REQUEST FOR ACTION (RFA) RESPONSE

GLAST LAT Project
Calorimeter Peer Review 17 – 18 March 2003

Action Item:	CAL – 001
Presentation Section:	Mechanical
Submitted by:	Jim Ryan

Request: Preload of end caps. State minimum preload for end caps (max load of 30 N was only presented). How will preload be verified for all CsI logs?

Reason / Comment: It is not clear how the "less than 30N" requirement will be verified.

Addendum to Response: 29 April 2003

There is limited data on the compressive strength of CsI(Tl). In response to the RFA we will measure the compressive strength of a few samples (20 x 27 x 30 mm) of our CsI(Tl) from Amcrys. The test will load the crystal sample against the endcap as in the PEM design. These tests will be executed in the next week and results will be reported. This report may not be available until after CDR. We should note that the EM module just completed qualification level vibration test without mechanical problems. I believe the only issue is perhaps a long-term compressive set that changes the preload. This would not be enough to impact the light yield performance of the crystals.

We presume that the explanation of the preload requirement is sufficient and the only issue is the ability of the CsI to handle the loads. As to the tolerance issue of the composite structure (length 339mm +/- 0.1mm), this tolerance has been demonstrated in the manufacture of the EM structure and subsequently in the recent autoclaved structure that is the pre-SM test structure.

Response: 25 April 2003

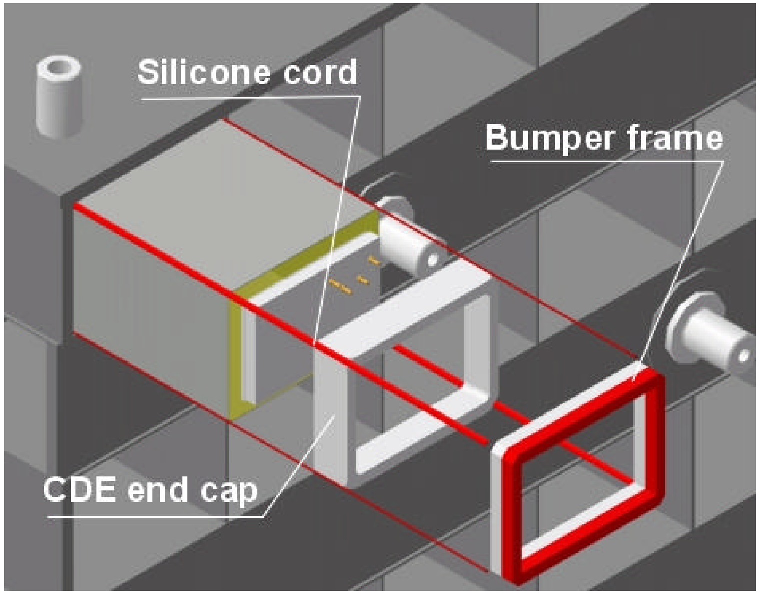
Preload on the end caps of the CDE is provided from the bumper frame. Preload on the end caps range from 0 N to 56.3 N. The goal of the bumper is not to guarantee a minimum preload, but to ensure that no gap exists between the end of the CDE and the close-out plate. The bumper acts as a damper for longitudinal vibrations.

During assembly, preload is verified by ensuring that the bumpers make contact with the close-out plate before the plates are secured to the structure.

These values are summarized in the attached technical note, LAT-TD-02050-01 (LLR-GLAST-TN-083). The attached view graph, which was presented at the CAL Peer Review, has been updated to address the request of this RFA.

Design Concept – Interface With CDEs

- **Elastomeric Parts to Interface the CDEs with the Mechanical Structure**
  - Silicone Cords Placed Along the Chamfers of the Crystals Center the Logs Inside the Cells and Ensure Their Transverse Support
  - A Bumper Frame Placed Between the End of the CDEs and the Closeout Plate Ensures the Longitudinal Stop (Soft Silicone and Rigid Plastic Frame), which Acts as a Damper for Longitudinal Vibrations. The Bumper Frame does not Provide a Specific Preload, but Ensures that No Clearance Exists Between the End of the CDE and the Close-Out Plate.



- **Tension of the Silicone Cords Reduces Their Diameter and Provide Room for the Insertion of the CDEs: 200% to Reduce Diameter from 1 mm to 0.7 mm**
- **Compression of the Cords: 0.1mm per 100N Ensure Efficient Support of the CDEs Under Launch Loads**
- **Preload of the Bumper Frames Provide CDE Longitudinal Stop Independently of the Crystal Length**
- **Preload Range of 0 N - 56N Keeps Stress on the CsI Material within Acceptable Levels**

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Note Technique / Technical Note			
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Compression load On the CsI logs

LAT reference : LAT-TD-02050-01

Change History log

					S. Le Quellec	O. Ferreira
Ind.	**Date**	**Modifications**	**Prepared**	**Checked**	**PA Approval**	**Project Approval**

1 SCOPE OF THE DOCUMENT

This document present the load levels on the CsI logs of the CAL module resulting from their assembly inside the mechanical structure and the environmental loads.

