BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page

Lifting Device Numbers:

FNAL Site No.:_____ if applicable Div. Specific No.: 135 if applicable Asset No. _____ if applicable

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

Device Name or Description: MINOS NEAR COIL LIFTING FIXTURE

Device was: (check all applicable)
- ˇ Purchased from a Commercial Lifting Device Manufacturer
  mfg. name: _____
- ˇ Designed and Built at Fermilab
- ˇ Designed by Fermilab and Built by a Vendor
  Assy drawing number: 9213.300-ME-384634
- ˇ Provided by a User or Other Laboratory
- ˇ Other. Describe: _____

Engineering Note Prepared by: JIM KILMER, BOB WANDS Date: 3/21/02

Engineering Note Reviewed by: MARK FRENCHMASTER Date: 4/1/02

Lifting Device Data:

Capacity: 4500 lbs

Fixture Weight: 1575 lbs

Service: ˇ normal ˇ heavy ˇ 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: 5625 OR 5/1 lbs ON EACH CLAMP.

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

Satisfactory Load Test Witnessed by: [signature] 8/27/2004 (Not to be used for vertical lifts without further load test) (PD)

Signature (of Load Test Witness): Patrick Donahoe #13311 [signature] Donahoe #13311

Notes or Special Information:

SUGGEST ADDING LIFTING LUG @ C.G. ~~HER~~ for vertical service without counter loads. FRENCHMASTER

OK for vertical lifts (PD) 8/27/04

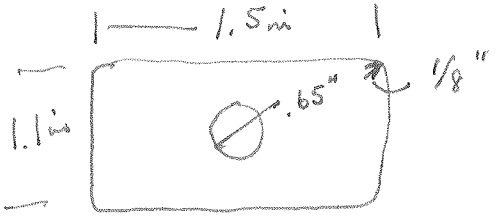
FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			1

SUBJECT: Wt of 712 in of 6 Conductors

NAME: James R. Kilmer

DATE: | REVISION DATE:



$A = 1.1 \times 1.5 - \frac{\pi}{4}(.65)^2 - [4 \times .125\,in^2 - \frac{\pi}{4}(.25in)^2]$

$= 1.65\,in^2 - .33\,in^2 - [.0625\,in^2 - .049\,in^2]$

$= 1.30\,in^2$

$V = 1.30\,in^2 \times 712\,in$

$= 930.29\,in^3$

$W = \rho V = (.0975\,lb/in^3)(930.29\,in^3)$

$= 90.7\,lb/pc$

TOTAL OF 6 = 544 lbs

ESTIMATE MANIFOLD WEIGHT ASSUMING SIMPLE SHAPE AND NO HOLES.

VOLUME = $1.1in \times 9in \times 9"$

$= 89.1\,in^3$

Wt = (2 MANIFOLDS)$\left(\frac{89.1\,in^3}{\text{MANIFOLD}}\right)(.098\,lb/in^3)$ = 17.5 lbs

SO EACH TURN WEIGHS 544 + 17.5 lbs = 561.4 lbs

FIXTURE IS DESIGNED TO CARRY AT MAXIMUM 8 TURNS OF CONDUCTOR

$8 \times 561.4\,lbs = 4492\,lbs$

OR $\frac{4492.1\,lbs}{62\,ft} = 72\,lbs/ft$ DISTRIBUTED LOAD.

SEE BOB WANDS NOTE MSG-EAR-00270

CHECK WELDS ON TOP 1/4 POINT LIFTING LUGS.

LOAD ON EACH LUG IS $\frac{(4492 + 1575)}{2} = \frac{6067}{2} = 3033.5$ lbs

WELD IS A 1/2" FILLET ALL AROUND LUG.

$L = 1 + 1 + 4 + 4 = 10$ in

$t_{WELD} = \frac{.5in}{\sqrt{2}} = .35$ in AT THROAT.

$A_W = 10in \times .35in = 3.5in^2$

$\sigma_{TENSILE} = \frac{3033.5 lbs}{3.5 in^2} = 860$ PSI $\Rightarrow$ STRESS OK. ON LUG. (<8KSI)

LOOK AT LUG (PART 9 ON PRINT) ME-384634

THIS LUG HOLDS ENTIRE LOAD = 6067 lbs.

AREA OF WELD $= 2 \times (4in + 4in + 4in) \times \frac{.125in}{\sqrt{2}}$

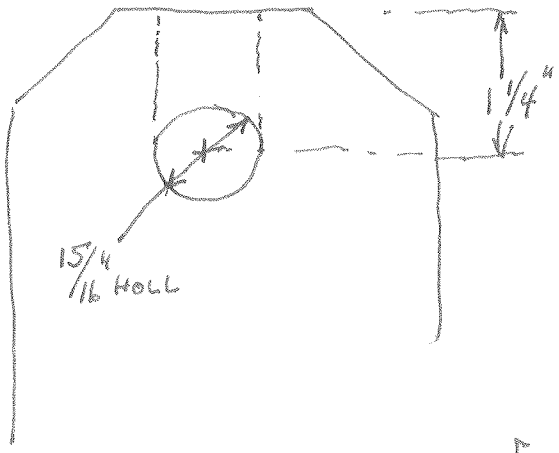
$= (12.8in)(.176in)$

$= 22.6 in^2$

$\sigma_{SHEAR} = \frac{6067 lbs}{22.6 in^2} = 268$ PSI $\Rightarrow$ STRESS OK (<8KSI)

LOOK AT BLOCK SHEAR ON THE LUGS.

LOAD ON ONE LUG IS MAXIMUM
6067 lbs



$A = 2 \times 1.25in \times 1in$

$= 2.5in^2$

$\sigma_{SHEAR} = \frac{6067 lbs}{2.5in^2} = 2427 PSI$

$F_{sy} = 20KSI$ FROM pg 11 ENGINEERING DATA FOR ALUMINUM STRUCTURES

$\frac{F_{sy}}{3} = 6666 PSI$

LUGS ARE OK $\Rightarrow$ $2427 PSI < 6666 PSI$

FIXTURE LOAD IS HELD BY 22 EACH 3/4"-10 UNC THREADED RODS.

ROD IS B7 ALLOY STEEL WITH MINIMUM TENSILE STRENGTH OF 125KSI

LOAD IS SMALL SO USE AVERAGE MEAN THREAD AREA APPROACH.

STRESS AREA OF 5/4"-10 IS $.334in^2$

LOAD/BOLT $= \frac{4500 lbs}{22} \approx 205 lbs$

$\sigma = \frac{F}{A} = \frac{205 lbs}{.334 in^2}$

$= 613 PSI$

$\therefore$ 3/4"-10 ROD AND NUTS ARE FINE FOR THIS SMALL A LOAD.

ie $613 << \frac{125KSI}{3} = 41 KSI$

LASTLY, DRAWINGS SPECIFY THAT THE 10" I BEAM AT TOP IS AN AMERICAN STANDARD SHAPE 10" X 8.76lb I BEAM. RYERSON ACTUALLY SENT US AN ALUMINUM ASSOCIATION STANDARD I BEAM WHICH IS 10" DEEP X 6" WIDE. IT IS STRONGER THAN THE ONE SPECIFIED SO WE USED IT. HERE'S THE TABLE BOB WAND'S GENERATED AS A COMPARISON

	AMERICAN STANDARD 10"	ALUMINUM ASSOC. 10"
I_{xx}	123.39 in^4	132.09 in^4
S_{xx}	24.68 in^3	26.42 in^3
I_{yy}	6.78 in^4	14.78 in^4
S_{yy}	2.91 in^3	4.93 in^3
r_{xx}	4.07 in	4.24 in
r_{yy}	0.97 in	1.42 in

∴ THE RYERSON AL. ASSOC. BEAM IS STRONGER THAN SPECIFIED.

MSG-EAR-00270
March 20, 2000

Stress Analysis of Coil Moving Fixture

Bob Wands

Introduction and Summary

The coils for the far detector will be moved within the cavern using a 62-foot long aluminum fixture. The load on the fixture is 72 lb./ft from the coils. A stress analysis shows that the current fixture is adequate in terms of both stress and stability requirements, as given in the Aluminum Association handbook.

Geometry

The geometry for the finite element model was based on drwg 9213.300-ME-384634. The fixture consists of three basic aluminum components:

1. The top beam -- a composite section consisting of one I10x8.76 I-beam and two C4x2.5 channels. It is oriented to provide maximum lateral buckling resistance.

2. The trusses - I4x2.64 I-beams.

3. The bottom beam -- I8x6.35 I-beam

Section Properties

The section properties for the various components are listed in Table I.

Table I. Section Properties

Component	Area (in^2)	Ixx (in^4)	Iyy (in^4)	r_{min} (in)
Top Beam	**11.71 in**	**15.94**	**230.75**	**4.43**
Trusses	**2.25**	**-**	**-**	**0.58**
Bottom Beam	**5.4**	**57.55**	**3.73**	**0.83**

Load Cases

Two load casese were considered. The first is when the fixture is supported horizontally at the ends, and loaded with the coil. The second is the case where the fixture, with coils attached, is held vertically by one end, as will be the case when the coils are lowered into the shaft.

It should be noted that the horizontal load case will only be encountered when the coil fixture is rotated from its vertical position (in which it comes down into the experiment's cavern), to the horizontal position. At this time, supports for the fixture will have their maximum separation. However, during actual crane-handling of the fixture will occur at lugs welded to the 1/4 points of the top beam.

Design Basis

The Aluminum Association "Specifications for Aluminum Structures" provided the following allowable stresses in 6062-T6 aluminum:

Tension (all members): $S_t = 19$ ksi

Compression (trusses only): For $L/r = 48/0.58 = 82.7$,

$$S_c = 8.9\text{-}0.037(L/r) = 5.84 \text{ ksi}$$

Compression (top beam only): Due to the depth of the fixture in the vertical direction, the failure mode of the top beam is lateral (out of plane) buckling. For conservatism, the entire 62 foot length is assumed to be under uniform compression. For $L/r = 744/4.43 = 167.9$,

$$S_c = 51000/(L/r)^2 = 1.8 \text{ ksi}$$

Fillet Weld Shear

For a 5183 filler alloy and 6061 parent material, the maximum allowable fillet weld shear stress is 8 ksi.

Finite Element Model

Horizontal Load Case

A 2-d beam finite element model was created (Fig. 1). The diagonal braces were modeled as trusses, which transmit no moment through their connections at the top and bottom beams.

The fixture was constrained at the endpoints of the top beam of the sixty two foot span. Distributed forces on the bottom beam simulated the 72 LB/foot coil weight; fixture weight was automatically included by the program from density, volume, and acceleration input.

The weight of the fixture alone was calculated by the program as 1500 lb..

Vertical Load Case

When the fixture is turned vertically, the coil load will produce a moment around the bottom beam. To simulate this moment, stiff offsets equal to 1/2 the coil package thickness were added to the beam at several locations, and mass elements were applied to their free ends. This model is shown in Fig. 2.

Results - Horizontal Load Case

Displacements

The maximum vertical displacement is 0.78 inches, as shown in Fig. 3.

Top Beam

The maximum tensile stress occurs near the constraints, and is 4.4 ksi. The maximum compressive stress is 1.3 ksi and occurs at the center of the span.

Both of these stresses are less than the allowable. In addition, the compressive stress allowable is based on uniform compression in the entire 62 foot span, when in fact, the compression is a maximum only in the region of the span center.

Trusses

The maximum tensile stress in the trusses is 2.2 ksi. The maximum compressive stress is 1.65 ksi. Both of these stresses occur near the ends of the span, and both are below the allowable stresses.

Bottom Beam

The bottom beam experiences only tensile stresses, as expected. These are a maximum of 3.3 ksi, which is below the allowable tensile stress.

Results -- Vertical Load Case

Displacements

The vertical displacements for this orientation are very small, because of the very stiff orientation of the members. The maximum displacement is 0.05 inches.

Top Beam

Stresses in the top beam are negligible for this orientation.

Trusses

Stresses in the trusses are negligible for this orientation.

Bottom Beam

The bottom beam is the most highly stressed for this orientation, as expected. However, all stresses in the bottom beam are less than 1200 pi.

Weld Forces

The maximum weld forces on the truss/beam connections occur in the horizontal load case. These forces were extracted from the nodal forces of the model. The maximum force acting on a weld between the trusses and beams is 5600 lb..

The present design specifies a 1/2 in fillet weld around the perimeter of the truss. This weld length is a minimum for the vertical truss members. For a 4x2.64 I-beam, the perimeter is 13.28 inches. The resulting fillet weld stress area is 4.69 inches. This gives a working stress of 1194 pi. This is well below the maximum allowable shear stress of 8 ksi.

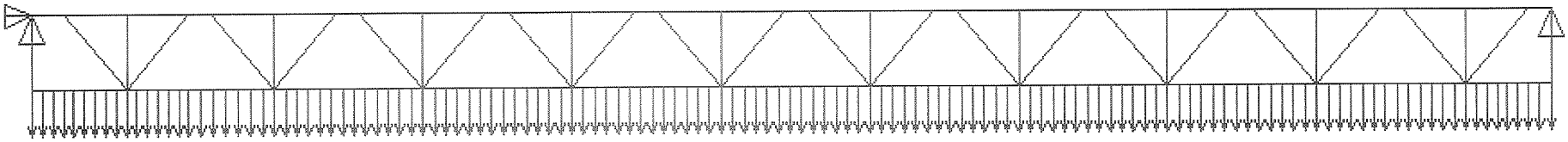
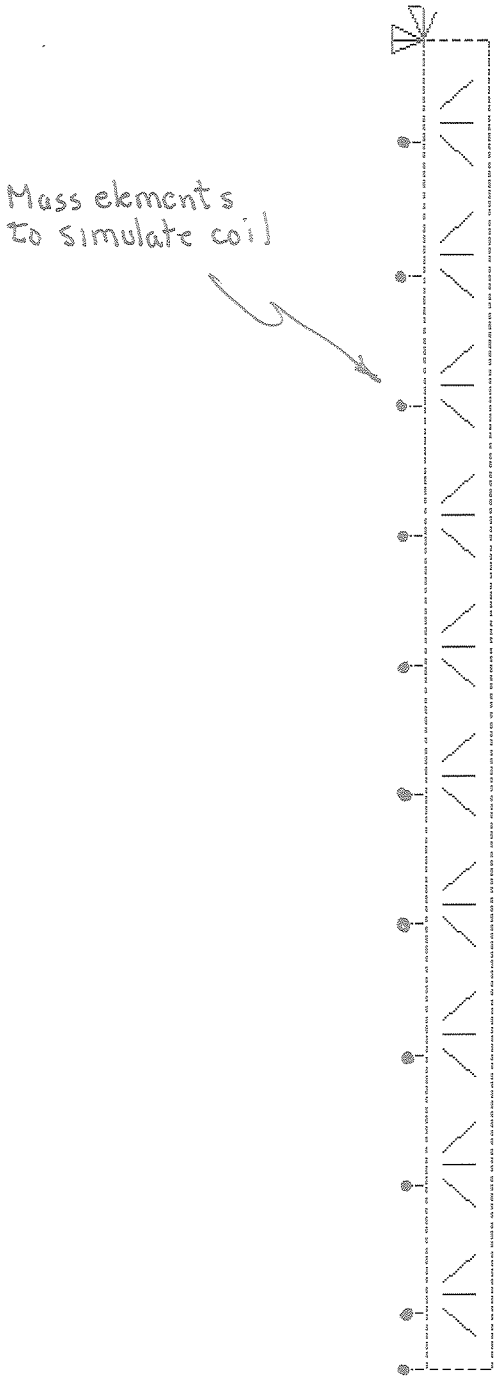


Fig 1. Horizontal load case

2-d Finite Element Beam Model of Fixture



2-d Finite Element Beam Model of Fixture

Fig 2. Vertical load case

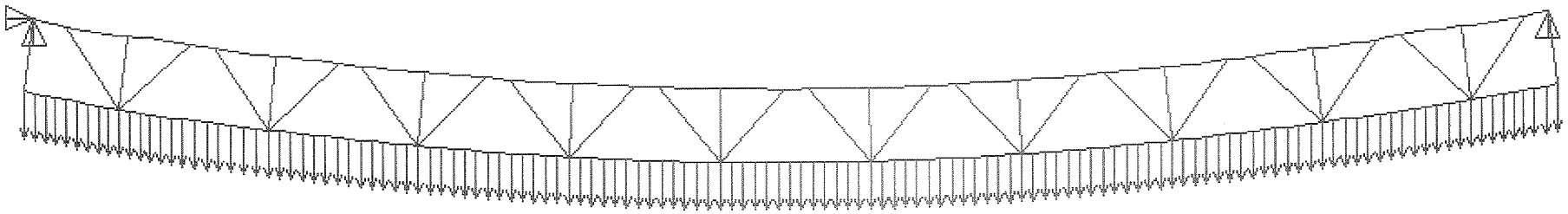
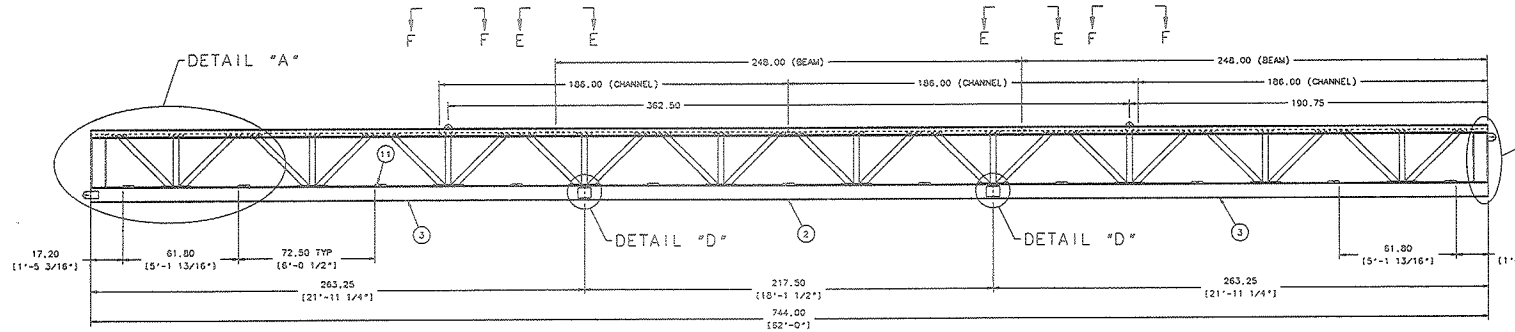


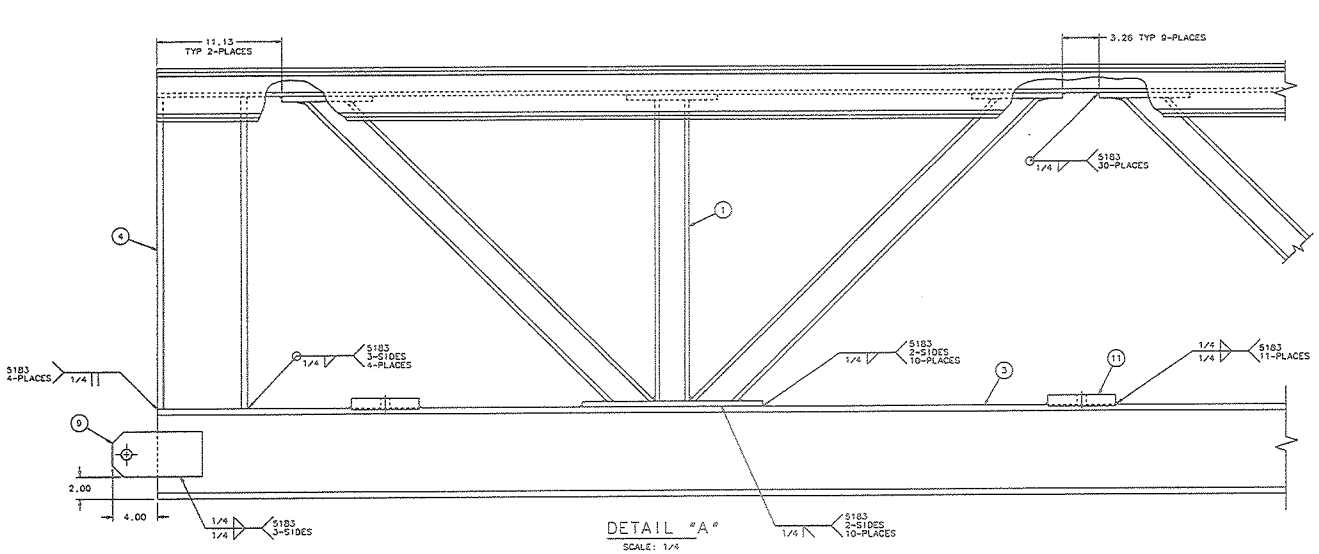
Fig. 3

Vert ·al displacements under coil + dea· weight -- max = 0.78 in

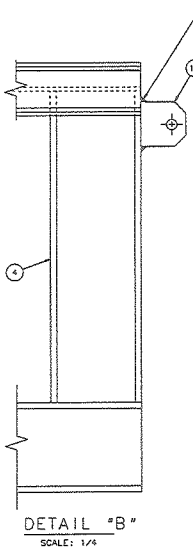
[DWG#]	roj]	[Cat.]	Sh	Rev	- DRAWING T[illegible] -	Init.	INIT.BY.	STATU
384634	ME	9213 300	01		TRANSPORT WELDMENT, NEAR MAGNET COIL, MINOS	02/22/00	bcyko	IN * R L
384635	MD	9213 300	01		TRUSS WELDMENT, NEAR MAGNET COIL, MINOS	02/22/00	bcyko	IN * R L
384636	MB	9213 300	01		TRUSS CORD, TRANSPORT, NEAR MAGNET COIL, MINOS	02/22/00	bcyko	IN * R L
384637	MB	9213 300	01		TRUSS BASE PLATE, TRANSPORT, NEAR MAGNET COIL, MINOS	02/22/00	bcyko	IN * R L
384638	MB	9213 300	01		LIFTING LUG, TRANSPORT, NEAR MAGNET COIL, MINOS	02/22/00	bcyko	IN * R L
384664	MB	9213 300	01		LIFTING LUG, TRANSPORT, NEAR MAGNET COIL, MINOS	03/02/00	bcyko	IN * R L
384700	ME	9213 300	01		TRANSPORT & COIL ASSY., NEAR COIL TRANSPORT, MINOS	03/14/00	bcyko	IN * R L
384701	MB	9213 300	01		MAGNET COIL CLAMPING PLATE, NEAR COIL TRANSPORT, MINOS	03/14/00	bcyko	IN * R L
384708	MB	9213 300	01		I-BEAM CLAMPING PLATE, NEAR COIL TRANSPORT, MINOS	03/16/00	bcyko	IN * R L
384752	MB	9213 300	01		CLAMP ROD WELDMENT, NEAR COIL TRANSPORT, MINOS	03/21/00	bcyko	IN * R L

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



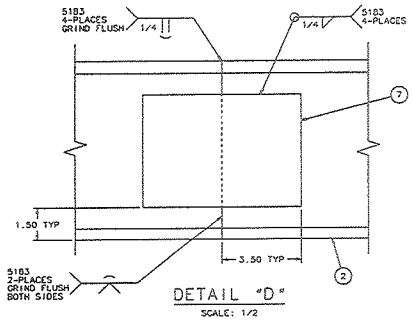


DETAIL "A"
SCALE: 1/4

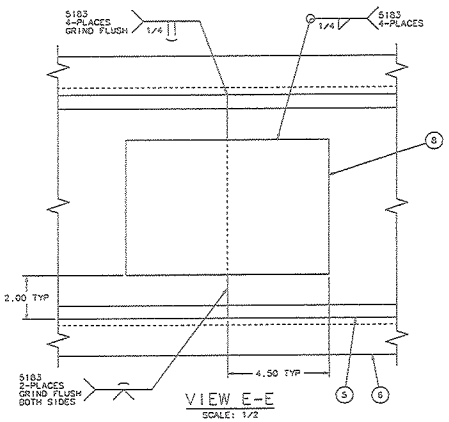


DETAIL "B"
SCALE: 1/4

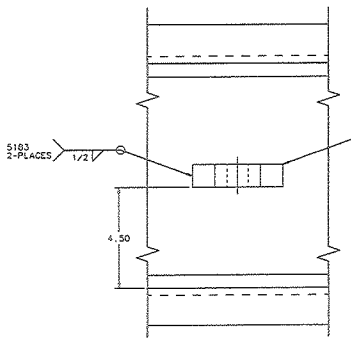
VIEW C-C
SCALE: 1/4



DETAIL "D"
SCALE: 1/2



VIEW E-E
SCALE: 1/2



VIEW F-F
SCALE: 1/2

APPROX. WEIGHT: 1575 LBS.

