Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Title: Responses to the first Pivoter Review

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Reviewer(s): none

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Applicable Codes: Not applicable

Abstract Summary:

A review of the NOvA far detector block pivoter occurred in April of 2007 which generated several suggestions (see NOvA document 3111), some of which were used as the design work progressed, some of which were investigated and found not useful and some were dismissed immediately.

During a follow-up review of the same device in March of 2011, review committee criticized the engineering team working on the pivoter for not documenting the how each comment from the previous review was considered. See NOvA document 5775. This engineering note documents the Responses to each suggestion and comment.

The review committee report in document 5775 included a sub-set of the comments from the 2007 review, but omitted several other comments from that review. This document attempts to address all comments from the April 2007 review.

Responses to comments from the 2007 review as mentioned in document 5775:

1. One issue that has not been fully addressed is the alignment requirement of the guide rails.

Response:
Pivoter rails are installed as part of the building contract and the alignment requirements are specified in the building contract documents. Pivoter is designed to accommodate a ¼ inch variation in the rail center to center distance and rail width tolerance. This accommodation is in excess of similar variations seen on other similar installations.

2. In the NOvA TDR Chapter 17-138, it states that the pivoter velocity is limited, but does not explained how it is limited. Information regarding the maximum velocity should be explained.

Response:
Hydraulic drive power unit uses a 3 phase drive motor, rotational velocity of the drive motor is set by the line frequency (60 Hz). Motor directly drives a positive displacement hydraulic oil pump. The positive displacement hydraulic motors are coupled to the hydraulic pump in a closed loop system. Hydraulic motors drive gear reducers which directly drive the drive wheels. Therefore, the maximum rotational velocity of the drive wheels is set by the line frequency of the alternating current power. Specified maximum velocity is 1 mile per hour. Velocity is controlled by the operation of a spool valve, controlled by a joy stick. FHEP Operating experience at CDF shows that this control allows the velocity to be maintained well below one mile per hour.

3. Also, the dunnage supports need to be analyzed and they should be designed to be portable and height adjustable so they can be used if there is any power loss or other operational issues where the table needs to be supported unexpectedly.

Response:
Done. See PPD engineering note 251 written by Ernie Villegas and filed as PPD document 1237.

4. The pinching risk of the table as it is being lowered needs to be addressed adequately. In addition to a Hazard Analysis, optoelectronic sensors should also be investigated (such as used in a press brake).

Response:
An HA for the FHEP pivoter was written, reviews and walk-throughs held, and ultimately ropes and signs used to warn people and exclude them from the area. Optoelectronic sensors were investigated and determined to require more manpower to implement than resources allowed.

5. For the hydraulic cylinders and slave cylinders, the factor of safety is not discussed nor the potential problems of having two cylinders working in conjunction with each other. Flow control valves and synchronization control of the two cylinders with feedback (LVDT) should be investigated. A constrained step type of controller so the movement is ratcheted is suggested.

Response:
Pivot cylinders and kneeling cylinders have a manufacture specified rated load. Pivoter design is such that all cylinders always operate below the rated load.

Synchronization of the kneeling cylinders is controlled with a position read back and spool valves provided by a hydraulic system vendor. These have been shown to maintain displacement differences of less than 1 millimeter.

Pivot cylinders are operated such that the pressure in both cylinders is the same and relative displacement of each side is the result of a stiff, rigid base and an equally stiff and rigid table. This is consistent with the industrial application for truck dumpers. A displacement of 300 or more inches exceeds the displacement of commercial LVDT devices.

Ratcheting of the pivoter movement was dismissed as an idea to pursue immediately. The last thing one wants to do is to start and stop the movement of a large, massive object and potentially match the ratcheting frequency with the natural frequency of the structure, leading to a catastrophic failure.

6. It is important that adequately reinforced pick points for each major pivoter subassembly are incorporated into the respective designs. I'm sure that this has been considered, but it was not discussed during our review.

Response:
***Adequate pick points are included in each major weldment. Refer to the drawings of each weldment. Drawings are posted in the ADMS-PPD I-Find website at*:**
http://www-admscad.fnal.gov/MSDMain/cgi-bin/TP_PPDifind-web.pl

7. Provisions for appropriate personnel protection measures (rail system with kick plates, adjustable platforms, etc.) should be considered during the pivoter table design to ensure personnel safety and facilitate access during the stacking process of block fabrication.

Response:
Good comment but not within the scope of the pivoter design effort. Walking and working surfaces with hand rails and toe plates and vertical adjustment features are being provided as part of the building outfitting contract.

