Thermal Blanket

Status May 9, 2006

Joanne has updated xmlGeoDbs to include new volumes for the updated blanket including the crown.
Heather updated materials.xml to include the element Boron and to modify the blanket description according to the details that are described further down on this page.

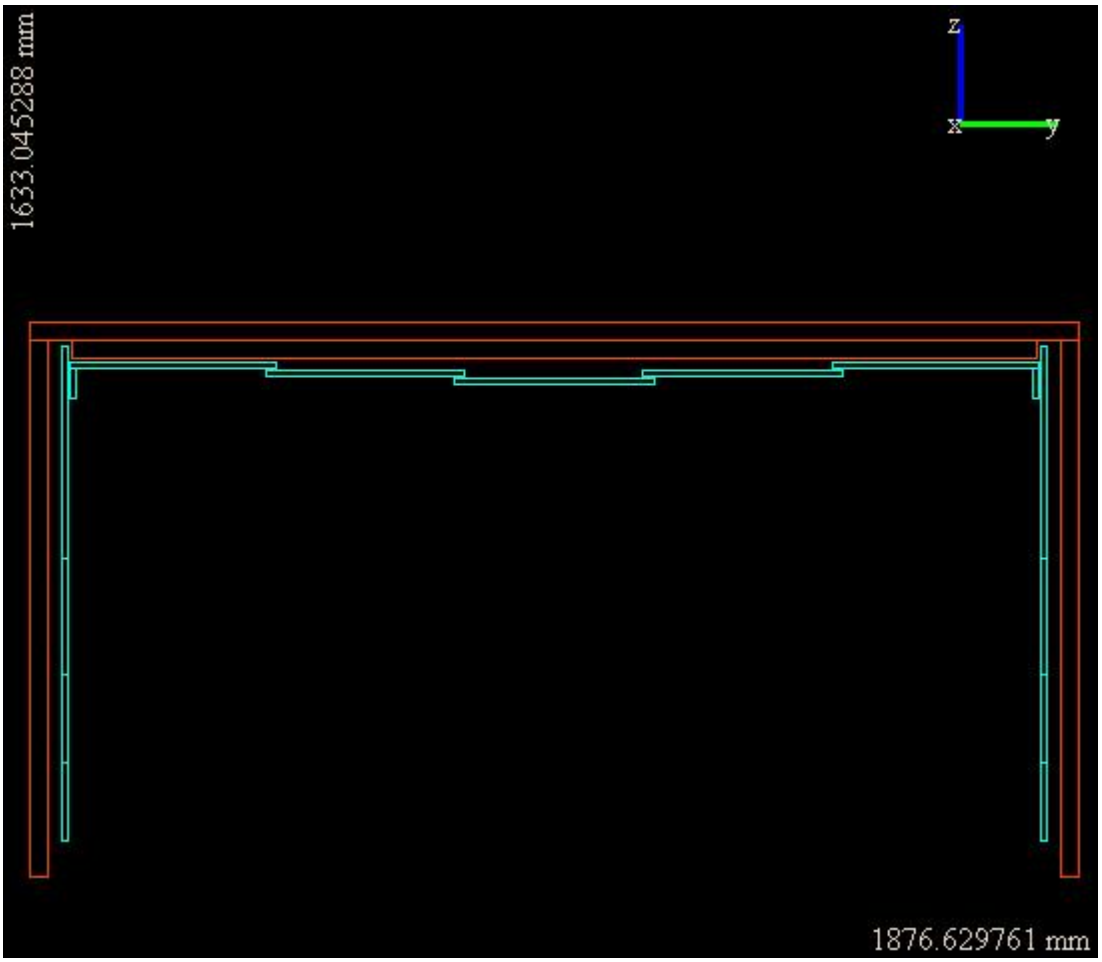
The final design document for the MMS reports: "The measured mass of the ACD MMS/MLI is 39.455 kg."
Using detCheck v1r5 and its summary.exe application, we find that the blanket material results in:
blanket: #Log = 5 #Phys = 7 Total volume = 302152 cu cm Mass = 37769 gm
Seems fairly close.

Joanne ran the test application in detCheck which checks for overlaps - none were found.

