DØ ENGINEERING NOTE

#3740.214-EN-149

MFH SHIPPING BOX

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MARCH 31, 1988

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Manufacturing Sciences Corporation has designed a shipping box for the MFH uranium plates to be used in the DØ detector. The following page shows the drawing they provided on the final design.

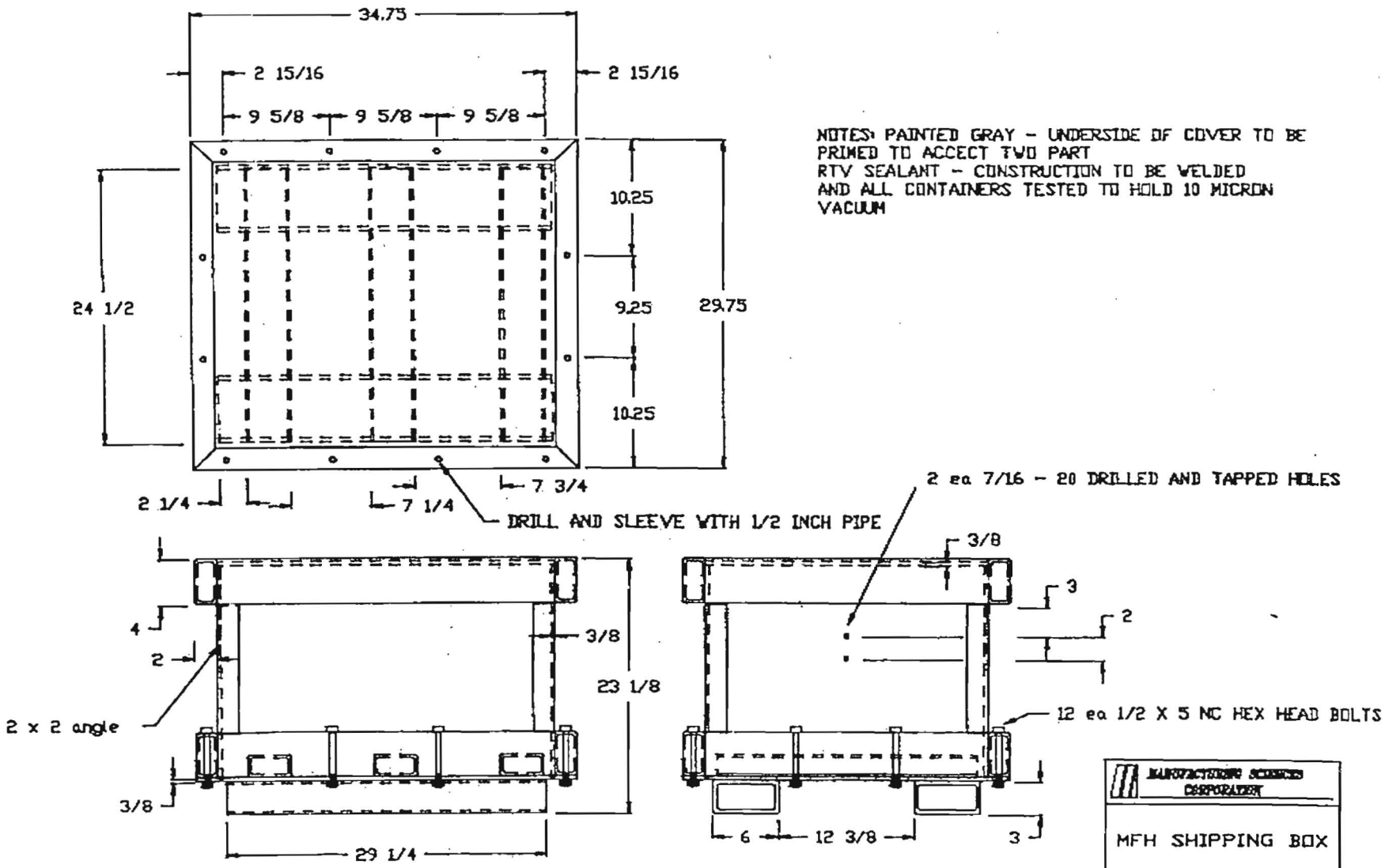
CONSTRUCTION

The material used is to be A-36 carbon steel or better with 3/8" plates to be used for the walls, top and base. The top and bottom of the walls are reinforced with 4"x2"x1/4" rectangular tubing running around the parimeter of the box, as shown. For vertical reinforcement, 2"X2" angles are used at the four wall corners between the upper and lower rectangular tubing. The structure rests on two 6"x3"x3/16" rectangular tubes running approximately the length of the box. The box is bolted (sealed) at the base, as shown, and welded according to the attached diagram.

The boxes will be tested to hold a vacuum on the order of 10 microns. The welds should be made as air tight as possible and a gasket material is used to seal the bolted interface between the base plate and the top cover assembly. The gasket material chosen for this application is Gasket Eliminator 518 Instant Seal manufactured by Loctite Corporation. Ernie Ramirez of the Cryogenic Systems Department tested this material and found no leaks in both the vacuum test and the pressure test (18 psig).

LOADING

Each of these shipping boxes will contain a 5000 lb. load of uranium plates. The weight of each box alone is approximately 700 lbs. (steel vol. $\simeq$ 2450 cu.-in.; Dens=0.283 lbs/cu.-in.)

