Peter Ford: 09.10.06 to 13.10.06

CMS ECAL – 4th Assembly and Integration Tests (version 1)

Week 09-13 Oct 2006 – EE-F (DEE 4)

For the week of 09.10.06 to 13.10.06 a series of tests were carried out on EE-F (DEE 4) in exactly the same way as were previously performed on EE-N (DEE 3) and EE+F (DEE1), as described in documents 'Assembly Test 1.2.pdf/doc' and 'Assembly Test 3.1.pdf/doc'.
As before, these tests were conducted to investigate the early assembly of the crystal components (alveolars, inserts, Interface plates, housings and positional spacers – these did not include the super crystals themselves) and the integration of a maximum of ten of these assemblies onto the (Dee) back-plates. Again, the principal purpose at this stage was to ensure that the environmental screen could be fitted to the back-plate without interference with any of the other components mounted on the back-plate.

1. INTEGRATION OF CRYSTAL ASSEMBLIES AND SCREEN TO BACK-PLATE

The four 'Dees' are paired to form essentially two discs. The identity of each Dee is paired using the following notations:

Dee 3 (notation 1.2) is paired with Dee 4 (notation 1.1)
Dee 2 (notation 2.2) is paired with Dee 1 (notation 2.1)

General Required Actions – for all locations

(Updated as necessary, these actions may not necessarily appear in all earlier versions of documents produced from previous tests, but this titled section should always be referred to in the latest versions of subsequent documents. Then a final document will be submitted after all the tests have been carried out):

- Each Dee must be assigned an identity, and an aluminium plaque must be engraved with the necessary identity and fastened to each Dee, e.g. '**EE-F (DEE 4)'.** Labelling of lifting frames, screen, blue brackets and all associated parts must also be carried out.
- Positional spacers will have bar codes assigned to them, and the right-angled perpendicular edges must be marked up so that they are clear to see.
- Survey of the fixing holes on the screen is also required to reference the Dees (contact Frederique and Raphael in Metrology).
- The side screens will also be tested and these too will require labelling.

- Gareth Smith (PPD) to be contacted to obtain permission to be able to access the web area for placing photographic images for our test records.
- All environmental shields will require an Alochrom coating on their external surface. Due to its hazardous properties, great care must be taken to ensure that the application is performed without it dripping into regions where damage may result. Screw-holes, overlaps and mating surfaces must be screened and masked.
- During assembly of the thermal screen it is recommended that the fixing screw tightening sequences should be carried out in a way that more uniformly disperses the internal loads. For example the following sequence: 1-16-9-13-5-11 etc. – Refer to section 1.2 for more information.
- Effort must be made to ensure that the single and double pairs of cooling tubes emerging on both the 'left' and 'right' sides of the exit slots in the Dee are symmetrical and do not interfere with any part of the adjacent structure – this leads to poor alignment of the fixing holes which imposes non-uniform internal loads and distortions on the screen.
- It was concluded, as for the previous tests, that during the integration of the screen with the super-crystal assemblies in place that stops should be provided to prevent the screen coming into contact with them (see earlier document: Assembly Test 1.2.doc/pdf).

- Check that all screw hole positions are aligned and if not, marking up those regions where there may be poor fit problems

- Check the alignment of adjacent and mating edges and surfaces are correct to the drawings, marking up regions that show excessive deviations.

- Before tightening the screws, ensure that edges and surfaces of adjacent parts to be aligned are moved to their correct positions within the limits of the play in the available holes' clearances. This can be done by levering or jacking and then tightening to secure to the correct position.

- All environmental shields will require an alochrom coating on their external surface. Due to its hazardous properties, great care must be taken to ensure that the application is performed without it dripping into regions where damage may result. Screw-holes, overlaps and mating surfaces must be screened and masked.

- It is recommended that an initial trial fitting of the environmental shield should be performed without the crystals in place for all four shields.

- Keep Rob Loos informed of progress during the assembly tests, reporting any faults or misalignments. Ensure he is able to inspect each one so he is happy about the positioning of the pre-shower assembly.

- Carefully inspect the material coating of the cooling tubes for possible de-fragmentation caused by the flexing of the shield during assembly. This issue may require further serious thought in how to reduce the friability of the material.

- The thickness of the coatings on the cooling tubes must be controlled so that they do not risk coming into contact with the alveolars – see section 1.3.3, reference to B8M andB9M proximity to tube.

1.1 Trial fitting of environmental screen

As for the previous tests there were ten dummy super-crystal assemblies available, the locations of their mountings on the back-plate were chosen to represent the worst possible case for potential assembly collisions and interferences. There are three particular regions that require attention and consequently three separate tests are envisaged, since at this time there are only a limited number of the correct sizes of dummy crystal assemblies available. Of the assemblies those that are currently available are:

4 off standard 5x5,
1 off 4x5,
2 off 5x4,
2 off 2x5,
2 off 5x2.

1.2 Trial fitting of environmental screen

The first of the Dees to have a trial assembly of the environmental screen was **EE-N (DEE 3)'.** It was expected and rather hoped that the results of the tests on **DEE 1** would show minimal deviations from the tests on **DEE 3**, however it was found not to be the case. Differences were noticed between each of the two above back-plate assemblies and as will be seen in this document the same is true for **DEE 4.** As for the other cases, this **DEE** was supported horizontally on its support ring with the surface supporting the super-crystals uppermost.

As was found during the previous tests, the open-shell nature of the environmental screen meant that the structure was somewhat compliant, making it dangerous to assemble it to the back-plate with the super-crystals already in place. The first test, therefore, involved placement of the screen to an unpopulated obstacle-free back-plate surface.

As before, it was clear during placement of the screen that as it came into contact with the back-plate there were significant movements at the interfaces. This was caused by the distortions within the structure resulting from the progressive relaxation of the gravity induced loads due to lifting.

Again, after placement of the screen and removal of the hoist, the screen required a certain amount of manipulation to bring it into alignment with the fixing holes. However for this particular back-plate the fixing holes' alignments were very good and the screw torques required were noticeably lower than for previous **DEE**s. Assigning a general convention for the purposes of this report, one can define fixing screw positions as shown in the photo in FIG. 1.2.1: with hole position 1 as the first on the 'LEFT' of the **DEE** sequentially up to hole position 16 on the opposite far 'RIGHT' of the **DEE**. During the assembly of the screen, the screws were loosely fixed to the back-plate.

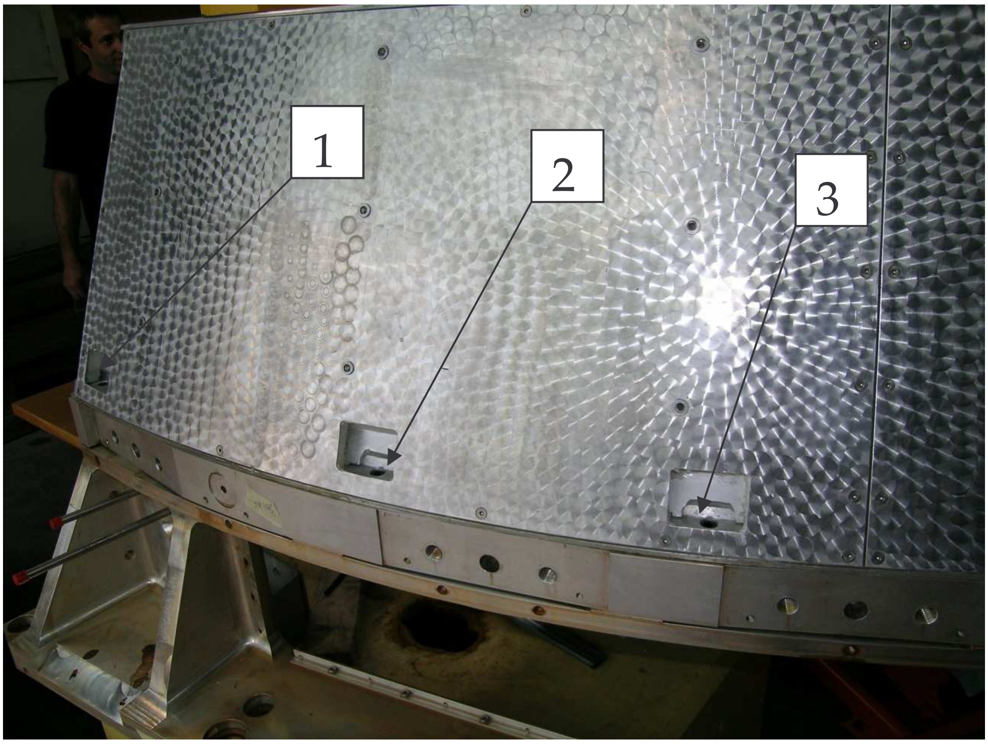

FIG. 1.2.1

As was learned from the previous tests on **DEE 3** and **DEE 1**, the screw tightening sequence was carried out in a way that more uniformly disperses the internal loads. For example the following sequence: 1-16-9-13-5-11 etc. or similar logical sequences.

