University of Regina

Barrel Calorimeter Module Construction Procedure Manual

Proper Safety Procedures, Clothing, Equipment, and Materials Must be Used During the entire construction and all measuring equipment must be properly calibrated before use.

Preparing Base Plate

1. Clean the bottom of base plate with a water soluble degreaser followed by ethanol.

2. Check that the inserts (two sets of four) have been properly installed. Position is checked at Ross Machine Shop using the gauges that we provided.

3. Using a calibrated tape measure check the position, of the bolt hole pockets, report only out of specification measurements on the traveler for that specific base plate.

4. Measure the width of each bolt hole pocket with calibrated digital callipers at the top of the draft, report only out of specification measurements on the traveler for that specific base plate.

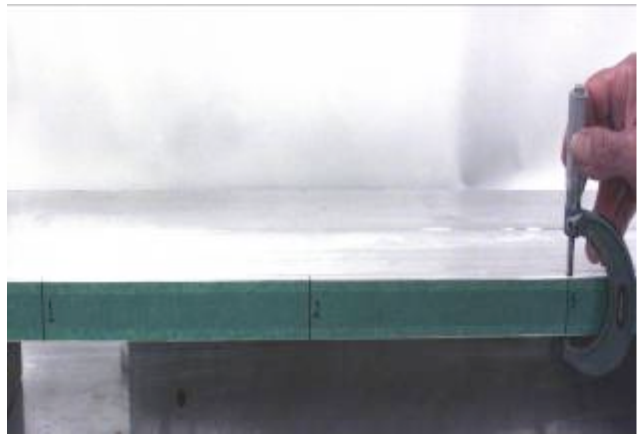
5. Measure the length of each bolt hole pocket with calibrated digital callipers at the top of the draft, report only out of specification measurements on the traveler for that specific base plate.

6. Measure the depth of each bolt hole pocket with calibrated digital depth gauge, report only out of specification measurements on the traveler for that specific base plate.

7. Turn plate up-side-down and clean the top and side of plate.

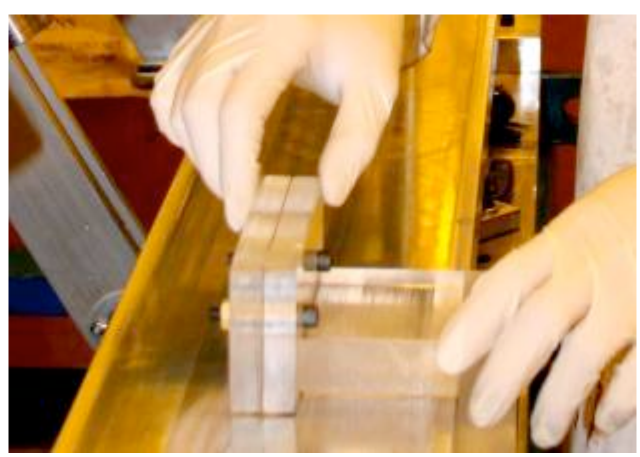
8. Label 16 points on the side of the plate:
   Facing the machine side (front side), point 1 is on the left; stamp is near point 16. Either use the drill holes on a top plate as a guide, transferring them to the base plate as shown here or measure the position using tape measure. Center to center spacing is 10 inches. Point 8 and point 9 are centered on the length of the plate.

9. Measure and log the thickness of the plate at each of the 16 points. Two measurements on each side (front and back) are needed – from the bottom to the top of plate, and from the bottom of the plate to the top of recess. Enter all measurements into a digital spread sheet.



10. Using an orbital sander, abrade the top of the plate using 80 grit sand paper to improve epoxy bonding characteristics.

