

**Fermilab**

**Particle Physics Division  
Mechanical Department Engineering Note**

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Project: NOvA Ash River Block Pivoter

Title: NOvA Block Pivoter Maximum Loading with a Moving CG

Author(s): Mike Zuckerbrot

Reviewer(s): *DAVE PUSHKA*

Key Words: NOvA, Far Detector, Ash River, Block Pivoter loading

Applicable Codes:

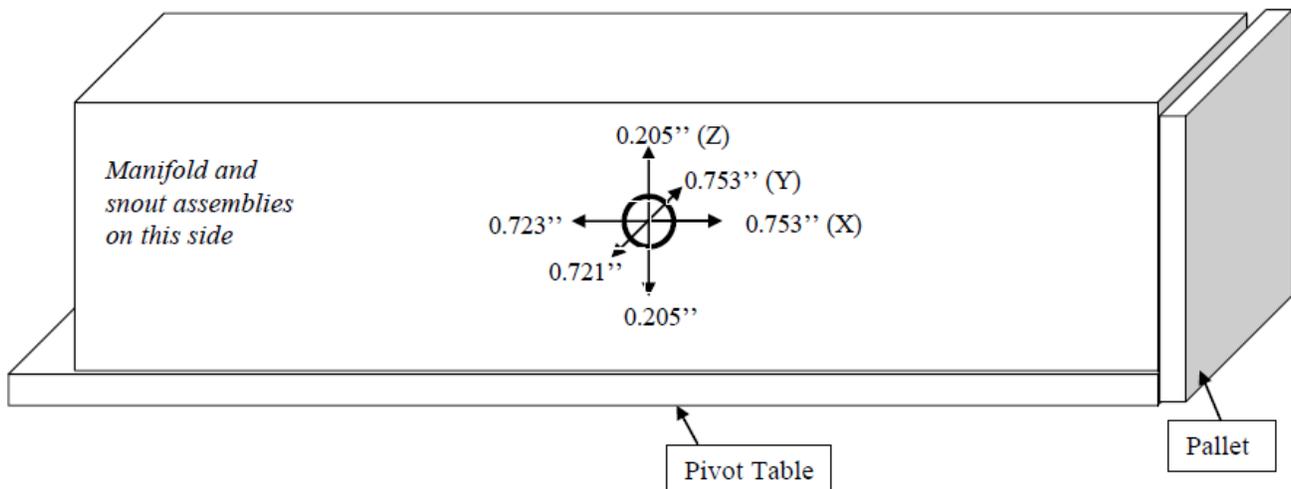
**Abstract Summary:** The following note details the maximum reactions on the Ash River block pivoter due to the maximum variance of the block center of gravity. Loads were computed at the main pin (upper frame), the forward and rearward pin (lower frame), the pivot cylinders, and the kneeling cylinders. The maximum variance of the center of gravity of a block is based on previous engineering note # 335. The reactions are computed using the excel spreadsheet attached to Dave Pushka's previous engineering note # 320.

## Introduction and Discussion

The maximum loading on the framing and hydraulics of the NOvA Ash River block pivoter has been computed using Dave Pushka's previous engineering note #320 and excel spreadsheet located on PPD Docdb # 1384 V1. Values of the horizontal and vertical block CG distances (located in excel spreadsheet, Page 1) were changed to minimum and maximum values, and resulting reactions were recorded. Values were first recorded due to only a changing CG-x, then a changing CG-z in combination with the changing CG-x, and lastly a changing CG-y was applied to the previous maximum. This will be better detailed as results are shown.

- Reactions were recorded for:
  1. The table pivot pin (located in excel spreadsheet, Page 16)
    - *Note 1: In the analysis the maximum weight of the table, pallet, and block was used as the main pin reaction force. This is already taken as the maximum value and a changing CG has no effect.*
  2. The rearward pin (located in excel spreadsheet, Page 16)
  3. The forward pin (located in excel spreadsheet, Page 16)
  4. The kneeling cylinders (located in excel spreadsheet, Page 16)
  5. And the pivot cylinders (located in excel spreadsheet, Page 9)

The maximum variance of the block center of gravity comes from previous engineering note # 335. A summary picture is included below showing the maximum variances with respect to direction.



## Summary Table

*Table 1:* The following table lists the reaction forces with an ideal block CG (a CG with all extrusions at the same weight), and maximum possible reaction forces with a moving block CG on the 5 items listed above.

Component	Maximum load with ideal block CG (lbs)	Maximum Load with moving block CG (lbs)	Situation for maximum loading
Table pivot pins ( <i>full maximum weight already used, see note 1</i> )	653,538	<b><u>653,538</u></b>	The maximum reactions occur with the block's CG-x shifted +0.753'' (toward the pallet), the blocks CG-z shifted +0.205'' (away from the table), and the CG-y shifted +0.753'' in either direction
Forward pins ( <i>Table at 45° from horizontal</i> )	550,089	<b><u>550,964</u></b>	
Rearward pins ( <i>Table at 45° from horizontal</i> )	215,656	<b><u>216,202</u></b>	
Individual cylinder ( <i>Table at 20° from horizontal</i> )	70,700	<b><u>71,900</u></b>	
Individual Kneeling cylinder	250,033	<b><u>252,183</u></b>	