Ran constsDoc.exe in detCheck and produced this HTML page.
In particular we can take a look at the Blanket constants:

NADBlanketTopThick	30.22 mm	Blanket thickness as of May, 2006. See https://confluence.slac.stanford.edu/display/ACD/Thermal+Blanket
NADBlanketSideThick	30.8 mm	Blanket thickness as of May, 2006. See https://confluence.slac.stanford.edu/display/ACD/Thermal+Blanket
NADCrownToTile	2.26 mm	Distance from top of side tile to bottom of crown of blanket (room temperature). May, 2006.
NADBlanketToTopTile	6.89 mm	Distance from top tile to bottom of blanket. May, 2006
NADCrownWidth	101.6 mm	Transverse distance across crown. May, 2006
NADCrownDepth	31.75 mm	Z-distance from top of crown to top of lower, central part of blanket. May, 2006
NADBlanketTopTrans	1790.7 mm	Max transverse distance across top blanket, from outside of crown. From as-build document ACD-RPT-000394 RevA
NADBlanketSideZ	918 mm	Z-dimension of blanket sides, from https://confluence.slac.stanford.edu/display/ACD/Thermal+Blanket, May, 2006

NADBlanketTopThick 30.22 mm is determined below in the section "Final Design"
NADBlanketSideThick 30.8 mm is determined below in the section "Final Design"
NADCrownToTile 2.26 mm is determined below in the section: "Distance between MMS/MLI and ACD Tiles"
NADBlanketToTopTile 6.89 mm is determined below in the section: "Distance between MMS/MLI and ACD Tiles"
NADCrownWidth from the Final Design Document is 4.0" converted to mm is 101.6 mm
NADCrownDepth is 1.25" converted to mm is 31.75 mm
NADBlanketTopTrans is obtained directly from the Final Design Document diagram
NADBlanketSideZ is obtained directly from the Final Design Document 918 mm



Blanket Model since the AO

Currently the top of the thermal blanket is modeled as 32.7 mm thick. All dimensions are available from the RM, for example GR v9r1 https://www.slac.stanford.edu/www-glast-dev/cgi/xmlParams?sessionId=1470ea98f085564ae73de7ac067b43fa&cpId=6219#NADDimPrim
From which we see that the top is 1756.34 mm x 1756.34 mm x 32.7 mm

Constants for the sides:

NADBlanketSideY_I	1756.34 mm	length in long (X) dimension of Y-sides of blanket
NADBlanketSideX_I	1690.94 mm	length in long (Y) dimension of X-sides of blanket, shorter than Y-sides because Y-sides cover corners
NADBlanketSideZ	1075.11 mm	height of a side piece of the blanket: approx. height of ACD side tiles + height of cal

The current material definition is:

<composite name="blanket" density = "0.081">
<addmaterial material="Aluminum">
<fractionmass fraction="27" />
</addmaterial>
<addmaterial material ="Silicon">
<fractionmass fraction="144" />
</addmaterial>
<addmaterial material ="Oxygen">
<fractionmass fraction="70" />
</addmaterial>
<addmaterial material ="Carbon">
<fractionmass fraction="530" />
</addmaterial>
<addmaterial material ="Hydrogen">
<fractionmass fraction="26" />
</addmaterial>
</composite>

Distance between MMS/MLI and ACD Tiles

Please refer to Figure 3 of this documentPlease note that while this document contains some dimensions, these were not finalized and as such, where possible we use the dimensions provided in the Final Design Document (linked in the next section) which was release in January 2006.

Currently in the simulation we model the blanket as simple boxes on the top and four sides without the crown. It may be time to modify that. But for the time being we will provide number both for this simplified blanket model and something closer to reality that includes the crown. Using a conversion factor of 2.54 to get cm from inches.

Simplified version (without crown):
Distance from bottom of MMS and top of top ACD tiles: **32.26 mm**
Distance from bottom of MMS and top of side ACD tiles: **2.26 mm**
Distance between MMS and start of side ACD tiles: **18.03 mm**

With Crown:
Distance from bottom of MMS and top of top ACD tiles: **6.89 mm**
Distance from bottom of MMS and top of side ACD tiles: **2.26 mm**
Distance between MMS and start of side ACD tiles: **18.03 mm**

Note that the big difference is the distance between the top of the ACD tiles and the bottom of blanket, due to the need in the simplified model to have one box represent the blanket along the top, which must also clear the crown of the tiles themselves.

Final Design

Here is a link to the final design document.

The blanket is constructed of mulitple layers of material:
Kevlar C21H15N3O3
56 cm radiation length
6 layers on the top, 8 layers on the sides
Nextel Al2O3 (62.5%) SiO2 (24.5%) B2O3 (13%)
42 cm radiation length
4 layers
Solomide Foam density = 0.005 g/cm3
No chemical formula is provided
Material properties 0.0036 g/cm2
0.65 cm thickness/layer (density 0.0055 g/cm3)
according to the final design document, Composition similar to that of Kapton. Equivalent thickness of Kapton determined by scaling by the density = 0.010 cm
Radiation length of Kapton 28.2 cm
MLI&Handling Layers density = 1.4 g/cm3
Thickness 0.07 cm total of all materials
Area density 0.098 g/cm2
Radiation length 28.2 cm
From the description sounds like mostly Kapton (C22H10N2O5) The only other material explicitly mentioned is Germanium, but after consulting with Dave Thompson (GSFC) it was decided that could be ignored..it only contributes 1000 Angstroms, or 0.00001 cm.

