

FERMILAB

ACCELERATOR DIVISION

MECHANICAL SUPPORT DEPARTMENT

BOOSTER NOTCH ABSORBER

ENGINEERING NOTE: MSDN-1320.000-ES-296467

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Notching Absorber Design, Overview.

The conceptual design of the Booster Notching Absorber is based on **Primary beam loss calculations at notching** and **Energy deposition simulations with MARS**. The New Booster Notching Absorber will be located in the Long 13 section of the Booster Ring.



Fig.1 Booster Ring, Long 13.

1. Booster Notching Absorber Components.

The vacuum liner (item 1) is surrounded with steel absorber blocks (item 2) and concrete (item 3). Polyethylene masks (item 4) are mounted around the vacuum liner in the upstream and downstream ends of the absorber. The driving system (item 5) provides 1.00" movement of the moving block (item 6) with vacuum liner in the horizontal direction. Two bellows (item 7) are connected to the vacuum liner and to the Booster beam pipe.

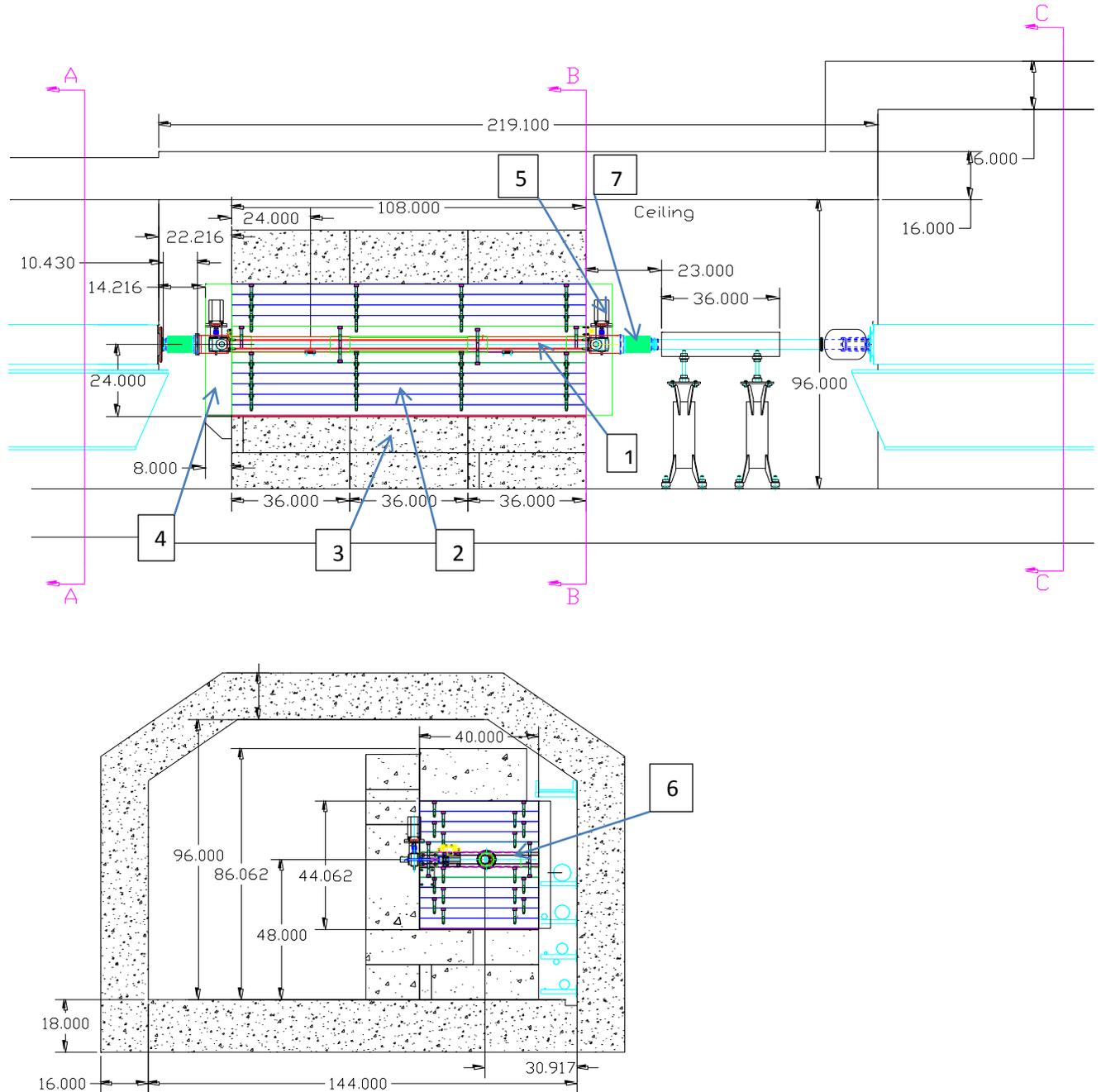


Fig.2 Booster Notching Absorber.

Vacuum Liner Design.

Vacuum liner is welded from 3"x4" section stainless steel tube, 1"x2.5" section stainless steel flat, two 6" quick disconnect flanges, 6" OD tube and two end round plates. Two thermocouple grooves are milled on the flat side of the liner. The center of the liner square 2.5"x2.5" hole and the center of the Booster beam pipe hole are fair in the neutral position. The liner flat edge is located 0.79" (20mm) from the center of the beam in the working position.

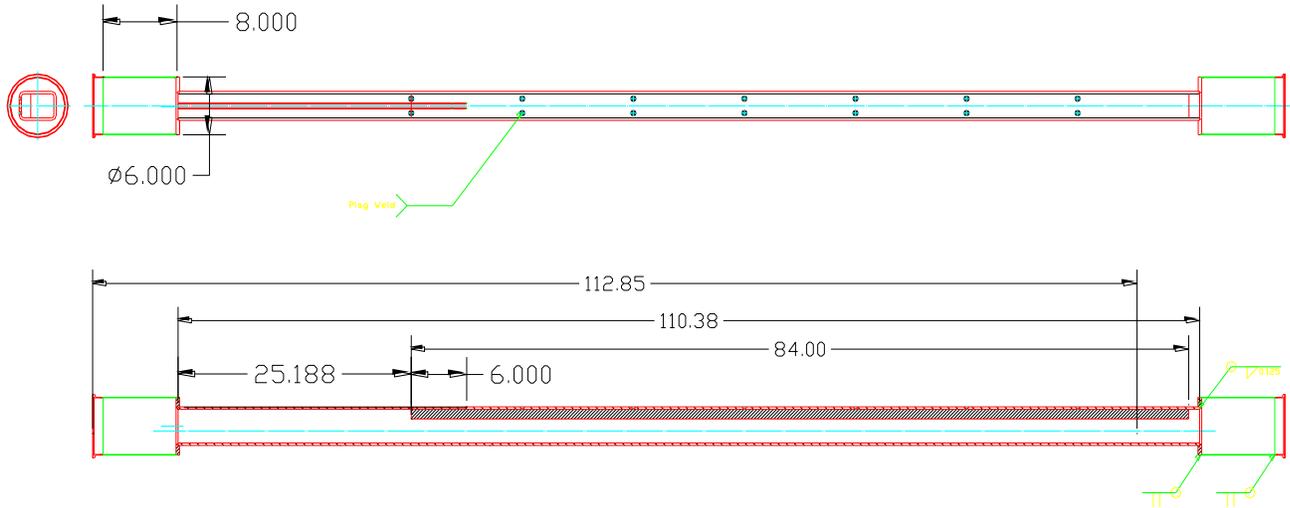


Fig.3 Vacuum Liner.

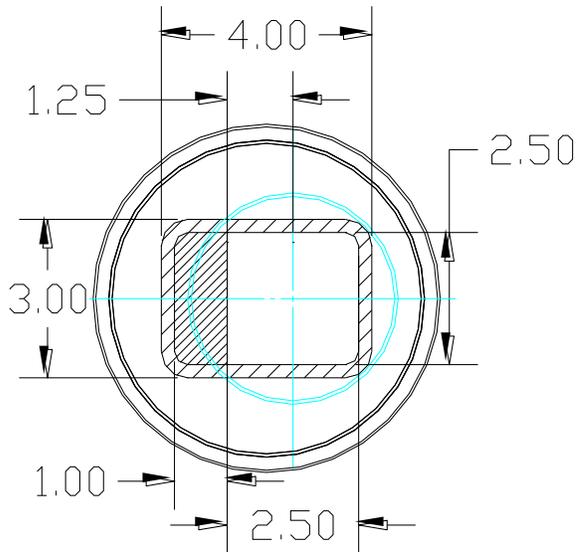


Fig.4 Vacuum Liner neutral position.

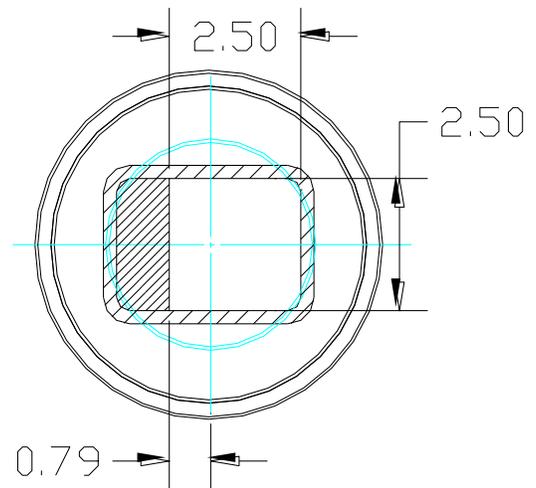


Fig.5 Vacuum Liner working position.

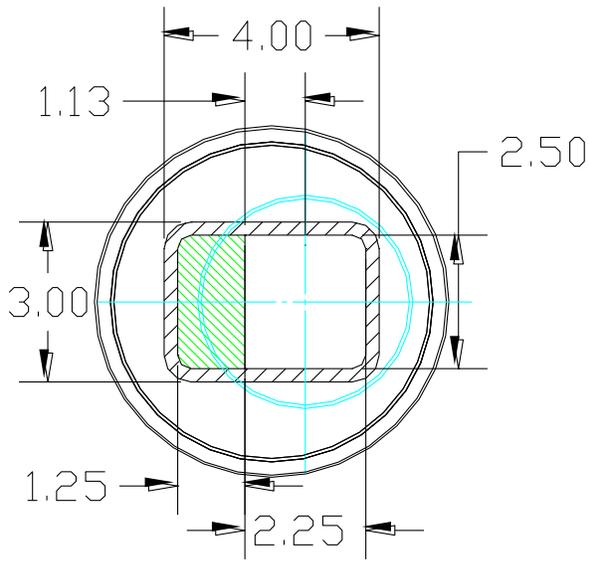


Fig.4a Vacuum Liner neutral position.

