Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-098 Date: March 1, 2006

Project Internal Reference:

Project: Coupp

Title: Coupp Veto Support Analysis

Author(s): C. M. Lei

Reviewer(s): 3-1-06

Key Words: Coupp, veto, support, analysis

Abstract Summary: A double wall scintillator enclosure was needed for the COUPP bubble chamber experiment. Two mobile L-shape wall assemblies together with a top assembly were designed and made.

Applicable Codes:

COUPP Veto Support Analysis

PPD/MD Eng Note 098

C. M. Lei
PPD/MD

January 18, 2006

(I) The Design

A double wall scintillator enclosure is needed for the COUPP bubble chamber experiment. Existing scintillator counters that had been used previously for KTeV experiment are planned to be re-used. The typical dimensions of this counter are as shown in Figure 1. The top part is the scintillator and the bottom part is the PhotoMultiplier Tube (PMT). In between, it is the wedge-form light guide and support is preferred to be made here.

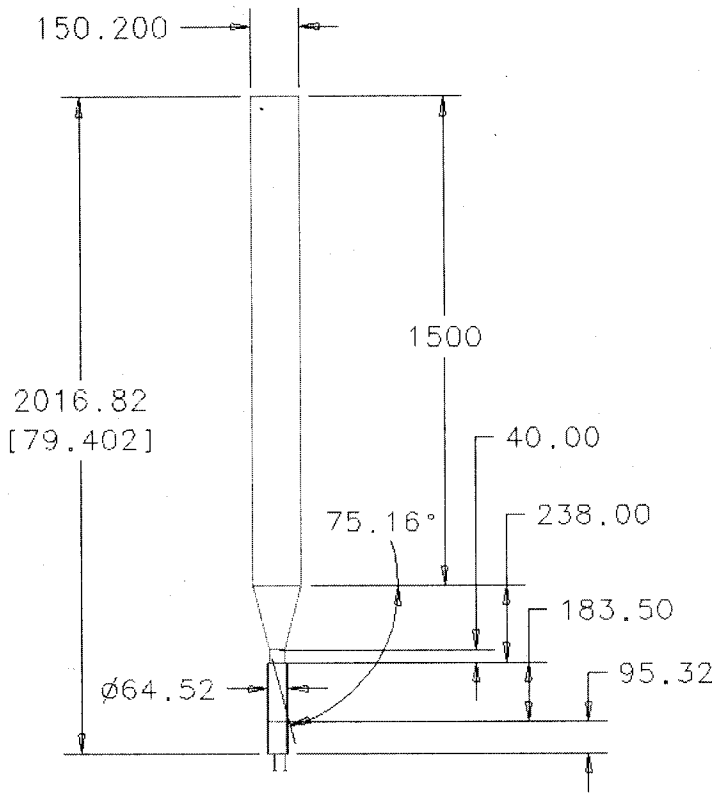

Figure 1. The Measured Dimensions of the Existing Counter

It is found that a 2-inch thick plastic as an absorbing material for background neutrons is needed in between the double-wall scintillator counter panels Two pieces of 1-inch thick high density polyethylene (HDPE) are thus inserted and they are used as the structural walls as well.

Aluminum end caps are added to enhance the rigidity of the whole structure. To facilitate the ease of installation and maintenance, two L assemblies consisting of such double walls and working as clamp-shells are designed. Swivel casters are provided underneath to facilitate the ease of moving. Also, lifting blocks are also provided on the top and they are weld and hidden behind the aluminum end cap. The design of this L assembly can be shown in Figure 2 in which counters inner and outer are all mounted on the HDPE walls. The existing bubble chamber, which is not shown in this figure, will be housed at the center of these two identical L-assemblies.