Top

Dimensions: 1798 mm x 1798 mm

Crown dimensions: width: 4.0 inches = 101.50 mm depth: 1.25 inches = 31.75 mm

The top has surface area of 32328 cm2 = (179.8 x 179.8) neglecting the inside of the crown
The inside of the crown provides an additional 2022 cm2 = (158.0 x 3.2) 4

The thickness of the top can be computed as:
MLI&Handling Layers: 0.07 cm
Solomide Foam: 4(0.65 cm)
Nextel: 4(0.043 cm)
Kevlar: 6(0.03 cm)
Total Thickness: 30.22 mm
From Section 7 of the Final Design Document: Top (6 layers Kevlar): 0.137 + 0.119 + 0.015 + 0.098 = 0.36 g/cm2
Top 0.36 g/cm2 x 34350 cm2 = 12366 g
Top ignoring crown 0.36 g/cm2 x 32328 cm = 11638.08 g

Density: 0.36 g/cm2 / 3.02cm = 0.12 g/cm3

Determining how to model the material

Solomide Foam (modeled as Kapton): 32328 cm2 (2.6 cm) (0.0055 g/cm3) = 462.29 g
C22H10N2O5 1 mole = 22(12.011) + 10(1.0079) + 2(14.0067) + 5(15.9994) = 382.33 g
462.29 g / 382.33 g = 1.21 moles
22(12.011)(1.21) = 319.73 C
10(1.0079)(1.21) = 12.20 H
2(14.0067)(1.21) = 33.90 N
5(15.9994)(1.21) = 96.80 O

Nextel: 32328 cm2 (4(0.043)) (0.69) = 3836.69 g
Al2O3 (62.5%) SiO2 (24.5%) B2O3 (13%)
3836.69 (0.625) = 2397.93 g
2(26.98154) + 3 (15.9994) = 101.96 g/mole
2397.93 / 101.96 = 23.52 moles
2(26.98154)(23.52) = 1269.21 g Al
3(15.9994)(23.52 = 1128.91 g O

SiO2: 3836.69(0.245) = 939.99 g
SiO2: 28.0855 + 2(15.9994) = 60.08 g/mole
939.99/60.08 = 15.65 moles
28.0855(15.65) = 439.54 g Si
2(15.9994)(15.65) = 500.78 g O

B2O3: 3836.69(0.13) = 498.77 g
B2O3: 2(10.81) + 3(15.9994) = 69.62 g/mole
498.77/69.62 = 7.164 moles
2(10.81)(7.164) = 154.89 g B
3(15.9994)(7.164) = 343.86 g O

Kevlar 32328 cm2 (6 (0.03 cm)) (0.76 g/cm3) = 4422.47 g
C21H15N3O3 1 mole = 21(12.011) + 15 (1.0079) + 3 (14.0067) + 3 (15.9994) = 357.37 g
4422.47 g / 357.37 g = 12.38 moles
21(12.011)(12.38) = 3122.62 g C
15(1.0079)(12.38) = 187.17 g H
3(14.0067)(12.38) = 520.21 g N
3(15.9994)(12.38) = 594.22 g O

Kapton 32328 cm2 (0.07 cm) (1.4 g/cm3) = 3168.14 g
C22H10N2O5 1 mole = 22(12.011) + 10(1.0079) + 2(14.0067) + 5(15.9994) = 382.33 g
3168.14 / 382.33 = 8.29 moles
22(12.011)(8.29) = 2190.57 g C
10(1.0079)(8.29) = 83.55 g H
2(14.0067)(8.29) = 232.23 g N
5(15.9994)(8.29) = 663.18 g O

Total for each element

C	H	N	O	B	Al	Si
319.73	12.20	520.21	594.22	154.89	1269.21	439.54
3122.62	187.17	232.23	663.18			
2190.57	83.55	33.90	1128.91			
			343.86			
			96.80			
			500.78			
5632.92 g	**282.92 g**	**786.34 g**	**3327.75 g**	**154.89 g**	**1269.21 g**	**439.54 g**

Total: 11893.57 g
Mass Fractions:
C: 5632.92/11893.57 = 0.474
H: 282.92/11893.57 = 0.024
N: 786.34/11893.57 = 0.066
O: 3327.75/11893.57 = 0.280
B: 154.89/11893.57 = 0.013
Al: 1269.21 / 11893.57 = 0.107
Si: 439.54 / 11893.57 = 0.037

