

A04 M    GR           -6     58    -29     65       -5       7       9      12
         T1          447   -427   2062   2153     1073    -434    -400    1225
         R1            8      0      7     11        2       2       3       4
         R2            1      0      1      1        0       0       0       0
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -369   2034   2113     1068    -428    -391    1215
         SEIS          9      0      8     12        2       2       3       4
         TOTAL       450    370   2042   2123     1071     429     394    1219

A04 F    GR           -6     51    -29     59       10       9      10      17
         T1          447   -427   2062   2153     1224    -592    -466    1438
         R1            6      0      7      9        3       1       4       5
         R2            1      0      1      1        0       0       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -376   2034   2114     1234    -583    -455    1439
         SEIS          7      0      8     11        3       1       5       6
         TOTAL       448    376   2042   2124     1238     585     460    1444

A05 N    GR           -6     22    -29     37       71      19      10      74
         T1          447   -427   2062   2153      512   -1339    -466    1507
         R1            2      1      7      8        3      11       4      12
         R2            0      0      1      1        0       1       0       1
         R3            0      0      0      0        0       0       0       0
         GR+T1       441   -405   2034   2120      583   -1320    -455    1513
         SEIS          2      1      8      9        3      13       5      14
         TOTAL       443    406   2042   2128      585    1332     460    1526
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MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS    ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                        AutoPIPE+4.60 RESULT PAGE  18
-------------------------------------------------------------------------------


              G L O B A L   F O R C E S   &   M O M E N T S

Point     Load           FORCES (lb    )              MOMENTS (ft-lb  )
name   combination     X      Y      Z   Result      X       Y       Z   Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A05 M    GR            -6     15    -29     33      78      17       8      80
         T1           447   -427   2062   2153     361   -1195    -403    1312
         R1             1      2      7      7       2      13       4      14
         R2             0      0      1      1       0       1       0       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -412   2034   2121     438   -1178    -396    1318
         SEIS           1      2      8      8       2      15       5      16
         TOTAL        442    413   2041   2129     441    1193     400    1333

A05 F    GR            -6      8    -29     31      80       8       4      80
         T1           447   -427   2062   2153     298    -531    -252     659
         R1             0      2      7      7       2      16       5      17
         R2             0      0      1      1       0       2       1       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -418   2034   2122     378    -524    -249     692
         SEIS           0      2      8      8       2      18       6      19
         TOTAL        441    420   2041   2130     380     541     254     708

A06  -   GR            -6      6    -29     30      80       3       2      80
         T1           447   -427   2062   2153     298    -181    -180     392
         R1             0      2      7      7       2      17       5      18
         R2             0      0      1      1       0       2       1       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -421   2034   2123     378    -178    -177     454
         SEIS           0      2      8      8       2      19       6      20
         TOTAL        441    423   2041   2131     380     197     183     465

A06  +   GR            -6     -2    -29     30      80       3       2      80
         T1           447   -427   2062   2153     298    -181    -180     392
         R1             3      2      7      8       2      17       5      18
         R2             0      0      1      1       0       2       1       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -429   2034   2125     378    -178    -177     454
         SEIS           3      2      8      9       2      19       6      20
         TOTAL        444    431   2041   2133     380     197     183     465

A07 N    GR            -6     -5    -29     30      80      -2       3      80
         T1           447   -427   2062   2153     298     170    -107     360
         R1             4      2      7      8       2      18       6      19
         R2             0      0      1      1       0       2       1       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -432   2034   2125     378     168    -104     426
         SEIS           4      2      8      9       2      20       6      21
         TOTAL        445    434   2041   2134     380     188     110     438
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MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS    ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                        AutoPIPE+4.60 RESULT PAGE  19
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              G L O B A L   F O R C E S   &   M O M E N T S

Point     Load           FORCES (lb    )              MOMENTS (ft-lb  )
name   combination     X      Y      Z   Result      X       Y       Z   Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A07 M    GR            -6    -12    -29     32      78     -12       6      79
         T1           447   -427   2062   2153     236     834      44     867
         R1             6      2      7      9       2      20       6      21
         R2             1      0      1      1       0       2       1       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -439   2034   2127     314     822      50     881
         SEIS           6      2      8     10       2      22       7      23
         TOTAL        447    441   2041   2136     316     844      57     903

A07 F    GR            -6    -19    -29     35      73     -14       8      74
         T1           447   -427   2062   2153      85     978     106     987
         R1             9      1      7     12       1      19       7      20
         R2             1      0      1      1       0       2       1       2
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -446   2034   2128     157     964     114     983
         SEIS          10      1      8     13       1      21       7      22
         TOTAL        451    447   2041   2138     158     985     122    1005

A08 N    GR            -6    -51    -29     58       9      -2       8      12
         T1           447   -427   2062   2153    -699     157     106     724
         R1            10      1      7     12       1       2       7       7
         R2             1      0      1      1       0       0       1       1
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -477   2034   2135    -690     154     114     716
         SEIS          11      1      8     14       2       2       7       8
         TOTAL        452    479   2041   2145     692     156     122     719

A08 M    GR            -6    -55    -29     62      -6      -1       9      11
         T1           447   -427   2062   2153    -598      51      63     604
         R1            10      1      7     12       1       0       6       6
         R2             1      0      1      1       0       0       1       1
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -482   2034   2136    -605      50      71     611
         SEIS          11      1      8     14       1       1       6       6
         TOTAL        452    483   2041   2146     606      51      77     613

A08 F    GR            -6    -60    -29     66     -19       0      10      21
         T1           447   -427   2062   2153    -154       8     -43     160
         R1            10      1      7     12       1       1       3       4
         R2             1      0      1      1       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1        441   -486   2034   2137    -173       7     -33     176
         SEIS          11      1      8     14       1       2       4       4
         TOTAL        452    488   2041   2147     173       9      36     177
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MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS      ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                          AutoPIPE+4.60 RESULT PAGE  20
-------------------------------------------------------------------------------

                 G L O B A L   F O R C E S   &   M O M E N T S

Point     Load             FORCES (lb     )               MOMENTS (ft-lb  )
name   combination      X      Y      Z Result       X       Y       Z  Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A09     GR             -6   -205    -29    207     -21       0      11      23
        T1            447   -427   2062   2153     -16       8     -73      75
        R1             10      1      7     12       1       1       3       3
        R2              1      0      1      1       0       0       0       0
        R3              0      0      0      0       0       0       0       0
        GR+T1         441   -631   2034   2174     -37       7     -62      73
        SEIS           11      1      8     14       1       2       3       4
        TOTAL         452    633   2042   2185      38       9      65      76

A10     GR             -6   -205    -29    207     -22       0      11      24
        T1            447   -427   2062   2153      66       8     -91     112
        R1             10      1      7     12       1       1       2       3
        R2              1      0      1      1       0       0       0       0
        R3              0      0      0      0       0       0       0       0
        GR+T1         441   -631   2034   2174      44       7     -80      91
        SEIS           11      1      8     14       2       2       2       3
        TOTAL         452    633   2042   2185      46       9      82      95

A11     GR             -6   -208    -29    210     -27       0      12      30
        T1            447   -427   2062   2153     458       8    -175     491
        R1             10      1      7     12       3       1       0       3
        R2              1      0      1      1       0       0       0       0
        R3              0      0      0      0       0       0       0       0
        GR+T1         441   -635   2034   2175     431       7    -163     461
        SEIS           11      1      8     14       3       2       0       3
        TOTAL         452    636   2042   2186     434       9     164     464

*** Segment A  end   ***
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MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS      ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                          AutoPIPE+4.60 RESULT PAGE  21
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                        ASME B31.3c (1992)  CODE COMPLIANCE
                       (Moments in ft-lb  )             (Stress in psi      )
Point     Load       In-Pl. Out-Pl. Torsion  S.I.F      Eq. Load   Code  Code
name   combination   Moment  Moment  Moment  In  Out    no. type Stress Allow.
------ ----------- ------- ------- ------- ---- ----   ---- ---- ------ ------

*** Segment A  begin ***

A00    Max P                                          (3a) HOOP   4844  16700
       GR + Max P       67       7         1.00 1.00 (18) SUST   2388  16700
       Cold to T1       25     588      94 1.00 1.00 (17) DISP   2225  25050
       Sus. + R1        72      12         1.00 1.00 (18)  OCC   2422  22211
       Sus. + R2        67       8         1.00 1.00 (18)  OCC   2391  22211
       Sus. + R3        67       7         1.00 1.00 (18)  OCC   2388  22211

A01    Max P                                          (3a) HOOP   4844  16700
       GR + Max P       25       3         1.00 1.00 (18) SUST   2187  16700
       Cold to T1      106     287      94 1.00 1.00 (17) DISP   1195  25050
       Sus. + R1        30       8         1.00 1.00 (18)  OCC   2218  22211
       Sus. + R2        25       4         1.00 1.00 (18)  OCC   2190  22211
       Sus. + R3        25       3         1.00 1.00 (18)  OCC   2187  22211

A02    Max P                                          (3a) HOOP   4844  16700
       GR + Max P       20       2         1.00 1.00 (18) SUST   2161  16700
       Cold to T1      126     232      88 1.00 1.00 (17) DISP   1040  25050
       Sus. + R1        25       7         1.00 1.00 (18)  OCC   2192  22211
       Sus. + R2        20       3         1.00 1.00 (18)  OCC   2165  22211
       Sus. + R3        20       2         1.00 1.00 (18)  OCC   2161  22211

A03 N- Max P                                          (3a) HOOP   4844  16700
       GR + Max P       15       1         1.00 1.00 (18) SUST   2138  16700
       Cold to T1      153     136      88 1.00 1.00 (17) DISP    833  25050
       Sus. + R1        20       5         1.00 1.00 (18)  OCC   2168  22211
       Sus. + R2        16       2         1.00 1.00 (18)  OCC   2141  22211
       Sus. + R3        15       1         1.00 1.00 (18)  OCC   2138  22211

A03 N+ Max P                                          (3a) HOOP   4844  16700
       GR + Max P       15       1         2.56 2.13 (18) SUST   2251  16700
       Cold to T1      153     136      88 2.56 2.13 (17) DISP   1850  25050
       Sus. + R1        20       5         2.56 2.13 (18)  OCC   2323  22211
       Sus. + R2        16       2         2.56 2.13 (18)  OCC   2259  22211
       Sus. + R3        15       1         2.56 2.13 (18)  OCC   2251  22211

A03 M  Max P                                          (3a) HOOP   4844  16700
       GR + Max P        0       5         2.56 2.13 (18) SUST   2113  16700
       Cold to T1      110     198     114 2.56 2.13 (17) DISP   1945  25050
       Sus. + R1         4       7         2.56 2.13 (18)  OCC   2163  22211
       Sus. + R2         1       5         2.56 2.13 (18)  OCC   2119  22211
       Sus. + R3         0       5         2.56 2.13 (18)  OCC   2113  22211
```

```
                          ASME B31.3c (1992)  CODE COMPLIANCE
                            (Moments in ft-lb  )              (Stress in psi      )
Point     Load       In-Pl. Out-Pl. Torsion  S.I.F    Eq. Load    Code   Code
name   combination  Moment  Moment  Moment  In   Out  no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ---- ------ ------
A03 F- Max P                                        (3a) HOOP    4844  16700
       GR + Max P        1       8         2.56 2.13 (18) SUST    2146  16700
       Cold to T1      194     417     369 2.56 2.13 (17) DISP    4043  25050
       Sus. + R1         2       8         2.56 2.13 (18)  OCC    2157  22211
       Sus. + R2         2       8         2.56 2.13 (18)  OCC    2148  22211
       Sus. + R3         1       8         2.56 2.13 (18)  OCC    2146  22211

A03 F+ Max P                                        (3a) HOOP    4844  16700
       GR + Max P        3       7         1.00 1.00 (18) SUST    2103  16700
       Cold to T1      393     239     369 1.00 1.00 (17) DISP    2201  25050
       Sus. + R1         4       7         1.00 1.00 (18)  OCC    2107  22211
       Sus. + R2         3       7         1.00 1.00 (18)  OCC    2104  22211
       Sus. + R3         3       7         1.00 1.00 (18)  OCC    2103  22211

A04 N- Max P                                        (3a) HOOP    4844  16700
       GR + Max P        3       7         1.00 1.00 (18) SUST    2104  16700
       Cold to T1      407     242     369 1.00 1.00 (17) DISP    2240  25050
       Sus. + R1         4       7         1.00 1.00 (18)  OCC    2108  22211
       Sus. + R2         3       7         1.00 1.00 (18)  OCC    2104  22211
       Sus. + R3         3       7         1.00 1.00 (18)  OCC    2104  22211

A04 N+ Max P                                        (3a) HOOP    4844  16700
       GR + Max P        3       7         1.95 1.63 (18) SUST    2130  16700
       Cold to T1      407     242     369 1.95 1.63 (17) DISP    3583  25050
       Sus. + R1         4       7         1.95 1.63 (18)  OCC    2138  22211
       Sus. + R2         3       7         1.95 1.63 (18)  OCC    2131  22211
       Sus. + R3         3       7         1.95 1.63 (18)  OCC    2130  22211

A04 M  Max P                                        (3a) HOOP    4844  16700
       GR + Max P        5      11         1.95 1.63 (18) SUST    2165  16700
       Cold to T1     1073     590      24 1.95 1.63 (17) DISP    8604  25050
       Sus. + R1         7      12         1.95 1.63 (18)  OCC    2184  22211
       Sus. + R2         5      12         1.95 1.63 (18)  OCC    2167  22211
       Sus. + R3         5      11         1.95 1.63 (18)  OCC    2165  22211

A04 F- Max P                                        (3a) HOOP    4844  16700
       GR + Max P       10       9         1.95 1.63 (18) SUST    2183  16700
       Cold to T1     1224     592     466 1.95 1.63 (17) DISP    9777  25050
       Sus. + R1        13      10         1.95 1.63 (18)  OCC    2214  22211
       Sus. + R2        10       9         1.95 1.63 (18)  OCC    2187  22211
       Sus. + R3        10       9         1.95 1.63 (18)  OCC    2183  22211

A04 F+ Max P                                        (3a) HOOP    4844  16700
       GR + Max P       10       9         1.00 1.00 (18) SUST    2130  16700
       Cold to T1     1224     592     466 1.00 1.00 (17) DISP    5367  25050
       Sus. + R1        13      10         1.00 1.00 (18)  OCC    2146  22211
       Sus. + R2        10       9         1.00 1.00 (18)  OCC    2132  22211
       Sus. + R3        10       9         1.00 1.00 (18)  OCC    2130  22211
```

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                          ASME B31.3c (1992)  CODE COMPLIANCE
                            (Moments in ft-lb  )              (Stress in psi      )
Point     Load       In-Pl. Out-Pl. Torsion  S.I.F    Eq. Load    Code   Code
name   combination  Moment  Moment  Moment  In   Out  no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ---- ------ ------
A05 N- Max P                                        (3a) HOOP    4844  16700
       GR + Max P       71      19         1.00 1.00 (18) SUST    2418  16700
       Cold to T1      512    1339     466 1.00 1.00 (17) DISP    5626  25050
       Sus. + R1        73      30         1.00 1.00 (18)  OCC    2474  22211
       Sus. + R2        71      20         1.00 1.00 (18)  OCC    2424  22211
       Sus. + R3        71      19         1.00 1.00 (18)  OCC    2418  22211

A05 N+ Max P                                        (3a) HOOP    4844  16700
       GR + Max P       19      71         1.95 1.63 (18) SUST    2648  16700
       Cold to T1     1339     512     466 1.95 1.63 (17) DISP   10387  25050
       Sus. + R1        30      73         1.95 1.63 (18)  OCC    2756  22211
       Sus. + R2        20      71         1.95 1.63 (18)  OCC    2659  22211
       Sus. + R3        19      71         1.95 1.63 (18)  OCC    2648  22211

A05 M  Max P                                        (3a) HOOP    4844  16700
       GR + Max P       17      49         1.95 1.63 (18) SUST    2483  16700
       Cold to T1     1195     540      30 1.95 1.63 (17) DISP    9307  25050
       Sus. + R1        30      51         1.95 1.63 (18)  OCC    2607  22211
       Sus. + R2        18      50         1.95 1.63 (18)  OCC    2497  22211
       Sus. + R3        17      49         1.95 1.63 (18)  OCC    2483  22211

A05 F- Max P                                        (3a) HOOP    4844  16700
       GR + Max P        8       4         1.95 1.63 (18) SUST    2142  16700
       Cold to T1      531     252     298 1.95 1.63 (17) DISP    4310  25050
       Sus. + R1        23       9         1.95 1.63 (18)  OCC    2296  22211
       Sus. + R2         9       4         1.95 1.63 (18)  OCC    2159  22211
       Sus. + R3         8       4         1.95 1.63 (18)  OCC    2142  22211

A05 F+ Max P                                        (3a) HOOP    4844  16700
       GR + Max P        4       8         1.00 1.00 (18) SUST    2106  16700
       Cold to T1      252     531     298 1.00 1.00 (17) DISP    2462  25050
       Sus. + R1         9      23         1.00 1.00 (18)  OCC    2186  22211
       Sus. + R2         4       9         1.00 1.00 (18)  OCC    2115  22211
       Sus. + R3         4       8         1.00 1.00 (18)  OCC    2106  22211

A06    Max P                                        (3a) HOOP    4844  16700
       GR + Max P        2       3         1.00 1.00 (18) SUST    2083  16700
       Cold to T1      180     181     298 1.00 1.00 (17) DISP    1464  25050
       Sus. + R1         8      20         1.00 1.00 (18)  OCC    2169  22211
       Sus. + R2         3       5         1.00 1.00 (18)  OCC    2092  22211
       Sus. + R3         2       3         1.00 1.00 (18)  OCC    2083  22211

A07 N- Max P                                        (3a) HOOP    4844  16700
       GR + Max P        3       2         1.00 1.00 (18) SUST    2084  16700
       Cold to T1      107     170     298 1.00 1.00 (17) DISP    1343  25050
       Sus. + R1         9      20         1.00 1.00 (18)  OCC    2175  22211
       Sus. + R2         4       4         1.00 1.00 (18)  OCC    2094  22211
       Sus. + R3         3       2         1.00 1.00 (18)  OCC    2084  22211
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------------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS    ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                        AutoPIPE+4.60 RESULT PAGE  24
------------------------------------------------------------------------------


                    ASME B31.3c (1992)  CODE COMPLIANCE
                      (Moments in ft-lb  )             (Stress in psi     )
Point     Load     In-Pl.  Out-Pl. Torsion   S.I.F    Eq. Load   Code   Code
name   combination  Moment  Moment  Moment  In  Out   no. type Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ---- ------ ------
A07 N+ Max P                                         (3a) HOOP   4844  16700
       GR + Max P        2       3         1.95 1.63 (18) SUST   2097  16700
       Cold to T1      170     107     298 1.95 1.63 (17) DISP   1789  25050
       Sus. + R1        20       9         1.95 1.63 (18)  OCC   2274  22211
       Sus. + R2         4       4         1.95 1.63 (18)  OCC   2116  22211
       Sus. + R3         2       3         1.95 1.63 (18)  OCC   2097  22211

A07 M  Max P                                         (3a) HOOP   4844  16700
       GR + Max P       12      51         1.95 1.63 (18) SUST   2478  16700
       Cold to T1      834     136     198 1.95 1.63 (17) DISP   6176  25050
       Sus. + R1        32      54         1.95 1.63 (18)  OCC   2668  22211
       Sus. + R2        14      51         1.95 1.63 (18)  OCC   2498  22211
       Sus. + R3        12      51         1.95 1.63 (18)  OCC   2478  22211

A07 F- Max P                                         (3a) HOOP   4844  16700
       GR + Max P       14      73         1.95 1.63 (18) SUST   2646  16700
       Cold to T1      978      85     106 1.95 1.63 (17) DISP   7155  25050
       Sus. + R1        33      73         1.95 1.63 (18)  OCC   2825  22211
       Sus. + R2        16      73         1.95 1.63 (18)  OCC   2666  22211
       Sus. + R3        14      73         1.95 1.63 (18)  OCC   2646  22211

A07 F+ Max P                                         (3a) HOOP   4844  16700
       GR + Max P       73      14         1.00 1.00 (18) SUST   2420  16700
       Cold to T1       85     978     106 1.00 1.00 (17) DISP   3685  25050
       Sus. + R1        73      33         1.00 1.00 (18)  OCC   2512  22211
       Sus. + R2        73      16         1.00 1.00 (18)  OCC   2430  22211
       Sus. + R3        73      14         1.00 1.00 (18)  OCC   2420  22211

A08 N- Max P                                         (3a) HOOP   4844  16700
       GR + Max P        9       2         1.00 1.00 (18) SUST   2109  16700
       Cold to T1      699     157     106 1.00 1.00 (17) DISP   2703  25050
       Sus. + R1        10       4         1.00 1.00 (18)  OCC   2121  22211
       Sus. + R2         9       3         1.00 1.00 (18)  OCC   2111  22211
       Sus. + R3         9       2         1.00 1.00 (18)  OCC   2109  22211

A08 N+ Max P                                         (3a) HOOP   4844  16700
       GR + Max P        9       2         2.56 2.13 (18) SUST   2176  16700
       Cold to T1      699     157     106 2.56 2.13 (17) DISP   6803  25050
       Sus. + R1        10       4         2.56 2.13 (18)  OCC   2202  22211
       Sus. + R2         9       3         2.56 2.13 (18)  OCC   2179  22211
       Sus. + R3         9       2         2.56 2.13 (18)  OCC   2176  22211

A08 M  Max P                                         (3a) HOOP   4844  16700
       GR + Max P        6       5         2.56 2.13 (18) SUST   2162  16700
       Cold to T1      598      80       8 2.56 2.13 (17) DISP   5749  25050
       Sus. + R1         7       9         2.56 2.13 (18)  OCC   2201  22211
       Sus. + R2         7       6         2.56 2.13 (18)  OCC   2167  22211
       Sus. + R3         6       5         2.56 2.13 (18)  OCC   2162  22211
```

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------------------------------------------------------------------------------
MA-J6A    W320- C-FARM  JUMPER STRESS ANALYSIS    ICF KAISER HANFORD COMPANY
09/11/95  JUMPER C-06C-6-A                        AutoPIPE+4.60 RESULT PAGE  25
------------------------------------------------------------------------------


                    ASME B31.3c (1992)  CODE COMPLIANCE
                      (Moments in ft-lb  )             (Stress in psi     )
Point     Load     In-Pl.  Out-Pl. Torsion   S.I.F    Eq. Load   Code   Code
name   combination  Moment  Moment  Moment  In  Out   no. type Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ---- ------ ------
A08 F- Max P                                         (3a) HOOP   4844  16700
       GR + Max P       19      10         2.56 2.13 (18) SUST   2319  16700
       Cold to T1      154      43       8 2.56 2.13 (17) DISP   1508  25050
       Sus. + R1        19      13         2.56 2.13 (18)  OCC   2353  22211
       Sus. + R2        19      11         2.56 2.13 (18)  OCC   2322  22211
       Sus. + R3        19      10         2.56 2.13 (18)  OCC   2319  22211

A08 F+ Max P                                         (3a) HOOP   4844  16700
       GR + Max P       19      10         1.00 1.00 (18) SUST   2168  16700
       Cold to T1      154      43       8 1.00 1.00 (17) DISP    597  25050
       Sus. + R1        19      13         1.00 1.00 (18)  OCC   2184  22211
       Sus. + R2        19      11         1.00 1.00 (18)  OCC   2170  22211
       Sus. + R3        19      10         1.00 1.00 (18)  OCC   2168  22211

A09    Max P                                         (3a) HOOP   4844  16700
       GR + Max P       21      11         1.00 1.00 (18) SUST   2177  16700
       Cold to T1       16      73       8 1.00 1.00 (17) DISP    279  25050
       Sus. + R1        22      13         1.00 1.00 (18)  OCC   2191  22211
       Sus. + R2        21      11         1.00 1.00 (18)  OCC   2179  22211
       Sus. + R3        21      11         1.00 1.00 (18)  OCC   2177  22211

A10    Max P                                         (3a) HOOP   4844  16700
       GR + Max P       22      11         1.00 1.00 (18) SUST   2183  16700
       Cold to T1       66      91       8 1.00 1.00 (17) DISP    420  25050
       Sus. + R1        23      13         1.00 1.00 (18)  OCC   2195  22211
       Sus. + R2        22      11         1.00 1.00 (18)  OCC   2184  22211
       Sus. + R3        22      11         1.00 1.00 (18)  OCC   2183  22211

A11    Max P                                         (3a) HOOP   4844  16700
       GR + Max P       27      12         1.00 1.00 (18) SUST   2209  16700
       Cold to T1      458     175       8 1.00 1.00 (17) DISP   1831  25050
       Sus. + R1        30      12         1.00 1.00 (18)  OCC   2222  22211
       Sus. + R2        28      12         1.00 1.00 (18)  OCC   2210  22211
       Sus. + R3        27      12         1.00 1.00 (18)  OCC   2209  22211

*** Segment A  end   ***
```

```
                      S Y S T E M   S U M M A R Y
                      ---------------------------


Maximum displacements (in)
--------------------------

        Maximum X :      0.064      Point : A05 N      Load Comb.: TOTAL
        Maximum Y :      0.042      Point : A07 N      Load Comb.: TOTAL
        Maximum Z :      0.035      Point : A07 M      Load Comb.: TOTAL
        Max. total:      0.075      Point : A05 N      Load Comb.: TOTAL

Maximum rotations (deg)
-----------------------

        Maximum X :      0.232      Point : A03 M      Load Comb.: TOTAL
        Maximum Y :      0.202      Point : A07 N      Load Comb.: T1
        Maximum Z :     -0.211      Point : A03 N      Load Comb.: T1
        Max. total:      0.333      Point : A03 M      Load Comb.: TOTAL


Maximum restraint forces(lb)
--------------------------

        Maximum X :        452      Point : A11        Load Comb.: TOTAL
        Maximum Y :        636      Point : A11        Load Comb.: TOTAL
        Maximum Z :      -2062      Point : A00        Load Comb.: T1
        Max. total:       2186      Point : A11        Load Comb.: TOTAL

Maximum restraint moments(ft-lb)
-----------------------------

        Maximum X :        458      Point : A11        Load Comb.: T1
        Maximum Y :       -588      Point : A00        Load Comb.: T1
        Maximum Z :       -175      Point : A11        Load Comb.: T1
        Max. total:        602      Point : A00        Load Comb.: TOTAL
```

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                      S Y S T E M   S U M M A R Y
                      ---------------------------


Maximum pipe forces (lb)
-------------------------

        Maximum X :        452      Point : A08 M      Load Comb.: TOTAL
        Maximum Y :        636      Point : A11        Load Comb.: TOTAL
        Maximum Z :       2062      Point : A00        Load Comb.: T1
        Max. total:       2186      Point : A11        Load Comb.: TOTAL

Maximum pipe moments (ft-lb)
-----------------------------

        Maximum X :       1238      Point : A04 F      Load Comb.: TOTAL
        Maximum Y :      -1339      Point : A05 N      Load Comb.: T1
        Maximum Z :       -466      Point : A04 F      Load Comb.: T1
        Max. total:       1526      Point : A05 N      Load Comb.: TOTAL
```

```
                        S Y S T E M   S U M M A R Y
                        ---------------------------


    Maximum sustained stress

                             Point            : A05 N
                             Stress     psi   : 2648
                             Allowable psi    : 16700
                             Ratio            : 0.16
                             Load combination : GR + Max P

    Maximum displacement stress

                             Point            : A05 N
                             Stress     psi   : 10387
                             Allowable psi    : 25050
                             Ratio            : 0.41
                             Load combination : Cold to T1

    Maximum occasional stress

                             Point            : A07 F
                             Stress     psi   : 2825
                             Allowable psi    : 22211
                             Ratio            : 0.13
                             Load combination : Sus. + R1

    Maximum hoop stress

                             Point            : A00
                             Stress     psi   : 4844
                             Allowable psi    : 16700
                             Ratio            : 0.29
                             Load combination : Max P

    Maximum sustained stress ratio

                             Point            : A05 N
                             Stress     psi   : 2648
                             Allowable psi    : 16700
                             Ratio            : 0.16
                             Load combination : GR + Max P

    Maximum displacement stress ratio

                             Point            : A05 N
                             Stress     psi   : 10387
                             Allowable psi    : 25050
                             Ratio            : 0.41
                             Load combination : Cold to T1
```

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                        S Y S T E M   S U M M A R Y
                        ---------------------------


    Maximum occasional stress ratio

                             Point            : A07 F
                             Stress     psi   : 2825
                             Allowable psi    : 22211
                             Ratio            : 0.13
                             Load combination : Sus. + R1

    Maximum hoop stress ratio

                             Point            : A00
                             Stress     psi   : 4844
                             Allowable psi    : 16700
                             Ratio            : 0.29
                             Load combination : Max P


    * * * The system satisfies ASME B31.3 code requirements * * *
    * * * for the selected options                          * * *
```
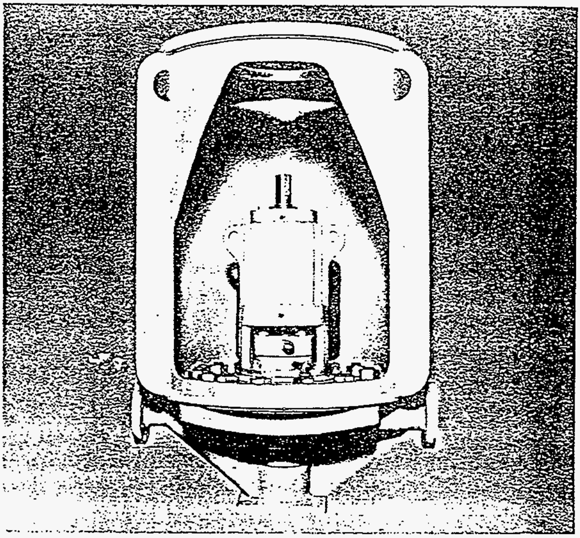

(NEW PUMP IN SUMP) as of
PIT 6/6/95

Series 1400
In-Line Bearing Frame True Line Pumps

- Partial emissions hydraulics for optimum efficiency
  - Heads to 700 FT (213m) at 3550 RPM with a single stage
- 700 lb. casing
- Back Pullout feature
- Mag Drive option
- High speed designs available
- Variable speed options available



Series 1400 2" x 2" - 13" Vertical In-Line Pump Figure 1

Optimized Low Flow, High Head Performance

True Line pumps from Lawrence Pumps Inc. are designed to deliver long term mechanical and hydraulic reliability for your low flow, high head applications.

- Designed to API-610 Standards
- Mechanical seal life is extended because the robust shaft design, combined with low radial loads minimizes shaft deflection
- Alignment between the pump and motor is guaranteed by a precision machined fit
- Liberal internal clearances and reduced radial thrust virtually eliminate the potential for any internal metal to metal contact
- Extreme temperature designs available (-50°F/-45°C to 700°F/370°C)
- Back Pullout feature allows ease of maintenance without disturbing the motor or connecting piping
- Seal chamber design accommodates Single, Double and Tandem mechanical seals
- Complete seal flush piping arrangements available

There are no close clearance wear rings or stuffing box bushing, and the axial clearances on both the front and back of the impeller are typically 0.035". Ultimately, the True Line design will withstand prolonged process upsets, or loss of suction, if seal lubrication is maintained.

Improved Process Pump Performance. Reduced Total Cost of Ownership.

- High efficiency at low flows
- Stable operations at all design points
- Minimum shaft deflection at off-design flows
- Reliable performance through process upsets
- Low maintenance from high seal reliability
- True In-Line with suction and discharge flanges on same plane
- Low NPSH characteristics

LAWRENCE
PUMPS INC.

NEMA FRAMES 182HP - 449HP — (See drawings below.) - Dimensions in inches/millimeters

FRAME	P	T	CAST IRON TERMINAL BOX				AJ	AX(2)	BB	BD	BE	BF	AG		AH(4)	BY		SHAFT AND KEY						WT. LBS./KG.	
			AA	AB	AC	AF							STD	LG(5)		STD	LG(5)	V	U(1)	EU(3)	EP(MIN)	LGTH	SQ.KEY	STD.	LG(5)
182HP	9.50 241	1.44 36.5	.75 19	7.75 197	6.31 150	1.94 49.3	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	17.56 446	19.06 484	2.750 69.85	9.38 238	10.12 257	2.75 69.8	1.1250 28.575	.875 22.22	1.16 29.5	1.28 32.5	.250 6.35	120 54	145 65
L184HP	9.50 241	1.44 36.5	.75 19	7.75 197	6.31 160	1.94 49.3	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	18.56 471	20.06 509	2.750 69.85	9.88 251	10.62 270	2.75 69.8	1.1250 28.575	.875 22.22	1.16 29.5	1.28 32.5	.250 6.35	130 59	155 70
213HP	10.50 257	1.44 36.5	1.00 25.4	9.75 248	7.75 197	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	19.50 495	21.25 540	2.750 69.85	9.75 248	10.62 270	2.75 69.8	1.1250 28.575	.875 22.22	1.38 35.0	1.28 32.5	.250 6.35	175 79	190 86
215HP	10.50 257	1.44 36.5	1.00 25.4	9.75 243	7.75 197	2.50 53.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	21.00 533	21.88 555	2.750 69.85	10.50 257	10.94 273	2.75 69.8	1.1250 28.575	.875 22.22	1.38 35.0	1.28 32.5	.250 6.35	200 91	215 97
254HP	13.83 352	2.25 57.2	1.25 31.8	10.19 259	8.22 209	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	22.94 582	— —	2.750 69.85	10.81 275	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	215 98	— —
256HP	13.83 352	2.25 57.2	1.25 31.8	10.19 259	8.22 209	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	24.69 627	— —	2.750 69.85	11.69 297	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	245 111	— —
284HP	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	9.12 232	8.250 210	.25 6.4	10.00 254	.69 17.5	.44 11.1	25.88 657	— —	2.750 69.85	12.25 311	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	270 122	— —
286HP	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	9.12 232	8.250 210	.25 6.4	10.00 254	.69 17.5	.44 11.1	27.38 695	— —	2.750 69.85	13.00 330	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	320 145	— —
284HPH	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	14.75 375	13.500 343	.25 6.4	16.50 492	.88 22.2	.69 17.5	25.88 657	— —	4.500 114	12.25 311	— —	4.50 114	1.6250 41.3	1.250 31.8	1.75 44.4	1.28 77	.375 9.5	300 136	— —
286HPH	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	14.75 375	13.500 343	.25 6.4	16.50 492	.88 22.2	.69 17.5	27.38 695	— —	4.500 114	13.00 330	— —	4.50 114	1.6250 41.3	1.250 31.8	1.75 44.4	1.28 77	.375 9.5	350 159	— —
324HP	17.75 451	2.25 57.2	2 50.8	14.69 373	10.94 278	3.63 92.1	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	29.06 738	— —	4.500 114	13.50 343	— —	4.50 114	1.6250 41.275	1.250 31.75	2.12 53.8	3.03 77.0	.375 9.52	480 218	— —
326HP	17.75 451	2.25 57.2	2 50.8	14.69 373	10.94 278	3.63 92.1	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	30.56 776	— —	4.500 114	14.25 362	— —	4.50 114	1.6250 41.275	1.250 31.75	2.12 53.8	3.03 77.0	.375 9.52	530 240	— —
364HP	20.50 521	2.25 57.2	3 76	17.94 456	13.75 349	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	33.38 847	— —	4.500 114	15.38 390	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	660 299	— —
365HP	20.50 521	2.25 57.2	3 76	17.94 456	13.75 349	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	33.38 847	— —	4.500 114	15.38 390	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	710 322	— —
404HP	22.62 575	2.50 63.5	3 75	19.19 487	15.00 381	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.94 23.8	.69 17.5	35.19 893	— —	4.500 114	15.12 384	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	950 431	— —
405HP	22.62 575	2.50 63.5	3 75	19.19 487	15.00 381	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.94 23.8	.69 17.5	35.19 893	— —	4.500 114	15.12 384	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	1075 488	— —
444HP	25.50 648	2.50 63.5	3 76	22.13 562	17.37 441	6.00 152	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	40.88 1038	— —	4.500 114	18.00 457	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	1405 637	— —
445HP	25.50 648	2.50 63.5	3 76	22.13 562	17.37 441	6.00 152	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	40.88 1038	— —	4.500 114	18.00 457	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	1555 705	— —
447HP	25.25 641	2.50 63.5	(5)	23.37 594	18.12 460	7.00 178	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	49.38 1254	— —	4.500 114	22.25 565	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	2900 1314	— —
449HP	25.25 641	2.50 63.5	(5)	23.37 594	18.12 460	7.00 178	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	49.38 1254	— —	4.500 114	22.25 565	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	2900 1314	— —

(1) "U" Varies — up to 2.125 +.0000, -.0005 53.975 +.000, -.013
— 2.125 and larger +.000, -.001 53.975 and larger +.00, -.03

(2) "AK" Varies —180 HP,—250HP, +.003, -.000 +.08,—.00
— 280HPH, -440HP +.005, -.000 +.13, -.00

Face runout and eccentricity —182HP —445HP, .004 Max. T.I.R. .10
—447HP —449HP, .007 Max. T.I.R. .18

(3) "EU" Varies +.000, -.005 +.00, -.13

(4) "AH" Varies +.030, -.030 +.76, -.76

(5) "AA" Varies with full load amps: 4" (120 mm) @ 201 amps, 5" (127 mm) @ 335 amps, 6" (152 mm) @ 600 amps.

Maximum permissible shaft runout when measured at end of shaft extension is .002 inches (.051 mm) Max. T.I.R. (.003 inches, .076 mm on 447HP — 449HP).

If mounting clearance is required, consult factory.

NORMAL THRUST, TEFC Above-NEMA, 350 — 400 HP

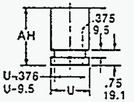
5010P Frame, 460 Volts

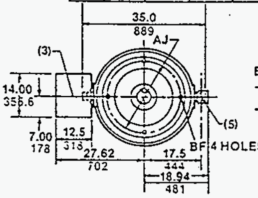
HP	350	400
Full Load Speed	3560 1773	3558 1773
Frame Size	5010P 5010P	5010P 5010P
Up or Down Thrust	720 720	720 720

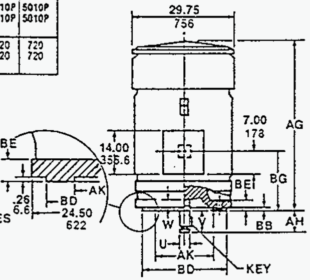
5010P Frame, 2300, 4000 Volts

HP	200	250	300	350	400
Full Load Speed	1189 890	1783 1189	3571 1783 1188	3570 1784	3579 1784
Frame	5010P 5010P	5010P 5010P	5010P 5010P 5010P	5010P 5010P	5010P 5010P
Up or Down Thrust	960 1120	720 960	720 720 960	720 720	720 720

- 5010P Frames
- 460, 2300, 4000 Volts
- 3-Phase, 60 Hz
- 1.0 S.F., Continuous Duty
- 40°C. Ambient
- Class B Insulation
- Ball Bearing
- Solid Shaft







ABOVE NEMA 5010P — Dimensions in inches/millimeters

FRAME	RPM (MAX.)	U(2)	V	AG	AH	AJ	AX(1)	BB	BD	BE	BG	W	BF	KEY		WT. (LBS/KG)
														SQ.	LGTH.	
5010P 5010P	3600 3600	2.375 60.33	6.75 171	62.5 1587	6.75 171	14.75 374	13.500 343	.25 6.4	20.00 508	1.75 45	17.94 456	4.44 113	.667 18	.625 15.88	4.00 102	6200 2360
5010P 5010P	1800 1800	3.375 85.73	6.75 171	62.5 1587	6.75 171	14.75 374	13.500 343	.25 6.4	20.00 508	1.75 45	17.94 456	4.44 113	.687 18	.875 22.23	5.0 127	6200 2360

(1) This Dimension Varies +.005 -.000 +.13, -.00

(2) This Varies +.000, -.001, +.00 -.03

(3) Customer to drill hole in Conduit Box.

(4) Face Runout and Eccentricity .007 (.18 mm) max. T.I.R.

(5) 3/4 N.P.T. for space heater leads.

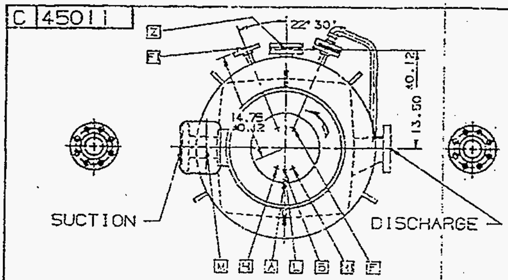
Conduit Box can be rotated 360° in 90° steps.

If mounting clearance details are required, consult factory.

Maximum permissible shaft runout when measured at end of std. shaft extension is .003 (.08 mm) T.I.R.

MAXIMUM FULL LOAD AMPERES	AA (4X6) PIPE TAP*
201	4
335	5
600	6

* On 5010P frame, customer to drill hole in conduit box.



CONNECTIONS:

- A 1/4-18 NPT - ALTERNATE LUBRICANT INLET TO THRUST BEARING (PLUGGED)
- B 1/4-18 NPT - OIL OUTLET FROM BEARING HOUSING
- F 1/2-14 NPT - INLET TO SEAL THRU API PLAN 11 FROM PUMP DISCHARGE
- F 1/2-300 LB. R.F. S.W. FLANGE - CASING VENT
- H 1/2-14 NPT - SEAL VENT
- H 1/2-14 NPT - SEAL DRAIN
- L 1/4-18 NPT - OIL MIST INLET TO BEARING HOUSING
- M MOTOR CONNECTION FOR POWER LEADS
- Z 3/4-300 LB. R.F. S.W. FLANGE - CASING DRAIN (COVERED WITH BLIND FLANGE)

WEIGHTS:

PUMP 800 LBS.
① MOTOR 2700 ~~450~~ LBS.
TOTAL 3500 ~~1200~~ LBS. APPROXIMATE

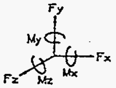
DRIVER DATA:

① 250 HP - 3600 RPM, T.E.F.C., VERTICAL ELECTRIC MOTOR, RELIANCE FRAME NO. 326TC

NOZZLE LOADS:

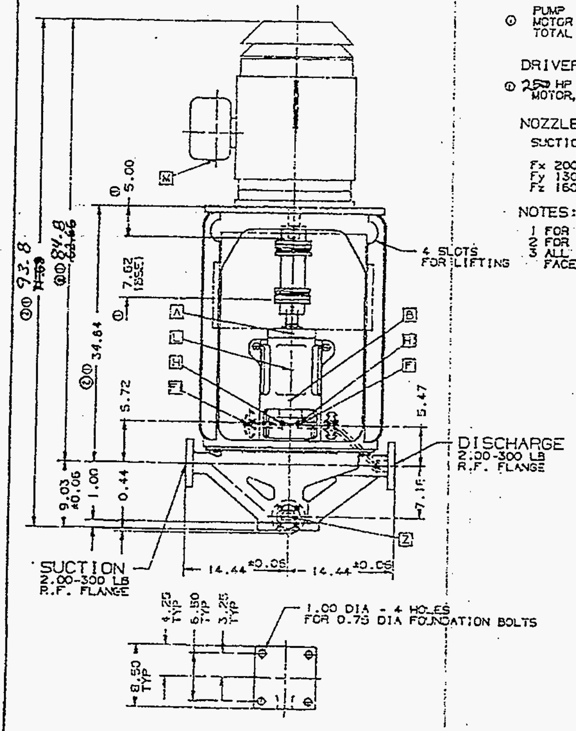
SUCTION & DISCHARGE

Fx	200 LBS.	Mx	340 FT-LBS.
Fy	130 LBS.	My	250 FT-LBS.
Fz	160 LBS.	Mz	170 FT-LBS.



NOTES:

1 FOR ASSEMBLY SEE DRAWING NO.C45010.
2 FOR PARTS LIST SEE "LIST OF COMPONENTS".
3 ALL FLANGE CONNECTIONS TO CONFORM TO A FACE FINISH OF 125 RMS.



NO.	BY	DATE	CHK.BY	DESCRIPTION
2	RM	[illegible]	BAM	DIM.S DECREASED 0.50
1	MQ	[illegible]	RAM	MOTOR WAS 325 HP FRAME

R REVISIONS

LAWRENCE PUMPS INC.

TRUE-LINE SERIES

PUMP SIZE: [illegible]
SERIES: 1400
MODEL: 14-4A
DR.BY: JJ
CHK.BY: RAM 11/28/88
APPV.BY:
DATE: 21 NOV 88

CUSTOMER:
PURCHASE ORDER NO.:
PUMP SERIAL NO.:
PUMP ITEM NO.:
CERTIFIED BY:
DATE:

PUMP ASSEMBLY:
PUMP PARTS LIST:

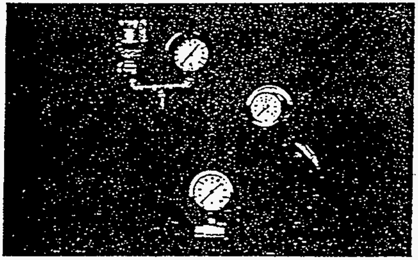
PUMP ELEVATION

DRAWING NO.: C 45011

Pressure Sensors

F-03-23

- Protects and isolates instrumentation
- Full 360° pressure reading
- Self cleaning, flexing action
- Won't clog like traditional diaphragm seals
- Excellent pump protection
- Accuracy, ±2% of installed instrument



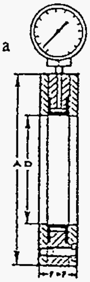
Materials of Construction

- Carbon Steel, Stainless Steel, or PVC body
- Sleeves available in Pure Gum Rubber, Neoprene, Hypalon, Chlorobutyl, Polyurethane, Buna-N, Viton and EPDM
- ANSI Class 150, 300, 600"

Red Valve's complete line of Pressure Sensors isolate and protect instrumentation from the process line, providing accurate, repeatable instrument measurement.

Reliable, accurate instrument readings are often difficult or even impossible to obtain on pipelines carrying slurries, solids, or chemical process slurries.

With Series 40 and 42 Pressure Sensors, line pressure is sensed 360° through the flexible rubber sleeve. The captive fluid is displaced through the pressure sensor body to the instrument's bourdon tube. Instruments are isolated and protected from the process assuring positive and accurate readings..



The thru-bolted Series 40 can be mounted in any flow direction, submerged in a tank, or mounted with a blind flange as a dead end to monitor tank levels.

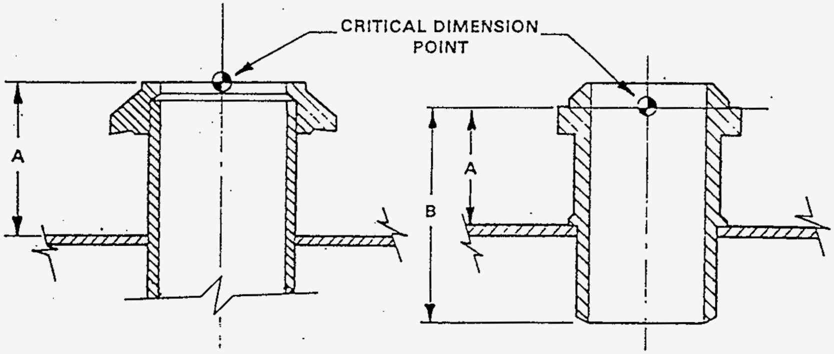
The threaded end model Series 42 is available in sizes 1/2"-2".

Two Pressure Sensors with a differential pressure switch can be used to monitor pressure drop across a filter or pump. They can also be used to send a signal to shut a pump or open a by-pass valve.

Series 40

VALVE SIZE D	LENGTH F to F	BODY O.D. A	WORKING PRESSURE (psi)	VALVE WEIGHT (lbs)
1"	1-7/8"	4-1/2"	200	6
1-1/2"	1-7/8"	5"	200	8
2"	1-7/8"	6"	200	12
2-1/2"	1-7/8"	7"	200	16
3"	1-7/8"	7-1/2"	200	18
4"	2-1/8"	9"	200	27
5"	2-1/4"	10"	200	32
6"	2-1/4"	11"	200	37
8"	2-1/2"	13-1/2"	200	58
10"	2-3/4"	16"	200	79
12"	3"	19"	200	125
14"	3"	21"	200	157
16"	3"	23-1/2"	200	190
18"	3"	25"	200	250
20"	3"	27-1/2"	200	185
24"	3"	32"	200	220

8.3 PUREX and Hanford Nozzle



HANFORD NOZZLE

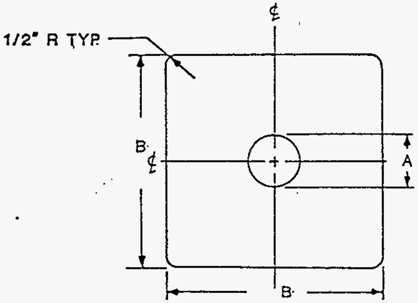
PUREX NOZZLE

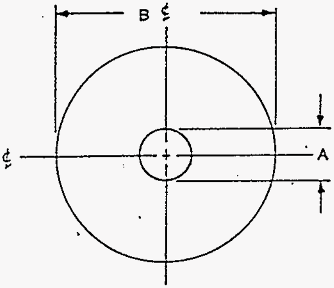
Size	Type	A	B	Weight (lbs.)	Drawing No.
2"	Hanford	3-5/8		5	H-2-32705-9
3"	Hanford	3-5/8		3.5	H-2-32705-8
4-Way	Hanford	3-5/8		6	H-2-32705-*
1"	Purex	1-7/8		1.5	H-2-90184-2
2"	Purex	2-1/4	3-29/32	2.5	H-2-90185-2
3-Way	Purex	2-9/32		5	H-2-32447-1
3"	Purex	3	4-13/16	6.5	H-2-90186-2
4"	Purex	3-3/8	5-5/32	11	H-2-90187-2

*See Drawing for Dash Number.

4 13/16
3 9/16
3 [illegible]
11 3/4

8.4 .Kick-Off Plate





TYPE	SHAPE	SIZE	WT#	A	B	THK.	C.S. P.N.	SST. P.N.
PUREX	SQ.	1	4	1-25/32	6-1/4	3/8	H-2-30600-2	H-2-30600-1
PUREX	SQ.	2	3.5	2-21/32	6-1/4	3/8	H-2-30600-4	H-2-30600-3
PUREX	SQ.	3	12	3-25/32	11	3/8	H-2-30600-6	H-2-30600-5
PUREX	SQ.	4	16.5	4-27/32	13	3/8	H-2-30600-8	H-2-30600-7
PUREX	RD.	1	3	1-25/32	6	3/8	H-2-3194-1 TYPE II	H-2-3194-1 TYPE I
PUREX	RD.	2	2.5	2-21/32	6-1/4	3/8	H-2-3194-2 TYPE II	H-2-3194-2 TYPE I
PUREX	RD.	3	9	3-25/32	11	3/8	H-2-3194-3 TYPE II	H-2-3194-3 TYPE I
PUREX	RD.	4	12.5	4-27/32	13	3/8	H-2-3194-4 TYPE II	H-2-3194-4 TYPE I
HANFORD	SQ.	2	12.5	2-7/16	11	3/8	H-2-74755-11	H-2-74755-1
HANFORD	SQ.	3	12	3-9/16	11	3/8	H-2-74755-12	H-2-74755-2
HANFORD	SQ.	4-WAY	13	?	11	3/8	H-2-74755-?	H-2-74755-?
HANFORD	RD.	2	9.5	2-7/16	11	3/8	H-2-74755-16	H-2-74755-6
HANFORD	RD.	3	9	3-9/16	11	3/8	H-2-74755-17	H-2-74755-7
HANFORD	RD.	4-WAY	10	?	11	3/8	H-2-74755-?	H-2-74755-?

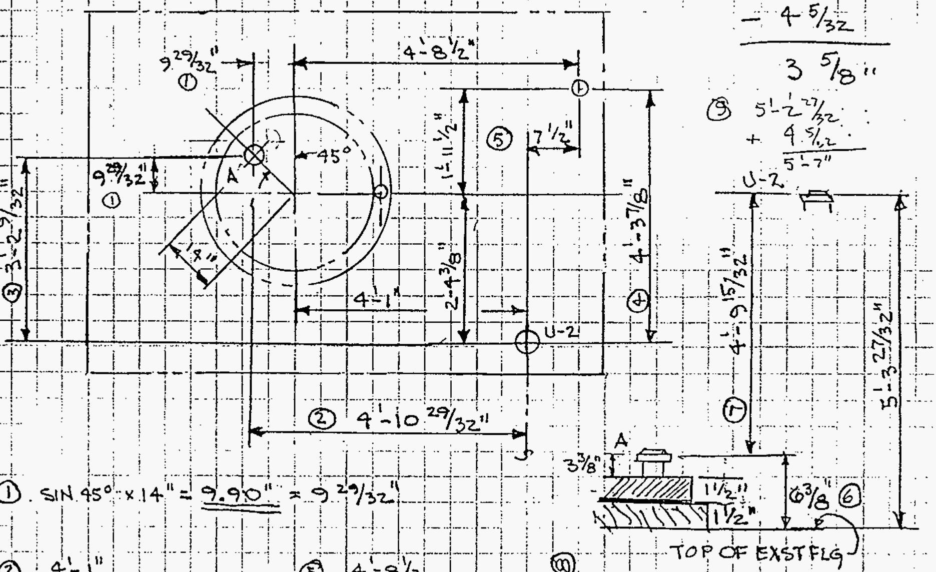
KAISER ENGINEERS
HANFORD

DESIGN ANALYSIS

Calc. No.
Revision 0
Page No. 1 of 1

Client WHC
WO/Job No. W-320 /
Subject JUMPER CRITICALS FOR H-2-818503
Date 6-20-95 By D. PECK.
Checked By
Location SLUCE PIT 241-AY-02E
Revised By

REF: H-2-818543, SH1 (REVIEW 14)
H-2-818494, SH1 (REVIEW 14)
H-2-818498 SH 1 (REVIEW 15)
H-2-818499, SH 2 (REVIEW 8)



⑧ 5'-11 5/8" − 5'-3 27/32" = 7 25/32
20/32, 52, −27, 25
7 25/32 − 4 5/32 = 3 5/8"

⑨ 5'-2 27/32 + 4 5/32 = 5'-7"

① SIN 45° × 14" = 9.90" = 9 29/32"

② 4'-1" + 9 29/32" = 4'-10 29/32"

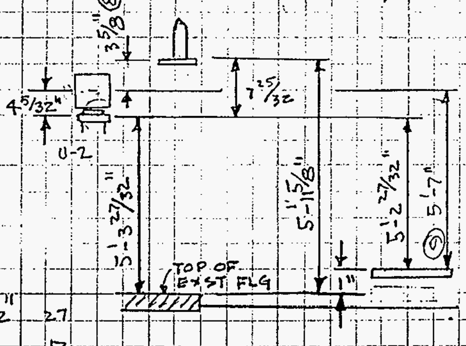
③ 2'-4 3/8 + 9 29/32" = 3'-2 9/32
12 + 29 = 41, −32 = 9.

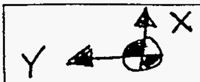
④ 2'-4 3/8 + 1'-11 1/2 = 4'-3 7/8

⑤ 4'-8 1/2 − 4'-1" = 7 1/2"

⑥ 3 3/8" + 1 1/2" + 1 1/2" = 6 3/8"

⑦ 5'-3 27/32" − 6 3/8 = 4'-9 15/32"
15, 27, 12, 15





KAISER ENGINEERS HANFORD

JUMPER CALCULATION

JOB NO. ER4319	DWG. NO. H-2-818503	DATE 6-13-95	PAGE 4/4
BLDG. NO. 241-AY		BY BAM	CHKD.

β — PN 8L

72.0 Y

X

PART	DESCRIPTION	WEIGHT LBS.	X - X AXIS		Y - Y AXIS	
			MOM. ARM IN.	MOMENT IN. LBS.	MOM. ARM IN.	MOMENT IN. LBS.
A	2" BLK CONN	86.98	2,187	157 ~~190,22~~	19,62	~~1706,55~~ 191
B	2 BARS	2,03	48	97,44	12,87	26,12
C						
D						
E						
F						
G		4297		127796		62380
H	SH 3/4	< ~~4277,62~~ >		< 127341,33 >		< ~~61056,82~~ >
J						
K	8x8x1/2 ?	9,09	31,5	286,33	12,87	116,99
L						
M						
N						
P						
Q						
R						
S						
T						
U		4380				
V		~~4378~~		128238		65373

ΣW = ~~4375,72~~

ΣMx = ~~127915.32~~

ΣMy = ~~62906.48~~

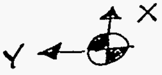
$\bar{x} = \frac{\Sigma Mx}{\Sigma W} =$ 29,239 → 29 1/4 29.27"

$\bar{y} = \frac{\Sigma My}{\Sigma W} =$ 14,376 14.92" 14 3/8"

	COEFF. OF. EXP. / °F	Δt °F	ΔX		ΔY		ΔZ	
			EXPANDING LENGTH	EXPANSION	EXPANDING LENGTH	EXPANSION	EXPANDING LENGTH	EXPANSION
JUMPER								
VESSEL								
DUNNAGE								
TOLERANCE								
			ΔX =		ΔY =		ΔZ =	

KEH-63 (3-82)

* 2" CONN, SEE SH 4/4



KAISER ENGINEERS HANFORD

JUMPER CALCULATION

JOB NO. ER4319	DWG. NO. H-2-818503	DATE 6-9-95	PAGE 1/4
BLDG. NO. 241-AY		BY BAM	CHKD. D. PECK

	PART	DESCRIPTION	WEIGHT LBS.	Y X – X AXIS MOM. ARM IN.	MOMENT IN.LBS.	X Y – Y AXIS MOM. ARM IN.	MOMENT IN. LBS.
U-2	A	4" ~~HORIZ~~ VERT CONN	120	0	0	0	0
A	B	4" ~~HORIZ~~ VERT CONN	120	38,25	4590,0	58,87	7064,4
* B	C	2" MALE CONN	2,5	0	0	18,37	45,92
	D	2" KP (Round)	2,5	0	0	18,37	45,92
* ↑	E	4" PIPE (14 3/16")	12,87	48.62	625,74	58,87	757,65
↓ →	F	4" PIPE 2'-7 3/8"	28.2	55,37	1561,43	43,19	1217,96
→	G	4" x 2" RDCR	3	55,37	166,11	25,5	76,5
ADD ~~5~~ 9# →	H	2" FLG					
FOR STUDS →	J	2" FLG	36	55,37	~~1716,47~~	19,69	~~610~~,39
& NUTS →	K	PRES IND	36		1993		709
1 →	L	PRES GAGE					
→	M	2" PIPE 3"	,91	54,25	49,37	14.37	13,07
↓		2" PIPE 6 15/16	2,1	52.31	109,85	12,87	27,03
↓	P	2" FLG 9	18	31,5	~~567~~	12,87	~~231,66~~
Pu1 ↓	Q	2" FLG 9	23	~~2~~	725		296
↓	R	2" x 4" ROCR	3	12,19	36,57	12.87	38,61
↓	S	4" PIPE 10 1/4"	9,21	5,12	47,15	12,87	118,53
⊙	T	4" PIPE 6"	5,39	0	0	12,87	69,37
25 ea ⊙	U	(2) 4" FLG	50 - 60	0	0	12,87	~~643,5~~ 77
⊙	V	PRES IND	27	0	0	12,87	347,49

ADD 10# FOR STUDS, NUTS

ΣW = 435,68
455.68

ΣMx = 9469,69
9924

ΣMy = 11308.0
11601

$\bar{x} = \frac{\Sigma Mx}{\Sigma W} =$

$\bar{y} = \frac{\Sigma My}{\Sigma W} =$

	COEFF. OF. EXP. / °F	Δt °F	ΔX EXPANDING LENGTH	ΔX EXPANSION	ΔY EXPANDING LENGTH	ΔY EXPANSION	ΔZ EXPANDING LENGTH	ΔZ EXPANSION
JUMPER								
VESSEL								
DUNNAGE								
TOLERANCE								
			ΔX =		ΔY =		ΔZ =	

KEH-63 (3-82)

KAISER ENGINEERS
HANFORD

JUMPER CALCULATION

JOB NO. ER4319	DWG. NO. H-2-818503	DATE 6-9-95	PAGE 2/4
BLDG. NO. 241-AY		BY BAM	CHKD.

PART	DESCRIPTION	WEIGHT LBS.	X - X AXIS (Y) MOM. ARM IN.	X - X AXIS MOMENT IN.LBS.	Y - Y AXIS (X) MOM. ARM IN.	Y - Y AXIS MOMENT IN. LBS.
A	PRES GAGE	1	0	0	12.87	12.87
B	4" PIPE 14 1/8"	12.7	0	0	12.87	163.45
C	FLOW METER	35	0	0	12.87	450.45
D	4" FLG (2)	50 60	0	0	12.87	~~643.5~~
E	4" PIPE 14 1/4"	12.8	0	0	12.87	164.73
F	4" PIPE 9 11/16"	8.71	0	0	8.0	69.68
G	2" PIPE 3 1/4"	.99	0	0	16.75	16.58
H	2" PIPE 3"	.91	0	0	18.37	16.71
J	PUMP W/MTR	3500	31.5	110250.0	12.87	~~45046.~~ ~~[illegible]~~
K		455.68		9924		11601
L	SH 1	(~~435.68~~)		(~~9469.69~~)		(4308.0
M		~~[illegible]~~				
N						
P						
Q						
R						
S						
T						
U						
V						

25cu

NOZ

$\Sigma W =$ ~~4057.79~~ 4077.79

$\Sigma Mx =$ ~~119719.69~~ 120174

$\Sigma My =$ ~~57890.9~~ 58312

$\bar{x} = \frac{\Sigma Mx}{\Sigma W} = 29.50$

$\bar{y} = \frac{\Sigma My}{\Sigma W} = 14.266$

	COEFF. OF. EXP. / °F	Δt °F	ΔX EXPANDING LENGTH	ΔX EXPANSION	ΔY EXPANDING LENGTH	ΔY EXPANSION	ΔZ EXPANDING LENGTH	ΔZ EXPANSION
JUMPER								
VESSEL								
DUNNAGE								
TOLERANCE								
			$\Delta X =$		$\Delta Y =$		$\Delta Z =$	

Y

HANFORD

JUMPER CALCULATION

JOB NO. ER4319	DWG. NO. H-2-818503	DATE 6-11-95	PAGE 3/4
BLDG. NO. 241-AY		BY BAM	CHKD.

	PART	DESCRIPTION	WEIGHT LBS.	X – X AXIS (Y) MOM. ARM IN.	MOMENT IN.LBS.	Y – Y AXIS (X) MOM. ARM IN.	MOMENT IN. LBS.
L	A	W4x13	60,7	50,75	3080,5	12,87	781,21
R	B	W4X13	60.7	12,25	743,57	12.87	781,21
L	C	1½ Φ BAR	2,4	50,75	121,8	12,87	30,89
R	D	1½ Φ BAR	2.4	12,25	29,4	12.87	30.89
	E	MTR RING	30,20	31,5	951,3	12,87	389 ~~405,40~~ -16
	F	C3x4,1	3,03	47.69	144,5	-,25	-~~.75~~.075 +.75
	G	C3x4.1	3,03	44,62	135,2	-2,62	-7,94
	H	C3x 4,1	23,2	48	1113,6	25 36	~~580,0~~835
	J	SUPPORT	5,5	46.87	257,78	58,87	323,78
L	K	2 BARS 2¼x⅜	,79	47,94	37,87	12,87	10,17
R	L	" "	,79	15,06	11,9	12,87	10,17
	M	~~BAR~~ PLATE 3/8" THK	1,52	51,87	78,84	-7,5	-11,4
	N	~~BAR~~ PLATE 3/8	1,2	49.75	59,7	-5,37	-6,4
L	P	2" FLG BKT	6.04	47,06	284,24	12,87	77,73
R	Q	2" FLG BKT	6,04	15.87	95,85	12,87	77,73
R	R	2 BARS	2,03	15,19	30,83	12,87	26,12
	S	Mounting PL	10,26	31,5	323,19	12,87	132,04
	T		<219,83>		<7621,64>	4060	<~~3165,85~~>
	U	SH 2 OF 3	4077 ~~4057,79~~	120174	~~119719,69~~	58320	~~57890,97~~
	V						

ΣW = ~~4277,62~~ 4297

ΣMx = ~~127341,33~~ 127795

ΣMy = ~~61056,82~~ 62380

$\bar{x} = \frac{\Sigma Mx}{\Sigma W} = 29,769$ CA 29¾"

$\bar{y} = \frac{\Sigma My}{\Sigma W} = 14,273$ 1'-2¼"

	COEFF. OF. EXP. / °F	Δt °F	ΔX EXPANDING LENGTH	ΔX EXPANSION	ΔY EXPANDING LENGTH	ΔY EXPANSION	ΔZ EXPANDING LENGTH	ΔZ EXPANSION
JUMPER								
VESSEL								
DUNNAGE								
TOLERANCE								
			ΔX =		ΔY =		ΔZ =	

KEH-63 (3-82)

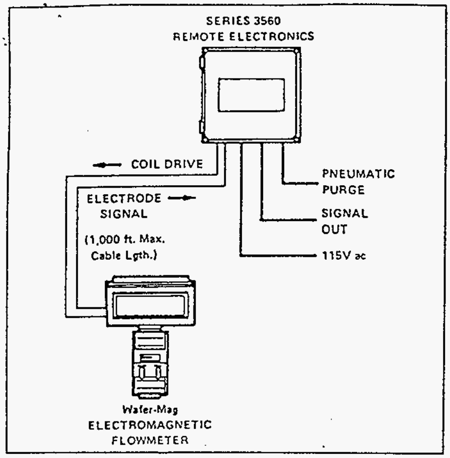


Figure 4 Typical Installation — Series 3560 Remote Electronics With Wafer-Mag Magnetic Flowmeter

3. For accurate operation, it is mandatory that the flowmeter be installed so that the flow tube will be completely full of process liquid under all operating conditions. When the meter is only partially filled, even though the electrodes are covered, an inaccurate measurement will result. Refer to Figure 5.

   It is desirable that the meter be installed in a vertical pipe run with flow upward, refer to Figure 6. In slurry applications, the vertical position insures a more even distribution of solids under all flow conditions and minimizes the chances of suspended solids adhering to the flow tube.

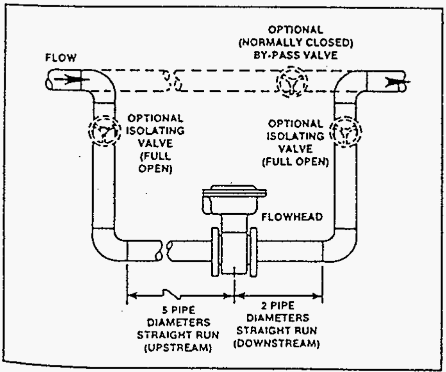


Figure 5 Horizontal Installation Piping (Meter shown In Optional Line Drop)

4. The position of the flow tube in relation to other devices in the system is also important in assuring system accuracy. Any upstream tee, elbows, valves, etc., should be placed at least five pipe diameters from the flowhead to minimize any obstructions or flow disturbances.

Liquid Flow Characteristics

The characteristics of the liquid to be metered, the liquid flow parameters and the environment of the meter are determining factors in the accuracy of a particular meter.

1. Conductivity - electrical conductivity is simply a way of expressing the ability of a liquid to conduct electricity. Just as copper wire is a better conductor that steel wire, some liquids are better conductors than others. Of even greater importance, however, is the fact that some liquids have little or no conductivity.

   The conductivity of a metered liquid must be at least 3 micromhos/cm for use with the flowmeter. The conductivity of the liquid can change throughout the process operation as long as it is homogenous and remains above the 3 micromhos/cm threshold.

2. Acids/Caustics - the chemical composition of the product to be measured must be compatible with the meter liner and electrodes to assure maximum service life from the meter.

   Refer to a publication such as the Corrosion Survey, National Association of Corrosion Engineers, etc., to determine the compatibility of the liner with the process liquid. Many process slurries or liquids are designated by a generic name but may contain other

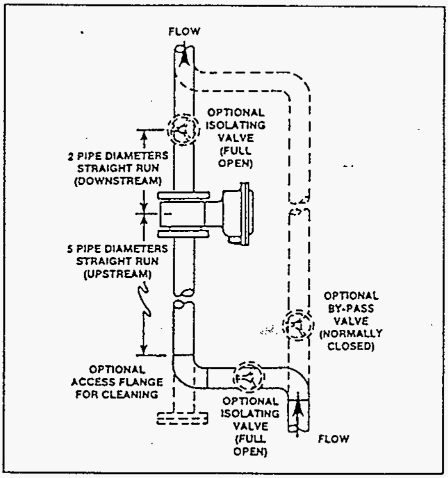


Figure 6 Vertical Installation

ORDERING INFORMATION

1. Meter Size
2. Liner Material*
3. Electrode Material
4. Pressure and Temperature Requirements (Ambient and Process)
5. Flow Rate (Normal, Maximum, Minimum)
6. Electrical Requirements
7. Output(s) Required
8. Liquid to be metered (name, conductivity)
9. Meter Orientation (horizontal or vertical).
10. Accessories Required

* See Wafer Mag Model Code Table 6.

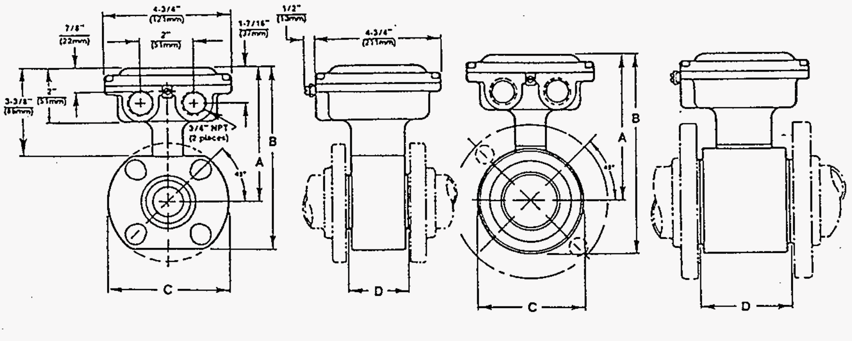
Purchase Specification

The magnetic flowmeter shall be of the wafer body construction utilizing the pulsed direct current field coil excitation to eliminate manual zero verification.

The flowmeter transmitter shall produce an output signal of 0-10 kHz proportional to flow rate and provide a factored and/or scaled pulse output. Factoring, to convert to engineering unit output (gpm, liters per minute, m³/hr. etc.), is accomplished by dividing the pulse output frequency by 1.000 to 15.000 using direct reading detent switches (1.000 to F.000). Scaling is accomplished by setting a field selectable DIP switch for divide by 1, 10, 100, 1,000 or 10,000.

Table 5 Dimensions (Meter Sizes 0.15" through 8") with Remote Electronics

Meter Size		Flange Size		A		B		C		D	
Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
0.15	4	1/2	15	4-15/16	125	6-3/8	162	3-9/16	90	2-3/16	56
0.30	8										
1/2	15										
1	25	1	25	9	132	6-15/16	176	4-1/2	114	2-3/16	56
1-1/2	40	1-1/2	40	9	133	6-7/8	175	3-1/4	83	2-3/4	70
2	50	2	50	9-5/16	141	7-1/2	191	3-7/8	98	3-1/4	83
3	76	3	76	9-15/16	157	8-3/4	222	5-1/8	130	4-11/16	119
4	102	4	102	10-5/8	175	10-1/8	257	6-1/2	165	5-7/8	149
6	152	6	152	11-11/16	202	12-1/4	311	8-9/16	218	6-7/8	175
8	203	8	203	12-3/4	229	14-3/8	365	10-11/16	272	8-7/8	225



.15" - 1"

1 1/2" - 8"

Figure 8 Dimensions (Meter Sizes 0.15" through 8") with Remote Electronics

Table 6 Wafer-Mag Electronics — Outputs, Performance Options

Outputs, Performance Options		Electronics Model			
		Integral Series III	Remote 3560 CRE Series III	3570 Integral/Remote (MagLite)	3580 SMART
Accuracy:	±0.5% Rate	Yes	Yes	Optional	Yes
	±1% Rate 0.5% Optional	N/A	N/A	Yes	N/A
Output Range: (For above stated accuracy)	1-10 m/Sec.	Yes	Yes	Yes	
	1-10 ft/Sec.	Yes	Yes	N/A	N/A
	1-30 ft/Sec.	N/A	N/A	N/A	Yes
Electrical Outputs:	4-20 mA Analog	Yes	Yes	Yes	Yes
	0-20 mA Analog	Yes	Yes	Yes	N/A
	0-10 kHz Unfactored	Note (3)	Note (3)	Yes	N/A
	0-10 kHz Scaled	Yes	Yes	N/A	N/A
	0-1 kHz Scaled	Note (2)	Note (2)	N/A	Yes
Repeatability:	0.25% Rate	Yes	Yes	Yes	0.2%
Power Consumption:	less than 15 Watts	Yes	Yes	Yes	
	less than 20 Watts				Yes
Input Voltage: (Note 1)	10-30 Vdc	Yes	Yes	Yes	N/A
	115 Vac 50-60 Hz	Yes	Yes	Yes	Yes
	220 Vac 50-60 Hz	Yes	Yes	Yes	N/A
Communications:	Hart Protocol	N/A	N/A	N/A	Yes
Bi-Directional Flow Option:		N/A	Yes	N/A	Standard
Integral Mounting:		Yes	No	N/A	Note 4
Remote Mounting:		No	Yes	N/A	Yes
Universal:	Integral/Remote	No	No	Yes	No
Class I, Division 2, NEMA 4X (FM Approved)		Yes	Yes	Yes	Yes
Features:		Most Flexible Integral	Most Flexible Remote	Best Value All Flowheads	All Flowheads Digital Keypad Micro Processor

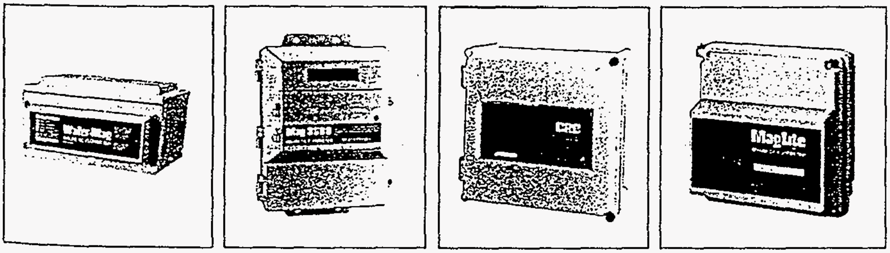
NOTES:

(1) Series III Integral and 3560/3570 have jumper-selected power inputs 10-30 Vdc 115 Vac and 230 Vac.

(2) Can use divide-by 10 scaler function to reduce 10 kHz to 1,000 Hz.

(3) 0-10- kHz unfactored output when factor option board is removed (two-board module).

(4) Integral mounting with adaptor



The Series III Integral Electronics represents the most versatile unit in the Brooks family of Mag electronics. Multitude of user-selectable output signals.

The newest member of the Brooks group is the Model 3580 "Smart" Electronics. This microprocessor-based magnetic flow transmitter offers keypad entry and display of selectable information, aids in flow-tube and transmitter testing and provides diagnostic helps in operation and maintenance of the system and communications.

The Model 3560 Complete Remote Electronics "CRE" eliminates the need for supplying line voltage at the flowmeter elements and allows for convenient, accessible location. It can be mounted up to 1,000 feet from the flowmeter and offers many selectable features. (Models 3561, 3562, 3563 and 3564.)

The Model 3570, possibly Brooks' best value in electronic instrumentation, is used on all flowheads 0.15" - 8" and exclusively on the MagLite. Mounting may be integral or remote.

Figure 9 Wafer-Mag Electronics

RED VALVE
Pressure Sensors

SERIES 40

RED VALVE PRESSURE SENSORS provide a full 360° circumferential reading of line fluids, while isolating them from the gauge. The flexible rubber sleeve provides accurate pressure readings of slurries and other hard to gauge corrosive fluids. Plugging or chemical attack of the gauge is eliminated.

A full circumferential reading eliminates pressure reading changes from trapped air or sediment deposits in the line. Readings taken at one point with a pipe tap are prone to bridge or clog from sediment.

Accuracy is dependent on the gauge. Red Valve's standard gauge has an accuracy of 2%. Gauges with greater accuracy are also available.

Pressure sensors can be mounted in any flow direction. Flow pressure is transferred from the flexible rubber sleeve to the gauge through a captive fluid. The sensor cannot clog because there are no line obstructions inducing buildup. Build up is fully eliminated by the flexing action of the sleeve which can break off adhering substances.

Series 40 FLANGED SENSORS conform to ANSI #125 flange drilling specifications. Class #300, #600, #900, #1200 flanges are also available. The small liquid chamber eliminates inaccurate readings due to thermal expansion of the fluid. Large chamber volumes are available on request.

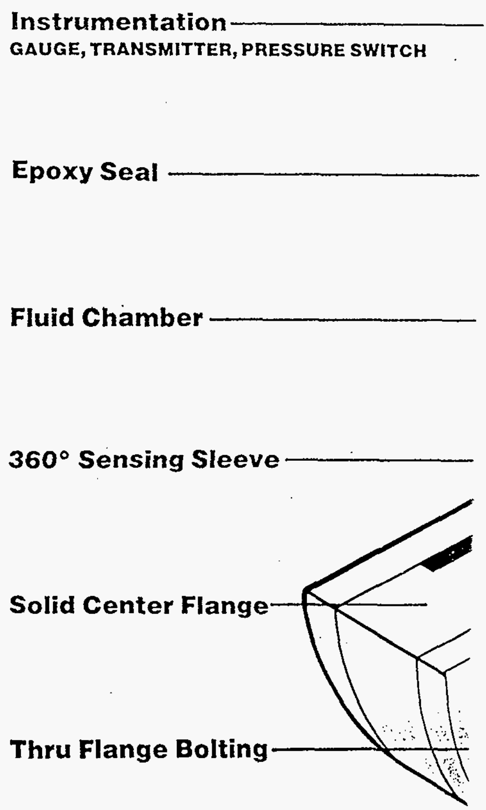
The Series 40 is bolted directly in the line during installation and removal, eliminating costly welding associated with diaphragm seals.

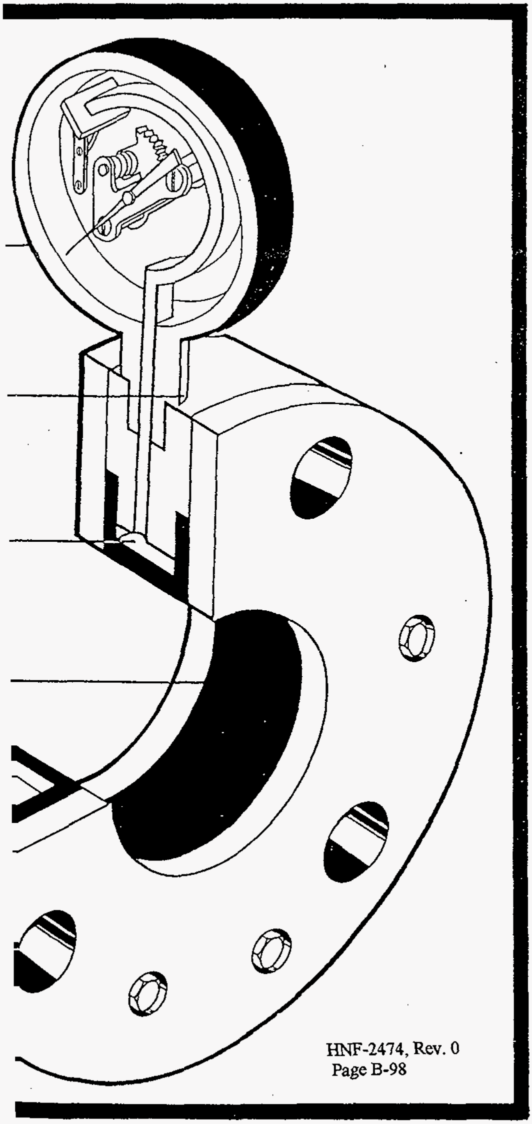
The Series 40 can be mounted in any flow direction or it can be mounted with a blind flange as a dead end. End flange mounting can monitor tank levels.

FEATURES The Standard Red Valve Series "40" Sensor is manufactured with a very small chamber for the sensing liquid (less than ¼ of cubic inch). The volume of liquid in the Sensor Body is kept at a minimum because the pressure reading of the Sensor is effected by the thermal expansion or contraction of the sensing liquid. If a larger volume is required for bellows type instrumentation, it can be furnished on request.

In many applications the process is brought from atmospheric to over 100 degrees. A large volume of sensing liquid would expand and cause an increase of pressure because of the thermal expansion of the sensing liquid.

Red Valve Series "40" Sensors have less than ¼ of a cubic inch of liquid.





EXCEPTIONS: WHEN USING INSTRUMENTATION THAT REQUIRES A LARGE VOLUME OF SENSING LIQUID AS NEEDED BY CERTAIN MAKES OF PRESSURE SWITCHES, DIFFERENTIAL PRESSURE METERS, ETC., USER SHOULD SPECIFIY THIS ON HIS PURCHASE ORDER. (We will then furnish a Sensor with a larger volume.)

EPOXY SEAL-FILL CONNECTION Red Valve Pressure Sensors are now being furnished with the **Cap Fill Connection** covered with an epoxy plastic seal. Precision workmanship and caution is exercised in filling the Pressure Sensors at the factory. All air pockets are removed with a vacuum pump after which the fill connection is sealed with a fill plug. The epoxy plastic over the hole makes the fill plug tamper-proof. The epoxy plastic can be chipped out very easily with a nail setting tool or drilled out if necessary in the future.

SOLID CONSTRUCTION Pressure Sensors are now being furnished with double the "holding screws" to hold the unit firmly together. This prevents overcompressing in installation which could change the pressure reading.

Full flange to the O.D. of the pipe guarantees that the Series 40 Sensor is centered when installed and makes installation easier, particularly for large diameter sensors.

THE CENTER FLANGE IS FURNISHED SOLID AT THE CIRCUMFERENCE TO PREVENT COMPRESSION.

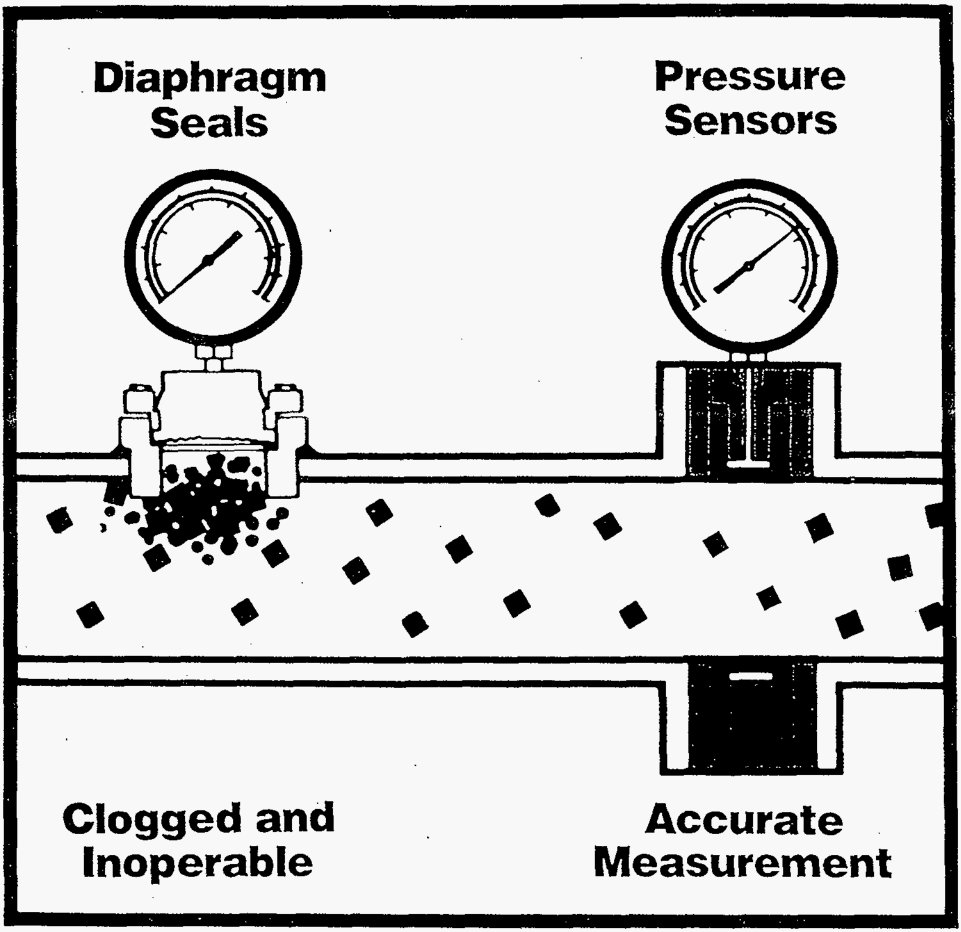
Filling Instructions Red Valve Pressure Sensors should be refilled with a vacuum pump after the instrument is assembled to assure that all air is removed from the cavity of the sensor and instruments. If the sensor can not be removed from the line or a portable vacuum is not available, the alternate method is to gravity fill the sensor.

Following are simple instructions:

Gravity fill the sensor and lightly tap it to eliminate air bubbles. The gauge can also be gravity filled or filled separately under vacuum in the instrument shop.

After the gauge is filled, a piece of Saran Wrap should be placed over the threads of the pressure gauge to keep the liquid in the gauge from spilling when the gauge is inverted to thread into the sensor. The Saran Wrap should be left on when inverting the sensor because the Saran Wrap breaks very easily when the gauge is threaded into the sensor. This will prevent fill liquid from dripping out.

Gravity fill is not as good as vacuum fill but if care is exercised, it can work.



Red Valve Pressure Sensors will not clog!

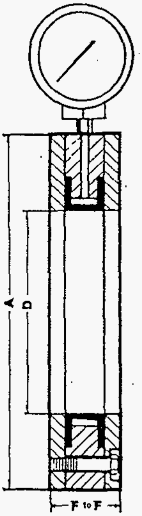
Assuring accurate measurement and dependable systems control.

GPS-501 3/85

Red Valve
Company, Inc.
P.O. Box 548 600 N. Bell Ave.
CARNEGIE, PA 15106
(412) 279-0044 Telex 86-6138
FAX (412) 279-7878

SPECIFICATIONS

SIZES Series 40 Pressure Sensors are available in sizes 1" to 48". Pressure Sensors have an inside diameter equal to Schedule 40 Pipe.



PRESSURES Standard operating pressures are equivalent to the pressure rating of the flange. Standard Series 40 Sensors are manufactured to A.N.S.I. Class 125/150 pound flange and bolting dimensions.

Sensors can be supplied with Class 300, 600, 900 and 1200 pound flanges with comparable pressure ratings of 740, 1480, 2220, and 2960 PSI. Higher pressure ratings up to 20,000 PSI with raised faces or ring-grooves are also available.

MATERIALS Standard body and end flanges are Carbon Steel. Optional Materials include Stainless Steel, P.V.C. and Teflon.

ACCURACY The accuracy is equal to the gauge installed on the sensor. A ±2% of the gauge reading is common with off-the-shelf gauges. Higher accuracy and sensitivity is obtainable with more precise instrumentation.

GAUGES All standard ranges are available. A 0-100 psi gauge is furnished as standard unless otherwise specified. 0-60 psi and 0-200 psi gauges are also furnished at no extra charge.

LIQUIDS Standard sensing liquid is a 50% mixture of ethylene glycol (anti-freeze) and water. Special fluids can be supplied on request.

Mineral Oil	220°F	Vegetable Oil	230°F
Distilled	200°F	Silicone Oil (FDA Approved)	450°F

ELASTOMERS The standard Sensing Sleeve material is Buna-N. Other materials available include Pure Gum Rubber, Neoprene, Butyl, Hypalon, EPT, Food Grade Rubber and TEFLON. Other elastomers are available on request.

SPECIFICATIONS FOR FLANGED PRESSURE SENSORS This specification covers; Pressure Sensors and Gauge Isolator devices designed for isolating pipeline flow media from a gauge or instrument. The Sensor shall be flanged and bolted directly into ANSI flanged pipelines. Face-to-face shall be no greater than a wafer style of a butterfly valve. The flanges shall have thru bolt holes to enable positive alignment in the pipeline. Inside diameter of the sensor shall be the same as the mating pipe with a full thru uninterrupted flow. There shall be no dead ends or crevices and flow passage shall make the sensor self-cleaning.

The Pressure Sensing Ring shall measure pressure for 360° around the full inside circumference of the pipeline. The sensing ring shall also be clamped into the body for the full radial width of the sensor. Pressure shall be transmitted to the gauge by a locked in and sealed fluid such as ethylene glycol or silicone oil. The Sensor shall have an auxiliary tapped and plugged port to allow filling connection of other equipment.

Red Valve Pressure Sensors are also available with capillary tubing for remote locations of instrumentation. Capillary tubing is available in various materials and sizes per your specifications. Red Valve can also fill and mount your instrumentation on our Pressure Sensors.

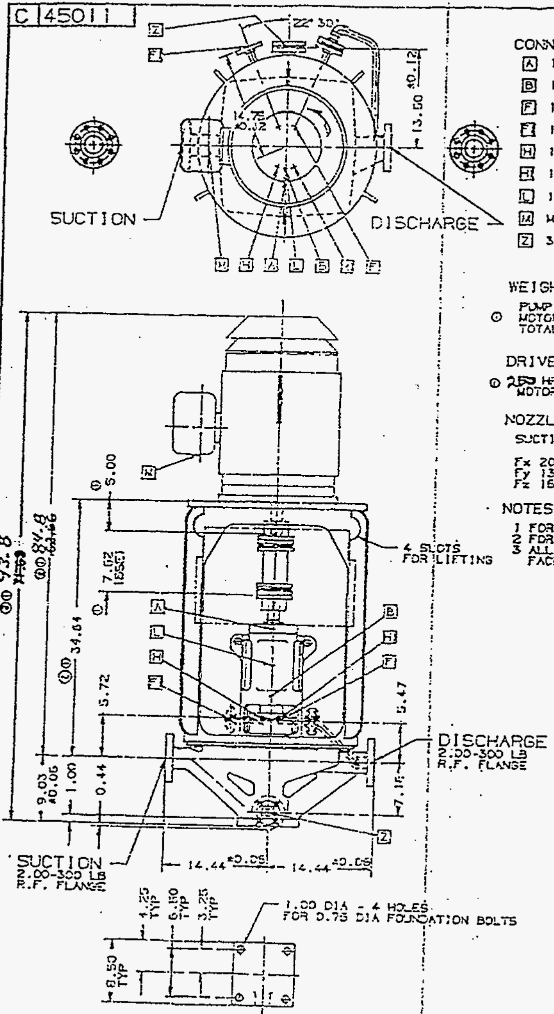
All Sensors shall be as the Series 40, as manufactured by the Red Valve Co., of Carnegie, PA, 600 N. Bell Ave.

SIZE "D"	LENGTH F TO F*	O.D. "A"	STEEL (LBS).
1"	1⅞"	4½"	6
1½"	1⅞"	5"	8
2"	1⅞"	6"	12
2½"	1⅞"	7"	16
3"	1⅞"	7½"	18
4"	2⅛"	9"	27
5"	2¼"	10"	32
6"	2¼"	11"	37
8"	2½"	13½"	58
10"	2¾"	16"	79
12"	3"	19"	125
14"	3"	21"	157
16"	3"	23½"	190
18"	3"	25"	250
20"	3"	27½"	185
24"	3"	32"	220
30"	3"	38¾"	295
36"	4"	46"	380
42"	4"	53"	475
48"	4"	59½"	610

F to F of Teflon Sensors is different.

® Teflon is Du Pont trademark for TFE flourocarbon resins

C 45011



CONNECTIONS:

- A 1/4-18 NPT - ALTERNATE LUBRICANT INLET TO THRUST BEARING (PLUGGED)
- B 1/4-18 NPT - OIL OUTLET FROM BEARING HOUSING
- F 1/2-14 NPT - INLET TO SEAL THRU API PLAN 11 FROM PUMP DISCHARGE
- E 1/2-300 LB. R.F. S.W. FLANGE - CASING VENT
- H 1/2-14 NPT - SEAL VENT
- H 1/2-14 NPT - SEAL DRAIN
- L 1/4-18 NPT - OIL MIST INLET TO BEARING HOUSING
- M MOTOR CONNECTION FOR POWER LEADS
- Z 3/4-300 LB. R.F. S.W. FLANGE - CASING DRAIN (COVERED WITH BLIND FLANGE)

WEIGHTS:

PUMP	800	LBS.
① MOTOR	2700 ~~[illegible]~~	LBS.
TOTAL	9500 ~~[illegible]~~	LBS. APPROXIMATE

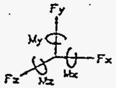
DRIVER DATA:

① 250 HP - 3600 RPM, T.E.F.C., VERTICAL ELECTRIC MOTOR, RELIANCE FRAME NO. 326TC

NOZZLE LOADS:

SUCTION & DISCHARGE

Fx 200 LBS.	Mx 340 FT-LBS.
Fy 130 LBS.	My 250 FT-LBS.
Fz 160 LBS.	Mz 170 FT-LBS.



NOTES:

1 FOR ASSEMBLY SEE DRAWING NO.C45010.
2 FOR PARTS LIST SEE "LIST OF COMPONENTS".
3 ALL FLANGE CONNECTIONS TO CONFORM TO A FACE FINISH OF 125 RMS.

NO.	BY	DATE	CHK.BY	DESCRIPTION
2	[illegible]	[illegible]	RAM	DIM.S DECREASED 0.50
1	MD	[illegible]	RAM	MOTOR WAS 325 HP FRAME

R SEVISIONS

LAWRENCE PUMPS INC.

TRUE-LINE SERIES

PUMP SIZE [illegible]
SERIES: 1400
MODEL: 14-4A
DR.BY: JJ
CHK.BY: RAM 11/28/88
APPV.BY:
DATE: 21 NOV 88

CUSTOMER:
PURCHASE ORDER NO.:
PUMP SERIAL NO.:
PUMP ITEM NO.:
CERTIFIED BY:

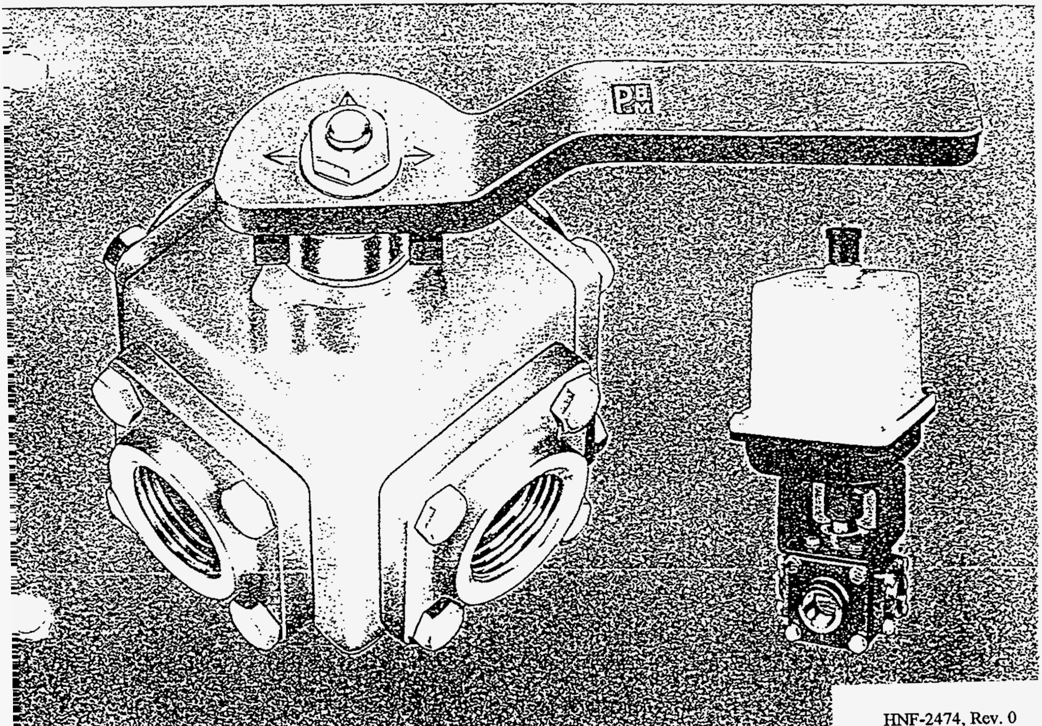
PUMP ASSEMBLY:
PUMP PARTS LIST:

PUMP ELEVATION

DRAWING NO.: C 45011

Multi-Port Ball Valves

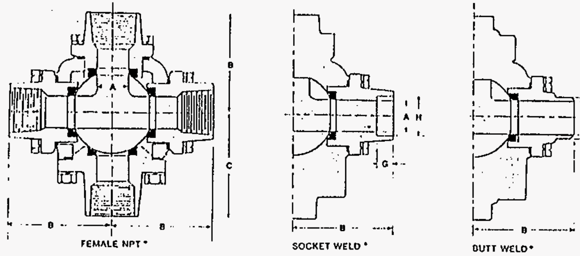
Three, Four, and Five-Way

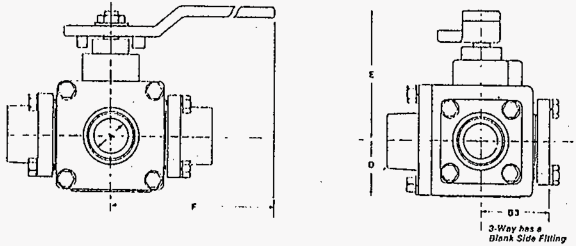


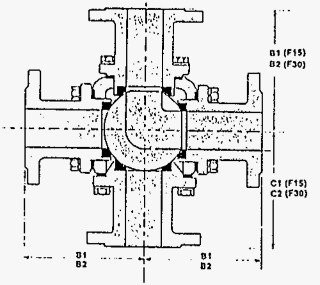
PBM, INC. • R.D. 6, BOX 387-A, Sandy Hill Road, Irwin, PA 15642-9407 • 412-863-0550 • FA

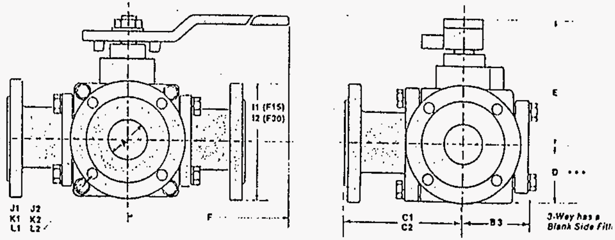
Dimensions for 3 & 4-Way MP

DRAWINGS ARE FOR ILLUSTRATION PURPOSES ONLY...
PLEASE CONSULT FACTORY PRIOR TO ANY FABRICATION OR INSTALLATION WORK









Female NPT • Socket • Butt Weld

PIPE SIZE (Inch)	A Port Dia.	B CL to Side Face	B3 CL to Blank Face	C CL to End Face	D Center to Bottom	E Center to Top	F Handle Length	G Socket Weld Depth	H Socket Weld Dia.	3-Way Wt. (Lbs.) S/S & C/S**
½"	.62"	2.00"	1.47"	2.00"	2.00"	4.56"	5.50"	.81"	.86"	8
¾"	.62"	2.00"	1.47"	2.00"	2.00"	4.56"	5.50"	.81"	1.06"	8
1"	1.00"	2.36"	2.00"	2.36"	1.56"	3.72"	6.00"	.94"	1.34"	12
1¼"	1.00"	2.38"	2.00"	2.38"	1.56"	3.72"	6.00"	.62"‡	1.69"	12
1½"	1.50"	3.28"	2.88"	3.28"	2.25"	5.17"	8.00"	1.16"	1.92"	28
2"	2.00"	3.88"	3.30"	3.88"	2.62"	5.61"	8.00"	1.12"	2.41"	40
3"	2.25"	5.53"	3.75"	5.53"	3.75"	9.56"	11.62"	1.88"	3.55"	65

*I Port shown. See Flow Charts, pages 5 & 6, for other possibilities.
**Weights for other metals and for 4-Way supplied upon request.
‡ NOT STANDARD BORE DEPTH.

150# RF Flange (F15)

PIPE SIZE (Inch)	A Port Dia.	B1 CL to Side	B3 Blank Side	C1 CL to End	D CL to Bottom	E CL to Top	I1 Flg. O.D.	F Handle Length	J1 Dia. B.C.	K1 No. Bolt Holes	L1 Bolt Dia.	3-Way Wt. (Lbs.)** S/S & C/S
1½"	1.50"	5.28"	2.88"	5.28"	2.25"	5.17"	5.00"	8.00"	3.88"	4	.50"	46
2"	2.00"	5.97"	3.30"	5.97"	2.62"	5.61"	6.00"	8.00"	4.75"	4	.62"	64
3"	2.25"	7.28"	3.75"	7.28"	3.75"	9.56"	7.50"	11.62"	6.00"	4	.62"	105
4"	3.00"	8.50"	5.00"	8.50"	5.00"	11.25"	9.00"	13.75"	7.50"	8	.62"	220

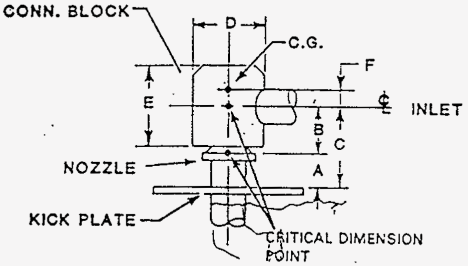
300# RF Flange (F30)

PIPE SIZE (Inch)	A Port Dia.	B2 CL to Side	B3 Blank Side	C2 CL to End	D CL to Bottom	E CL to Top	I2 Flg. O.D.	F Handle Length	J2 Dia. B.C.	K2 No. Bolt Holes	L2 Bolt Dia.	3-Way Wt. (Lbs.)** S/S & C/S
1½"	1.50"	5.41"	2.88"	5.41"	2.25"	5.17"	6.12"	8.00"	4.50"	4	.75"	57
2"	2.00"	6.09"	3.30"	6.09"	2.62"	5.61"	6.50"	8.00"	5.00"	8	.62"	76
3"	2.25"	7.47"**	3.75"	7.47"**	3.75"	9.56"	8.25"	11.62"	6.62"	8	.75"	117
4"	3.00"	8.81"	5.00"	8.81"	5.00"	11.25"	10.00"	13.75"	7.88"	8	.75"	252

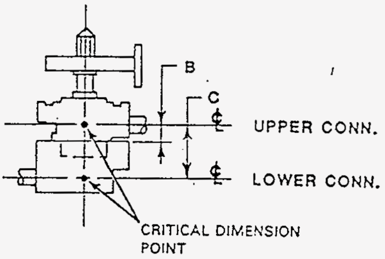
Note: Consult factory for 6" MP valve.

8.0 DESIGN DATA

8.1 PUREX Connector



PROCESS CONNECTOR



ELECTRICAL CONNECTOR

Connector Block		Dimensions (inches)						Horizontal		Vertical	
Size	Type	A	B	C	D	E	F	Weight (lbs.)	Drawing No.	Weight (lbs.)	Drawing No.
1	1 x 1	1-7/8	1-23/32	3-19/32	2-1/2	2-1/2		15.5	H-2-32410-1	15.5	H-2-32410-2
1	Blank	1-7/8	1-23/32	3-19/32	2-1/2	2-1/2		16	H-2-32410-3	16.5	H-2-32410-4
					.6875						
2	2 x 2	2-1/4	2-7/16	4-11/16	3-3/8	3-5/8	1-1/8	29	H-2-32420-1	29	H-2-32420-2
2	2 x 1½ Dip tube	2-1/4	2-7/16	4-11/16	3-3/8	3-5/8				29	H-2-32420-5
2	3 Way 3 1/2	2-9/32	2-13/32	4-11/16	3-3/8	3-5/8	1-1/8	31.5	H-2-32427-1	32	H-2-32427-2
2	Recirculation									31.5	H-2-32427-7
2	Thermowell	2-1/4	2-7/8	5-1/8	3-3/8					*	H-2-90154
2	Blank	2-1/4	2-7/8	4-11/16	3-3/8	3-5/8	1-1/8	32	H-2-32420-3	34.5	H-2-32420-4
					.5625						
3	3 x 3	3	3-9/13	6-9/16	5	5-9/16	1-7/16	76	H-2-32430-1	77	H-2-32430-2
3	3 x 2 Dip Tube	3	3-9/13	6-9/16	5	5-9/16				80	H-2-32430-5
3	2 x 3	3	3-9/13	6-9/16	5	5-9/16	1-7/16	76	H-2-32430-3	77	H-2-32430-4
3	2 x 2 Dip Tube	3	3-9/13	6-9/16	5	5-9/16				83	H-2-32430-6
3	3-Way 3 1/2	3	3-9/13	6-9/16	5	5-9/16				87.5	H-2-32437-1
3	Thermowell	3	3-9/13	6-9/16	5	5-9/16				*	H-2-90156
3	Blank	3	3-9/13	6-9/16	5	5-9/16	1-7/16	87.5	H-2-32430-7	93	H-2-32430-8
4	4 x 4	3-3/8	4-5/32	7-17/32	6-3/8	6-1/2	1-11/16	120	H-2-32440-1	122	H-2-32440-2
4	4 x 3 Dip Tube	3-3/8	4-5/32	7-17/32	6-3/8	6-1/2				126	H-2-32440-3
4	3 x 3 Dip Tube	3-3/8	4-5/32	7-17/32	6-3/8	6-1/2				131	H-2-32440-4
4	2 x 3 Dip Tube	3-3/8	4-5/32	7-17/32	6-3/8	6-1/2				135	H-2-32440-5
4	Blank	3-3/8	4-5/32	7-17/32	6-3/8	6-1/2	1-11/16	150	H-2-32440-6	153	H-2-32440-7
	Elec. Upper		1-11/16					56	H-2-32400-2	7-Point	
	Eqpt. Conn. Lower			5-19/32				29	H-2-32401-2	7-Point	
	Wall Conn. Lower			5-27/32					H-2-32408-1	7-Point	

*Establish Weight from Drawing

Author: Dianna L Stone at ~KEH10
Date: 06/25/96 03:18 PM
Priority: Normal
TO: Mohammed M Ahmed at ~WHC4
Subject: Datum

------------------------------------ Message Contents ------------------------------------

Hi Mo,

The top side of the plate to which the seismic restraint is welded is located 6' - 0 9/32" above the centerline of the Pump Discharge (shown as Detail 2, Lifting Frame Sub-Assy, on Dwg H-2-818508, Sht 2).

Hope that works for you.
Dianna

W320-27-017

Distributor Stress Analysis

KAISER ENGINEERS HANFORD

CALCULATION IDENTIFICATION AND INDEX

Page i of iii

Date

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27- Piping WO/Job No. ER4319 / W320 Calculation No. W320 - 27 - 017

Project No. & Name W320, 241-C106 Sluicing

Calculation Item Distributor Stress Analysis

These calculations apply to:

Dwg. No. H-2-818537 Rev. No. 0

Dwg. No. Rev. No.

Other (Study, CDR)

Rev. No.

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated)

☐ Void Calculation (Reason Voided)

Incorporated in Final Drawings? ☒ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	[illegible]		
Checked by	A. Ahmed 8-26-94		
Approved by	CD Jones 8/31/94		
Checked Against Approved Vendor Data	A. Ahmed 4.10.98		

CARROLL D. JONES

10/19/94

EXPIRES: 5/3/98

INDEX

Design Analysis Page No.	Description
i	Calculation Identification and Index
ii	Calculation Cross Index
iii	Design Verification Screening Criteria
1.	Objectives, Criteria, Given Data, Assumptions, Methods, References, Calculation
2.	Conclusions
Appendix A	Autopipe Analysis

KEH 0378.00 (06/92)

CALCULATION CROSS INDEX (Typical)

Subject Calculation No. D320-27-017

Page ii of iii

Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calculation/documents require revision?		Has the output interface calculation/documents been revised?		Discipline manager's signature and date indicating evaluation complete.
		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No	
0		H-2-818537	01	H-2-818537	01		X		X	D.L. Evans 7/16/98

SFS No. ______

DESIGN VERIFICATION SCREENING CRITERIA

Pg. iii of iii

Project/Document No. W320/W320-27-016

When the design or design change affects hardware, formal design verification must be performed if one or more of the following questions must be answered affirmatively (YES).

YES	NO	
	✓	1. Does the design or design change involved meet the established criteria to be considered Safety Class 1?
	✓	2. Does this design or design change cause or permit changes to Safety Class 1 instrument or alarm setpoints outside of previously approved operational limits?
	✓	3. Does this design or design change significantly affect the nuclear or environmental safety consequences of a malfunction or failure of the structure, system, or component?
	✓	4. Does this design or design change involve or change design that has previously undergone formal design verification?

Carroll D. Jones — 8/31/94

Assigned Lead Engineer — Date

Danny L. Evans — 4/28/98

Responsible Discipline Manager — Date

Original Design Package Distribution:

- Project Manager
- Design Verification Officer
- Engineering Document Control

Design Change Distribution:

- Attach to Engineering Change Notice

ICF Kaiser Hanford Company

DESIGN ANALYSIS

Calc. No. W320-27-17
Revision 0
Page No. 1 **of** 2

Client WHC
Subject Distributor Stress Analysis

Location: 241-AY-02

WO/Job No. ER4319/W320
Date 7-19-94 **By** Rodney Campbell
Checked 8-24-94 **By** Ahmed
Revised **By**

OBJECTIVE:

The objective of this calculation is to verify that the design of the distributor meets ASME B31.3 code stress requirements.

CRITERIA:

1. Functional Design Criteria WHC-SD-W320-FDC-001, Rev. 2.
2. ASME B31.3-1993, Chemical Plant and Petroleum Refinery Piping, With Addenda.

GIVEN DATA:

1. Specific Gravity of fluid: 1.25
2. Ambient temperature: 40°F.
3. Maximum temperature: 180°F.

ASSUMPTIONS:

1. The same volume of material flows throughs the four nozzles at the same velocity, causing static equilibrium.
2. There is no damping from the fluid in the tank, on the distributor during an earthquake.

METHODS:

1. Autopipe+ Version 4.50
2. Hand calculations

REFERENCES:

1. Drawing H-2-818537, Rev. 0.
2. ASME B31.3-1993, Chemical Plant and Petroleum Refinery Piping, With Addenda.

CALCULATION:

1. Calculate the Stress Intensification Factors of the tee required for the analysis. (Ref. 2, Appendix D, Unreinforced Fabricated Tee)

$T := .337 \cdot in$ Average wall thickness of pipe being welded to.

$r_2 := 2.25 \cdot in$ Radius of pipe being welded to.

$$h := \frac{T}{r_2}$$

$$h = 0.15$$

$$i_o := \frac{0.9}{h^{\frac{2}{3}}}$$ Out of plane Stress Intensification Factor.

$$i_o = 3.19$$

$$i_i := \frac{3}{4} \cdot i_o + \frac{1}{4}$$ In plane Stress Intensification Factor.

$$i_i = 2.64$$

According to the AutoPipe calculation (Appendix A), the piping meets ASME B31.3-1993. The piping system is built from 4", schedule 80 pipe and 2", schedule 80 nozzles.

ICF Kaiser Hanford Company

DESIGN ANALYSIS

Calc. No. W320-27-17
Revision 0
Page No. 2 **of** 2

Client WHC
Subject Distributor Stress Analysis

Location: 241-AY

WO/Job No. ER4319/W320
Date 7-19-94 **By** Rodney Campbell
Checked 8-24-94 **By** Ahmed
Revised **By**

CONCLUSIONS:

The distributor as designed meets ASME B31.3.

APPENDIX A