'LEFT' 'RIGHT'

FIG. 1.2.2

Using the 'LEFT - RIGHT' convention defined above, FIG. 1.2.2 shows the single cooling tubes emerging from both sides of the Dee. As for the other **DEE**s, these tubes are noticeably non-symmetric with respect to the exit slots, albeit not so extreme as the others. The 'LEFT' tube is closest to the left hand edge of the slot by approximately 8.5mm, while the 'RIGHT' tube is closest to the left hand edge of the slot by approximately 6.0mm.

Similarly, the double sets of cooling tubes (FIG. 1.2.3) emerging on both the 'LEFT' and 'RIGHT' sides are not just non-symmetrical, but interfere with the edges of the exit slots in both cases. This was also the case for the previous **DEE**s that were tested. Here, it was the left hand side tube that contacted the edge of the slot in both 'LEFT' and 'RIGHT' cases. The right hand side tube of each pair cleared the edge of the slot by approximately 1.0mm on the 'LEFT' side and 3.0mm on the 'RIGHT' side.

‘LEFT’ ‘RIGHT’

FIG. 1.2.3

1.3 Trial fitting of super-crystal assemblies

For checking the clearances of the screen around the super-crystal assemblies three separate tests were carried out due to the limited number of each type of super-crystal assembly available. The locations chosen for each test are shown in FIG. 1.3.1. For all of these tests it was possible to mount all super-crystal assemblies without the removal of the environmental shield.

The first of the tests was to look at the super-crystal assemblies mounted at the outer and inner extreme regions on the Dee, where there may be risk of contact with the outer wall of the screen or outer surface of the shield surrounding the beam-pipe and cone. The red circles on FIG. 1.3.1 show the regions of principal concern where the super-crystal assemblies would come closest to the surrounding structures.

The remaining two tests were to observe the regions lying underneath the cooling pipes within the shield. These are shown as Test 2 zone and Test 3 zone in FIG. 1.3.1 where the projected position of the cooling circuit is shown superimposed. Numerous photographs were taken at all of these locations, not all of which show in very clear detail their proximities to the screen since the enclosed volume was very restricted. All or a selection of these images (numbering 46 in total) can be viewed on the CMS ECAL website under “Installation”.

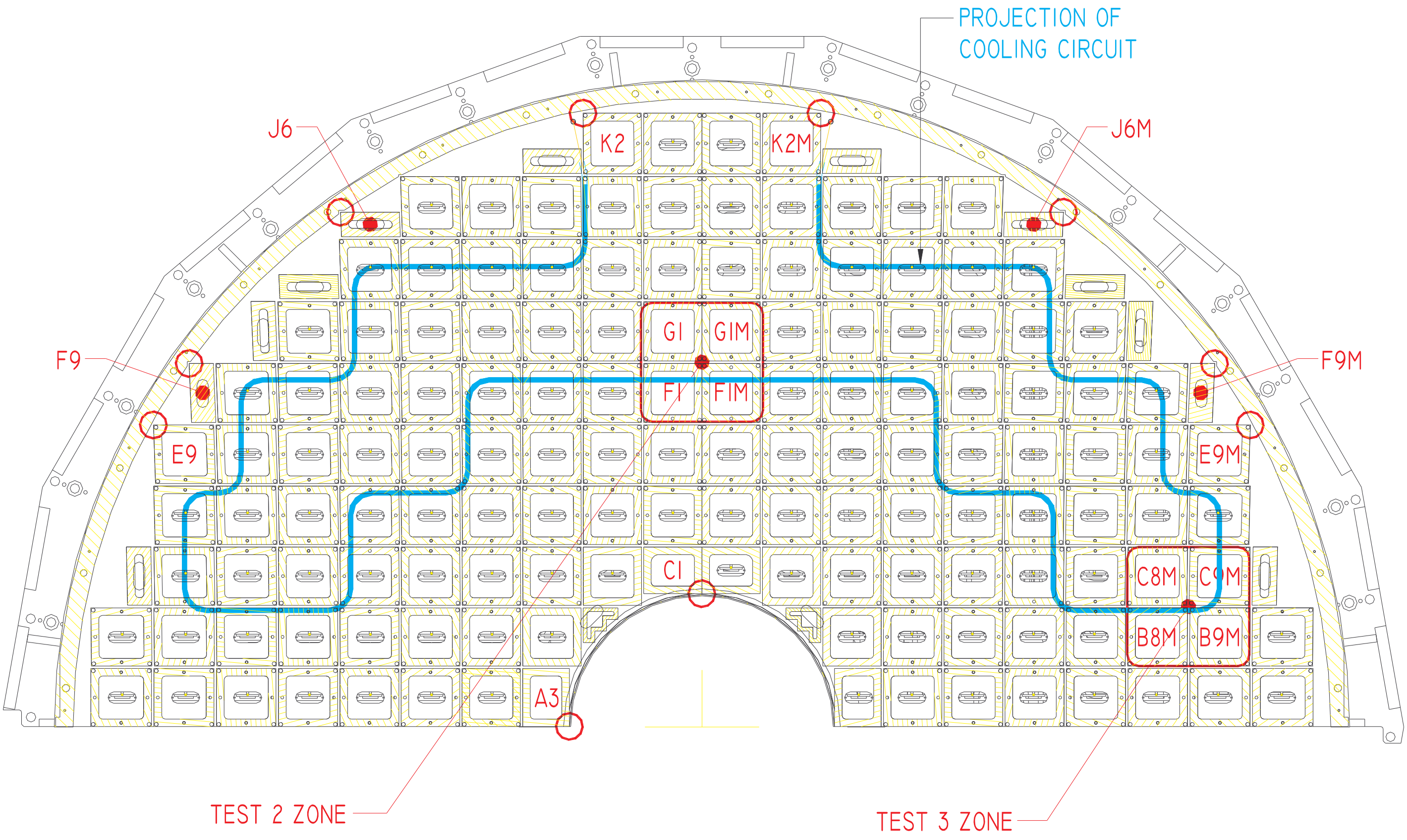

FIG. 1.3.1

With some difficulty, approximate measurements were also made of the distances of the closest points of the super-crystal assemblies from all parts of the surrounding structures.

1.3.1 Test 1

The following locations were chosen for this test, using all ten of the super-crystal assemblies (crystal configurations shown in brackets):-

Location **E9** (5x5)
Location **E9M** (5x5)
Location **F9** (5x2)
Location **F9M** (2x5)
Location **J6** (2x5)
Location **J6M** (5x2)
Location **K2** (5x5)
Location **K2M** (5x5)
Location **A3** (5x4)
Location **C1** (4x5)

For checking the clearances between each of the super-crystal assemblies and their surroundings, each location was carefully inspected with a torch from inside the shield (access was quite straightforward, if not a little uncomfortable). A steel rule was used to best obtain an approximate distance of the closest region of each of the assemblies to the screen and beam-pipe shield components. The following observations and measurements were made at each position with the clearance of the most nearby feature at the beginning of each paragraph.

E9: **>5mm** from outermost upper corner of the alveolar, as indicated by arrow ‘A’ in FIG. 1.3.2 to the top panel of the thermal shield vertically above. The closest part of the alveolar to the cooling tube is indicated approximately by arrow ‘C’ which is along the top edge of the alveolar (about 12.0mm from the nearest corner shown in the image) – the distance to the tube is approximately 11.0mm. The lower corner of the positional spacer (position ‘B’ in the adjacent image) has a generous clearance to the nearest part of the cut in the wall of the thermal shield in the order of 15mm. This is generally the case for all other crystal assemblies around the outer edge of this and all other **DEE**s**.**

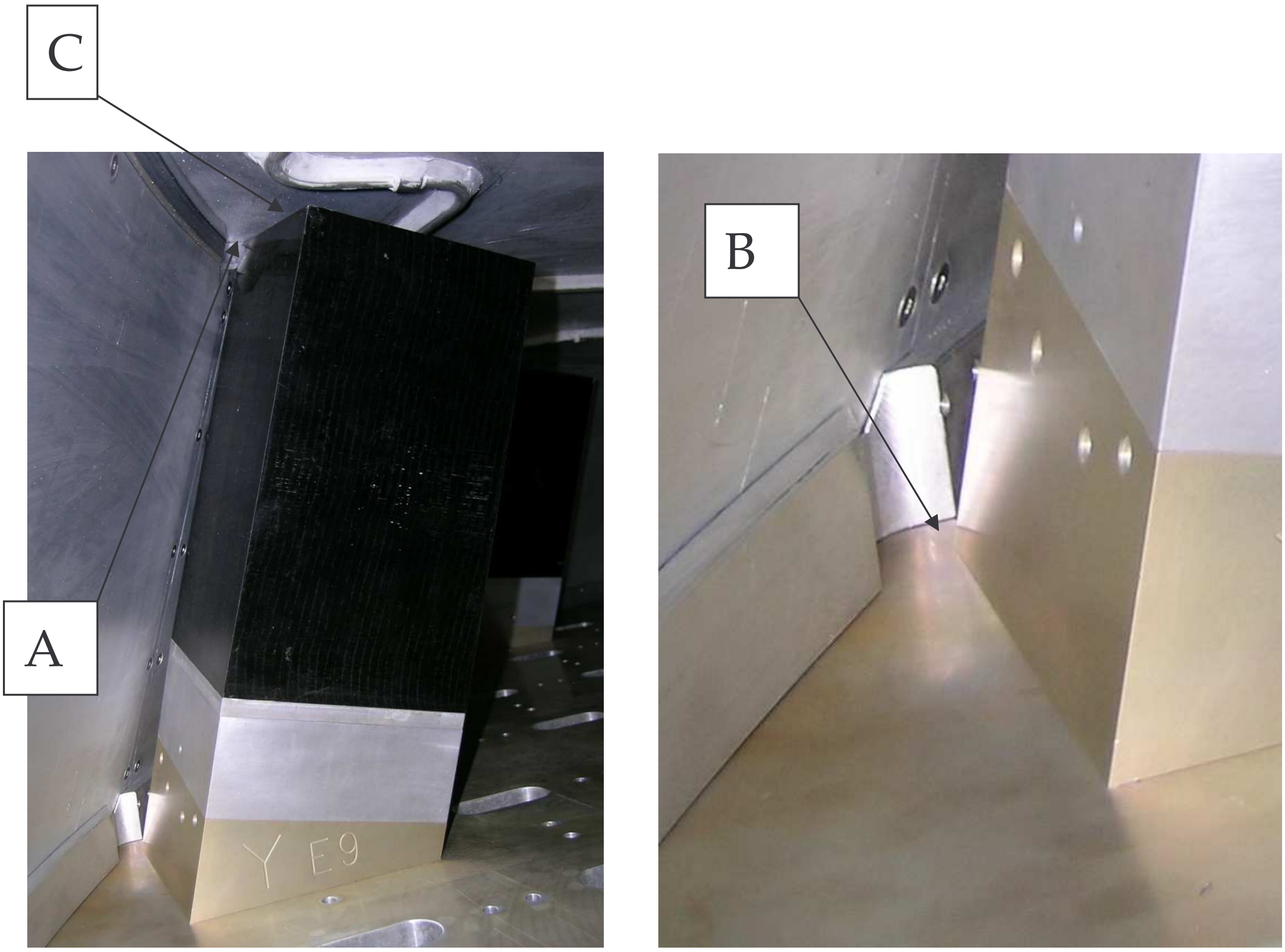

FIG. 1.3.2

E9M: **>7mm** from outermost upper corner of the alveolar (as indicated by arrow 'A' in FIG. 1.3.3, with F9M shown alongside) to the top panel of the thermal shield vertically above.

NOTE: The distance between the upper surface of the **DEE** and top panel ('roof') of the thermal shield was observed to be approximately 3.0mm greater than the nominal design distance. The precisely cut wooden baton, which is used to correct for the sag of this panel while measurements are being taken, was found not to span this distance, leaving a gap of some 3.0mm. This would suggest that there is some upward bow in the panel in this region!

The closest part of the alveolar to the cooling tube is indicated approximately by arrow 'B' which is along the top edge of the alveolar (about 20.0mm from the nearest upper corner shown in the image) – the distance to the tube here is approximately 9.0mm.

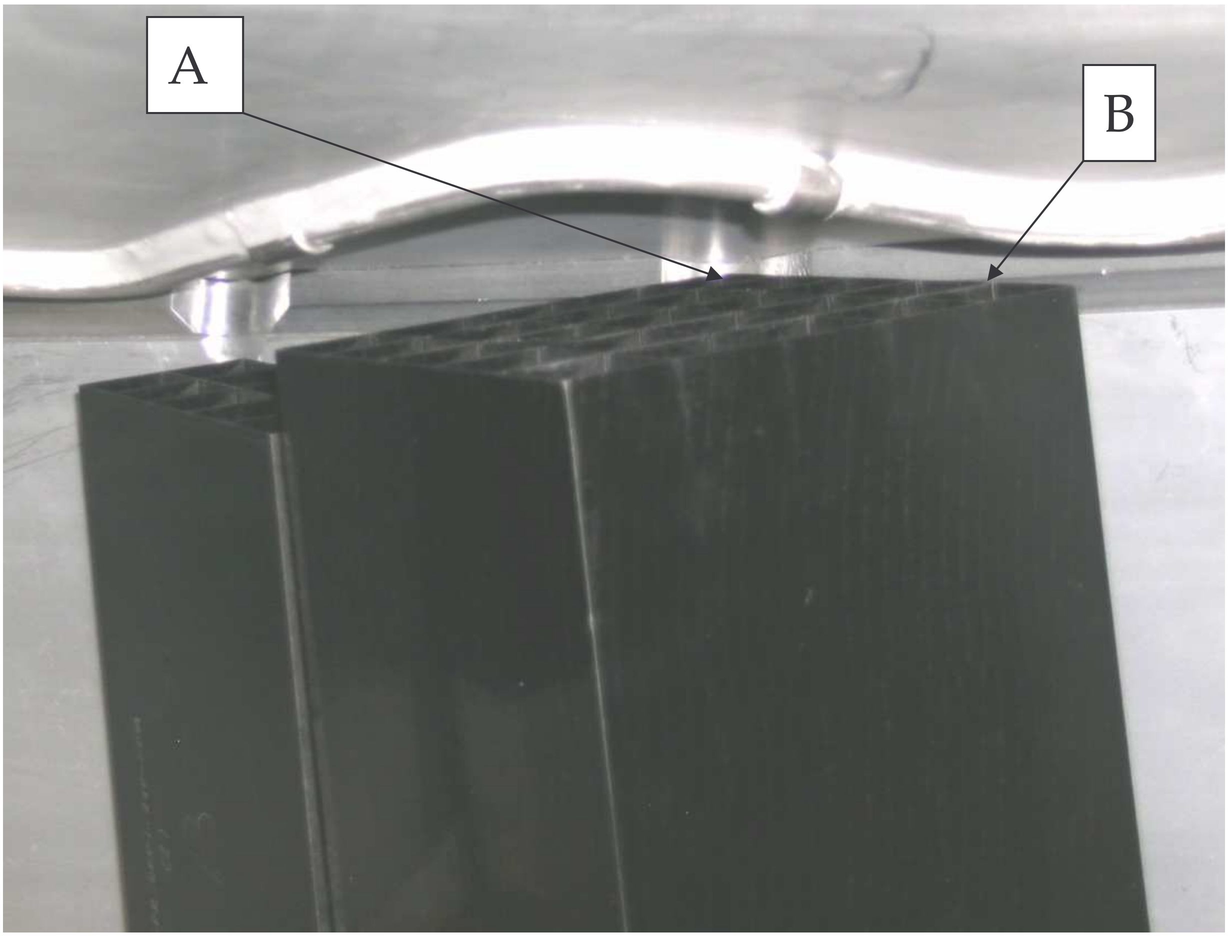

FIG. 1.3.3

F9: **>7mm** from outermost upper corner of alveolar (as indicated by arrow 'A' in FIG. 1.3.4) to the nearest point of the machined clearance pocket in the shield wall. Approx. 25mm from the same point to the top panel vertically above. The lower corner of the positional spacer has a typically generous clearance to the nearest part of the cut in the wall of the thermal shield in the order of 12mm (not shown).

FIG. 1.3.4

F9M: **>10mm** from the outermost upper corner of alveolar (as if a mirror of the same point 'A' in FIG. 1.3.4) to the nearest point of the machined pocket in the shield wall, in a similar sense to F9. A measurement of approximately 25mm was made from the outermost upper corner of alveolar to the top panel vertically above. Similar generous clearances around the positional spacer were found.

J6 and J6M: **>10**mm from outermost upper corner of alveolar to the nearest point of the machined clearance pocket in the shield wall, in the same sense and unremarkably similar to F9 and F9M.

K2 and K2M: **>7mm** from outermost upper corner of alveolar to the top panel vertically above. **>11mm** from the same point to the edge of the machined clearance pocket in the screen wall.

C1: The top-left view in FIG. 1.3.5 shows C1 assembly from the 'RIGHT' position on the **DEE.** The two remaining views are taken from the 'LEFT' position, showing the upper and lower parts of the assembly. The corner of the positional spacer (marked 'A') is 'visibly' in contact with the weld on the inner conical wall of the screen. This edge will be bevelled, as previous tests have proven to be necessary so that adequate clearances are maintained.

FIG. 1.3.5

At the upper regions there is a 2mm clearance between the nearest corner to the camera of the alveolar (indicated by point 'B') and the weld on the screen conical wall. Also approximately 9mm from outermost upper edge of alveolar (point 'C') to the top panel adjoining strip vertically above.

A3: There was a clearance between the positional spacer and the weld on the outer surface of the screen inner wall of approximately 2mm – (FIG. 1.3.6 – point 'B'). At the upper regions there was also approximately 2mm clearance between alveolar corner and the thickest section of the screen inner wall (FIG. 1.3.6 – point 'A').

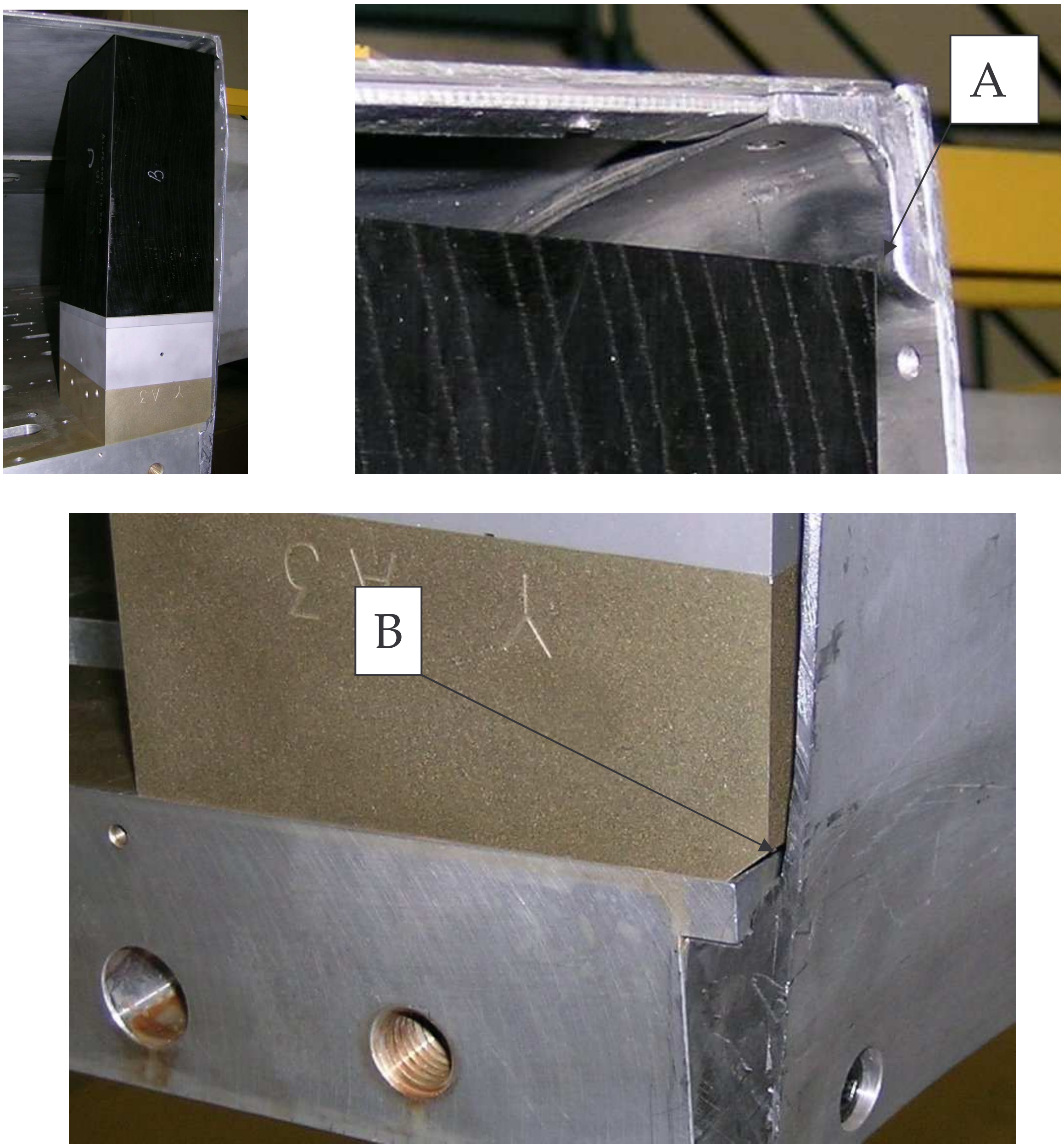

FIG. 1.3.6

1.3.2 Test 2 zone:

As for the tests in the previous section, for checking the clearances between each of the super-crystal assemblies and their surroundings, each location was carefully inspected with a torch from inside the shield. A steel rule was used as before to best obtain an approximate distance of the closest region of each of the assemblies to the screen, including the cooling circuits mounted on the underside of the top plate of the screen and both inner an outer walls. The following observations and measurements were made at each position:

F1 and G1: FIG. 1.3.7a and 1.3.7b shows two images of the 'RIGHT' side pair of the four super-crystal assemblies mounted underneath the screen in this zone. Gravity induced loads acting on the upper part of the screen caused a noticeable sagging of approximately 5-6mm. This would have brought the screen into contact with the upper parts of the super-crystal assemblies. Several wooden batons (one shown) were cut to length to prop up the screen and restore it to the correct heights for these tests.

