



**Particle Physics Division  
Mechanical Department Engineering Note**

Number: MD-ENG-235

Date: 12 March 2010

Project Internal Reference: none

Project: NOvA Block Pivoter

Title: Upper Frame Lift fixture # 1

Author(s): Dave Pushka

Reviewer(s): Ingrid Fang

Key Words: NOvA, Upper Frame Lift Fixture, Below-the-hook lifting device

Abstract Summary: Calculations to show conformance with ASME B30.20 for lifting fixtures used to move the upper frame of the NOvA block pivoter.

Applicable Codes: ASME B30.20

Givens:

Frame weight 34,000 pounds

Number of Lift Points 3

Design Load per lift pt. 34,000 pounds

5022TA

**BELOW-THE-HOOK LIFTING DEVICE**

***Engineering Note Cover Page***

Lifting Device Numbers:

FNAL Site No/ \_\_\_\_\_ Div. Specific No. \_\_\_\_\_ Asset No. \_\_\_\_\_

If applicable

If applicable

If applicable

ASME B30.20 Group: [X] Group I Structural and Mechanical Lifting Devices  
(check one) [ ] Group II Vacuum Lifting Devices  
[ ] Group III Magnets, Close Proximity Operated  
[ ] Group IV Magnets, Remote Operated

Device Name or Description NOvA-FHEP UPPER FRAME, LIFTING FIXTURE

Device was [ ] Purchased from a Commercial Lifting  
(check all [ ] Designed and Built at Fermilab Mfg Name \_\_\_\_\_  
applicable) [ ] Designed by Fermilab and Built by a 3929.000-MC-466741  
Vendor. Assy drawing number \_\_\_\_\_  
[ ] Provided by a User or other Laboratory  
[ ] Other: Describe \_\_\_\_\_

Engineering Note Prepared by Dave Pushka Date 12 March 2010

Engineering Note Reviewed by \_\_\_\_\_ Date \_\_\_\_\_

Lifting Device Data:

Capacity 34,000 pounds

Fixture Weight 122 pounds

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

Duty Cycle \_\_\_\_\_ 8, 16 or 24 hour rating (applicable to groups III, and IV)

Inspections Frequency Before each use

Rated Load Test by FNAL (if applicable) Date \_\_\_\_\_ Load \_\_\_\_\_

[ ] Check if Load Test was by Vendor and attach the certificate

Satisfactory Load Test Witnessed by: \_\_\_\_\_

Signature (of Load Test Witness) \_\_\_\_\_

Notes or Special Information:

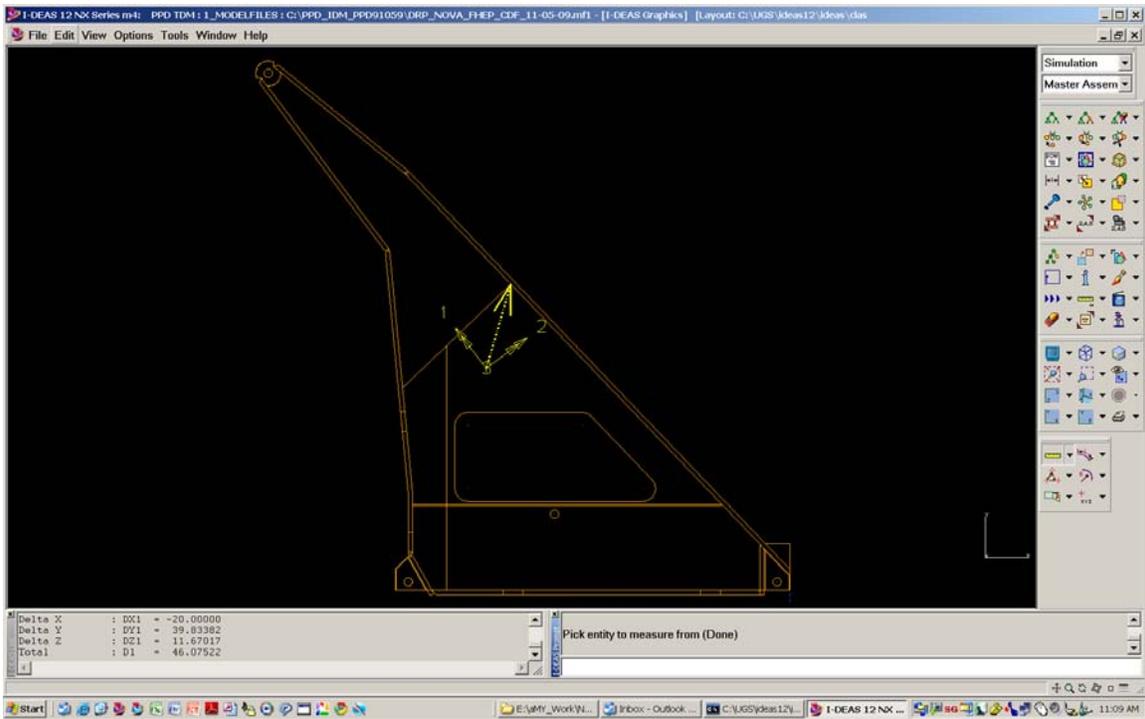


Image 1: Side view of the Upper frame for the NOvA blocks Pivotor.

Center of gravity is shown in yellow.

Holes at each corner are 4.0 inches in diameter.



## Discussion:

Upper frame weighs approximately 34,000 pounds. At each corner, a 4 inch diameter hole exists. Three lifting bars will be used to lift the frame, one lifting bar in each hole.

Design each lifting bar for 30,000 pounds, the allowable working limit for a 1.5 inch hoist ring used on one end of the fixture. Item numbers refer to the Item number shown on the assembly drawing. Three will be used to lift frame when on its side.

Item 1: Schedule 80 carbon steel pipe, 3 inch nominal diameter. Allowable stress is  $1/3 F_y$ , assume  $F_y = 30,000$  psi, therefore, allowable stress is 10,000 psi. Cross sectional area is 6.605 square inches. Therefore, allowable tensile load is 66,050 pounds. This exceeds the 30,000 pound design load.

Weld at end of item 1 to machined ends: Weld is 0.30 inch partial penetration groove weld with 70,000 psi filler material. Allowable stress is  $0.3 F_y$  per welding code (this is slightly more conservative than  $1/3 F_y$  per ASME B30.20, so use it instead). Area is  $(\pi / 4) * (3.5^2 - (3.5 - (2 * 0.3))^2) = (\pi / 4) * 3.84 = 3.01$  square inches. Load is 30,000 pounds. Stress is  $P/A = 30,000/3.01 = 9.947$  psi. This is less than 21,000 psi, therefore, satisfactory.

Item 2: Plate Washer, 2 inches thick, 1018 material. Yield stress of 1018 is listed as 36 ksi minimum for hot rolled material in the latest Ryerson catalog. Therefore, the allowable working stress is  $1/3 F_y = 12,000$  psi. Use formula from Roark and Young, 7<sup>th</sup> edition, Table 11.2, page 459, Case #1 (Round flat plate of uniform thickness with load applied at the inner diameter and restrained at the outer diameter):

$b = 1.0$  inches

$a = 2.0$  inches

$b/a = 0.5$

Thickness,  $t = 2.0$  inches

Moment,  $M = K_m * w * a$

$w =$  uniform line load  $= 30,000$  pounds /  $\pi * d = 30,000 / \pi * 2 = 4774.6$  pounds per inch

$K_m = 0.7757$  (look up value from Special cases table for  $b/a = 0.5$ )

Moment,  $M = 0.7757 * 4774.6$  pounds per inch \* 2.0 inches = 7407.3 in-pounds.

Bending stress,  $\sigma = 6M/t^2$  (see notes for table 11.2)

Bending stress,  $\sigma = 6 * 7407 / (2.0^2) = 11,111$  psi

Bending stress in washer is less than 12,000 psi, therefore okay.

Item 3: Hoist Ring. Commercial hoisting and rigging hardware with an allowable load rating of 30,000 pounds.

Item 4: Heavy Hex Head structural bolt, 2 1/4 inch diameter, grade 5 material with minimum tensile strength of 90,000 psi. Nominal area is 3.97 square inches. Therefore, allowable tensile load =  $1/3 * 90,000$  psi \* 3.14 inches = 94,248 pounds. Tensile load on bolt exceeds lifting fixture design capacity.

Item 4: catalog cut:

