5022TA

BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page

Lifting Device Numbers:

FNAL Site No/ _____ (If applicable) Div. Specific No. 158 (If applicable) Asset No. _____ (If applicable)

ASME B30.20 Group: (check one)
- [X] 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: CCM COIL REMOVAL FIXTURE

Device was (check all applicable)
- [ ] Purchased from a Commercial Lifting Device Manufacturer. Mfg Name _____
- [X] 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: JIM KILMER & B. WOODS Date: 5-4-06

Engineering Note Reviewed by: DAVE PUSHKA Date: 5-5-06

Lifting Device Data:

Capacity: 14,000 lbs

Fixture Weight: 8

Service: [X] 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: 5/17/06 Load: +4375 AT 4 POINTS = 17,500 lbs

[ ] Check if Load Test was by Vendor and attach the certificate

Satisfactory Load Test Witnessed by: MICHAEL P. ANDREWS

Signature (of Load Test Witness) _____

Notes or Special Information:

Fermilab

Revision 1.0
1/21/1999

Particle Physics Division
Engineering and Technical Teams

Mechanical Support Engineering Note

Number: MD-ENG-108 Date: 4/27/06

Project: CCM Magnet Move Project Internal Reference:

Title: Equipment to Lower the CCM coil

Author(s): Jim Kilmer, Bob Woods

Reviewer(s): Dave Pushka

Key Words: CCM, Chicago Cyclotron Magnet

Abstract/Summary:
This engineering note shows the calculations for the posts used to support the upper CCM pole pieces and the lifting fixture needed to lower the upper CCM coil to the bottom pole piece.

Applicable Codes:
AISC code, B30.20 Lifting fixture standard

Equipment to Lower CCM coil
April 27, 2006
Jim Kilmer

A proposal to remove the CCM from the New Muon Lab is being pursued now with the rigging now out for bid. In order for the contractor to be able to remove the top magnet iron pieces it is neccessary to lower the upper coil from it's present position hanging from the upper iron to set on the lower pole piece. A fixture has been designed to lower the coil. Additionally once the coil is removed the upper pole pieces will have to be supported by posts. Those pole pieces are hung from the top iron by large studs that go through the upper iron pieces into the pole pieces. Pictures attached at the end of this document show the magnet top with the stud nuts and the bottom where the studs are in the bottom pole piece. Drawing 9204.000-ME-435797 shows the plan view layout of the fixture and support posts in relation to the magnet coil and pole piece.

First look at the posts. Old drawings from eariler work on the magnet showed a post made out of structural square tubing 10" by 10" by 1/2" wall. The drawing number is 2753.700-MD-156431. We will use the material we have in our stock which is the same size or heavier. The distance from pole to pole is 50 1/4". The drawing shows posts 49 1/4" allowing for shimming to exact height required. Now look at the sizing of the posts using the Manual of Steel Construction, by the AISC, 9th edition.

Use four columns, two of which are 10" by 10" and two of which are 10" by 14 all with 1/2" wall. Find the load.

$Pt := 129000 \cdot lb \cdot 2$ Pt is the total load on the four columns

$Po := \frac{Pt}{4}$ Po is load on a single column

$Po = 6.45 \times 10^4 lb$

To be conservative assume that K = 2 for the ends of these short columns and Kl is 5 ft*2 or 10 ft. In looking at the AISC manual page 3-40 for 10" by 10" by 1/2" tubing at Kl = 10 feet the allowable load indicated is 459 Kips. Since each post only has to support 64.5 Kips these columns are OK. The 14" by 10" columns can support even more at 562 Kips.

Next look at stresses in the lifting fixture. The coil weighs about 14,000 lbs. I is carried in four spots on the two main I-beams. See drawings attached.For each beam use case 10from page 2-299 of the AISC code. It is for a simple beam with two equal concentrated loads that are unsymetrically placed.

$P := 3500 \cdot lb$ Weight of 1/4 of the coil

$l := 228 \cdot in$ length of main beams

$a := 46 \cdot in$ left side distance to load

$b := 78 \cdot in$ right side distance to load

$R1 := \left(\frac{P}{l}\right) \cdot (l - a + b)$ Left Reaction load

$R2 := \left(\frac{P}{l}\right) \cdot (l - b + a)$ Right Reaction load

$R1 = 3.991 \times 10^3\, lb$

$R2 = 3.009 \times 10^3\, lb$

$M1 := R1 \cdot a$ $M2 := R2 \cdot b$

$M1 = 1.836 \times 10^5\, lb \cdot in$ $M2 = 2.347 \times 10^5\, lb \cdot in$

Use the larger M2 to calculate the beam required. Also use Fb = 0.33*Fy. Because this is a lifting fixture B30.20 requires that a maximum stress of 1/3 of yield is allowable.

$Fb := 0.33 \cdot 36000 \cdot \frac{lb}{in^2}$

$S := \frac{M2}{Fb}$

$S = 19.755\, in^3$ Required Section Modulus of the beam

Note that any of the W8 beams will be able to supply this section modulus as follows:

W8 by 28	24.3 cubic inches
W8 by 31	27.5 cubic inches
W8 by 35	31.2 cubic inches

We have enough W8 beams in stock to make this frame.

Procedure to lower the CCM Upper Coil
April 27, 2006
Jim Kilmer

This procedure is needed to lower the upper coil to release it from the top iron of the CCM. It is not possible to take any of the CCM iron apart until the top coil has been lowered because the top coil is bolted to the upper iron pieces. Additionally the top pole pieces are bolted to the top iron by large tension bolts. The top pole pieces must also be supported to take the magnet apart. An engineering note has been written for the posts to support the pole pieces and the fixture needed to lower the coil. Drawing number 9204.000-ME-435797 shows the positioning of the fixture in the bore.