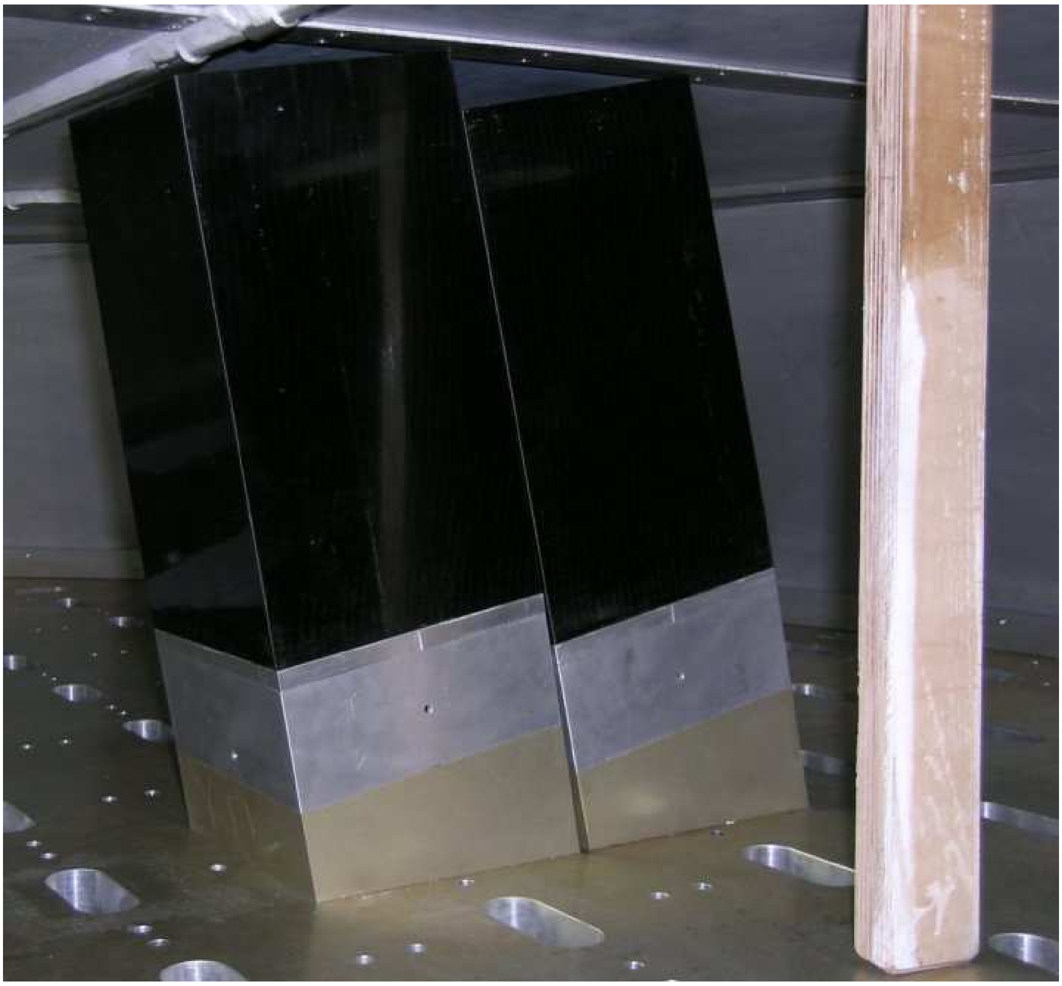

FIG. 1.3.7a

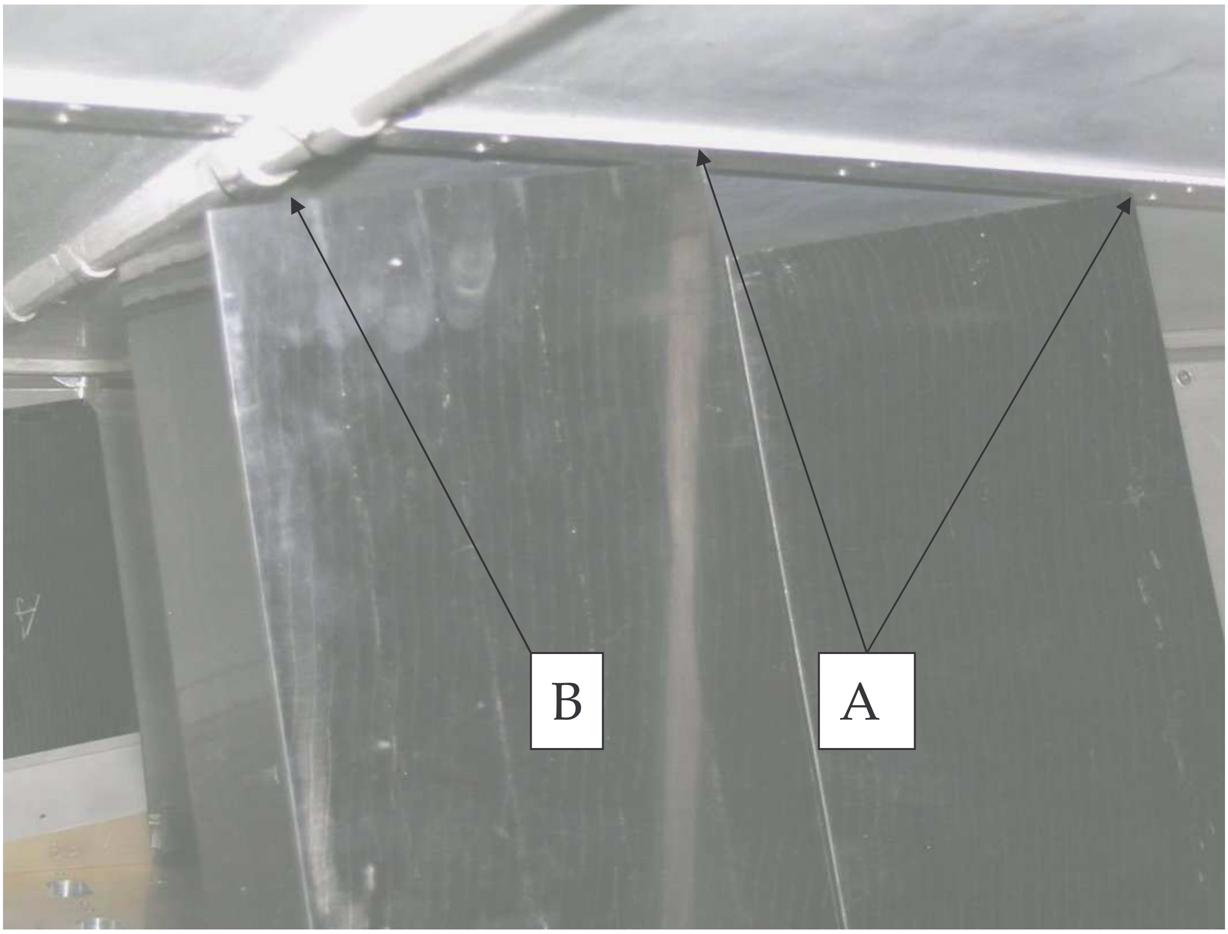

FIG. 1.3.7b

For each of the two super-crystal assemblies the closest proximities are between the highest points on the alveolar (indicated by points 'A' in each assembly) and the adjoining strip running along the screen. In both cases there was contact between these alveolar corners and the adjoining strip. In fact, on trying to lift the upper plate of the thermal screen to create a separation between the assemblies, a worryingly large force was required to achieve this, in spite of the fact that the screen height ought to have been correctly set by the wooden batons.

The edge on assembly F1 (approximate position indicated by point 'B') shows the point of closest proximity to the cooling tube. This measured a little over 10mm to the tube itself and about 8mm to the tube support ring.

