Fermilab

Particle Physics Division

Mechanical Department Engineering Note

Number: MD-ENG-231 Date: 03/12/2010

Project:----------NOvA

Proj Intern Ref:

Title:----------MUON CATCHER FRAME

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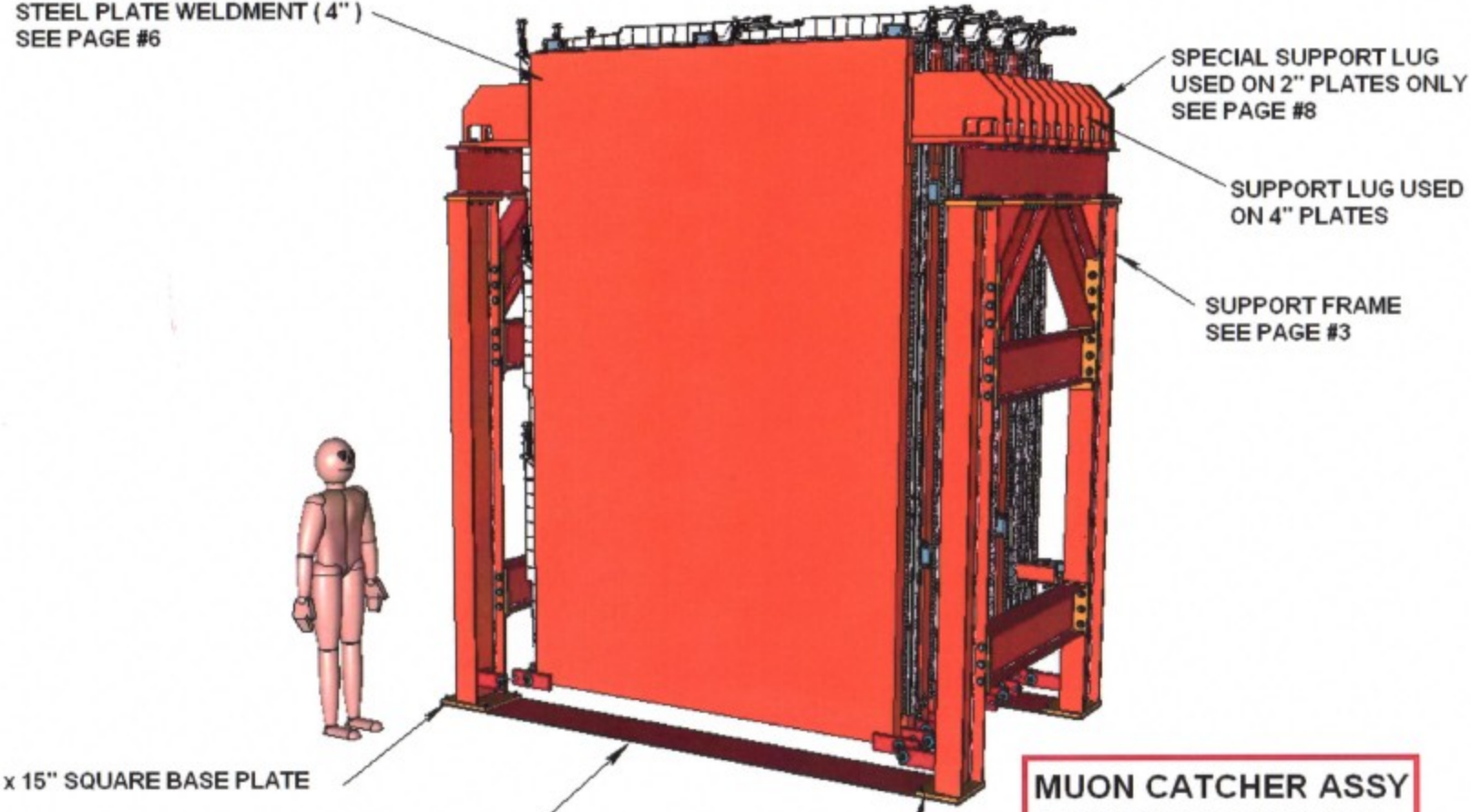
Key Words:--------BASE PLATES,SUPPORT FRAME,SUPPORT LUGS, CLIPS

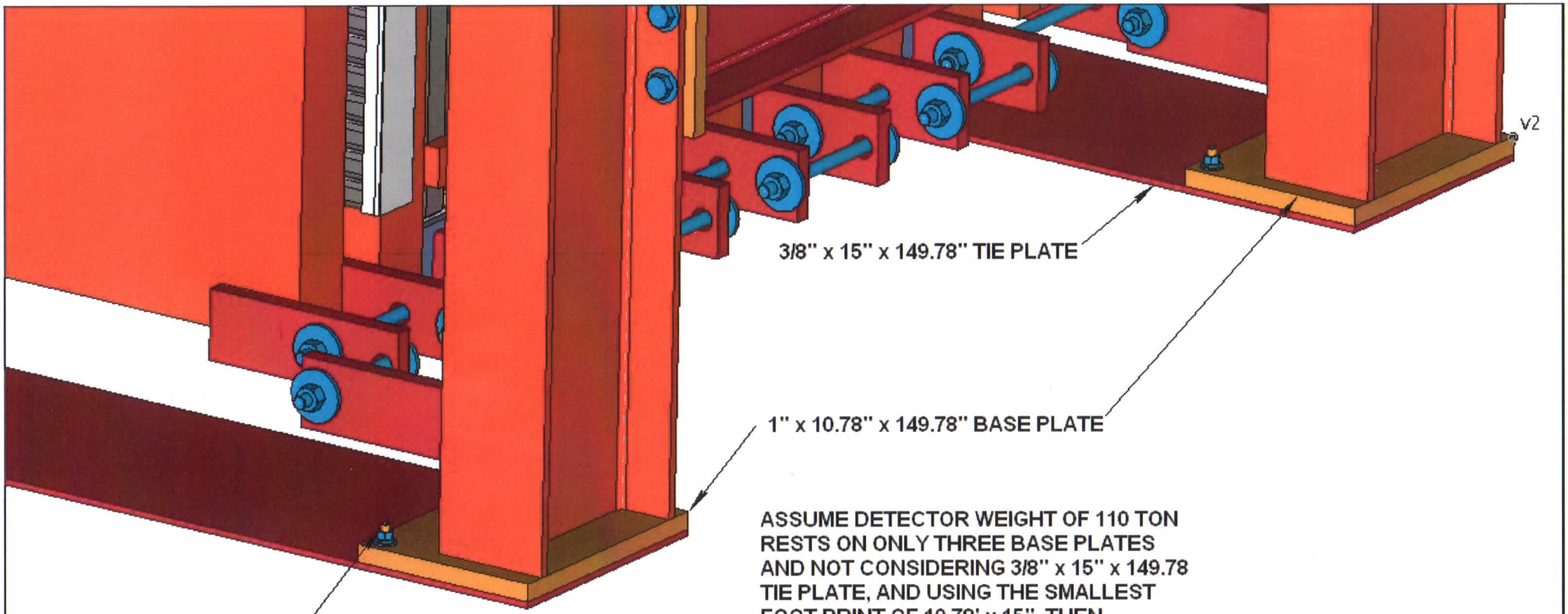
Abstract/Summary:THE DETECTOR IS COMPOSED OF THE FOLOWING:

(1) FIVE HORIZ PLANES MOUNTED ON 4" THICK PLATES
(2) FOUR VERT. PLANES MOUNTED ON 4" THICK PLATES
(3) ONE 4-PLANE BLOCK MOUNTED ON 2" THICK PLATE
(4) A 2" NAKED PLATE IS MOUNTED JUST UPSTEAM OF ITEM #3
(5) EACH PLATE IS MOUNTED BY MEANS OF SUPPORT LUGS TO A FRAME WHICH IS BOLTED TO 3/8" x 15" x 150"

(6) THE DETECTOR WEIGHT IS APPROXIMATELY 110 TON

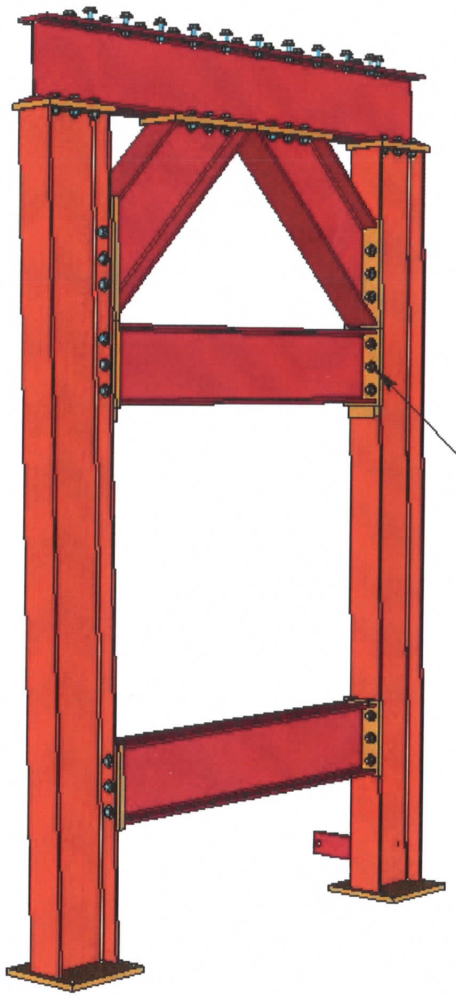
Applicable Codes:--AISC " MANUAL OF STEEL CONSTRUCTION "


STEEL PLATE WELDMENT (4")
SEE PAGE #6
SPECIAL SUPPORT LUG
USED ON 2" PLATES ONLY
SEE PAGE #8
SUPPORT LUG USED
ON 4" PLATES
SUPPORT FRAME
SEE PAGE #3
1" x 15" SQUARE BASE PLATE
3/8" x 15 x 149.78 TIE PLATE
1" x 10.78 x 15 BASE PLATE
SEE PAGE #2
MUON CATCHER ASSY
APPROX WT 110 TON



ASSUME DETECTOR WEIGHT OF 110 TON RESTS ON ONLY THREE BASE PLATES AND NOT CONSIDERING 3/8" x 15" x 149.78 TIE PLATE, AND USING THE SMALLEST FOOT PRINT OF 10.78' x 15", THEN
110/3 x 2000/(10.78 x 15) = 454PSI < 4000PSI
ASSUMING 4000PSI CONCRETE IS USED.