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
11	MD-384708	I-BEAM CLAMPING PLATE	11
10	MD-384564	LIFTING LUG	3
9	MD-384638	LIFTING LUG	2
8	COML	RECTANGLE, 1/4 x 6 x 9.00 LG., ALUMINUM 6061-T6511	4
7	COML	RECTANGLE, 1/4 x 3 x 7.00 LG., ALUMINUM 6061-T6511	4
6	COML	CHANNEL, AMER. STD., 4 x 2.50# x 186.00 LG., ALUMINUM 6061-T6	8
5	COML	I-BEAM, AMER STD., 10 x 6.57# x 248.00 LG., ALUMINUM 6061-T6	3
4	COML	I-BEAM, AMER STD., 8 x 5.34# x 28.00 LG., ALUMINUM 6061-T6	2
3	COML	I-BEAM, AMER STD., 8 x 5.34# x 263.25 LG., ALUMINUM 6061-T6	2
2	COML	I-BEAM, AMER STD., 8 x 5.34# x 217.50 LG., ALUMINUM 6061-T6	1
1	MD-384635	TRUSS WELDMENT	10

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	03-01-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	03-01-00
±.03	±	±	CHECKED		
			APPROVED		

1. BREAK ALL SHARP EDGES 0.03 MAX.
2. DO NOT SCALE DWG.
3. DIMENSIONING IS ACCORD WITH ANSI Y14.5M-1982
4. ALL DIMENSIONS ARE IN INCHES.

USED ON ME-384700 ITEM 1

250 MAX. ALL MACHINED SURFACES

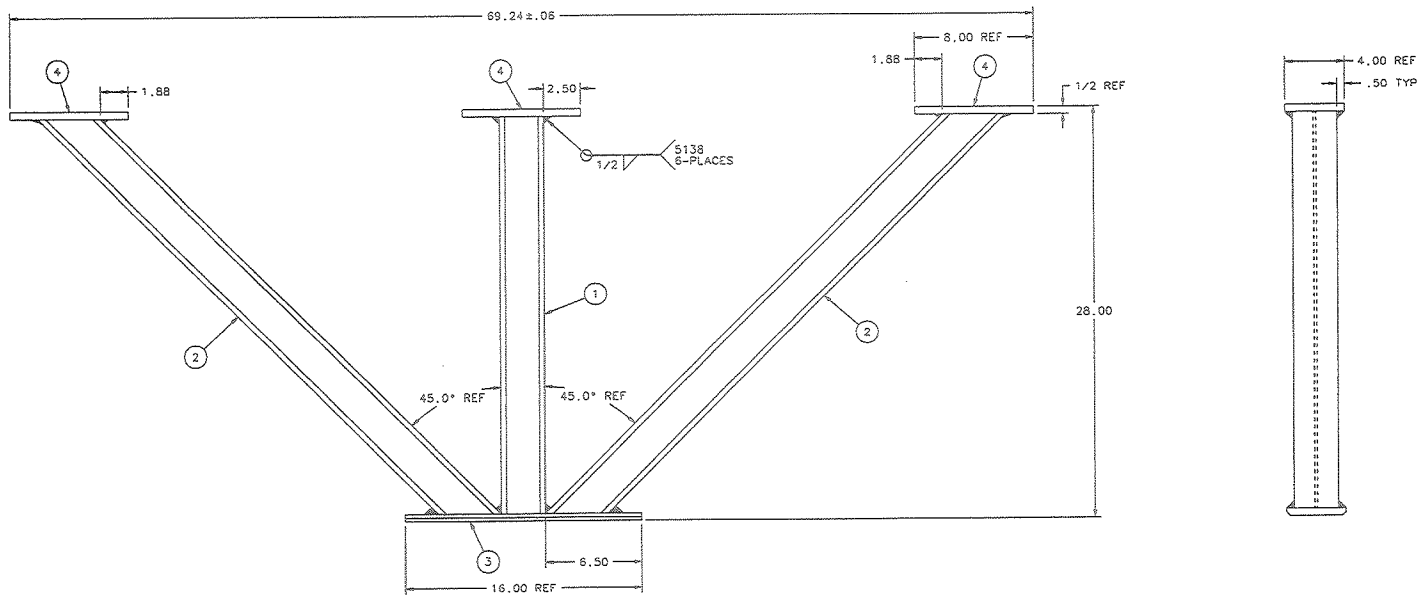
MATERIAL SEE ABOVE PARTS LIST

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
TRANSPORT WELDMENT

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2=1=0 AS NOTED	9213.300-ME-384634	1 OF 1	

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
4	COML.	PLATE, 1/2 x 4 x 8, ALUMINUM 6061-76	3
3	MB-384637	BASE PLATE	1
2	MC-384636	TRUSS CORD	2
1	COML.	I-BEAM, AMER. STD., 3 x .170 x 27.00 LG., ALUMINUM 6061-76.	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	02-24-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	02-24-00
±.02	± —	± —	CHECKED		
			APPROVED		

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

125 √ MAX. ALL MACHINED SURFACES

USED ON ME-384634 ITEM 1

MATERIAL SEE ABOVE PARTS LIST

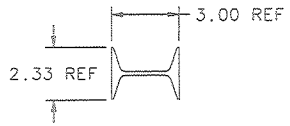
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

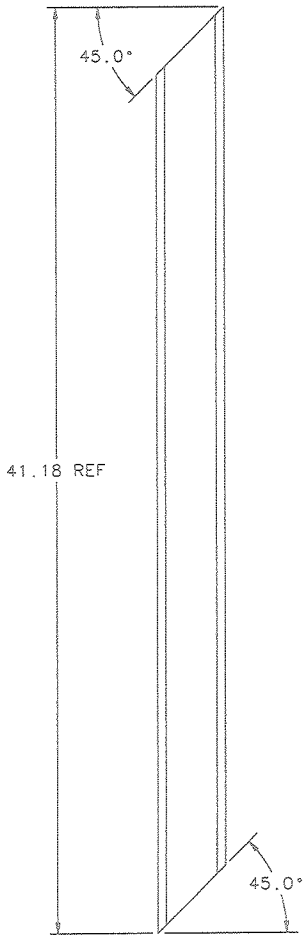
PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
TRUSS WELDMENT, TRANSPORT FIXTURE

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/4	9213.300-MD-384635	1 OF 1	

Plotted by bcyko on 22-Mar-00 , File: 384635-01.pff

REV.	DESCRIPTION	N	DATE
		OVED	DATE





ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	02-24-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	02-24-00
± .02	± —	± 1°	CHECKED		
			APPROVED		

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.

250 √ MAX. ALL MACHINED SURFACES

USED ON MD-384635 ITEM 2

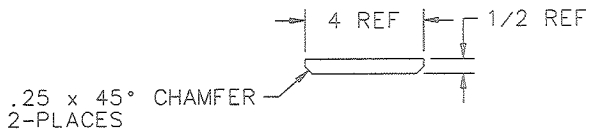
MATERIAL
I-BEAM, AMER. STD., 3 x .170, ALUMINUM 6061-T6

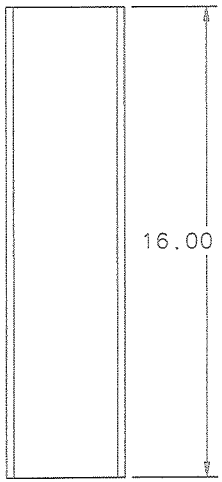
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
TRUSS CORD, TRANSPORT FIXTURE

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/4	9213.300-MC-384636	1 OF 1	

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE





ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	02-24-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	02-24-00
± .02	± ——	± 1°	CHECKED		
			APPROVED		

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.

125 √ MAX. ALL MACHINED SURFACES

USED ON MD-384635 ITEM 3

MATERIAL
RECTANGLE, 1/2 x 4 x 16.00, ALUMINUM 6061-T6

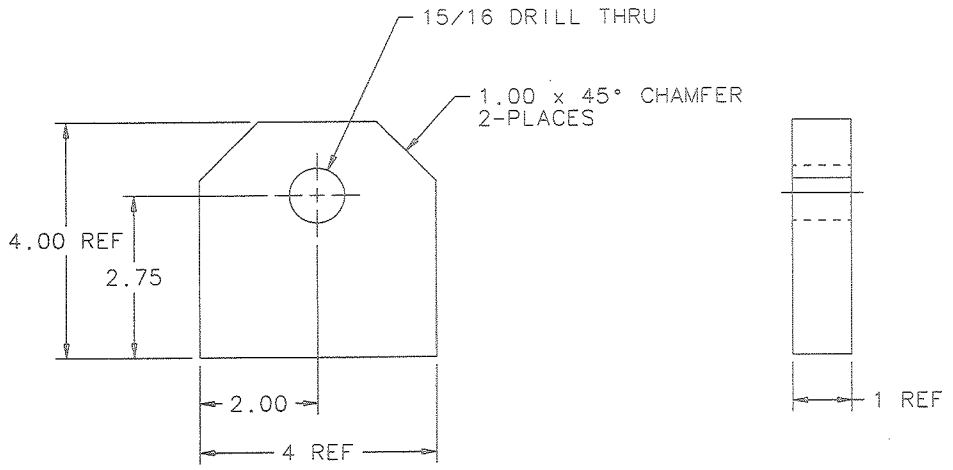
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
TRUSS BASE PLATE

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/4	9213.300-MB-384637	1 OF 1	

Plotted by bcyko on 22-Mar-00 , File: 384637-01.pff

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	03-06-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	03-06-00
±.02	± —	± 1°	CHECKED		
			APPROVED		

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.

125 MAX. ALL MACHINED SURFACES

USED ON ME-384634 ITEM 10

MATERIAL
RECTANGLE, 1 x 4 x 4.00 LG., ALUMINUM 6061-T6511

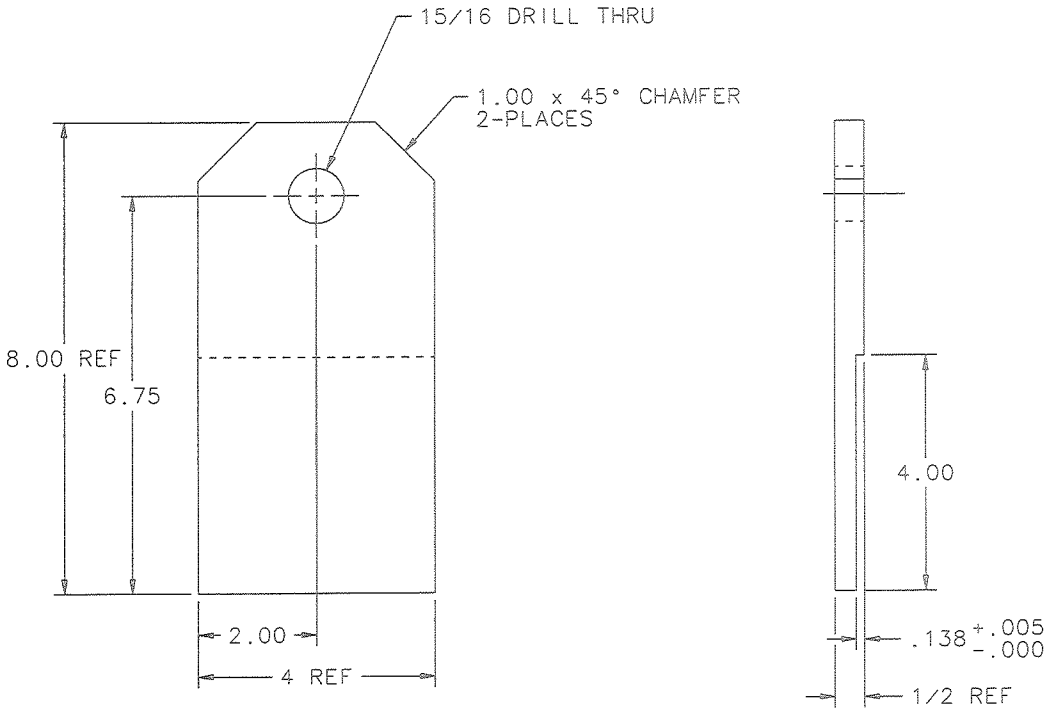
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT MINOS NEAR MAGNET COIL LIFTING LUG, TRANSPORT

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2	9213.300-MB-384664	1 OF 1	

Plotted by bcyko on 22-Mar-00 , File: 384664-01.pff

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	03-06-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	03-06-00
±.02	± ——	± 1°	CHECKED		
			APPROVED		

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.

125 √ MAX. ALL MACHINED SURFACES

USED ON ME-384634 ITEM 9

MATERIAL
RECTANGLE, 1/2 x 4 x 8.00 LG., ALUMINUM 6061-T6511

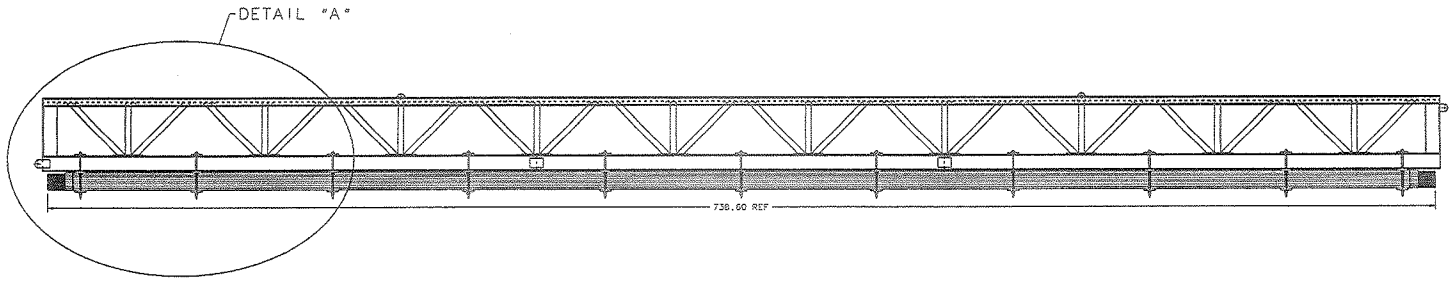
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

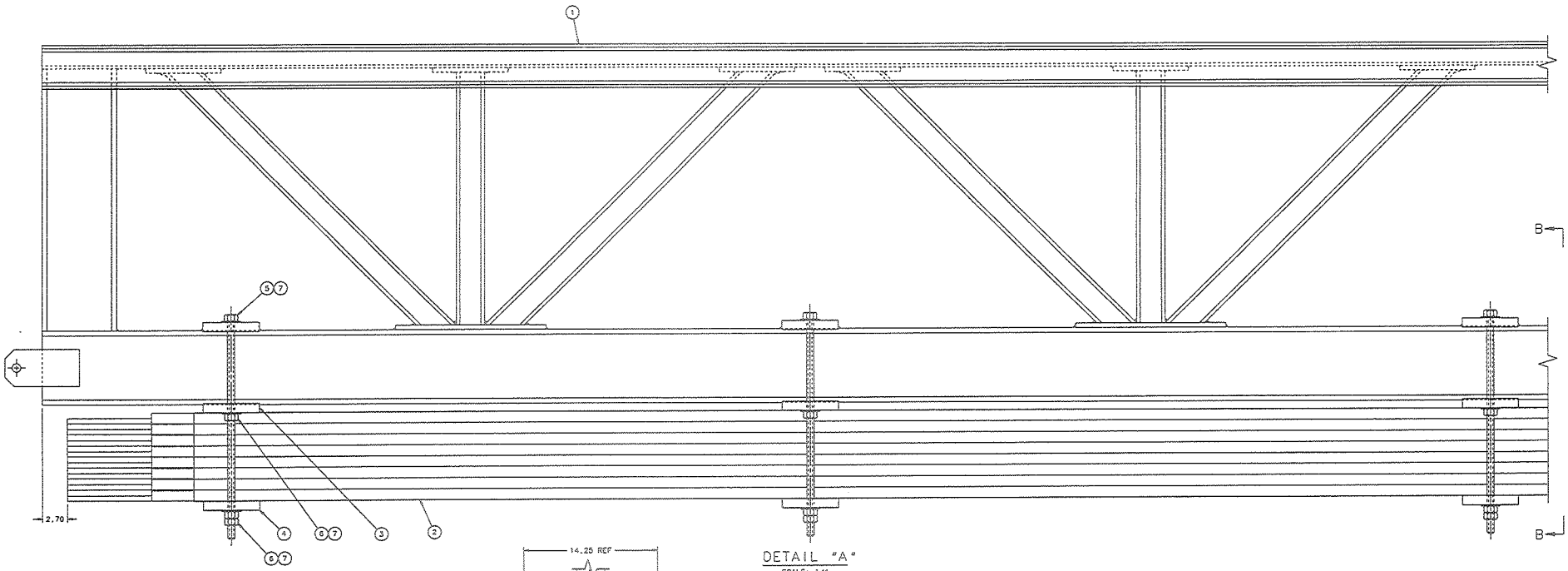
PPD/MECHANICAL SUPPORT MINOS NEAR MAGNET COIL LIFTING LUG, TRANSPORT

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2	9213.300-MB-384638	1 OF 1	

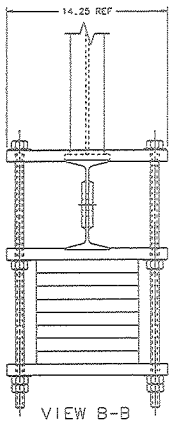
Plotted by bcyko on 22-Mar-00 , File: 384638-01.pff

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE





DETAIL "A"
SCALE: 1/4



VIEW B-B
SCALE: 1/4

ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
7	COML	WASHER, FLAT, 3/4 NOM. CARBON STEEL ASTM F436	66
6	COML	HEX NUT, HEAVY, 3/4-10 UNC CARBON STEEL ASTM A194	66
5	MD-384752	CLAMP ROD WELDMENT	22
4	MC-384701	MAGNET COIL CLAMPING PLATE	11
3	MC-384708	I-BEAM CLAMPING PLATE	11
2	MD-384222	MAGNET COIL ASSEMBLY, LONG	8
1	ME-384634	TRANSPORT WELDMENT	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED
.XX | .XXX | ANGLES
± .12 | ± ---- | ± ----

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. INTERPRET DRAWING PER ASME Y14.5M-1994
4. ALL DIMENSIONS ARE IN INCHES.

MAT. ALL MACHINED SURFACES

ORIGINATOR	J. KILMER 03-16-00
DRAWN	B. CYKO 03-16-00
CHECKED	
APPROVED	
USED ON	
MATERIAL	SEE ABOVE PARTS LIST

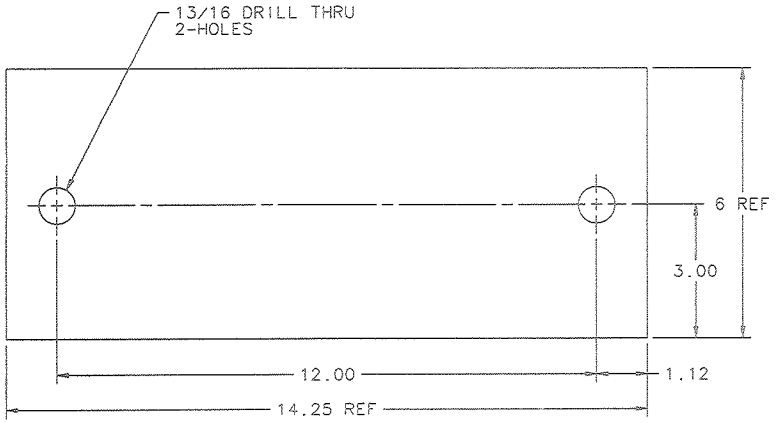
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

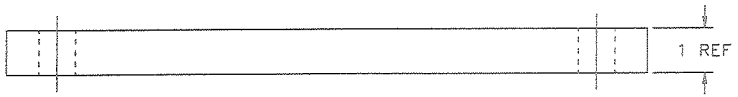
PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
TRANSPORT & COIL ASSEMBLY

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2-11-0 AS NOTED	9213.300-ME-384700	1 OF 1	

Plotted by bcyko on 22-Mar-00 ; File: 384700-01.plt

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE





ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	03-16-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	03-16-00
±.02	± ——	± ——	CHECKED		
			APPROVED		

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.

125 √ MAX. ALL MACHINED SURFACES

USED ON ME-384700 ITEM 4

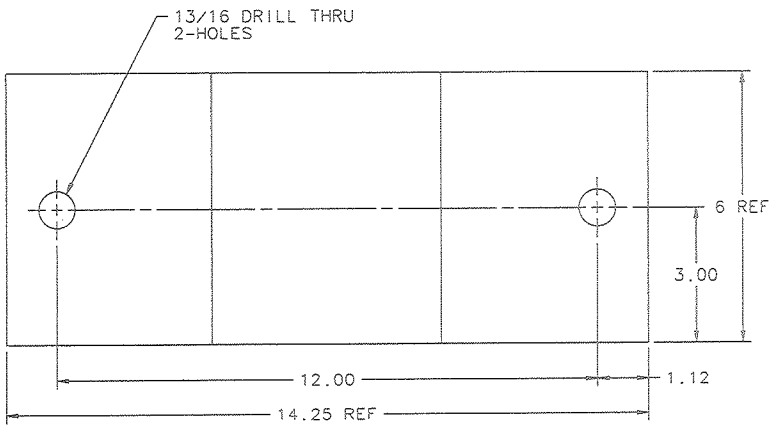
MATERIAL
RECTANGLE, 1 x 6 x 14.25 LG., ALUMINUM 6061-T6511

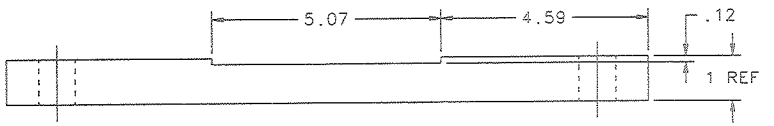
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
MAGNET COIL CLAMPING PLATE

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2	9213.300-MC-384701	1 OF 1	

REV.	DESCRIPTION	IN	DATE
		APPROVED	DATE





ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
	PARTS LIST		

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	03-16-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	03-16-00
±.02	± —	± —	CHECKED		
			APPROVED		

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.