F1M: & G1M: FIG. 1.3.8a and FIG. 1.3.8b show similar images to the previous set of assemblies. The situation here is much the same as for F1 and G1. With G1M, the

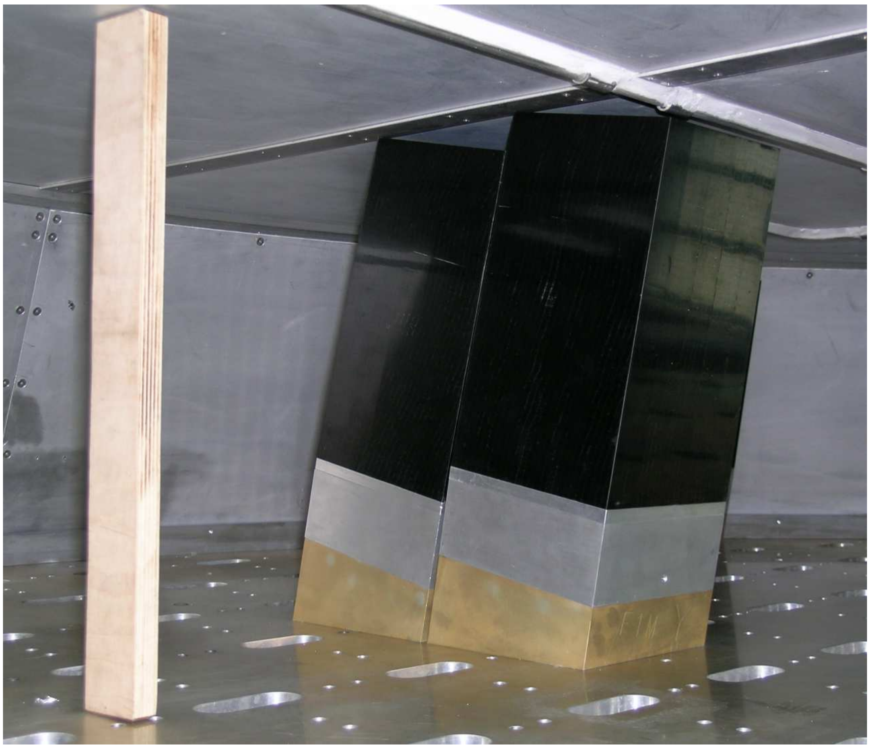

FIG. 1.3.8a

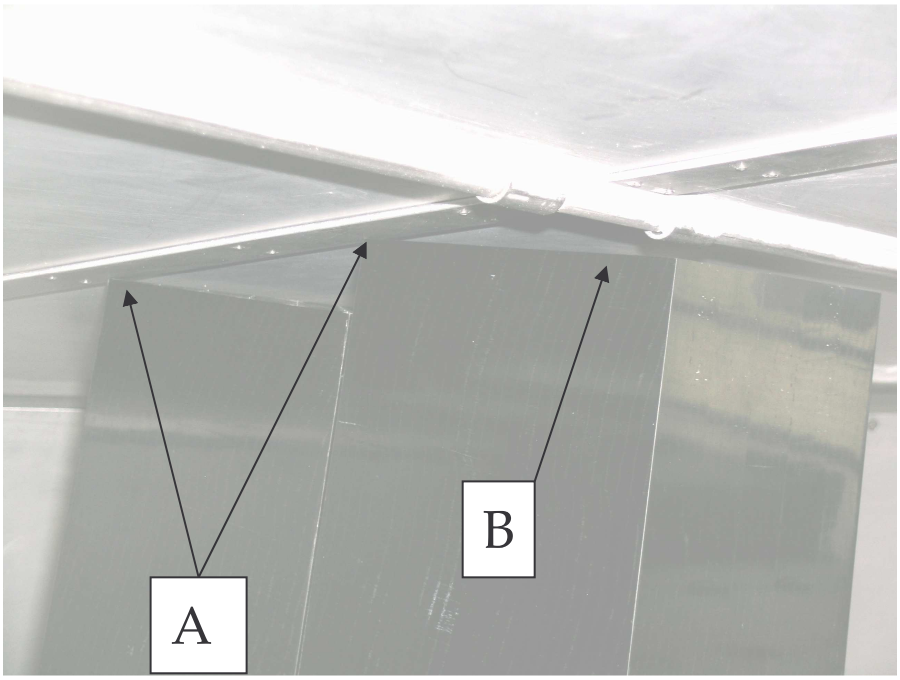

FIG. 1.3.8b

uppermost corner of the alveolar appears to be in contact with the adjoining strip, but a piece of paper will pass between it and the strip. F1M however is clearly on contact with the strip. The closest separation between F1M upper edge around point 'B' and the cooling tube is about the same as for F1.

1.3.3 Test 3 zone:

C9M: This super-crystal assembly is shown in FIGs. 1.3.9a and 1.3.9b with the wooden support batons positioned close by (not shown).

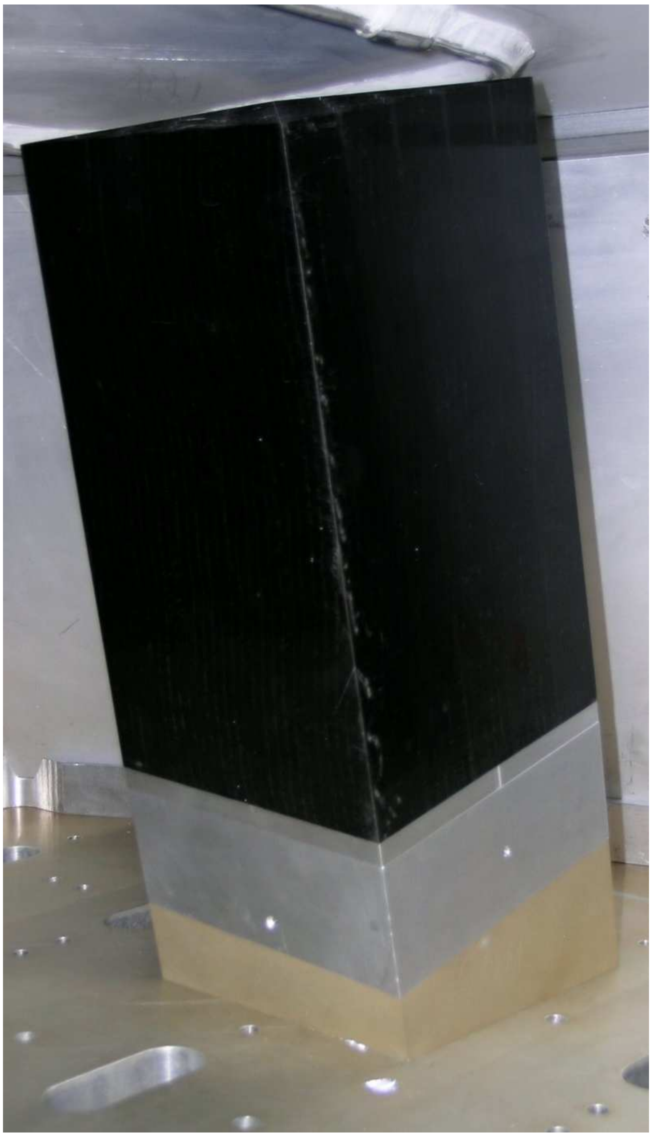

FIG. 1.3.9a

The proximity of the alveolars to the cooling tubes is very clear, as is the quantity of the thermal compound used to cover the cooling tubes. The uppermost corner of the alveolar is indicated by arrow ‘A’, and this point is 5mm below the thermal screen (‘roof’) lower surface. Point ‘B’ is the closest point on the upper edge of the alveolar from the cooling tube directly above it. This point is about 15mm in from the right hand corner as shown in the image, and the clearance here is a mere 2mm to the nearest point on the cooling tube.

