BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page

Lifting Device Numbers:

FNAL Site No.:______ (if applicable) Div. Specific No.: ~~114~~ 119 (if applicable) Asset No. ______ (if applicable)

ASME B30.20 Group: (check one)
- (Group I) — Structural and Mechanical Lifting Devices [circled]
- Group II — Vacuum Lifting Devices
- Group III — Magnets, Close Proximity Operated
- Group IV — Magnets, Remote Operated

Device Name or Description: Strong back lifting Frame (A-layer pixel octant)

Device was: (check all applicable)
- Purchased from a Commercial Lifting Device Manufacturer
  mfg. name: ______
- Designed and Built at Fermilab
- (✓) Designed by Fermilab and Built by a Vendor
  Assy drawing number: 3823-130-ME-386141
- Provided by a User or Other Laboratory
- Other. Describe:______

Engineering Note Prepared by: EDWARD CHI Date: 3/1/00

Engineering Note Reviewed by: [signature] Date: 4/4/00

Lifting Device Data:

Capacity: 1,200 lbs

Fixture Weight: ~1,200 lbs

Service: (normal) [circled] heavy severe (refer to B30.20 for definitions)

Duty Cycle: ______ 8, 16 or 24 hour rating (applicable to groups III, and IV)

Inspections Frequency: ______

Rated Load Test by FNAL (if applicable): Date :______ Load: ______

Check if Load Test was by Vendor and attach the certificate.

Satisfactory Load Test Witnessed by: ______

Signature (of Load Test Witness):______

Notes or Special Information:

Fermilab

D0 STRONG-BACK LIFTING FRAME
(FOR THE A-LAYER PIXEL OCTANT FRAME)

D-ZERO ENGINEERING NOTE #3823.130-EN-518

Author: Edward Chi
PPD/ETT/D-Zero Upgrade Group

March 1, 2000

Reviewer: [signature] 4/4/00

Approver:

CONTENTS

PREFACE

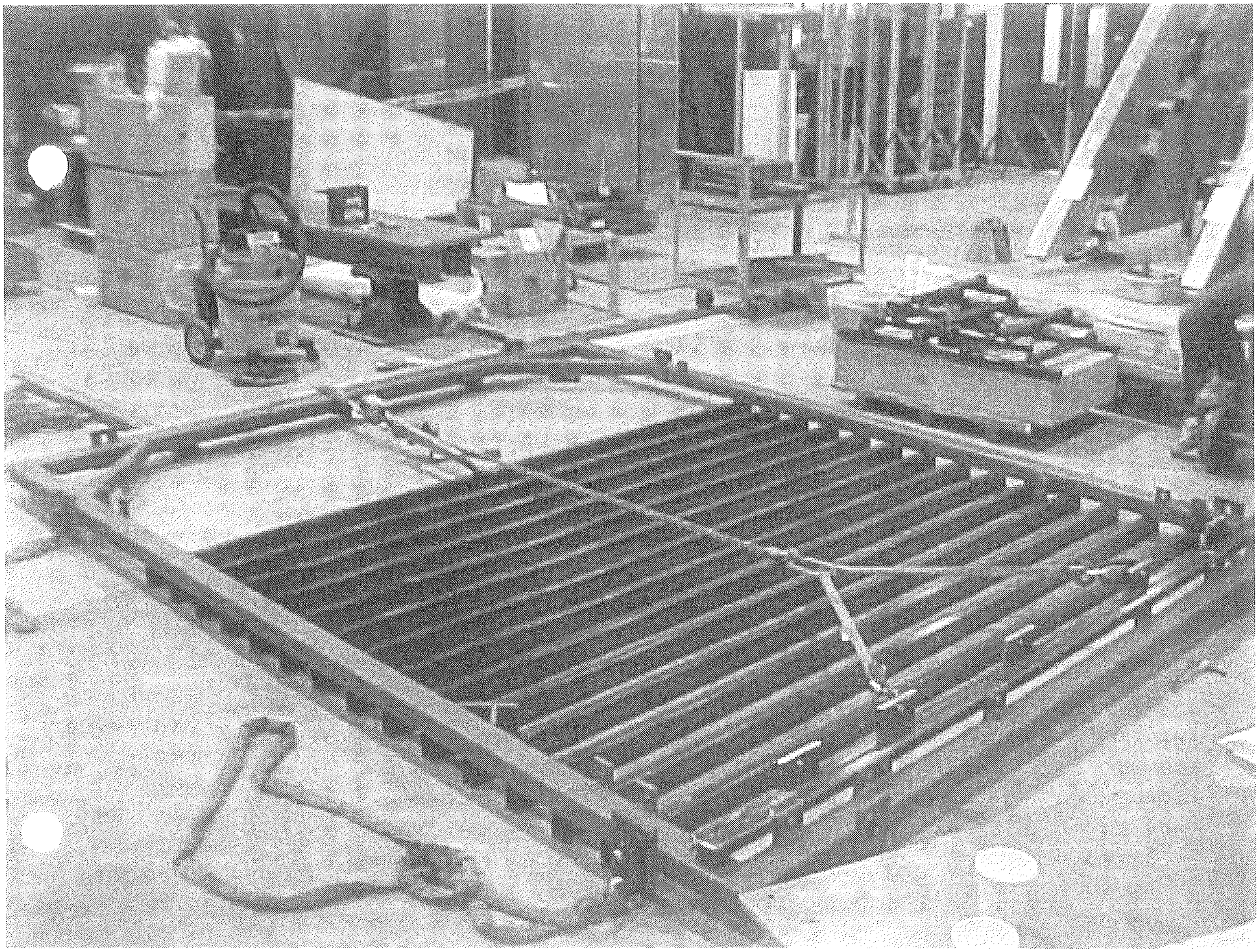
The A-layer pixel support frame is located between the D0 central calorimeter and the A-layer MDT. The frame is composed by 8 octant frames, each octant is mounted by 96 pixels and photomultipliers which are designed at specific locations in 12 rows. The octant pixel frame is a 45 degree trapezoidal frame with sandwich type of structure in cross section, see the drawing MD-372015 on page 2.9 as reference. The pixels and photomultipliers are mounted to the octant frame as showing on photo-picture copy in appendix.

The Strong-back Lifting Frame is a rectangular shape steel frame, which performs two major functions:

1. As a "Structural and Mechanical Lifting Device", give the assembled pixel octant frame of the opportunity of moving, lifting and shipping to different locations horizontally and vertically.
2. As a mechanical support device, give the assembled pixel octant frame supports in far side surface to minimize the deflection during the shipment, and prevent any permanent deformation to the pixel octant frame.

The attached engineering note outlines the Lifting Frame for designing and fabricating, analyze the structures per the specifications of ASME B30.20 and Fermi ES&H Manual 5022.1-1. The scope of this note only covered function #1, which is governed by the safety of personnel and equipment to use the "Below The Hook Lifting Devices".

Because of the unavailability of the detail drawings of the device at this moment, the author feels sorry for using the design sketches and layouts as the reference in the appendix. The related design drawings will be added to the appendix once they are available.



FERMILAB ENGINEERING NOTE	SECTION Pixel Frame STRONG BACK	PROJECT D0 upgrade	SERIAL-CATEGORY	PAGE 1.1
SUBJECT Weight cal. Frame _ STRONG Back lifting		NAME E. CHI	DATE 2/24/00	REVISION DATE

Ref. dwg:

Per layout Assembly dwg: ME-386141

Yur 4" x 3" x 3/16" Rectangular Tube: @ 8.15 #/FT

$L_1 = 162.50" \times 2 + 119.50" \times 2$

$= 564" = 47$ FT

$W_{L_1} = 383$ #

2" x 3" x 1/4" Rectangular Tube @ 7.11 #/FT

$L_2 = 147.75" + 28.678" \times 2$

$= 205.106" = 17$ FT

$W_{L2} = 122$ #

Mounting plate: (18)

$W_{plt_1} = 0.2833$ #/in³ $\times 18 \times 4" \times 5.25" \times 0.5"$

$= 54$ #

lifting plates (8) (2)

$W_{plt_2} = 0.2833$ #/in³ $\times 8 \times 5.0" \times 7" \times 0.5"$

$= 40$ #

SUBJECT: weight cal.

NAME: E. CHI

DATE: 2-24-00

REVISION DATE:

$W_{plt_3} = 0.2833\#/in^3 \times 8 \times 5.0'' \times 7'' \times 0.75''$

$= 60\#$

Corner flange BKT & MTG. plate (2)

per dwg: ME-386141

$W_{BKt} = 0.2833\# in^{-3} \times 2 \times [(7'' \times 4.25'') \times 0.5''$

$+ (3.90'' \times 3'' \times 0.50'')] = 12\#$

$W_{Boss\,plt} = 0.2833\# in^{-3} \times 2 \times 6'' \times 4.25'' \times 0.5'' = 7\#$

$W_{MTG.\,plt} = 0.2833\# in^{-3} \times 6'' \times 4.25'' \times 0.375'' \times 2$

$= 5.5\#$

$W_{corn.\,flange} = W_{BKt} + W_{MTG.\,plt} + W_{Boss\,plt}$

$= 24.5\#$

Spacer (2)

$W_{S1} = 0.2833\# in^{-3} \times 2 \times 6'' \times 2'' \times 0.25'' \times 2$

$= 3.5\#$

$W_{S2} = 2 \times 2.125''/12 \times 4.1\#/FT$ (for C3×4.1 channel)

$= 1.5\#$

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			1-3

SUBJECT

NAME: E. CHI

DATE: 2-24-00

REVISION DATE:

$W_{spacer} = 5^{\#}$

UNISTRUT:

per layout design: ME-386141

there are 14 UNISTRUT (P5000, $3.05^{\#}$/FT)

With length $l = 127$ in for each.

$W_{UNISTRUT} = (127'' \times 14)/12 \text{ FT} \times 3.05^{\#} \text{FT}^{-1}$

$= 452^{\#}$

"U" shape BKT: UNISTRUT # P1050 (25)

$W_{U} = 0.2833^{\#} \text{in}^{-3} \times 25 \times 1.625'' \times (10.375 + 1.5'' \times 2) \times 0.25''$

$\approx 13^{\#}$

bolts and other Accessories:

Assuming

$W_{mis.} = 10^{\#}$

$$W_{sub.tot\,1} = W_{L1} + W_{L2} + W_{plt_1} + W_{plt_2} + W_{plt_3} + W_{cornerflange} + W_{spacer} + W_{misc.}$$

$$= 383^{\#} + 122^{\#} + 54^{\#} + 40^{\#} + 60^{\#} + 24.5^{\#} + 5^{\#} + 10^{\#}$$

$$= 699^{\#}$$

$$W_{sub.2} = W_{unistrut} + W_{u}$$

$$= 452^{\#} + 13^{\#}$$

$$= 468^{\#}$$

Total weight of the strong backer lifting fixture frame:

$$W_{fixture} = W_{S1} + W_{S2} = 699^{\#} + 468^{\#}$$

$$= 1{,}167^{\#} \cong 1{,}170^{\#}$$

Total weight of the A-layer pixel frame and the strongbacker lifting fixture frame: W_{tot} per attached: "the weight, moment arm & magnetic force calculations for the A-layer pixel octant" on page

Total weight of the octant frame with pixels:

$$W_{octant} = 1{,}081^{\#} \cong 1{,}100^{\#}$$

$$W_{tot} = W_{fixture} + W_{octant}$$

$$= 1{,}170^{\#} + 1{,}100^{\#}$$

$$= 2{,}270^{\#}$$

The weight, moment arm, moment and magnetic force calculations for the A-layer pixel octant

References: 1. A. Stefanik's "A-layer fishscale sizes" dated on 1/27/98
2. A. Stefanik's "Moment arms for PMT shields & pixels in the A-layer" dated on 6/11/98
3. Data file of "map_pma_new1.xls"