BASE PLATES AND TIE PLATES



SEE PAGES 4 & 5 FOR
ONE-DIMENSIONAL
FRAME FEA

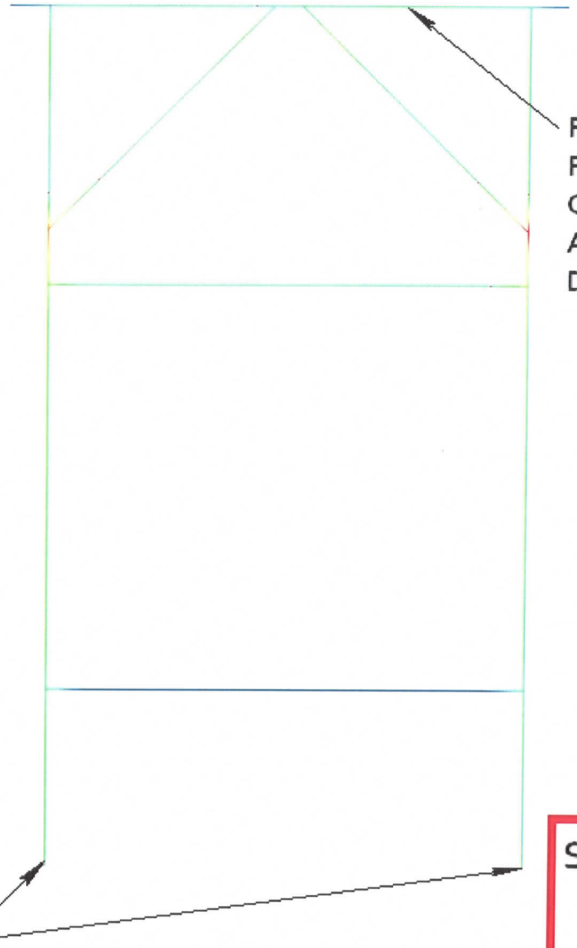
ALL FASTENERS 3/4-10 GRADE 8 BOLTS

SUPPORT EAST FRAME

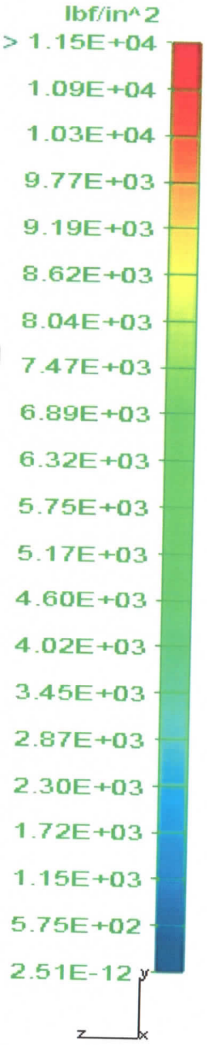
I-DEAS 12 NX Series m2: I-DEAS Visualizer

MUON_CATCHER_SUPT_FRAME_FEM
55_TON_LOAD
STRESS Von Mises Averaged Top shell
Beam stress: Von Mises , maximum point
Min: 2.51E-12 lbf/in^2 Max: 1.15E+04 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 0.00E+00 in

MATERIAL: ASTM A36 STEEL
Fvm = 0.6 X 36,000 = 21,600 PSI (ALLOWED)



FOUR LOADS OF 10522#
FIVE LOADS OF 10,468#
ONE LOAD OF 12806#
ALL LOADS ACT VERTICALLY
DOWNWARD ON W12X35 BEAM



HILTI FASTEN TO 4000 PSI
CONCRETE FLOOR

SUPPORT FRAME FEM
STRESSES

I-DEAS 12 NX Series m2: I-DEAS Visualizer

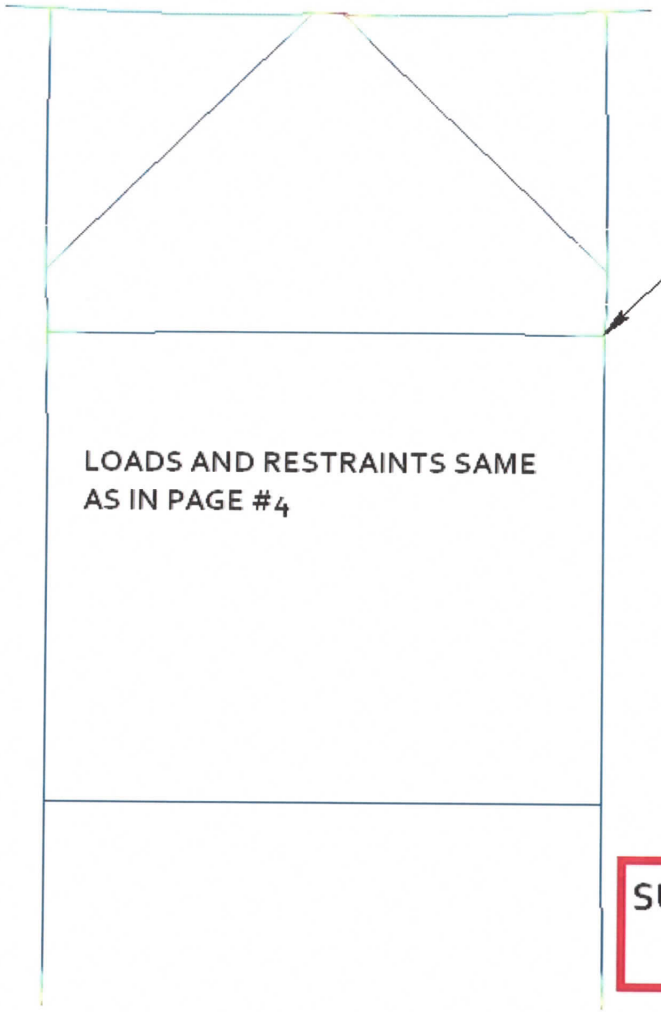
MUON_CATCHER_SUPT_FRAME_FEM
55_TON_LOAD
ELEMENT FORCE Magnitude Averaged Top shell
Min: 0.00E+00 lbf Max: 5.85E+04 lbf
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 4.04E-02 in

BOLTS USED : 3/4-10 GRADE 8 (A = .3344 IN^2)
PROOF LOAD TEST = 12,000 PSI
MAXIMUM CLAMP LOAD ALLOWED
= 75%X120,000 X .3344 = 30,096 #

58500#/6BOLTS = F = 9750# CLAMP FORCE REQUIRED

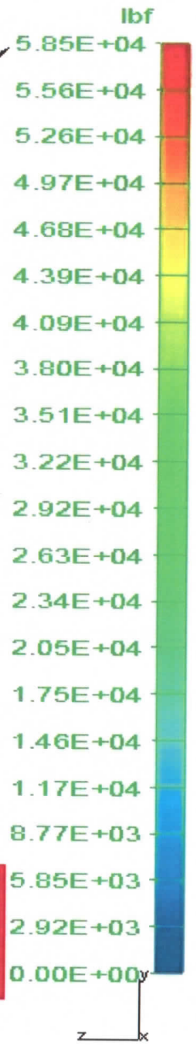
TORQUED = KFD = .25 X 9750 X .75 = 1828 IN-LB
= 152 FT-LB