```
                  P O I N T   D A T A   L I S T I N G

POINT       -----OFFSETS (ft )-----
NAME  TYPE    X       Y       Z    PIPE ID  DESCRIPTION
----- ---- ------- ------- ------- -------- --------------------------------
*** SEGMENT A
A00   Run        0       0       0 4SCHED80
A01   Run        0   -2.54       0
A02   Tee        0  -35.15       0
A03   Run        0   -0.42       0

*** SEGMENT B
A02   Tee        0  -37.69       0 2SCHED80
B01   Run     0.50       0       0

*** SEGMENT C
A02   Tee        0  -37.69       0 2SCHED80
C01   Run    -0.50       0       0

*** SEGMENT D
A02   Tee        0  -37.69       0 2SCHED80
D01   Run        0       0    0.50

  * SEGMENT E
A02   Tee        0  -37.69       0 2SCHED80
E01   Run        0       0   -0.50

 Total weight of empty pipes : 595 lb
```

```
                 C O M P O N E N T   D A T A   L I S T I N G

POINT   ---COORDINATE(ft  )---  DATA
NAME      X       Y       Z     TYPE  DESCRIPTION
----- ------- ------- ------- ------ ----------------------------------------
*** SEGMENT A
A00      0.00    0.00    0.00 ANCHOR Rigid
                                      Thermal movements : None

A01      0.00   -2.54    0.00
A02      0.00  -37.69    0.00 TEE    Other
                                      SIF - In = 2.60, Out = 3.14

A03      0.00  -38.10    0.00

*** SEGMENT B
A02      0.00  -37.69    0.00 TEE    Other
                                      SIF - In = 2.60, Out = 3.14

B01      0.50  -37.69    0.00

*** SEGMENT C
A02      0.00  -37.69    0.00 TEE    Other
                                      SIF - In = 2.60, Out = 3.14

C01     -0.50  -37.69    0.00

  * SEGMENT D
A02      0.00  -37.69    0.00 TEE    Other
                                      SIF - In = 2.60, Out = 3.14

D01      0.00  -37.69    0.50

*** SEGMENT E
A02      0.00  -37.69    0.00 TEE    Other
                                      SIF - In = 2.60, Out = 3.14

E01      0.00  -37.69   -0.50


Number of points in the system : 12
```

```
 -----------------------------------------------------------------------------
W3202717  AY FARM DISTRIBUTOR ANALYSIS          ICF KAISER HANFORD COMPANY
08/11/94  W320 TANK 241-C-106 SLUICING ER4319   AutoPIPE+4.50 MODEL  PAGE   4
 -----------------------------------------------------------------------------


                    P I P E   D A T A   L I S T I N G

Pipe ID/      Nom/ O.D.  -----Thickness(inch)-----  Spec   Weight(lb/ft )
Material      Sch  inch  W.Th. Corr Mill Insu Ling  Grav  Pipe  Other Total
------------ ---- ----- ----- ---- ---- ---- ----  ----  ----- ----- -----
4SCHED80        4 4.500 0.337 0.06 0.04    0    0  1.25  15.33     0 21.56
A312-TP304L  80S

2SCHED80    2.000 2.375 0.218 0.06 0.03    0    0  1.25   5.14     0  6.74
A312-TP304L  80S
```

```
              M A T E R I A L   D A T A   L I S T I N G

 Material              Density  Pois. Temper. Modulus  Expans.   Allow.
   Name       Pipe ID  lb/cu.ft Ratio deg F   E6 psi   in/100ft  psi
------------ -------- -------- ----- ------- -------- -------- --------
A312-TP304L 4SCHED80     501.0  0.30    40.0    28.42            16700.0
                                       180.0              1.5442 16700.0

A312-TP304L 2SCHED80     501.0  0.30    40.0    28.42            16700.0
                                       180.0              1.5442 16700.0
```

```
                        TEMPERATURE AND PRESSURE DATA
      -----C A S E   1------  -----C A S E   2------  -----C A S E   3------
POINT PRESS. TEMPER  EXPAN.   PRESS. TEMPER  EXPAN.   PRESS. TEMPER  EXPAN.
NAME  psi    deg F  in/100ft  psi    deg F  in/100ft  psi    deg F  in/100ft
----- ------ ------ --------  ------ ------ --------  ------ ------ --------

*** SEGMENT A
A00      320    180    1.544
A03      320    180    1.544

*** SEGMENT B
A02      320    180    1.544
B01      320    180    1.544

*** SEGMENT C
A02      320    180    1.544
C01      320    180    1.544

*** SEGMENT D
A02      320    180    1.544
D01      320    180    1.544

*** SEGMENT E
  2      320    180    1.544
E01      320    180    1.544
```

```
                    A N A L Y S I S   S U M M A R Y


  Current model revision number : 32

    Static - Date and Time of analysis ............. Aug 11, 1994   7:03 AM
             Model Revision Number ................. 32
             Number of load cases .................. 3
             Load cases analyzed ................... GR T1 P1
             Gaps/Friction/Yielding considered ..... No
             Hanger design run ..................... No
             Cut short included .................... No
             Weight of contents included ........... Yes
             Pressure stiffening case .............. 0
             Water elevation for buoyancy loads .... Not considered

     Modal - Date and Time of analysis ............. Aug 11, 1994   7:03 AM
             Model Revision Number ................. 32
             Number of modes ....................... 2
             Cutoff frequency (Hz) ................. 33.0
             Weight of contents included ........... Yes
             Pressure stiffening case .............. 0
             Water elevation for buoyancy loads .... Not considered

  Response - Date and Time of analysis ............. Aug 11, 1994   7:04 AM
             Model Revision Number ................. 32
             Number of load cases .................. 3
             Load cases analyzed ................... R1 R2 R3
             Date and time of modal analysis ....... Aug 11, 1994   7:03 AM
             Number of modes ....................... 2
             Cutoff frequency (Hz) ................. 33.0
             Model revision of modal analysis ...... 32
             Weight of contents included ........... Yes
             Pressure stiffening case .............. 0
             Water elevation for buoyancy loads .... Not considered
```

```
                       CODE COMPLIANCE COMBINATIONS

   Combination  Category   Method     Load     Factor Allowable  Remarks
   -----------  ---------- -------- ---------- ------ ---------  -------
   GR + Max P   Sustain    Sum      Gravity      1.00 Automatic  Default
                                    Max Long     1.00

   Cold to T1   Expansion  Sum      Thermal 1    1.00 Automatic  Default

   Sus. + R1    Occasion   Abs sum  Response 1   1.00 Automatic  Default
                                    Max Sus      1.00

   Sus. + R2    Occasion   Abs sum  Response 2   1.00 Automatic  Default
                                    Max Sus      1.00

   Sus. + R3    Occasion   Abs sum  Response 3   1.00 Automatic  Default
                                    Max Sus      1.00

   Max P        Hoop                Max Hoop     1.00 Automatic  Default

   RTOTAL       Occasion   SRSS     Response 1   1.00 Automatic  User
                                    Response 2   1.00
                                    Response 3   1.00

               OTHER USER COMBINATIONS

   Combination  Method     Load     Factor  Remarks
   -----------  -------- ---------- ------  -------
   GR           Sum      Gravity      1.00  Default

   T1           Sum      Thermal 1    1.00  Default

   P1           Sum      Press 1      1.00  Default

   R1           Sum      Response 1   1.00  Default

   R2           Sum      Response 2   1.00  Default

   R3           Sum      Response 3   1.00  Default

   GR+T1        Sum      Gravity      1.00  User
                         Thermal 1    1.00

   RT           Abs sum  Response 1   1.00  User
                         Response 2   1.00
                         Response 3   1.00

   GR+T1+RT     Abs sum  GR+T1        1.00  User
                         RT           1.00
```

```
CODE COMPLIANCE

Y - Factor ............................ 0.40
Weld efficiency factor ................ 1.00
Range reduction factor ................ 1.00
Design Pressure Factor ................ 1.00
Minimum stress ratio used in reports... 0.00
Include corrosion in stress calcs. .... Y
Include torsion in code stress ........ N
Include axial force in code stress .... N
Longitudinal pressure calculation ..... PD/4t
Include rigorous pressure ............. N
```

```
   RESPONSE SPECTRUM LOAD CASES :
   ------------------------------

   Number of load cases analysed :  3

   Load case 1  -  R1

   Missing mass : No
   ZPA          : No

   Combination method : SRSS

   X- Spectrum : SC2&3
   Multiplier  :   1.00

   SC2&3

 Freq(Hz)  Grav(         )   Freq(Hz)  Grav(         )   Freq(Hz)  Grav(         )
 --------  -------------   --------  -------------   --------  -------------
   0.100           0.01      0.160           0.02      0.250           0.04
   0.400           0.06      0.600           0.09      1.100           0.17
   1.640           0.25      8.000           0.25     12.000           0.20
  20.000           0.16     33.000           0.12    100.000           0.12
```

```
   Load case 2  -  R2

   Missing mass : No
   ZPA          : No

   Combination method : SRSS

   Y- Spectrum : SC2&3
   Multiplier  :   1.00

   SC2&3

 Freq(Hz)  Grav(        )    Freq(Hz)  Grav(        )    Freq(Hz)  Grav(        )
 --------  -------------    --------  -------------    --------  -------------
   0.100           0.01       0.160           0.02       0.250           0.04
   0.400           0.06       0.600           0.09       1.100           0.17
   1.640           0.25       8.000           0.25      12.000           0.20
  20.000           0.16      33.000           0.12     100.000           0.12
```

```
    Load case 3   -   R3

    Missing mass : No
    ZPA          : No

    Combination method : SRSS

    Z- Spectrum : SC2&3
    Multiplier  :   1.00

    SC2&3

  Freq(Hz)  Grav(        )   Freq(Hz)  Grav(        )   Freq(Hz)  Grav(        )
  --------  -------------   --------  -------------   --------  -------------
    0.100           0.01      0.160           0.02      0.250           0.04
    0.400           0.06      0.600           0.09      1.100           0.17
    1.640           0.25      8.000           0.25     12.000           0.20
   20.000           0.16     33.000           0.12    100.000           0.12
```

```
                         D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )        ROTATIONS (deg  )
name    combination      X       Y       Z          X       Y       Z
------  -----------    ------  ------  ------     ------  ------  ------

*** Segment A  begin ***

A00     GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000   0.000   0.000      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000
        R1              0.000   0.000   0.000      0.000   0.000   0.000
        R2              0.000   0.000   0.000      0.000   0.000   0.000
        R3              0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1           0.000   0.000   0.000      0.000   0.000   0.000
        RT              0.000   0.000   0.000      0.000   0.000   0.000
        GR+T1+RT        0.000   0.000   0.000      0.000   0.000   0.000

A01     GR              0.000   0.000   0.000      0.000   0.000   0.000
        T1              0.000  -0.039   0.000      0.000   0.000   0.000
        P1              0.000   0.000   0.000      0.000   0.000   0.000
        R1              0.022   0.000   0.000      0.000   0.000   0.081
        R2              0.000   0.000   0.000      0.000   0.000   0.000
        R3              0.000   0.000   0.022      0.081   0.000   0.000
        GR+T1           0.000  -0.039   0.000      0.000   0.000   0.000
        RT              0.022   0.000   0.022      0.081   0.000   0.081
        GR+T1+RT        0.022   0.039   0.022      0.081   0.000   0.081

A02     GR              0.000  -0.002   0.000      0.000   0.000   0.000
        T1              0.000  -0.582   0.000      0.000   0.000   0.000
        P1              0.000  -0.005   0.000      0.000   0.000   0.000
        R1              3.286   0.000   0.000      0.000   0.000   0.624
        R2              0.000   0.000   0.000      0.000   0.000   0.000
        R3              0.000   0.000   3.286      0.624   0.000   0.000
        GR+T1           0.000  -0.584   0.000      0.000   0.000   0.000
        RT              3.286   0.000   3.286      0.624   0.000   0.624
        GR+T1+RT        3.286   0.584   3.286      0.624   0.000   0.624

A03     GR              0.000  -0.002   0.000      0.000   0.000   0.000
        T1              0.000  -0.588   0.000      0.000   0.000   0.000
        P1              0.000  -0.005   0.000      0.000   0.000   0.000
        R1              3.341   0.000   0.000      0.000   0.000   0.624
        R2              0.000   0.000   0.000      0.000   0.000   0.000
        R3              0.000   0.000   3.341      0.624   0.000   0.000
        GR+T1           0.000  -0.590   0.000      0.000   0.000   0.000
        RT              3.341   0.000   3.341      0.624   0.000   0.624
        GR+T1+RT        3.341   0.590   3.341      0.624   0.000   0.624

*** Segment A  end   ***

  * Segment B  begin ***
```

```
                        D I S P L A C E M E N T S

Point      Load            TRANSLATIONS (in  )           ROTATIONS (deg  )
name     combination        X       Y       Z           X       Y       Z
------   -----------      ------  ------  ------      ------  ------  ------
A02      GR               0.000  -0.002   0.000       0.000   0.000   0.000
         T1               0.000  -0.582   0.000       0.000   0.000   0.000
         P1               0.000  -0.005   0.000       0.000   0.000   0.000
         R1               3.286   0.000   0.000       0.000   0.000   0.624
         R2               0.000   0.000   0.000       0.000   0.000   0.000
         R3               0.000   0.000   3.286       0.624   0.000   0.000
         GR+T1            0.000  -0.584   0.000       0.000   0.000   0.000
         RT               3.286   0.000   3.286       0.624   0.000   0.624
         GR+T1+RT         3.286   0.584   3.286       0.624   0.000   0.624

B01      GR               0.000  -0.002   0.000       0.000   0.000   0.000
         T1               0.008  -0.582   0.000       0.000   0.000   0.000
         P1               0.000  -0.005   0.000       0.000   0.000   0.000
         R1               3.286   0.065   0.000       0.000   0.000   0.624
         R2               0.000   0.000   0.000       0.000   0.000   0.000
         R3               0.000   0.000   3.286       0.624   0.000   0.000
         GR+T1            0.008  -0.584   0.000       0.000   0.000   0.000
         RT               3.286   0.065   3.286       0.624   0.000   0.624
         GR+T1+RT         3.294   0.649   3.286       0.624   0.000   0.624

*** Segment B   end    ***

*** Segment C   begin ***

A02      GR               0.000  -0.002   0.000       0.000   0.000   0.000
         T1               0.000  -0.582   0.000       0.000   0.000   0.000
         P1               0.000  -0.005   0.000       0.000   0.000   0.000
         R1               3.286   0.000   0.000       0.000   0.000   0.624
         R2               0.000   0.000   0.000       0.000   0.000   0.000
         R3               0.000   0.000   3.286       0.624   0.000   0.000
         GR+T1            0.000  -0.584   0.000       0.000   0.000   0.000
         RT               3.286   0.000   3.286       0.624   0.000   0.624
         GR+T1+RT         3.286   0.584   3.286       0.624   0.000   0.624

C01      GR               0.000  -0.002   0.000       0.000   0.000   0.000
         T1              -0.008  -0.582   0.000       0.000   0.000   0.000
         P1               0.000  -0.005   0.000       0.000   0.000   0.000
         R1               3.286   0.065   0.000       0.000   0.000   0.624
         R2               0.000   0.000   0.000       0.000   0.000   0.000
         R3               0.000   0.000   3.286       0.624   0.000   0.000
         GR+T1           -0.008  -0.584   0.000       0.000   0.000   0.000
         RT               3.286   0.065   3.286       0.624   0.000   0.624
         GR+T1+RT         3.294   0.649   3.286       0.624   0.000   0.624

*** Segment C   end    ***

*** Segment D   begin ***
```

```
--------------------------------------------------------------------------------
W3202717  AY FARM DISTRIBUTOR ANALYSIS               ICF KAISER HANFORD COMPANY
08/11/94  W320 TANK 241-C-106 SLUICING ER4319        AutoPIPE+4.50 RESULT PAGE   9
  ------------------------------------------------------------------------------

                        D I S P L A C E M E N T S

Point     Load          TRANSLATIONS (in  )           ROTATIONS (deg  )
name     combination      X       Y       Z            X       Y       Z
------   -----------   ------  ------  ------       ------  ------  ------
A02      GR             0.000  -0.002   0.000        0.000   0.000   0.000
         T1             0.000  -0.582   0.000        0.000   0.000   0.000
         P1             0.000  -0.005   0.000        0.000   0.000   0.000
         R1             3.286   0.000   0.000        0.000   0.000   0.624
         R2             0.000   0.000   0.000        0.000   0.000   0.000
         R3             0.000   0.000   3.286        0.624   0.000   0.000
         GR+T1          0.000  -0.584   0.000        0.000   0.000   0.000
         RT             3.286   0.000   3.286        0.624   0.000   0.624
         GR+T1+RT       3.286   0.584   3.286        0.624   0.000   0.624

D01      GR             0.000  -0.002   0.000        0.000   0.000   0.000
         T1             0.000  -0.582   0.008        0.000   0.000   0.000
         P1             0.000  -0.005   0.000        0.000   0.000   0.000
         R1             3.286   0.000   0.000        0.000   0.000   0.624
         R2             0.000   0.000   0.000        0.000   0.000   0.000
         R3             0.000   0.065   3.286        0.624   0.000   0.000
         GR+T1          0.000  -0.584   0.008        0.000   0.000   0.000
         RT             3.286   0.065   3.286        0.624   0.000   0.624
         GR+T1+RT       3.286   0.649   3.294        0.624   0.000   0.624

*** Segment D   end    ***

*** Segment E   begin ***

A02      GR             0.000  -0.002   0.000        0.000   0.000   0.000
         T1             0.000  -0.582   0.000        0.000   0.000   0.000
         P1             0.000  -0.005   0.000        0.000   0.000   0.000
         R1             3.286   0.000   0.000        0.000   0.000   0.624
         R2             0.000   0.000   0.000        0.000   0.000   0.000
         R3             0.000   0.000   3.286        0.624   0.000   0.000
         GR+T1          0.000  -0.584   0.000        0.000   0.000   0.000
         RT             3.286   0.000   3.286        0.624   0.000   0.624
         GR+T1+RT       3.286   0.584   3.286        0.624   0.000   0.624

E01      GR             0.000  -0.002   0.000        0.000   0.000   0.000
         T1             0.000  -0.582  -0.008        0.000   0.000   0.000
         P1             0.000  -0.005   0.000        0.000   0.000   0.000
         R1             3.286   0.000   0.000        0.000   0.000   0.624
         R2             0.000   0.000   0.000        0.000   0.000   0.000
         R3             0.000   0.065   3.286        0.624   0.000   0.000
         GR+T1          0.000  -0.584  -0.008        0.000   0.000   0.000
         RT             3.286   0.065   3.286        0.624   0.000   0.624
         GR+T1+RT       3.286   0.649   3.294        0.624   0.000   0.624

*** Segment E   end    ***
```

```
-------------------------------------------------------------------------------
W3202717  AY FARM DISTRIBUTOR ANALYSIS           ICF KAISER HANFORD COMPANY
08/11/94  W320 TANK 241-C-106 SLUICING ER4319    AutoPIPE+4.50 RESULT PAGE  10
   ----------------------------------------------------------------------------

                          S U P P O R T   F O R C E S

 Point/  Connect/    Load            L O C A L              G L O B A L
Supp. ID   Type   Combination  Dirn  Force    Deform    Dirn   Force    Deform
-------- -------- -----------  ---- -------- --------   ---- -------- --------


***  End of system , no supports  encountered.  ***
```

```
--------------------------------------------------------------------------------
W3202717  AY FARM DISTRIBUTOR ANALYSIS           ICF KAISER HANFORD COMPANY
08/11/94  W320 TANK 241-C-106 SLUICING ER4319    AutoPIPE+4.50 RESULT PAGE  11
   ----------------------------------------------------------------------------

                        R E S T R A I N T   R E A C T I O N S

Point     Load              FORCES (lb    )            MONEMTS (ft-lb  )
name   combination    X      Y      Z    Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------

A00      Anchor
         GR              0   -835      0    835       0       0       0       0
         T1              0      0      0      0       0       0       0       0
         P1              0      0      0      0       0       0       0       0
         R1             29      0      0     29       0       0    1097    1097
         R2              0      0      0      0       0       0       0       0
         R3              0      0     29     29    1097       0       0    1097
         GR+T1           0   -835      0    835       0       0       0       0
         RT             29      0     29     41    1097       0    1097    1552
         GR+T1+RT       29    835     29    836    1097       0    1097    1552
```

```
              G L O B A L   F O R C E S   &   M O M E N T S

Point      Load              FORCES (lb    )              MOMENTS (ft-lb  )
name   combination    X      Y      Z    Result    X       Y       Z    Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------

*** Segment A  begin ***

A00     GR             0    835      0    835       0       0       0       0
        T1             0      0      0      0       0       0       0       0
        P1             0      0      0      0       0       0       0       0
        R1            29      0      0     29       0       0    1097    1097
        R2             0      0      0      0       0       0       0       0
        R3             0      0     29     29    1097       0       0    1097
        GR+T1          0    835      0    835       0       0       0       0
        RT            29      0     29     41    1097       0    1097    1552
        GR+T1+RT      29    835     29    836    1097       0    1097    1552

A01     GR             0    780      0    780       0       0       0       0
        T1             0      0      0      0       0       0       0       0
        P1             0      0      0      0       0       0       0       0
        R1            29      0      0     29       0       0    1023    1023
        R2             0      0      0      0       0       0       0       0
        R3             0      0     29     29    1023       0       0    1023
        GR+T1          0    780      0    780       0       0       0       0
        RT            29      0     29     41    1023       0    1023    1447
        GR+T1+RT      29    780     29    781    1023       0    1023    1447

A02   - GR             0     22      0     22       0       0       0       0
        T1             0      0      0      0       0       0       0       0
        P1             0      0      0      0       0       0       0       0
        R1            29      0      0     29       0       0       0       0
        R2             0      0      0      0       0       0       0       0
        R3             0      0     29     29       0       0       0       0
        GR+T1          0     22      0     22       0       0       0       0
        RT            29      0     29     41       0       0       0       0
        GR+T1+RT      29     22     29     47       0       0       0       0

A02   + GR             0      9      0      9       0       0       0       0
        T1             0      0      0      0       0       0       0       0
        P1             0      0      0      0       0       0       0       0
        R1             0      0      0      0       0       0       0       0
        R2             0      0      0      0       0       0       0       0
        R3             0      0      0      0       0       0       0       0
        GR+T1          0      9      0      9       0       0       0       0
        RT             0      0      0      0       0       0       0       0
        GR+T1+RT       0      9      0      9       0       0       0       0
```

```
              G L O B A L   F O R C E S   &   M O M E N T S

Point     Load              FORCES (lb     )             MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
A03      GR             0      0      0      0       0       0       0       0
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      0      0      0       0       0       0       0
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      0      0      0       0       0       0       0

*** Segment A  end    ***

*** Segment B  begin ***

A02      GR             0      3      0      3       0       0       1       1
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      3      0      3       0       0       1       1
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      3      0      3       0       0       1       1

B01      GR             0      0      0      0       0       0       0       0
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      0      0      0       0       0       0       0
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      0      0      0       0       0       0       0

*** Segment B  end    ***

*** Segment C  begin ***

A02      GR             0      3      0      3       0       0      -1       1
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      3      0      3       0       0      -1       1
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      3      0      3       0       0       1       1
```

```
             G L O B A L   F O R C E S   &   M O M E N T S

Point      Load              FORCES (lb     )           MOMENTS (ft-lb  )
name   combination    X      Y      Z    Result    X       Y       Z     Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
C01      GR             0      0      0      0       0       0       0       0
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      0      0      0       0       0       0       0
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      0      0      0       0       0       0       0

*** Segment C  end   ***

*** Segment D  begin ***

A02      GR             0      3      0      3      -1       0       0       1
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      3      0      3      -1       0       0       1
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      3      0      3       1       0       0       1

D01      GR             0      0      0      0       0       0       0       0
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      0      0      0       0       0       0       0
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      0      0      0       0       0       0       0

*** Segment D  end   ***

*** Segment E  begin ***

A02      GR             0      3      0      3       1       0       0       1
         T1             0      0      0      0       0       0       0       0
         P1             0      0      0      0       0       0       0       0
         R1             0      0      0      0       0       0       0       0
         R2             0      0      0      0       0       0       0       0
         R3             0      0      0      0       0       0       0       0
         GR+T1          0      3      0      3       1       0       0       1
         RT             0      0      0      0       0       0       0       0
         GR+T1+RT       0      3      0      3       1       0       0       1
```

```
              G L O B A L   F O R C E S   &   M O M E N T S

Point     Load          FORCES (lb    )                 MOMENTS (ft-lb  )
name   combination   X      Y      Z    Result     X       Y       Z    Result
------ ----------- ------ ------ ------ ------ ------- ------- ------- -------
E01      GR           0      0      0      0      0       0       0       0
         T1           0      0      0      0      0       0       0       0
         P1           0      0      0      0      0       0       0       0
         R1           0      0      0      0      0       0       0       0
         R2           0      0      0      0      0       0       0       0
         R3           0      0      0      0      0       0       0       0
         GR+T1        0      0      0      0      0       0       0       0
         RT           0      0      0      0      0       0       0       0
         GR+T1+RT     0      0      0      0      0       0       0       0

*** Segment E  end    ***
```

```
           G E N E R A L   P I P E   S T R E S S   R E P O R T
                                        (Stress in psi     )
Point      Load       Hoop   Longitudinal Tors.    Principal     Max        Oct
name    combination Stress   Max     Min  Shear   Max     Min   Shear  Loc Shear
------ ----------- ------ ------ ------ ------ ------ ------ ------ --- ------

*** Segment A  begin ***

A00     SIFI= 1.00   SIFO= 1.00
        GR               0    227    227      0    227      0    114  NA    227
        T1               0      0      0      0      0      0      0  NA      0
        P1            2936   1001   1001      0   2936   1001   1468  NA   2585
        R1               0   3601  -3601      0   3601  -3601   1801  MT   3601
        R2               0      0      0      0      0      0      0  NA      0
        R3               0   3601  -3601      0   3601  -3601   1801  MT   3601
        GR+T1            0    227    227      0    227      0    114  NA    227
        RT               0   5093  -5093      0   5093  -5093   2547  MT   5093
        GR+T1+RT         0   4866  -5320      0   4866  -5320   2660  MC   5320

A01     SIFI= 1.00   SIFO= 1.00
        GR               0    212    212      0    212      0    106  NA    212
        T1               0      0      0      0      0      0      0  MT      0
        P1            2936   1001   1001      0   2936   1001   1468  NA   2585
        R1               0   3357  -3357      0   3357  -3357   1678  MT   3357
        R2               0      0      0      0      0      0      0  NA      0
        R3               0   3357  -3357      0   3357  -3357   1678  MT   3357
        GR+T1            0    212    212      0    212      0    106  NA    212
        RT               0   4748  -4748      0   4748  -4748   2374  MT   4748
        GR+T1+RT         0   4535  -4960      0   4535  -4960   2480  MC   4960

A02   - SIFI= 2.60   SIFO= 3.14
        GR               0      6      6      0      6      0      3  NA      6
        T1               0      0      0      0      0      0      0  MT      0
        P1            2936   1001   1001      0   2936   1001   1468  NA   2585
        R1               0      1     -1      0      1     -1      1  MT      1
        R2               0      0      0      0      0      0      0  NA      0
        R3               0      1     -1      0      1     -1      1  MT      1
        GR+T1            0      6      6      0      6      0      3  NA      6
        RT               0      2     -2      0      2     -2      1  MT      2
        GR+T1+RT         0     -4     -8      0      0     -8      4  MC      8

A02   + SIFI= 2.60   SIFO= 3.14
        GR               0      2      2      0      2      0      1  NA      2
        T1               0      0      0      0      0      0      0  MC      0
        P1            2936   1001   1001      0   2936   1001   1468  NA   2585
        R1               0      1     -1      0      1     -1      1  MT      1
        R2               0      0      0      0      0      0      0  NA      0
        R3               0      1     -1      0      1     -1      1  MT      1
        GR+T1            0      2      2      0      2      0      1  NA      2
        RT               0      2     -2      0      2     -2      1  MT      2
        GR+T1+RT         0     -1     -4      0      0     -4      2  MC      4
```

```
-----------------------------------------------------------------------------
W3202717  AY FARM DISTRIBUTOR ANALYSIS           ICF KAISER HANFORD COMPANY
08/11/94  W320 TANK 241-C-106 SLUICING ER4319    AutoPIPE+4.50 RESULT PAGE  17
  ---------------------------------------------------------------------------

          G E N E R A L   P I P E   S T R E S S   R E P O R T
                                    (Stress in psi     )
Point     Load      Hoop   Longitudinal Tors.    Principal    Max        Oct
name   combination Stress   Max    Min   Shear   Max    Min   Shear  Loc Shear
------ ----------- ------ ------ ------ ------ ------ ------ ------ --- ------
A03    SIFI= 1.00   SIFO= 1.00
       GR               0      0      0      0      0      0      0 NA      0
       T1               0      0      0      0      0      0      0 MC      0
       P1            2936   1001   1001      0   2936   1001   1468 NA   2585
       R1               0      0      0      0      0      0      0 NA      0
       R2               0      0      0      0      0      0      0 NA      0
       R3               0      0      0      0      0      0      0 NA      0
       GR+T1            0      0      0      0      0      0      0 MC      0
       RT               0      0      0      0      0      0      0 NA      0
       GR+T1+RT   -     0      0      0      0      0      0      0 MC      0

*** Segment A  end   ***

*** Segment B  begin ***

A02    SIFI= 2.60   SIFO= 3.14
       GR               0     46    -46      0     46    -46     23 MT     46
       T1               0      0      0      0      0      0      0 MT      0
       P1            2773    859    859      0   2773    859   1386 NA   2459
       R1               0      0      0      0      0      0      0 MC      0
       R2               0      0      0      0      0      0      0 NA      0
       R3               0      4     -4      0      4     -4      2 MT      4
       GR+T1            0     46    -46      0     46    -46     23 MT     46
       RT               0      4     -4      0      4     -4      2 MC      4
       GR+T1+RT         0     46    -46      0     46    -46     23 MC     46

B01    SIFI= 1.00   SIFO= 1.00
       GR               0      0      0      0      0      0      0 MT      0
       T1               0      0      0      0      0      0      0 MT      0
       P1            2773    859    859      0   2773    859   1386 NA   2459
       R1               0      0      0      0      0      0      0 NA      0
       R2               0      0      0      0      0      0      0 NA      0
       R3               0      0      0      0      0      0      0 NA      0
       GR+T1            0      0      0      0      0      0      0 MT      0
       RT               0      0      0      0      0      0      0 NA      0
       GR+T1+RT         0      0      0      0      0      0      0 MC      0

*** Segment B  end   ***

*** Segment C  begin ***
```

```
                 G E N E R A L   P I P E   S T R E S S   R E P O R T
                                        (Stress in psi     )
Point      Load      Hoop   Longitudinal Tors.     Principal     Max        Oct
name   combination Stress   Max     Min  Shear   Max      Min   Shear  Loc Shear
------ ----------- ------ ------ ------ ------ ------ ------ ------ --- ------
A02    SIFI= 2.60   SIFO= 3.14
       GR               0     46    -46      0     46    -46     23  MT     46
       T1               0      0      0      0      0      0      0  MT      0
       P1            2773    859    859      0   2773    859   1386  NA   2459
       R1               0      0      0      0      0      0      0  MC      0
       R2               0      0      0      0      0      0      0  NA      0
       R3               0      4     -4      0      4     -4      2  MT      4
       GR+T1            0     46    -46      0     46    -46     23  MT     46
       RT               0      4     -4      0      4     -4      2  MC      4
       GR+T1+RT         0     46    -46      0     46    -46     23  MC     46

C01    SIFI= 1.00   SIFO= 1.00
       GR               0      0      0      0      0      0      0  MT      0
       T1               0      0      0      0      0      0      0  MT      0
       P1            2773    859    859      0   2773    859   1386  NA   2459
       R1               0      0      0      0      0      0      0  NA      0
       R2               0      0      0      0      0      0      0  NA      0
       R3               0      0      0      0      0      0      0  NA      0
       GR+T1            0      0      0      0      0      0      0  MT      0
       RT               0      0      0      0      0      0      0  NA      0
       GR+T1+RT         0      0      0      0      0      0      0  MC      0

