Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project Internal Reference: none

Project: NOvA Near Detector

Title: Muon Catcher Weight

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Key Words: NOvA Near Detector Muon Catcher Weight

Abstract Summary: Calculation of the weight of the detector and steel weights for the NOvA Integration Prototype and Near Detector (IPND)

Applicable Codes: None

Result:

The Muon Catcher Steel Planes weigh about 95 tons total for 10 planes

The Muon Catcher Detector Planes weight about 16,183 pounds for 10 planes

Gross weight of the Muon Catcher (Steel filter planes and detector planes) is about 104 tons.

Calculations:

IPND and Near Detector Scintillator Volume Calculations:	Value	Units	Reference or Formula
Cell Interior Width, mm	38.4	mm	see dwg MC-435388
Cell Interior Depth, mm	59.4	mm	see dwg MC-435388
Number of Cells per extrusion	16		see dwg MC-435388
Raw Vertical Extrusion Length, mm	4114.8	mm	see dwg MD-444814
Raw Horizontal Extrusion Length, mm	2794	mm	see dwg MD-444812
Raw Vertical Extrusion Length, inches	162	inches	
Raw Horizontal Extrusion Length, inches	110	inches	
Volume of a RAW vertical extrusion, mm3	150171107	mm3	B3*B4*B5*B6
Volume of a RAW vertical extrusion, m3	0.150	m3	B9/1000/1000/1000
Volume of a RAW vertical extrusion, liters	150.2	liters	B10*1000
Volume of a RAW vertical extrusion, gallons	39.7	gallons	B11/3.785
Volume of a RAW horizontal extrusion, mm3	101968036	mm3	B3*B4*B5*B7
Volume of a RAW horizontal extrusion, m3	0.102	m3	B14/1000/1000/1000
Volume of a RAW horizontal extrusion, liters	102.0	liters	B15*1000
Volume of a RAW horizontal extrusion, gallons	26.9	gallons	B16/3.785
Number of Horizontal planes in a horizontal block	16		see dwg ME-444583
Number of Vertical planes in a horizontal block	15		see dwg ME-444583
Number of Horizontal extrusions in a plane in a horizontal block	6		see dwg ME-444583
Number of Vertical extrusions in a plane in a horizontal block	4		see dwg ME-444583
Number of Horizontal planes in a vertical block	15		see dwg ME-444096
Number of Vertical planes in a vertical block	16		see dwg ME-444096
Number of Horizontal extrusions in a plane in a vertical block	6		see dwg ME-444096
Number of Vertical extrusions in a plane in a vertical block	4		see dwg ME-444096
Volume of Scintillator in a Horizontal Block, liters	18792 18799.2	liters	B19*B21*B16+B20*B22*B11 150×4×15 + 102×6×16
Volume of Scintillator in a Vertical Block, liters	18780 18788.1	liters	B24*B26*B16+B25*B27*B11 150×4×16 + 102×6×15
Volume of Scintillator in a Horizontal Block, gallons	4961 4966.8	gallons	B29/3.785
Volume of Scintillator in a Vertical Block, gallons	4957 4963.8	gallons	B30/3.785
Volume of Scintillator in a Horizontal Block, ft3	663.9	ft3	B29/28.316
Volume of Scintillator in a Vertical Block, ft3	663.5	ft3	B30/28.316

Number of Horizontal blocks in IPND	3		Un-documented, assumed value
Number of Vertical blocks in IPND	3		Un-documented, assumed value
Total Scintillator in IPND, liters	112761.8	liters	B38*B29+B39*B30 18799 x 3 + 18788 x 3
Total Scintillator in IPND, gallons	29791.8	gallons	B38*B32+B39*B33
Total Scintillator in IPND, ft3	3982.3	ft3	B38*B35+B39*B36
IPND Secondary Containment Width	15	ft	see dwg ME-444109
IPND Secondary Containment Length	45.25	ft	see dwg ME-444109
IPND Secondary Containment Depth	5.8670571	ft	

MUON CATCHER:

5 planes of horizontals with 3 modules per plane
5 planes of verticals with 2 modules per plane

Weight of a horizontal module (two extrusions + end cap + manifold) is about 125 pounds
Weight of a vertical module (two extrusions + end cap + manifold) is about 255 pounds empty

So, weights of the empty modules:
horizontals: 15 * 125 pounds = 1875 pounds

number of planes	5	
number of modules per plane	3	
weight of one horizontal plane	125	pounds
weight of all horizontal planes:	1875	pounds

verticals: 10 * 255 pounds = 2550 pounds

number of planes	5	
number of modules per plane	2	
weight of one vertical plane	255	pounds
weight of all vertical planes:	2550	pounds

Volume of the cells in one extrusion is:

horizontals	26.9	gallons	from calculation above
vertical	39.7	gallons	from calculation above

Volume of the cells in one module (2 extrusions) is:

horizontals	53.9	gallons	2 times the above number for one extrusion
vertical	79.4	gallons	2 times the above number for one extrusion

Specific Gravity of the scintillator	0.88		
Weight of Water per unit volume	62.4	pounds per cubic foot	x .88 / 7.48 gal/ft³
Weight of Scintillator per unit volume	7.34	pounds per gallon	

Weight of Scintillator:			
Weight of scintillator in one horizontal module	395.5	pounds	53.9 x 7.34
number of planes	5		
number of modules per plane	3		
Weight of scintillator in all horizontal modules	5932.7	pounds	
Weight of scintillator in one vertical module	582.5	pounds	79.9 x 7.34
number of planes	5		
number of modules per plane	2		
Weight of scintillator in all vertical modules	5824.9	pounds	
Weight of PVC and Scintillator:			
Horizontals:	7,808	pounds	5932.7 + 1875
Verticals:	8,375	pounds	5824.9 + 2550
Combined Muon Filter Detector Weight:	16,183	pounds	
Muon Filter Steel Dimensions:			
Thickness	4	inches	
Width	107.5	inches	
Height	157.25	inches	
Volume:	67,618	in3	
Density	0.284	#/in3	
Weight of one Filter Steel Plane	19,203 19,174	pounds	
Number of Filter Steel Planes	10		
Weight of all filter steel planes	192,000 191,739	pounds	.0005 tons/ft
Weight of all filter steel planes	95.87	tons	
Weight of Muon Catcher Steel + Detectors	207,922	pounds	
Weight of Muon Catcher Steel + Detectors	103.96	tons	