WHERE K = .25 = COEFFICIENT OF FRICTION
F = 9750 = DESIGN LOAD
D = .75 = BOLT DIAMETER



LOADS AND RESTRAINTS SAME AS IN PAGE #4

ASSUME MAXIMUM AXIAL FORCE FOR BOLT CALCULATIONS IS ACTING ON POINT SHOWN



SUPPORT FRAME FEA FORCES

USE 1/2" FILLET WELDS, 3" LONG, 3 PER SIDE

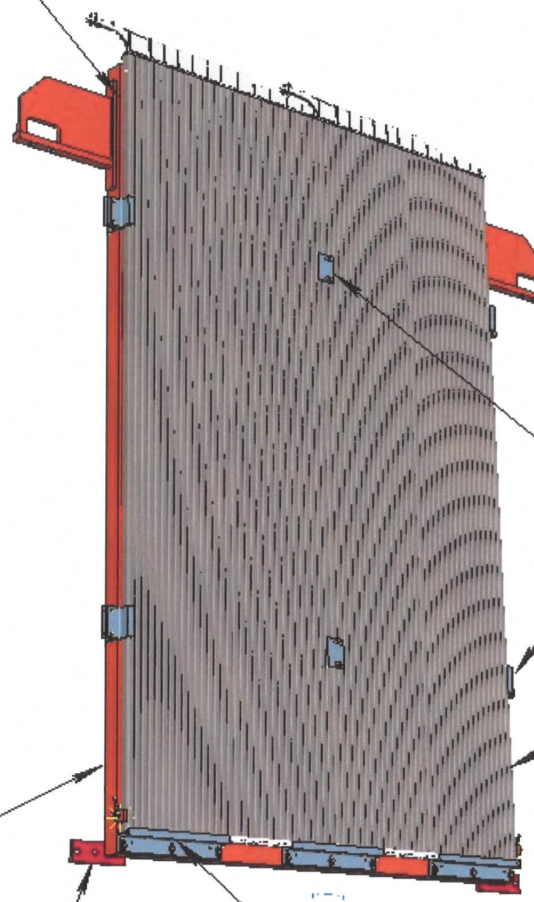
MATERIAL : ASTM A36, Fvm = 0.6 X 36,000
= 21,600 PSI ALLOWED

USING WELD ELECTRODES E60XX
Fv = 0.3 62,000 = 18,600 PSI ALLOWED
Fw = SIN45 X 0.5 X Fv
=6,576 #/IN ALLOWED

WELDS IN SHEAR
fw = 21,044/2X2X3X3 = 585 #/IN < Fw

MINIMUM WELD SIZE REQUIRED :
w = fw/Fw = 585/6576 = .089"

1/2" WELD WAS USED TO CONFORM WITH HEAT DISTRIBUTION PRINCIPLE OF THICKER PLATE (4")