*** Segment C  end   ***

*** Segment D  begin ***

A02    SIFI= 2.60   SIFO= 3.14
       GR               0     46    -46      0     46    -46     23  MT     46
       T1               0      0      0      0      0      0      0  MT      0
       P1            2773    859    859      0   2773    859   1386  NA   2459
       R1               0      4     -4      0      4     -4      2  MT      4
       R2               0      0      0      0      0      0      0  NA      0
       R3               0      0      0      0      0      0      0  MC      0
       GR+T1            0     46    -46      0     46    -46     23  MT     46
       RT               0      4     -4      0      4     -4      2  MC      4
       GR+T1+RT         0     46    -46      0     46    -46     23  MC     46

D01    SIFI= 1.00   SIFO= 1.00
       GR               0      0      0      0      0      0      0  MT      0
       T1               0      0      0      0      0      0      0  MT      0
       P1            2773    859    859      0   2773    859   1386  NA   2459
       R1               0      0      0      0      0      0      0  NA      0
       R2               0      0      0      0      0      0      0  NA      0
       R3               0      0      0      0      0      0      0  NA      0
       GR+T1            0      0      0      0      0      0      0  MT      0
       RT               0      0      0      0      0      0      0  NA      0
       GR+T1+RT         0      0      0      0      0      0      0  MC      0

*** Segment D  end   ***
```

```
              G E N E R A L   P I P E   S T R E S S   R E P O R T
                                      (Stress in psi     )
Point     Load      Hoop   Longitudinal Tors.    Principal    Max        Oct
name   combination Stress   Max    Min  Shear   Max     Min  Shear  Loc Shear
------ ----------- ------ ------ ------ ------ ------ ------ ------ --- ------

*** Segment E  begin ***

A02    SIFI= 2.60   SIFO= 3.14
       GR               0     46    -46      0     46    -46     23  MT     46
       T1               0      0      0      0      0      0      0  MT      0
       P1            2773    859    859      0   2773    859   1386  NA   2459
       R1               0      4     -4      0      4     -4      2  MT      4
       R2               0      0      0      0      0      0      0  NA      0
       R3               0      0      0      0      0      0      0  MC      0
       GR+T1            0     46    -46      0     46    -46     23  MT     46
       RT               0      4     -4      0      4     -4      2  MC      4
       GR+T1+RT         0     46    -46      0     46    -46     23  MC     46

E01    SIFI= 1.00   SIFO= 1.00
       GR               0      0      0      0      0      0      0  MT      0
       T1               0      0      0      0      0      0      0  MT      0
       P1            2773    859    859      0   2773    859   1386  NA   2459
       R1               0      0      0      0      0      0      0  NA      0
       R2               0      0      0      0      0      0      0  NA      0
       R3               0      0      0      0      0      0      0  NA      0
       GR+T1            0      0      0      0      0      0      0  MT      0
       RT               0      0      0      0      0      0      0  NA      0
       GR+T1+RT         0      0      0      0      0      0      0  MC      0

*** Segment E  end   ***
```

```
------------------------------------------------------------------------------------
W3202717  AY FARM DISTRIBUTOR ANALYSIS             ICF KAISER HANFORD COMPANY
08/11/94  W320 TANK 241-C-106 SLUICING ER4319      AutoPIPE+4.50 RESULT PAGE  20
  ----------------------------------------------------------------------------------

                      ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in  ft-lb  )              (Stress in psi      )
Point      Load       In-Pl. Out-Pl. Torsion   S.I.F      Eq. Load   Code   Code
name    combination   Moment  Moment  Moment  In   Out    no. type   Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----   ------ ------

*** Segment A  begin ***

A00     Max P                                             (3a) HOOP    2936  16700
        GR + Max P        0       0          1.00 1.00 (18) SUST    1300  16700
        Cold to T1        0       0        0 1.00 1.00 (17) DISP       0  25050
        Sus. + R1         0    1097          1.00 1.00 (18)  OCC    4901  22211
        Sus. + R2         0       0          1.00 1.00 (18)  OCC    1300  22211
        Sus. + R3      1097       0          1.00 1.00 (18)  OCC    4901  22211
        RTOTAL         1097    1097          1.00 1.00 (18)  OCC    5093  22211

A01     Max P                                             (3a) HOOP    2936  16700
        GR + Max P        0       0          1.00 1.00 (18) SUST    1300  16700
        Cold to T1        0       0        0 1.00 1.00 (17) DISP       0  25050
        Sus. + R1         0    1023          1.00 1.00 (18)  OCC    4657  22211
        Sus. + R2         0       0          1.00 1.00 (18)  OCC    1300  22211
        Sus. + R3      1023       0          1.00 1.00 (18)  OCC    4657  22211
        RTOTAL         1023    1023          1.00 1.00 (18)  OCC    4748  22211

  2   - Max P                                             (3a) HOOP    2936  16700
        GR + Max P        0       0          2.60 3.14 (18) SUST    1300  16700
        Cold to T1        0       0        0 2.60 3.14 (17) DISP       0  25050
        Sus. + R1         0       0          2.60 3.14 (18)  OCC    1301  22211
        Sus. + R2         0       0          2.60 3.14 (18)  OCC    1300  22211
        Sus. + R3         0       0          2.60 3.14 (18)  OCC    1301  22211
        RTOTAL            0       0          2.60 3.14 (18)  OCC       2  22211

A02   + Max P                                             (3a) HOOP    2936  16700
        GR + Max P        0       0          2.60 3.14 (18) SUST    1300  16700
        Cold to T1        0       0        0 2.60 3.14 (17) DISP       0  25050
        Sus. + R1         0       0          2.60 3.14 (18)  OCC    1301  22211
        Sus. + R2         0       0          2.60 3.14 (18)  OCC    1300  22211
        Sus. + R3         0       0          2.60 3.14 (18)  OCC    1301  22211
        RTOTAL            0       0          2.60 3.14 (18)  OCC       2  22211

A03     Max P                                             (3a) HOOP    2936  16700
        GR + Max P        0       0          1.00 1.00 (18) SUST    1300  16700
        Cold to T1        0       0        0 1.00 1.00 (17) DISP       0  25050
        Sus. + R1         0       0          1.00 1.00 (18)  OCC    1300  22211
        Sus. + R2         0       0          1.00 1.00 (18)  OCC    1300  22211
        Sus. + R3         0       0          1.00 1.00 (18)  OCC    1300  22211
        RTOTAL            0       0          1.00 1.00 (18)  OCC       0  22211

*** Segment A  end   ***

 ** Segment B  begin ***
```

```
                ASME B31.3c (1992)  CODE COMPLIANCE
                       (Moments in ft-lb  )              (Stress in psi      )
Point      Load       In-Pl. Out-Pl. Torsion   S.I.F      Eq.  Load   Code    Code
name    combination   Moment  Moment  Moment   In   Out   no.  type  Stress  Allow.
------  -----------  ------- ------- ------- ---- ---- ---- ----  ------  ------
A02     Max P                                          (3a) HOOP    2773   16700
        GR + Max P         1       0         2.60 3.14 (18) SUST    1227   16700
        Cold to T1         0       0       0 2.60 3.14 (17) DISP       0   25050
        Sus. + R1          1       0         2.60 3.14 (18)  OCC    1227   22211
        Sus. + R2          1       0         2.60 3.14 (18)  OCC    1227   22211
        Sus. + R3          1       0         2.60 3.14 (18)  OCC    1229   22211
        RTOTAL             0       0         2.60 3.14 (18)  OCC       2   22211

B01     Max P                                          (3a) HOOP    2773   16700
        GR + Max P  -      0       0         1.00 1.00 (18) SUST    1203   16700
        Cold to T1         0       0       0 1.00 1.00 (17) DISP       0   25050
        Sus. + R1          0       0         1.00 1.00 (18)  OCC    1203   22211
        Sus. + R2          0       0         1.00 1.00 (18)  OCC    1203   22211
        Sus. + R3          0       0         1.00 1.00 (18)  OCC    1203   22211
        RTOTAL             0       0         1.00 1.00 (18)  OCC       0   22211

*** Segment B  end   ***

*** Segment C  begin ***

A02     Max P                                          (3a) HOOP    2773   16700
        GR + Max P         1       0         2.60 3.14 (18) SUST    1248   16700
        Cold to T1         0       0       0 2.60 3.14 (17) DISP       0   25050
        Sus. + R1          1       0         2.60 3.14 (18)  OCC    1249   22211
        Sus. + R2          1       0         2.60 3.14 (18)  OCC    1248   22211
        Sus. + R3          1       0         2.60 3.14 (18)  OCC    1252   22211
        RTOTAL             0       0         2.60 3.14 (18)  OCC       4   22211

C01     Max P                                          (3a) HOOP    2773   16700
        GR + Max P         0       0         1.00 1.00 (18) SUST    1203   16700
        Cold to T1         0       0       0 1.00 1.00 (17) DISP       0   25050
        Sus. + R1          0       0         1.00 1.00 (18)  OCC    1203   22211
        Sus. + R2          0       0         1.00 1.00 (18)  OCC    1203   22211
        Sus. + R3          0       0         1.00 1.00 (18)  OCC    1203   22211
        RTOTAL             0       0         1.00 1.00 (18)  OCC       0   22211

*** Segment C  end   ***

*** Segment D  begin ***

A02     Max P                                          (3a) HOOP    2773   16700
        GR + Max P         0       1         2.60 3.14 (18) SUST    1255   16700
        Cold to T1         0       0       0 2.60 3.14 (17) DISP       0   25050
        Sus. + R1          0       1         2.60 3.14 (18)  OCC    1258   22211
        Sus. + R2          0       1         2.60 3.14 (18)  OCC    1255   22211
        Sus. + R3          0       1         2.60 3.14 (18)  OCC    1255   22211
        RTOTAL             0       0         2.60 3.14 (18)  OCC       3   22211
```

```
                      ASME B31.3c (1992)  CODE COMPLIANCE
                        (Moments in ft-lb  )             (Stress in psi      )
Point      Load       In-Pl. Out-Pl. Torsion   S.I.F     Eq. Load   Code   Code
name    combination   Moment  Moment  Moment  In   Out   no. type  Stress Allow.
------ ----------- ------- ------- ------- ---- ---- ---- ----   ------ ------
D01     Max P                                           (3a) HOOP    2773  16700
        GR + Max P          0       0         1.00 1.00 (18) SUST    1203  16700
        Cold to T1          0       0       0 1.00 1.00 (17) DISP       0  25050
        Sus. + R1           0       0         1.00 1.00 (18)  OCC    1203  22211
        Sus. + R2           0       0         1.00 1.00 (18)  OCC    1203  22211
        Sus. + R3           0       0         1.00 1.00 (18)  OCC    1203  22211
        RTOTAL              0       0         1.00 1.00 (18)  OCC       0  22211

*** Segment D  end   ***

*** Segment E  begin ***

A02     Max P                                           (3a) HOOP    2773  16700
        GR + Max P          0       1         2.60 3.14 (18) SUST    1258  16700
        Cold to T1          0       0       0 2.60 3.14 (17) DISP       0  25050
        Sus. + R1           0       1         2.60 3.14 (18)  OCC    1261  22211
        Sus. + R2           0       1         2.60 3.14 (18)  OCC    1258  22211
        Sus. + R3           0       1         2.60 3.14 (18)  OCC    1258  22211
        RTOTAL              0       0         2.60 3.14 (18)  OCC       3  22211

E01     Max P                                           (3a) HOOP    2773  16700
        GR + Max P          0       0         1.00 1.00 (18) SUST    1203  16700
        Cold to T1          0       0       0 1.00 1.00 (17) DISP       0  25050
        Sus. + R1           0       0         1.00 1.00 (18)  OCC    1203  22211
        Sus. + R2           0       0         1.00 1.00 (18)  OCC    1203  22211
        Sus. + R3           0       0         1.00 1.00 (18)  OCC    1203  22211
        RTOTAL              0       0         1.00 1.00 (18)  OCC       0  22211

*** Segment E  end   ***
```

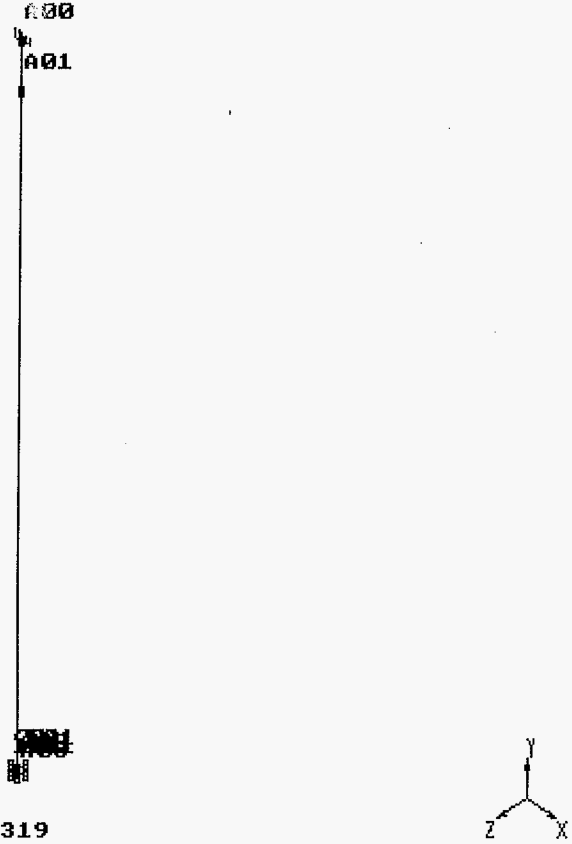
```
                            S Y S T E M   S U M M A R Y
                            ---------------------------

Maximum displacements (in)
--------------------------

         Maximum X :      3.341     Point : A03        Load Comb.: R1
         Maximum Y :      0.649     Point : B01        Load Comb.: GR+T1+RT
         Maximum Z :      3.341     Point : A03        Load Comb.: R3
         Max. total:      4.761     Point : A03        Load Comb.: GR+T1+RT

Maximum rotations (deg)
-----------------------

         Maximum X :      0.624     Point : D01        Load Comb.: GR+T1+RT
         Maximum Z :      0.624     Point : B01        Load Comb.: GR+T1+RT
         Max. total:      0.883     Point : D01        Load Comb.: GR+T1+RT



Maximum restraint forces(lb)
--------------------------

         Maximum X :         29     Point : A00        Load Comb.: R1
         Maximum Y :       -835     Point : A00        Load Comb.: GR
         Maximum Z :         29     Point : A00        Load Comb.: R3
         Max. total:        836     Point : A00        Load Comb.: GR+T1+RT

Maximum restraint moments(ft-lb)
------------------------------

         Maximum X :       1097     Point : A00        Load Comb.: R3
         Maximum Z :       1097     Point : A00        Load Comb.: R1
         Max. total:       1552     Point : A00        Load Comb.: RT
```

```
                           S Y S T E M   S U M M A R Y
                           ---------------------------

Maximum pipe forces (lb)
------------------------

        Maximum X :        29      Point : A00        Load Comb.: R1
        Maximum Y :       835      Point : A00        Load Comb.: GR
        Maximum Z :        29      Point : A00        Load Comb.: R3
        Max. total:       836      Point : A00        Load Comb.: GR+T1+RT

Maximum pipe moments (ft-lb)
----------------------------

        Maximum X :      1097      Point : A00        Load Comb.: R3
        Maximum Y :         0      Point : A02        Load Comb.: R3
        Maximum Z :      1097      Point : A00        Load Comb.: R1
        Max. total:      1552      Point : A00        Load Comb.: RT
```

```
                       S Y S T E M   S U M M A R Y
                       ---------------------------

  Maximum sustained stress

                         Point              : A00
                         Stress    psi      : 1300
                         Allowable psi      : 16700
                         Ratio              : 0.08
                         Load combination : GR + Max P

  Maximum displacement stress

                         Point              : A02
                         Stress    psi      : 0
                         Allowable psi      : 25050
                         Ratio              : 0.00
                         Load combination : Cold to T1

  Maximum occasional stress

                         Point              : A00
                         Stress    psi      : 5093
                         Allowable psi      : 22211
                         Ratio              : 0.23
                         Load combination : RTOTAL

  Maximum hoop stress

                         Point              : A00
                         Stress    psi      : 2936
                         Allowable psi      : 16700
                         Ratio              : 0.18
                         Load combination : Max P

  Maximum sustained stress ratio

                         Point              : A00
                         Stress    psi      : 1300
                         Allowable psi      : 16700
                         Ratio              : 0.08
                         Load combination : GR + Max P

  Maximum displacement stress ratio

                         Point              : A02
                         Stress    psi      : 0
                         Allowable psi      : 25050
                         Ratio              : 0.00
                         Load combination : Cold to T1
```

```
                           S Y S T E M   S U M M A R Y
                           ----------------------------

    Maximum occasional stress ratio

                              Point            : A00
                              Stress    psi    : 5093
                              Allowable psi    : 22211
                              Ratio            : 0.23
                              Load combination : RTOTAL

    Maximum hoop stress ratio

                              Point            : A00
                              Stress    psi    : 2936
                              Allowable psi    : 16700
                              Ratio            : 0.18
                              Load combination : Max P