8. It is strongly recommended that the structure be designed and fabricated to the requirements of the AWS structural welding code (D1.1), with independent oversight on fabrication.

Response:
Structure is designed with the structural welding code requirements and drawings specify conformance to D1.1 as is the standard practice for work performed within the PPD mechanical department.

Independent oversight of the fabrication is not deemed necessary for these weldments. Inspection upon receipt has been conducted.

9. Considerations need to be made for the requirements of AWS Structural Welding code. Allowable stress specified by the AWS Structural Welding code is determined based on the loading characteristics of the member (Static, Cyclic)

Allowable stress will go from 0.3 to 1.0 times the listed ASTM tensile strength depending on the loading conditions of the member and the welding joint design used. Also heavy tubular members or critical members should be considered for Charpy impact testing (Charpy "v" notched or CVN) certification.

Response:
Members used in the block pivoter use allowable stress design per AISC 9th edition Allowable stress design. Welds are sized and do not exceed 30% of the yield stress. (it is very unclear where the above mentioned allowable stress of 1.0 times the ASTM tensile strength comes from – therefore, this is ignored as bad advice, inconsistent with normal ASIC design practice). No heavy, highly loaded tubular members are used and the CVN certification recommendation is not applicable.

As already mentioned above, fabrication drawings already incorporate notes requiring conformance to D1.1, Structural Welding Code - Steel.

It bears mentioning that the deflection criteria drives the design of the block pivoter and as such, the members are sized based on defection criteria, not stress criteria. As a

result, the stress in the majority of each member is very low as compared to the allowable values. Finite element analysis (FEA) has been applied to all members and local high stress regions have been individually evaluated. Traditional hand calculations (upon which the AISC allowable values are based) ignore the local high stress regions. Refer to AISC commentary section A5, Design Basis.

10. Considerations should be made for thermal stress relief. In heavy members (members over 1.5 inches thick in carbon steel) where stress levels are approaching 50% of allowable, residual stress can be of concern for catastrophic failure. Caution; do not apply thermal stress relief to materials that are quenched and tempered or thermo-mechanically strengthened or subject to precipitation hardening to achieve strength. Also when CVN certification is required, stress relief may reduce impact energy absorption values at a given temperature above the transition temperature. Having to thermally stress relieve weldments supports the concept of a bolted modular design.

Response:
Post weld stress relief has been specified for the upper weldment. This is the only weldment with significant sections exceeding 1.5 inch thickness.

11. Consideration should be made for NDE of members where stress levels are high and complete joint penetration is required. RT or UT examination would be required.

Response:
Non-destructive examination of the weldments has not been performed because of the low stress values in materials predicted by the FEA.

12. The recommendation for a tubular frame with platform mechanically applied after welding and stress relief is complete will be key in obtaining the required flatness goal of the gluing surface.

Response:
This recommendation has been ignored. The added complication of adding tubes to the surface of the assembly table advocated by this comment offers no apparent means for improving the table flatness.

13. The committee should examine the referenced report from the standpoint of conceptual design. This committee member was made aware of this design concept because a cost estimate was needed for welding of the proposed pivot assembly. The tubular frame is a simpler design and will significantly decrease welding costs, however, from a mechanical design point of view, it is uncertain if it is a better concept.

Response:

This recommendation has been ignored. The design being advocated by the reviewer was initially considered but rejected for reasons including high deflections for the structure weight, difficulty in getting large, long stroke double acting hydraulic cylindered needed for this configuration, and overall instability as the block center of gravity rotated past the forward portion of the wheels.

Responses to comments from the 2007 review omitted from document 5775:

1) Committee members suggested we should consider the companies who build river barge equipment as a possible fabricator as they routinely weld relatively thin steel structures of comparable dimensions.

Response:
This recommendation has investigated and it was determined that the components of the pivoter are much smaller than river barges and are adequately fabricated by the fabricators presently on the purchasing departments list of potential vendors.

2) One reviewer suggested installing the pivot cylinders with the upper support frame in lieu of later in the assembly sequence.

Response:
This recommendation has been adopted; the cylinder is installed in a trunion mount prior to installation in the upper weldment.

3) One reviewer mentioned not using thermal processes to disassemble structure after testing it at FNAL.

Response:
This recommendation has implicitly been adopted. Nothing is welded together at FNAL and then disassembled (except by bolting) prior to shipment to Ash River.

4) One reviewer suggested changing the number of weldments from 12 to 6 since a 104 inch wide weldment can be easily shipped on a flat bed truck.

Response:
This recommendation has been adopted.

5) One review suggested moving the drive wheels to a location below the assembly c.g.

Response:
This recommendation has been adopted.