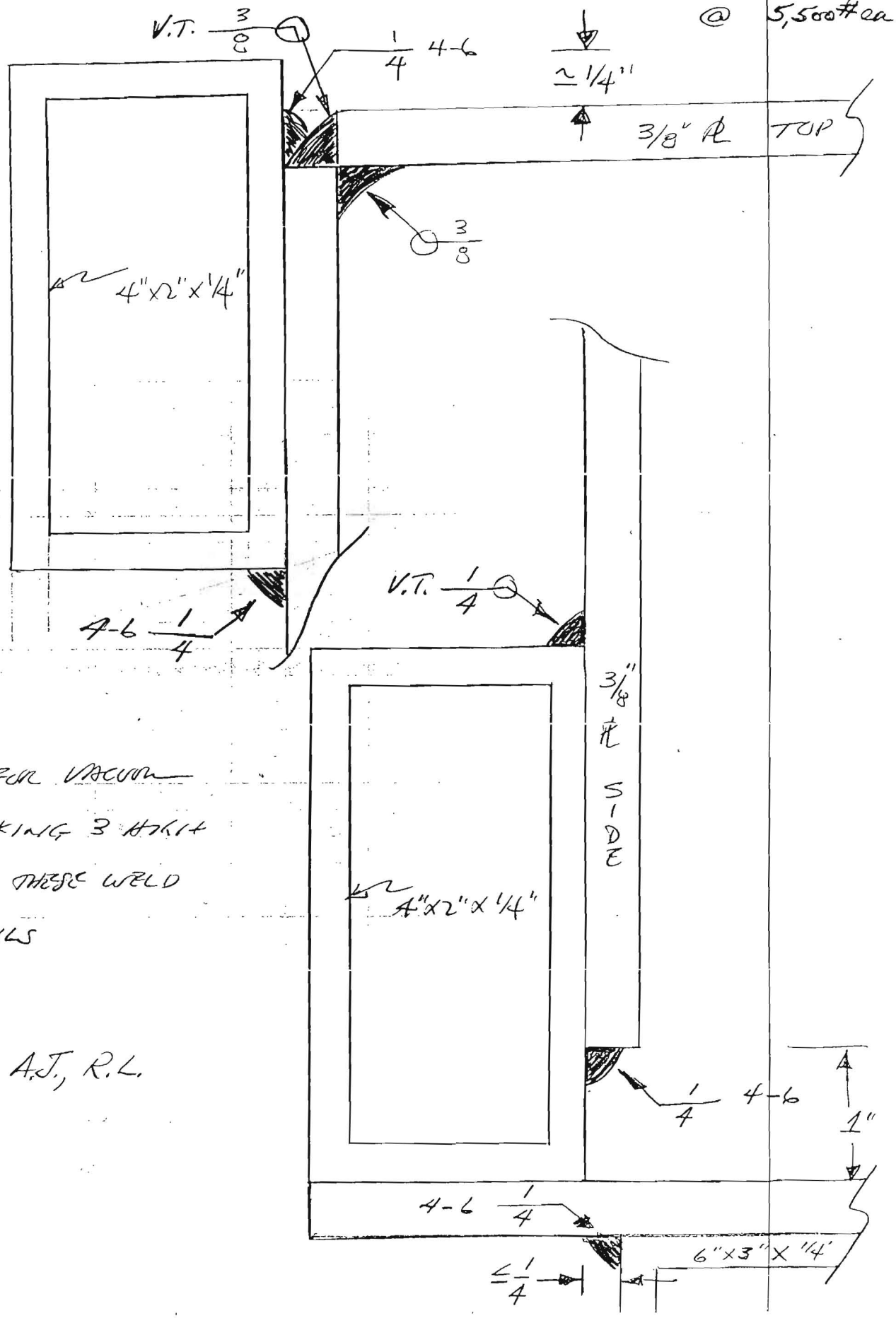


NOTES: PAINTED GRAY - UNDERSIDE OF COVER TO BE PRIMED TO ACCECT TWO PART RTV SEALANT - CONSTRUCTION TO BE WELDED AND ALL CONTAINERS TESTED TO HOLD 10 MICRON VACUUM

MANUFACTURING SCIENCES CORPORATION	
MFH SHIPPING BOX	
DWG NO. 8803	DRAWN BY MRL
REV A	DATE 1/26/88

FAX TO MIKE LUNDBERG

MSC MFH SHIPPING BOX – V.T., STACKABLE 3 HIGH @ 5,500# ea



O.K. FOR VACUUM + STACKING 3 HIGH WITH THESE WELD DETAILS

X.C. A.J., R.L.

Once loaded with the uranium plates, the shipping boxes are to be stacked 3 high and although not intended to be vacuum loaded while stacked, should be able to withstand an accidental vacuum loading. The total deadweight load on the top plate of the lower box is approximately 11400 lbs. (two 5000 lb. loads of plates and two 700 lb. boxes). This load is essentially applied through the four outermost corners of the two 6"x3"x3/16" rectangular bottom supports.

The worst possible loading case would be an accidental vacuum load being placed on the lowest box in a 3 high configuration. With a surface area of 750 sq.-in. (30"x25"), the top plate would experience a total pressure load of approximately 11250 lbs. (P (atm)=15 psi). The total load on the bottom box top plate due to the four point load of the upper boxes and it's own vacuum loading would then be 22650 lbs.

STRESS ANALYSIS

Using this total of 22650 lbs., the compression and shear stresses in the plates are found to be insignificant (<1000 psi). Even with stress concentration in the corners, the 3/8" thick steel plates have more than sufficient strength.

The bending stresses, however, proved to be rather significant at the middle of the 4 edges of the top plate. Documentation is scarce, if any, for point loading on a flat rectangular plate, but adequate information is found on flat rectangular plates under uniform pressure loads. The following equation is given for this situation in Raymond J. Roark's Formulas for Stress and Strain; 5th edition; p. 392, table 26, case #8a.

$$\text{Max "bending stress"} = \frac{-B_1 q b^2}{T^2}$$

a = 30 in. (long edge)
b = 25 in. (short edge)
B_1= 0.3834 (a/b = 1.2)
q = 15 psi (load)
t = 0.375 (plate thickness)

This yields a bending stress of 25560 psi at the midpoint of the long edge of the top plate.

Taking into account that the weight of the upper boxes is applied near or at the corners of the top plate, the corresponding small bending moment would be concentrated at the corner elements of the top plate. Thus the deadweight load would not significantly increase the high bending stresses found at the midpoints of the plate edges.

