



Fermilab

**Particle Physics Division
Mechanical Department Engineering Note**

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Title: Fall Protection safety tie off anchor sizing in Wideband laboratory.

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Abstract Summary:

Fall Protection to be used at Wideband requires an adequately sized tie off anchors. Existing structure has embedded unistrut located in the wall. This engineering note details the connection between the hook on the fall protection lanyard and embedded unistrut required to meet the 5000 pound capacity anchor load rating required by OSHA

Applicable Codes: OSHA 1910.66

Discussion:

OSHA 1910.66 says: "Anchorages to which personal fall arrest equipment is attached shall be capable of supporting at least 5,000 pounds (22.2 kN) per employee attached, or shall be designed, installed, and used as part of a complete personal fall arrest system

which maintains a safety factor of at least two, under the supervision of a qualified person”

And:

“(2) The anchorage should be rigid, and should not have a deflection greater than .04 inches (1 mm) when a force of 2,250 pounds (10 kN) is applied.”

Unistrut makes a product designed to be embedded in cast-in-place concrete. Fermilab standard is to use minimum 8 foot lengths of Unistrut channel number P 3270 embedded in the vertical orientation in cast in place concrete walls. This channel has a maximum allowable point load of 2000 pounds with a minimum spacing of 12 inches between point loads.

Hook for the commercial fall protection restraint lanyard requires a minimum 3/4 inch diameter hole in order to close the safety clip.

To get a 5000 pound capacity requires distributing the load along the length of the embedded Unistrut for a distance of approximately three feet. Three (3) feet at 2000 pound per foot give a capacity of 6000 pounds.

1/2 - 13 fasteners are typically used to connect to the Unistrut. The allowable pull out strength listed in the Unistrut catalog is 2000 pounds each. But since the direction of the load is parallel to the direction of the embedded unistrut, the slip load governs. Allowable slip load is 1500 pounds. Therefore, four (4) 1/2-13 fasteners are needed to achieve a capacity in excess of 5000 pounds. Four fasteners at 1500 pounds each give 6000 pounds capacity.

Use an aluminum angle, minimum size of 2 1/2” by 2 1/2” by 3/8”, 42 inch overall length. Locate four (4) 9/16” diameter holes for 1/2-13 bolts 12 inches on center and 3 inches from one end.

On the angle leg that will be perpendicular to the wall, drill one hole, one inch in diameter centered on the face of the leg, twenty-four (24) inches from one end. Shear stress due to a 5000 pound load applied normal to the wall surface is given by: $\tau = P/A = 5000 \text{ pounds} / 2 * 3/8 * 1 = 6274 \text{ psi}$. Allowable load is 0.4 Fy. Assume 6061-T6 material with Fy = 40,000 psi. Allowable shear stress is 0.4 * 40,000 psi = 16,000 psi. 16,000 psi exceeds the actual shear stress, so this angle has adequate block tear-out strength.

Because the applied load will be largely be vertical and in the down direction, the shear stress with a 5000 pound load applied vertically is given by: $\tau = P/A = 5000 \text{ pounds} / (3/8'' * 42/2'') = 635 \text{ psi}$. This is very low and is acceptable.

Bearing stress on the lanyard attachment hole: Area = $3/4'' * 3/8'' = 0.28$ square inches. Bearing stress, $\sigma = P/A = 5000 \text{ pounds} / 0.28 \text{ sq. in.} = 17,777 \text{ psi}$. Allowable bearing stress is $0.75 * F_y$. For 6061-T6 aluminum, $F_y = 40,000 \text{ psi}$, so the allowable stress is 30,000 psi. Actual bearing stress is less than the allowable, therefore, satisfactory.