SUMMARY OF THE WORK DONE FOR THE ASSEMBLY OF ONE ENDCAP OUTER THERMAL ENCLOSURE

L. Sospedra, J.V. Civera, P. Modesto, C. Garcia, R. Oliete, F. Gonzalez, J. Nacer, S. Gonzalez, V. Strachko

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• Introduction

The perimeter of the OTE Airex cylinder according to drawings along different diameters is:

Perimeter of the inner OTE diameter:	**Pi * 1196.75 =**	**3759.7 mm**
Perimeter along the neutral axis:	**Pi*(1196.75+8) =**	**3784.84 mm**
Perimeter along the Outer diameter:	**Pi*(1196.75+16) =**	**3809.97 mm**

Following P. Ford's suggestion, based on his experience, we defined the length of the sheet of Airex to be cut larger than along the neutral axis to compress it later when gluing on the cylinder, ensuring a good edge contact.

Needed length has been calculated multiplying the perimeter along the neutral axis by a constant factor obtained by experience:

Sheet lenght (including extra material): pi* (1196.75+8)*1.00625 = 3808.49 mm

After some test with Airex + Aluminised kapton in both sides (before receiving the Cu-Kapton) we realized that the needed distance was smaller than this one, and fix it at **3790 mm.**

Now with the Cu-kapton, as in a real assembly, the required distance increased up to **3810 mm** as it does not expand as much as the previous one.

04.10.05 Assembly steps:

• Prepare the Airex

1. The dimensions of the OTE cylinder are:
   - Length 1924.24 mm
   - Perimeter of the Outer diameter 3809.97 mm
2. We strongly recommended to start working with bigger dimensions so that material could be cut off later on.
3. So the dimensions of the Airex sheet (obtained by gluing pieces) is:
   - Length 1950 mm (extra 25,76 mm)
   - Perimeter 3898 mm (extra 78 mm)
4. This surface is obtained by adding together 3 pieces of Airex of the following sizes:
   - (1) A full Airex sheet of 2800*1350 mm.
   - (2) A strip of Airex 2800*600 mm width.
   - (3) A strip of Airex of 1100*1950 mm.

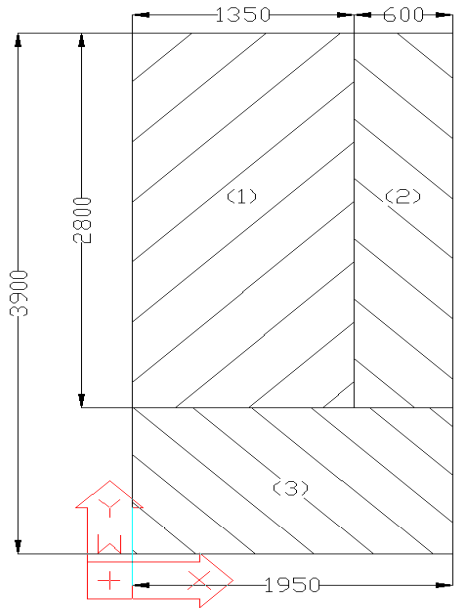

Fig 1. Gluing of the Airex sectors.

5. The gluing was done in two steps; first we glued (1) and (2) pieces and the next day we glued them to sector nº(3).
6. The steps to be followed are:
7. Use a flat and uniform table as a working area.
8. Sheets are in edge to edge contact. Place a protective film underneath the gluing line avoiding the glue to stick on the table.
9. Place the pieces of Airex edge to edge checking that no lateral step due to misalignment of the pieces appears. Two metal bars are located on the table and fixed with G clamps to a distance of 1945 mm thus leaving 5 mm of Airex to be compressed. After removing the pressure the Airex will move to its original width again.
10. Prepare the glue and mix it:

    Mixed 9 gr Not Used 2 gr Used 7 gr
11. Extend the glue along the contact line.
12. Place a rigid bar, longer than the joint to be glued, on top of it and also protected with film. Fix this bar with G clamps, compressing the extra material over the junction and thus, increasing the pressure.

