Fermilab

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Particle Physics Division
Engineering and Technical Teams

Mechanical Support Engineering Note

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Project: *E875* **Project Internal Reference:**

Title: The MINOS NEAR DETECTOR STRONGBACK DESIGN

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Key Words: *MINOS, Near Detector Steel Plane, Strongback, Scintillator Modules, Detector Support Structure, and Near Detector Scintillator plane*

Abstract/Summary:

The near detector strongback is an assembly platform and lifting fixture for the steel and scintillator detector plane. It is used as a rigid support for mounting scintillator modules and steel plates. It is also used to hang the steel and scintillator detector plane while being raised into a vertical orientation by a 15 ton bridge crane onto the detector support structure.

The design of the strongback is one of the most important tasks in the MINOS project. The strongback must be as light as possible while still being strong enough to keep the steel and detector plane flat during assembly and mounting. It must also hold the steel and detector plane securely during the mounting procedure without interfering with the plane of scintillator modules.

The design of the strongback takes advantage of standard structural steel shapes. It is fabricated from W12x16 shapes and 4x16 tubes, and connected by bolts and welds at the joints. It's shape is the same as a near detector steel plane. Four clamping devices are designed to securely hold the steel and detector plane to the strongback. Two pivot roller assemblies are also designed to provide a smooth transition from horizontal to vertical orientation during a single lift pick up point.

In order to investigate the lifting characteristics of the strongback with the steel and detector plane attached, an FEA model was simulated in ANSYS. Three critical lifting positions were analyzed to determine the combined stresses and deflection variations: horizontal, 45 degree tilted, and vertical.

The design analysis was performed according to both AISC, "Allowable Stress Design" Code and ANSI B30-20, " Below the Hook Lifting Devices". The results show that all members will safely support the steel and detector plane within the allowable stress and deflection limits. See tables below:

1. DESIGN STRESSES AND SAFETY FACTOR SUMMARY TABLE

	Combined Stresses*	***Allowable Stresses***	***Safety Factor*****	***Shear Stress***	***Allowable Shear***	***Safety Factor*****
W12x16 Shapes	9.99 ksi	12 ksi	1.2	11.92 ksi	12 ksi	**1.0**
4 x 16 Tubes	[illegible] ksi	15.3 ksi	[illegible]	[illegible] ksi	15.3 ksi	[illegible]

**Combined stresses – Member subject to both axial tension/compression and bending stresses*

***The safety factor shown above does not include the built in safety factor of 3*

2. DESIGN DEFLECTION AND SAFETY FACTOR SUMMARY TABLE

	Strongback Maximum Deflection	***Allowable Maximum Deflection***	***Safety Factor***
Vertical Position	***0.045 inch***	***0.350 inch***	***7.8***
[illegible]	[illegible]	[illegible]	[illegible]
Horizontal Position	***0.107 inch***	***0.350 inch***	***3.3***

The detail design was documented in the following sections:

- *Section A – Finite Element Analysis*
- *Section B – Strongback Frame Design*
- *Section C – Strongback Connection Design at Point D, I, N, O, P, M & H*
- *Section D – Strongback Connection Design at Point A & C*
- *Section E – Strongback Connection Design at Point J, K, L & F*
- *Section F – Strongback Connection Design at Point E &G*
- *Section G – Strongback Connection Design at Point B*
- *Section H – Strongback Connection Design at Point AA, CC, HH, MM, PP, NN, II, & DD*
- *Section I – Stronback Ear Supporting Brackets Design*
- *Section J – Strongback Roller Pivot Weldment Assembly Design*
- *Section K – Strongback Clamping Assembly & Supporting Lip Design*
- *Section L – Strongback Lifting Device Design*

Applicable Codes:

- *AISC Manual of Steel Construction, Allowable Stress Design, Ninth Edition*
- *ASME B30.20 – 1993, Below the Hook Lifting Devices*
- *ASTM A6/A6M – 96B, Standard Specification for General Requirements for Rolled Structure Steel Bars, Plates, Shapes and Sheet Piling.*

Reference Books:

- *Roark's Formulas for Stress and Strain, Sixth Edition, by Warren C. Young*
- *Mechanical Engineering Design, Fifth Edition, by Shigley and Mischke*
- *Mark's Standard Handbook for Mechanical Engineers, Tenth Edition, by Avallone Baumeister*
- *Design of Welded Structures, by Blodgett*
- *Mechanisms and Mechanical Devices Sourcebook, by Chironis*
- *Fundamentals of Mechanical Design, Third Edition, by Phelan*
- *Structural Steel Design, by Lynn S. Beedle*
- *Steel Design Manual, by R.L. Brockenbrough*

Reference Drawings and Reports:

- *9213.300 – ME – 367179, MINOS Near Detector Steel Plane*
- *9213.300 – MB – 367781, MINOS Modified Axial Restraint Bolt*
- *The MINOS Detectors Technical Design Report, October 1998*