    * * * The system satisfies ASME B31.3 code requirements * * *
    * * * for the selected options                         * * *
```

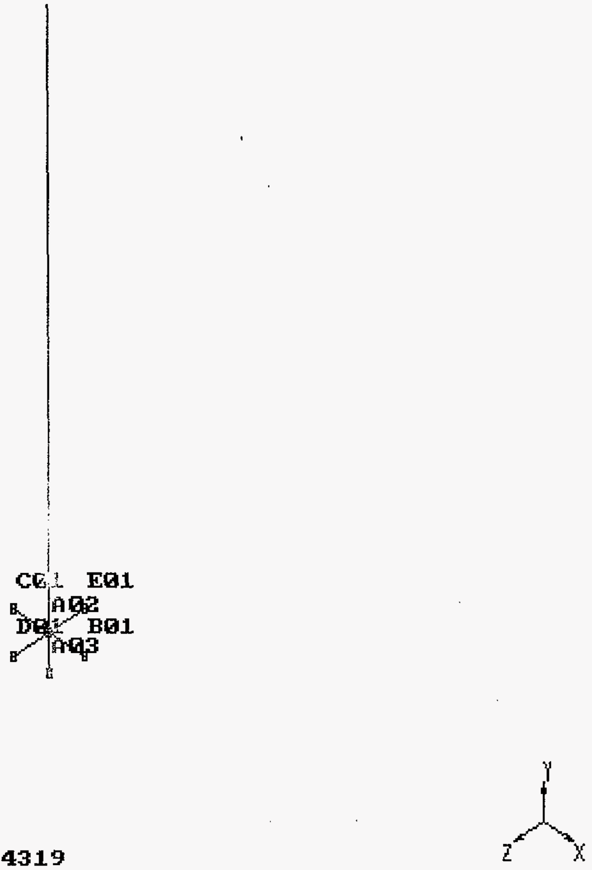
Point A01 A



AY FARM DISTRIBUTOR ANALYSIS

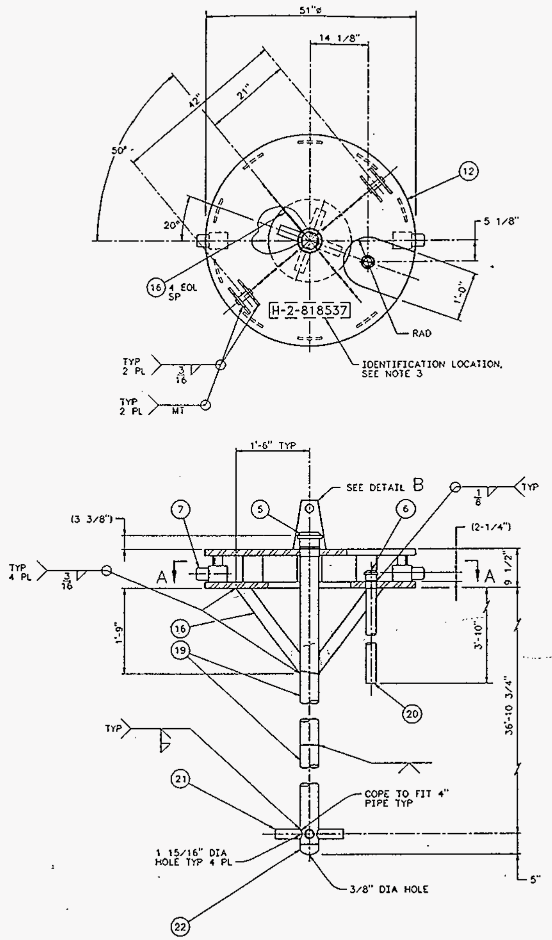
W320 TANK 241-C-106 SLUICING ER4319

Point A02 A

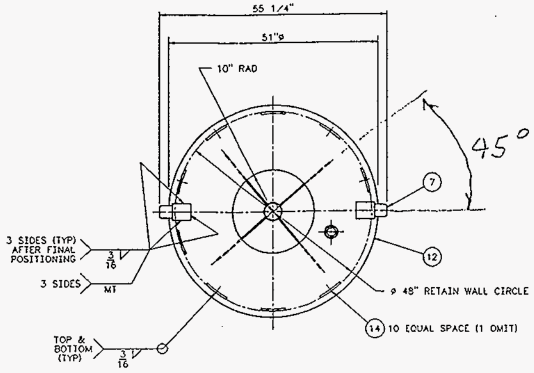


AY FARM DISTRIBUTOR ANALYSIS

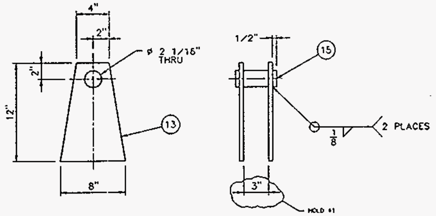
W320 TANK 241-C-106 SLUICING ER4319



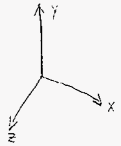
① FLANGE ASSEMBLY
SCALE: 1"= 1'-0"
(FOR TRUE ORIENTATION SEE PLAN)



SECTION A-A
SCALE: 1 1/2"= 1'-0



DETAIL B
SCALE: 3"= 1'-0



PARTS/MATERIAL LIST					
QTY REQD	PART/DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO.
☒	-010	ASSEMBLY			1
					2
					3
					4
1	H-2-90187-3	NOZZLE, MALE CONN 4" SCHED 80			5
1	H-2-90185-2	NOZZLE, MALE CONN 2"			6
2	H-2-64426-1	TRUNNION			7
1	H-2-90161-5	LIFTING BAIL			8
					9
					10
					11
AR		PL 1 1/2"	ASTM A 36		12
AR		PL 1/2"	ASTM A 36		13
9		PL 1/2" x 6" x 6 1/2"	ASTM A 36		14
2		BAR ø2" x 5" LG	ASTM A 36		15
AR		BAR 3" x 3/8"	ASTM A 276 304L		16
					17
					18
AR		PIPE, 4" SCHED 80S	ASTM A 312 GR TP 304L		19
AR		PIPE, 2" SCHED 40S	ASTM A 312 GR TP 304L		20
4		PIPE, 2" SCHED 80S x 6" LG	ASTM A 312 GR TP 304L		21
1		CAP, 4" SCHED 80 BW	ASTM A 403 WP-S 304L		22

NOTES:

1. FOR GENERAL NOTES, LEGEND AND KEY PLAN, SEE DWG H-2-818518
2. ASSEMBLY, WELDING, PROTECTIVE COATING AND PAINTING SHALL BE CONFORMANCE WITH SPEC W-320-C3.
3. PAINT 2" HIGH BLACK LETTERS ON YELLOW BACKGROUND.
4. DIMENSIONS ARE IN INCHES. TOLERANCE ARE AS FOLLOW UNLESS OTHERWISE NOTED:
   FRACTIONAL ±1/8" DECIMALS ±.06" ANGLES ±2°

Not Used

C.D. JONES, PE

PRELIMINARY
DESIGNER Ba MEYER sr
SAFETY CLASS 3
U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
ICF KAISER HANFORD COMPANY
SAFETY SEE DR/AT FORM
ENVIR SEE DR/AT FORM
QUAL ENGR SEE DR/AT FORM
PIPING
DISTRIBUTOR ASSEMBLY
02A-R6-(A)-(B)
REVIEW NO. 3 6-23 1994
PROJECT W320, TANK 241-C-106 SLUICING
APPROVED FOR IMPLEMENTATION BY FOR WHC DATE
SIZE F BLDG NO. 241-AY INDEX NO. 8405 DWG NO. H-2-818537 REV NO. 0
SCALE SHOWN JOB NO. ER4319 SHEET 1 OF 1

H-2-818423 DRAWING LIST
CAD FILE B818537A CAD CODE 2B:IBM:ACD2:12.0:NN
PLOT SCALE: 1=12
KEHCAD

11250 27100

W320-27-019

Winch Analysis -Slurry/Sluice Pump

ICF KAISER *HANFORD COMPANY*	CALCULATION IDENTIFICATION AND INDEX	Page i of ii Date 9 / 8 /95

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27,Piping and Vessels WO/Job No. ER4319 Calculation No. W320-27-019

Project No. & Name Project W-320 Waste Retrieval for Tank 241-C-106

Calculation Item WINCH ANALYSIS - Slurry/Sluice Pump

These calculations apply to:

Dwg. No. H-2-818442, -443, -444, -494, -495, -496, Rev. No. 0 1

Dwg. No. -497, -498, -499 Rev. No. 0 1

Other (Study, CDR) Rev. No.

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated)

☐ Void Calculation (Reason Voided)

Incorporated in Final Drawings? ☒ Yes ☐ No

This calculation verified by independent "check" calculation? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature / Date	Rev. 1 Signature / Date	Rev. 2 Signature / Date
Originator	D. L. Stone 9/8/95		
Checked by	Michael L Custer 9/8/95		
Approved by	CD Jones 9/8/95 [redacted]		
Checked Against Approved Vendor Data	R. Ahmed 4.10.98		

INDEX

Design Analysis Page No.	Description
i	Calculation Identification and Index
ii	Calculation Cross Index
1	Objective, Design Criteria ,Design Inputs and Assumptions
2-3	References
4- 78	Calculations and Conclusion
Appendix	Supporting Documentation

INDX-W.XLS

CALCULATION CROSS INDEX (Typical)

Subject Calculation No. W320-27-~~028~~ 019

Page __ii__ of __ii__

Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calculation/ documents require revision?		Has the output interface calculation/ documents been revised?		Discipline manager's signature and date indicating evaluation complete.	
		Calcualtion/Document No.	Revision. No.	Calcualtion/Document No.	Revision. No.	Yes	No	Yes	No		
0	NA	Calc.# W320-27-016	0	NA			X		X		D.L. Evans 7/17/98
0	NA	Calc.# W320-27-028	0	NA			X		X		D.L. Evans 7/17/98

KEH 1975.00 (12/88)

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Calc. No. W-320-27-019
Revision No.: 0
Page No. 1 of 72

DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-01.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. Stone
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. COSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

OBJECTIVES:

The objective of this calculation is to provide a detailed design for a winch, to raise and lower submersible pumps inside tanks 241-C-106 and 241-AY-102. The pumps will transfer the contents of Tank 241-C-106 to Tank 241-AY-102, and provide supernate to the sluicing process.

DESIGN CRITERIA:

1. Project W320, Tank 241-C-106 Sluicing, Functional Design Criteria (WSC document No. WHC-SD-W320-FDC-001, Rev. 0).
2. SDC 4.1, Rev. 11, Design Loads For Facilities.
3. DOE-RL-92-36, *Hanford Site Hoisting and Rigging Manual* , Section 9.2.3.2, January 15, 1993
4. Project 93L-EWW-320, Tank 241-C-106, Letter of Instruction, Addendum 14

DESIGN INPUTS:

Design Methodology :

Seismic analysis was performed according to SDC 4.1, Rev. 11, Design Loads For Facilities. (Ref. 2)

Standard engineering methods were used to determine Shear, Tensile, Bearing and Bending stresses.

Weld analysis uses Blodgetts's method for analysis of a weld as a line (Ref. 9)

Moment Distribution Method for Indeterminent Beams is used to determine reaction forces on Axle 12. (Ref. 13)

Shaft design methods include torsion analysis for shafts of varying diameters, (Ref. 14)
and minimum shaft diameter equation. (Ref. 8)

Bearing loads were determined using Equivalent Load equations provided in bearing vendor catalogs. (Ref. 26 & 27)

Stress on Reel Hub is determined by standard beam analysis and correction for a curved beam. (Ref. 8)

Gear Strength is determined using the AGMA Strength Formula and Lewis Beam Strength Formula. (Ref. 12)

Data:

Safety factor will be 3 to 1, ($SF_y = 3$), against Yield Strength ,
or 5 to 1, ($SF_u = 5$) against Ultimate Strength. Ref. 3

Assumptions:

1. Pit and winch are both rigid structures and are rigidly connected.
2. Hose/Pipe connection at plate is assumed as a hinged joint and that the pipe will be allowed to deflect with movement of the pump and assemblies.
3. Pump and motor weight = 3000 lbs. (Ref. 23 & 24)

References :

1. Project W320, Tank 241-C-106 Slucing, Functional Design Criteria (WSC document No. WHC-SD-W320-FDC-001, Rev. 2).
2. SDC 4.1, Rev. 12, Design Loads For Facilities.
3. NUREG-0800, U.S. Nuclear Regulatory Commission Standard Review Plan, Section 3.7.2, Rev.2 (8/89)
4. DOE-RL-92-36, *Hanford Site Hoisting and Rigging Manual* , Section 9.2.3.2, January 15, 1993
5. ANSI B16.9
6. ANSI B16.5
7. Steel Construction Manual, Ninth edition.
8. Machinery's Handbook, 24th edition
9. Design of Welded Structures, Homer Blodgett.
10. Formulas for Stress and Strain, R.J. Roark and W.C. Young, Edition 5
11. Machine Design, Shigley & Miscke, Edition 5, 1989
12. Machine Design, Shigley & Miscke, Edition 1
13. Structural Analysis, Jack. C McCormac, 4th Edition, 1984
14. Mechanics and Materials, I.J. Levinson, 2nd Edition.
15. Crane Technical Paper No. 410, *Flow of Fluids Through Pipes, Fittings and Valves, 25th Printing*
16. Joseph T. Ryerson, Inc., *Stock List and Data Book*, 1994
17. T-M Swivel Joint Catalog.
18. Gates Hose Catalog, No.39496-000, Dated 3/30/92
19. Catalog sheets by Fax from American Hose & Fitting Co., 7/6/95
20. Boston Gear Catalog, 1995.
21. Associated Spring Catalog
22. Mc White Wire Rope Catalog, 4th Edition, 1991
23. Lawrence Pump information sheets, dated June 6, 1995.
24. Reliance Motor information sheets, dated June 6, 1995.
25. Crucible Materials Corporation, *ARMCO Product Data Bulletin No. S-45*
26. Timkin Bearing Selection Handbook for Tapered Roller Bearings, Revised 1986
27. Torrington Bearing Catalog Form # 100-889-50M, 1st Edition, Second Printing
28. Journal Entry, June 6, 1995. Teleconference with Torrington Bearing Co.
29. *Mathcad* , *Version 4.0*, by MathSoft, Inc.
30. *Excel* , *Version 4.0*, by Microsoft.
31. *Autocad* , Release 12 , Autodesk, inc, 1993, Inc.
32. Calculation #W320-27-016 Stress Analysis for W-320 C-Farm Jumpers

33.0. Project W320 Drawing No. H-2-818442, Rev. 0

33.1. Project W320 Drawing No. H-2-818443, Rev. 0

33.2. Project W320 Drawing No. H-2-818444, Rev. 0

33.3. Project W320 Drawing No. H-2-818494, Rev. 0

33.4. Project W320 Drawing No. H-2-818495, Rev. 0

33.5. Project W320 Drawing No. H-2-818496, Rev. 0

33.6. Project W320 Drawing No. H-2-818497, Rev. 0

33.7. Project W320 Drawing No. H-2-818498, Rev. 0

33.8. Project W320 Drawing No. H-2-818499, Rev. 0

CALCULATIONS:

Page:

5 - 8	Seismic Evaluation
9 - 20	Analysis of Pump and Sheave Assembly Components
21 - 25	Analysis of Retrieval Cable Assembly
26 - 40	Axle 12 - Component Design
41 - 46	Design of Reel Hub
47 - 50	Gear Analysis
51 - 54	Axle 11 - Component Design
55 - 60	Axle 15 - Component Design
61 - 62	Analysis of Winch Housing Stresses
63 - 67	Upper Driveshaft Analysis
68 - 70	Guide Idler Component Analysis
71 - 75	Plate Stress and Bolt Analysis
76 - 78	Analysis of Lifting Brackets

CONCLUSIONS:

The results of this analysis indicate that the components of of the Winch Assembly meet, exceed or fall within acceptable limits of the Safety Factor requirements set forth in DOE-RL-92-36, *Hanford Site Hoisting and Rigging Manual*, Section 9.2.3.2, January 15, 1993.

Seismic Analysis of Winch and Pump Assembly to Safety Class 1 Criteria

The winch / pump assembly is classified as Safety Class 3 per the Functional Design Criteria for the project. Based on the SDC 4.1, Rev. 11, the design for the winch / pump assembly is required to be analyzed to Safety Class 1 criteria, due to the potential structural failure and impact of the winch/ pump assembly on the Safety Class 1 structure (the tank structure). Safety Class 1 design requires a dynamic analysis to be performed using the response spectra per SDC 4.1, Rev.11 (Figure 3) as the seismic input for the design. Conservatively, an equivalent static load method is used in the evaluation since the winch may be represented by a single model configuration. A factor of 1.5 is applied to the peak acceleration of the appropriate response spectrum per SDC 4.1, Rev.11.

The upper, winch structure is rigidly attached to the top of the base slab of the pump pit in both horizontal directions. The pump pit is considered a rigid structure, therefore, the ground acceleration is used as the seismic input.

The lower winch structure consists of a cable and sheave assembly suspending the process pump and includes the associated hose and connections. The configuration of the lower structure, therefore can be represented as a single mass suspended by a flexible cable, subjected to seismic loading.

The primary concern for the tank structure is the potential impact of the pump with the tank wall. The maximum displacement of the pump will be evaluated based on the seismic input and a comparison made as to the proximity of the pump relative to the tank wall.

The remaining concern is the structural adequacy of the winch plate, which supports the winch/ pump assembly, spanning the penetration opening in the tank. The magnitude of the vertical, seismic response required to be used is defined in SDC 4.1, Rev. 11, as 2/3 of the peak, horizontal response.

Seismic Components: (Assume 2 % damping, conservative) (Ref. 4, Section 3.7.2, II - 1.b)

$g := 386.4 \cdot \frac{in}{sec^2}$	Acceleration of gravity	(Ref. 2, Table 7)
$LF := 1.5$	Load Factor	
$ag := 0.2 \cdot g$	Peak Horizontal Free-field Ground Acceleration	(Ref. 4, Section 3.7.2, II - 1.b.iii) (Ref. 2, Fig.3)
$A := 2.74$	Acceleration Amplifcation at 2% damping	(Ref. 2, Table 7, 2 % Damping)

$a_{maxh} := ag \cdot A \cdot 1.5 \qquad a_{maxh} = 317.621 \cdot \frac{in}{sec^2} \quad = \quad 0.822 \cdot g$ Horizontal seismic component

$a_{maxv} := \left(\frac{2}{3}\right) \cdot a_{maxh} \qquad a_{maxv} = 211.747 \cdot \frac{in}{sec^2} \quad = \quad 0.548 \cdot g$ Vertical seismic component (Ref. 2, B.3.3)

Client WESTINGHOUSE HANFORD COMPANY
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. ER4319
Date 9 / 8 / 95
Checked 9/8/95
Revised

Filename WIN-03.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Potential Impact of the Pump with the Tank Wall

The primary concern to be addressed in this evaluation is the potential interaction of the pump with the tank wall, due to pendulum action of the pump/ cable system.

Determine the maximum, horizontal displacement of the pump relative to the tank wall:

$L := 26 \cdot ft$ $L = 312 \cdot in$ (Maximum "L" USED, conservative)

$f := \left(\frac{1}{2 \cdot \pi}\right) \cdot \sqrt{\frac{g}{L}}$ $f = 0.177 \cdot time^{-1}$ Natural Frequency

$T := \frac{1}{f}$ $T = 5.646 \cdot sec$ Natural Period

$d := 13 \cdot in$ Displacement Ref. 2, Fig.3

$D := 1.63$ Spectrum Amplification Factor at 2% damping Ref. 2, Table 7

$d_{SDC4.1} := D \cdot d$ $d_{SDC4.1} = 21.19 \cdot in$ Based on engineering judgement, displacement of 21" is considered to be negligible.

Hose / Pipe Assembly

$SG := 1.2$ Specific Gravity of Process Fluid Ref. 1

$\rho_w := 62.41 \cdot \frac{lbf}{ft^3}$ Density of water at Minimum Operating Temperature Ref. 15, Pg. A6

$\rho := SG \cdot \rho_w$ $\rho = 74.892 \cdot \frac{lbf}{ft^3}$ Density of Process Fluid at Minimum Operating Temperature

$W_f := 7.5 \cdot \frac{lbf}{ft}$ Weight per foot of hose. Ref. F, Pg. 69

$L_{hose} := (9.8 + 10.8) \cdot ft$ ✓ Combined length of hoses

$R_h := 2 \cdot in$ Inner Radius of hose. Ref. 18, Pg. 69

$W_{hose} := W_f \cdot L_{hose}$ $W_{hose} = 154.5 \cdot lbf$ Weight of 4" hose. Ref. 33.2, Sh.2

$V_h := \pi \cdot R_h^2 \cdot L_{hose}$ $V_h = 1.798 \cdot ft^3$ Volume of hose.

$Hose_{contents} := V_h \cdot \rho$ $Hose_{contents} = 134.633 \cdot lbf$ Weight of Process Fluid fluid in combined length of hose.

Hose / Pipe Assembly (continued....)

$W_p := 10.79 \cdot \frac{lbf}{ft}$ Weight per foot of pipe. Ref. 15

$pipe_L := 114 \cdot in$ Pipe Length

$W_{pipe} := W_p \cdot pipe_L$ $W_{pipe} = 102.505 \cdot lbf$ Weight of 93.8" of 4" pipe.

$R_p := 2.013 \cdot in$ Inner Radius of pipe.

$V_p := \pi \cdot R_p^{\,2} \cdot pipe_L$ $V_p = 0.84 \cdot ft^3$ Volume of pipe.

$Pipe_{contents} := V_p \cdot \rho$ $Pipe_{contents} = 62.898 \cdot lbf$ Weight of Process Fluid fluid in pipe.

$Coupling := 4 \cdot (27 \cdot lbf)$ Est. Weight of 4 Hose Couplings Ref. 19, Pg. 399

$Swivel_{joint} := 36 \cdot lbf + 2 \cdot (72 \cdot lbf)$ Weight of 1, 3" and 2, 4" swivel joints Ref. 17, Pg. 11

$pipe_{CG} := \frac{pipe_L}{2}$ $pipe_{CG} = 57 \cdot in$ Center of Gravity of Pipe

$$Mass_{pipe} := \frac{W_{pipe} + Pipe_{contents}}{g}$$

$Mass_{pipe} = 165.269 \cdot lb$ Mass of the Pipe

$$Mass_{hose} := \frac{W_{hose} + Hose_{contents} + Coupling + Swivel_{joint}}{g}$$

$Mass_{hose} = 576.668 \cdot lb$ Mass of the Hose

$F_{pipeH} := Mass_{pipe} \cdot a_{maxh}$ $F_{pipeH} = 135.961 \cdot lbf$ Horizontal Seismic Force due to Pipe

$F_{hoseH} := Mass_{hose} \cdot a_{maxh}$ $F_{hoseH} = 474.403 \cdot lbf$ Horizontal Seismic Force due to Hose Assembly

$F_V := \left(Mass_{pipe} + 2 \cdot Mass_{hose}\right) \cdot \left(g + a_{maxv}\right)$ $F_V = 2.043 \cdot 10^3 \cdot lbf$ Vertical Seismic Force due to Pipe/Hose Assembly

$M := \left(F_{pipeH}\right) \cdot \left(pipe_{CG}\right) + \left(F_{hoseH}\right) \cdot \left(pipe_L\right)$ $M = 6.183 \cdot 10^4 \cdot lbf \cdot in$ Moment due to Pipe/Hose Assembly

Stress at Pipe Connection to Winch Plate

Shear Stress due to Horizontal Seismic Force

$A := 3.174 \cdot in^2$ Area of Shear plane (Metal Area of pipe)

$S_y := 30000 \cdot \frac{lbf}{in^2}$ Yield strength of Schedule 40S, ASTM A-312 Gr Tp 304 Pipe

$S_{all} := (0.40) \cdot S_y$ $S_{all} = 1.2 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress Ref. 7, Part 5, Chap. D.3.1

$S_{act} := \frac{F_{pipeH} + F_{hoseH}}{A}$ $S_{act} = 192.301 \cdot \frac{lbf}{in^2}$ Calculated stress on pipe.

$SF := \frac{S_{all}}{S_{act}}$ $SF = 62.402$ Safety factor > 3 *OK*

Tensile Stress due to Vertical Seismic Force

$T_{all} := (0.45) \cdot S_y$ $T_{all} = 1.35 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Stress in Tension Ref. 11, Page 12

$T_{act} := \frac{F_V}{A}$ $T_{act} = 643.619 \cdot psi$ Calculated Tensile Stress on Pipe resulting from Bending Moment at Plate

$\frac{T_{all}}{T_{act}} = 20.975$ Safety factor > 3 *OK* See Assumptions, #2

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Calc. No. W-320-27-019
Revision No.: 0
Page No. 9 of 78

DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-04.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

WEIGHT of PUMP ASSEMBLY (Supported by the Sheave Assembly)

(Most conservative configuraiton considered as the pump in the fully elevated position.) Ref. 33.4

Weight of Pump Ref. 33.6, Sh. 1&2

$W_{pump} := 3000 \cdot lbf$ Weight of pump. Ref. 23

Weight of Hose and Contents Ref. 33.2

$W_{hose} := 81 \cdot lbf$ Weight of 10.8' of 4" hose.

$W_{contents} := 70.584 \cdot lbf$ Weight of Process Fluid fluid in 8 feet of hose.

Weight of pipe fittings (on pump discharge).

$W_C := 2 \cdot (27 \cdot lbf)$	Weight of Hose Couplings	Ref. 33.0, Sh. 1, Item 1	Ref. 19
$Flange3 := 13 \cdot lbf$	3", 300 lb, slip on flange	Ref. 33.4, Sh. 1, Item 27	Ref. 6
$E_{90} := 4.58 \cdot lbf$	3" elbow (90)	Ref. 33.4, Sh. 1, Item 24	Ref. 5
$SJ_3 := 37 \cdot lbf$	3" swivel joint	Ref. 33.4, Sh. 1, Item 11	Ref. 17, Pg. 11
$SJ_4 := 1.5 \cdot (72 \cdot lbf)$	1-1/2 4" swivel joints	Ref. 33.4, Sh. 1, Item 12	Ref. 17, Pg. 11
$Reducer := 3.5 \cdot lbf$	3 x 4 Standard Reducer	Ref. 33.4, Sh. 1, Item 26	Ref. 5
$Pipe_3 := 7.58 \cdot \frac{lbf}{ft}$	Attached 3 inch pipe	Ref. 33.4, Sh. 1, Item 30	Ref. 15, Pg. B-16
$Pipe_4 := 10.79 \cdot \frac{lbf}{ft}$	Attached 4 inch pipe	Ref. 33.4, Sh. 1, Item 29	Ref. 15, Pg. B-17
$L_{pipe} := 2.25 \cdot in$	Length of attached pipes (typ)		

$RE_{3x4} := L_{pipe} \cdot \left(Pipe_3 + Pipe_4\right) + Reducer$ $RE_{3x4} = 6.944 \cdot lbf$

$W_{fj} := Flange3 + E_{90} + SJ_3 + SJ_4 + RE_{3x4}$ $W_{fj} = 169.524 \cdot lbf$ Combined Weight of fittings and joints

Total Weight of Pump Assembly :

$W_P := W_{pump} + W_{hose} + W_{contents} + W_{fj} + W_C$ $W_P = 3.375 \cdot 10^3 \cdot lbf$ Pump Assembly

$W_{PA} := 1.2 \cdot W_P$ $W_{PA} = 4.05 \cdot 10^3 \cdot lbf$ Impact Loading Considered
Ref. 7, Pg. 5-29, Section A4.2

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Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

CHECK of PUMP / WINCH SUPPORT SYSTEM COMPONENTS

3/4" Diam. Pump Support BOLTS

Ref. 33.4, Pg. 1, Item 33

(Assume A307 structural bolts, worst case.)

$n_b := 8$ Number of bolts used

$A_{blt} := 0.442 \cdot in^2$ Cross sectional area of bolt

$F_v := 10000 \cdot \frac{lbf}{in^2}$ Allowable shear strength of bolts Ref. 7, Pg 4-5, Table I-D

$S_{act} := \frac{\frac{(W_{PA} - W_{pump})}{n_b}}{A_{blt}}$ $S_{act} = 296.982 \cdot \frac{lbf}{in^2}$ Calculated shear stress

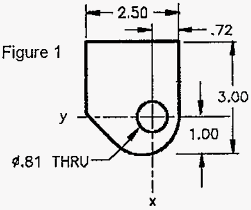
$SF := \frac{F_v}{S_{act}}$ $SF = 33.672$ Safety factor > 5 OK

Pump Support Brackets welded to the 3"x3" square tube plates.

Ref. 33.6, Sh. 2, Detail A.

$w := \left[\left(1 - \frac{0.81}{2}\right) \cdot in\right]$ $w = 0.595 \cdot in$ Width of Shear plane.

Figure 1



$th := \left(\frac{3}{8}\right) \cdot in$ $th = 0.375 \cdot in$ Plate thickness

$AR_b := 4 \cdot w \cdot th$ $AR_b = 0.892 \cdot in^2$ Area of brackets loaded by the bolt.

$S_y := 25000 \cdot \frac{lbf}{in^2}$ Yield strength of ASTM A240 Type 304L

$S_{all} := (0.45) \cdot S_y$ $S_{all} = 1.125 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Stress Ref.7, Pg 5, Chap. D.3.1

$S_{act} := \frac{W_{PA}}{AR_b}$ $S_{act} = 4.538 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated stress on brackets.

$SF := \frac{S_y}{S_{act}}$ $SF = 5.509$ Safety factor > 3 OK

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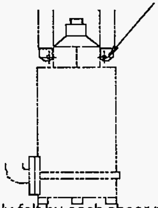
Sizing of Bolts connecting Pump to Sheave Assembly Brackets

Ref. 33.6, Pg 2



Shear stress

$D := \left(0.81 - \frac{1}{16}\right)\cdot in$ Bolt Diameter

$A_a := \frac{\pi \cdot D^2}{4}$ $A_a = 0.439 \cdot in^2$ Cross Sectional Area

$F_{bolt} := \left(\frac{W_{PA}}{4}\right)$ $F_{bolt} = 1.013 \cdot 10^3 \cdot lbf$ Force of Pump Assembly felt by each shear plane.

$S_{act} := \frac{F_{bolt}}{A_a}$ $S_{act} = 2.307 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated Shear Stress per Bolt.

$S_y := 100000 \cdot \frac{lbf}{in^2}$ Yield strength for ASTM A 193, Class 2, B8T

$S_{all} := 0.22 \cdot S_y$ $S_{all} = 2.2 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress Ref. 7, Pg. 4.5

$SF_S := \frac{S_{all}}{S_{act}}$ $SF_S = 9.535$ Safety factor > 3 OK

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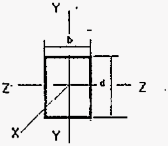
Welds connecting pump support brackets to the 3" x 3" plate. Ref. 33.6, Sh. 2, Detail A.

$Fx := \frac{W_{PA}}{4}$ Weld Tensile Load
("x" direction on subroutine sketch, below)

$M_{arm} := \left(\frac{2.50}{2} - 0.72\right)\cdot in$ Moment arm (Moment about Z)
(distance from weld centerline to load application point)

WELD PROPERTIES:



$b := 0.375\cdot in$		Weld Outline Dimension - short side	Ref. 9, Pg. 7.4 6 &7
$d := 2.5\cdot in$		Weld Outline Dimension - long side	
$Cy := \frac{b}{2}$	$Cy = 0.188\cdot in$	Location of center of gravity with respect to y axis.	
$Cz := \frac{d}{2}$	$Cz = 1.25\cdot in$	Location of center of gravity with respect to z axis.	
$Aw := 2\cdot(b + d)$	$Aw = 5.75\cdot in$	Weld length (1 Bracket)	
$Swy := b\cdot d + \frac{b^2}{3}$	$Swy = 0.984\cdot in^2$	Section modulus about y axis	
$Swz := b\cdot d + \frac{d^2}{3}$	$Swz = 3.021\cdot in^2$	Section modulus about z axis	
$Jw := \frac{(b + d)^3}{6}$	$Jw = 3.961\cdot in^3$	Polar Moment of Inertia	

JOINT LOADS:

Tensile	$Fx = 1.013\cdot 10^3\ \cdot lbf$	$Fy := 0\cdot lbf$	$Fz := 0\cdot lbf$
Moment	$Mx := 0\cdot in\cdot lbf$	$My := 0\cdot in\cdot lbf$	$Mz := \left(Fx\cdot M_{arm}\right)$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx\cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx\cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 353.74\cdot\frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800\cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$w := \frac{fw}{0.707\cdot S}$ $w = 0.032\cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\frac{3}{16}\cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness of 3/8". Ref. 7, Part 5, Section J.2.2, Table J2.4

$w_{act} := \left(\frac{1}{4}\cdot in\right)$ Weld size specified in design drawings. Ref. 33.6, Pg. 2

$SF_{fw} := \frac{w_{act}}{w}$ $SF_{fw} = 7.895$ Safety factor based on a 1/4" weld > 3 OK

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By M.R. CUSTER MRC
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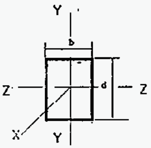
Weld on the two 3" x 3" x 3/8" plates attached to the 3" square tubes.

$Fx := \frac{W_{PA}}{2}$ Weld Tensile Load
(In "x" direction on subroutine sketch, below) Ref. 33.6, Sh. 1&2, Item 17

$M_{arm} := \left(\frac{2.50}{2} - 0.72\right) \cdot in$ Moment arm (Moment about Z imposed by eccentric bracket loading.

Ref. 9, Pg. 7.4 6 &7

WELD PROPERTIES:



$b := 3 \cdot in$ Weld Outline Dimension - short side

$d := 3 \cdot in$ Weld Outline Dimension - long side

$Cy := \frac{b}{2}$ $Cy = 1.5 \cdot in$ Location of center of gravity with respect to y axis.

$Cz := \frac{d}{2}$ $Cz = 1.5 \cdot in$ Location of center of gravity with respect to z axis.

$Aw := 2 \cdot (b + d)$ $Aw = 12 \cdot in$ Weld length (1 Tube)

$Swy := b \cdot d + \frac{b^2}{3}$ $Swy = 12 \cdot in^2$ Section modulus about y axis

$Swz := b \cdot d + \frac{d^2}{3}$ $Swz = 12 \cdot in^2$ Section modulus about z axis

$Jw := \frac{(b + d)^3}{6}$ $Jw = 36 \cdot in^3$ Polar Moment of Inertia

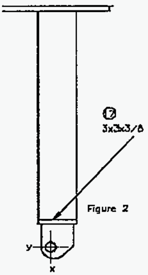


Figure 2

JOINT LOADS:

Tensile $Fx = 2.025 \cdot 10^3 \cdot lbf$ $Fy := 0 \cdot lbf$ $Fz := 0 \cdot lbf$

Moment $Mx := 0 \cdot in \cdot lbf$ $My := 0 \cdot in \cdot lbf$ $Mz := \left(Fx \cdot M_{arm}\right)$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 258.196 \cdot \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$w := \frac{fw}{0.707 \cdot S}$ $w = 0.023 \cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\frac{3}{16} \cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness of 3/8". Ref. 7, Part 5, Section J.2.2, Table J2.4

$w_{act} := \left(\frac{5}{16} \cdot in\right)$ Weld size specified in design drawings. Ref. 33.6, Pg. 2

$SF_{fw} := \frac{w_{act}}{w}$ $SF_{fw} = 13.52$ Safety factor based on a 5/16" weld > 3 OK

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WEIGHT of SHEAVE ASSEMBLY (Supported by Axles)

$W_{steel} := 490.8 \cdot \frac{lbf}{ft^3}$ (Ref.7, Page 6-8)

Weight of 2 Sheaves

$$V_{sheavs} := 4 \cdot \left[(0.25 \cdot in) \cdot \left[\frac{\pi \cdot (9.5 \cdot in)^2}{4} - \frac{\pi \cdot (1.508 \cdot in)^2}{4} \right] \right] + 2 \cdot \left[(2 \cdot in) \cdot \left[\frac{\pi \cdot (7.25 \cdot in)^2}{4} - \frac{\pi \cdot (1.508 \cdot in)^2}{4} \right] \right]$$ Volume

(Ref. 33.6, Item 3)

$W_{sheavs} := (V_{sheavs} \cdot W_{steel})$ $W_{sheavs} = 64.498 \cdot lbf$ Weight

Weight of 2 Square Tubing Support Arms

$w_{tube} := 8.81 \cdot \frac{lbf}{ft}$ Weight of 3 x 3 x 1/4 Square Carbon Steel Tubing : (Ref. 16)

$L_{tube} := 2 \cdot (17.875 \cdot in)$ Total Length of 2 Support Arms (Ref. 33.6, Item 2)

$W_{tube} := L_{tube} \cdot w_{tube}$ $W_{tube} = 26.246 \cdot lbf$ Weight

---

$w_{psf} := 15.32 \cdot \frac{lbf}{ft^2}$ Weight of 3/8 in. Hot Rolled Carbon Steel plate per square foot: (Ref. 16)

Weight of 4 Support Brackets

$A_{plate} := 4 \cdot \left[(2.5) \cdot (3) - 1 - \frac{\pi \cdot (0.81)^2}{4} \right] \cdot in^2$ $A_{plate} = 23.939 \cdot in^2$ Area of 4 Brackets (Ref. 33.6, Item A)

$W_{brackets} := A_{plate} \cdot w_{psf}$ $W_{brackets} = 2.547 \cdot lbf$ Weight

Weight of 2, 3 x 3 x 3/8 End Plates

(Ref. 33.6, Item 2)

$A_{plate} := 2 \cdot \left(3 \cdot 3 \cdot in^2\right)$ $A_{plate} = 18 \cdot in^2$ Area of 2 Plates

$W_{ends} := A_{plate} \cdot w_{psf}$ $W_{ends} = 1.915 \cdot lbf$ Weight

Sheave housing walls

(Ref. 33.6, Detail 2

$A_{plate} := 2 \cdot \left[((21) \cdot (11)) - (2 \cdot 2) - 2 \cdot \left[\frac{\pi \cdot (1.505)^2}{4} \right] \right] \cdot in^2$ $A_{plate} = 446.884 \cdot in^2$ Area of Wall Plate

$W_{housing} := A_{plate} \cdot w_{psf}$ $W_{housing} = 47.544 \cdot lbf$ Weight

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Sheave housing cross brace

(Ref. 33.6, Item 2)

$A_{plate} := 2\cdot(((8.625)\cdot(11)) - (3\cdot3) - (4.5\cdot4.5))\cdot in^2$ $\quad A_{plate} = 131.25\cdot in^2$ Area of Cross Brace Plate

$W_{brace} := A_{plate}\cdot w_{psf}$ $\quad W_{brace} = 13.964\cdot lbf$ Weight

Sheave housing Stabilizer Braces

(Ref. 33H.6, Item 2)

$A_{plate} := 4\cdot((1.5)\cdot(7))\cdot in^2$ $\quad A_{plate} = 42\cdot in^2$ Area of Bracket Plates

$W_{braces} := A_{plate}\cdot w_{psf}$ $\quad W_{braces} = 4.468\cdot lbf$ Weight

Sheave Assembly Support Bracket

$A_{plate} := \left[\left[\frac{\pi}{2}\cdot\left(1.5^2\right) + (3\cdot3)\right] - \frac{\pi}{4}\cdot\left(1.5^2\right)\right]\cdot in^2$ $\quad A_{plate} = 10.767\cdot in^2$ Area of Bracket Plates

(Ref. 33.6, Item 2)

$W_{sab} := A_{plate}\cdot w_{psf}$ $\quad W_{sab} = 1.146\cdot lbf$ Weight

Retrieval Cable Bracket

(Ref. 33H.6, Item 6)

$$V_{cb} := \left[2\cdot(0.47)\cdot\left[\left[\frac{\pi\cdot\left(1.25^2\right)}{2} + (1.25\cdot3)\right] - \frac{\pi}{4}\cdot\left(0.75^2\right)\right] + (0.25\cdot1.5\cdot3) + 2\cdot(2\cdot3\cdot0.54)\right]\cdot in^3$$

$V_{cb} = 13.022\cdot in^3$ Metal Volume of Bracket

$w_{240} := 0.284\cdot\frac{lbf}{in^3}$ Weight of ASTM A-240 Tp 304 SST

$W_{cb} := V_{cb}\cdot w_{240}$ $\quad W_{cb} = 3.698\cdot lbf$ Weight

Retrieval Cable

$w_{rope} := 24.3\cdot\frac{lbf}{100\cdot ft}$ Weight per 100 ft of 3/8", 7 x 19 in Strand Core Wire Rope Ref. 33.4, Item 20

$L_{rope} := (638.33 - 608)\cdot ft$ $\quad L_{rope} = 30.33\cdot ft$ Total Length of Wire Rope

$W_{rope} := w_{rope}\cdot L_{rope}$ $\quad W_{rope} = 7.37\cdot lbf$ Weight of 75 ft of Wire Rope Ref. 22

Sheave Assembly Base Plate

(Ref. 33.6, Item 2)

$A_{plate} := ((20.5)\cdot(3.5))\cdot in^2$ $\quad A_{plate} = 71.75\cdot in^2$ Area of Plate

$w_{psf} := 20.42\cdot\frac{lbf}{ft^2}$ Weight of 1/2 in. Hot Rolled Carbon Steel plate per square foot: (Ref. 16)

$W_{base} := A_{plate}\cdot w_{psf}$ $\quad W_{base} = 10.175\cdot lbf$ Weight

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Location C TANK FARM - HANFORD 200 EAST AREA

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By M.R. CUSTER MRC
By

Weight of Axles

$w_{N60} := \left(6.01 \cdot \frac{lbf}{ft}\right)$ Weight per ft of 1-1/2 Inch Diameter Nitronic 60 Round Stock (Ref. 16)

$L_{axle} := 2 \cdot (5.0 \cdot in)$ Total Length of 2 Axles (Ref. 33.6, Item 2)

$W_{axle} := L_{axle} \cdot w_{N60}$ $W_{axle} = 5.008 \cdot lbf$ Weight

---

Total Weight of Sheave Assembly

$$W_{SA} := W_{sheavs} + W_{tube} + W_{brackets} + W_{ends} + W_{housing} + W_{brace} \cdots + W_{braces} + W_{sab} + W_{cb} + W_{rope} + W_{base} + W_{axle}$$

$W_{SA} = 188.578 \cdot lbf$

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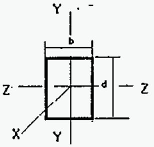
Weld Strength of the welds attaching the 3"square tube to the Sheave Assembly Baseplate.

$Fx := \dfrac{W_{PA} + W_{tube} + W_{brackets} + W_{ends}}{2}$ Weight of Sheave Assembly components below baseplate. Ref. 33.6, Sh. 2.

$M_{arm} := \left(\dfrac{2.50}{2} - 0.72\right) \cdot in$ Moment arm (Moment about Z imposed by eccentric bracket loading.

WELD PROPERTIES:



$b := 3 \cdot in$		Weld Outline Dimension - short side	Ref. 9, Pg. 7.4 6 &7
$d := 3 \cdot in$		Weld Outline Dimension - long side	
$Cy := \dfrac{b}{2}$	$Cy = 1.5 \cdot in$	Location of center of gravity with respect to y axis.	
$Cz := \dfrac{d}{2}$	$Cz = 1.5 \cdot in$	Location of center of gravity with respect to z axis.	
$Aw := 2 \cdot (b + d)$	$Aw = 12 \cdot in$	Weld length (1 Tube)	
$Swy := b \cdot d + \dfrac{b^2}{3}$	$Swy = 12 \cdot in^2$	Section modulus about y axis	
$Swz := b \cdot d + \dfrac{d^2}{3}$	$Swz = 12 \cdot in^2$	Section modulus about z axis	
$Jw := \dfrac{(b + d)^3}{6}$	$Jw = 36 \cdot in^3$	Polar Moment of Inertia	

JOINT LOADS:

Tensile	$Fx = 2.04 \cdot 10^3 \cdot lbf$	$Fy := 0 \cdot lbf$	$Fz := 0 \cdot lbf$
Moment	$Mx := 0 \cdot in \cdot lbf$	$My := 0 \cdot in \cdot lbf$	$Mz := (Fx \cdot M_{arm})$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 260.153 \cdot \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$w := \dfrac{fw}{0.707 \cdot S}$ $w = 0.023 \cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\dfrac{3}{16} \cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness of 1/2". Ref. 7, Part 5, Section J.2.2, Table J2.4

$SF_{fw} := \dfrac{w_{Code}}{w}$ $SF_{fw} = 8.051$ Safety factor based on a 3/16" weld > 3 OK

Stress on sheave axles

Ref. 33.6, Pg 2, Item 44

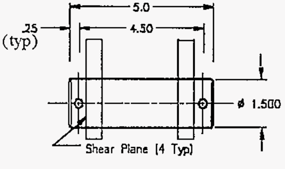


Figure 3

Shear stress

$D := 1.5 \cdot in$ Axle Diameter

$A_a := \frac{\pi \cdot D^2}{4}$ $A_a = 1.767 \cdot in^2$ Cross Sectional Area

$F_{axle} := \left[\frac{(W_{SA} - W_{axle}) + W_{PA}}{8} \right]$ $F_{axle} = 529.212 \cdot lbf$ Force of sheave assembly felt by each shear plane.

$S_{actS} := \frac{F_{axle}}{A_a}$ $S_{actS} = 299.473 \cdot \frac{lbf}{in^2}$ Calculated Shear Stress at each shear plane.

$S_y := 44400 \cdot \frac{lbf}{in^2}$ Yield Strength of ASTM A-276, *ARMCO Nitronic 60* Stainless Steel (1.5" not listed. Stress used is conservative for 1") Ref. 25, Table 36

$S_{allS} := 0.4 \cdot S_y$ $S_{allS} = 1.776 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress Ref. 11, Sec.1.8

$SF_S := \frac{S_{allS}}{S_{actS}}$ $SF_S = 59.304$ Safety factor > 3 OK

Bending stress

$D_m := 0.18 \cdot in$ Thrust Washer Thickness (Moment arm on axle between sheave and housing.) Ref. 33H.6, Pg. 2, Item 5

$M := F_{axle} \cdot D_m$ Moment applied to axle

$y := \frac{1.5}{2} \cdot in$ Distance from centroidal axis to outside fiber.

$I := \frac{\pi \cdot D^4}{64}$ Axle Moment of Inertia

$S_{actB} := \frac{M \cdot y}{I}$ $S_{actB} = 287.494 \cdot \frac{lbf}{in^2}$ Calculated Maximum Bending Stress per axle. Ref. 8, Pg. 177 (*Table of Simple Stresses*)

$S_{allB} := 0.75 \cdot S_y$ $S_{allB} = 3.33 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Bending Stress Ref. 7, Pg 5-48 (F2-1)

$SF_B := \frac{S_{allB}}{S_{actB}}$ $SF_B = 115.828$ Safety factor > 3 OK

Shear Stress of Sheave Housing at Axles

Calculation considers two plates in double shear at each axle.

$D := 5 \cdot in$ Depth of Housing Plate section Ref. 33H.6, Pg. 2, Item 2

$Th := \frac{3}{8} \cdot in$ Thickness of Sheave Housing Plate

$A_a := D \cdot Th \cdot 4$ $A_a = 7.5 \cdot in^2$ Area of metal supported by axles

$$F_{SH} := W_{PA} + W_{tube} + W_{brackets} + W_{ends} + W_{housing} + W_{brace} + W_{braces} + W_{sab} + W_{cb} + W_{base}$$

$F_{SH} = 4.162 \cdot 10^3 \cdot lbf$ Force on sheave Housing

$S_y := 25000 \cdot \frac{lbf}{in^2}$ Yield strength of ASTM A240 Type 304L

$S_{all} := (0.45) \cdot S_y$ $S_{all} = 1.125 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Stress Ref.7, Chap. D.3.1

$S_{act} := \frac{F_{SH}}{A_a}$ $S_{act} = 554.911 \cdot \frac{lbf}{in^2}$ Calculated Shear stress on Housing.

$SF := \frac{S_{all}}{S_{act}}$ $SF = 20.274$ Safety factor > 3 OK

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DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-04.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

Strength of Weld between housing walls and 1/2" base plate.

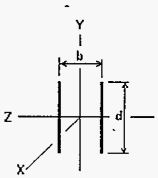
$Fx := W_{PA} + W_{tube} + W_{brackets} + W_{ends} + W_{base}$

$Fx = 4.091 \cdot 10^3 \cdot lbf$ Weld Tensile Load *(In "x" direction on subroutine sketch, below)*

WELD PROPERTIES:

$b := 3.5 \cdot in$ Weld Outline Dimension - short side Ref. 9, Pg. 7.4 6 &7

$d := 20.5 \cdot in$ Weld Outline Dimension - long side



$Cy := \frac{b}{2}$ $Cy = 1.75 \cdot in$ Location of center of gravity with respect to y axis.

$Cz := \frac{d}{2}$ $Cz = 10.25 \cdot in$ Location of center of gravity with respect to z axis.

$Aw := 2 \cdot d$ $Aw = 41 \cdot in$ Weld length

$Swy := b \cdot d$ $Swy = 71.75 \cdot in^2$ Section modulus about y axis

$Swz := \frac{d^2}{3}$ $Swz = 140.083 \cdot in^2$ Section modulus about z axis

$Jw := \frac{d \cdot \left(3 \cdot b^2 + d^2\right)}{6}$ $Jw = 1.561 \cdot 10^3 \cdot in^3$ Polar Moment of Inertia

JOINT LOADS:

Tensile	$Fx = 4.091 \cdot 10^3 \cdot lbf$	$Fy := 0 \cdot lbf$	$Fz := 0 \cdot lbf$
Moment	$Mx := 0 \cdot in \cdot lbf$	$My := 0 \cdot in \cdot lbf$	$Mz := 0 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 99.781 \cdot \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$w := \frac{fw}{0.707 \cdot S}$ $w = 0.009 \cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\frac{3}{16} \cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness of 1/2". Ref. 7, Part 5, Section J.2.2, Table J2.4

$SF_{fw} := \frac{w_{Code}}{w}$ $SF_{fw} = 20.991$ Safety factor based on a 3/16" weld > 3 OK

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DESIGN ANALYSIS

Client WESTINGHOUSE HANFORD COMPANY
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. ER4319
Date 9 / 8 / 95
Checked 9/8/95
Revised

Filename WIN-05.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Check of Retrieval Cable and Brackets

Check of Retrieval Cable

$W_{PA} := 3375 \cdot lbf$ Total Weight of Pump Assembly , impact loading not considered.

$W_{SA} := 188.578 \cdot lbf$ Total Weight of Sheave Assembly

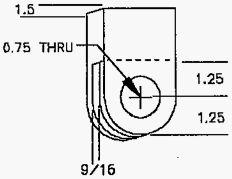
$W_{PA} + W_{SA} = 3.564 \cdot 10^{3} \cdot lbf$

$S_{cable} := 22800 \cdot lbf$ Breaking Strength of Type 304 Stainless Steel, 1/2", 6 x 19 IWRC Cable

$SF := \dfrac{S_{cable}}{\left(W_{PA} + W_{SA}\right)}$ $SF = 6.398$ Safety factor > 5 OK

Cable Support Brackets welded to the Winch Plate

Ref. 33.7, Sh. 2, Detail 3



Shear

$w := \left(1.25 - \dfrac{0.75}{2}\right) \cdot in$ $w = 0.875 \cdot in$ Width of Shear plane.

$th := (.4687) \cdot in$ $th = 0.469 \cdot in$ Plate thickness

$A := 2 \cdot (w \cdot th)$ $A = 0.82 \cdot in^{2}$ Area of bracket loaded by the clevis pin.

$S_{y} := 30000 \cdot \dfrac{lbf}{in^{2}}$ Yield strength of ASTM A240 Type 304

$S_{all} := (0.45) \cdot S_{y}$ $S_{all} = 1.35 \cdot 10^{4} \cdot \dfrac{lbf}{in^{2}}$ Allowable Stress Ref.7, Part 5, Chap. D.3.1

$S_{act} := \dfrac{\left(W_{PA} + W_{SA}\right)}{A}$ $S_{act} = 4.345 \cdot 10^{3} \cdot \dfrac{lbf}{in^{2}}$ Calculated stress on brackets.

$SF := \dfrac{S_{all}}{S_{act}}$ $SF = 3.107$ Safety factor > 3 OK

Cable Support Brackets (continued...)

Bearing Stress

$d := 0.75 \cdot in$ Hole Diameter

$A := \left(\frac{\pi \cdot d}{2} \cdot th\right)$ $A = 0.552 \cdot in^2$ Bearing Surface Area.

$S_y := 30000 \cdot \frac{lbf}{in^2}$ Yield strength of ASTM A240 Type 304

$S_{all} := (0.9) \cdot S_y$ $S_{all} = 2.7 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Stress Ref.11, Pg 12

$S_{act} := \frac{W_{PA} + W_{SA}}{A}$ $S_{act} = 6.454 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated stress on brackets.

$SF := \frac{S_{all}}{S_{act}}$ $SF = 4.184$ Safety factor $>$ 3 OK

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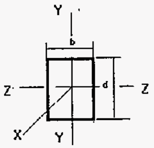
DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-05.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

Weld connecting Support Bracket to the Winch Plate. Ref. 33.7, Sh. 2, Detail 3

WELD PROPERTIES:



$b := 1.5 \cdot in$ Weld Outline Dimension - short side Ref. 9, Pg. 7.4 6 &7

$d := 3 \cdot in$ Weld Outline Dimension - long side

$Cy := \frac{b}{2}$ $Cy = 0.75 \cdot in$ Location of center of gravity with respect to y axis.

$Cz := \frac{d}{2}$ $Cz = 1.5 \cdot in$ Location of center of gravity with respect to z axis.

$Aw := 2 \cdot (b + d)$ $Aw = 9 \cdot in$ Weld length (1 Bracket)

$Swy := b \cdot d + \frac{b^2}{3}$ $Swy = 5.25 \cdot in^2$ Section modulus about y axis

$Swz := b \cdot d + \frac{d^2}{3}$ $Swz = 7.5 \cdot in^2$ Section modulus about z axis

$Jw := \frac{(b + d)^3}{6}$ $Jw = 15.187 \cdot in^3$ Polar Moment of Inertia

JOINT LOADS:

Tensile	$Fx := W_{PA} + W_{SA}$	$Fy := 0 \cdot lbf$	$Fz := 0 \cdot lbf$
Moment	$Mx := 0 \cdot in \cdot lbf$	$My := 0 \cdot in \cdot lbf$	$Mz := 0 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz} \right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw} \right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw} \right)^2 \right]^{0.5} \qquad fw = 395.953 \cdot \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

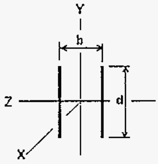
$w := \frac{fw}{0.707 \cdot S}$ $w = 0.035 \cdot in$ Minimum Allowable Fillet Weld Required by Design

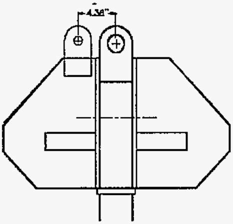
$w_{Code} := \left(\frac{5}{16} \cdot in \right)$ Minimum Size Fillet Weld Required by Code for material thickness of over 3/4". Ref. 7, Part 5, Section J.2.2, Table J2.4

$SF_{fw} := \frac{w_{Code}}{w}$ $SF_{fw} = 8.816$ Safety factor based on a 5/16" weld > 3 OK

Weld connecting Eye Tabs to Sheave Housing Ref. 33.6, Sh. 2, Detail 3

WELD PROPERTIES:





$b := 3 \cdot in$ Weld Outline Dimension - short side Ref. 9, Pg. 7.4 6 &7

$d := 2 \cdot in$ Weld Outline Dimension - long side

$Cy := \frac{b}{2}$ $Cy = 1.5 \cdot in$ Location of center of gravity with respect to y axis.

$Cz := \frac{d}{2}$ $Cz = 1 \cdot in$ Location of center of gravity with respect to z axis.

$Aw := 2 \cdot d$ $Aw = 4 \cdot in$ Weld length

$Swy := b \cdot d$ $Swy = 6 \cdot in^2$ Section modulus about y axis

$Swz := \frac{d^2}{3}$ $Swz = 1.333 \cdot in^2$ Section modulus about z axis

$Jw := \frac{d \cdot \left(3 \cdot b^2 + d^2\right)}{6}$ $Jw = 10.333 \cdot in^3$ Polar Moment of Inertia

JOINT LOADS:

Tensile $Fx := 0 \cdot lbf$ $Fy := \frac{W_{PA} + W_{SA}}{2}$ $Fz := 0 \cdot lbf$

Moment $Mx := 0 \cdot in \cdot lbf$ $My := 0 \cdot in \cdot lbf$ $Mz := 0 \cdot in \cdot lbf$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw} + \frac{My}{Swy} + \frac{Mz}{Swz}\right)^2 + \left(\frac{Fy}{Aw} + \frac{Mx \cdot Cy}{Jw}\right)^2 + \left(\frac{Fz}{Aw} + \frac{Mx \cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 445.447 \cdot \frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$w := \frac{fw}{0.707 \cdot S}$ $w = 0.04 \cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\frac{3}{16} \cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness of 3/8". Ref. 7, Part 5, Section J.2.2, Table J2.4

$w_{act} := \left(\frac{1}{4} \cdot in\right)$ Weld size specified in design drawings. Ref. H.6, Pg. 2

$SF_{fw} := \frac{w_{act}}{w}$ $SF_{fw} = 6.269$ Safety factor based on a 3/16" weld > 3 OK

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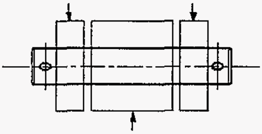
DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-05.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

Shear on Eye Bolt

Ref. 33.6, Pg 2



$D := \left(\frac{45}{64}\right)\cdot in$ $D = 0.703 \cdot in$ Axle Diameter

$A_a := \frac{\pi \cdot D^2}{4}$ $A_a = 0.388 \cdot in^2$ Cross Sectional Area

$F_{axle} := \left(\frac{W_{SA} + W_{PA}}{2}\right)$ $F_{axle} = 1.782 \cdot 10^3 \cdot lbf$ Force of sheave assembly felt by each shear plane.

$S_{actS} := \frac{F_{axle}}{A_a}$ $S_{actS} = 4.589 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated Shear Stress per axle.

$S_y := 100000 \cdot \frac{lbf}{in^2}$ Yield Strength of ASTM 193, Class 2, B8T

$S_{allS} := 0.4 \cdot S_y$ $S_{allS} = 4 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress Ref. 11, Sec.1.8

$SF_S := \frac{S_{allS}}{S_{actS}}$ $SF_S = 8.717$ Safety factor > 3 OK

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DESIGN ANALYSIS

Client WESTINGHOUSE HANFORD COMPANY
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. ER4319
Date 9 / 8 / 95
Checked 9/8/95
Revised

Filename WIN-06.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Weight of Reel Axle (12) Supported Components

$W_{PA} := 4050 \cdot lbf$ Weight of Pump Assembly (Impact Considered)

$W_{SA} := 188.578 \cdot lbf$ Weight of Sheave Assembly

Weight of Reel (Ref. 33.5, Sh. 2&4)

Weight of 2 Flanges

$w_{psf} := 15.32 \cdot \frac{lbf}{ft^2}$ Weight of 3/8 in. Hot Rolled Carbon Steel plate per square foot: (Ref. 16)

$A_{plate} := 2 \cdot \left[\frac{\pi}{4} \cdot \left(28^2 - 3.25^2\right)\right] \cdot in^2$ $A_{plate} = 1.215 \cdot 10^3 \cdot in^2$ Area of 2 Flanges

$W_{flanges} := A_{plate} \cdot w_{psf}$ $W_{flanges} = 129.253 \cdot lbf$ Flange Weight

Weight of Inner (Axle) Hub

$w_{r3} := 24.03 \cdot \frac{lbf}{ft}$ Weight per ft of 3 Inch Diameter 304L Round Stock Ref.16

$w_{r1.938} := 10.02 \cdot \frac{lbf}{ft}$ Weight per ft of 1-15/16 Inch Diameter 304L Round Stock Ref. 16

$L_{hub} := (3.75 \cdot in)$ Total Length of Hub

$W_{hubA} := L_{hub} \cdot \left(w_{r3} - w_{r1.938}\right)$ $W_{hubA} = 4.378 \cdot lbf$ Inner Hub Weight

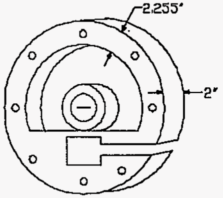
Weight of Outer (Reel) Hub (Ref. 33.5, Sh. 6)

(Ref. 7, Page 6-8)

$W_{steel} := 490.8 \cdot \frac{lbf}{ft^3}$

$r_{solid} := \left(\frac{11.75}{2}\right) \cdot in$ $r_{solid} = 5.875 \cdot in$

$A_{solid} := \pi \cdot r_{solid}^{\ 2}$ $r_{cutout} := 3.62 \cdot in$



$$A_{cutout} := \left(\frac{\pi \cdot r_{cutout}^{\ 2}}{2}\right) + 2 \cdot \left[(1.5 \cdot in) \cdot r_{cutout}\right] + \left[(1.5 \cdot 2.25) \cdot in^2\right] + \left[\left(\frac{3}{8} \cdot 5\right) \cdot in^2\right]$$

$A_{cutout} = 36.694 \cdot in^2$ Approximation of Semicircular Cutout Area.

$w := 2 \cdot in$ Hub Length

$V_{hub} := (w) \cdot \left(A_{solid} - A_{cutout}\right)$ $V_{hub} = 143.479 \cdot in^3$ Metal Volume of Hub

$W_{hubB} := \left(V_{hub} \cdot W_{steel}\right)$ $W_{hubB} = 40.752 \cdot lbf$ Approximate weight

TOTAL Weight of Reel

$W_{reel} := W_{flanges} + W_{hubA} + W_{hubB}$ $W_{reel} = 174.383 \cdot lbf$

Weight of Gear

$W_{gear25} := 105 \cdot lbf$ *Weight of 54 tooth 18 PD, 3 DP, 3" Spur Gear obtained by telecon from Boston Gear, 8 / 15 / 95.* Ref. 20

Weight of Wire Rope

$w_{rope} := 0.69 \cdot \frac{lbf}{ft}$ Weight per ft of 1/4 x 1-1/2 in Flat Wire Rope Ref. 8, Pg. 332, Tbl 7

$L_{rope} := 75 \cdot ft$ Total Length of Wire Rope Ref. 33.1

$W_{rope} := w_{rope} \cdot L_{rope}$ $W_{rope} = 51.75 \cdot lbf$ Weight of 75 ft of Wire Rope

Weight of Reel / Spur Gear Shaft (Axle)

$w_{2} := 10.68 \cdot \frac{lbf}{ft}$ Weight per ft of 2 Inch Diameter 4140 Round Stock Ref. 16

$w_{1.938} := 10.02 \cdot \frac{lbf}{ft}$ Weight per ft of 1-15/16 Inch Diameter 4140 Round Stock Ref. 16

$w_{1.25} := 4.17 \cdot \frac{lbf}{ft}$ Weight per ft of 1-1/4 Inch Diameter 4140 Round Stock Ref. 16

$W_{shaft} := \left[(10.55 \cdot in) \cdot w_{1.938}\right] + \left[(5.44 \cdot in) \cdot w_{2}\right] + \left[(5.5 \cdot in) \cdot w_{1.25}\right]$ $W_{shaft} = 15.562 \cdot lbf$ Axle Weight

Weight of Pump, Sheave and Rope Assemblies on Reel Hub

$W_{Hub} := W_{PA} + W_{SA} + W_{rope}$ $W_{Hub} = 4.29 \cdot 10^{3} \cdot lbf$

Weight of Loaded Reel on Axle (12)

$W_{Reel} := W_{PA} + W_{SA} + W_{reel} + W_{rope}$ $W_{Reel} = 4.465 \cdot 10^{3} \cdot lbf$

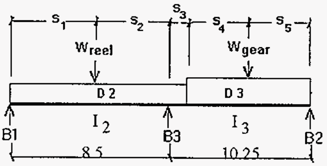
Total Weight of Reel / Spur Gear Assembly on Bearings

$W_{RA} := W_{PA} + W_{SA} + W_{reel} + W_{gear25} + W_{rope} + W_{shaft}$ $W_{RA} = 4.585 \cdot 10^{3} \cdot lbf$

Shear on Reel Axle (12) Bearings

$D2 := \left(10.032 \cdot \frac{lbf}{ft}\right)$ $D3 := \left(10.69 \cdot \frac{lbf}{ft}\right)$ Weight per foot of Shaft

Ref. C, Page 1-108



$s_1 := 3.89 \cdot in$ Span 1 = Axle Length between Bearing 1 and Reel. Ref. 33.5, Pages 1 & 5

$s_2 := 4.61 \cdot in$ Span 2 = Axle Length between Reel and Center Bearing (Bearing 3).

$s_3 := 3.435 \cdot in$ Span 3 = Axle Length between Bearing 3 and Diameter change.

$s_4 := 1.625 \cdot in$ Span 4 = Axle Length between Diameter Change and Gear 25.

$s_5 := 5.19 \cdot in$ Span 5 = Axle Length between Gear25 and Bearing 2.

Ref. 8, Page 191

$d_2 := 1.9375 \cdot in$ $I_2 := \frac{\pi \cdot d_2^{\,4}}{64}$ $I_2 = 0.6917 \cdot in^4$ Moment of Inertia for shaft diameter = 1.9375 in

$d_3 := 2 \cdot in$ $I_3 := \frac{\pi \cdot d_3^{\,4}}{64}$ $I_3 = 0.7854 \cdot in^4$ Moment of Inertia for shaft diameter = 2 in

$K_1 := \frac{I_2}{(s_1 + s_2)} \cdot \left(\frac{3}{4}\right)$ $K_1 = 0.061 \cdot in^3$ Stiffness Factor adjusted for simple supports. Ref. 13, Page 530

$K_2 := \frac{I_3}{(s_3 + s_4 + s_5)} \cdot \left(\frac{3}{4}\right)$ $K_2 = 0.057 \cdot in^3$ Stiffness Factor adjusted for simple supports.

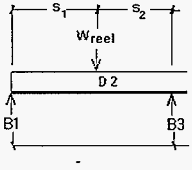
$DF_{K1} := \frac{K_1}{K_1 + K_2}$ $DF_{K1} = 0.515$ Distribution Factor Ref. 13, Page 528

$DF_{K2} := \frac{K_2}{K_1 + K_2}$ $DF_{K2} = 0.485$ Distribution Factor

Loading on Axle from Bearings B1 to B3

$W_{reel} := 4465 \cdot lbf$

Ref. 13, Page 528



$F_{cB1} := \dfrac{W_{reel} \cdot (s_2)}{(s_1 + s_2)}$ $F_{cB1} = 2.422 \cdot 10^3 \cdot lbf$ Concentrated vertical Load at B1

$F_{cB3} := \dfrac{W_{reel} \cdot (s_1)}{(s_1 + s_2)}$ $F_{cB3} = 2.043 \cdot 10^3 \cdot lbf$ Concentrated vertical Load at B3

$F_d := \dfrac{D2 \cdot (s_1 + s_2)}{2}$ $F_d = 3.553 \cdot lbf$ Distributed vertical Load from B1 to B3

$F_{B1} := F_{cB1} + F_d$ $F_{B1} = 2425.159 \cdot lbf$ Combined vertical Loading at B1.

$F_{B3} := F_{cB3} + F_d$ $F_{B3} = 2046.947 \cdot lbf$ Combined vertical Loading at B3.

Fixed End Moments (Span B1 - B3)

Ref. 13, Page 528
Ref. 33.5, Pages 1 & 5

$P := W_{reel}$ Concentrated Load

$l := s_1 + s_2$ Total Spacing

$w := D2$ Distributed Load (Conservatively assumed as spanning full length of beam.)

$FEM_{cB1} := \dfrac{P \cdot s_1 \cdot s_2^{\,2}}{l^2}$ $FEM_{cB1} = 5.109 \cdot 10^3 \cdot lbf \cdot in$ Left Fixed End Moment resulting from Concentrated Load

$FEM_{cB3} := \dfrac{P \cdot s_1^{\,2} \cdot s_2}{l^2}$ $FEM_{cB3} = 4.311 \cdot 10^3 \cdot lbf \cdot in$ Right Fixed End Moment resulting from Concentrated Load

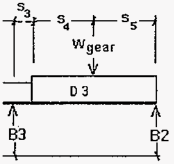
$M_d := \dfrac{w \cdot l^2}{12}$ $M_d = 5.033 \cdot lbf \cdot in$ Fixed End Moment resulting from Uniformly Distrbuted Load

$FEM_L := FEM_{cB1} + M_d$ $FEM_L = 5114.024 \cdot lbf \cdot in$

$FEM_R := FEM_{cB3} + M_d$ $FEM_R = 4316.09 \cdot lbf \cdot in$

Loading on Axle from Bearings B3 to B2

Ref. 13, Page 528



$W_{gear} := 105 \cdot lbf$

$F_{cB3} := \dfrac{W_{gear} \cdot (s_5)}{(s_3 + s_4 + s_5)}$ $F_{cB3} = 53.166 \cdot lbf$ Concentrated vertical Load felt at B3

$F_{cB2} := \dfrac{W_{gear} \cdot (s_3 + s_4)}{(s_3 + s_4 + s_5)}$ $F_{cB2} = 51.834 \cdot lbf$ Concentrated vertical Load felt at B2

$F_d := \dfrac{(D2 \cdot s_3) + [D3 \cdot (s_4 + s_5)]}{2}$ $F_d = 4.471 \cdot lbf$ Distributed vertical Load from B1 and B2

$F_{B2} := F_{cB2} + F_d$ $F_{B2} = 56.305 \cdot lbf$ Combined vertical Loading at B2.

$F_{B3} := F_{cB3} + F_d$ $F_{B3} = 57.637 \cdot lbf$ Combined vertical Loading at B3.

Fixed End Moments (Span B3 - B2)

Ref. 13, Page 528

$P := W_{gear}$ Concentrated Load

$l := (s_3 + s_4 + s_5)$ Total Spacing

$w := D3$ Distributed Load (Conservatively assumed as spanning full length of beam.)

$FEM_{cB3} := \dfrac{P \cdot (s_3 + s_4) \cdot (s_5)^2}{l^2}$ $FEM_{cB3} = 136.216 \cdot lbf \cdot in$ Left Fixed End Moment resulting from Concentrated Load

$FEM_{cB2} := \dfrac{P \cdot (s_3 + s_4)^2 \cdot (s_5)}{l^2}$ $FEM_{cB2} = 132.804 \cdot lbf \cdot in$ Right Fixed End Moment resulting from Concentrated Load

$M_d := \dfrac{w \cdot l^2}{12}$ $M_d = 7.799 \cdot lbf \cdot in$ Moment resulting from Distrbuted Load

$FEM_R := FEM_{cB2} + M_d$ $FEM_R = 140.603 \cdot lbf \cdot in$

$FEM_L := FEM_{cB3} + M_d$ $FEM_L = 144.015 \cdot lbf \cdot in$

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DESIGN ANALYSIS

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Client	**WESTINGHOUSE HANFORD CO.**	WO/Job No.	ER4319	Filename	**WIN-8.XLS**
Subject	**WINCH ANALYSIS - SLURRY /SLUICE PUMP**	Date	**9/8/95**	By	**D. L. STONE**
PROJECT	**W-320 WASTE RETRIEVAL for Tank 241-C-106**	Checked	9/8/95	By	**M. R. CUSTER** MRC
Location	**C TANK FARM - HANFORD 200 EAST AREA**	Revised		By	

REEL SHAFT FORCES AND MOMENTS
Determined by Moment Distribution Method for Beams

		0.515	0.485	
Fixed End Moments	-5114.02	4316.09	-144.02	140.60
Reaction Due to Unbalanced Moment	5114.02	2557.01	-70.30	-140.60
Distributed Reactions	0.00	-3429.27	-3229.51	0.00
Sum		3443.83	-3443.83	
Simple Support Reactions of:				
Vertical Load, P/L + wL/2 (AISC)	2425.16	2046.95	57.64	56.31
Distributed Moments , M/L	-405.16	405.16	335.98	-335.98
Sum	2020.00	2452.10	393.62	-279.68
Total Vertical Reactions at Supports	2020.00 lb	2845.72 lbs		-279.68 lbs

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Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-07.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

Reel Shaft Forces

Determined by Moment Distribution Method for Indeterminant Beams

$B1 := 2020.00 \cdot lbf$ $B3 := 2845.72 \cdot lbf$ $B2 := -279.68 \cdot lbf$

Bending Moments for Reel Axle (12)

$D2 = 10.032 \cdot \frac{lbf}{ft}$ $D3 = 10.69 \cdot \frac{lbf}{ft}$ Weight per foot of Shaft

$W_{reel} = 4.465 \cdot 10^3 \cdot lbf$ $W_{gear} = 105 \cdot lbf$

$a := B1$ $a = 2.02 \cdot 10^3 \cdot lbf$

$b := a - (s_1) \cdot D2$ $b = 2.017 \cdot 10^3 \cdot lbf$

$c := b - W_{reel}$ $c = -2.448 \cdot 10^3 \cdot lbf$

$d := c - (s_2) \cdot D2$ $d = -2.452 \cdot 10^3 \cdot lbf$

$e := d + B3$ $e = 393.614 \cdot lbf$

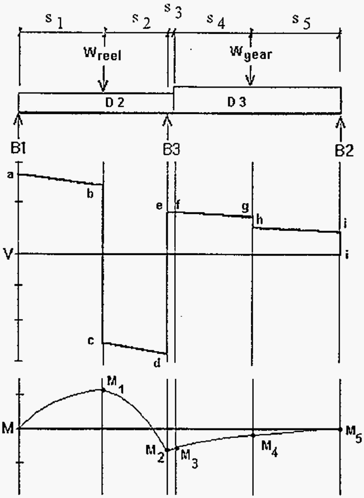
$f := e - (s_3) \cdot D2$ $f = 390.742 \cdot lbf$

$g := f - (s_4) \cdot D3$ $g = 389.295 \cdot lbf$

$h := g - W_{gear}$ $h = 284.295 \cdot lbf$

$i := h - (s_5) \cdot D3$ $i = 279.671 \cdot lbf$

$j := i + B2$ $j = 0 \cdot lbf$



Maximum Bending Moment on the Shaft

$M_1 := b \cdot (s_1) + \frac{(a - b) \cdot (s_1)}{2}$ $M_1 = 7.851 \cdot 10^3 \cdot lbf \cdot in$ <---------- Maximum Bending Moment

$M_2 := M_1 + \left[c \cdot (s_2) + \frac{(d - c) \cdot (s_2)}{2} \right]$ $M_2 = -3.444 \cdot 10^3 \cdot lbf \cdot in$

$M_3 := M_2 + \left[f \cdot (s_3) + \frac{(e - f) \cdot (s_3)}{2} \right]$ $M_3 = -2.097 \cdot 10^3 \cdot lbf \cdot in$

$M_4 := M_3 + \left[g \cdot (s_4) + \frac{(f - g) \cdot (s_4)}{2} \right]$ $M_4 = -1.463 \cdot 10^3 \cdot lbf \cdot in$

$M_5 := M_4 + \left[i \cdot (s_5) + \frac{(h - i) \cdot (s_5)}{2} \right]$ $M_5 = 0.554 \cdot lbf \cdot in \approx 0 \cdot (lbf \cdot in)$

Client WESTINGHOUSE HANFORD COMPANY WO/Job No. ER4319 Filename WIN-07.mcd
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP Date 9 / 8 / 95 By D.L. STONE
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106 Checked 9/8/95 By M.R. CUSTER MRC
Location C TANK FARM - HANFORD 200 EAST AREA Revised By

Equivalent Radial load - Radial Ball Bearings

Shaft End (B1 and B2) Bearings

Pillow Block, RSAO (1-1/4" Shaft Diameter)	Ref. 27, Pg 174
Bearing, GN104KRRB	Ref. 27, Pg 144

$C_o := 4500 \cdot lbf$ Published STATIC LOAD RATING (Maximum Permissible Radial Load) Ref. 27, Pg. 174

$i_B := 1$ Number of adjacently mounted bearings.

$R := B1$ Maximum APPLIED RADIAL LOAD on Bearings

$Thr := 0 \cdot lbf$ APPLIED THRUST LOAD on Bearing

$K_{Thr} := \frac{Thr}{i_B \cdot C_o}$ $K_{Thr} = 0$ Relative Thrust Load Factor for Ball Bearings Ref. 27, Pg. E-50, Table 1.1

$Y_1 := 0$ Thrust Load Factor for Ball Bearings (from Table 2) Ref. 27, Pg. E-51, Table 2

Formula for Single Row *WIDE INNER RING BALL BEARINGS*

Equivalent Radial Load on Bearing is the Larger result of the two following Formulas

$P := 0.56 \cdot R + Y_1 \cdot Thr$ $P = 1.131 \cdot 10^3 \cdot lbf$ Ref. 27, Pg. E-50, Table 1.2

