| Fermilab | Particle Physics Division<br>Mechanical Department |
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| Engineering note number: | MD – ENG – 03 - 006 | Date: | 12/18/2002 |
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| | |
|---|---|
| Experiment | **Site Support** |
| Project | Lab 5 Extrusion Line Feeder Support |
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| Reviewer(s) | Ang Lee (FNAL) Ang Lee 4/07/2003 |
| Abstract | Structural analysis of Lab 5 Extrusion Line Feeder Support. |

## Summary

# 1. Overview

Lab 5 Extrusion Line Feeder is supported and located by a structural aluminum frame. The frame main features are:

- Made out of aluminum to prevent rust or paint peel to get into the line.
- Can be disassembled and shipped to the extrusion line manufacturer for testing.
- It will be anchored to the floor.

This note addresses the structural analysis of this support.

# 2. Structural Analysis

The design criterium use in this note is:

- Minimum design factor of 3 over the operational load, based on yield strength .

## 2.1. Allowable Stresses

Hand Calculations:

*Stresses* - individual stress components should be in accordance with the Aluminum Association standard.
*Stability* - if compressive forces are present, they should be in accordance with the Aluminum Association standard.

Finite Element Analysis:

*Stresses*:

- Maximum peak Von Mises stresses (nodal averaging) < 1/3 of the Yield Strength.
- Maximum peak shear stresses (nodal averaging) < 1/6 of the Yield Strength.

This is very conservative, since localized stresses can be linearized and peak stresses maybe discarded. Nonetheless, it is safe.

*Stability* - if compressive forces are present:

- Buckling Load Factor (linear buckling) > 5 (see note below).

Published safety factors for buckling vary according to the application. A safety factor greater than 5 is comfortably above what is recommended by some very accepted references as, for instance, the ASME pressure vessel code (see sec. II, appendix 3, item 3-600 (c) (1), p.705). It addresses axial compression of thin cylinders which is experimentally known to be one of the cases that most diverges from buckling theories. Another example is the Aluminum Association standard (see tb. 3.3.3, p.17), which covers aluminum structures.

This note verifies the stresses in the most critical members and connections only. The minimum specified yield strength for the tubing is 25ksi and for the other parts is 35ksi.

Using 25 ksi for all parts:

- 1/3 of the Yield Strength = 8.3 ksi
- 1/6 of the Yield Strength = 4.1 ksi

## 2.2. F.E.A.

### 2.2.1. Model

The model has the ½-inch plates that connect the top of the frame to the legs created and meshed as solids. Everything else is modeled as shells.

### 2.2.2. Parameters Used

- Program: SDRC I-DEAS v. 8m4 / Simulation.
- Analysis: Linear Statics / Linear Buckling
- Material properties -

  All elements are aluminum:

  density = $2.53886 \times 10^{-4}$ lbf.sec$^2$/in$^4$

  $\eta$ = 0.3

  Modulus of elasticity = $1 \times 10^7$ psi
- Elements:

  Solids: solid parabolic tetrahedron with 1" average mesh size.

  Shells: parabolic quad shell with 1" average mesh size.

### 2.2.3. Boundary Conditions

The operational load is estimated to be:

- On top plate: 550 lb
- On shelf: 100 lb
- Lateral load: 10% of total load
- Weight of parts: 275 lb (own weight, generated by gravity)

The total vertical reaction is 925 lb and the reaction from the lateral load is 100 lb.

### 2.2.4. Results

The maximum Von Mises and Shear stress (ksi), the overall deflections (in) and the buckling load factor are indicated in the table bellow.

| Linear Analysis Type | Boundary Conditions Set | Load Set | Restraint Set | Maximum Von Mises Peak Stress (ksi) | Maximum Shear Peak Stresses (ksi) | Maximum Deflection (in) |
|---|---|---|---|---|---|---|
| Static | 4 | 3 | 2 | 4.70 | 2.41 | 0.298 |
| Buckling | 5 | 3 | 2 | BLF = 36.0 | | |

As can be seen on the plots attached, only a few spots of the structure reach stresses above 1 ksi, which indicates concentration of stresses in those spots.

- Maximum peak Von Mises stresses < 8.3 ksi
- Maximum peak shear stresses < 4.1 ksi
- Buckling Load Factor > 5

Hence, the structure is *OK*.

In addition to that, analyzing the channels for local buckling:

$r_y$ = 0.54″ (from 6 x 2.83 lb/ft channel properties) and
$L_b$ = 36.8″ (length of beam between points at which the compression flange is supported against lateral movement).

So: $L_b / r_y = 68.1$ and
$Fn = 23.9-[0.124 \times (L_b / r_y)] = 15.4$ ksi.

From AA #30, 5th ed., 1986, Tb. 3.3.27, Spec 11 specifies a maximum allowable of 15.4 ksi if $L_b / r_y < 79$ or 12 ksi within 1 inch of a weld if $L_b / r_y < 85$ .

In either case, the maximum compressive stress in the whole structure in the direction of the channel length is 4.44 ksi.

## 2.3. Analysis Of Connections

### 2.3.1 Welded Connections

From the Aluminum Association standard, Tb. 3.3.2, p.16, min. shear is 6.50 ksi. Thus it is conservative to assume:

- $F_{allowable} = 6.5$ ksi.

It should be noted that, in hand calculations, shear is not combined with normal stresses in bending of *members* because these two kinds of stresses are present in different parts of the members [1]. However, in *welds* under off-plane bending, both kinds of stresses may be present in the same region. So, they should be vectorially added.

The method used for calculation of stresses in welds in this note is the elastic vector analysis. Only the most critical joint was analyzed.

The stresses are less than 1/3 of the allowable stress of 6.5 ksi.

All welds were sized to be equal or larger than the minimum size from AWS, considering the parts to be joined.

### 2.3.1 Bolted Connections

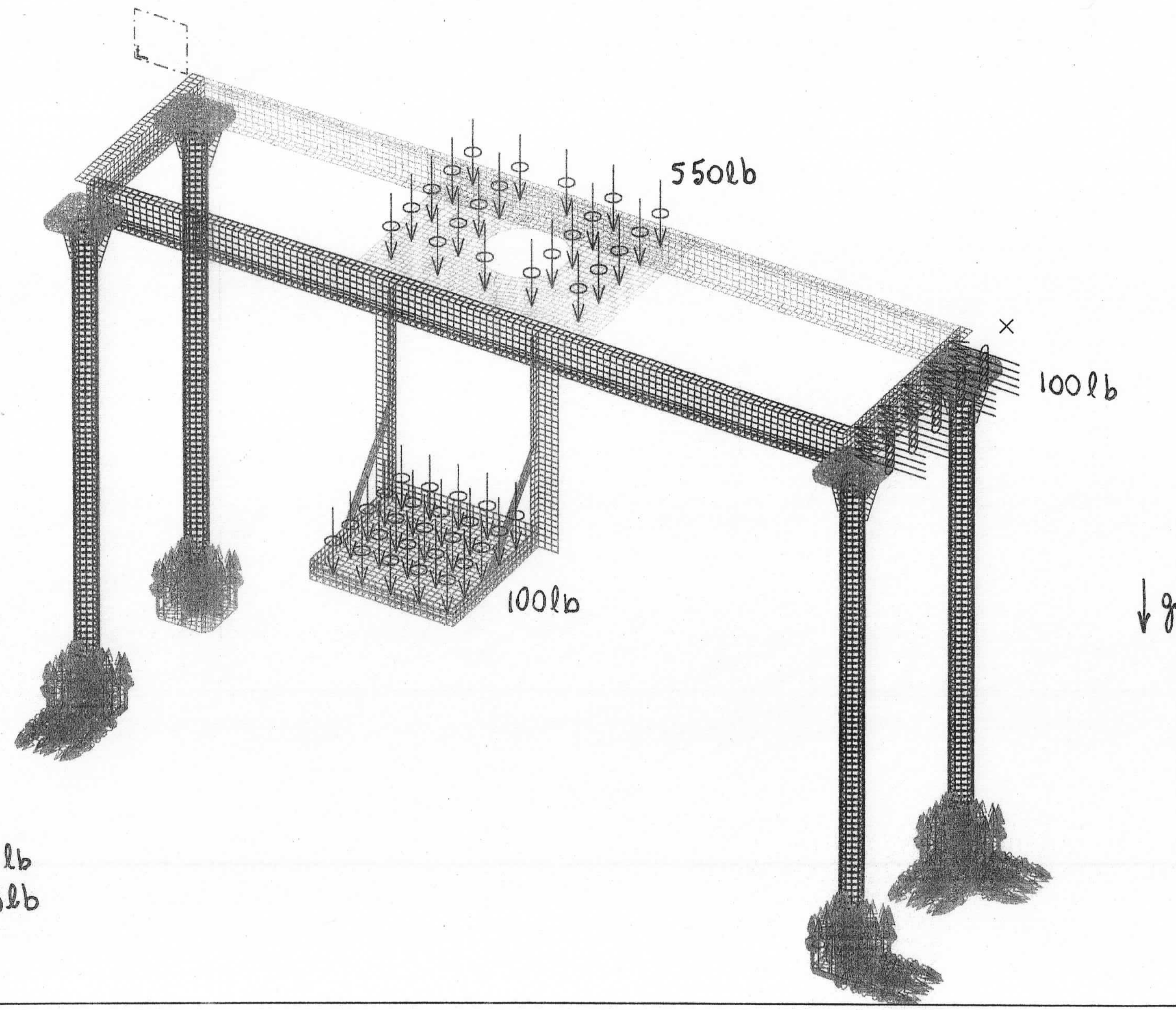
There are 3 bolted connections. One is between the tops and the legs. Another is between the legs and the floor, through anchor-bolts. The third one is between the shelf and the top of the frame. The analysis of the top and shelf joints were done with calculations based on "Steel Structures: Design and Behavior", Salmon and Johnson, Harper Collins, 3rd ed., 1990, chap 4.15, Shear and Tension From Eccentric Loading, p. 183-190.

They are also in accordance with AISC/ASD, 9th ed., Chapter J, except that the material of the screws (stainless steel) is not listed by the code. For the approved carbon steels, standard size holes, in slip-critical connections, the AISC/ASD code specifies a minimum allowable of .33 of tensile strength in tension and .14 of tensile strength in shear. These factors were applied to the material of the screws.

The anchor bolts were analyzed according to the criterium laid out in the manufacturer's catalog, Hilti.

The calculations show that both joints are loaded below their allowed safe loads.

[1]See Roark and Young, Formulas for Stress and Strain, 6th ed., p.97 and Shigley and Mischke, Mechanical Engineering Design, 5th ed., p.51.



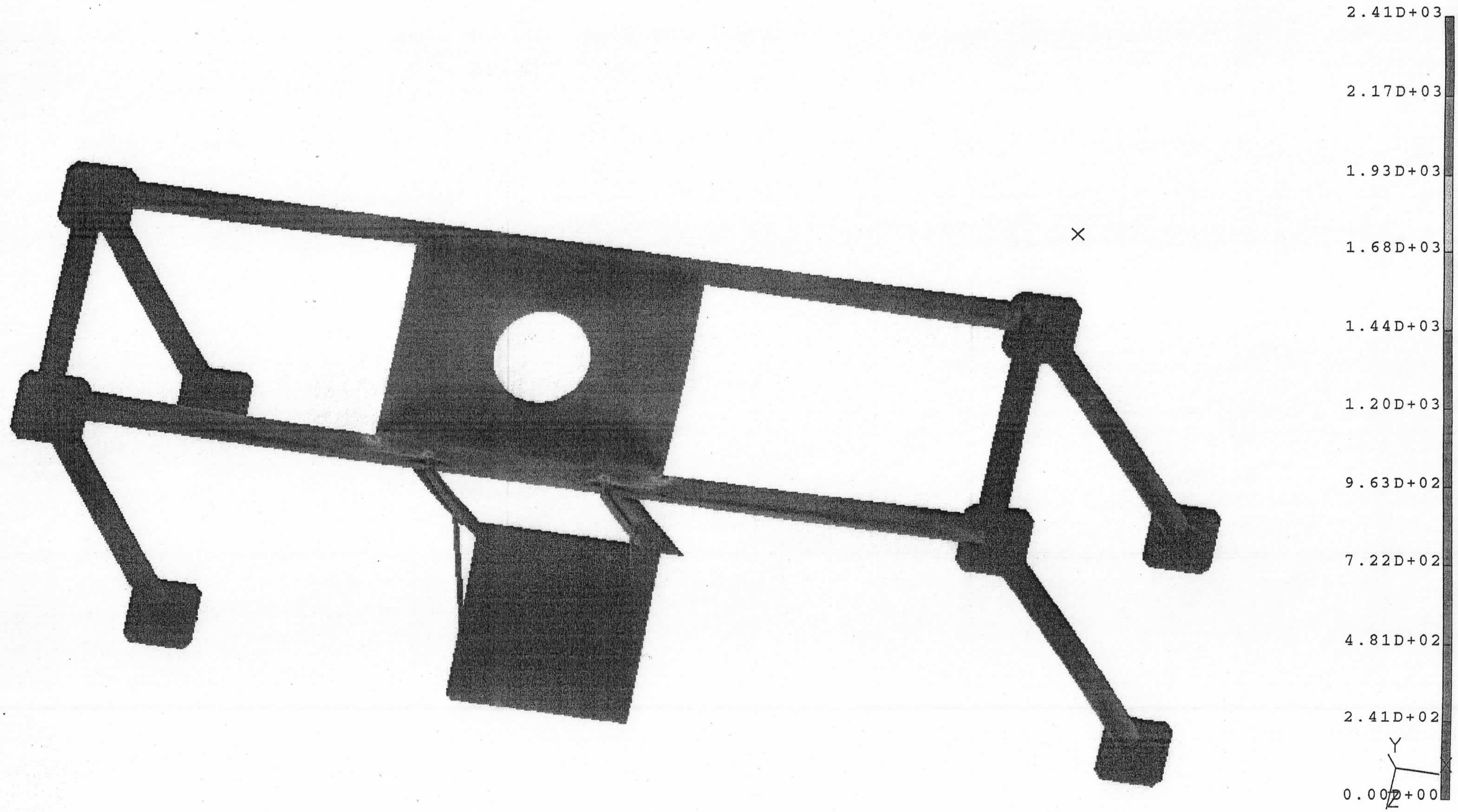

TOTAL REACTIONS: X = 100 lb
Y = 925 lb
Z = ∅

Plotted by rafael on 18-Dec-02 , File: L5FS_mesh.pff

/cadwhs/server03/ms_rafael/Lab5_platform_FEA.mf1

RESULTS: 28- B.C. 4,STRESS_28,LOAD SET 3
STRESS - MAX SHEAR MIN: 0.00E+00 MAX: 2.41E+03
DEFORMATION: 26- B.C. 4,DISPLACEMENT_26,LOAD SET 3
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 2.98E-01
FRAME OF REF: PART

VALUE OPTION:ACTUAL
SHELL SURFACE: TOP




Plotted by rafael on 19-Dec-02 , File: L5FS_A_MS.pff

/cadwhs/server03/ms_rafael/Lab5_platform_FEA.mf1

RESULTS: 28- B.C. 4,STRESS_28,LOAD SET 3
STRESS - VON MISES MIN: 0.00E+00 MAX: 4.70E+03
DEFORMATION: 26- B.C. 4,DISPLACEMENT_26,LOAD SET 3
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 2.98E-01
FRAME OF REF: PART