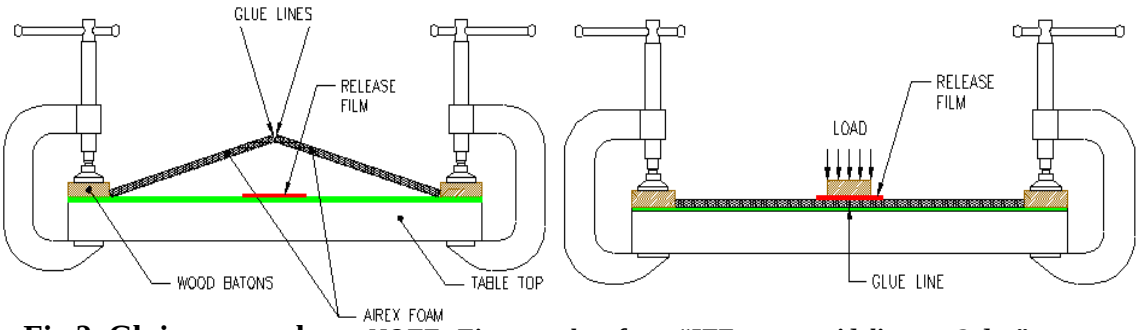

Fig 2. Gluing procedure. ***NOTE: Figures taken from "ITE_assy_guideliness_v2.doc".***

13. Leave it curing until next day.
14. Remove the bars and the protective layers and check result. It should present a continuous glued line without steps and with both surfaces in good and full contact.
15. Repeat steps from 7 to 14 for gluing sector (3).
16. Clean the edges of the glued strips, removing any debris from the cutting process or any excess of glue, ensuring that no steps are presented. Use a sandpaper to smooth it if needed.
17. Mark and cut a line few mm inside the 1950 mm sides of the sheet, having two parallel sides and leaving **a total distance of 3820 mm**. The remaining extra 10 mm will be removed just before gluing on the cylinder.
18. **The width of the Airex is maintained as 1950mm.**

- **Prepare & Glue the external Cu-Kapton layer**

1. Cut a strip of Cu- Kapton layer of 4840*1220 mm
2. Cut a second layer of 4840*800 mm
3. There will be **1 cm overlap** so final width of Cu-K is 2010 mm (60 mm wider than Airex)
4. This overlap is free of glue. Mark the overlap line on one sheet, to be followed when placing sheets relatively each other.
5. Prepare the glue. Mix it and extend it over the Airex surface until having a uniform colour, so uniform glue layer distribution.
6. Measurement of used glue:
   Mixed:1260gr Remaning:260gr USED:1000gr
7. Place the Cu-Kapton layer over the Airex and manually extend it. Place one edge on line with one of the 1950 mm sides of the Airex and project the Cu-Kapton over the Airex at the opposite side.
8. The Cu-K extends laterally at both sides and also over the Airex length.

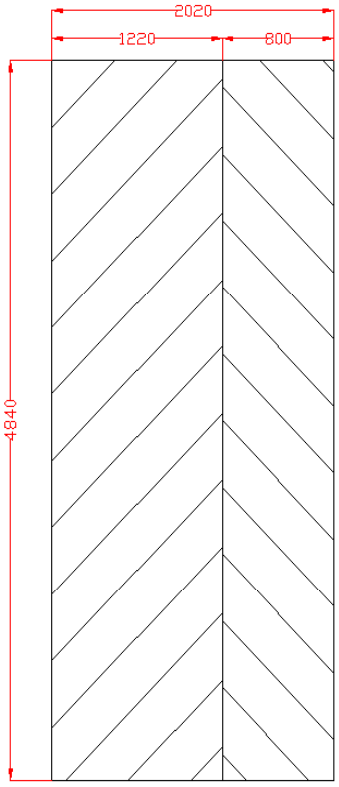

Fig 3.Al-k pieces dimensions

9. Fix it with tape.
10. Place laterally two pieces of Airex underneath the Cu-k layer and in contact with the Airex long edges avoiding the Cu-k to bend and glue laterally if there is some excess of glue. A tape on the edge of the added pieces prevent them from gluing.
11. Apply the vacuum bagging system, bringing components together. Leave it curing the rest of the day.
12. Release the vacuum.
13. Evaluate the quality of the gluing. Reject it if large areas remain unglued or there are creases on the Cu-k or the glue spread over the Cu surface.
14. Cut the extra length of Cu-Kapton leaving 20 mm to overlap when gluing the cylinder. Still do not cut the extra width.