SUPT LUG

(2)INNER CLIPS

(4) OUTER CLIPS

VERTICAL PLANE

4"PLATE WELDMENT
SEE PAGE #9

ANCHOR PLATES

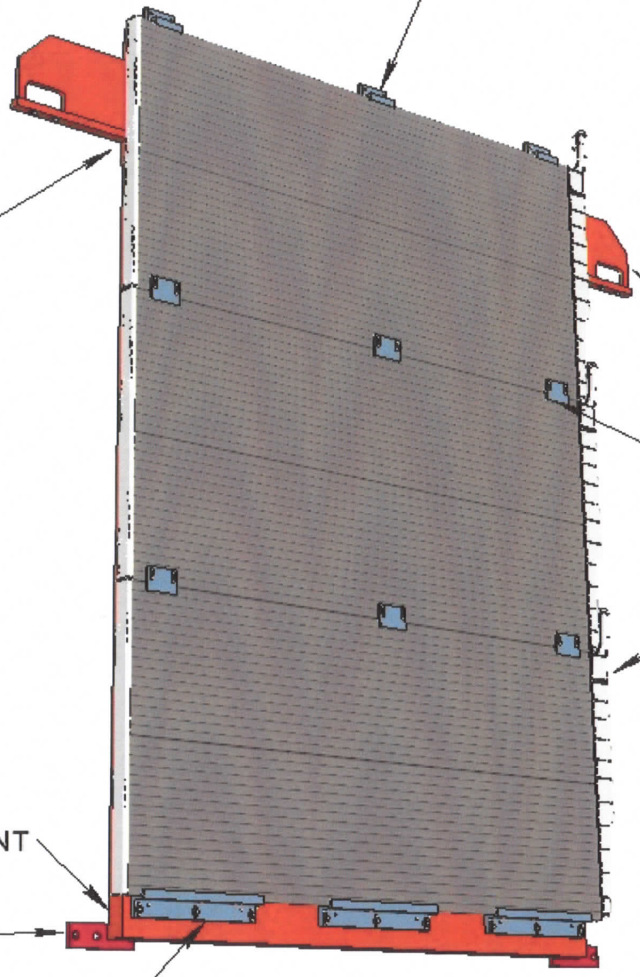
(3) BOTTOM CLIPS
SEE PAGE #10

WEIGHT

PVC----------514#
OIL----------1030
STEEL PLATE 4"----------19500
TOTAL-----21,044#

VERTICAL PLANE ASSY

PAGE #6

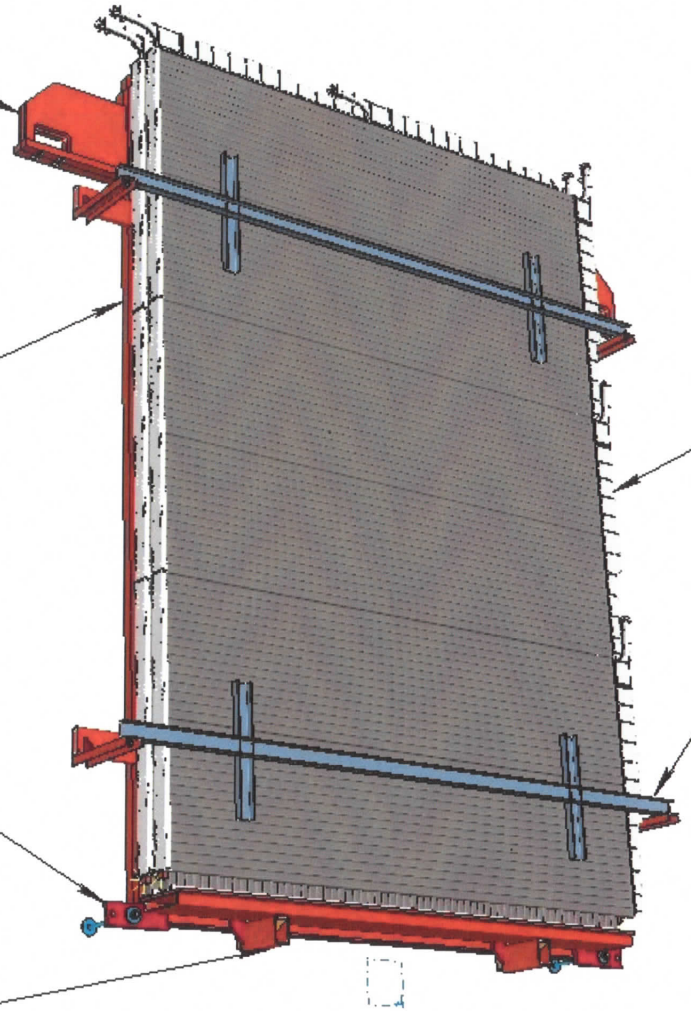


NOTE :
SEE PAGE # 6 FOR WELD CALCULATIONS PERTAINING TO SUPT LUGS

WEIGHT

PVC----------393#
OIL----------1,044
STEEL PLATE (4")-----19,500
TOTAL--21,044#

HORIZONTAL PLANE ASSY



WEIGHT

PVC----------1,814#
OIL----------4,148
STEEL PLATE (2")----------9,825
TOTAL------15,787#

BLOCK ASSEMBLY

I-DEAS 12 NX Series m2: I-DEAS Visualizer

BLOCK_PLATE_WELDMENT_FEM
12K_LOAD_PLUS_GRAVITY
STRESS Von Mises Averaged Top shell
Min: 2.97E+00 lbf/in^2 Max: 9.64E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.25E-02 in

MATERIAL : ASTM A36
Fvm = 0.6 X 36,000 = 21,600 PSI ALLOWED

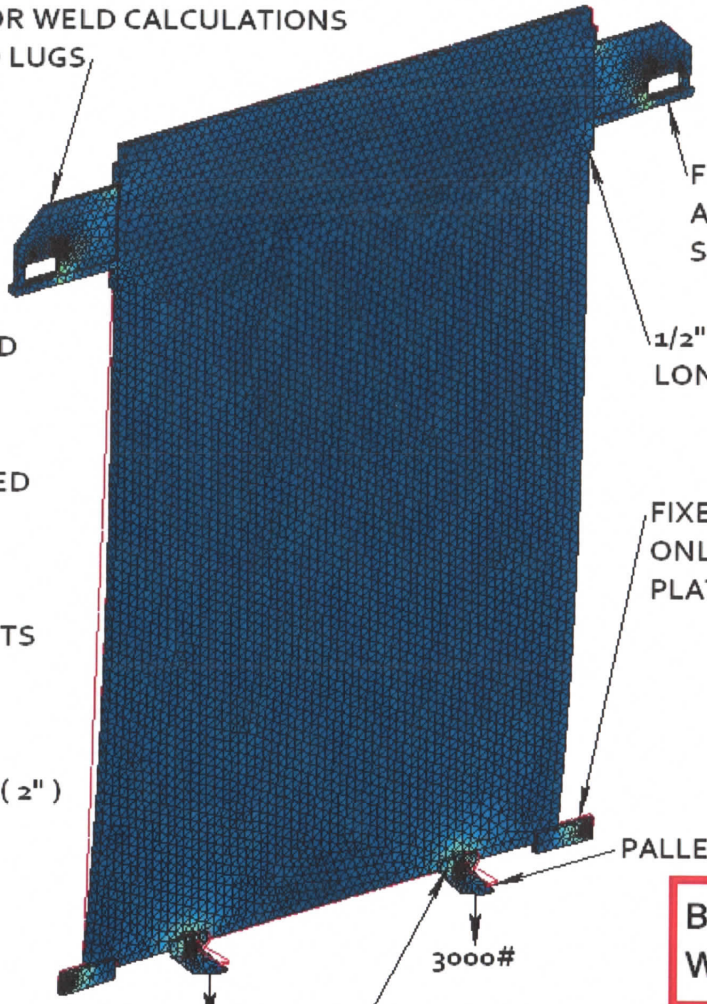
WELD ELECTRODES E60XX
Fv = 0.3 X 62,000 = 18,600 PSI
Fw = sin45 X 0.5 X Fv = 6576 #/IN ALLOWED

WELDS IN SHEAR AT BLOCK & PALLET SUPPORTS
fw = 3000/2/2 = 750#/IN < Fw

WELD SIZE REQUIRED AT BLOCK & PALLET SUPPORTS
w = fw/Fw = 750/6576 = .144"

1/2" WELD WAS USED TO CONFORMED WITH
HEAT DISTRIBUTION PRINCIPLE OF THICKER PLATE (2")

SPECIAL SUPPORT LUG
SEE PAGE #6 FOR WELD CALCULATIONS
PERTAINING TO LUGS



FIXED RESTRAINTS ON ALL PLANES FOR BOTH SUPPORT LUGS

1/2" GROOVE WELDS, 3" LONG 3 PER SIDE

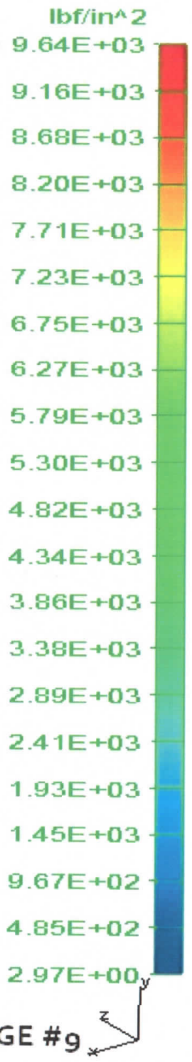
FIXED RESTRAINT ON Z ONLY FOR ANCHOR PLATES