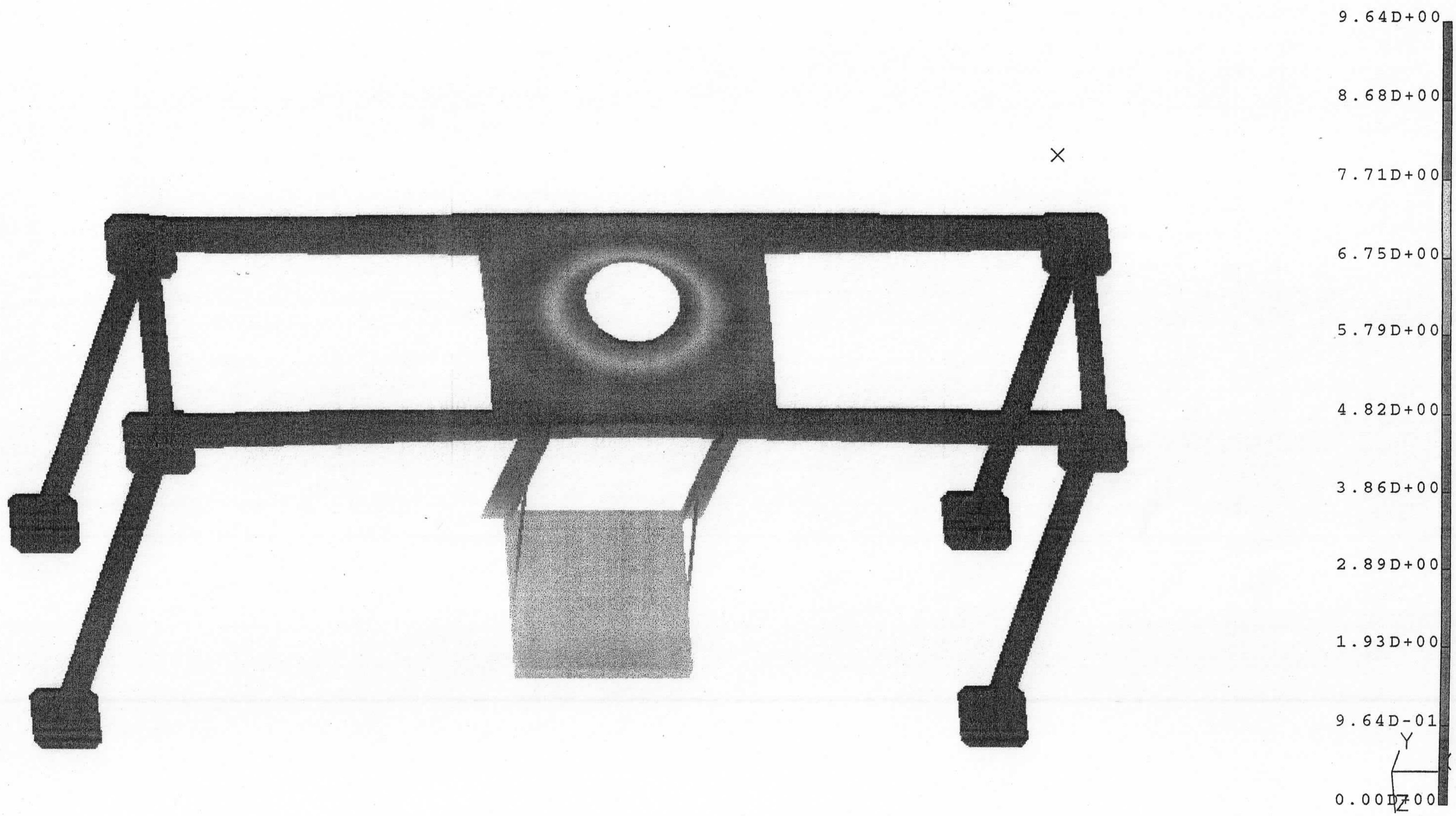
VALUE OPTION:ACTUAL
SHELL SURFACE: TOP


Plotted by rafael on 19-Dec-02 , File: L5FS_A_VM.pff

/cadwhs/server03/ms_rafael/Lab5_platform_FEA.mf1

RESULTS: 31- B.C. 5,NORMAL_MODE 1,DISPLACEMENT_31
MODE: 1 BUCKLING LOAD FACTOR: 35.96753
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 9.64E+00
DEFORMATION: 31- B.C. 5,NORMAL_MODE 1,DISPLACEMENT_31
MODE: 1 BUCKLING LOAD FACTOR: 35.96753
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 9.64E+00
FRAME OF REF: PART

VALUE OPTION:ACTUAL




Plotted by rafael on 19-Dec-02 , File: L5FS_A_BUCK.pff

/cadwhs/server03/ms_rafael/Lab5_platform_FEA.mf1

RESULTS: 28- B.C. 4,STRESS_28,LOAD SET 3
STRESS - X MIN:-4.44E+03 MAX: 3.19E+03
DEFORMATION: 26- B.C. 4,DISPLACEMENT_26,LOAD SET 3
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 2.98E-01
FRAME OF REF: PART

VALUE OPTION:ACTUAL
SHELL SURFACE: TOP


Plotted by rafael on 12-Mar-03 , File: lab5_X.pff

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Tubular Welded Joint with Residual Stresses | Units | Comment | Value |
| 2 | Weld size | - | - | 3/16 |
| 3 | Weld type | - | - | Fillet |
| 4 | **Base metals yield strength** | **Fy (ksi)** | Minimum, 6063-T6 | **25.00** |
| 5 | Alowable Stess | (ksi) | TB. 3.3.2, p.16, min. shear | 6.50 |
| 6 | Depth or leg | (in) | From geometry | 0.19 |
| 7 | Eff. throat | (in) | (leg) ^ (1/2) | 0.13 |
| 8 | Length | (in) | From geometry | 11.00 |
| 9 | **Rw** | **(kips/in)** | Eff. throat x Allowable stress | **0.86** |
| 10 | Ix | ($in^4$/in) | Ixcg from I-DEAS | 37.60 |
| 11 | Iz | ($in^4$/in) | Izcg from I-DEAS | 37.60 |
| 12 | Ip | ($in^4$/in) | Ipolar = Ixcg + Izcg | 75.20 |
| 13 | xcg | (in) | From geometry | 1.75 |
| 14 | zcg | (in) | From geometry | 1.75 |
| 15 | Sx | ($in^3$/in) | Ix / ycg | 21.49 |
| 16 | Sz | ($in^3$/in) | Iz / xcg | 21.49 |
| 17 | Jx | ($in^3$/in) | Ip / ycg | 42.97 |
| 18 | Jz | ($in^3$/in) | Ip / xcg | 42.97 |
| 19 | Lx | (kips) | Load in x (lateral load / 2) | 0.05 |
| 20 | Ly | (kips) | Load in y (weight / 2) | 0.47 |
| 21 | Lz | (kips) | Load in z | 0.00 |
| 22 | ax | (in) | X lever arm | 80.00 |
| 23 | ay | (in) | Y lever arm | 0.00 |
| 24 | az | (in) | Z lever arm | 80.00 |
| 25 | Mx | (kips-in) | Lx * ax | 4.000 |
| 26 | My | (kips-in) | Ly * ay | 0.000 |
| 27 | Mz | (kips-in) | Lz * az | 0.000 |
| 28 | sx | (kips/in) | Lx / Length | 0.005 |
| 29 | sy | (kips/in) | Ly / Length | 0.042 |
| 30 | sz | (kips/in) | Lz / Length | 0.000 |
| 31 | Ryx | (kips/in) | Mx / Sx | 0.186 |
| 32 | Ryz | (kips/in) | Mz / Sz | 0.000 |
| 33 | Rx | (kips/in) | My / Jx | 0.000 |
| 34 | Rz | (kips/in) | My / Jz | 0.000 |
| 35 | Fx (total) | (kips/in) | sx + Rx | 0.005 |
| 36 | Fy (total) | (kips/in) | sy + Ryx + Ryz | 0.228 |
| 37 | Fz (total) | (kips/in) | sz + Rz | 0.000 |
| 38 | **Vector Sum** | **(kips/in)** | { [ (Fx) ^ 2 ] + [ (Fy) ^ 2 ] + [ (Fz) ^ 2 ] } ^ (1/2) | **0.23** |
| 39 | ***Vector Sum / Rw*** | - | - | **0.27** |
| 40 | ***Base metal yield strength / Vector Sum*** | - | - | **14.51** |

## Bolted Joint

File: bolted_joint.mcd

Bolted joints of Lab 5 Feeder Support.

Calculations based on Steel Structures: Design and Behavior, Salmon and Johnson, Harper Collins, 3rd ed., 1990, and in accordance with AISC/ASD, Chapter J (*).

Chap 4.15, Shear and Tension From Eccentric Loading, p. 183-190.

- Slip-critical Connection;
- Size of holes: standard, 9/16";
- Threads not excluded from shear planes;
- Bolt specification: 18-8 S.S. 1/2"-13 UNRC x 2" long, socket head cap screw.

From Foremost catalog (minimum values):

Ultimate Strength (ksi): $F_u := 75$

Yield Strength (ksi): $F_y := 30$

(*) For the approved carbon steels, standard size holes, in slip-critical connections, the AISC/ASD code specifies a minimum allowable of .33 of tensile strength in tension and .14 of tensile strength in shear. Applying these factors to 18-8 s.s., gives:

Allowable in tensile: $F_t := .33 \cdot F_u$ $F_t = 24.8$

Allowable in shear: $F_v := .14 \cdot F_u$ $F_v = 10.5$

Screw diameter (in): $d := \frac{1}{2}$

Screw area ($in^2$): $A_b := \frac{\pi}{4} \cdot d^2$ $A_b = 0.2$

**Allowable shear load (kips):** $R_v := F_v \cdot A_b$ $R_v = 2.1$

**Allowable tensile load (kips):** $R_t := F_t \cdot A_b$ $R_t = 4.9$

Loads (kips):

Lateral load /2: $P_x := .05$

Weight / 2: $P_y := \frac{.463}{4}$

Lateral load in z: $P_z := 0$

Lever arm, from geometry (in):

$l_x := 80$

Number of screws: $m := 4$

**Tension (in X) from off plane bending around Y:**

Bending moment (in-kips): $M_y := P_z \cdot l_x$ $M_y = 0.0$

**Tension (in X) from off plane bending around Z:**

Bending moment (in-kips): $M_z := P_y \cdot l_x$ $M_z = 9.3$

Calculation of Σy2: $\Sigma y2 := 2 \cdot 4.24^2$ $\Sigma y2 = 36.0$

$y_{max} := 4.24$

Max. tension on bolt (kips): $T_{x2} := \frac{M_z \cdot y_{max}}{\Sigma y2}$ $T_{x2} = 1.09$

**Maximum tensile load (in X):**

Total tensile load (kips): $T_t := T_{x2} + \frac{P_x}{m}$ $T_t = 1.10$

$R_t$ (4.9) > $T_t$ (1.1) ⇒ *OK*.

**Direct Y shear:**

Shear (kips): $V_y := \frac{P_y}{m}$ $V_y = 0.03$

**Direct Z shear:**

Shear (kips): $V_z := \frac{P_z}{m}$ $V_z = 0.00$

**Total Shear load:**

Total shear load (kips): $V_t := \sqrt{V_y^2 + V_z^2}$ $V_t = 0.03$

$R_v$ (2.1) > $V_t$ (0.03) ⇒ *OK*.

**Combined Tension and Shear in Slip-critical Joints:**

Minimum pre-tension, tb. J3.7, p.5-77 (kips): $T_b := .7 \cdot F_u \cdot A_b$ $T_b = 10.3$

Maximum tensile stress (ksi): $f_t := \frac{T_t}{A_b}$ $f_t = 5.6$

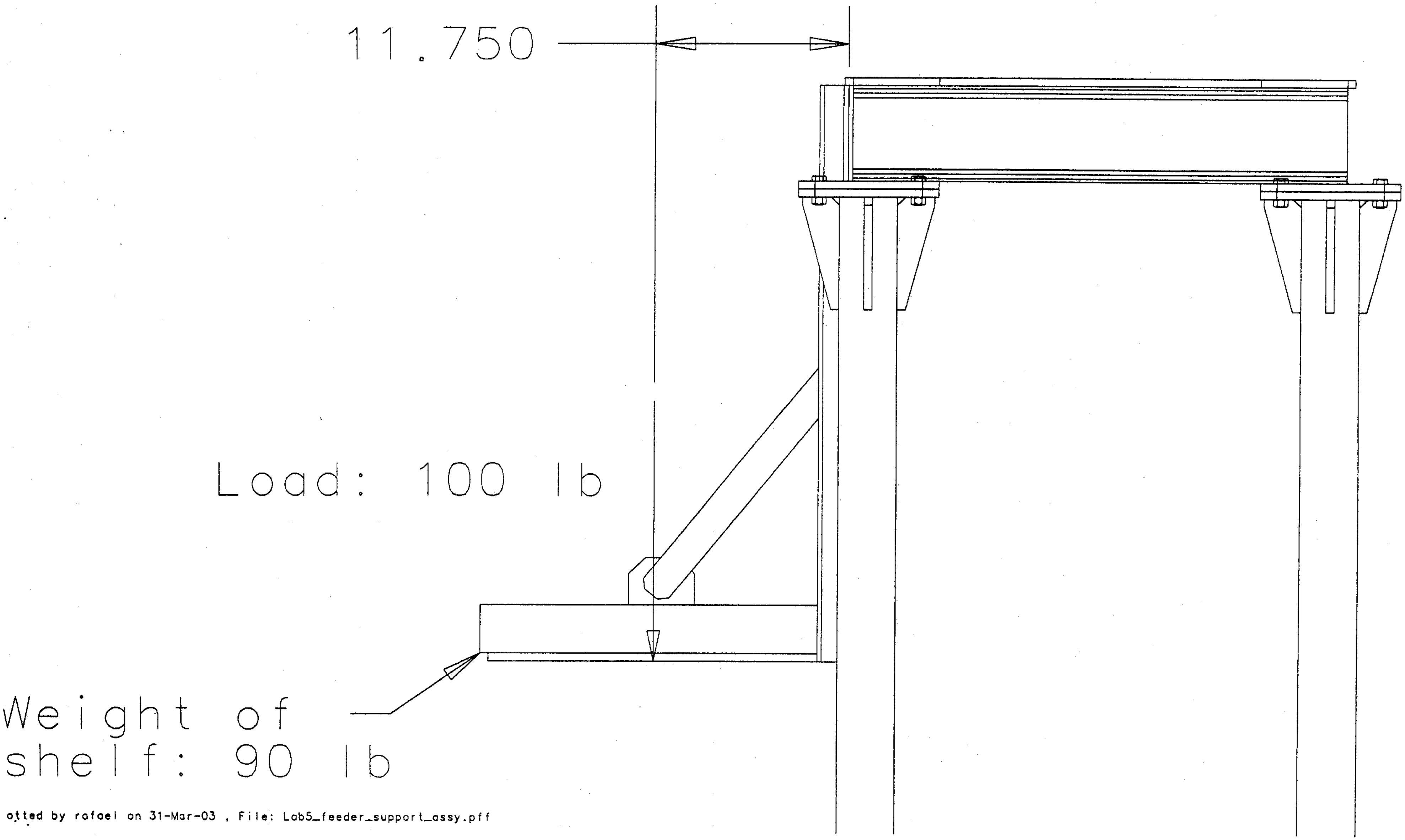
Allowable shear (J.6, p. 5-74): $f_v := F_v \cdot \left(1 - f_t \cdot \frac{A_b}{T_b}\right)$ $f_v = 9.4$

