

## ALTAIR PLUS® FABRICATED PRODUCTS

### Small Boat Hulls

Aristech Surfaces has been the leader in thermoformed acrylic product ideas for over 30 years. Many O.E.M./fabricators have discovered new possibilities in the use of Aristech Surfaces Acrylic Sheet products. The advantages of Aristech Surfaces Composite Sheet products are unlimited in the areas of design, configuration, colors, fabrication and superior surface appearance. Let your imagination run wild—specify Aristech Surfaces Acrylic Sheet products for many of your marine parts. Altair Plus® consists of a partially crosslinked acrylic sheet laminated to an impact grade ABS. Altair Plus® is ideally suited for marine applications.

#### Introduction

This technical bulletin describes how small boat hulls (Figure 1) can be produced from Aristech Surfaces Altair Plus® sheet. A general procedure follows with enough detail to enable an existing FRP boat manufacturer to convert from gel-coated polyester surfaced boat hulls to Altair Plus® thermoformed hulls.

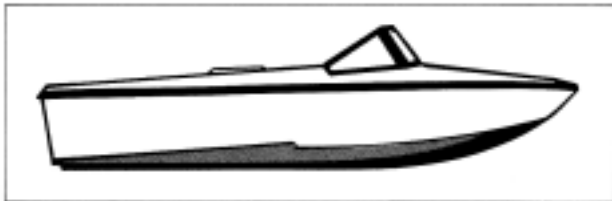


Figure 1. Small Boat

#### Plant Layout

Many plant layout variations accommodating numerous manufacturing throughputs are possible. Therefore, no attempt to define a specific flow diagram will be made in this bulletin. Perhaps the most important feature is to keep the material or product moving in a continuous, logical mode. Each operation will be discussed in process sequence starting with Altair Plus® sheet handling and storage and finishing with the trimming of the thermoformed hull. The final boat assembly and finishing will not be covered in this bulletin, but are virtually the same as for gel-coated surfaced boats.

#### Altair Plus® sheet handling and storage area

A typical sheet size to produce a 17' (5.2 m) hull would be 0.350" (8.9 mm) thick x 110" (280 cm) wide x 228" (580 cm) long. Sizes and thicknesses will vary depending on product design, size and depth of vacuum forming draws. The sheet length and width are always greater than the finished product dimension to provide for clamping the sheet during thermoforming.

The Altair Plus® can only be supplied in sheet form on pallets. A typical pallet will contain 6 sheets and weigh about 2000 lbs. (900 kg). The ABS substrate of Altair Plus® attracts moisture from the air and, if allowed to absorb moisture, cannot be thermoformed successfully without first drying the material. Because of this, it is imperative that Altair Plus® be kept packaged as received and stored inside in a dry protected area. Also, it is good practice to keep the material away from sources of heat combustion and operations involving solvent vapors. See Aristech Surfaces Technical Bulletin #165 for more detail on the care and handling of the material. The pallets should be arranged with the product mix and production schedules in mind. It is highly recommended that a first-in first-out sheet inventory procedure be utilized. This involves always using the oldest sheet available. Each package should be plainly marked with the color and identification number so the proper material is selected and so vacuum forming machine operators can easily record any problems in the production log by color and package tag numbers.

#### Vacuum Forming Area

It is best to have the vacuum forming area enclosed and relatively free of drafts and airborne dirt. The area should be kept clean at all times. The entrance from the sheet storage and cutting area can be an overhead garage-type door that is only open when sheet material is being delivered to the vacuum forming machine. The exit to the finishing area will generally be open. Positive pressure may be needed in this area to minimize dirt from the finishing area.

#### Sheet Cleaning Devices

As sheets are individually removed from the pallet and loaded into the clamping frame of the vacuum forming machine, they should be cleaned to remove any dust, dirt or particles that might adhere to them. The sheet usually contains some static electricity, especially if the relative humidity is less than 50%. Cleaning is best accomplished by using an antistatic device attached to an air hose. These devices can be obtained from either the 3M Company or the Simco Company. (See sources of supply in Technical Bulletin #159 for complete address, etc.) The device is attached to a standard OSHA approved air hose and is activated by a push button on the air nozzle. Air is simply blown across both sides of the sheet to remove the adhered particles and static electricity. It is important to remove the static electricity to prevent the dirt and dust particles from "jumping" immediately back on the sheet. If a sheet is extremely dirty, it should be wiped with a tack cloth such as those supplied by the Detron Manufacturing Company.