PALLET & BLOCK SUPPORTS

3000#

3000#

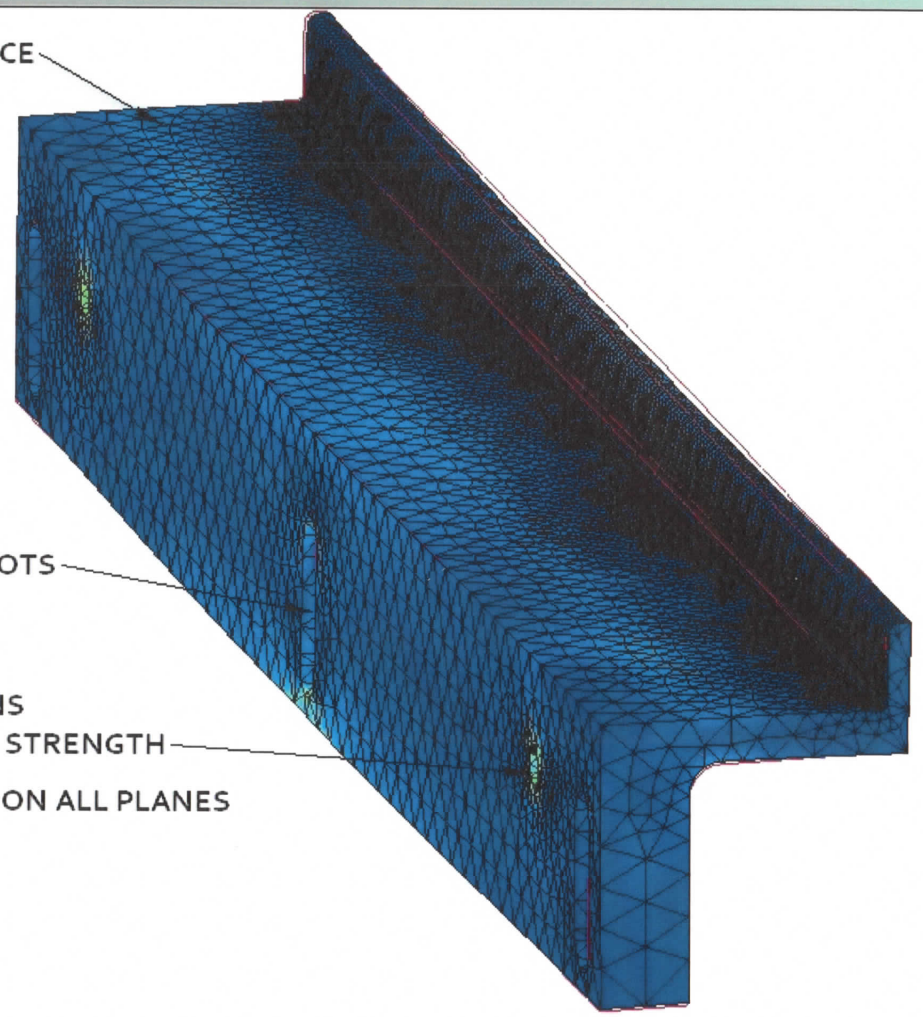
1/2" FILLET WELDS BOTH SIDES



BLOCK PLATE WELDMENT FEM

PAGE #9

I-DEAS 12 NX Series m2: I-DEAS Visualizer



CLIP_BOTT_VERT_FEM
775LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 1.95E-01 lbf/in^2 Max: 4.11E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.19E-03 in

MATERIAL : ALUMINUM 6061-T6

Fvm = .06 X 35,000 = 21,000 PSI
ALLOWED

lbf/in^2
Fvm > 4.11E+03
3.90E+03
3.69E+03
3.49E+03
3.28E+03
3.08E+03
2.87E+03
2.67E+03
2.46E+03
2.26E+03
2.05E+03
1.85E+03
1.64E+03
1.44E+03
1.23E+03
1.03E+03
8.21E+02
6.16E+02
4.11E+02
2.05E+02
1.95E-01

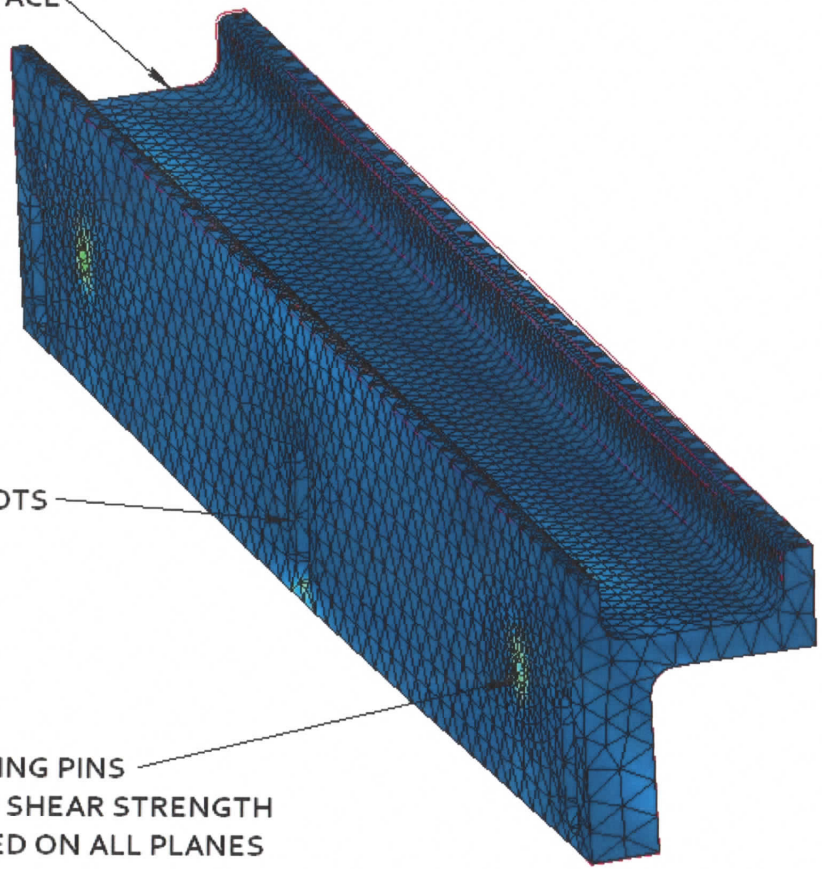
CLIP BOTTOM VERTICAL FEM

I-DEAS 12 NX Series m2: I-DEAS Visualizer

750# LOAD ON SURFACE

CLIP_BOTT_HORIZ_FEM
750LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 2.98E-01 lbf/in^2 Max: 4.46E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.31E-03 in