- **Prepare the Airex + Cu-K prior to be placed on the cylinder**

15. Now Airex have to be cut to dimensions.
16. Using as reference the 1950 mm Airex edge from the side where the extra Cu-k is, mark a square line some mm inside along one long edge of the Airex and cut it following this line and having a clean edge finishing.
17. Starting from the same reference edge on the Airex, measure the length of the Airex sheet and mark a line to a distance of 3820 mm (perimeter is 3809 mm but we left some extra material to be cutt just before gluing on the cylinder) and cut removing the extra material from the edge opposite to the reference one.
18. Finally measure the width of the Airex staring form the long cut edge and mark a new line at a distance equal to the length of the cylinder on drawings (1924,24mm)
19. Make a straight cutting removing the extra material.
20. This side must have a sloped cut, so a dedicate tooling is used. The blade has the angle of the slope and having as reference the straight cut already done on the Airex, the tooling is moved and the angled cut is made.
21. As it is, this composite will be brought to the cylinder to shape it cylindrical. This operation helps to eliminate any small bubble or crease remaining from the glue step.

- **Prepare the inner Kapton layer**

1. **The length of the OTE is 1924.24 mm** but is recommended to cover a longer distance allowing the Al-k to be fixed from its edges, cutting the extra material once glued. **So total length to cover was fixed at 1960 mm.**
2. Cut a sheet of Aluminised Kapton of **4100 *1220 mm.**

