PEAK OF FLIGHT NEWSLETTER

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BUILDING CUSTOM TUBES FOR SCALE MODELS

https://www.apogeerockets.com/Rocket-Kits/Skill-Level-5-Model-Rocket-Kits/Saturn-1B-1-70th-Scale

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PEAK OF FLIGHT

Building Custom Tubes for Scale Models

By Chris Flanigan

Introduction

Building a scale model is a fun and challenging activity. There are many excellent kits available. However, there are occasions when non-standard part sizes are required. This often occurs when modeling a new prototype or when building a model to a specific size or scale factor.

A common way to approach a new scale prototype is to select an existing body tube for a significant part (such as the first stage body tube) and then use nearest available tubes for other components (boosters, upper stage tanks, etc.). However, for national and international scale model contests, having a "sort of" close tube size isn't satisfactory since dimension errors as small as 1% will lose accuracy points.

This article describes techniques for making body tubes to satisfy specific dimensions. In addition, these techniques produce tubes that have excellent surface finish for painting.

Materials

The main ingredient for cooking up a custom size body tube is thin cured fiberglass sheets. These are available from ACP Composite (https://store.acpsales.com/categories/320/fiberglass-solid-sheets). The sheets are available in two colors (natural and black) and in a variety of sheet thicknesses (0.005" to 0.030") and sizes. The natural color sheet is recommended for general use. The black fiberglass sheet might be used for black or dark scale models.

The 0.010" sheet is suitable for 2" diameter tubes and larger. The 0.005" sheet can be used for smaller diameter tubes or small specialty components.

Some people have successfully used 1/64" plywood instead of fiberglass sheets. Fiberglass has several advantages including the ready-to-paint surface finish (i.e., no wood grain to fill).

Sizing

The basic technique for making a custom size tube is to cut a flat sheet to the appropriate dimensions, then roll it into a cylinder. The starting point is the desired diameter of the tube. The circumference of the tube is:

Circumference = 3.14159 x Diameter

For example, let's say that we need a tube that is 4.5" diameter. For a 4.5" diameter tube, the circumference (width of the sheet) is 14.137". The other dimension is the length of the model component (tank, interstage adapter, etc.).

Note that the circumference above is correct for a theoretical sheet with zero thickness. A slight adjustment of the circumference is required to achieve the desired outside diameter (OD) including the thickness of the material plus the primer and paint (see Figure 1).

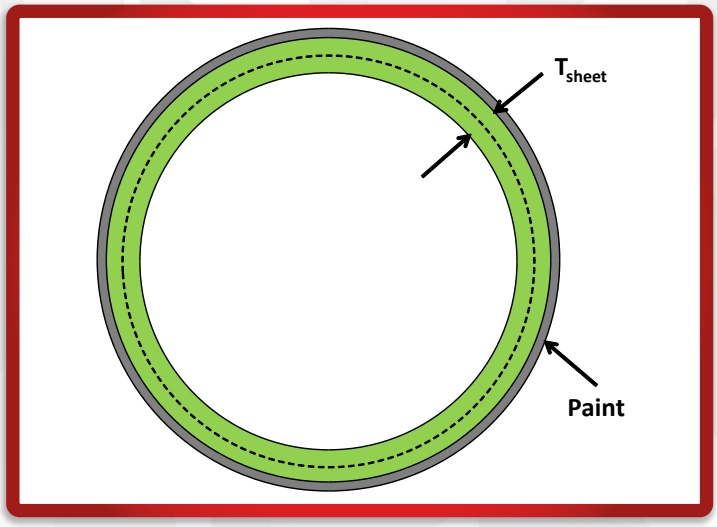

FIGURE 1 - THE WIDTH OF THE SHEET SHOULD BE ADJUSTED TO ACCOUNT FOR THE THICKNESS OF THE MATERIAL AND PAINT (NOTE: THICKNESSES ARE EXAGGERATED IN THE ILLUSTRATION).

The adjusted circumference is:

Adjusted Circumference = 3.14159 x (Diameter – Tsheet – Tpaint)

For our example 4.5" diameter tank using 0.010" fiberglass sheet and primer/paint thickness of 0.003", the adjusted circumference is 14.096", 0.041" smaller than the nominal circumference. That doesn't sound like much, but it can be critical for achieving perfect accuracy points (error < 1%) on high precision scale models.

Cut the Sheet and Glue Tab

Lay the fiberglass sheet on a flat surface, preferably a cut-

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ting mat. Mark the length and height of the material to be cut. This can be done by hand or by using computer-generated templates. If using computer-printed templates, be sure to check the length, width, and "square-ness" of the printed sheet. Some printers (particularly ink jet printers) may slightly pull the paper and distort the printed image. In most cases, the computer-printed templates are sufficiently accurate, but it's always a good idea to check.