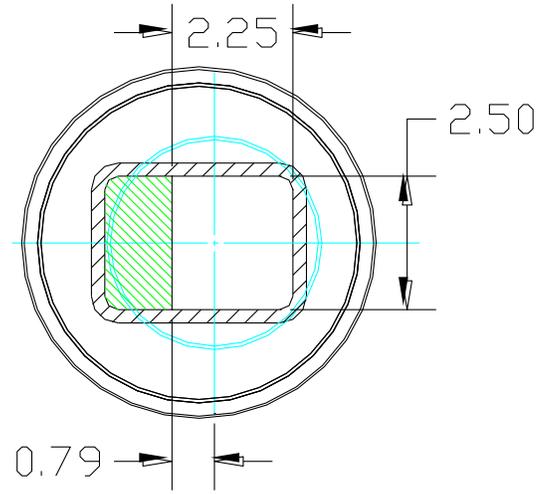


Fig.5a Vacuum Liner working position.



Fig.6 Vacuum liner 3d pictures.

Moving Block.

The moving block is assembled from three bottom plates two side blocks, vacuum liner between blocks and three top plates. The vacuum liner and side blocks must have proper contact for a heat transfer. The moving block has two pivot brackets for the screw jacks clevis connection.

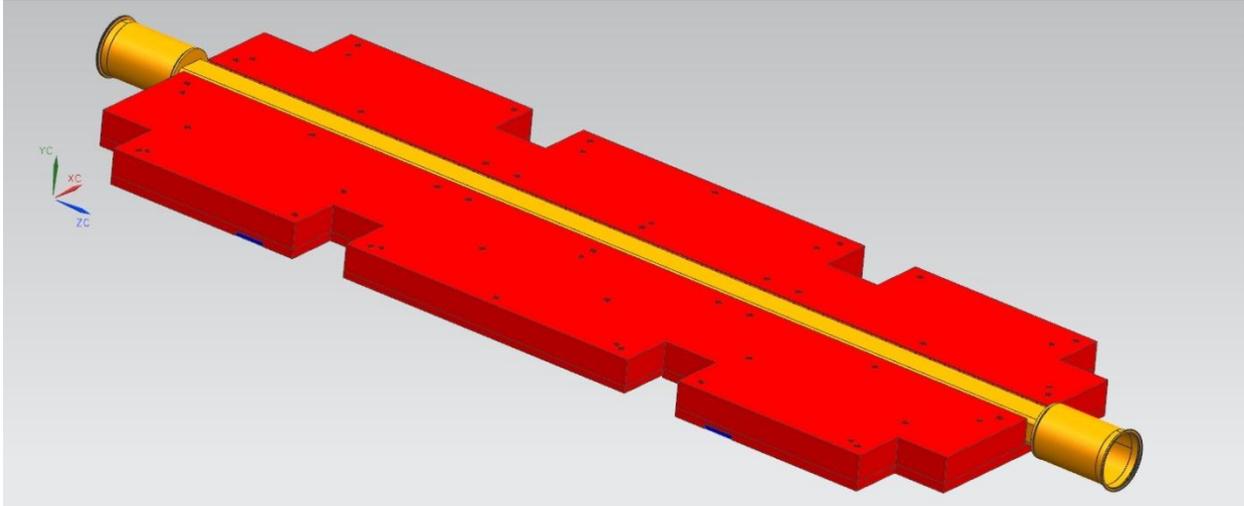


Fig.7 Vacuum Liner inserted into the shielding.

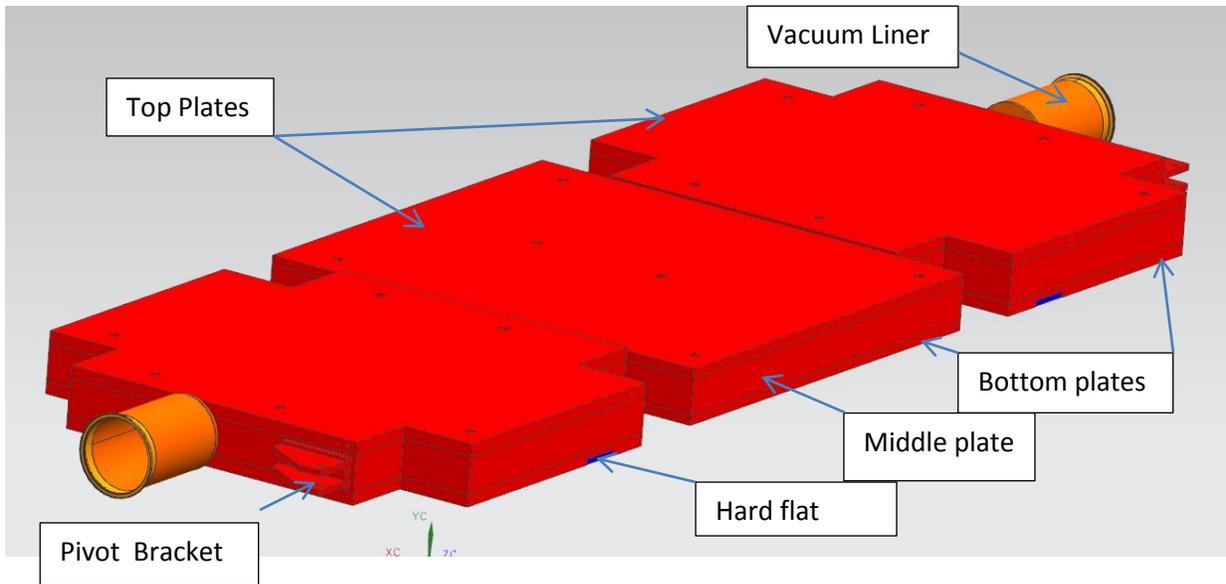


Fig.8 Moving block assembly.

Moving Block and support plates assembly

The bottom base plate of the moving block is bolted to the bottom shielding blocks assembly. The base plate has eight support stands to support the top portion of the steel shielding. Four flat rollers are placed on the hard plates to support the moving block.

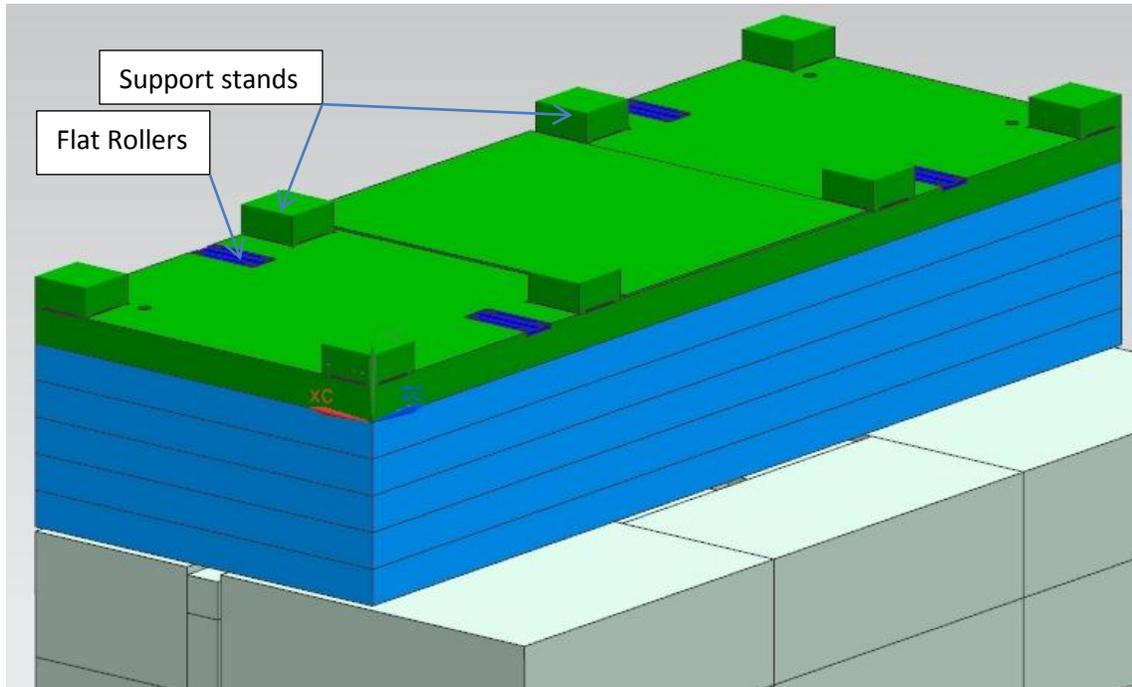


Fig.9 Base plates with flat rollers and top shielding support stands.

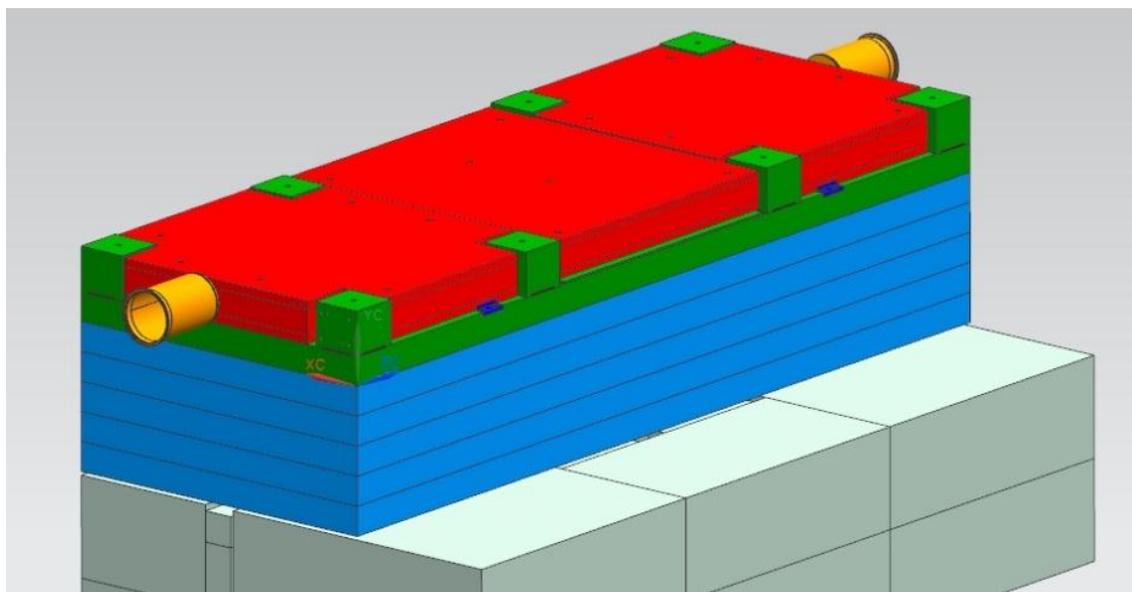


Fig.10 Moving Block placed on the base plate flat rollers

The top plate is bolted to the base plate stands and supports the top portion of the absorber shielding. Two screw jacks 2.5 ton capacity are mounted on the base plate stands and connected to the moving block pivot bracket.