Assumptions: mtg bracket weight Wm=65 lbs/octant, cable weight Wc=50 lbs/octant, same moment arm as the pixel,
the weight distribution as proportional ratio as the each row of pixel. Wmis=Wm + Wc =115 lbs,
Wt1=pmt weight + weight/pixel, Wf=weight of the support frame per octant=386.1 lbs,
Wt=total weight of the A-layer pixel octant=Wt1+Wmic.+Wf=1,081 lbs.

pixel row number	number of pixels	pmt arm (inches)	pixel arm (inches)	pmt weight (lbs)	weight/pixel (lbs)	Wt1/pixel (lbs)	% of weight of each row	Wmis/pixel (lbs)	ave. arm (inches)	Mx/pixel (in-lb)	Wf/pixel (lbs)	Wt/pixel (lbs)	Wt/row (lbs)	Mx/row (in-lb)
1	7	5.4	3.9	2.5	1.18	3.6800	0.044457	0.7304	4.7503	20.950	2.452	-6.8625	-48.0373	146.653
2	9	4.7	2.7	2.5	1.39	3.8900	0.060420	0.7720	3.7725	17.588	2.592	-7.2541	-65.2867	158.288
3	10	4.8	2.3	2.5	1.67	4.1700	0.071966	0.8276	3.5506	17.745	2.779	-7.7762	-77.7622	177.445
4	10	4.6	2.3	2.5	2.02	4.5200	0.078006	0.8971	3.3615	18.209	3.012	-8.4289	-84.2890	182.093
5	10	4.5	2.3	2.5	2.5	5.0000	0.086290	0.9923	3.2178	19.282	3.332	-9.3240	-93.2400	192.824
6	10	4.3	2.3	2.5	3.13	5.6300	0.097163	1.1174	3.0410	20.519	3.751	-10.4988	-104.9883	205.190
7	10	4.2	2.3	2.5	4	6.5000	0.112177	1.2900	2.9098	22.667	4.331	-12.1212	-121.2120	226.671
8	10	4.1	2.3	2.5	5.25	7.7500	0.133750	1.5381	2.7845	25.863	5.164	-14.4522	-144.5220	258.627
9	10	4	2.3	2.5	7.08	9.5800	0.165332	1.9013	2.6702	30.657	6.383	-17.8648	-178.6479	306.570
10	6	3.9	2.3	2.5	5.54	8.0400	0.083253	1.5957	2.7151	26.162	5.357	-14.9930	-89.9580	156.972
11	3	3.9	2.3	2.5	6.8	9.3000	0.048150	1.8457	2.6589	29.635	6.197	-17.3426	-52.0279	88.906
12	1	4.2	2.7	2.5	8.53	11.0300	0.019036	2.1891	2.9837	39.442	7.350	-20.5687	-20.5687	39.442

pixels/octant: 96

Total pixel weight per octant: 579.44

Total weight per octant (including pixels, frame and accessories): -1081

Total moment per octant: 2140

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		DØ upgrade		2-1

SUBJECT	NAME	
Z direction CTR. gravity location Strong back frame & pixel octant frame	E. CHI	
	DATE 2-25-00	REVISION DATE

Ref: weight calculation in SECTION 1. Page 1 to Page 5

design drawings:

ME-386141

Assumption:

Z direction is the normal direction to the major plane of the strong-backer lifting fixture & pixel frame.

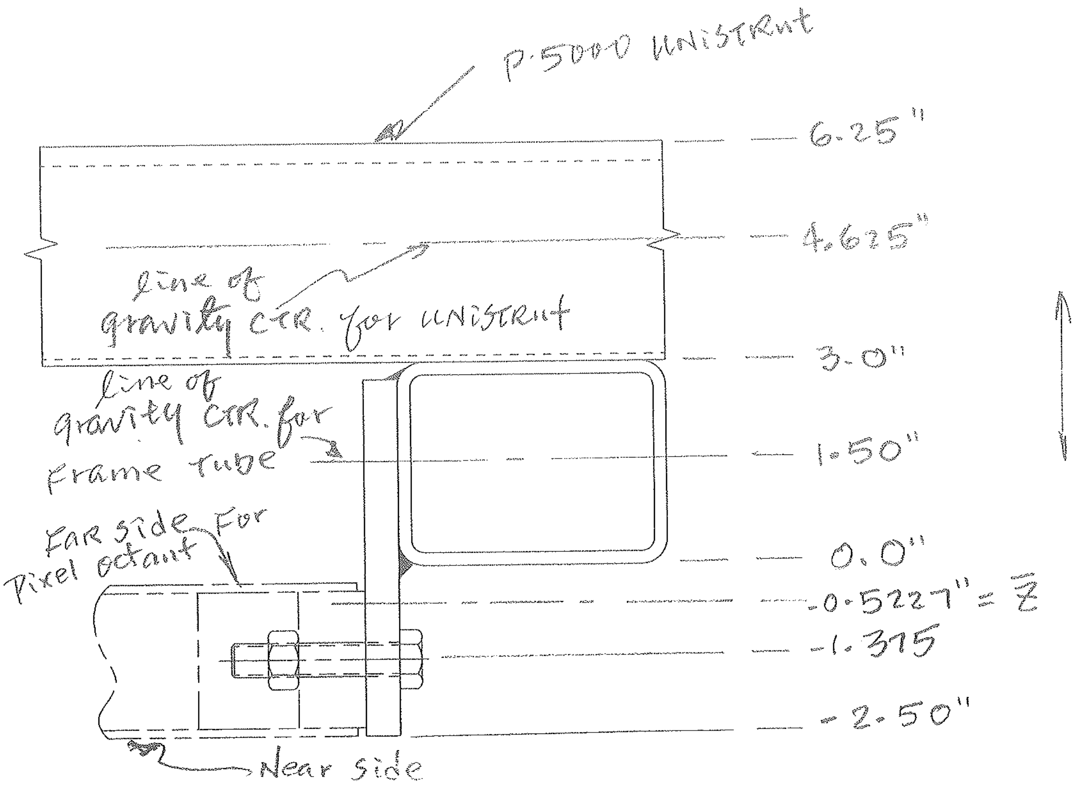


Fig 2.1. Cross view of the strong back frame with the A-layer pixel frame.

SUBJECT: Z dir. center gravity

NAME: E. CHI

DATE: 2-25-00 | REVISION DATE

per "the wt., moment arm, moment & magnetic force cal. for the A-layer pixel octant" on page

Total moment per octant caused by eccentric force of the pixel: $M_t = 2{,}140^{\#}$

The weight of the pixels and other accessories (less pixel frame wt.)

$$W_{pixel} = 1{,}081^{\#} - 386^{\#}$$
$$= 695^{\#}$$

$$\bar{Z}_{1a} = \frac{2{,}140^{\#}\text{ in}}{695^{\#}}$$

$= 3.0791''$ (From Near side surface of the pixel frame)

if take $Z=0$ from fig 2.1 as datum. then

$$\bar{Z}_1 = -(Z_{1a} + 2.50)$$
$$= -5.5791''$$

if take $Z = -1.375''$ as datum. the combination of frame & pixel:

$$\bar{Z}_{1a} = -\frac{695^{\#} \times (3.0791'' + 1.125'') + 386^{\#} \times 0}{1081^{\#}} = -2.7029''$$

FERMILAB ENGINEERING NOTE

SECTION:

PROJECT: pdupgrade

SERIAL-CATEGORY:

SUBJECT: Z dir. CTR. gravity

NAME: E. CHI

DATE: 2-25-00

REVISION DATE:

Per Fig 2.1 of page 2.1

Per weight calculations on SECTION 1

Per formula:

$$\bar{Z} = \frac{\sum_{i=1}^{n} W_i Z_i}{\sum_{i=1}^{n} W_i}$$

$$= \frac{-5.5791'' \times \text{wt. of pixel} - 1.375'' \times \text{wt. of pixel octant} + 1.50'' \times W_{sub1} + 4.625'' \times W_{sub2}}{\text{weight of the pixel frame} + \text{wt. strong backer}}$$

$$= \frac{-5.5791'' \times 695\# - 1.375'' \times 386\# + 1.50'' \times 699\# + 4.625'' \times 468\#}{1{,}167\# + 1081\#}$$

$$= -0.5317''$$

∴ the CTR. gravity of the combination of the strong backer lifting fixture and the pixel octant frame in Z direction is ~0.53" away from outside surface of 4" × 3" × 3/16" tube as showing in Fig. 2.1.

SUBJECT: x, y direction CTR. of gravity location STRONG Back Frame & Pixel octant Frame

NAME: E. CHI

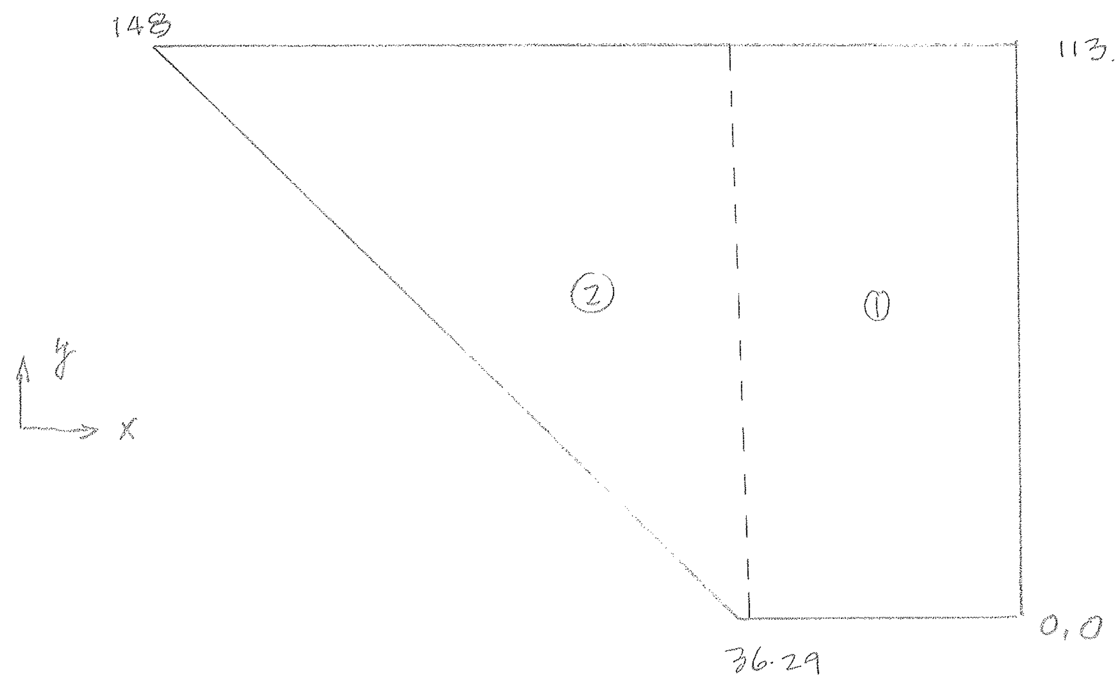
DATE: 2-25-00

REVISION DATE

Assumption: xy plane is the same as major plane of pixel octant and STRONG back frame.

Ref. dwg: MD-372015

Fig 2.2. xy plane view of the A-layer pixel frame.



