Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project: NOVA ASH RIVER PIVOTER

Title: Evaluation of Design for Heavier Modules

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Key Words: Block Pivot Table

Applicable Codes: AISC

Abstract Summary:

Heavier Extrusions are being considered for the NOvA Far detector. This note evaluates the effect of the heavier extrusions on the block pivoter.

Additional loads due to the heavier table are also considered.

Discussion:

Engineering note 184 (Dated 29 April 2009) and posted in the PPD document data base as document 1003 was prepared to document the calculations used to determine the hydraulic cylinder loads. This note uses a NOVA PVC Block weight of 394,828 pounds (197 tons). This value was

determined by taking the weight of the PVC extrusions at the maximum material condition and using this value when calculating the hydraulic cylinder loads as a function of the table rotation and cylinder extension.

For the heavier extrusions being considered, Richard Talaga indicated that these weigh at least 1050 pounds each in an email dated 1-7-2011.

Pat Lukens is considering assembling blocks from 32 planes instead of 31 planes as described in the TDR.

Pat Lukens is also considering using the same extrusion for both the vertical and the horizontal modules.

For the purposes of this analysis, assume all three changes are implemented and calculate the block weight:

Block weight = 1100 pounds per module * 12 modules per plane * 32 planes per block. Therefore, the block weight is 422,400 pounds.

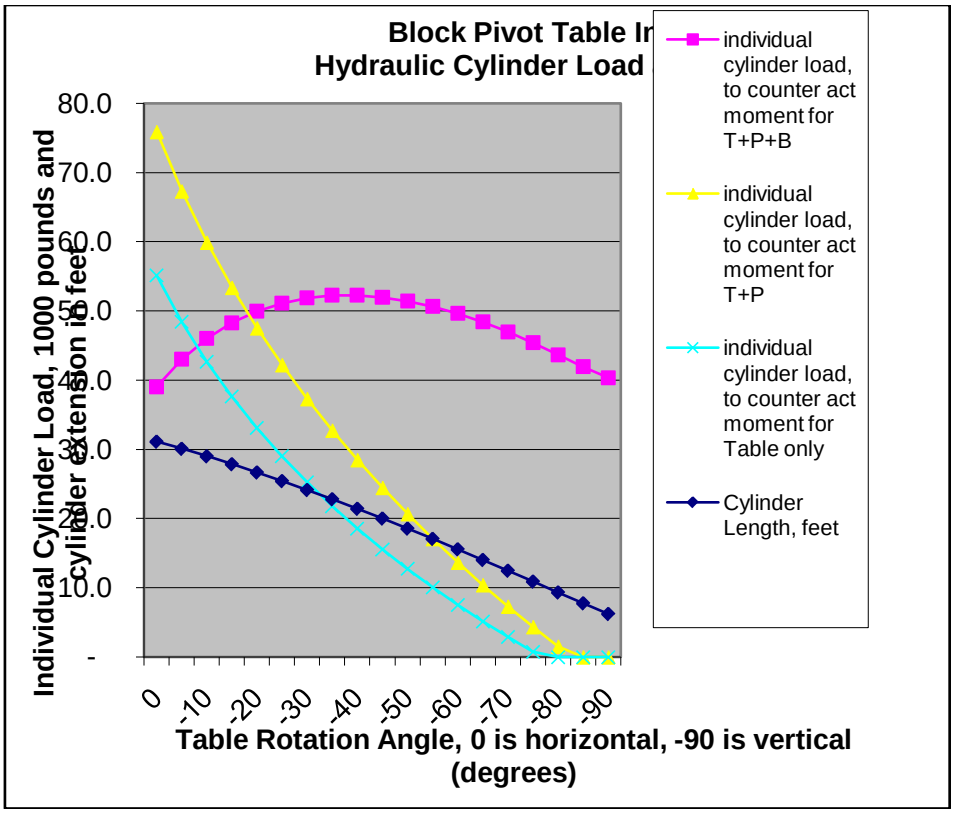
On a percentage basis, these changes increase the block weight by almost exactly 7%.