125 MAX. ALL MACHINED SURFACES

USED ON ME-384700 ITEM 3

MATERIAL
RECTANGLE, 1 x 6 x 14.25 LG., ALUMINUM 6061-T6511

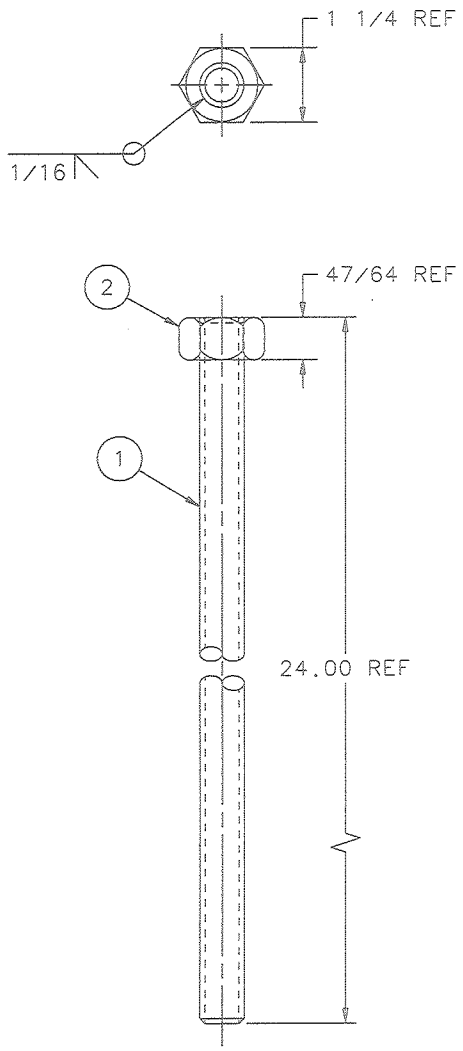
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT
MINOS NEAR MAGNET COIL
I-BEAM CLAMPING PLATE

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2	9213.300-MC-384708	1 OF 1	

Plotted by bcyko on 22-Mar-00 , File: 384708-01.pff

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
2	COML	HEX NUT, HEAVY, 3/4-10 UNC, CARBON STEEL ASTM A194	1
1	COML	ROD, FULLY THREADED, 3/4-10 UNC x 24.00 LG., ALLOY STEEL AISI 4140, ASTM A193 GR. B	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	03-21-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	03-21-00
±.06	± ——	± ——	CHECKED		
			APPROVED		

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.

250 MAX. ALL MACHINED SURFACES

USED ON ME-384700 ITEM 5

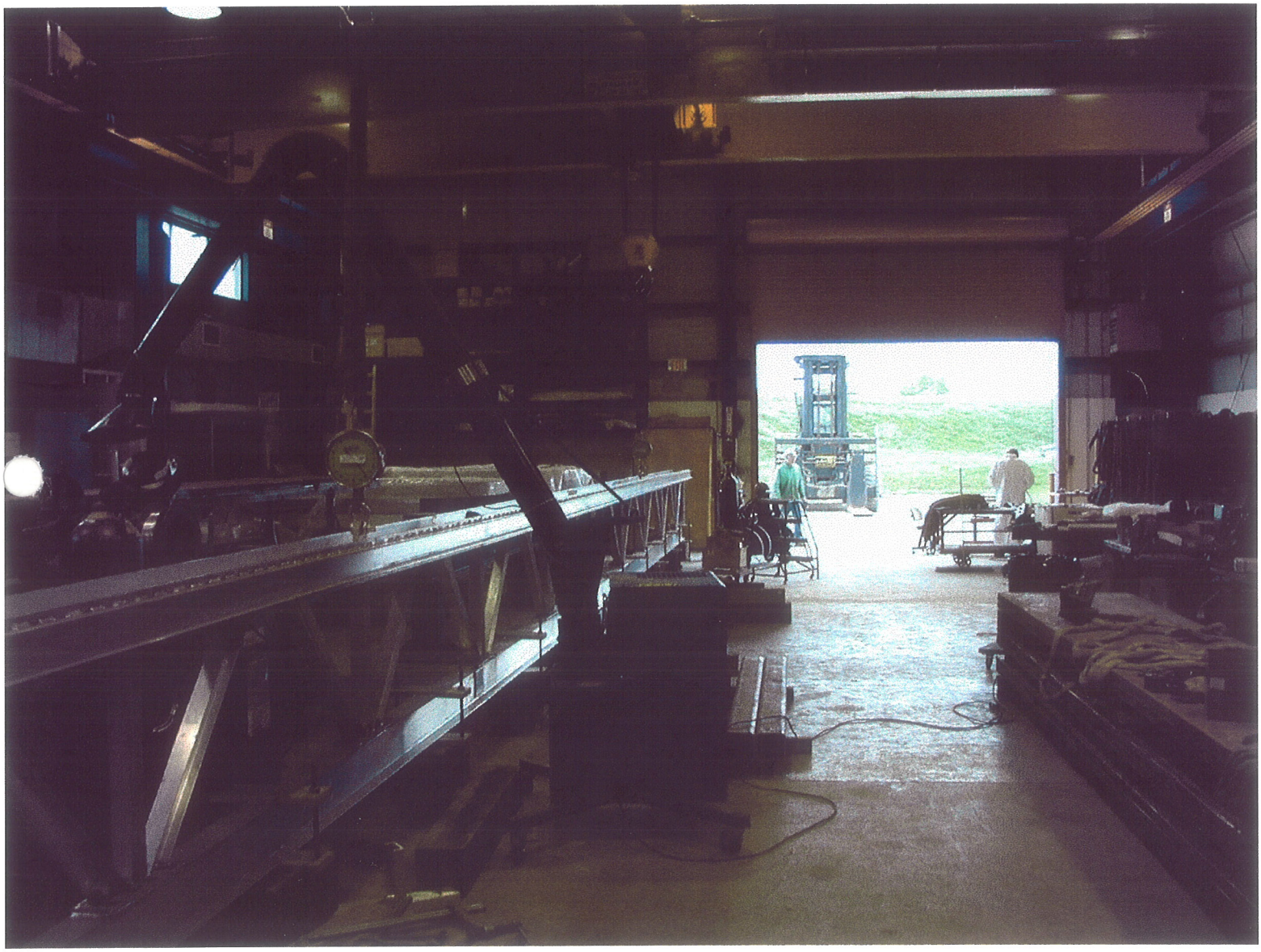
MATERIAL SEE ABOVE PARTS LIST

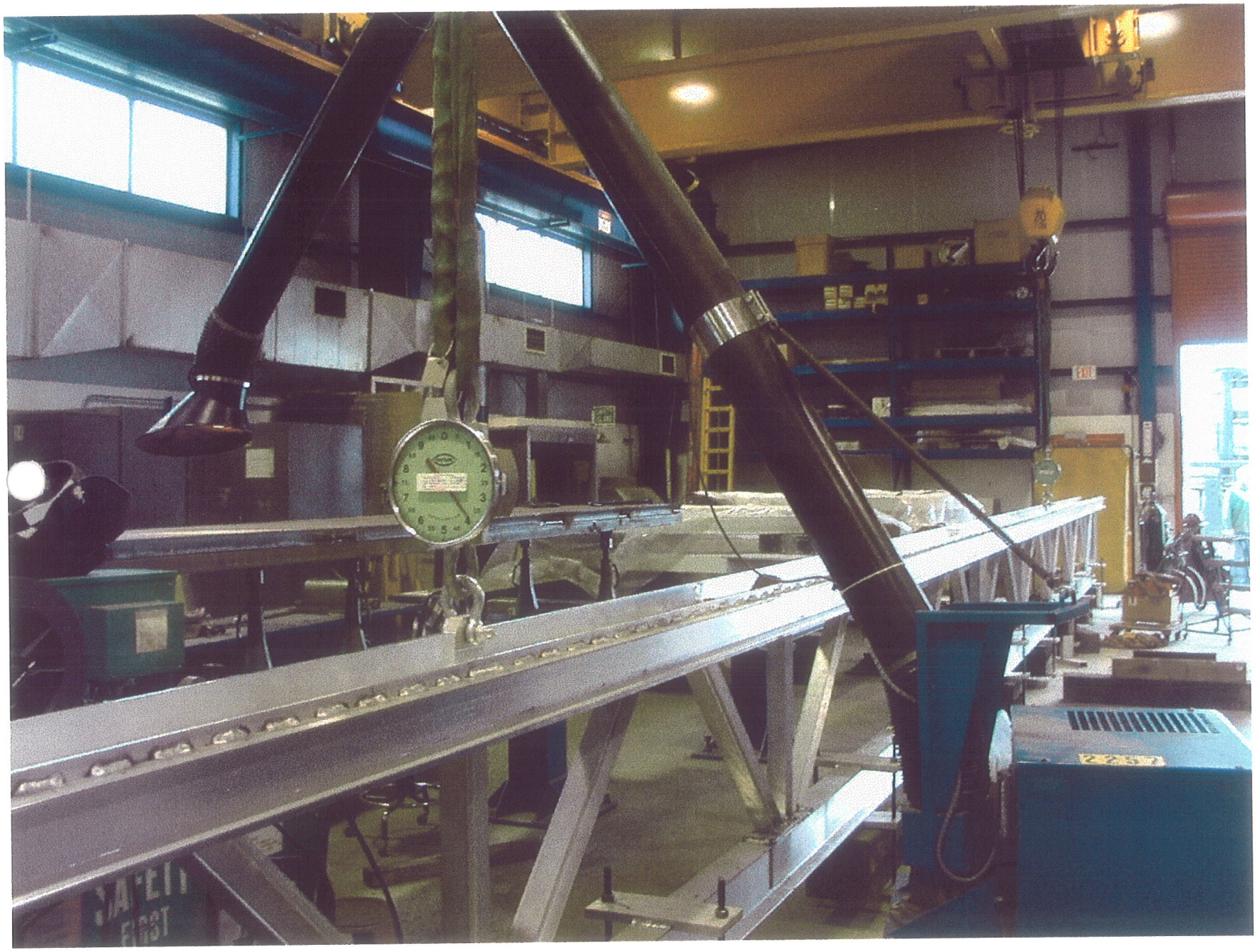
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

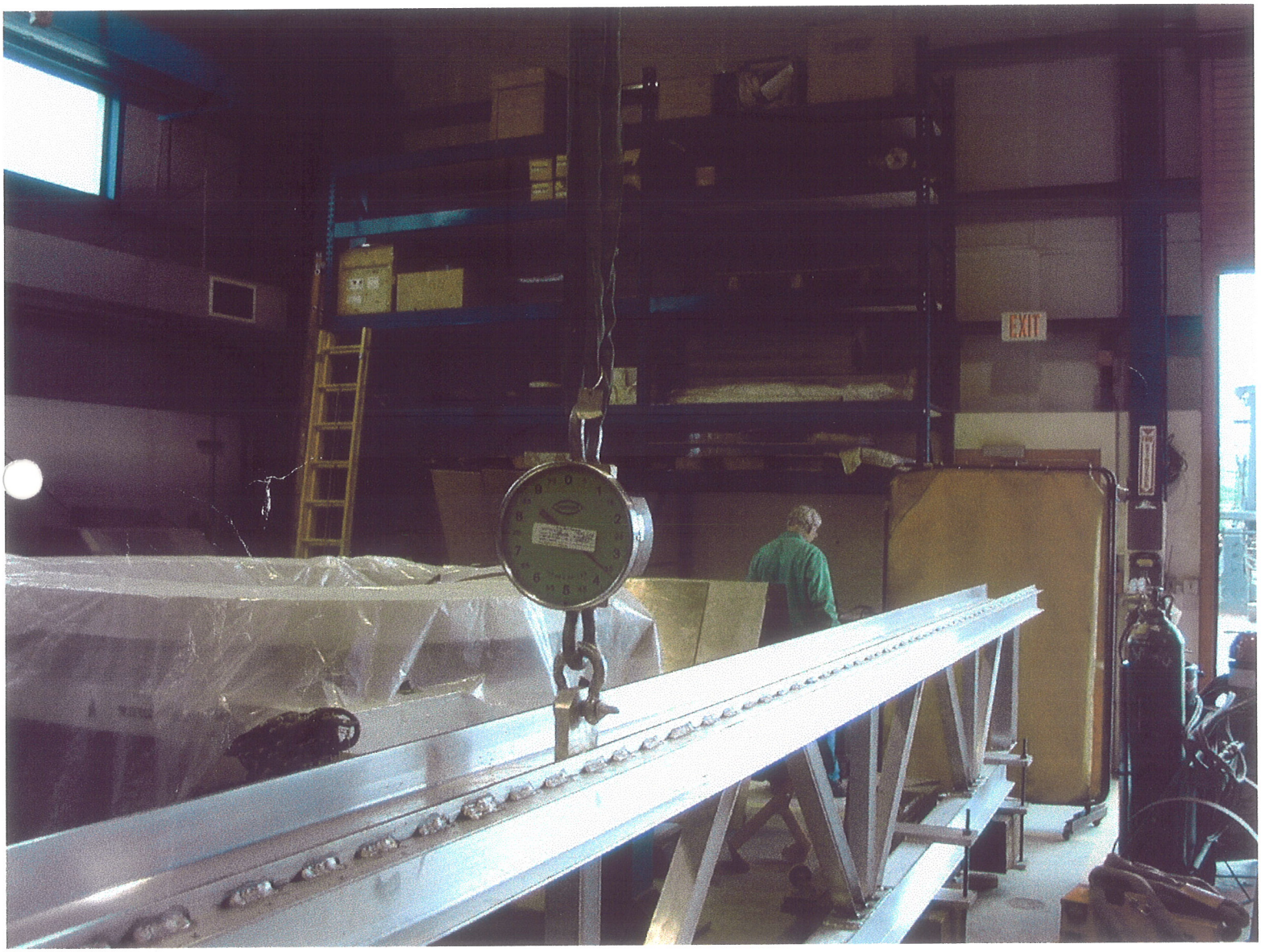
PPD/MECHANICAL SUPPORT MINOS NEAR MAGNET COIL CLAMP ROD WELDMENT

SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/2	9213.300-MB-384752	1 OF 1	

Plotted by bcyko on 22-Mar-00 , File: 384752-01.pff




SAFETY
FIRST


EXIT

BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page

ADDENDUM TO NOTE 135

Lifting Device Numbers:

FNAL Site No.:_____ if applicable Div. Specific No.: 135 if applicable Asset No. _____ if applicable

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

Device Name or Description: NEAR COIL LIFTING FIXTURE

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: _____
- ˅ Provided by a User or Other Laboratory
- ˅ Other. Describe: _____

Engineering Note Prepared by: JAMES KILMER Date: 12/16/03

Engineering Note Reviewed by: [signature] Date: 01/08/04

Lifting Device Data:

Capacity: 4500 lbs

Fixture Weight: _____

Service: ˅ normal ˅ 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:

THIS NOTE DESCRIBES A SPECIAL ADDITION TO FIXTURE NO 135 WHAT ALLOWS IT TO CARRY A SET OF COILS IN A VERTICAL POSITION.

THIS ADDENDUM TO THE ENGINEERING NOTE (NO. 138) FOR THE NEAR COIL LIFTING FIXTURE DOCUMENTS AN ADDITIONAL ATTACHMENT THAT ALLOWS THE FIXTURE TO LIFT THIS COIL PACKAGE VERTICALLY AS WELL AS HORIZONTALLY. NOTE THAT ALTHOUGH THE FIXTURE HAS H CLAMPING BARS THAT COULD, BY FRICTION, HOLD THE COIL PARTS THESE CALCULATIONS ASSUME THAT THOSE CLAMPS DON'T HELP AT ALL.

EACH COIL PIECE WEIGHS 561 lbs AND IS 1.1" THICK

FOR BOLT CALCULATIONS ASSUME THAT THE ENTIRE WEIGHT ACTS AT THE CENTRAL AXIS OF THE COIL LOAD.

THEN $F = 8 \times 561 lbs = 4490 lbs$

MOMENT FROM THE END OF THE BEAM IS

$M = FL = 4490 lbs \times 34.5 in$

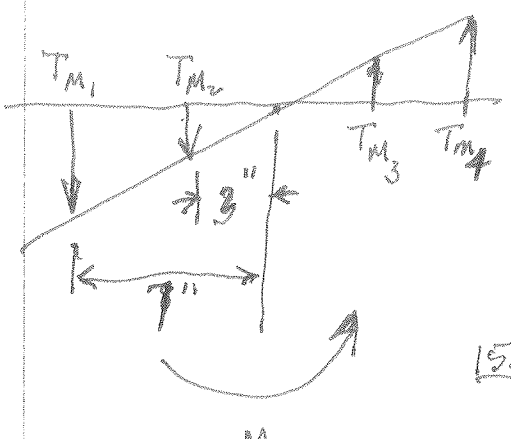
$= 155{,}000 lbs\ in$

THE FORCE ON EACH BOLT IS A COMBINATION OF TENSION AND THE MOMENT FORCE

IF THE BOLTS ARE ONLY IN TENSION FROM LOAD THEN LOAD ON EACH OF THE 8 BOLTS IS

T_S = STRAIGHT TENSION $= \frac{4490 lbs}{8 BOLTS} = 561 lb/BOLT$

FOR MOMENT ASSUME THAT THE MOMENT ACTS ABOUT THE CENTRAL AXIS OF THE BOLT SET:



NOTE THAT T_{M3} AND T_{M4} ARE IN COMPRESSION, BUT EQUAL TO T_{M1} AND T_{M2}

$\Rightarrow M = (2 \times T_{M1} \times 7" + 2 \times T_{M2} \times 3") \times 2 \text{ SIDES}$

$\frac{T_{M1}}{7"} = \frac{T_{M2}}{3"} \qquad T_{M2} = \frac{3}{7} T_{M1}$

$\frac{155{,}000 lb\text{-}in}{2} = 14\, T_{M1} + 2 \times \frac{3}{7} T_{M1} \times 3"$

$4676.7 lbs \quad \varepsilon \quad T_{M1}$

MAXIMUM TENSION IN BOLT $= T = T_S + T_M$

$= 561 \text{ lbs} + 4676.7 \text{ lbs}$

$= 5237.7 \text{ lbs}$

FROM AISC, MANUAL OF STEEL CONSTRUCTION pg 4-3 9th EDITION

TABLE 1-B PICK ASTM A449 THREADED ROD $\frac{7}{8}$-9 UNC x 23" LONG

FROM TABLE $F_y = 92$ KSI, BUT FROM LIFTING FIXTURE STANDARD

WE ONLY ALLOW $F_y/3 = \frac{92 \text{ KSI}}{3} = 30,667 \text{ PSI} = F_t$

SO MAXIMUM TENSILE LOAD ON GROSS AREA ALLOWED IS

$T_{ALL} = F_t A = (30.67 \text{ KSI})(0.6013 \text{ in}^2)$

$= 18.44 \text{ KIPS ALLOWED}$ VS $5.2 \text{ KIPS REQUIRED}$

$\Rightarrow$ THESE FASTENERS ARE OK.

NOW LOOK AT BENDING STRESS ON THE ALUMINUM I BEAM

ASSUME THAT BENDING CANTILEVER IS FROM CENTERLINE OF LOWEST THREADED ROD, AS ON PAGE 1 ASSUME THAT THE WHOLE LOAD IS THEN APPLIED ON CENTERLINE OF THE COIL PACKAGE. THEN

$M_B = F \ell$

$= (4490 \text{ lbs})(16 \text{ in})$

$= 71,800 \text{ lb-in}$

FROM ENGINEERING DATA FOR ALUMINUM STRUCTURES

CHOOSE AN 8" X 4" I BEAM MATERIAL IS 6061-T6 OR T651

THEN $F_y = 35$ KSI $\Rightarrow F_{ALLOW} = F_y/3 = \frac{35 \text{ KSI}}{3} = 11,600 \text{ PSI}$

I BEAM 8" X 4" WITH WT = 6.35 lb/ft from ABOVE pg 35 $S = 14.39 \text{ in}^3$

WE NEED TO CHECK THAT THE ORIGINAL STRUCTURE WILL ALSO WORK VERTICALLY. FROM DRAWING 9213.300-ME-384634 IN A VERTICAL RICK ASSUME ALL OF THE LOAD IS CARRIED BY THE BOTTOM 8"X4" I BEAM, BECAUSE THE CG OF THE LOAD IS IN THAT BEAM.

WEIGHT OF LOAD = COIL WT + FIXTURE WT.

= ~~5000~~ 4490 lb + 1575 lbs

= 6075 lbs

I BEAM $A = 5.4 in^2$

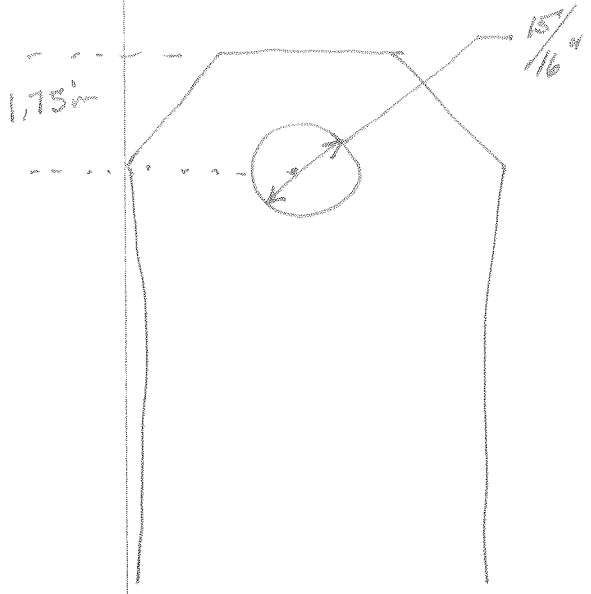
$$\text{TENSILE STRESS ON BEAM} = \frac{WT}{A} = \frac{6075 lbs}{5.4 in^2}$$

$$= 1{,}120 \text{ PSI}$$

THIS IS MUCH LESS THAN $F_{b/3}$ = 11,600 PSI ALLOWABLE SO BEAM IS OK

ALSO NOTE THAT THIS IS THE EQUIVALENT WELD STRESS OF I BEAM CONNECTIONS SHOWN IN DETAIL "D". ⇒ WELDS ARE OK.

LOOK AT LUG ITEM 9 OF THE ABOVE DRAWING



FOR TEAROUT

$A = 1.75" \times 2 \times 1"$ THICK

$= 3.5 in^2$

$$\sigma_{SHEAR} = \frac{WT}{A} = \frac{6075 lbs}{3.5 in^2} = 1740 \text{ PSI}$$

⇒ THIS SHEAR STRESS IS OK FOR 6061

LOOK AT BEARING ON THE LUG

$A_B = 15/16" \times 1" = 15/16 in^2 = .938 in^2$

$\sigma_{BEARING} = \frac{WT}{A_B} = \frac{6075 lbs}{.938 in^2} = 6480 PSI$

THIS IS LESS THAN $F_{B/3} = 11{,}600$ PSI FOR 6061-T650 LUG

IS OK IN BEARING.