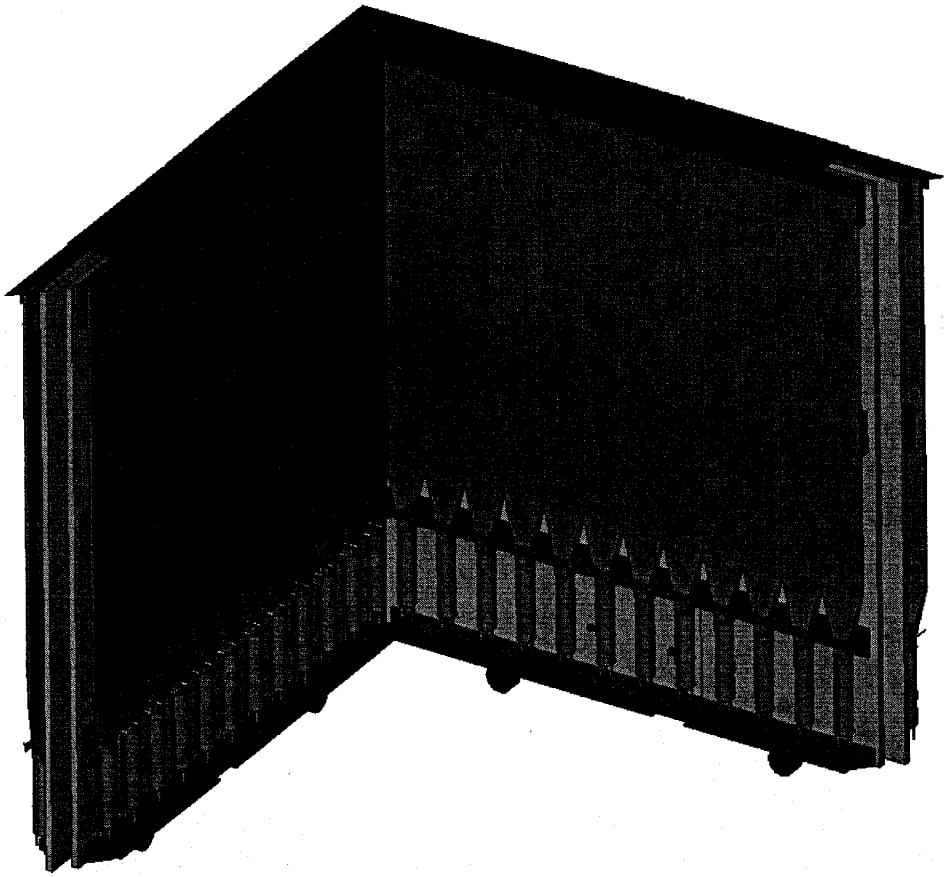

Figure 2. The Design of the L-assembly Counters

To cover the bubble chamber on top, another two layers of counters are added and laid horizontally. They are basically supported by a welded steel frame made of unistruts, box and angle beams. In between, two pieces of 1-inch thick HDPE are laid. Since the glued joint of the counter is quite brittle, over constraint on these counters has to be avoided and these panels are simply just stacking on each other except the top layer of counters in which gentle clamping is applied at the end of the light guide. For the same reason, excessive deflection of the loaded steel frame is not allowed. With the aid of Finite Element Analysis (FEA), it was found that the most dangerous process was happened when this top assembly was being lifted during the installation. To minimize this deflection, twelve lifting spots are thus provided. In addition, rubber strips which act as cushion for the counters are glued on the steel frame. The design of this steel frame without any HDPE panels and counters on top is shown in Figure 3 and its

corresponding FEA is shown in Figure 4 in which the result of maximum displacement is about 1/8".

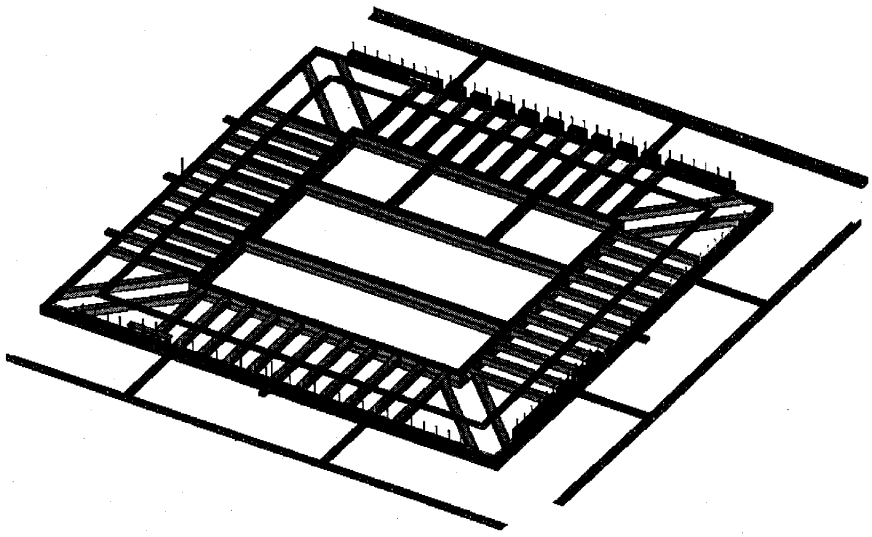

Figure 3. The Design of the Top Panel Steel Frame

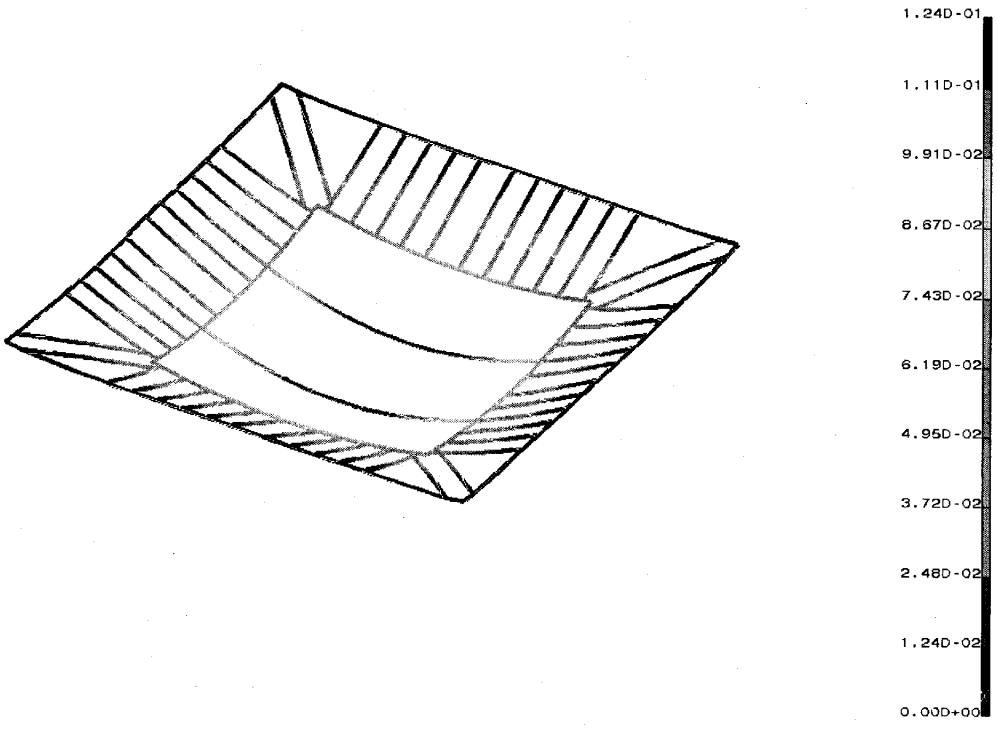

Figure 4. FEA Displacement Result

The complete assembly with all counters mounted is shown in Figure 5. To prevent the counters moving around in case the top panel is tilt while being lift, capturing members are added on top and sides as shown in this figure.