Side

Dimensions: 1798 mm x 918 mm
Outer surface area: (179.8 cm x 91.8 cm) = 16505.64 cm2

MLI&Handling Layers: 0.07 cm
Solomide Foam: 4(0.65 cm)
Nextel: 4(0.043 cm)
Kevlar: 8(0.03 cm)
Total: 3.08 cm
From Section 7 of the Final Design Document: Top (8 layers Kevlar): 0.182 + 0.119 + 0.015 + 0.098 = 0.41 g/cm2
Top 0.41 g/cm2 x 16505.64 cm2 = 6767.31g

Density: 0.41 g/cm2 / 3.08 cm =0.13 g/cm3

Solomide Foam (modeled as Kapton): 16505.64 cm2 (2.6 cm) (0.0055 g/cm3) = 236.03 g
C22H10N2O5 1 mole = 22(12.011) + 10(1.0079) + 2(14.0067) + 5(15.9994) = 382.33 g
236.03 g / 382.33 g = 0.62 moles
22(12.011)(0.62) = 163.83 C
10(1.0079)(0.62) = 6.25 H
2(14.0067)(0.62) = 17.37 N
5(15.9994)(0.62) = 49.60 O

Nextel: 16506 cm2 (4(0.043)) (0.69) = 1958.93 g
Al2O3 (62.5%) SiO2 (24.5%) B2O3 (13%)
1958.93(0.625) = 1224.33 g
2(26.98154) + 3 (15.9994) = 101.96 g/mole
1958.93/ 101.96 = 19.21 moles
2(26.98154)(19.21) = 1036.63 g Al
3(15.9994)(19.21) = 922.05 g O

SiO2: 1958.93(0.245) = 479.94 g
SiO2: 28.0855 + 2(15.9994) = 60.08 g/mole
479.94/60.08 = 7.99 moles
28.0855(7.99) = 224.40 g Si
2(15.9994)(7.99) = 255.67 g O

B2O3: 1958.93(0.13) = 254.66 g
B2O3: 2(10.81) + 3(15.9994) = 69.62 g/mole
254.66/69.62 = 3.66 moles
2(10.81)(3.66) = 79.13 g B
3(15.9994)(3.66) = 175.67 g O

Kevlar 16506 cm2 (8 (0.03 cm)) (0.76 g/cm3) = 3010.69 g
C21H15N3O3 1 mole = 21(12.011) + 15 (1.0079) + 3 (14.0067) + 3 (15.9994) = 357.37 g
3010.69 g / 357.37 g = 8.42 moles
21(12.011)(8.42) =2123.79 g C
15(1.0079)(8.42) = 127.30 g H
3(14.0067)(8.42) = 353.81 g N
3(15.9994)(8.42) = 404.14 g O

Kapton 16506 cm2 (0.07 cm) (1.4 g/cm3) = 1617.59 g
C22H10N2O5 1 mole = 22(12.011) + 10(1.0079) + 2(14.0067) + 5(15.9994) = 382.33 g
1617.59/ 382.33 = 4.23 moles
22(12.011)(4.23) = 1117.74 g C
10(1.0079)(4.23) = 42.63 g H
2(14.0067)(4.23) = 118.50 g N
5(15.9994)(4.23) = 338.39 g O

Total for each element

C	H	N	O	B	Al	Si
1117.74	42.63	118.50	338.39	79.13	1036.63	224.40

2123.79	127.30	353.81	404.14			
163.83	6.25	17.37	175.67			
			255.67			
			922.05			
			49.60			
3405.36	**176.18**	**489.68**	**2145.52**	**79.13**	**1036.63**	**224.40**

Total: 7556.90
Mass Fractions:
C: 0.451
H: 0.023
N: 0.065
O: 0.284
B: 0.010
Al: 0.137
Si: 0.030

Suggested Material Definition

The material for the top and sides of the blankets are "close enough" that it seems appropriate to use the same material for both. We'll use the mass fractions from the side computation

<composite name="blanket" density = "0.125">
<addmaterial material="Aluminum">
<fractionmass fraction="0.137" />
</addmaterial>
<addmaterial material ="Silicon">
<fractionmass fraction="0.030" />
</addmaterial>
<addmaterial material ="Oxygen">
<fractionmass fraction="0.284" />
</addmaterial>
<addmaterial material ="Carbon">
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</addmaterial>
<addmaterial material ="Hydrogen">
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</addmaterial>
<addmaterial material = "Nitrogen">
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</addmaterial>
<addmaterial material="Boron">
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</addmaterial>
</composite>