Fin Can Layup Standard Operating Procedure (SOP)

Author: Dayna Erdmann (daynae@mit.edu)

Purpose

The purpose of this procedure is to provide a step-by-step guide for members to construct a fin can, which consists of a phenolic tube with four fins attached, covered in either fiberglass (for a test fin can) or carbon fiber (for a flight fin can). Below is a list of risks, required materials, and a step-by-step procedure including the expected length of time that each step should take.

Prerequisites

All participants in the layup must have general lab safety training, and must have completed a respiratory medical evaluation at MIT Medical, and a respirator fit check in EHS. All participants should be wearing respirators and gloves when working with epoxy and colloidal silica, and safety glasses and dust masks when sanding. Participants should be under the supervision of at least one member who has performed a similar fin can layup previously.

Participants should also refrain from operating machinery while sleep-deprived or otherwise unfit, and should be accompanied by another member in the lab at all times when using power tools or hazardous chemicals.

Risks and Risk Corrections

Though this procedure is relatively safe and straightforward, there are a few chemicals that present risks, which can be mitigated through proper use of Personal Protective Equipment (PPE):

Epoxy
Risk: Inhaling epoxy fumes can cause respiratory problems, and skin contact with epoxy causes sensitization.
Risk Correction: Wear a respirator when working with epoxy, ensuring a positive/negative pressure test passes. Wear gloves when working with epoxy, and wash hands with cold, abrasive soap afterwards.

Colloidal Silica
Risk: Inhaling ultra-fine colloidal silica particles can cause respiratory toxicity and an increased risk for pulmonary diseases.
Risk Correction: Wear a respirator when working with colloidal silica, enduring a positive/negative pressure test passes. Wear gloves when working with colloidal silica.

Composites
Risk: After a layup is cured, the edges of the composite can be sharp. In general, when working with composites, small fibers can irritate the skin.
Correction: Wear gloves when working with composites, and exercise caution when handling cured composites.

Required Materials for Test Fin Can and Flight Fin Can

*Most of the materials used to make the test fin can and the flight fin can are identical, and cases where materials are only used for one or the other have been outlined in the materials list below.

Raw Materials

- Fiberglass (test) or Carbon Fiber (flight)
- Fin preforms (plywood for test, G10 + phenolic for flight)
- Phenolic tube

Layup tools

- System 3000 Epoxy
- 5-minute epoxy

- Popsicle sticks
- Boats
- Fillet tool
- Squeegees
- Rollers
- Fin can jig and stabilizing feature
- *Flight only*:
    - Aluminum mandrel
    - Layup jig
    - Proline
    - Laminating epoxy
    - Mylar

Bagging Materials

- Release film
- Bleeder fabric
- Vacuum bag
- Vacuum tape
- Peel ply

Miscellaneous

- Spray glue
- Scissors
- Sandpaper (60, 120, 220 grit)
- Wax paper
- Sharpie
- *Test Fin Can only:* Dremel (with sanding bit)
- *Flight only:* 15 degree angled end mill

- **Personal Protection Equipment**
- Gloves
- Dust masks
- Safety glasses
- Respirators

TEST FIN CAN PROCEDURE

Cut and Sand Fins (2 hours)

1) Cut plywood fins to shape on the laser cutter

2) Put on safety glasses and a dust mask

3) Sand the face of each fin using 120 grit sandpaper

4) Bevel edges of fins using a Dremel and sanding bit

Cut and Sand Tube (1 hour)

5) Wearing safety glasses, cut phenolic tube to size on a bandsaw

6) Put on safety glasses and a dust mask

7) Sand tube until it fits over the motor case (start with 60 grit, work up to 220)

8) Score the tube (using 60-180 grit sandpaper)

Prepare Tip-to-Tip Cutouts (4 hours)

9) Prepare paper cutouts for tip-to-tip layup

10) Stick wax to fiberglass using spray glue

11) Cut fiberglass shapes with scissors

12) Record mass of fiberglass (will use later to calculate wetness ratio)