MATERIAL : ALUMINUM 6061-T6
Fvm = 0.6 X 35,000 = 21,000 PSI ALLOWED



(3) 1/2-13 SCREWS THOUGH SLOTS
RESTRAINED ON " Z " ONLY

(2) 3/8 SPRING PINS
17,600# SHEAR STRENGTH
RESTRAINED ON ALL PLANES

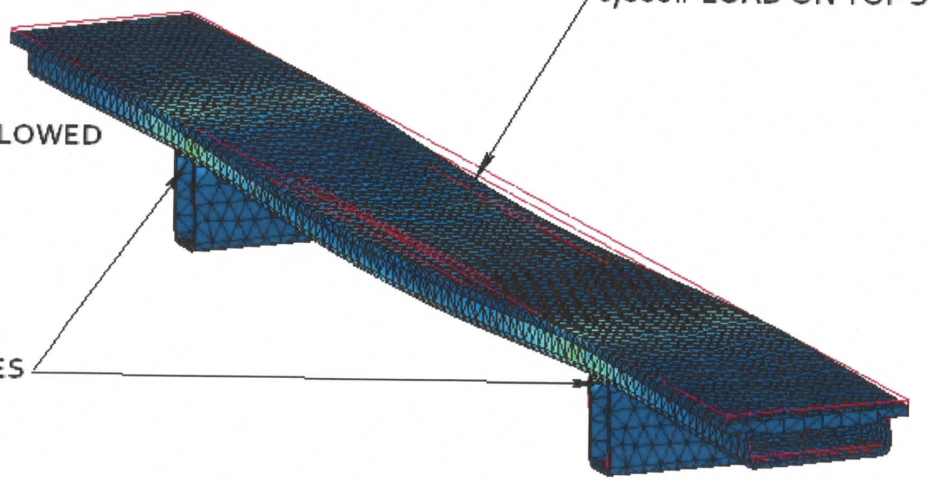
lbf/in^2
Fvm > 4.46E+03
4.24E+03
4.01E+03
3.79E+03
3.57E+03
3.34E+03
3.12E+03
2.90E+03
2.67E+03
2.45E+03
2.23E+03
2.01E+03
1.78E+03
1.56E+03
1.34E+03
1.11E+03
8.92E+02
6.69E+02
4.46E+02
2.23E+02
2.98E-01

CLIP BOTTOM HORIZONTAL

I-DEAS 12 NX Series m2: I-DEAS Visualizer

MUON_CATCHER_BLOCK_PALLET_FEM
6000LB_LOAD_2-RESTRAINTS
STRESS Von Mises Averaged Top shell
Min: 1.65E+00 lbf/in^2 Max: 1.17E+04 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 1.78E-02 in

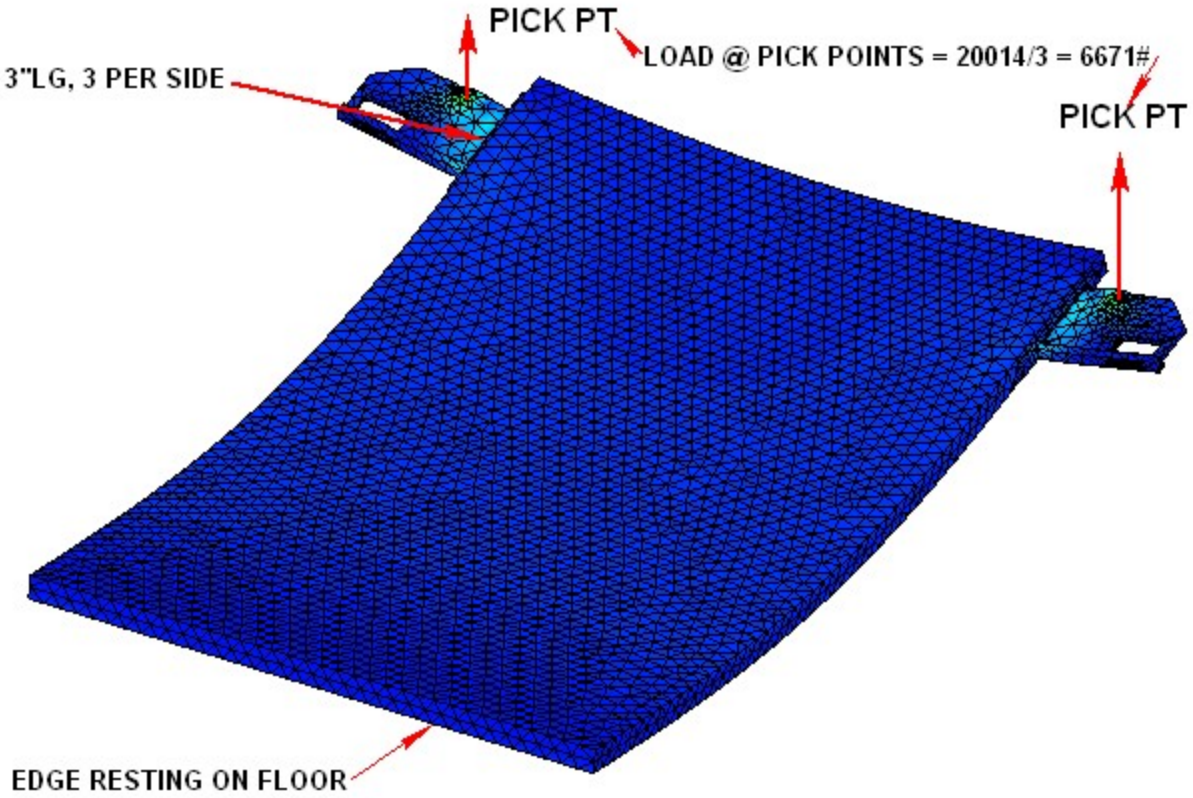
MATERIAL : ASTM A36 STEEL
Fvm = 0.6 X 36,000 = 21,600 PSI ALLOWED