## Vacuum Forming Machines

The recommended vacuum forming machine (see Figure 2) is an automatic single station type equipped with top and bottom moving platens. The sheet clamping frame should be activated with air cylinders and move horizontally into an electric infrared-type oven with heaters on both top and bottom. At the start of the heating cycle, the top heaters are usually 10" (25 cm) from the sheet and the bottom heaters 20" (50 cm) from the sheet. The heaters should be controlled with 15-second percentage timers. The automatic vacuum forming machines used in this process should have adjustable clamp frames that can be set to clamp exact sheet sizes.

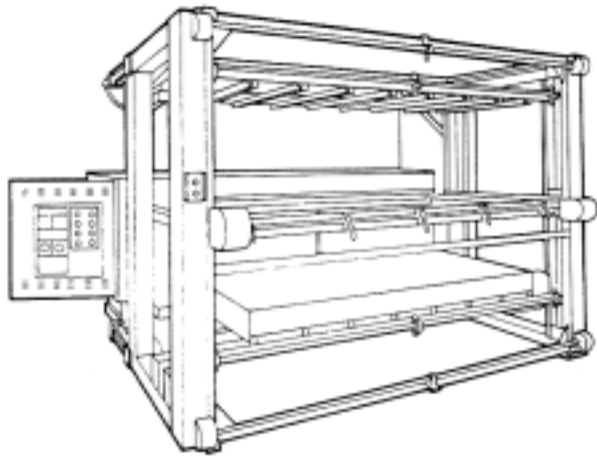


Figure 2. Vacuum Forming Machine

The clamping frames should be designed to move out from the machine horizontally for easy loading of the sheet and unloading of the formed part. The clamp frame should load from the bottom which will allow a sheet to be automatically loaded into the frame with a simple air operated vertically moving platform. The formed part can be unloaded similarly directly onto support jigs. See Figure 3 for a simple schematic of the vacuum forming area.

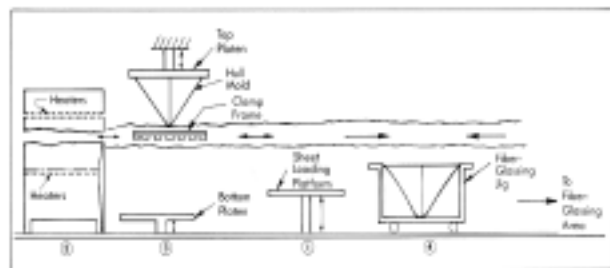


Figure 3. Vacuum Forming Area

Many other types of equipment design can be used to produce these parts (i.e. a simple sign making vacuum forming machine). Manufacturers of vacuum forming equipment are generally prepared to offer considerable technical advice and assistance. They sometimes will have machines set up for a potential customer to observe in actual operation. Some of the manufacturers will vacuum form some shape or part to demonstrate the equipment.

## Tooling or Molds

The recommended tooling for this type operation is made from glass reinforced tooling grade polyester or glass reinforced epoxy. Typical boat hull mold configuration is illustrated in Figure 4.

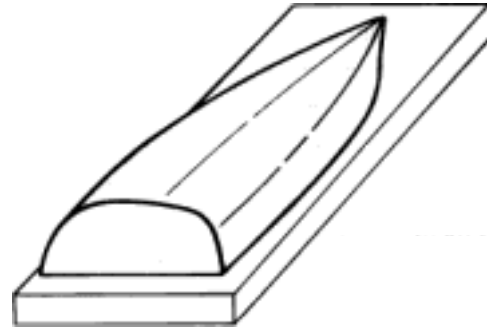


Figure 4. Vacuum Forming Mold

Usually, FRP boat manufacturers using polyester gel-coating techniques will have mold making technology and capability. If this is the case, then the conversion from gel-coat molds to vacuum forming molds is not very difficult. If mold making technology is not in-house, there are many experienced mold manufacturers. See Technical Bulletin #159 for sources of supply for a listing of several. Mold prices will vary widely, depending upon size, configuration and type of tooling required. A very general procedure for producing these molds is:

- Engineering drawings of the hull are used to fabricate wood patterns which are nearly exact replicas of the finished vacuum formed Altair Plus® parts.
- The wood patterns are used to produce polyester or epoxy female, or reverse "Master" molds.
- The master molds are used to produce vacuum forming tools or molds which again are nearly exact replicas of the finished vacuum formed Altair Plus® parts. (Note: A finished vacuum forming mold is sometimes slightly different in dimensions from the finished part to take into account the Altair Plus® sheet thickness and the thermal shrinkage of the part. A mold can yield as many as 2000-3000 finished Altair Plus® parts if properly cared for and maintained).
- In the vacuum forming molds, vacuum holes are drilled every one inch (2.5 cm) in the heart of recessed mold radii. These holes can be as large as 1/16" (1.6 mm) in diameter. Several larger holes up to 1/4" (6.4 mm) in diameter may be strategically placed to allow for rapid evacuation of the air during the vacuum forming step. However, care in hole placement must be taken to prevent mold mark-off in the finished part.

## Process Operation and Direct Labor Consumed

### A. Vacuum Forming

Based on the production schedule, the Altair Plus® sheet is moved to the vacuum forming area. The operator(s) will record the package numbers, color, and number and type of parts to be run in the log or daily work sheet. Four (4) minutes per boat hull will be required using two (2) operators. The vacuum forming ovens are preheated and percentage timers set. An Altair Plus® sheet is loaded in the clamp frame (40 seconds) and the automatic vacuum forming machine started. The sheet will be heated for about 15 minutes to a temperature of about 350 to 380°F (177 to 193°C) on the acrylic side and about 300 to 340°F (149 to 171°C) on the ABS side. Percentage timers must be adjusted to arrive at these conditions. After the sheet is heated, it will automatically exit the oven, vacuum form (40 seconds) and cool (1 to 2 minutes). If mold release is a problem, use air pressure through the vacuum holes only to facilitate part removal. Mold releases may also be used to facilitate part removal. The part is removed and placed on a trimming jig (40 seconds). Two machine operators will be required in this area.

**Table 1. Direct Labor Requirements**

Operation	Direct Labor (Man-Minutes)	Number Of Personnel
Sheet Handling	4	2*
Vacuum Forming	40	2
Trimming	15	2*
Auxiliary Operations	6	2*
Total	65	4

\* Same Two Operators

It is usually desirable to keep several formed parts as a buffer between vacuum forming and trimming. This total operation will consume about 40 man-minutes per part produced. Trimming will consume about 15 man-minutes per part produced.

### Finishing Area

Established FRP boat manufacturers will have an existing part trimming area. Thermoformed Altair Plus® parts can be trimmed using the same equipment used to trim gel-coated FRP parts. The saws and routers usually utilize carbide or diamond tipped blades/cutters. These work very well for Altair Plus® parts.

## Materials And Quantities Used Per Example

### A. Altair Plus® Sheet

One sheet 0.350" (8.9 mm) thick by 110" (280 cm) wide by 228" (580 cm) long. Each sheet contains 174.2 ft<sup>2</sup> (16.2 m<sup>2</sup>) and weighs 348.4 lbs. (158 kg). The completed hull after trimming will contain about 240 lbs. (109 kg) of Altair Plus®. It is often possible to use some of waste area to form auxiliary parts, such as bait well lids, hatch covers, etc. to more efficiently utilize the materials. Contact the Aristech Surfaces Technical Group for ideas and suggestions.

### B. Raw Material Cost

With the information given above and using current prices of the various raw materials, raw material costs can be calculated. Of course, raw material costs will increase based on material usage efficiencies and scrap rates. A well run operation will have a material usage efficiency of 90 to 95% and finished goods scrap rate under 5%.

*For cautions and other information relating to handling of an exposure to this product, please see the applicable material safety data sheet published by Aristech Surfaces.*

These instructions are based upon experience with Aristech Surfaces products only. Experience with products of other manufacturers is specifically disclaimed. For most uses, check for local code approval and test for application suitability. These procedures, techniques and suggested materials should only be used by personnel who are properly trained in the safe handling of the chemicals and the equipment with which they are working. Acrylic sheet is a versatile thermoplastic, however, it is combustible. Avoid exposure to heat and aromatic solvents, clean with mild soap and water, avoid abrasives. These suggestions are based on information believed to be reliable, however, Aristech Surfaces makes no warranty, guarantee, or representation as to the absolute correctness or sufficiency of any of the foregoing, or that additional or other measures may not be required under particular conditions or circumstances.