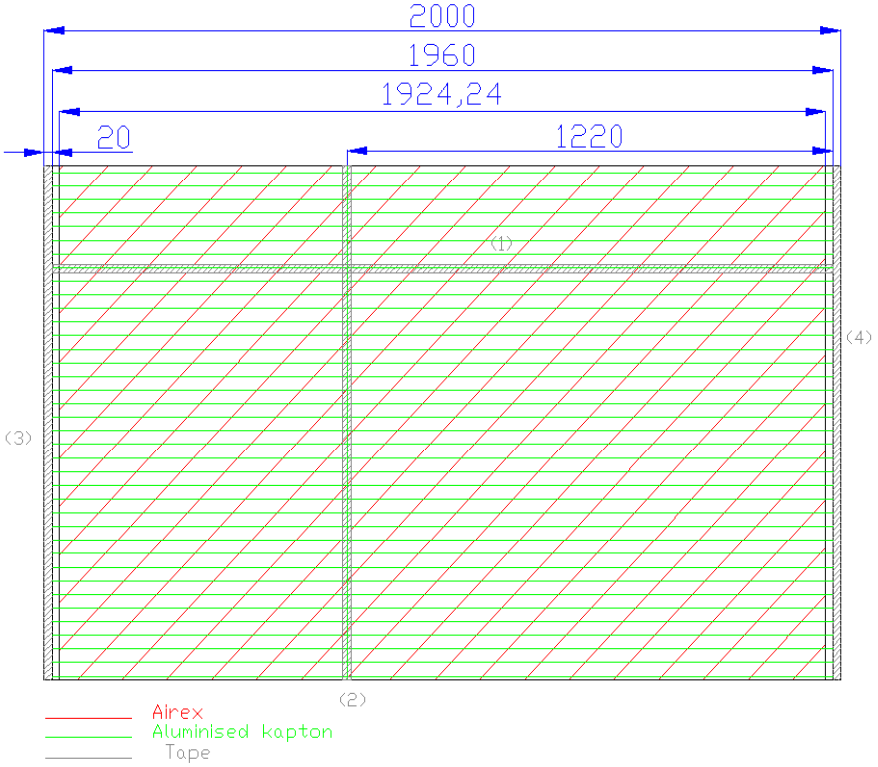

Fig 4. Distribution of the Al-k on the mould

3. Cut a second piece of Al-k. The needed width is calculated including the 10 mm of lateral overlap between pieces. So dimensions are: **4100*750 mm**
4. Place the first sheet of Al-k on the mould cylinder. Tape one end of the Al-kapton (1) on fig 4, to the mould avoiding any movement when extending the film.
5. Manually extend the kapton film while rotating the cylinder tooling to eliminate any crease, fixing it at the lateral flange ends (2) and (4) on Fig 4 until 360 degrees has been covered.
6. Place a second tape over the existing tape nº 2 (see tape (b) on Fig 5).This second tape will cover the first one (tape (a) on Fig 5) at the same place. The purpose of it is to provide a surface that, if stained while applying the glue, could be later on removed.
7. Cut off 307 mm as the sheet overlap was bigger than needed (the perimeter of the inner OTE diameter is 3759.7 mm). **So final length was 3793 mm with 33 mm overlap.**
8. Add some glue at an area of the inner face of the sheet overlapping material ensuring that it will not contact the Aluminium tooling.
9. Pull the overlapping material and hold it with tape.
10. Remove tape (1) on Fig 4 as the Al-k is well fixed by the lateral tapes.
11. At edge nº (2) on Fig 4 , mark a line 10 mm inside the Al-k sheet and place another tape (tape (c) on Fig 5) following this line. This will define a 10 mm strip, the overlap between layers, to be filled with glue.
12. Measurement of used glue:

    Mixed:18 gr Remaning:15 gr USED 3 gr
13. Apply the glue and remove the tape (b) & (c) on Fig5 that defined the lateral area filled with glue.

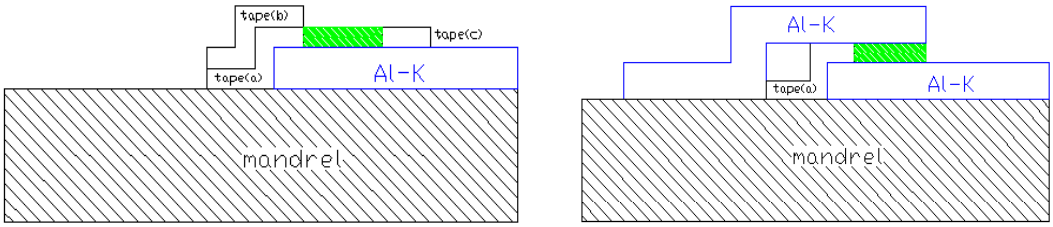

Fig 5. Adding the glue and gluing the overlap between Al-k layers

14. Place the second piece of Al-k, starting at the same point and fix it, as with the other sheet, at point (1) on fig 4.
15. Extend along the perimeter maintaining the 10 mm lateral overlap along it.
16. Fix it with tape at point (3) on Fig 4.
17. The other end is fixed by the glue that sticks both sheets together.
18. Add some glue at an area of the inner face of the sheet overlapping material ensuring that it will not contact the Aluminium tooling.
19. Pull the overlapping material and hold it with tape.
20. Leave it curing
21. Once glued the two Al-k sheets it has to be taken off from the mandrel in order to remove tape (a) that remains under the lateral overlap.
22. Place it upside down on a flat surface, remove the tape and finally add glue on the area where the tape was.
23. Once glued, move it back to the mandrel fixing it laterally at points (3) and (4).

- **Glue the Airex to the internal Al-k layer on the cylinder**

1. **Dimensions of the Airex surface were: 3820*1950 mm.**
2. **Cut the 1950mm width to the needed length of the OTE: 1924.24 mm** (proceed as at previous cutting, measuring the distance at different points, drawing a line, putting a ruler and then cutting precisely.)
3. **From the side where the Airex+ Cu-k are on edge, cut the 10 mm extra length of the Airex to reach the perimeter one: 3810 mm.**
4. **So final dimensions of the Airex is: 3810*1924.24 mm**
5. Place the Airex facing down over a flat surface, so having the Cu-k side backwards and the plain surface of Airex shown.
22. Prepare the glue. Mix it and extend it on the Airex until having a uniform colour, so uniform glue layer distribution.
23. Also extend the glue along the short length of the Airex edges.
24. Measurement of used glue:

    Mixed:1260 gr Remaning:325 gr USED:935 gr
25. Bring the Airex + Cu-Kapton to the mould and place it over the inner aluminised kapton layer. Do not meet the cut on the cylinder mould with the one on the Airex trying to get a better round shape.
26. Put glued edges in contact having at the same time the sloped circumferential edge well positioned and without lateral step on it.
27. Use a stopper on the opposite edge to avoid any lateral displacement of the Airex once placed or later on when compressed during the gluing step.
28. Fix the Airex over the mould with straps.
29. Add tape perpendicularly over the Airex contact line and then remove the straps. Some people are needed to support the Airex on place during this phase.
30. Put the protective film over the gluing line and the vacuum bagging covering everything.
31. Apply vacuum.
32. Just in case something could happen with the vacuum system during the hours its working, we added several straps to ensure that some pressure will be applied if the vacuum pump fails.
33. Leave it curing.
34. Remove the straps, the vacuum bagging system and the tapes over the junction.
35. Remove the tapes from the Al-k sides and move the OTE cylinder to one side removing the excess of Al-k.
36. In order to electrically connect the internal Al-k to the external Cu-k up to 8 strips of conductive material per side of the OTE cylinder are glued. The strips are made from Cu-k with the Cu side facing down.
37. Cut strips 21mm width and 50 mm length.
38. Glue them by using conductive glue (TRA-DUCT 2902) on the center of the strip and the standard Araldite 2011 surrounding it.
39. Put some tape to fix it and let it curing all night long.
40. Remove the tape and check the electrical conductivity. Values were all below 3 Ohms. Very good conductivity.

- **Subassembly of the Rear Flange**

1. The assembly is managed by the tooling. It has been designed with a 0.5 mm step to allocate the external CF and it also has 5 mm holes precisely machined where pins with two different diameters (5 and 8 mm) are placed.
2. Put the Rear Flange tooling in a horizontal position apart from the main tooling.
3. Spread glue along the contact surface of the **Rear Flange reinforcement strip** element (TD-1012-553) and place it in the tooling.
4. Add the **aluminised kapton** layer. This film has been previously cut to shape and with the needed holes already on place. Laterally 1 cm extra has been added to overlap with the neighbour ones. Add glue on the overlap.
5. Allocate the pins on place.
6. Place then the 5 mm Airex with the 13 mm diameter holes to allocate the ULTEM inserts on it. Previously the contact surface with the Al-k layer has been covered with glue.
7. Add glue on the visible Airex surface (already on the tooling), place the inserts in the holes and fill in the gaps with glue.
8. Add the **Rear Flange reinforcement strip** element (TD-1012-497).
9. Place the **copper kapton layer**.
   These sectors have been cut bearing in mind all the extra material needed:
   - As for the Al-k layer, there is 10 mm extra material to laterally overlap the neighbour Cu-k sectors.
   - Also they have been cut to an external diameter 10 mm longer than the Rear Flange one so that this area could be cut into tabs spaced 15 mm in order to be glued along the edge of the Rear Flange.
   - Finally the inner diameter is 21 mm smaller and once glued has to be cut into tabs spaced 18 mm which will be glued over the OTE cylinder providing an electrical connection.
10. Add glue on the overlap.
11. Measurement of used glue:
    Mixed: 324 gr **Remaining: 172 gr** **USED: 152 gr**
12. The gluing will be done under vacuum, so to avoid the bending of the Cu-k layer that projects over the Airex, some pieces of Airex are placed in between the Al-k and the Cu-k layers providing a uniform support. The inner edge of these pieces is covered with tape to avoid it gluing to the Airex sector of the RF.
13. Place the tooling inside the vacuum bag and cover it with breathe clothes.
14. Apply vacuum and let glue curing.
15. Remove the vacuum and take out the RF and check results. No crease should appear on the surface and the gluing must be good without areas of unglued material.