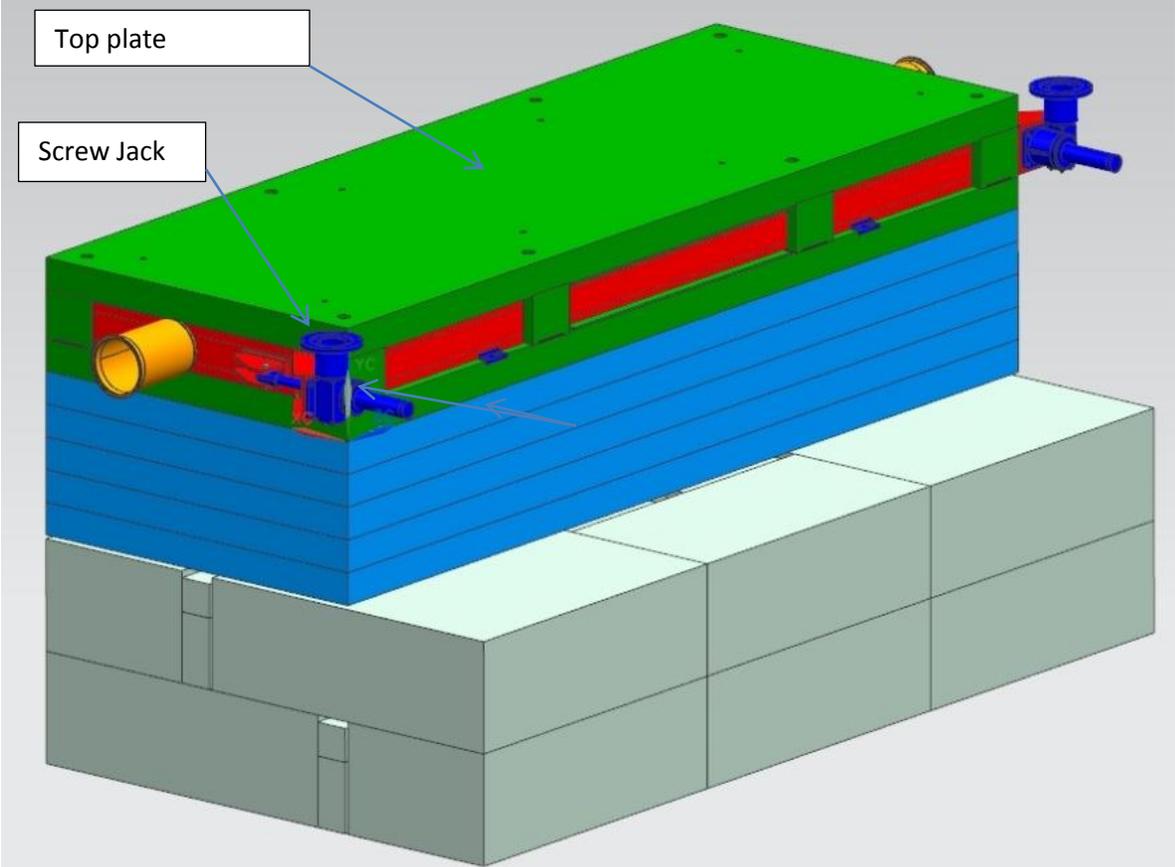


Fig.11 Moving block assembly.

Top shielding plates installation.

Top steel shielding plates are bolted to the moving block base top plate and to each other.

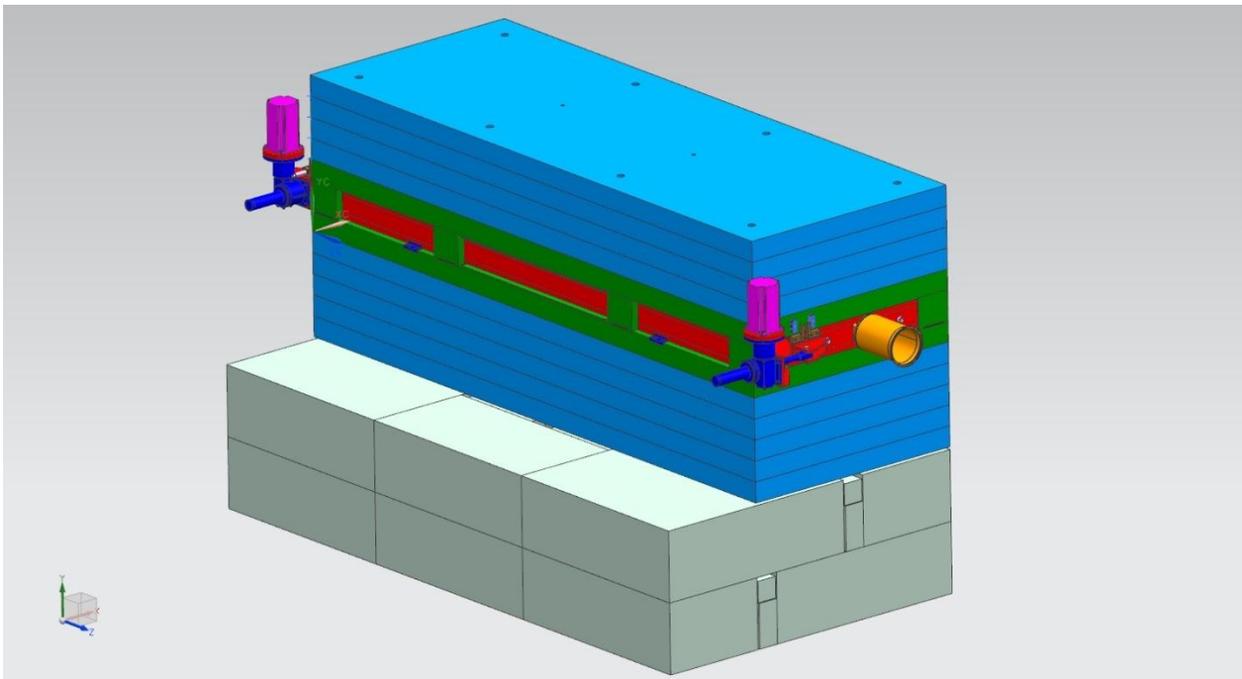
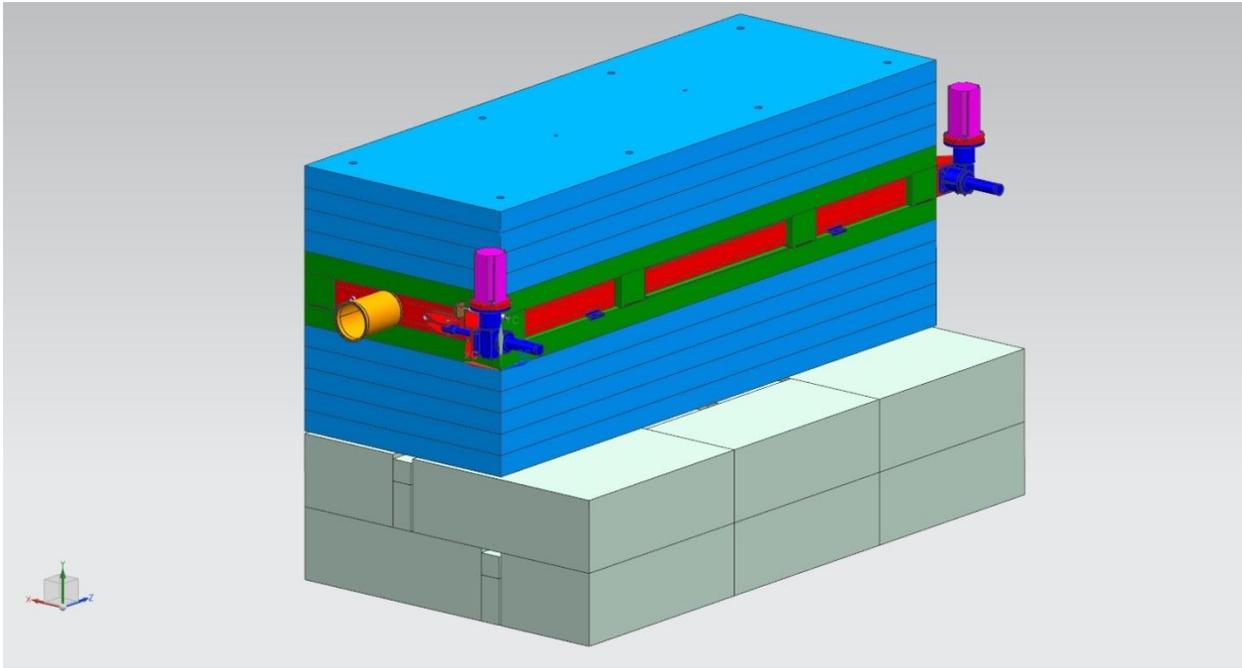


Fig.12 Top steel plates installation.

Concrete Blocks installation

Concrete blocks are surrounded the steel shielding from the top and aisle side of the absorber and secured with aluminum frame.