Tape the fiberglass sheet to the mat, and tape the templates to the fiberglass sheet. Get a straight edge (metal ruler) and a fresh/sharp X-Acto knife or single edge razor blade. Run the knife using medium pressure along the straight edge to score the fiberglass. Repeat a few times as needed. The objective is to score the fiberglass, not to cut all the way through. After scoring the sheet, flex the edge up and down until the fiberglass edge fractures. [Suggestion: practice this technique on some test/scrap material before cutting a production part.] Proceed with the other edges until the desired sheet is completely cut.

Repeat the process to cut a 0.5" glue tab of the same length as the part. The glue tab will be used to bond the sheet into a rolled tube.

Sanding

Sand the edges of the sheet lightly using 220 or 320 sandpaper to smooth the edges. Be extremely careful while doing this as the very thin fiberglass material can unexpectedly cut through sandpaper if not done carefully.

Mark one side of the sheet as the outer surface. Sand the outer surface with 320 grit sandpaper. This will remove any residual release agent used to manufacture the sheet. It will also provide a good surface for primer/paint.

Flip the sheet and sand the inner surface using 220 sandpaper. This will help with bonding of any interior components such as centering rings and spacers. Along the "left" and "right" edges (where the glue tab will go), sand using 150 grit sandpaper to provide a good surface for bonding. Also sand the glue tab with 150 grid sandpaper.

Form the Tube

Get a flat board that is longer than the height of the sheet. A 1x4 piece of pine shelving works well. Apply a long piece of tape to the center of the board. This will prevent the tube from bonding to the board.

Place one end of the sheet on the board such that the end of the sheet is centered on the base piece of tape. The "outer surface" of the sheet should be face down. Tape the sheet to the board (see Figure 2). Offset the tape from the edge of the sheet to save room for the glue tab.

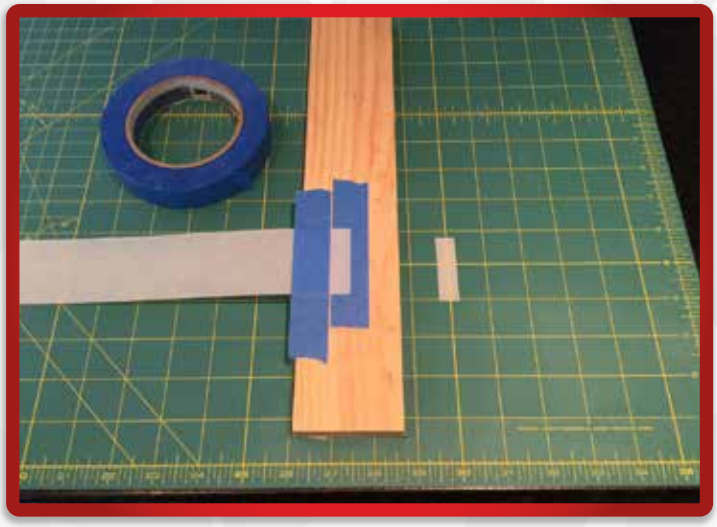

FIGURE 2 - TAPE THE SHEET TO THE BOARD, LEAVING ROOM FOR THE GLUE TAB.

Roll the sheet and butt the other edge of the sheet to the taped-down edge. Tape the sheet to the board, again re-

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membering to save room for the glue tab (see Figure 3).

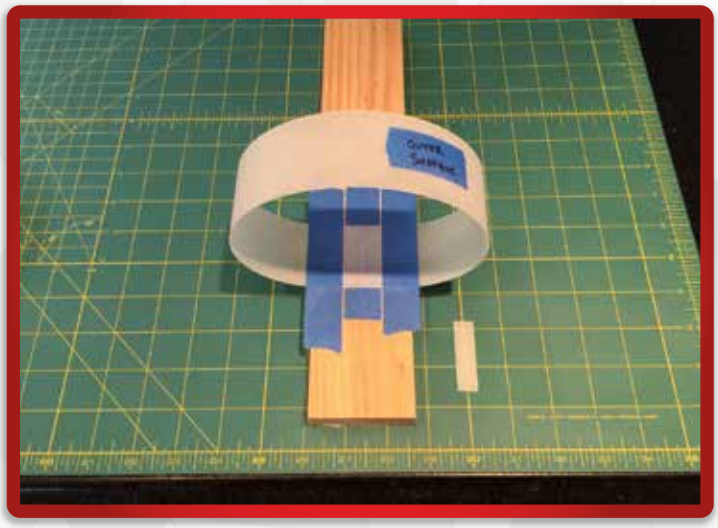

FIGURE 3 - ROLL THE SHEET AND TAPE THE OTHER EDGE TO THE BOARD, SAVING ROOM FOR THE GLUE TAB.

