Fermilab

Particle Physics Division

Mechanical Department Engineering Note

Number: MD-ENG-552 Date: 08/26/2016

Project: MicroBooNE

Project Internal Reference:

Title: MicroBooNE Muon Tagger Panels Vacuum Lifting Fixture

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Reviewer(s): Erik Voirin – ID#15426N

Key Words: Vacuum, lifting

Abstract/Summary:

Two layers of muon tagger panels are planned to be installed on the top, bottom, and on the two long sides of the Liquid Argon Time Projection Chamber (LArTPC) within the Liquid Argon Test Facility (LArTF). A commercial vacuum lifting fixture designed and fabricated by Anver is purchased for installing the Side panels in place. A set of documentations including the test Certificate of Conformance provided by Anver Corp. is kept in PPD-doc-2183. This test was conducted and complied with the ASME B30.20 with a rated load of 500 lbs at vendor'. A load test with 500 lbs was repeated at Fermilab with the vacuum pad locations slightly moved out by 1.5".

10110TA

BELOW-THE-HOOK LIFTING DEVICE

A. Engineering Note Cover Page

Lifting Device Numbers:

FNAL Site No/ 787 LATF (If applicable) Div. Specific No. 202 (If applicable) Asset No. _____ (If applicable)

ASME B30.20 Group: (check one)

[ ] Group I Structural and Mechanical Lifting Devices
[X] Group II Vacuum Lifting Devices
[ ] Group III Magnets, Close Proximity Operated
[ ] Group IV Magnets, Remote Operated

Device Name or Description: SBN-CM lifting Fixture

Device was
[X] Purchased from a Commercial Lifting
[ ] Designed and Built at Fermilab
[ ] Designed by Fermilab and Built by a Vendor:
[ ] Provided by a User or other Laboratory
[ ] Other: Describe

Engineering Note Prepared by: C. M. Lei Date: 8/23/2016

Engineering Note Reviewed by: Erik Voirin Date: 8/23/2016

Lifting Device Data:

Capacity: 400 lb

Fixture Weight: 495 lb

Service: [X] normal [ ] heavy [ ] severe
(refer to B30.20 for definitions)

Duty Cycle: N/A (applicable to groups III, and IV)

Inspections Frequency: Before each use

Rated Load Test by FNAL (if applicable) Date: 8/23/2016 Load: 500 lb

[X] Check if Load Test was by Vendor and attach the certificate (Attachment #3)

Satisfactory Load Test Witnessed by: C. M. Lei

Signature (of Load Test Witness)

I. Lifting Fixture Introduction

A set of panels are needed to be installed for the side panels. The width of the panel is about 68.5” and is the same for all panels. However, the length of the panels is variable with the longest one about 161.8”. The weight of the longest panel is about 387 lbs. As excessive deflection may damage the scintillation panels during the installation process, an 8-pad vacuum lifting fixture is thus purchased to handle the load more evenly and safely. The design of the lifting fixture is shown below in Figure 1, and all other documentations, drawings, user guide, installation, operation and maintenance manuals are kept in the PPD doc 2183.

