Engineering Note
for
E906 Detector Assembly

PROJECT: E906

TITLE: Station 3-Plus Drift Chamber

AUTHOR: Tom O'Connor – Argonne National Laboratory

DATE: April 8, 2011

REVIEWER(S): Kevin Bailey – Argonne National Laboratory

ABSTRACT: This document describes an I-beam framework which will be attached to a drift chamber and hung in the E906 beamline.

DESIGN:
The Station 3-Plus drift chamber was designed and built by the Tokyo Institute of Technology. The weight of this chamber is approximately 770 pounds. There are two aluminum hanger blocks attached to the top of this chamber which will be bolted to a turnbuckle and I-beam assembly shown in Figure 1. The entire package will be inserted into the beamline by resting the ends of the bottom surface of the aforementioned I-beam (S8 x 6.35) onto the top surface of a pair of cantilevered steel I-beams that are part of an existing structure in the experimental hall.

ANALYSIS:
The drift chamber and I-beam assembly from Figure 1 will be inserted into the beamline by wrapping slings around the I-beam and using the crane in NM4. The hanger block, turnbuckle, I-beam and all the fasteners must be strong enough to hang vertically for the duration of the experiment. Each of these components is analyzed separately as follows:

Hanger Block:
The hanger blocks are attached to the drift chamber frame using eight (8) 3/8-16 bolts. See Figure 1, Detail A. The load on each hanger block is 385-lbs. Therefore the load on each of the 3/8-16 bolt is 48.125-lbs. These bolts are always in shear. With a minor diameter of 0.2970" and an area of 0.069-in^2, the resulting shear stress in each 3/8-16 bolt is roughly 697.5psi. Grade 5 bolts with yield strength of 92ksi (per SAE J429) are readily available. Assuming shear strength is 60% of yield strength results in shear strength of 55ksi which is far in excess of these expected actual values. These same hanger blocks are attached to the turnbuckle assembly using a single ¾-10 bolt, in shear. The load on each of these ¾-10 bolts is 385-lbs. With a minor diameter of 0.6255" and an area of 0.307-in^2, the resulting shear stress in each 3/4-10 bolt is roughly 1254psi which is also acceptable for Grade 5 fasteners per SAE J429.

Turnbuckle Assembly:
They turnbuckles are purchased from McMaster Carr (part number 3022T54) and have a certified work load limit of 2,200 pounds. The actual load on each turnbuckle is only 385 pounds and is well below this limit.

I-Beam:
The chamber and turnbuckle are attached to the aluminum I beam using four (4) 3/8-16 bolts. See Figure 1, Detail B. The load on each connection is 385-lbs. Therefore the load on each of the 3/8-16 bolts is 96.25-lbs. These bolts are always in tension. With a tensile stress area of 0.0774-in^2 each of these bolts experience a tensile stress of 1244psi, which is acceptable for Grade 5 fasteners.

The chamber assembly will be inserted into the beam line by resting the ends of the bottom surface of the aluminum I-beam onto the top surface of a pair of cantilevered steel I-beams that beams that are part of an existing structure in the experimental hall. Once in place this aluminum I-beam will experience stress and deflection from the weight of the drift chamber. If treated as a beam supported on both ends subject to concentrated

identical loads equidistant from center then the stress and deflection of the I-beam can be calculated using standard formulas:

Stress at center of constant cross section: $s = \frac{-Wa}{Z}$ **(1)**

Maximum deflection at center: $y = \frac{Wa}{24EI}(3L^2 - 4a^2)$ **(2)**

Where: W is the weight of each load (385-lb)
L is the length of the beam(180 inches)
a is the distance from the end to the load (41.4 inches)
I is the moment of inertia of S8x6.35 beam ($57.6in^4$)
Z is the section modulus
E is the modulus of elasticity of aluminum (10.2e6psi)

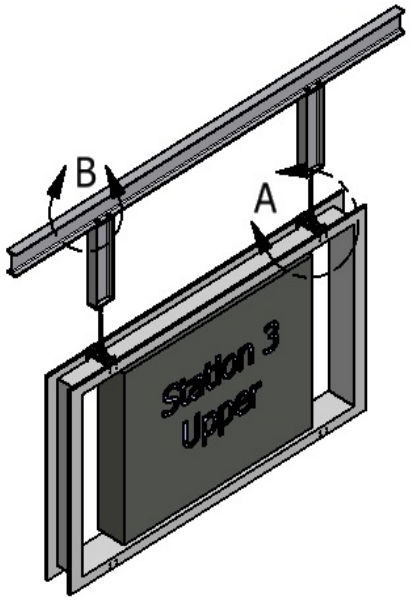
Substituting the values from Table 1 into equation (1) yields:

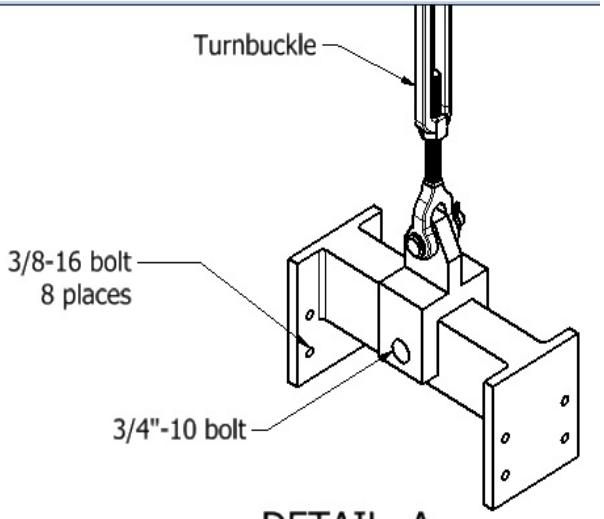
$$s = -\frac{385lb \times 41.4in}{\left(57.6in^4 \big/ 4in\right)} = -1106.9lb/in^2$$

Likewise, substituting the values into equation (2) yields:

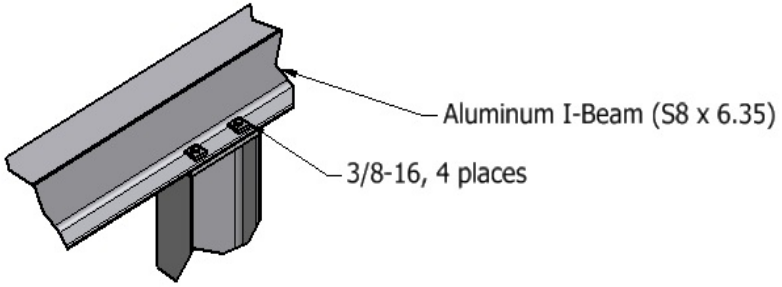
$$y = \frac{1}{24}\left[\frac{385lb \times (41.4in)}{10.2e6psi \times 57.6in^4}\right]\left[3(180in)^2 - 4(41.4in)^2\right] = 0.102in$$

The bending stress of 1106.9 psi and deflection of 0.102-in of the S8x6.35 I-beam are not a cause for concern.





DETAIL A
Turnbuckle and Hanger



DETAIL B
I-beam Connection