1. Put the coil fixture inside the magnet bore in the location indicated on the drawing.
2. Using a forklift with fork extensions place the posts inside the bore at the locations indicated on the drawing. Be careful to keep the forklift away from the pit grating.
3. Shim from the top of the posts to the bottom of the pole piece as tightly as possible.
4. Using the two building cranes raise the fixture until it contacts the bottom of the coil. Make sure it hits the coil in the correct positions.
5. Remove the screws and clamp bars holding the coil to the upper magnet iron.
6. Lower the fixture until the cross beams are sitting on the bottom pole piece.
7. Leave the fixture and coil in that position until all of the top iron is removed.

COIL WEIGHT = 14,000# (FROM PART I BY J. KILMER THIS CALC.)

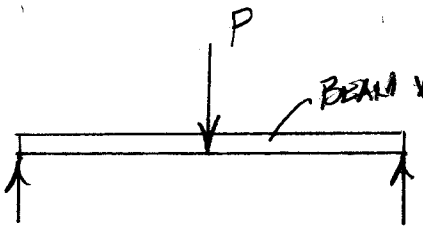
SEE DRWG 435797 FOR LIFTING FIXTURE LAYOUT

CHECK BEARING PLATES & CHANNELS:

DIAGONAL CHANNEL:

SPAN ≈ 30.5" (CONSERVATIVE)

FOR MOMENT, USE SINGLE LOAD @ CENTER OF SPAN:



CONSERVATIVELY ASSUME 3 OF 4 SUPPORTS CARRY LOAD.

$P = 14{,}000/3 = 4700\#$

BEAM WT = 11.5#/FT = 0.96#/IN

$R = 4700/2 + 0.96(30.5)/2 = 2364.6\#$ SAY 2500#

$M_{MAX} = Pl/4 + wl^2/8$

$= 4700(30.5)/4 + 0.96(30.5)^2/8$

$= 35837.5 + 111.6$

$= 35949\ \#\text{-IN}$

FOR LIFTING FIXTURE $F_b = 0.33(36) = 12\ KSI = 12000\ PSI$

$S_x\ REQ'D = M/S = 35949/12000 = 3.0\ IN^3$

S_x FOR C8X11.5 = $8.14_{IN}^3 > 3.0_{IN}^2$ ok

FOR SHEAR, TRY TOTAL LOAD @ END (VERY CONSERVATIVE)

TOTAL LOAD = 4700 + 30.5(0.96) = 4729#

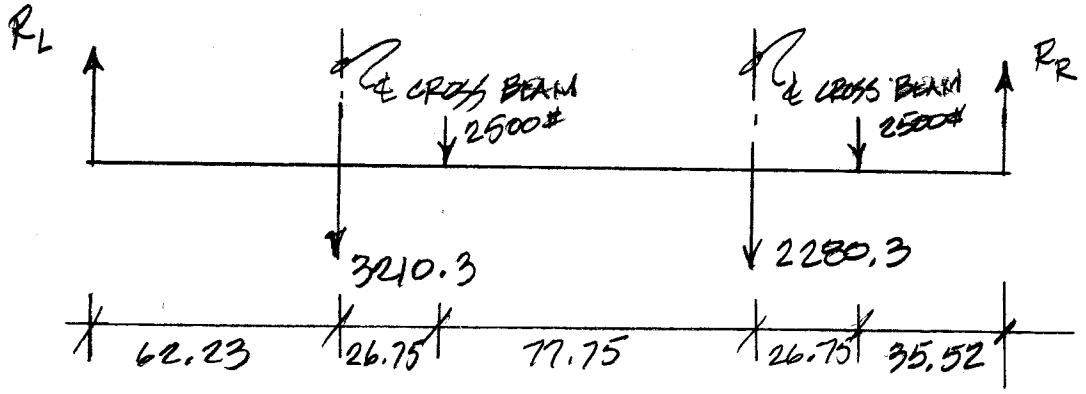
$f_a = R/A = 4729/3.38 = 1399\ psi$

$F_A = 0.33(36{,}000) = 12000\ psi > 1399\ psi$ ok

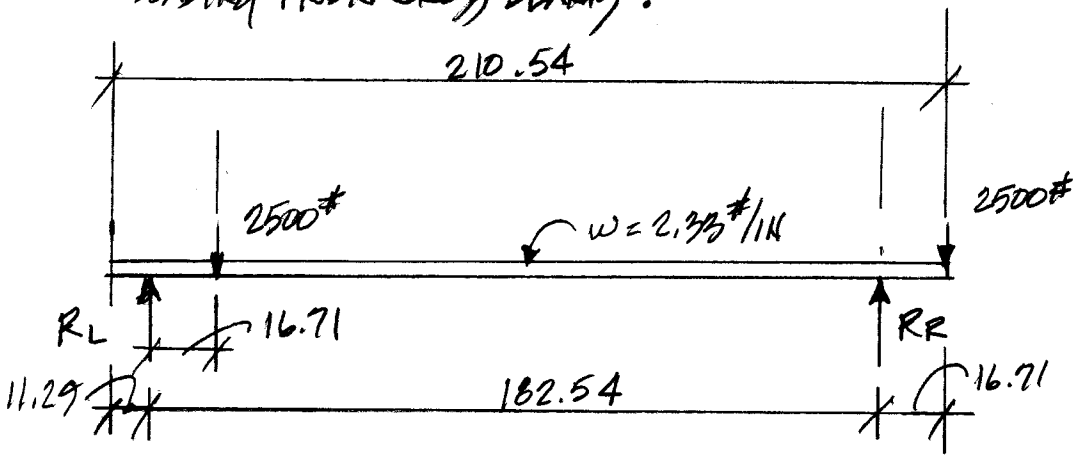
USE C8X11.5

CHECK 229" BEAMS:

CASE #1 BEAM SUPPORTED BY CRANES:



LOADING FROM CROSS BEAMS:



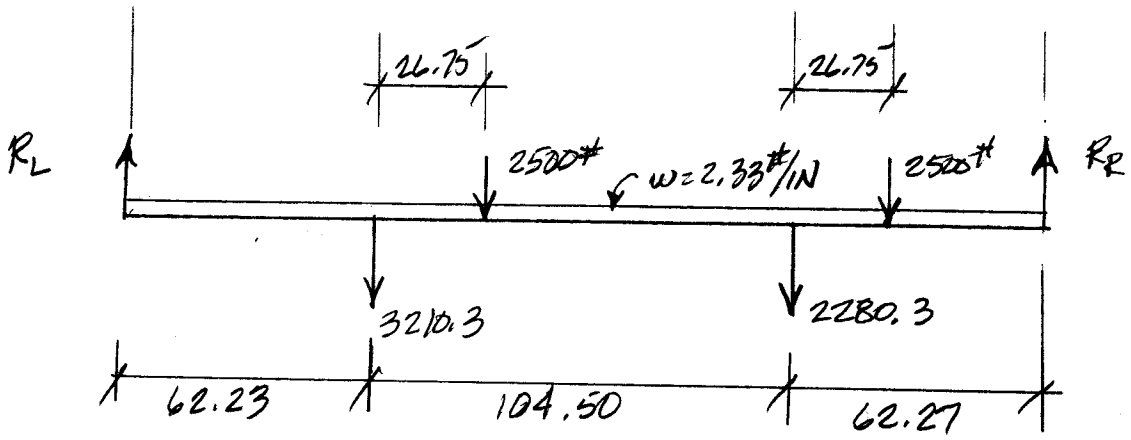
ASSUME BEAM = W8x28, $w = 28/12 = 2.33$#/IN

$$182.54R_R = -11.29(2.33)(11.29/2) + (182.54+16.71)(2.33)((182.54+16.71)/2) + 16.71(2500) + (182.54+16.71)(2500)$$

$$R_R = 3210.27\#$$

$$182.54R_L = -16.17(2.33)(16.17/2) + (182.54+11.29)(2.33)((182.54+11.29)/2) - 2500(16.71) + (182.54-16.71)(2500)$$

$$R_L = 2280.29\#$$

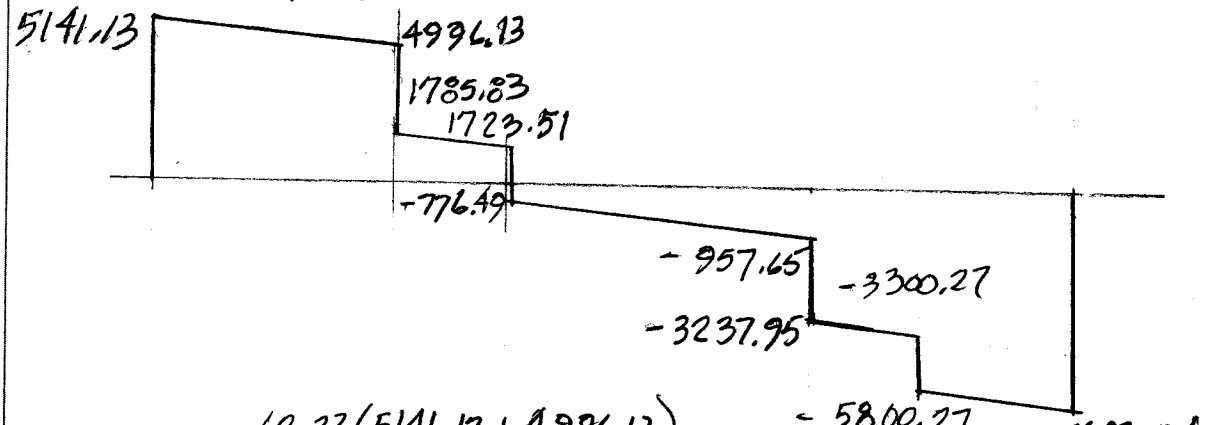


$$229\,R_R = 229(2.33)(229/2) + 62.23(3210.3) + 88.98(2500) + 166.73(2280.3) + 193.48(2500)$$

$$R_R = 5883.04\ \#$$

$$R_L = 229(2.33)(229/2) + 35.52(2500) + 62.27(2280.3) + 140.02(2500) + 166.77(3210.3)$$

$$= 5141.13\ \#$$



$$M = \frac{62.23(5141.13 + 4996.13)}{2} + \frac{26.75(1785.83 + 1723.51)}{2}$$

$$= 362358.3\ \#\text{-IN}$$

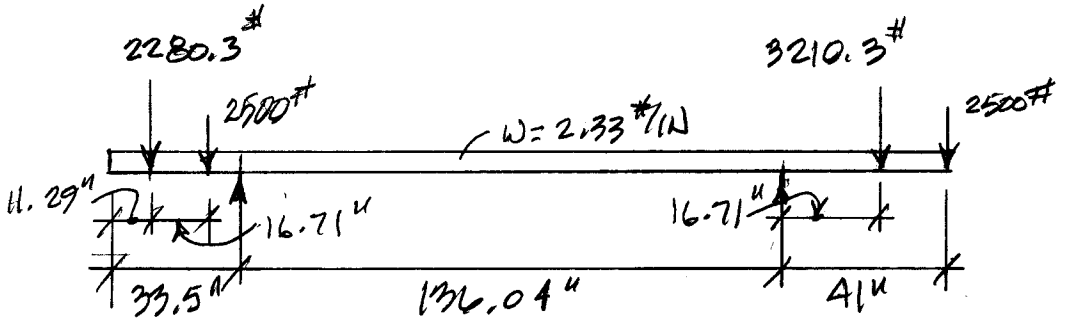
$$S_{X\ REQ'D} = 362358.3/12000 = 30.12\ IN^2$$

SMALLEST WB THAT WILL WORK = WB×35

$S_X = 31.2$

CHECK 210.54 BEAMS

CASE 2 BEAMS SUPPORTED BY LOWER POLE:

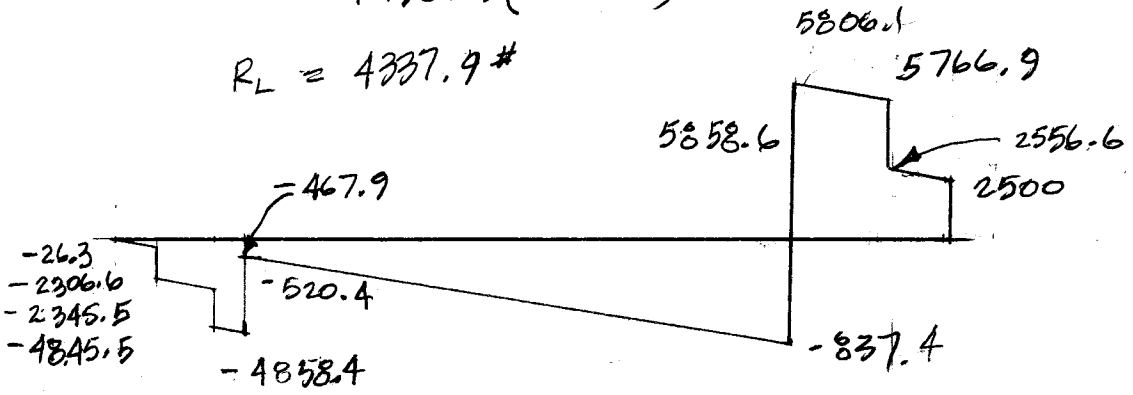


$$136.04(R_R) = -33.5(2.33)(33.5/2) - 5.5(2500)$$
$$-22.21(2280.3) + 177.04(2.33)\left(\frac{177.04}{2}\right)$$
$$+152.75(3210.3) + 177.04(2500)$$

$$R_R = 6643.5\ \#$$

$$136.04(R_L) = -41(2.33)(41/2) - 16.71(3210.3) - 41(2500)$$
$$+169.54(2.33)(169.54/2) + 141.54(2500)$$
$$+158.25(2280.3)$$

$$R_L = 4337.9\ \#$$



$$M = \left(\frac{26.3(11.29)}{2} + \frac{(2306.6+2345.5)(16.71)}{2} + \frac{(845.5+858.4)5.5}{2} + \frac{(520.4+837.4)(136.04)}{2}\right) / 136.04$$

$$= 158{,}060 \#\text{-IN}$$

S_x REQ'D $= 158\,060 / 12000$

$= 13.2 \text{ IN}^3$ $\quad S_x$ OF W8X28 $= 24.3 \text{ IN}^3 > 13.2 \text{ IN}^3$ OK

CHECK SHEAR:

LARGEST SHEAR LOAD $= 5858.6$ #

$A_{REQ'D} = \frac{5858.6}{12000}$

$= 0.49 \text{ IN}^2$

AREA OF W8X28 $= 8.25 \text{ IN}^2 > 0.49 \text{ IN}^2$

USE W 8 X 28 FOR 210.54 BEAM *

USE W 8 X 35 FOR 229.0 BEAM *

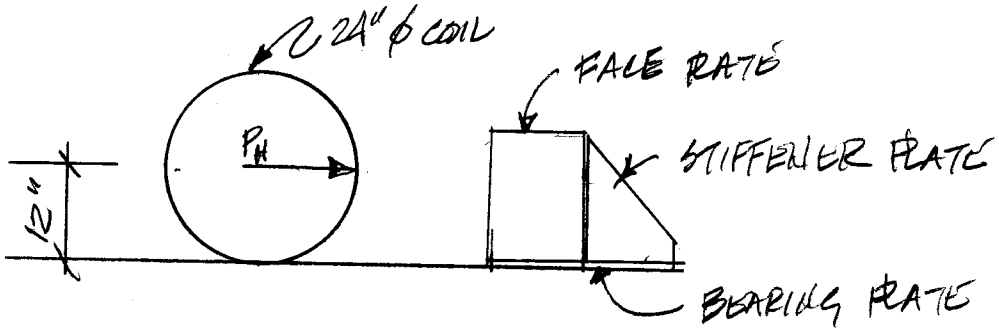
* NOTE: S 12 X 50 MAY BE SUBSTITUTED FOR W 8 BEAMS, SINCE $S_x = 50.0 \text{ IN}^4$

SAFETY BRACKET ON 229" BEAMS TO PREVENT COIL FROM SLIPPING OFF LIFTING FIXTURE IN THE EVENT OF A SINGLE CRANE FAILURE:

USE 10% OF THE VERTICAL LOAD AS THE HORIZONTAL LOAD:

$14{,}000\#(10\%) = 1400\#$

DIAMETER OF COIL = 24"



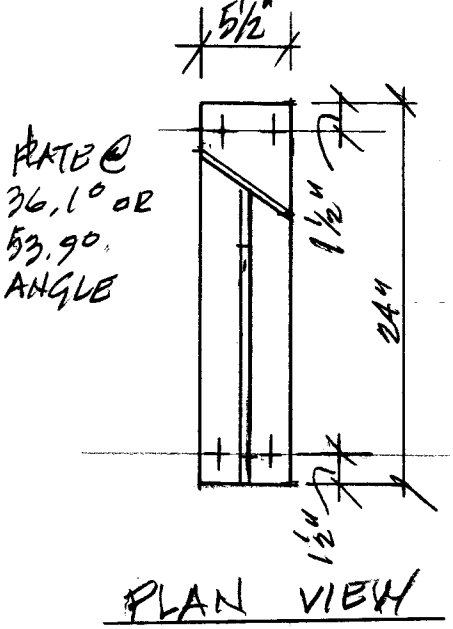
HORIZONTAL LOAD:

LOAD ON EACH BLOCK = 1400/2
= 700#

USE 100% ADD'L LOAD FOR IMPACT

$P_H = 700\# + 700\# = 1400\#$

$M = 12 \times 1400 = 16{,}800\#\text{-IN}$



PLAN VIEW

ADD'L MOMENT ON BEAM =
16,800#-IN

S_x ADD'L = 16,800/12,000
= 1.4 IN³

SINCE S12x50 BEAM WAS SELECTED, $S_x = 50.8$

S_x REQ'D = 30.2 + 1.4 = 31.6 < 50 OK

CHECK BOLTS;

MAX. TENSION LOAD = 16,800/(24 - 2(1.5))
= 800#

USING 2 BOLTS, LOAD PER BOLT = 800/2
= 400#

USE 3/4" ϕ GR. 5 BOLTS
ALLOW LOAD = F_t = 36,000/3 = 12,000psi

12,000(0.4418) = 5300#/BOLT > 800#/BOLT
OK

FOR WELD BETWEEN STIFFNER PLATE & BASE PLATE;

USING 1/2" THICK PLATES, MINIMUM WELD = 3/16
(AISC P5-67 TAB. J2.4)

MAX. WELD = 1/2 - 1/16 = 7/16"
(AISC. P5-67 2b)

TRY 5/16" WELD. STRENGTH = 0.707(0.30)(70)(5/16)
= 4.64 K/IN

WELD FACE PLATE W/ 5/16 WELD BOTH SIDES TO BASE PL.

ALLOW. SHEAR = 4.64(2)(6") = 55.7K > 1.4K OK

WELD STIFFENER PLATE TO BASE PLATE AND FACE PLATE W/ 6" WELD, BOTH SIDES.

ALLOW. SHEAR = 4.64(2)(6") = 55.7K > 1.4K OK

REVISED BRACKET DESIGN:

BASE PLATES WERE CUT 18" LONG INSTEAD OF 24" LONG AS SHOWN.

MAX TENSION LOAD = $16800/(18 - 2(1.5))$
$= 1120\#/2$ BOLTS
$= 1120\#/2 = 560\#/$BOLT

SHEAR/BOLT = $1400/4 = 350\#/$BOLT

FOR GRADE 5 BOLTS $F_V = 10.0$ KSI AISC P 5-73 TAB. J 3.2 FOR A307 BOLTS

FOR GRADE 5 BOLTS $F_T = 26 - 1.8 f_V \leq 20$

FOR $\frac{3}{4}"\phi$ BOLTS $= 26 - 1.8(.560/.4418)$
$= 23.7$ KSI USE 20 KSI

AISC P 5-74 TAB J3.3 FOR A307 BOLTS

$f_V = 350/0.4418$
$= 792$ PSI

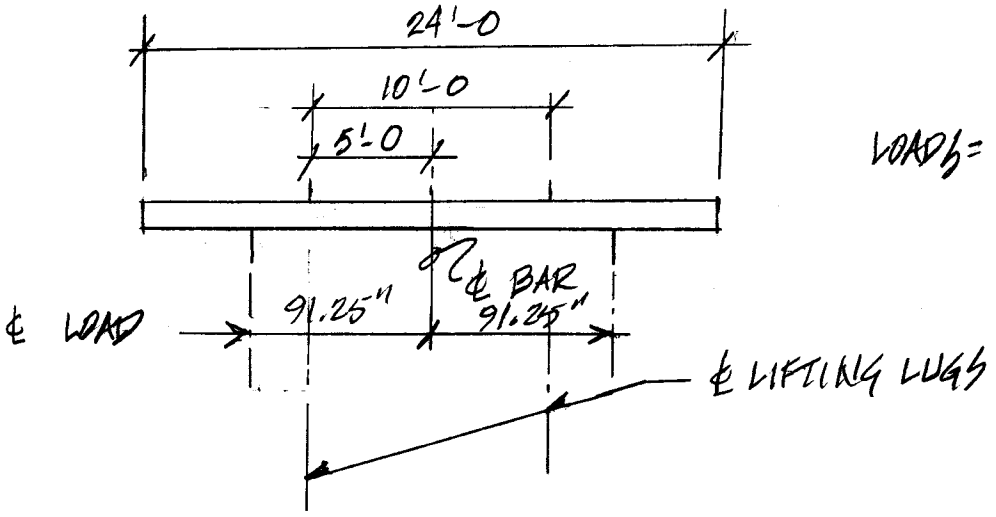
$F_T = 560/0.4418$
$= 1268$ PSI

$f_V/F_V + f_T/F_T = 792/10{,}000 + 1268/20{,}000$
$= 0.079 + 0.063$
$= 0.142 < 1.0$ OK

18" LONG 1/2" PLATE OK
W 4 $\frac{3}{4}"\phi$ GRADE 5 BOLTS

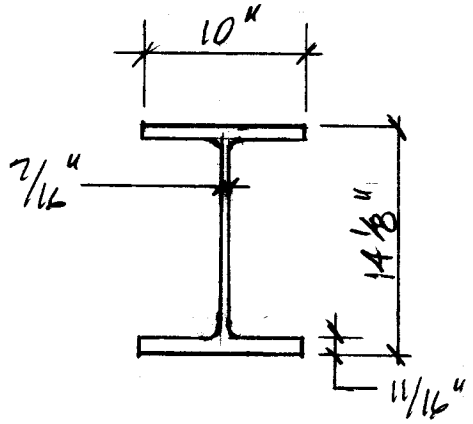
CCM MAGNET REMOVAL	COIL LIFTING FIXTURE SPREADER BAR	R. J. HOUDE MAY 12, 2002	1

INVESTIGATE EXISTING SPREADER BAR AS SHOWN:



LOAD = 2 X 4000#

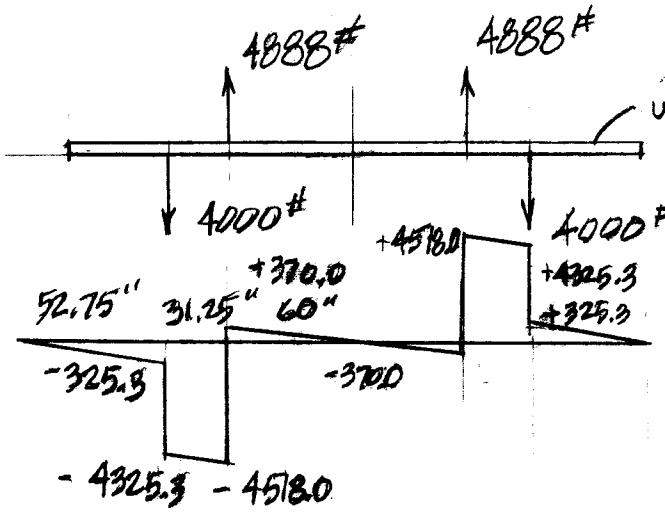
SIDE VIEW



CROSS SECTION

DESIGN FOR MINIMUM 45° SLING ANGLE WHERE, FOR THIS CASE, HOOK WOULD BE A MINIMUM OF 5'-0 ABOVE SPREADER BAR.

BEAM SECTION CLOSELY RESEMBLES W 14 X 74



VERTICAL MOMENT:

$$M_{CNT} = 52.75(325.3)/2 + 31.25(4325.3 + 4518.0)/2$$
$$= 8579.8 + 138,176.6$$
$$= 146,756.4\ \#\text{-IN}$$

FOR A36 STEEL $F_y = 36,000$ PSI

FOR BELOW THE HOOK LIFTING FIXTURE $F_b = 1/3\ F_y$
$= 12,000$ PSI

S_x REQ'D $= 146756.4/12000$
$= 12.2\ IN^3 \quad < 112\ IN^3$ PROVIDED ok

COMPRESSION DUE TO 45° SLING ANGLE:

$$f_a = P_H/A = 4888/21.8$$
$$= 224\ \text{PSI}$$

COMBINED COMPRESSION & BENDING:

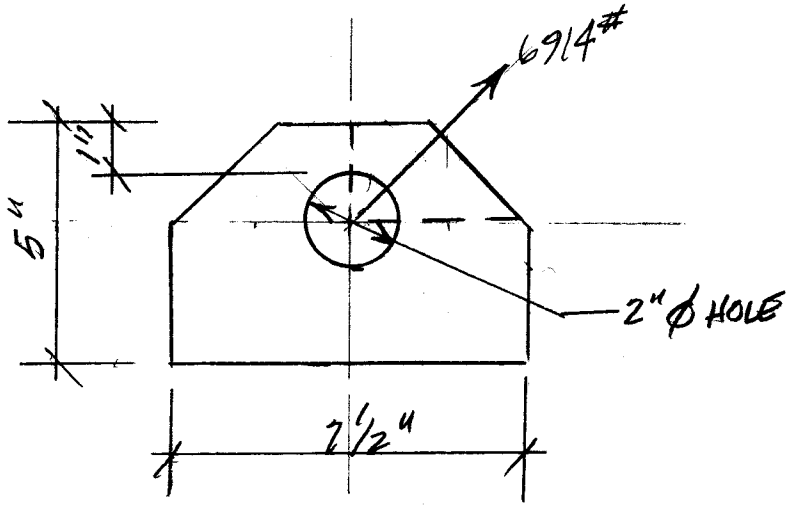
$$f_b/F_b + f_a/F_a \overset{?}{\leq} 1.0$$

$$f_b = 146756.4/112 = 1310\ \text{PSI}$$

$$1310/12000 + 224/12000 = 0.128 < 1.0 \quad \text{ok}$$

USE W14 X 74

LIFTING LUG:



BEARING LOAD:

$P = 4888 / 0.707$
$= 6914\#$

ASSUME 1" SHACKLE, $f_p = 6914 / 1.0(2.0")$
$= 3457$ PSI $< 12{,}000$ PSI
OK

TEAROUT SHEAR:

FOR 45° SLING ANGLE, TEAROUT @ 0° & 90°

AREA $= (1" \times 2") \times 2$ SIDES $= 4 IN^2$

ALLOW. LOAD $= 4(12{,}000) = 48{,}000\# > 6914\#$
OK

MAXIMUM WELD SIZE GOVERNED BY BEAM FLANGE THICKNESS $= 11/16 - 1/16 = 10/16"$

ALLOW. LOAD PER INCH OF WELD $= 0.3(70)(0.707)(10/16)$
$= 9.3\#/IN$

LENGTH OF WELD $= 7\frac{1}{2}"$/SIDE,
ASSUME 1ST & LAST $\frac{1}{2}"$ NOT EFFECTIVE $= 6\frac{1}{2}"$/SIDE
ALLOWABLE LOAD $= (6.5)(2)(9.3) = 121K > 4K$
OK