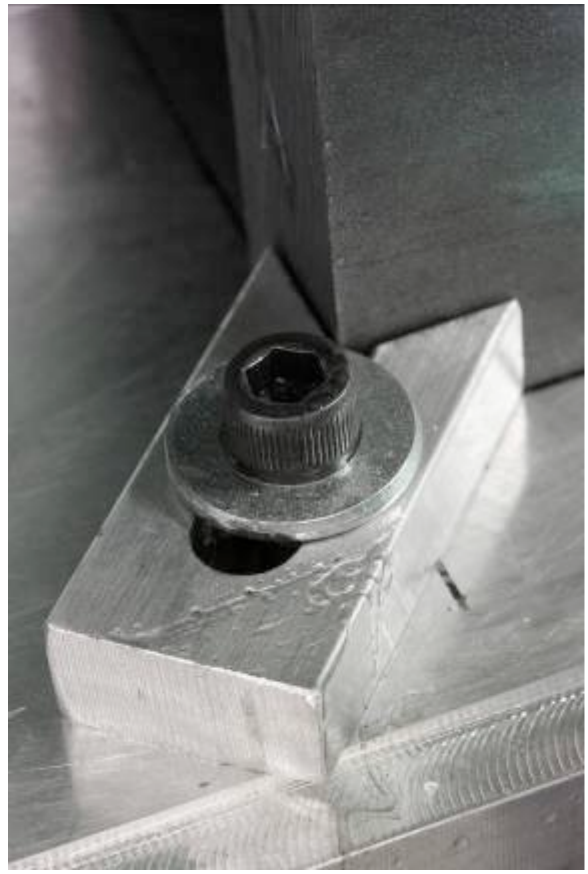
11. Using the groove cutting and cleaning tool rework the alignment groove if necessary to ensure the minimum depth is .024 inches. Ethanol may be used as a lubricant.



12. Set up posts and wire, and set guides .5 mm above the top of the plate.

13. Move the base plate with rails attached on to the press, level, shim if necessary, center and align the groove parallel to the wire.

14. Fix into place using 4 corner brackets pressed tight to the rails.



15. Clean the plate using appropriate solvents. Mask the side, ends and top recess of the plate using green masking tape. Transfer numbers onto tape.

Preparing Fibers

1. Make sure the copper covered fiber table is grounded.

2. Take a box of fibers from the crate onto the fiber table.

3. Open the box at one end. There are two large bags of fibers in each box. One person holds the bags and keeps the fibers on the table, while another person pulls the box out.

4. Cut the end of the large bags. There are 12 small bags of fibers in each large bag. One person holds the small bags, while another person pulls the large bag out.

5. Cut one end of the small bag. Be careful not to damage the fibers. Also cut a small portion of the side of the bag. This will allow one person to hold on to the fibers while another person will pull the bag off the fibers keeping the bag and fibers in constant contact with the grounded copper plate.

6. During the fiber placement process on each layer it is more productive to leave 3 to 4 grooves without fibers in them, later after placing the "reduced pack of fibers", the actual number of opened grooves are then counted and filled from a reserve pack.

   The total number of fibers needed to be placed on each layer will depend on the width of the lead sheet to be used in the construction:

   -13cm --Use a reduced Pack = 93 fibers   Total fibers needed approx. – 96-97 fibers
   -12cm --Use a reduced Pack = 85 fibers   Total fibers needed approx. – 88 -89 fibers
   -11cm-- Use a reduced Pack = 77 fibers   Total fibers needed approx. – 80-81 fibers
   -10cm-- Use a reduced Pack = 70 fibers   Total fibers needed approx. – 73-74 fibers

   To make reduced packs, subtract fibers from bag quantities, which contain approximately 100 fibers.

   Gently gather, align the fiber ends and very loosely lightly tie each bundle with a color coded 24 gauge insulated wire made into a twist tie.

   When changing lot numbers, mark each bundle with a coded twist tie.

Preparing Epoxy

1. Check and recalibrate the scale if necessary using both a 20 and 100g weight.
2. Cover the scale with plastic wrap.
3. Put a plastic cup on the scale. Zero (tare) the scale.
4. Measure the resin and hardener separately in clean new 10 ml. plastic cups:
5. The ratios are as follows:

Bicron Optical Epoxy:	100.0g resin
	28.0g hardener
Araldtite 2011 Industry Epoxy:	100.0g resin
	80.0g hardener

6. **Do not mix** the epoxy until it is ready to be used. Cover the resin and hardener with plastic wrap until such time.
7. When the epoxy is ready to be used, add the hardener to the resin. Stir and fold with a mixing stick for one minute in the original cup and then transfer mixed contents to the center of a clean new cup and continuing mixing for a total minimum time of 4 minutes.