Find out the gravity CTR. of the pixel frame in x & y direction:

$$Area_1 = 36.29'' \times 113''$$
$$= 4101 \ in^2$$

$$Area_2 = (148'' - 36.29'') \times 113 \times \frac{1}{2}$$
$$= 6,312 \ in^2$$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		D0 upgrade		2-5

SUBJECT	NAME	
	E. CHI	
	DATE 2-25-00	REVISION DATE

$$\bar{y}_1 = \frac{(\frac{2}{3} \times 113'') \times 6{,}312\ in^2 + \frac{113''}{2} \times 4{,}101\ in^2}{10{,}413\ in^2}$$

$$\simeq 67.9159'' \cong 68\ in$$

$$\bar{X}_1 = \frac{\frac{36.29''}{2} \times 4{,}101\ in^2 + 73.5267\ in \times 6{,}312\ in^2}{10{,}413\ in^2}$$

$$\simeq -51.7154\ in$$

Transfer to the coordinate system as showing the layout on page 2-9 *

* (define the Right bottom corner as 0,0 datum)

$$\bar{y}_2 = \bar{y}_1 + 4'' + 3.25\ in$$

$$\simeq 75.25\ in$$

$$\bar{X}_2 = \bar{X}_1 - 0.5\ in - .4\ in - 0.25\ in$$

$$= -56.4654\ in$$

To find out the CTR. of gravity location for strong back frame.

since it is symmetric in y direction, so

$$\bar{y}_3 = 127.50\ in/2 = 63.75\ in$$

$$\bar{x}_3 = \frac{\bar{X}_{UNISTRUT} \cdot W_{sub.2} + \bar{X}_{Tube} \cdot W_{sub.1}}{\text{weight of the strong back frame}}$$

$$= \frac{65.27'' \times 468^{\#} + 81.25'' \times 699^{\#}}{1,167^{\#}}$$

$$= 74.84\ in$$

To find out the CTR. of gravity location for the combination of strong backer frame with the pixel frame.

$$\bar{y} = \frac{\bar{y}_2 \times \text{Pixel wt.} + \bar{y}_3 \times \text{STRONG back frame wt.}}{\text{Pixel frame wt} + \text{strong back frame wt.}}$$

$$= \frac{75.25\ in \times 1,100^{\#} + 63.75\ in \times 1,170^{\#}}{2,270^{\#}}$$

$$= 69.323\ in$$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE 2.7
SUBJECT			NAME E. CHI	
			DATE 2-25-00	REVISION DATE

$$\bar{X} = \frac{-56.4654\text{ in} \times 1{,}100^{\#} + (-74.84\text{in} \times 1{,}170^{\#})}{2{,}270^{\#}}$$

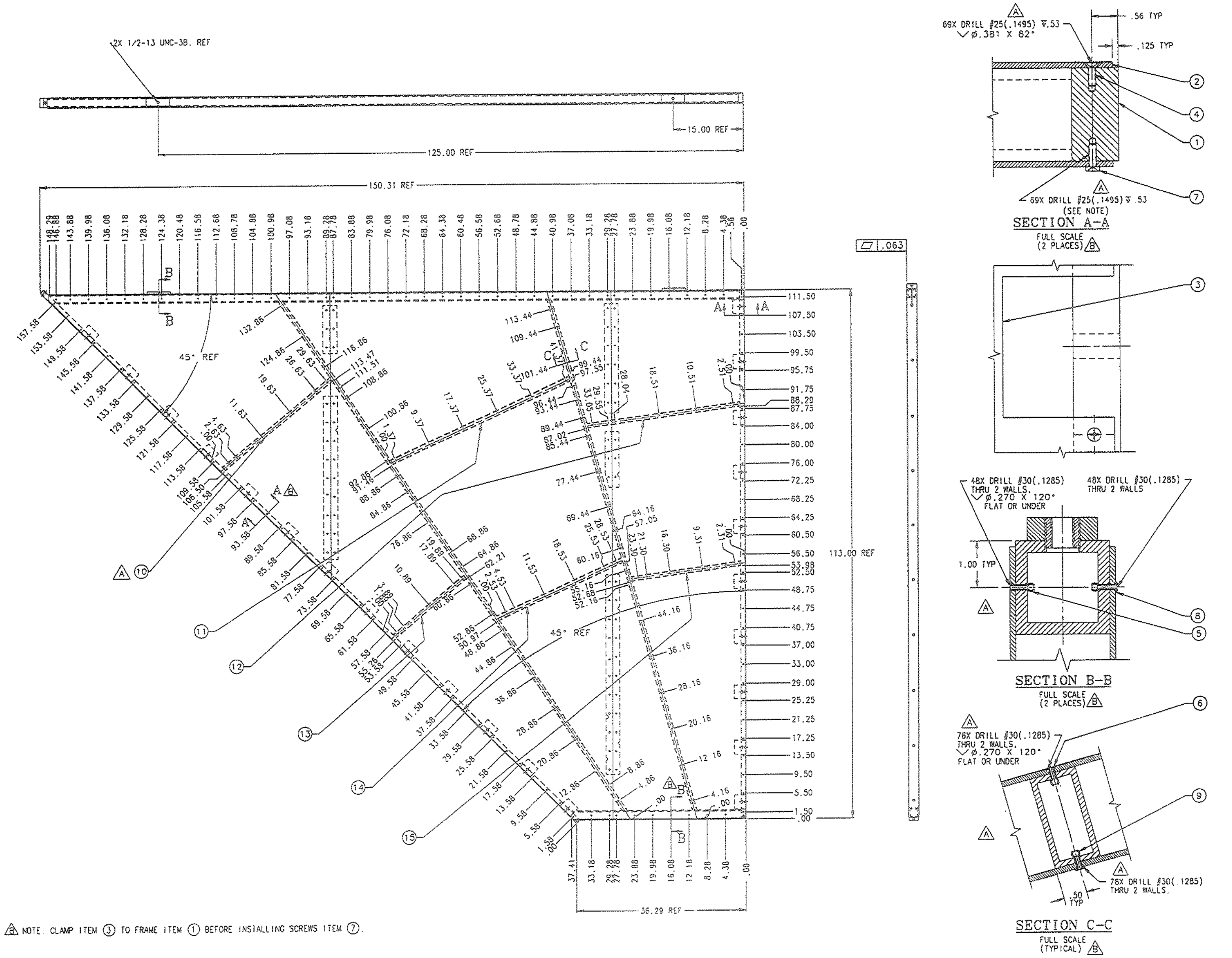
$= -65.94$ in

∴ the coordinate location of the CTR. gravity of the strong back frame with the pixel octant together in XY plane is:

$$(X, Y) = (-65.94'', 69.323'')$$

(Based on the most right bottom corner as 0,0 datum point for the XY plane. see page 2.9 as reference)

REV.	DESCRIPTION	DRAWN / APPROVED	DATE
A	CHANGE TAP DRILL FROM #29 TO #25. CHANGE SHAPES OF TUBES. INCREASE QTY RIVETS ITEMS 6 AND 9. ADD PARTS "CROSS BAR".	F.YOFFE / A.CHI	01-11-99 / 01-27-99
B	ADD SECTIONS A-A AND B-B FOR CLARITY. CHANGE NOTE. ADD THREE DIGIT TOLERANCE AND MATERIAL NOTE.	F.YOFFE	03-01-99



NOTE: CLAMP ITEM ③ TO FRAME ITEM ① BEFORE INSTALLING SCREWS ITEM ⑦.

REV.	ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
A	15	MC-372544-6	CROSS BAR	1
A	14	MC-372544-5	CROSS BAR	1
A	13	MC-372544-4	CROSS BAR	1
A	12	MC-372544-3	CROSS BAR	1
A	11	MC-372544-2	CROSS BAR	1
A	10	MC-372544-1	CROSS BAR	1
A	9	COM	BUTTON HEAD ALUMINUM BLIND RIVET 1/8 X .400 LG, AB4-4A, MARSON CREATIVE FAST. INC	76
	8	COM	BUTTONHEAD ALUMINUM BLIND RIVET 1/8 X .525 LG, AB4-6A, MARSON CREATIVE FAST. INC	48
	7	COM	PAN HEAD PHILLIPS TAPPING SCREW 8-32 1/2 LG, #90410A194 McMASTER	69
A	6	COM	120° COUNTERSUNK ALUMINUM BLIND RIVET 1/8 X .400 LG, AC4-4A, MARSON CREATIVE FAST. INC	76
	5	COM	120° COUNTERSUNK ALUMINUM BLIND RIVET 1/8 X .525 LG, AC4-6A, MARSON CREATIVE FAST. INC	48
	4	COM	FLAT HEAD PHILLIPS TAPPING SCREW 8-32 1/2 LG, #92485A624 McMASTER	69
	3	MD-372043	BACK COVER ASSEMBLY	1
	2	MD-372042	FRONT COVER ASSEMBLY	1
	1	MD-358971	OCTANT SANDWICH FRAME, WELDMENT	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED					
.XX	.XXX	ANGLES	ORIGINATOR	E.CHI, A.STEFANIK	
± .02	± .005	± .25°	DRAWN	F.YOFFE	07-27-98
			CHECKED	REEDER	08.10.98
			APPROVED	E.CHI	08.11.98

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRWG.
3. DIMENSIONING IN ACCORD WITH ANSI Y14.5M-1982 STD'S.
4. ALL DIMENSIONS ARE IN INCHES.

√ MAX. ALL MACHINED SURFACES

USED ON

MATERIAL: SEE ABOVE (B)

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

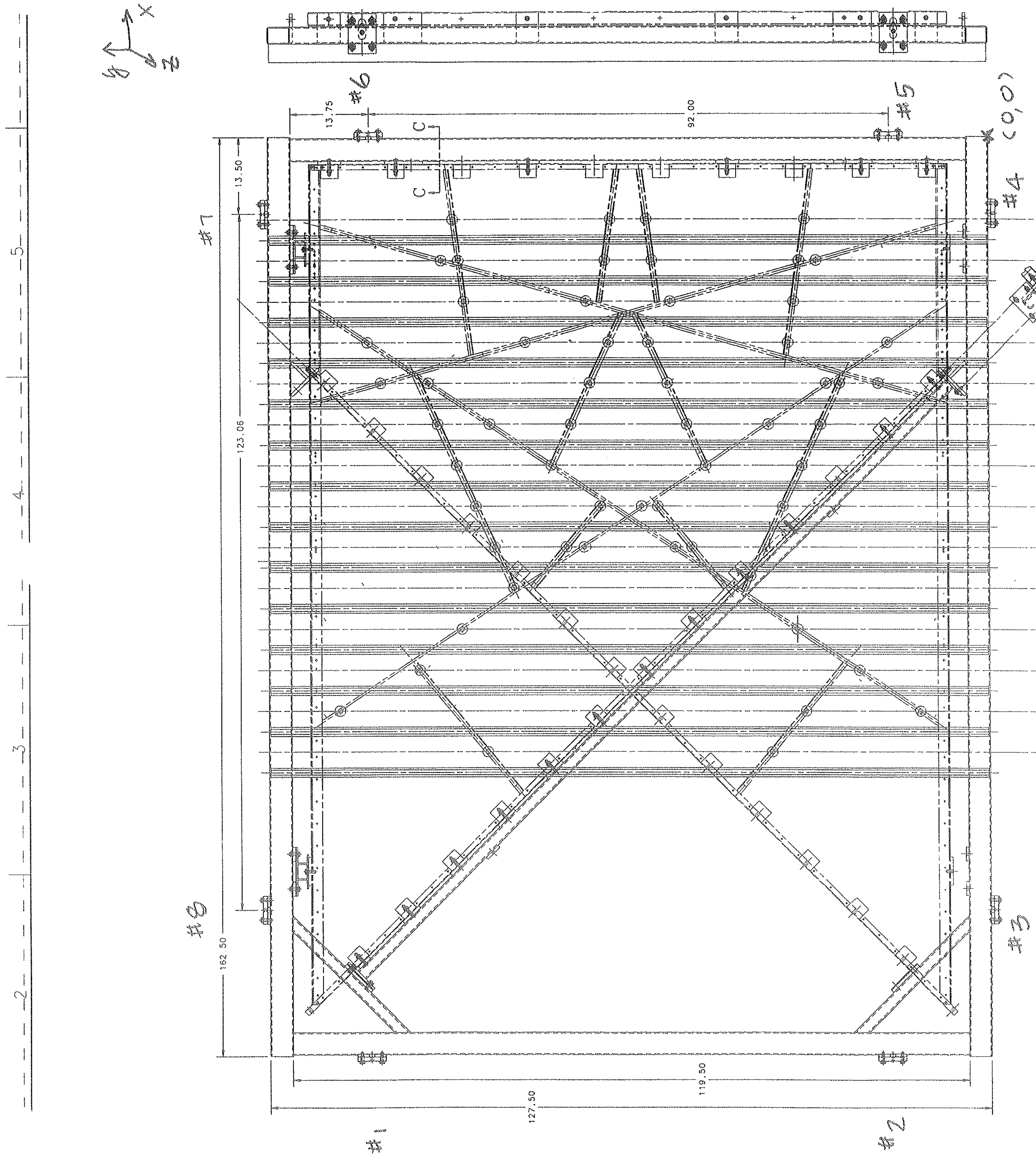
PPD/MECHANICAL SUPPORT
D-ZERO, PIXEL, LAYER A, OCTANT SANDWICH FRAME ASSEMBLY

SCALE 1:10 | DRAWING NUMBER 3823.130-MD-372015 | SHEET NO. 1 OF 1 | REV. B

Plotted by eldchi on 29-Feb-2000 , File: 37201501_B.pff

2-8

2.9



Plotted by edchi on 28-Feb-00 . File sb1bio7c.plf

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
	Dzupgrade		3.1

SUBJECT: Structural Analysis & Cal. For Strong-back lifting Frame

NAME: E. CHI

DATE: 2-25-00

REVISION DATE:

For the Rectangular Tube $4'' \times 3'' \times 3/16''$ ASTM A500 $F_Y = 46$ KSi

$A = 2.39\ in^2$

$I_x = 5.23\ in^4$

$S_x = 2.62\ in^3$

Per § 20-1.2.2, ASME B30.20-1993

$F_v = F_b = 46\ KSi / 3.0 = 15.33\ KSi$

Per F3.1 of AISC 9th Edition Per F3.2.