WELD STRESS

THROAT OF WELD $t = \frac{.25 in}{\sqrt{2}} = .177 in$ (1/4" FILLET)

LENGTH OF WELD = $2 \times 12 in = 24"$ (ALL AROUND LUG ON BOTH SIDES!)

$A_W = 24 in \times .177 in = 4.24 in^2$

$\sigma_{WELD\ SHEAR} = \frac{WT}{A_W} = \frac{6075 lbs}{4.24 in^2} = 1430 PSI$

THIS STRESS IS OK FOR ALUMINUM WELD.

ALSO NEED TO LOOK AT SHEAR ON WELDS ON PART #4 ON THE RIGHT SIDE OF ME-38634. I BEAM IS WELDED BY 1/4" FILLET ALL AROUND THE 8" X 4" I BEAM

THROAT $t = .177 in$ (STILL 1/4" WELD FILLET)

$L = 2X8 + 2X4 = 24 in^2$ $A = 24 in^2 \times .177 = 4.24 in^2$

$\sigma_{WELD\ SHEAR} = \frac{WT}{A} = \frac{6075 lbs}{4.24 in^2} = 1430 PSI$

→ WELD ON PART #4 IS OK.

SINCE THE WEBS ON BOTH PART 4 OF DRAWING ME-384634 AND THE NEW I BEAM PIECE ARE AT HIGH COMPRESSIVE LOAD FROM THE BOLTS WEB STIFFENERS ARE ADDED IN BOTH BEAMS TO SUPPORT THE LOAD FROM THE 8 THREADED RODS.

WHILE AISC ALLOWS STIFFENED BEAMS TO TAKE SOME CREDIT FOR THE WEB MATERIAL WE TAKE NONE.

LOAD ON EACH BOLT IS FROM PAGE 2 EQUAL TO 5258 lbs.

STIFFENER IS ½" THICK AND 2" − .125 = 1.875" WIDE IN COMPRESSION

$$A = (.5")(1.875")$$

$$= .933 in^2$$

$$\sigma_{COMPRESSION} = \frac{F}{A} = \frac{5258 lbs}{.933 in^2} = 5614 PSI$$

THIS IS THE REQUIRED COMPRESSION STRESS IN A STIFFENER. ON THE NEXT PAGE IS THE CALCULATION FOR THE ALLOWABLE STRESS IN THE STIFFENER. ON PAGE 5-83 OF THE AISC CODE BOOK IT REQUIRES THAT FOR STIFFENERS IN COMPRESSION USE SECTION E-2, Page 5-42, TO FIND THE ALLOWABLE STRESS.

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\cdot\pi^2\,(10\times10^6\ \text{PSI})}{(35{,}000\ \text{PSI})}}$$

$F_y = 35\ \text{KSI}$

$E = 10\times10^6$

$$= 75.1\ \text{in}$$

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right]F_y}{5/3 + \frac{3}{8}\frac{Kl/r}{C_c} - \frac{1}{8}\left(\frac{Kl/r}{C_c}\right)^3}$$

$K = 1$

$l = 8\ \text{in}$

$r = \frac{d}{\sqrt{8}}$

$= (.577)(1.75\ \text{in})$

$= 1.01\ \text{in}$

$$= \frac{\left[1 - \frac{8^2}{2(75.1)^2}\right]35{,}000\ \text{PSI}}{5/3 + \frac{3}{8}\left(\frac{8}{75.1}\right) - \frac{1}{8}\left(\frac{8}{75.1}\right)^3}$$

$\frac{Kl}{r} = 8 < C_c = 75.1$

$$= \frac{[1 - .0113]\,35{,}000}{5/3 + \frac{3}{8}(.107) - \frac{1}{8}(.107)^3}$$

$$= \frac{34{,}600}{1.71}$$

$$= 20{,}300\ \text{PSI}$$

$\Rightarrow$ 5614 PSI REQUIRED $<$ 20,300 PSI ALLOWED

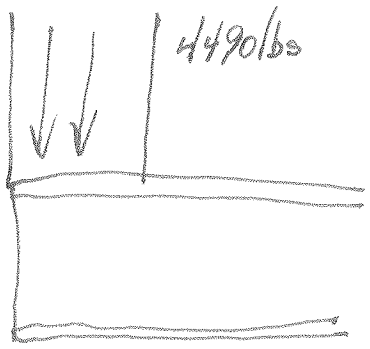
∴ STIFFENERS ARE OK

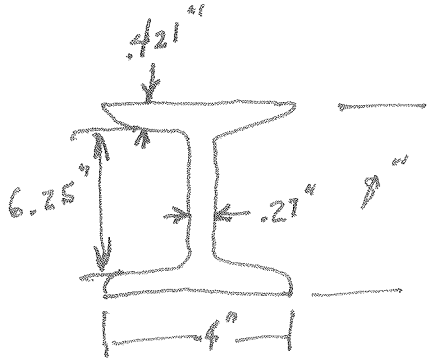
NOTE THAT THIS IS ALSO LESS THAN SIMPLE CALCULATION OF MAXIMUM ALLOWABLE STRESS AS $F_y/3 = 35\text{KSI}/3 = 11{,}667$ PSI

i.e. 5614 PSI REQUIRED $<$ 11,667 PSI ALLOWED

∴ ALL STIFFENERS ARE OK IN COMPRESSION

NEED TO LOOK AT SECTION K OF THE AISC pg 5-80 FOR THE EFFECT OF THE CONCENTRATED LOAD ON THE END OF THE SUPPORT BEAM (STIFFENERS MIGHT BE REQUIRED.)





PER K1-2

$$t_f = .421'' \geq 0.4\sqrt{\frac{P_{bf}}{F_{yc}}}$$

$$\geq 0.4\sqrt{\frac{5/3 \times 4.49\,kip}{35\,ksi}}$$

$$\geq .185''$$

$P_{bf} = 5/3 \times F = 5/3 \times 4490lbs$

$F_{yc} = 35ksi$

SO K1-2 LOCAL FLANGE BENDING IS OK

K1-3

$$\frac{R}{t_w(N+2.5k)} \leq .66\,F_y$$

$F_y = 35ksi$

$R = 4.49\,kip$

$N = 10''$

$k = \frac{8'' - 6.25''}{2} = .875''$

$t_w = .27''$

$$\frac{4.49\,kip}{(.27'')(10'' + 2.5[.875''])} \leq .66(35\,ksi)$$

$$1.41\,ksi \leq 23ksi$$

THEREFORE LOCAL WEB YIELDING IS OK

K1-5 WEB CRIPPLING

LOAD LIMIT $R = 34 t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{F_{yw}\frac{t_f}{t_w}}$

$t_f = .421"$
$t_w = .27"$
$N = 10"$
$d = 8"$

$= 34(.27")^2\left[1 + 3\left(\frac{10"}{8"}\right)\left(\frac{.27"}{.421"}\right)^{1.5}\right]\left[\sqrt{35\,\text{ksi}\times\frac{.421"}{.27"}}\right]$

$= 2.48\ [2.93]\ [7.39]$

$= 53.68\ \text{kip}$

$53.68\,\text{kip} >> 4.49\,\text{kip}$ ACTUAL LOAD

∴ WEB CRIPPLING IS OK.

K1-7 SIDESWAY WEB BUCKING

FIRST $\left(\frac{d_c}{t_w}\right)\Big/\left(\frac{l}{b_f}\right) = \frac{6.25\text{in}/.27"}{\frac{20.}{4"}}$

$= 4.629$

THIS IS GREATER THAN 1.7 SO

SIDESWAY WEB BUCKING IS OK

$k = .875$

$d_c = d - 2k$
$= 8" - 2(.875)"$
$= 6.25"$

$t_w = .27$

$l \simeq 20"$ UNBRACED

$b_f = 4\text{in}$

K1-8 COMPRESSION BUCKLING OF THE WEB

$d_c = 6.25" \leq \frac{4100\, t_{wc}^3 \sqrt{F_{yc}}}{P_{bf}}$

$\leq \frac{4100\,(.27")^3\sqrt{35\,\text{ksi}}}{5/3 \times 4.49\,\text{kip}}$

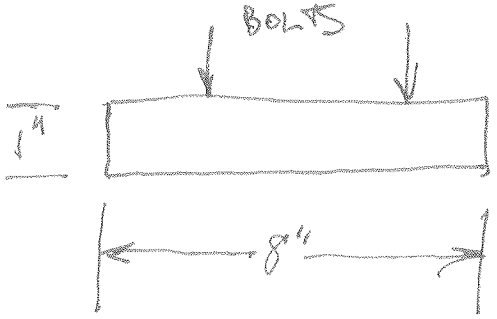
$\leq 63.8"$

$d_c = 6.25"$
$F_{yc} = 35\,\text{ksi}$
$P_{bf} = 5/3 \times 4.49\,\text{kip}$

∴ COMPRESSION BUCKLING OF THE WEB IS OK!

LASTLY LOOK AT PLATE NUMBER 10 IN DRAWING ME-384700. THE LOAD ON THE PLATE IS ALMOST ENTIRELY SHEARING BECAUSE THE BOLTS APPLY FORCE SO CLOSE TO THE EDGE OF THE I BEAM

THEN TOTAL FORCE APPLIED IS $2 \times 16{,}500 \text{ lbs} = 33{,}000 \text{ lbs}$



AREA IS PLATE AREA − BOLT HOLES

$$\Rightarrow A = 1" \times (8" - 2 \times .91in)$$

$$= 6.18 in^2$$

THEN SHEAR STRESS IS

$$\sigma_{SHEAR} = \frac{F}{A} = \frac{33{,}000 \text{ lbs}}{6.18 in^2}$$

$$= 5340 \text{ PSI}$$

FROM ENGINEERING DATA FOR ALUMINUM STRUCTURES pg 11

THE SHEARING YEILD STRESS FOR 6061-T6 IS

$F_{SY} = 20 \text{ KSI}$ $\qquad \frac{F_{SY}}{3} = 6670 \text{ PSI}$

SINCE $\sigma_{SHEAR} = 5340 \text{ PSI} < 6670 \text{ PSI}$ ALLOWED

THE PLATE IS OK.

Fermilab

Revision 1.0

1/21/1999

Particle Physics Division

Engineering and Technical Teams

Mechanical Support Engineering Note

Number: Addendum No2, lifting fixture 135 Date:

Project: Minos Project Internal Reference:

Title: Lifting lug and outrigger casters

Author(s): Jim Kilmer

Reviewer(s):

Key Words:

Abstract/Summary:

This addendum describes an addition to lifting fixture number 135 that is the fixture for handling the Minos Near Coil pieces. The lifting lug in the addendum corrects an instability in the lift from horizontal to vertical. The outriggers allow the fixture to be used to support the fixture and coil parts off the floor for transport.

Applicable Codes:

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			1

SUBJECT: ADDENDUM 2 TO FIXTURE NOTE 135

NAME:

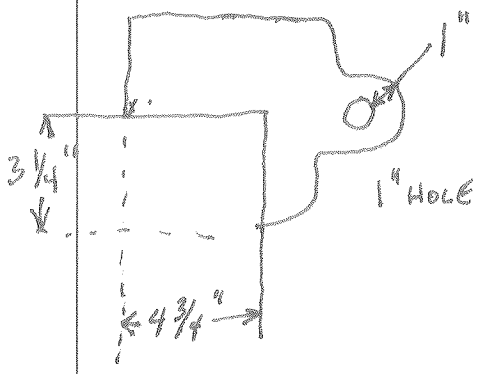
DATE:

REVISION DATE:

IN INITIAL ATTEMPTS TO DO THE VERTICAL LOAD TEST WE NOTICED A VERTICAL INSTABILITY THIS ADDENDUM DESCRIBES THE FIXES FOR THAT PROBLEM.

HIGH PICK POINT

WHEN WE ATTEMPTED TO PICK UP THE FIXTURE WITH THE CRANE WE NOTICED THAT ONE PICK POINT ON THE ℄ CG AXIS IS NOT STABLE AND THE FIXTURE WANTS TO TRY AND TWIST. THE SOLUTION IS A BRIDLE AND SNATCH BLOCK ARRANGEMENT THAT CHANGES THE PICK POINT CONTINUOUSLY AS THE FIXTURE IS LIFTED FROM HORIZONTAL TO VERTICAL. THE WIRE ROPE SLING, SNATCH BLOCK, AND SHACKLES ARE ALL COMMERCIAL ITEMS RATED WELL ABOVE THE REQUIRED LOAD. THE NEW ADDITION IS THE EXTRA WELDED PICK LUG.



THE LUG IS 1" PLATE, 6061 T6 TEMPER.

IT HAS A 3/8" WELD ON BOTH SIDES OF THE LUG

$$L_{WELD} = 3.25in + 4.75in = 8in \times 2 = 16in$$

$$A_{WELD} = (16in)(.375in/\sqrt{2}) \quad \text{AREA AT THROAT}$$

$$= (16in)(.265in) = 4.25in^2$$

FROM PAGE 2 OF ORIGINAL NOTE LOAD (MAX) ON LUG WOULD BE WEIGHT OF LOAD AND FIXTURE OR 6067 lbs

$$\tau_{SHEAR} = \frac{6067\,lbs}{4.25in^2} = 1428psi$$

FROM Pg 15 OF ENGINEERING DATA FOR ALUMINUM STRUCTURES THE LISTED MAXIMUM SHEAR YIELD FOR 6061 WHEN WELDED IS 9KSI.

$$\frac{9ksi}{1.4ksi} = 6.3\,SF \Rightarrow \text{OK FOR A LIFTING FIXTURE.}$$

BEARING STRESS ON LUG

A = 1" ϕ HOLE × 1" PLATE THICKNESS = $1in^2$

$\sigma_{BEARING} = \frac{6067 lbs}{1 in^2} = 6067 PSI$

FROM THE SAME REFERENCE FOR 6061-T6 BEARING YEILD STRESS = 30 KSI

THEN $\frac{30 KSI}{6067 PSI} = 4.9$ SAFETY FACTOR ⇒ OK.

SHEAR STRESS ON LUG (TEAROUT)

A = 1" PLATE THICKNESS × 1" LUG THICKNESS = $1in^2$

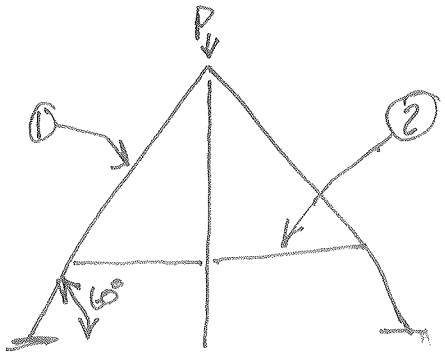
$\tau_{SHEAR} = \frac{6067 lbs}{1 in^2} = 6067 PSI$

TENSION F_y = 40 KSI

$\frac{40 KSI}{6067 PSI} = 6.6$ SAFETY FACTOR ⇒ OK

TO KEEP THE LOWER END VERTICALLY STABLE AS THE FIXTURE WAS RAISED FROM HORIZONTAL TO VERTICAL OUTRIGGER CASTERS HAVE BEEN MADE FOR BOTH ENDS. THESE ALLOW THE FIXTURE TO BE WHEELED ACROSS THE FLOOR IN THE MINOS TUNNEL AS WELL AS FOR RAISING THE FIXTURE. THE CASTERS AT THE PICK END ARE SLIGHTLY DIFFERENT. THEY ARE ONLY USED FOR TRANSPORT ACROSS THE FLOOR.

PICK POINT END OUTRIGGERS
USE DRAWING 9213.300-MD-435153



TOTAL FIXTURE WEIGHT WITH LOAD IS 6067 lbs

THIS END MUST CARRY P: $\frac{6067 \text{ lbs}}{2}$

$= 3033.5 \text{ lbs}$

PART 1 HAS A COLUMN LOAD AS FOLLOWS

$$F_{comp} = \frac{\frac{3033.5}{2}}{\sin 60^\circ} = \frac{1516.75}{.866} = 1751.4 \text{ lbs.}$$

THE PART IS 45" LONG SO SAY 48" LONG UNSUPPORTED
IT IS A 4X4X3/16" WALL SQUARE TUBE.

FROM AISC CODE BOOK pg 3-43 THAT COLUMN HAS AN ALLOWABLE LOAD OF 69 KIPS

$\Rightarrow$ THIS MEMBER IS OK

NOTICE THAT THIS MEMBER WOULD STILL BE FINE UNDER A 3G SHOCK LOAD.

ie LOAD = 1751.4 X 3 = 5254 lbs AND

$$\frac{69 \text{ KIPS}}{5254 \text{ lbs}} = 13.1 \text{ SAFETY FACTOR.}$$

PART #2

LOAD ON PART #2 IS ~~COMPRE~~ TENSILE AND IS TAN 30° $\left(\frac{3033.5}{2}\right)$ = 876 lbs

PART #2 IS 13.85" LONG AND 4"X2"X 3/16" STRUCTURAL STEEL TUBING

~~FROM THE AISC CODE Pg 3-52 A 24" LOD~~

FIND THE TENSILE STRESS WHERE $A = 2.02 in^2$

$$\sigma_{TENSILE} = \frac{876 lbs}{2.02 in^2} = 433 PSI$$

STRUCTURAL TUBING HAS A YEILD STRESS F_y = 46KSI & $\frac{F_y}{3}$ = 15.33 KSI.

⇒ STRUT #2 IS OK.

ASSUME A MAXIMUM FORCE ON STRUT (PART #3)
SAY THAT THE HORIZONTAL FORCE IS 3G OF VERTICAL LOADON PART 1

THEN LOAD WOULD BE 5254 lbs. THIS COULD BE EITHER TENSICE OR COMPRESSIVE.

TENSILE

$$\sigma_{TENSILE} = \frac{5254 lbs}{2.02 in^2} = 2600 PSI \quad (4 X 2 X 3/16" \text{ TUBING})$$

FROM ABOVE FOR STRUCTURAL TUBING 2600 PSI < 15.33KSI
⇒ STRUT IS FINE IN TENSILE LOADING.

STRUT 3 IS 37" LONG FROM AISC CODE Pg 3-52 THE ALLOWABLE LOADING IS APPROXIMATELY 47 KIPS

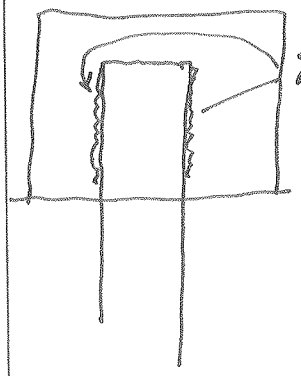
$$\frac{47 KIPS}{5254 lbs} = 8.9 \text{ SAFETY FACTOR}$$

⇒ STRUT 3 IS FINE FOR COMPRESSIVE LOADING.

ALL WELDS ARE 1/4" SO THROAT DISTANCE = $\frac{.25in}{2}$ = .177in

WELD FROM PART 1 TO MOUNTING PLATE

FROM SIDE



WELD AREA $A_w = (14in)(.177in) = 2.47in^2$

FROM PAGE THREE USE THE 3G SHOCK LOAD

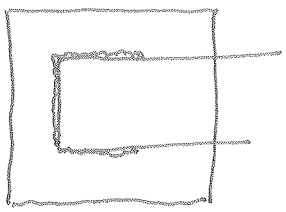
THEN $\sigma_w = \frac{5254lbs}{2.47in^2} = 2122.9PSI$ SHEAR LOAD. PRINCIPALLY.

ROD USED IS E6011 ROD SO $F_y = 20KSI$.

$\frac{20KSI}{2.1KSI} = 9.4$ SAFETY FACTOR $\Rightarrow$ OK.

AT OTHER END OF PART 1

FROM TOP



WELD ON 3 SIDES OF THE 4"x4"

$\therefore A = 3 \times 4in \times .177in = 2.124in^2$

THEN $\sigma_w = \frac{5254lbs}{2.124in^2} = 2473.6PSI$

AND $\frac{20KSI}{2473.6PSI} = 8$ SAFETY FACTOR. $\Rightarrow$ OK

FOR PART 2 NOTICE THAT WELD IS TENSION ~~OR COMPRESSION~~ LOADED

TENSION FORCE IS 876lbs. WELDS ON FLANGE AND TO PART 1 HAVE THIS APPROXIMATE AREA

$A_w = (.177in)(2 + 4 + 2 + 4in)$

$= 2.12in^2$

$\sigma_w = \frac{876lbs}{2.12in^2} = 413PSI$ $\Rightarrow$ NO PROBLEM ON EITHER END

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			6

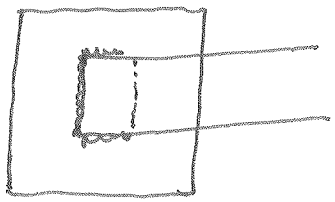
SUBJECT

NAME

DATE | REVISION DATE

WELDS FOR PART 3 USE THE SAME 3G FORCE.

FOR FLANGE END



ASSUME WELD ON ONLY 3 SIDES. THEN

$$A_w = (.177\text{in})(4\text{in} + 2\text{in} + 2\text{in}) = 1.41\ \text{in}^2$$

$$\sigma_w = \frac{5254\ \text{lbs}}{1.41\ \text{in}^2} = 3710\ \text{PSI}$$

$$\frac{20\text{ksi}}{3710\ \text{PSI}} = 5.4 \quad \text{SAFETY FACTOR} \Rightarrow \text{OK}$$

THE END WITH THE ATTACHMENT TO THE 4X4 IS SIMILAR IN WELD AREA AND STRESS

NOW CONSIDER BOLTED FLANGES

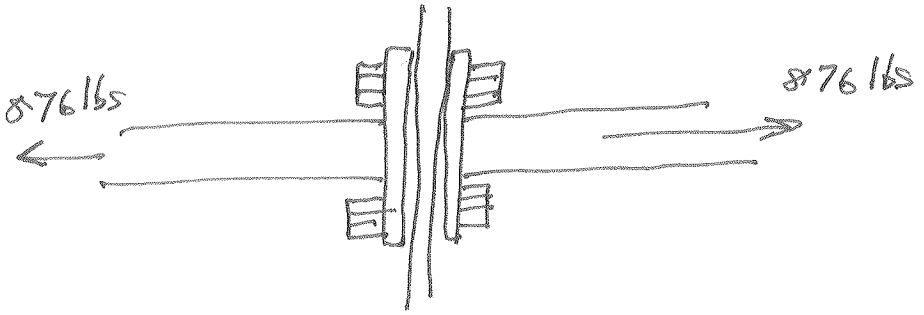
CONNECTION FLANGE AT TOP OF PART 1.