- **Glue the Rear Flange to the OTE cylinder**

1. Place the Rear Flange on a flat surface and add glue on the 5 mm thickness Airex that will contact the cylinder. This strip is visible between the Al-k and the Cu-k. Glue nº (2) on Fig 7.
2. Add glue on the cylinder. We have to fill with glue a surface covering not only the Airex from the Rear Flange (2) but also the Cu-k tabs that projects over it (1) . Measure 21 mm from the edge of the cylinder and place a tape following this line. Fill in with glue from there to the edge of the cylinder.

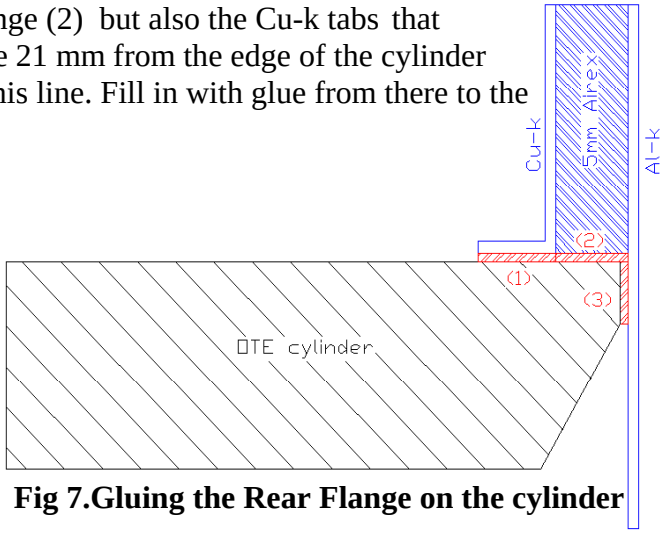

Fig 7.Gluing the Rear Flange on the cylinder

3. Add glue also on the edge of the cylinder (3) to glue a part of the Al-k tabs.
4. Measurement of used glue:
   Mixed: 36 gr Remaining: 27 gr USED: 9 gr
5. Place the Rear Flange on its tooling.
6. Put the RF on the mould and move it close to the OTE cylinder.
7. To get a full contact we project the cylinder over the mandrel, adjust the RF on it and then move the whole system back until being at the mandrel end again.
8. Screw the RF tooling to the mandrel rib.
9. Place a stopper from the other end to maintain the pressure of the OTE cylinder over the RF along the curing time.
10. Lay down the Cu-k tabs and glue them. Remove any excess of glue.
11. Put a tape on top of them with a flexible metal bar in between to keep them on place. The metal piece is placed against the square of the tab and the RF to obtain a real square corner, not a sloped one.
12. After gluing, remove the tooling and prepare for gluing the part of the Al-k tab still unglued.
13. Prepare glue and cover the sloped edge of the OTE cylinder.
14. Glue the Al-k tabs and fix it with tape.
15. Measurement of used glue:
    Mixed: 16.2 gr Remaining: 11 gr USED: 5.2 gr
16. Let it curing.
17. Remove the tape and cut the excess of material.

- **Glue the Front Flange to the OTE cylinder**

1. Place one of the CF sectors on a flat surface and clean it.
2. Apply glue over the contact surface on the inner side of the cylinder.
3. Bring it to the OTE cylinder and left it at a place where the ends of the CF are at a different location that the joining lines of the Airex or de Al-k on the cylinder trying to make the OTE more rigid.
4. Check with a square that the CF is at the same edge that the OTE cylinder one and fix it with tweezers.
5. Place as many as needed until cover the ½ circumference sector.
6. Remove the excess of glue and let it curing.
7. Remove the tweezers and do the same with the second sector.
8. Measurement of used glue (both sectors):
   Mixed: 18 gr **Remaining: 14 gr** **USED: 4 gr**
9. Put a drop of glue at the inner side of the contact lines.