Setting up the Post and Guide Wire

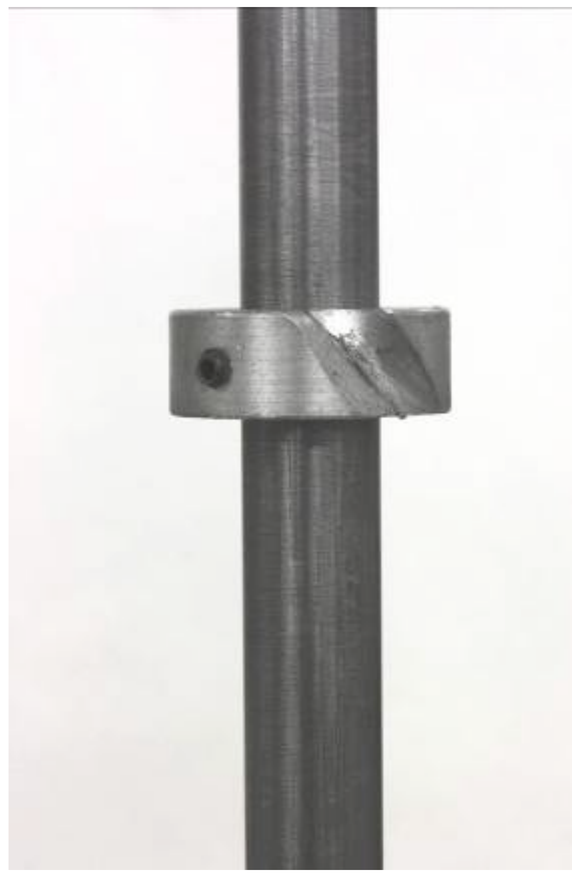
1 Ensure that the aluminum plates that the posts sit on are clean and flat. If you are unsure contact the construction manager before proceeding.

2 Using the Lufkin #59 level placed on the above plates check that both ends of the press are level within 3 divisions of level, if more than 3 divisions contact the construction manager to re-level the press before proceeding.

3 Brush off any particles and any high points underneath the post. Repeat #1

4 Install the posts at each end of the press. There is a number stamped on each post on the blue press (press1) and letters on the red press (press2). Make sure that the stamp on each post matches the one on the press. Tighten the screws evenly with an hex allen wrench.

5 Put the aluminum alignment wire guide on Post # 1 (or Post D for Press 2). Adjust the height so that the top of the guide is about 1mm above the module. Tighten the set screw lightly to lock the position.

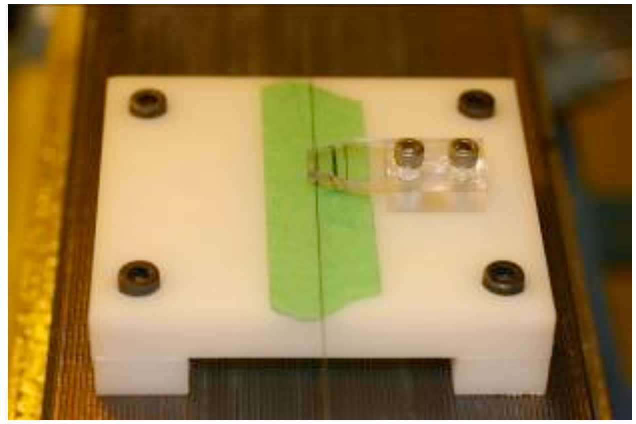


6 When not in use put the wire on the plastic holders at the top of the press.

7 Wrap the wire around the pole so that the wire is on the side along the center line.

8 Put the other end of the wire on top of the aluminum guide and wrap around the post. Attach a weight to pull the wire tight and straight.

9 The alignment of the grooved lead sheets can be checked by setting the alignment wire height 1 mm above the cart and then running the traveling cart along the grooves on top of the module from one end to the other while viewing directly from above. The mark on the cart stays aligned with the wire if the module is straight



Construction

Preparation

While two crew members are preparing for the constructions with the following steps, the other two should prepare fibers and optical epoxy.

1. Open the press and clean up the top of the BCAL module. Using custom built re-grooving and groove grooming tools remove any epoxy that might have migrated into the grooves on the sides and ends of the module.

2. Remove the tape on the top sides of the base plate recess. Measure and log the height of the module at each of both the front and back positions of the 16 labelled points. These points correspond to the 16 #8-32 holes spaced at 10.0 in. centers on the top aluminum plate.

3. Enter the data into an electronic spreadsheet.

4. Tape the top sides of the recesses of the base plate to prevent epoxy running onto it.

5. From the schematics and the height data, determine the appropriate width of lead sheet to be used.

6. Set up the posts and wire. The wire represents the center of the module. Use either a caliper or gauge plates with appropriate width to outline where the lead should be positioned. Use masking tape to mark the position of the next lead sheet.