Mix some 5-minute epoxy. Apply a smooth coat to the bond area. Also apply a thin coat to the glue tab to make sure that the bonding area is completely wetted. Place the glue tab onto the tube joint and gently press down. Remove any excess epoxy from the edges of the glue tab. While 5-minute epoxy reaches initial cure in 5-7 minutes, it is not at full strength yet. It's recommended that you leave the tube taped to the board for at least 15 minutes (30 to 60 minutes is better).

After the curing time, remove the tube from the board by pulling up and removing the two strips of tape. Next, apply a second thin layer of epoxy to glue tab area, forming small fillets at the edges of the glue tab. This will minimize stress concentrations at the edges of the glue tab, resulting in a stronger bond.

The completed tube will look like Figure 4. There may be some epoxy that leaked through the butt joint. If so, it can be removed with some light sanding. Additional examples of completed tubes are shown in Figure 5.

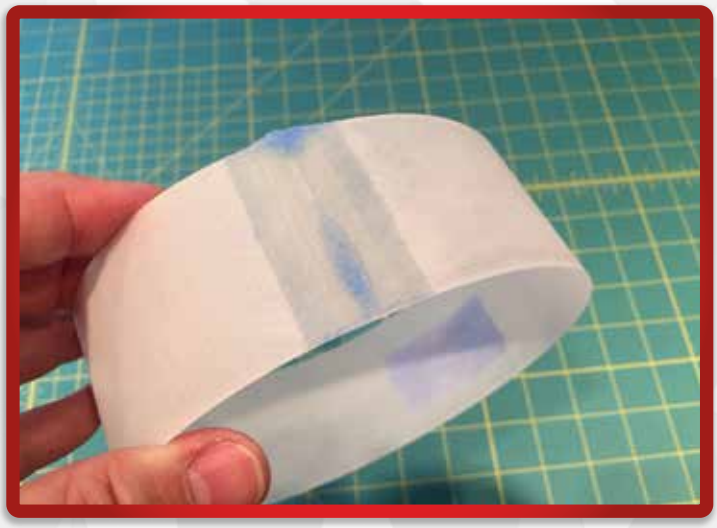

FIGURE 4 - SAND ANY RESIDUAL EPOXY AT THE BOND JOINT.

FIGURE 5- THESE TECHNIQUES CAN BE USED TO CREATE TUBES OF VARIOUS DIAMETERS AND LENGTH.

Frustums

These techniques can also be used to create frustums

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(cones) such as interstage adapters. You'll need to generate the appropriate templates using equations for the planar shape layout of the frustum surface. This can be done using "shroud calculators" or by using Rocksim or OpenRocket which automatically create the templates.

Internal Bulkheads

You may need large diameter centering rings for large body tubes. A good material is Gatorfoam, available from Micro-Mark, art supply stores, and sign companies. Gatorfoam has a polystyrene foam core and 1/32" wood-fiber veneers, forming a 3/16" thick panel that is strong, light-weight and warp-resistant. It cuts and sands easily.

One technique is to computer-print a template for the centering ring (see Figure 6). Cut out the template, then use spray cement to bond the template to the Gatorfoam. Use an X-Acto knife or single edge razor blade to cut out the rough outline of the centering ring. Use a sanding block or Dremel tool to form the ring to the final outline of the template. A Dremel tool can also be used to make lightening holes to save weight of the final part (see Figure 6).

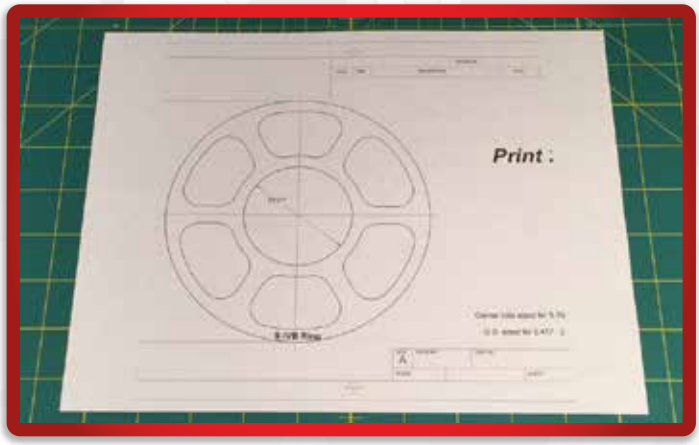

FIGURE 6 - CREATE A TEMPLATE FOR THE CENTERING RING.