2 CDE ASSEMBLY

The CsI logs are mounted inside the cells of the composite structure with silicone elastomeric piece-parts to interface them with the structure. The cords along the chamfers of the logs provide the transverse support of the crystals and a friction force that prevents their longitudinal motion. The bumper frames at each end ensure the longitudinal stop against the closeout plates.
The bumper frames needs to compensate for any clearance between the CsI logs and the closeout plate whatever the length of the crystals is, to avoid any peak load that could result from the motion of a log. The goal is not to guaranty a minimum preload but to ensure that is no clearance left so that the bumper frame can act as a damper for longitudinal vibrations.

3 MECHANICAL PROPERTIES OF CESIUM IODIDE

The mechanical properties of the Cesium Iodide are presented in the table below.

Property	Average	Min	Max
Yield tensile strength (MPa)	1.86	0.73	2.28
Ultimate tensile strength (MPa)	4.05	2.24	11.86
Compression strength (MPa)	1.12	0.28	2.4
Tensile Modulus (MPa)	12100	11000	13500
Compression modulus (MPa)	12000	4000	30000
Shear modulus (Mpa)	6800	6200	7930
Poisson's ratio	0.26	0.21	0.30
CTE (10^{-6}/°C)	54	-	-
Thermal conductivity (W/m°C)	1.54	-	-
Density (Kg/m^3)	2760	2670	4420

The values are from NASA Technical Memorandum NASA TM X-64741: Scintillator handbook with emphasis on Cesium Iodide (April 13th 1973). Measurements show large variations from sample to sample, particularly on compression strength. The variations can be attributed to flaws in the crystalline structure. They should be related to the position of the sample in the boules and to fabrication process of the vendor.

4 PRELOAD OF THE BUMPER FRAMES

4.1 COMPRESSION PROPERTIES OF THE BUMPER FRAMES

The compression versus load characteristics have been measured on 20 bumper frames from the lot fabricated for the EM model. The testing has been performed by the company ADDIX which is the company in charge of the fabrication. The dimensions and materials are the same as for the flight parts:

- VALOX DR48 PBTP from GE PLASTICS

- 7601B silicone from ADDIX

The samples have been cured 16 hours at 175°C.

Compression (mm)	Load (N)	Confidence 5% risk	RMS (N)
0.05	3.8	+/- 0,7	1.5
0.1	14.6	+/- 2,7	5.9
0.15	23.6	+/- 0,1	0.2
0.2	23.7	+/- 0,1	0.2
0.25	24.8	+/- 0,5	1.0
0.3	34.7	+/- 4,2	9.0
0.35	51.0	+/- 0,8	1.7
0.4	52.8	+/- 0,6	1.2
0.45	53.5	+/- 0,5	1.2
0.5	56.3	+/- 1,9	4.0
0.55	67.1	+/- 7,2	15.5
0.6	85.5	+/- 12,1	25.9
0.7	143.9	+/- 12,7	27.2
0.8	205.0	+/- 12,5	26.6
0.9	264.5	+/- 12,9	27.7
1	329.5	+/- 14,6	31.1
1.1	402.8	+/- 16,6	35.4
1.2	494.5	+/- 20,8	44.5
1.3	605.3	+/- 24,2	51.6
1.4	744.1	+/- 32,4	69.2
1.5	926.3	+/- 42,7	91.3
1.6	1146.0	+/- 53,2	113.7
1.7	1418.3	+/- 66,2	141.5
1.8	1741.7	+/- 79,5	169.9
1.9	2188.0	+/- 101,0	216.2
2	2654.0	+/- 121,0	259.2

4.2 STIFFNESS OF THE CLOSEOUT PLATES

The closeout plates bend between the attachment points as the preload is applied on the bumper frames. A FE structural analysis has been performed to evaluate the deflection. An max value of 0.20 mm has been calculated when considering a constant preload of 20 N from each bumper frame.