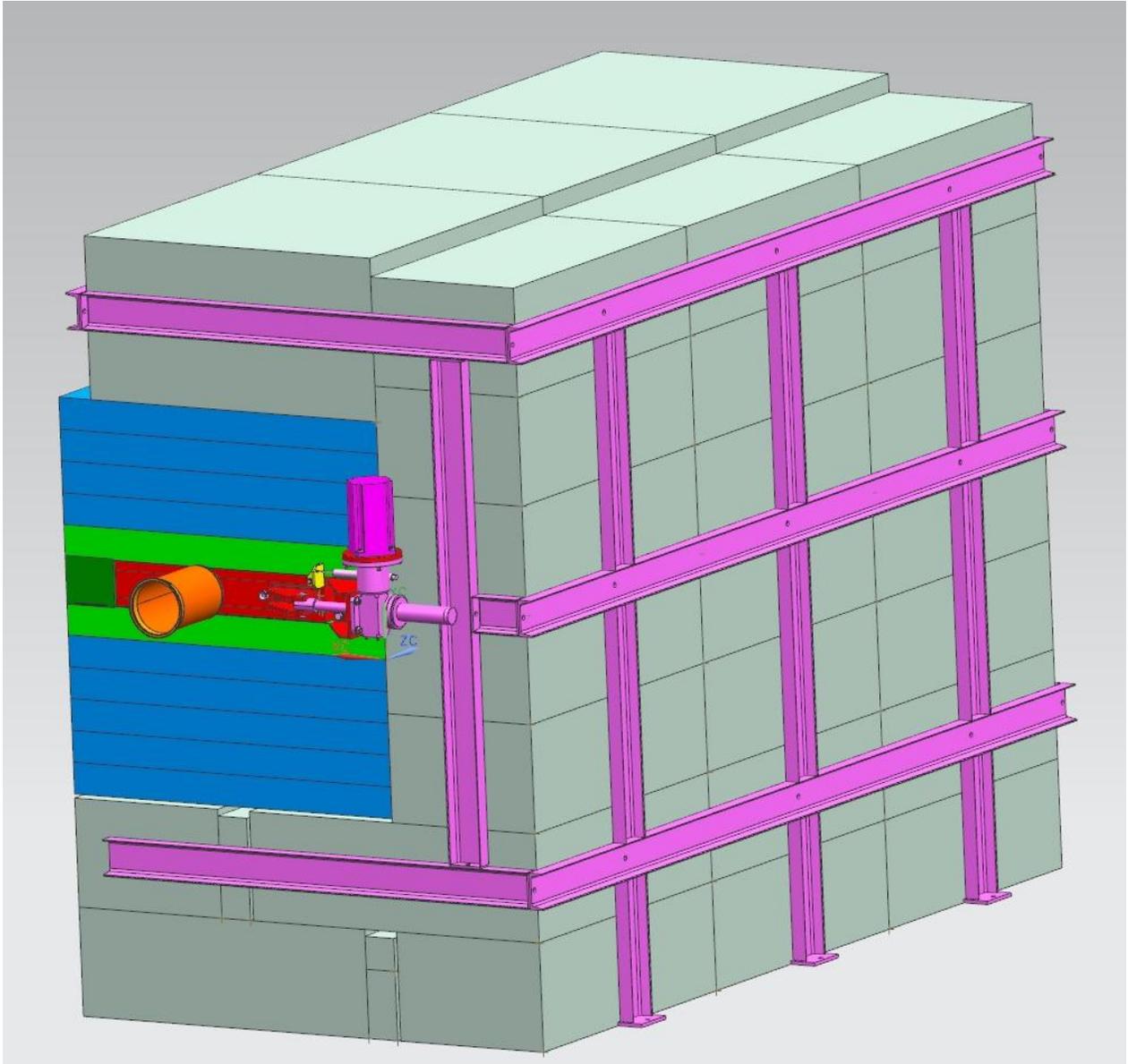


Fig.13 Concrete blocks installation.

Polyethylene masks installation.

Two polyethylene blocks 43"x40" x 4" are bolted to the steel shielding plates on upstream and downstream ends of the absorber.

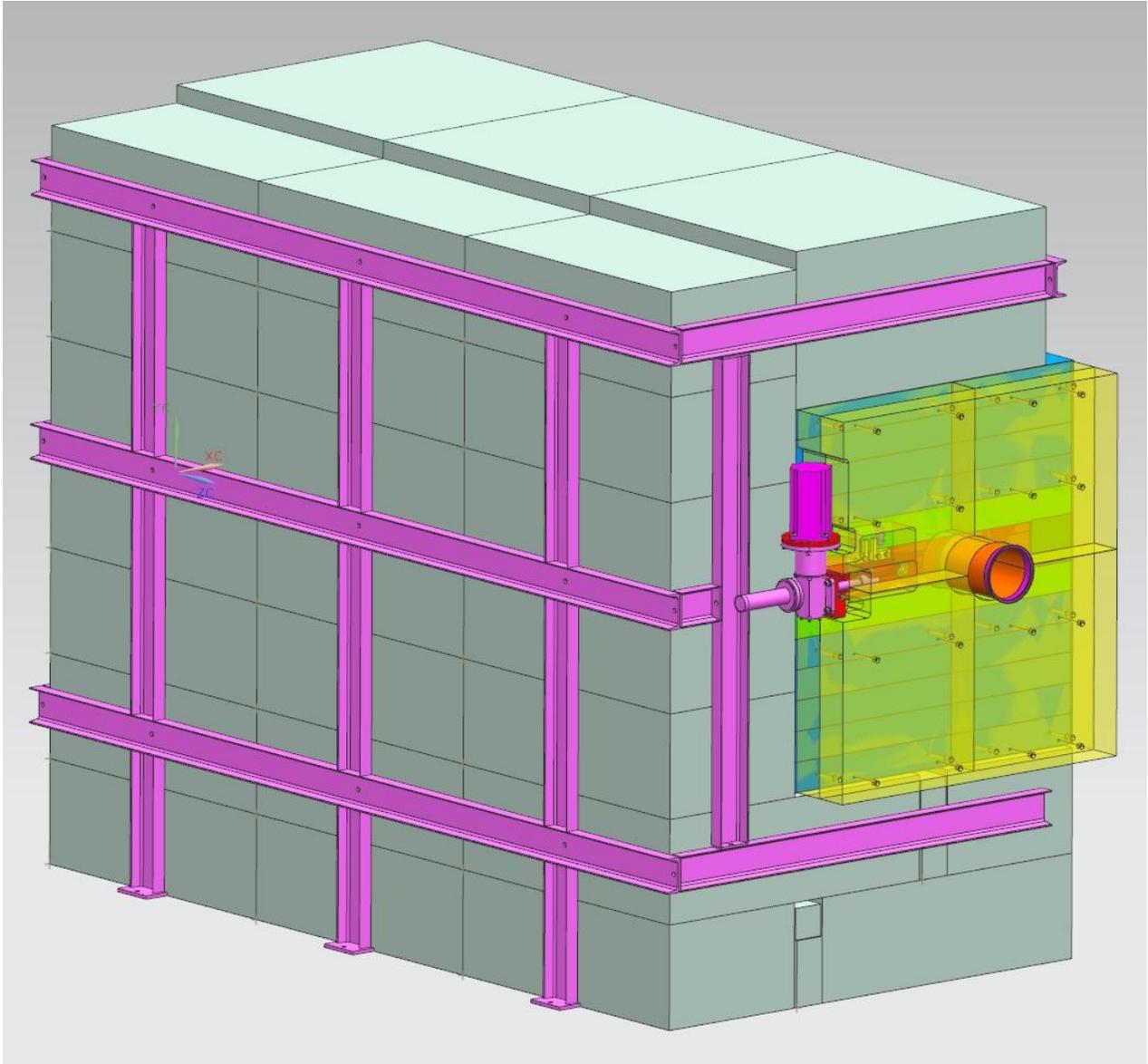


Fig.14 Polyethylene Mask Installation

Control System.

The horizontal LVDT (item1) control the position of the moving block during operation and connected to the ACNET. Limit switches and (item 2), keep the moving block in limits (1.0" horizontally) and protect motors from the overdrive. Two thermocouples are inserted into the vacuum liner. One of them is connected to the ACNET.

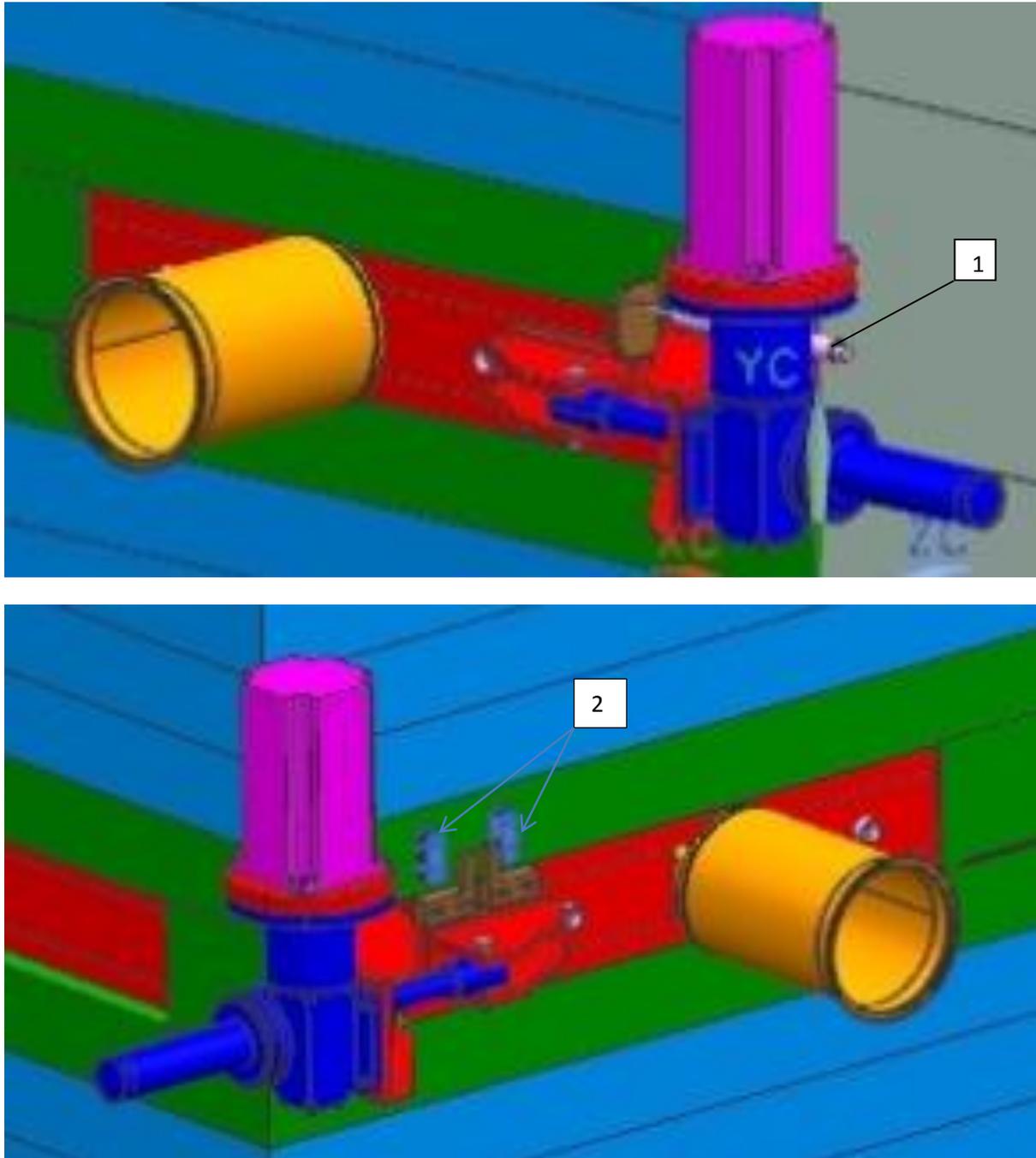


Fig.15 LVDT and Limit Switches location.

