

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"

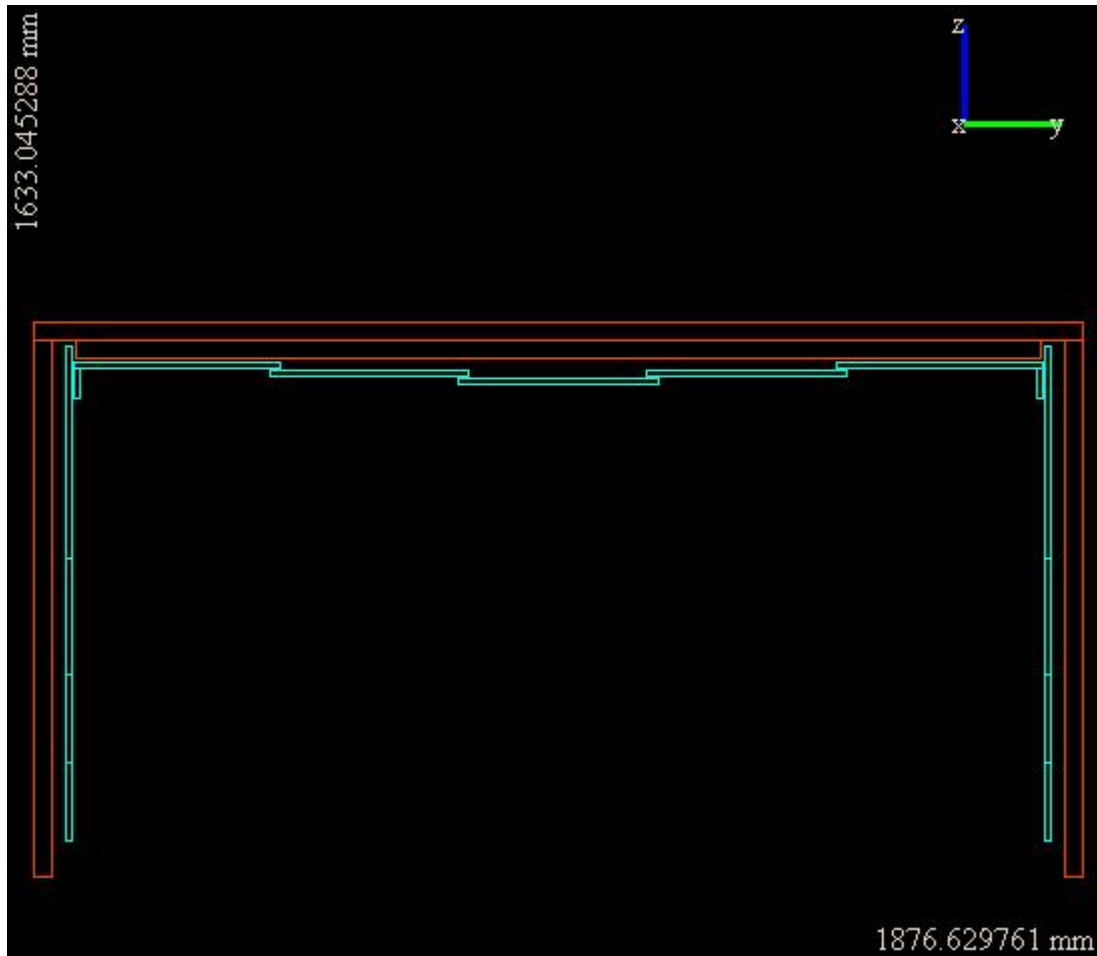
NADBlanketToTopTile 6.89 mm is determined below in the section: "Distance between MMS/MLI and ACD Tiles"

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 document](#). Please 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 released 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 numbers 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 multiple 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): $0.137 + 0.119 + 0.015 + 0.098 = 0.36 \text{ g/cm}^2$

Top $0.36 \text{ g/cm}^2 \times 34350 \text{ cm}^2 = 12366 \text{ g}$

Top ignoring crown $0.36 \text{ g/cm}^2 \times 32328 \text{ cm}^2 = 11638.08 \text{ g}$