Build Process

Once the preparation is done, mix the optical epoxy. Write the time when the epoxy is first mixed in the log book. Pour a small sample of the mixed epoxy for a reference. Within two hours after the epoxy is first mixed, build up alternate layers of optical fibers and lead on the BCAL module. The procedures for building one layer are as follows.

1. Two people paint optical epoxy evenly on the top lead layer, each starting at opposite ends of the module crossing over at the center and recoating and checking each other's work.

2. One person with clean gloves (no epoxy) should lift one end of a bundle of fibers, with the aid of toothpicks, from the grounded copper covered fiber sorting table so that another person can hold the fibers from that end. Repeat this at the middle of the bundle and at the other end. Three people carry the fibers to the module.

3. Line up the fibers on the top lead sheet so that they extend evenly past both ends.

4. Placing the fibers into the grooves: One person rolls and massages the fibers into the grooves at the middle of the lead sheet while two people using their fingers comb, untangle and slide the fibers into the proper grooves along the rest of the length of the lead sheet to the ends. At this point all fibers should be seated in their grooves and be parallel to each other.

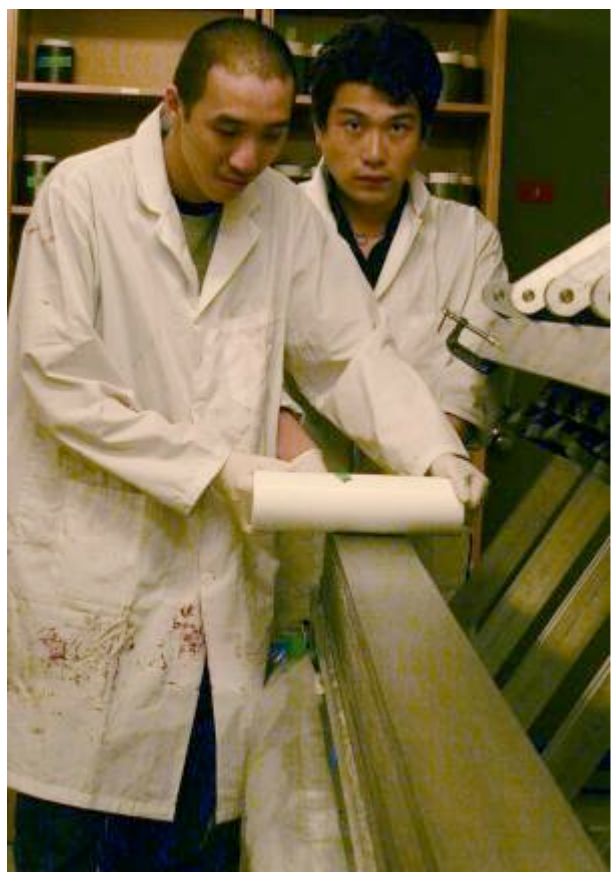
5. If additional fibers are needed, the person with clean gloves will count and lift them for the other three people. If there are too many fibers in the bundle which has been in contact with the epoxy, put the extra fibers on a piece of clean poly and use them for next layers. Once all fibers are placed and the quantity is known, record the batch number of the fibers and number of fibers used for that layer in the log book.

6. Slide you fingers gently over the top of the fibers to feel for irregularities in fibre height. Irregularities may be caused by particles underneath the fibers, or there may be irregularity of the lead sheet. Use a toothpick to get rid of any particles underneath the fibers. If the grooves of the lead sheet are deformed or if you are unable to seat the fibers properly in the grooves, inform the construction manager before proceeding.

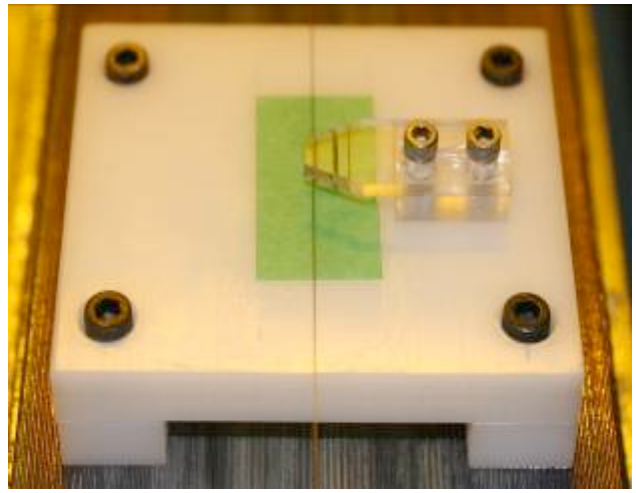
7. Two people starting at opposite ends of the module paint an even coat optical epoxy on the fibres, cross at the center and recoat while checking each other's work.