Motion System .

Two Action Jack 2.5-MSJ-series screw actuators, 24 : 1 ratio, are used to push-pull 6,200 pounds of the moving part of the absorber. Required push-pull force is: $6,200 \times 0.8 = 4,960$ lb. Where: 0.8 – coefficient of static friction between rollers and absorber steel block in case of sliding.

2.5-MSJ SPECIFICATIONS

GEAR RATIO	CAPACITY (lbs.)	LIFTING SCREW (in.)			TURNS OF WORM FOR 1" TRAVEL	MAX INPUT TORQUE (in.-lb.)	MAX ALLOWABLE INPUT (HP)	MAX WORM SPEED AT RATED LOAD (RPM)	
		DIAMETER	LEAD	ROOT DIA.				NON-KEYED	KEYED
24:1	5000	1	0.25	0.698	96	53	0.5	594	516

MAX LOAD AT 1750 RPM (lbs.)		TORQUE TO RAISE 1 LB. (in.-lbs.)		TARE DRAG TORQUE (in.-lbs.)	STARTING TORQUE (in.-lb.)	WEIGHT (Approx. in lbs.)			PDF PAGE
NON-KEYED	KEYED	NON-KEYED	KEYED			"0" TRAVEL	PER INCH OF TRAVEL	GREASE	
1699	1476	0.0106	0.0122	5	0.0212	17	0.45	0.5	323

1. Determine Unit Running Torque: (T₁) (lb-in)

$$T_1 = 0.0122 \times 4960 / 2 = 30.25$$

0.0122 – Torque to raise 1 lb (from chart)

2. Find Unit Power:

$$HP = (T_1 \times RPM) / 63025 = 30.25 \times 300 / 63025 = 0.15$$

3. Determine Unit Starting Torque: (T_s)

$$T_s = 2T_1 = 30.25 \times 2 = 60.5$$

4. Motor selected:

. Anaheim Automation Stepper Motor NEMA 42 K Series, 42K322S-CB8, Motor speed- 5 RPS, Torque – 4000 oz-in.

5. Motor running torque: (lb-in)

$$1200 / 16 = 75 > 30.25$$

6. Motor Power: (HP)

$$75 \times 300 / 63025 = 0.357 > 0.15$$

7. Motor starting torque: (lb-in)

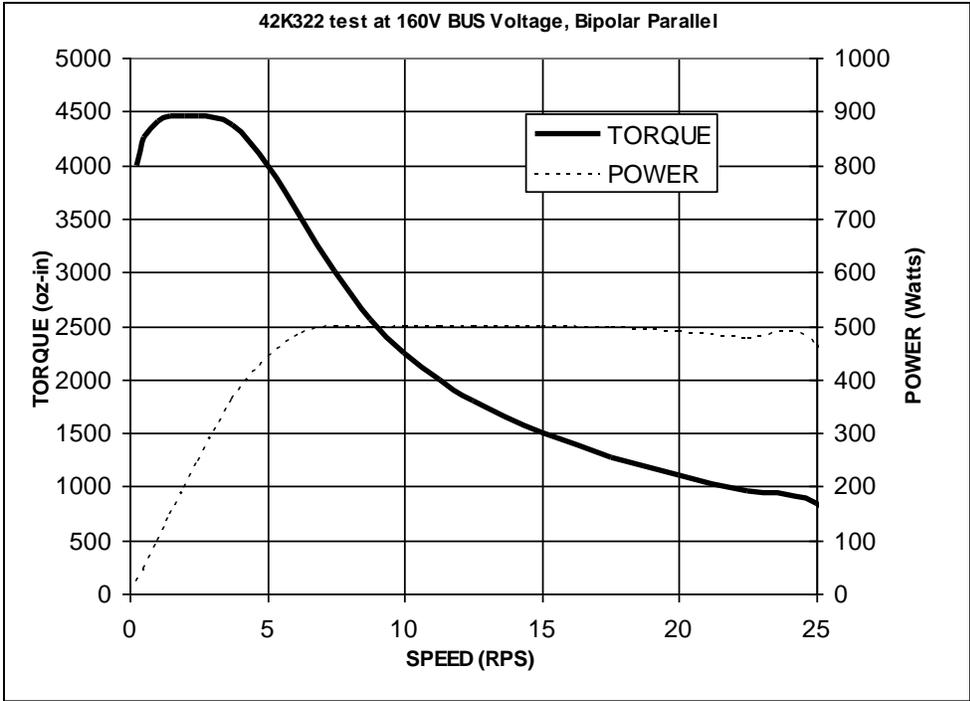
$$2720 / 16 = 170 > 60.5$$

8. Time to move 1"

Travel time –0.32 min=20sec., Travel speed 3.125 in / min

Calculated Torque Chart for Stepper Motor 42K312.

SPEED		TORQUE	POWER
PPS	RPS		
400	0.25	4000	22.18
800	0.5	4250	47.1325
1600	1	4400	97.592
2400	1.5	4450	148.0515
3200	2	4450	197.402
4000	2.5	4450	246.7525
6000	3.75	4375	363.890625
8000	5	4000	443.6
10000	6.25	3500	485.1875
12000	7.5	3000	499.05
14000	8.75	2550	494.89125
16000	10	2250	499.05
18000	11.25	2000	499.05
20000	12.5	1800	499.05
24000	15	1500	499.05



Moving Block Base FEA Calculations.

Top steel shielding plates and concrete blocks (Total weight 23350lb) are supported by the base plate. The calculation pressure is 5.4 Psi.

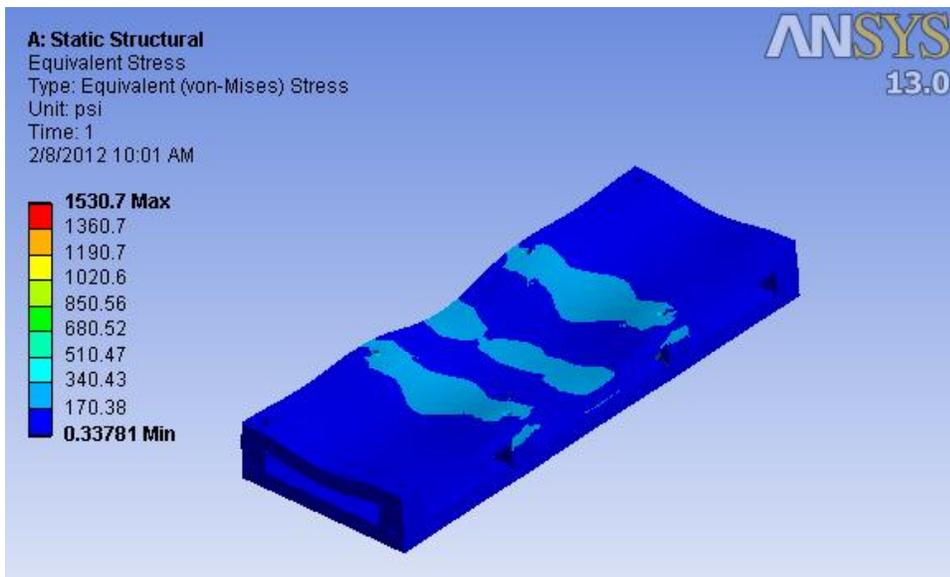
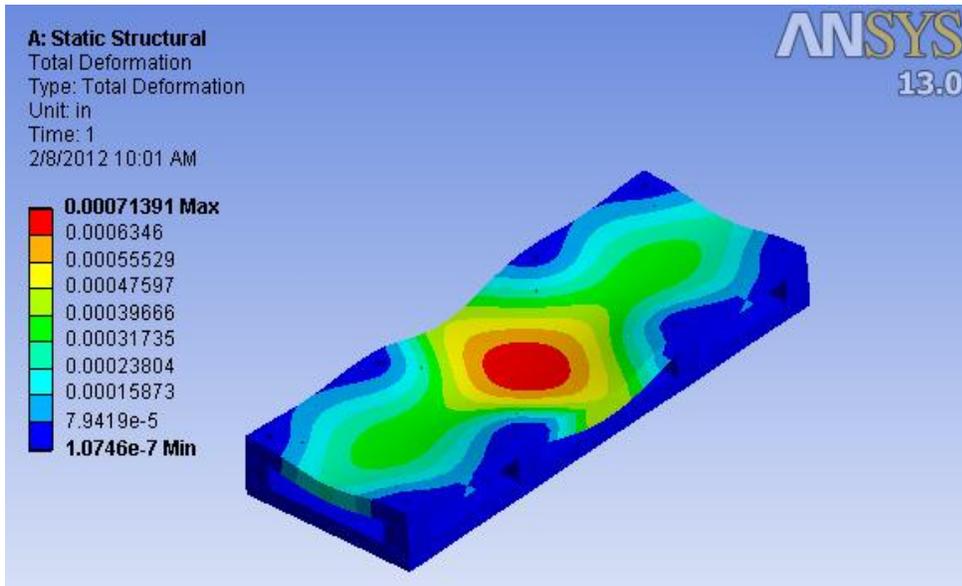
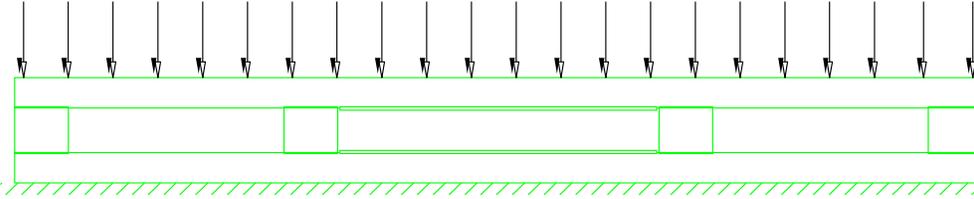


Fig. 16 Moving block base stress and deformation.

Moving block FEA Calculations.

The weight of the moving block is supported by four roller bearings. The deformation and stress from own weights are shown below. The calculation pressure is 1 Psi.