13) Mark centerline of each piece with sharpie

Attach Fins to Tube (Root Bond) (1 day)

14) Score fins

15) Put tube in fin can jig

16) Put on gloves

17) Mix epoxy

18) Put 5-minute on root chord of each fin

19) Slide fins into slots in the jig

20) Finish assembling jig by putting the top layer of the jig on and securing the nuts

21) Attach stabilizing feature

22) Let cure

Root Fillet (1 day)

23) Remove the fin can from the jig

24) Put on gloves and respirator, ensuring the respirator fits well with a positive/negative pressure test

25) Mix laminating epoxy with colloidal silica

26) Use fillet tool to add fillets

27) Let cure (24 hours)

28) Sand the root fillets

29) Mark centerlines on the tube

Tip-to-tip Layup (1 day)

30) Put on your respirator and gloves

31) Mix epoxy

32) Record mass of epoxy used

33) Wet the glass sheets with laminating epoxy using squeegees

34) Remove the sheets from the wax paper and apply to the tube (layup)

35) Implement "Vacuum Procedure"

Post-processing (3 hours)

36) Sand fin can

FLIGHT FIN CAN PROCEDURE

Cut and Sand Fins (1 day)

1) Cut fins out of 1/8” G10 sheet on the waterjet

2) Cut phenolic leading edge on waterjet

3) Use a mill to cut slot into the phenolic

4) Use a mill to cut tabs in the G10

5) Attach the phenolic leading edge to the G10 fin core with epoxy and let cure

6) Score the fins

Cut and Sand Tube (3 hours)

7) Cut phenolic tube to length

8) Make sure it fits over motor case

9) If not, sand using 60 grit sandpaper, working up to 220 grit

10) Score the tube

11) Check to see that the tube fits in the fin can jig

Tube Layup Preparation (2 hours)

12) Prepare paper cutouts for carbon fiber tube layup

13) Spray the wax paper with spray glue

14) Apply the carbon fiber

15) Cut the carbon fiber/wax paper on the laser cutter (this is safe because the carbon fiber has not been wetted yet)

16) Record mass of each piece (to calculate wetness ratio later)

Tube Layup (1 day)

17) Put on respirator and gloves

18) Wet the carbon fiber pieces with epoxy

19) Record mass to use for wetness ratio calculation

20) Carefully separate the carbon fiber from the wax paper and apply it to the tube (layup), using more epoxy when necessary

21) Let cure for 24 hours

Root Bond (1 day)

22) Put tube in fin can jig

23) Put on gloves

24) Mix epoxy

25) Put 5-minute on root chord of each fin

26) Slide fins into slots in the jig

27) Finish assembling jig (put top layer on, push gently until the slots contact the leading edge, tighten the nuts)

28) Attach stabilizing feature

29) Let cure

Tip-to-Tip Preparation (4 hours)

30) Make paper cutouts for tip-to-tip layup

31) Spray wax paper with spray glue

32) Stick CF to wax paper

33) Use paper cutout to cut shapes

34) Record mass of shapes (for wetness ratio)

Root Fillet (2 days)

35) Put on respirator and gloves

36) Mix colloidal silica and epoxy

37) Apply inner fillets

38) Let cure for 24 hours

39) Sand inner fillets

40) Wearing gloves, apply outer fillets (Proline)

41) Let cure for 24 hours

42) Sand outer fillets

43) Mark centerlines

Tip-to-Tip Layup (1 day)

44) Mix epoxy

45) Wet the carbon fiber pieces

46) Record mass (for wetness ratio)

47) Separate the carbon fiber from the wax paper and apply to tube (layup)

48) Follow “Vacuum Bagging” procedure

Post-Processing

49) Follow “Oven Cure” procedure to cure fin can in Autoclave

50) Wearing a dust mask and respirator, sand the fin can

51) In a well-ventilated area, apply paint

Expected Outcome

Below are some images depicting the expected outcome of this procedure.

Date	Revision	Changes Made
10/16/2018	1.0	N/A