PICTURES OF THE ASSEMBLY PROCESS

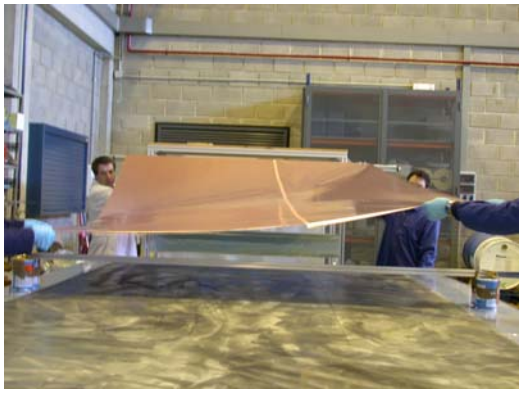

Fig 8. Placing the Cu-k layer onto the Airex sheet covered with glue.

Fig 9. Cu-k layer already glued to Airex substrate.

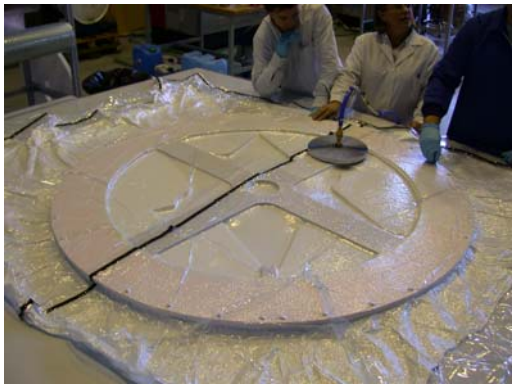

Fig 10. Apply vacuum for gluing the Rear Flange.

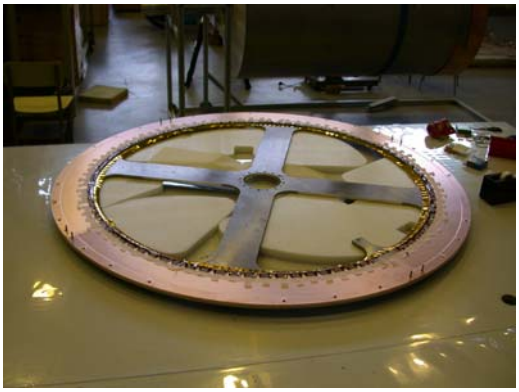

Fig 11. Rear Flange assembled. Tabs on the Al-k and also on the Cu-k already cut.

Fig 12. Al-k inner layer placed on the mandrel. Two sheets used to cover the length.

Fig 13. Apply glue on the back side of the Airex + CU-k subassembly before gluing to Al-k layer

Fig 14. Main cylinder assembly. Vacuum used on the mandrel

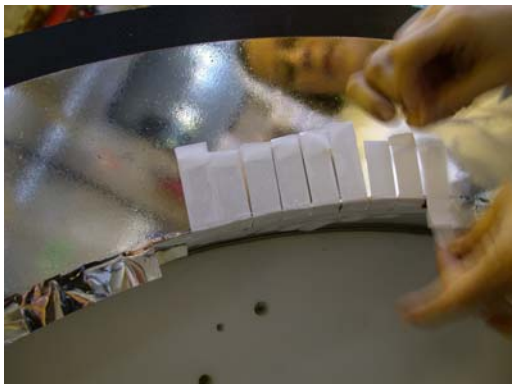

Fig 15. Gluing the Rear Flange Al-k tabs over the sloped edge of the OTE cylinder

Fig 16. Tweezers used for gluing one CF sector of the Front Flange.

Fig 17. Surface finishing of the Al-k side of the OTE cylinder

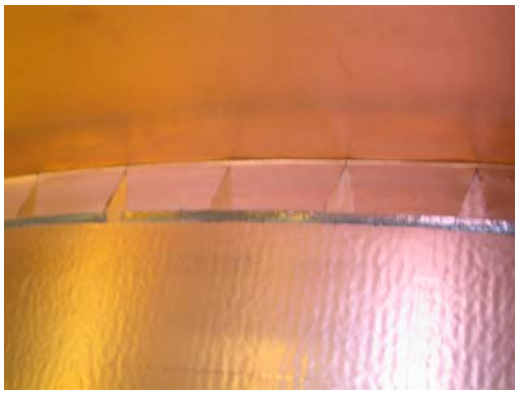

Fig 18. Soldering of the Cu-k tabs to the Cu-k layer of the cylinder.