$F_{b_1} = 0.66 F_Y = 30.36$ KSi * $F_{b_2} = 0.6 F_Y = 27.6$ KSi

Per F4-1 of SECTION F4, AISC 9th Edition

$F_v = 0.40 F_Y = 18.4$ KSi *

Select the lesser $F_v = 15.33\ KSi = F_b$
As the Allowable STRESS for the calculations.

* see pages 3.15 and 3.16 for the details of the selection of F_b & F_v Per AISC 9th Edition.

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		DØupgrade		3.2

SUBJECT	NAME	
Rectangular tube analysis FOR $L_b = 119.50''$	E. CHI	
	DATE 2-25-00	REVISION DATE

Per Assembly drawing and the layout on Page 2.9:

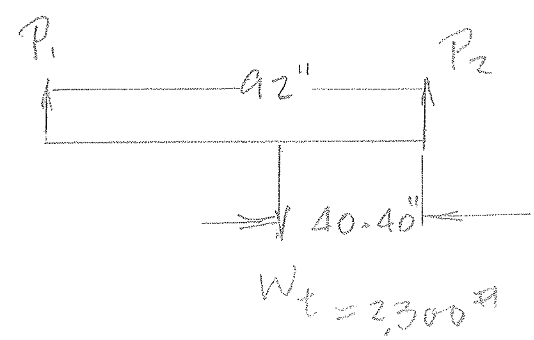
Assuming the crane lifting the frame with Pixel octant by the lifting hole location #1 & #2 vertically.

Because of the Eccentic loading, we can find that

$P_1 = 1{,}010$ #

$P_2 = 1{,}290$ #

Fig 3.1



where:

$119.50'' - 2 \times 13.75''$

$= 92''$

$69.323'' - 4'' - 13.75''$

$= 51.573'' \cong 51.60''$

$92'' - 51.60'' = 40.40''$

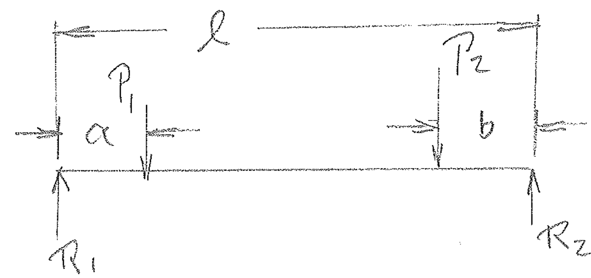
then the lifting case can be simplized as showing in Fig 3.2.

SUBJECT: Rectangular Tube analysis

NAME: E. CHI

DATE: 2-25-00 | REVISION DATE

Fig 3.2



where

$l = 119.50''$

$a = b = 13.75''$

$P_1 = 1{,}010\#$

$P_2 = 1{,}290\#$

$$R_1 = \frac{P_2 \cdot b + P_1(L-a)}{l}$$

$\cong 1{,}042\#$

$$R_2 = \frac{P_1 \cdot a + P_2(L-b)}{l}$$

$\cong 1{,}258\#$

$M_{max} = R_2 \cdot b$

$= 16{,}040\ \#\cdot in$

SUBJECT: Rectangular Tube analysis

NAME: E. CHI

DATE: 2-25-00

REVISION DATE

$f_{bx} = M_{max}/S_x$

$= 16{,}040\ \# \text{ in} / 2.62 \text{ in}^3$

$= 6.122 \text{ KSi} < F_b = 15.33 \text{ KSi}$ OK

$f_v = R_2/A$

$= 1{,}258\ \# / 2.39 \text{ in}^2$

$= .526 \text{ KSi} < F_v = 15.33 \text{ KSi}$ OK

weldment: 3/16" weld all around.

material E70XX. $F_u = 70$ KSi

Base metal: $F_y = 46$ KSi

Allowable stress of the weldment:

Per § 20-1.2.2a, ASME B30.2-1993

$F_b = 0.3 \times 70 \text{ KSi} = 21 \text{ KSi}$

$F_v = 0.4 \times 46 \text{ KSi} = 18.4 \text{ KSi}$

$\therefore F_b = F_v = 15.33$ KSi is the lesser among

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		DØupgrade		3.5

SUBJECT	NAME	
Rectangular tube analysis	E. CHI	
	DATE 2-25-00	REVISION DATE

21 ksi, 18.4 ksi and 15.33 ksi

use: $F_b = F_v = 15.33$ ksi for the weld too.

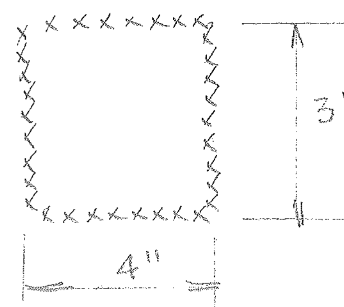


fig 3.3

SHEAR force of the weldment can take: P_v

$P_v = F_v \times 0.707 \times 0.1875'' \times 3'' \times 2$

$= 15,330\ \#/in^2 \times 0.7954\ in^2$

$= 12,190\ \# \gg R_2 = 1,258\ \#$

OK

SUBJECT: Rectangular tube analysis For L_6=158.50"

NAME: E. CHI

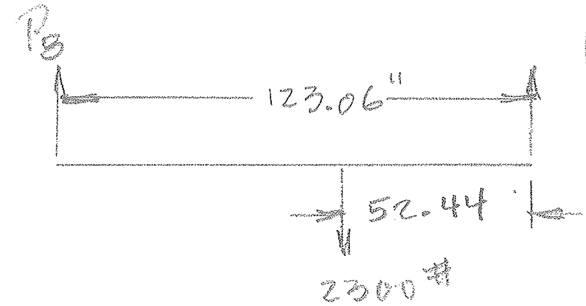
DATE: 2-28-00 | REVISION DATE

Per Assembly drawing and layout dwg on page 2.9:

Assuming the crane lifting the frame with pixel detector by the lifting hole location of #7 & #8 vertically.

Because of the Eccentic loading Regarding the ctr. gravity of the whole lifting component, Per lift hole location, simplized as:

Fig 3.4



Per Fig 3.4.

Find:

$P_7 = 1,320$ #

$P_8 = 980$#

Where $65.94" - 13.50" = 52.44"$ (see page 2-6)

$123.06 = l$ see attached layout, the ctr-dist. between lifting holes.

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		DØ upgrade		3.7

SUBJECT: Rectangular Tube Analysis

NAME: E. CHI

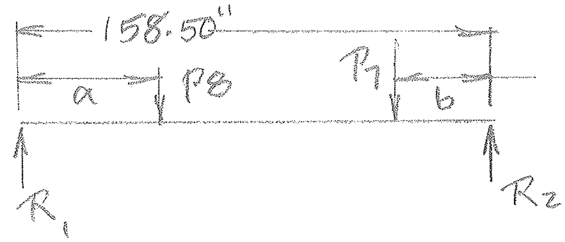
DATE: 2-28-00

REVISION DATE:

To find out the Reaction force @ the end of the $3'' \times 4'' \times 3/16''$ (162.50" long) tube:

(for simple & conservative approach, neglecting the influences of 14 P5000 unistruts & $2'' \times 3'' \times \frac{1}{4}''$ corner tube)

Fig 3.5



Simplized the lifting case as showing in Fig. 3.5: Two unequal concentrated loads unsymmetrically placed

(see case 11, AISC 9th Edition)

where: $l = 162.50'' - 4'' = 158.50''$

$a = 25.94''$ $\quad P_7 = 1,320\#$

$b = 13.50''$ $\quad P_8 = 980\#$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		D0 upgrade		3.8

SUBJECT	NAME	
Rectangular Tube Analysis	E. CHI	
	DATE 2-28-00	REVISION DATE

$$R_1 = \frac{P_7 \cdot b + P_8 (l-a)}{158.50''}$$

$$\cong 932^{\#}$$

$$R_2 = \frac{P_8 \cdot a + P_7 (l-b)}{158.50''}$$

$$= 1{,}368^{\#}$$

$$M_{max_1} = R_2 \cdot b$$

$$= 1{,}368^{\#} \times 13.50''$$

$$= 18{,}468\ \#\cdot in$$

$$M_{max_2} = R_1 \cdot a$$

$$= 932^{\#} \times 25.94''$$

$$= 24{,}176\ \#\cdot in$$

$$f_{b_x} = M_{max2} / S_x$$

$$= 24{,}176\ \#\cdot in / 2.62\ in^3$$

$$= 9.227\ KSi < F_b = 15.33\ KSi$$

OK

SUBJECT Rectangular tube Analysis

NAME E. CHI

DATE 2-28-00

REVISION DATE

$f_v = R_1 / A$

$= 1,368^{\#} / 2.39 \text{ in}^2$

$= .572 \text{ ksi} < F_v = 15.33 \text{ ksi}$ ok

weldment:

Ref. to Page 3-5

$P_v = 12,190^{\#} > R_2 = 1,318^{\#}$ ok

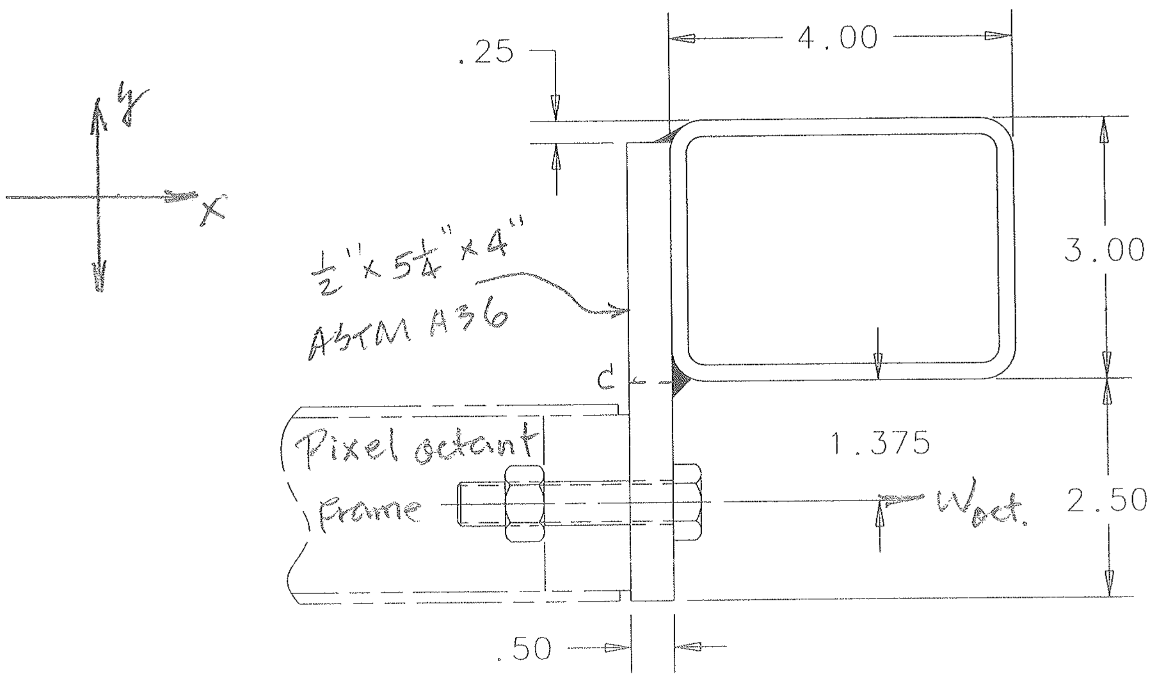


Fig 3.6

Per general Assembly drawing, find out that the 119.50" long 3" x 4" x $\frac{3}{16}$" Tube of the strong back frame has 6 plates ($\frac{1}{2}$" x 5$\frac{1}{4}$" x 4") to connect the pixel octant frame

Conservatively assuming all weight of the pixel octant purely applying to the plates, and only assuming 3 plates.