$P := R$ $P = 2.02 \cdot 10^3 \cdot lbf$

$SF := \frac{2.5 \cdot C_o}{P} = \frac{F_{all}}{F_{act}}$ $SF = 5.569$ Given that actual bearing failure (ball fracture or disintegration) would require 2 to 3 times the Static Load Rating, a factor of 2.5 times Co has been assumed to represent Ultimate Strength. Ref. 28

Safety > 5 ***OK***

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Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. ER4319
Date 9 / 8 / 95
Checked 9/8/95
Revised

Filename WIN-07.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Center Bearings (B3)

Flanges, RCJO (1-15/16" Shaft Diameter)	Ref. 27, Pg 186
Bearing, GN115KRRB	Ref. 27, Pg 144

$C_o := 8000 \cdot lbf$	Published STATIC LOAD RATING (Maximum Permissible Radial Load)	
$i_B := 2$	Number of adjacently mounted bearings.	Ref. 27, Pg. 174
$R := B3$	Maximum APPLIED RADIAL LOAD on Bearings	
$Thr := 0 \cdot lbf$	APPLIED THRUST LOAD on Bearing	
$K_{Thr} := \frac{Thr}{i_B \cdot C_o}$ $\quad K_{Thr} = 0$	Relative Thrust Load Factor for Ball Bearings	Ref. 27, Pg. E-50, Table 1.1
$Y_1 := 0$	Thrust Load Factor for Ball Bearings (from Table 2)	Ref. 27, Pg. E-51, Table 2

Formula for Single Row *WIDE INNER RING BALL BEARINGS*

Equivalent Radial Load on Bearing is the Larger result of the two following Formulas

$P := 0.56 \cdot R + Y_1 \cdot Thr \quad P = 1.594 \cdot 10^3 \cdot lbf$

$P := R \quad P = 2.846 \cdot 10^3 \cdot lbf$

Ref. 27, Pg. E-50
Table 1.2

$SF := \frac{i_B \cdot 2.5 \cdot C_o}{P} = \frac{F_{all}}{F_{act}} \quad SF = 14.056$ Safety factor > 5 ***OK*** Ref. 28

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Client	**WESTINGHOUSE HANFORD CO.**	WO/Job No.	**ER4319**	Filename	**WIN-9.XLS**
Subject	**WINCH ANALYSIS**	Date	**9/8/95**	By	**D. L. STONE**
PROJECT	**W-320 WASTE RETRIEVAL for Tank 241-106-C**	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM- HANFORD 200 EAST AREA	Revised		By	

Radial Distance from Reel Axis to Outermost Coil of Wire Rope on Reel

	Wrap Diameter d	Circumference c	Radius
Hub Diameter	11.75	36.91	5.875
Wrap 1	12.25	38.48	0.25
Wrap 2	12.75	40.06	0.25
Wrap 3	13.25	41.63	0.25
Wrap 4	13.75	43.20	0.25
Wrap 5	14.25	44.77	0.25
Wrap 6	14.75	46.34	0.25
Wrap 7	15.25	47.91	0.25
Wrap 8	15.75	49.48	0.25
Wrap 9	16.25	51.05	0.25
Wrap 10	16.75	52.62	0.25
Wrap 11	17.25	54.19	0.25
Wrap 12	17.75	55.76	0.25
Wrap 13	18.25	57.33	0.25
Wrap 14	18.75	58.90	0.25
Wrap 15	19.25	60.48	0.25
Wrap 16	19.75	62.05	0.25
Wrap 17	20.25	63.62	0.25
Wrap 18	20.75	65.19	0.25
	Sum	933.05	10.375

Length of Wire Rope	933.05	inches
(Length of Wire Rope	77.75	feet)

Axle 12 Center Bearing Stresses

Ref. 33.5

$B3 := 2845.72 \cdot lbf$		Vertical loading at Center Bearings	
$M2 := 3444 \cdot lbf \cdot in$		Moment at Center Bearings	

Bearing Stress on Wall at the Screws

$th := \frac{1}{2} \cdot in$		Plate Thickness	Ref. 33.5, Sh. 3
$d := \left(\frac{11}{16}\right) \cdot in$		Hole Diameter	Ref. 33.5, Sh. 3
$A := \left(\frac{\pi \cdot d}{2} \cdot th\right)$	$A = 0.54 \cdot in^2$	Bearing Surface Area.	
$S_y := 36000 \cdot \frac{lbf}{in^2}$		Yield strength of ASTM A36	
$S_{all} := (0.9) \cdot S_y$	$S_{all} = 3.24 \cdot 10^4 \cdot \frac{lbf}{in^2}$	Allowable Stress	Ref. 11, Page12
$S_{act} := \frac{B3}{4 \cdot A}$	$S_{act} = 1.318 \cdot 10^3 \cdot \frac{lbf}{in^2}$	Calculated stress on 1/2" wall plate.	
$SF := \frac{S_{all}}{S_{act}}$	$SF = 24.591$	Safety factor > 3 <u>OK</u>	

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DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-10.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER MRC
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

Check stress on 5/8 - 11 - UNC - 2B Hex Head Screws

Shear

$n_b := 4$ Number of Screws per Housing Ref. 33.5, Sh. 3

$n_B := 1$ Number of Bearings

$n := 11$ Number of threads per inch

$D := \frac{5}{8} \cdot in$ Major Diameter of Screw

$A_T := 0.7854 \cdot \left[\left[D - \left(\frac{0.9743}{n} \right) \cdot in \right] \right]^2$ $A_T = 0.226 \cdot in^2$ Tensile Stress Area of Screw Ref. 7, Pg. 4-147

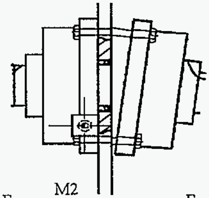
$F_u := 100000 \cdot psi$ Ultimate Tensile Strength of A193 Class2 B8T Stainless Steel Fasteners

$S_{all} := 0.17 \cdot F_u$ $S_{all} = 1.7 \cdot 10^4 \cdot psi$ Allowable shear strength of screws Ref. 7, Pg. 4-5

$S_{act} := \frac{B3}{n_b \cdot A_T}$ $S_{act} = 3.148 \cdot 10^3 \cdot psi$ Calculated shear stress

$\frac{S_{all}}{S_{act}} = 5.4$ Safety factor > 5 OK

Tensile



$n_b := 2$ Number of Screws stressed by Moment Ref. 33.5, Sh. 3

$d := 5.125 \cdot in$ Center to center distance of housing bolts. Ref. 27, Page 186

$y := \frac{d}{2}$ Housing base edge to screw C_L distance to determine maximum prying stress.

$F_T := \frac{M2}{n_B \cdot y}$ $F_T = 1.344 \cdot 10^3 \cdot lbf$ Tension on Screws resulting from combined moment on housing

$T_{act} := \frac{F_T}{n_b \cdot A_T}$ $T_{act} = 2.973 \cdot 10^3 \cdot psi$ Calculated Tensile stress at each screw

$T_{all} := 0.33 \cdot F_u$ Allowable Yield Strength in Tension Ref. 7, Pg. 4-3

$\frac{T_{all}}{T_{act}} = 11.098$ Safety factor > 5 OK

DESIGN ANALYSIS

Client WESTINGHOUSE HANFORD COMPANY
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

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Filename WIN-11.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Design of Reel Axle

$W_{Hub} := 4290 \cdot lbf$	Weight on the Reel Hub
$R := 10.375 \cdot in$	Outer radius of reel plus 18 layers of 1/4" x 1- 1/2" flat wire rope wraped on the reel.
$T := W_{Hub} \cdot R \qquad T = 4.451 \cdot 10^{4} \cdot in \cdot lbf$	Applied Torsional Moment on winch axle
$M_b := 7851 \cdot lbf \cdot in$	Maximum Bending Moment

Determination of Torsion on a Shaft of Varying Diameters

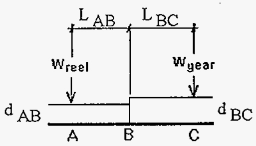
Ref. 14, Page 74.

$L_{AB} := (4.61 + 3.435) \cdot in \qquad L_{BC} := 1.625 \cdot in$ Shaft Section Lengths

$d_{AB} := 1.9375 \cdot in \qquad d_{BC} := 2 \cdot in$ Shaft Diameters

$Gs = Gb$ Modulus of Rigidity

$\theta = \left(\frac{T \cdot L}{G} \cdot \frac{32}{\pi \cdot d^4}\right)$ Twist Angle



Equation 1

$$\theta_{AB} = \theta_{BC}$$

$$\left(\frac{T_{AB} \cdot L_{AB}}{Gs} \cdot \frac{32}{\pi \cdot d_{AB}{}^4}\right) = \left(\frac{T_{BC} \cdot L_{BC}}{Gb} \cdot \frac{32}{\pi \cdot d_{BC}{}^4}\right)$$

$$\left(\frac{T_{AB} \cdot L_{AB}}{d_{AB}{}^4}\right) = \left(\frac{T_{BC} \cdot L_{BC}}{d_{BC}{}^4}\right)$$

$$\frac{T_{AB}}{T_{BC}} = \qquad x := \left(\frac{L_{BC}}{L_{AB}}\right) \cdot \left(\frac{d_{AB}{}^4}{d_{BC}{}^4}\right) \qquad x = 0.178$$

$$T_{AB} = T_{BC} \cdot x$$

Equation 2

$$T_{AB} + T_{BC} = T = 4.451 \cdot 10^{4} \cdot lbf \cdot in$$

$$T_{AB} = T - T_{BC}$$

$$T_{AB} = T_{AB}$$

$$T_{BC} \cdot x = T_{applied} - T_{BC}$$

$$(T_{BC} \cdot x) + T_{BC} = T_{applied}$$

$$T_{BC} \cdot (x + 1) = T_{applied}$$

$T_{BC} := \frac{T}{(x + 1)} \qquad T_{BC} = 3.779 \cdot 10^{4} \cdot lbf \cdot in$ Torsion on Section B

$T_{AB} := T_{BC} \cdot x \qquad T_{AB} = 6.722 \cdot 10^{3} \cdot lbf \cdot in$ Torsion on Section A

Design of Reel Axle , *(continued.....)*

$S_y := 120000 \cdot \frac{lbf}{in^2}$		Yield Strength of ASTM A291-92, Class B Steel	
$S_{allC} := 0.30 \cdot S_y$	$S_{allC} = 3.6 \cdot 10^4 \cdot \frac{lbf}{in^2}$	Maximum Allowable Shearing Stress for Combined Torsion and Bending	Ref. 8, Pg 270 ((b), Below Table 2)
$P_t := 0.75 \cdot S_{allC}$	$P_t = 2.7 \cdot 10^4 \cdot \frac{lbf}{in^2}$	Maximum Allowable Stress for Solid Shafts using Keyways	Ref. 8, Pg 270
$B := 1$		B defines hollow shafts and is assumed as 1 for solid shafts.	Ref, 8, Pg 270 (Below Table 3)
$K_t := 1.0$ $K_m := 1.5$		Combined Shock and Fatigue factors for Steady, gradually applied, loading	Ref. 8, Pg 270, Table 1
$D_c := B \cdot \left[\frac{5.1}{P_t} \cdot \left[\left(K_m \cdot M_b \right)^2 + \left(K_t \cdot T_{BC} \right)^2 \right]^{\frac{1}{2}} \right]^{\frac{1}{3}}$	$D_c = 1.955 \cdot in$	Minimum Required Shaft Diameter for Combined Bending and Torsional Loading	Ref. 8, Pg. 269,(3a)
$D_{act} := 1.9375 \cdot in$		Design Shaft Diameter	
$D_{act} \ge D_c$	***OK***	Acceptance Criteria for Minimum Shaft Diameter	

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DESIGN ANALYSIS

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Client WESTINGHOUSE HANFORD COMPANY
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. ER4319
Date 9 / 8 / 95
Checked 9/8/95
Revised

Filename WIN-11.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Key stress

Key, Reel and Spur Gear (typical) = 1/2 " x 1/2" x 4.75 ". Ref. 33.5, Page 5

$F_{ky} := 100000 \cdot \frac{lbf}{in^2}$ Yield Strength for (ASTM A 276-94b, Type 304, Condiiton B)

$SA_{ky} := 0.577 \cdot F_{ky}$ $SA_{ky} = 5.77 \cdot 10^4 \cdot psi$ Allowable Shear Stress . Ref. 11, Page 370

Reel	Spur Gear	
$A_{kyr} := (0.50 \cdot in) \cdot (3.75 \cdot in)$	$A_{kyg} := (0.50 \cdot in) \cdot (4.75 \cdot in)$	
$A_{kyr} = 1.875 \cdot in^2$	$A_{kyg} = 2.375 \cdot in^2$	Area of key cross section
$d_{AB} := 1.9375 \cdot in$	$d_{BC} := 2 \cdot in$	Shaft Diameters
$r_r := \frac{d_{AB}}{2}$	$r_g := \frac{d_{BC}}{2}$	Shaft Radius
$F_{kyr} := \frac{T_{AB}}{r_r}$ $F_{kyr} = 6.939 \cdot 10^3 \cdot lbf$	$F_{kyg} := \frac{T_{BC}}{r_g}$ $F_{kyg} = 3.779 \cdot 10^4 \cdot lbf$	Force on key
$S_{kyr} := \frac{F_{kyr}}{A_{kyr}}$ $S_{kyr} = 3.701 \cdot 10^3 \cdot \frac{lbf}{in^2}$	$S_{kyg} := \frac{F_{kyg}}{A_{kyg}}$ $S_{kyg} = 1.591 \cdot 10^4 \cdot \frac{lbf}{in^2}$	Stress on key
$SF_r := \frac{SA_{ky}}{S_{kyr}}$	$SF_g := \frac{SA_{ky}}{S_{kyg}}$	
$SF_r = 15.591$ > 3 ***OK***	$SF_g = 3.627$ > 3 ***OK***	Safety factor

Loading on Circular Hub

Forces / Moments on Reel Hub

$W_{Hub} := 4290 \cdot lbf$ Weight on Reel Hub

$T := 44510 \cdot lbf \cdot in$ Torsional Moment

$Tension := W_{Hub}$ $Tension = 4.29 \cdot 10^3 \cdot lbf$ Tension on Rope

$d := 1.5 \cdot in$ Rope Diameter (Width of Flat Wire Rope) Ref. 33.1

$D := 11.75 \cdot in$ Hub (Drum) Diameter Ref. 33.5, Page 6

$P := \frac{2 \cdot Tension}{D \cdot d}$ $P = 486.809 \cdot \frac{lbf}{in^2}$ Radial Pressure Ref. 8, Pg. 334

$h := (2.255) \cdot in$ Hub Thickness (Radial)

$D_m := (11.75 \cdot in - h)$ $D_m = 9.495 \cdot in$ Hub Mean Diameter

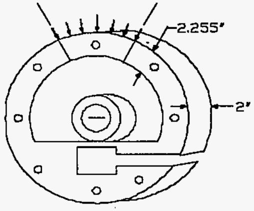
$circ := \pi \cdot D_m$ $circ = 29.829 \cdot in$ Hub Circumference at mean Diameter

$F_{rad} := P \cdot d$ $F_{rad} = 730.213 \cdot \frac{lbf}{in}$ Distributed Force due to Radial Pressure Ref. 33.5, Sh. 4

Forces and Moment on Reel Hub

Stresses on curved beam are calculated using the standard straight beam formula, S = Mc / I , multiplied by a Stress Correction Factor, K . This calculation considers the initial straight beam length to be the distance between bolts, or 1/8 of the hub circumference.

$+\uparrow \Sigma F = 0 = \quad W_{Hub} + F_{rad} \cdot \left(\frac{circ}{8}\right) - R_1 - R_2$



$\circlearrowright \Sigma M_{R_1} = 0 = \quad R_2 \cdot \left(\frac{circ}{8}\right) - W_{Hub} \cdot \left(\frac{circ}{16}\right) - F_{rad} \cdot \left(\frac{circ}{8}\right) \cdot \left(\frac{circ}{16}\right)$

$R_2 := \frac{W_{Hub} \cdot \left(\frac{circ}{16}\right) + F_{rad} \cdot \left(\frac{circ}{8}\right) \cdot \left(\frac{circ}{16}\right)}{\left(\frac{circ}{8}\right)}$ $R_2 = 3.506 \cdot 10^3 \cdot lbf$

$R_1 := W_{Hub} + F_{rad} \cdot \left(\frac{circ}{8}\right) - R_2$ $R_1 = 3.506 \cdot 10^3 \cdot lbf$

Bending Moments for Hub as a Straight Beam

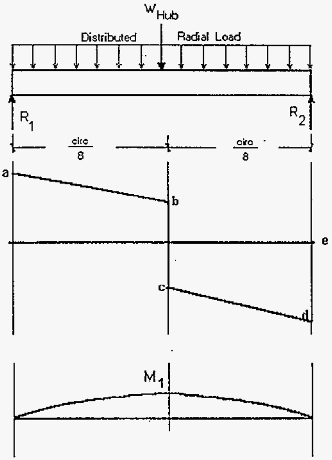
$a := R_1$ $a = 3.506 \cdot 10^3 \cdot \text{lbf}$

$b := a - F_{rad} \cdot \left(\frac{circ}{16}\right)$ $b = 2.145 \cdot 10^3 \cdot \text{lbf}$

$c := b - W_{Hub}$ $c = -2.145 \cdot 10^3 \cdot \text{lbf}$

$d := c - F_{rad} \cdot \left(\frac{circ}{16}\right)$ $d = -3.506 \cdot 10^3 \cdot \text{lbf}$

$e := d + R_2$ $e = 0 \cdot \text{lbf}$



Maximum Bending Moment for Hub as a Straight Beam

$$M_1 := b \cdot \left(\frac{circ}{16}\right) + \frac{(a-b) \cdot \left(\frac{circ}{16}\right)}{2} \qquad M_1 = 5.268 \cdot 10^3 \cdot \text{lbf} \cdot \text{in}$$

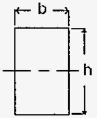
Calculated Straight Beam Stress

Ref 8, Page 242

$b := 2 \cdot \text{in}$ Hub "Length" (Axial)

$h = 2.255 \cdot \text{in}$ Hub Width (Radial)

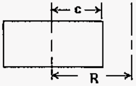
$I := \frac{b \cdot h^3}{12}$ $I = 1.911 \cdot \text{in}^4$ Moment of Inertia



Parameters for determination of Stress Correction Factor, K

Ref 8, Page 243

$c := \frac{h}{2}$ $R := \frac{D}{2} - c$ $\frac{R}{c} = 4.211$



Interpolation of correction factor for inside fiber

$$\left\{ \begin{array}{lll} A_i \equiv 4 & a_i \equiv 1.2 & x_i := \frac{A_i - B_i}{A_i - C_i} \cdot (a_i - c_i) \\ B_i \equiv 4.211 & b_i & \\ C_i \equiv 6 & c_i \equiv 1.12 & b_i := a_i - x_i \qquad b_i = 1.192 \end{array} \right\}$$

Ref 8, Page 242

Calculated Curved Beam Stress

$S := \frac{M_1 \cdot c}{I}$ $S = 3.108 \cdot 10^3 \cdot psi$

$S_{act} := b_i \cdot S$ $S_{act} = 3.703 \cdot 10^3 \cdot psi$ Maximum Stress for inner fiber of a Curved Beam

$S_y := 120000 \cdot psi$ Yield Stress for ASTM A-291-92, Class 6, (BHN = 321)

$S_{all} := 0.45 \cdot S_y$ $S_{all} = 5.4 \cdot 10^4 \cdot psi$ Allowable Tensile Stress Ref. 11, Page 12

$\frac{S_{all}}{S_{act}} = 14.581$ Safety Factor > 3 ***OK***

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DESIGN ANALYSIS

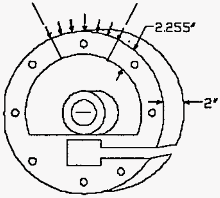
Client WESTINGHOUSE HANFORD COMPANY
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Location C TANK FARM - HANFORD 200 EAST AREA

WO/Job No. ER4319
Date 9 / 8 / 95
Checked 9/8/95
Revised

Filename WIN-13.mcd
By D.L. STONE
By M.R. CUSTER MRC
By

Analysis of Reel Hub Connections

$W_{Hub} := 4290 \cdot lbf$		Concentrated Vertical Load on Reel Hub
$P := 486.809 \cdot \frac{lbf}{in^2}$		Radial Pressure
$F_{rad} := 730.213 \cdot \frac{lbf}{in}$		Distributed Force due to Radial Pressure
$T := 44510 \cdot lbf \cdot in$		Torsional Moment
$b := 2 \cdot in$		Hub Length (Axial)
$h := (2.255) \cdot in$		Hub Thickness (Radial)
$D_m := (11.75 \cdot in - h)$	$D_m = 9.495 \cdot in$	Hub Mean Diameter
$circ := \pi \cdot D_m$	$circ = 29.829 \cdot in$	Hub Circumference



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DESIGN ANALYSIS

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Filename WIN-13.mcd
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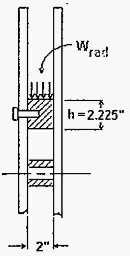
By

Check stress on 1/2 - 13 - UNC - 2A x 1-1/4 L Hex Head Screws

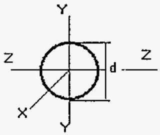
Ref. 33.4, Pg. 4, Item 63

$n_b := 8$		Number of Screws	
$n := 13$		Number of threads per inch	
$D := \frac{1}{2} \cdot in$		Major Diameter of Screw	
$A_T := 0.7854 \cdot \left[\left[D - \left(\frac{0.9743}{n} \right) \cdot in \right] \right]^2$	$A_T = 0.142 \cdot in^2$	Tensile Stress Area of Screw	Ref. 7, Pg. 4-147
$F_u := 125000 \cdot psi$		Ultimate Tensile Strength of A193 Class2 B8T Stainless Steel Fasteners	
$S_{all} := 0.17 \cdot F_u$	$S_{all} = 2.125 \cdot 10^4 \cdot psi$	Allowable shear strength of screws	Ref. 7, Pg. 4-147
$W_{rad} := \frac{P \cdot circ}{n_b}$	$W_{rad} = 1.815 \cdot 10^3 \cdot \frac{lbf}{in}$	Uniform Load resulting from Radial Pressure, per screw.	
$S_{act} := \frac{W_{Hub} + W_{rad} \cdot b}{n_b \cdot A_T}$	$S_{act} = 6.977 \cdot 10^3 \cdot psi$	Calculated Shear Stress	Ref. 7, Pg. 4-147
$M_{rad} := \frac{W_{rad} \cdot b^2}{12}$	$M_{rad} = 605.051 \cdot lbf \cdot in$	Moment due to radial loading.	
$M_{con} := \frac{\frac{W_{Hub}}{8} \cdot b}{8}$	$M_{con} = 134.063 \cdot lbf \cdot in$	Moment due to concentrated loading.	
$W_T := \frac{M_{rad} + M_{con}}{\left(\frac{h}{2} \right)}$	$W_T = 655.533 \cdot lbf$	Tensile Force on Screw	
$T_{act} := \frac{W_T}{A_T}$	$S_{act} = 6.977 \cdot 10^3 \cdot psi$	Calculated Tensile stress	
$T_{all} := .33 \cdot F_u$	$T_{all} = 4.125 \cdot 10^4 \cdot psi$	Allowable Yield Strength in Tension	
$SF := \frac{S_{all}}{S_{act}} + \frac{T_{all}}{T_{act}}$	$SF = 11.975$	Safety factor > 5 *OK*	



Client **WESTINGHOUSE HANFORD COMPANY** WO/Job No. **ER4319** Filename **WIN-13.mcd**
Subject **WINCH ANALYSIS - SLURRY/SLUICE PUMP** Date **9 / 8 / 95** By **D.L. STONE**
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106 Checked 9/8/95 By **M.R. CUSTER** MRC
Location **C TANK FARM - HANFORD 200 EAST AREA** Revised By

Weld Stresses Resulting from Radial and Vertical Loading



WELD PROPERTIES: Ref. 9, Pg. 7.4 6 &7

$d := 11.75\cdot in$		Weld Diameter
$Cy := \frac{d}{2}$	$Cy = 5.875\cdot in$	Location of center of gravity wrt b.
$Cz := \frac{d}{2}$	$Cz = 5.875\cdot in$	Location of center of gravity wrt d.
$Aw := \pi\cdot d$	$Aw = 36.914\cdot in$	Weld length
$Swy := \frac{\pi\cdot d^2}{4}$	$Swy = 108.434\cdot in^2$	Section modulus
$Swz := Swy$	$Swz = 108.434\cdot in^2$	Section modulus
$Jw := \frac{\pi\cdot d^3}{4}$	$Jw = 1.274\cdot 10^3\cdot in^3$	Polar Moment of Inertia

JOINT LOADS:

Tensile	$Fx := \frac{F_{rad}\cdot 1\cdot in}{2}$	$Fy := W_{Hub}\cdot \sin(61.1\cdot deg)$	$Fz := W_{Hub}\cdot \cos(61.1\cdot deg)$
Moment	$Mx := \frac{T}{2}$	$My := Fz\cdot\left(\frac{b}{2}\right)$	$Mz := Fy\cdot\left(\frac{b}{2}\right)$

WELD STRESS:

$$fw := \left[\left(\frac{Fx}{Aw}+\frac{My}{Swy}+\frac{Mz}{Swz}\right)^2+\left(\frac{Fy}{Aw}+\frac{Mx\cdot Cy}{Jw}\right)^2+\left(\frac{Fz}{Aw}+\frac{Mx\cdot Cz}{Jw}\right)^2\right]^{0.5} \qquad fw = 266.512\cdot\frac{lbf}{in}$$

FILLET WELD SIZE REQUIRED:

$S := 15800\cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7,4-8

$w := \frac{fw}{0.707\cdot S}$ $w = 0.024\cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\frac{5}{16}\cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness > 3/4". Ref. 7, Part 5, Section J.2, Table J2.4

$SF_{fw} := \frac{w_{Code}}{w}$ $SF_{fw} = 13.098$ Safety factor > 3 OK

DESIGN ANALYSIS

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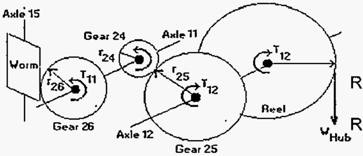
Subject **WINCH ANALYSIS - SLURRY/SLUICE PUMP** Date **9 / 8 / 95** By **D.L. STONE**
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106 Checked 9/8/95 By **M.R. CUSTER** MRC
Location **C TANK FARM - HANFORD 200 EAST AREA** Revised By

Tooth Loading on Gears

Ref: 33.5, Sh. 1



$r_{reel} := 10.375 \cdot in$ Maximum Radius of Coil on Reel

$r_{25} := 9 \cdot in$ Pitch Radius of Gear 25 Ref. 20, Page A 83

$r_{24} := 2 \cdot in$ Pitch Radius of Gear 24 Ref. 20, Page A 83

$r_{26} := 6 \cdot in$ Pitch Radius of Gear 26 (Worm Gear) Ref. 20, Page A 83

$r_{worm} := 2.00 \cdot in$ Pitch Radius of the WORM

$W_{Hub} := 4290 \cdot lbf$ Weight on Reel Hub

$T_{12} := W_{Hub} \cdot r_{reel}$ $T_{12} = 4.451 \cdot 10^{4} \cdot lbf \cdot in$ Torsional Moment on Axle 12 imposed by Winch Reel

$F_{tran} := \frac{T_{12}}{r_{25}}$ $F_{tran} = 4.945 \cdot 10^{3} \cdot lbf$ Force transmitted to Gear 24 by Gear 25

$T_{11} := F_{tran} \cdot r_{24}$ $T_{11} = 9.891 \cdot 10^{3} \cdot lbf \cdot in$ Torsional Moment on Axle 11 Gear 25

$F_{worm} := \frac{T_{11}}{r_{26}}$ $F_{worm} = 1.648 \cdot 10^{3} \cdot lbf$ Axial force on Worm by Gear 25

****

AGMA Strength Formula

Ref. 12, Page 407

$S_y := 120000$ Yield Strength for ASTM A-291-92, Class 6, BHN = 321

Interpolation of K_L

$A_i \equiv 250$ $a_i \equiv 2.4$ $x_i := \frac{A_i - B_i}{A_i - C_i} \cdot (a_i - c_i)$
$B_i \equiv 321$ b_i
$C_i \equiv 450$ $c_i \equiv 3.4$ $b_i := a_i - x_i$ $b_i = 2.755$

$K_L := b_i$ $K_L = 2.755$ Life cycle Requirement

$Temp := 220$ Operating Temparature

$K_T := \frac{460 + Temp}{620}$ Temperature Requirement

$K_R := 1.5$ Reliability Requirement

$S := \frac{S_y \cdot K_L}{K_T \cdot K_R}$ $S = 2.01 \cdot 10^{5}$ Calculated Allowable Strength for Gear Teeth

---

Lewis Beam Strength Formula (Barth Revision) for Tooth Loading on Spur Gears

Gear 25 - *54 tooth Spur Gear on Reel Axle (12)*

$D_{25} := 18\ \text{in}$	Pitch Diameter	Ref. 20. Pg. 15
$F := 3\ \text{in}$	Face Width	
$P := 3$	Diametral Pitch	
$Y := 0.352$	Tooth Form Factor	Ref. 20. Pg. 137
$rpm := 1.08$	Reel Speed	
$V := 0.262 \cdot D_{25} \cdot rpm \quad V = 5.093\ \frac{ft}{min}$	Pitch Line Velocity	Ref. 20. Pg. 137
$c := 600$	Material Constant for Metallic Gears	
$W := \left[\frac{S \cdot F \cdot Y}{P} \cdot \left(\frac{c}{c+V}\right)\right] \quad W = 7.014 \cdot 10^{4}\ \text{lbf}$	Maximum Safe (Allowable) Loading	Ref. 20. Pg. 137

$$F_{all} := W \cdot lbf$$

$$F_{act} := \frac{T_{12}}{r_{25}} \qquad F_{act} = 4.945 \cdot 10^{3} \cdot lbf$$

$$SF := \frac{F_{all}}{F_{act}} \qquad SF = 14.183$$

Safety factor > 3 OK

Lewis Beam Strength Formula (Barth Revision) for Tooth Loading on Spur Gears

Gear 24 - 12 *tooth Spur Gear on Axle (11)*

Ref. 20. Pg. 15

$D_{24} := 4\ \text{in}$	Pitch Diameter	
$GR := \frac{54}{12}$	Gear Ratio	
$F := 4\ \text{in}$	Face Width	
$P := 3$	Diametral Pitch	
$Y := 0.210$	Tooth Form Factor	Ref. 20. Pg. 137
$V := 0.262 \cdot D_{24} \cdot (GR \cdot rpm) \quad V = 5.093\ \frac{ft}{min}$	Pitch Line Velocity	Ref. 20. Pg. 137
$c := 600$	Material Constant	
$W := \frac{S \cdot F \cdot Y}{P} \cdot \left(\frac{c}{c+V}\right) \quad W = 5.579 \cdot 10^{4}\ \text{lbf}$	Maximum Safe (Allowable) Loading	Ref. 20. Pg. 137
$F_{all} := W \cdot lbf$		
$F_{act} := \frac{T_{11}}{r_{24}} \quad F_{act} = 4.945 \cdot 10^{3} \cdot lbf$	Actual Loading on Gear 24	
$SF := \frac{F_{all}}{F_{act}} \quad SF = 11.282$	Safety factor > 3 OK	

Worm and Worm Gear Analysis

Ref. 11

$l := 4.767 \cdot deg$	Lead Angle	Ref. 20, Page A 83
$f_n := 14.5 \cdot deg$	Pressure Angle	Ref. 20, Page A 83
$m := 0.06$	Coefficient of friction	Ref. 11, Fig. 13-42

$W_{Gt} := \dfrac{T_{11}}{r_{26}}$ $W := W_{Gt}$	$W_{Gt} = 1.648 \cdot 10^3 \cdot lbf$	Transmitted Load onto the GEAR Normal to the worm-tooth profile, neglecting friction.	Ref. 11, Edition 1, Page 453
$W_x := W \cdot \cos(f_n) \cdot \sin(l)$	$W_x = 132.631 \cdot lbf$	Tangential component of force onto the worm.	Ref. 11, Edition 5, Page 565
$W_y := W \cdot \sin(f_n)$	$W_y = 412.744 \cdot lbf$	Radial component of force onto the worm.	
$W_z := W \cdot \cos(f_n) \cdot \cos(l)$	$W_z = 1.59 \cdot 10^3 \cdot lbf$	Axial component of force onto the worm.	

$W_{gt} := W \cdot \left(\cos(f_n) \cdot \cos(l) - m \cdot \sin(l)\right)$	$W_{gt} = 1.582 \cdot 10^3 \cdot lbf$	Transmitted Load onto the GEAR Normal to the worm-tooth profile, friction considered.	Ref. 11, Edition 1, Page 454
$W_{wa} := W_z - m \cdot W \cdot \sin(l)$	$W_{wa} = 1.582 \cdot 10^3 \cdot lbf$	Axial force on the WORM.	
$W_{wt} := W_x + m \cdot W \cdot \cos(l)$	$W_{wt} = 231.197 \cdot lbf$	Tangential force acting on the WORM.	
$W_{ga} := -W_{wt}$	$W_{ga} = -231.197 \cdot lbf$	Axial force acting on the GEAR.	Ref. 11, Edition 5, Page 565
$W_{gr} := W_y \;=\; -W_{wr}$	$W_{gr} = 412.744 \cdot lbf$	Radial force acting on the GEAR.	
$W_{gt} := -W_{wa}$	$W_{gt} = -1.582 \cdot 10^3 \cdot lbf$	Tangential force acting on the GEAR.	
$T_w := r_{worm} \cdot W_{wt}$	$T_w = 462.394 \cdot lbf \cdot in$	Required Torsional input to the WORM.	Ref. 11, Edition 1, Page 454

* Due to the greater contact area and inherent strength of the worm teeth over the gear teeth, a comparative analysis of the worm Gear will be considered as a conservative comparison for the worm for this calculation.

Gear 26 - 36 tooth Worm Gear on Gear Axle (11)

Lewis Beam Strength Formula (Barth Revision) for Tooth Loading on Spur Gears

$D_{26} := 12 \ \text{in}$		Pitch Diameter	Ref. 20, Page A 83
$F := 2 \ \text{in}$		Face Width	Ref. 20, Page A 83
$P := 3$		Diametral Pitch	Ref. 20, Page A 83
$Y := 0.223$		Tooth Form Factor	Ref. 20. Pg. 137
$V := 0.262 \cdot D_{26} \cdot (GR \cdot rpm)$	$V = 15.28 \ \dfrac{ft}{min}$	Pitch Line Velocity	Ref. 20. Pg. 137
$c := 600$		Material Constant	
$W := \dfrac{S \cdot F \cdot Y}{P} \cdot \left(\dfrac{c}{c + V} \right)$	$W = 2.913 \cdot 10^{4} \ \text{lbf}$	Maximum Safe (Allowable) Loading	Ref. 20. Pg. 137
$F_{all} := W \cdot lbf$			
$F_{act} := \dfrac{T_{11}}{r_{26}}$	$F_{act} = 4.945 \cdot 10^{3} \cdot lbf$	Actual Loading on Gear 26	
$SF := \dfrac{F_{all}}{F_{act}}$	$SF = 11.282$	Safety factor > 3 OK	

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DESIGN ANALYSIS

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Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
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WO/Job No. ER4319
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Filename WIN-15.mcd
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By

Shear on Gear Axle *(11)* Bearings

$D2 := \left(6.01 \cdot \frac{lbf}{ft}\right)$ $D3 := \left(3.77 \cdot \frac{lbf}{ft}\right)$ Weight per foot of Shaft Ref. 7, Page 1-108

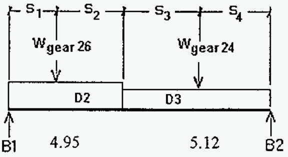
$s_1 := 3.815 \cdot in$

$s_2 := 1.135 \cdot in$

$s_3 := 1.46 \cdot in$

$s_4 := 3.66 \cdot in$

$W_{gear26} := 40 \cdot lbf$ $W_{gear24} := 11 \cdot lbf$



Gear Shaft Forces

$+\uparrow\ S\,F = 0 = \quad B1 + B2 - D2 \cdot (4.95 \cdot in) - D3 \cdot (5.12 \cdot in) - W_{gear24} - W_{gear26}$

$\circlearrowright +\ S\,M_{B1} = 0 = \ (B2 \cdot 10.07 \cdot in) - \left[D2 \cdot \left(\frac{4.95 \cdot in}{2}\right)^2\right] - (D3 \cdot (5.12 \cdot in) \cdot (7.51 \cdot in)) - W_{gear24} \cdot (6.41 \cdot in) - \left(W_{gear26} \cdot 3.815 \cdot in\right)$

$$B2 := \frac{\left[D2 \cdot \left(\frac{4.95 \cdot in}{2}\right)^2\right] + D3 \cdot (5.12 \cdot in) \cdot ((7.51 \cdot in)) + W_{gear24} \cdot (6.41 \cdot in) + W_{gear26} \cdot (3.815 \cdot in)}{10.07 \cdot in} \qquad B2 = 23.66 \cdot lbf$$

$$B1 := D2 \cdot (4.95 \cdot in) + D3 \cdot (5.12 \cdot in) + W_{gear24} + W_{gear26} - B2 \qquad B1 = 31.427 \cdot lbf$$

Shear

$a := B1$ $a = 31.427 \cdot lbf$

$b := a - (s_1) \cdot D2$ $b = 29.517 \cdot lbf$

$c := b - W_{gear26}$ $c = -10.483 \cdot lbf$

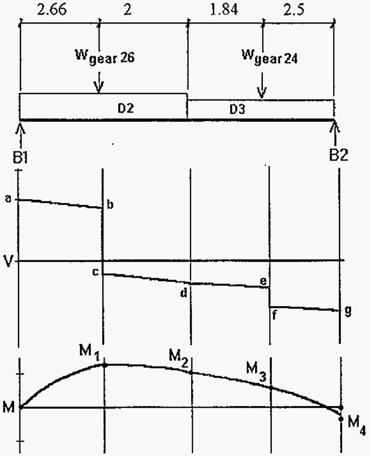
$d := c - (s_2) \cdot D2$ $d = -11.052 \cdot lbf$

$e := d - (s_3) \cdot D3$ $e = -11.51 \cdot lbf$

$f := e - W_{gear24}$ $f = -22.51 \cdot lbf$

$g := f - (s_4) \cdot D3$ $g = -23.66 \cdot lbf$

$h := -(g + B2)$ $h = -3.534 \cdot 10^{-15} \cdot lbf \approx 0$



Maximum Bending Moment on the Shaft

$$M_1 := b \cdot (s_1) + \left[\frac{(a - b) \cdot s_1}{2} \right]$$

$M_1 = 116.251 \cdot \mathrm{lbf} \cdot \mathrm{in}$ <----------- Maximum Bending Moment

$$M_2 := M_1 + \left[c \cdot (s_2) + \frac{(d - c) \cdot (s_2)}{2} \right]$$

$M_2 = 104.03 \cdot \mathrm{lbf} \cdot \mathrm{in}$

$$M_3 := M_2 + \left[d \cdot (s_3) + \frac{(e - d) \cdot (s_3)}{2} \right]$$

$M_3 = 87.56 \cdot \mathrm{lbf} \cdot \mathrm{in}$

$$M_4 := M_3 + \left[f \cdot (s_4) + \frac{(g - f) \cdot (s_4)}{2} \right]$$

$M_4 = 3.068 \cdot \mathrm{lbf} \cdot \mathrm{in}$

Equivalent Radial load - Radial Ball Bearings

Pillow Block, RSAO (1-3/16" Shaft Diameter) Ref. 27, Pg. 174

Bearing, GN103KRRB Ref. 27, Pg. 144

$C_o := 3550 \cdot \mathrm{lbf}$ Published STATIC LOAD RATING (Maximum Permissible Radial Load) Ref. 27, Pg. 174

$i_B := 1$ Number of adjacently mounted bearings.

$\frac{221}{2} = 110.5$

$R := B1$ Maximum APPLIED RADIAL LOAD on Bearings

$Thr := \frac{231.197}{2} \cdot \mathrm{lbf}$ APPLIED THRUST LOAD on Bearing

$K_{Thr} := \frac{Thr}{i_B \cdot C_o}$ $K_{Thr} = 0.033$ Relative Thrust Load Factor for Ball Bearings Ref. 27, Pg. E-50, Table 1

$Y_1 := 2.00$ Thrust Load Factor for Ball Bearings (from Table 2) Ref. 27, Pg. E-51, Table 2

For Single Row WIDE INNER RING BALL BEARINGS

Equivalent Radial Load on Bearing is the Larger result of the two following Formulas

$P := R$ $P = 31.427 \cdot \mathrm{lbf}$ Ref. 27, Pg. E-50 Table 1

$P := 0.56 \cdot R + Y_1 \cdot Thr$ $P = 248.796 \cdot \mathrm{lbf}$

$SF := \frac{C_o}{P} = \frac{F_{all}}{F_{act}}$ $SF = 14.269$ Safety factor >3 ***OK***

Due to low reactions at shaft ends, bearing stress on the wall at the Flange and bolt prying stresses have been considered negligible relative to material tensile strengths.

Design of Gear Axle *(11)*

$T_{11} := 9891 \cdot \mathrm{lbf \cdot in}$ $T_{11} = 9.891 \cdot 10^{3} \cdot \mathrm{in \cdot lbf}$ Applied Torsional Moment on Axle 11

$M_b := M_1$ $M_b = 116.251 \cdot \mathrm{lbf \cdot in}$ Maximum Bending Moment on Winch Axle

$S_y := 120000 \cdot \frac{\mathrm{lbf}}{\mathrm{in}^2}$ Yield Strength for (ASTM A-291-92, Class 6, BHN = 321)

$S_{allC} := 0.30 \cdot S_y$ $S_{allC} = 3.6 \cdot 10^{4} \cdot \frac{\mathrm{lbf}}{\mathrm{in}^2}$ Maximum Allowable Shearing Stress for Combined Torsion and Bending — Ref. 8, Pg 270 ((b), Below Table 2)

$P_t := 0.75 \cdot S_{allC}$ $P_t = 2.7 \cdot 10^{4} \cdot \frac{\mathrm{lbf}}{\mathrm{in}^2}$ Maximum Allowable Stress for Solid Shafts using Keyways — Ref. 8, Pg 270

$B := 1$ B factor defines hollow shafts and is assumed as 1 for solid shafts. — Ref, 8, Pg 270 (Below Table 3)

$K_t := 1.0$ $K_m := 1.5$ Combined Shock and Fatigue factors for Steady, gradually applied, loading — Ref. 8, Pg 270, Table 1

$$D_c := B \cdot \left[\frac{5.1}{P_t} \cdot \left[\left(K_m \cdot M_b\right)^2 + \left(K_t \cdot T_{11}\right)^2 \right]^{\frac{1}{2}} \right]^{\frac{1}{3}} \quad D_c = 1.232 \cdot \mathrm{in}$$

Required Shaft Diameter for Combined Bending and Torsional Loading — Ref. 8, Pg. 269,(3a)

$D_{act} := 1.313 \cdot \mathrm{in}$ Design Shaft Diameter

$D_{act} \geq D_c$ ***OK*** Acceptance Criteria for Minimum Shaft Diameter

Key stress

Key, Spur and Worm Gear (typical) = 3/8 " x 3/8" x 2.375 ".

$A_k := \left(\frac{3}{8} \cdot in\right) \cdot 2.375 \cdot in$ $A_k = 0.891 \cdot in^2$ Area of key cross section Ref. 33.5, Sh. 5, Item 11, Sh. 1, Item 78

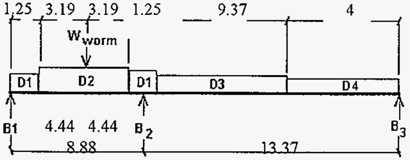
$F_y := 100000 \cdot \frac{lbf}{in^2}$ Yield Strength for (ASTM A 276-94b, Condiiton B, Type 304)

$S_{all} := 0.577 \cdot F_y$ $S_{all} = 5.77 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress Ref. 11, Pg. 370

Worm Gear (26)		Spur Gear (24)		
$r_w := \frac{1.5}{2} \cdot in$		$r_s := \frac{1.1875}{2} \cdot in$		Shaft Radius
$F_{kw} := \frac{T_{11}}{r_w}$	$F_{kw} = 1.319 \cdot 10^4 \cdot lbf$	$F_{ks} := \frac{T_{11}}{r_s}$	$F_{ks} = 1.666 \cdot 10^4 \cdot lbf$	Force`on key
$S_{kw} := \frac{F_{kw}}{A_k}$	$S_{kw} = 1.481 \cdot 10^4 \cdot \frac{lbf}{in^2}$	$S_{ks} := \frac{F_{ks}}{A_k}$	$S_{ks} = 1.87 \cdot 10^4 \cdot \frac{lbf}{in^2}$	Stress on key
$SF_w := \frac{S_{all}}{S_{kw}}$		$SF_s := \frac{S_{all}}{S_{ks}}$		Safety factor
$SF_w = 3.897$	> 3 OK	$SF_s = 3.085$	> 3 OK	

Design of Worm Axle (15)

$W_{gt} := 1582 \cdot lbf$ Transmitted Load onto the GEAR normal to the worm-tooth profile.



$W_w := 17 \cdot lbf$ Weight of the worm

$W_{wa} := 1582 \cdot lbf$ Axial force on the worm.

$W_{ax.max} := W_{wa} + W_w$ Maximum Thrust loading on Bearing

$W_{wt} := 231.197 \cdot lbf$ Tangential force acting on the worm

$W_{wr} := 412.744 \cdot lbf$ Radial force acting on the worm.

Load acting on bearings.

By inspection:

$M_b := 0.5 \cdot W_{wr} \cdot (4.44 \cdot in)$ $M_b = 916.292 \cdot lbf \cdot in$ Maximum Bending Moment on the Shaft

$R_w := 2 \cdot in$ Pitch Radius of the Worm

$T_w := R_w \cdot W_{wt}$ $T_w = 462.394 \cdot lbf \cdot in$ Applied Torsional Moment on the Axle

Determine Minimum Diameter of Axle Required

$S_y := 120000 \cdot \frac{lbf}{in^2}$ Safe Static Stress for.40 C. Alloy (Heat Treated) (ASTM A-291-92, Class 6, BHN = 321)

$S_{allC} := 0.3 \cdot S_y$ $S_{allC} = 3.6 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Maximum Allowable Shearing Stress for Combined Torsion and Bending Ref. 8, Pg 271 ((b), Below Table 2)

$P_t := 0.75 \cdot S_{allC}$ $P_t = 2.7 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Maximum Allowable Stress for Solid Shafts using Keyways Ref. 8, Pg 270

$B := 1$ B factor defines hollow shafts and is assumed as 1 for solid shafts. Ref, 8, Pg 270 (Below Table 3)

$K_t := 1.0$ $K_m := 1.0$ Combined Shock and Fatigue factors for Steady, gradually applied, loading Ref. 8, Pg 270, Table 1

$$D_c := B \cdot \left[\frac{5.1}{P_t} \cdot \left[\left(K_m \cdot M_b \right)^2 + \left(K_t \cdot T_w \right)^2 \right]^{\frac{1}{2}} \right]^{\frac{1}{3}}$$

$D_c = 0.579 \cdot in$ Required Shaft Diameter for Combined Bending and Torsional Loading Ref. 8, Pg. 269, (3a)

$D_{act} := (1.50) \cdot in$ Shaft Design Diameter at Worm Centerline

$D_{act} \ge D_c$ ***OK*** Acceptance Criteria for Minimum Shaft Diameter

Allowable Loads for Radial Tapered Roller Bearings

Bearing: Timken TDI , Cone: 17116D, Cup: 17244, Bore Diam. 1.1875", (Ref. 26, Pg 212)

$F_t := W_{wt}$ $F_t = 231.197 \cdot \mathrm{lbf}$

$F_r := W_{wr}$ $F_r = 412.744 \cdot \mathrm{lbf}$

$F_a := \frac{W_{ax.max}}{2}$ $F_a = 799.5 \cdot \mathrm{lbf}$ APPLIED THRUST LOAD per Bearing

****

(Ref. 26, Pg 49, 50)

$$F_{rA} := \sqrt{\left(\frac{F_t \cdot 3.815 \cdot in}{7.63 \cdot in}\right)^2 + \left[\frac{F_r \cdot 3.815 \cdot in}{7.63 \cdot in} + \frac{F_a \cdot 4 \cdot in}{2 \cdot (7.63) \cdot in}\right]^2} \qquad F_{rA} = 431.704 \cdot \mathrm{lbf}$$ Bearing Reactions (Typical)

$K := 1.53$ Relative Thrust Load Factor for Bearings

$$F_A := \frac{0.6 \cdot F_{rA}}{K} + F_a$$

$P := 0.5 \cdot F_{rA} + 0.83 \cdot K \cdot F_A$ $P = 1.446 \cdot 10^3 \cdot \mathrm{lbf}$ Equivalent Radial Load for ~~Single~~ DOUBLE MRC DLS Row RADIAL TAPERED ROLLER BEARINGS (Ref. 26, Pg 40)

$P_{all} := 1.374 \cdot (18100 \cdot \mathrm{lbf})$ Maximum Permissible Radial Load at 175 rpm

$SF := \frac{P_{all}}{P}$ $SF = 17.197$ Safety factor > 3 ***OK***

Key stress

Key = 3/8 " x 3/8" x 2.00 ".

$A_k := \left(\frac{3}{8}\cdot in\right)\cdot 2.00\cdot in$ $\quad A_k = 0.75\cdot in^2$	Area of key cross section	Ref. 33.5, Sh. 5, Item 15 and Sh. 1, Item 78
$F_y := 100000\cdot\frac{lbf}{in^2}$	Yield Strength for (ASTM A 276-94b, Condiiton B, Type 304)	
$S_{all} := 0.577\cdot F_y$ $\quad S_{all} = 5.77\cdot 10^4\cdot\frac{lbf}{in^2}$	Allowable Shear Stress	Ref. 11, Pg. 370
$r_w := \frac{1.5}{2}\cdot in$	Shaft Radius	
$F_{kw} := \frac{T_w}{r_w}$ $\quad F_{kw} = 616.525\cdot lbf$	Force`on key	
$S_{kw} := \frac{F_{kw}}{A_k}$ $\quad S_{kw} = 822.034\cdot\frac{lbf}{in^2}$	Stress on key	
$SF_w := \frac{S_{all}}{S_{kw}}$ $\quad SF_w = 70.192$ $\quad > 3$ OK	Safety factor	

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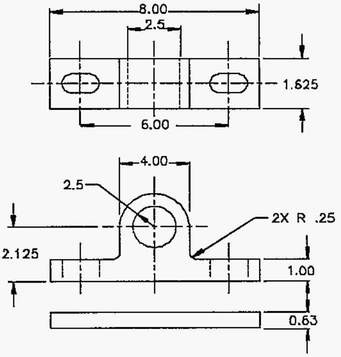
DESIGN ANALYSIS

Client	WESTINGHOUSE HANFORD COMPANY	WO/Job No.	ER4319	Filename	WIN-16.mcd
Subject	WINCH ANALYSIS - SLURRY/SLUICE PUMP	Date	9 / 8 / 95	By	D.L. STONE
	PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106	Checked	9/8/95	By	M.R. CUSTER
Location	C TANK FARM - HANFORD 200 EAST AREA	Revised		By	

Ref. 33.5, Pg. 5, Item 20

Stress on the worm axle Support Bracket



$W_{wa} = 1.582 \cdot 10^3 \cdot lbf$ Axial force transmitted to shaft at the worm

$F_{housing} := \frac{W_{wa}}{2}$ Force divided by number of bearings.

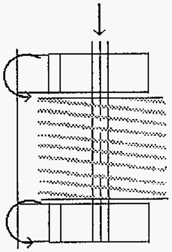
$w := 1.625 \cdot in$ Width of Housing base.

$t := 1.00 \cdot in$ Height of Housing base.

$b := 6 \cdot in$ Distance between bolts

$C_L := 2.125 \cdot in$ Distance from Mounting Block to Bearing Center Line (Moment Arm)

$M_B := W_{wa} \cdot C_L$ $M_B = 3.362 \cdot 10^3 \cdot lbf \cdot in$ Moment on the worm axle pillow blocks.



Check Stress on Bearing Housings

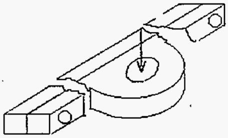
Torsion at Base

$T := \frac{M_B}{2}$ Torsion per section

$S_{act} := \frac{T}{w \cdot t^2} \cdot \left(3 + 1.8 \cdot \frac{t}{w}\right)$ $S_{act} = 4.249 \cdot 10^3 \cdot psi$ Formula to approximate torsional stress on a rectangular area. Ref. 11, Pg 55

$S_u := 145000 \cdot psi$ Ultimate stress for ASTM A291

$S_{sy} := 0.35 \cdot S_u$ Ref. P, Pg 423



$SF := \frac{S_{sy}}{S_{act}}$ $SF = 11.944$ Safety factor > 5 OK

Shear and Bending at Housing Ring

$cup := 2.46 \cdot in$ Bearing cup Outer Diameter

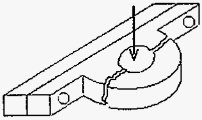
$H_D := 4.00 \cdot in$ Bearing Housing Ring Outer Diameter

$th := \left(\frac{H_D - cup}{2}\right)$ $th = 0.77 \cdot in$ Metal Thickness at thinnest section of the bracket

$A_b := (w \cdot th) \cdot 2$ $A_b = 2.502 \cdot in^2$ Cross sectional Area at thinnest section of the bracket

$S_y := 120000 \cdot \frac{lbf}{in^2}$ Yield stress for ASTM A291

$S_{all} := 0.4 \cdot S_y$ $S_{all} = 4.8 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress



$S_{act} := \frac{F_{housing}}{A_b}$ $S_{act} = 316.084 \cdot \frac{lbf}{in^2}$ Calculated Shear Stress

$Z := \frac{th \cdot w^2}{6}$ Section modulus of minimum Cross sectional area

$T_{act} := \frac{M_B + M_b}{2 \cdot Z}$ $T_{act} = 6.312 \cdot 10^3 \cdot psi$ Tensile stress due to bending.

$T_{all} := 0.45 \cdot S_y$ $T_{all} = 5.4 \cdot 10^4 \cdot psi$

$\frac{T_{all}}{T_{act}} = 8.555$ $\frac{S_{all}}{S_{act}} = 151.858$ Safety factor > 3 OK

Check stress on 1/2 - 13 - UNC - 2A x 1-5/8 L Hex Head Screws

Shear

			Ref. 33.4, Pg. 1, Item 32
$n_b := 2$		Number of Screws per Housing	
$n_B := 2$		Number of Bearing Housings	
$n := 13$		Number of threads per inch	
$D := \frac{5}{8} \cdot in$		Major Diameter of Screw	
$A_T := 0.7854 \cdot \left[\left[D - \left(\frac{0.9743}{n}\right) \cdot in\right]\right]^2$	$A_T = 0.238 \cdot in^2$	Tensile Stress Area of Screw	Ref. 7, Pg. 4-147
$F_u := 125000 \cdot psi$		Ultimate Tensile Strength of A193 Class2 B8T Stainless Steel Fasteners	
$S_{all} := 0.17 \cdot F_u$	$S_{all} = 2.125 \cdot 10^4 \cdot psi$	Allowable shear strength of screws	Ref. 7, Pg. 4-5
$S_{act} := \frac{F_{housing}}{n_b \cdot A_T}$	$S_{act} = 1.664 \cdot 10^3 \cdot psi$	Calculated shear stress	Ref. 7, Pg. 4-147

$\frac{S_{all}}{S_{act}} = 12.768$ Safety factor > 3 OK

Tensile

$w = 1.625 \cdot in$		Width of Housing base.	
$y := \frac{w}{2}$		Housing base edge to screw C_L distance to determine maximum prying stress.	
$F_T := \frac{(M_B + M_b)}{n_B \cdot y}$	$F_T = 2.633 \cdot 10^3 \cdot lbf$	Tension on Screws resulting from combined moment on housing	
$T_{act} := \frac{F_T}{n_b \cdot A_T}$	$T_{act} = 5.539 \cdot 10^3 \cdot psi$	Calculated Tensile stress at screw	
$T_{all} := 0.33 \cdot F_u$	$T_{all} = 4.125 \cdot 10^4 \cdot psi$	Allowable Yield Strength in Tension	Ref. 7, Pg. 4-3

$\frac{T_{all}}{T_{act}} = 7.447$ Safety factor > 5 OK

Check Stresses in Gear Housing at Axle #15 Bearing Housings

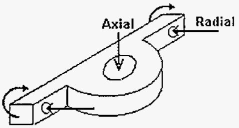
$W_a := 1582\cdot lbf$ Axial force on the WORM.

$W_t := 231.197\cdot lbf$ Tangential force acting on the WORM.

$W_r := 412.744\cdot lbf$ Radial force .

$Base_w := 1.625\cdot in$ Width of Bearing Housing Base

$Base_L := 8.00\cdot in$ Length of Bearing Housing Base



Ref. 33.5, Sh.5, Item 2

$th := \left(\frac{1}{2} + 0.63\right)\cdot in$ Plate Thickness

$M := W_a\cdot(3.00\cdot in)$ $M = 4.746\cdot 10^3 \cdot lbf\cdot in$

Shear on Housing wall due to Radial Loading

$A := Base_w\cdot th$ $A = 1.836\cdot in^2$ Minimum Cross Sectional Area of Plate

$S_{act} := \frac{\left(\frac{W_r}{2}\right)}{A}$ $S_{act} = 112.388\cdot psi$ Calculated shear at plate resulting due to radial load on worm.

$S_y := 36000\cdot psi$ Yield Strength of A36 plate at at 250° F.

$S_{all} := 0.4\cdot S_y$ $S_{all} = 1.44\cdot 10^4 \cdot psi$ Allowable shear stress

$SF := \left(\frac{S_{all}}{S_{act}}\right)$ $SF = 128.128$ Safety factor > 3 OK

Stress in Housing Wall due to Torsional Moment resulting from axial force. Ref. 7, Pg. 4-147

$y := \frac{Base_w}{2}$ Block edge to C_L distance to determine maximum prying stress.

$I := \frac{Base_L\cdot Base_w^3}{12}$ Moment of Inertia of Housing base

$B_1 := \frac{M\cdot y}{I}$ $B_1 = 1.348\cdot 10^3 \cdot psi$ Calculated compressive shear at plate due to moment.

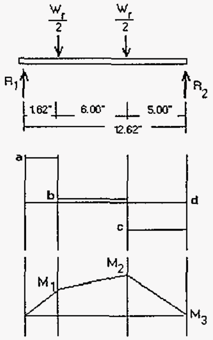
Stress in Housing Wall due to Bending Moment resulting from radial force.

$$+\uparrow\sum F = 0 = W_r - R_1 - R_2$$

$$\circlearrowright + \sum_{R_1} M = 0 = \left(R_2 \cdot 12.62 \cdot in\right) - \left(\frac{W_r}{2}\right)\cdot 1.62\cdot in - \left(\frac{W_r}{2}\right)\cdot 7.62\cdot in$$

$R_2 := \dfrac{\left(\frac{W_r}{2}\right)\cdot 1.62\cdot in + \left(\frac{W_r}{2}\right)\cdot 7.62\cdot in}{12.62\cdot in}$ $\qquad R_2 = 151.1 \cdot lbf$

$R_1 := W_r - R_2$ $\qquad R_1 = 261.644 \cdot lbf$



$a := R_1$ $\qquad a = 261.644 \cdot lbf$

$b := a - \left(\dfrac{W_r}{2}\right)$ $\qquad b = 55.272 \cdot lbf$

$c := b - \left(\dfrac{W_r}{2}\right)$ $\qquad c = -151.1 \cdot lbf$

$d := c + R_2$ $\qquad d = 0 \cdot lbf$

Maximum Bending Moment on the Wall

$M_1 := (a \cdot 1.62 \cdot in)$ $\qquad M_1 = 423.864 \cdot lbf \cdot in$

$M_2 := M_1 + (b \cdot 6.00 \cdot in)$ $\qquad M_2 = 755.498 \cdot lbf \cdot in$ <------------ Maximum Bending Moment

$M_3 := M_2 + (c \cdot 5.00 \cdot in)$ $\qquad M_3 = -1.258 \cdot 10^{-13} \cdot lbf \cdot in \approx 0$

$B_{all} := 0.6 \cdot S_y$ $\qquad B_{all} = 2.16 \cdot 10^{4} \cdot psi$ Allowable stress due to Bending Ref. 7, Pg. 4-147

$y := \dfrac{th}{2}$ $\qquad y = 0.565 \cdot in$ C_L *of plate.*

$I := \dfrac{th^3 \cdot (10.01 \cdot in)}{12}$ $\qquad I = 1.204 \cdot in^4$ Moment of Inertia of Plate cross section

$B_2 := \dfrac{M_2 \cdot y}{I}$ $\qquad B_2 = 354.645 \cdot psi$ Calculated stress at plate due to bending

$SF := \left(\dfrac{B_{all}}{B_1 + B_2}\right)$ $\qquad SF = 12.686$ Safety factor > 5 OK

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DESIGN ANALYSIS

Client WESTINGHOUSE HANFORD COMPANY WO/Job No. ER4319 Filename WIN-18.mcd
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP Date 9 / 8 / 95 By D.L. STONE
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106 Checked 9/8/95 By M.R. CUSTER MRC
Location C TANK FARM - HANFORD 200 EAST AREA Revised By

Design of Drive Assembly Shaft

$T_w := 462.394 \cdot \mathrm{lbf \cdot in}$ Applied Torsional Moment on the Axle

$M_b := 0 \cdot \mathrm{in \cdot lbf}$ Maximum Bending Moment on the Shaft

Determine Minimum Diameter of Axle Required

$S_y := 120000 \cdot \dfrac{\mathrm{lbf}}{\mathrm{in}^2}$ Safe Static Stress for.40 C. Alloy (Heat Treated) (ASTM A-291-92, Class 6, BHN = 321)

$S_{allC} := 0.3 \cdot S_y \quad S_{allC} = 3.6 \cdot 10^4 \cdot \dfrac{\mathrm{lbf}}{\mathrm{in}^2}$ Maximum Allowable Shearing Stress for Combined Torsion and Bending Ref. 8, Pg 270 ((b), Below Table 2)

$P_t := 0.75 \cdot S_{allC} \quad P_t = 2.7 \cdot 10^4 \cdot \dfrac{\mathrm{lbf}}{\mathrm{in}^2}$ Maximum Allowable Stress for Solid Shafts using Keyways Ref. 8, Pg 271

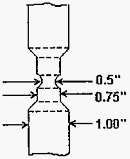
$B := 1$ B factor defines hollow shafts and is assumed as 1 for solid shafts. Ref, 8, Pg 270 (Below Table 3)

$K_t := 1.0 \qquad K_m := 1.0$ Combined Shock and Fatigue factors for Steady, gradually applied, loading Ref. 8, Pg 270, Table 1

$$D_c := B \cdot \left[\frac{5.1}{P_t} \cdot \left[\left(K_m \cdot M_b\right)^2 + \left(K_t \cdot T_w\right)^2 \right]^{\frac{1}{2}} \right]^{\frac{1}{3}}$$

Ref. 8, Pg. 269,(3a)

$D_c = 0.444 \cdot \mathrm{in}$ Required Shaft Diameter for Combined Bending and Torsional Loading



$D_{act} := 0.75 \cdot \mathrm{in}$ Shaft Shaft Design Diameter

$D_{act} \geq D_c$ ***OK*** Acceptance Criteria for Minimum Shaft Diameter

Calculation of Force Required to Compress Nut Lock Springs

Weight of Upper Shaft Assembly

$w_{1.5} := 6.01 \cdot \frac{lbf}{ft}$ Weight per ft of 1.5" A36 Rod Ref. 16

$L_{sec5} := 14.44 \cdot in$ Length of Upper Shaft Ref. 33.3, Sh. 3, Item 5

$W_1 := w_{1.5} \cdot L_{sec5}$ $W_1 = 7.232 \cdot lbf$ Weight of Upper Shaft

Weight of Drive Assembly

$w_2 := 2.67 \cdot \frac{lbf}{ft}$ Weight per ft of 1" A36 Rod Ref. 16

$L_{sec6} := 80.13 \cdot in$ Length of Drive Assembly Shaft Ref. 33.3, Sh. 3, Item 7

$W_2 := w_2 \cdot L_{sec6}$ $W_2 = 17.829 \cdot lbf$ Weight of Drive Assembly Shaft

Estimated weight of Socket

$w_{1.25} := 4.17 \cdot \frac{lbf}{ft}$ $W_3 := \left[(0.783 + 0.358) \cdot in \cdot w_{1.25}\right]$ $W_3 = 0.396 \cdot lbf$ Upper Diameter of Socket

$w_2 := 10.68 \cdot \frac{lbf}{ft}$ $W_4 := \left[(2.358 \cdot in) \cdot w_2\right]$ $W_4 = 2.099 \cdot lbf$ Lower Diameter of Socket

$W_{socket} := W_3 + W_4$ $W_{socket} = 2.495 \cdot lbf$

Weight of Nut Lock

Ref. 33.5, Sh.5, Item 19

$w_{pl.375} := 16.5 \cdot \frac{lbf}{ft^2}$ Weight of 3/8" Stainless Steel Plate Ref. 16

$d := 4 \cdot in$ Nut Lock Diameter

$c := 3.91 \cdot in^2$ Hex Cutout

$A_{NL} := \frac{p \cdot d^2}{4} - c$ Total Plate Area of Nut Lock

$W_{NL} := w_{pl.375} \cdot A_{NL}$ $W_{NL} = 0.992 \cdot lbf$

Weight of Drive Guide Assembly — Ref. 33.5, Sh. 6, Item 21

$R_{cone} := 5 \cdot in$ — Cone Large Radius

$r_{cone} := 1.5 \cdot in$ — Cone Small Radius

$h_{cone} := 7.5 \cdot in$ — Cone Height

$A_{cone} := p \cdot \sqrt{\left(R_{cone} - r_{cone}\right)^2 + h_{cone}^2} \cdot \left(R_{cone} + r_{cone}\right)$ — Cone Area — Ref. 8, Pg 64

$A_{cone} = 169.008 \cdot in^2$

$d_{cyl} := 4 \cdot in$ — Support Cylinder Diameter

$h_{cyl} := 3.71 \cdot in$ — Support Cylinder Height

$A_{cyl} := p \cdot d_{cyl} \cdot h_{cyl}$ — $A_{cyl} = 46.621 \cdot in^2$ — Support Cylinder Area

$A_{SecKK} := p \cdot \left(4^2 - 2^2\right) \cdot in^2$ — $A_{SecKK} = 37.699 \cdot in^2$ — Area of Section K-K

$A_{DG} := A_{cone} + A_{cyl} + A_{SecKK}$ — $A_{DG} = 253.329 \cdot in^2$ — Total Area of Guide Assembly

$w_{569pl} := 7.5 \cdot \frac{lbf}{ft^2}$ — Weight per square ft of ASTM 569 Plate — Ref.16

$W_{DG} := A_{DG} \cdot w_{569pl}$ — $W_{DG} = 13.194 \cdot lbf$ — Total Weight of Guide Assembly

$W_{DA} := W_1 + W_2 + W_{socket} + W_{NL} + W_{DG}$ — $W_{DA} = 41.742 \cdot lbf$ — Total Weight of Drive Assembly

Spring Force

Ref. 33.5, Pgs 1, Item 36
Pgs 5, Item 19

$L := 2.25 \cdot in$ Length of 1/2 -13 UNC-2B x 2-1/4 L Hex Screws

$th_{bp} := 0.5 \cdot in$ Thickness of baseplate.

$th_{nl} := 0.375 \cdot in$ Thickness of nutlock.

$SL_{req} := L - th_{bp} - th_{nl}$ $SL_{req} = 1.375 \cdot in$ Minimum Spring length required.

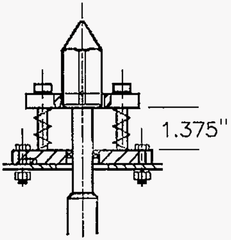
$k := 0.833 \cdot \left(53 \cdot \frac{lbf}{in}\right)$ $k = 44.149 \cdot \frac{lbf}{in}$ Spring Rate, Cat # CO600-081-2000S Ref. 21, Page 19
Multiply Spring Rate by 0.833 for Stainless Steel

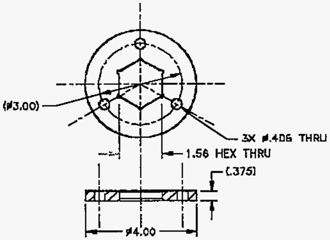
$y := \frac{3}{8} \cdot in$ $y = 0.375 \cdot in$ Length of compression (Plate thickness)

$n_s := 3$ Number of Springs

$F := n_s \cdot k \cdot y$ $F = 49.668 \cdot lbf > W_{DA}$ Force required to compress n Springs y inches Ref. 11, Page 9

Strength of Nutlock Bolts





$T := 0.5 \cdot T_w$ $T = 231.197 \cdot lbf \cdot in$ Estimated Torsional Moment applied at the drive shaft due to the transfer of load from Shaft 15 to the drive assembly.

$W := \frac{T}{1.5 \cdot in}$ $W = 154.131 \cdot lbf$ Force at bolt ring

$M := W \cdot (1.375 \cdot in)$ $M = 211.931 \cdot lbf \cdot in$ Applied Moment on Bolts

Check stress on 1/2 - 13 - UNC - 2B Fasteners

Ref. 33.5, Pg. 5, Item 14

Shear

$n_b := 3$		Number of Fasteners Sharing Load	
$n := 13$		Number of threads per inch	
$D := \frac{1}{2}\cdot in$		Major Diameter of Fastener	
$A_T := 0.7854\cdot\left[\left[D - \left(\frac{0.9743}{n}\right)\cdot in\right]\right]^2$	$A_T = 0.142\cdot in^2$	Tensile Stress Area of Fastener	Ref. 7, Pg. 4-147
$F_u := 125000\cdot psi$		Ultimate Tensile Strength of A193 Class2 B8T Stainless Steel Fasteners	
$S_{all} := 0.17\cdot F_u$	$S_{all} = 2.125\cdot 10^4\cdot psi$	Allowable shear strength of Fasteners	Ref. 7, Pg. 4-5
$S_{act} := \frac{W}{n_b\cdot A_T}$	$S_{act} = 362.069\cdot psi$	Calculated shear stress	
$\frac{S_{all}}{S_{act}} = 58.691$		Safety factor > 5 OK	

Tensile Stress due to bending moment

$D := \left(\frac{1}{2}\right)\cdot in$		Major diameter of bolt	
$y := \frac{D}{2}$		Radius of Bolt	
$I := \frac{p\cdot D^4}{64}$	$I = 0.003\cdot in^4$	Moment of Inertia of bolt	
$T_{act} := \frac{M\cdot y}{n_b\cdot I}$	$T_{act} = 5.757\cdot 10^3\cdot psi$	Calculated Tensile stress at Fasteners	
$T_{all} := 0.33\cdot F_u$		Allowable Yield Strength in Tension	Ref. 7, Pg. 4-3
$\frac{T_{all}}{T_{act}} = 7.166$		Safety factor > 5 OK	

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Revision No.: 0
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DESIGN ANALYSIS

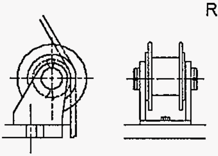
Client WESTINGHOUSE HANFORD COMPANY
WO/Job No. ER4319
Filename WIN-19.mcd
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP
Date 9 / 8 / 95
By D.L. STONE
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106
Checked 9/8/95
By M.R. CUSTER
Location C TANK FARM - HANFORD 200 EAST AREA
Revised
By

Design of Guide Idler

Ref. 33.5, Pg 1, View A-A

$W_T := 4290 \cdot lbf$ Tension on Wire Rope

Resolution of forces on idler axle due to loading from winch cable.
Dimension obtained from Autocad.



Ref. 31

$FH_{empty} := W_T \cdot \cos(61.1 \cdot deg)$ $FH_{empty} = 2.073 \cdot 10^3 \cdot lbf$ Maximum load condition at empty reel

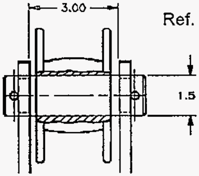
$FV_{empty} := W_T \cdot \sin(61.1 \cdot deg)$ $FV_{empty} = 3.756 \cdot 10^3 \cdot lbf$

$FH_{full} := W_T \cdot \cos(76.66 \cdot deg)$ $FH_{full} = 989.828 \cdot lbf$

$FV_{full} := W_T \cdot \sin(76.66 \cdot deg)$ $FV_{full} = 4.174 \cdot 10^3 \cdot lbf$ Maximum load condition at full reel

$M_b := FH_{empty} \cdot 3.88 \cdot in$ $M_b = 8.044 \cdot 10^3 \cdot lbf \cdot in$ Moment on Bracket

Stress on sheave axles



Ref. 33.5, Pg. 4, Item 8

Shear stress

$D := 1.5 \cdot in$ Axle Diameter

$A_a := \frac{p \cdot D^2}{4}$ $A_a = 1.767 \cdot in^2$ Cross Sectional Area

$W_{axle} := \left(\frac{W_T}{2}\right)$ $W_{axle} = 2.145 \cdot 10^3 \cdot lbf$ Force of sheave assembly felt by each shear plane.

$S_{actS} := \frac{W_{axle}}{A_a}$ $S_{actS} = 1.214 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated Shear Stress per axle.

$S_y := 120000 \cdot \frac{lbf}{in^2}$ Yield Strength for ASTM 291

$S_{allS} := 0.4 \cdot S_y$ $S_{allS} = 4.8 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Shear Stress Ref. 11, Sec.1.8

$SF_S := \frac{S_{allS}}{S_{actS}}$ $SF_S = 39.545$ Safety factor > 3 OK

Bending stress

$D_m := 0.18 \cdot in$ Thrust Washer Thickness (Moment arm on axle between sheave and housing.) Ref. 33.5, Pg. 4, Item 7

$M := W_{axle} \cdot D_m$ Moment applied to axle

$y := \frac{1.5}{2} \cdot in$ Distance from centroidal axis to inside fiber.

$I := \frac{p \cdot D^4}{64}$ Axle Moment of Inertia

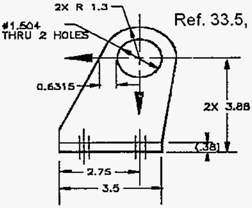
$B_{act} := \frac{M \cdot y}{I}$ $B_{act} = 1.165 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated Maximum Bending Stress per axle. Ref.8B, Pg. 177 (Table of Simple Stresses)

$B_{all} := 0.75 \cdot S_y$ $B_{all} = 9 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Bending Stress Ref. 7, Pg 5-48 (F2-1)

$SF_B := \frac{B_{all}}{B_{act}}$ $SF_B = 77.235$ Safety factor > 3 OK

Stress on Bracket

Ref. 33.5, Pg. 4, Item 5



Shear, Horizontal

$w := 0.672 \cdot in$ Width of Shear plane.

$th := \left(\frac{3}{8}\right) \cdot in$ $th = 0.375 \cdot in$ Plate thickness

$A := 2 \cdot (w \cdot th)$ $A = 0.504 \cdot in^2$ Area of bracket loaded by the axle.

$S_y := 30000 \cdot \frac{lbf}{in^2}$ Yield strength of ASTM A240 Type 304

$S_{all} := (0.45) \cdot S_y$ $S_{all} = 1.35 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Stress Ref.7, Part 5, Chap. D.3.1

$S_{act} := \frac{(FH_{empty})}{A}$ $S_{act} = 4.114 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated stress on brackets.

$SF := \frac{S_{all}}{S_{act}}$ $SF = 3.282$ Safety factor > 3 OK

Bearing

Ref. 33.5, Pg. 4, Item 5

$d := 1.054 \cdot in$ Hole Diameter

$A := 2 \cdot \left(\frac{p \cdot d}{2} \cdot th \right)$ $A = 1.242 \cdot in^2$ Bearing Surface Area.

$S_y := 30000 \cdot \frac{lbf}{in^2}$ Yield strength of ASTM A240 Type 304

$S_{all} := (0.9) \cdot S_y$ $S_{all} = 2.7 \cdot 10^4 \cdot \frac{lbf}{in^2}$ Allowable Stress

$S_{act} := \frac{FV_{full}}{A}$ $S_{act} = 3.362 \cdot 10^3 \cdot \frac{lbf}{in^2}$ Calculated stress on brackets.

$SF := \frac{S_{all}}{S_{act}}$ $SF = 8.032$ Safety factor > 3 OK

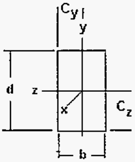
Weld Strength at Base / Wall Connection

WELD PROPERTIES:

Ref. 9, Pg. 7.4 6 &7

$b := 0.38 \cdot in$ Weld Outline Dimension - short side

$d := 3.5 \cdot in$ Weld Outline Dimension - long side



$Cy := \frac{b}{2}$	$Cy = 0.19 \cdot in$	Location of center of gravity with respect to y axis.
$Cz := \frac{d}{2}$	$Cz = 1.75 \cdot in$	Location of center of gravity with respect to z axis.
$Aw := b \cdot d$	$Aw = 1.33 \cdot in^2$	Weld length
$Iy := \frac{b^3 \cdot d}{12}$	$Iy = 0.016 \cdot in^4$	Moment of Inertia about y axis
$Iz := \frac{b \cdot d^3}{12}$	$Iz = 1.358 \cdot in^4$	Moment of Inertia about z axis

JOINT LOADS:

Tensile	$Fx := \frac{FV_{full}}{2}$	$Fy := \frac{FH_{empty}}{2}$	$Fz := 0 \cdot lbf$
Moment	$Mx := 0 \cdot in \cdot lbf$	$My := 0 \cdot in \cdot lbf$	$Mz := \frac{M_b}{2}$

WELD STRESS:

$$S_{act} := \left[\left(\frac{Fx}{Aw}\right)^2 + \left(\frac{Fy}{Aw}\right)^2 + \left(\frac{Mz \cdot Cz}{Iz}\right)^2\right]^{0.5} \qquad S_{act} = 5.472 \cdot 10^3 \cdot psi$$

FILLET WELD SIZE REQUIRED:

$S_{all} := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$SF := \frac{S_{all}}{S_{act}}$ $SF = 2.887$ Safety factor based on full pennetration weld $\approx$ > 3 OK

Check stress on 3/4 - 10 - UNC - 2B Screws — Ref. 33.5, Pg. 3, Sec.C-C

Shear

$n_b := 2$ — Number of Screws per Bracket

$n := 10$ — Number of threads per inch

$D := \left(\frac{3}{4}\right)\cdot in$ — Major Diameter of Screw

$A_T := 0.7854\cdot\left[\left[D - \left(\frac{0.9743}{n}\right)\cdot in\right]\right]^2$ $\quad A_T = 0.334\cdot in^2$ — Tensile Stress Area of Screw — Ref. 7, Pg. 4-147

$F_u := 125000\cdot psi$ — Ultimate Tensile Strength of A193 Class2 B8T Stainless Steel Fasteners

$S_{all} := 0.17\cdot F_u$ $\quad S_{all} = 2.125\cdot 10^4\ \cdot psi$ — Allowable shear strength of screws — Ref. 7, Pg. 4-5

$S_{act} := \frac{FH_{empty}}{n_b\cdot A_T}$ $\quad S_{act} = 3.099\cdot 10^3\ \cdot psi$ — Calculated shear stress — Ref. 7, Pg. 4-147

$\frac{S_{all}}{S_{act}} = 6.856$ — Safety factor > 5 OK

Tensile

$y := 1.75\cdot in$ — Bracket base edge to screw C_L distance to determine maximum prying stress. — Ref. 33.5, Pg. 4, Item 5

$M_b = 8.044\cdot 10^3\ \cdot lbf\cdot in$ — Moment on Bracket