To provide more validity to this assumption, an ANSYS program was run to simulate this combination loading on a flat, fixed rectangular plate. A quarter of the plate was modeled due to symmetry. A plot of the model, showing element pressure and the point load due to the upper boxes, is included at the end of this report. Once again, the maximum stress was found at the midpoint of the long edge. The ANSYS value for this bending stress was 21042 psi.

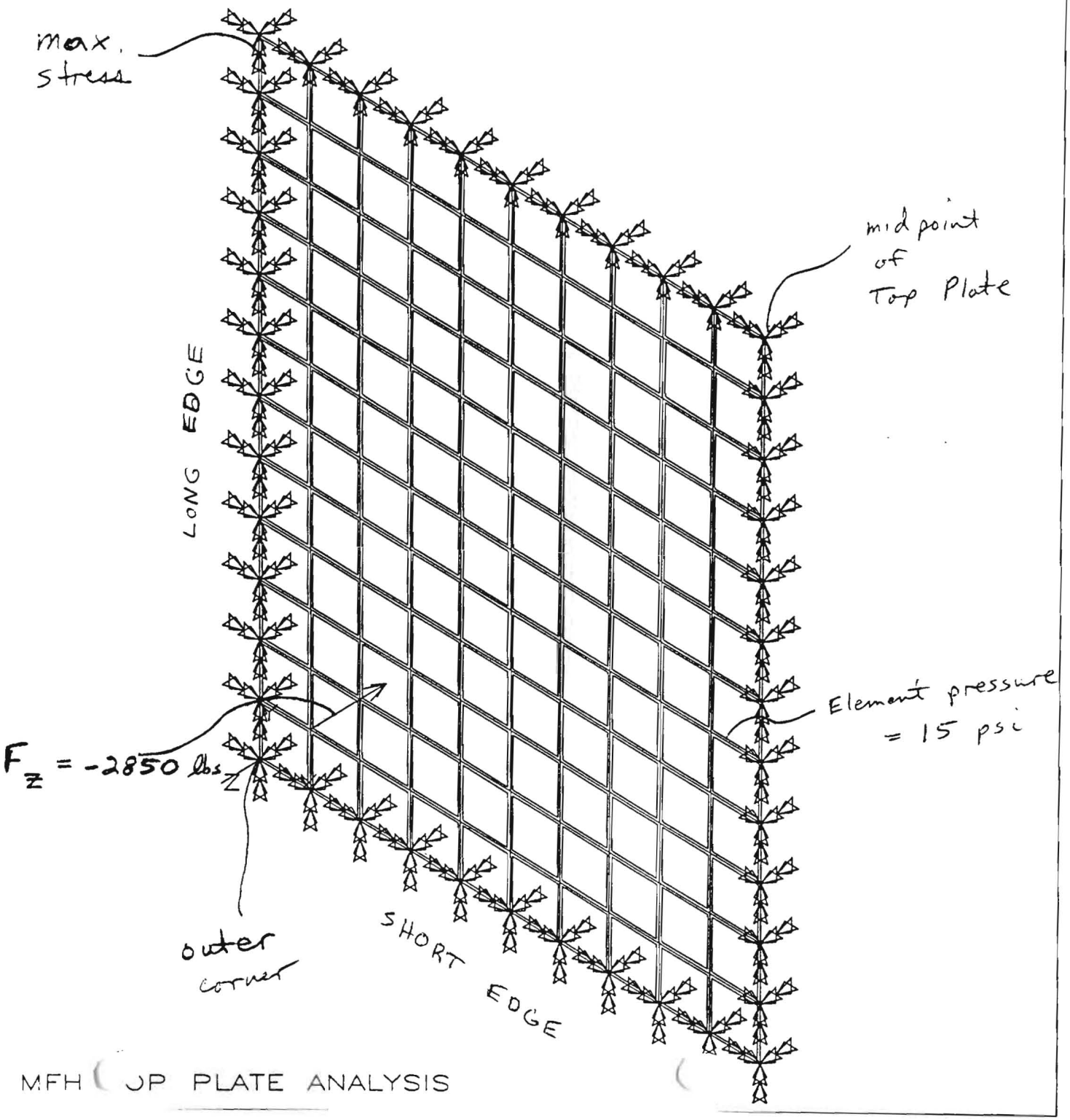
To determine what portion of this is due to the point loading, the element pressure was removed and the result was a bending stress of essentially zero (<10 psi). In this case the higher bending stresses were found near the corner (≃ 5000 psi), just as assumed.