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		odupgrade		3.11

SUBJECT	NAME	
Mounting plate cal. & Analysis	E. CHI	
	DATE 2-28-00	REVISION DATE

$P = W_{oct}/3$ (see page 1.5)

$= 1100^{\#}/3 = 367^{\#}$

Also, per page 2-2

the CTR. gravity of the pixel octant frame in y direction (as defined in Fig 3.6) Regarding CTR. of ½" bolt is: 2.7029"

then Regarding bottom surface of the tube is:

$e = 2.7029" + 1.375"$

$= 4.0779"$

Bending moment M_b @ that location "c" will be:

$M_{b@c} = e \cdot P$

$= 4.0779 \times 367^{\#}$

$= 1{,}497^{\#} \cdot in$

I_x value $I_x = \frac{0.5^3 \times 4}{12} in^4 = 0.04167\ in^4$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		D0 upgrade		3.12

SUBJECT	NAME
Mounting plate Cal. & Analysis	E. CHI
	DATE 2-28-00 / REVISION DATE

$S_x = 0.1667 \ in^3$

the Allowable STRESS: For ASTM A36 $F_Y = 36$ KSI

$F_b = 36 \ KSI / 3.0 = 12 \ KSI = F_v$

per §20-1.2.2, ASME B30.20-1993

$F_b = 0.66 F_Y = 23.76$ KSI

per F3.1 of AISC 9th Edition

$F_v = 0.4 F_Y = 14.4$ KSI

per F4-1, §F4, AISC 9th Edition

select the lesser of $F_v = 12 \ KSI = F_b$

$f_{bx} = M_b / S_x$

$= 1,497 \ \#\cdot in / 0.1667 \ in^3$

$= 8.98 \ KSI < F_b = 12$ KSI

OK

for cross-section Area:

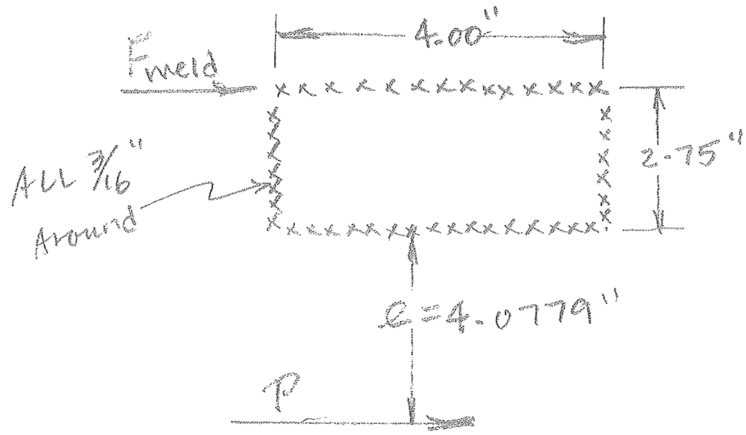
$A_c = 0.5" \times 4" = 2\ in^2$

$f_v = 367^{\#}/2\ in^2$

$= 0.184\ ksi < F_v = 12\ ksi$ OK

Fig 3.7

weldment:



Allowable stress of the weldment:

Ref page 3.4.

Assuming $F_b = F_v = 12\ ksi$ for the welds.

the shear force of the welds:

$P_v = F_v \times 0.707 \times 0.1875" \times 4" \times 2$

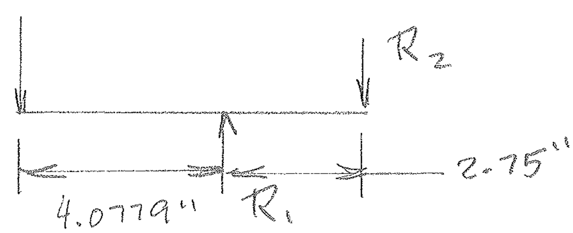
FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
	pdupgrade		3.14

SUBJECT	NAME	DATE	REVISION DATE
Mounting plate cal. & Analysis	E. CHI	2-28-00	

$P_V = 12,726^{\#}$

Fig. 3.8



$\therefore P = 367^{\#}$ ↓

$\therefore R_1 = 911^{\#}$ ↑

$R_2 = 544^{\#}$ ↓

$P_V = 12,726^{\#} > R_1 = 911^{\#} > R_2 = 544^{\#}$

∴ the weld size is OK.

SUBJECT: The Allowable Stress of the Rect. Tube under diff. cases per AISC Steel.

NAME: E. CHI

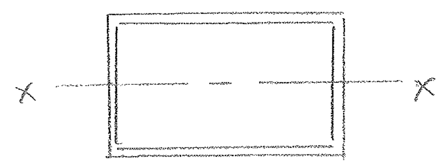
DATE: 2-25-00 | REVISION DATE

To find Allowable Bending Stress F_b:

For Rectangular Tube $4'' \times 3'' \times 3/16''$ under the loading case described from page 3.2 to 3.9.

Per §B5.1 (d), Pag 1-103, of AISC, 9th Ed.:

$b = 4'' - 3 \times 3/16'' = 3.4375''$



$d = 3''$

$t_f = 3/16'' = 0.1875'' = t_w$

$F_Y = 46$ ksi $\Rightarrow 190/(F_Y)^{1/2} = 28$

Per Table B5.1 of §B5, AISC 9th Ed.

$b/t = 3.4375/0.1875$

$= 18.3 < 190/(F_Y)^{1/2} = 28$

In Addition, per F3-1 of AISC 9th Ed.

$d/b = 3/3.4375 = .873 < 6.0$

$t_f/t_w = 1.0 < 2.0$

$h = 3 - 2 \times \frac{3}{16}''$

$= 2.625''$

Per §F3.1 of AISC.

$$L_c = (1{,}950 + 1200\frac{M_1}{M_2})\frac{b}{F_y}$$

$$= (1950 - 0) \times \frac{3.4375}{46}$$

$$= 145.7$$

Since L_{b_1} (for the case of $l = 119.50''$) (see page 3.2)

$L_{b_1} = 119.50'' < 145.7$

$\therefore F_{b_1} = 0.66 F_Y$

For the case of $l = 158.50''$ (see page 3.6)

$F_{b2} = 0.60 F_Y$.

Per eq F3-3, §F3.2. AISC 9th

$h/t_w = 2.625''/0.1875''$

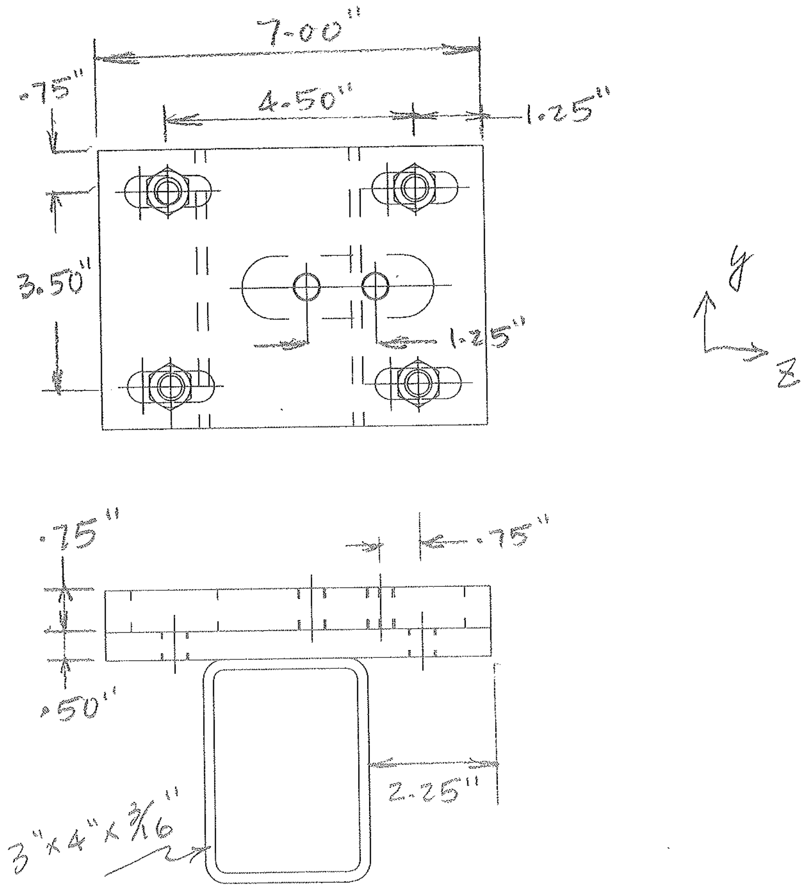
$= 14 < 380/(F_Y)^{1/2} = 56$

$\therefore F_v = 0.40 F_Y$ Per eq F4-1, §F4, AISC 9th.

FERMILAB ENGINEERING NOTE	SECTION: Strong back lifting Frame	PROJECT: D0 upgrade	SERIAL-CATEGORY	PAGE: 4-1
SUBJECT: Cal. & Analysis the Adjustable vertical lifting Device		NAME: E. CHI		
		DATE: 2-28-00	REVISION DATE	

Fig 4.1

Strong Back lifting frame - Adjustable vertical lifting Device.



the Adjustable lifting Device can move in z dir. ±0.5" (within current position, see Fig 4.1)

if assuming the worst conservative position:

the 3/4" lifting plate moving 1/2" in +z direct.

Fig 2.1 is the force distribution of the position. where:

SUBJECT: Cal. & Analysis the Adjustable lifting Device

NAME: E. CHI

DATE: 2-29-00 | REVISION DATE

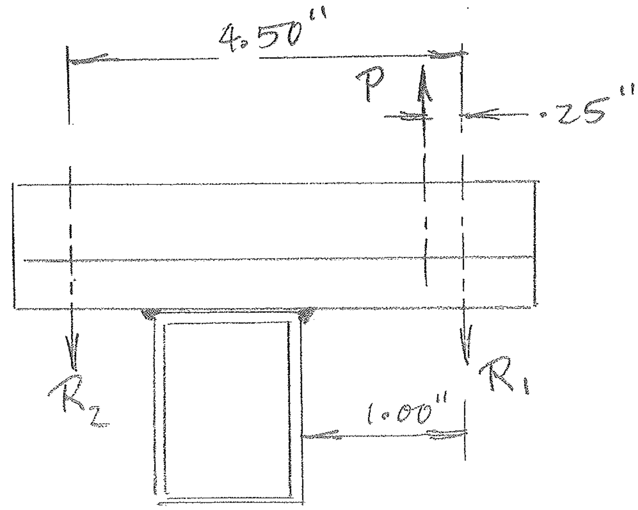


Fig 4.2

$P = P_7 = 1{,}320^{\#}$ (see page 3.7, for the max. value)

Find out. $R_1 = 1{,}247^{\#}$

$R_2 = 73^{\#}$

If use $\frac{1}{2}$-13 UNC Material A325 Bolts

then each bolt has tensile load:

$P_{bolt_t} = 1{,}247^{\#}/2 = 624^{\#}$ (compute load)

For A325 bolt with $\frac{1}{2}$" Dia. $F_u = 120$ KSI

Per page 4-4, Part 4 of AISC. 9th Ed.