8. One person centers and unrolls a lead sheet of appropriate width on the fibres, (Alternating Type 1 and Type 2.) Another person "massages" the lead back and forth gently to ensure the grooves lock onto the fibers.

9. With one person holding the lead sheet from moving another rolls the lead sheet flat using a Teflon roller all in one motion across the entire module.
   Note: The roller can also be used in a sliding motion.



Alignment



To ensure the alignment of the lead is correct, each sheet must be checked. To check each sheet, put the wire on the posts and guides and use a weight at one end to pull the wire taught. Check using the travelling guide that the lead sheet is straight and aligned with the wire. If not, roll up the lead sheet on a core (spool) and reseat the fibres, if it is on the last layer of the day and has epoxy on the top side of the lead sheet, discard it and re-apply a coat of epoxy and use a clean lead sheet. All discarded lead sheets must be documented in the log book.

When checking for straightness of the build put the brass wire guide on the appropriate post, Post 2 for press 1 (Post C for Press 2). Adjust the height so that it is about 1mm above the traveling cart. Lightly tighten the set screw to lock the position. Position the al. guide at the same level on the opposite

Note: the guide wire is made using .011inch dia. musical wire fastened to this guide with a loop tied at the other end for weighting purposes. If substantial kinks develop in the wire it be must be changed.

Last Layer of the Build

- Change gloves (no epoxy). Clean the Teflon roller and traveling cart.
- Use a lead sheet that is 1cm wider and approximately 6 cm. longer than other layers you built that day. (If you are building 13cm, use 13cm for the last layer since there is no 14cm lead.)
- Lift the PVC core slightly while unrolling the lead sheet. If there is any fibre not in the groove, the person "massaging" the lead sheet will feel it more easily.
- The last lead layer is carefully covered with a strip of clean 6 mil poly approximately 10 inches wide x 14 feet long.
- With the press in the upright position and using an alignment guide, a 1-1/4 inch aluminum base plate with the machined surface facing the poly is placed on top and a ¾ inch aluminum plate is placed on top of it.

The Press

Press in the opened position.

A pneumatic press is used to hold the lead, aluminum and optical fibers together in close contact with epoxy until it is cured. Each press has 20 pneumatic cylinders that operate in pairs, used for pressing and are controlled by 10 two way electro-mechanical valves . Two smaller cylinders, both controlled by a single electro-mechanical valve, are used to recline and raise the upper unit of the press. The former position is used during the build process and to accommodate lifting of the finished module, the latter position is for pressing. A panel of toggle switches on the front of the press control all cylinders. The cylinder air pressure is regulated to 85 lbs. per sq. inch of pressure. To recline (open) the press all lower pins from each of the 12 vertical links must be removed and links moved to their upright position.

Press in the closed position.

First Build

- Layer 0 is glued to the base plate using industry epoxy and layers 1 to 5 are using BC-600 optical epoxy.

- Five layers are built on top of Layer 0 so that there is enough height for the epoxy to flow down. This minimizes the amount of epoxy that goes on top of the lead sheet and that the 13 cm. step can be built in two builds.

1. Measure and dispense only in separate cups, Araldite 2011 industry 100 g epoxy resin and 80 g hardener and cover cups with plastic wrap. Do Not Mix.

2. Measure and dispense only, in 4 separate cups, 100 g each of Bicron BC-600 Optical Epoxy Resin and 4 cups 28 g each hardener, cover cups with plastic wrap. Do Not Mix.

3. Sort 5 bundles of 93 fibers each.

4. Take off the wire. Place a fiber, to act as a guide, in the groove of the abraded and pre-cleaned base plate.

5. Note the length of a clean rolled up 13 cm. sheet of swaged lead. Set the end of it where the unrolled length will be centered on the length of the base plate. Align and place, setting the center most groove of the lead sheet onto the fiber in the base plate. Slowly unroll the lead carefully following the fiber under it, making sure the fiber remains in the groove.

6. Set up the guide wire. Use the traveling cart to check that the lead sheet is straight. If necessary, "massage" the lead sheet back and forth gently to straighten, align and ensure it is parallel with the guide wire and guide fiber. Feel the top of the lead sheet to confirm that the fiber is still in the base plate groove. If not roll up the lead and repeat step 5.

7. Roll back up about ¾ of the lead sheet from one end on a core. The other ¼ of the lead sheet should remain on the base plate to ensure the position and alignment remains unchanged.