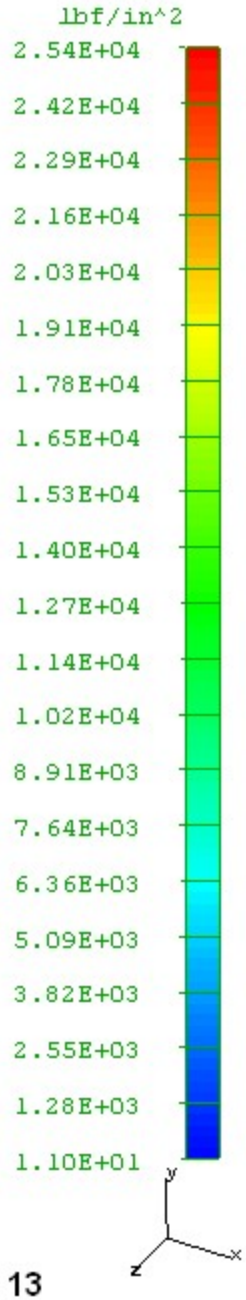


lbf/in^2
Fvm > 1.17E+04
1.11E+04
1.05E+04
9.91E+03
9.33E+03
8.75E+03
8.16E+03
7.58E+03
7.00E+03
6.42E+03
5.83E+03
5.25E+03
4.67E+03
4.08E+03
3.50E+03
2.92E+03
2.33E+03
1.75E+03
1.17E+03
5.85E+02
1.65E+00

MUON CATCHER BLOCK PALLET
ATTACHED TO 2" STEEL PLATE AND
BLOCK IS FILLED WITH OIL

I-DEAS Visualizer
MUON_CATCHER_VERT_SUPT_WLDNT_FEM
GRAVITY_PLUS_PVC_HORIZ_PICK
STRESS Von Mises Averaged Top shell
Min: 1.47E+01 lbf/in^2 Max: 2.54E+04 lbf/in^2
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 5.52E-02 in





USE WELD ELECTODES E60XX

Fv = 0.3 x 62,000 = 18,600 PSI ALLOWED

Fw = SIN45x0.5xFv = 6,576 3/IN ALLOWED

WELD IN SHEAR

fw = 20014/2x2x3X3 = 556 #/IN < Fw

WELD IN BENDING

fw = M/Sw = 3336 #/IN < Fw

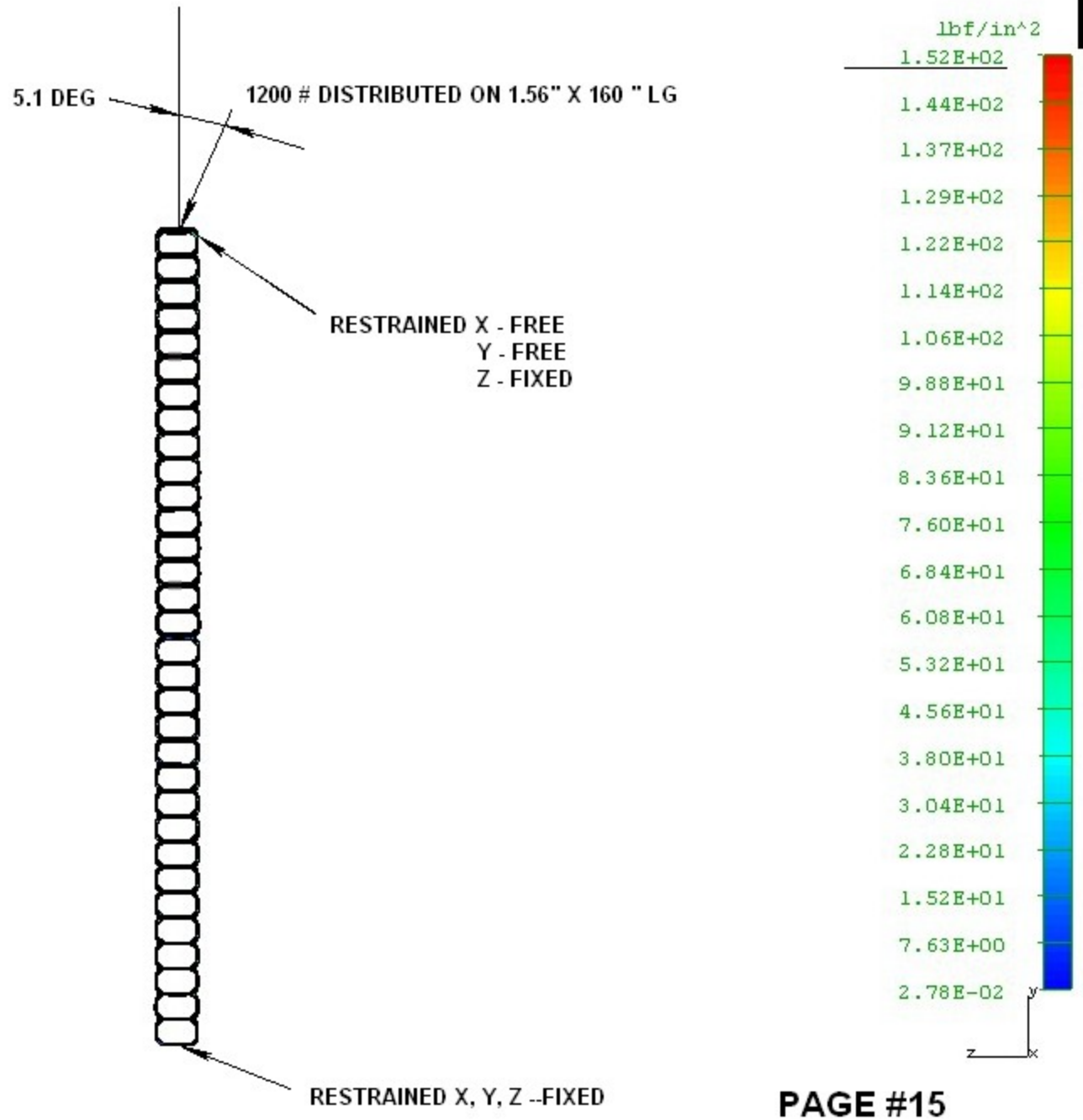
WHERE SECTION MODULUS OF WELD = (3x3)2 = 18
MOMENT = 9" X 6671 = 60039 IN-LBS
9" IS DISTANCE OF PICK HOLE TO
TO BASE OF BRACKET

WEIGHT

PVC----------514#
STEEL PLATE 4"-----19500
TOTAL------20014#

VERTICAL PLANE ASSY
HORIZ PICK

I-DEAS Visualizer
IPND_16_CELL_HORIZ_GLUED_EXTRUSION_FEM
1200_LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 2.78E-02 lbf/in^2 Max: 1.52E+02 lbf/in^2
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 6.24E-03 in

MATERIAL: POLYVINYL CHLORIDE

YIELD STRENGTH ----------8350 PSI