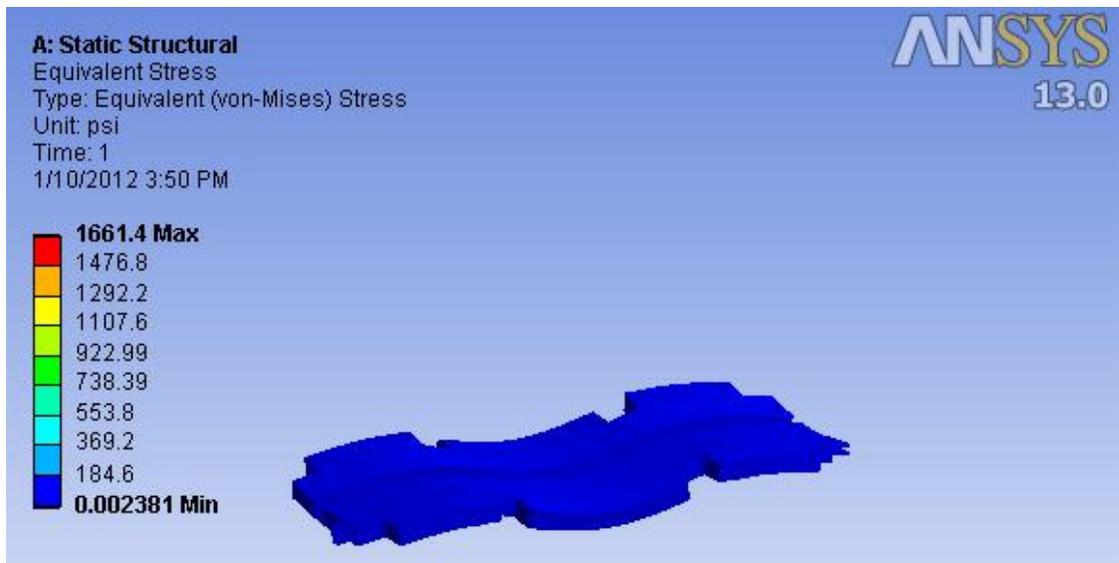
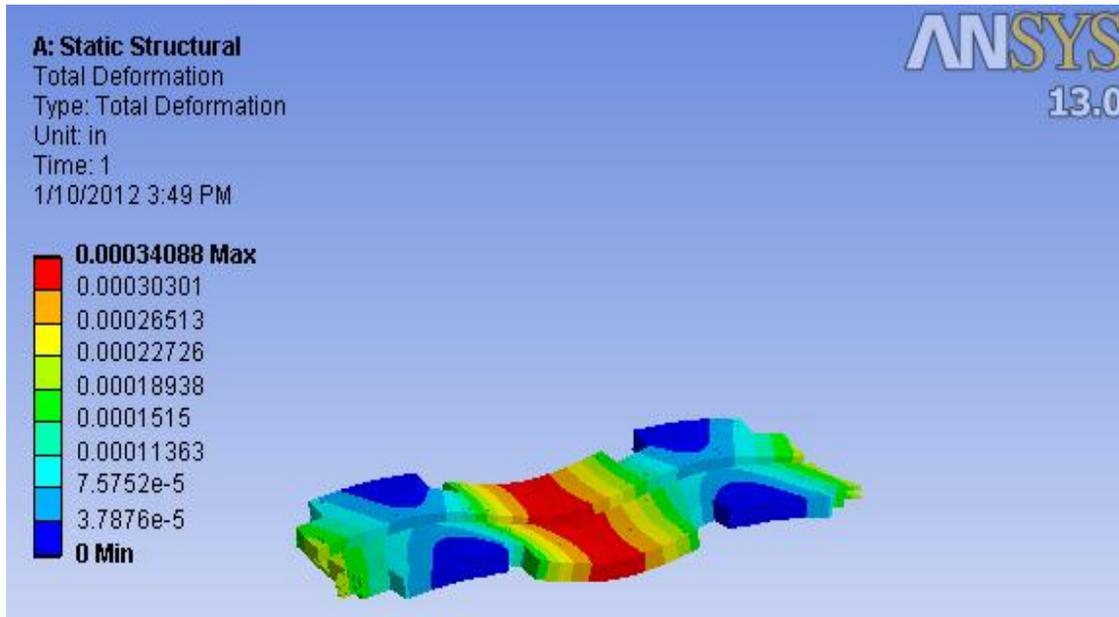
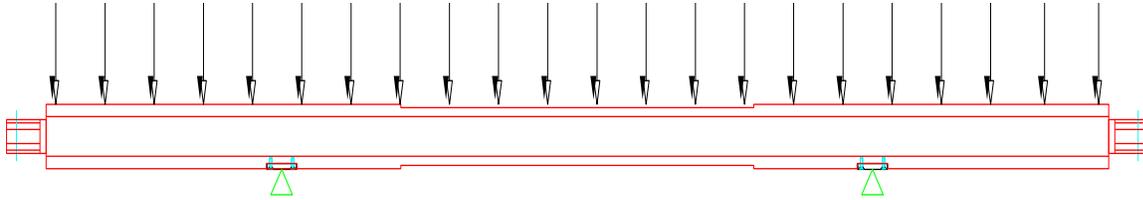
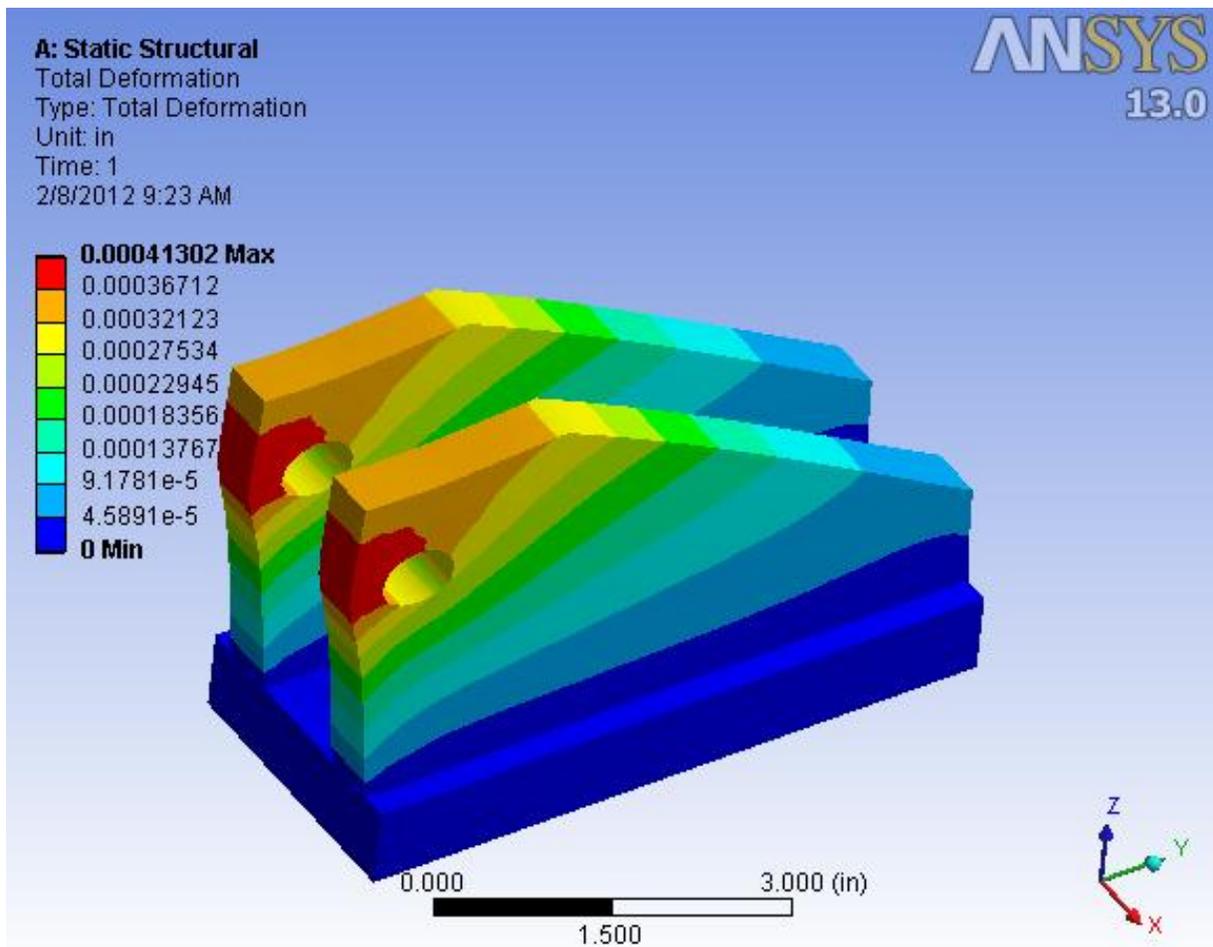
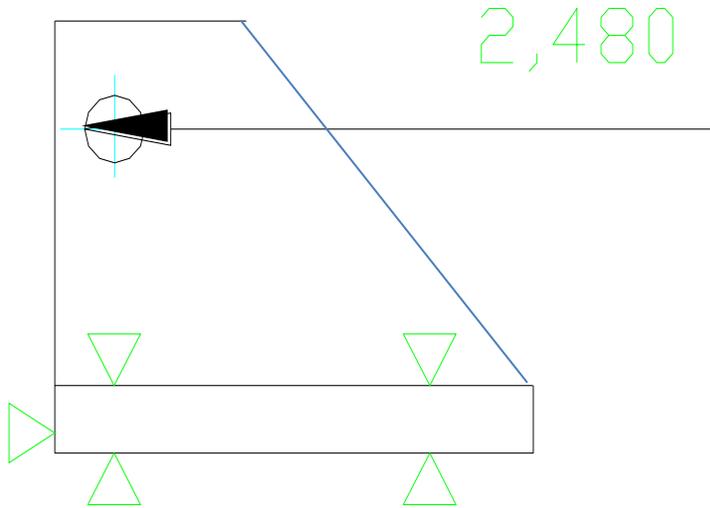


Fig.17 Moving block parts stress and deformation.

Moving block pivot bracket FEA calculations

The push-pull force applied to the pivot bracket is 2480lb.