8. Mix the industry epoxy resin and hardener together.

9. Using a 18 pitch hacksaw blade as a notched trowel, spread the industry epoxy evenly on the base plate keeping the epoxy a minimum of 3 mm away from the fibre to avoid forming a high spot in the center, caused by epoxy getting squeezed and trapped under the guide fiber.

10. Unroll the lead sheet onto the epoxy again using the fiber as a guide.

11. From the opposite end, roll up the lead sheet on a core, until the epoxy is exposed, make sure that the epoxy doesn't contact the top of the lead sheet.

12. Use the saw blade to spread the industry epoxy evenly on the remaining surface of the base plate.

13. Unroll the remaining lead sheet following the guide fiber.

14. Set up the guide wire to check that the lead sheet is straight and parallel to it.

15. Inspect the top of the lead using your fingers to ensure the guide fiber is set in the base plate groove.

    NOTE: If conditions of step 14 or 15 can not be satisfied, DO NOT CONTINUE to step 16, the lead must be repositioned or removed and the process started over.

16. Mix the Bicron BC-600 Optical Cement (epoxy)

17. Build 2 layers of 13-cm lead sheets with optical fibers in all grooves using optical epoxy , inspect each for alignment and then roll down using a Teflon roller. Continue with 3 more layers, rolling each down. The last lead sheet must be longer to prevent migration of epoxy during pressing. press.

Last Build of Each Step

1 Reference drawing Stepwedge.pdf to determine the minimum height needed to complete the step.

2 Using a digital depth gauge measure the height of the build from the top of lead sheet to the top of base plate step at positions 1-16, front and back. Enter the data into a spread sheet which will automatically add the thickness of the base plate that was measured at each of the 32 points. The sum of the two will equate to the distance from top of the lead to the bottom of base plate.

3 Use the point where the smallest total distance was measured to determine the number of layers needed at that point to finish to the minimum required height for each step.

4 After a step is pressed and cured, use the guide wire and alignment templates to center the next build.

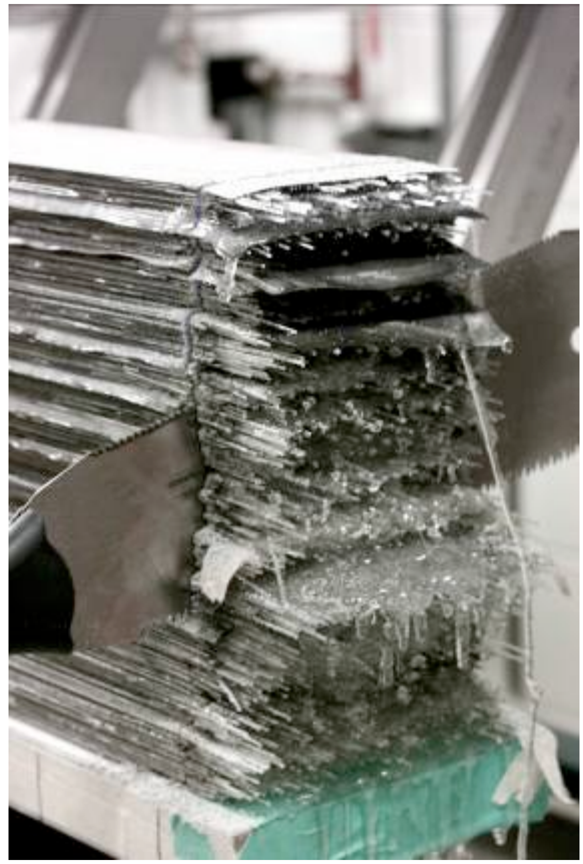
Note:

- The total fiber/ lead height should be as close as possible to 253.7 mm, but never exceed 254.0mm measured from bottom base plate to top of lead sheet.

- If the lead sheet is above 254 mm the lands of the lead must be shaved down taking care, not to damage any fibers.