## Computations

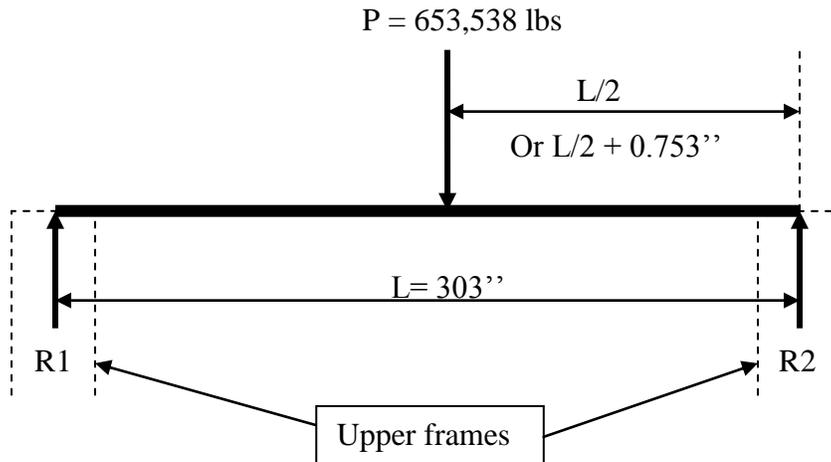
*Table 2:* Shown below are the reactions on the 5 items with the maximum variance of the block's CG-x only (0.753'' toward the pallet and 0.723'' away from the pallet).

Component	Max Load with ideal CGs (lbs)	Max Load with +0.753'' CG-x (toward pallet) (lbs)	Max Load with -0.723'' CG-x (away from pallet) (lbs)
<b>Table Pivot Pins</b>	653,538 (max weight)	653,538 (max weight)	653,538 (max weight)
<b>Forward Pins (@ 45 deg)</b>	550,089	550,767	549,438
<b>Rearward Pins (@ 45 deg)</b>	215,656	216,334	215,005
<b>Individual Cylinder</b>	70,700 (@ 20 deg)	71,800 (@ 20 deg)	69,700 (@ 25 deg)
<b>Individual Kneeling Cylinder</b>	250,471	250,928	250,033

*Table 3:* Shown below are the reactions on the 5 items with the varying block CG-x shown above combined with the maximum variance of the block's CG-z (0.204'' toward or away from the table). Maximums shown in bold.

Component	Max Load with +0.205'' CG-z (away from table) and -0.723'' CG-x (away from pallet) (lbs)	Max Load with +0.205'' CG-z (away from table) and +0.753'' CG-x (toward pallet) (lbs)	Max Load with -0.205'' CG-z (toward table) and -0.723'' CG-x (away from pallet) (lbs)	Max Load with -0.205'' CG-z (toward table) and +0.753'' CG-x (toward pallet) (lbs)
<b>Table Pivot Pins</b>	653,538 (max weight)	<b>653,538 (max weight)</b>	653,538 (max weight)	653,538 (max weight)
<b>Forward Pins (@ 45 deg)</b>	549,653	<b>550,964</b>	549,242	550,571
<b>Rearward Pins (@ 45 deg)</b>	215,202	<b>216,530</b>	214,809	216,138
<b>Individual Cylinder</b>	69,800 (@ 25 deg)	<b>71,900 (@ 20 deg)</b>	69,500 (@ 20 and 25 deg)	71,700 (@ 20 deg)
<b>Individual Kneeling Cylinder</b>	250,033	<b>250,928</b>	250,033	250,928

*Table 4 (shown at the bottom of the page):* Shown below are the maximum reactions (repeated from *Table 1*) due to the maximum variance of the blocks CG-x, CG-y, and CG-z. Computation was done considering a simply loaded beam as shown below applied to the maximum loading as computed in the previous table (*Table 3*). A percentage increase was computed (using the total table pivot pin load) and applied to the maximum loads of the 4 other components.



- Ideal reaction force with load at  $L/2 = (R1 = R2) = P/2 = 326,769 \text{ lbs}$
- Reaction force with maximum CG-y variation,  $0.753''$  in either direction =

$$R_{\max} = [P \cdot (L/2 + 0.753)] / L = 328,393 \text{ lbs}$$

- ✓ Percentage change =  $(R_{\max} - R) / R = (328,393 - 326,769) / 326,769 = 0.005$
- ✓ Increase all maximum loads by **0.5%** to account for maximum variance of CG-y

Component	Maximum Load with moving block CG (lbs)	Situation for maximum loading
Table pivot pins ( <i>full maximum weight already used, see note 1</i> )	<b>653,538</b>	The maximum reactions occur with the block's CG-x shifted $+0.753''$ (toward the pallet), the blocks CG-z shifted $+0.205''$ (away from the table), and the CG-y shifted $+0.753''$ in either direction
Forward pins ( <i>Table at <math>45^\circ</math> from horizontal</i> )	<b>550,964</b>	
Rearward pins ( <i>Table at <math>45^\circ</math> from horizontal</i> )	<b>216,202</b>	
Individual cylinder ( <i>Table at <math>20^\circ</math> from horizontal</i> )	<b>71,900</b>	
Individual Kneeling cylinder	<b>252,183</b>	