TENSION @ BASE OF ½ LUG = 4000 × 3"/7½" = 1600#

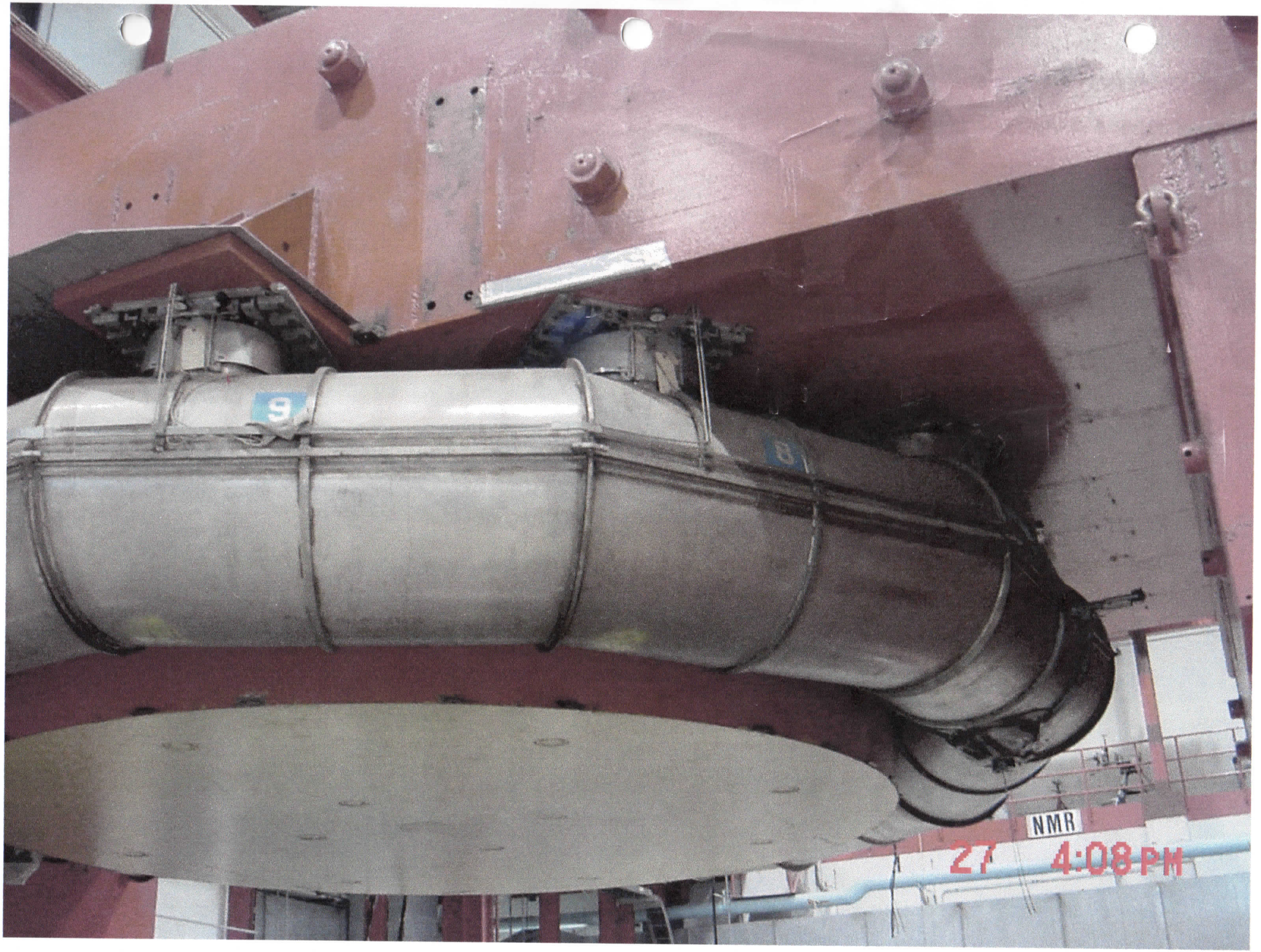
½ VERT LOAD = 2000#

3600#

ASSUME 1" OF WELD ON 2" EDGE IS EFFECTIVE; ALLOW LOAD = 1(9.3 K/in) = 9300#

> 3600# OK

LIFTING LUG IS OK

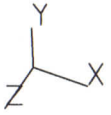

9
8
NMR
27 4:08PM

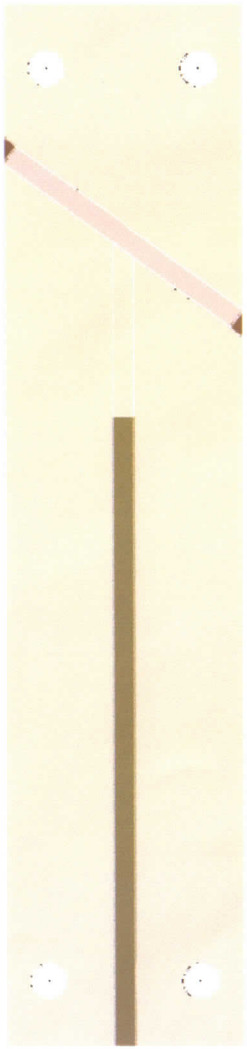

NMR
27 4:07 PM


27 4:06 PM


27 4:08 PM

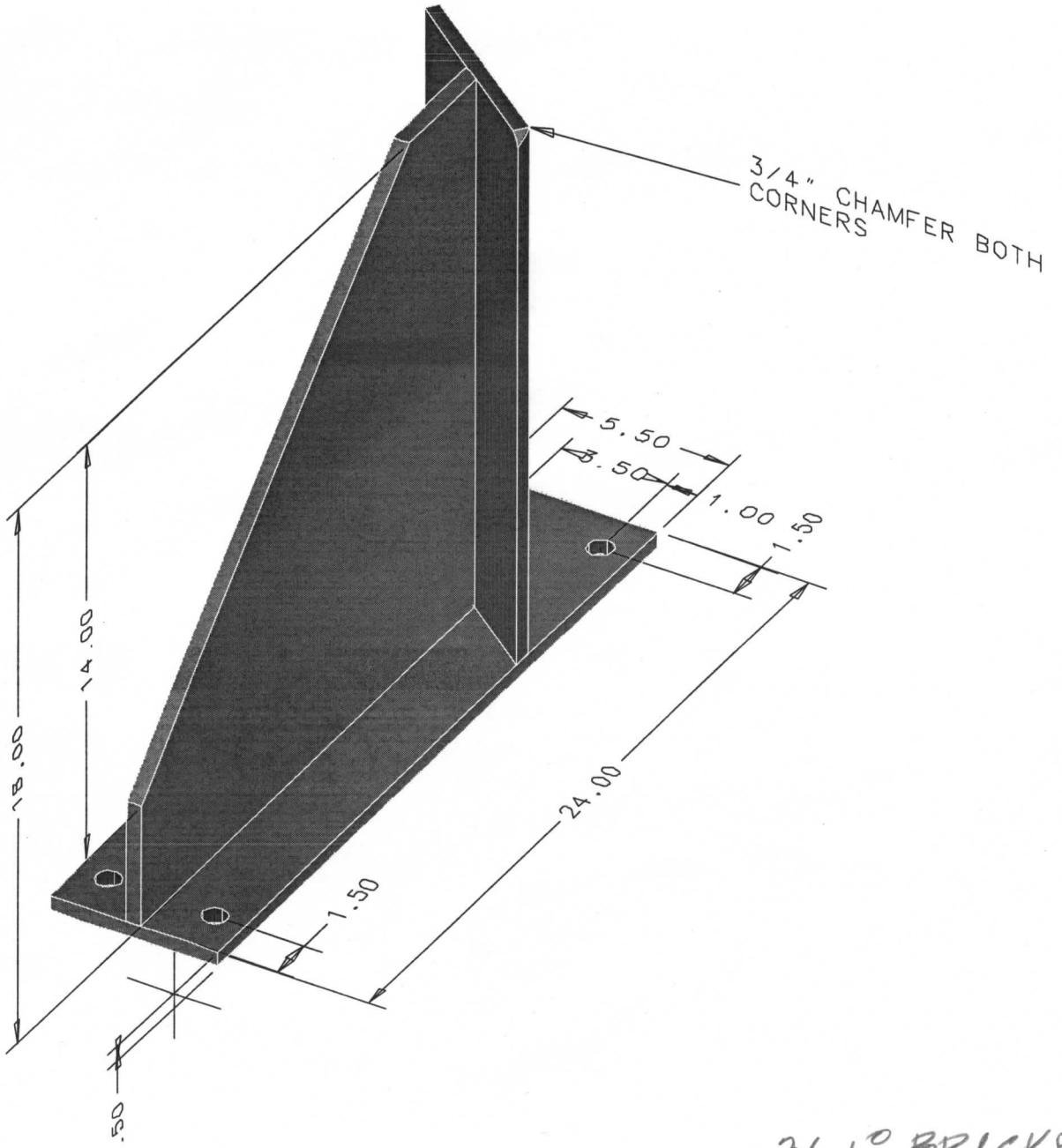
36.1° BRACKET





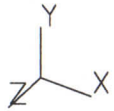
36.1° BRACKET

Y X
Z


3/4" CHAMFER BOTH CORNERS
5.50
3.50
1.00
1.50
14.00
18.00
24.00
1.50
.50
Y
X
Z

36.1° BRACKET

53.9° BRACKET



HAZARD ANALYSIS

Work Plan Title: _Lower CCM coil_____ Date: __4/27/06_____
Prepared By: ___Jim Kilmer_____
Reviewed By:(optional) _____
Approved By: _____
Supervisor/Task Manager

Description of work: This task is to lower the upper CCM coil from the top iron pieces. To do this job requires a special lifting fixture and special posts to support the pole pieces. The fixture is positioned correctly, raised to the coil and held by the cranes. Then the coil holding bars are removed and the coil is lowered until it rests on the lower magnet pole piece.

Personal Protective Equipment: (Check protective equipment required for the job.)

x Safety glasses □ Side shields
□ Chemical splash goggles
□ Hearing Protection
x Hard Hats
□ 3.0 Braising goggles
□ Impact goggles
□ Face shield
□ Rubber apron
x Leather gloves
□ Hot/Cold thermal protective gloves
□ Chemical resistant gloves (specify type):
□ Respirators
□ Other required PPE (specify):
□ Fall protection equipment (specify):

Equipment required for the job: (List the tools needed to perform the job.)
Both NML cranes, forklift with fork extensions, hand tools

Work Plan History Information: (List any lessons learned accidents from this job, tips from previous jobs)

In this task making sure that the coil load is maintained stable while on the fixture is very important.

HAZARD ANALYSIS

Step	Description	Hazards	Precautions / Safety Procedures
1	Install the coil fixture inside the magnet bore in the location indicated on the drawings.	Rigging heavy loads	Use trained operators. Use properly rated lifting equipment. Keep un-involved people out of the work area. Do not walk under the load. Watch for pinch points when handling the fixture.