Allowable shear load (kips): $R_{v'} := f_v \cdot A_b$ $R_{v'} = 1.8$

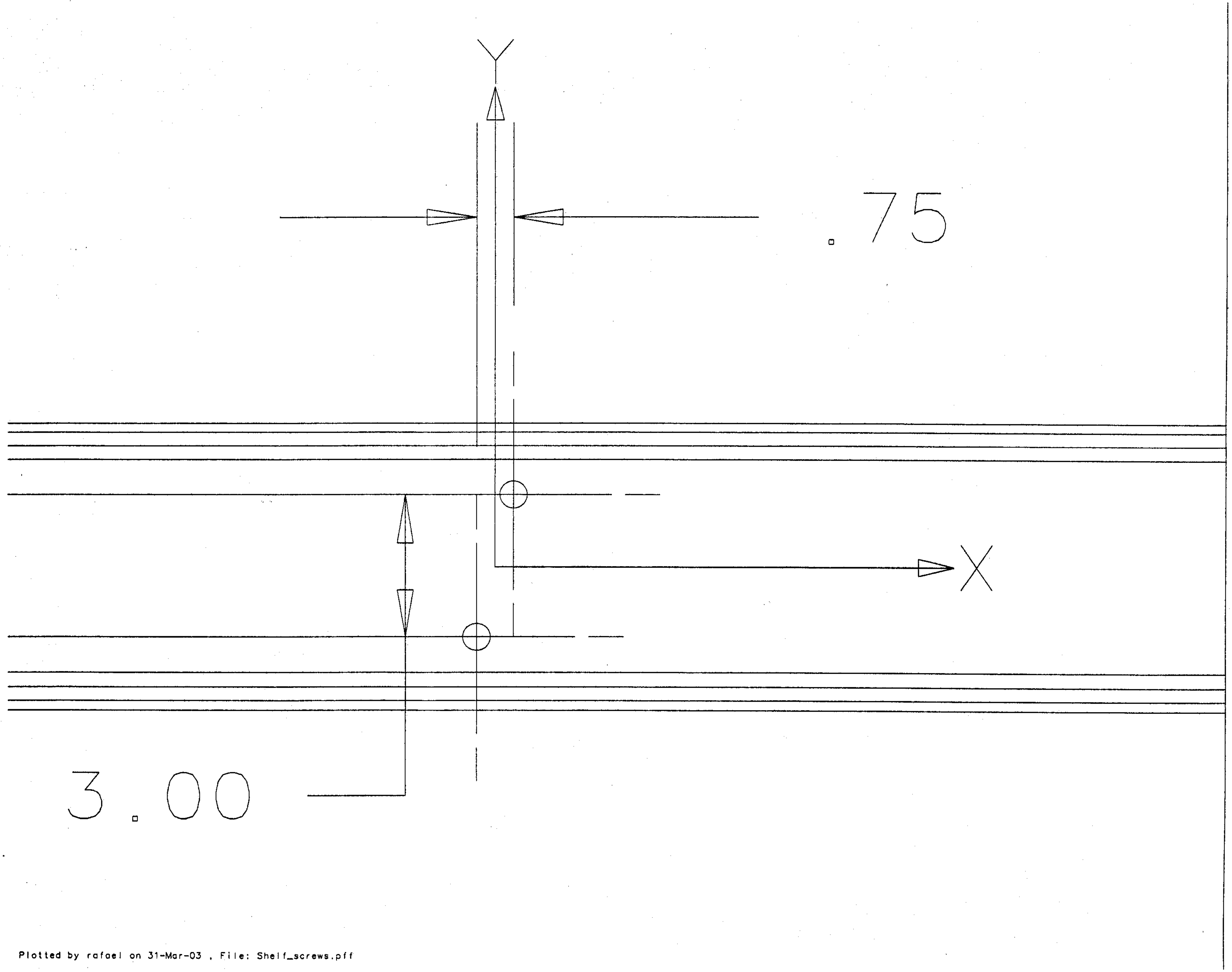
$\mathbf{R_{v'}}$ (1.8) > $\mathbf{V_t}$ (0.03) ⇒ ***OK***.

**Conclusion:**

**$R_t$ (4.9) > $T_t$ (1.1), $R_v$ (2.1) > $V_t$ (0.03) and $R_{v'}$ (1.8) > $V_t$ (0.03) ⇒ bolts are *OK*.**




otted by rafael on 31-Mar-03 , File: Lab5_feeder_support_assy.pff




Plotted by rafael on 31-Mar-03 , File: Shelf_screws.pff

# Lab 5 Shelf Bolted Joint

File: Shelf_screws.mcd

Calculations based on Steel Structures: Design and Behavior, Salmon and Johnson, Harper Collins, 3rd ed., 1990, and in accordance with AISC/ASD, Chapter J (*).

Chap 4.15, Shear and Tension From Eccentric Loading, p. 183-190.

- Slip-critical Connection;
- Size of holes: standard, 9/16";
- Threads not excluded from shear planes;
- Bolt specification: 1/2"-13 UNRC x 1" long, s.s., hex head cap screw.

Ultimate Strength (ksi): $F_u := 80$

Yield Strength (ksi): $F_y := 40$

(*) For the approved carbon steels, standard size holes, in slip-critical connections, the AISC/ASD code specifies a minimum allowable of .33 of tensile strength in tension and .14 of tensile strength in shear. Applying these factors to stainless steel gives:

Allowable in tensile: $F_t := .33 \cdot F_u$ $F_t = 26.4$

Allowable in shear: $F_v := .14 \cdot F_u$ $F_v = 11.2$

Screw diameter (in): $d := \frac{1}{2}$

Screw area (in$^2$): $A_b := \frac{\pi}{4} \cdot d^2$ $A_b = 0.2$

**Allowable shear load (kips):** $R_v := F_v \cdot A_b$ $R_v = 2.2$

**Allowable tensile load (kips):** $R_t := F_t \cdot A_b$ $R_t = 5.2$

Loads (kips):

$P_x := 0$

$P_y := .190$

$P_z := 0$

Lever arm, from geometry (in):

$l_z := 11.75$

Number of screws: $m := 2$

**Tension (in Z) from off plane bending around X:**

Bending moment (in-kips): $M_x := P_y \cdot l_z$ $M_x = 2.2$

Calculation of $\Sigma y2$: $\Sigma y2 := 2 \cdot (1.5)^2$ $\Sigma y2 = 4.5$

$y_{max} := 1.5$

Max. tension on bolt (kips): $T_z := \frac{M_x \cdot y_{max}}{\Sigma y2}$ $T_z = 0.7$

**$R_t$ (5.2) > Tz (0.7)** $\Rightarrow$ ***OK*.**

**Direct Y shear:**

Shear (kips): $V_y := \frac{P_y}{m}$ $V_y = 0.1$

**$R_v$ (2.2) > Vy (0.1)** $\Rightarrow$ ***OK*.**

**Combined Tension and Shear in Slip-critical Joints:**

Minimum pre-tension, tb. J3.7, p.5-77 (kips): $T_b := .7 \cdot F_u \cdot A_b$ $T_b = 11.0$

Maximum tensile stress (ksi): $f_t := \frac{T_z}{A_b}$ $f_t = 3.8$

Allowable shear (J.6, p. 5-74): $f_v := F_v \cdot \left(1 - f_t \cdot \frac{A_b}{T_b}\right)$ $f_v = 10.4$

Allowable shear load (kips): $R_{v'} := f_v \cdot A_b$ $R_{v'} = 2.1$

**$R_{v'}$ (2.1) > Vy (0.1)** $\Rightarrow$ ***OK*.**

**Conclusion:**

**$R_t$ (5.2) > $T_z$ (0.7), $R_v$ (2.2) > $V_y$ (0.1) and $R_{v'}$ (2.1) > $V_y$ (0.1)** $\Rightarrow$ **bolts are *OK*.**

# Torque - Shelf

File: Torque_shelf.mcd

Torque Required

The calculations are based on the methodology presented by Shigley & Mischke, Chapter 8.
For permanent connections, the pre-load is based on ASD recommendations (Table 4, p.5-274) of tension required of 70% of tensile strength plus 5% for torque wrenches (total of 78.5%).
For reusable connections, the pre-load is based on Shigley & Mischke, Chapter 8, p. 349, equations 8-25 or 8-26, representing 75% of the proof load or, in the abscence of that, 85% of the yield strength.

Type of connection assumed in this case: **Permanent.**

| | | |
|---|---|---|
| Bolt **Tensile**/Proof/Yield Stress (ksi): | $Fa := 80$ | |
| Req. Bolt Tension, **ASD**/Shigley (ksi): | $Rb := .785 \cdot Fa$ | $Rb = 62.8$ |
| Torque Factor, (Zn=.2,Blk=.3), p.347: | $K := .2$ | |
| Major Screw Diameter (in): | $d := \frac{1}{2}$ | |
| Pitch (threads/in): | $n := 10$ | |
| Grip Threaded Length (in): | $lt := 1$ | |
| Grip Unthreaded Length (in): | $ld := 0$ | |
| Bolt Elastic Modulus (ksi): | $Eb := 29000$ | |
| External Tensile Load (kips): | $P := 0.7$ | |
| Threaded Member Elastic Modulus (ksi): | $Et := 29000$ | |
| Threaded Member Thickness (in): | $tt := .448$ | |
| Unthreaded Member Elastic Modulus (ksi): | $Eu := 10000$ | |
| Unthreaded Member Thickness (in): | $tu := .45$ | |
| Washer Diameter [D≅1.5xd] (in): | $D := 1.25$ | |
| Half-Apex Angle (°): | $a := 30$ | |

$\alpha := \frac{\pi}{180} \cdot a$ $\quad \alpha = 0.52$ $\qquad Ad := \frac{\pi}{4} \cdot d^2$ $\quad Ad = 0.20$

$At := .7854 \cdot \left( d - \frac{.9743}{n} \right)^2$ $\quad At = 0.127$ $\qquad kb := \frac{Ad \cdot At \cdot Eb}{Ad \cdot lt + At \cdot ld}$ $\quad kb = 3.69 \times 10^3$

$$kt := \frac{\pi \cdot Et \cdot d \cdot \tan(\alpha)}{\ln\left[\left[\frac{(2 \cdot tt \cdot \tan(\alpha) + D - d) \cdot (D + d)}{(2 \cdot tt \cdot \tan(\alpha) + D + d) \cdot (D - d)}\right]\right]} \qquad ku := \frac{\pi \cdot Eu \cdot d \cdot \tan(\alpha)}{\ln\left[\left[\frac{(2 \cdot tu \cdot \tan(\alpha) + D - d) \cdot (D + d)}{(2 \cdot tu \cdot \tan(\alpha) + D + d) \cdot (D - d)}\right]\right]}$$

$kt = 99021.85$ $\qquad ku = 34042.60$

$KM := \frac{1}{\frac{1}{kt} + \frac{1}{ku}}$ $\quad KM = 2.53 \times 10^4$ $\qquad C := \frac{kb}{kb + KM}$ $\quad C = 0.13$

| | | |
|---|---|---|
| Total Bolt Load from Req. Bolt Tension (kips): | $Fb := Rb \cdot At$ | $Fb = 8.0$ |
| Preload - Clamping Force (kips): | $Fi := Fb - C \cdot P$ | $Fi = 7.9$ |
| Torque Required (ft-lb): | $T := \frac{K \cdot Fi \cdot 1000 \cdot d}{12}$ | $T = 66$ |

I-DEAS 9 m3: Simulation 20-Mar-03 15:07:08
/cadwhs/server03/ms_rafael/lab5.mf1
Lab 5 platform - Reactions on anchors

Group ID : None
Result Set : 38 - B.C. 6,REACTION FORCE_38,LOAD SET 3
Report Type : Contour Units : IN
Result Type : REACTION FORCE
Frame of Reference: Part Data Component: Magnitude

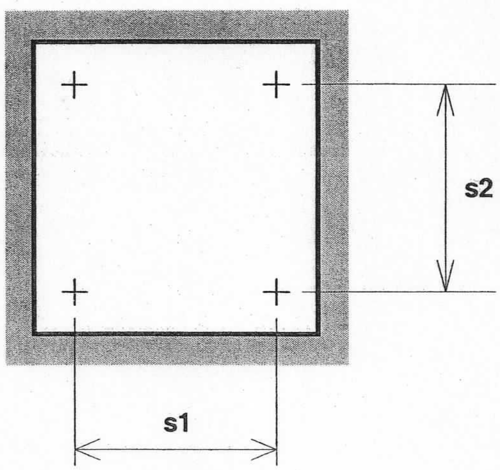
| Node | Reacti-X | Reacti-Y | Reacti-Z | Reacti-RX | Reacti-RY | Reacti-RZ |
|---|---|---|---|---|---|---|
| 16974 | 1.003E+01 | -3.799E+01 | 1.316E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 16990 | 1.194E+01 | 1.464E+02 | -5.690E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17006 | 1.297E+01 | 1.329E+02 | 3.683E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17022 | 9.545E+00 | -5.146E+01 | -2.796E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17070 | 3.891E+00 | 3.339E+00 | -3.899E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17086 | 5.437E+00 | 7.834E+01 | 2.006E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17102 | -1.059E+00 | 7.228E+01 | 4.126E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17118 | -2.780E+00 | -2.715E+00 | -2.913E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17166 | -7.070E+00 | 5.139E+01 | -2.744E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17182 | -2.751E+00 | 8.700E+01 | -3.826E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17198 | 2.726E+00 | 8.500E+01 | -1.277E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17214 | -1.414E+00 | 4.939E+01 | 5.845E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17262 | 1.329E+01 | -3.673E+01 | 3.323E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17278 | 1.543E+01 | 1.873E+02 | -5.936E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17294 | 1.824E+01 | 1.924E+02 | 7.138E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 17310 | 1.157E+01 | -3.162E+01 | -1.071E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Total | 1.000E+02 | 9.252E+02 | -4.768E-07 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| | 17294 | 17294 | 17294 | 16974 | 16974 | 16974 |
| Maximum | 1.824E+01 | 1.924E+02 | 7.138E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| | 17166 | 17022 | 17278 | 16974 | 16974 | 16974 |
| Minimum | -7.070E+00 | -5.146E+01 | -5.936E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Average | 6.250E+00 | 5.783E+01 | -2.980E-08 | 0.000E+00 | 0.000E+00 | 0.000E+00 |

MAXIMUM TENSION ON ANCHORS: 51.5 lb $\ll$ 1,690 lb
" SHEAR: $\sqrt{(18.2)^2+(7.1)^2} = 19.5$ lb $\ll$ 1,560 lb

# Anchor fastening design for HDI-1/2

**As per Hilti USA method**

## Positioning

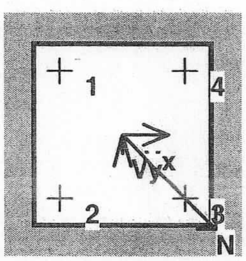



### Anchoring plate:

lx=8.50 in ly=8.50 in
s1=6.00 in s2=6.00 in

+ Anchor
○ Anchor in slotted hole

## Loads




### Tensile Load:

N=206 Lbf

### Shear Load:

Vx=73 Lbf Vy=29 Lbf

## Concrete

Compressive strength: 4000 PSI
Thickness of base material: 8.00 in

## Results for USA

With the Tabs you can select the particular Results or Messages (Errors and Warnings)


| Symbol | Meaning |
|---|---|
| N | Actual tension load |
| $V_x$ | Actual shear load on x-axis |
| $V_y$ | Actual shear load on y-axis |
| $V_{res}$ | Resulting shear load |
| Res | Resulting combined load |
| $\alpha$ | Angle of the combined load |
| $f_{RN}$ | Edge distance adjustment factor for tension |
| $f_{RV}$ | Edge distance adjustment factor for shear |
| $f_{AN}$ | Spacing adjustment factor for tension |
| $f_{AV}$ | Spacing adjustment factor for shear |
| $I_N$ | Actual tensile load / recommended tensile load |
| $I_V$ | Actual shear load / recommended shear load |
| $I_{Res}$ | $(I_N)_N + (I_V)_N$ |
| $h_{act}$ | Actual embedment depth |