FLANGES ON BOTH LEGS ARE BOLTED THROUGH TO EACH OTHER WITH 1/2-13 BOLTS. WEIGHT OF FIXTURE AND LOAD IS CARRIED BY WEB OF ALUMINUM FIXTURE I BEAM RESTING ON THE AREA OF THE TWO FLANGES IN BEARING. BOLTS JUST KEEP THE FLANGES FROM SEPARATING, ALTHOUGH WHEN SETTING ON THE CASTERS THE LOAD FORCES THE TWO FLANGES TOGETHER. ALL BOLTS ON THE OUT RIGGER CASTERS ARE GRADE 5 OR BETTER.

FROM McGRAW-HILL MACHINING AND METALWORKING HANDBOOK BY RONALD A. WALSH, 2ND EDITION ON PAGE 4-63 TABLE 6.5 DRY NON LUBRICATED 1/2"-13 BOLTS ARE LISTED AT A CLAMP RANGE OF ≈ 9791 lbs FOR A TORQUE OF 61.2 lb-ft FOR GRADE 5 BOLTS. THIS IS WELL IN EXCESS OF OUR REQUIREMENTS FOR ALL FLANGES. CHOOSE ONLY 30 lb-ft. THEN FORCE IS ≈ 4792 lbs

ABOVE FLANGE HAS 4 BOLTS ⇒ TOTAL CLAMP FORCE = 4 X 4792 ≅ 19,000 lbs
THIS IS PLENTY FOR THIS FLANGE WHERE NO FORCES TRY TO SEPARATE THEM.

FOR THE FLANGE END OF PART NUMBER 2 WE HAVE ANOTHER FLANGE WITH 4 ea. 1/2-13 BOLTS, OR 19,000 lbs CLAMP FORCE. THESE PARTS DO HAVE A TENSILE FORCE TO RESIST. FROM PAGE 4 THE SYSTEM IS AS FOLLOWS



TOTAL TENSILE FORCE ON BOLTS IS THEN EFFECTIVELY

$$\frac{2 \times 876\,\text{lbs} + 19{,}000\,\text{lbs}}{4} = 5188\,\text{lbs each bolt}$$

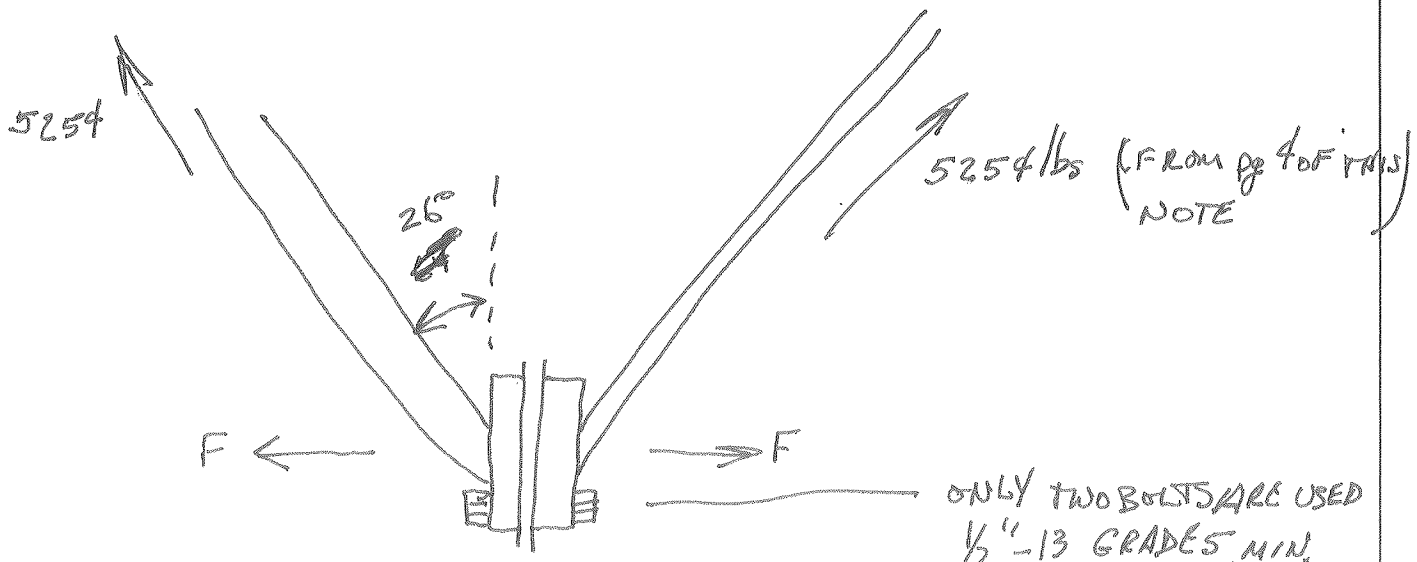
FROM THE WALSH BOOK, Pg 461 THE STRESS AREA FOR A 1/2-13 BOLT IS $A = .1419\,in^2$ AND THE STRESS IN A BOLT IS

$$\sigma_B = \frac{5188\,\text{lbs}}{.1419\,in} = 36{,}561\,\text{PSI}$$

FROM Pg 457 TABLE 6.1 A GRADE 5 BOLT HAS A TENSILE STRENGTH OF 120,000 PSI AND FROM TABLE 6.2 Pg 459 AN ALLOWABLE PROOF LOAD OF 12,100 lbs FORCE. THEREFORE EVEN WITH A LARGE PRELOAD TORQUE THE SAFETY FACTOR IS

$$SF = \frac{120\,KSI}{36.5\,KSI} \geq 3.3 \Rightarrow \text{OK FOR A LIFTING FIXTURE}$$

NOW LOOK AT THE FLANGE FOR PART #3.
FIRST FIND A FORCE TRYING TO SEPARATE FLANGES.



THEN $F = \sin 26^\circ (5254\,lbs) = 2303\,lbs$

AND THE LOAD ON EACH BOLTS IS

~~$2 \times 2303 + 2 \times 4792 = 14,190\,lbs$~~

$2303 + 4792 = 7095\,lbs.$

THEN IN TENSION $\sigma_{BOLT} = \frac{7095\,lbs}{.1419\,in^2} = 50{,}000\,PSI$

THEN $SF = \frac{120\,KSI}{50\,KSI} = 2.4$

NOTE THAT THIS IS OK FOR THE FIXTURE. IN NORMAL OPERATION THERE ARE MINIMAL LOADS ON THIS FLANGE. THE CALCULATED LOAD ONLY OCCURS IN ON DIRECTION AND THEN ONLY IF THE FIXTURE IS MOVING AND STOPPED SO FAST ON ONE SIDE, SUCH AS BY HITTING SOMETHING THAT A 3G LOAD IS PUT ON THE STRUT HORIZONTALLY.

NOW LOOK AT THE OUTRIGGER AT THE OTHER END OF THE FIXTURE. IT IS DIFFERENT TO ALLOW FOR MOVING THE CASTER TO A POINT WHERE IT IS THE LOWEST PART OF THE FIXTURE AS IT IS RAISED AT ALL ANGLES.

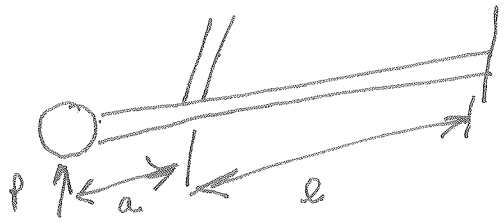
PIVOT END OUTRIGGERS
USE DRAWING 9213.300-MD-435145

LOOK AT ITEM 8.
SITTING ON THE GROUND HORIZONTALLY THE LOAD IS THE SAME AS THE OTHER OUTRIGGER ON PAGE 3 OF THIS NOTE.
$\Rightarrow$ THE $F_{COMPRESSION}$ = 1751 lbs.

AS BEFORE: THE COLUMN IS 50" LONG. FROM AISC pg 3-43 A 4"x4"x 3/16" SQUARE TUBE IS ALLOWED TO HAVE A 69KIP CONCENTRIC LOAD AT 48" LONG AND 67 KIPS AT 60" LONG. THEREFORE THE MEMBER IS OK. AGAIN LOOK AT A 3G SHOCK LOAD OF 3 x 1751 = 5254 lbs.

$$\frac{67\text{KIPS}}{5254\text{lbs}} \approx 12.88$$ SAFETY FACTOR WHICH IS OK.

AS THE FIXTURE LIFTS OFF THE CRANE STILL LIFTS AT LEAST 1/2 OFF THE DETECTOR. HOWEVER THE STRUT STARTS TO TAKE THE LOAD IN BENDING. AT THE VERTICAL THE PICTURE LOOKS AS FOLLOWS.



ASSUME THAT THE FLANGE AND STRUT 10 ARE FIXED.
FROM THE AISC THIS LOOKS LIKE CASE 26 pg 2-305 IN THE BEAM DIAGRAMS.
WHERE

$\ell = 32"$
$a = 18"$
$S = 3.3\ in^3$
(FOR 4"x4"x 3/16" SQ TUBING)

$M_{MAX} = Pa$
$= (1751\ lbs)(18\ in)$
$= 31518\ lb\ in$

$$\sigma_{BENDING} = \frac{M_{MAX}}{S} = \frac{31518\ lb\ in}{3.3\ in^2}$$

$= 9551\ psi$

SUBJECT | NAME | DATE | REVISION DATE

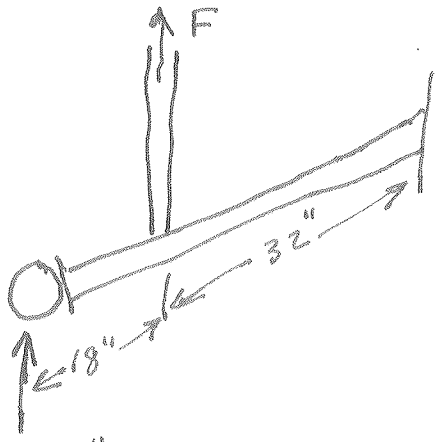
FOR STRUCTURAL TUBING $F_y = 46$ KSI AND $F_y/3 = 15.3$ KSI

SO IN BENDING 9551 PSI < 15.3 KSI SO MEMBER IS OK

IF THE FIXTURE WERE LOADED SUCH THAT A 3G FORCE WAS PLACED ON THE WHEELS WHEN IT LANDED THE BENDING STRESS WOULD STILL BE LESS THAN THE YIELD STRESS OF THE TUBE.

NEXT LOOK AT ITEM 9

WORST CASE LOADING IS COMPRESSIVE FORCE WHEN THE FIXTURE IS BEING LIFTED TO VERTICAL OR JUST BEING LANDED VERTICALLY.

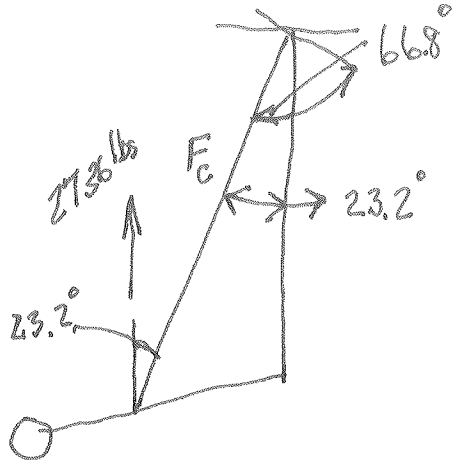


$F(32") = 1751 lbs (50"$

$F = 2736 lbs$

P = 1751 lbs

NEW STRUT ANGLE (HORIZONTAL) $\cos 23.2^\circ = \frac{F_c}{2736} \quad \frac{2736}{F_c}$



$F_c = 2977 lbs.$

COMPRESSIVE LOAD ON STRUT.

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			11

SUBJECT

NAME

DATE | REVISION DATE

THE STRUT IS 4"x2"x3/16" STRUCTURAL TUBING AND MAXIMUM LENGTH IS 49". FROM THE AISC CODE pg 3-52, FOR THIS TUBE AT 4' THE ALLOWABLE CONCENTRIC LOAD IS 43 KIPS, AT 5' THE ALLOWABLE LOAD IS 38 KIPS. ⇒ STRUT IS OK.

ALSO NOTE THAT THE STRUT IS STILL OK FOR A 3G LOAD ON LANDING OF ALMOST 9 KIPS.

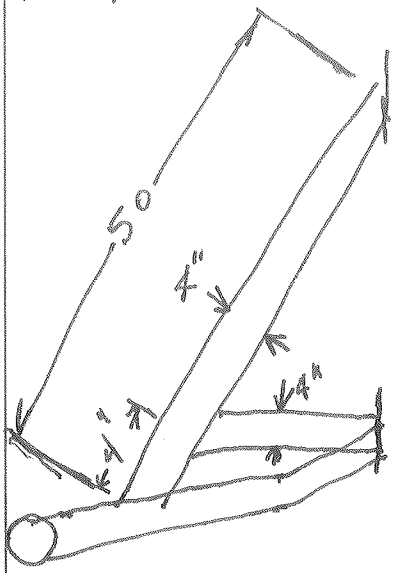
IF THIS STRUT WAS BEING PUSHED IN THE OTHER DIRECTION AND THIS CASTOR WAS TO STOP SUDDENLY THEN THE STRUT WOULD SEE A TENSILE FORCE. ASSUME AS IN PAGE 4 FOR PART #3 THAT THE FORCE IS 3 G's AND EQUAL TO 5254 lbs. THEN THE TENSILE STRESS IS

$$\sigma_T = \frac{F}{A} = \frac{5254\ lbs}{2.02\ in^2} = 2601\ PSI$$

SINCE THE F_y OF THE TUBING IS 46KSI AND $F_y/3 = 15.33$ KSI THEN

2601 PSI < 15.33 KSI SO STRUT IS ALSO FINE IN TENSION.

LASTLY THIS STRUT SUFFERS A BENDING MOMENT. AS SEEN FROM PAGE 3,4 OF THIS PAPER THERE IS A FORCE OF 876 lbs BECAUSE OF THE STRUT ANGLES TRYING TO SPREAD THE CASTERS. THIS FORCE IS RESISTED BY PART 10 THROUGH PART NINE AS IN THIS SKETCH FROM ABOVE



ASSUME THAT BOTH FLANGES ARE FIXED.
ALSO USE CASE 26 FROM THE AISC pg 2-305 AGAIN
a = 4" ℓ = 46" S = 1.93 in³ IN XX AXIS

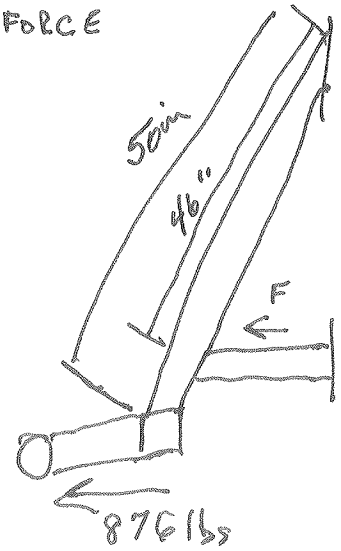
$$M_{MAX} = P a = (876\ lbs)(4\ in) = 3504\ lb\text{-}in$$

$$\sigma_{BEND} = \frac{M}{S} = \frac{3504\ lb\text{-}in}{1.93\ in^3} = 1815\ PSI$$

⇒ THIS STRUT IS ALSO OK FOR THE BENDING
(1815 PSI < 15.33 KSI)

NOW LOOK AT STRUT (PART 10)

FORCE IS A TENSILE FORCE TO RESIST SPREADING OF RASTERS. FIND THAT FORCE



$F(46") = 876 lbs (50 in)$

$F = 952 lbs$

THE TENSILE STRESS ON THE STRUT IS

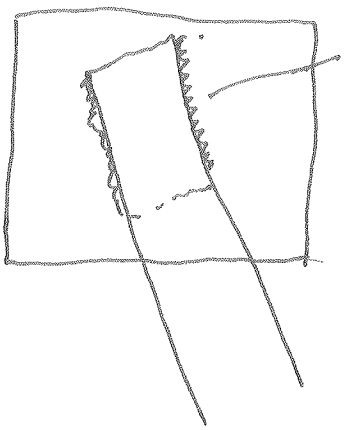
$$\sigma_T = \frac{F}{A} = \frac{952 lbs}{2.02 in^2} = 471 PSI$$

SINCE $471 PSI < 15.33 KSI$ THIS STRUT IS OK.

LOOK NOW AT WELDS.

WELD FROM STRUT (PART 8) TO THE MOUNTING FLANGE

ALL WELDS ARE AGAIN 1/4" SO THROAT DISTANCE IS $\frac{.25 in}{\sqrt{2}} = .177 in$



WELD AREA IS $A_w = (14 in)(.177 in) = 2.47 in^2$

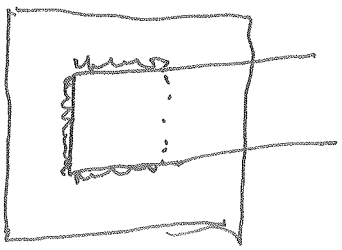
AGAIN ASSUME A 3G SHOCK LOAD OF 5254 lbs

$$\sigma_w = \frac{5254 lbs}{2.47 in^2} = 2122.9 PSI$$ PRINCIPALLY SHEAR LOADING

ROD USE IS E60XX OR BETTER SO $F_y = 20 KSI$

$\frac{20 KSI}{2.1 KSI} = 9.4$ SAFETY FACTOR $\Rightarrow$ OK

AT THE OTHER END OF PART 8'

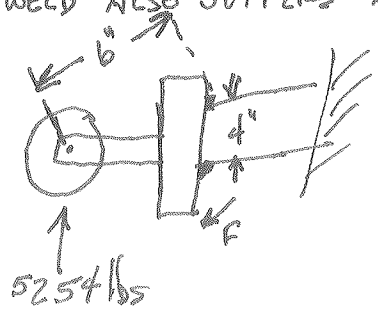


WELD ON 3 SIDES OF THE 4"X4"
SO $A_w = 3 \times 4in \times .177in = 2.124in^2$

IN SHEAR $\tau_w = \frac{5254 lbs}{2.124 in^2} = 2473.6 PSI$

AND $\frac{20 KSI}{2473. PSI} = 8$ SAFETY FACTOR. $\Rightarrow$ OK

THIS WELD ALSO SUFFERS A MOMENT.



NOW TAKE NO CREDIT FOR END WELD AND ASSUME THAT UPPER WELD IS A PIVOT

THEN $F(4in) = (5254 lbs)(6in$

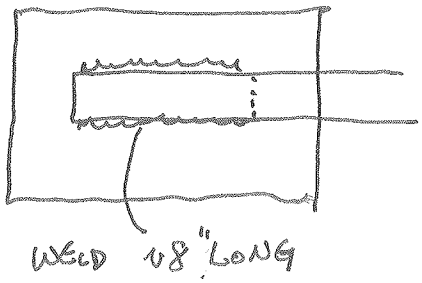
$F = 7881 lbs$

$A_{WELD} = (4in)(.177in) = .708 in^2$

$\sigma_{WELD\ (TENSION)} = \frac{7881 lbs}{.708 in^2} = 11,131 PSI$

AND $11,131 PSI < 20 KSI$ SO THIS WELD IS OK.

WELDS ON PART 9
AT FLANGE END.



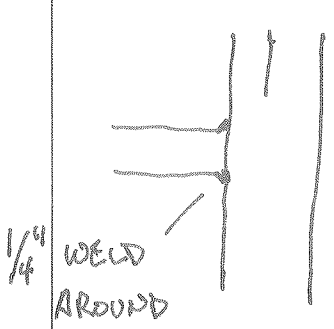
$A_w = 2 \times 8\text{in} \times .177\text{in}$
$= 2.832\text{in}^2$

FROM PAGE 11 AT A HARD LANDING THIS STRUT COULD SEE A TENSILE FORCE OF
$3G's = 3 \times 2977\text{lbs} = 8931\text{lbs}$ SHOWING UP AS A SHEAR ON THE WELD

$$\sigma_{WELD} = \frac{F}{A_w} = \frac{8931\text{lbs}}{2.832\text{in}^2} = 3153\text{ PSI}$$

SO THIS WELD IS OK $(3153\text{ PSI} < 20\text{KSI})$

AT THE OTHER END



$A_{WELD} = 2 \times (4+2\text{in}) \times .177\text{in} = 12\text{in} \times .177\text{in}$
$= 2.124\text{in}^2$

TO PUT A TENSILE LOAD ON THIS FROM PAGE 11
THE FORCE COULD BE 5254lbs

$$\sigma_T = \frac{5254\text{lbs}}{2.124\text{in}^2} = 2473\text{ PSI}$$

$(2473\text{ PSI} < 20\text{KSI})$ SO WELDS ARE OK.

LASTLY LOOK AT WELDS ON PART 10 STRUT

BOTH ENDS HAVE $A_w = 2 \times (2in + 4in) \times .177in = 2.124in^2$

FROM PAGE 12 THE TENSILE FORCE ON THESE WELDS IS THE SAME AND IS 952 lbs

$$\sigma_{weld} = \frac{F}{A_w} = \frac{952\,lbs}{2.124in^2} = 448\,PSI$$

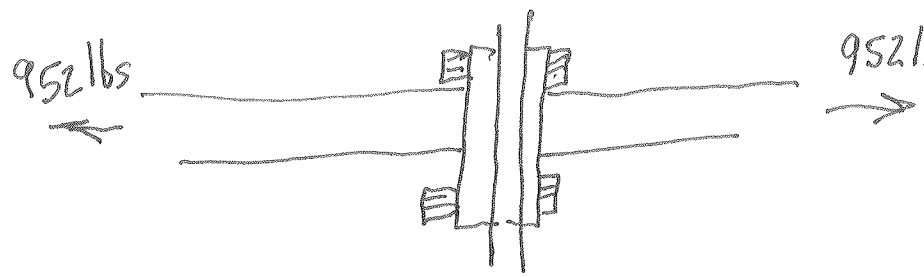
SO THESE WELDS ARE OK.

AS ON THE LIFTING END OUTRIGGERS THESE LOWER OUT RIGGERS ARE SECURED WITH 1/2"-13 BOLTS, GRADE 5 OR BETTER.

LOOK AT TOP FLANGE BOLTS ON STRUT PART 8

NOTE THAT AGAIN THE ACTUAL WEIGHT IS CARRIED BY THE EDGES OF THE TWO FLANGES ON THE WEB OF THE FIXTURE UPPER I BEAM. THE BOLTS (4 EACH) ONLY NEED TO CLAMP THE FLANGES TOGETHER. ALSO THE NATURAL TENDENCY OF THE CASTERS TO SPREAD BECAUSE OF THE ANGLE TRIES TO FORCE THE FLANGES TOGETHER. NEVER THE LESS THE FLANGE USES 4 EACH 1/2"-13 BOLTS TORQUED TO 30 lb-ft. BY LOOKING AT THE PREVIOUS REFERENCE (WALSH) THESE FOUR BOLTS ARE DETERMINED TO HAVE A CLAMPING FORCE OF $4 \times 4792 = 19,168$ lb. MORE THAN ENOUGH TO KEEP THEM IN PLACE.