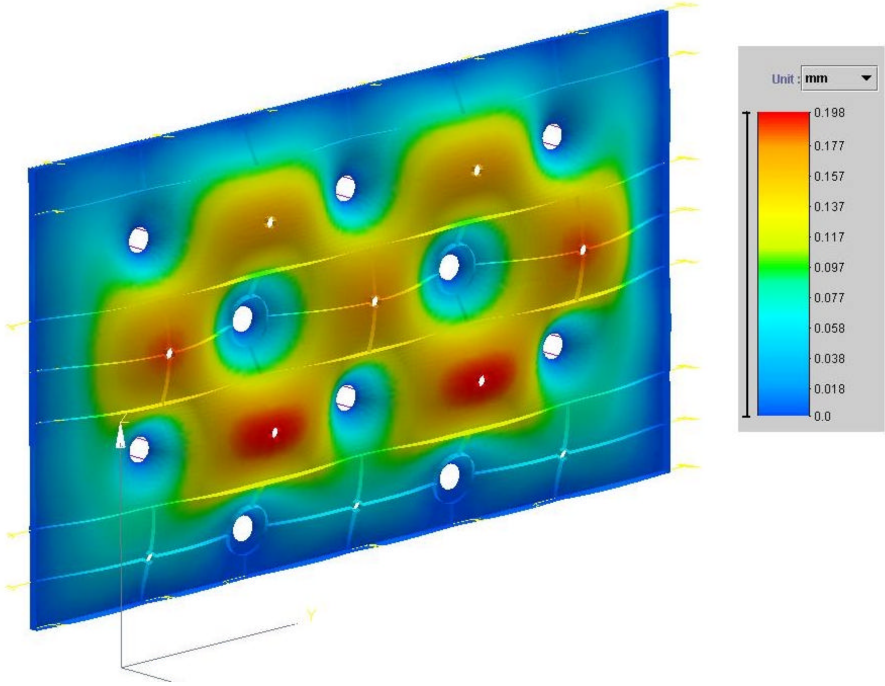

Figure 1: Deflection of the closeout with 20 N preload on the bumpers

4.3 PRELOAD

The variations of the compression load on the bumper frames can be calculated from the min and max dimensions of the parts. The 339 mm dimension on the composite structure defines the closeout plate to closeout plate distance.

Component height	Average	Min	Max
CsI log length in mm	325.7	325.4	326.0
End cap thickness in mm	2.75	2.7	2.8
Bumper frame thickness in mm	4.0	3.9	4.1
Composite structure	338.9	339.0	338.8
Compression per bumper in mm	0.15	0	0.5
Preload in N	23.6	0	56.3

The preload is calculated without taking into account the deflection of the closeout plate. For logs located far from the attachment points of the plate, the max preload would be reduced from 56.3 N to around 28 N. However, close to corners of the plate, the flexibility is very limited and the 56.3 N can be kept as a conservative preload value.

5 LOAD ON THE CSI LOGS

5.1 ACCELERATION OF THE LOGS

The loads on the CsI logs have been recovered from the CAL structural analysis for quasi-static load events. The logs are modeled as beams connected to the closeout plates and the composite walls by linear springs. Assumption has been made that no slippage occurs between a CDE and the corresponding cells: the motion of the log is only the result of the shear strain of the silicone cords and the compression of the bumper frame.
The table below show for each load case the max reaction loads on the X side and Y side logs.

Load	Log	N (N)	TY (N)	TZ (N)	MX (N.mm)	MY (N.mm)	MZ (N.mm)
12GX	X side log	21.48	0.75	2.57	0.00	185.35	89.13
	Y side log	4.03	7.06	2.77	0.00	174.92	233.45
12GY	X side log	3.94	6.95	3.07	0.00	191.18	223.07
	Y side log	25.18	0.73	2.42	0.00	190.14	88.31
12GZ	X side log	6.78	0.88	20.73	0.00	1181.19	62.65
	Y side log	2.59	0.89	20.56	0.00	1165.77	64.31
7,5g X-Y 8,5g Z	X side log	13.34	4.66	14.31	0.00	888.78	181.10
	Y side log	15.03	4.88	14.44	0.00	859.82	202.57

The maximum compression load on the logs is:

$$F = 25.2\ N$$

If the deflection of the closeout plate is not taken into account (conservative approach), the corresponding compression of the bumper frames is:

$$dL = 0.25\ mm$$

5.2 THERMAL EXPANSION OF THE LOGS

The survival temperature of the CAL is +50°C which corresponds to a temperature increase of 30°C from the assembly temperature. The corresponding expansion of the logs is given by:

$$dL = 326 \times 30 \times 54\ 10^{-6}$$

$$dL = 0.528\ mm$$

If the deflection of the closeout plate is not taken into account (conservative approach), the corresponding compression load on the bumper frames is:

$$F = 26.8\ N$$

5.3 MAX TOTAL LOAD ON THE CSI LOGS

Thermal loads are slightly higher than launch quasi-static loads. Since both are not applied simultaneously, the max total load on the CsI logs is the sum of the preload and thermal load:

$$Fmax = 83.1\ N$$

6 MARGINS OF SAFETY

The load at the end of the CsI logs is applied on a reduced area: the contact area between the CDE end cap and the crystal surface. The minimum contact surface is around 110 mm². The corresponding average stress on the CsI material is 0.75 MPa.
If a factor of safety of 1.25 is used, the margin of safety to the compression proportional limit is:

$$MoS = 0.21$$

This margin of safety is based on the average value of the compression proportional limit from the NASA TM X-64741 memo. Because of the factor 4 between the min and average values, a permanent set is possible depending on the mechanical properties of the CAL CsI crystals.