



Particle Physics Division Mechanical Department Engineering Note

Number: MD-ENG-166 Date: 16 September 2008

Project Internal Reference: none.

Project: Minerva

Title: Lifting Fixture Calculations for the Minerva Plate fixture

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Key Words: Lifting Fixture,

Applicable Codes: B30.20

Abstract Summary:

A group of individuals conducting a walk-thru of the Minerva Plate assembly work in Wideband noted that the outer covering of a polyester sling used to handle the plates was dirty due to contact with the plates. Although the outer covering of the sling was not torn and the tell tale colored strands in the sling cover were in tack, the individuals felt that the dirt on the sling represented a safety hazard. Because the sling is choked on each dirty plate each time a plate is moved, replacing the slings to keep them looking clean is not a viable option.

Therefore, this lifting fixture was designed to allow a commercial hoist ring to thread into this fixture to trap the plate between to steel surfaces. The polyester sling will connect to the relatively clean hoist ring (using a choker connection) for future lifts. This should eliminate any real or perceived safety hazard due to a dirty sling.

Calculations:

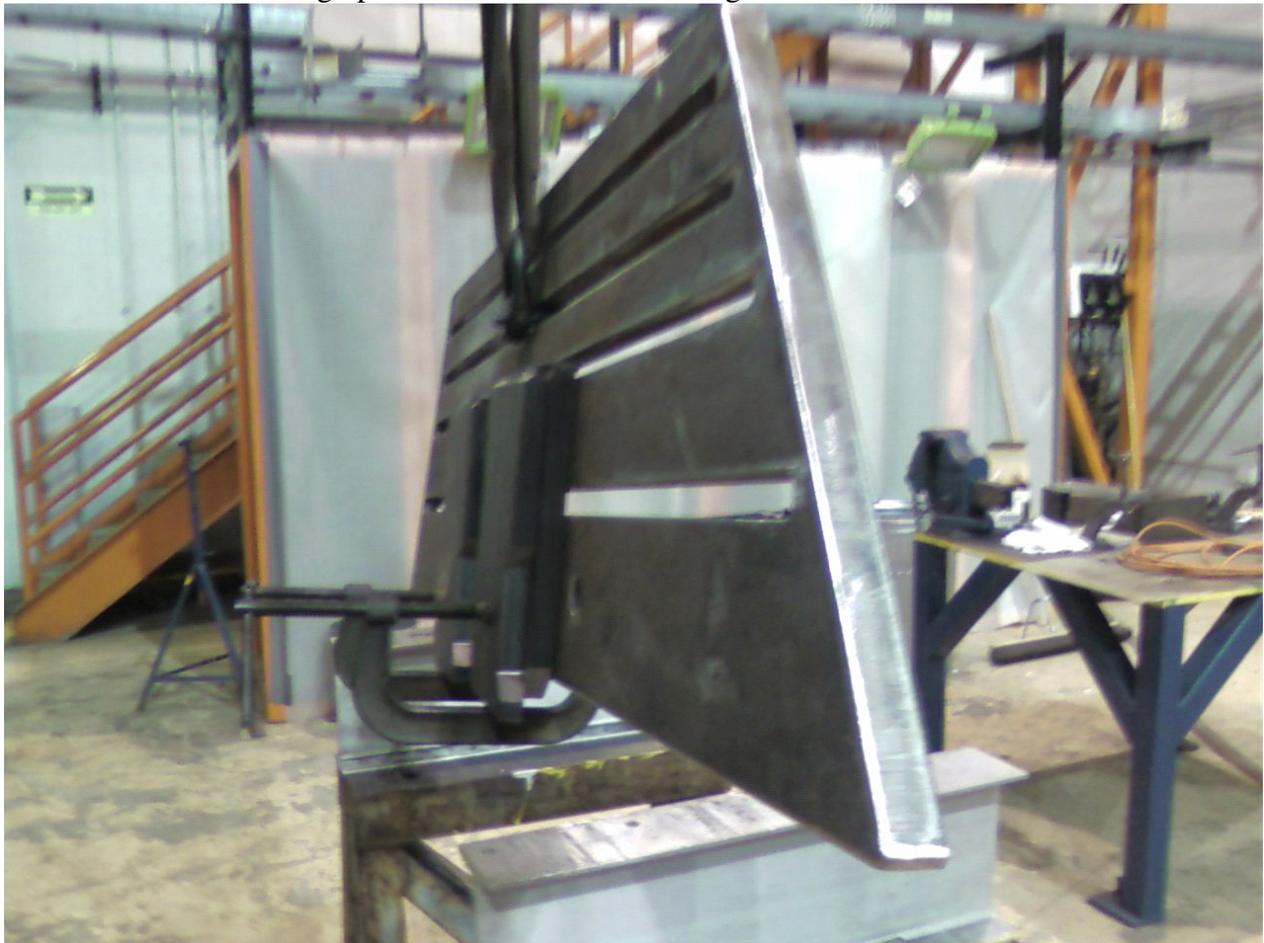
Plates have each been weighed and shown to be about 480 pounds each. Therefore, the design load for this fixture is 500 pounds.

A 2500 pound capacity hoist swivel ring with a ½-13 threaded connection will thread into a tapped hole in the fixture.

When the plate is horizontal, the load on the hoist swivel ring and the lifting fixture will be approximately 240 pounds.

When the plate is rotated to the vertical orientation, the load on the hoist swivel ring and lifting fixture is equal to the plate weight of about 480 pounds.