SUBJECT
C & A the Adjustable lifting Device

NAME
E. CHI

DATE
2-29-00

REVISION DATE

The Allowable Tensile stress in threaded Fastener

$F_t = 0.33 F_u$ (Per Page 4-3, Part 4 of AISC 9th Ed.)

$= 39.6$ ksi

The Root dia. of $\frac{1}{2}$-13 bolt is

$d_r = 0.4001''$

the effective Area of the bolt:

$A_e = (\pi d_r^2)/4$ in^2

$= 0.1257$ in^2

The Allowable Tensile load:

$P_t = F_t \cdot A_e$

$= 39.6$ ksi $\times 0.1257$ in^2

$= 4{,}978^{\#} > P_{bolt_t} = 624^{\#}$

<u>SHEAR load</u>:

There is SHEAR force applying to the bolts (R_1 & R_2) when lifting the Fixture horizontally (i.e. 2,300# will shear by 3 lifting holes)

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		Ddupgrade		4.4

SUBJECT	NAME	
C & A the Adjustable lifting Device	E. CHI	
	DATE 2-29-00	REVISION DATE

For simple and conservative approach.

Assuming again that: $P = 1{,}320^{\#}$ (see Fig 4.2 on Page 4.2)

then each bolt has shear load:

$$P_{bolt.s} = 624^{\#}$$

Per Page 4-5, Part 4 of AISC 9th Edition

the Allowable shear stress of the bolt when threads are included in a SHEAR.

$$F_v = 0.17\,F_u$$
$$= 20.4 \text{ KSI}$$

the Allowable shear load per each $\frac{1}{2}$-13. A325 bolt:

$$P_v = F_v \cdot A_e$$
$$= 20.4 \text{ KSI} \times 0.1257 \text{ in}^2$$
$$= 2{,}564^{\#} > P_{bolt.s} = 624^{\#}$$

<u>Bearing load</u>

For $\frac{1}{2}''$ thick ASTM A36 plate.

$$F_u = 55 \text{ KSI}$$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		D0 upgrade		4.5

SUBJECT	NAME	
C & A for the Adjustable lifting Device	E. CHI	
	DATE 2-29-00	REVISION DATE

Per eq. J3-1, chapter J of AISC 9th Ed.

the Allowable bearing stress F_p

$F_p = 1.2 F_u$

$= 66 \text{ ksi}$

effective Bearing area: (see § J3.3. AISC 9th.)

$A_{Bearing} = 0.5'' \times 0.5''$

$= 0.25 \text{ in}^2$

Allow. Bearing load: F_B

$F_B = F_p \cdot A_B$

$= 16{,}500^{\#} > F_{bolt.s} = 624^{\#}$

For $\frac{3}{4}''$ thick ASTM A36 plate

∵ there is slot per eq. J3-2, J3-7 AISC 9th.

$F_p = 1.0 F_u = 55 \text{ ksi}$

$A_{Bearing} = 0.75'' \times 0.5''$

$= 0.375 \text{ in}^2$

$F_B = 55 \text{ ksi} \times 0.375 \text{ in}^2$

$= 20{,}625^{\#} > 624^{\#}$ OK !

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
	D0 upgrade		4.6

SUBJECT	NAME	DATE	REVISION DATE
C & A for the Adjustable lifting Device	E. CHI	2-29-00	

$\frac{1}{2}$-13 lifting hole @ $\frac{3}{4}$" thick plate:

The designated lifting Ring to match with $\frac{1}{2}$-13 lifting tap hole is:

Swivel Hoist Ring

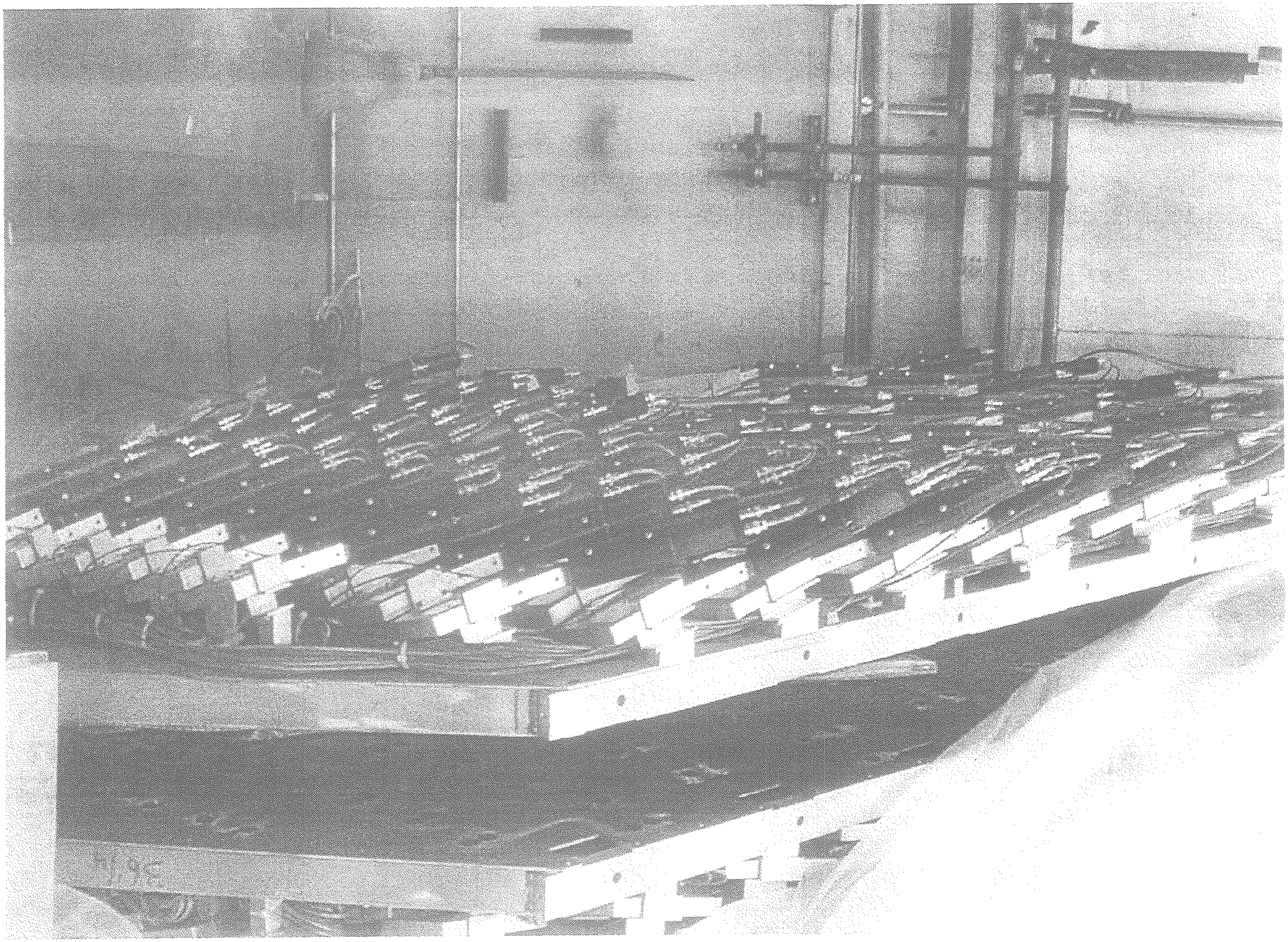
(see page for details)

The load Rating for $\frac{1}{2}$-13 is 2,500# which is larger than the largest applying load. (1,320#, see page 3.7)

Weldment:

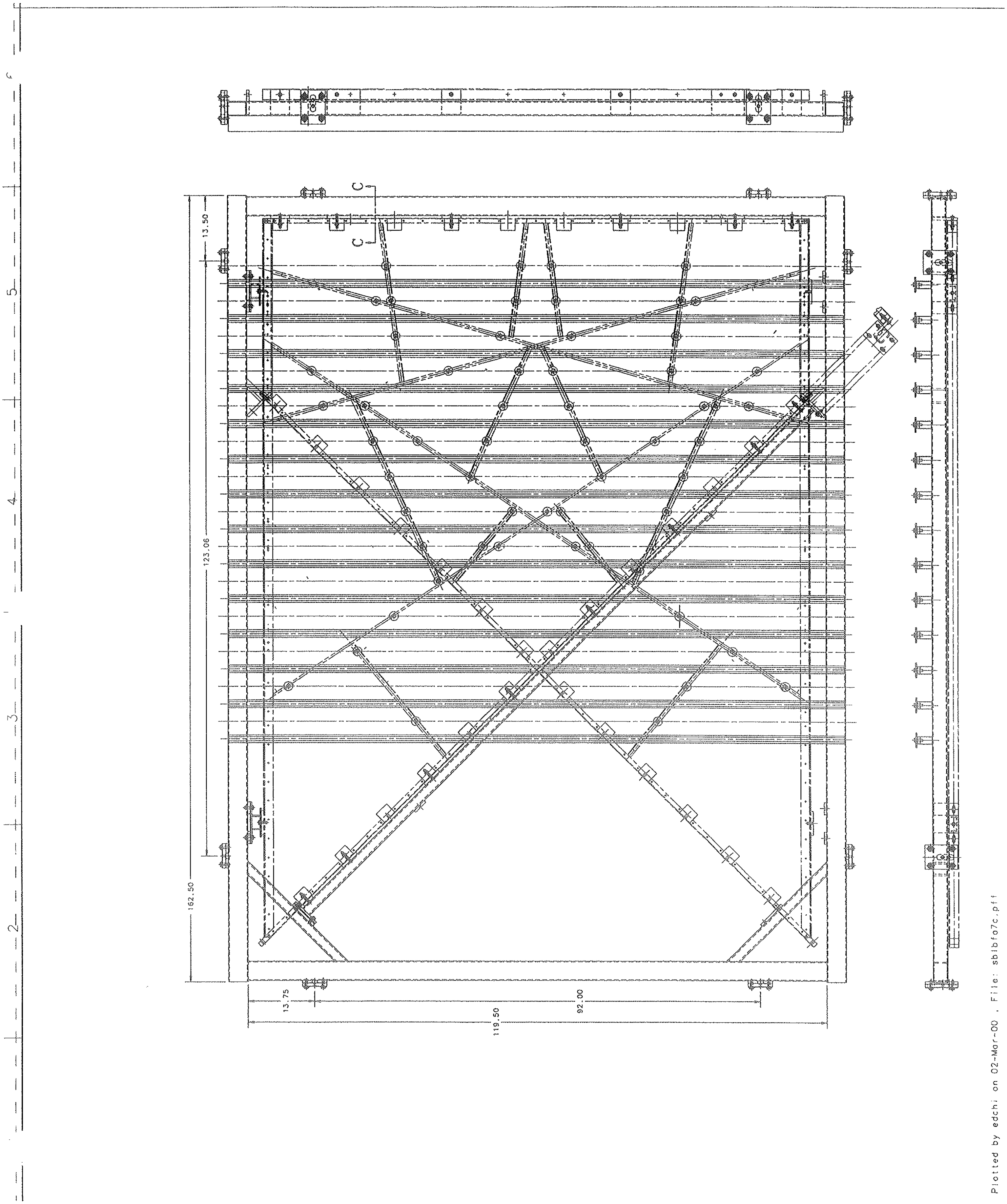
3/16" all around, to compare with the application on page 3.13, the designer feel it is a very safe approach, for the simplicity, cal. detail is omitted.