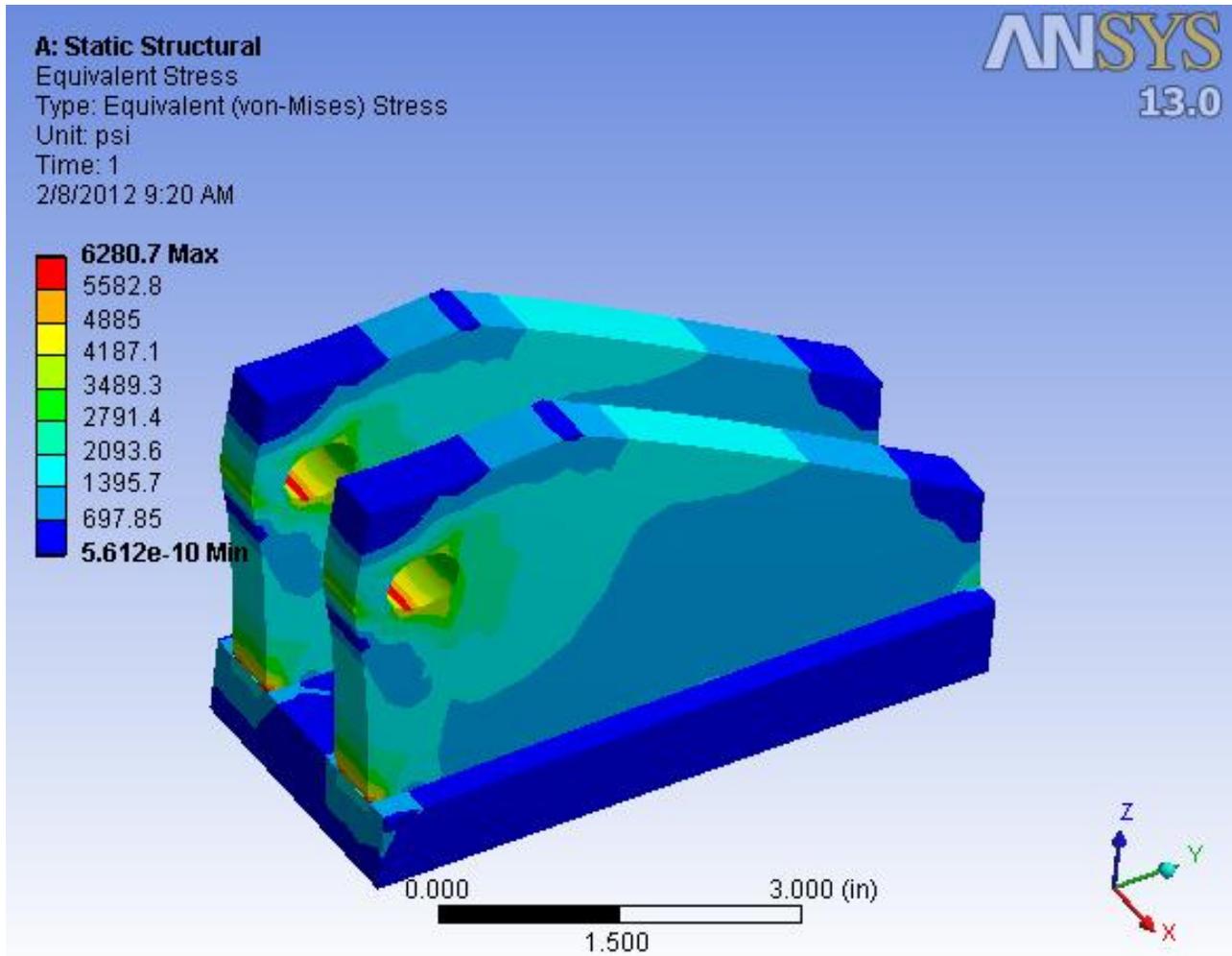


Fig.18 Pivot Bracket stress and deformation.

Additional shielding.

According MARS calculations the star density behind the tunnel concrete wall in case of the 13" gap between the absorber and tunnel wall is about 8000.

Required limit of the star density is 4000.

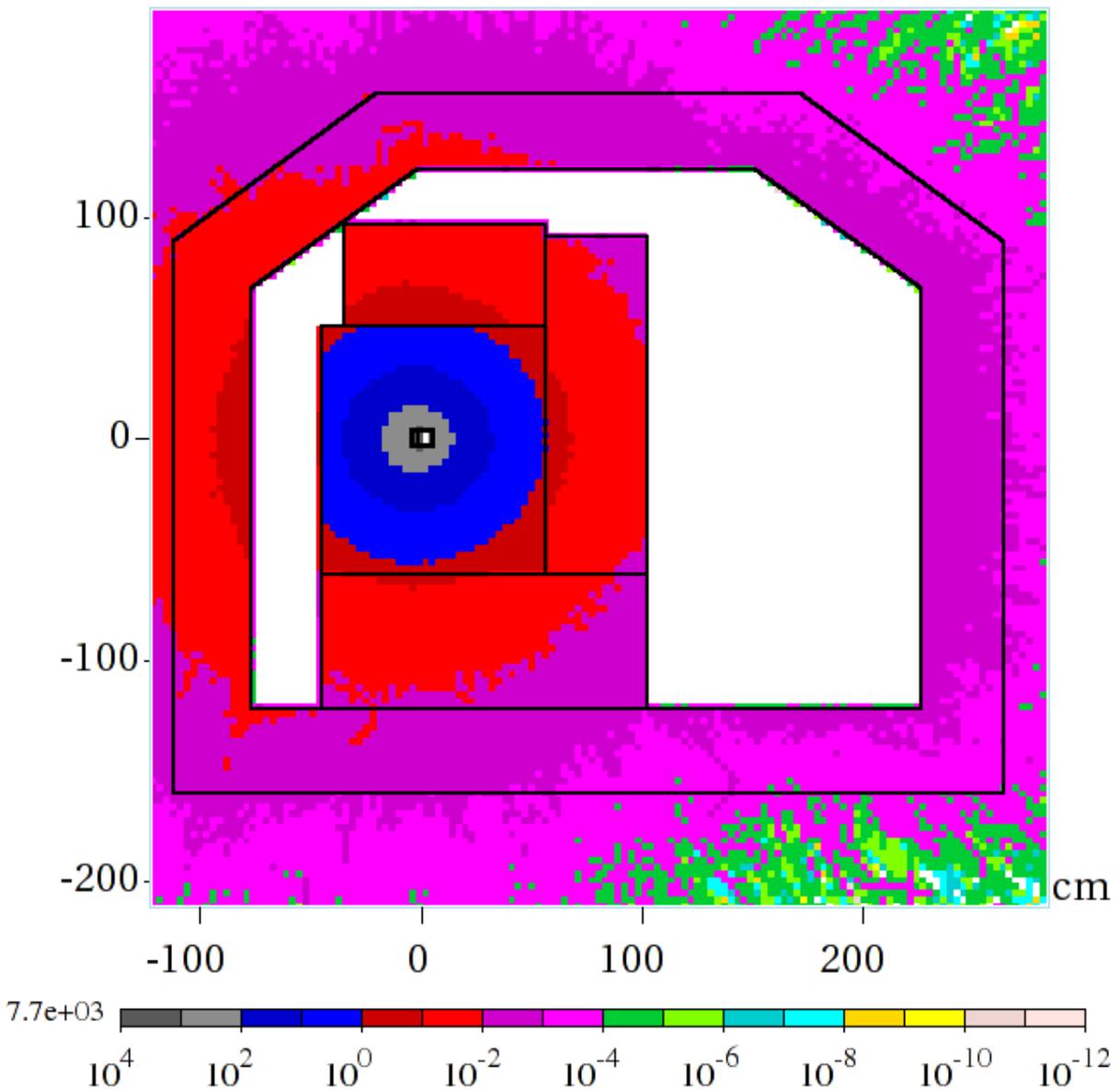


Fig.19 Energy deposition, MARS Calculations.

The gap between Notch Absorber and wall must be filled with the steel shielding six inches thick and sand bags. The Star Density will be decreased till 3000.

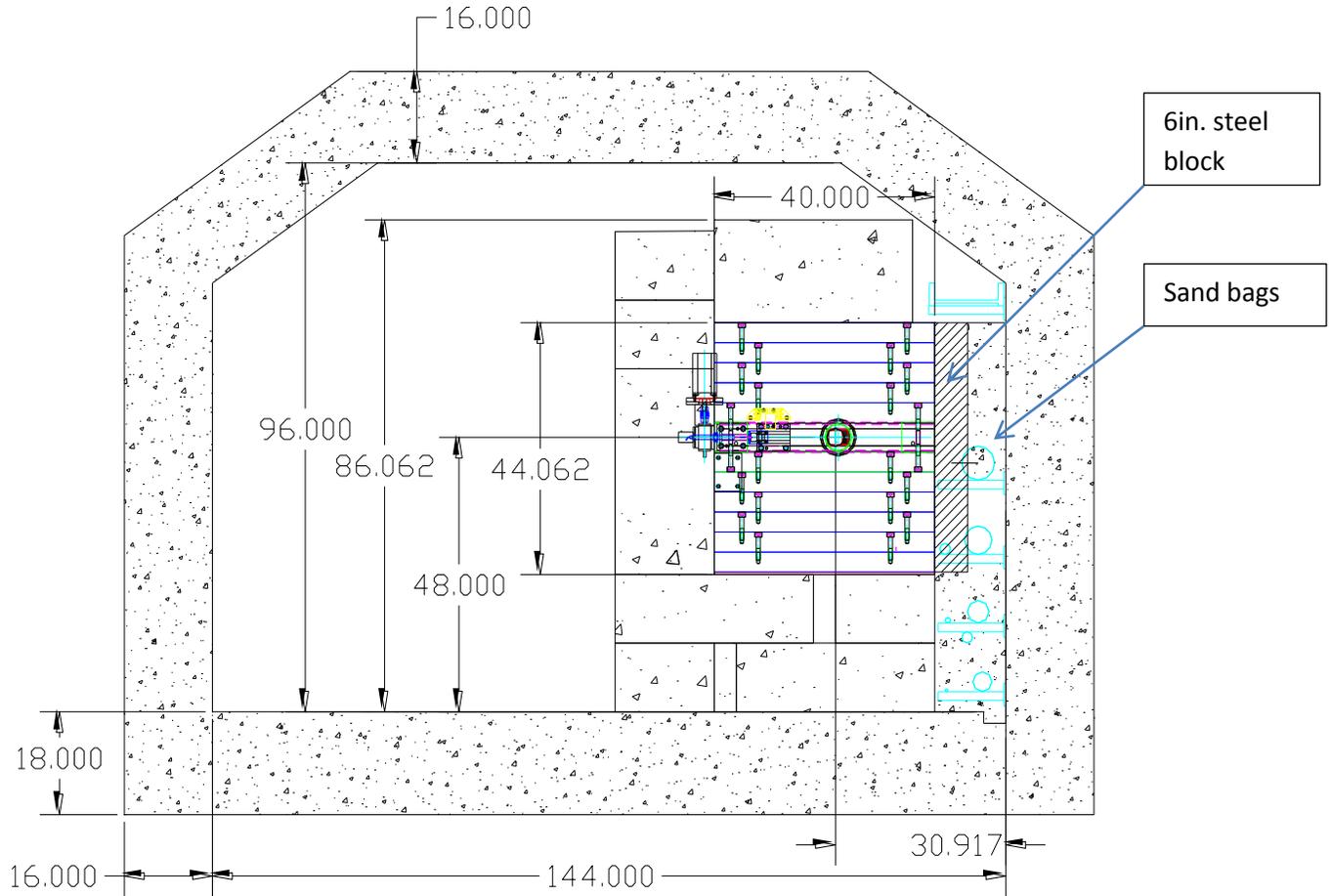


Fig.20 Additional shielding .