2	Using a forklift with fork extensions place the posts inside the bore at the locations indicated on the drawing.	Forklift accidents	Use trained forklift operators. Be careful to keep the forklift back from the pit surrounding the magnet. Watch out for pinch points while setting the posts. Do not over exert when moving the posts around. Let the machine do the work.
3	Shim from the top of the posts to the bottom of the pole pieces.	Poor footing	Maintain a stable footing while doing this step. Use ladders properly or set up scaffolding as required.
4	Using the two building cranes raise the fixture until it contacts the bottom of the coil.	Lifting heavy loads	Communication between the two crane operators is critical. Have spotters looking at other parts of the area to look for interferences.
5	Remove the screws and clamp bars holding the coil to the upper magnet iron.	Back strains Slips and falls	Do not over-reach. Use proper wrenches. Do not over-exert on pulling the wrenches. Make sure footing is good before pulling on the wrenches. Watch out for over-reaching. Use ladders or scaffolding as required.
6	Lower the fixture and coil until the cross beams are sitting on the bottom pole piece.	Load falling	Make sure the coil is stable as the move is started. Communicate between crane operators so the fixture comes

			down evenly.
7			
8			
9			
10			

(Use additional pages as needed.)

My supervisor has reviewed this hazard analysis with me and I understand the hazards and required precautionary actions. I will follow the requirements of this hazard analysis or notify my supervisor if I am unable to do so. I understand that there are Environmental, Safety and Health Professionals on staff if I need further assistance or clarification.

Name (please print)	Signature	Date

The following drawings are part of Lifting Fixture 158 but are not available electronically.

9204.200-ME-435797

9204.200-ME-435799

9204.200-ME-435706

Please refer to Lifting Fixture Binder # 8 for copies of these drawings.