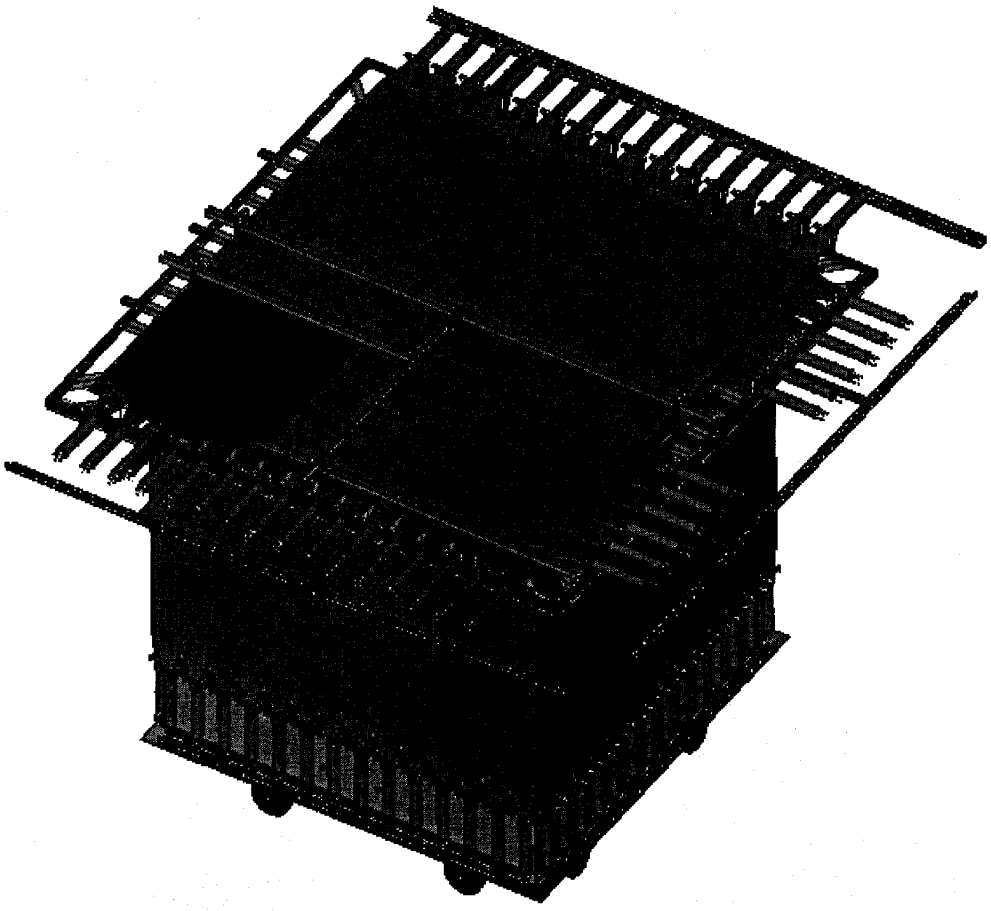

Figure 5. The Complete Assembly of the Veto Counter System

(II) Allowable Stress Calculations

The following spots of interest were calculated in order to make sure the design is safe:

1. Stress at lifting spots when the L assembly is being lifted

   Three lifting spots in which ½-13 steel insert is embedded are provided for lifting the L assembly. The total weight of the assembly with counters is about 3,300 lbs.

   Tensile force, P, on each threaded insert = 3,300/3
   = 1,100 lbs

   The tensile stress area of the 1/2-13 thread, A_t = 0.1419 in^2.

   Tensile stress, S_t = 1,100/0.1419
   = 7,750 psi

The minimum tensile strength of steel insert = 70,000 psi. With a safety factor of 3 in tensile,

The allowable stress = 23,330 psi > 7,750 psi .. OK.

Pivot and swivel hoist ring will be used to attach to the insert. For ½-13 hoist ring, the limiting load capacity is 2,500 lbs > 1,100 lbs...OK.

2. Weld around 1.5"x0.75"x0.083" thick steel tubing

Unit throat approach was used.

The total weight of whole top panels with all counters and parts = 1,520 lbs, and this load will be shared by twelve lifting lugs in order to minimize the panel deflection.

Shear load, P, on each lifting lug = 1,520/6
= 260 lbs

By conservative assumption, the lifting contact line is 2" from the weldment plane, the generated moment, M, on the weld = 260*2
= 520 in-lbs

Total weld length, L = 2*(1.5"+0.75")
= 4.5"

Moment of Inertia of weld, I = summation of $(b*d^3/12 + A*z2)$
= $(2*1*0.75^3/12) + (2*1*1.5*0.375^2)$
= 0.4922 $inches^4$

The resultant stress, $S_{R,}$ on the weld is the vector sum of direct shear stress and moment stress. i.e.

$S_{R,}$ = $SQRT((P/L)^2 + (M*c/I)^2)$
= $SQRT((130/4.5)^2 + (520*0.375/0.4922)^2)$
= 397 psi

The allowable stress, $S_{A,}$ of the weld is 14,400 psi.

The minimum leg dimension of weld = $S_R/(0.707* S_A)$
= 397/(.707*14,400)
= 0.04" << 0.09".....OK

3. The load capacity of the casters
The weight of the complete system including the L assemblies, the top panel with all the HDPE panels and counters is about 6,800 lbs. This load will be shared by six casters with load capacity 1,400 lbs.

Load on caster, P, = 6,800/6
= 1,130 lbs < 1,400…OK

(III) Conclusion

The COUPP design was completed and was safe to move round and lifted.