FOR THE FLANGE END OF PART 10 THE FLANGE IS AGAIN CONNECTED WITH 4 EACH 1/2"-13 BOLTS, TORQUED TO 30 lb-ft OR ALSO ≈ 19,168 lbs. THIS MUST RESIST THE SPREADING FORCE SHOWN



TOTAL TENSILE FORCE ON THE BOLTS EACH IS

$$\frac{2 \times 952 \text{ lbs} + 19{,}168 \text{ lbs}}{4} = 5268 \text{ lbs}$$

STRESS IN THE BOLT IS THEN

$$\sigma_T = \frac{F}{A_B} = \frac{5268 \text{ lbs}}{.1419 \text{ in}^2}$$

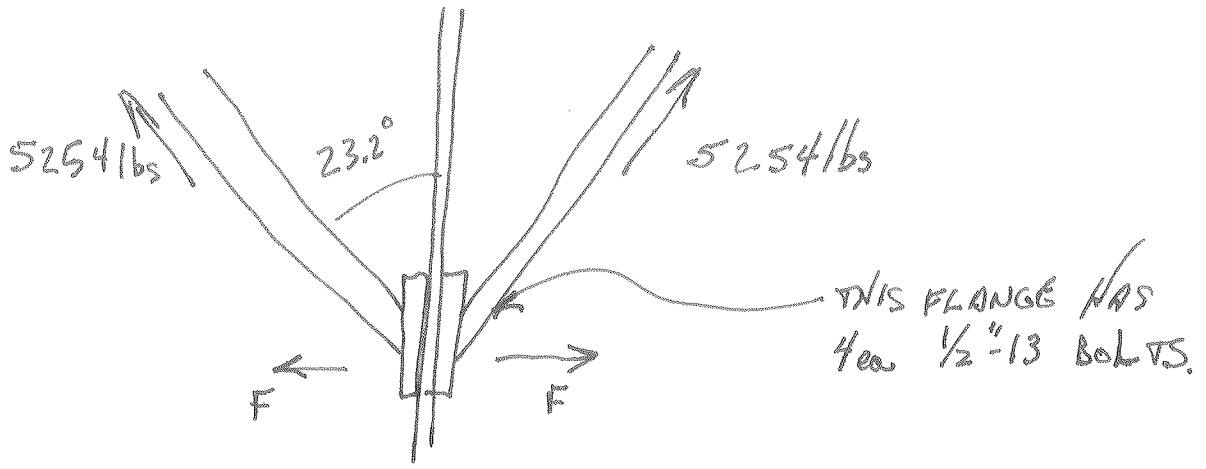
$$= 37124 \text{ PSI}$$

FROM WALSH, pg #57, TABLE 6, A GRADE 5 BOLT HAS A TENSILE STRENGTH OF 120,000 PSI. THEREFORE THE SAFETY FACTOR IS

$$SF = \frac{120 \text{ KSI}}{37.1 \text{ KSI}} = 3.2$$ AND THIS IS OK.

THE LAST BOLTED JOINT TO LOOK AT IS THE FLANGE END JOINT FOR STRUT (PART 9).

AS ON PAGE 8 FIND THE FORCE THE BOLTS SEE IN TENSION FIRST.



THEN $F = \sin 23.2^\circ \ (5254 \text{ lbs}) = 2070 \text{ lbs}$

THE BOLTS ARE ALSO TORQUED TO 30 lb-ft SO THE PRELOAD ON A BOLT IS 4792 lbs. THE LOAD THEN ON EACH BOLT IN TENSION IS

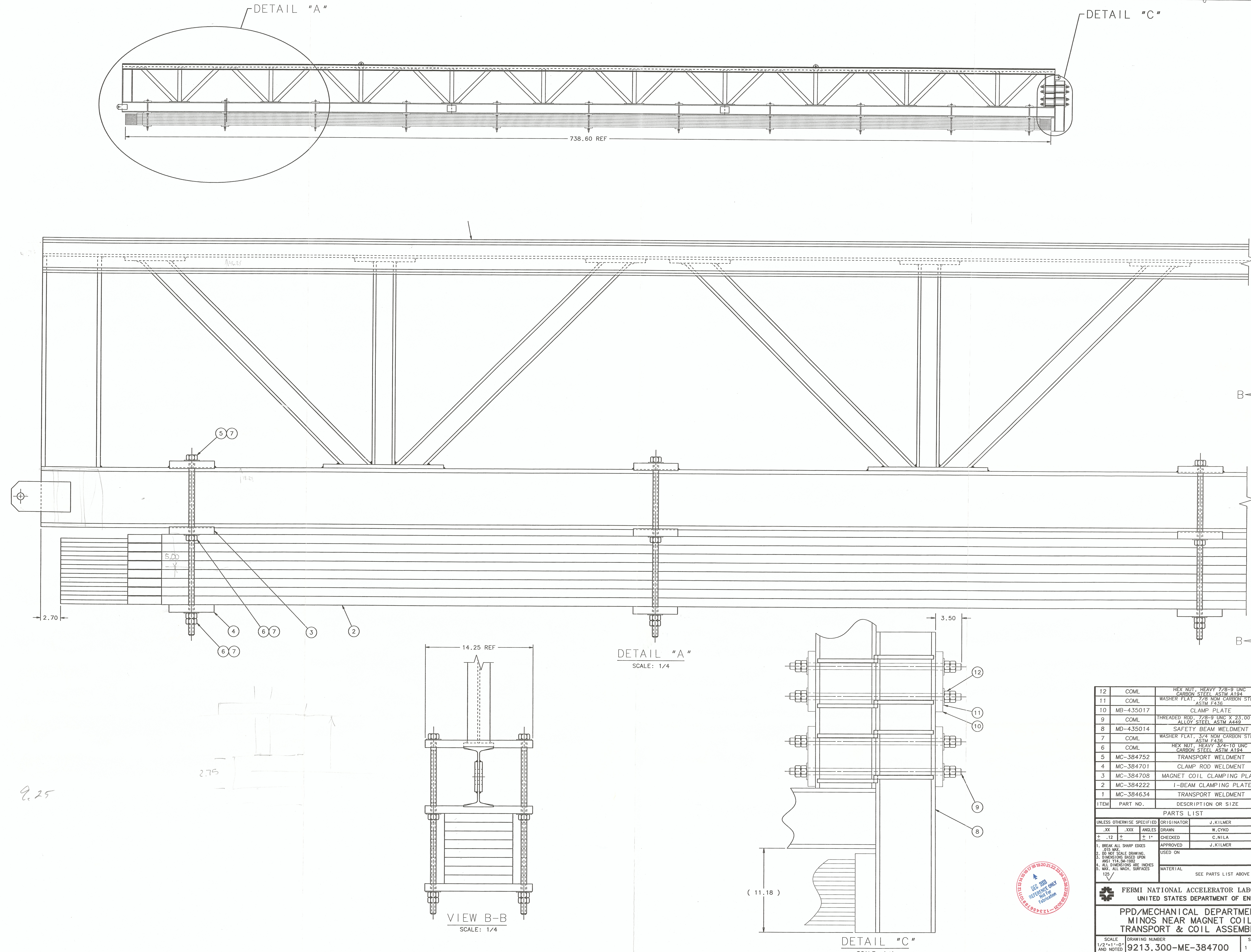
$$\frac{2 \times 207 \text{ lbs}}{4 \text{ BOLTS}} + \frac{4792 \text{ lbs}}{\text{BOLT}} = 5827 \text{ lb/BOLT}$$

$$\sigma_{TENSION} = \frac{F}{A_B} = \frac{5827 \text{ lbs}}{.1419 \text{ in}^2} = 41{,}063 \text{ PSI}$$

$$\text{THEN} \quad SF = \frac{120 \text{ KSI}}{41 \text{ KSI}} = 2.92$$

THIS IS ALSO OK SINCE THE LOAD DESCRIBED HERE ONLY OCCURS IN A SITUATION WHERE THE FIXTURE IS BEING MOVED QUICKLY AND MAKES A FAST STOP TO SUPPLY A FORCE EQUAL TO 3G'S ON THE FLANGE. IN NORMAL CIRCUMSTANCES THERE IS MINIMAL LOAD ON THE STRUT.

REV	DESCRIPTION	DRAWN / APPROVED	DATE / DATE
A	ADDED ITEMS 8 THRU 12 & DETAIL "C"	F. MCCONOLOGUE / JRK	12-15-04 / 12/17/03



12	COML	HEX NUT, HEAVY 7/8-9 UNC CARBON STEEL ASTM A194	32
11	COML	WASHER FLAT, 7/8 NOM CARBON STEEL ASTM F436	16
10	MB-435017	CLAMP PLATE	4
9	COML	THREADED ROD, 7/8-9 UNC X 23.00 LG. ALLOY STEEL ASTM A449	8
8	MD-435014	SAFETY BEAM WELDMENT	1
7	COML	WASHER FLAT, 3/4 NOM CARBON STEEL ASTM F436	66
6	COML	HEX NUT, HEAVY 3/4-10 UNC CARBON STEEL ASTM A194	66
5	MC-384752	TRANSPORT WELDMENT	22
4	MC-384701	CLAMP ROD WELDMENT	11
3	MC-384708	MAGNET COIL CLAMPING PLATE	11
2	MC-384222	I-BEAM CLAMPING PLATE	8
1	MC-384634	TRANSPORT WELDMENT	1
ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	16-MAR-2000
.XX	.XXX	ANGLES	DRAWN	W.CYKO	16-MAR-2000
± .12	±	± 1°	CHECKED	C.NILA	16-MAR-2000
			APPROVED	J.KILMER	16-MAR-2000

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ANSI Y14.5M-1982
4. ALL DIMENSIONS ARE INCHES
5. MAX. ALL MACH. SURFACES 125

USED ON

MATERIAL
SEE PARTS LIST ABOVE

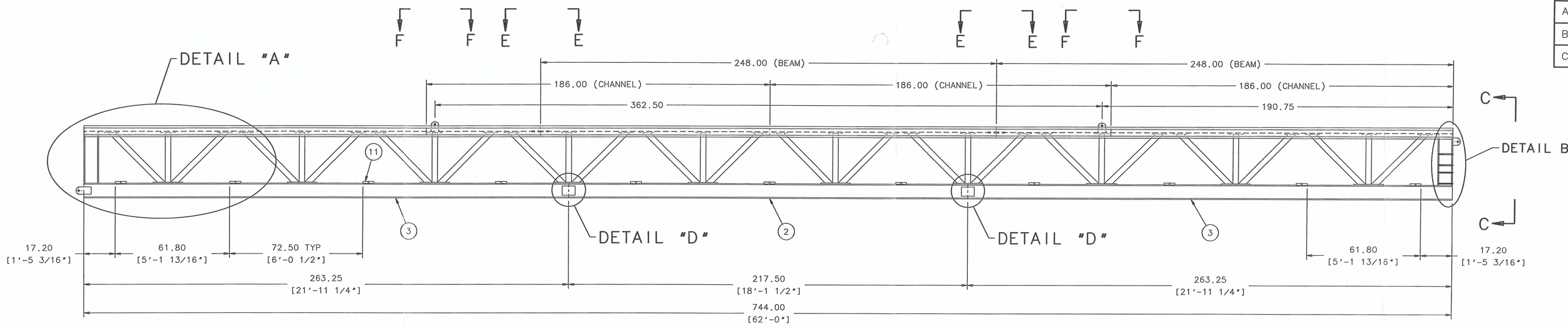
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

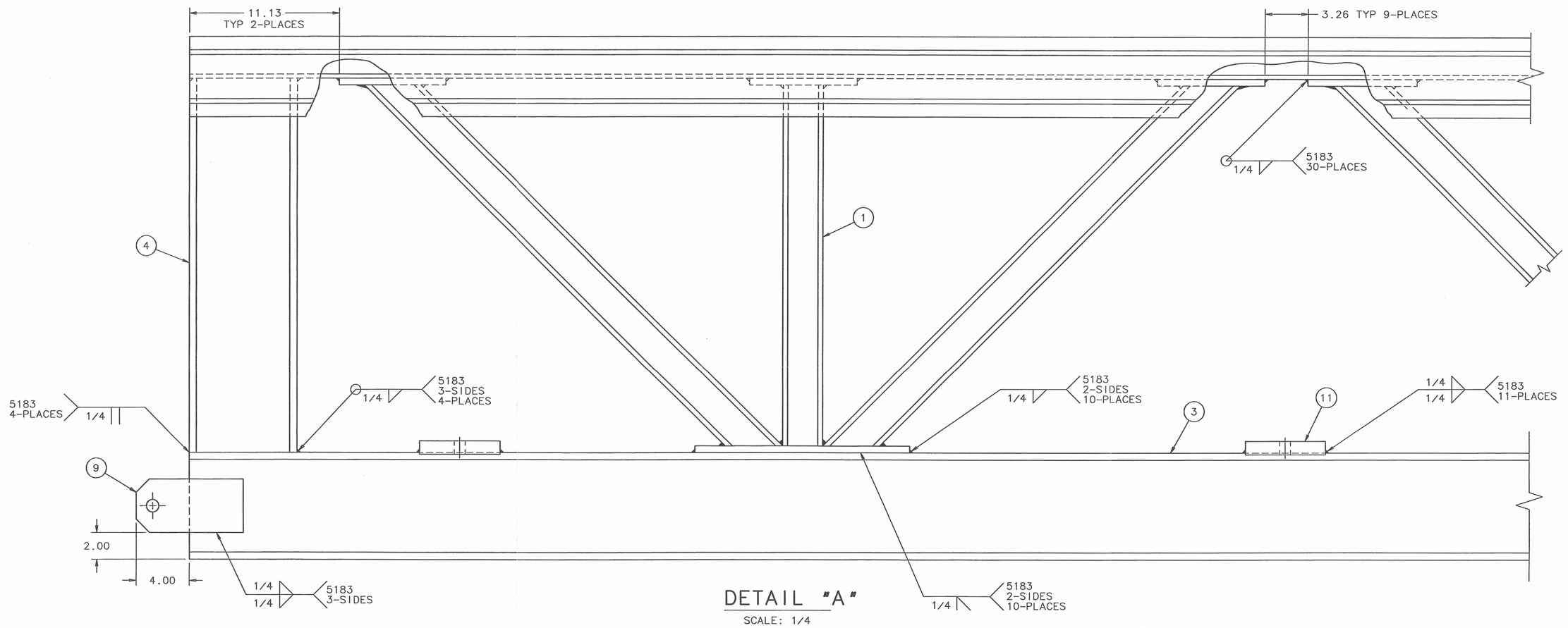
PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL
TRANSPORT & COIL ASSEMBLY

SCALE	DRAWING NUMBER	SHEET	REV
1/2"=1'-0" AND NOTED	9213.300-ME-384700	1 OF 1	A

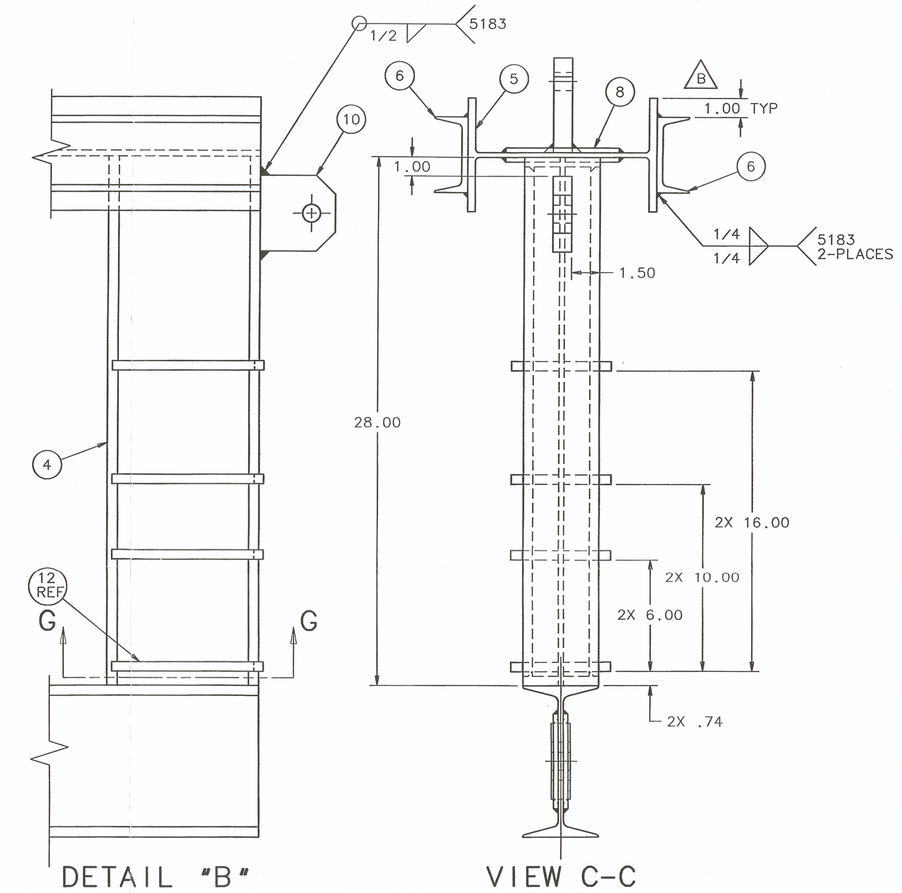
CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE
A	ADDED NOTE 1.	B. CYKO	06-12-00
		J. KILMER	06-13-00
B	REVISED MATERIAL ITEM 5, I-BEAM FROM AMER. STD. 10 x 8.76 # TO ALUM. ASSOC. 10 x 8.646#.	B. CYKO	02-28-02
		C. NILA	03-01-02
C	ADDED ITEM 12. ADDED SECTION "G-G"	F. MCCONOLOGUE	12-12-03
		J.K	12/17/03



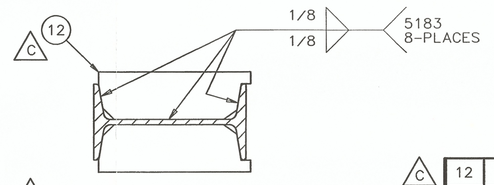


DETAIL "A"
SCALE: 1/4

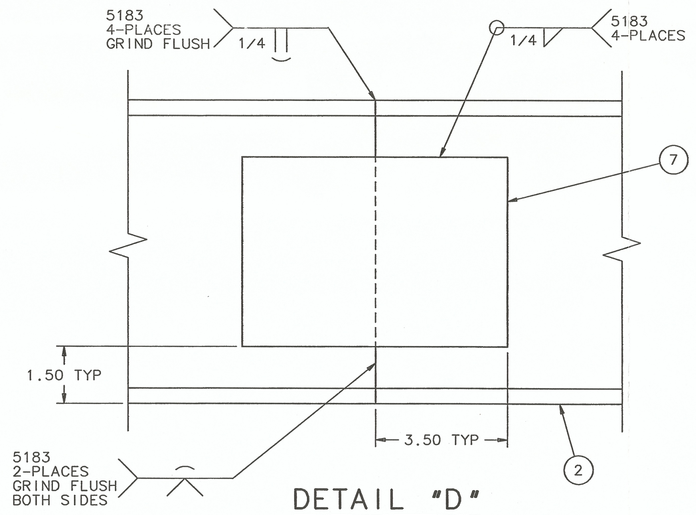


DETAIL "B"
SCALE: 1/4

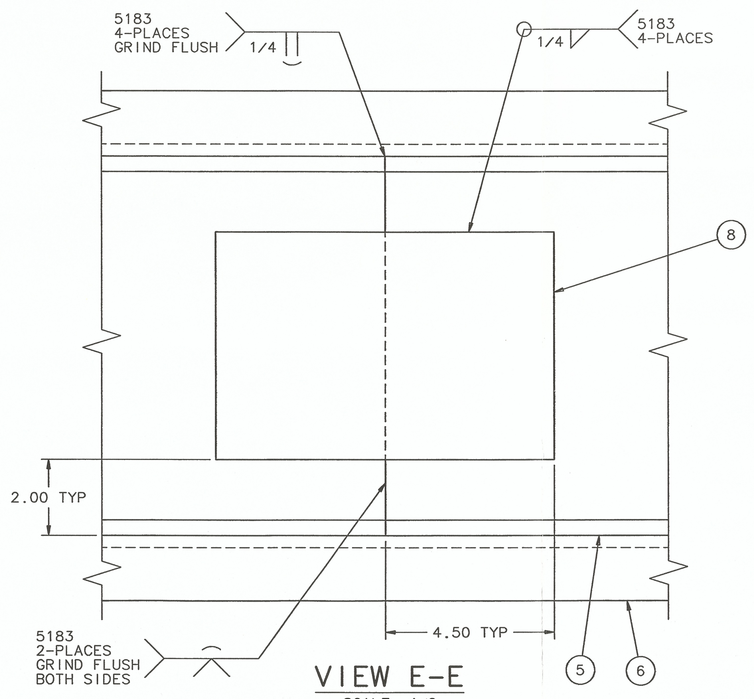
VIEW C-C
SCALE: 1/4



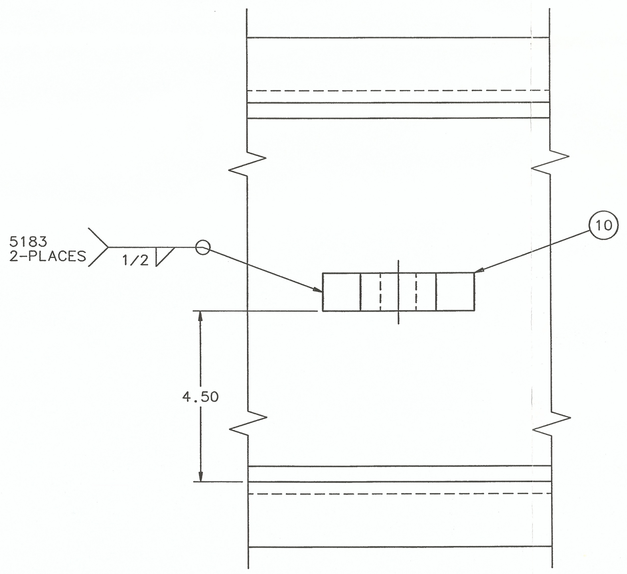
C SECTION "G-G"
SCALE: 1/4



DETAIL "D"
SCALE: 1/2



VIEW E-E
SCALE: 1/2



VIEW F-F

APPROX. WEIGHT: 1575 LBS.