Top Aluminum Plate Installation

Preparing the Module and Plate



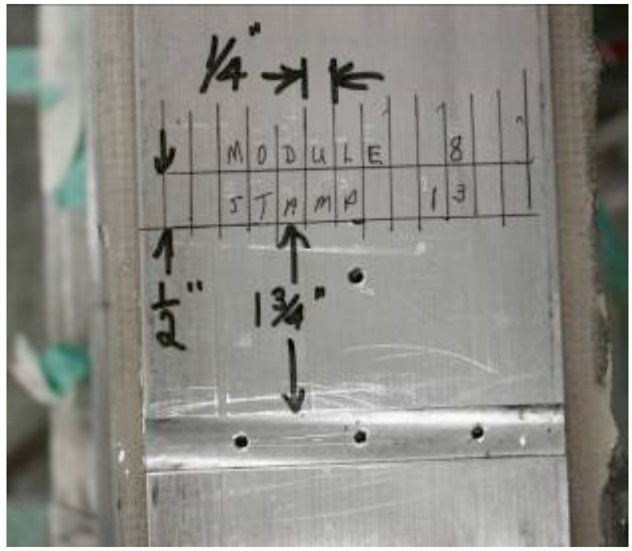
1 Trim off both ends of the cured module using a pull saw leaving a minimum of 26 mm for final machining.

2 Clean all surfaces of the top aluminum plate using water based industrial cleaner followed with ethanol.

3 Abrade the inside surface of the top plate using an orbital sander with 80 grit sandpaper as done with the base plate.

4 Clean abraded surface with ethanol

5 With the machined front sides facing you stamp the top right hand side of the plate.



6 Example after stamping is paint filled.

Setting the Plate into Position

7 Measure into 5 cups each, 100g of industrial epoxy resin and into 5 cups each, 80g of hardener . Do Not Mix.

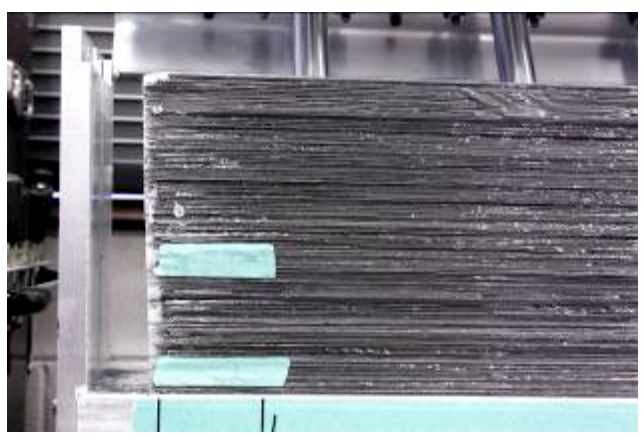
8 Wrap 1 layer yellow sealant tape around the top of the top of the module. It is important that the top edge is slightly below the top of the lead layer even when it is compressed from the side.

9 Remove the paper from the previous tape and wrap another layer of tape on top of it leaving the top edge forming a dam 2 mm above anticipated glue height.

10 Wrap two layers of packing tape around the sealant tape to support it.

11 Cut the corners of the tape to allow the top plate to fit inside.

12 Bolt alignment/height plates at both ends of the base plate using 2 - 5/16 socket head capscrews and washers with the fixed top plate stop facing the front of the module. The front edge should be flush with the front edge of the base plate and the bottom step should be pulled down tight to the top of the base plate, using the 3 bottom screws on the bottom clamp.

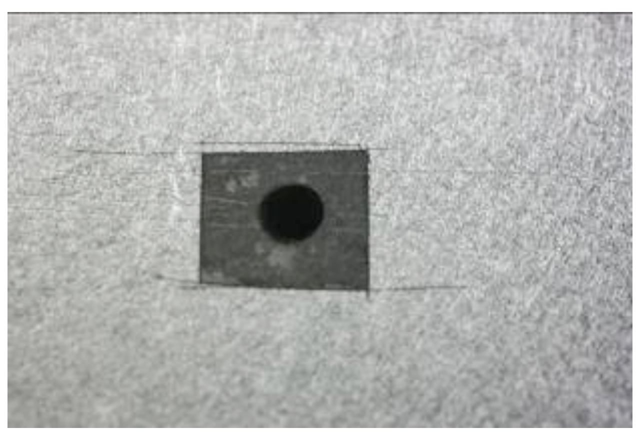


13 Set up 16 stand-offs along the back side of the base plate at the number 1 to 16 positions.

14 Screw 16 angle brackets facing up, on top plate using # 8-32 screws. Note: nuts shown are not necessary if screws of the proper length are available.