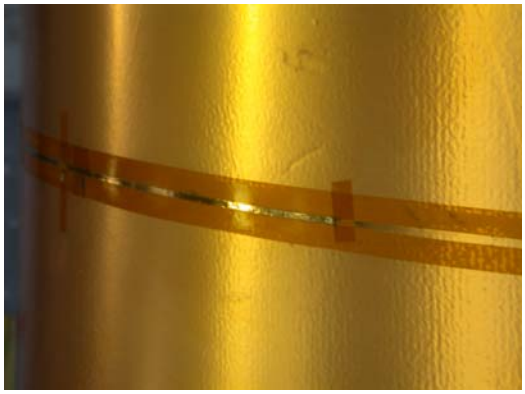

Fig 19. Soldering the two sheets of Cu-k used to cover the OTE length.

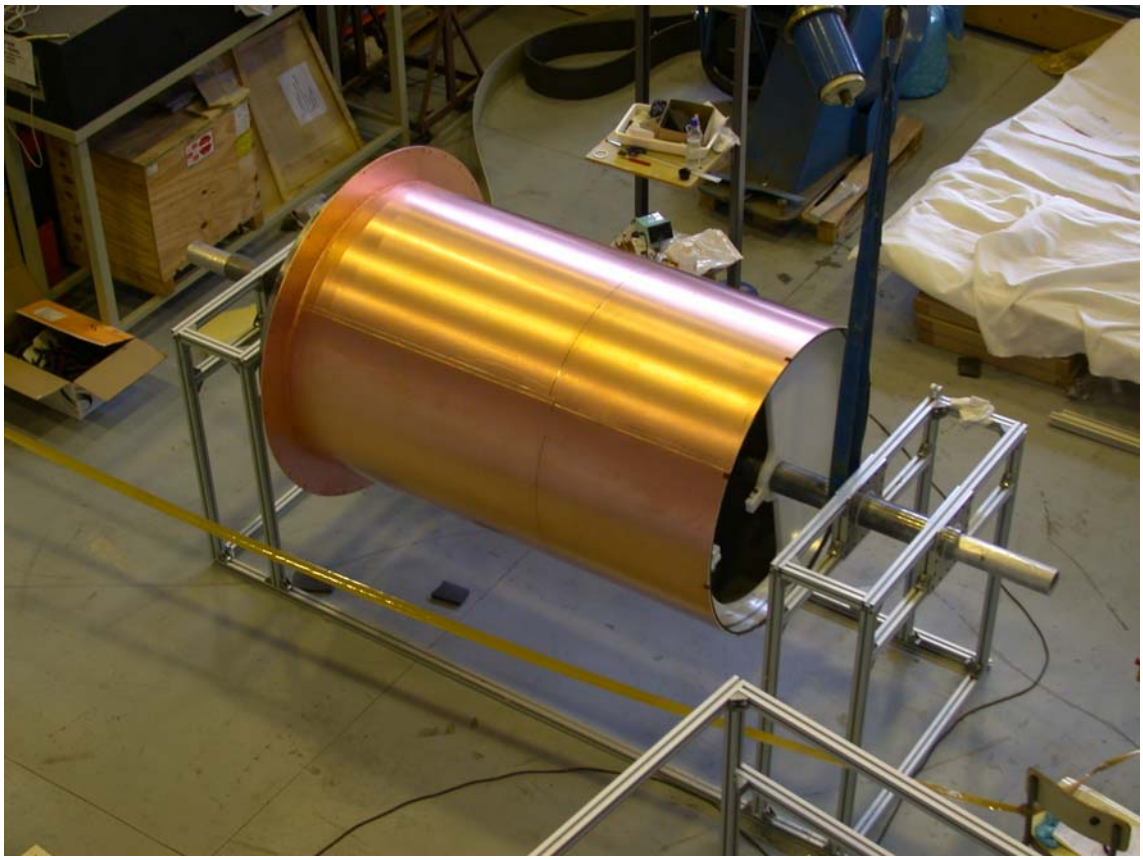

Fig 20. OTE for the END CAP C assembled at Valencia.