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
C 12	MB-435016	STIFFENER	8
11	MB-384708	I-BEAM CLAMPING PLATE	11
10	MD-384664	LIFTING LUG	3
9	MB-384638	LIFTING LUG	2
8	COML	RECTANGLE, 1/4 x 6 x 9.00 LG., ALUMINUM 6061-T6511	4
7	COML	RECTANGLE, 1/4 x 5 x 7.00 LG., ALUMINUM 6061-T6511	4
6	COML	CHANNEL, AMER. STD., 4 x 2.50# x 186.00 LG., ALUMINUM 6061-T6	8
B 5	COML	I-BEAM, ALUM. ASSOC., 10 x 8.646# x 248.00 LG., ALUMINUM 6061-T6	3
4	COML	I-BEAM, AMER STD., 8 x 6.348# x 28.00 LG., ALUMINUM 6061-T6	2
3	COML	I-BEAM, AMER STD., 8 x 6.348# x 263.25 LG., ALUMINUM 6061-T6	2
2	COML	I-BEAM, AMER STD., 8 x 6.348# x 217.50 LG., ALUMINUM 6061-T6	1
1	MD-384635	TRUSS WELDMENT	10

PARTS LIST

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	J.KILMER	01-MAR-2000
.XX .XXX ANGLES	DRAWN	W.CYKO	01-MAR-2000
± .03 ± ±	CHECKED	C.NILA	21-MAR-2000
1. BREAK ALL SHARP EDGES .015 MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ANSI Y14.5M-1982 4. MAX. ALL MACH. SURFACES 250	APPROVED	J.KILMER	21-MAR-2000
	USED ON	ME-384700 ITEM1	
	MATERIAL	SEE ABOVE PARTS LIST	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL TRANSPORT WELDMENT

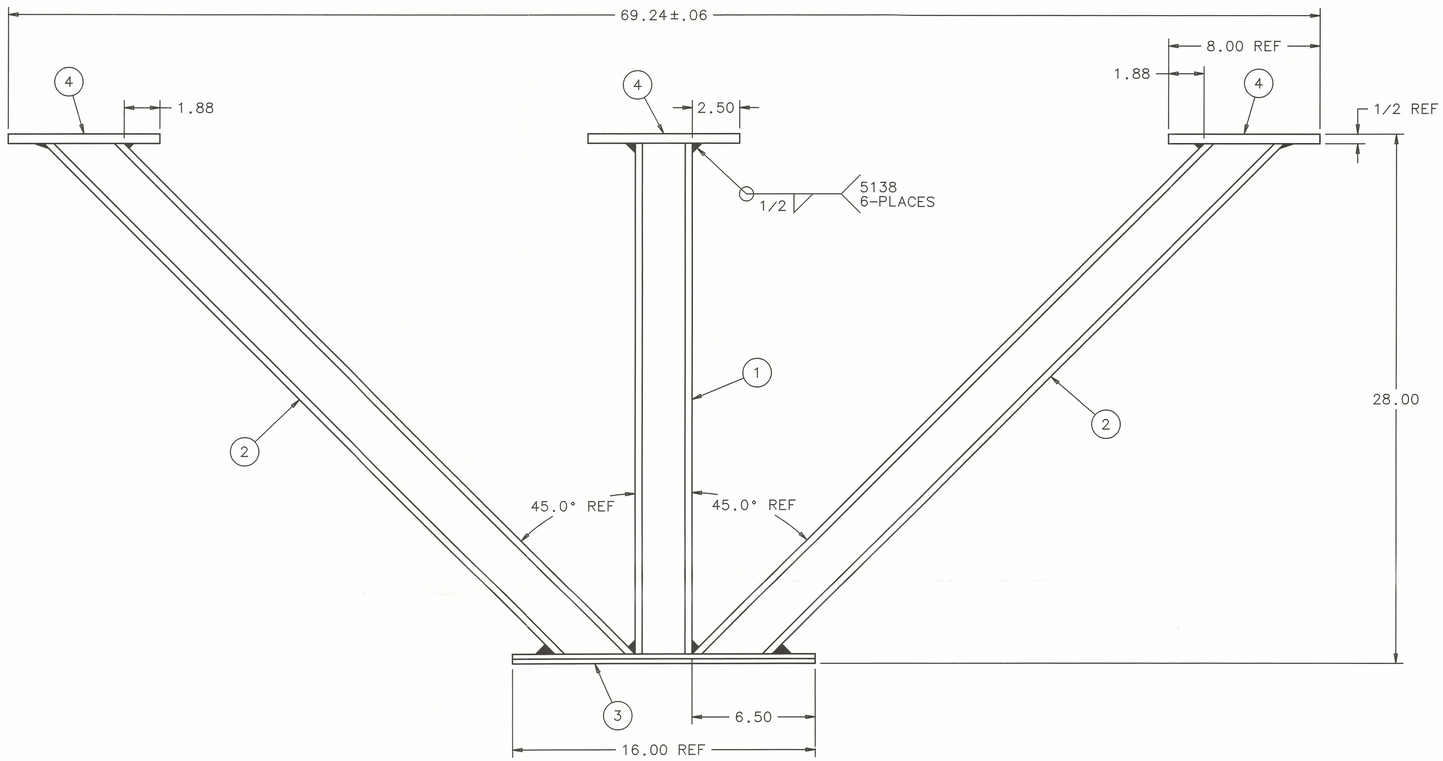
SCALE	DRAWING NUMBER	SHEET	REV
1/2=1'-0" & AS NOTED	9213.300-ME-384634	1 OF 1	C

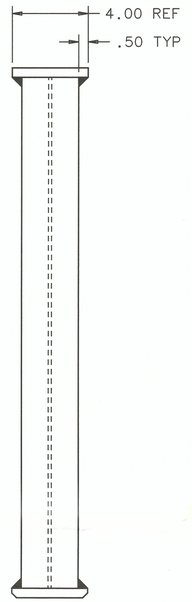
CREATED WITH : Ideas9m3 GROUP: PPD/MECHANICAL DEPARTMENT

A 1. MODIFY COIL TRANSPORT PER DRAWING MD-384846 AFTER MOVING TO TRAGET AREA.

NOTE:

REV.	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE





ITEM NO.	PART NO.	DESCRIPTION OR SIZE	QTY. REQ.
4	COML.	PLATE, 1/2 x 4 x 8, ALUMINUM 6061-T6	3
3	MB-384637	BASE PLATE	1
2	MC-384636	TRUSS CORD	2
1	COML.	I-BEAM, AMER. STD., 3 x .170 x 27.00 LG., ALUMINUM 6061-T6.	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J. KILMER	02-24-00
.XX	.XXX	ANGLES	DRAWN	B. CYKO	02-24-00
±.02	± ——	± ——	CHECKED		
			APPROVED		

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.

125 MAX. ALL MACHINED SURFACES

USED ON ME-384634 ITEM 1

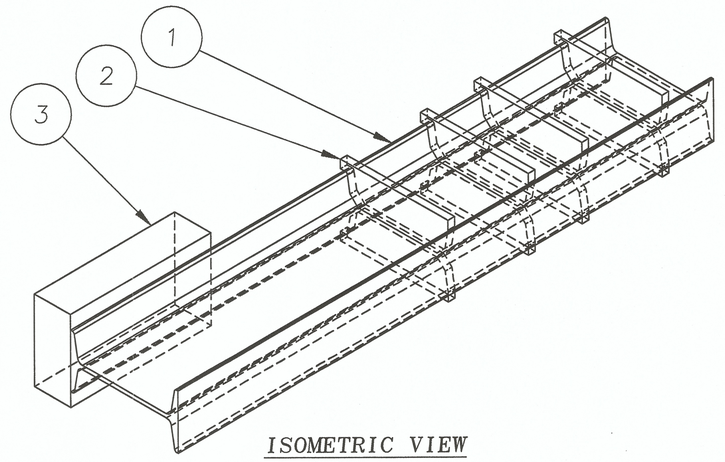
MATERIAL SEE ABOVE PARTS LIST

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT MINOS NEAR MAGNET COIL TRUSS WELDMENT, TRANSPORT FIXTURE

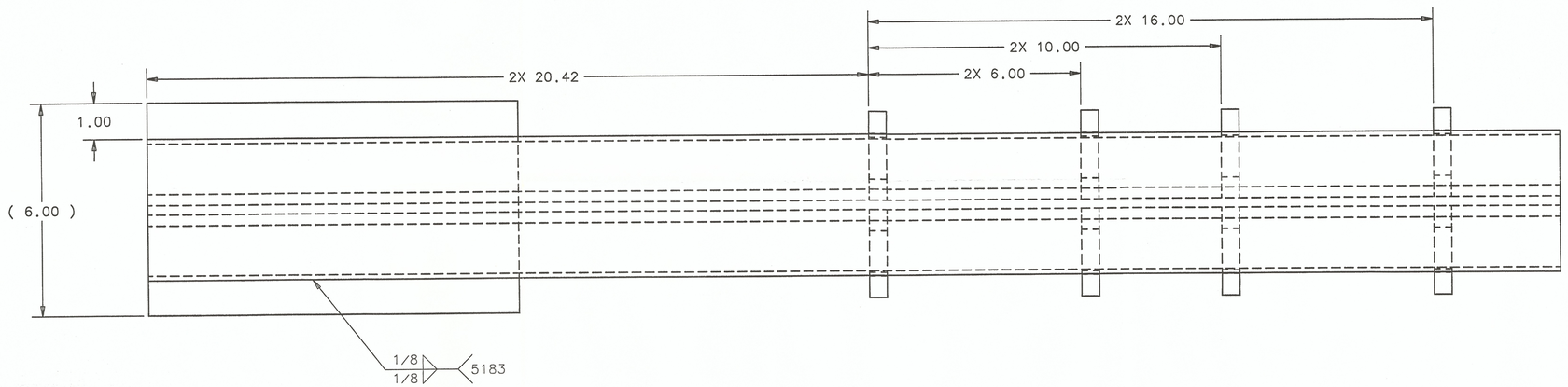
SCALE	DRAWING NUMBER	SHEET NO.	REV.
1/4	9213.300-MD-384635	1 OF 1	

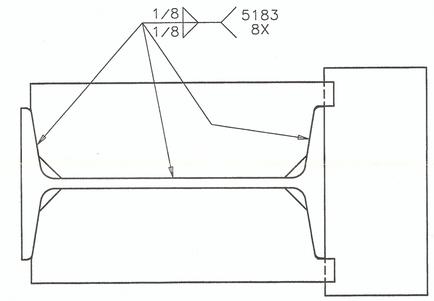
REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE

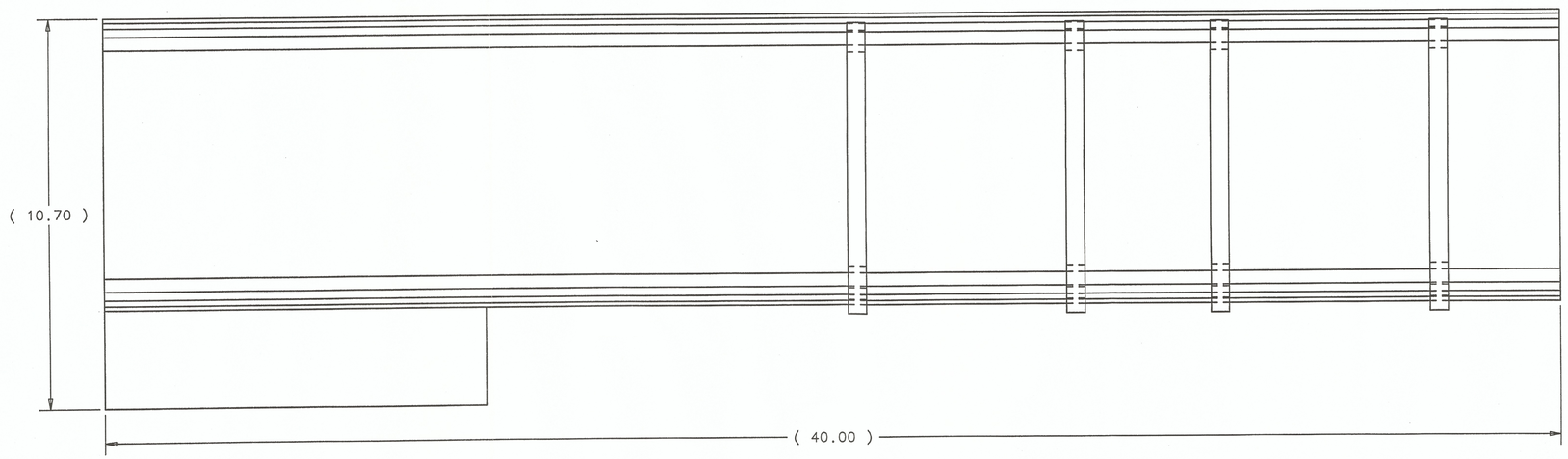


ISOMETRIC VIEW

SCALE: 1:4







ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
3	MB-435018	REST PAD	1
2	MB-435016	STIFFENER	8
1	MD-435015	SAFETY STOP BEAM	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	11-DEC-2003
.XX	.XXX	ANGLES	DRAWN	F.MCCONOLOGUE	11-DEC-2003
± .03	±	± 1°	CHECKED	C. Johnson	17-DEC-03
			APPROVED	James R. Kilmer	12/17/03

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. ALL DIMENSIONS ARE INCHES
5. MAX. ALL MACH. SURFACES

125

USED ON: ME-384700

MATERIAL: SEE PARTS LIST ABOVE

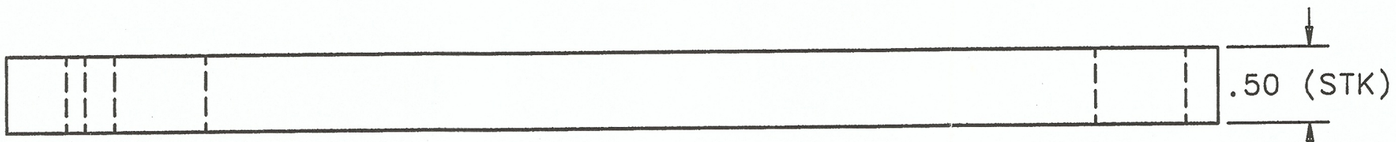
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

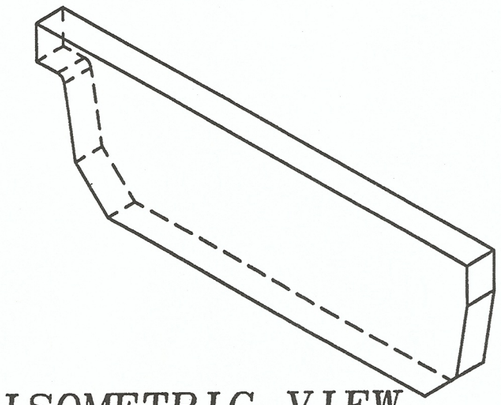
PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL
SAFETY BEAM WELDMENT

SCALE	DRAWING NUMBER	SHEET	REV
1:2 & NOTED	9213.300-MD-435014	1 OF 1	

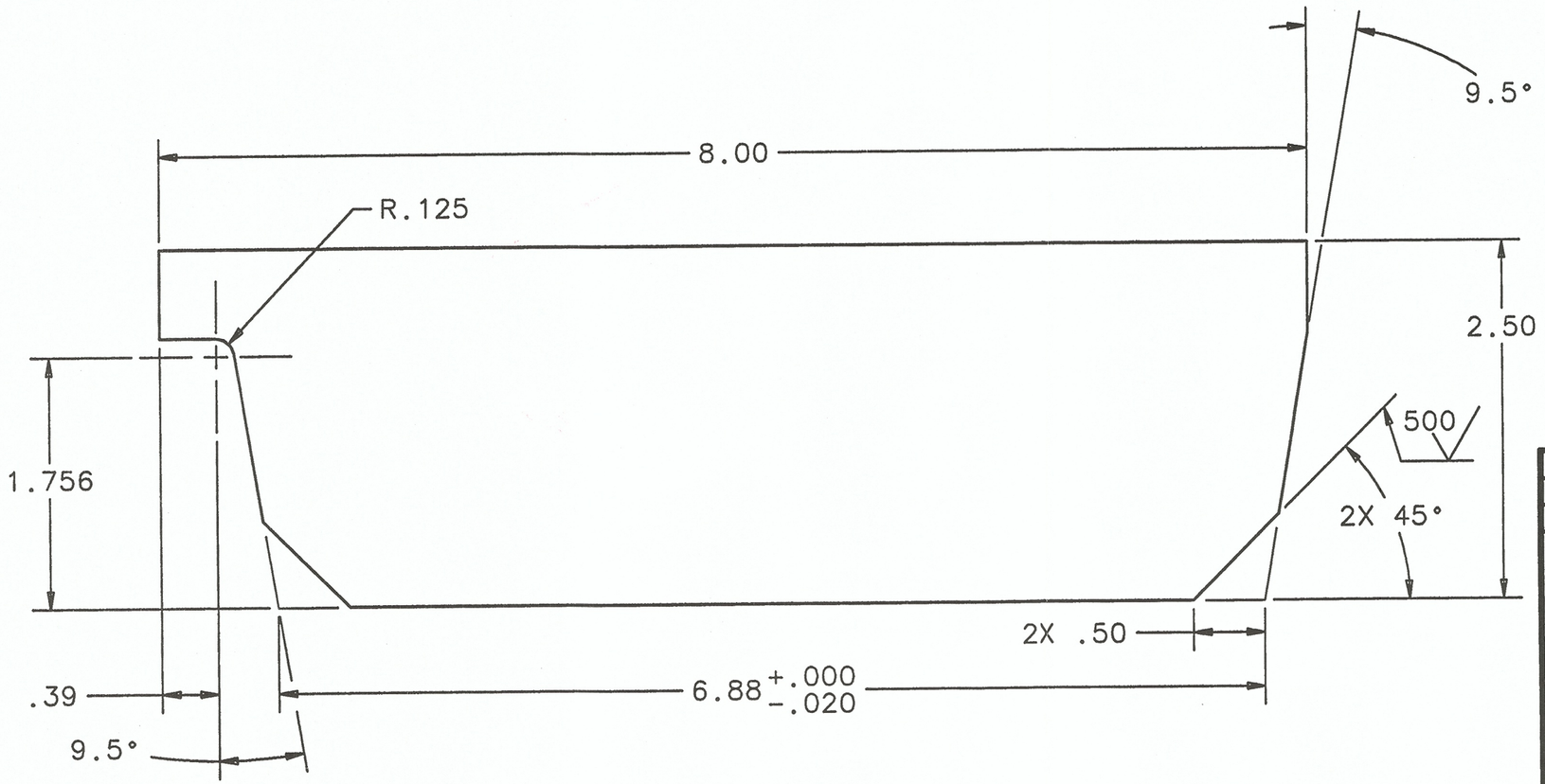
CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE





ISOMETRIC VIEW
SCALE: 1:2



UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	05-DEC-2003
.XX	.XXX	ANGLES	DRAWN	F.MCCONOLOGUE	05-DEC-2003
± .01	± .005	± 1°	CHECKED	C. Gingu	17-DEC-03
1. BREAK ALL SHARP EDGES .015 MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M-1994 4. ALL DIMENSIONS ARE INCHES 5. MAX. ALL MACH. SURFACES 250			APPROVED	James R. Kilmer	12/17/03
			USED ON	MD-435014, ME-384634	
			MATERIAL	6061-T6 ALUMINUM	

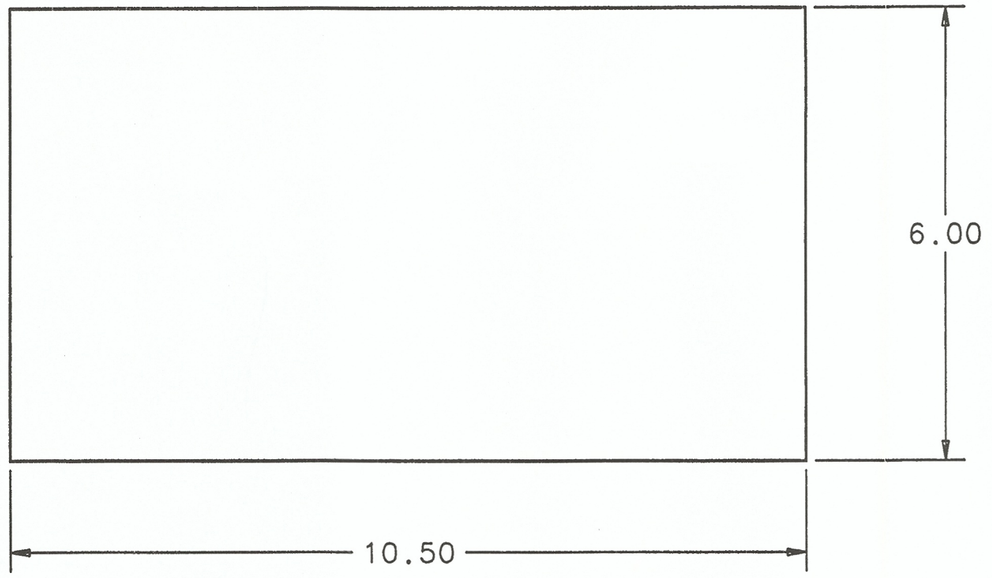
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

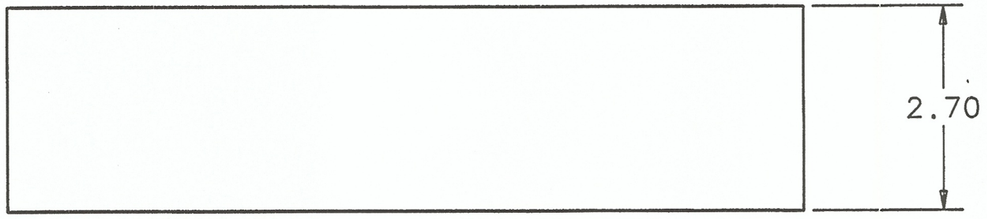
PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL STIFFENER

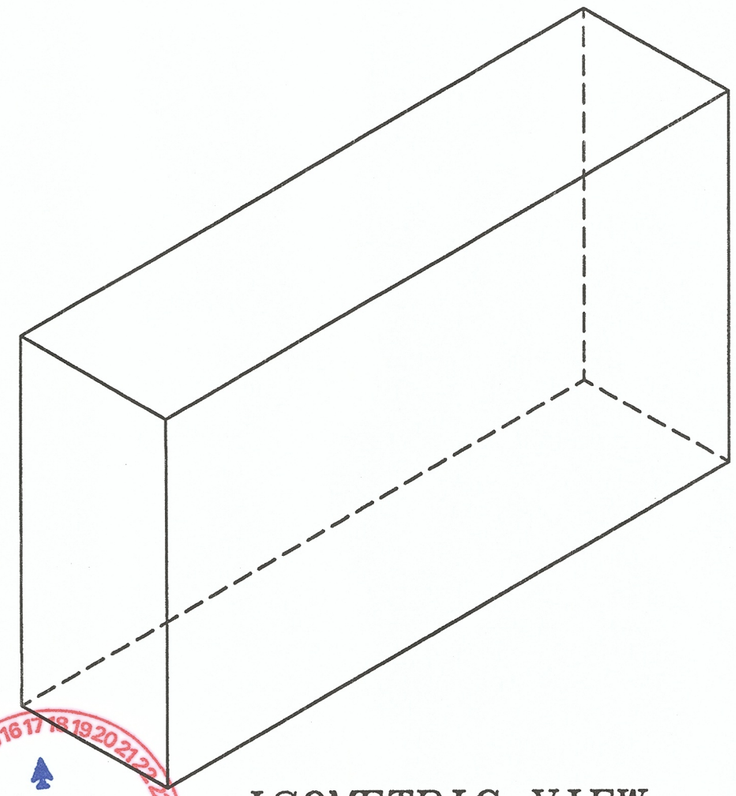
SCALE	DRAWING NUMBER	SHEET	REV
1:1 & AS NOTED	9213.300-MB-435016	1 OF 1	

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE







ISOMETRIC VIEW

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	15-DEC-2003
.XX	.XXX	ANGLES	DRAWN	F.MCCONOLOGUE	15-DEC-2003
± .02	±	± 1°	CHECKED	C. Johnson	17-DEC-03
			APPROVED	James R. Kilmer	12/17/03