# Results for HDI-1/2

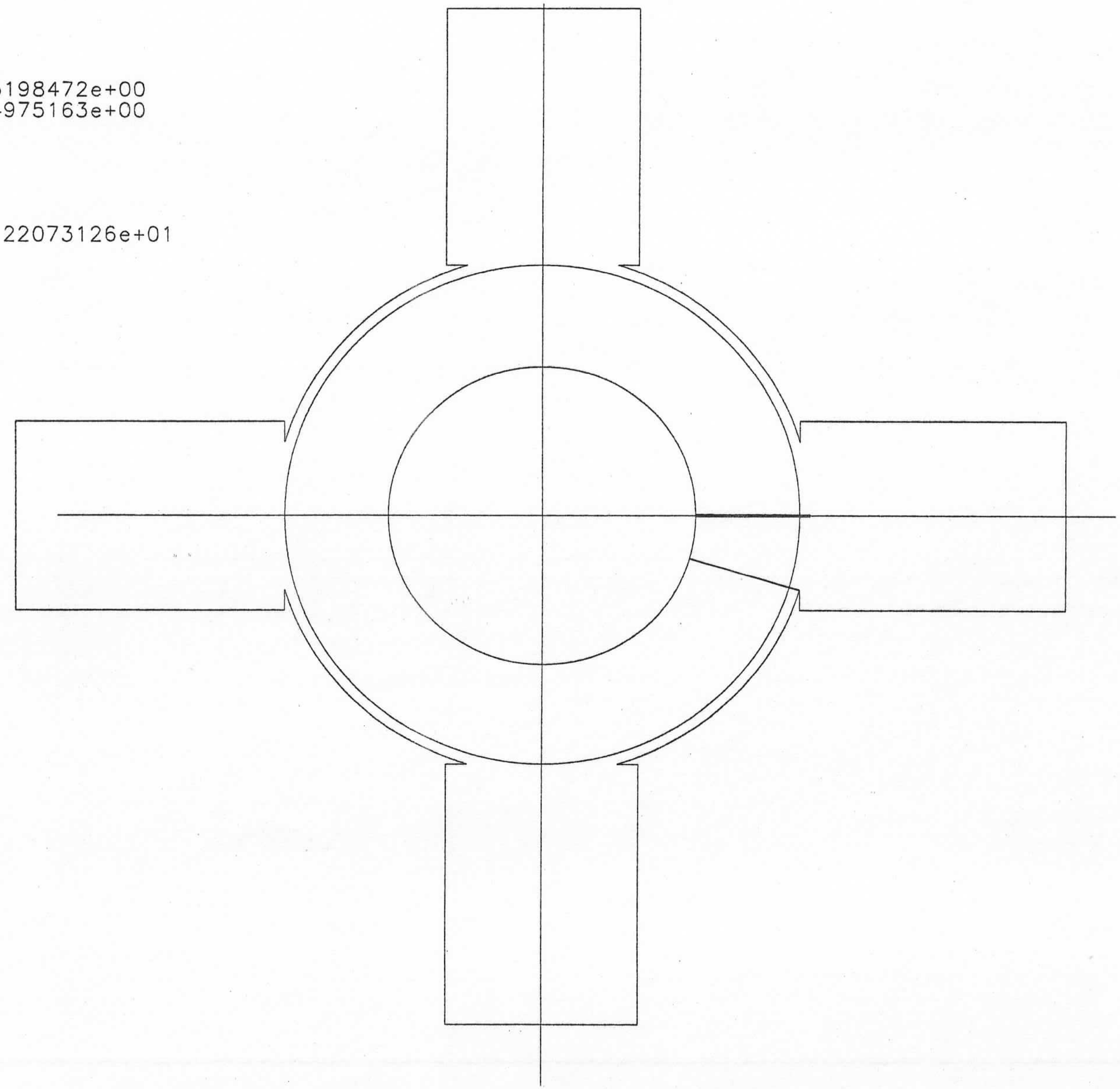
| **Anchor** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| N [Lbf] | 51 | 52 | 52 | 51 |
| $V_x$ [Lbf] | 18 | 18 | 18 | 18 |
| $V_y$ [Lbf] | 7 | 7 | 7 | 7 |
| $V_{res}$ [Lbf] | 20 | 20 | 20 | 20 |
| Res [Lbf] | 55 | 55 | 55 | 55 |
| $\alpha$ | 21 | 21 | 21 | 21 |
| $f_{RN}$ | 1.00 | 1.00 | 1.00 | 1.00 |
| $f_{RV}$ | 1.00 | 1.00 | 1.00 | 1.00 |
| $f_{AN}$ | 0.69 | 0.69 | 0.69 | 0.69 |
| $f_{AV}$ | 0.69 | 0.69 | 0.69 | 0.69 |
| $N_{rec}$ [Lbf] | 1240 | 1240 | 1240 | 1240 |
| $V_{rec}$ [Lbf] | 1476 | 1476 | 1476 | 1476 |
| $I_N$ | 0.04 | 0.04 | 0.04 | 0.04 |
| $I_V$ | 0.01 | 0.01 | 0.01 | 0.01 |
| $I_{Res}$ | 0.01 | 0.01 | 0.01 | 0.01 |
| $h_{act}$ [in] | 2 | 2 | 2 | 2 |

Area=1.15646227e+01

Ixcg=2.11385422e+01
Iycg=2.10687704e+01

Kxcg=1.35198472e+00
Kycg=1.34975163e+00

Ipolar=4.22073126e+01



Area=2.70704750e+01

Ixcg=1.18380711e+02
Iycg=1.18366050e+02

Kxcg=2.09118538e+00
Kycg=2.09105589e+00

Ipolar=2.36746762e+02

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Tubular Welded Joint with Residual Stresses | Units | Comment | Value |
| 2 | Weld size | - | - | 3/16 |
| 3 | Weld type | - | - | Fillet |
| 4 | **Base metals yield strength** | **Fy (ksi)** | Minimum, 6063-T6 | **25.00** |
| 5 | Alowable Stess | (ksi) | TB. 3.3.2, p.16, min. shear | 6.50 |
| 6 | Depth or leg | (in) | From geometry | 0.19 |
| 7 | Eff. throat | (in) | (leg) ^ (1/2) | 0.13 |
| 8 | Length | (in) | From geometry (pipe [11"] + gussets[16"]) | 27.00 |
| 9 | **Rw** | **(kips/in)** | Eff. throat x Allowable stress | **0.86** |
| 10 | Ix | ($in^4$/in) | Ixcg from I-DEAS | 118.40 |
| 11 | Iz | ($in^4$/in) | Izcg from I-DEAS | 118.40 |
| 12 | Ip | ($in^4$/in) | Ipolar = Ixcg + Izcg | 236.80 |
| 13 | xcg | (in) | From geometry | 4.60 |
| 14 | zcg | (in) | From geometry | 4.60 |
| 15 | Sx | ($in^3$/in) | Ix / ycg | 25.74 |
| 16 | Sz | ($in^3$/in) | Iz / xcg | 25.74 |
| 17 | Jx | ($in^3$/in) | Ip / ycg | 51.48 |
| 18 | Jz | ($in^3$/in) | Ip / xcg | 51.48 |
| 19 | Lx | (kips) | Load in x (lateral load / 2) | **0.27** |
| 20 | Ly | (kips) | Load in y (weight / 2) | 0.47 |
| 21 | Lz | (kips) | Load in z | 0.00 |
| 22 | ax | (in) | X lever arm | 80.00 |
| 23 | ay | (in) | Y lever arm | 0.00 |
| 24 | az | (in) | Z lever arm | 80.00 |
| 25 | Mx | (kips-in) | Lx * ax | 21.840 |
| 26 | My | (kips-in) | Ly * ay | 0.000 |
| 27 | Mz | (kips-in) | Lz * az | 0.000 |
| 28 | sx | (kips/in) | Lx / Length | 0.010 |
| 29 | sy | (kips/in) | Ly / Length | 0.017 |
| 30 | sz | (kips/in) | Lz / Length | 0.000 |
| 31 | Ryx | (kips/in) | Mx / Sx | 0.849 |
| 32 | Ryz | (kips/in) | Mz / Sz | 0.000 |
| 33 | Rx | (kips/in) | My / Jx | 0.000 |
| 34 | Rz | (kips/in) | My / Jz | 0.000 |
| 35 | Fx (total) | (kips/in) | sx + Rx | 0.010 |
| 36 | Fy (total) | (kips/in) | sy + Ryx + Ryz | 0.866 |
| 37 | Fz (total) | (kips/in) | sz + Rz | 0.000 |
| 38 | **Vector Sum** | **(kips/in)** | { [ (Fx) ^ 2 ] + [ (Fy) ^ 2 ] + [ (Fz) ^ 2 ] } ^ (1/2) | **0.87** |
| 39 | ***Vector Sum / Rw*** | - | - | **1.00** |
| 40 | ***Base metal yield strength / Vector Sum*** | - | - | **3.83** |

**Rafael Silva**

**From:** "Rafael Silva" <rafael@fnal.gov>
**To:** "Hans Jostlein" <jostlein@fnal.gov>; "Alan Bross" <bross@fnal.gov>; "Anna Pla-Dalmau" <pla@fnal.gov>
**Cc:** "Dave Pushka" <pushka@fnal.gov>
**Sent:** Tuesday, February 18, 2003 6:50 PM
**Subject:** Lab 5 feeder support gussets

Hello,

Hans stopped by my office a few minutes ago and asked me if the Lab 5 feeder support could be fabricated without item 2 of dwg # 397896 - the triangular gussets for the columns - to save money.

The concern is the stresses in the welds generated by the moment created if a load is applied horizontally to the top of the column. With the gussets, each column can be loaded horizontally at the top with at least 270 lb safely; without the gussets this load is reduced to about 120 lb. As the whole structure (with the feeders) weighs 925 lb, the usual 10% lateral load used in calculations would amount to 93 lb, and this load would be safely divided by at least 2 columns. It is, however, a small load: one person can easily exert this force over the structure.

Two other considerations:
1) The maximum weld size between the pipe and the base plate should not exceed the thickness of the pipe wall (.216"), and it is called out in the drawings as 3/16" (.1875"). It is hard for the welder to control the size of this weld accurately.
2) A defect (visible or not) in this weld may severely compromise its integrity and, without the gussets, there is nothing else in this connection to resist the load. There are 8 welds between pipes and base plates.

I think that the gussets add a comfortable margin of safety, but their absence will not necessarily compromise the structure, as long as the welds have no relevant defects and the lateral loads are kept below 120 lb / column (240 lb of lateral load /whole structure).

Me, I would keep the gussets...

Rafael Silva
http://home.fnal.gov/~rafael/

**Rafael Silva**

---

**From:** "Alan Bross" <bross@fnal.gov>
**To:** "'Rafael Silva'" <rafael@fnal.gov>; "'Hans Jostlein'" <jostlein@fnal.gov>; "'Anna Pla-Dalmau'" <pla@fnal.gov>
**Cc:** "'Dave Pushka'" <pushka@fnal.gov>
**Sent:** Tuesday, February 18, 2003 10:39 PM
**Subject:** RE: Lab 5 feeder support gussets

Hi Rafael,

Yes, we should keep the gussets. It would be quite easy for a person to exert a 100 lb lateral force.
We must assume that people will often be working around the platform and that on occasion one or two people
might be climbing around on the structure loading the hoppers, inspecting things or trying to determine what is
wrong. If the h. load without the gussets is reduced to around 100 lb per column, this is just cutting it too close.

Alan

| LAB 5 - HOPPER SUPPORT | RAFAEL | | 11/12/02 |
|---|---|---|---|

PRE - CHECK

1) AA, 33, p. 45:

Sch 40 pipe, 3" => OD = 3.500" ; ID = 3.068" ; t = .216" ; A = 2.228 in²

W = 2.621 lb/ft ; I = 3.017 in⁴ ; S = 1.724 in³ ; r = 1.164 in

$R_b = \frac{3.5}{2} - \frac{.216}{2} = 1.642$.

AA, 30, Tb. 3.3.29, 6063 - T6, p. 42, case 12:

$S = \frac{R_b}{t} = \frac{1.642}{.216} = 7.6$ ; $S_1 = 33$ ; $S_2 = 102$

As $S < S_1$ => $F_c = 18$ ksi

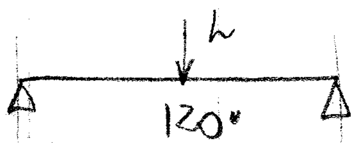
CASE 3: TENSION: F = 18 ksi

LOAD: 18,000 × 2.228 = **40,104 lb** => OK

2) 2 × 6 Channel, 6061-T6

CASE 2: F = 18 ksi

CASE 11: $F_{min} = 21$ ksi



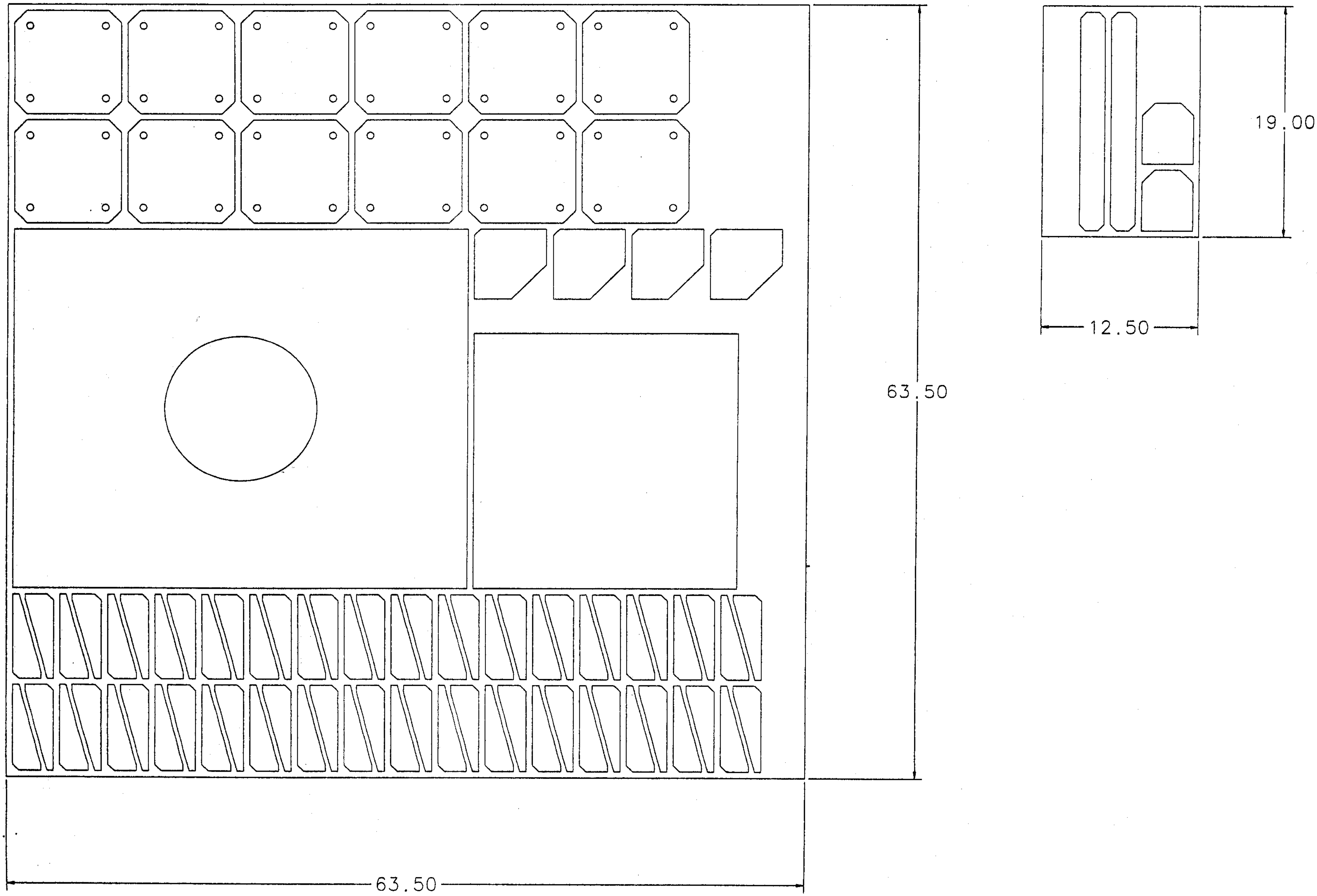

L = 550 + 100 + 100 = 750 lb

$M_{max} = \frac{Pl}{4} = \frac{750 \times 120}{4} = 22,500$ lb·in

$S = 4.37$ in³

$\sigma_{max} = \frac{22,500}{4.37} = 5,149$ p[si]