CONCLUSIONS

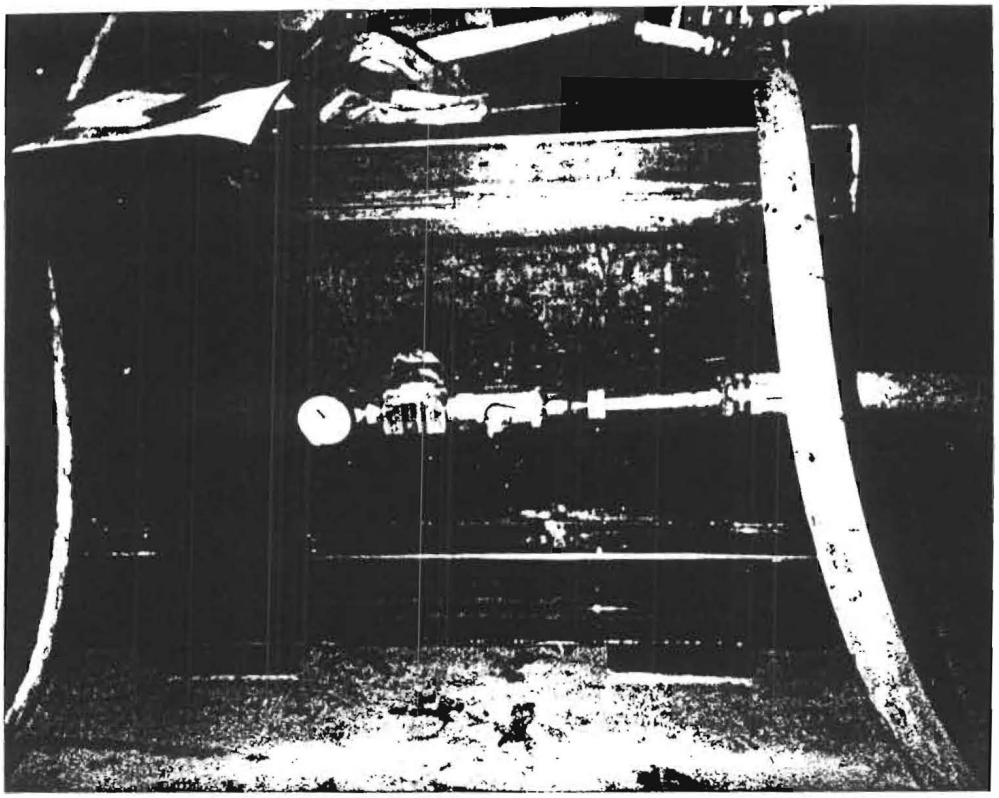
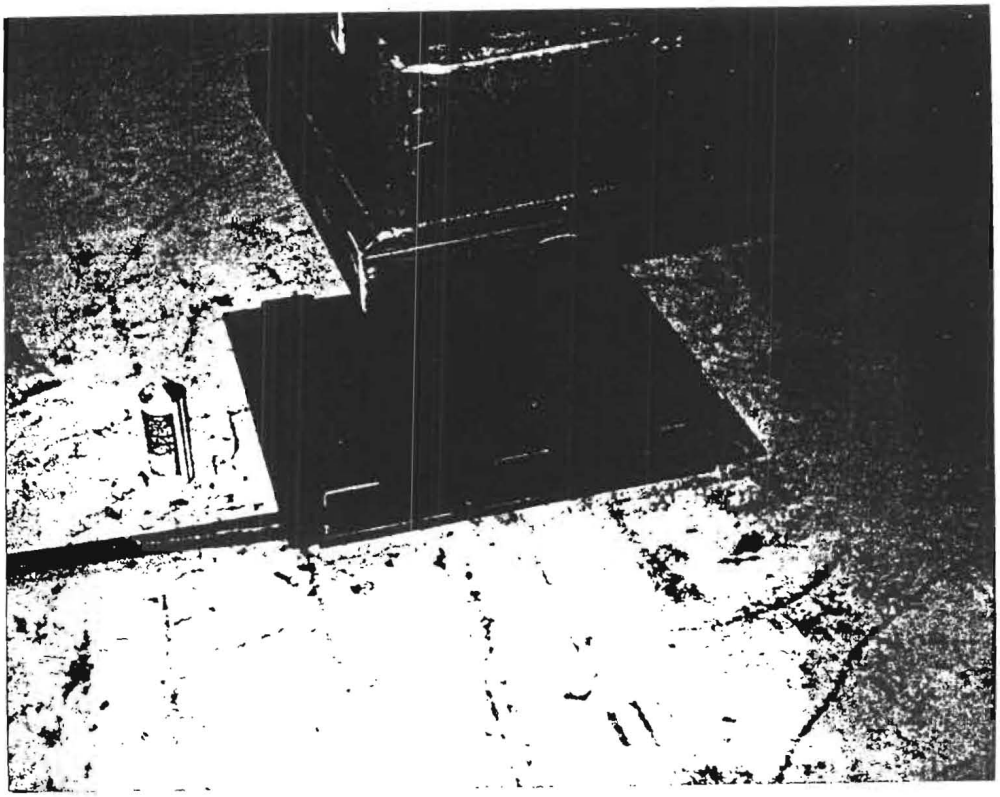
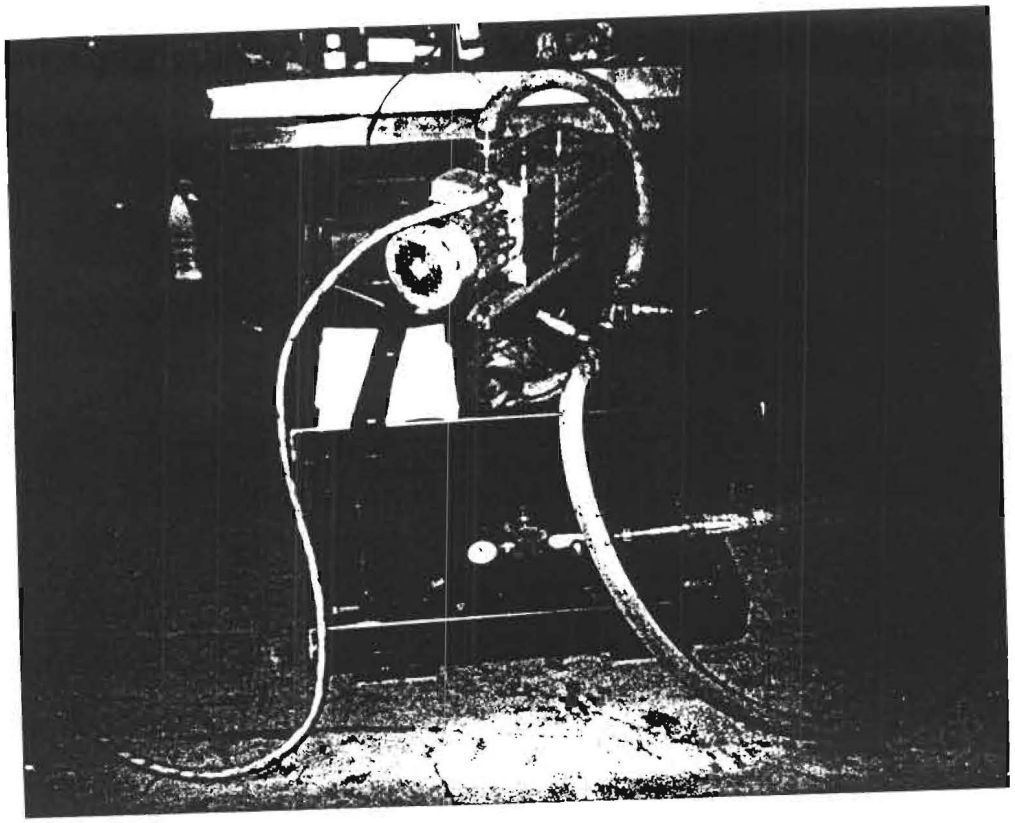
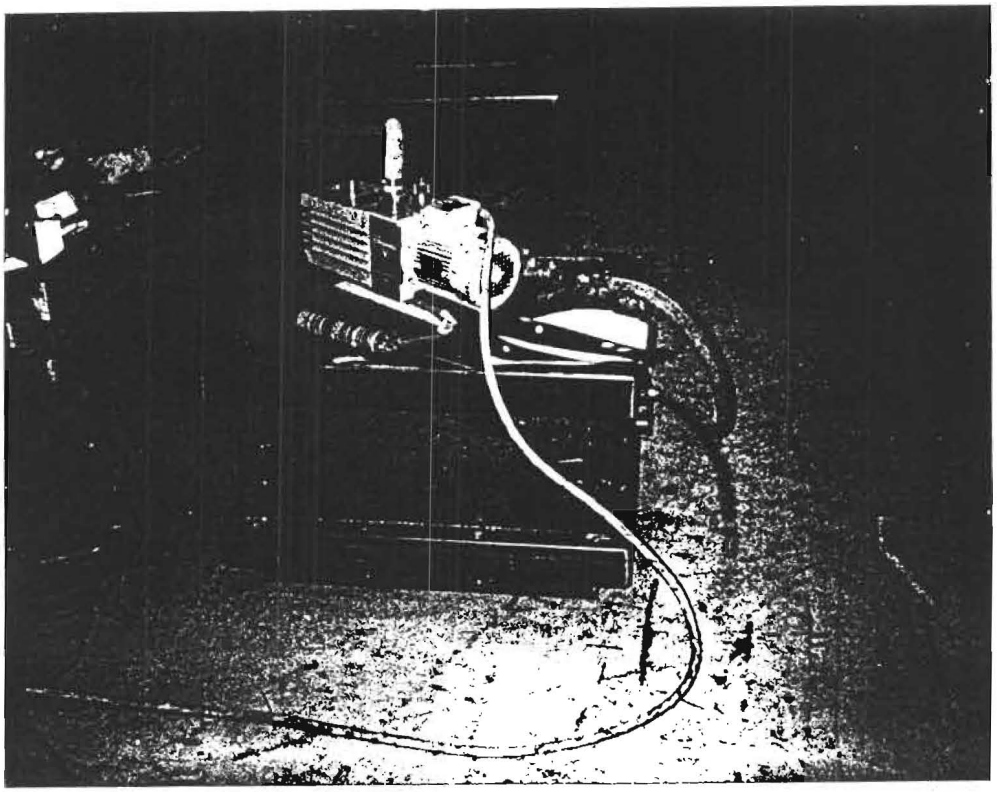
For these calculations, the upper limit of allowable stress was defined as 75% of the yeild strength of A-36 carbon steel (36000 psi) which is 27000 psi. Taking the maximum bending stress value (Roark equ.) of 25560 psi and increasing it by the shear and compression stress values (< 1000 psi) would still leave the total stress at the midpoint of the long edge below the allowable 27000 psi.

The M.S.C. MFH shipping box has thus theoretically been deemed structurally sufficient to withstand the worst case loading without

structural failure. Copies of snapshots of the completed box undergoing leak tests are included at the end of this report.



ANSYS 4.3
MAR 11 1988
13:10:47
PLOT NO. 3
PREP7 ELEMENTS
RDIS BC
TDIS BC
FORC BC
PRES BC

ORIG
XV=1
YV=1
ZV=1
DIST=9.54
XF=6.25
YF=7.5
MX=15
MN=15
NCON=18
VMIN=15

MFH TOP PLATE ANALYSIS