A1



A2

A3



Plotted by edchi on 02-Mar-00 , File: sblbfo7c.pff

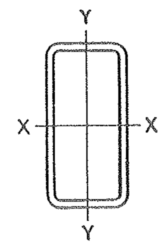
A4

L TUBING
jular
d properties

	Properties**							
	Axis		Y-Y Axis					J
	Z_x	r_x	I_y	S_y	Z_y	r_y		
	In.[3]	In.	In.[4]	In.[3]	In.[3]	In.	In.[4]	
	19.8	2.38	21.5	10.8	13.3	1.52	53.0	
	16.0	2.45	18.1	9.06	10.8	1.57	43.3	
	13.8	2.49	16.0	7.98	9.36	1.60	37.5	
	11.5	2.52	13.5	6.75	7.78	1.63	31.2	
i	[illegible]	[illegible].55	10.7	5.34	6.06	1.66	24.2	
	16.6	2.25	10.5	6.99	8.84	1.12	29.8	
	13.5	2.33	9.08	6.05	7.32	1.18	25.1	
0	11.8	2.37	8.11	5.41	6.40	1.20	22.0	
1	9.79	2.41	6.95	4.63	5.36	1.23	18.5	
2	7.63	2.45	5.57	3.71	4.21	1.26	14.6	
18	8.10	2.26	2.69	2.69	3.19	0.812	8.36	
77	6.36	2.31	2.21	2.21	2.54	0.839	6.74	
3	18.1	2.14	32.1	12.8	16.0	1.85	62.9	
9	14.7	2.21	26.8	10.7	12.9	1.91	50.9	
4	12.7	2.24	23.5	9.40	11.2	1.94	43.9	
74	10.5	2.27	19.8	7.91	9.26	1.97	36.3	
.87	8.15	2.30	15.6	6.23	7.20	2.00	28.1	
.8	15.4	2.06	18.4	9.21	11.5	1.48	42.1	
.90	12.5	2.13	15.6	7.82	9.44	1.54	34.6	
.72	10.9	2.16	13.8	6.92	8.21	1.57	30.1	
.36	9.06	2.19	11.7	5.87	6.84	1.60	25.0	
.81	7.06	2.23	9.32	4.66	5.34	1.63	19.5	
7.92	10.4	2.02	7.78	5.19	6.34	1.16	20.3	
7.03	9.11	2.06	6.98	4.65	5.56	1.18	17.9	
5.98	7.62	2.09	6.00	4.00	4.67	1.21	15.1	
4.76	5.97	2.13	4.83	3.22	3.68	1.24	11.9	

outsiue corner radius equal to two times the wall

STRUCTURAL TUBING
Rectangular
Dimensions and properties



Dimensions				Properties**									
Nominal* Size	Wall Thickness		Weight per Ft	Area	X-X Axis				Y-Y Axis				J
					I_x	S_x	Z_x	r_x	I_y	S_y	Z_y	r_y	
In.	In.		Lb.	In.[2]	In.[4]	In.[3]	In.[3]	In.	In.[4]	In.[3]	In.[3]	In.	In.[4]
6×2	0.3750	3/8	17.27	5.08	17.8	5.94	8.33	1.87	2.84	2.84	3.61	0.748	8.72
	0.3125	5/16	14.83	4.36	16.0	5.34	7.33	1.92	2.62	2.62	3.22	0.775	7.94
	0.2500	1/4	12.21	3.59	13.8	4.60	6.18	1.96	2.31	2.31	2.75	0.802	6.88
	0.1875	3/16	9.42	2.77	11.1	3.70	4.88	2.00	1.90	1.90	2.20	0.829	5.56
5×4	0.3750	3/8	19.82	5.83	18.7	7.50	9.44	1.79	13.2	6.58	8.08	1.50	26.3
	0.3125	5/16	16.96	4.98	16.6	6.65	8.24	1.83	11.7	5.85	7.05	1.53	22.9
	0.2500	1/4	13.91	4.09	14.1	5.65	6.89	1.86	9.98	4.99	5.90	1.56	19.1
	0.1875	3/16	10.70	3.14	11.2	4.49	5.39	1.89	7.96	3.98	4.63	1.59	14.9
5×3	0.5000	1/2	21.63	6.36	16.9	6.75	9.20	1.63	7.33	4.88	6.35	1.07	18.2
	0.3750	3/8	17.27	5.08	14.7	5.89	7.71	1.70	6.48	4.32	5.35	1.13	15.6
	0.3125	5/16	14.83	4.36	13.2	5.27	6.77	1.74	5.85	3.90	4.72	1.16	13.8
	0.2500	1/4	12.21	3.59	11.3	4.52	5.70	1.77	5.05	3.37	3.99	1.19	11.7
	0.1875	3/16	9.42	2.77	9.06	3.62	4.49	1.81	4.08	2.72	3.15	1.21	9.21
5×2	0.3125	5/16	12.70	3.73	9.74	3.90	5.31	1.62	2.16	2.16	2.70	0.762	6.24
	0.2500	1/4	10.51	3.09	8.48	3.39	4.51	1.66	1.92	1.92	2.32	0.789	5.43
	0.1875	3/16	8.15	2.39	6.89	2.75	3.59	1.70	1.60	1.60	1.86	0.816	4.40
4×3	0.3125	5/16	12.70	3.73	7.45	3.72	4.75	1.41	4.71	3.14	3.88	1.12	9.89
	0.2500	1/4	10.51	3.09	6.45	3.23	4.03	1.45	4.10	2.74	3.30	1.15	8.41
	0.1875	3/16	8.15	2.39	5.23	2.62	3.20	1.48	3.34	2.23	2.62	1.18	6.67
4×2	0.3125	5/16	10.58	3.11	5.32	2.66	3.60	1.31	1.71	1.71	2.17	0.743	4.58
	0.2500	1/4	8.81	2.59	4.69	2.35	3.09	1.35	1.54	1.54	1.88	0.770	4.01
	0.1875	3/16	6.87	2.02	3.87	1.93	2.48	1.38	1.29	1.29	1.52	0.798	3.26
3.5×2.5	0.2500	1/4	8.81	2.59	3.97	2.27	2.88	1.24	2.33	1.86	2.28	0.948	4.99
	0.1875	3/16	6.87	2.02	3.26	1.86	2.31	1.27	1.93	1.54	1.83	0.977	4.02
3×2	0.2500	1/4	7.11	2.09	2.21	1.47	1.92	1.03	1.15	1.15	1.44	0.742	2.63
	0.1875	3/16	5.59	1.64	1.86	1.24	1.57	1.06	0.977	0.977	1.18	0.771	2.16

*Outside dimensions across flat sides.
**Properties are based upon a nominal outside corner radius equal to two times the wall thickness.

BOLTS AND THREADED PARTS
ASTM Specifications

TABLE I-C. MATERIAL FOR ANCHOR BOLTS AND TIE RODS

	ASTM Specification	Strength, Ksi Proof Load	Yield (Min.)	Tensile (Min.)	Maximum Diameter In.	Type of Material[b]	Headed or Unheaded
Bolts and Studs	A307	—	—	60	4	C	H
	A325[a]	85 74	92 81	120 105	½ to 1, incl. 1⅛ to 1½ incl.	C, QT	H
	A354 Gr. BD	120 105	130 115	150 140	¼ to 2½ incl. over 2½ to 4 incl.	A, QT	H, U
	A354 Gr. BC	105 95	109 99	125 115	¼ to 2½ incl. over 2½ to 4 incl.	A, QT	H, U
	A449	85 74 55	92 81 58	120 105 90	¼ to 1 incl. 1⅛ to 1½ incl. 1¾ to 3 incl.	C, QT	H, U
	A490	120	—	150	½ to 1½ incl.	A, QT	H
	A687	—	105	150[c]	⅝ to 3 incl.	A, QT, NT	U
Threaded Round Stock	A36	—	36	58	8	C	U
	A572 Gr. 50	—	50	65	2	HSLA	U
	A572 Gr. 42	—	42	60	6	HSLA	U
	A588	— — —	50 46 42	70 67 63	To 4 incl. over 4 to 5 incl. over 5 to 8 incl.	HSLA, ACR	U

[a]Available with weathering (atmospheric corrosion resistance) characteristics comparable to ASTM A242 and A588 steel.

[b]C = carbon
QT = quenched and tempered
A = alloy
NT = notch tough (Charpy V-notch 15 ft-lb. @ −20°F)
HSLA = high-strength low alloy
ACR = atmospheric corrosion-resistant

[c]Maximum (ultimate tensile strength)

Notes:

ASTM specified material for anchor bolts, tie rods and similar applications can be obtained from either specifications for threaded bolts and studs normally used as connectors or for structural material available in round stock that may then be threaded. The material supplier should be consulted for availability of size and length.

Suitable nuts by grade may be obtained from ASTM Specification A563.

Anchor bolt material that is quenched and tempered should not be welded or heated.

Threaded rod with properties meeting A325, A490 or A449 Specifications may be obtained by the use of an appropriate steel (such as AISI C1040 or C4140), quenched and tempered after fabrication.

A5

BOLTS, THRE

Allo

T/

	ASTM Desig-nation	Conn-ection Type[a]	Hole Type[b]
Bolts	A307	—	STD NSL
	A325	SC[a] Class A	STD
			OVS, SSL
			LSL
		N	STD, NSL
		X	STD, NSL
	A490	SC[a] Class A	STD
			OVS, SSL
			LSL
		N	STD, NSL
		X	STD, NSL
Rivets	A502-1	—	STD
	A502-2 A502-3	—	STD
Threaded Parts	A36 (F_u=58 ksi)	N	STD
		X	STD
	A572, Gr. 50 (F_u=65 ksi)	N	STD
		X	STD
	A588 (F_u=70 ksi)	N	STD
		X	STD

[a]SC = Slip critical connection.
N: Bearing-type connection with thre
X: Bearing-type connection with thre
[b]STD: Standard round holes (d + ¹⁄
LSL: Long-slotted holes normal to
NSL: Long-or short-slotted hole nor
(required in bearing-type conr
[c]S: Single shear D: Double sh
For threaded parts of materials not lis
plane, and F_v = 0.22F_u when threads
To fully pretension bolts 1⅛-in. dia. a
When bearing-type connections used
measured parallel to the line of force,
AISC ASD Commentary Sect. J3.4.

ADED PARTS
ications

R ANCHOR BOLTS
ODS

Maximum Diameter In.	Type of Material[b]	Headed or Unheaded
4	C	H
1, incl. to 1½ incl.	C, QT	H
2½ incl. 2½ to 4 incl.	A, QT	H, U
2½ incl. 2½ to 4 incl.	A, QT	H, U
1 incl. to 1¼ incl. to 3	C, QT	H, U
1½ incl.	A, QT	H
3 incl.	A, QT, NT	U
8	C	U
2	HSLA	U
6	HSLA	U
incl. 4 to 5 incl. 5 to 8 incl.	HSLA, ACR	U

sistance) characteristics comparable to

−20°F)

nd similar applications can be obtained
ds normally used as connectors or for
hen be threaded. The material supplier
h.
Specification A563.
should not be welded or heated.
r A4 Specifications may be obtained
40 140), quenched and tempered