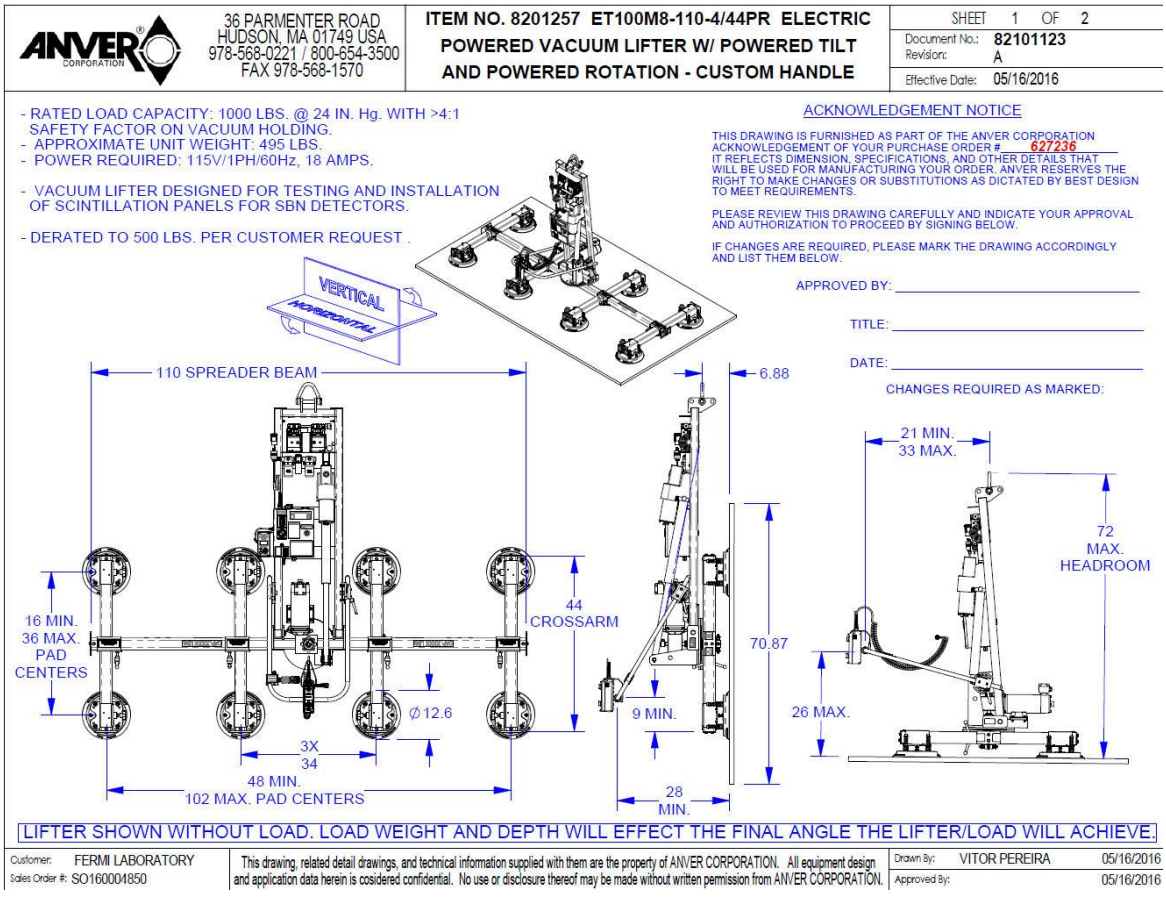

Figure 1. Vacuum Lifting Fixture Design by Anver Corp.

A slight adjustment was needed to make the vacuum fixture usable for the panels because there is a thin plate in the central panel region and the vacuum pads would be on the step. The Vacuum pads were thus moved out by 1.5” along the cross-arm direction from it’s original maximum positions. Set screws were engaged and an additional 3/8”x16 bolt was then used at each of the 8 arms to prevent any sliding of the adjustable pads, as shown in Figure 2. This bolt goes through both the inner and outer sleeve, locking them together. It is attached with lock washers as well as nylon lock nuts. Disregarding the additional holding strength of the set screws, we calculate the maximum shear stress on the 3/8” bolts, which is less than 1 ksi, far below the allowable shear of 19 ksi. Detailed Calculations are shown in Appendix A at the end of the document.