$F_T := \frac{M_b}{y}$ $\quad F_T = 4.597\cdot 10^3\ \cdot lbf$ — Tension on Screws resulting from combined moment on housing

$T_{act} := \frac{F_T}{n_b\cdot A_T}$ $\quad T_{act} = 6.872\cdot 10^3\ \cdot psi$ — Calculated Tensile stress at screw

$T_{all} := 0.33\cdot F_u$ — Allowable Yield Strength in Tension — Ref. 7, Pg. 4-3

$\frac{T_{all}}{T_{act}} = 6.003$ — Safety factor > 5 OK

Forces and Moments on Winch Baseplate

Weights of winch and winch housing components.

Ref. 33.5. Pg 3

$T := 4290 \cdot lbf$ Weight of Pump and Sheave Assembly

$Axle_{12} := 610 \cdot lbf$

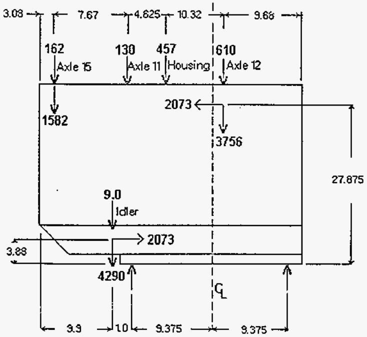
$Axle_{11} := 130 \cdot lbf$

$Axle_{15} := 162 \cdot lbf$

$Housing := 457 \cdot lbf$

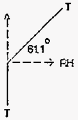
$Idler := 9 \cdot lbf$

$F_{worm} := 1582 \cdot lbf$



$RH := T \cdot \cos(61.1 \cdot deg)$ $RH = 2.073 \cdot 1\ ^{3}$ · [illegible]

$RV := T \cdot \sin(61.1 \cdot deg)$ $RV = 3.756 \cdot 10^{3} \cdot lbf$



$+\downarrow \sum F = 0 =$ $F_y := F_{worm} + T + Axle_{12} + Axle_{11} + Axle_{15} + Housing + Idler$

$F_y = 7.24 \cdot 10^{3} \cdot lbf$

$$\circlearrowright \sum M = 0 = M_{cL} := (T + Idler) \cdot (10.375 \cdot in) + ((RH) \cdot (27.375 - 3.88) \cdot in) + (Housing \cdot 5.945 \cdot in) \ldots + \left[\left(Axle_{11} \cdot 8.37 \cdot in \right) + \left[\left(Axle_{15} + F_{worm} \right) \cdot 16.04 \cdot in \right] \right] - \left[\left[Axle_{12} + (RV) \right] \cdot 1.95 \cdot in \right]$$

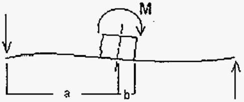
$M_{cL} = 1.166 \cdot 10^{5} \cdot lbf \cdot in$

Analysis for Stress due to central couple on a simply supported plate.

Roark - Table 24 Case 20

Ref. 10, Page 369

(Moment produced by eccentricity of winch is considered centrally located for this portion of the analysis and will produce conservative results.)



$a := 22.5 \cdot in$ Radius to plate edge

$b := 9.375 \cdot in$ Radial distance to winch baseplate edge

$\frac{b}{a} = 0.417$ Ratio for determination of proportionality constants.

Analysis for Stress due to central couple (continued...)

$b := 1.73$ Proportionality constant

$a := 0.167$ Proportionality constant

$M := M_{cL}$ Moment at winch baseplate centerline

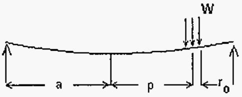
$t := 1.5 \cdot in$ Plate thickness

$E := 29 \cdot 10^6 \cdot psi$ Modlus of Elasticity of Stainless Steel

$s_w := \frac{b \cdot M}{a \cdot t^2}$ $s_w = 3.984 \cdot 10^3 \cdot psi$ Stress Resulting from moment imposed by Winch

Analysis for Stress due to uniform loading over a small eccentric circular area of radius, r_o, for a simply supported plate. Ref. 10, Page 367

Roark - Table 24 Case 18



$a = 22.5 \cdot in$ Radius to plate edge

$n := 0.3$ Poisson's Ratio

$p := 14 \cdot in$ Distance ffrom plate center to center of eccentric circle

$r_o := 3 \cdot in$ Radius of eccentric circle

$W := (453 + 635) \cdot lbf$ Weight at eccentric circle
(Weight of hose assembly and Vertical Jumper Nozzle loading. Ref. 32

$C := 2 \cdot p \cdot a$ Winch plate Circumference

$$M_r := \frac{W}{4 \cdot p} \cdot \left[1 + (1 + n) \cdot \ln\left[\frac{(a - p)}{r_o}\right] - \frac{(1 - n) \cdot r_o^2}{4 \cdot (a - p)^2} \right]$$

$M_r = 201.913 \cdot \frac{lbf \cdot in}{in}$ Maximum Moment at the load.

$s_n := \frac{6 \cdot M_r}{t^2}$ $s_n = 538.435 \cdot psi$ Stress resulting from Bending moment imposed at nozzle

$S_y := 25000 \cdot (psi)$ Yield strength of ASTM A240 Type 304L

$B_{all} := 0.6 \cdot S_y$ $B_{all} = 1.5 \cdot 10^4 \cdot psi$ Allowable stress due to Bending Ref. 7, Pg. 5-49

$SF := \left(\frac{B_{all}}{s_w + s_n}\right)$ $SF = 3.317$ Safety factor > 3 OK

Check Tensile Stress on 3/4 - 10 - UNC - 2B Fasteners

Ref. 33.4, Pg. 1, Item 33

$n_b := 2$		Number of Fasteners	
$n := 10$		Number of threads per inch	
$D := \frac{3}{4} \cdot in$		Major Diameter of Fasteners	
$A_T := 0.7854 \cdot \left[\left[D - \left(\frac{0.9743}{n}\right) \cdot in\right]\right]^2$	$A_T = 0.334 \cdot in^2$	Tensile Stress Area of Fasteners	Ref. 7, Pg. 4-147
$F_u := 125000 \cdot psi$		Ultimate Tensile Strength of A193 Class2 B8T Stainless Steel Fasteners	
$y := 18.75 \cdot in$		Distance between fasteners to determine maximum prying stress.	Ref. 33.5, Pg.3
$F_T := \frac{(M_{cL})}{n_b \cdot y}$	$F_T = 3.109 \cdot 10^3 \cdot lbf$	Tension on each fastener resulting from combined moment on housing.	
$T_{act} := \frac{F_T}{A_T}$	$T_{act} = 9.295 \cdot 10^3 \cdot psi$	Calculated Tensile stress at each fastener	
$T_{all} := 0.33 \cdot F_u$	$T_{all} = 4.125 \cdot 10^4 \cdot psi$	Allowable Tensile Strength of threaded fastener	Ref. 7, Pg. 4-3
$SF := \frac{T_{all}}{T_{act}}$	$SF = 4.438$	Safety factor ≈ 5 OK	

Winchplate Lifting Brackets

$W_{Hub} := 4290 \cdot lbf$ Weight of Pump and Sheave Assembly Ref. 33.5. Pg 3

$Winch := 1365 \cdot lbf$ Weight of Winch Assembly

$Hose := 494 \cdot lbf$ Weight of hose and pipe assembly at Nozzle

$Winchplate := 700 \cdot lbf$ Weight of Winchplate

$Shieldplate := 453 \cdot lbf$ Weight of Shielding plate

$W := W_{Hub} + Winch + Hose + Winchplate + Shieldplate$ $W = 7.302 \cdot 10^{3} \cdot lbf$

Stress on Lifting Bracket Bars

Shear stress in Lifting Pins

Ref. 33.7, Pg. 2, Item 13

$D := 2 \cdot in$ Bar Diameter

$A_a := \frac{p \cdot D^2}{4}$ $A_a = 3.142 \cdot in^2$ Cross Sectional Area

$W_{shear} := \left(\frac{W}{4}\right)$ $W_{shear} = 1.826 \cdot 10^{3} \cdot lbf$ Force of sheave assembly felt by each shear plane.

$S_{actS} := \frac{W_{shear}}{A_a}$ $S_{actS} = 581.075 \cdot psi$ Calculated Shear Stress per axle.

$S_y := 100000 \cdot \frac{lbf}{in^2}$ Yield Strength for ASTM 276

$S_{allS} := 0.4 \cdot S_y$ $S_{allS} = 4 \cdot 10^{4} \cdot psi$ Allowable Shear Stress Ref. 11, Sec.1.8

$SF_S := \frac{S_{allS}}{S_{actS}}$ $SF_S = 68.838$ Safety factor > 3 OK

Bending stress in Lifting Pin

$L := 3.0 \cdot in$		Span of Lifting Pin Bracket	Ref. 33.7, Pg. 2, Item 2
$M := \left(\frac{W}{2}\right) \cdot \left(\frac{L}{2}\right)$		Maximum Moment potentially applied to axle	
$y := 1 \cdot in$		Distance from centroidal axis to inside fiber.	
$I := \frac{p \cdot D^4}{64}$		Axle Moment of Inertia	
$B_{act} := \frac{M \cdot y}{I}$	$B_{act} = 6.973 \cdot 10^3 \cdot \frac{lbf}{in^2}$	Calculated Maximum Bending Stress per axle.	Ref. 8, Pg. 177 (Table of Simple Stresses)
$B_{all} := 0.75 \cdot S_y$	$B_{all} = 7.5 \cdot 10^4 \cdot \frac{lbf}{in^2}$	Allowable Bending Stress	Ref. 7, Pg 5-48, (F2-1)
$SF_B := \frac{B_{all}}{B_{act}}$	$SF_B = 10.756$	Safety factor > 3 OK	

Stress on Bracket Ref. I, Pg. 4, Item 5

Shear

$w := 0.97 \cdot in$		Width of Shear plane.	
$th := \left(\frac{1}{2}\right) \cdot in$	$th = 0.5 \cdot in$	Plate thickness	
$A := 2 \cdot (w \cdot th)$	$A = 0.97 \cdot in^2$	Area of bracket loaded by the axle.	
$S_y := 25000 \cdot \frac{lbf}{in^2}$		Yield strength of ASTM A240 Type 304L	
$S_{all} := (0.45) \cdot S_y$	$S_{all} = 1.125 \cdot 10^4 \cdot psi$	Allowable Stress	Ref. 7, Part 5, Chap. D.3.1
$S_{act} := \frac{W}{2 \cdot A}$	$S_{act} = 3.764 \cdot 10^3 \cdot \frac{lbf}{in^2}$	Calculated stress on brackets.	
$SF := \frac{S_{all}}{S_{act}}$	$SF = 2.989$	Safety factor $\approx$ 3 OK	

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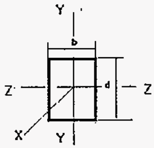
Revision No.: 0
Page No. 78 of 78

DESIGN ANALYSIS

Client WESTINGHOUSE HANFORD COMPANY — WO/Job No. ER4319 — Filename WIN-21.mcd
Subject WINCH ANALYSIS - SLURRY/SLUICE PUMP — Date 9 / 8 / 95 — By D.L. STONE
PROJECT W-320 WASTE RETRIEVAL for TANK 241-C-106 — Checked 9/8/95 — By M.R. CUSTER MRC
Location C TANK FARM - HANFORD 200 EAST AREA — Revised — By

Weld Strength at Lifting Bracket Base

WELD PROPERTIES:



$b := 0.5 \cdot in$ Weld Outline Dimension - short side Ref. 9, Pg. 7.4 6 &7

$d := 8 \cdot in$ Weld Outline Dimension - long side

$Aw := 2 \cdot 2 \cdot (b + d)$ $Aw = 34 \cdot in$ Weld length (2 Plates)

JOINT LOADS:

Tensile $Fx := \frac{W}{2}$ $Fy := 0 \cdot lbf$ $Fz := 0 \cdot lbf$

Moment $Mx := 0 \cdot in \cdot lbf$ $My := 0 \cdot in \cdot lbf$ $Mz := 0 \cdot in \cdot lbf$

WELD STRESS:

$fw := \left(\frac{Fx}{Aw}\right)$ $fw = 107.382 \cdot \frac{lbf}{in}$

FILLET WELD SIZE REQUIRED:

$S := 15800 \cdot psi$ Allowable Weld Stress per AWS & AISC Ref. 9, Pg. 7.4-8

$w := \frac{fw}{0.707 \cdot S}$ $w = 0.01 \cdot in$ Minimum Allowable Fillet Weld Required by Design

$w_{Code} := \left(\frac{3}{16} \cdot in\right)$ Minimum Size Fillet Weld Required by Code for material thickness of 1/2". Ref. 7, Part 5, Section J.2.2, Table J2.4

$w_{act} := \left(\frac{1}{4} \cdot in\right)$ Weld size specified in design drawings. Ref. 33.6, Pg. 2

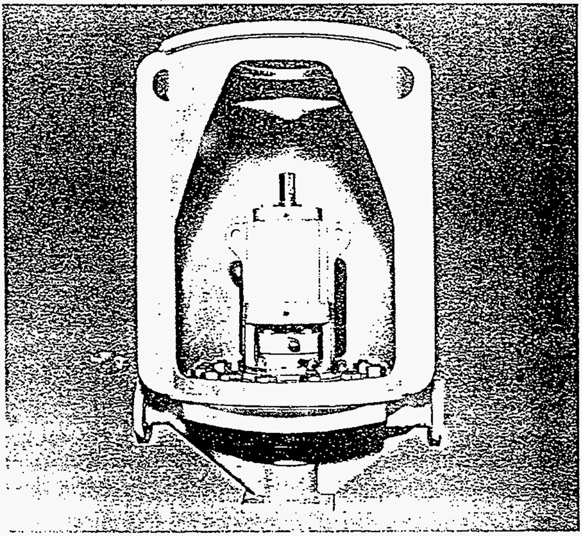
$SF_{fw} := \frac{w_{act}}{w}$ $SF_{fw} = 26.007$ Safety factor based on a 1/4" weld > 3 OK

APPENDIX A

(NEW PUMP IN SUMP) as of
PIT 6/6/95

Series 1400
In-Line Bearing Frame True Line Pumps

- Partial emissions hydraulics for optimum efficiency
  - Heads to 700 FT (213m) at 3550 RPM with a single stage
- 700 lb. casing
- Back Pullout feature
- Mag Drive option
- High speed designs available
- Variable speed options available



Series 1400 2" x 2" - 13" Vertical In-Line Pump Figure 1

Optimized Low Flow, High Head Performance

True Line pumps from Lawrence Pumps Inc. are designed to deliver long term mechanical and hydraulic reliability for your low flow, high head applications.

- Designed to API-610 Standards
- Mechanical seal life is extended because the robust shaft design, combined with low radial loads minimizes shaft deflection
- Alignment between the pump and motor is guaranteed by a precision machined fit
- Liberal internal clearances and reduced radial thrust virtually eliminate the potential for any internal metal to metal contact
- Extreme temperature designs available (-50°F/-45°C to 700°F/370°C)
- Back Pullout feature allows ease of maintenance without disturbing the motor or connecting piping
- Seal chamber design accommodates Single, Double and Tandem mechanical seals
- Complete seal flush piping arrangements available

There are no close clearance wear rings or stuffing box bushing, and the axial clearances on both the front and back of the impeller are typically 0.035". Ultimately, the True Line design will withstand prolonged process upsets, or loss of suction, if seal lubrication is maintained.

Improved Process Pump Performance, Reduced Total Cost of Ownership.

- High efficiency at low flows
- Stable operations at all design points
- Minimum shaft deflection at off-design flows
- Reliable performance through process upsets
- Low maintenance from high seal reliability
- True In-Line with suction and discharge flanges on same plane
- Low NPSH characteristics

LAWRENCE
PUMPS INC.

NEMA FRAMES 182HP - 449HP — (See drawings below.) - Dimensions in inches/millimeters

FRAME	P	T	CAST IRON TERMINAL BOX				AJ	AX(2)	BB	BD	BE	BF	AG		AH(4)	BY		SHAFT AND KEY						WT. LBS./KG.	
			AA	AB	AC	AF							STD	LG(5)		STD	LG(5)	V	U(1)	EU(3)	EP(MIN)	LGTH	SQ.KEY	STD.	LG(5)
182HP	9.50 241	1.44 36.5	.75 19	7.75 197	6.31 150	1.94 49.3	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	17.56 446	19.06 484	2.750 69.85	9.38 238	10.12 257	2.75 69.8	1.1250 28.575	.875 22.22	1.16 29.5	1.28 32.5	.250 6.35	120 54	145 65
L184HP	9.50 241	1.44 36.5	.75 19	7.75 197	6.31 160	1.94 49.3	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	18.56 471	20.06 509	2.750 69.85	9.88 251	10.62 270	2.75 69.8	1.1250 28.575	.875 22.22	1.16 29.5	1.28 32.5	.250 6.35	130 59	155 70
213HP	10.50 257	1.44 36.5	1.00 25.4	9.75 248	7.75 197	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	19.50 495	21.25 540	2.750 69.85	9.75 248	10.62 270	2.75 69.8	1.1250 28.575	.875 22.22	1.38 35.0	1.28 32.5	.250 6.35	175 79	190 86
215HP	10.50 257	1.44 36.5	1.00 25.4	9.75 248	7.75 197	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	21.00 533	21.88 555	2.750 69.85	10.50 257	10.94 273	2.75 69.8	1.1250 28.575	.875 22.22	1.38 35.0	1.28 32.5	.250 6.35	200 91	215 97
254HP	13.88 352	2.25 57.2	1.25 31.8	10.19 259	8.22 209	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	22.94 582	— —	2.750 69.85	10.81 275	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	215 98	— —
256HP	13.88 352	2.25 57.2	1.25 31.8	10.19 259	8.22 209	2.50 63.5	9.12 232	8.250 210	.19 4.8	10.00 254	.62 15.9	.44 11.1	24.69 627	— —	2.750 69.85	11.69 297	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	245 111	— —
284HP	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	9.12 232	8.250 210	.25 6.4	10.00 254	.69 17.5	.44 11.1	25.88 657	— —	2.750 69.85	12.25 311	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	270 122	— —
286HP	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	9.12 232	8.250 210	.25 6.4	10.00 254	.69 17.5	.44 11.1	27.38 695	— —	2.750 69.85	13.00 330	— —	2.75 69.8	1.1250 28.575	.875 22.22	1.75 44.4	1.28 32.5	.250 6.35	320 145	— —
284HPH	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	14.75 375	13.500 343	.25 6.4	16.50 492	.88 22.2	.69 17.5	25.88 657	— —	4.500 114	12.25 311	— —	4.50 114	1.6250 41.3	1.250 31.8	1.75 44.4	1.28 77	.375 9.5	300 136	— —
286HPH	15.50 394	2.25 57.2	1.5 38	12.00 305	9.56 243	3.00 76.2	14.75 375	13.500 343	.25 6.4	16.50 492	.88 22.2	.69 17.5	27.38 695	— —	4.500 114	13.00 330	— —	4.50 114	1.6250 41.3	1.250 31.8	1.75 44.4	1.28 77	.375 9.5	350 159	— —
324HP	17.75 451	2.25 57.2	2 50.8	14.69 373	10.94 278	3.63 92.1	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	29.06 738	— —	4.500 114	13.50 343	— —	4.50 114	1.6250 41.275	1.250 31.75	2.12 53.8	3.03 77.0	.375 9.52	480 218	— —
326HP	17.75 451	2.25 57.2	2 50.8	14.69 373	10.94 278	3.63 92.1	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	30.56 776	— —	4.500 114	14.25 362	— —	4.50 114	1.6250 41.275	1.250 31.75	2.12 53.8	3.03 77.0	.375 9.52	530 240	— —
364HP	20.50 521	2.25 57.2	3 76	17.94 456	13.75 349	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	33.38 847	— —	4.500 114	15.38 390	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	660 299	— —
365HP	20.50 521	2.25 57.2	3 76	17.94 456	13.75 349	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.88 22.2	.69 17.5	33.38 847	— —	4.500 114	15.38 390	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	710 322	— —
404HP	22.62 575	2.50 63.5	3 76	19.19 487	15.00 381	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.94 23.8	.69 17.5	35.19 893	— —	4.500 114	15.12 384	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	950 431	— —
405HP	22.62 575	2.50 63.5	3 76	19.19 487	15.00 381	4.13 105	14.75 375	13.500 343	.25 6.4	16.50 419	.94 23.8	.69 17.5	35.19 893	— —	4.500 114	15.12 384	— —	4.50 114	1.6250 41.275	1.250 31.75	2.25 57.2	3.03 77.0	.375 9.52	1075 488	— —
444HP	25.50 648	2.50 63.5	3 76	22.13 562	17.37 441	6.00 152	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	40.88 1038	— —	4.500 114	18.00 457	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	1405 637	— —
445HP	25.50 648	2.50 63.5	3 76	22.13 562	17.37 441	6.00 152	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	40.88 1038	— —	4.500 114	18.00 457	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	1555 705	— —
447HP	25.25 641	2.50 63.5	(5)	23.37 594	18.12 460	7.00 178	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	49.38 1254	— —	4.500 114	22.25 565	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	2900 1314	— —
449HP	25.25 641	2.50 63.5	(5)	23.37 594	18.12 460	7.00 178	14.75 375	13.500 343	.25 6.4	16.50 419	1.06 27.0	.69 17.5	49.38 1254	— —	4.500 114	22.25 565	— —	4.50 114	2.125 53.975	1.750 44.45	2.25 57.2	3.03 77.0	.500 12.70	2900 1314	— —

(1) "U" Varies { — up to 2.125 + .0000, − .0005 53.975 + .000, − .013
— 2.125 and larger + .000, − .001 53.975 and larger + .00, − .03

(2) "AK" Varies { —180 HP.—250HP, + .003, − .000 + .08, — .00
— 280HPH, − 440HP + .005, − .000 + .13, − .00

Face runout and Eccentricity { —182HP —445HP, .004 Max. T.I.R. .10
—447HP —449HP, .007 Max. T.I.R. .18

(3) "EU" Varies + .000, − .005 + .00, − .13

(4) "AH" Varies + .030, − .030 + .76, − .76

(5) "AA" Varies with full load amps: 4" (120 mm) @ 201 amps, 5" (127 mm) @ 335 amps, 6" (152 mm) @ 600 amps.

Maximum permissible shaft runout when measured at end of shaft extension is .002 inches (.051 mm) Max. T.I.R. (.003 inches, .076 mm on 447HP — 449HP).

If mounting clearance is required, consult factory.

NORMAL THRUST, TEFC Above-NEMA, 350 — 400 HP

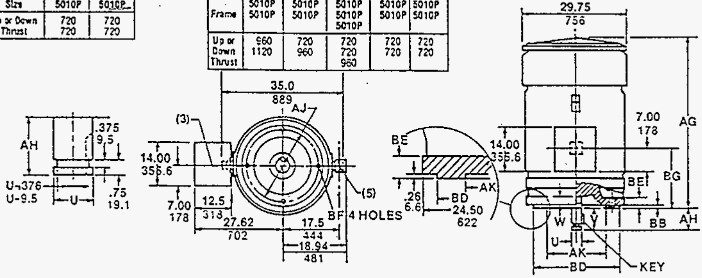
5010P Frame, 460 Volts

HP	350	400
Full Load Speed	3560 1773	3558 1773
Frame Size	5010P 5010P	5010P 5010P
Up or Down Thrust	720 720	720 720

5010P Frame, 2300, 4000 Volts

HP	200	250	300	350	400
Full Load Speed	1189 890	1783 1189	3571 1783 1188	3570 1784	3579 1784
Frame	5010P 5010P	5010P 5010P	5010P 5010P 5010P	5010P 5010P	5010P 5010P
Up or Down Thrust	960 1120	720 960	720 720 960	720 720	720 720

- 5010P Frames
- 460, 2300, 4000 Volts
- 3-Phase, 60 Hz
- 1.0 S.F., Continuous Duty
- 40°C. Ambient
- Class B Insulation
- Ball Bearing
- Solid Shaft



ABOVE NEMA 5010P — Dimensions in inches/millimeters

FRAME	RPM (MAX.)	U(2)	V	AG	AH	AJ	AX(1)	BB	BD	BE	BG	W	BF	KEY		WT. (LBS/KG)
														SQ.	LGTH.	
5010P 5010P	3600 3600	2.375 60.33	6.75 171	62.5 1587	6.75 171	14.75 374	13.500 343	.26 6.4	20.00 508	1.75 45	17.94 456	4.44 113	.687 18	.625 15.88	4.00 102	6200 2360
5010P 010P	1800 1800	3.375 85.73	6.75 171	62.5 1587	6.75 171	14.75 374	13.500 343	.26 6.4	20.00 508	1.75 45	17.94 456	4.44 113	.687 18	.875 22.23	5.0 127	6200 2360

(1) This Dimension Varies + .005 − .000 − 13. − 00

(2) This Varies + .000, − .001, − 00 − 03

(3) Customer to drill hole in Conduit Box.

(4) Face Runout and Eccentricity .007 (.18 mm) max. T.I.R.

(5) 3/4 N.P.T. for space heater leads.

Conduit Box can be rotated 360° in 90° steps.

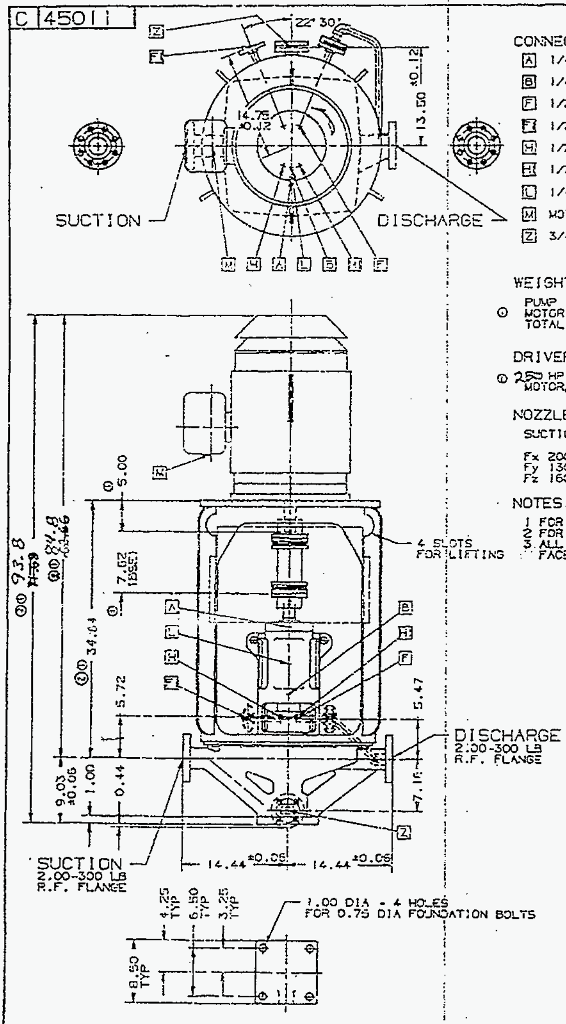
If mounting clearance details are required, consult factory.

Maximum permissible shaft runout when measured at end of std. shaft extension is .003 (.08 mm) T.I.R.

MAXIMUM FULL LOAD AMPERES	AA (4X6) PIPE TAP*
201	4
335	5
600	6

* On 5010P frame, customer to drill hole in conduit box.

C 45011



CONNECTIONS:

A	1/4-18 NPT - ALTERNATE LUBRICANT INLET TO THRUST BEARING (PLUGGED)
B	1/4-18 NPT - OIL OUTLET FROM BEARING HOUSING
F	1/2-14 NPT - INLET TO SEAL THRU API PLAN 11 FROM PUMP DISCHARGE
F1	1/2-300 LB. R.F. S.W. FLANGE - CASING VENT
H	1/2-14 NPT - SEAL VENT
H1	1/2-14 NPT - SEAL DRAIN
L	1/4-18 NPT - OIL MIST INLET TO BEARING HOUSING
M	MOTOR CONNECTION FOR POWER LEADS
Z	3/4-300 LB. R.F. S.W. FLANGE - CASING DRAIN (COVERED WITH BLIND FLANGE)

WEIGHTS:

	PUMP	800 LBS.
①	MOTOR	2700 ~~400~~ LBS.
	TOTAL	3500 ~~1200~~ LBS. APPROXIMATE

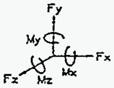
DRIVER DATA:

① 250 HP - 3600 RPM, T.E.F.C., VERTICAL ELECTRIC MOTOR, RELIANCE FRAME NO. 326TC

NOZZLE LOADS:

SUCTION & DISCHARGE

Fx	200 LBS.	Mx	340 FT-LBS.
Fy	130 LBS.	My	250 FT-LBS.
Fz	160 LBS.	Mz	170 FT-LBS.



NOTES:

1 FOR ASSEMBLY SEE DRAWING NO.C45010.
2 FOR PARTS LIST SEE "LIST OF COMPONENTS".
3 ALL FLANGE CONNECTIONS TO CONFORM TO A FACE FINISH OF 125 RMS.

NO.	BY	DATE	CHK.BY	DESCRIPTION
2	RM	[illegible]	BAM	DIM.S DECREASED 0.50
1	MD	[illegible]	RAM	MOTOR WAS 325 HP FRAME

R. REVISIONS

LAWRENCE PUMPS INC.

TRUE-LINE SERIES

PUMP SIZE 2x2x15C 2x2x8 1/4 D
SERIES: 1400
MODEL: 14-4A
DR.BY: JJ
CHK.BY: RAM 11/28/88
APPV.BY:
DATE: 21 NOV 88

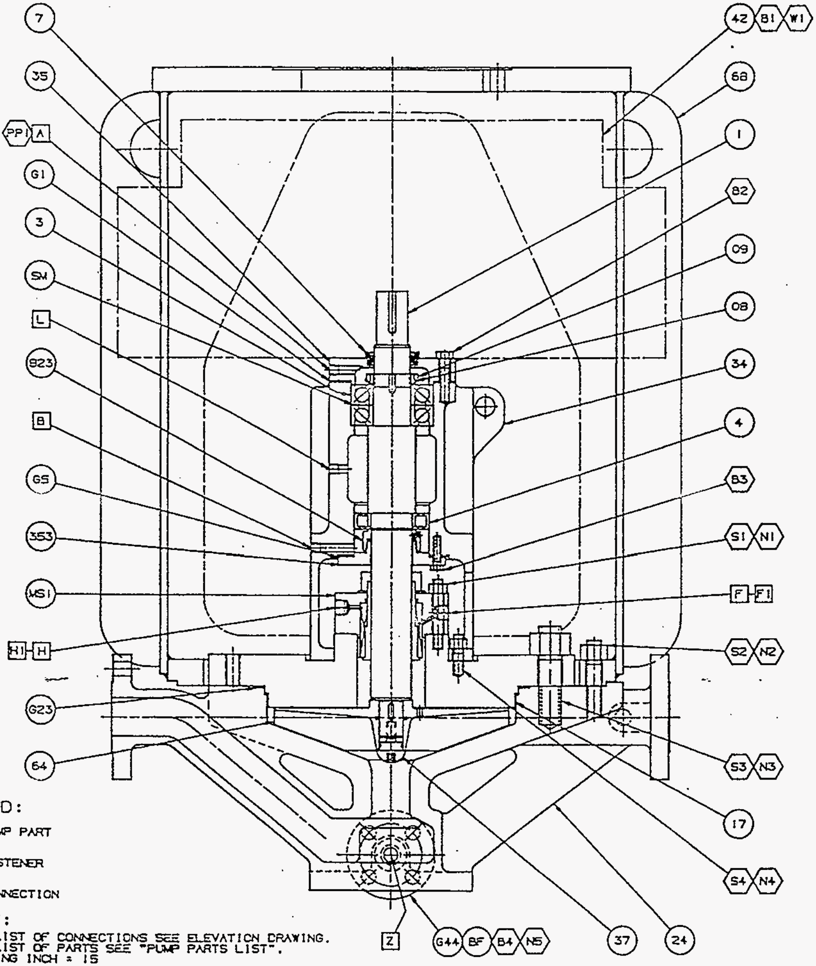
CUSTOMER:
PURCHASE ORDER NO.:
PUMP SERIAL NO.:
PUMP ITEM NO.:
CERTIFIED BY:
DATE:

PUMP ASSEMBLY:
PUMP PARTS LIST:

PUMP ELEVATION

DRAWING NO.: C 45011

C 45010



LEGEND:
○ PUMP PART
⬡ FASTENER
☐ CONNECTION

NOTES:
1 FOR LIST OF CONNECTIONS SEE ELEVATION DRAWING.
2 FOR LIST OF PARTS SEE "PUMP PARTS LIST".
3 BEARING INCH = 15

1	DRS	7/5 92	RSA	PT NO. SM ADDED
NO.	BY	DATE	CHK BY	DESCRIPTION
REVISIONS				

LAWRENCE PUMPS INC.

TRUE-LINE SERIES

PUMP SIZE [illegible]
SERIES: 1400
MODEL: 14-4A
DR.BY: JJ
CHK.BY: RAM 11/28/88
APPV.BY:
DATE: 21 NOV 88

CUSTOMER:
PURCHASE ORDER NO.:
PUMP SERIAL NO.:
PUMP ITEM NO.:
CERTIFIED BY:
DATE:

PUMP ELEVATION:
PUMP PARTS LIST:

CROSS-SECTIONAL
PUMP ASSEMBLY

DRAWING NO.: C 45010

REL. S.O.	FRAME	HP	TYPE	PHASE/ HERTZ	RPM	VOLTS
	[redacted]	250	P	3/60	1785	460

AMPS	DUTY	AMB°C/ INSUL.	S.F.	NEMA DESIGN	CODE LETTER	ENCL. FCXP-1D
273	CONT	40/F	1.15	B	G	[redacted]

E/S	ROTOR	TEST S.O.	TEST DATE	STATOR RES.@25°C OHMS (BETWEEN LINES)
533698	418143-31-GE	---	---	.0124

PERFORMANCE

LOAD	HP	AMPERES	RPM	% POWER FACTOR	% EFFICIENCY
NO LOAD	0	75.6	1800	3.92	0
1/4	62.5	100	1796	61.6	94.6
2/4	125	150	1793	80.8	96.4
3/4	187	209	1789	86.9	96.6
4/4	250	273	1784	89.0	96.4
5/4	312	341	1780	89.4	95.9

SPEED TORQUE

	RPM	TORQUE % FULL LOAD	TORQUE LB.-FT.	AMPERES
LOCKED ROTOR	0	158	1160	1820
PULL UP	700	143	1052	1660
BREAKDOWN	1728	247	1816	1037
FULL LOAD	1784	100	736	273

AMPERES SHOWN FOR 460. VOLT CONNECTION. IF OTHER VOLTAGE CONNECTIONS ARE AVAILABLE, THE AMPERES WILL VARY INVERSELY WITH THE RATED VOLTAGE

REMARKS: XE MOTOR-TYPICAL DATA-NEMA NOM. EFF. 96.2 PCT.
GUARANTEED MIN. EFF 95.8 PCT.

RELIANCE ELECTRIC
CLEVELAND, OHIO 44117 U.S.A.

DR. BY D. MAY
CK. BY J.P. TSAO
APP. BY J.P. TSAO
DATE 01/21/81

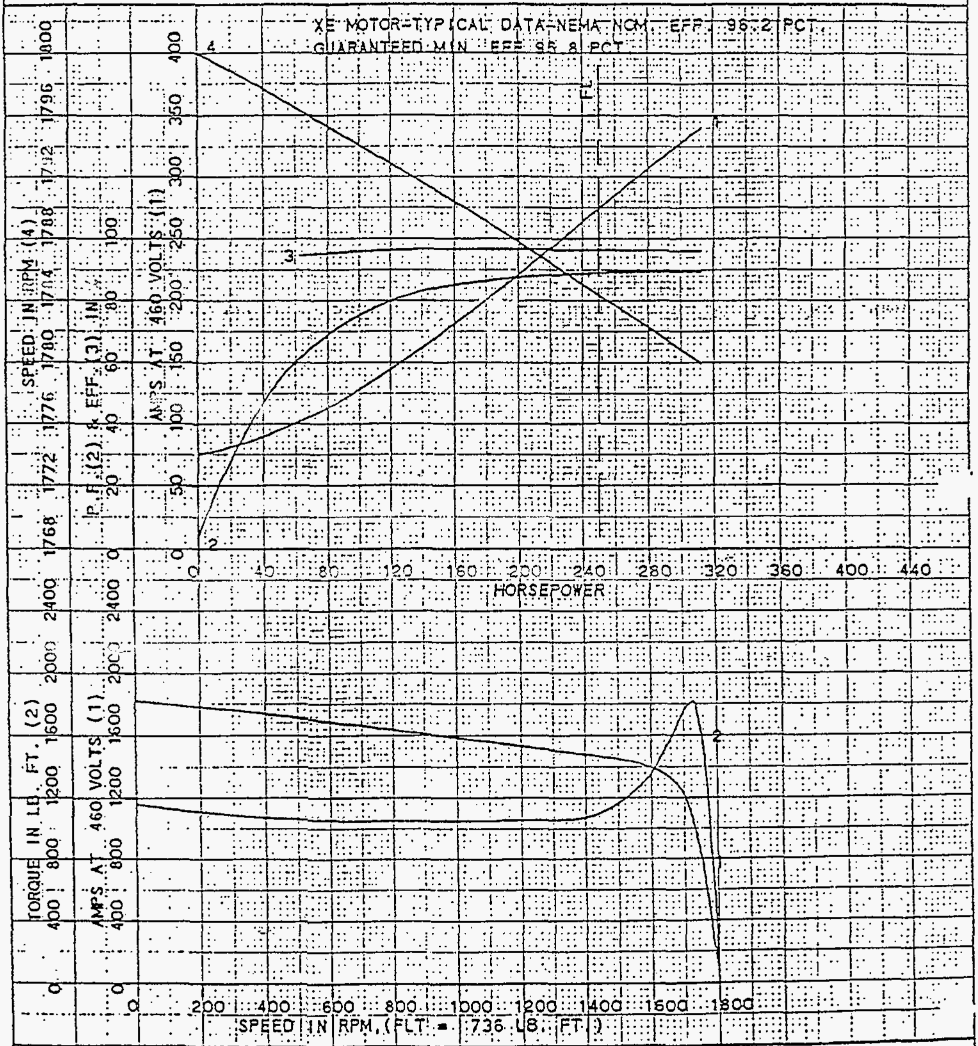
A-C MOTOR PERFORMANCE DATA

E06854-A-A001

ISSUE DATE 06/05/84

C/R 279416

REL S.O.	RPM 1785	S.F. 1.15	ROTOR 418143-31-GE
FRAME [redacted]	VOLTS 460	NEMA DESIGN B	TEST S.O. ---
HP 250	AMPS 273	CODE LETTER G	TEST DATE ---
TYPE P	DUTY CONT	ENCLOSURE TEFC	STATOR RES.@ 25°C .0124
PHASE/HERTZ 3/60	AMB°C/INSUL 40/F	E/S 533598	OHMS (BETWEEN LINES)



AMPERES SHOWN FOR 460 VOLT CONNECTION. IF OTHER VOLTAGE CONNECTIONS ARE AVAILABLE, THE AMPERES WILL VARY INVERSELY WITH THE RATED VOLTAGE.

RELIANCE ELECTRIC
CLEVELAND, OHIO 44117 U.S.A.

DR. BY D. MAY
CK. BY J.P. TSAO
APP. BY J.P. TSAO
DATE 01/21/81

A-C MOTOR PERFORMANCE CURVES

E06854-A-A001

ISSUE DATE 06/05/84

G-33-05

Armco NITRONIC 60 Stainless Steel

FIGHTS WEAR AND GALLING

- **Best galling resistance of *all* stainless steels.**
- **Corrosion resistance better than Type 304.**
- **Pitting resistance better than Type 316.**

Applications Potential

Outstanding galling resistance at both ambient and elevated temperatures makes patented Armco NITRONIC 60 Stainless Steel a valuable material for valve stems, seats and trim; fastening systems, including nuts and bolts; screening; chain-drive systems; pins, bushings and roller bearings; and pump components such as wear rings and lobes.

Atlas Impeller Casting of Armco NITRONIC 60 Stainless Steel.

ARMCO NITRONIC 60 STAINLESS STEEL

(UNS S21800)

ARMCO Product Data Bulletin No. S-45

Oxidation Resistance

NITRONIC 60 offers far superior oxidation resistance compared to AISI Types 304 and 316, and about the same oxidation resistance as AISI Type 309.

Table 28
Static Oxidation Resistance*

Test Temperature, F (C)		Weight Loss, mg/cm²			
		RA 333	Type 310	NITRONIC 60	Type 304
2100 (1149)	Before Descaling	3.1	4.6	16.5	1220
	After Descaling	12.2	15.7	23 2	1284
2200 (1204)	Before Descaling	10.1	10.1	26 1	2260
	After Descaling	16.7	20.6	35 4	2265

*240 hours at temperature, duplicate tests

Table 29
Cyclic Oxidation Resistance

Cycle	Alloy	Weight Change, mg/in², at number of cycles indicated					
		134 cycles	275 cycles	467 cycles	200 cycles	304 cycles	400 cycles
1600-1700 F (871-927 C)	RA 330	+ 3.4	+ 4 9	+ 6 4		—	—
25 minutes heat.	Type 310	+ 4 0	+ 6 7	- 22.7	—	—	—
5 minutes cool -	Type 309	+ 3 0	- 41 6	- 100 4	—	—	—
duplicate tests	NITRONIC 60	+ 1 5	- 69.2	- 167.6	—	—	—
	Type 316	-473.0	-970.8	-1287.0	—	—	—
		Weight Loss, mg/cm²					
1900 F (1038 C)	Type 446	—	—		1.47	1.72	1 97
30 minutes heat.	Type 310	—	—	—	2.70	15.95	17 22
30 minutes cool	Type 309	—	—	—	22 53	26 34	33:69
	NITRONIC 60	—	—	—	42 99	60 40	74.80
	Type 316	—	—	—	93 04	135 34	178.27

Mechanical Properties

Table 30
Typical Room Temperature Tensile Properties*

Condition	Size	Hardness	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % In 4XD	Reduction of Area, %
Annealed	1" (25.4 mm) ϕ	95 HRB	103 (710)	60 (414)	64	74
Annealed	1-3/4" (44.4 mm) ϕ	100 HRB	101 (696)	56 (386)	62	73
Annealed	2-1/4" (57.2 mm) ϕ	100 HRB	101 (696)	60 (414)	60	76
Annealed	3" (76.2 mm) ϕ	97 HRB	113 (779)	65 (448)	55	67
Annealed	4-1/8" (104.8 mm) ϕ	95 HRB	106 (731)	56 (386)	57	67
10% Cold Drawn	442" (11.2 mm) ϕ	24 HRC	120 (827)	91 (627)	51	68
20% Cold Drawn	Start Size	31 HRC	140 (965)	112 (772)	35	65
30% Cold Drawn		34 HRC	161 (1110)	132 (910)	26	62
40% Cold Drawn		37.5 HRC	195 (1344)	153 (1055)	20	57
50% Cold Drawn		41 HRC	217 (1496)	174 (1200)	15	53
60% Cold Drawn		43 HRC	240 (1655)	195 (1344)	12	48
70% Cold Drawn		46 HRC	263 (1813)	217 (1496)	10	40

*Data based on duplicate tests.
(1) CG bar

G-33-05

Table 31

Typical Room Temperature Torsion and Shear Properties*

Condition	Size	Hardness HRB	Torsional Modulus, G ksi (MPa)	0.2% Torsional YS ksi (MPa) γ	ϵ	Modulus of Rupture ksi (MPa)	Double Shear Strength ksi (MPa)
Annealed	1" ø (25.4 mm)	95	8.83 x 10^3 (61 x 10^3)	48.9 (337)	50.7 (350)	124 (855)	—
Annealed	3/8" ø (9.6 mm)	95	—	—	—	—	86 (593)

*Data based on duplicate tests

Table 32

Double Shear Strength*
(Cold Drawn — 0.442" [11.23 mm] start size)

% Cold Drawn	Shear Strength, ksi (MPa)
10	89 (614)
20	98 (676)
30	106 (731)
40	113 (779)
50	122 (841)
60	130 (896)

*Triplicate tests

Table 33

Fatigue Strength
(R.R. Moore Machine)

Condition	Size	Hardness	Fatigue Limit, ksi (MPa) 10^8 Cycles
Annealed	1" (25.4 mm) ø	95 HRB	37.5 (258)
Cold Worked 54.6%	0.70" (17.8 mm) ø	44 HRC	72.5 (500)

Table 34

Room Temperature Compression Strength

Condition	Size	0.2% Compressive YS, ksi (MPa)
Annealed	0.500" ø (12 7 mm)	67 6 (466)
Cold Drawn 39%	0.440" ø (11 2 mm)	121 0 (834)

Table 35

Properties Acceptable for Material Specification
(Bar and Wire)

Condition	Size	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 4XD	Reduction of Area, %	Hardness HRB
Annealed	1/2" ø + under (12.7 mm)	105 min (724)	55 min (379)	35 min	55 min	85 min
Annealed	Over 1/2" ø (12.7 mm)	95 min (655)	50 min (345)	35 min	55 min	85 min

Table 36

Typical Elevated Temperature Mechanical Properties* (Annealed 3/4" and 1" [19.05 and 25.4 mm] Diameter Bar Stock)

Test Temperature F (C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 4XD	Reduction of Area %	Hardness Brinell
Room Temperature	106.5 (734)	56.5 (389)	61.7	71 9	200
200 (93)	98.2 (677)	44.4 (306)	63.3	72.4	187
300 (149)	89.9 (620)	37 8 (260)	64.4	73 7	--
400 (204)	84.4 (580)	32.8 (227)	64.0	73.7	168
500 (260)	82.1 (566)	32.1 (222)	61.5	73.0	—
600 (316)	80.5 (555)	29.7 (205)	59.6	73.1	155
700 (371)	79.5 (548)	29.2 (201)	59.1	72 6	—
800 (427)	78.3 (540)	29.0 (200)	56.5	72 1	148
900 (482)	77.1 (532)	28.3 (195)	53 9	71.6	—
1000 (538)	75.4 (520)	28.0 (193)	52.2	70.4	145
1100 (593)	71 6 (494)	28.7 (198)	48 7	70 0	--
1200 (649)	66.6 (459)	28.1 (194)	48 2	69.6	144
1300 (704)	59.0 (407)	27.5 (189)	41 4	50.0	—
1400 (760)	49 8**(344)	25.3 (174)	47 1	53 9	143
1500 (816)	37 0**(255)	23 8 (164)	72 8	75 0	
1600 (871)	30 2**(208)	16 4 (113)	72 8	·	110

*Triplicate tests of 2 heats and single tests of 1 heat

**Single tests of 1 heat

Table 37

Elevated Temperature Tensile Properties (Cold Swaged 54% to 0.700" [17.8 mm] ⌀)

Test Temp. F (C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 4XD	Reduction of Area, %
RT	230 (1586)	216 (1489)	12	55
200 (93)	215 (1482)	205 (1413)	12	54
300 (149)	206 (1420)	199 (1372)	11	52
400 (204)	200 (1379)	194 (1338)	11	51
500 (260)	195 (1344)	191 (1317)	11	48
600 (316)	193 (1331)	188 (1296)	11	47
700 (371)	191 (1317)	176 (1213)	10	47
800 (427)	190 (1310)	184 (1269)	9	46
900 (482)	187 (1289)	177 (1220)	11	44
1000 (538)	179 (1234)	166 (1145)	11	47
1100 (593)	162 (1117)	144 (993)	13	52
1200 (649)	112 (772)	72 (496)	11	25

Table 38

Elevated Temperature Stress Rupture Strength (Annealed Bars 5/8" to 1" [16.0 to 25.4 mm] Diameter)

Temperature F (C)	Number of Heats	Stress Rupture Strength, ksi (MPa)		
		100 hr. life	1000 hr. life	10,000 hr. life
1000 (538)	3	72 (496)	52 (359)	35 (241)
1100 (593)	3	49 (338)	31 (214)	20 (138)
1200 (649)	4	29 (200)	17 (117)	10* (69)
1350 (732)	1	14 (97)	8 (55)	—
1500 (816)	1	6.7 (46)	4 (28)	–

*Extrapolated

Table 39
Cryogenic Tensile Properties*

Condition	Size	Temperature, F (C)	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 4XD	Reduction of Area, %
Annealed	3/8" (9.5 mm) ⌀	-100 (-73)	155 (1069)	76 (524)	57	69
	3/8" (9.5 mm) ⌀	-200 (-129)	170 (1172)	87 (600)	56	71
	1"(25.4 mm) ⌀	-320 (-196)	213 (1469)	109 (752)	60	67
Cold Swaged 54%	.700" (17.8 mm) ⌀	-320 (-196)	322 (2220)	272 (1875)	10	53
	.700" (17.8 mm) ⌀	-200 (-129)	287 (1979)	250 (1724)	13	62

*Duplicate tests

Table 40
Low Temperature Mechanical Properties of NITRONIC 60 Stainless Steel Longitudinal Tensile Specimens*

Test Temperature F (C)	UTS ksi (MPa)	0.2% Offset YS ksi (MPa)	Elongation % in 1" (25.4 mm) or 4XD	Reduction of Area %	Fracture Strength ksi (MPa)	Modulus psi (MPa)	N/U** Tensile Ratio	Charpy V-Notch Impact ft-lbs (J)
75 -(24)	109.3 (754)	58.1 (400)	66.4	79.0	336.1 (2317)	24.0×10^6 (165.000)	1.44	231 (310)
0 (-18)	128.1 (883)	67.3 (464)	71.3	79.7	433.4 (2988)	23.7×10^6 (163.000)	1.37	216 (292)
-100 (-73)	148.4 (1023)	77.9 (537)	70.5	80.9	447.1 (3083)	24.2×10^6 (167.000)	1.45	197 (267)
-200 (-129)	167.5 (1155)	87.4 (603)	63.4	79.4	457.0 (3151)	24.2×10^6 (167.000)	1.46	170 (231)
-320 (-196)	217.9 (1502)	101.4 (699)	59.5	65.8	594.0 (4095)	24.8×10^6 (171.000)	1.26	138 (188)
-423 (-253)	203.8 (1405)	125.3 (864)	23.5	26.6	277.6 (1914)	24.8×10^6 (171.000)	1.33	— —

*0.250" (6.35 mm) diameter, machined from a 1" (25.4 mm) diameter annealed and straightened bar. Four specimen average.
**Average Stress Concentration Factor $K_t = 7.0$
Data taken with permission from NASA TM X-73359, Jan. 1977.

Table 41
Impact Properties**

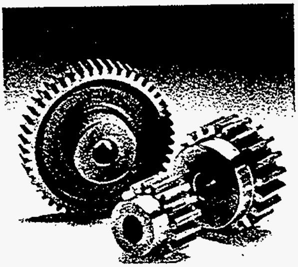
Condition	Size	Test Temperature, F (C)	Charpy V-Notch Impact, ft-lbs (J)
Annealed	1" ⌀ (25.4 mm)	Room Temperature	240* (325)
		-100 (-73)	229 (310)
		-320 (-196)	144 (195)
Annealed	2-1/4" ⌀ (54.2 mm)	Room Temperature	240* (325)
		-100 (-73)	240* (325)
		-320 (-196)	160 (217)
Cold Swaged 18% Hardness R_C 29	.932" ⌀ (23.7 mm)	-320 (-196)	67 (91)
Cold Swaged 40% Hardness R_C 37	.795" ⌀ (20.2 mm)	-320 (-196)	40 (54)
Cold Swaged 54% Hardness R_C 42	.700" ⌀ (17.8 mm)	-320 (-196)	26 (35)
Cold Swaged 18% Hardness R_C 29	.932" ⌀ (23.7 mm)	-200 (-129)	90 (122)
Cold Swaged 40% Hardness R_C 37	.795" ⌀ (20.2 mm)	-200 (-129)	44 (60)
Cold Swaged 54% Hardness R_C 42	.700" ⌀ (17.8mm)	-200 (-129)	30 (41)

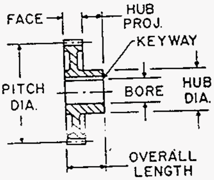
*Did not fracture completely
**Data based on duplicate tests

SPUR GEARS

4 AND 3 DIAMETRAL PITCH
STEEL AND CAST IRON

14½° PRESSURE ANGLE
(Will not operate with 20° spurs)





ALL DIMENSIONS IN INCHES
ORDER BY CATALOG NUMBER OR ITEM CODE

No. of Teeth	Pitch Dia.	Bore	Hub		Style See Page A93	Without Keyway or Setscrew	
			Dia.	Proj.		Catalog Number	Item Code
4 DIAMETRAL PITCH	FACE = 2" OUTSIDE DIA. = PITCH DIA. + .500" OVERALL LENGTH = 2" + HUB PROJ.						
STEEL							
11	3.000*	1-1/8	2-17/64	7/8	A	NL11B	09860
12	3.000		2-17/64			NL12B	09862
14	3.500		2-49/64			NL14B	09864
15	3.750		3-1/64			NL15B	09866
16	4.000		3-17/64			NL16B	09868
18	4.500		3-49/64			NL18B	09870
20	5.000		4-17/64			NL20B	09872
22	5.500		4-49/64			NL22B	09874
CAST IRON							
24	6.000	1-1/8	3-1/2	1-1/2	A	NL24B	10484
28	7.000	1-1/4			B	NL28B	10486
30	7.500					NL30B	10488
32	8.000					NL32B	10490
36	9.000					NL36B	10492
40	10.000		4		C	NL40B	10494
42	10.500					NL42	10496
44	11.000					NL44B	10498
48	12.000				D	NL48B	10500
54	13.500					NL54	10502
56	14.000					NL56B	10504
60	15.000					NL60	10506
64	16.000					NL64B	10508
72	18.000					NL72B	10510
80	20.000	1-3/8	4-1/2	1-1/2		NL80B	10512
84	21.000					NL84	10514
88	22.000			1-3/4		NL88B	10516
96	24.000					NL96B	10518
3 DIAMETRAL PITCH	FACE = 3" OUTSIDE DIA. = PITCH DIA. + .667" OVERALL LENGTH = FACE + HUB PROJ.						
STEEL							
11	4.000*	1-5/16	—	—	A	NO11B†	09876
12	4.000					NO12B†	09878
14	4.667					NO14B	09880
15	5.000					NO15B	09882
16	5.333					NO16B	09884
18	6.000					NO18B	09886
20	6.667					NO20	09888
21	7.000					NO21B	09890
CAST IRON							
24	8.000	1-7/16	4-1/2	1-1/4	B	NO24B	10524
30	10.000		5-1/4			NO30B	10526
36	12.000			1-3/4		NO36B	10528
42	14.000				C	NO42	10530
48	16.000	1-9/16	5-1/4	1-3/4	D	NO48B	10532
54	18.000					NO54	10534
60	20.000					NO60B	10536
72	24.000	1-11/16	5-1/2	1-3/4		NO72B	10538
84	28.000		5-3/4			NO84B	10540
96	32.000	1-15/16	5-3/4	1-3/4		NO96B	10542
108	36.000					NO108B	10544

#24

#25

≈ 11/16

≈ 13/16

* Special Pitch Diameter, used for calculating Center Distance only, not Ratio.
†NO11B and NO12B have 4" Face.

STANDARD TOLERANCES

DIMENSION		TOLERANCE
BORE	All	±.0005

REFERENCE PAGES
Alterations—A92
Horsepower Ratings—A9, A10
Lubrication—A92
Materials—A93
Selection Procedure—A2

BOSTON Gear
INCOM INTERNATIONAL INC.

SPUR GEARS

APPROXIMATE HORSEPOWER AND TORQUE* RATINGS FOR CLASS I SERVICE (Service Factor = 1.0)

4 DIAMETRAL PITCH CAST IRON 14½° PRESSURE ANGLE 2" FACE REFERENCE PAGE A25.

[illegible]	25 RPM		50 RPM		100 RPM		200 RPM		300 RPM		600 RPM		900 RPM		1200 RPM		1800 RPM		3600 RPM	
	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque
[illegible]	2.00	5042	3.77	4750	6.75	4257	11.19	3525	14.32	3008	19.88	2089	22.84	1600						
[illegible]	2.43	6129	4.54	5723	8.02	5053	12.99	4094	16.38	3441	22.16	2328								
[illegible]	2.62	6599	4.87	6135	8.53	5378	13.69	4314	17.14	3601	22.92	2408								
[illegible]	2.86	7211	5.30	6675	9.22	5811	14.65	4616	18.22	3829	24.11	2534								
[illegible]	3.25	8187	5.96	7514	10.24	6454	15.98	5034	19.64	4126	25.49	2677								
[illegible]	3.64	9177	6.63	8354	11.24	7085	17.24	5433	20.97	4406	26.77	2812								
[illegible]	3.80	9588	6.90	8694	11.63	7328	17.69	5575	21.42	4499	27.12	2849								
[illegible]	4.04	10161	7.29	9195	12.22	7703	18.46	5816	22.24	4672	27.97	2938								
[illegible]	4.36	10999	7.82	9858	12.95	8163	19.28	6074	23.02	4837	28.58	3002								
[illegible]	4.97	12530	8.81	11104	14.35	9045	20.94	6598	24.72	5193										
[illegible]	5.13	12933	9.06	11419	14.68	9253	21.29	6708	25.04	5261										
[illegible]	5.44	13727	9.55	12034	15.32	9652	21.94	6915	25.65	5388										
[illegible]	5.86	14763	10.20	12852	16.20	10209	22.95	7233	26.66	5601										
[illegible]	6.47	16305	11.11	14005	17.33	10923	24.07	7585	27.65	5810										
[illegible]	7.18	18101	12.18	15350	18.68	11772	25.48	8029												
[illegible]	7.47	18838	12.60	15877	19.17	12079	25.93	8170												
[illegible]	7.76	19561	13.00	16387	19.63	12372	26.35	8304												
[illegible]	8.32	20970	13.78	17365	20.50	12922	27.13	8548												

3 DIAMETRAL PITCH STEEL 14½° PRESSURE ANGLE 3" FACE REFERENCE PAGE A25.

[illegible]	25 RPM		50 RPM		100 RPM		200 RPM		300 RPM		600 RPM		900 RPM		1200 RPM		1800 RPM		3600 RPM	
	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque
[illegible]	2.94	7421	5.67	7146	10.56	6652	18.55	5846	24.82	5213	37.47	3936	45.15	3162	50.30	2642				
[illegible]	3.20	8067	6.14	7743	11.37	7167	19.80	6239	26.30	5524	39.14	4111	46.74	3273	51.78	2719				
[illegible]	4.15	10462	7.92	9979	14.49	9134	24.79	7812	32.48	6824	47.09	4947	55.40	3880						
[illegible]	4.61	11618	8.76	11046	15.96	10056	27.06	8528	35.24	7403	50.49	5304	59.01	4132						
[illegible]	5.09	12825	9.64	12156	17.47	11008	29.38	9259	38.03	7989	53.89	5661	62.60	4383						
[illegible]	6.03	15214	11.37	14333	20.38	12845	33.75	10637	43.20	9076	60.03	6303	68.93	4827						
[illegible]	6.97	17570	13.05	16454	23.16	14599	37.80	11913	47.89	10062	65.33	6863								
[illegible]	7.46	18795	13.92	17549	24.59	15495	39.64	12556	50.24	10554	67.96	7139								

3 DIAMETRAL PITCH CAST IRON 14½° PRESSURE ANGLE 3" FACE REFERENCE PAGE A25.

No. Teeth	25 RPM		50 RPM		100 RPM		200 RPM		300 RPM		600 RPM		900 RPM		1200 RPM		1800 RPM		3600 RPM	
	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque	H.P.	Torque
[illegible]	5.23	13175	9.67	12195	16.84	10617	26.76	8433	33.30	6995	44.05	4627								
[illegible]	6.81	17164	12.40	15626	21.03	13251	32.25	10162	39.23	8241	50.07	5259								
[illegible]	8.41	21199	15.07	18998	24.96	15732	37.15	11707	44.37	9322	55.08	5786								
[illegible]	9.81	24721	17.32	21828	28.06	17687	40.69	12822	47.87	10056										
[illegible]	11.20	28241	19.50	24586	30.99	19530	43.91	13838	51.00	10715										
[illegible]	12.71	32043	21.83	27523	34.06	21466	47.30	14906	54.35	11417										
[illegible]	13.87	34965	23.52	29651	36.08	22740	49.22	15509												
[illegible]	16.35	41223	27.08	34136	40.30	25402	53.32	16803												
[illegible]	18.76	47293	30.40	38322	44.08	27782	56.87	17923												
[illegible]	20.75	52300	32.96	41545	46.71	29437	59.02	18597												
[illegible]	22.99	57968	35.87	45212	49.81	31395	61.84	19486												

Ratings are based on strength calculation. Basic static strength rating, or for hand operation of above gears is approximately 3 times the 100 RPM rating.

NOTE: Ratings to right of heavy line are not recommended, as pitch line velocity exceeds 1000 feet per minute. They should be used for interpolation purposes only.

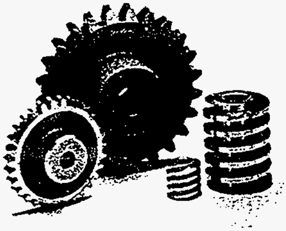
*Torque Rating (Lb. Ins.).

WORMS AND WORM GEARS

3 DIAMETRAL PITCH
CAST IRON WORM GEARS
STEEL WORMS – UNHARDENED AND HARDENED

PRESSURE ANGLE – 14½°

RATIO = Gear Teeth ÷ Worm Threads
All Worm and Worm Gears stocked RIGHT HAND ONLY



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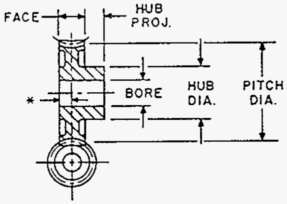


ALL DIMENSIONS IN INCHES
ORDER BY CATALOG NUMBER OR ITEM CODE

3 DIAMETRAL PITCH — WORM GEARS — FACE = 2 — CENTER LINE WORM TO FLUSH END = 1.000"

No. of Teeth	Pitch Dia.	Bore	Hub		Style See Page A93	SINGLE Thread		DOUBLE Thread		FOUR Thread	
			Dia.	Proj.		Catalog Number	Item Code	Catalog Number	Item Code	Catalog Number	Item Code
18	6.000	1	3	1-1/2	B	G1110	13248	–	–	–	–
24	8.000	1-1/2	3-1/2	1-1/2		G1111	13250	–	–	–	–
30	10.000					G1112	13252	–	–	–	–
36	12.000					G1113	13254	–	–	–	–
48	16.000		4		C	G1114	13256	–	–	–	–
54	18.000				D	G1115	13258	–	–	–	–

#26

STANDARD TOLERANCES

DIMENSION		TOLERANCE
Bore	All	±.0005

WORM LEAD and LEAD ANGLE

LEAD	1.0472"
LEAD ANGLE	4°46'

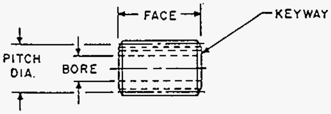
3 DIAMETRAL PITCH — WORMS FOR ABOVE GEARS

Pitch Dia.	Face	Bore	Hub		SINGLE Thread		DOUBLE Thread		QUAD Thread	
			Dia.	Proj.	Catalog Number*	Item Code	Catalog Number	Item Code	Catalog Number	Item Code
UNHARDENED										
4.000	4	1-1/2	–	–	G1116K	12880	–	–	–	–
	5-1/2				L1116	12910	–	–	–	–
HARDENED										
4.000	4	1-1/2	–	–	H1116	12978	–	–	–	–
	5-1/2				HL1116	13016	–	–	–	–

#27

*All Worms furnished with 3/8" keyway.

Hardened Worms have ground and polished threads.



REFERENCE PAGES

Alterations – A92
Horsepower Ratings – A66, A67
Lubrication – A92
Materials – A93
Selection Procedure – A65

BOSTON Gear®
INCOM INTERNATIONAL INC.

WORMS AND WORM GEARS

STEEL-HARDENED, GROUND AND POLISHED WORMS BRONZE WORM GEARS

APPROXIMATE HORSEPOWER AND TORQUE* RATINGS FOR CLASS I SERVICE (Service Factor = 1.0)

Worm RPM		1800		600		100		Worm .Cat. No.	Gear Cat. No.	DP
Ratio	Center Distance	Input HP	Output Torque	Input HP	Output Torque	Input HP	Output Torque			
[illegible]	1.000	.52	50	.27	72	.06	83	H1607	QB1212	12
	1.500	1.19	109	.66	183	.15	227	H1627	QB812	8
[illegible]	1.167	.78	99	.40	143	.08	166	H1607	QB1216	12
	1.425	1.11	142	.61	223	.13	267	H1618	QB1016	10
	1.750	1.77	216	.98	361	.22	454	H1627	QB816	8
	2.333	3.01	392	1.84	689	.45	933	H1638	QB616	6
[illegible]	1.333	.68	109	.34	158	.07	180	H1607	DB1600	12
	1.625	1.03	165	.57	257	.12	309	H1618	DB1610	10
	2.000	1.73	264	.96	441	.22	551	H1627	DB1620	8
	2.667	3.92	639	2.40	1124	.59	1512	H1638	QB620	6
[illegible]	3.000	3.82	746	2.34	1317	.57	1777	H1638	DB1630	6
[illegible]	1.750	1.04	247	.53	355	.11	411	H1607	DB1601	12
	2.125	1.59	381	.87	599	.19	714	H1618	DB1611	10
	2.625	2.65	607	1.47	1016	.33	1276	H1627	DB1621	8
	3.500	4.80	1174	2.94	2064	.72	2789	H1638	DB1631	6
[illegible]	1.333	.44	130	.23	189	.05	208	H1407	DB1400	12
	1.625	.67	196	.38	305	.09	366	H1418	DB1410	10
	2.000	1.05	318	.63	525	.15	649	H1427	DB1420	8
	2.167	1.39	441	.71	641	.15	756	H1607	DB1602	12
	2.667	2.01	616	1.26	1071	.32	1450	H1438	DB620	6
	2.625	2.11	672	1.16	1061	.25	1267	H1618	DB1612	10
	3.250	3.54	1082	1.96	1806	.44	2270	H1627	DB1622	8
	4.333	6.43	2094	3.94	3685	.96	4980	H1638	DB1632	6
[illegible]	3.000	2.39	882	1.50	1537	.38	2042	H1438	DB1430	6
[illegible]	2.583	1.72	683	.87	985	.18	1134	H1607	DB1603	12
	3.125	2.61	1042	1.44	1641	.31	1961	H1618	DB1613	10
	3.875	4.40	1681	2.44	2810	.55	3466	H1627	DB1623	8
[illegible]	1.750	.64	284	.33	410	.07	463	H1407	DB1401	12
	2.125	.98	436	.55	678	.13	804	H1418	DB1411	10
	2.625	1.54	699	.92	1150	.22	1428	H1427	DB1421	8
	3.000	2.04	966	1.03	1402	.22	1617	H1607	QB1260	12
	3.500	2.94	1355	1.84	2364	.47	3120	H1438	DB1431	6
[illegible]	5.000†	2.27	[illegible]	1.39	2373	.41	4198	H1116	G1110†	3
20	1.333	.28	140	.15	210	.04	227	H1056	GB1050	12
	1.625	.42	217	.25	336	.06	391	H1066	GB1060	10
	2.000	.65	343	.41	567	.10	706	H1076	GB1070	8
	2.167	.83	483	.43	693	.09	794	H1407	DB1402	12
	2.667	1.22	665	.60	1156	.22	1550	H1086	GB1077	6
	2.625	1.25	742	.71	1156	.16	1374	H1418	DB1412	10
	3.250	1.98	1191	1.18	1974	.28	2433	H1427	DB1422	8
	3.833	2.61	1660	1.32	2395	.28	2773	H1607	DB1604	12
	4.000	2.92	1667	1.99	3025	.64	4663	H1106	GB1100	4
	4.333	3.77	2318	2.36	4034	.60	5420	H1438	DB1432	6
24	3.000	1.42	933	.93	1613	.26	2163	H1086	GB1080	6
	6.000†	3.23	2218	1.81	4020	.53	7109	H1116	G1111†	3
	4.500	3.41	2336	2.32	4235	.75	6504	H1106	GB1101	4
25	2.583	.99	726	.52	1048	.11	1197	H1407	DB1403	12
	3.125	1.50	1112	.85	1730	.19	2048	H1418	DB1413	10
	3.875	2.39	1794	1.43	2962	.34	3671	H1427	DB1423	8
	4.667	3.14	2495	1.59	3591	.33	4096	H1607	DB1605	12
	5.167	4.53	3475	2.84	6055	.72	8035	H1438	DB1433	6
30	1.750	.40	294	.21	410	.05	473	H1056	GB1051	12
	2.125	.59	452	.35	693	.09	831	H1066	DB1061	10
	2.625	.90	725	.57	1197	.13	1286	H1076	GB1071	8
	3.000	1.15	1008	.60	1450	.13	1663	H1407	DB1260	12
	3.500	1.69	1386	1.12	2426	.31	3233	H1086	GB1081	6
	3.625	1.74	1544	.98	2395	.22	2836	H1418	DB1414	10
	4.500	2.75	2489	1.65	4128	.39	5105	H1427	DB860	8
	7.000†	4.23	3326	2.53	6002	.76	10683	H1116	G1112†	3
32	5.500	4.26	3909	2.92	7092	.94	10890	H1106	GB1102	4
36	4.000	1.95	1915	1.29	3366	.36	4470	H1086	GB1082	6
	8.000†	3.87	3990	1.33	4130	.68	12816	H1116	G1113†	3

* Torque in Lb. Ins.

†Cast Iron Gear Rating with Hardened Worm shown.

All Worm and Worm Gear Ratings are based on a Hardened Steel Worm used with a Bronze Worm Gear.

1. For a Hardened Steel Worm used with a Cast Iron Gear, multiply the listed Rating by .50.
2. For an Unhardened Steel Worm used with a Cast Iron Gear, multiply the listed Rating by .25.

BOSTON Gear®
INCOM INTERNATIONAL INC.

Table 7. Weights and Strengths of Standard Flat Wire Rope, Not Preformed

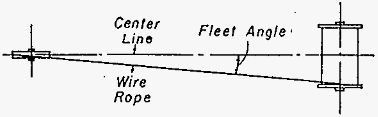
Flat Wire Rope

This rope consists of a number of 4-strand rope units placed side by side and stitched together with soft steel sewing wire.

Width and Thickness, Inches	No. of Ropes	Approx. Weight per Ft., Pounds	Breaking Strength, Tons of 2000 Lbs.	
			Plow Steel	Mild Plow Steel
¼ × 1½	7	0.69	16.8	14.6
¼ × 2	9	0.88	21.7	18.8
¼ × 2½	11	1.15	26.5	23.0
¼ × 3	13	1.34	31.3	27.2
5/16 × 1½	5	0.77	18.5	16.0
5/16 × 2	7	1.05	25.8	22.4
5/16 × 2½	9	1.33	33.2	28.8
5/16 × 3	11	1.61	40.5	35.3
5/16 × 3½	13	1.89	47.9	41.7
5/16 × 4	15	2.17	55.3	48.1
⅜ × 2	6	1.25	31.4	27.3
⅜ × 2½	8	1.64	41.8	36.4
⅜ × 3	9	1.84	47.1	40.9
⅜ × 3½	11	2.23	57.5	50.0
⅜ × 4	12	2.44	62.7	54.6
⅜ × 4½	14	2.83	73.2	63.7
⅜ × 5	15	3.03	78.4	68.2
⅜ × 5½	17	3.42	88.9	77.3
⅜ × 6	18	3.63	94.1	81.9
½ × 2½	6	2.13	54.5	47.4
½ × 3	7	2.47	63.6	55.4
½ × 3½	8	2.82	72.7	63.3
½ × 4	9	3.16	81.8	71.2
½ × 4½	10	3.82	90.9	79.1
½ × 5	12	4.16	109.	94.9
½ × 5½	13	4.50	118.	103.
½ × 6	14	4.85	127.	111.
½ × 7	16	5.85	145.	126.
⅝ × 3½	6	3.40	85.8	74.6
⅝ × 4	7	3.95	100.	87.1
⅝ × 4½	8	4.50	114.	99.5
⅝ × 5	9	5.04	129.	112.
⅝ × 5½	10	5.59	143.	124.
⅝ × 6	11	6.14	157.	137.
⅝ × 7	13	7.23	186.	162.
⅝ × 8	15	8.32	214.	186.
¾ × 5	8	6.50	165.	143.
¾ × 6	9	7.31	185.	161.
¾ × 7	10	8.13	206.	179.
¾ × 8	11	9.70	227.	197.
⅞ × 5	7	7.50	190.	165.
⅞ × 6	8	8.56	217.	188.
⅞ × 7	9	9.63	244.	212.
⅞ × 8	10	10.7	271.	236.

Source: Rope diagram, Bethlehem Steel Co.; all data, U. S. Simplified Practice Recommendation 198-50.

When the rope is underwound on the drum, a right lay rope should be started from the left flange and a left lay rope from the right flange. When this is done, the rope will spool evenly and the turns will lie snugly together.



Sheaves and drums should be properly aligned to prevent undue wear. The proper position of the main or lead sheave for the rope as it comes off the drum is governed by what is called the fleet angle or angle between the rope as it stretches from drum to sheave and an imaginary center-line passing through the center of the sheave groove and a point halfway between the ends of the drum. When the rope is at one end of the drum, this angle should not exceed one and a half to two degrees. With the lead sheave mounted with its groove on this center-line, a safe fleet angle is obtained by allowing 30 feet of lead for each two feet of drum width.

Sheave and Drum Dimensions: Sheaves and drums should be as large as possible to obtain maximum rope life. However, factors such as the need for lightweight equipment for easy transport and use at high speeds, may call for relatively small sheaves with consequent sacrifice in rope life in the interest of over-all economy. No hard and fast rules can be laid down for any particular rope if the utmost in economical performance is to be obtained. Where maximum rope life is of prime importance, the following recommendations of Federal Specification RR-R-571a for minimum sheave or drum diameters D in terms of rope diameter d will be of interest. For 6 × 7 rope (six strands of 7 wires each) $D = 72\,d$; for 6 × 19 rope, $D = 45\,d$; for 6 × 25 rope, $D = 45\,d$; for 6 × 29 rope, $D = 30\,d$; for 6 × 37 rope, $D = 27\,d$; and for 8 × 19 rope, $D = 31\,d$.

Too small a groove for the rope it is to carry will prevent proper seating of the rope in the bottom of the groove and consequently uneven distribution of load on the rope will result. Too large a groove will not give the rope sufficient side support. Federal specifications RR-R-571a recommend that sheave groove diameters be larger than the nominal rope diameters by the following minimum amounts: For ropes of ¼- to 5/16-inch diameters, 1/64 inch larger; for ⅜- to ¾-inch diameter ropes, 1/32 inch larger; for 13/16- to 1⅛-inch diameter ropes, 3/64 inch larger; for 1 3/16- to 1½-inch ropes, 1/16 inch larger; for 1 9/16- to 2¼-inch ropes, 3/32 inch larger; and for 2 5/16 and larger diameter ropes, ⅛ inch larger. For new or regrooved sheaves these values should be doubled; in other words for ¼- to 5/16-inch diameter ropes, the groove diameter should be 1/32 inch larger, etc.

Drum or Reel Capacity: The length of wire rope, in feet, that can be spooled onto a drum or reel, is computed by the following formula, where

Table 8. Factors K Used in Calculating Wire Rope Drum and Reel Capacities

Rope Diam., In.	Factor K	Rope Diam., In.	Factor K	Rope Diam., In.	Factor K
3/32	23.4	½	0.925	1⅜	0.127
⅛	13.6	9/16	0.741	1½	0.107
9/64	10.8	⅝	0.607	1⅝	0.0886
5/32	8.72	11/16	0.506	1¾	0.0770
3/16	6.14	¾	0.428	1⅞	0.0675
7/32	4.59	13/16	0.354	2	0.0597
¼	3.29	⅞	0.308	2⅛	0.0532
5/16	2.21	1	0.239	2¼	0.0476
⅜	1.58	1⅛	0.191	2⅜	0.0419
7/16	1.19	1¼	0.152	2½	0.0380

Note: The values of "K" allow for normal oversize of ropes, and the fact that it is practically impossible to "thread-wind" ropes of small diameter. However, the formula is based on uniform rope winding and will not give correct figures if rope is wound non-uniformly on the reel. The amount of tension applied when spooling the rope will also affect the length. The formula is based on the same number of wraps of rope in each layer, which is not strictly correct, but which does not result in appreciable error unless the width (B) of the reel is quite small compared with the flange diameter (H).

STEEL-HARDENED, GROUND AND POLISHED WORMS
BRONZE WORM GEARS

APPROXIMATE HORSEPOWER AND TORQUE* RATINGS FOR CLASS I SERVICE (Service Factor = 1.0)

Worm RPM ➡		1800		600		100		Worm Cat. No.	Gear Cat. No.	DP
Ratio	Center Distance	Input HP	Output Torque	Input HP	Output Torque	Input HP	Output Torque			
40	2.167	.48	490	.26	672	.06	782	H1056	GB1052	12
	2.625	.72	742	.43	1134	.11	1361	H1066	GB1062	10
	3.250	1.12	1190	.71	1974	.18	2420	H1076	GB1072	8
	3.833	1.43	1680	.74	2395	.16	2748	H1047	DB1404	12
	4.333	2.11	2310	1.39	4034	.38	5345	H1086	GB1078	6
	4.625	2.16	2562	1.22	3991	.28	4790	H1418	DB1080	10
	5.750	3.42	4130	2.05	6807	.48	8319	H1427	DB1424	8
48	3.750	1.26	1614	.79	2622	.20	3267	H1076	GB1073	8
	5.000	2.37	3110	1.56	5445	.43	7260	H1086	GB1083	6
	10.000†	4.06	5320	1.68	6608	.72	17088	H1116	G1114†	3
50	2.583	.55	700	.30	998	.07	1134	H1056	GB1053	12
	3.125	.83	1068	.51	1733	.12	1954	H1066	GB1063	10
	3.875	1.30	1716	.82	2836	.21	3498	H1076	GB850	8
	5.167	2.43	3327	1.60	5777	.44	7563	H1086	GB1079	6
54	11.000†	4.34	5985	1.79	7434	.77	19224	H1116	G1115†	3
60	3.000	.60	924	.33	1323	.08	1664	H1056	GB1260	12
	3.625	.91	1408	.54	2142	.13	2571	H1066	GB1064	10
	4.500	1.42	2269	.89	3718	.23	4538	H1076	GB860	8
	6.000	2.66	4370	1.75	7625	.49	10210	H1086	GB1087	6
72	7.000	2.79	5521	1.84	9605	.51	12705	H1086	GB1084	6
80	3.833	.64	1288	.35	1849	.08	2118	H1056	GB1054	12
	4.625	.96	1961	.57	3042	.14	3630	H1066	GB1067	10
	5.750	1.49	3165	.94	5210	.24	6555	H1076	GB1074	8
100	4.667	.60	1505	.33	2206	.08	2458	H1056	GB1055	12
	5.625	.90	2310	.54	3571	.13	4223	H1066	GB1065	10
	7.000	1.40	3711	.88	6092	.22	7563	H1076	GB8100	8

*Torque in Lb. Ins.

†Cast Iron Gear Rating with Hardened Worm shown.

All Worm and Worm Gear Ratings are based on a Hardened Steel Worm used with a Bronze Worm Gear.

1. For a Hardened Steel Worm used with a Cast Iron Gear, multiply the listed Rating by .50.
2. For an Unhardened Steel Worm used with a Cast Iron Gear, multiply the listed Rating by .25.

CENTER DISTANCES AND RATIOS AVAILABLE WITH STOCK WORM GEARING

Center Distance (Inches)	Pitch	No.of Teeth in Gear	Worm Thread Single	Worm Thread Double	Worm Thread Quad
			Ratio		
.375	48	20	20	10	5
.479	48	30	30	15	7.5
.531	32	20	20	10	5
.583	48	40	40	20	10
.666	24	20	20	10	5
.688	48	50	50	25	12.5
.688	32	30	30	15	7.5
.792	48	60	60	30	15
.844	32	40	40	20	10
.875	24	30	30	15	7.5
.938	16	20	20	10	5
1.000	48	80	80	40	20
1.000	32	50	50	25	12.5
1.083	24	40	40	20	10
1.156	32	60	60	30	15
1.208	48	100	100	50	25
1.250	16	30	30	15	7.5
1.292	24	50	50	25	12.5
1.333	12	20	20	10	5
1.469	32	80	80	40	20
1.500	24	60	60	30	15
1.562	16	40	40	20	10
1.625	10	20	20	10	5
1.719	32	96	96	48	24
1.750	24	72	72	36	18
1.750	12	30	30	15	7.5
1.781	32	100	100	50	25
1.875	16	50	50	25	12.5
1.917	24	80	80	40	20
2.000	8	20	20	10	5
2.125	10	30	30	15	7.5
2.167	12	40	40	20	10
2.188	16	60	60	30	15
2.250	24	96	96	48	24
2.333	24	100	100	50	25
2.583	12	50	50	25	12.5
2.625	10	40	40	20	10
2.625	8	30	30	15	7.5
2.667	6	20	20	10	5
2.812	16	80	80	40	20
3.000	12	60	60	30	15
3.000	6	24	24	12	6
3.125	10	50	50	50	12.5
3.250	8	40	40	20	10
3.438	16	100	100	50	25
3.500	6	30	30	15	7.5
3.625	10	60	60	30	15
3.750	8	48	48	—	—
3.833	12	80	80	40	20
3.875	8	50	50	25	12.5
4.000	6	36	36	—	—
4.000	4	20	20	—	—
4.333	6	40	40	20	10
4.500	8	60	60	30	15
4.500	4	24	24	—	—
4.625	10	80	80	40	20
4.667	12	100	100	—	—
5.000	6	48	48	—	—
5.000	3	18	18	—	—
5.167	6	50	50	25	12.5
5.500	4	32	32	—	—
5.625	10	100	100	50	25
5.750	8	80	80	40	20
6.000	6	60	60	30	15
6.000	3	24	24	—	—
6.500	4	40	40	—	—
6.750	8	96	96	—	—
7.000	8	100	100	50	25
7.000	6	72	72	36	18
7.000	3	30	30	—	—
7.500	4	48	48	—	—
7.667	6	80	80	40	20
8.000	3	36	36	—	—
9.000	6	96	96	—	—
9.333	6	100	100	50	25
9.500	4	64	64	—	—
10.000	3	48	48	—	—
11.000	3	54	54	—	—

Example: Given a center distance of 2.625", Table lists Worm and Worm Gear Ratios available:

10 Pitch, 40 tooth, single =40 to 1
10 Pitch, 40 tooth, double = 20 to 1
10 Pitch, 40 tooth, quad = 10 to 1

8 pitch, 30 tooth, single = 30 to 1
8 pitch, 30 tooth, double = 15 to 1
8 pitch, 30 tooth, quad = 7.5 to 1

BOSTON Gear®
INCOM INTERNATIONAL INC.

SPUR GEARS

LEWIS FORMULA (Barth Revision)

Gear failure can occur due to tooth breakage (tooth stress) or surface failure (surface durability) as a result of fatigue and wear. Strength is determined in terms of tooth-beam stresses for static and dynamic conditions, following well established formula and procedures. Satisfactory results may be obtained by the use of Barth's Revision to the Lewis Formula, which considers beam strength but not wear. The formula is satisfactory for commercial gears at Pitch Circle velocities of up to 1500 FPM. It is this formula that is the basis for all Boston Spur Gear ratings.

METALLIC SPUR GEARS

Safe

$$W = \frac{SFY}{P}\left(\frac{600}{600 + V}\right)$$

W = Tooth Load, Lbs. (along the Pitch Line)
S = Safe Material Stress (static) Lbs. per Sq. In. (Table II)
F = Face Width, In.
Y = Tooth Form Factor (Table I)
P = Diametral Pitch
D = Pitch Diameter
V = Pitch Line Velocity, Ft. per Min. = .262 × PD × RPM

For NON-METALLIC GEARS, the modified Lewis Formula shown below may be used with (S) values of 6000 PSI for Phenolic Laminated material.

$$W = \frac{SFY}{P}\left(\frac{150}{200 + V} + .25\right)$$

TABLE II—VALUES OF SAFE STATIC STRESS (s)

Material		(s) Lb. per Sq. In.
Bronze		10000
Cast Iron		12000
Steel	.20 Carbon (Untreated)	20000
	.20 Carbon (Case-hardened)	25000
	.40 Carbon (Untreated)	25000
	.40 Carbon (Heat-treated)	30000
	.40 C. Alloy (Heat-treated)	40000

Max. allowable torque (T) that should be imposed on a gear will be the safe tooth load (W) multiplied by $\frac{D}{2}$ or $T = \frac{W \times D}{2}$

The safe horsepower capacity of the gear (at a given RPM) can be calculated from $HP = \frac{T \times RPM}{63,025}$ or directly from (W) and (V);

$$HP = \frac{WV}{33,000}$$

For a known HP, $T = \frac{63025 \times HP}{RPM}$

TABLE I Y FACTORS