$\sigma_{max}$ (5.1) < 18 ksi => OK

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**PAGE 1**

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SHIP TO: FERMILAB - PROCARD
KIRK & WILSON STREETS
CUT SHOP, 27 WINNEBAGO
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ATTENTION : RAFAEL SILVA, (630)840-8311

*** DELIVERY CONTINGENT UPON DATE ORDERED

| ITEM | QUANTITY | DESCRIPTION | UNIT PRICE | TOTAL | DELIVERY DATE |
|---|---|---|---|---|---|
| 1 | **141.30 LB** 2.00 PC | **6061-T6 ALUMINUM CHANNEL-25FT AM STD 040114 - 6 X 1.920 X .200 CUT IN HALF FOR HANDLING - 300" ML** FOB: ORIGINATION, OUR DELIVERY ASTM-B308, AMS-QQ-A-200/8 | **2.2100 LB** | **$312.27** | **10/31/2002** |
| 2 | **43.23 LB** 1.00 PC | **6061-T6 ALUMINUM CHANNEL-25FT AM STD 040017 - 3 X 1.498 X .258 CUT IN HALF FOR HANDLING - 300" ML** FOB: ORIGINATION, OUR DELIVERY ASTM-B308, AMS-QQ-A-200/8 | **2.4200 LB** | **$104.62** | **10/31/2002** |
| 3 | **183.69 LB** 1.00 PC | **6061-T651 ALUMINUM PLATE 089744 - .375 (+.020-0) NO PROCESSING - 60.5" X 80.473" Mill** Dimensions. FOB: ORIGINATION, OUR DELIVERY AMS-QQ-A-250/11, AMS 4027, ASTM-B209 | **3.3900 LB** | **$622.71** | **10/31/2002** |
| 4 | **52.43 LB** 2.00 PC | **6063-T6 SCH 40 SEAMLESS ALUM PIPE-20 FT 094349 - 3 X 20 FT CUT 120" (+.063,-0)** FOB: ORIGINATION, OUR DELIVERY ASTM-B241, AMS-QQ-A-200/9 | **4.6500 LB** | **$243.80** | **10/31/2002** |
| | | QUOTE TOTAL | | $1,283.40 | |

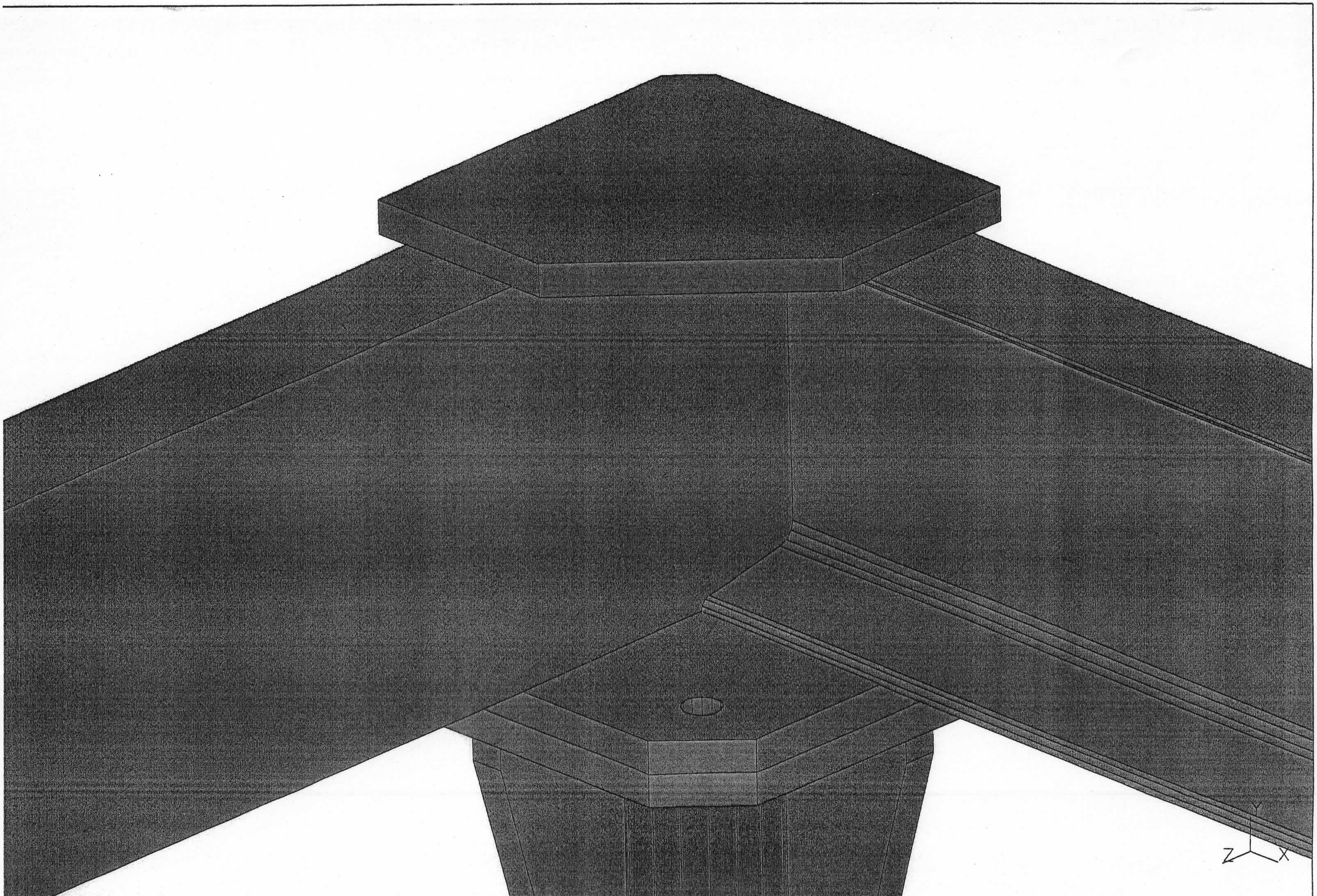
'RICES ARE QUOTED AS PRICE IN EFFECT AT TIME OF SHIPMENT.

TERMS : NET 30

PLEASE REVIEW THE ABOVE ITEMS FOR ACCURACY

*Our standard terms and conditions apply should this quote become an order.*

Any obvious damage must be noted on the material delivery documentation at the time of receipt. Tax exemption status documentation must be forwarded to credit department prior to order approval. All returned material subject to re-stock charge.

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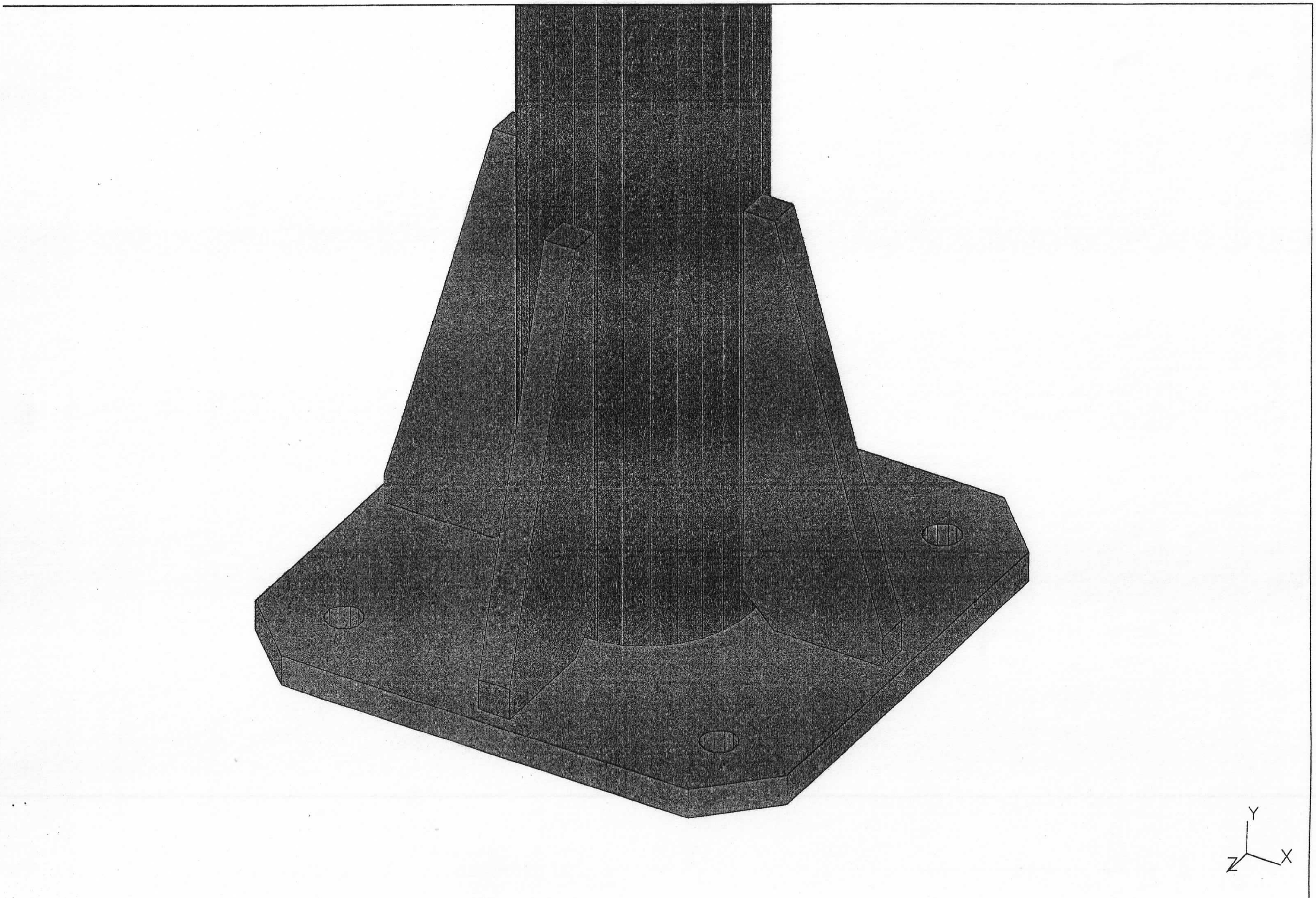


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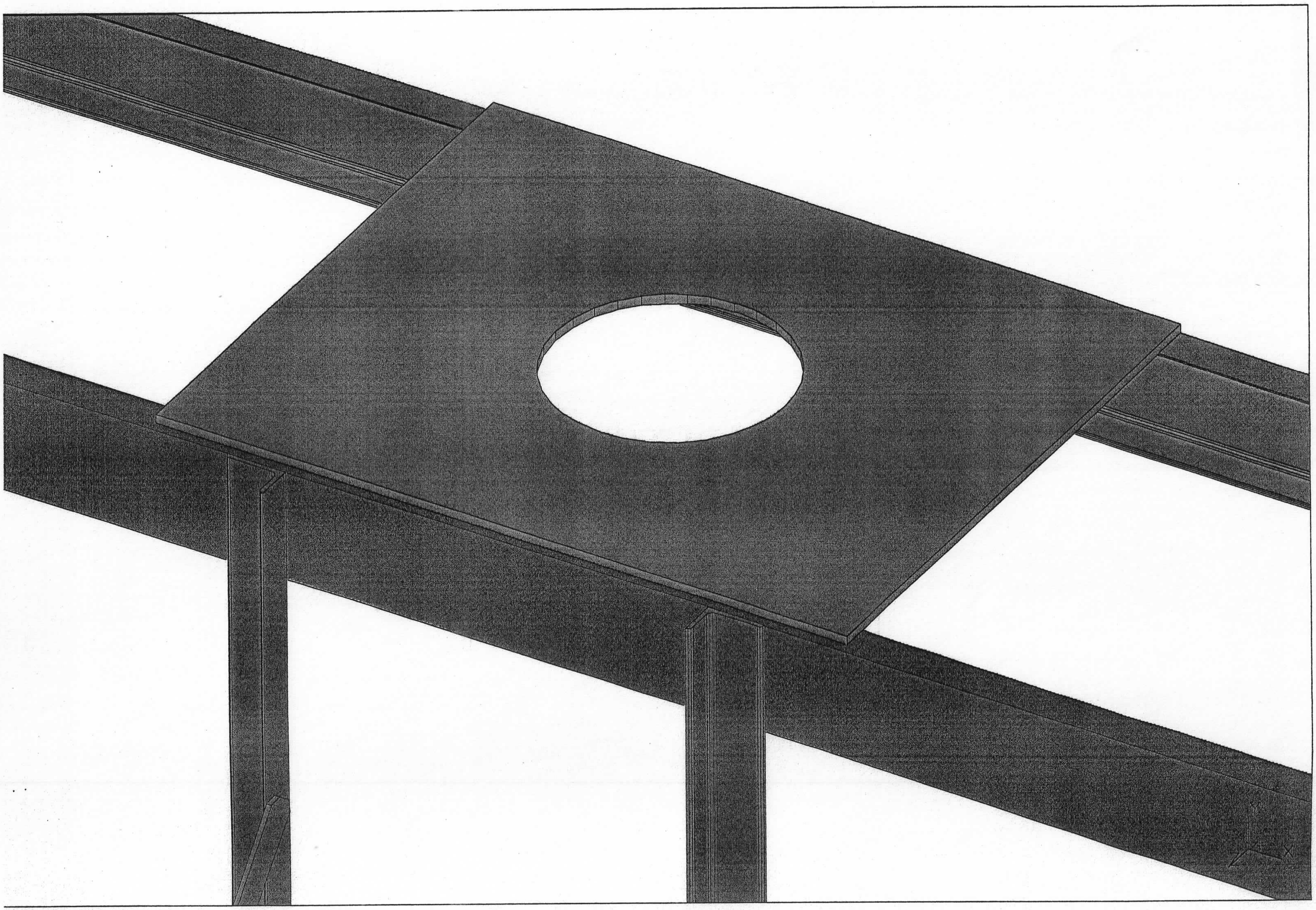
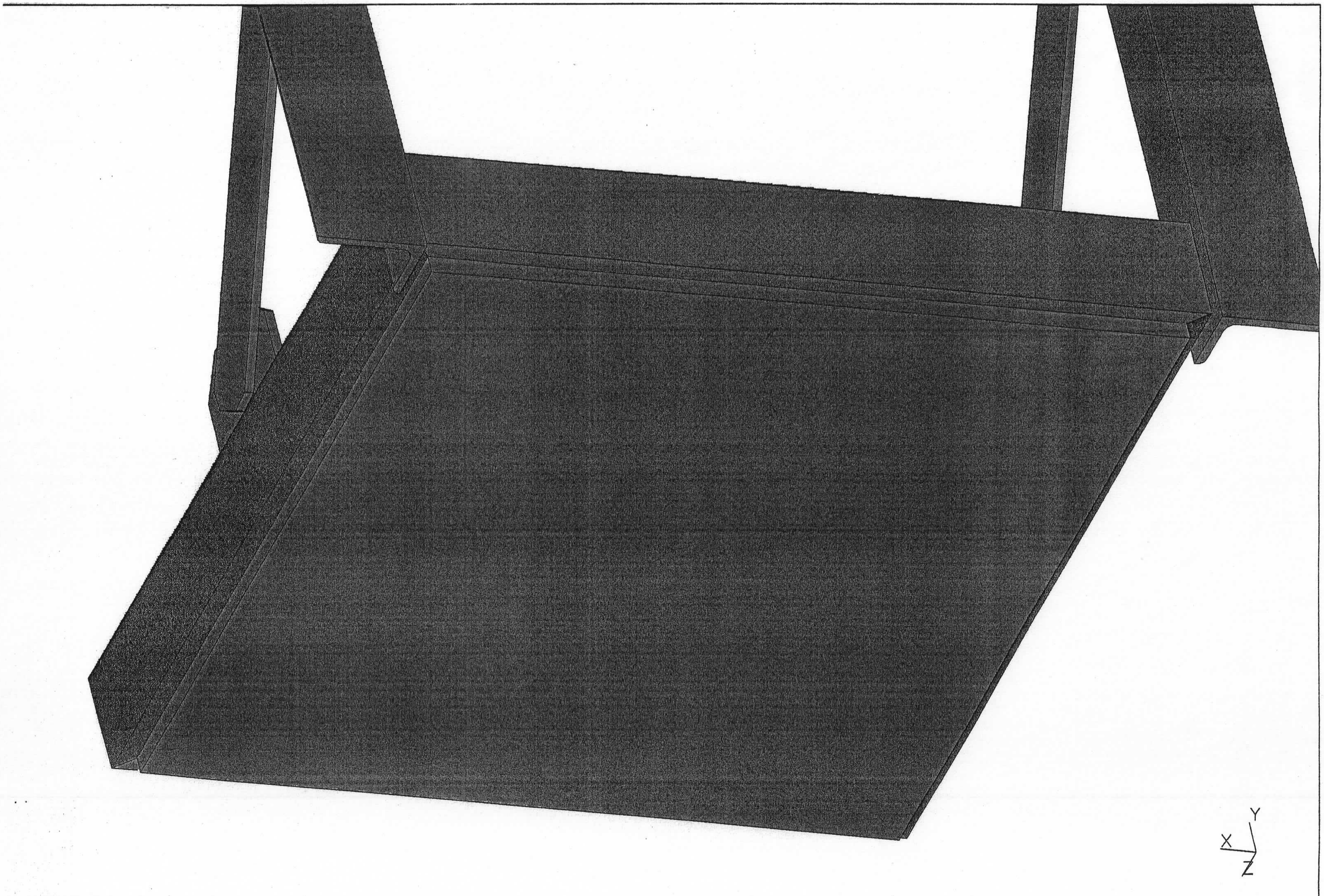
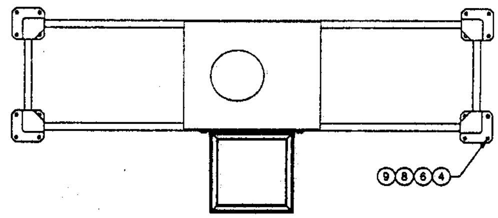
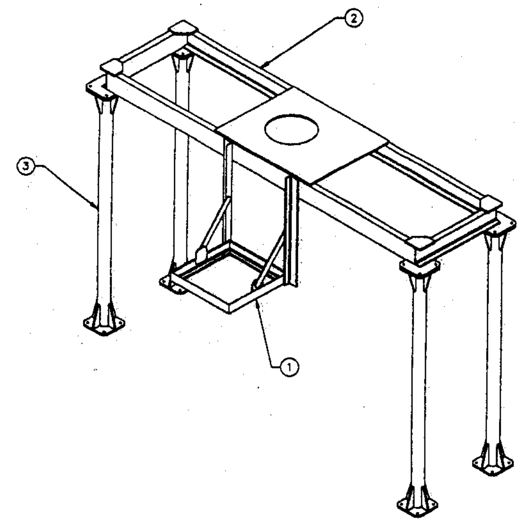
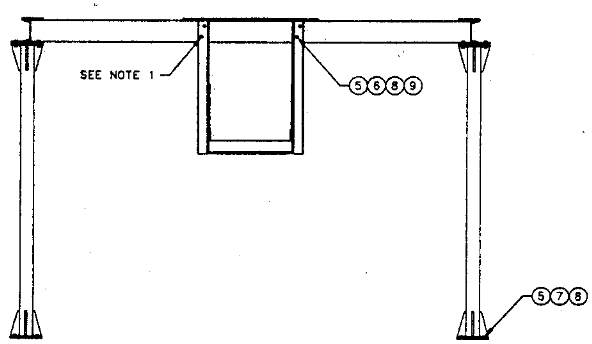


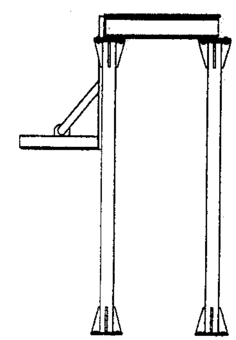

Y
X
Z

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| | | APPROVED | DATE |



| ITEM | PART NO. | DESCRIPTION OR SIZE | QTY. |
|---|---|---|---|
| 9 | 1210-074000 | WASHER, 1/2" S.S. .562 ID 1.375 OD .109 THK. | 20 |
| 8 | COML | WASHER, SAFETY 1/2" S.S. SCHNORR SERRATED P/N S12,7SS | 36 |
| 7 | COML | ANCHOR, FLUSH DROP-IN HILTI S.S. P/N 457895, 1/2-13 BOLT SIZE | 16 |
| 6 | 1210-074000 | NUT, HEX FULL SS, 1/2-13 | 20 |
| 5 | 1226-063000 | SCREW CAP HEX SS, 1/2-13NC X 1" LG | 20 |
| 4 | 1226-063500 | SCREW CAP HEX SS, 1/2-13NC X 1 1/2 | 16 |
| 3 | MD-397896 | LEG ASSEMBLY | 4 |
| 2 | MD-397895 | TOP ASSEMBLY | 1 |
| 1 | MD-397893 | SHELF ASSEMBLY | 1 |

PARTS LIST

| UNLESS OTHERWISE SPECIFIED | | | | | |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 08-FEB-2003 |

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

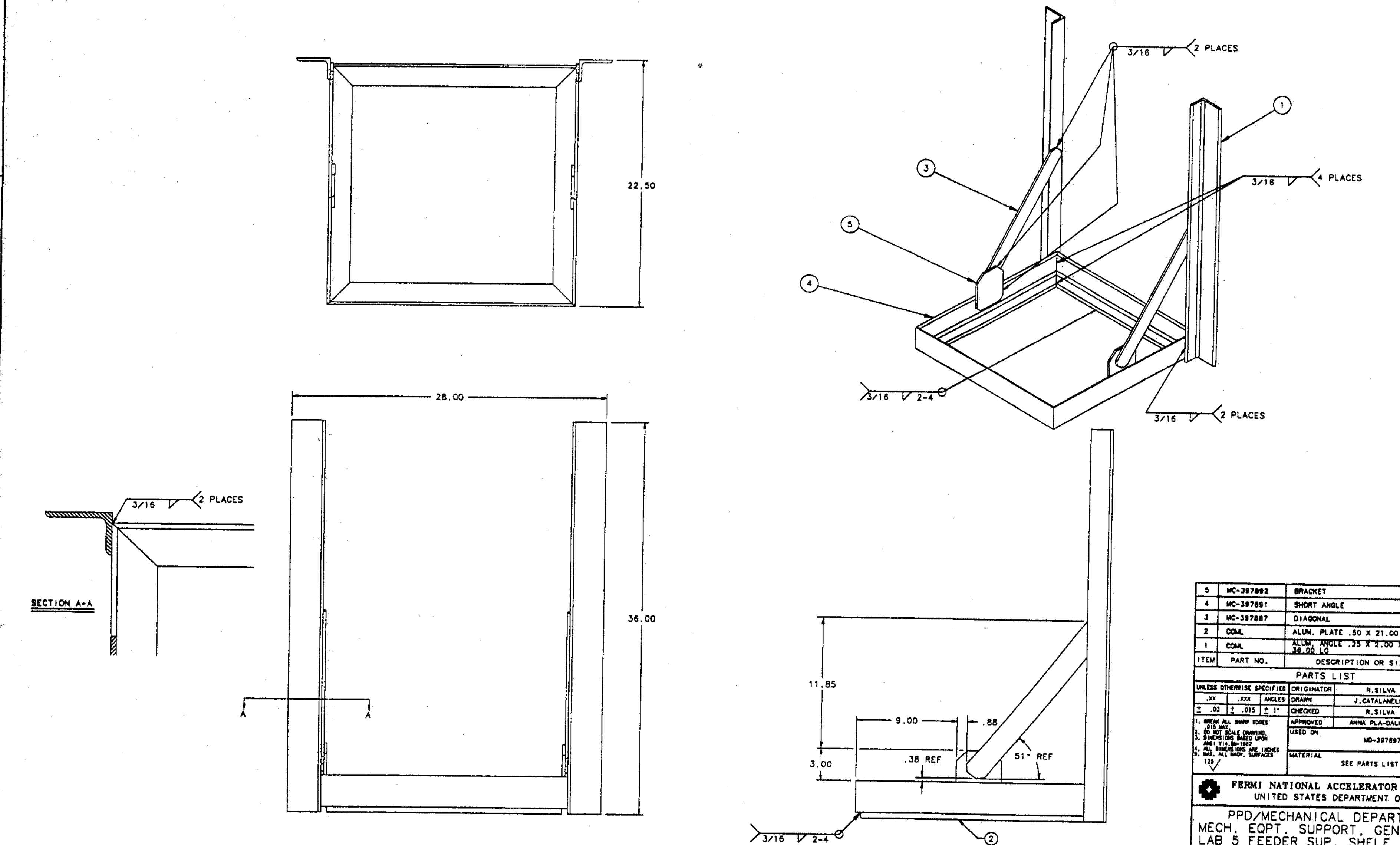
PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, ASSEMBLY

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1:16 | 9209.050-MD-397897 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

NOTES:

1. HOLES ON ANGLE TO BE MADE IN THE FIELD.




| 5 | MC-397892 | BRACKET | 2 |
|---|---|---|---|
| 4 | MC-397891 | SHORT ANGLE | 4 |
| 3 | MC-397887 | DIAGONAL | 2 |
| 2 | COML | ALUM. PLATE .50 X 21.00 X 21.00 | 1 |
| 1 | COML | ALUM. ANGLE .25 X 2.00 X 3.00 X 36.00 LG | 2 |
| ITEM | PART NO. | DESCRIPTION OR SIZE | QTY. |

PARTS LIST

| UNLESS OTHERWISE SPECIFIED | | | | | |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | ORIGINATOR | R.SILVA | 08-JAN-2003 |
| ± .03 | ± .015 | ± 1° | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| | | | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397897

MATERIAL: SEE PARTS LIST ABOVE

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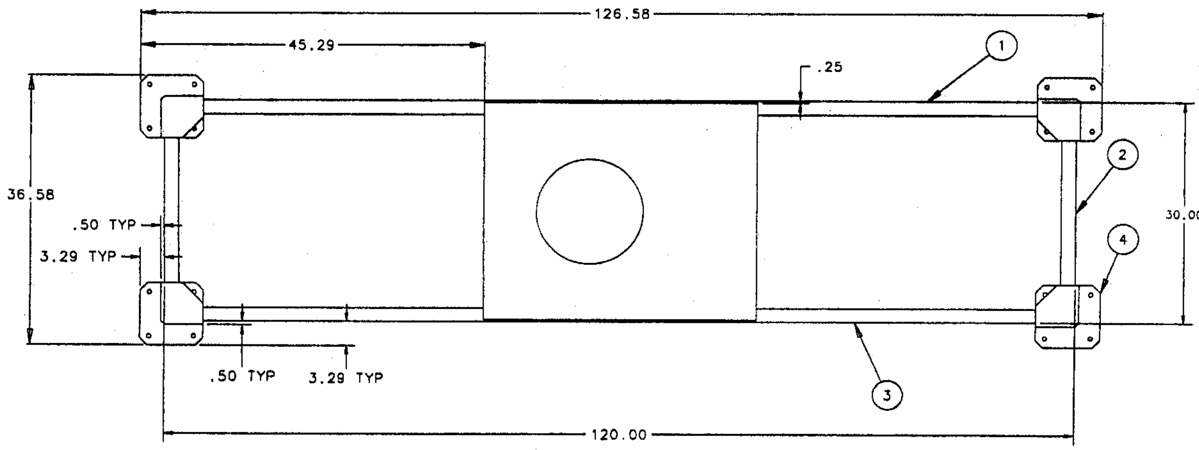
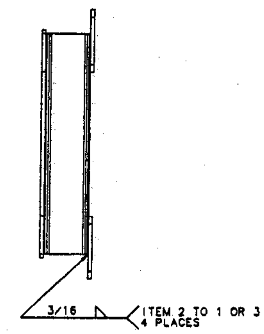
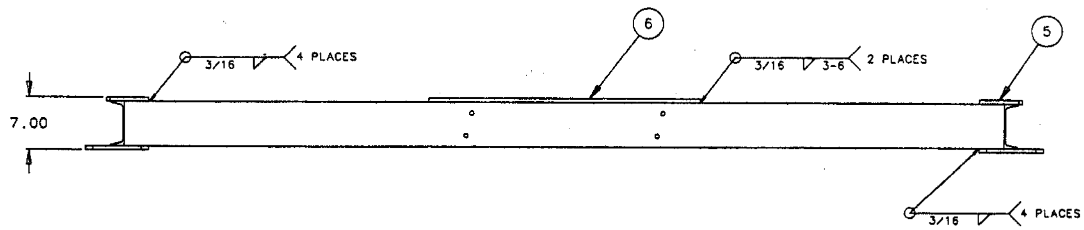
PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, SHELF ASSEMBLY

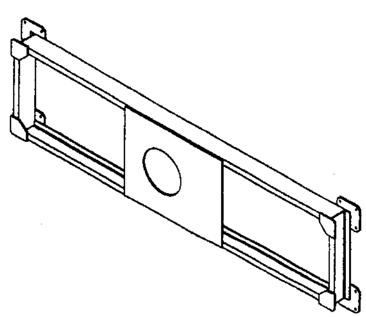
| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1/4 | 9209.050-MD-397893 | 1 OF 1 | |