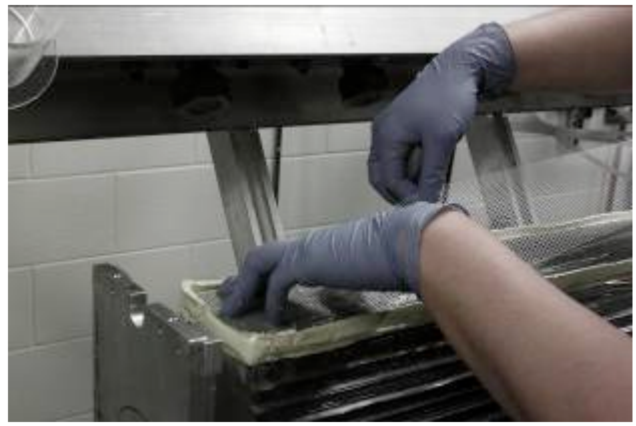
15 Move top plate with brackets attached to the solvent room, abraded side up, don appropriate safety clothing and equipment and degrease abraded surface with degreasing solvents. Leave the plate in the room for minimum 5 minutes.

16 Tape all holes on the abraded side of the plate using 2 layers of transparent tape approx. 8 mm sq. being careful not to touch the cleaned surface any more than necessary. Clean any surface that may have been touched.



17. Mix up 300g batch of industrial epoxy resin plus hardener and coat the top surface of the module.

18 Referencing the last build total measurement chart lay in 4 inch (and 2 inch if necessary) fibreglass tape to bring up to a level .5 mm under 253.7 mm.



19 Fill the dam level to about 254.7 with mixed epoxy, more of the measured epoxy may be needed, but mix only as needed.

20 Set up 16 stand-offs at the front of the base plate at number 1 to 16 positions.

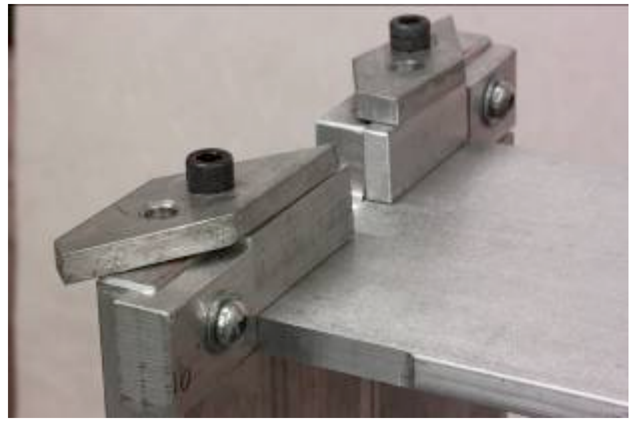
21 Making absolutely sure not to touch the cleaned and degreased bottom surface of the top plate, start installing it with angle brackets installed. With the stamp on the right side and with both ends aligned and held higher than the epoxy on top of the module lift one end higher and lower the opposite end and insert it into the top recess of the alignment plate and fix into position. Slowly and carefully lower the opposite end, making sure that the top plate doesn't contact the sealant tape. As it is lowered the brackets should rest on the stand-offs, and the end should be insert and fix it into the alignment plates.

22 The stops on the front of the alignment plate are fixed and the rear ones are adjustable. Move the top plate forward at both ends until the machined front edge is tight against them and lock in place.

Note: In this and the following diagram the module is removed for clarity.

21 Slowly partially clamp both ends of the top plate down to the alignment plate using spacer blocks Excess epoxy should start to squeeze out.

Note: Steps 2-5 should be done is a systematic manner to ensure that the plate is pressed into the epoxy bed as perpendicular to the base plate of the module as possible. Continually check to ensure all stand off's are tight to the base plate.



22 Attach the 16 brackets to the stand-offs using 3/8" socket head machine screws and ensure all 16 - # 8 bracket screws are tight.

23 Adjust all screws and nuts to fix the top plate at the proper height. Excess epoxy should squeeze out.

24 Continue to adjust all screws and nuts as epoxy squeezes out.

25 As the epoxy squeezes out pressure is released so check and readjust all screws at least 4 times before leaving.

26 Let epoxy cure overnight.

27 Remove brackets, stand-offs and alignment plates.

28 Remove sealant tape and excess cured epoxy.

29 Scrape top and sand using orbital sander.

30 Debur all holes.

31 Trim off ends of top plate and paint module ends with 2 coats of black latex chalkboard paint.

32 Undo clamps and place module into crate and fix into place. Cover both ends with a black mask and entire module with black poly.

33 Place cover on crate and screw down with 4 wood screws, mark the position of the screws with a felt pen, label crate cover indicating both module and stamp number and prepare crate for shipping to Ross Machine Shop.