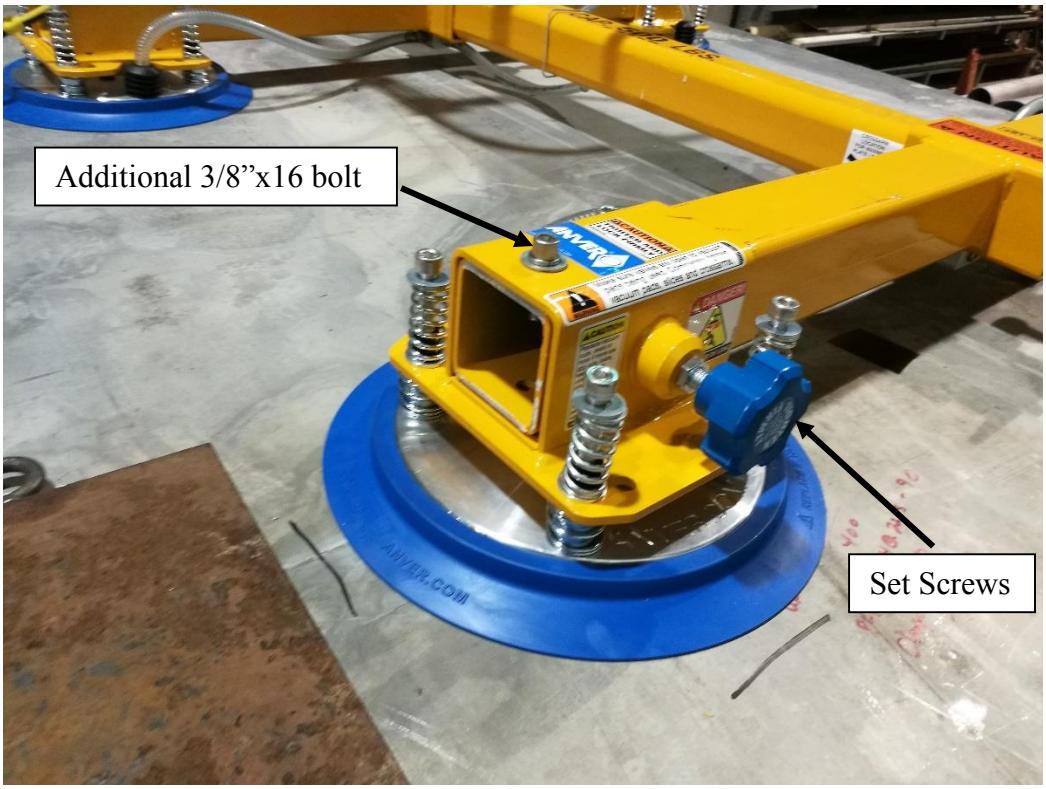

Figure 2. Vacuum pad assembly is locked with 3/8”x16 Bolt

II. Inspection and Testing

An inspection on the electric powered vacuum lifting device was conducted when it was shipped to Lab F. After passing the visual inspection, a 500 lb loading test was performed along with practice maneuvers for operating the lifting fixtures tilt feature. A 6'x 11' testing plate made of 3/8"-thick aluminum plate plus some added-on channels and small steel plates in order to make up of 500 lbs was used for the test. Test was successfully done with the testing plate in horizontal orientation as shown in Figure 3. A vacuum reserve was also checked to verify if the vacuum holding power remained when the electrical power was turned off. The vacuum lifting fixture held the 500 lbs weight for 1.5 hour successfully without dropping the load. The vacuum gauge read 25.1 inHg at the beginning of the test. At the end of the test, the gauge read 24.7 inHg. Some tilting and spinning tests at 500 load were done also as shown in Figure 4. The fixture could achieve to the vertical orientation without any problems.

Figure 3. 500-lbs Loading Test at Horizontal Orientation

Figure 4. Tilting and Spinning Test with Load at 500 lbs

III. Conclusions

This brand new 8-pad vacuum lifting fixture purchased from Anver Corp. meets the standards of ASME B30.20 and the 500-lbs loading test repeated at Fermilab has successfully conducted. This fixture is adequate to be used for actual applications.

IV. APPENDIX A – Calculations for Bolt Shear stress.

Design Factor of 2 according to BTH-1

$N_d := 2.0$

Ultimate tensile strength for weakest Grade 2 bolt.
Actual bolts used are stronger grade

$\sigma_{Ultimate} := 74ksi$

BTH-1 Equation for allowable bolt shear

$$\tau_{allowable} := \frac{0.62 \cdot \sigma_{Ultimate}}{1.2 \cdot N_d} = 19.117\,ksi$$

Shear area of threaded portion of 3/8"x16 bolts
Shigley - Mech. Engineering Design (Table 8-2)

$Area_{shear} := 0.0775in^2$

Rated Load of Fixture

$Rated_{Load} := 500lbf$

number of 3/8" bolts

$num_{bolts} := 8$

Shear stress of bolts

$$\tau_{bolt} := \frac{Rated_{Load}}{Area_{shear} \cdot num_{bolts}} = 0.806\,ksi$$

Safety Factor to Allowable

$$SF := \frac{\tau_{allowable}}{\tau_{bolt}} = 23.705$$