CREATED WITH : Ideas9m3 GROUP: PPD/MECHANICAL DEPARTMENT



| ITEM | PART NO. | DESCRIPTION OR SIZE | QTY. |
|---|---|---|---|
| 6 | MC-397894 | TOP SHELF | 1 |
| 5 | MC-397890 | CORNER PLATE | 4 |
| 4 | MC-397889 | SQUARE PLATE | 4 |
| 3 | MC-397886 | LONG CHANNEL | 1 |
| 2 | COML | CHANNEL 2.00 X 6.00 X 30.00 LG (2.83 LBS/FT) | 2 |
| 1 | COML | CHANNEL 2.00 X 6.00 X 116.16 LG (2.83 LBS/FT) | 1 |

PARTS LIST

| UNLESS OTHERWISE SPECIFIED | | | | | |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397897

MATERIAL: SEE PARTS LIST ABOVE

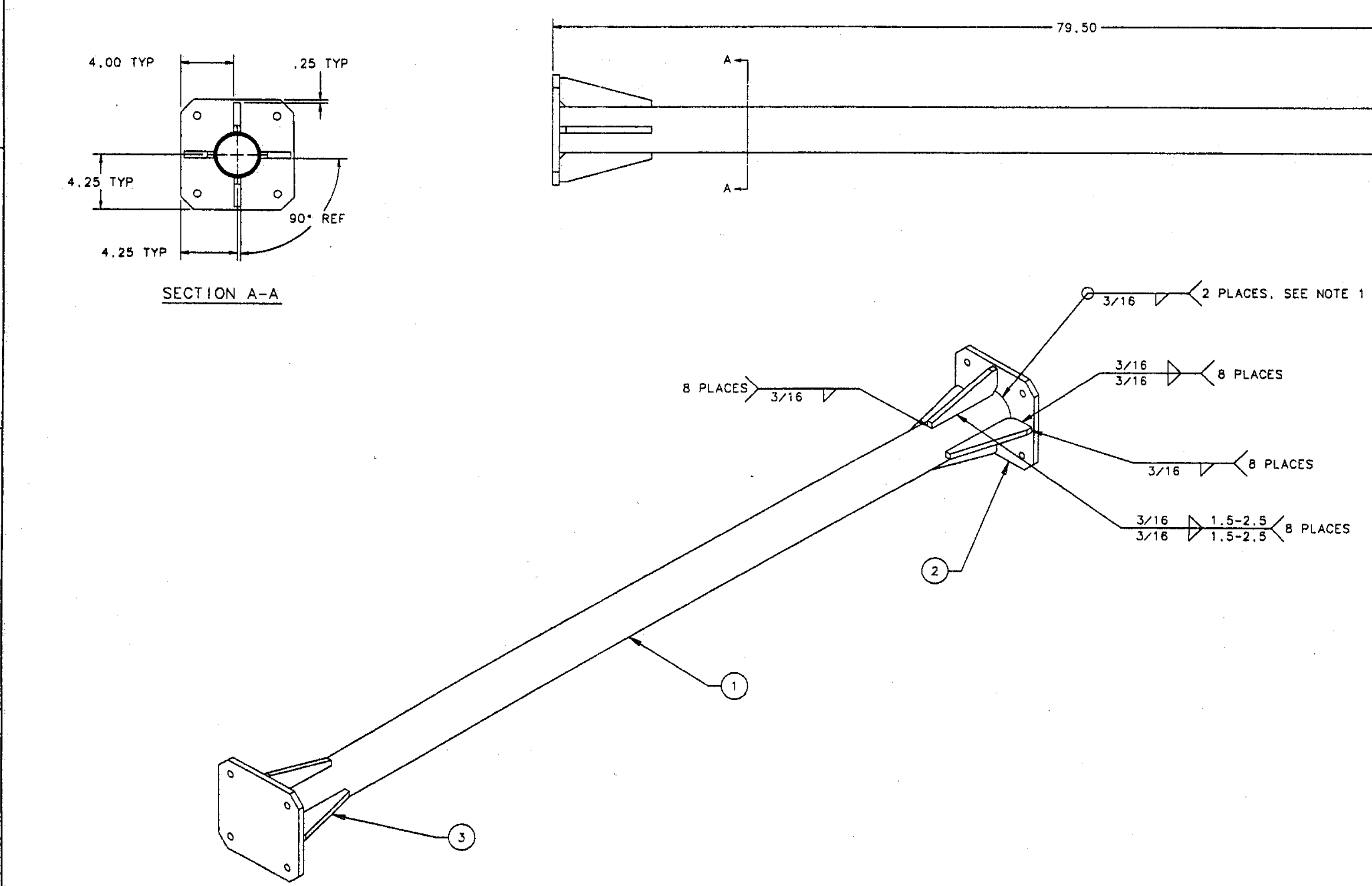
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, TOP ASSEMBLY

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1:8 | 9209.050-MD-397895 | 1 OF 1 | |

CREATED WITH : ideas9m3 GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|




NOTES:

1. WELD PART 1 TO PART 2 BEFORE WELDING PART 3.

| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|
| | | | |

| ITEM | PART NO. | DESCRIPTION OR SIZE | QTY. |
|---|---|---|---|
| 3 | MC-397888 | TUBE GUSSET | 8 |
| 2 | MC-397889 | SQUARE PLATE | 2 |
| 1 | COML | TUBE, ⌀3.50 X 78.50 LONG | 1 |

PARTS LIST

| UNLESS OTHERWISE SPECIFIED | | | | | |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | ORIGINATOR | R.SILVA | 08-JAN-2003 |
| ± | ± | ± 1° | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| | | | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397897

MATERIAL: SEE PARTS LIST ABOVE

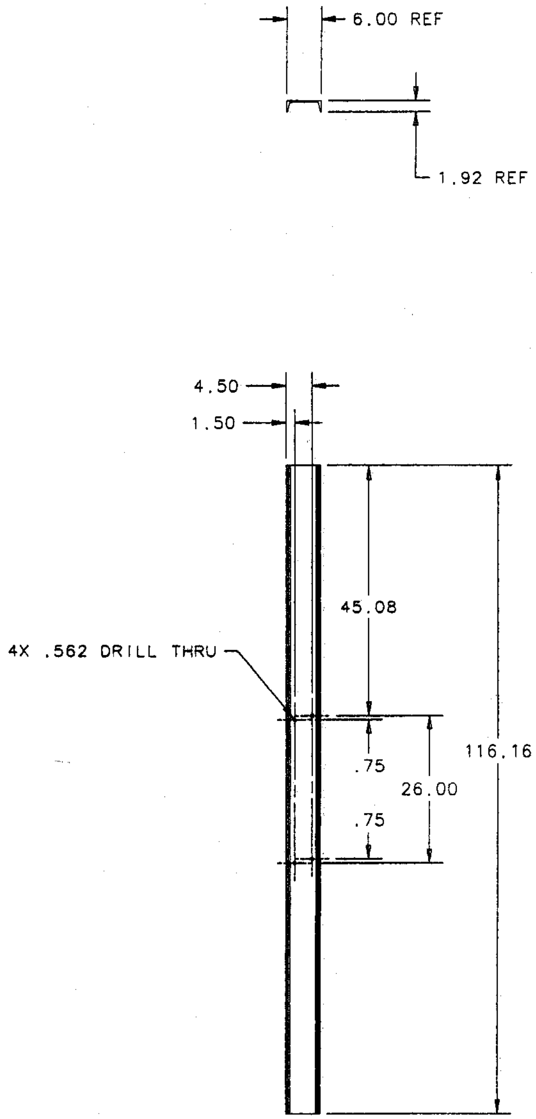
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP. LEG ASSEMBLY

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1:4 | 9209.050-MD-397896 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|
| | | | |




| | | | | | |
|---|---|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397895

MATERIAL: 6061-T6 ALUMINUM

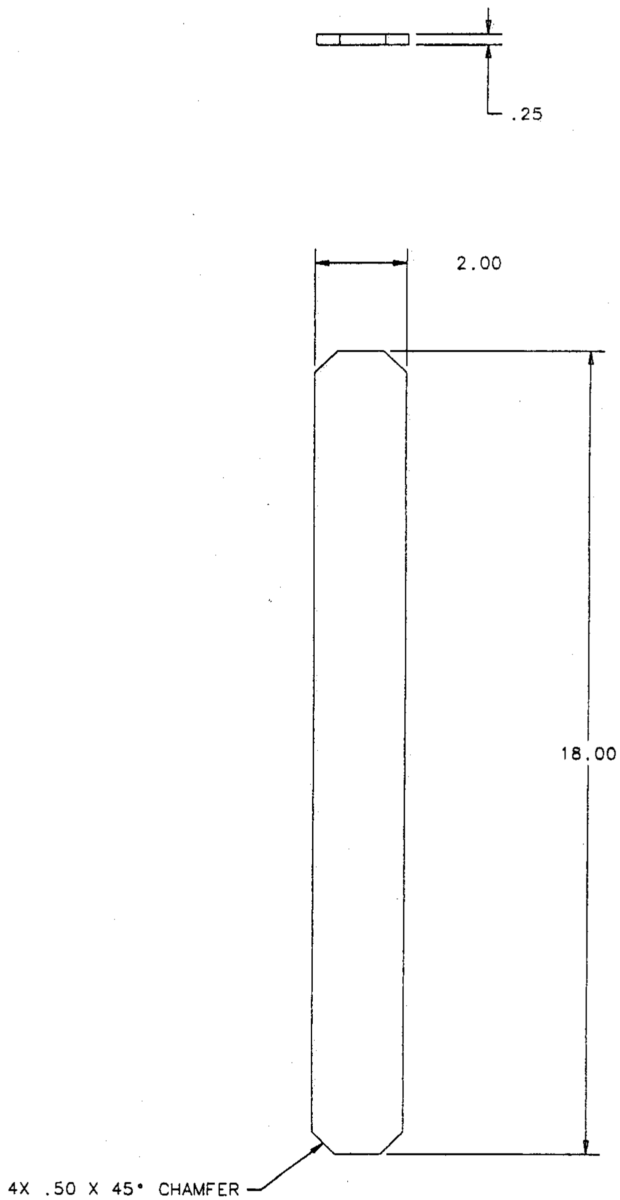
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, LONG CHANNEL

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1:16 | 9209.050-MC-397886 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| | | APPROVED | DATE |




| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397893

MATERIAL: 6061-T6 ALUMINUM BAR .25 X 2.00 X 18.00 LG

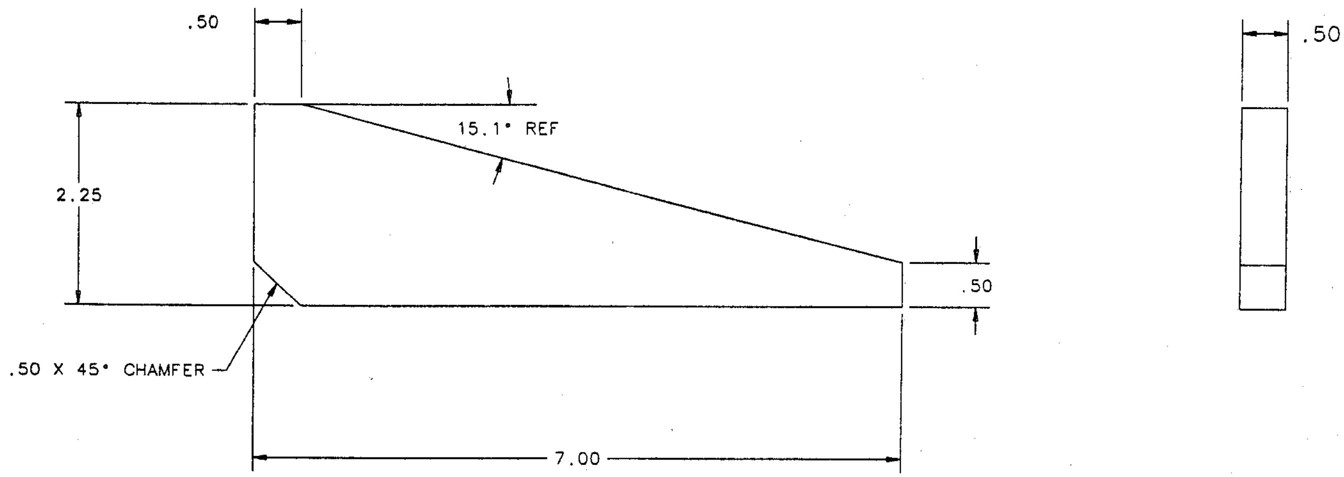
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, DIAGONAL

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1/2 | 9209.050-MC-397887 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|




| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397896

MATERIAL: 6061-T6 ALUMINUM PLATE .50 X 2.25 X 7.00

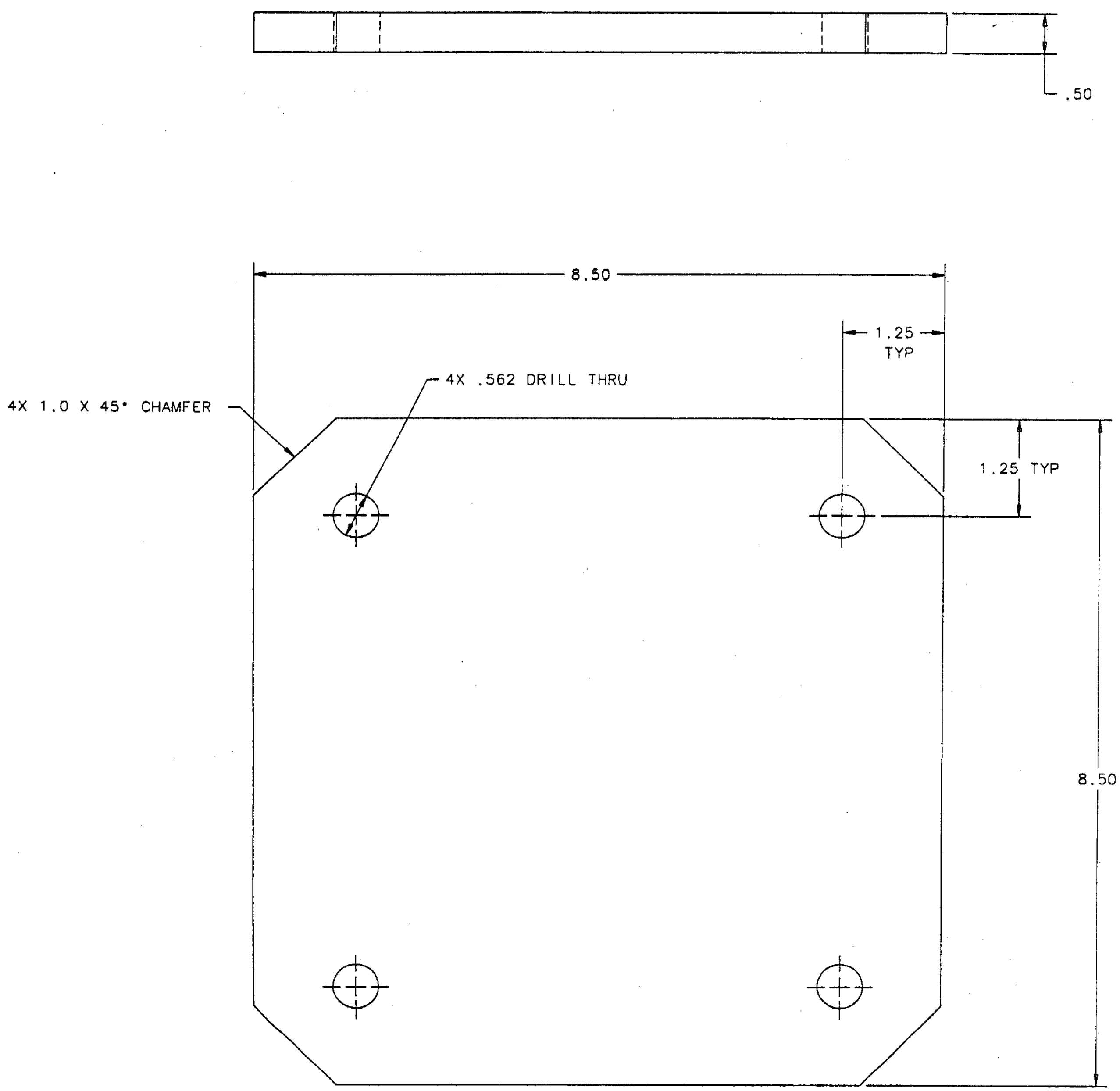
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, TUBE GUSSET