BOLTS, THREADED PARTS AND RIVETS
Shear
Allowable load in kips

TABLE I-D. SHEAR

	ASTM Designation	Connection Type[a]	Hole Type[b]	F_v ksi	Loading[c]	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
					Area (Based on Nominal Diameter) in.²	.3068	.4418	.6013	.7854	.9940	1.227	1.485	1.767
Bolts	A307	—	STD NSL	10.0	S	3.1	4.4	6.0	7.9	9.9	12.3	14.8	17.7
					D	6.1	8.8	12.0	15.7	19.9	24.5	29.7	35.3
	A325	SC[a] Class A	STD	17.0	S	5.22	7.51	10.2	13.4	16.9	20.9	25.2	30.0
					D	10.4	15.0	20.4	26.7	33.8	41.7	50.5	60.1
			OVS, SSL	15.0	S	4.60	6.63	9.02	11.8	14.9	18.4	22.3	26.5
					D	9.20	13.3	18.0	23.6	29.8	36.8	44.6	53.0
			LSL	12.0	S	3.68	5.30	7.22	9.42	11.9	14.7	17.8	21.2
					D	7.36	10.6	14.4	18.8	23.9	29.4	35.6	42.4
		N	STD, NSL	21.0	S	6.4	9.3	12.6	16.5	20.9	25.8	31.2	37.1
					D	12.9	18.6	25.3	33.0	41.7	51.5	62.4	74.2
		X	STD, NSL	30.0	S	9.2	13.3	18.0	23.6	29.8	36.8	44.5	53.0
					D	18.4	26.5	36.1	47.1	59.6	73.6	89.1	106.0
	A490	SC[a] Class A	STD	21.0	S	6.44	9.28	12.6	16.5	20.9	25.8	31.2	37.1
					D	12.9	18.6	25.3	33.0	41.7	51.5	62.4	74.2
			OVS, SSL	18.0	S	5.52	7.95	10.8	14.1	17.9	22.1	26.7	31.8
					D	11.0	15.9	21.6	28.3	35.8	44.2	53.5	63.6
			LSL	15.0	S	4.60	6.63	9.02	11.8	14.9	18.4	22.3	26.5
					D	9.20	13.3	18.0	23.6	29.8	36.8	44.6	53.0
		N	STD, NSL	28.0	S	8.6	12.4	16.8	22.0	27.8	34.4	41.6	49.5
					D	17.2	24.7	33.7	44.0	55.7	68.7	83.2	99.0
		X	STD, NSL	40.0	S	12.3	17.7	24.1	31.4	39.8	49.1	59.4	70.7
					D	24.5	35.3	48.1	62.8	79.5	98.2	119.0	141.0
Rivets	A502-1	—	STD	17.5	S	5.4	7.7	10.5	13.7	17.4	21.5	26.0	30.9
					D	10.7	15.5	21.0	27.5	34.8	42.9	52.0	61.8
	A502-2 A502-3	—	STD	22.0	S	6.7	9.7	13.2	17.3	21.9	27.0	32.7	38.9
					D	13.5	19.4	26.5	34.6	43.7	54.0	65.3	77.7
Threaded Parts	A36 (F_u=58 ksi)	N	STD	9.9	S	3.0	4.4	6.0	7.8	9.8	12.1	14.7	17.5
					D	6.1	8.7	11.9	15.6	19.7	24.3	29.4	35.0
		X	STD	12.8	S	3.9	5.7	7.7	10.1	12.7	15.7	19.0	22.6
					D	7.9	11.3	15.4	20.1	25.4	31.4	38.0	45.2
	A572, Gr. 50 (F_u=65 ksi)	N	STD	11.1	S	3.4	4.9	6.7	8.7	11.0	13.6	16.5	19.6
					D	6.8	9.8	13.3	17.4	22.1	27.2	33.0	39.2
		X	STD	14.3	S	4.4	6.3	8.6	11.2	14.2	17.5	21.2	25.3
					D	8.8	12.6	17.2	22.5	28.4	35.1	42.5	50.5
	A588 (F_u=70 ksi)	N	STD	11.9	S	3.7	5.3	7.2	9.3	11.8	14.6	17.7	21.0
					D	7.3	10.5	14.3	18.7	23.7	29.2	35.3	42.1
		X	STD	15.4	S	4.7	6.8	9.3	12.1	15.3	18.9	22.9	27.2
					D	9.4	13.6	18.5	24.2	30.6	37.8	45.7	54.4

Nominal Diameter d, in.

[a]SC = Slip critical connection.
N: Bearing-type connection with threads *included* in shear plane.
X: Bearing-type connection with threads *excluded* from shear plane.
[b]STD: Standard round holes (d + 1/16 in.)
OVS: Oversize round holes
LSL: Long-slotted holes normal to load direction
SSL: Short-slotted holes
NSL: Long-or short-slotted hole normal to load direction (required in bearing-type connection).
[c]S: Single shear D: Double shear.
For threaded parts of materials not listed, use $F_v = 0.17F_u$ when threads are included in a shear plane, and $F_v = 0.22F_u$ when threads are excluded from a shear plane.
To fully pretension bolts 1⅛-in. dia. and greater, special impact wrenches may be required.
When bearing-type connections used to splice tension members have a fastener pattern whose length, measured parallel to the line of force, exceeds 50 in., tabulated values shall be reduced by 20%. See AISC ASD Commentary Sect. J3.4.

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nd drawings.

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A7

BOLTS, THREADED PARTS AND RIVETS
Tension
Allowable loads in kips

TABLE I-A. BOLTS AND RIVETS
Tension on gross (nominal) area

ASTM Designation	F_t Ksi	Nominal Diameter d, In.							
		5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
		Area (Based on Nominal Diameter), In.^{2}							
		0.3068	0.4418	0.6013	0.7854	0.9940	1.227	1.485	1.767
A307 bolts	20.0	6.1	8.8	12.0	15.7	19.9	24.5	29.7	35.3
A325 bolts	44.0	13.5	19.4	26.5	34.6	43.7	54.0	65.3	77.7
A490 bolts	54.0	16.6	23.9	32.5	42.4	53.7	66.3	80.2	95.4
A502-1 rivets	23.0	7.1	10.2	13.8	18.1	22.9	28.2	34.2	40.6
A502-2,3 rivets	29.0	8.9	12.8	17.4	22.8	28.8	35.6	43.1	51.2

The above table lists ASTM specified materials that generally are intended for use as structural fasteners.
For dynamic and fatigue loading, only A325 or A490 high-strength bolts should be specified. See AISC Specification. Appendix K4.
For allowable combined shear and tension loads, see AISC ASD Specification Sects. J3.5 and J3.6.

TABLE I-B. THREADED FASTENERS
Tension on gross (nominal) area

ASTM Designation	F_y Ksi	F_u ksi	F_t ksi	Nominal Diameter d, In.							
				5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
				Area (Based on Nominal Diameter), In.^{2}							
				0.3068	0.4418	0.6013	0.7854	0.9940	1.227	1.485	1.767
A36	36	58	19.1	5.9	8.4	11.5	15.0	19.0	23.4	28.4	33.7
A572, Gr. 50	50	65	21.5	6.6	9.5	12.9	16.9	21.4	26.4	31.9	38.0
A588	50	70	23.1	7.1	10.2	13.9	18.1	23.0	28.3	34.3	40.8
A449											
$d \leq 1$	92	120	39.6	12.1	17.5	23.8	31.1	—	—	—	—
$1 < d \leq 1\frac{1}{2}$	81	105	34.7	—	—	—	—	34.5	42.6	51.5	61.3

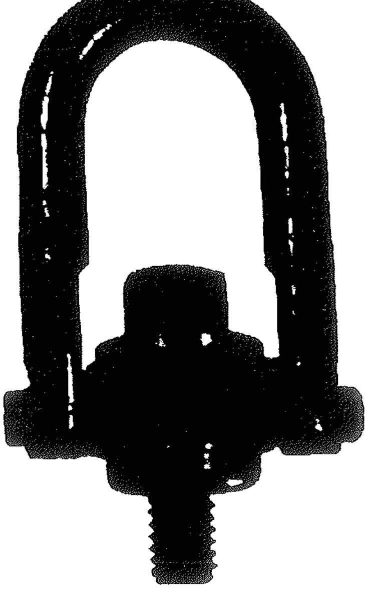
The above table lists ASTM specified materials available in round bar stock that are generally intended for use in threaded applications such as tie rods, cross bracing and similar uses.
The tensile capacity of the threaded portion of an upset rod shall be larger than the body area times $0.6F_y$.
F_u = specified minimum tensile strength of the fastener material.
$F_t = 0.33F_u$ = allowable tensile stress in threaded fastener.

SPEC

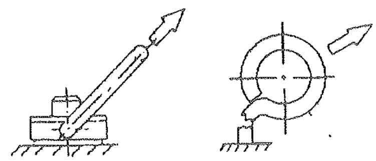
A8

SWIVEL HOIST RINGS

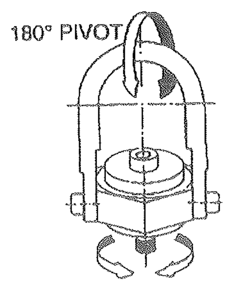
BODY, RING: 4140 STEEL, HEAT TREATED RC 43-48
BOLT: ALLOY STEEL, HEAT TREATED RC 39-43
BLACK OXIDE FINISH OR CADMIUM PLATED

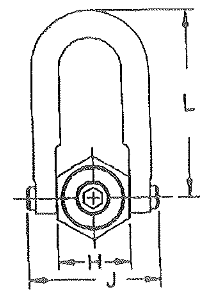


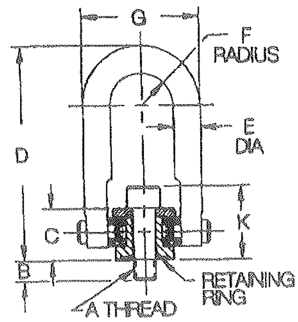
Pivots 180° and rotates 360° simultaneously to allow lifting from any direction. Choice of bolt lengths available: Use the shortest only for steel plates, the other lengths for weaker materials ... for through-hole mounting with a ...sher and nut. See safety precautions on page 27.



Swivel Hoist Rings (left) are designed to withstand much greater side loads than eye bolts (right).







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BLACK OXIDE FINISH (USA)

PART NO.	LOAD RATING (LBS)*	A	B	C	D	E DIA	F	G	H	J	K	L	INSTALLATION TORQUE (FT-LB)	REPLACEMENT BOLT (WITH RETAINING RING)
CL-800-SHR-1	800	5/16-18	.29	.72	2.71	3/8	7/16	1-5/8	1	1.82	1.03	2.35	7	CL-800-SHRB-1
CL-800-SHR-2			.54											CL-800-SHRB-2
CL-1000-SHR-1	1000	3/8-16	.54	.72	2.71	3/8	7/16	1-5/8	1	1.82	1.09	2.35	12	CL-1000-SHRB-1
CL-2500-SHR-1	2500	1/2-13	.77	1.23	4.77	3/4	7/8	3-1/4	2	3.52	1.73	4.24	28	CL-2500-SHRB-1
CL-2500-SHR-2			1.02											CL-2500-SHRB-2
CL-2500-SHR-3			1.27											CL-2500-SHRB-3
CL-4000-SHR-1	4000	5/8-11	.77	1.23	4.77	3/4	7/8	3-1/4	2	3.52	1.86	4.24	60	CL-4000-SHRB-1
CL-4000-SHR-2			1.02											CL-4000-SHRB-2
CL-4000-SHR-3			1.27											CL-4000-SHRB-3
CL-5000-SHR-1	5000	3/4-10	1.02	1.23	4.77	3/4	7/8	3-1/4	2	3.52	1.98	4.24	100	CL-5000-SHRB-1
CL-5000-SHR-2			1.52											CL-5000-SHRB-2
CL-7000-SHR-1	7000	3/4-10	1.03	1.72	6.55	1-1/16	1-13/32	4-15/16	3	5.06	2.47	5.80	100	CL-7000-SHRB-1
CL-7000-SHR-2			1.53											CL-7000-SHRB-2
CL-8000-SHR-1	8000	7/8-9	1.03	1.72	6.55	1-1/16	1-13/32	4-15/16	3	5.06	2.60	5.80	160	CL-8000-SHRB-1
CL-8000-SHR-2			1.53											CL-8000-SHRB-2
CL-10000-SHR-1	10000	1-8	1.28	1.72	6.55	1-1/16	1-13/32	4-15/16	3	5.06	2.72	5.80	230	CL-10000-SHRB-1
CL-10000-SHR-2			1.53											CL-10000-SHRB-2
CL-10000-SHR-3			2.28											CL-10000-SHRB-3
CL-15000-SHR-1	15000	1-1/4–7	1.89	2.11	8.73	1-1/4	1-3/4	6	3.76	6.50	3.36	7.76	470	CL-15000-SHRB-1
CL-24000-SHR-1	24000	1-1/2–6	2.70	2.81	12.47	1-3/4	2-1/4	8	4.87	8.55	4.36	11.12	800	CL-24000-SHRB-1
CL-30000-SHR-1	30000	2–4-1/2	2.96								5.36			CL-30000-SHRB-1

*Safety factor = 5:1. Larger sizes available as specials...please contact factory.

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