Number of Teeth	14½° Full Depth Involute	20° Full Depth Involute
10	0.176	0.201
11	0.192	0.226
12	0.210	0.245
13	0.223	0.264
14	0.236	0.276
15	0.245	0.289
16	0.255	0.295
17	0.264	0.302
18	0.270	0.308
19	0.277	0.314
20	0.283	0.320
22	0.292	0.330
24	0.302	0.337
26	0.308	0.344
28	0.314	0.352
30	0.318	0.358
32	0.322	0.364
34	0.325	0.370
36	0.329	0.377
38	0.332	0.383
40	0.336	0.389
45	0.340	0.399
50	0.346	0.408
55	0.352	0.415
60	0.355	0.421
65	0.358	0.425
70	0.360	0.429
75	0.361	0.433
80	0.363	0.436
90	0.366	0.442
100	0.368	0.446
150	0.375	0.458
200	0.378	0.463
300	0.382	0.471
Rack	0.390	0.484

SPUR GEARS

BACKLASH

Stock spur gears are cut to operate at standard center distances. The standard center distance being defined by:

$$\text{Standard Center Distance} = \frac{\text{Pinon PD} + \text{Gear PD}}{2}$$

When mounted at this center distance, stock spur gears will have the following average backlash:

Diametral Pitch	Backlash (Inches)	Diametral Pitch	Backlash (Inches)
3	.013	8-9	.005
4	.010	10-13	.004
5	.008	14-32	.003
6	.007	33-64	.0025
7	.006		

An increase or decrease in center distance will cause an increase or decrease in backlash.

Since, in practice, some deviation from the theoretical standard center distance is inevitable and will alter the backlash, such deviation should be as small as possible. For most applications, it would be acceptable to limit the deviation to an increase over the nominal center distance of one half the average backlash. Varying the center distance may afford a practical means of varying the backlash to a limited extent.

The approximate relationship between center distance and backlash change of 14½° and 20° pressure angle gears is shown below:

For 14½° – Change in Center Distance = 1.933 × Change in Backlash
For 20° – Change in Center Distance = 1.374 × Change in Backlash

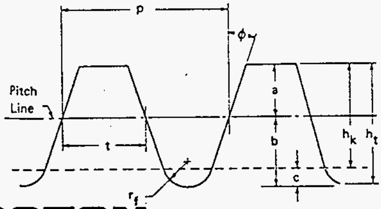
From this, it is apparent that a given change in center distance, 14½° gears will have a smaller change in backlash than 20° gears. This fact should be considered in cases where backlash is critical.

UNDERCUT

When the number of teeth in a gear is small, the tip of the mating gear tooth may interfere with the lower portion of the tooth profile. To prevent this, the generating process removes material at this point. This results in loss of a portion of the involute adjacent to the tooth base, reducing tooth contact and tooth strength.

On 14½°PA gears undercutting occurs where number of teeth is less than 32 and for 20°PA less than 18. Since this condition becomes more severe as tooth numbers decrease, it is recommended that the minimum number of teeth be 16 for 14½°PA and 13 for 20°PA.

In a similar manner INTERNAL Spur Gear teeth may interfere when the pinion gear is too near the size of its mating internal gear. The following may be used as a guide to assure proper operation of the gear set. For 14½°PA, the difference in tooth numbers between the gear and pinion should not be less than 15. For 20°P.A. the difference in tooth numbers should not be less than 12.



a = Addendum
b = Dedendum
c = Clearance
h_k = Working Depth
h_t = Whole Depth
p = Circular Pitch
r_f = Fillet Radius
t = Circular Tooth Thickness
φ = Pressure Angle

SPUR GEAR FORMULAS

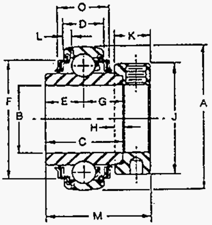
FOR FULL DEPTH INVOLUTE TEETH

To Obtain	Having	Formula
Diametral Pitch (P)	Circular Pitch (p)	$P = \frac{3.1416}{p}$
	Number of Teeth (N) & Pitch Diameter (D)	$P = \frac{N}{D}$
	Number of Teeth (N) & Outside Diameter (D_o)	$P = \frac{N+2}{D_o}$ (Approximate)
Circular Pitch (p)	Diametral Pitch (P)	$p = \frac{3.1416}{P}$
Pitch Diameter (D)	Number of Teeth (N) & Diametral Pitch (P)	$D = \frac{N}{P}$
	Outside Diameter (D) & Diametral Pitch (P)	$D = D_o - \frac{2}{P}$
Base Diameter (D_b)	Pitch Diameter And Pressure Angle	$D_b = D\cos\phi$
Number of Teeth (N)	Diametral Pitch (P) & Pitch Diameter (D)	$N = P \times D$
Tooth Thickness (t) @Pitch Diameter (D)	Diametral Pitch (P)	$t = \frac{1.5708}{P}$
Addendum (a)	Diametral Pitch (P)	$a = \frac{1}{P}$
Outside Diameter (D_o)	Pitch Diameter (D) & Addendum (a)	$D_o = D + 2a$
Whole Depth (h_t) (20P & Finer)	Diametral Pitch (P)	$h_t = \frac{2.2}{P} + .002$
Whole Depth (h_t) (Coarser than 20P)	Diametral Pitch (P)	$h_t = \frac{2.157}{P}$
Working Depth (h_K)	Addendum	$h_K = 2(a)$
Clearance (c)	Whole Depth (h_t) Addendum (a)	$c = h_t - 2a$
Dedendum (b)	Whole Depth (h_t) & Addendum (a)	$b = h_t - a$
Contact Ratio (M_c)	Outside Radii, Base Radii, Center Distance and Pressure Angle	$M_c = \frac{\sqrt{R_o^2 - R_b^2} + \sqrt{r_o^2 - r_b^2} - C\sin\phi}{P_c\cos\phi}$ *
Root Diameter (D_r)	Pitch Diameter and Dedendum	$D_r = D - 2b$
Center Distance (C)	Pitch Diameter or No. of Teeth and Pitch	$C = \frac{D_1 + D_2}{2}$ or $\frac{N_1 + N_2}{2P}$

*R_o = Outside Radius, Gear
r_o = Outside Radius, Pinion
R_b = Base Circle Radius, Gear
r_b = Base Circle Radius, Pinion

N-KRRB Heavy Series
Relubricatable Type

ne heavy series R-Seal wide inner ring bearings are similar to the stan-
ard series described on page 141 but are capable of withstanding con-
nuous, heavy or shock loads. The GN-KRRB series utilizes a heavier
ter ring than the standard series, as well as, a considerably thicker
ealing member in the contact-type diaphragm seal. This design assures
mplete retention of the lubricant and positive exclusion of all
ntaminants. These bearings are especially effective at slow-to-
oderate speeds under the severest conditions of dirt and corrosion.



commended shaft tolerances: 1/2"-2 3/16", nominal to -.0005", -.013 mm;
2 7/16"-3 15/16", nominal to -.001", -.025 mm.

ORDER, SPECIFY BEARING NUMBER FOLLOWED BY "AND COLLAR." Example: GN303KRRB and Collar.

Bearing Number	Collar Number	Basic Outer Ring Size	Bore(1) B	O.D. A	Ring Widths		E	G	H	J	K	L	M	F	O	Brg. & Collar Wt.		Static Load Rating C_o	Extended Dynamic Load Rating C_E
					Inner	Outer													
			in.	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	lbs.	kg	lbs. N	lbs. N
N103KRRB	SN103K	G306	1 3/16	2.8346 72	1 7/16 36.51	.787 20	11/16 17.5	3/4 19.1	5/32 4.0	1 15/16 49.2	11/16 17.5	.142 3.61	1 31/32 50.0	2.369 60.17	.925 23.50	1.22	.553	3550 15600	7500 33500
N104KRRB N105KRRB N106KRRB N107KRB	SN104K SN105K SN106K SN107K	G307	1 1/4 1 5/16 1 3/8 1 7/16	3.1496 80	1 1/2 35.10	.866 22	23/32 18.3	25/32 19.8	5/32 4.0	2 3/16 55.6	11/16 17.5	.156 3.96	2 1/32 51.6	2.638 67.01	1.063 27.00	1.68 1.64 1.60 1.56	.762 .744 .726 708	4500 20000	9150 40500
KRRB	SN108K	G308	1 1/2	3.5433 90	1 5/8 41.28	.984 25	25/32 19.8	27/32 21.4	3/16 4.8	2 1/2 63.5	13/16 20.6	.182 4.62	2 1/4 57.2	2.955 75.06	1.050 26.67	2.54	1.152	5500 24500	11000 49000
N110KRRB N111KRRB N112KRRB(2)	SN110K SN111K SN112K	G309	1 5/8 1 11/16 1 3/4	3.9370 100	1 11/16 42.86	1.063 27	25/32 19.8	29/32 23.0	3/16 4.8	2 3/4 69.9	13/16 20.6	.197 5.00	2 5/16 55.7	3.251 82.58	1.123 28.52	3.65 3.21 2.95	1.656 1.456 1.388	6700 30000	13200 58500
N114KRRB N115KRRB	SN114K SN115K	G310	1 7/8 1 15/16	4.3307 110	1 15/16 49.21	1.142 29	31/32 24.6	31/32 24.6	3/16 4.8	2 63/64 75.8	7/8 22.2	.211 5.36	2 5/8 66.7	3.654 82.87	1.215 30.86	4.35 4.20	1.973 1.905	8000 35500	15300 68000
N200KRRB N203KRRB	SN200K SN203K	G311	2 2 3/16	4.7244 120	2 3/16 55.56	1.220 31	1 3/32 27.8	1 3/32 27.8	3/16 4.8	3 1/4 82.6	7/8 22.2	.216 5.49	2 7/8 73.0	4.007 101.78	1.475 37.47	4.70 5.22	2.132 2.368	9300 41500	18000 80000
N207KRRB	SN207K	G312	2 7/16	5.1181 130	2 7/16 61.91	1.299 33	1 7/32 31.0	1 7/32 31.0	1/4 6.4	3 1/2 88.9	15/16 23.8	.230 5.84	3 1/8 79.4	4.312 109.52	1.535 38.99	6.26	2.839	10800 48000	20400 90000
N211KRRB	SO211K	G314	2 11/16	5.9055 150	2 11/16 68.26	1.457 37	1 11/32 34.1	1 11/32 34.1	1/4 6.4	4 101.6	1 1/16 27.0	.265 6.73	3 1/2 88.9	4.973 126.31	1.770 44.96	9.94	4.509	14300 63000	26000 116000
N215KRRB	SN215K	G315	2 15/16	6.2992 160	2 15/16 74.61	1.535 39	1 15/32 37.3	1 15/32 37.3	1/4 6.4	4 7/16 112.7	1 1/4 31.8	.255 6.48	3 15/16 100.00	5.273 133.02	2.013 51.13	12.42	5.634	16000 71000	28500 125000
N303KRRB	SN303K	G316	3 3/16	6.6929 170	3 3/16 80.96	1.614 41	1 19/32 40.5	1 19/32 40.5	1/4 6.4	4 11/16 119.1	1 1/4 31.8	.286 7.26	4 3/16 106.4	5.623 142.82	2.010 51.05	15.71	7.126	18000 80000	30500 137000
N307KRRB	SN307K	G318	3 7/16	7.4803 190	3 7/16 87.31	1.772 45	1 21/32 42.1	1 21/32 42.1	5/16 7.9	5 1/4 133.4	1 7/16 36.5	.322 8.18	4 9/16 115.9	6.353 161.37	2.072 52.63	20.26	9.190	22400 98000	35500 156000
N315KRRB	SN315K	G320	3 15/16	8.4646 215	3 15/16 100.01	1.929 49	1 31/32 50.0	1 31/32 50.0	5/16 7.9	5 3/4 146.1	1 7/16 36.5	.308 7.82	5 1/16 128.6	7.199 182.85	2.337 59.36	26.97	12.233	229000 13200	43000 193000

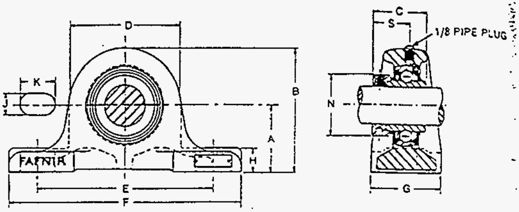
ore tolerances: 1 3/16"- 2 3/16", nominal to +.0005", .013 mm; 2 7/16"- 3 3/16", nominal to +.0006", .015 mm
7/16"- 3 15/16", nominal to +.0007", .018 mm.

lso available with cylindrical O.D Delete suffix "B" Example: GN108KRR

RSAO Heavy Series

Fafnir RSAO units are ideally suited for installations where the load is heavy in proportion to the shaft diameter or where considerable shock loads exist. Incorporating a high capacity GN-KRRB (R-Seal) wide inner ring bearing, these units have the same base-to-center height and bolt hole spacing as Fafnir heavy series SAO pillow blocks.

These pillow blocks are prelubricated and ready for immediate use. For wet or extremely dirty conditions, a grease fitting installed in place of the standard 1/8 pipe plug will provide means of relubrication through a groove in the inside surface of the housing. All units are supplied with self-locking collars.



Recommended shaft tolerances: 1 1/16"-1 15/16", nominal to -.0005", -.013 mm;
2"-3 15/16", nominal to -.0010", -.025 mm.

Bearing Data

Unit	Bearing Number	Dimensions and Load Ratings
RSAO	GN . . . KRRB	Page 144

TO ORDER, SPECIFY UNIT AND SHAFT DIAMETER. Example: RSAO 1 7/16".

Unit	Shaft Diam.	A	B	C	D	E	F	G	H	J	K	N	S	Bolt Size	Bearing Number	Collar Number	Housing Number	Unit Wt.
	in.	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm				lbs. kg
RSAO	1 1/16	2 3/8 60.33	4 1/4 108.0	1 31/32 50.0	3 3/4 95.2	6 5/8 168.3	8 1/4 209.6	2 3/8 60.3	7/8 22.2	5/8 15.9	1 25.4	1 15/16 49.2	1 9/32 32.5	1/2 12.7	GN101KRRB	SN101K	T-22578	6.47 2.937
RSAO	1 1/8														GN102KRRB	SN102K	T-22678	
RSAO	1 3/16														GN103KRRB	SN103K	T-22578	
RSAO	1 1/4	2 3/4 69.85	4 13/16 122.2	2 1/32 51.6	4 1/8 104.8	8 1/4 209.6	6.57 10 5/8 269.9	1.88 2 3/4 69.8	15/16 23.8	3/4 19.0	1 1/8 28.6	2 3/16 55.6	1 5/16 33.3	5/8 15.9	GN104KRRB	SN104K	T-22496	9.15 4.154
RSAO	1 5/16														GN105KRRB	SN105K	T-22496	
RSAO	1 3/8														GN106KRRB	SN106K	T-22496	
RSAO	1 7/16														GN107KRRB	SN107K	T-22496	
RSAO	1 1/2	3 1/8 79.38	5 3/8 136.6	2 1/4 57.2	4 1/2 114.3	9 228.6	11 3/8 288.9	3 1/8 79.4	1 1/16 27.0	3/4 19.0	1 1/8 28.6	2 1/2 63.5	1 15/32 37.3	5/8 15.9	GN108KRRB	SN108K	T-22672	12.90 5.857
RSAO	1 9/16														GN109KRRB	SN109K	T-22672	
RSAO	1 5/8	3 1/8 79.38	5 5/8 142.9	2 5/16 58.7	5 127.0	9 228.6	11 3/8 288.9	3 1/8 79.4	1 3/16 30.2	3/4 19.0	1 1/8 28.6	2 3/4 69.8	1 17/32 38.9	5/8 15.9	GN110KRRB	SN110K	T-22498	14.45 6.560
RSAO	1 11/16														GN111KRRB	SN111K	T-22498	
RSAO	1 3/4														GN112KRRB	SN112K	T-22498	
RSAO	1 13/16	3 1/8 79.38	5 27/32 148.4	2 5/8 66.7	5 7/16 138.1	9 228.6	11 3/8 288.9	3 1/8 79.4	1 5/16 33.3	3/4 19.0	1 1/8 28.6	3 76.2	1 21/32 42.1	5/8 15.9	GN113KRRB	SN113K	T-22502	15.96 7.245
RSAO	1 7/8														GN114KRRB	SN114K	T-22502	
RSAO	1 15/16														GN115KRRB	SN115K	T-22502	
RSAO	2	3 3/4 95.25	6 23/32 170.7	2 7/8 73.0	5 15/16 150.8	10 1/4 260.4	12 5/8 320.7	3 1/2 88.9	1 7/16 36.5	7/8 22.2	1 3/8 34.9	3 1/4 82.6	1 25/32 45.2	3/4 19.0	GN200KRRB	SN200K	T-22500	22.45 10.192
RSAO	2 1/16														GN201KRRB	SN201K	T-22500	
RSAO	2 1/8														GN202KRRB	SN202K	T-22500	
RSAO	2 3/16														GN203KRRB	SN203K	T-22500	
RSAO	2 1/4	4 1/8 104.78	7 11/32 186.5	3 1/8 79.4	6 7/16 163.5	11 1/4 285.8	13 3/4 349.2	4 101.6	1 1/2 38.1	7/8 22.2	1 3/8 34.9	3 1/2 88.9	1 29/32 48.4	3/4 19.0	GN204KRRB	SN204K	T-22494	33.56 15.144
RSAO	2 5/16														GN205KRRB	SN205K	T-22494	
RSAO	2 3/8														GN206KRRB	SN206K	T-22494	
RSAO	2 7/16														GN207KRRB	SN207K	T-22494	
RSAO	2 5/8	4 9/16 115.89	8 9/32 210.3	3 1/2 88.9	7 7/16 188.9	12 304.8	15 3/8 390.5	4 3/8 111.1	1 3/4 44.4	1 25.4	1 3/8 34.9	4 101.6	2 5/32 54.8	7/8 22.2	GN210KRRB	S0210K	T-22492	42.50 19.295
RSAO	2 11/16														GN211KRRB	S0211K	T-22492	
RSAO	2 3/4														GN212KRRB	S0212K	T-22492	
RSAO	2 13/16	4 9/16 115.89	8 9/16 217.5	3 15/16 100.0	8. 203.2	12 3/8 314.3	15 3/8 390.5	4 3/8 111.1	1 7/8 47.6	1 25.4	1 3/8 34.9	4 7/16 112.7	2 15/32 62.7	7/8 22.2	GN213KRRB	SN213K	T-22490	44.25 20.090
RSAO	2 7/8														GN214KRRB	SN214K	T-22490	
RSAO	2 15/16														GN215KRRB	SN215K	T-22490	
RSAO	3 3/16	4 9/16 115.89	8 25/32 223.0	4 3/16 106.4	8 7/16 214.3	12 3/8 314.3	15 3/8 390.5	4 3/8 111.1	1 15/16 49.2	1 25.4	1 3/4 44.4	4 11/16 119.1	2 15/32 65.9	7/8 22.2	GN303KRRB	SN303K	T-22444	50.25 22.814
RSAO	3 7/16	5 1/8 130.18	9 7/8 250.8	4 9/16 115.9	9 1/2 241.3	13 3/8 339.7	16 1/8 409.6	4 3/4 120.6	2 1/4 57.2	1 1/8 28.6	2 1/8 54.0	5 1/4 133.4	2 27/32 72.2	1 25.4	GN307KRRB	SN307K	T-22446	66.25 30.086
RSAO	3 15/16	5 11/16 144.45	11 1/16 281.0	5 1/16 128.6	10 3/4 273.0	14 3/4 374.6	17 5/16 439.7	5 1/8 130.2	2 9/16 65.1	1 1/8 28.6	1 3/4 44.4	5 3/4 146.0	3 3/32 78.6	1 25.4	GN315KRRB	SN315K	T-22448	89.50 40.633

RCJO Heavy Series

RCJO type heavy series flange cartridges are similar in design to e standard series. They are for applications where a minimum amount machining is to be done and are supplied completely assembled, eing mounted in place by means of bolts through the flange.

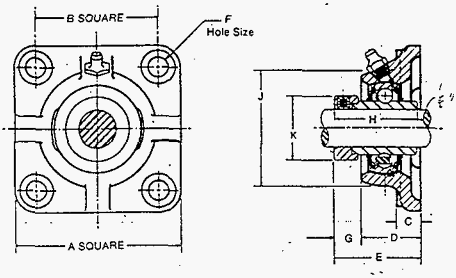
RCJO units are equipped with GN-KRRB (R-Seal) wide inner ring earings.

A grease fitting provides for relubrication if required. Units are supplied with self-locking collars and are dimensionally interchangeable.

ecommended shaft tolerances: 1 3/16"-1 15/16", nominal to -.0005", -.013 mm; 2"-3 15/16", nominal to -.0010", -.025 mm.

earing Data

nit	Bearing Number	Dimensions and Load Ratings
CJO	GN . . . KRRB	Page 144



O ORDER, SPECIFY UNIT AND SHAFT DIAMETER. Example: RCJO 1 7/16".

Unit	Shaft Diam.	A	B	C	D	E	F	G	H	J	K	Bolt (4 req'd)	Bearing Number	Collar Number	Housing Number	Unit Wt.
	in.	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in.				lbs. kg
RCJO	1 3/16	4 3/4 120.6	3 5/8 92.08	9/16 14.3	1 1/2 38.1	2 3/32 53.2	9/16 14.3	19/32 15.1	1 31/32 50.0	3 13/16 96.8	1 15/16 49.2	1/2	GN103KRRB	SN103K	T-19165	4.00 1.816
RCJO	1 7/16	5 1/8 130.2	4 101.60	5/8 15.9	1 19/32 40.5	2 5/32 54.8	9/16 14.3	9/16 14.3	2 1/32 51.6	4 1/8 104.8	2 3/16 55.7	1/2	GN107KRRB	SN107K	T-19167	5.50 2.497
RCJO	1 1/2	5 3/8 136.5	4 1/8 104.78	5/8 15.9	1 3/4 44.4	2 3/8 60.3	5/8 15.9	5/8 15.9	2 1/4 57.2	4 1/2 114.3	2 1/2 63.5	9/16	GN108KRRB	SN108K	T-19169	6.90 3.133
RCJO	1 11/16	5 5/8 142.9	4 3/8 111.12	11/16 17.5	1 27/32 46.8	2 7/16 61.9	5/8 15.9	19/32 15.1	2 5/16 58.7	4 7/8 123.8	2 3/4 69.8	9/16	GN111KRRB	SN111K	T-19171	7.87 3.573
RCJO	1 15/16	6 1/2 165.1	5 1/8 130.18	11/16 17.5	2 3/32 53.2	2 3/4 69.8	11/16 17.5	21/32 16.7	2 5/8 66.7	5 9/16 141.3	3 76.2	5/8	GN115KRRB	SN115K	T-19173	11.42 5.185
RCJO	2 3/16	7 177.8	5 5/8 142.88	11/16 17.5	2 5/16 58.7	3 76.2	11/16 17.5	11/16 17.5	2 7/8 73.0	6 1/16 154.0	3 1/4 82.6	5/8	GN203KRRB	SN203K	T-19175	14.15 6.424
RCJO	2 7/16	7 1/2 190.5	5 7/8 149.22	3/4 19.0	2 9/16 65.1	3 5/16 84.1	13/16 20.6	3/4 19.0	3 1/8 79.4	6 5/16 160.3	3 1/2 88.9	3/4	GN207KRRB	SN207K	T-19177	16.32 7.409
RCJO	2 11/16	8 7/8 225.4	7 177.80	7/8 22.2	2 27/32 72.2	3 11/16 93.7	15/16 23.8	27/32 21.4	3 1/2 88.9	7 5/16 185.7	4 101.6	7/8	GN211KRRB	SN211K	T-19179	21.00 9.534
RCJO	2 15/16	9 1/8 231.8	7 1/4 184.15	7/8 22.2	3 1/16 77.8	4 1/8 104.8	15/16 23.8	1 1/16 27.0	3 15/16 100.0	7 13/16 198.4	4 7/16 112.7	7/8	GN215KRRB	SN215K	T-19181	31.12 14.128
RCJO	3 7/16	11 279.4	8 1/2 215.90	1 1/8 28.6	3 5/16 84.1	4 3/4 120.6	1 1/16 27.0	1 7/16 36.5	4 9/16 115.9	9 228.6	5 13/64 132.2	1	GN307KRRB	SN307K	T-24475	47.30 21.474
RCJO	3 15/16	12 1/2 317.5	9 1/2 241.30	1 1/4 31.8	3 13/16 96.8	5 1/4 133.4	1 3/16 30.2	1 7/16 36.5	5 1/16 128.6	10 1/2 266.7	5 47/64 145.7	1 1/8	GN315KRRB	SN315K	T-24477	67.50 30.645

LM67000 SERIES

BORE RANGE
31.750
1.2500

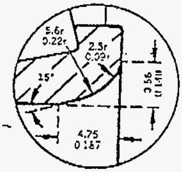
d R B

Any cone in this series may be used with any cup in this series.

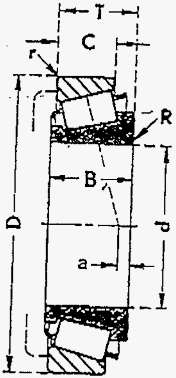
					cup no. LM67010			
					outside diameter D	max housing fillet radius r	width C	bearing width T
31.750 1.2500	**	LM67048	16.764 0.6600	-3.0 -0.12	59.131 2.3280	1.3 0.05	11.811 0.4650	15.875 0.6250

a

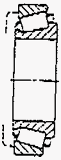
** Compound radius—see illustration



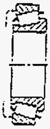
Compound Radius



LM67010



LM67010 (half size)



LM67010 (1:2.5 size)

x 1.374 for 175 RPM

THE TIMKEN COMPANY

No. of Pages 1

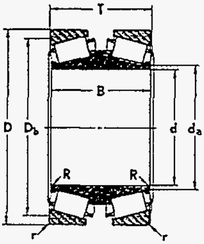
To MIKE CUSTER
Co.
Dept.
Fax No.

From JIM LEE
Co.
Phone No.
Fax No.

basic rating @ 500 rpm for 3000 hours L_{10}	
radial	9460 N 2130 lbf
thrust	6680 N 1500 lbf
K	1.42

use modifying factors to compare Timken bearing capacity-ratings with other makes of bearings.

TWO-ROW ASSEMBLY - DOUBLE CONE, SINGLE CUPS



[illegible]	[illegible]	width		rating at 500 rpm for 3000 hours L_{10}			factor	part numbers		cone		cup	
		over cups T -	[illegible]	one-row radial N lbf	thrust N lbf	two-row radial N lbf	K	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	D_b
30.162 1.1875	62.000 2.4409	33.797 1.3306	34.925 1.3750	10400 2330	6800 1530	18100 4060	1.53	17116D	17244	0.8 0.03	35.5 1.40	1.5 0.06	54.0 2.13
36.512 1.4375	68.262 2.6875	36.810 1.4492	38.100 1.5000	12200 2740	9260 2080	21200 4760	1.31	19145D	19268	0.8 0.03	42.5 1.67	1.5 0.06	61.0 2.40
36.512 1.4375	71.438 2.8125	36.810 1.4492	38.100 1.5000	12200 2740	9260 2080	21200 4760	1.31	19145D	19281	0.8 0.03	42.5 1.67	1.0 0.04	63.0 2.48
36.512 1.4375	72.000 2.8346	39.096 1.5392	38.100 1.5000	12200 2740	9260 2080	21200 4760	1.31	19145D	19283	0.8 0.03	42.5 1.67	1.5 0.06	63.0 2.48
42.862 1.6875	85.000 3.3465	50.267 1.9790	52.375 2.0620	19600 4420	10300 2320	34200 7690	1.91	358D	354A	1.5 0.06	51.0 2.01	1.3 0.05	77.0 3.03
42.862 1.6875	90.119 3.5480	54.991 2.1650	52.375 2.0620	19600 4420	10300 2320	34200 7690	1.91	358D	352	1.5 0.06	51.0 2.01	2.3 0.09	78.0 3.07
44.450 1.7500	80.962 3.1875	34.925 1.3750	31.750 1.2500	12200 2740	11000 2480	21200 4770	1.11	13176D	13318	SPCL	50.0 1.97	1.5 0.06	72.0 2.83
50.800 2.0000	93.264 3.6718	50.013 1.9690	53.188 2.0940	21100 4750	12200 2750	36800 8260	1.73	375D	374	0.8 0.03	57.0 2.24	1.3 0.05	85.0 3.35
†54.988 †2.1649	136.525 5.3750	66.091 2.6020	65.989 2.5980	41100 9230	60900 13700	71500 16100	0.67	78216D	78537	2.3 0.09	79.0 3.11	3.3 0.13	115.0 4.53
†54.988 †2.1649	140.030 5.5130	66.091 2.6020	65.989 2.5980	41100 9230	60900 13700	71500 16100	0.67	78216D	78551	2.3 0.09	79.0 3.11	2.3 0.09	117.0 4.61
61.912 2.4375	110.000 4.3307	55.550 2.1870	55.550 2.1870	23700 5340	16300 3670	41300 9290	1.45	399D	394A	0.8 0.03	70.0 2.76	1.3 0.05	101.0 3.98
61.912 2.4375	110.000 4.3307	55.550 2.1870	55.550 2.1870	23700 5340	16300 3670	41300 9290	1.45	399D	394AS	0.8 0.03	70.0 2.76	3.3 0.13	99.0 3.90
63.500 2.5000	112.712 4.4375	60.325 2.3750	60.325 2.3750	40100 9010	23300 5230	69800 15700	1.72	39585D	39520	0.8 0.03	72.0 2.83	3.3 0.13	101.0 3.98
63.500 2.5000	112.712 4.4375	60.325 2.3750	60.325 2.3750	40100 9010	23300 5230	69800 15700	1.72	39585D	39521	0.8 0.03	72.0 2.83	0.8 0.03	103.0 4.06
63.500 2.5000	136.525 5.3750	66.091 2.6020	65.989 2.5980	41100 9230	60900 13700	71500 16100	0.67	78251D	78537	2.3 0.09	79.0 3.10	3.3 0.13	115.0 4.53
63.500 2.5000	140.030 5.5130	66.091 2.6020	65.989 2.5980	41100 9230	60900 13700	71500 16100	0.67	78251D	78551	2.3 0.09	79.0 3.10	2.3 0.09	117.0 4.61
†64.988 †2.5586	136.525 5.3750	66.091 2.6020	65.989 2.5980	41100 9230	60900 13700	71500 16100	0.67	78255D	78537	1.5 0.06	79.0 3.11	3.3 0.13	115.0 4.53
†64.988 †2.5586	140.030 5.5130	66.091 2.6020	65.989 2.5980	41100 9230	60900 13700	71500 16100	0.67	78255D	78551	1.5 0.06	79.0 3.11	2.3 0.09	117.0 4.61
76.200 3.0000	115.888 4.5625	53.975 2.1250	53.975 2.1250	29900 6720	13900 3130	52100 11700	2.15	LM114848D	LM114811	0.8 0.03	83.0 3.27	1.5 0.06	107.0 4.21

① These maximum fillet radii will be cleared by the bearing corners.

† For standard class ONLY, the maximum metric size is a whole millimetre value.

* Cone is extended on one side.

LOAD RATINGS AND
E CALCULATIONS

BALL BEARINGS

Fatigue Life

Because of the dispersion in life of identical bearings operating under dentical conditions, a statistical result will be obtained for bearing fatigue life. For most calculations life is expressed as the number of hours that 90% of a group of identical bearings will exceed under a given set of conditions, and is referred to as the L_{10} life. For life values of greater reliability than 90% refer to Table 4.

The basic life equation for radial ball bearings is:

$$L_n = \frac{16667 \times a_1 \times a_2 \times a_3}{N} \left[\frac{f_B \times C_E}{P} \right]^3 \text{ Hours} \qquad \boxed{1}$$

The basic life equation for radial roller bearings is:

$$L_n = \frac{16667 \times a_1 \times a_2 \times a_3}{N} \left[\frac{f_B \times C}{P} \right]^{10/3} \text{ Hours} \qquad \boxed{2}$$

Notations Used in this Section:

C = Basic Dynamic Load Rating — Radial Roller Bearings Pounds or Newtons

C_E = Extended Basic Dynamic Load Rating — Radial Ball Bearings Pounds or Newtons

C_o = Basic Static Load Rating — Radial Bearings Pounds or Newtons

C_{oa} = Basic Static Thrust Load Rating Pounds or Newtons

= Basic Thrust Dynamic Load Rating — Ball and Roller Bearings

K = Thrust Rating Calculation Factor

K_T = Relative Thrust Load Factor — Ball Bearings

L_f = Life Factor

L_n = Fatigue Life for Reliability Level "r" — Hours

N = Operating Speed — R.P.M.

N_f = Speed Factor

R = Applied Radial Load on Bearing Pounds or Newtons

P = Equivalent Radial Load on Bearing Pounds or Newtons

T_e = Equivalent Thrust Load — Thrust Ball and Roller Bearings Pounds or Newtons

T = Applied Thrust Load on Bearing Pounds or Newtons

X = Radial Load Factor

Y, Y_1, Y_2, Y_3 = Thrust Load Factors

a_1 = Life Adjustment Factor for Reliability

a_2 = Life Adjustment Factor for Bearing Material

a_3 = Life Adjustment Factor for Application Conditions

f_B = Dynamic Load Rating Adjustment Factor for Number of Adjacently Mounted Bearings

i_B = Number of Adjacently Mounted Bearings

$P_1 \ldots P_n$ = Proportion of Time at Load/Speed Conditions 1 through n

r = Percent reliability of Survival Life

μ = Operating Viscosity — Centistokes

μ_R = Reference Viscosity — Centistokes

d Ratings — Radial Ball Bearings

The load ratings published in this catalog are based on AFBMA Standard 9, but are increased to reflect improvements in materials and processing. These new ratings are referred to as EXTENDED BASIC DYNAMIC LOAD RATINGS, C_E. Care must be taken that the EXTENDED BASIC DYNAMIC LOAD RATINGS only be used in equations containing C_E, and should not be used in any equations in prior published Fafnir catalogs.

NOTE: C_E does <u>not</u> represent the maximum permissible radial load which in general is equal to C_o the Static Radial Load Ratings.

Life — Radial Ball Bearings

Equation $\boxed{1}$ in the case of single row bearings and where a, a_2, a_3 can be considered each equal to one, may be simplified for general purpose as follows:

$$L_{10} = \frac{16667}{N} \left[\frac{C_E}{P} \right]^3 \text{ Hours} \qquad \boxed{3}$$

Equivalent Radial Load — Radial Ball Bearings

Calculate equivalent radial load (P) by using Table 1 and required Y factors from Table 2.

Table 1

Bearing Description	Single Row Bearings and Tandem Mountings	Double Row Bearings and Preload Pair Mountings
Bearing Type and/or Series	$K_T = \frac{T}{i_B C_o}$	$K_T = \frac{T}{C_o}$
RADIAL TYPE BALL BEARINGS	Use larger of Resulting "P" Value	
M9300K, MM9300K M9100K, MM9100K M200K, MM200K M300K, MM300K	P = R or P = 0.56R + Y₁T	P = R + 1.20Y₁T or P = 0.78R + 1.625Y₁T
Small inch and Metric 9300, 9100, 200, 300 and derivatives "XLS" Large Inch "W" and "GW" Tri-Ply Sea'	P = R or P = 0.56R + Y₁T	
WIDE INNER RING BALL BEARINGS HOUSED UNITS	P = R or P = 0.56R + Y₁T	
ANGULAR CONTACT BALL BEARINGS		
7201K-7202W-7206W 7303W 5200K-5205K, 5218W, 5220W 5302K-5305K 5311W-5318W, 5320W 5322W, 5328W	P = R or P = 0.43R + T	P = R + 1.09T or P = 0.70R + 1.63T
5205K-5208K, 5206W-5212W 5213-5217, 5219, 5222 5306W-5310W, 5319, 5324	P = R or P = 0.39R + 0.76T	P = R + 0.78T or P = 0.63R + 1.24T
7219WN-7232WN 7319WN-7330WN	P = R or P = 0.36R + 0.62T	P = R + 0.60T or P = 0.58R + 1.01T
7207WN-7218WN 7304WN-7218WN 7412WN-7415WN	P = R or P = 0.35R + 0.57T	P = R + 0.55T or P = 0.57R + 0.93T
2M9300WI 2M9100WI, 2MM9100WI 2M200WI, 2MM200WI 2MM300WI 2MMF9500WI	P = R or P = 0.44R + Y₂T	P = R + 1.124Y₂T or P = 0.72R + 1.625Y₂T
2MM9100WO	P = R or P = 0.44R + Y₂T	P = R + 1.124Y₃T or P = 0.72R + 1.625Y₃T
2MM9300WO	P = R or P = 0.43R + 1.06T	P = R + 1.16T or P = 0.70R + 1.72T
3MMF9500WI 3M9300WI 3M9100WI, 3MM9100WI 3M200WI, 3MM200WI 3MM300WI	P = R or P = 0.41R + 0.67T	P = R + 0.92T or P = 0.67R + 1.41T

Date: * June 6, 1995

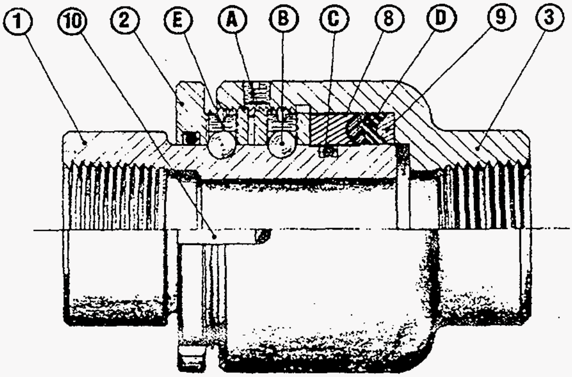
Teleconference with engineer (Jim Good) at Torrington Bearing Co., 206-455-4466 regarding Safety factor incorporated into their published Static Load Ratings. Loading less than the Static Load Rating will result in less than 1/10 inch deformation of the ball, and would correspond to a yield strength. Actual bearing failure (ball fracture or disintegration) would require 2 to 3 times that force, which would correspond to ultimate strength. Since we are designing to safety factors of 5 to ultimate and 3 to yield, a calculated SF of 3 based on the Static Load Rating should be sufficient.

- OK but still require heavy duty bearings, resulting in enlargement of winch box.

New pumps issued - Submersible pump now weighs 3000 lbs. Three bearings will be required.

E-21-15

T-M SWIVEL JOINTS ENGINEERING SPECIFICATIONS



Manufactured in eight styles. Sizes from 3/8" through 16" pipe size in steel, and 3/8" to 4" in aluminum and stainless steel. The basic components of T-M Union Assembly Joints are as follows:

① Swivel Nipple: Rotates on 2 rows of chrome alloy steel balls to ensure ease of rotation under severe thrust and radial loads.

② Holding Nut: Provides half of bearing race and utility of (1) Providing initial compression on packing (2) Take-up on worn packing (3) Quick disassembly for repacking. Ball races of 6000 PSI and 15,000 PSI series are through hardened to 42 to 58 Rockwell "C" scale, for maximum strength and wear.

③ Body: Parts 1 and 3 are changed in configuration to provide eight different styles.

⑧ Back-up Ring: Furnished in similar metal to part 1 to back up packing and act as outboard bearing during severe radial loads. Optional materials: Aluminum, stainless steel, teflon.

⑨ Male Adaptor: Acts as wedge to expand chevron packing and effect seal. Furnished in Buna N as standard, but may be furnished in aluminum, steel, stainless steel or aramid fiber.

⑩ Lock Bar: Locks assembly of parts 1 and 2 to part 3. Removal of lock bar allows holding nut to be rotated to (1) Take-up on packing in increments of .005" or (2) Remove assembly of parts 1 and 2 from body for repacking.

Ⓐ Grease Plug: Hole is tapped to receive Alemite fitting but since T-M joints usually do not require lubrication until repacked, a flush set screw is inserted at factory.

E-21-15

Basic Components:

Ⓑ Balls: Hardened chrome alloy steel balls are furnished as standard. Optional material: stainless steel.

Ⓒ "O" Rings: Act as grease seals to (1) Seal grease in assembly to insure proper lubrication of bearings (2) Seal against grit and dirt from outside sources (3) Seal bearings against line contaminants. Standard 6227 and 6230 sizes used. Optional materials: Silicone, teflon, viton.

Ⓓ Chevron Packing: The most effective packing design known, used in standard JIC and AN-6225 sizes in Buna N. Optional materials: teflon, aramid fiber, viton.

Ⓔ Ball Plugs: Retain balls in races. Assembly of parts 1 and 2 is made at factory and need not be disassembled to repack the joint. The T-M joints can be repacked without handling balls.

When ordering specify Size, Style, Material, e.g.: steel, stainless steel, etc., working pressure, working temperature, material to be handled, and end connections.

Standard end connections are threaded, (TE), bored for welding, (BR), or flanged (F); see price list for prices. Other end connections on special order.

Component parts can be ordered to suit individual requirements, e.g.: 2" style 100 1000 PSI MWP, steel with bronze male adaptor (9) teflon packing (D), bronze back-up ring (8), and stainless steel balls (B).

T-M Swivel Joints Out-perform All Others:

They can be repacked in the line or in the field without the handling of balls. Result: Less down time.

Union Assembly allows for take up on worn packing. Result: Up to 400% longer packing life. Provides positive pressure on packing to insure against low pressure and low temperature leaks. Result: No leaks, less maintenance.

Bearing assembly is protected against outside and inside contaminants, and grease is sealed in. Result: Longer life, less maintenance.

They will withstand heavier radial loads and thrust loads while maintaining seal due to high quality bearing races, outboard bearing, and modern engineering design. Result: Lower final cost.

All packing, "O" rings, used in T-M Swivel Joints are standard to JIC and AN sizes. Commercially available. Relult: Less inventory.

T-M

E-21-15

SWIVEL JOINTS

ESTIMATED WEIGHTS

STYLE	100	200	300	400	500	600	700	800
3/8" & 1/2" Alum.	1	1	1	1	2	2	2	2
Steel	2	2	2	3	4	4	5	6
1" & 3/4" Alum.	2	2	2	3	4	4	6	6
Steel	4	5	6	9	9	10	13	13
1 1/4" Alum.	2	3	3	4	5	5	7	7
Steel	5	6	7	10	11	12	15	16
1 1/2" Alum.	3	4	4	5	6	6	8	9
Steel	9	11	12	16	18	19	23	24
2" Alum.	6	8	9	12	13	15	18	19
Steel	13	19	23	31	34	38	48	51
15000 PSI Steel	18	21	24	34	39	44	52	57
2 1/2" Alum.	8	9	12	15	17	19	23	25
Steel	21	25	31	38	43	47	59	65
3" Alum.	10	12	15	21	23	26	30	33
Steel	25	29	37	49	57	65	82	90
4" Alum.	19	23	27	31	42	47	58	62
Steel	52	60	72	85	98	110	136	144
6" Steel	95	110	125	205	220	235	315	330
8" Steel	115	146	177	262	292	323	407	438
10" Steel	140	195	250	335	390	445	530	585
12" Steel	155	233	311	388	466	544	621	699

Note: All weights given in pounds for threaded or welded ends. (Flanged weights not included.)

TERMS AND CONDITIONS OF SALES:

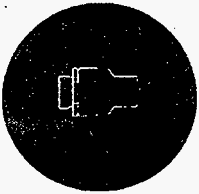
Prices and conditions of sale are subject to change without notice. Prices of all T-M Products are f. o. b., Sunnyvale, California. All material for export is subject to a 4% charge for export boxing. Material will be accepted for credit when returned with permission, and material returned for credit is subject to a restocking charge. Orders for products incorporating variations from catalog listed items are special; are subject to cancellation at extra charge and cannot be accepted for credit upon return. We insure to the common carrier but not normally beyond the point of delivery to the common carrier unless otherwise instructed. We maintain responsibility to the extent of the insurance carried . . . to the common carrier . . . or beyond when so instructed.

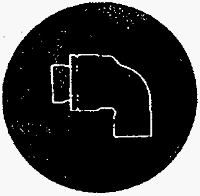
GUARANTEE:

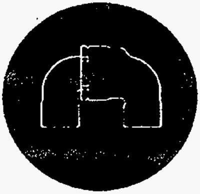
All T-M Products are unconditionally guaranteed for one year against defective material or workmanship. Materials returned, f. o. b. Sunnyvale, if found defective will be repaired. Material found damaged, but not defective, will be repaired at nominal service charge.

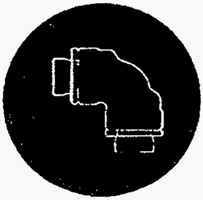
WHEN ORDERING SPECIFY:

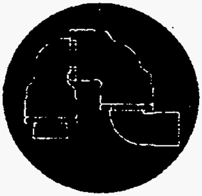
1. Pipe Size.
2. Style number of joints.
3. Material (aluminum, steel, stainless steel).
4. Product to be handled
5. Operating pressure.
6. Operating temperature.
7. End connections (threaded, flanged, bored or beveled for weld).

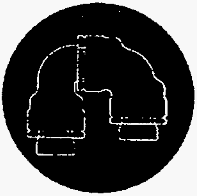


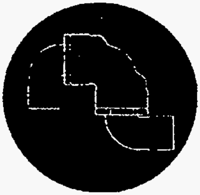


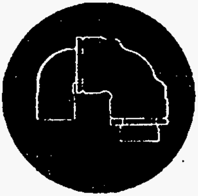












- THE FINAL COST OF AN ITEM IS DETERMINED BY ITS PERFORMANCE
- T-M SWIVEL JOINTS ARE OUTPERFORMING ALL OTHERS
- SPECIFY AND BUY T-M SWIVEL JOINTS FROM

REPRESENTATIVE

T-M

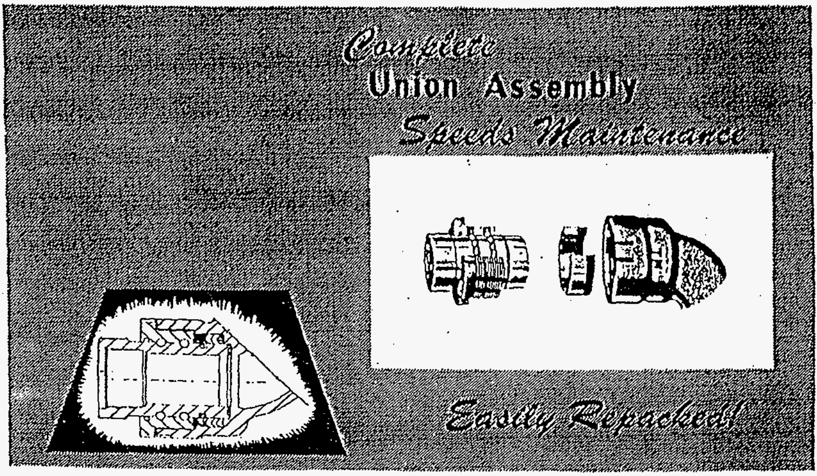
SWIVEL JOINTS

T-M MFG. CO.. 695 E. ARQUES AVE.. SUNNYVALE. CALIF. 94086 (408) 736-5202 FAX (408) 736-3743

REV 4/92

PRINTED IN U.S.A.

E-21-15



The T-M Swivel Joints are the result of modern engineering methods applied to the design and manufacture of Ball-Bearing Swivel Joints. Over 400 different types, styles, and sizes have been developed for pressures and services from 28" vacuum to 15,000 p.s.i., and temperatures to 550 degrees F.

Along with the development of new types of Swivel Joints for many different services, T-M also carries on continuous research for the purpose of developing and perfecting Swivel Joints which will meet your performance specifications.

All T-M Ball Bearing Swivel Joints employ the basic principle that all turning movement takes place on double rows of Ball-Bearings. Although each rotating member turns in a single plane, unlimited flexibility is secured by combining swivels in the proper sequence.

The T-M Swivel Joint arrangement bridges the gap between the working parts so that abrasives are filtered out. Packing seals last longer, lubrication is sealed in, which maintains the life of the Ball-Bearings. T-M swivel joints are grease packed when assembled, and no further greasing is required unless the joint is in constant rotation.

T-M Swivel Joints are superior because:

They will withstand greater radial and thrust loads while maintaining seal.

The union assembly allows for repacking in minutes, while in the line.

Union assembly allows take-up for worn packing, thus extending the usable life of packing.

Union assembly allows take-up for pressure variances and for extremely volatile materials.

Union assembly permits repacking without the handling of balls.

Standard packing is used throughout T-M Swivel Joints. Available from T-M Manufacturing, their Dealers, or from your local supplier.

T-M
SWIVEL JOINTS

T-M MFG. CO., 695 E. ARQUES AVE., SUNNYVALE, CALIF. 94086 (408) 736-5202

PROBLEM HARD COPY

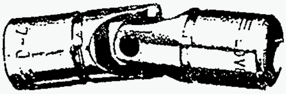
Lovejoy Universal Joints

Pin and Block

D Type

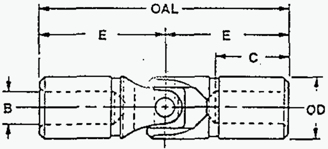
Standard industrial type universal joint with pin and block design. The special tapered shape of the yolks provide exceptional strength for long life, while allowing full free movement of the joint.

Ideal for applications with angles up to 25° and speeds up to 1750 RPM.* Available with your choice of round, hex, splined, or keyway bores. Boot retaining grooves are standard.



D Type

*Operation of all universal joints is determined by the angle/speed combinations of the application. Consult Lovejoy Engineering for specific limitations and recommendations.



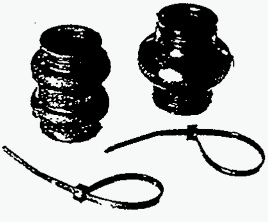
D Type Dimensional Data

Catalog Number Solid	Catalog Number Bored	O.D.	Overall Length OAL	Bore Diameter** B Std.	Bore Diameter** B Max.	E	Bore Depth C	Max. Bore with Keyway	Max. Square Hole	Static Breaking Torque In.-Lb.	Approx. Weight Lbs. Solid	Approx. Weight Lbs. Bored
D-1	D-1B	3/8	1 3/4	3/16	1/4	7/8	9/16	—	3/16	110	.05	.04
D-2	D-2B	1/2	2	1/4	3/8	1	5/8	—	1/4	378	.10	.08
D-3	D-3B	5/8	2 1/4	5/16	1/2	1 1/8	11/16	1/4	5/16	540	.17	.15
D-4	D-4B	3/4	2 11/16	3/8	5/8	1 11/32	7/8	7/16	3/8	768	.30	.25
D-5	D-5B	7/8	3	7/16	11/16	1 1/2	7/8	1/2	7/16	1,176	.45	.37
D-6	D-6B	1	3 3/8	1/2	3/4	1 11/16	1	9/16	1/2	1,560	.65	.55
D-7	D-7B	1 1/8	3 1/2	9/16	7/8	1 3/4	1	5/8	9/16	2,880	.85	.71
D-8	D-8B	1 1/4	3 3/4	5/8	1	1 7/8	1 1/16	3/4	5/8	5,220	1.11	.94
D-10	D-10B	1 1/2	4 1/4	3/4	1 1/8	2 1/8	1 3/16	7/8	3/4	7,920	1.8	1.5
D-11	D-11B	1 3/4	5	7/8	1 1/4	2 1/2	1 3/8	1	13/16	10,680	3.0	2.5
D-12	D-12B	2	5 7/16	1	1 1/2	2 23/32	1 1/2	1 3/16	7/8	15,600	4.2	3.5
D-13	D-13B	2 1/2	7	1 1/4	1 3/4	3 1/2	2	1 1/2	1 1/8	33,120	8.5	7.2
D-14	D-14B	3	9 1/16	1 1/2	2	4 17/32	2 3/4	1 13/16	1 3/8	65,400	16.0	13.0
D-15	D-15B	4	10 5/8	2	2 1/2	5 5/16	3 1/4	2 1/2	1 3/4	138,000	33.0	28.0

NOTE: Maximum operating angle for transmission of power is 25°.
Dimensions subject to change without notice.
**Applications which fall outside the limitations of these tables should be referred to our technical design staff.
Keyways, set screws, pin holes, special materials, or bores other than standard available at additional charge.

Universal Joint Boots

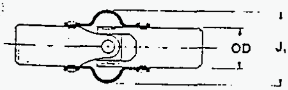
The life of a universal joint can be extended substantially if booted. Wear areas of the universal joint are protected from dirt and contaminants, while lubrication is retained. Lovejoy on-site replaceable boots ensure proper lubrication for up to 5 times longer universal joint life. Installation and replacement is fast and easy. Your machine can be back in operation in minutes. Lovejoy universal joints: D, D-SS, DD, DDX, HD, NB and LOJ come pre-grooved to accommodate on-site replaceable boots.



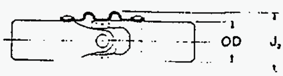
Boot Size	O.D.	Upper J_1	Lower J_2
D-1	3/8	23/32	5/8
D-2	1/2	29/32	3/4
D-3	5/8	1 3/32	15/16
D-4	3/4	1 11/32	1 1/16
D-5	7/8	1 1/2	1 1/4
D-6	1	1 3/4	1 3/8
D-7	1 1/8	2 1/32	1 1/2
D-8	1 1/4	2 1/32	1 11/16
D-10	1 1/2	2 9/16	1 15/16
D-11*	1 3/4	—	2 3/16
D-12*	2	—	2 19/32
D-13*	2 1/2	—	3 1/4
D-14*	3	—	4 1/4
D-15*	4	—	5 1/2

Boots are available separately.
Specify boot size and if upper or lower
(ex. D-1 Upper Boot)

Upper Type Boot (U)



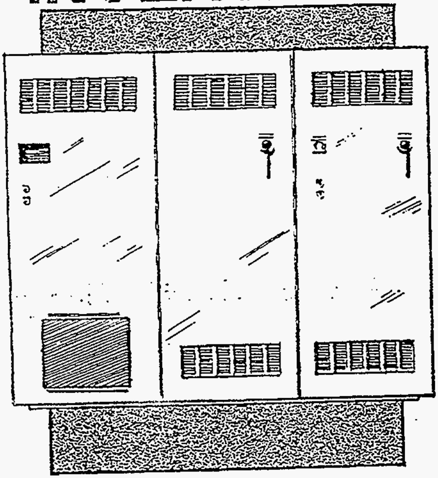
Lower Type Boot (L)



When possible use the larger diameter Upper Type boots. If sufficient space is not available then use the smaller diameter Lower Type boots. Standard boots are packaged two to a bag.

250HP AC Drive

INVERTRON



VGI and VCI
Digital PWM Inverters

RELIANCE ELECTRIC

INVERTRON
A-C DRIVES

250HP AC DRiVe

Standard Specifications

Inverter Model	VGI VCI	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	Sales Order Engineering Models						
Output Ratings	HP Rating @ 460V	150	200	250	300	350	400	500	600	700	800	900	1000	1200
	Output Current	180	240	300	360	420	480	625	750	875	960	1080	1200	1380
Output Ratings	Overload Capacity	Up to 150% for 1 minute				125%	110%	110% ≈ 936 A						
	Output Frequency	0–200 Hertz												
Input Ratings	Power Supply	3-Phase 380/400/415/460V												
	Allow. Variation	Plus or minus 10 percent												
Control Specs.	Control Method	VGI: Flux Regulated Sine Wave VCI: Flux Vector Regulation												
	Speed Regulation	VGI: 0.5% of base frequency with slip compensation VCI: 0.05% of base frequency												
	Freq. Regulation	0.1 Hertz												
	Volts/Hertz Ratio	VGI: Multi-point V/Hz curve shaping either linear or quadratic VCI: Programmable motor voltage regulation												
	Torque Boost	VGI: Up to 30 Volts at a programmable output frequency VCI: Calculated from motor input data												
	Carrier Frequency	Full-spectrum switching carrier frequency (between 800 Hz and 4 KHz) to lower motor noise												
	Auxiliary Functions	VGI: Three critical frequency avoidance bands, D-C braking, Start into a rotating motor, Slip compensation VCI: 8 selectable preset speeds, Torque limit, Programmable for winder applications												
Operating Specs.	Operating Method	Keypad, or hardwired pilot devices connected to control terminal strip												
	Speed Reference/ Input Signals	Up/Down arrow keys on keypad; 0–10 VDC (+/–), 0–20 or 4–20 mA analog signals wired to terminal strip, Static MOP inputs wired to terminal strip, 0–1 MHz (Pulse Train), and preset speeds												
	Accel. and Decel. Time	VGI: Linear or "J" curve 1 to 3277 seconds; acceleration and deceleration set independently VCI: Linear 0.1 to 3277 seconds, acceleration and deceleration set independently												
	External Output Signals (analog)	0–10 VDC analog outputs proportional to motor voltage, motor current, and motor speed; Optional 4–20 mA output signals												
	Digital Outputs	Fault contact, 1–N.O.; Run contact, 1–N.O.; 2–Programmable output relay contracts each 1–N.O.												
	Serial Communications	RS232C serial port with optional MMI software provides ability to upload/download drive parameters, and monitor register values												
Protective Functions	Inverter Trip	Run permissive open, heatsink overtemperature, line dip ride-through time exceeded, Overspeed, D-C bus overcurrent, Motoring overcurrent, Ground fault current, Microprocessor fault, Motor overcurrent												
	Fault Warning	D-C Bus Voltage less than 85%, plus two programmable input contacts from user												
	Ride Through	Six cycles with a programmable voltage ride-through level												
	Fault Reset	Fault reset by contact closure or keypad												
Indication and Keypad	Display Mode	Motor RPM, Input Speed Reference, Motor Voltage, Motor Current, D-C Bus Voltage, Slip Frequency, and Output Frequency; Units are scalable												
	Reference Mode	Displays the method of speed reference input such as analog input, MOP, preset speeds or speed pot												
	Control Mode	Displays the method of drive control either keypad, or terminal strip												
	Diagnostic Mode	Fault codes with English messages are displayed; As each fault occurs it is stored with an occurrence time in NVRAM; If several faults occur at once, they will be shown flashing												
	Code Mode	Provides the ability to enter and display the three levels of password protection												
Operating Conditions	Storage Temp.	–40° C to 65° C (–40° F to 149° F)												
	Ambient Temp.	0° C to 40° C (32° F to 104° F)												
	Humidity	Non-condensing, relative humidity to 95%												
	Installation	Indoor not more than 1000 m (3300 ft.) above sea level												
	Enclosure	NEMA I force-ventilated												
	Weight (kg)	980	980	980	980	980	980	2000	2000	2000	2000	3000	3000	3000
		Up to 400 HP						500–800 HP				900–1200 HP		

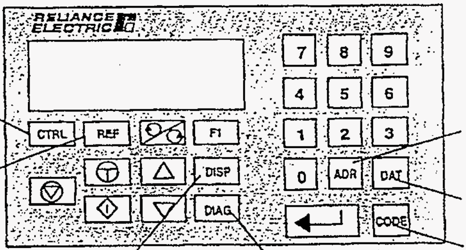
RELIANCE ELECTRIC

250 HP AC DRIVE

INVERTRON
A-C DRIVES

A multi-function alphanumeric keypad and display provides operation, programming, and monitoring of running condition.

The VGI/VCI keypad display is comprised of two lines and 40 characters. This backlit, LCD, English message display is easily visible when viewing – even from a distance.



CONTROL MODE: – Shows the selection and status of the control source (keypad, or remote operation) and any faults, alarms or other status indications.

REFERENCE MODE: – Displays which speed reference sources are configured and which one is active.

DISPLAY MODE: – Shows actual system values, such as voltage, current, frequency and speed.

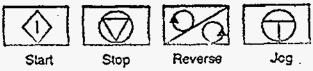
DIAGNOSTIC MODE: – Clear text indications of fault, alarm, and emergency conditions. Keeps an error log of faults coinciding with the working hours counter.

REGISTER MODE: Displays values in registers with proper address and ability to modify data (with proper passwords when necessary.)

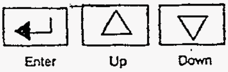
DATA MODE:

CODE MODE: In this mode, passwords and password levels can be defined.

OPERATOR KEYS:



NON-STATE KEYS:



RS232 PROGRAMMING PORT IS ALSO AVAILABLE – AS STANDARD.

Using Reliance MMI Software all parameters can be downloaded, uploaded, monitored, and saved as a file for transfering to future additional drives.

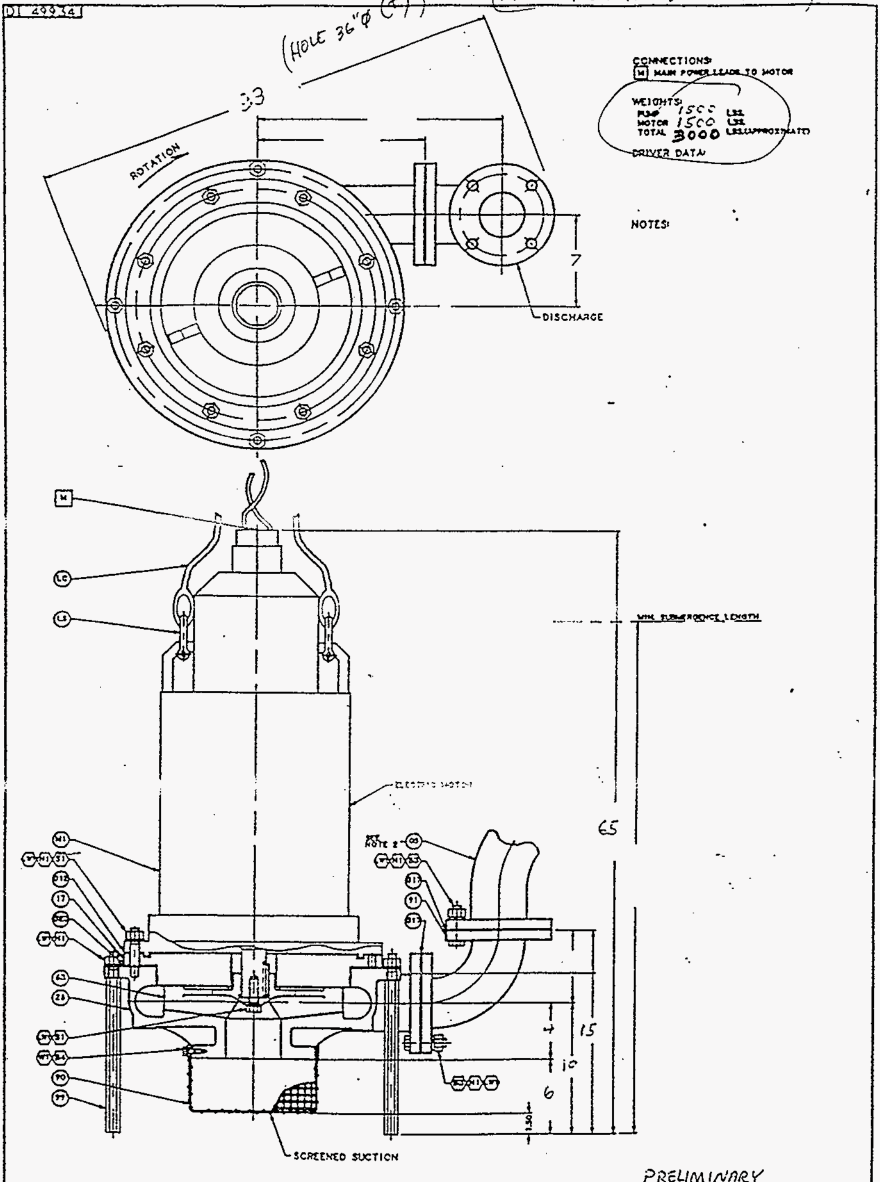
FAULT DISPLAYS (Sample List)

DISPLAY	DESCRIPTION
LOW_LINE_FLT	Line Dip Ride Thru Exceeded
BUS_OVERVOLT	Bus Overvoltage
OVERTEMP_INV	Overtemperature on Heatsink
BASE_DRV_FAULT	Power Supply Fault
BUS_OVERCURR	Bus Overcurrent Trip
MOT_OVERCURR	Motor Overcurrent
EARTH_CURRNT	Ground Fault Trip
LVOLT_TIMOUT	Coast Thru too Long
PROC:A-B_FAULT	Processor 'A' Fault
MCR_KPS_OPEN	Main Contactor Auxiliary Open
MCR_KPS_CLSD	Main Contactor Auxiliary Closed
±15/5V_FAULT	Logic Power Not Ready
PROC: B_W. DOG	Processor Watchdog Time Out
BUS_ASYM_VLT	D-C Bus Asym. Charged

RELIANCE ELECTRIC

(NEW PUMP IN TANK) as of 6/6/95

D 49934



PRELIMINARY

90754-2	16047-311-CX	2	[illegible]	3D-PP404-02
90754-1		1	[illegible]	3D-PP404-01
PUMP SERIAL NUMBER	ORDER NUMBER	UNIT NUMBER	EQUIPMENT NAME	EQUIPMENT NUMBER

OWNER:

PROJECT:

LEGEND
○ PUMP PART
○ FASTENER
☐ CONNECTION

REVISIONS

3 X 4 X 13

DATE 13 OCT 95

LAWRENCE PUMPS INC.

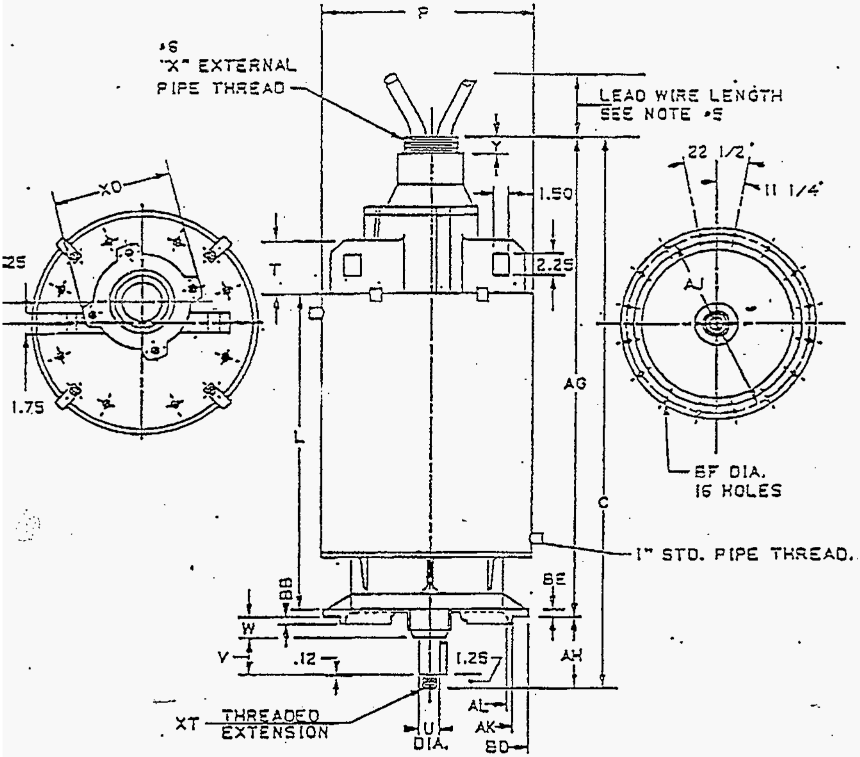
D 49934

ΓY MASTER ALTERNATING CURRENT MOTORS

SQUIRREL-CAGE INDUCTION

ENCLOSURE: TOTALLY ENCLOSED SUBMERSIBLE

FRAME L360TY



DIMENSIONS ARE IN INCHES

FRAME	C	L	P	T	U (3)	V	W	AG	AH	AJ	AK (4)	AL
360TY	51.81	33.25	20.38	4.25	2.4997	3.19	2.12	45.25	6.56	18.75	17.500	15.25

FRAME	BB	BD (2)	BE	BF	XT	LEAD CONNECTION			B.E. KEY	
						X	Y	XO	SQ.	LGTH.
360TY	.25	20.25	1.12	.69	1-1/2-12	3 - 8	1.25	10.88	.50	3.00

1.) SPECIAL DIMENSIONS APPLYING TO THIS ORDER ON THIS LINE.
2.) "BD" VARIES ±.010.
3.) "U" VARIES +.0000, -.0005.
4.) "AK" VARIES +.000, -.002
5.) LEAD WIRE LENGTH AS SPECIFIED ON SALES ORDER.
6.) 3 1/2 - 8 PIPE THREAD SUPPLIED WITH
CABLE SIZES LARGER THAN #1/0

FACE RUNOUT AND ECCENTRICITY .008 MAX. T.I.R.

PROTECTIVE CONDUIT FURNISHED BY CUSTOMER.

FE- L360TY TYPE- TENV CERTIFIED FOR-

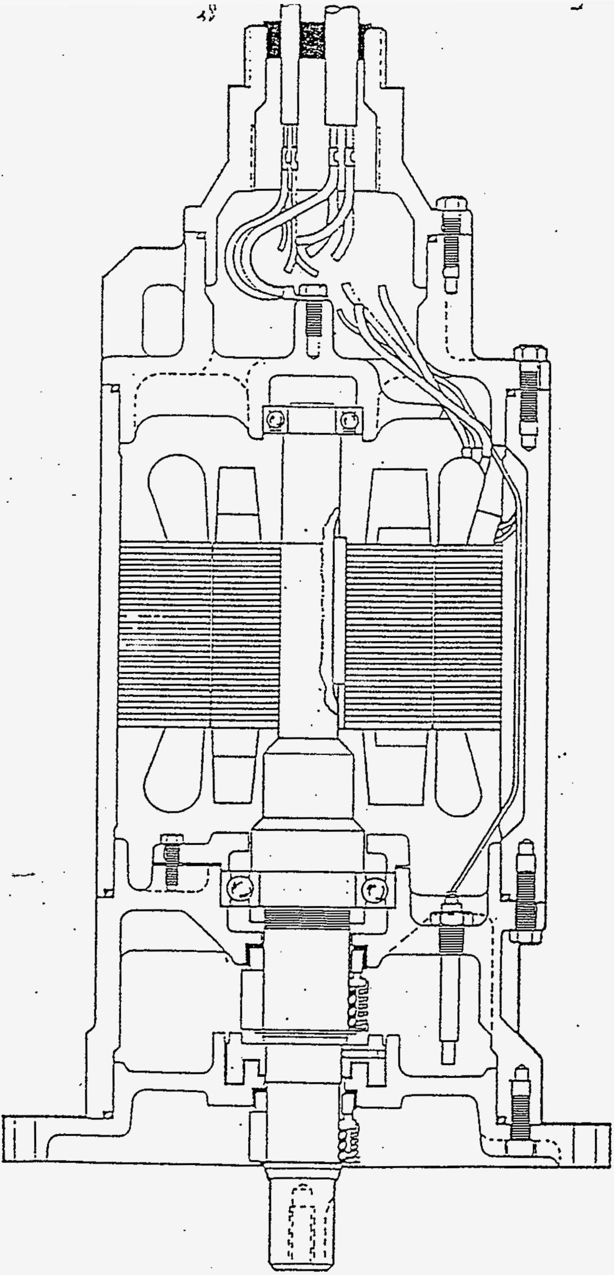
RDER- ITEM- HP- RPM- PH- 3 HZ 60 VOLTS 460

ELIANCE SALES ORDER- APPROVED BY- MMH DATE 7-15-92

RELIANCE ELECTRIC

DR. BY R.J. MUELLER
CK. BY R.B. MONTANEZ

DIMENSION 66930-120



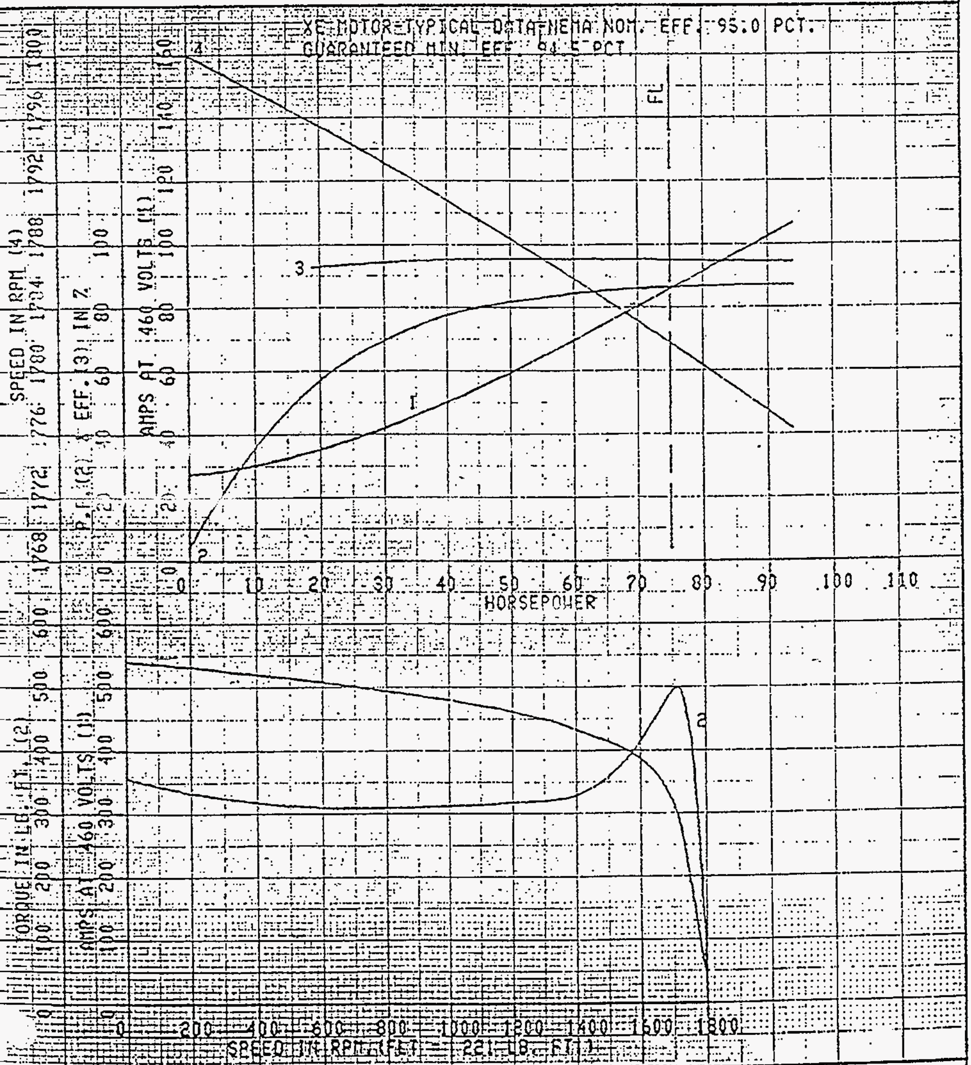
matl

EL S.O.-
AME [redacted]
5
PE P
HASE/HERTZ 3/60

RPM 1780
VOLTS 460
AMPS 85.5
DUTY CONT
AMB°C/INSUL 40/F

S.F. 1.15
NEMA DESIGN B
CODE LETTER G
ENCLOSURE TEFC-XT
E/S 592966

ROTOR 418141-33-RE
TEST S.O. ---
TEST DATE ---
STATOR RES. @ 25°C .0806
OHMS (BETWEEN LINES)



AMPERES SHOWN FOR 460 VOLT CONNECTION. IF OTHER VOLTAGE CONNECTIONS ARE AVAILABLE, THE AMPERES WILL VARY INVERSELY WITH THE RATED VOLTAGE.

RELIANCE
ELECTRIC

DR. BY P.B. GREENE
CK. BY D. M. BYRD
APP. BY D. M. BYRD

A-C MOTOR
PERFORMANCE

E3669A-A-002
ISSUE DATE 09/13/84

REL. S.O.	FRAME	HP	TYPE	PHASE/ HERTZ	RPM	VOLTS
-	[redacted]	75	P	3/60	1780	460

AMPS	DUTY	AMB°C/ INSUL.	S.F.	NEMA DESIGN	CODE LETTER	ENCL.
85.5	CONT	40/F	1.15	B	G	TEFC-XT

E/S	ROTOR	TEST S.O.	TEST DATE	STATOR RES.@25°C OHMS (BETWEEN LINES)
592966	418141-33-RE	---	---	.0806

PERFORMANCE

LOAD	HP	AMPERES	RPM	% POWER FACTOR	% EFFICIENCY
NO LOAD	0	27.5	1800	4.41	0
1/4	18.8	34.3	1796	55.3	92.8
2/4	37.5	48.6	1791	76.0	95.1
3/4	56.2	66.1	1787	83.6	95.4
4/4	74.9	85.5	1782	86.4	95.0
5/4	93.8	107	1776	87.0	94.4

SPEED TORQUE

	RPM	TORQUE % FULL LOAD	TORQUE LB.-FT.	AMPERES
LOCKED ROTOR	0	162	357	540
PULL UP	700	140	309	501
BREAKDOWN	1715	226	499	290
FULL LOAD	1782	100	221	85.5

AMPERES SHOWN FOR 460. VOLT CONNECTION. IF OTHER VOLTAGE CONNECTIONS ARE AVAILABLE, THE AMPERES WILL VARY INVERSELY WITH THE RATED VOLTAGE

REMARKS: XE MOTOR-TYPICAL DATA-NEMA NOM. EFF. 95.0 PCT.
GUARANTEED MIN. EFF. 94.5 PCT.

RELIANCE ELECTRIC
CLEVELAND, OHIO 44117 U.S.A.

DR. BY P.B. GREENE
CK. BY D. M. BYRD
APP. BY D. M. BYRD
DATE 09/17/84

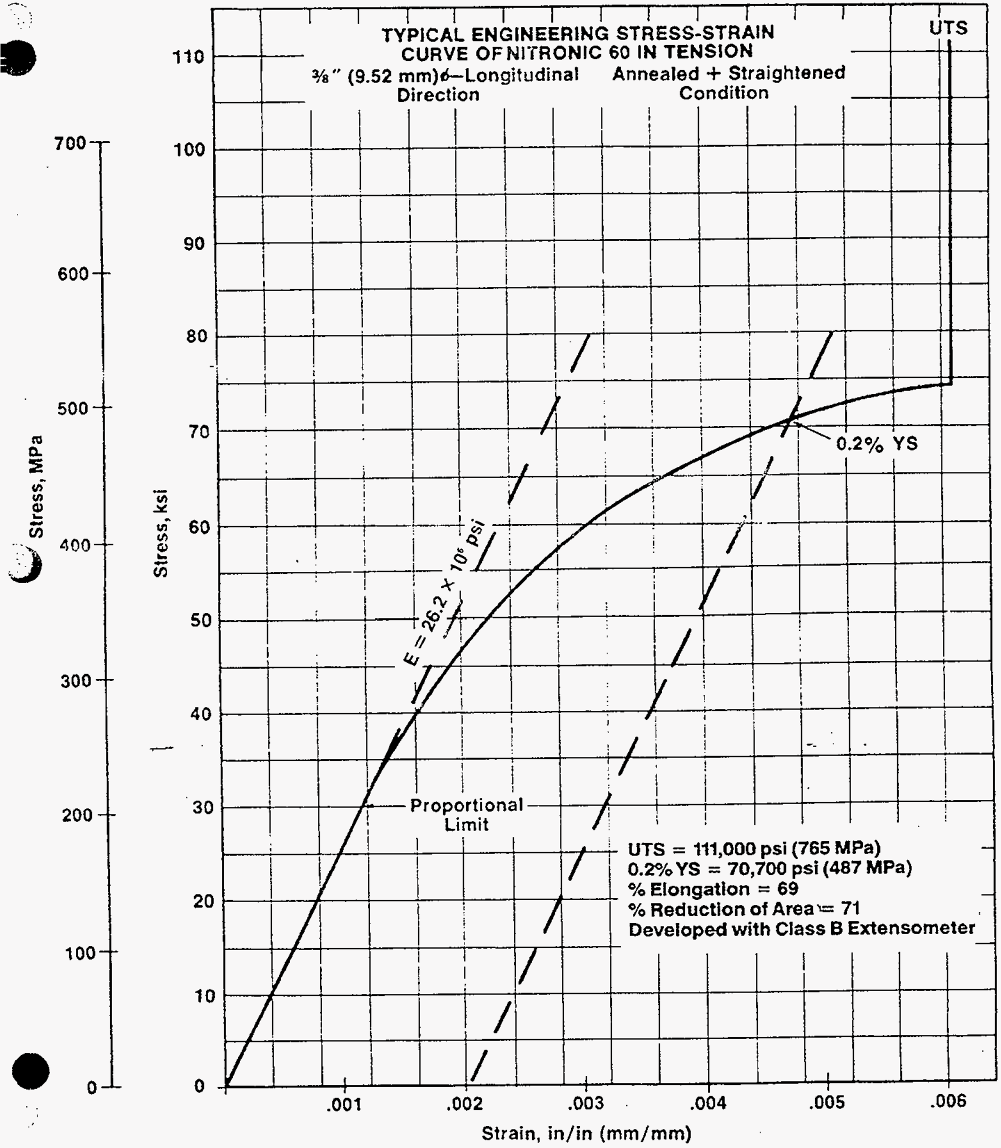
A-C MOTOR PERFORMANCE DATA

E3669A-A-002

ISSUE DATE 09/13/84

FIGURE 7

G-33-05



TYPICAL ENGINEERING STRESS-STRAIN CURVE OF NITRONIC 60 IN TENSION

⅜″ (9.52 mm)ϕ—Longitudinal Direction

Annealed + Straightened Condition

UTS = 111,000 psi (765 MPa)
0.2% YS = 70,700 psi (487 MPa)
% Elongation = 69
% Reduction of Area = 71
Developed with Class B Extensometer

WIRE ROPE Stainless Steel

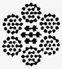
Stainless Steel Wire Rope

Stainless steel wire rope is especially suited for frequent, continuous exposure to extremely corrosive conditions. Stainless steel provides high resistance to corrosion from marine environments, petrochemicals, oxidizing acids, and food processing. It is available in the following five grades. TYPE 316—Provides chemical resistance along with low magnetic properties ideal for use around sensitive instruments. TYPE 302 AND TYPE 304—Breaking strength conforms to the latest revision to applicable Federal Specification RR-W-410 (except 1 x 7 Type 304 construction) or Mil-W-83420.

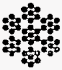
Controlled chemistry of Type 302 provides exceptionally high fa resistance, resulting in a high performance cable that far exc the endurance requirements of the applicable specification. ST LESS-PLUS SUPER ALLOY WIRE ROPE—See page 491. Deve to combat spreading crevice corrosion and pitting that attacks ventional Type 302 and Type 304 stainless steel in a marine a sphere. TYPE 305 NONMAGNETIC—See page 494. Meets Fe Specification Mil-C-18375A and is ideal for applications whic quire good corrosion resistance and low magnetic permeabil

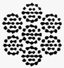
Type 316 Stainless Steel Wire Rope


1 × 19
Single Strand


6 × 19
IWRC

Dia.	Breaking Strength Lbs.	No.	NET/FOOT 1-99	NET/FOOT 100-299	NET/FOOT 300-Up
1 x 19 SINGLE STRAND					
1/8"	1,780	8908T12	$0.68	$0.55	$0.46
3/16"	4,000	8908T16	1.13	0.91	0.76
1/4"	6,900	8908T22	1.60	1.28	1.07
5/16"	10,600	8908T24	2.14	1.72	1.44
3/8"	14,800	8908T26	3.41	2.93	2.45
6 x 19 IWRC					
1/2"	19,300	8908T58	$6.57	$5.80	$4.85


7 × 7
Strand Core

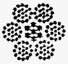

7 × 19
Strand Core

Dia.	Breaking Strength Lbs.	No.	NET/FOOT 1-99	NET/FOOT 100-299
7 x 7 STRAND CORE				
1/16"	360	8908T32	$0.38	$0.30
3/32"	700	8908T34	.61	.49
1/8"	1,360	8908T36	.86	.69
7 x 19 STRAND CORE				
1/8"	1,300	8908T44	$1.38	$1.11
3/16"	2,900	8908T48	1.54	1.24
1/4"	4,900	8908T52	2.35	1.89
5/16"	7,600	8908T54	3.64	2.93
3/8"	11,000	8908T56	4.56	3.67

Construction	Core	Characteristics: Strength	Characteristics: Abrasion Resistance	Characteristics: Flexibility	Characteristics: Corrosion Resistance	Applications: Light Hoisting	Applications: Heavy Hoisting	Applications: Small Drums and Sheaves	Applications: Signal and Control	Applications: Gu
1 x 19	Strand	Excellent	Very Good	Low	Excellent					X
7 x 7	Strand	Moderate	Very Good	Moderate	Excellent	X			X	
6 x 19	IWRC	Moderate	Good	Good	Excellent	X	X	X	X	
7 x 19	Strand	Moderate	Good	Good	Excellent	X	X	X	X	

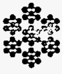
Type 304 Stainless Steel—Wire Rope

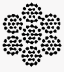

1 × 19
Single Strand


6 × 19
IWRC


6 × 37
IWRC

Dia.	Breaking Strength Lbs.	No.	NET/FOOT 1-99	NET/FOOT 100-299	NET/FOOT 300-Up
1 x 19 SINGLE STRAND					
1/16"	500	3461T14	$0.16	$0.13	$0.11
3/32"	1,200	3461T15	.30	.25	.21
1/8"	2,100	3461T16	.49	.40	.34
5/32"	3,300	3461T17	.62	.51	.43
3/16"	4,700	3461T18	.85	.69	.59
1/4"	6,200	3461T21	1.30	1.06	.90
5/16"	12,500	3461T23	1.87	1.53	1.29
3/8"	17,500	3461T24	2.72	2.23	1.89
6 x 19 IWRC					
7/16"	16,300	3461T74	$4.06	$3.32	$2.81
1/2"	22,800	3461T75	5.04	4.12	3.49
5/8"	35,000	3461T77	7.17	5.87	4.96
6 × 37 IWRC					
1/4"	5,400	3375T31	$2.10	$1.72	$1.45
5/16"	8,300	3375T32	2.89	2.44	2.07
3/8"	11,700	3375T33	3.71	3.03	2.57


7 × 7
Strand Core


7 × 19
Strand Core

Dia.	Breaking Strength Lbs.	No.	NET/FOOT 1-99	NET/FOOT 100-299
7 x 7 STRAND CORE				
1/16"	480	3461T44	$0.26	$0.21
3/32"	920	3461T45	.40	.32
1/8"	1,700	3461T46	.59	.49
5/32"	2,400	3461T47	.70	.57
3/16"	3,700	3461T48	.98	.80
1/4"	6,100	3461T51	1.37	1.12
7 x 19 STRAND CORE				
3/32"	920	3461T64	$0.73	$0.64
1/8"	1,760	3461T65	.91	.75
5/32"	2,400	3461T66	.97	.79
3/16"	3,700	3461T67	1.08	.88
7/32"	5,000	3461T68	1.44	1.18
1/4"	6,400	3461T69	1.61	1.32
5/16"	9,000	3461T72	2.41	1.97
3/8"	12,000	3461T73	3.11	2.55

Construction	Core	Characteristics: Strength	Characteristics: Abrasion Resistance	Characteristics: Flexibility	Characteristics: Corrosion Resistance	Applications: Light Hoisting	Applications: Heavy Hoisting	Applications: Small Drums and Sheaves	Applications: Signal and Control	Applications: Gu
1 x 19	Strand	Excellent	Very Good	Low	Very Good					X
7 x 7	Strand	Excellent	Very Good	Moderate	Very Good				X	X
6 x 19	IWRC	Very Good	Moderate	Very Good	Very Good	X	X			
7 x 19	Strand	Excellent	Moderate	Good	Very Good	X	X	X		
6 x 37	IWRC	Good	Moderate	Very Good	Very Good	X	X			

All descriptions of the wire rope applications listed on this page are general, and are provided with the intention of making it easie you to select the proper wire rope for your individual needs. To select wire rope correctly, be sure to apply sound engineering practi

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Stainless

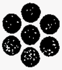
Type 302 Stainless St

osion resistant type 302 stainless steel provides excellent rmity in strength and elongation properties, plus high fatigue ance. The breaking strength conforms to the latest revision of al Specification RR-W-410, MIL-W-83420, and MIL-W-87161 to h it applies. This high performance cable far exceeds the ance requirements of the applicable specification. ely used in the chemical, food processing, petroleum, and

Breaking Strength Lbs.	No.	NET/FOOT 1-99	NET/FOOT 100-299	NET/FOOT 300-Up
SINGLE STRAND—Miniature sizes are used al cable and standard sizes for guy wire.				
ture Sizes				
25	3458T141	$0.07	$0.06	$0.05
55	3458T142	.06	.05	.04
60	3458T143	.06	.05	.04
100	3458T144	.06	.05	.04
125	3458T145	.07	.06	.05
250	3458T146	.09	.08	.06
ard Sizes				
40	3458T11	$0.05	$0.05	$0.04
150	3458T12	.08	.06	.05
500	3458T14	.14	.12	.10
1,200	3458T16	.24	.19	.16
2,100	3458T17	.40	.33	.27
3,300	3458T171	.69	.57	.47
4,700	3458T19	.82	.67	.55
19 SINGLE STRAND—Used for guying, bracnd as standing rigging.				
150	3458T21	$0.10	$0.09	$0.07
335	3458T22	.12	.10	.08
500	3458T23	.18	.16	.13
800	3458T24	.27	.23	.19
1,200	3458T25	.35	.30	.25
2,100	3458T26	.59	.50	.42
3,300	3458T27	.75	.64	.53
4,700	3458T28	.99	.84	.70
8,200	3458T91	1.40	1.18	.99
12,500	3458T93	1.87	1.59	1.33