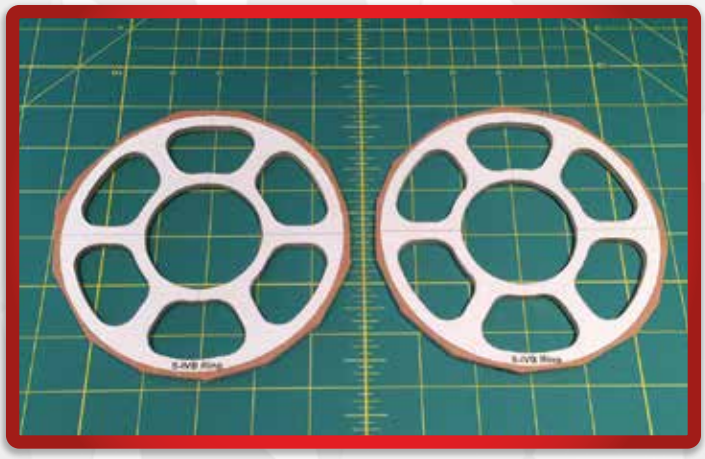

FIGURE 7 - THE GATORFOAM CAN BE CUT AND SANDED TO THE OUTLINES OF THE CENTERING RING TEMPLATE.

Examples

These techniques have been used on a variety of scale models including Saturn IB, N-1, Atlas V, and others. A 1:48 scale Saturn IB is shown in Figure 7. Custom tubes and frustums include the aft thrust structure, Stage 1 LOX and fuel tanks, Stage 2 tank, and Spacecraft/Lunar Module Adapter (SLA). For the 1:70 scale N-1 shown in Figure 8, custom frustums were used for the Stage 1, 2, and 3 shells, plus the LOK fairing components.

Summary

Using fiberglass sheets is an excellent technique for making custom size tubes and frustums for scale models. The components are dimensionally accurate, lightweight, and easily painted. It's a great method to add to your scale modeling toolbox.

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FIGURE 8- THIS LARGE 1:48 SCALE SATURN IB WAS LESS THAN 1,400 GRAMS AT LIFTOFF.

FIGURE 9 - CUSTOM FRUSTUMS WERE USED EXTENSIVELY FOR A 1:70 N-1 ENTERED AT THE 2010 SPACEMODELING WORLD CHAMPIONSHIPS.

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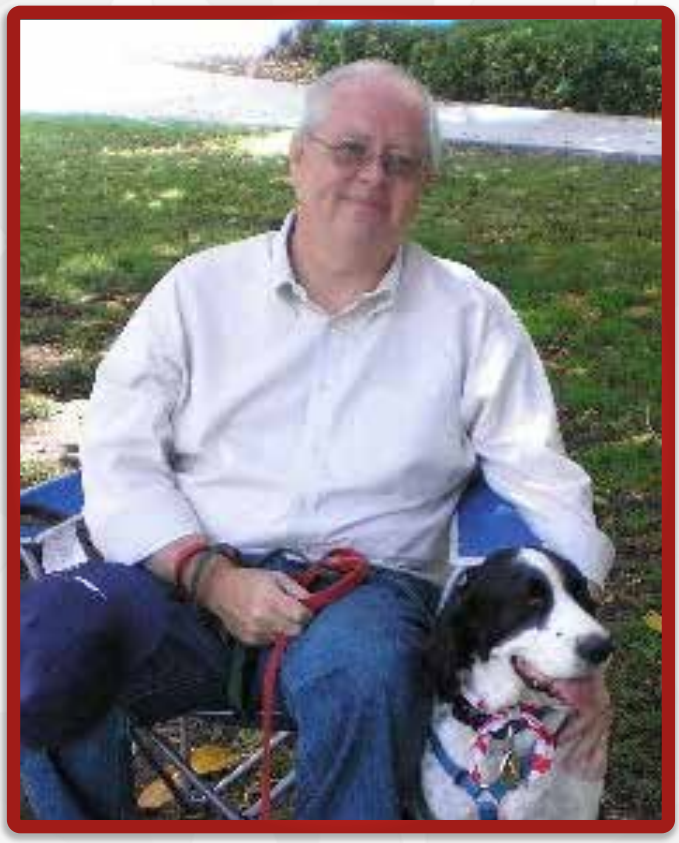

About the Author:

Chris Flanigan has been flying model rockets since the '70's. He is active in competition rocketry, both domestic and international. His day job involves real rockets, satellites, and other high technology systems. He is currently supporting independent review of loads and dynamics for NASA's new Space Launch System (SLS) vehicle.

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