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| FULL | 9209.050-MC-397888 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|




| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± .015 | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397895 & MD-397896

MATERIAL: 6061-T6 ALUMINUM PLATE .50 X 8.50 X 8.50 SQUARE

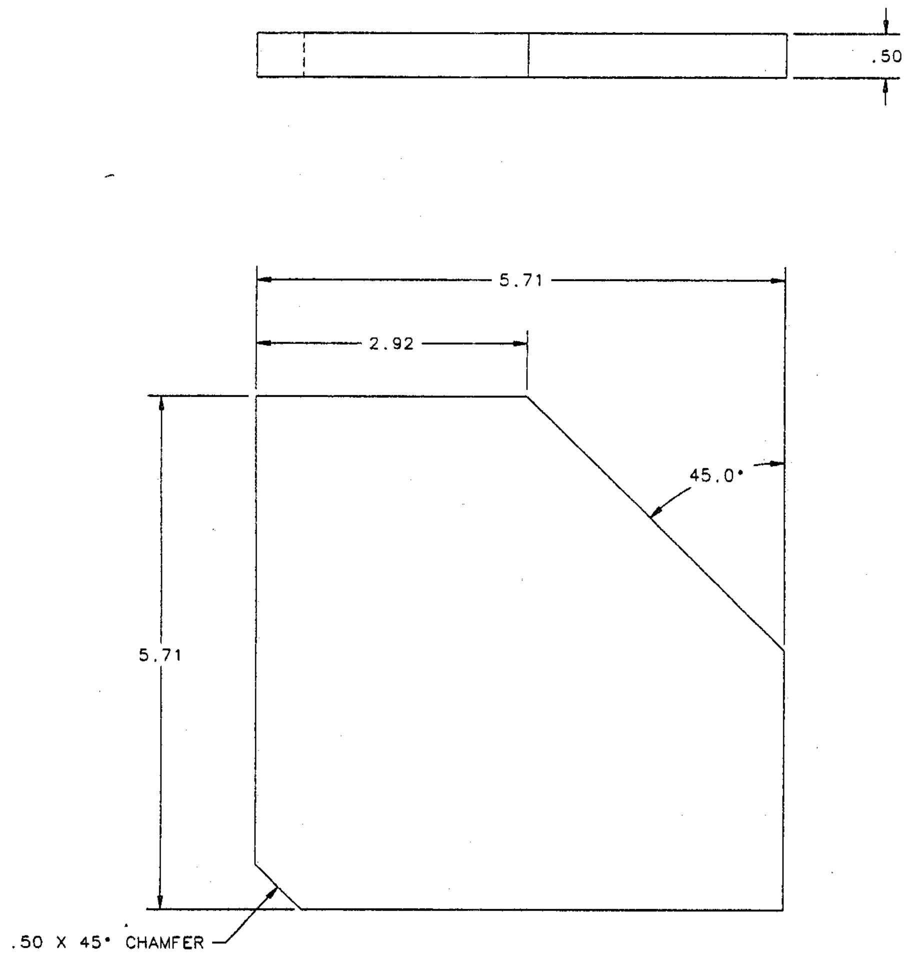
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, SQUARE PLATE

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| FULL | 9209.050-MC-397889 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| | | APPROVED | DATE |




| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| 1. BREAK ALL SHARP EDGES .015 MAX.<br>2. DO NOT SCALE DRAWING.<br>3. DIMENSIONS BASED UPON ANSI Y14.5M-1982<br>4. ALL DIMENSIONS ARE INCHES<br>5. MAX. ALL MACH. SURFACES 125 √ | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |
| | | | USED ON | MD-397895 | |
| | | | MATERIAL | 6061-T6 ALUMINUM<br>PLATE .50 X 5.71 X 5.71 SQUARE | |

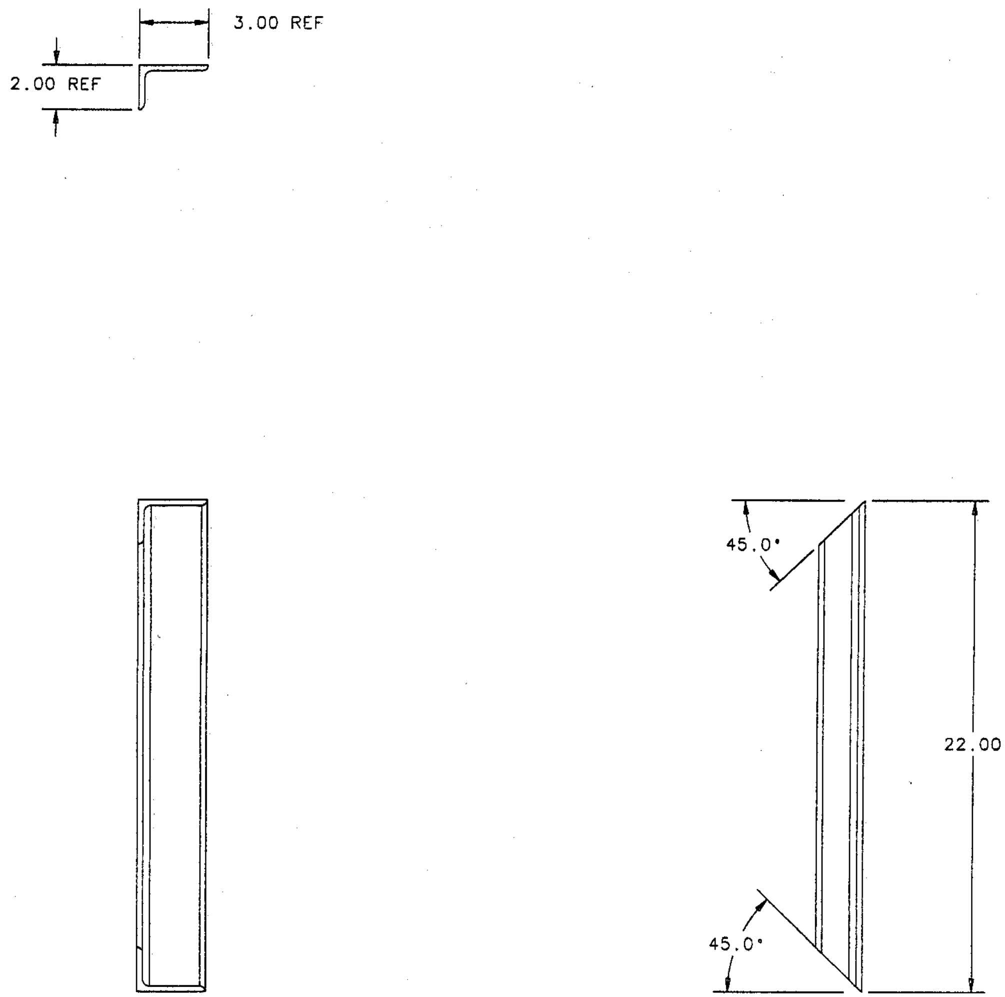
**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, CORNER PLATE

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| FULL | 9209.050-MC-397890 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| | | APPROVED | DATE |




| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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
MD-397893

MATERIAL
6061-T6 ALUMINUM
ANGLE .25 X 2.00 X 3.00 X 22.00 LG

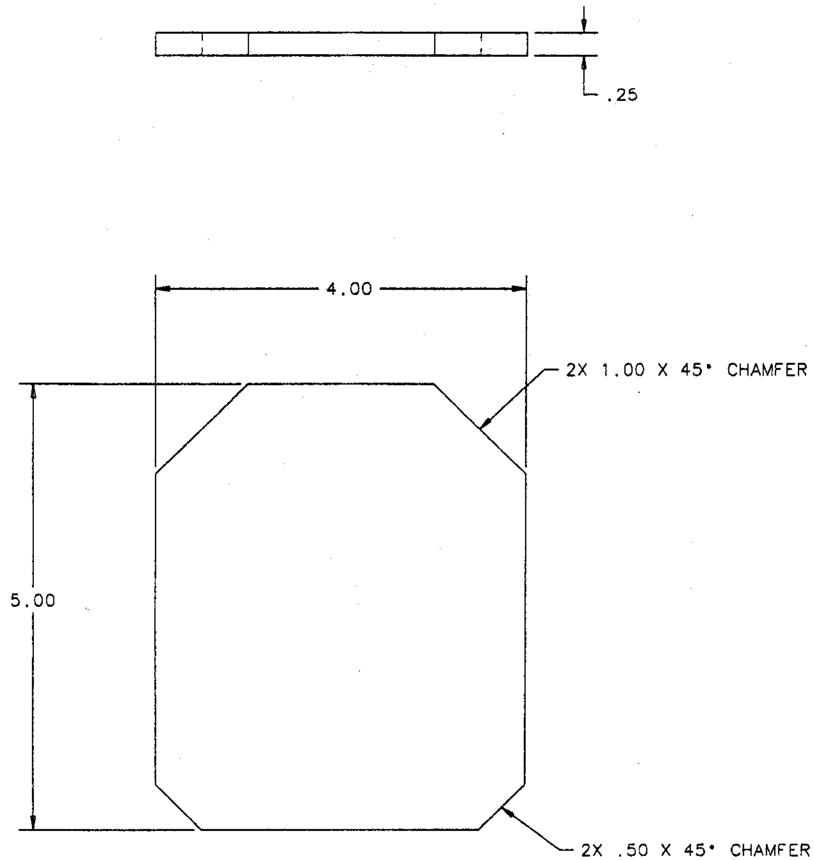
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, SHORT ANGLE

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1/4 | 9209.050-MC-397891 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT

| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|




| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397893

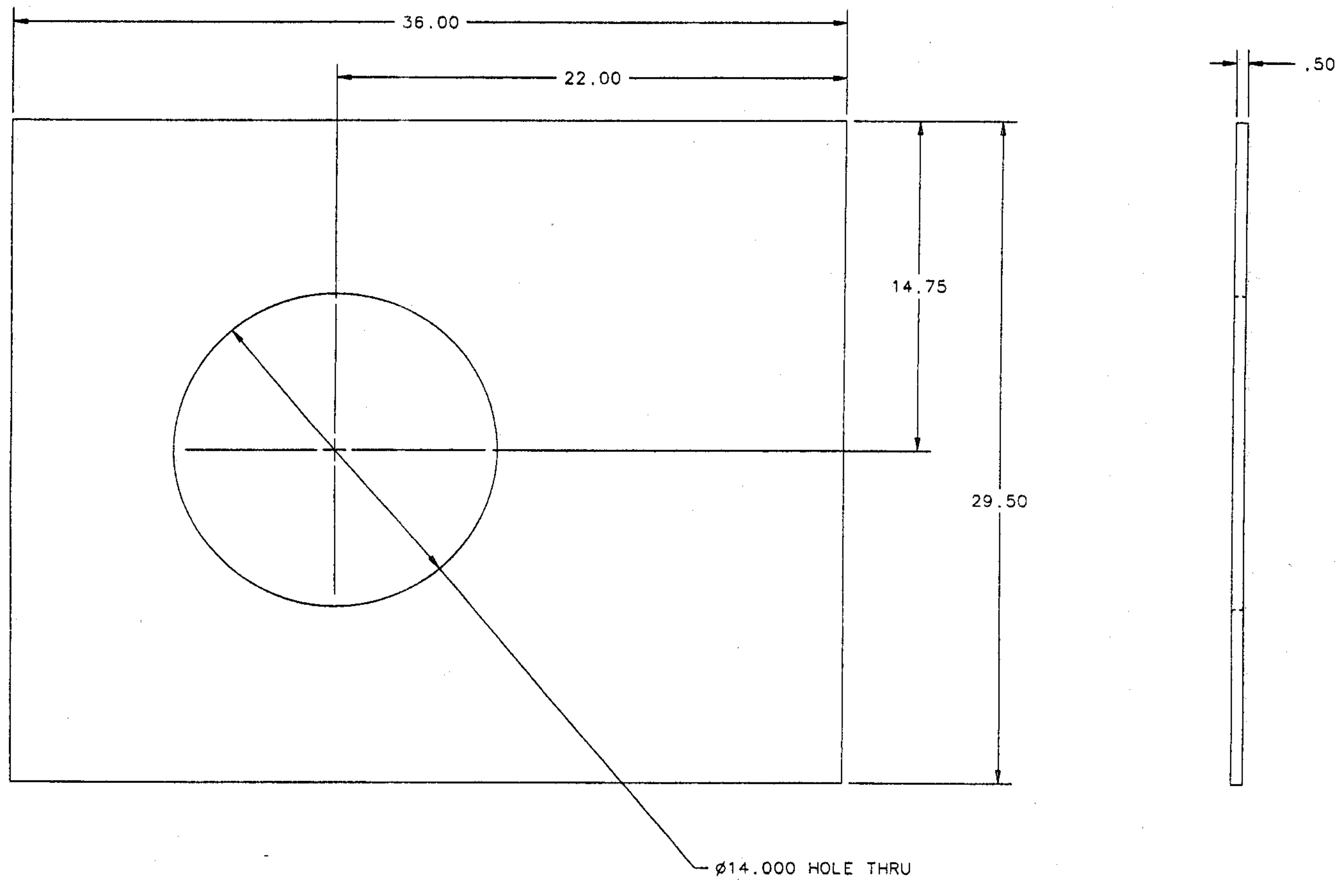
MATERIAL: 6061-T6 ALUMINUM PLATE .25 X 4.00 X 5.00

**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL DEPARTMENT
MECH. EQPT. SUPPORT, GEN SUPPORT
LAB 5 FEEDER SUP, BRACKET

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| FULL | 9209.050-MC-397892 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT




| REV | DESCRIPTION | DRAWN / APPROVED | DATE / DATE |
|---|---|---|---|

| UNLESS OTHERWISE SPECIFIED | | | ORIGINATOR | R.SILVA | 08-JAN-2003 |
|---|---|---|---|---|---|
| .XX | .XXX | ANGLES | DRAWN | J.CATALANELLO | 08-JAN-2003 |
| ± .03 | ± | ± 1° | CHECKED | R.SILVA | 28-JAN-2003 |
| | | | APPROVED | ANNA PLA-DALMAU | 05-FEB-2003 |

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: MD-397895

MATERIAL: 6061-T6 ALUMINUM PLATE .50 X 29.50 X 36.00

**FERMI NATIONAL ACCELERATOR LABORATORY**
UNITED STATES DEPARTMENT OF ENERGY

# PPD/MECHANICAL DEPARTMENT
# MECH. EQPT. SUPPORT, GEN SUPPORT
# LAB 5 FEEDER SUP, TOP SHELF

| SCALE | DRAWING NUMBER | SHEET | REV |
|---|---|---|---|
| 1:4 | 9209.050-MC-397894 | 1 OF 1 | |

CREATED WITH : Ideas9m3 | GROUP: PPD/MECHANICAL DEPARTMENT