17,500	3458T94	3.16	2.68	2.24

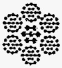
7 HOLLOW CORE		NET/FOOT 1-99	NET/FOOT 100-Up
110	3458T51	$0.16	$0.13
6 x 19 IWRC			
16,300	3458T121	$5.28	$4.60
22,800	3458T122	6.03	5.26

7 IWRC—More flexible than 6 x 19 construc-though it is not as durable.		NET/FOOT 1-99	NET/FOOT 100-299	NET/FOOT 300-Up
3,000	3458T111	$1.94	$1.61	$1.34
5,400	3458T54	3.10	2.56	2.14
8,300	3458T55	4.28	3.53	2.95
11,700	3458T56	5.27	4.35	3.64
20,400	3458T57	7.38	6.09	5.10


1 x 7
Single Strand


1 x 19
Single Strand


3 x 7
Hollow Core


6 x 19
IWRC


6 x 37
IWRC

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.024"
.031"
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19 x 7
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6 x 42
as filler
structior
subjecte

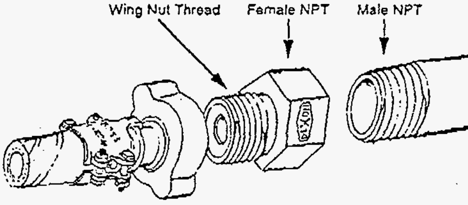
truction	Core	Characteristics: Strength	Characteristics: Abrasion Resistance	Characteristics: Flexibility	Characteristics: Corrosio Resistanc
x 7	Strand	Excellent	Very Good	Low	Excellen
x 19	Strand	Excellent	Very Good	Low	Excellen
x 7	Hollow	Very Good	Good	Excellent	Excellen
x 3	Hollow	Very Good	Good	Excellent	Excellen
x 7	Strand	Excellent	Good	Good	Excellen
x 7	Strand	Very Good	Moderate	Very Good	Excellen
x 19	IWRC	Excellent	Excellent	Very Good	Excellen
x 19	Strand	Excellent	Good	Excellent	Excellen
x 37	IWRC	Good	Very Good	Excellent	Excellen
x 42	Fiber	Moderate	Low	Excellent	Excellen

escriptions of wire rope applications listed on this are general, and are the proper wire rope for your individual needs. To select wire rope cc

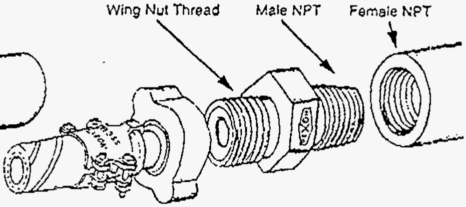
BOSS COUPLINGS

A

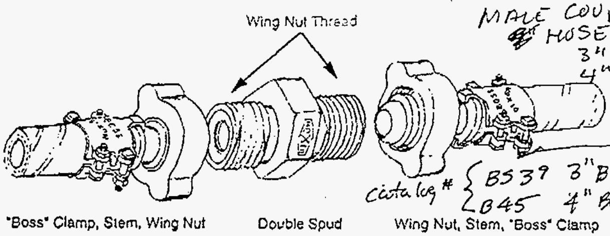
"BOSS" ASSEMBLY DIAGRAM



FEMALE SPUD COUPLING with CLAMP



MALE SPUD COUPLING with CLAMP



MALE COUPLING FOR
HOSE 3" (RNS36) 7.57
4" (RNS46) 12.07
CATALOG #

catalog # { BS39 3" BOSS CLAMP 12.100
{ B45 4" BOSS 15.045

DOUBLE SPUD COUPLING with CLAMP

"EZ-BOSS" GROUND JOINT SEAL

"EZ-Boss" non-metallic polymer seal is not subject to corrosion and offers resistance to chemicals and steam found in manufacturing facilities. precisely machined recess holds the seal firmly in place, allowing it to absorb harsh punishment. Recommended for steam service up to 450°F; easy to seal; works with existing "Boss" Ground Joint Stems; Made in the USA. Fittings will be supplied with Polymer seats as stock is depleted

PLATED STEEL &/or MALLEABLE IRON

	Coupling With Female Spud		Stem			Wing Nut			Female Spud			Male Spud		Double Spud	
Sizes	*Part #*	Price	*Part #*	Price	Pkg Qty	*Part #*	Price	Pkg Qty	*Part #*	Price	Pkg Qty	*Part #*	Price	*Part #*	Price
1/4"	*GF1*	$24.25	*GBA*	$7.75	100	*BA2*	$6.00	100	*GBC*	$10.50	100	*GMB*	$10.50		
3/8"	*GF3*	22.25	*GCA*	5.25	100	*CB*	6.00	100	*GCC*	11.00	100	*GMC*	10.50		
1/2"	*GF6*	15.40	*GB1*	4.00	100	*B2*	3.75	100	*GB3*	7.65	100	*GM3*	12.00	*GDB3*	$20.00
3/4"	*GF26*	21.85	*GB6*	9.00	50	*B12*	4.70	25	*GB8*	7.95	50	*GM8*	13.00	*GDB13*	23.15
1"	*GF36*	22.20	*GB11*	9.25	50	*B12*	4.70	25	*GB13*	8.25	50	*GM13*	14.00	*GDB13*	23.15
1 1/4"	*GF51*	36.80	*GB16*	11.00	25	*B17*	8.00	25	*GB18*	17.80	25	*GM18*	30.00	*GDB23*	40.00
1 1/2"	*GF61*	37.05	*GB21*	11.25	25	*B17*	8.00	25	*GB23*	17.80	25	*GM23*	28.30	*GDB23*	40.00
2"	*GF81*	43.80	*GB26*	12.00	10	*B27*	14.00	10	*GB28*	17.80	10	*GM28*	30.85	*GDB28*	41.00
2 1/2"	*GF96*	123.15	*GB31*	32.15	5	*B32*	35.00	5	*GB33*	56.00	5	*GM33*	80.00	*GDB33*	80.00
3"	*GF111*	132.00	*GB36*	36.00	5	*B37*	35.00	5	*GB38*	61.00	5	*GM38*	85.00	*GDB38*	90.00
4"	*GF141*	292.00	*GB46*	87.00	5	*B47*	95.00	5	*GB48*	110.00	5				
5"	*GF171*	765.00	*GB56*	340.00	2	*B67*	175.00	2	*GB58*	250.00	2				
6"	*GF201*	875.00	*GB66*	250.00	2	*B67*	175.00	2	*GB68*	400.00	2				

1/4", 3/8", 5" & 6" come with Copper seat spuds. Copper seats are available in other sizes - consult the Factory for pricing and availability.

**"Boss" Couplings And The Steam Quick Disconnects On P. 6
Are The Only Dixon Couplings Recommended For Steam Service**

Industrial Hose Products/List Prices

[redacted]

39496-000
March 30, 1992
Supersedes 39496-000
January 2, 1990

Steam Hose

200MB Steam Pile Driver

(Specification 3601)

Item No.	Nom. I.D. (In.)	Nom. O.D. (In.)	Maximum W.P. (psi)	Suction (In. Hg)	Min. Bend Radius (In.)	Wt. Per Ft. (Lbs.)	Standard Pack	Stock (X) or Minimum Order Qty.	Gates Prod. No.	List Price Per Ft.
303500	2	2.95	200	10.0	25.0	3.43	50 ft	500 ft	3601-0410	$48.438
303501	2½	3.45	200	10.0	30.0	3.88	50 ft	500 ft	3601-0420	68.209
303502	3	3.97	200	10.0	36.0	4.47	50 ft	X	3601-0430	77.516
303503	4	5.20	200	10.0	48.0	7.47	50 ft	X	3601-0440	125.364

RECOMMENDED FOR: Saturated steam up to 200 PSI and 388° F for pile driver applications. Service life will be severely shortened if steam without lubricating oil is used. **NOTE: NOT FOR USE WITH STEAM ONLY.**

TEMPERATURE: Maximum to 388°F (198°C) continuous service.

CONSTRUCTION: **Tube:** Type A (Neoprene) Black.
Reinforcement: Braided, high tensile steel wire.
Cover: Type A (Neoprene) Black. All sizes are perforated.

COUPLINGS: 14 or 15 . Reference pages 130-141.

PACKAGING: 50' coiled in a carton.

BRANDING: Rubber patch label every 5-10 ft. Example; "Gates 200MB Steam Pile Driver 200 PSI (1.38MPa) WP at 388 Degrees F Made In U.S.A. Caution: Tighten Clamps Before Using."

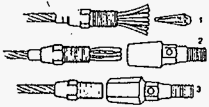
SPECIAL ORDER REQUIREMENTS: Special production runs require minimum order quantities of 500 feet per size.

REMNANT LENGTHS: Not Available.

Due to continual product improvements, Gates reserves the right to alter specs and prices without prior notice.

The world's most trusted name in belts and hose.

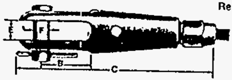
Positive Grip Wire Rope Fittings



Positive Grip Wire Rope Fitting Information

Fittings consist of three parts: A sleeve, plug and covering socket. To assemble: (1) Slip sleeve over end of wire rope. (2) Open rope strands and drive fluted plug into sleeve. (3) Close strands over plug and screw on covering socket. For safety, covering socket on fittings has inspection hole for checking correct installation. Fittings are reusable by replacing plug. Recommend use of kit listed below for easier, more efficient assembly of fitting.

Note: All Positive Grip Fittings can be used with all 6 strand fibre core wire rope, except tiller and extra improved plow steel wire rope. Fittings equipped with plugs to accommodate 6 strand IWRC, 7 × 7 and 7 × 19 wire rope, the plugs for other type of wire rope and fittings for use with extra improved plow steel wire rope are available. Prices on Request.



Machined Standard Clevis End Fittings

Material: Machined from bar stock.

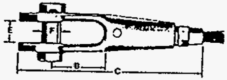
Special Feature: Positive grip socket equipped with clevis pin for easy, quick removal and changing of end fittings.

Uses: Ideal for all standard industrial rigging jobs.

Spark resistant Bronze in sizes listed available, specify 3473T999. Prices on Request.

♦ Note: Nos. 3473T, 3480T, 3511T and 3474T are for 6 strand fiber core wire rope. Fittings for other construction see top of this page.

Wire Rope Dia.	Center of Pin To Socket B	Approx. Overall Length C	Jaw Opening E	Pin Dia. F	Self-Colored Steel No.	Self-Colored Steel NET EACH	Cadmium-Plated Steel No.	Cadmium-Plated Steel NET EACH	Stainless Steel No.	Stainless Steel NET EACH
1/16"	3/8"	2 1/16"	3/16"	3/16"	3473T14	$12.76	3473T34	$15.95	3473T74	[illegible]
3/32"	1/2"	2 7/16"	1/4"	1/4"	3473T15	12.96	3473T35	16.20	3473T75	[illegible]
1/8"	1/2"	2 7/16"	1/4"	1/4"	3473T16	13.15	3473T36	16.44	3473T76	[illegible]
5/32"	5/8"	2 31/32"	5/16"	5/16"	3473T17	15.76	3473T37	19.70	3473T77	[illegible]
3/16"	5/8"	2 31/32"	5/16"	5/16"	3473T18	18.39	3473T38	22.99	3473T78	[illegible]
1/4"	3/4"	3 23/32"	3/8"	3/8"	3473T21	25.26	3473T41	31.58	3473T81	[illegible]
5/16"	7/8"	4 1/4"	3/8"	7/16"	3473T23	32.59	3473T43	40.74	3473T83	[illegible]
3/8"	1"	4 27/32"	7/16"	1/2"	3473T24	40.88	3473T44	51.09	3473T84	[illegible]
1/2"	1 3/8"	6 11/32"	1/2"	11/16"	3473T26	53.73	3473T46	67.16	3473T86	[illegible]



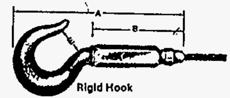
Forged Heavy Duty Clevis End Fittings

Material: Drop forged steel. Finishes: Self-colored or galvanized.

Special Feature: Positive socket equipped with clevis pin for easy, quick removal and changing of end fittings. Uses: Ideal for tough rigging jobs which demand maximum strength and durability.

See ♦ with No. 3473.

Wire Rope Dia.	Center of Pin To Socket B	Approx. Overall Length C	Jaw Opening E	Pin Dia. F	Self-Colored Steel No.	Self-Colored Steel NET EACH	Galvanized Steel No.	Galvanized Steel NET EACH
1/4"	1 1/4"	4 1/2"	17/32"	1/2"	3480T14	$23.70	3480T31	[illegible]
5/16"	1 1/2"	5 3/8"	11/16"	9/16"	3480T15	26.20	3480T32	[illegible]
3/8"	1 1/2"	5 1/2"	11/16"	5/8"	3480T16	30.69	3480T33	[illegible]
7/16"	2"	7 3/16"	1"	3/4"	3480T17	41.46	3480T34	[illegible]
1/2"	2"	7 3/16"	1"	7/8"	3480T18	44.33	3480T35	[illegible]
5/8"	2 1/2"	8 5/8"	1 1/4"	1"	3480T19	67.10	[illegible]	[illegible]
3/4"	3"	10 3/16"	1 1/2"	1 1/8"	3480T21	74.45	3480T37	[illegible]
7/8"	2 5/8"	11"	1 9/16"	1 1/2"	3480T22	126.44	3480T38	[illegible]
1"	3"	12 11/16"	1 7/8"	1 1/2"	3480T23	181.84	3480T39	[illegible]



Rigid Hook

Machined Standard Duty Hook Assemblies

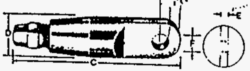
Material: Machined from bar stock. Available in alloy steel. Socket assembly machined from alloy steel. Hook forged alloy steel. Finish: Self-colored.

Special Features: Available with rigid or swivel hook. Uses: For hoisting and lifting operations.

Zinc-plated finish is available, specify 3511T999—Prices On Request.

See ♦ with No. 3473.

Wire Rope Dia.	Hook Opening E	Rigid Hooks Overall Length A	Rigid Hooks Socket Length B	Rigid Hooks No.	Rigid Hooks NET EACH	Swivel Hooks Overall Length A	Swivel Hooks Socket Length B	Swivel Hooks No.	Swivel Hooks NET EACH	Safety Latches No.	Safety Latches NET EACH
1/4"	1 1/16"	5 7/8"	2 1/2"	3511T14	$41.53	7 7/16"	4 3/16"	3511T34	$48.86	8944T12	[illegible]
3/8"	1 1/4"	7 19/32"	3 13/32"	3511T16	65.76	9 5/16"	5 5/16"	3511T36	81.78	8944T14	[illegible]
1/2"	1 1/2"	9 23/32"	4 1/2"	3511T18	87.04	11 13/16"	6 13/16"	3511T38	114.76	8944T16	[illegible]



Machined Standard Eye End Fittings

Material: Machined from bar stock.

Special Features: Positive Grip Sockets are ideal for most industrial applications especially where a smooth machined finish is desired for ease of handling and better appearance.

Spark Resistant Bronze in sizes listed available, specify 3474T999—Prices On Request.

See ♦ with No. 3473.

Wire Rope Dia.	Approx. Overall Length C	Socket Dia. D	Pin Hole Dia. F	Eye Width E	Self-Colored Steel No.	Self-Colored Steel NET EACH	Zinc Plated Steel No.	Zinc Plated Steel NET EACH	Stainless Steel No.	Stainless Steel NET EACH
1/16"	2 1/16"	1/2"	13/64"	11/64"	3474T14	$10.04	3474T34	$12.55	3474T74	[illegible]
3/32"	2 15/32"	3/8"	13/64"	15/64"	3474T15	10.28	3474T35	12.84	3474T75	[illegible]
1/8"	2 15/32"	5/8"	17/64"	15/64"	3474T16	10.51	3474T36	13.14	3474T76	[illegible]
5/32"	3"	3/4"	21/64"	19/64"	3474T17	11.56	3474T37	14.45	3474T77	[illegible]
3/16"	3"	3/4"	21/64"	19/64"	3474T18	12.61	3474T38	15.77	3474T78	[illegible]
1/4"	3 3/4"	15/16"	25/64"	23/64"	3474T21	14.75	3474T41	18.44	3474T81	[illegible]
5/16"	4 9/32"	1 1/16"	29/64"	23/64"	3474T23	22.08	3474T43	27.59	3474T83	[illegible]
3/8"	4 7/8"	1 3/16"	33/64"	27/64"	3474T24	24.15	3474T44	30.19	3474T84	[illegible]
1/2"	6 3/8"	1 9/16"	45/64"	31/64"	3474T26	44.66	3474T46	55.83	3474T86	[illegible]

Assembly Kits for Use with Positive Grip Wire Rope Fittings

Material: Extruded alloy steel. Finish: Self-colored.

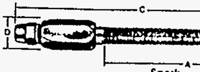
Special Features: Provide easier, more efficient assembly of Positive Grip Wire Rope Fittings listed on this page and on the following pages.

How It Works: Steel block holds wire strands firmly so that plug can be driven to a solid seat. Assembly block prevents wires of the rope strands from being nicked by the jaws of the vise. Note: Hollow tubing is used for terminating IWRC wire rope.

Wire Rope Dia.	No.	NET EACH
1/8-9/16"	8929T12	[illegible]
5/8-1"	8929T14	[illegible]

Positive Grip Wire Rope Fittings

Machined Standard Stud End Fittings



Material: Machined from bar stock. Special Feature: Positive grip socket has stud end. Uses: Ideal for most industrial rigging jobs requiring a quick method of attaching lines to beams, equipment or to various lifting devices.

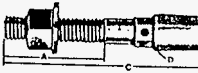
Stud Size	Threaded Stud Length A	Approx. Overall Length C	Socket Dia. D	Self-Colored Steel No.	Self-Colored Steel NET EACH	Cadmium Plated Steel No.	Cadmium Plated Steel NET EACH	Stainless Steel No.	Stainless Steel NET EACH
10-32	1 19/32"	3 1/32"	7/16"	3475T14	$11.00	3475T31	$13.75	3475T71	$23.10
1/4"-28	1 7/8"	3 1/2"	9/16"	3475T15	12.85	3475T32	16.06	3475T72	26.99
1/4"-28	1 7/8"	3 1/2"	9/16"	3475T16	14.71	3475T33	18.39	3475T73	30.90
3/8"-24	2 3/16"	4 3/16"	11/16"	3475T18	17.35	3475T35	21.69	3475T75	36.44
1/2"-20	4 9/16"	7 1/16"	7/8"	3475T21	20.98	3475T37	26.22	3475T77	44.05
5/8"-18	4 9/16"	7 1/2"	1"	3475T23	28.91	3475T39	36.14	3475T79	60.72
3/4"-16	4 15/16"	8 3/16"	1 1/8"	3475T24	33.38	3475T41	41.72	3475T81	70.09
7/8"-14	6 15/16"	11"	1 1/2"	3475T26	49.88	3475T43	62.34	3475T83	104.74

Spark
Bronze St
tings avail
fy 3475T
on request
♦ Nos. 3
3477T, 34
3470T and
for 6 strand
wire rope.
other const
top of page

Forged Heavy Duty Stud End Fittings

End Fittings for wire rope diameter up to 1 1/2" available, specify 3479T999—on Request.

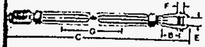
Stud Size	Threaded Stud Length A	Approx. Overall Length C	Socket Dia. D	Self-Colored Steel No.	Self-Colored Steel EACH	Galvanized Steel No.	Galvanized Steel NET EACH
1/2"-13	4 3/16"	7 3/8"	1"	3479T11	$21.50	3479T31	$26.88
1/2"-13	4 3/16"	7 9/16"	1"	3479T12	24.05	3479T32	30.06
5/8"-11	4 1/2"	8 1/4"	1 1/8"	3479T13	28.39	3479T33	35.49
3/4"-10	6 3/8"	10 15/16"	1 1/2"	3479T15	35.18	3479T35	43.97
7/8"-9	8 1/8"	13 7/8"	1 13/16"	3479T16	63.08	3479T36	78.84
1 1/8"-7	8 5/8"	15 1/4"	2 1/4"	3479T17	77.56	3479T37	96.95



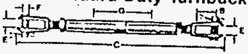
Material: Drop forged steel. Finis colored and galvanized. Special Feat duty for long dependable service unde vere operating conditions. Uses: For m industrial rigging.

See ♦ with No. 3475.

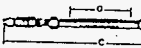
Machined Standard Duty Turnbuckles



Socket & Jaw Turnbuckle



Jaw and Jaw Turnbuckle



Double Socket Turnbuc

chined Turnbuckles made of Bronze are available—Prices on Request. See ♦ with No. 3475.

Socket & Jaw Turnbuckles

B	E	F	Rated Takeup G	Extended Length C	Self-Colored Alloy Steel No.	Self-Colored Alloy Steel NET EACH	Stainless Steel No.	Stainless Steel NET EACH
3/8"	3/16"	3/16"	2 1/2"	8 1/4"	3476T11	$32.43	3476T71	$68.09
1/2"	1/4"	1/4"	2 7/8"	9 5/8"	3476T13	41.41	3476T73	86.97
5/8"	5/16"	5/16"	3 1/8"	11 3/32"	3476T15	47.43	3476T75	99.59
3/4"	3/8"	3/8"	4 13/16"	15 3/4"	3476T17	55.20	3476T77	115.92
1"	7/16"	1/2"	5 5/16"	18 9/16"	3476T21	79.70	3476T81	167.37
1 3/8"	1/2"	11/16"	8 1/16"	25 13/16"	3476T23	137.01	3476T83	287.73

Jaw & Jaw Type Turnbuckles

Extended Length C	Self-Colored Alloy Steel No.	Self-Colored Alloy Steel NET EACH	Stain St No.
7 21/32"	3477T11	$32.43	3477T51
9 1/8"	3477T13	41.41	3477T53
10 7/16"	3477T15	47.43	3477T55
14 3/16"	3477T17	55.20	3477T57
17 5/16"	3477T21	79.70	3477T61
24 9/32"	3477T23	137.01	3477T63

BLE SOCKET TYPE TURNBUCKLES

Extended Length C	Rated Takeup G	Self-Colored Alloy Steel No.	Self-Colored Alloy Steel NET EACH	Stainless Steel No.	Stainless Steel NET EACH
8 7/8"	2 1/2"	3478T11	$29.56	3478T71	$62.08
10 1/8"	2 7/8"	3478T13	34.69	3478T73	72.84
11 3/4"	3 1/8"	3478T15	45.20	3478T75	94.92

Wire Rope Dia.	Extended Length C	Rated Takeup G	Self-Colored Alloy Steel No.	Self-Colored Alloy Steel NET EACH	Stain St No.
1/4"	16 11/16"	4 13/16"	3478T17	$56.23	3478T77
3/8"	19 13/16"	5 5/16"	3478T21	90.09	3478T81
1/2"	27 5/16"	8 1/16"	3478T23	140.06	3478T83

Forged Heavy Duty Eye End Fittings

and fittings for wire rope diameter up to 1" available, specify 3482T999—on Request. See ♦ with No. 3475.

Approx. Overall Length C	Eye Dia. D	Pin Hole Dia. F	Eye Width E	Self-Colored Steel No.	Self-Colored Steel NET EACH	Galvanized Steel No.	Galvanized Steel NET EACH
4 3/8"	1 5/32"	17/32"	1/2"	3482T11	$18.76	3482T31	$22.55
5 1/2"	1 5/16"	21/32"	9/16"	3482T13	23.23	3482T33	27.92
6 7/8"	1 3/4"	29/32"	3/4"	3482T15	33.88	3482T35	40.72

Material: Drop forged steel. Finishe colored or galvanized. Special Feature: H thickness of metal at bearing point. Uses: rugged rigging operations.

chined Standard Duty Drum Sockets

rial: Alloy steel. Machined bar stock. Special Feature: an extra strong terminal for rope ends. Uses: Used for at- winch lines to slotted , etc.

♦ with No. 3475.

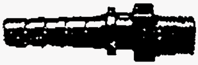
Overall Length A	Hex Size B	Self-Colored Steel No.	Self-Colored Steel NET EACH	Zinc Plated Steel No.	Zinc Plated Steel NET EACH
1 9/16"	9/16"	3470T14	$9.00	3470T31	$11.25
1 15/16"	5/8"	3470T15	10.43	3470T32	13.03
1 15/16"	3/4"	3470T16	11.75	3470T33	14.69
2 3/8"	7/8"	3470T17	12.93	3470T34	16.16
2 3/4"	15/16"	3470T18	13.68	3470T35	17.09
3 1/4"	1 1/8"	3470T19	17.64	3470T36	22.05
3 3/4"	1 1/4"	3470T21	31.40	3470T37	39.25

Forged Heavy Duty Oval Eye Fitt

Material: Drop forged steel. Special Feature: Oval shape eye for quick attachment of heavy hooks. Oval eye fittings for wire rope diameter up to 1 1/2" and galvanized finish are available, specify 3481T999—Prices on Request. See ♦ with No. 3475.

Wire Rope Dia.	Inside Eye Width A	Inside Eye Length B	Eye Thickness D	Approx. Overall Length E	Self-Colored Steel No.
1/4"	7/8"	1 15/16"	5/8"	5 1/2"	3481T14
3/8"	7/8"	1 15/16"	5/8"	5 13/16"	3481T16
1/2"	1"	2 1/16"	7/8"	6 7/8"	3481T18
3/4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

"BOSS" MALE STEM



STEEL BAR STOCK

Hose x NPT Size	*Part #*	Price	Pkg Qty
1/4" x 1/8"	*MS4X2*	$5.00	25
1/4" x 1/4"	*MSA*	4.15	50
1/4" x 3/8"	*MSB*	4.50	25
3/8" x 1/4"	*MS6X4*	4.25	25
3/8" x 3/8"	*MSC*	3.50	100
3/8" x 1/2"	*MS6X8*	4.40	25
1/2" x 1/4"	*MS8X4*	4.40	25
1/2" x 3/8"	*MS8X6*	4.40	50
1/2" x 1/2"	*MS1*	3.25	25
1/2" x 3/4"	*MS8X12*	8.95	25
3/4" x 1/2"	*MS12X8*	7.75	25
3/4" x 3/4"	*MS6*	5.50	25
3/4" x 1"	*MS12X16*	13.50	25
1" x 3/4"	*MS16X12*	13.50	25
1"	*MS11*	8.70	25

MALLEABLE IRON

Size	*Part #*	Price	Pkg Qty
1 1/4"	*MS16*	$11.00	20
1 1/2"	*MS21*	11.25	20
2"	*MS26*	16.80	10
2 1/2"	*MS31*	36.00	5
3"	*MS36*	48.00	5
4"	*MS46*	84.00	2

316 STAINLESS STEEL

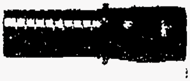
Size	*Part #*	Price
1/2"	*RMS1*	$40.00
3/4"	*RMS6*	47.00
1"	*RMS11*	47.00
1 1/4"	*RMS16*	105.00
1 1/2"	*RMS21*	105.00
2"	*RMS26*	110.00
2 1/2"	*RMS31*	300.00
3"	*RMS36*	390.00

BRASS

Size	*Part #*	Price
3/4"	*BMS6*	$13.50
1"	*BMS11*	25.00
1 1/4"	*BMS16*	31.00
1 1/2"	*BMS21*	42.00
2"	*BMS26*	58.00
3"	*BMS36*	145.00

"LP-BOSS" MALE STEM

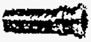
Non-porous tubular steel for volatile materials



	Plated, Male NPT End		Unplated, Beveled End	
Size	*Part #*	Price	*Part #*	Price
1 1/4"	*LP16*	$35.00		
1 1/2"	*LP21*	35.00		
2"	*LP26*	24.00	*LPB26*	$28.00
2 1/2"	*LP31*	80.00		
3"	*LP36*	80.00	*LPB36*	82.00
4"	*LP46*	80.00		
6"	*LP66*	175.00		

"BOSS" WASHER SEAL

PLATED STEEL &/or MALLEABLE IRON

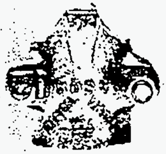
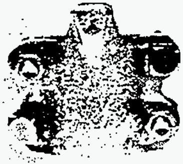
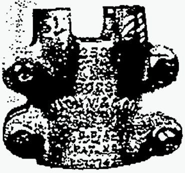
	Coupling With Female Spud		Stem			Wing Nut			Female Spud			Male Spud		Double Spud		Washer*	
Sizes	*Part #*	Price	*Part #*	Price	Pkg Qty	*Part #*	Price	Pkg Qty	*Part #*	Price	Pkg Qty	*Part #*	Price	*Part #*	Price	*Part #*	Price
3/8"	*WF3*	$15.00	*CA*	$3.50	100	*CB*	36.00	100	*CC*	$5.50	100	*WMC*	$10.00			*WBC*	$.35
1/2"	*WF6*	12.00	*B1*	4.25	100	*B2*	3.75	100	*B3*	4.00	100	*WM3*	10.00	*DB3*	$15.00	*W2*	.35
3/4"	*WF26*	19.45	*B6*	9.00	50	*B12*	4.70	25	*B8*	5.75	25	*WM8*	11.50	*DB13*	18.00	*W12*	.45
1"	*WF36*	19.70	*B11*	9.25	50	*B12*	4.70	25	*B13*	5.75	50	*WM13*	12.00	*DB13*	18.00	*W12*	.45
1 1/4"	*WF51*	35.50	*B16*	12.50	25	*B17*	8.00	25	*B18*	15.00	25	*WM18*	28.00	*DB23*	27.00	*W17*	.75
1 1/2"	*WF61*	35.00	*B21*	12.50	25	*B17*	8.00	25	*B23*	14.50	25	*WM23*	28.00	*DB23*	27.00	*W17*	.75
2"	*WF81*	43.00	*B26*	12.50	10	*B27*	14.00	10	*B28*	18.50	10	*WM28*	32.00	*DB28*	30.00	*W27*	.85
2 1/2"	*WF96*	99.00	*B31*	30.00	5	*B32*	35.00	5	*B33*	34.00	5	*WM33*	60.00	*DB33*	60.00	*W32*	1.10
3"	*WF111*	124.00	*B38*	39.00	5	*B37*	35.00	5	*B38*	50.00	5	*WM38*	60.00	*DB38*	77.00	*W37*	1.10
4"	*WF141*	292.00	*B46*	105.00	5	*B47*	95.00	5	*B48*	92.00	5					*W47*	5.25
5"	*WF171*	735.00	*B56*	340.00	2	*B67*	175.00	2	*B58*	220.00	2					*W67*	5.25
6"	*WF201*	660.00	*B66*	265.00	2	*B67*	175.00	2	*B68*	220.00	2					*W67*	5.25

* Washer is Klinger nylon, Nitrile bonded, Kevlar reinforced material.

BOSS COUPLINGS

"BOSS" CLAMPS

A

	Hose I.D.	Hose O.D.		Plated Malleable Iron			Brass Shipped from factory only.		Stainless Steel Shipped from factory only.		
	Size	From:	To:	Part #	Price	Qty	Part #	Price	Part #	Price	Torque**
 2-BOLT TYPE	1/4"	9/16"	21/32"	BD	$3.95	100					6
	3/8"	11/16"	7/8"	CD	3.95	100					6
	1/2"	13/16"	15/16"	DD	3.95	100					6
	1/2"	15/16"	1 1/16"	B4	3.95	25	BB4	$13.00	RB4	$90.00	12
	1/2"	1 1/16"	1 3/16"	B5	4.25	25					12
	3/4"	1 5/32"	1 9/32"	BU9S	5.30	50					21
	3/4"	1 3/16"	1 5/16"	BU9	5.30	50	BBU9	16.00	RBU9	99.00	21
	3/4"	1 5/16"	1 1/2"	B9	5.30	25	BB9	16.00	RB9	99.00	21
	3/4"	1 1/2"	1 11/16"	B10	6.00	25					21
 4-BOLT TYPE 2 GRIPPING FINGERS	1/2"	29/32"	1 1/32"	968	6.00	50					6
	1"	1 13/32"	1 9/16"	156*	9.45	20					21
	1"	1 17/32"	1 23/32"	BU14	9.45	25	BBU14	45.00	RBU14	126.00	21
	1"	1 11/16"	1 15/16"	B14	9.65	25	BB14	49.00	RB14	126.00	21
	1"	1 15/16"	2 1/8"	B15	11.00	20					21
	1 1/4"	1 1/2"	1 25/32"	BU18	18.00	10					40
	1 1/4"	1 11/16"	1 7/8"	187*	12.50	10					21
	1 1/4"	1 25/32"	2 3/32"	BU19	15.00	10					40
	1 1/4"	1 7/8"	2 1/16"	206*	13.00	20					21
	1 1/4"	2 1/8"	2 3/8"	B19	14.00	10	BB19	49.00	RB19	128.00	40
	1 1/2"	1 13/16"	2"	BU22	17.50	10					40
	1 1/2"	2"	2 7/32"	B22	18.00	10					40
	1 1/2"	2"	2 1/8"	212*	15.00	10					21
	1 1/2"	2 1/16"	2 1/4"	225*	16.50	10					40
	1 1/2"	2 3/16"	2 3/8"	BU24	15.00	10	BBU24	90.00	RBU24	135.00	40
	1 1/2"	2 3/8"	2 9/16"	B24	15.00	10	BB24	90.00	RB24	135.00	40
	1 1/2"	[illegible]	2 3/4"	B25	17.50	10					40
	2"	2 1/4"	2 1/2"	250*	17.50	10					40
	2"	2 11/32"	2 17/32"	BU28	18.00	10					60
	2"	2 1/2"	2 3/4"	275*	21.50	10					40
 4-BOLT TYPE *4 GRIPPING FINGERS	2"	2 1/2"	2 25/32"	BU29	17.50	10	BBU29	90.00	RBU29	200.00	60
	2"	2 3/4"	3 1/16"	B29	18.50	10	BB29	90.00	RB29	200.00	60
	2"	2 3/4"	3 1/16"	306*	24.00	10					60
	2"	3 3/32"	3 7/16"	B30	35.50	5					60
	2 1/2"	3 1/16"	3 1/2"	350*	25.00	5					60
	2 1/2"	3 3/32"	3 7/16"	BU34	40.00	5					60
	2 1/2"	3 1/2"	3 15/16"	B34	40.00	5					150
	3"	3 1/2"	3 3/4"	375*	35.50	5					60
	3"	3 1/2"	3 15/16"	BU35	63.00	5					150
	3"	3 3/4"	4"	401*	57.00	5					150
	3"	3 13/16"	4 1/16"	B35	45.00	5					150
	3"	4"	4 3/16"	418*	76.50	4					200
	3"	4 1/16"	4 7/16"	B39	70.00	5					200
	3"	4 3/16"	4 1/2"	450*	70.00	2					200

THREE-PIECE
8-BOLT TYPE

Hose I.D.	Hose O.D.		Plated Malleable Iron			
Size	From:	To:	Part #	Price	Qty	Torque**
3"	4 1/4"	4 13/16"	BS39	$130.00	2	150
4"	4 5/8"	5"	B45	140.00	2	150
4"	4 7/8"	5 1/4"	BS49	190.00	2	200
4"	5 1/4"	5 19/32"	BU49	200.00	2	200
4"	5 17/32"	5 15/16"	B49	200.00	2	200
6"	6 7/8"	7 3/8"	750	240.00	1	200
6"	7 1/2"	8"	850	240.00	1	200

* 4 Gripping Fingers

**Recommended torque rating in FT. LBS. (for malleable iron & stainless steel clamps only)

VE 8555 (pg 544) 0

How To Use The Coupling Section

Couplings are designated by Block Numbers, and are described as to construction and source. Adapters and fittings are available for special applications.

Each coupling has a pressure rating of Low, Medium or High. These terms have a general meaning as follows:

Low Pressure	100 psi maximum
Medium Pressure	315 psi maximum
High Pressure	800 psi maximum

Coupling ratings apply only where the recommended clamps or bands are used. Use this information as a guide since different tube stocks affect coupling retension.

Common shank couplings or nipples with bands or clamps should be used only on straight or plain end water or material handling hoses up to the following rated working pressures:

½ - 1 ½" I.D. — 315 psi
2 -3" I.D. — 100 psi
4" I.D. — 75 psi
5" I.D. — 60 psi
6" I.D. — 50 psi
8" I.D. — 40 psi
10" I.D. — 30 psi

NOTE: Band-It's Swaged Hose Nipples, a form of combination nipples, can be used for higher rated working pressures. They are available in plated and unplated steel plus stainless steel with Tapered Pipe Thread for ½" through 6" I.D. hose.

Listed are all of the clamps, bands and ferrules used to secure the couplings to the hose. The proper clamp size should be selected carefully, since many clamps will fit only one hose size or a narrow range of sizes.

For certain critical fluids, specific couplings are used, as follows:

Critical Applications

1. Use only the couplings recommended in this catalog for conveying:
   Steam
   LP Gas
   Corrosive Chemicals
   Petroleum Products
2. For any high temperature application, use only interlocking type couplings— 14 or 15.
3. For conveying flammable fluids, use couplings made of nonsparking materials, such as brass or aluminum.
4. For ground fueling of aircraft, use certified coupled assemblies only.

When you have selected a hose from the Hose Section, you will have found one or more coupling recommendations for that hose. The following procedure will help you make the final selection.

A. If more than one coupling is recommended, make a final selection for type of coupling on basis of cost, sizes available, thread type available and application.

B. Determine how the coupling is to be fastened to the hose--ferrule, band or clamp.

Due to continual product improvements, Gates reserves the right to alter specs and prices without prior notice.

Coupling Installation

Before making any hose assembly, check over these general instructions and precautions:

1. **Square Ends**—Before attaching a coupling to the hose, make sure the end is cut square. This will help prevent leakage of the coupling.
2. **Proper Fit of Ferrules and Clamps**—This is important. Make sure you are using the correct sizes for the hose being coupled. Never buff the cover, except when specified for certain hydraulic hose couplings, and you should not enlarge the hose tube in any way to make the coupling insert fit. Occasionally, a nipple pusher tool will be helpful in pushing the insert into the hose.
3. **Installation Lubricants**—Use of lubricants on coupling inserts and ferrules will simplify coupling installation and reduce possibility of damage to the hose. Some lubricants to use are water, soap solution or lactol. Or, you can use a solution of glycerin and alcohol made up of one (l) part glycerin and 15 parts wood alcohol by volume.
4. **Appearance of the Hose Assembly**—A properly installed coupling significantly improves customer acceptance of the product. It also provides added assurance of satisfactory service and safety of assembly.
5. **Seal the Ends**—Where the hose is intended for use in petroleum transfer applications and hose ends will be exposed after couplings are attached, apply a sufficient amount of quality Neoprene cement or shellac to seal the ends.
6. **Critical Applications.**

   (a) Use only the couplings recommended on pages 134-140 for conveying:
   - Steam
   - LP Gas
   - Corrosive Chemicals
   - Petroleum Products
   - Edible Products

   (b) For any high temperature applications, use only interlocking type couplings—14 or 15.

   (c) For conveying flammable fluids, use couplings made of nonsparking materials; i.e., brass or aluminum.

   (d) For aircraft ground fueling hose, use factory coupled assemblies only.

NOTE: For a complete listing of couplings and installation information, refer to Gates Coupling Manual #39505.

Due to continual product improvements, Gates reserves the right to alter specs and prices without prior notice.

E-14-41-01
E-14-41-03
E-14-41-05

Gates®

Industrial Hose Products/List Prices

39496-000
March 30, 1992
Supersedes 39496-000
January 2, 1990

Couplings for Gates Hoses

E-14-41-07
E-14-41-09
E-14-41-11

1 Long Shank

Description: Cast brass, serrated shank, set has hex male and hex swivel female couplings, with a washer seal. Threads are GHT or NPSM.
Sources: Dixon Valve & Coupling Co.
John W. Moon, Inc.
H.B. Sherman Mfg. Co.
Seal-Fast Bobo, Inc.

2 Lightweight Water Hose

Description: Spun or wrought brass serrated shank, round swivel female and solid male, both GHT, washer seal.
Sources: American Coupling Co.
L.R. Nelson Corp.
H.B. Sherman Mfg. Co.

3 Cast Brass Short Shank

Description: Cast brass, serrated shank, hex swivel female with washer, solid male, GHT threads, ¾-11½.
Sources: J.C. Gadd Co.
John W. Moon, Inc.
H.B. Sherman Mfg. Co.
Seal-Fast Bobo, Inc.
Stayput Clamp & Coupling Co.

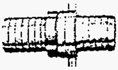
4 Machined Brass Short Shank

Description: Machined brass, serrated shank. Each set has round swivel female and solid male, GHT, washer seal. Octagon nut male and female.
Sources: American Coupling Co.
Anchor-Lenz Div.
Royal Brass, Inc.
H.B. Sherman Mfg. Co.

5 Brass Pin-~~Lug~~

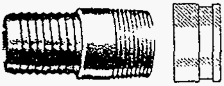
Description: Cast brass shank and swivel, shank is serrated. NPSM threads in female and male, with washer seal. Sizes under 3" have lugs on female only.
Sources: John W. Moon, Inc.
Dixon Valve & Coupling Co.

6 Malleable Iron Pin Lug



Description: Malleable iron shank and swivel with serrated shank, cadmium plated. NPSM threads in male and female, washer seal. Pin lugs on female only.
Sources: Dixon Valve & Coupling Co.
H.B. Sherman Mfg. Co.
Seal-Fast Bobo, Inc.

7 Combination Nipple



Victaulic Nipple

Description: Swaged steel with scored or serrated shank, NPT threads same nominal size as I.D. of hose. Special plastic materials available.
Sources: Band-It
Dixon Valve & Coupling Co.
Martin Brass Works, Inc.
Screw Machine Products Co.
Seal-Fast Bobo, Inc.
Stayput Clamp & Coupling Co.

MS-46

8 Tri-Lokt

Description: Machined steel insert, male NPT threads only. Held in place with steel yoke and Band-It Jr. clamps. Insert is reusable—can be reinstalled with new yoke and clamps.
Source: Band-It

10 Single or Double Bolt Malleable Iron Clamp

Description: Cast malleable iron, cadmium plated.
Source: Dixon Valve & Coupling Co.

[illegible]

Part #
S650
BU49 clamp

14 Interlocking, Ground Joint

Boss Coupling

Description: Malleable iron swivel. Inserts and spud may be either steel or malleable iron. All parts are cadmium plated. Male and female threads both NPT with same nominal size as hose I.D. Ground joint between spud and female insert. Available with 2- and 4-bolt clamps.
Sources: Dixon Valve & Coupling Co.
Seal-Fast Bobo, Inc.

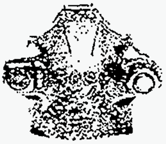
15 Interlocking, Washer Joint

Description: Malleable iron swivel. Insert and spud may be either malleable iron or steel. All parts are cadmium plated. Female thread in spud is NPT with same nominal size as hose I.D. Washer joint between insert and spud. Available with 2- and 4-bolt clamps.
Source: Dixon Valve & Coupling Co.

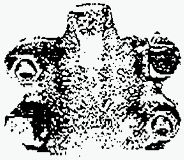
Due to continual product improvements, Gates reserves the right to alter specs and prices without prior notice.

BOSS COUPLINGS

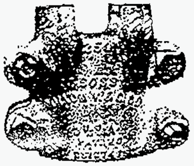
"BOSS" CLAMPS



2-BOLT TYPE



4-BOLT TYPE
2 GRIPPING FINGERS



4-BOLT TYPE
*4 GRIPPING FINGERS

Hose I.D.	Hose O.D.		Plated Malleable Iron			Brass Shipped from factory only.		Stainless Steel Shipped from factory only.		
Size	From:	To:	*Part #*	Price	Qty	*Part #*	Price	*Part #*	Price	Torque**
1/4"	9/16"	21/32"	*BD*	$3.95	100					6
3/8"	11/16"	7/8"	*CD*	3.95	100					6
1/2"	13/16"	15/16"	*DD*	3.95	100					6
1/2"	15/16"	1 1/16"	*B4*	3.95	25	*BB4*	$13.00	*RB4*	$90.00	12
1/2"	1 1/16"	1 3/16"	*B5*	4.25	25					12
3/4"	1 5/32"	1 9/32"	*BU9S*	5.30	50					21
3/4"	1 3/16"	1 5/16"	*BU9*	5.30	50	*BBU9*	16.00	*RBU9*	99.00	21
3/4"	1 5/16"	1 1/2"	*B9*	5.30	25	*BB9*	16.00	*RB9*	99.00	21
3/4"	1 1/2"	1 11/16"	*B10*	6.00	25					21
1/2"	29/32"	1 1/32"	*968*	6.00	50					6
1"	1 13/32"	1 9/16"	*156**	9.45	20					21
1"	1 17/32"	1 23/32"	*BU14*	9.45	25	*BBU14*	45.00	*RBU14*	126.00	21
1"	1 11/16"	1 15/16"	*B14*	9.65	25	*BB14*	49.00	*RB14*	126.00	21
1"	1 15/16"	2 1/8"	*B15*	11.00	20					21
1 1/4"	1 1/2"	1 25/32"	*BU18*	18.00	10					40
1 1/4"	1 11/16"	1 7/8"	*187**	12.50	10					21
1 1/4"	1 25/32"	2 3/32"	*BU19*	18.00	10					40
1 1/4"	1 7/8"	2 1/16"	*206**	13.00	20					21
1 1/4"	2 1/8"	2 3/8"	*B19*	14.00	10	*BB19*	49.00	*RB19*	128.00	40
1 1/2"	1 13/16"	2"	*BU22*	17.50	10					40
1 1/2"	2"	2 7/32"	*B22*	18.00	10					40
1 1/2"	2"	2 1/8"	*212**	15.00	10					21
1 1/2"	2 1/16"	2 1/4"	*225**	16.50	10					40
1 1/2"	2 3/16"	2 3/8"	*BU24*	15.00	10	*BBU24*	90.00	*RBU24*	135.00	40
1 1/2"	2 3/8"	2 9/16"	*B24*	15.00	10	*BB24*	90.00	*RB24*	135.00	40
1 1/2"	2 9/16"	2 3/4"	*B25*	17.50	10					40
2"	2 1/4"	2 1/2"	*250**	17.50	10					40
2"	2 11/32"	2 17/32"	*BU28*	[illegible]	10					60
2"	2 1/2"	2 3/4"	*275**	21.50	10					40
2"	2 1/2"	2 25/32"	*BU29*	17.50	10	*BBU29*	90.00	*RBU29*	200.00	60
2"	2 3/4"	3 1/16"	*B29*	[illegible]	10	*BB29*	90.00	*RB29*	200.00	60
2"	2 3/4"	3 1/16"	*306**	24.00	10					60
2"	3 3/32"	3 7/16"	*B30*	35.50	5					60
2 1/2"	3 1/16"	3 1/2"	*350**	25.00	5					60
2 1/2"	3 3/32"	3 7/16"	*BU34*	40.00	5					60
2 1/2"	3 1/2"	3 15/16"	*B34*	40.00	5					150
3"	3 1/2"	3 3/4"	*375**	35.50	5					60
3"	3 1/2"	3 15/16"	*BU35*	63.00	5					150
3"	3 3/4"	4"	*401**	57.00	5					150
3"	3 13/16"	4 1/16"	*B35*	45.00	5					150
3"	4"	4 3/16"	*418**	76.50	4					200
3"	4 1/16"	4 7/16"	*B39*	70.00	5					200
3"	4 3/16"	4 1/2"	*450**	70.00	2					200

THREE-PIECE
6-BOLT TYPE

Hose I.D.	Hose O.D.		Plated Malleable Iron			
Size	From:	To:	*Part #*	Price	Qty	Torque**
3"	4 1/4"	4 13/16"	*BS39*	$130.00	2	150
4"	4 5/8"	5"	*B45*	140.00	2	150
4"	4 7/8"	5 1/4"	*BS49*	190.00	2	200
4"	5 1/4"	5 19/32"	*BU49*	200.00	2	200
4"	5 17/32"	5 15/16"	*B49*	200.00	2	200
6"	6 7/8"	7 3/8"	*750*	240.00	1	200
6"	7 1/2"	8"	*850*	240.00	1	200

* 4 Gripping Fingers
**Recommended torque rating in FT. LBS. (for malleable iron & stainless steel clamps only)

GF-141 (4")
WF-141 (4")

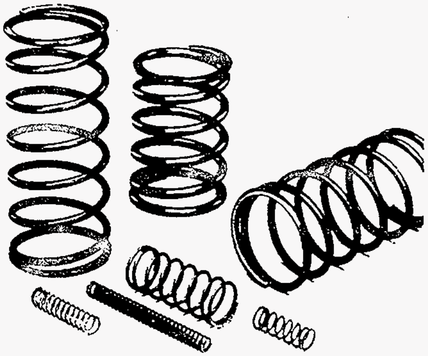
FAX MEMO

#PAGES 3 DATE 7/6 FAX#
CO.
ATTN: Mike Custer
FROM AMERICAN HOSE & FITTINGS 5
PH# (206) 872-8080 FAX# (206) 395-3410

J-25-05

Compression Springs

Stock sizes in music wire and stainless steel



Associated Spring offers a broad variety of helical compression springs in the SPEC selection. They are reliable, inexpensive and efficient — the right combination for general-purpose use throughout industry.

Material

Music wire
ASTM-A228 or AMS 5112
Stainless steel
Commercial Type 302, ASTM-A313 or
AMS 5688 spring temper. (chemical & physical only)

No charge for certificate of compliance when requested; certificate of chemical analysis available, see price book.

Music wire will be furnished unless stainless steel is specified. When inquiring or ordering, use letter "M" or letter "S" as suffix on catalog numbers to designate music wire or stainless steel wire, respectively.

Music wire springs are not recommended for applications where the temperature exceeds 250 deg F (121 deg C). Stainless steel springs are not recommended for applications where the temperature exceeds 500 deg F (260 deg C).

Direction of Helix

Right hand.

Ends

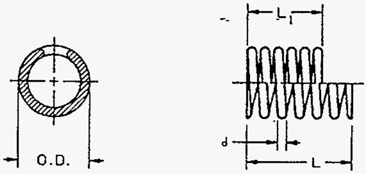
Squared and ground. Ends to be square within 3° with axis O.D. sizes 0.057-0.088 in (1.45-2.24 mm) squared ends not ground.

Free length L is for reference use only. Load P is attained at length L_1. For stainless steel multiply P by 0.833.

Load values shown are for music wire.

For normal service, springs should not be compressed below L_1.

To determine load P at any length other than L_1, multiply the proposed deflection by the rate R. *[P + (L-Lx) x R] When stainless steel is used the value for rate R must be corrected by multiplying R by 0.833.



Finishes

Standard finish is that of the normal wire. Shot-peened and plated finishes furnished on request. Allow sufficient additional time for special finishes.

Tolerances

O.D. (English)	O.D. (Metric)
0.057 to 0.119 in ± 0.003 in	1.45 to 3.02 mm ± 0.08 mm
0.120 to 0.240 in ± 0.005 in	3.05 to 6.10 mm ± 0.13 mm
0.241 to 0.500 in ± 0.008 in	6.12 to 12.70 mm ± 0.20 mm
0.501 to 1.000 in ± 0.015 in	12.73 to 25.40 mm ± 0.38 mm
1.001 to 1.225 in ± 0.020 in	25.43 to 31.12 mm ± 0.51 mm
1.226 to 1.460 in ± 0.030 in	31.14 to 37.08 mm ± 0.76 mm
1.461 to 2.000 in ± 0.040 in	37.11 to 50.80 mm ± 1.02 mm

STOCK COMPRESSION SPRINGS
Music Wire and Stainless Steel

Associated Spring Raymond BARNES

CATALOG NUMBER*	Outside Diameter		Wire Diameter		Free Length L, Approx.		Load, P at L_1		Length, L_1		Solid Height, Approx.		Spring Rate, R	
	in	*mm*	in	*mm*	in	*mm*	lb†	*N*†	in	*mm*	in	*mm*	lb/in†	*N/mm*†
C0600-063-2000	0.600	*15.24*	0.063	*1.60*	2.00	*50.80*	18.00	*80.07*	1.059	*26.90*	0.700	*17.78*	18.0	*3.15*
C0600-063-2250					2.25	*57.15*			1.184	*30.07*	0.768	*19.51*	15.9	*2.78*
C0600-063-2500					2.50	*63.50*			1.308	*33.22*	0.836	*21.23*	14.2	*2.49*
C0600-063-2750					2.75	*69.85*			1.433	*36.40*	0.863	*21.92*	13.7	*2.40*
C0600-063-3000					3.00	*76.20*			1.558	*39.57*	0.927	*23.55*	12.5	*2.19*
C0600-063-3500					3.50	*88.90*			1.807	*45.90*	1.055	*26.80*	10.6	*1.856*
C0600-067-0625			0.067	*1.70*	0.62	*15.75*	21.00	*93.41*	0.360	*9.14*	0.300	*7.62*	80.0	*14.01*
C0600-067-0750					0.75	*19.05*			0.430	*10.92*	0.336	*8.53*	66.0	*11.56*
C0600-067-0880					0.88	*22.35*			0.455	*11.56*	0.401	*10.19*	50.0	*8.76*
C0600-067-1000					1.00	*25.40*			0.530	*13.46*	0.430	*10.92*	45.0	*7.88*
C0600-067-1250					1.25	*31.75*			0.665	*16.89*	0.505	*12.83*	36.0	*6.30*
C0600-067-1500					1.50	*38.10*			0.780	*19.81*	0.594	*15.09*	29.0	*5.08*
C0600-067-1750					1.75	*44.45*			0.830	*21.08*	0.715	*18.16*	23.0	*4.03*
C0600-067-2000					2.00	*50.80*			1.106	*28.09*	0.771	*19.58*	22.5	*3.94*
C0600-067-2250					2.25	*57.15*			1.236	*31.39*	0.847	*21.51*	19.8	*3.47*
C0600-067-2500					2.50	*63.50*			1.366	*34.70*	0.923	*23.44*	17.7	*3.10*
C0600-067-2750					2.75	*69.85*			1.496	*38.00*	0.966	*24.54*	16.7	*2.92*
C0600-067-3000					3.00	*76.20*			1.626	*41.30*	1.040	*26.42*	15.3	*2.68*
C0600-072-0620			0.072	*1.83*	0.62	*15.75*	24.00	*106.76*	0.405	*10.29*	0.381	*9.68*	114.5	*20.05*
C0600-072-0750					0.75	*19.05*			0.445	*11.30*	0.396	*10.06*	78.0	*13.66*
C0600-072-0880					0.88	*22.35*			0.520	*13.21*	0.433	*11.00*	68.0	*11.91*
C0600-072-1000					1.00	*25.40*			0.565	*14.35*	0.502	*12.75*	55.0	*9.63*
C0600-072-1250					1.25	*31.75*			0.710	*18.03*	0.581	*14.76*	45.0	*7.88*
C0600-072-1500					1.50	*38.10*			0.830	*21.08*	0.691	*17.55*	36.0	*6.30*
C0600-072-1750					1.75	*44.45*			0.950	*24.13*	0.801	*20.35*	30.0	*5.25*
C0600-072-2000					2.00	*50.80*			1.140	*28.96*	0.848	*21.54*	28.0	*4.90*
C0600-072-2250					2.25	*57.15*			1.301	*33.05*	0.946	*24.03*	25.9	*4.54*
C0600-072-2500					2.50	*63.50*			1.438	*36.53*	1.033	*26.24*	23.1	*4.05*
C0600-072-2750					2.75	*69.85*			1.601	*40.67*	1.119	*28.42*	20.9	*3.66*
C0600-072-3000					3.00	*76.20*			1.742	*44.25*	1.206	*30.63*	19.1	*3.34*
C0600-081-0620			0.081	*2.06*	0.62	*15.75*	32.69	*145.41*	0.466	*11.84*	0.412	*10.46*	212.6	*37.23*
C0600-081-0750					0.75	*19.05*			0.553	*14.05*	0.459	*11.66*	165.6	*29.00*
C0600-081-0880					0.88	*22.35*			0.639	*16.23*	0.507	*12.88*	135.6	*23.74*
C0600-081-1000					1.00	*25.40*			0.719	*18.26*	0.552	*14.02*	116.2	*20.35*
C0600-081-1250					1.25	*31.75*			0.885	*22.48*	0.644	*16.36*	89.5	*15.67*
C0600-081-1500					1.50	*38.10*			1.051	*26.70*	0.736	*18.69*	72.8	*12.75*
C0600-081-1750					1.75	*44.45*			1.217	*30.91*	0.828	*21.03*	61.3	*10.73*
C0600-081-2000					2.00	*50.80*			1.383	*35.13*	0.920	*23.37*	53.0	*9.28*
C0600-081-2250					2.25	*57.15*			1.549	*39.34*	1.012	*25.70*	46.6	*8.16*
C0600-081-2500					2.50	*63.50*			1.715	*43.56*	1.104	*28.04*	41.7	*7.30*
C0600-081-2750					2.75	*69.85*			1.881	*47.78*	1.196	*30.38*	37.6	*6.58*
C0600-081-3000					3.00	*76.20*			2.047	*51.99*	1.288	*32.72*	34.3	*6.01*
C0600-081-3250					3.25	*82.55*			2.213	*56.21*	1.380	*35.05*	31.5	*5.52*
C0600-081-3500					3.50	*88.90*			2.379	*60.43*	1.472	*37.39*	29.2	*5.11*
C0600-081-3750					3.75	*95.25*			2.545	*64.64*	1.564	*39.73*	27.1	*4.75*
C0600-081-4000					4.00	*101.60*			2.711	*68.86*	1.656	*42.06*	25.4	*4.45*
C0600-085-0620			0.085	*2.16*	0.62	*15.75*	37.62	*167.33*	0.477	*12.12*	0.433	*11.00*	262.5	*45.96*
C0600-085-0750					0.75	*19.05*			0.565	*14.35*	0.484	*12.29*	203.6	*35.65*
C0600-085-0880					0.88	*22.35*			0.654	*16.61*	0.536	*13.61*	166.4	*29.14*
C0600-085-1000					1.00	*25.40*			0.736	*18.69*	0.583	*14.81*	142.3	*24.92*
C0600-085-1250					1.25	*31.75*			0.906	*23.01*	0.682	*17.32*	109.4	*19.16*
C0600-085-1500					1.50	*38.10*			1.076	*27.33*	0.781	*19.84*	88.8	*15.55*
C0600-085-1750					1.75	*44.45*			1.247	*31.67*	0.880	*22.35*	74.8	*13.10*
C0600-085-2000					2.00	*50.80*			1.417	*35.99*	0.978	*24.84*	64.5	*11.29*
C0600-085-2250					2.25	*57.15*			1.588	*40.34*	1.077	*27.36*	56.8	*9.95*
C0600-085-2500					2.50	*63.50*			1.758	*44.65*	1.176	*29.87*	50.7	*8.88*
C0600-085-2750					2.75	*69.85*			1.928	*48.97*	1.275	*32.39*	45.8	*8.02*
C0600-085-3000					3.00	*76.20*			2.099	*53.31*	1.374	*34.90*	41.7	*7.30*
C0600-085-3250					3.25	*82.55*			2.269	*57.63*	1.473	*37.41*	38.3	*6.71*
C0600-085-3500					3.50	*88.90*			2.439	*61.95*	1.572	*39.93*	35.5	*6.22*
C0600-085-3750					3.75	*95.25*			2.610	*66.29*	1.670	*42.42*	33.0	*5.78*
C0600-085-4000					4.00	*101.60*			2.780	*70.61*	1.769	*44.93*	30.8	*5.39*
C0600-092-0750			0.092	*2.34*	0.75	*19.05*	46.46	*206.65*	0.591	*15.01*	0.524	*13.31*	291.5	*51.04*
C0600-092-0880					0.88	*22.35*			0.684	*17.37*	0.581	*14.76*	237.0	*41.50*
C0600-092-1000					1.00	*25.40*			0.770	*19.56*	0.633	*16.08*	202.2	*35.41*

†For stainless steel, multiply values by 0.833.

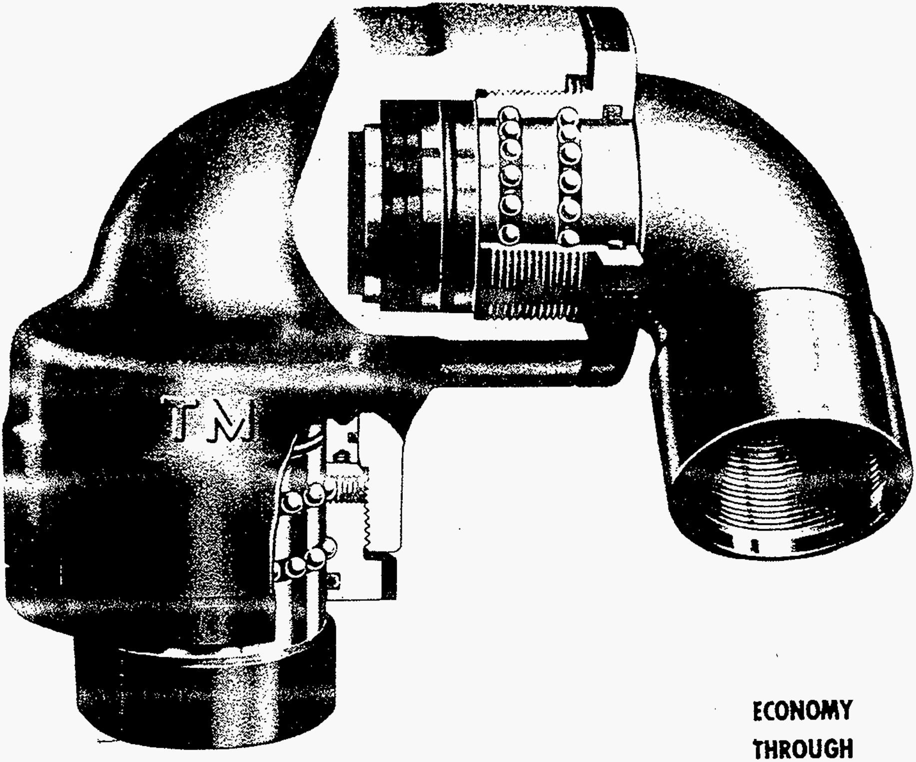
****When inquiring or ordering, use letter "M" or letter "S" as suffix on catalog numbers to designate music wire or stainless-steel wire, respectively.***

PHONE (408) 736-5202
1

VE 7954

— NPT (NATIONAL PIPE THREAD)
(SINGLE POINT THREAD)

E-21-15



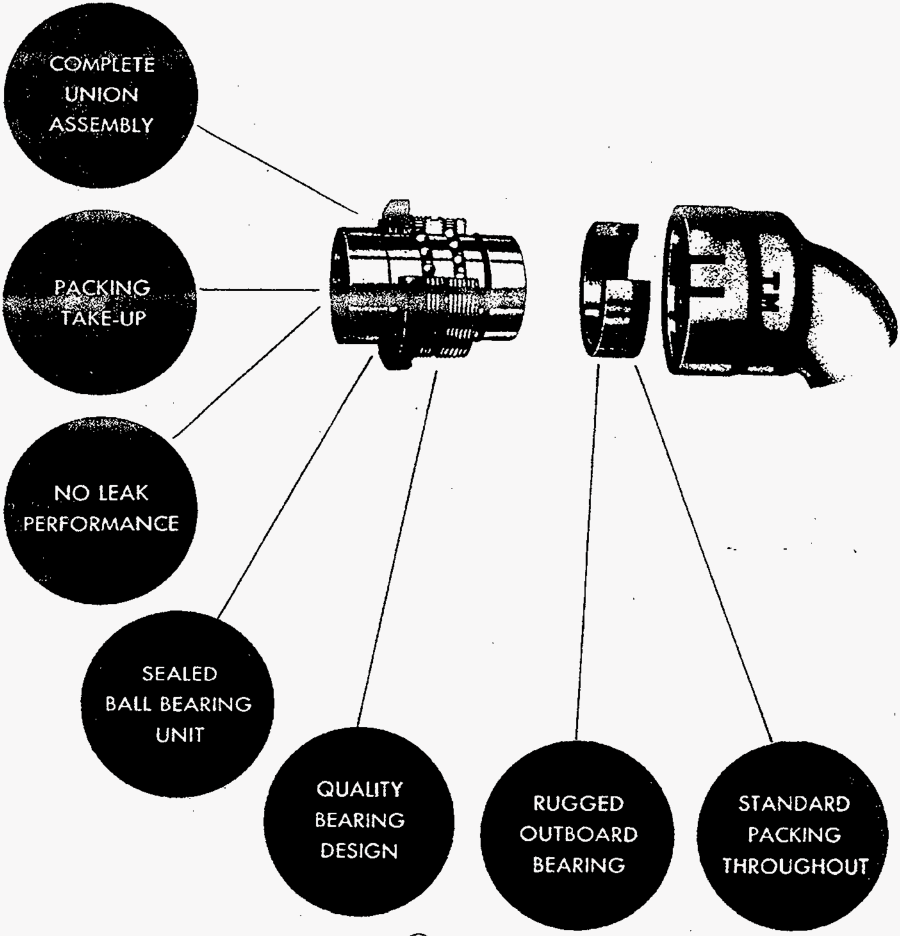
**ECONOMY
THROUGH
QUALITY**

T-M
SWIVEL JOINTS

T-M MFG. CO. 695 E. ARQUES AVE., SUNNYVALE, CALIF. 94086-3832
A

E-21-15

T-M SWIVEL JOINTS



B

E-21-15

COMPLETE UNION ASSEMBLY

Repack anywhere, anytime, without handling ball bearings, even when welded into the line. Reduces service and maintenance to an absolute minimum.

PACKING TAKE-UP

Chevron packing compensates for normal wear, varying temperatures, extremely volatile materials. Extends packing life as much as 400 %.

NO-LEAK PERFORMANCE

Superior engineering design enable guaranteed, no-leak performance from gases to acids to drilling cement.

SEALED BALL BEARING UNIT

Factory assembled rotating unit sealed from outside contaminants and line fluids by "o" rings. Lubricants are sealed in and foreign matter sealed out. Reduces maintenance costs by eliminating daily lubrication. Quality design will cut costs, extend life of joints.

QUALITY BEARING DESIGN

The finest alloy steels used in manufacture of T-M Joints. Through hardened ball races in 6000 and 15,000 steel series coupled with hardened chrome alloy steel balls assure longer life, lower maintenance costs and fewer replacements.

RUGGED OUTBOARD BEARING

The packing backup ring acts as a solid bearing during severe or shock loads. Protects the ball races from brinnelling. Eliminates misalignment leaks. Guarantees top performance under all conditions.

STANDARD PACKING THROUGHOUT

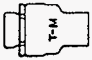
No special packing worries with T-M. Packing for all services is available in standard sizes and materials.

T-M

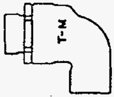
E-21-15
STYLES

SWIVEL JOINTS

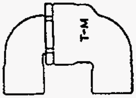
No. 100
STRAIGHT SINGLE SWIVEL



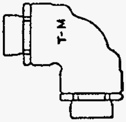
No. 200
ELL SINGLE SWIVEL



No. 300
2 ELL SINGLE SWIVEL



No. 400
1 ELL DOUBLE SWIVEL



MATERIALS

125 PSI Aluminum Alloy
Color Code: Aluminum

1000 PSI Steel
Color Code: Blue

6000 PSI Steel
Color Code: Red

15,000 PSI Steel
Color Code: Yellow

125 PSI Type 316 Stainless Steel
Color Code: #316

Special Alloys
Color Code by Type

PSI = Maximum Working Pressure

TEMPERATURES

225° Hycar Packing
450° Aramid Fiber
550° Aramid Fiber
300° Teflon
400° Viton

SIZES

3/8" – Thru 16" Pipe Size
Larger on request

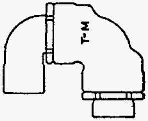
END CONNECTIONS

Threaded Ends (TE) (Female)
Beveled for Weld (BV) (Beveled)
Bored for Weld (BR) (Bored)
Flanged
Special ---On Order

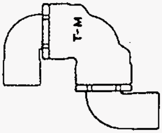
SPECIAL ORDERS

We will be pleased to submit prices on your special requirements. Manufactured on Order.

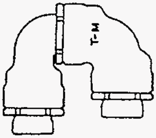
No. 500
2 ELL DOUBLE SWIVEL



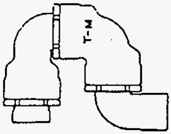
No. 600
3 ELL DOUBLE SWIVEL



No. 700
2 ELL TRIPLE SWIVEL

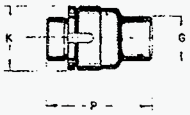


No. 800
3 ELL TRIPLE SWIVEL



E-21-15

THREADED AND BORED FOR WELDING



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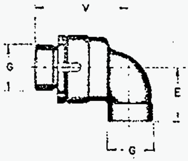

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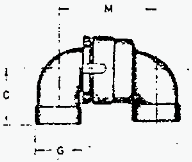

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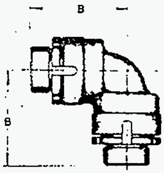

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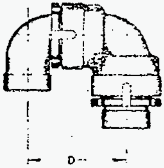

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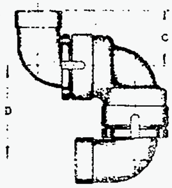

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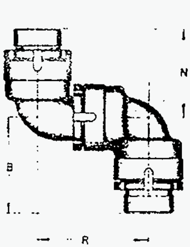

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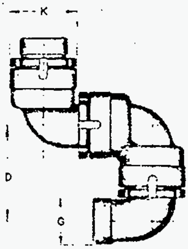


STYLE 800

DIMENSIONS

SIZES	B	C	D	E	G	K	M	N	P	R	V	SIZE
⅜ & ½	3½	2	3⅜	1⅞	1¼	2	3	3⅛	3⅞	3⅝	3⅞	⅜ & ½
¾ & 1	4¼	2⅜	4¼	2¼	1¾	2⅞	4⅛	4⅛	4⅜	5	4⅛	¾ & 1
1¼	4¾	2¾	4¾	2¾	2⅛	3⅛	4⅝	4⅝	5⅛	5 3/16	5¼	1¼
1½	5½	3	6	3¼	2½	3½	6	5¼	5¾	5 15/16	5⅛	1½
2	6⅜	3½	6⅝	4¼	3⅛	4⅝	6⅝	6	6⅜	7⅜	6¼	2
2½	6⅞	4	7⅜	4	3¾	5¼	6⅞	6⅜	6⅞	8¼	6⅜	2½
3	7¾	4⅞	9⅛	4¼	4¼	5⅞	8⅛	7⅓	7 5/16	10⅛	7	3
4	9¼	5½	10⅛	5½	5½	7¼	10⅛	9¼	8¾	11½	8⅝	4

All dimensions given in inches ±⅛"

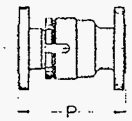
For sizes larger than 4" refer to section on fabricated joints.

E-21-15

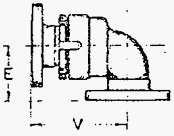
FLANGED (SERIES 15)

T-M

SWIVEL JOINTS



STYLE 100



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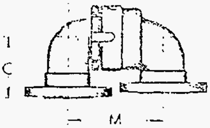

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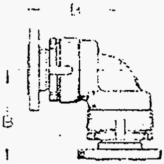

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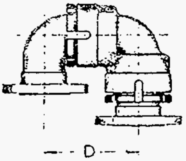

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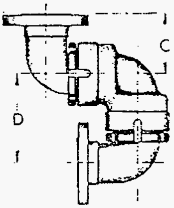

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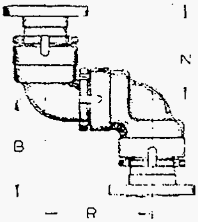

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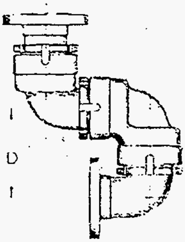


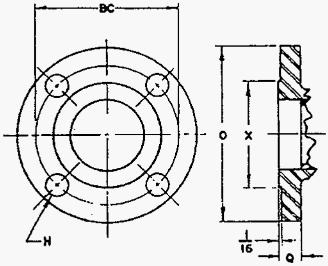
STYLE 800

JOINT DIMENSIONS											FLANGE DIMENSIONS						
SIZES	B	C	D	E	M	N	P	R	V	No. Holes	BC	H	Bolt Size	O	Q	X	SIZES
2	6⅞	4	6⅝	4¾	6⅝	6½	7⅜	7⅜	6¾	4	4¾	¾	⅝	6	¾	3⅝	2
2½	7½	4⅝	7⅜	4⅝	6⅞	7	8⅛	8¼	7	4	5½	¾	⅝	7	⅞	4⅛	2½
3	8½	5½	9⅛	4⅞	8⅛	7⅞	8¾	10⅛	7⅝	4	6	¾	⅝	7½	15/16	5	3
4	9⅞	6¼	10⅛	6¼	10⅛	10	10¼	11 7/16	9⅜	8	7½	¾	⅝	9	15/16	6 3/16	4

All dimensions given in inches ±1/8"

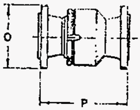
For sizes larger than 4" refer to section on fabricated joints.

For dimensions of other series flanged joints consult factory.



E-21-15

FABRICATED



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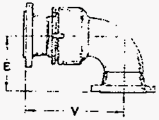

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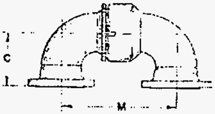

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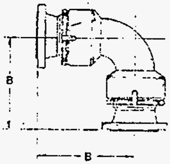

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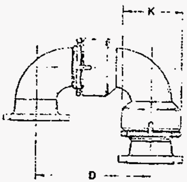

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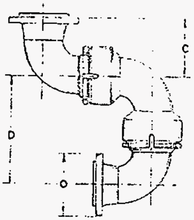

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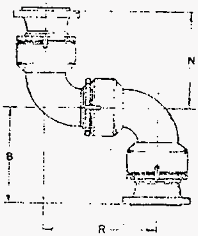

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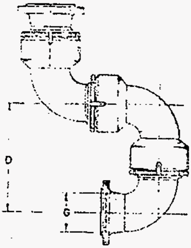


STYLE 800

D I M E N S I O N S

	SIZES	B	C	D	E	G	K	M	N	O	P	R	V	SIZES
BEVELED FOR WELDING	6	13¼	6	19½	6	—	9⅞	19¾	13½	—	7¼	19¾	13½	6
	8	16	8	24¼	8	—	12	24¼	16	—	7¾	24¼	16	8
	10	18	10	28¼	10	—	14	28¼	18	—	7¾	28¼	18	10
	12	20	12	32¼	12	—	16	32¼	20	—	7¾	32¼	20	12
THREADED	6	16	8¾	19	8¾	7½	9⅞	19¾	16¼	—	12¾	19¾	16¼	6
	8	19	11	24¼	11	9⅝	12	24¼	19	—	13¾	24¼	19	8
FLANGED (SERIES 15)	6	17¼	9¾	19½	9¾	—	9⅞	19¾	17	11	14¾	19¾	17¼	6
	8	20¼	12¼	24¼	12¼	—	12	24¼	20¼	13½	16¼	24¼	20¼	8
	10	22¼	14¼	28¼	14¼	—	14	28¼	22¼	16	16¼	28¼	22¼	10
	12	24¾	16¾	33¼	16¾	—	16	32¼	24¾	19	17¼	32¼	24¾	12

All dimensions given in inches ±⅛"

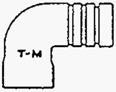
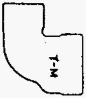
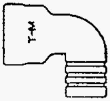
For dimensions of other series
flanged joints consult factory.

E-21-15

T-M

REPLACEMENT PARTS

SWIVEL JOINTS

Part 1 STRAIGHT SWIVEL NIPPLE 	Part 2 HOLDING NUT 	Part 3 STRAIGHT ONE SWIVEL BODY 	Part 4 ELL SWIVEL NIPPLE 
Part 5 ELL TWO SWIVEL BODY 	Part 6 ELL ONE SWIVEL BODY 	Part 7 ELL TWO SWIVEL NIPPLE 	ACCESSORIES: Ball Bearings Lock Bar O-Ring - V-Ring Adapters (Upper and Lower) Counterbalance Lug; designated by "X" after part number.

SERVICING

(1) T-M Swivel Joints are greased at the factory and require only occasional greasing unless joint is in constant rotation or high temperature service. When greasing, remove slotted plug on outside of body, and insert alemite fitting.

(2) Provision has been made for take-up on the packing. After packing wears, remove lock bar, turn nut clockwise to next locking slot and reinstall lock bar. Process may be repeated until packing has worn too badly to effect seal.

REPACKING

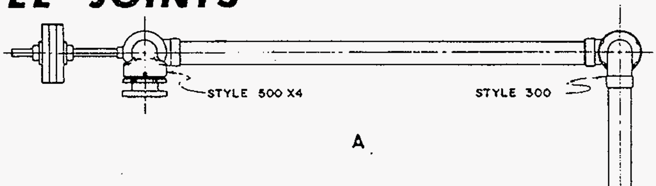
(1) Remove lock bar.
(2) Remove nut and nipple assembly from body by turning nut counter clockwise.
(3) Remove back-up ring from body.
(4) Remove 2 packing rings.
(5) Remove male adaptor.
(6) Clean packing chamber and reinstall (1) male adaptor (2) new packing and (3) back-up ring. Grease all parts thoroughly.
(7) Insert nut and nipple assembly in body and reassemble. Rotate nipple occasionally as the nipple passes through the packing.
(8) Screw nut clockwise until compression on packing causes nipple to rotate with a mild amount of torque.
(9) You do not need to handle the balls or disassemble the nut and nipple to repack the T-M Swivel Joint.

T-M

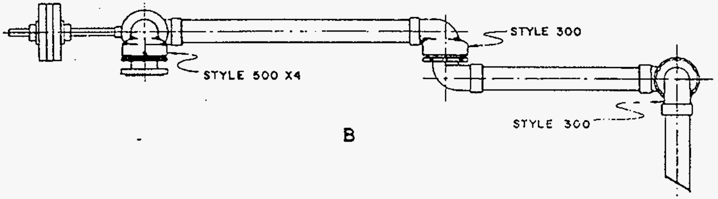
E-21-15

LOADING RACKS

SWIVEL JOINTS



A



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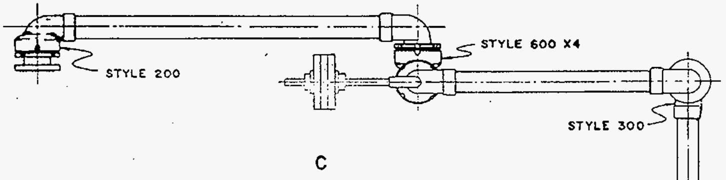
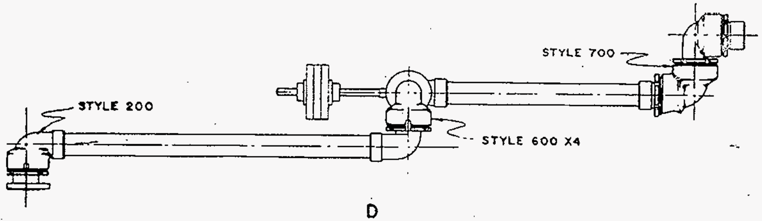


C



D

T-M Swivel Joints assembled into the 4 basic tank car and tank truck designs will enable you to transfer your product with economy and safety.

Even when welded into the line T-M Swivel Joints can be taken up to compensate for packing wear or separated for repacking. Overhung loads do not cause leaks on T-M loading arms due to the rugged design.

Furnished in aluminum, steel and stainless steel and packed to fit your individual requirements. Other designs on request.

COUNTER BALANCE DESIGN

Since counterbalance design necessarily varies with each installation, we have shown no standard design.

Please consult the factory for prices and furnish the following information (1) Clearance restrictions and (2) Overhung loading.

E-21-15

PACKING AND COMPONENT PARTS

SWIVEL JOINT SIZE	3/8" & 1/2"	3/4" & 1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	6"	8"	10"	12"
SIZE 6225 CHEVRON PACKING	-20	-28	-30	-32	-39	-44	-49	-54	-63	-68	-72	-76
SIZE 6229 MALE ADAPTOR	-20	-28	-30	-32	-39	-44	-49	-54	-63	-68	-72	-76
FEMALE ADAPTOR p/n 8	50-8	100-8	125-8	150-8	200-8	250-8	300-8	400-8	600-8	800-8	1000-8	1200-8
*SIZE 6227 AND 6230 "O" RING p/n 1	7-15	7-25	0-01	0-03	0-09	0-14	0-18	0-28	0-40	30-47	7-77	7-81
*SIZE 6227 AND 6230 "O" RING p/n 2	7-19	0-01	0-03	0-05	0-11	0-16	0-20	0-30	0-41	30-49	7-79	7-83
BALL SIZE	3/16	1/4	1/4	5/16	5/16	3/8	3/8	7/16	9/16	9/16	9/16	9/16
NUMBER OF BALLS PER ROTATING ELEMENT	32	40	46	42	56	58	66	74	80	104	126	148
SIZE DESIGNATION LOCK BAR p/n 10	1/4	1/4	1/4	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2
SIZE DESIGNATION BALL PLUGS	1/4	5/16	5/16	3/8	3/8	7/16	7/16	1/2	5/8	5/8	5/8	5/8

* ALL "O" RINGS PRECEDED BY 7 INDICATES 6227 SERIES; PRECEDED BY O INDICATES 6230 SERIES.

STANDARD AND OPTIONAL MATERIALS

CHEVRON PACKING

Standard Hycar: To 225°F working temperature
Optional Teflon: To + 300°F Acid Services
Optional Aramid Fiber: To 450°F working temp.
Optional Aramid Fiber: To 550°F working temp.
Optional Viton: To 400°F working temperature

MALE ADAPTOR

Standard Buna N: To 225°F working temperature
Optional Aluminum: Acid and corrosive services
Optional Teflon: Acid Services
Optional Stainless Steel: Alloy to suit application
Optional Hi-Temp: To 550°F working temperature

FEMALE ADAPTOR

Standard Steel: To 550°F working temperature
Optional Aluminum: Acid and corrosive services
Optional Stainless Steel: Alloy to suit application

ALL "O" RINGS

Standard Buna-N: To 225°F working temperature
Optional Teflon: Acid Services
Optional Silicon: To 450°F working temperature
Optional Viton: To 450°F working temperature

DISTRIBUTION SHEET

To Distribution	From JW Bailey	Page 1 of 1
		Date 23 July 1998
Project Title/Work Order Project W-320 Tank 106-C, HNF-2474, Piping Calculations, Vol. 4		EDT No. 622232
		ECN No. n/a

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
JW Bailey	S2-48				
W-320 Project Files	R1-29				