Photograph of the Load Test on Lifting Fixture Number 166



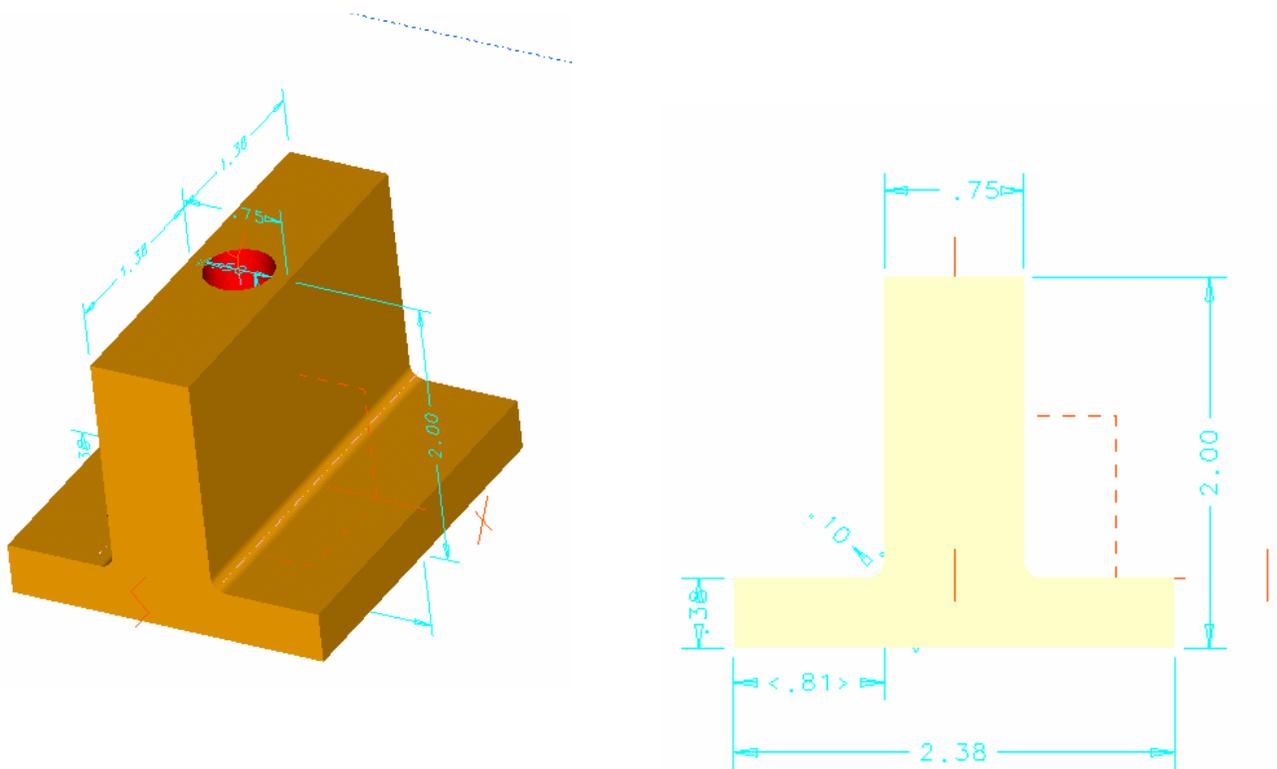
In the load test of fixture 166, the fixture is on the far (hidden) side of the plate and the hoist swivel ring is visible. Two additional steel plates are attached to the plate with the C-clamp to bring the load up to 125% of the fixture rating.

Material: Lifting fixture is made from generic carbon steel without certificates of conformance nor of known alloy. Therefore, treat the material yield value as being equal to 30,000 psi. From B30.20, the allowable stress is 1/3 of yield. So the allowable shear and tensile stress is $1/3 * 30,000 \text{ psi} = 10,000 \text{ psi}$.

Fixture is machined from solid bar stock. No welds or heat treatment processes are involved.

Fixture is 2.75 inches long (direction parallel to the direction of the slots in the plates) and is 2.375 inches wide (direction normal to the plate slot direction).

Fixture has one tapped hole, size 1/2-13. Tapped hole is in material 3/4 inch wide (same as the width across flats on a 1/2-13 hex nut).



The above two images show the fixture, first in an isometric and second in a front view, with dimensions.

Stress Calculations:

In both cases below, assume the fixture is located at the plate center of gravity and lifts the entire load. This is a conservative case. Plan is to locate swivel hoist ring to one side to pick the plate and roll it to a vertical orientation. In this case, the initial load seen by the hoist swivel ring is only one half the plate weight.

Tensile Stress Area, A is 2.75" by .75" = 2.0625 square inches

Load, P is 500 pounds

Tensile Stress, S is P/A ; $S = 500 \text{ pounds} / 2.06 \text{ inches}^2 = 242 \text{ psi}$

Allowable Tensile Stress is $F_y/3 = 10,000 \text{ psi}$.

Shear Stress Area, A_s is 2.75 inches by 3/8" times two areas = 2.0625 square inches

Load, P is 500 pounds

Shear Stress, T is P/A ; $T = 500 \text{ pounds} / 2.06 \text{ inches}^2 = 242 \text{ psi}$

Once the plate is vertical, the shear load is taken by the swivel hoist bolt. The 500 pound load is well below the 2500 pound rating for the commercial swivel hoist.

Manufacture's instructions for the swivel hoist ring require tightening the swivel hoist ring bolt to 90 foot-pounds. Assume the bolt is tightened to 100 % of its clamping force and assume that it is a grade 8 bolt. Maximum clamping force is approximately 15,000 pounds for a 1/2-13 grade 8 bolt (highest strength bolt commercially produced – data comes from the torque tensioning binder in the department library). Add the 500 pound plate load and the maximum load becomes 15,500 pounds. Repeat the above calculations using the 15,500 pound load and the stresses become 7524 psi. This value is still below the allowable stress of 1/3 yield stipulated by B30.20.