Thermal Analysis

The Absorber Liner jaw will be heated by energy deposition of three bunches from 84 of the beam.

Proton per pulls: 5×10^{12} , 15Hz, 700 MEV.

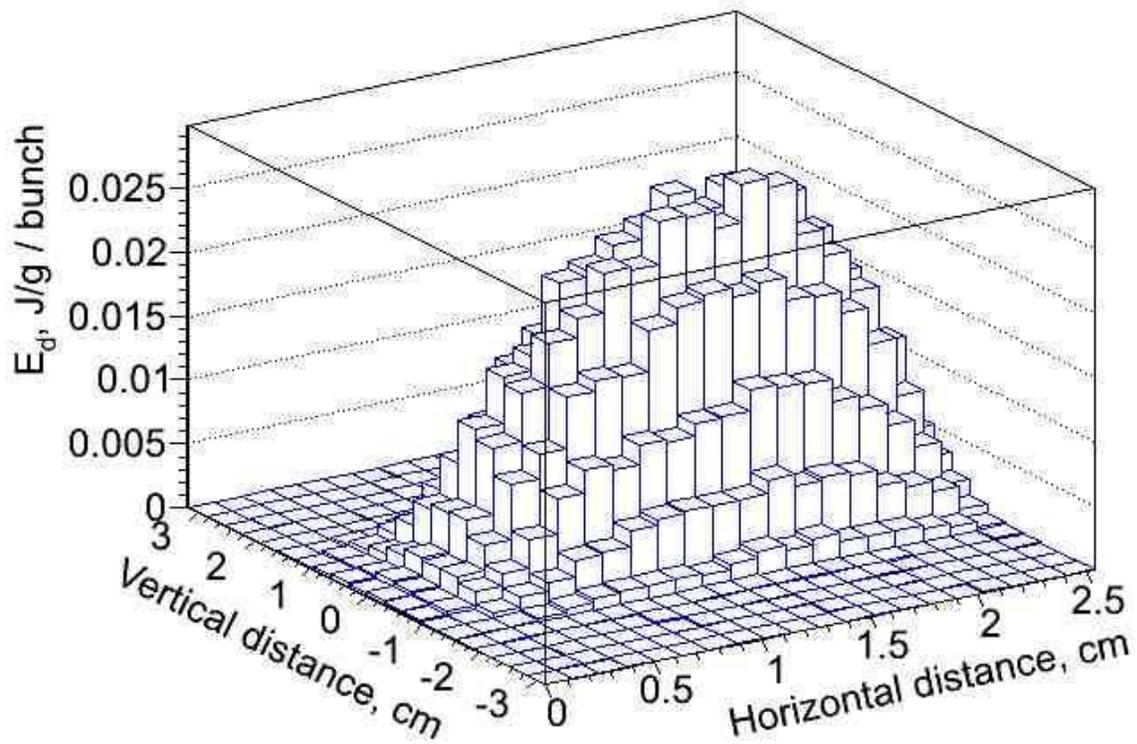


Fig.21 Energy deposition.

The conductive heat transfer only is used in this calculation.

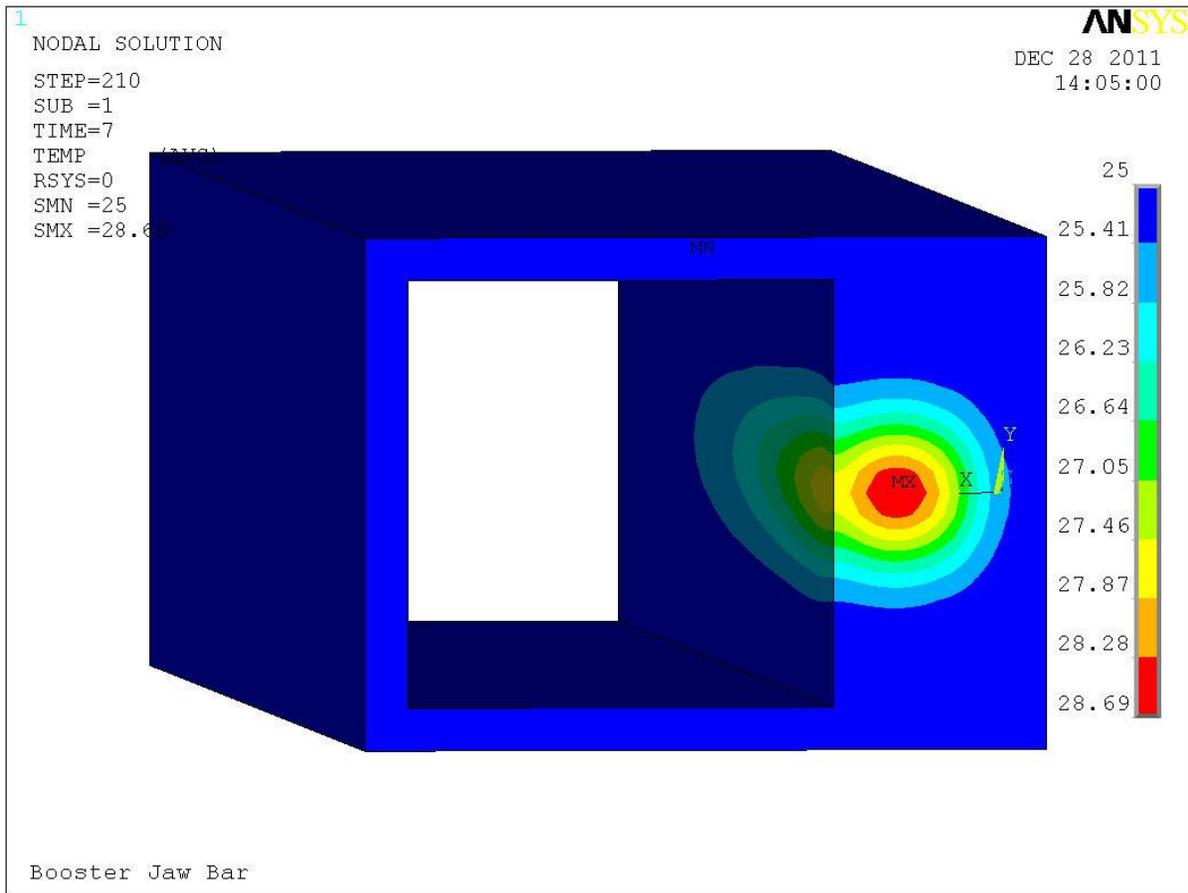


Fig.21 Model 1: Piece of tube with jaw inside two feet long is heated by beam.

1

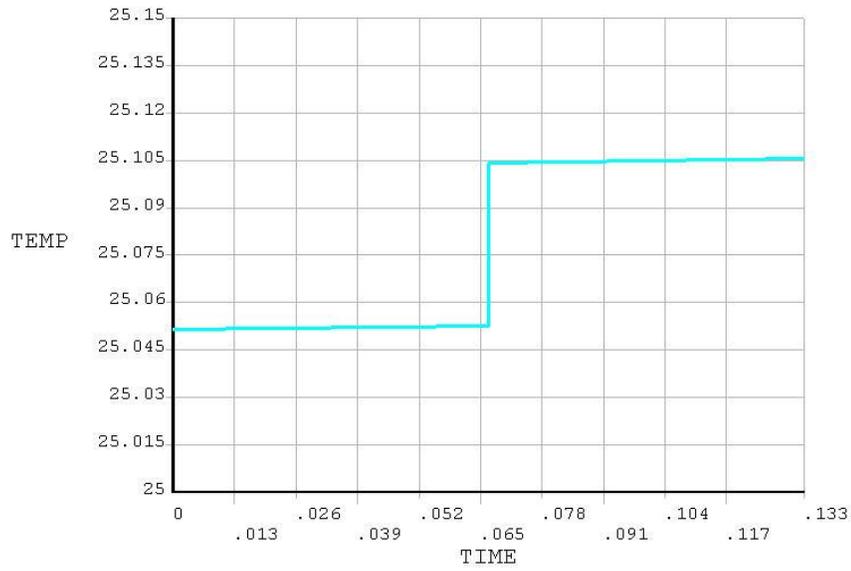
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Booster Jaw Bar

Fig.22 Instant temperature- rise per pulls is 0.6°C.

1

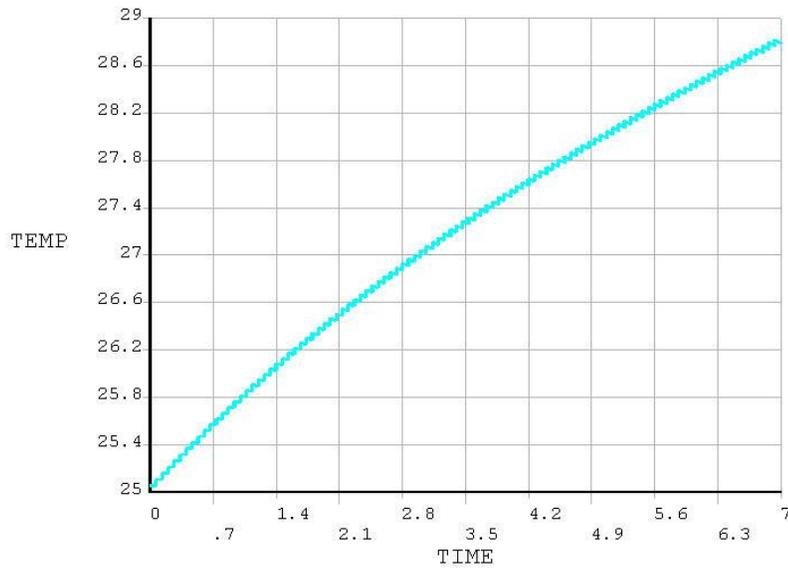
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Booster Jaw Bar

Fig.23 Instant temperature rise.