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. ALL DIMENSIONS ARE INCHES
5. MAX. ALL MACH. SURFACES 250

USED ON: MD-435014

MATERIAL: 6061-T6 ALUMINUM

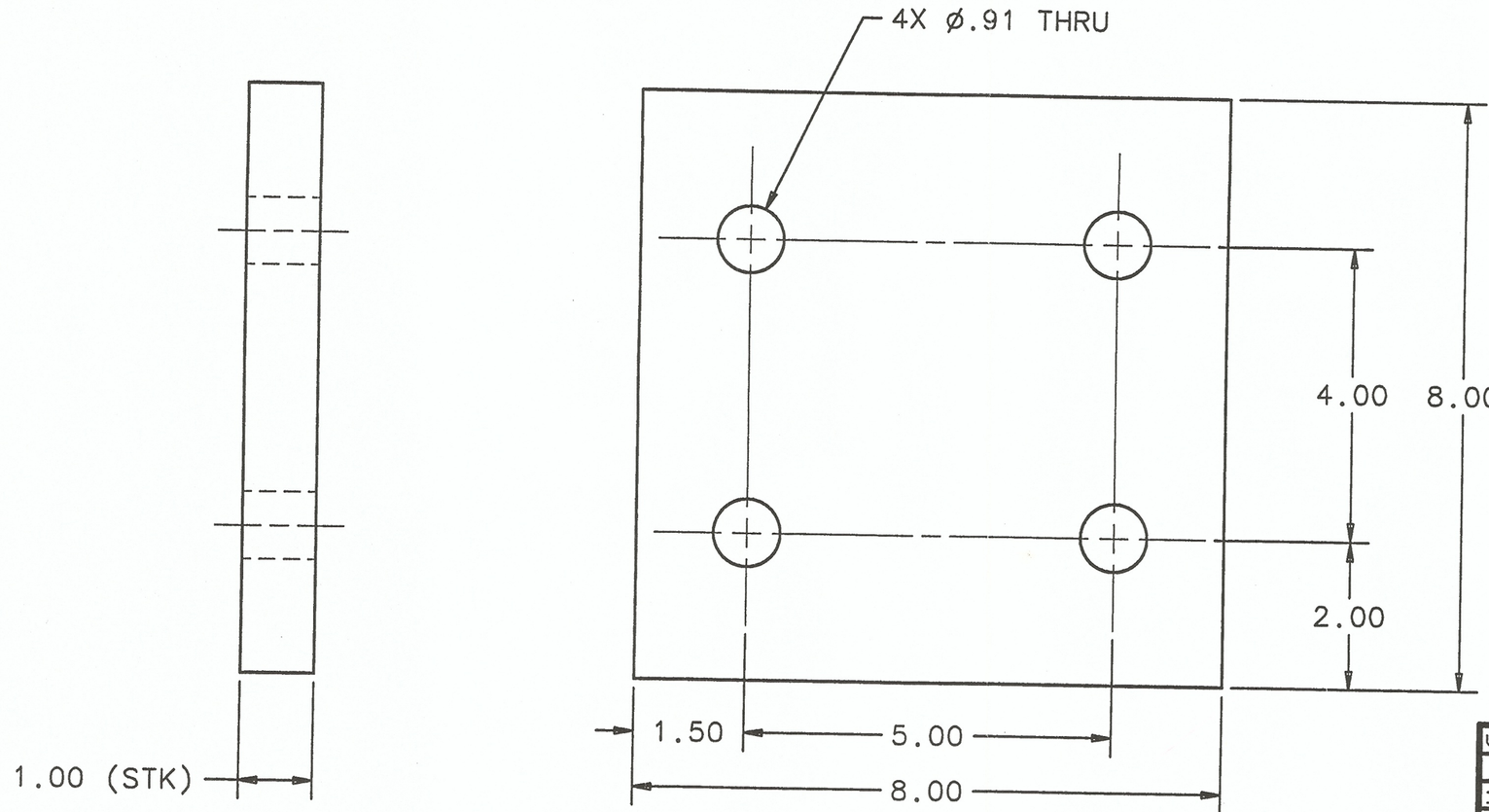
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL
REST PAD

SCALE	DRAWING NUMBER	SHEET	REV
1:2	9213.300-MB-435018	1 OF 1	

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	15-DEC-2003
.XX	.XXX	ANGLES	DRAWN	F.MCCONOLOGUE	15-DEC-2003
± .01	±	±	CHECKED	C. [illegible]	17-DEC-03
			APPROVED	James R. Kilmer	12/17/03

1. BREAK ALL SHARP EDGES .015 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. ALL DIMENSIONS ARE INCHES
5. MAX. ALL MACH. SURFACES 125

USED ON: ME-384700

MATERIAL: 6061-T6 ALUMINUM

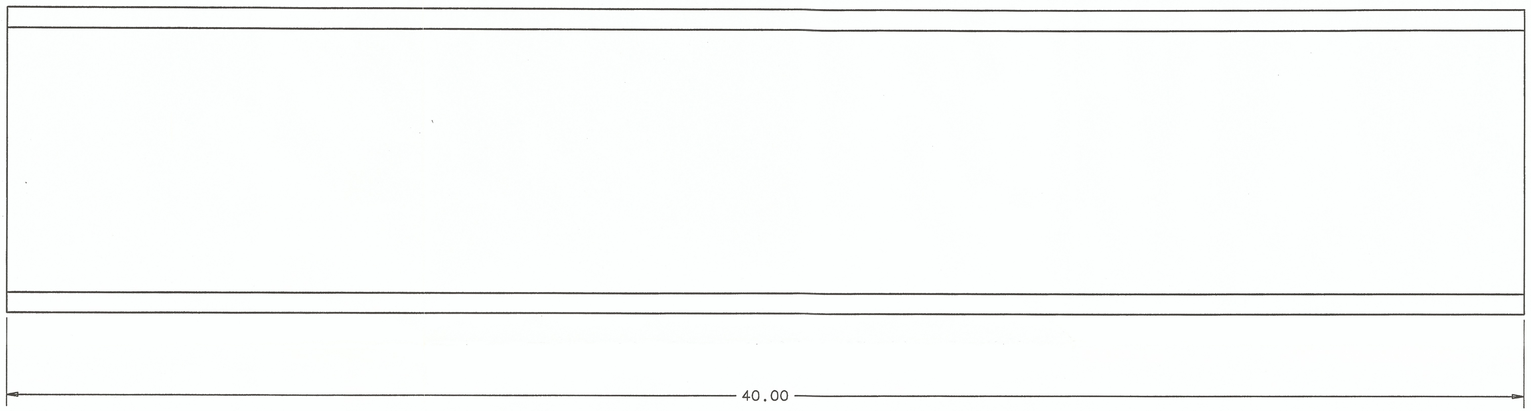
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

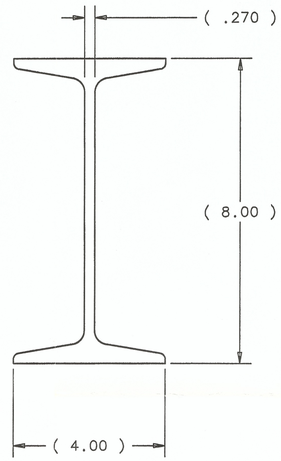
PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL
CLAMP PLATE

SCALE	DRAWING NUMBER	SHEET	REV
1:2	9213.300-MB-435017	1 OF 1	

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE





DEC 2003
REFERENCE ONLY
Not For Fabrication

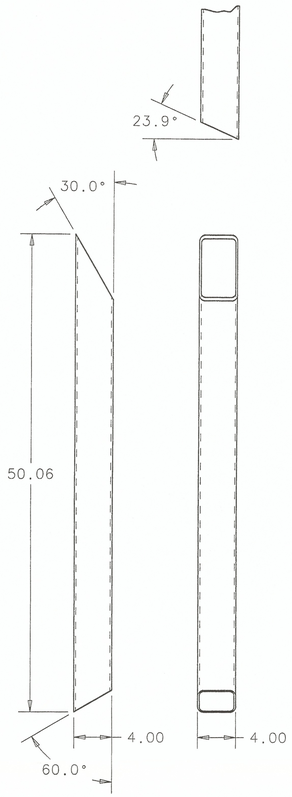
UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	05-DEC-2003
.XX	.XXX	ANGLES	DRAWN	F.MCCONOLOGUE	05-DEC-2003
± .12	±	±	CHECKED	C. Kendziora	17-DEC-03
1. BREAK ALL SHARP EDGES .015 MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M-1994 4. ALL DIMENSIONS ARE INCHES 5. MAX. ALL MACH. SURFACES 500			APPROVED	Jay R. Kilmer	12/17/03
			USED ON	ME-435014	
			MATERIAL	I-BEAM AMERICAN STANDARD 8.00" X 4.00" X .270" 6061 -T6 AL	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

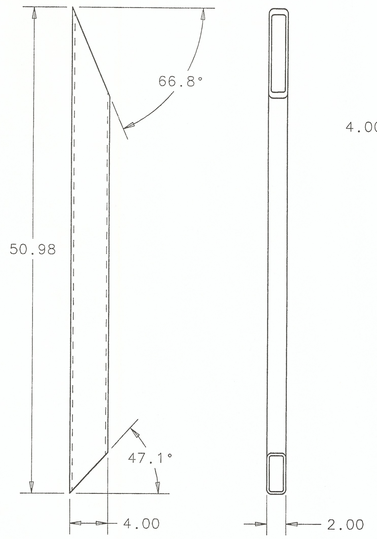
PPD/MECHANICAL DEPARTMENT
MINOS NEAR MAGNET COIL
SAFETY STOP BEAM

SCALE	DRAWING NUMBER	SHEET	REV
1:2	9213.300-MD-435015	1 OF 1	
CREATED WITH : Ideas9m3		GROUP: PPD/MECHANICAL DEPARTMENT	

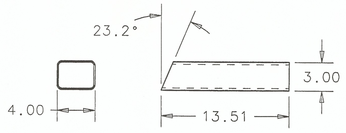
REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



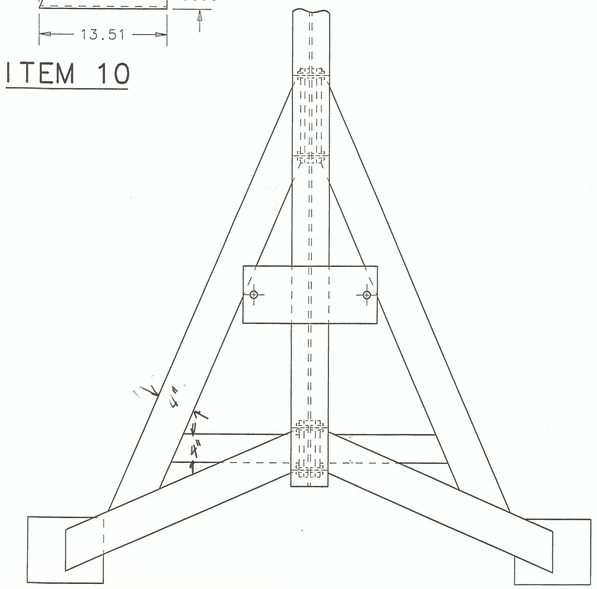
ITEM 8



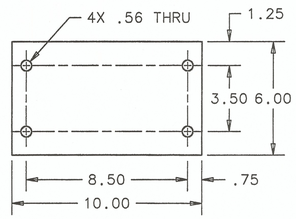
ITEM 9



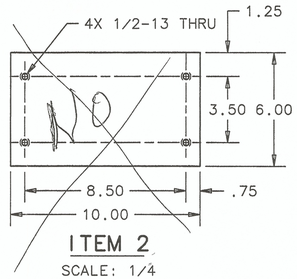
ITEM 10



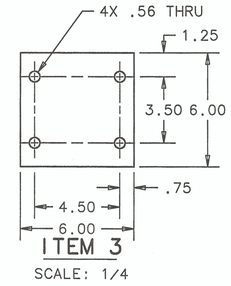
Changes needed on drawing



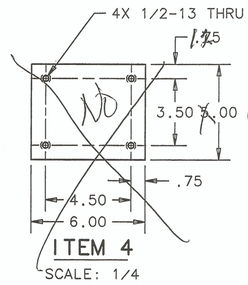
ITEM 1
SCALE: 1/4



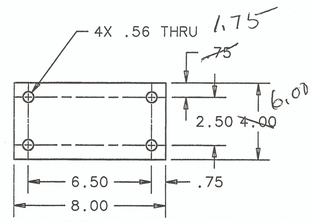
ITEM 2
SCALE: 1/4



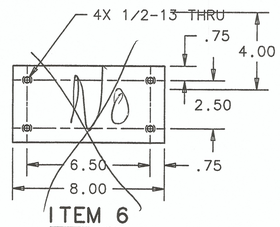
ITEM 3
SCALE: 1/4



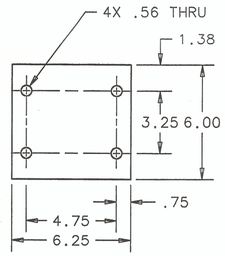
ITEM 4
SCALE: 1/4



ITEM 5
SCALE: 1/4

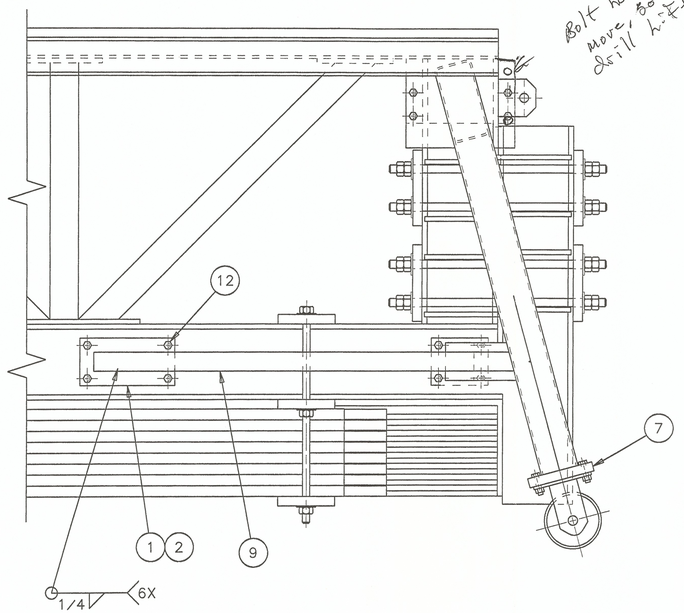


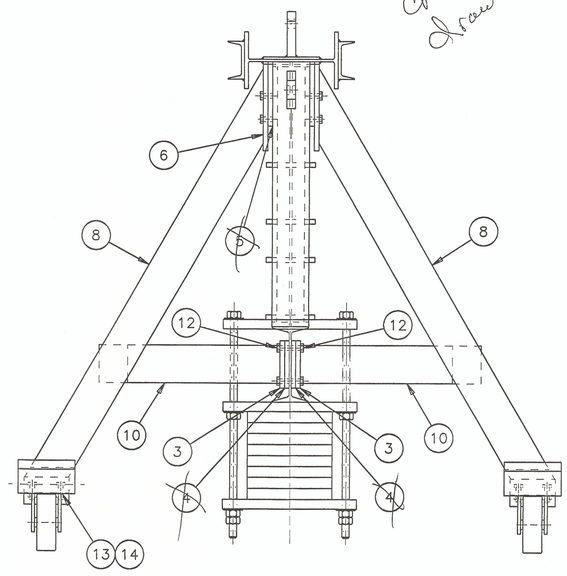
ITEM 6
SCALE: 1/4



ITEM 7
SCALE: 1/4

Bolt have been moved, so not to interfere with lifting leg





is not used

Bolt moved to miss lifting leg

Grade B

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
13	COM'L	STD. HEX NUT, 1/2-13 UNC, ~~S-S 304~~	8
12	COM'L	HHCS, 1/2-13 UNC x 1.50 LG., ~~Steel Grade B 18-8 304~~	8
11	COM'L	HHCS, 1/2-13 UNC x 1.00 LG., ~~S-S 304~~	224
10	COM'L	RECT. STRUCTURAL TUBING 4 x 3 x 1/8 x 13.51 LG., CARBON STEEL A500 GR. B	2
9	COM'L	RECT. STRUCTURAL TUBING 4 x 2 x 1/4 x 50.98 LG., CARBON STEEL A500 GR. B	2
8	COM'L	SQUARE STRUCTURAL TUBING 4 x 4 x 3/16 x 50.06 LG., CARBON STEEL A500 GR. B	2
7	COM'L	PLATE, 1.00 THK. x 6.25 x 4.75, CARBON STEEL A36	2
~~6~~	~~COM'L~~	~~PLATE, .500 THK. x 8.00 x 4.00, ALUMINUM 6061-T6~~	~~2~~
5	COM'L	PLATE, .500 THK. x 8.00 x ~~4.00~~ 6, CARBON STEEL A36	2
~~4~~	~~COM'L~~	~~PLATE, .500 THK. x 6.00 x 5.00, ALUMINUM 6061-T6~~	~~2~~
3	COM'L	PLATE, .500 THK. x 6.00 x 5.00, CARBON STEEL A36	2
~~2~~	~~COM'L~~	~~PLATE, .500 THK. x 10.00 x 5.00, ALUMINUM 6061-T6~~	~~2~~
1	COM'L	PLATE, .500 THK. x ~~10.00~~ 12 x ~~5.00~~ 9.00, CARBON STEEL A36	2

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	02-AUG-2004
.XX	.XXX	ANGLES	DRAWN	W.CYKO	02-AUG-2004
± .02	± ---	± 1°	CHECKED		
1. BREAK ALL SHARP EDGES .015 MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M 1994 4. MAX. ALL MACH. SURFACES 250 5. DRAWING UNITS: INCHES			APPROVED	James R. Kilmer	8/19/04
			USED ON		
			MATERIAL	SEE ABOVE PARTS LIST	

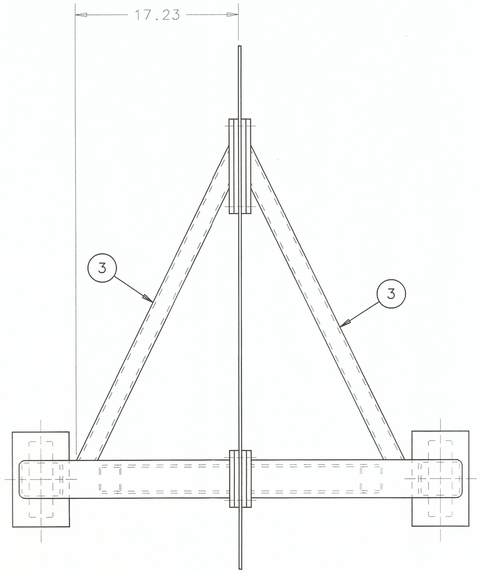
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

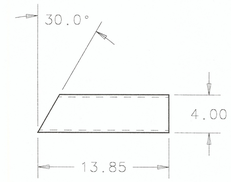
MINOS NEAR DETECTOR MAGNET COIL TRANSPORT MODIFICATION

SCALE	DRAWING NUMBER	SHEET	REV
1/8 & AS NOTED	9213.300-MD-435145	1 OF 1	

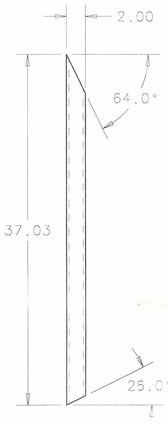
CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE

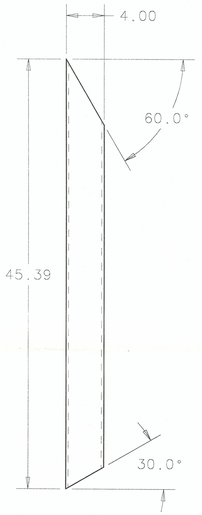




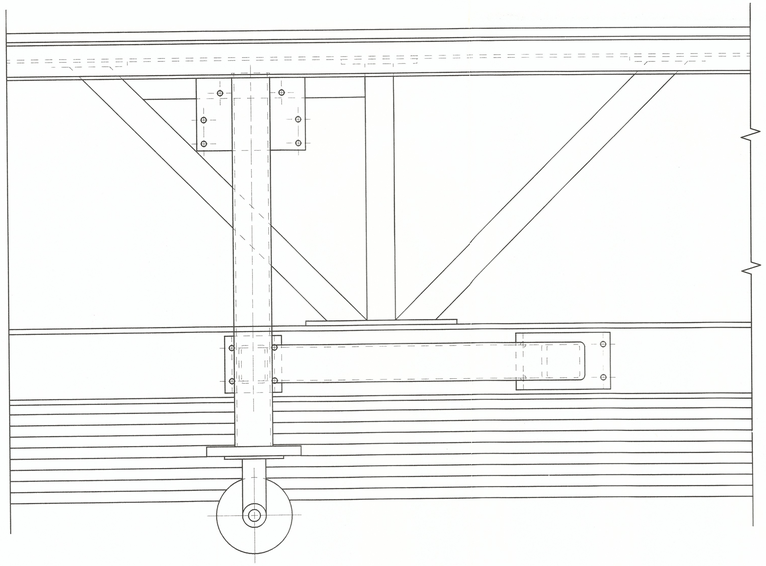
3 x 4
ITEM 2

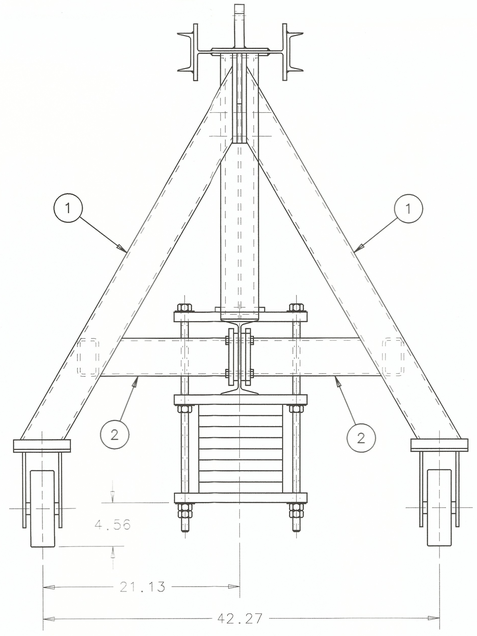


2 x 4
ITEM 3



4 x 4
ITEM 1





UNLESS OTHERWISE SPECIFIED			ORIGINATOR	J.KILMER	18-AUG-2004
.XX	.XXX	ANGLES	DRAWN	W.CYKO	18-AUG-2004
± .06	± ---	± 1°	CHECKED		
1. BREAK ALL SHARP EDGES .015 MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M 1994 4. MAX. ALL MACH. SURFACES 250 5. DRAWING UNITS: INCHES			APPROVED		
			USED ON		
			MATERIAL	SEE ABOVE PARTS LIST	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

MINOS NEAR DETECTOR MAGNET COIL TRANSPORT MODIFICATION 2

SCALE	DRAWING NUMBER	SHEET	REV
1/8	9213.300-MD-435153	1 OF 1	
CREATED WITH : Ideas9m3		GROUP: PPD/MECHANICAL DEPARTMENT	