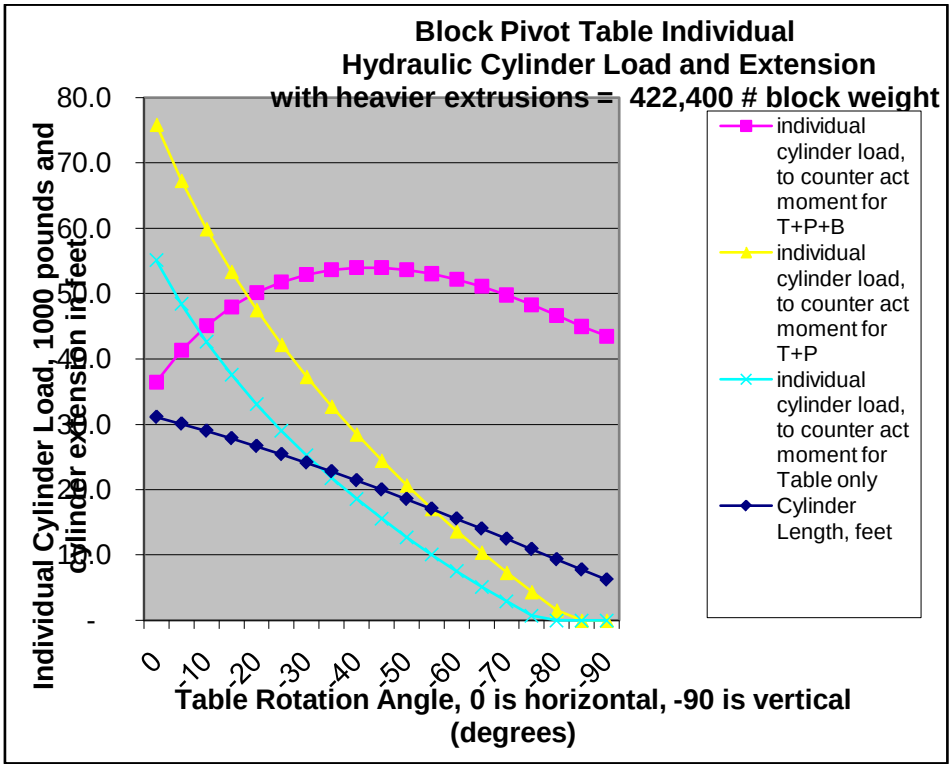
One other change that affects the pivoter loading is the heavier weight of the table. The assumed weight of the Ash River table based on the FHEP table used in the initial calculations was 137,038 pounds which was estimated by taking the FHEP table weight of 22,839 times 6. Ernie Villegas has largely completed the design of the Ash River Table and determined that it will likely weigh about 102 tons (204,000 pounds).

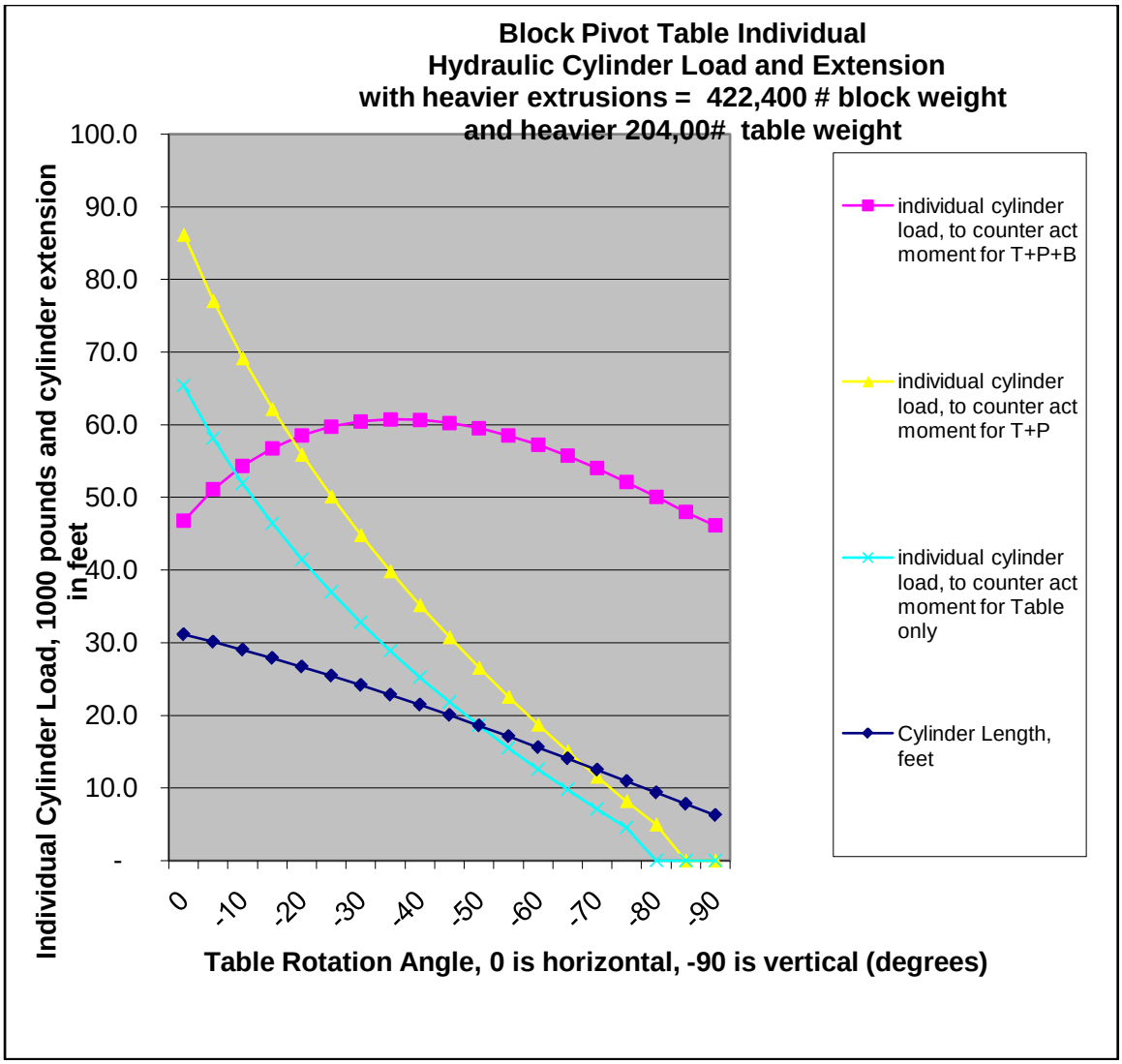
Three plots follow:

1) Original Design based on TDR modules and lighter table
2) Heavier (vertical) modules and lighter table
3) Heavier (vertical) modules and anticipated heavier table. Note this assumes the center of gravity of the table at -5.2 inches below the pivot and 55 inches forward (toward the pallet) when table is horizontal. (Original design used -16 and 69 inches.) See the original engineering note for a sketch.

Maximum Cylinder Load at 1800 psi is 99,000 pounds.


Block Pivot Table Ir
Hydraulic Cylinder Load
Individual Cylinder Load, 1000 pounds and cylinder extension in feet
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
-
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Table Rotation Angle, 0 is horizontal, -90 is vertical (degrees)
individual cylinder load, to counter act moment for T+P+B
individual cylinder load, to counter act moment for T+P
individual cylinder load, to counter act moment for Table only
Cylinder Length, feet


Block Pivot Table Individual
Hydraulic Cylinder Load and Extension
with heavier extrusions = 422,400 # block weight
Individual Cylinder Load, 1000 pounds and cylinder extension in feet
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
-
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Table Rotation Angle, 0 is horizontal, -90 is vertical (degrees)
individual cylinder load, to counter act moment for T+P+B
individual cylinder load, to counter act moment for T+P
individual cylinder load, to counter act moment for Table only
Cylinder Length, feet



In addition to the pivot cylinders, these changes add additional load to the following parts:

1) Main Table Pivot Pin
2) Upper Frame
3) Front Pin
4) Rear Pin
5) Rear Pin Support Weldment
6) Lower Frame

Of these parts, the main pivot pin and the rear pin are adequately addressed by hand calculations. The upper frame, lower frame and rear pin support weldment require FEA to address the changes to the mechanic stresses and strains resulting from the increased loads. This note will specifically address the parts adequately described by hand calculations; the main pivot and the rear pin.

Main Pivot Pin:	
Main pivot pin shear stress per original design:	10,820 psi
Main pivot pin shear stress with heavier table and block:	12,702 psi
Upper Frame Forward Pin:	
Forward pin shear stress per original design:	4,612 psi
Forward pin shear stress with heavier table and block:	5,358 psi
Rear Pin:	
Rear pin shear stress per original design:	1,831 psi
Rear pin shear stress with heavier table and block:	2,106 psi
Pin Material (applicable to all three pins)	AISI 4140
Turned or Drawn, Ground and Polished	
Pin Material Yield Stress	105,000 psi
Pin Material Allowable Stress (per AISC 9th)	42,000 psi

Conclusion:

Appendix, Extracted portions of spreadsheet calculations used in Engineering note 184. Calculations 8 are verbatim from engineering note 184, the original design. Calculations 9 are the same calculation but with the heavier modules and heavier table weights applied.

Table from Block Raiser Calculations 8 with original extrusions and table.

Maximum Load on the Table Pivot Pin, pounds	543,865	pounds
Number of Table Pivot Shear planes	4	
Table Pivot Pin Diameter, inches	4	inches
Table Pivot Pin shear stress, psi	10,820	psi
Maximum Load on the Upper Frame Forward Pin, pounds	463,658	pounds
Number of Upper Frame Foreward Pin Shear planes	8	
Upper Frame Forward Pin Diameter, inches	4	inches
Upper Frame Forward Pin shear stress, psi	4,612	psi
Maximum Load on the Upper Frame Rearward Pin, pounds	184,061	pounds
Number of Upper Frame Rearward Pin Shear planes	8	
Upper Frame Rearward Pin Diameter, inches	4	inches
Upper Frame Rearward Pin shear stress, psi	1,831	psi

Table from Block Raiser Calculations 9 with heavier extrusions and table.

Maximum Load on the Table Pivot Pin, pounds	638,466	pounds
Number of Table Pivot Shear planes	4	
Table Pivot Pin Diameter, inches	4	inches
Table Pivot Pin shear stress, psi	12,702	psi
Maximum Load on the Upper Frame Forward Pin, pounds	538,632	pounds
Number of Upper Frame Foreward Pin Shear planes	8	
Upper Frame Forward Pin Diameter, inches	4	inches
Upper Frame Forward Pin shear stress, psi	5,358	psi
Maximum Load on the Upper Frame Rearward Pin, pounds	211,735	pounds
Number of Upper Frame Rearward Pin Shear planes	8	
Upper Frame Rearward Pin Diameter, inches	4	inches
Upper Frame Rearward Pin shear stress, psi	2,106	psi