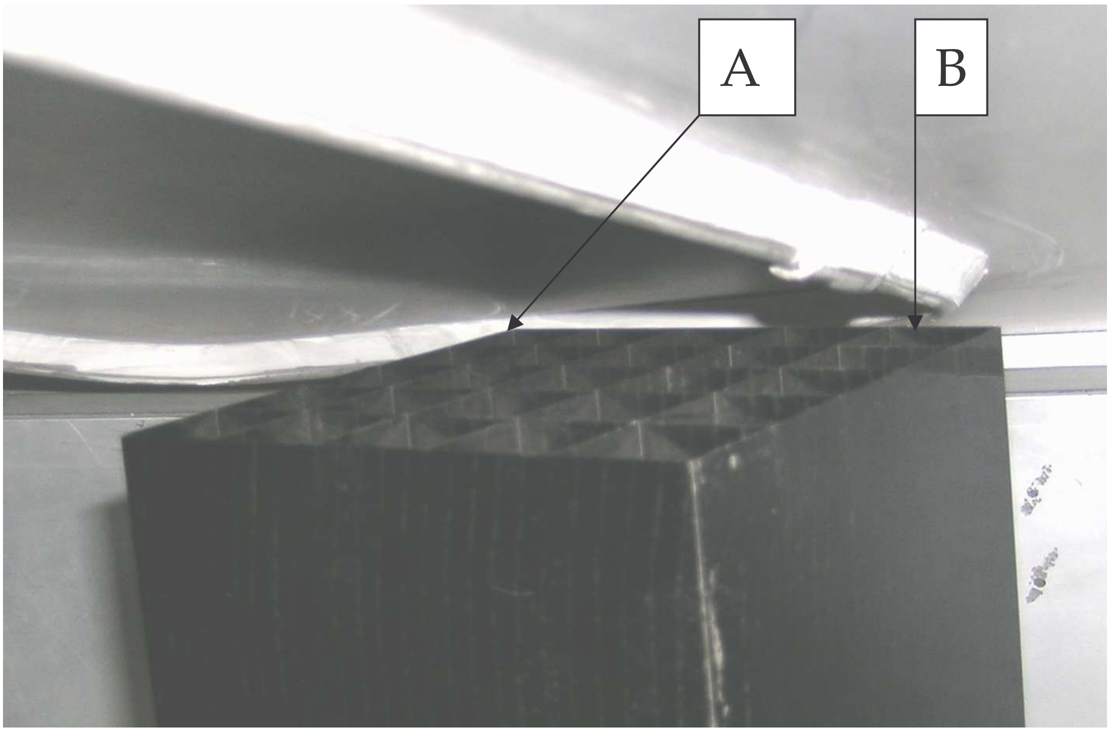

FIG. 1.3.9b

C8M: This super-crystal assembly is shown in FIGs. 1.3.10a and 1.3.10b along with super-crystal assembly C9M.

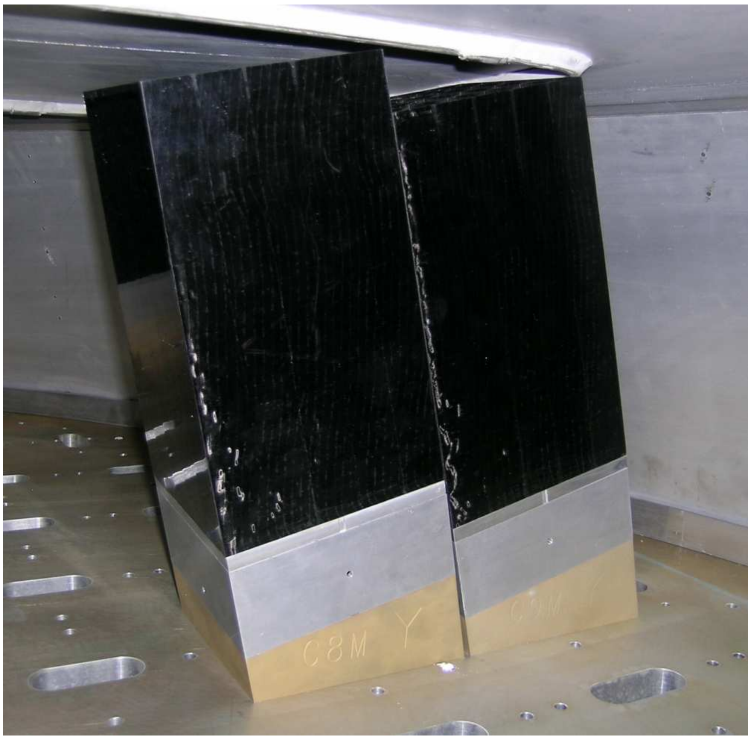

FIG. 1.3.10a

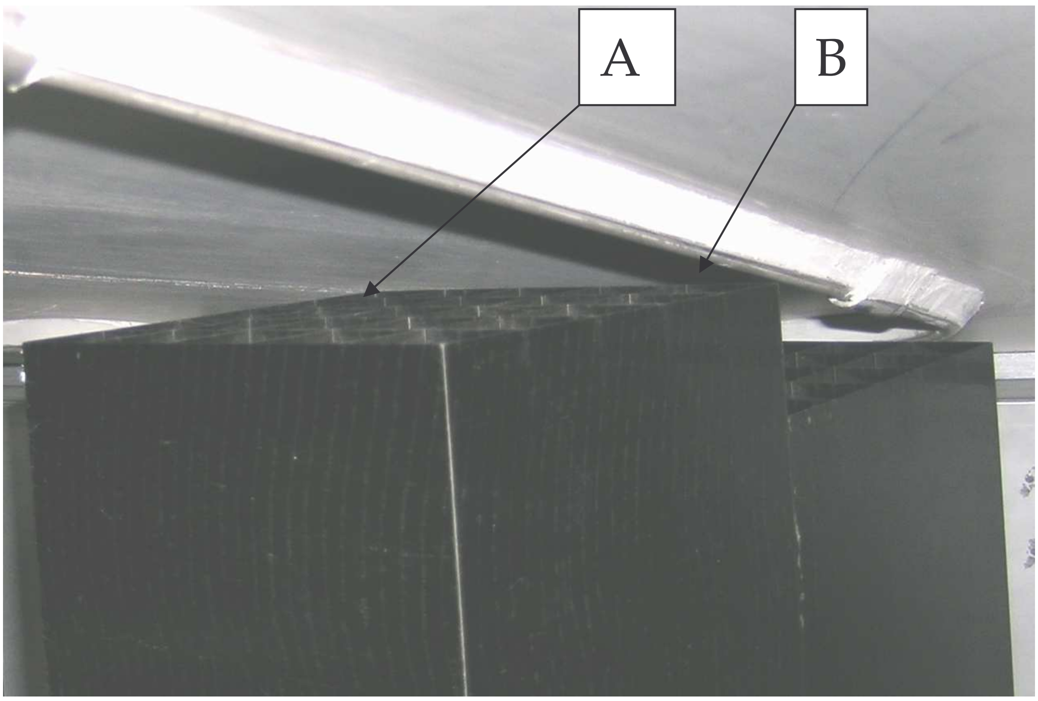

FIG. 1.3.10b

The uppermost corner of the alveolar is indicated by arrow ‘A’, and this point is 7mm below the thermal screen (‘roof’) lower surface. Point ‘B’ is the closest point on the upper edge of the alveolar from the cooling tube directly above it. This point is again approximately 15mm in from the right hand corner as shown in the image, and the clearance is slightly better than C9M at about 3.5mm to the nearest point on the cooling tube.

B9M: This is one of the two super-crystal assemblies nearest the ‘open’ region of the screen (FIG. 1.3.11a and 1.3.11b.) The points closest to the screen are the highest corners, indicated by arrow ‘A’, and the closest feature was the cooling tube as for