Density: $0.36 \text{ g/cm}^2 / 3.02 \text{ cm} = 0.12 \text{ g/cm}^3$

Determining how to model the material

Solomide Foam (modeled as Kapton): $32328 \text{ cm}^2 (2.6 \text{ cm}) (0.0055 \text{ g/cm}^3) = 462.29 \text{ g}$

$\text{C}_{22}\text{H}_{10}\text{N}_2\text{O}_5$ 1 mole = $22(12.011) + 10(1.0079) + 2(14.0067) + 5(15.9994) = 382.33 \text{ g}$

$462.29 \text{ g} / 382.33 \text{ g} = 1.21 \text{ moles}$

$22(12.011)(1.21) = 319.73 \text{ C}$

$10(1.0079)(1.21) = 12.20 \text{ H}$

$2(14.0067)(1.21) = 33.90 \text{ N}$

$5(15.9994)(1.21) = 96.80 \text{ O}$

Nextel: $32328 \text{ cm}^2 (4(0.043)) (0.69) = 3836.69 \text{ g}$

$\text{Al}_2\text{O}_3 (62.5\%) \text{ SiO}_2 (24.5\%) \text{ B}_2\text{O}_3 (13\%)$

$3836.69 (0.625) = 2397.93 \text{ g}$

$2(26.98154) + 3 (15.9994) = 101.96 \text{ g/mole}$

$2397.93 / 101.96 = 23.52 \text{ moles}$

$2(26.98154)(23.52) = 1269.21 \text{ g Al}$

$3(15.9994)(23.52) = 1128.91 \text{ g O}$

$\text{SiO}_2: 3836.69(0.245) = 939.99 \text{ g}$

$\text{SiO}_2: 28.0855 + 2(15.9994) = 60.08 \text{ g/mole}$

$939.99/60.08 = 15.65 \text{ moles}$

$28.0855(15.65) = 439.54 \text{ g Si}$

$2(15.9994)(15.65) = 500.78 \text{ g O}$

$\text{B}_2\text{O}_3: 3836.69(0.13) = 498.77 \text{ g}$

$\text{B}_2\text{O}_3: 2(10.81) + 3(15.9994) = 69.62 \text{ g/mole}$

$498.77/69.62 = 7.164 \text{ moles}$

$2(10.81)(7.164) = 154.89 \text{ g B}$

$3(15.9994)(7.164) = 343.86 \text{ g O}$

Kevlar $32328 \text{ cm}^2 (6 (0.03 \text{ cm})) (0.76 \text{ g/cm}^3) = 4422.47 \text{ g}$

$\text{C}_{21}\text{H}_{15}\text{N}_3\text{O}_3$ 1 mole = $21(12.011) + 15 (1.0079) + 3 (14.0067) + 3 (15.9994) = 357.37 \text{ g}$

$4422.47 \text{ g} / 357.37 \text{ g} = 12.38 \text{ moles}$

$21(12.011)(12.38) = 3122.62 \text{ g C}$

$15(1.0079)(12.38) = 187.17 \text{ g H}$

$3(14.0067)(12.38) = 520.21 \text{ g N}$

$3(15.9994)(12.38) = 594.22 \text{ g O}$

Kapton $32328 \text{ cm}^2 (0.07 \text{ cm}) (1.4 \text{ g/cm}^3) = 3168.14 \text{ g}$

$\text{C}_{22}\text{H}_{10}\text{N}_2\text{O}_5$ 1 mole = $22(12.011) + 10(1.0079) + 2(14.0067) + 5(15.9994) = 382.33 \text{ g}$

$3168.14 / 382.33 = 8.29 \text{ moles}$

$22(12.011)(8.29) = 2190.57 \text{ g C}$

$10(1.0079)(8.29) = 83.55 \text{ g H}$

$2(14.0067)(8.29) = 232.23 \text{ g N}$

$5(15.9994)(8.29) = 663.18 \text{ g O}$

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

2123.7 9	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">
<fractionmass fraction="0.451" />
</addmaterial>
<addmaterial material = "Hydrogen">
<fractionmass fraction="0.023" />
</addmaterial>
<addmaterial material = "Nitrogen">
<fractionmass fraction="0.065"/>
</addmaterial>
<addmaterial material="Boron">
<fractionmass fraction="0.010"/>
</addmaterial>
</composite>
```