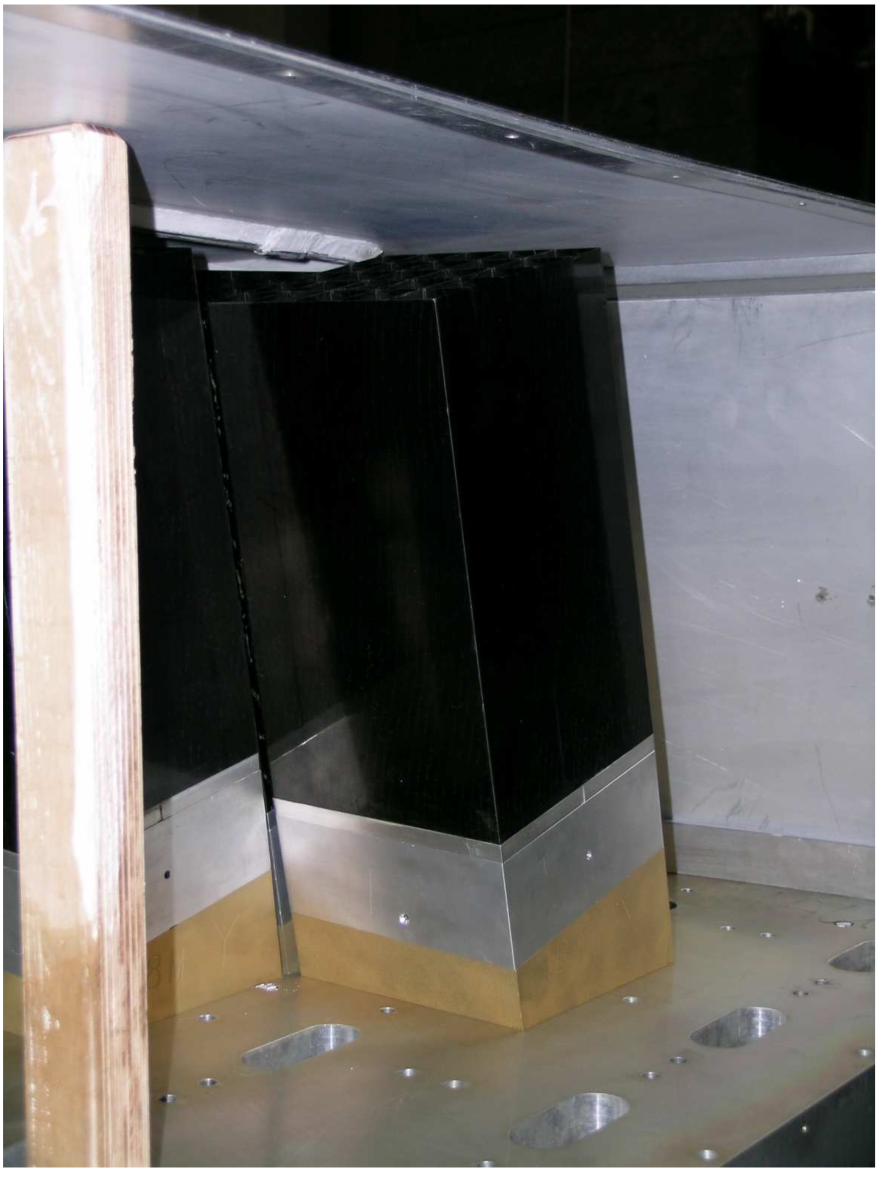

FIG. 1.3.11a

the previous cases. The corner of the alveolar at point 'A' was measured at 7mm below the thermal shield roof. However the distance of this point to the thermal compound that is applied to the cooling tubes is at worst about 5mm.

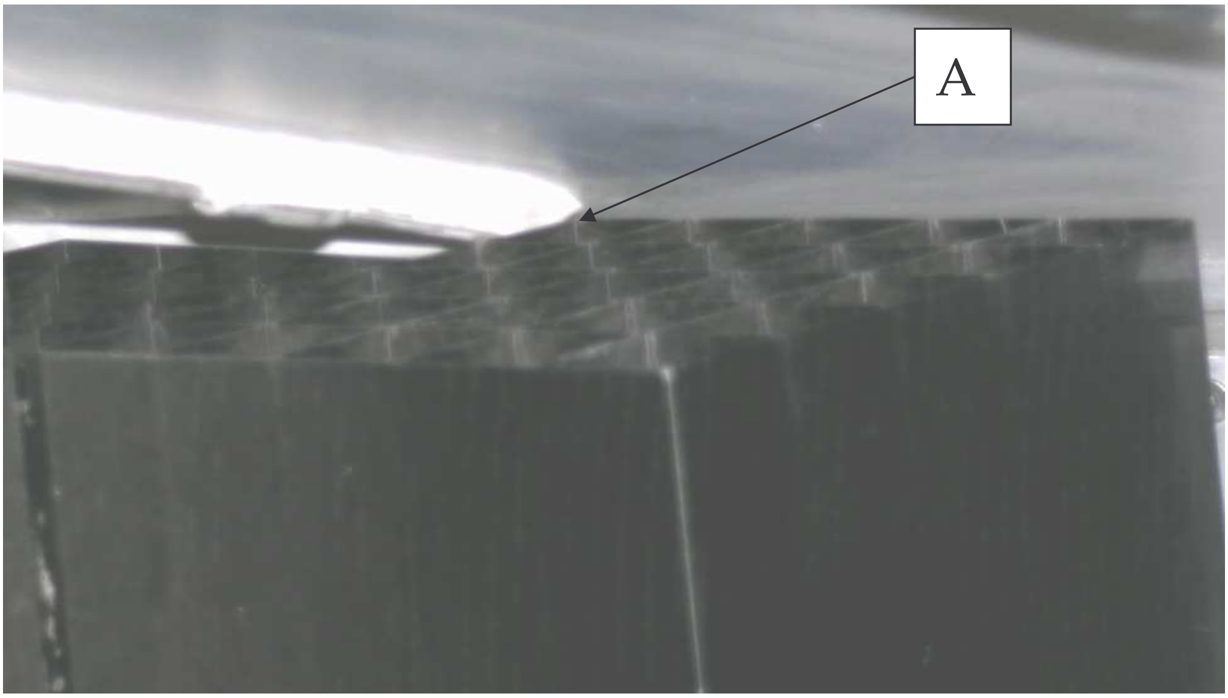

FIG. 1.3.11b

B8M: This is the remaining of the two super-crystal assemblies nearest the 'open' region of the screen (FIG. 1.3.12) The points closest to the screen are the highest corners, indicated by arrow 'A', and the closest feature was the cooling tube.

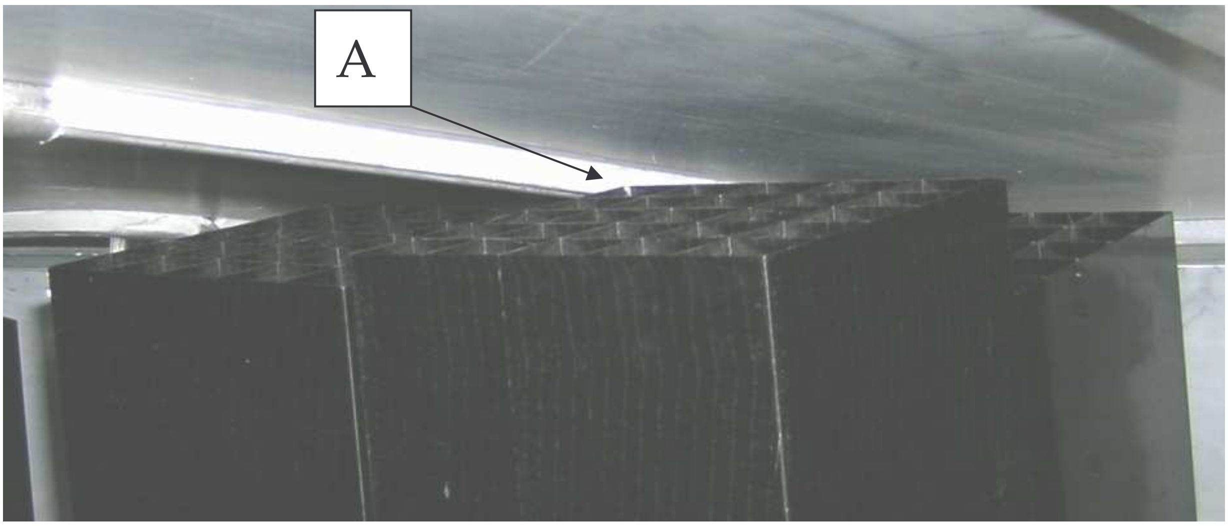

FIG. 1.3.12

The corner of the alveolar at point 'A' was measured again at 7mm below the thermal shield roof, same as for B9M. However the proximity of this point to the thermal compound that is applied to the cooling tubes is somewhat closer at about 3mm.

In general, the cooling tubes in this region around B8M and B9M have a noticeably uneven application of the thermal compound. Due to the close proximity of the cooling tubes to the alveolars in this region, it is important to control how this material is applied during the manufacture of the thermal shield in order to reduce the unevenness of the coating.

In addition, it is clear that the top panel of the thermal shield ('roof') undergoes large distortions under gravity. This makes it difficult to estimate the true flatness of the component when in its operating orientation. The deviation in the heights of the panel above the **DEE** surface in many regions is very irregular and consideration of its flatness and stiffness must be given important attention.