LAST-A-FOAM® PRODUCTS

GENERAL PLASTICS MANUFACTURING COMPANY

GUIDE TO TOOLING APPLICATIONS, BONDING, FILLING AND SEALING

INTRODUCTION:

All rigid **LAST-A-FOAM®** products are made with polyurethane resins. One of the best characteristics of polyurethane is chemical resistance, allowing use of a wide variety of adhesives and coatings to bond and seal **LAST-A-FOAM®** with little risk of damage. Also, all rigid **LAST-A-FOAM®** is closed-cell, and very resistant to solvent penetration.

Because **LAST-A-FOAM®** is a closed-cell material, **use of solvent-based adhesives to bond LAST-A-FOAM® is not recommended,** as solvents are unable to escape the bond line, and no bond will occur. An exception to this would be contact adhesives, which are allowed to dry before bonding takes place.

Also, since our rigid foams are good insulators, **heat-cured adhesives should not be used** unless the foam is to be "soaked" at high temperature long enough for the heat to penetrate the entire foam mass. Generally, this process should be avoided unless absolutely necessary.

You should follow manufacturer's safety instructions when using any bonding, filling or finishing product with **LAST-A-FOAM®**, and observe their recommended safety precautions.

LAST-A-FOAM® Tooling Applications:

Rigid **LAST-A-FOAM®** products have been used successfully in tooling applications for many years. Easy to machine, **LAST-A-FOAM®** products are grain-free, dimensionally-stable, and are conditioned to remove internal stresses. These factors make them excellent tooling substrates. Typical uses include:

- Bonding Fixtures, Machining supports
- Inspection Jigs
- Vacuum-forming Tools
- Mold Tools
- Hydro-forming Tools
- Foundry Patterns
- Mold Patterns
- Composite Lay-up Tools
- Fiberglass-mold plugs
- Drape-forming tools
- Trim Fixtures
- Autoclave Tools

Generally speaking, if higher strength, greater detail, or increased heat and pressure resistance at process temperature is required, you should use tooling material with a density greater than 20-pounds per cubic foot. On the other hand, if processing is carried out at room-temperature, and finished-item features do not include sharp lines, sharp corners, or fine details, lower density materials can be used very successfully, saving fabrication time and material cost.

LAST-A-FOAM® with a density in the range of 4 to 10-lbs. per cubic foot is easily cut and carved with hand tools. Common wood-working tools perform just fine for shaping these lower-density foams. Implements like the Stanley "Surform " tools can be used to shape curves and smooth surfaces. At densities above 10-lbs. per cubic foot, it may be necessary to use a power-tool to cut and carve **LAST-A-FOAM®** shapes. For dimensional accuracy and for holding close tolerances, CNC-cutting equipment and 20-40 lbs. per cubic foot material may be necessary. High-speed steel tools will work to cut all grades of **LAST-A-FOAM®**.

Here are some starting points for machining several grades of **LAST-A-FOAM®** tooling board products. The speeds and feeds shown here are general recommendations only, and should be adjusted for machine capability, tooling configuration, machine rigidity, and desired end results

General Machining Recommendations for LAST-A-FOAM® Tooling Board Grades

LAST-A-FOAM® Product (Density)	Roughing Speed (rpm)	Roughing Feed Rate (ipm)	Finishing Speed (rpm)	Finishing Feed Rate (ipm)
FR-7110 (10 lb.)	2,500-3,500	120 ipm	5,000	200 ipm
FR-7120 (20 lb.)	2,500	120 ipm	5,000	200 ipm
FR-7130 (30 lb.)	2,500	120 ipm	5,000	200 ipm
FR-6720 (20 lb.)	2,500	120 ipm	5,000	200 ipm
FR-6730 (30 lb.)	2,500	120 ipm	5,000	200 ipm
FR-4515, FR-4520 (15 and 20 lb.)	2,500	120 ipm	5,000	200 ipm
FR-4530, FR-4540 (30 and 40 lb.)	3,000-3,500	120 ipm	10,000	160-200 ipm
FR-4550 (50 lb.)	2,000-2,500	100 ipm	10,000	200 ipm
FR-10730 (high-temperature 30 lb.)	2,500-3,000	120 ipm	5,000	200 ipm

Roughing: Results were attained with a 1/2-1″ four-flute ball-end mill. HSS cutters were used, although carbide-tipped cutters were used on FR-4550 materials. Cutting depths up to 2″ deep can be used with 30-40% step-over.

Finishing: Results obtained with 1/2″ 2-flute ball-end mill. Cutting depths less than 0.125″ with small a step-over produce smoother surface finish results.

Less dusting is observed with lower spindle-speeds and higher feed-rates. FR-4500 Tooling Boards generally produce less dust when machined, and will produce shavings at appropriate feeds-and-speeds. Finish-cuts are most likely to produce the most dust. A dust-collector or shop-vacuum system should be used at the cutting head to keep airborne dust to a minimum level.

Here are some additional recommendations for specific applications. In all cases, it is advisable to do a test with the materials you intend to use before committing to a larger program. In this way, good tooling performance can be ensured, and subsequent problems can be avoided.

Bonding Fixtures, Inspection Jigs, Machining Supports, Trim Fixtures:

Tooling material density should be matched to the needed level of detail, as well as the amount of wear-and-tear the tool or fixture is expected to see. Higher density material gives greater durability, and is capable of rendering fine features, as well as having better dimensional stability over time.

If the tool or fixture requires threaded-fasteners, or removable pins in specific locations, it is a good idea to bond higher-density plastic or metallic inserts in these areas to accept these items.

Screw and Bolt-thread holding in LAST-A-FOAM®

LAST-A-FOAM® products at 20-pounds per cubic foot and above have good screw-holding ability, if screws are installed in pre-drilled pilot-holes. These pilot-holes should be close to the root-diameter of the threaded fastener. Coarse-thread self-tapping sheet metal screws, drywall screws, or particle-board screws are best choices for one-time insertion and static loads.

It is possible to “tap” threads into urethane foams to establish threaded holes, but it is easy to over-torque a fastener on installation and strip those threads, even if they are quite coarse. Tapped-thread strength in urethane foams is not sufficient for repeated insertion and withdrawal of fasteners—the threads tend to fracture and break-down with each insertion/withdrawal. A bonded threaded-insert (inserts with knurled outside surfaces are best), or even an epoxy-bonded Heli-Coil® insert will greatly improve thread retention.

High-density tooling board products (**FR-4540, FR-4550**) will hold threads better than other materials, but are still not optimal for these purposes. Using adhesives with inserts allows more reliable thread-holding. It also can allow more precise location of threaded fasteners if the insert is potted into an over-sized hole, and the insert is fixed in its proper location before the potting compound sets.

When using low-density foams, use of inserts can make it possible to generate considerable holding-power, if the insert is large enough to spread the load over a larger surface area. In these cases, a block of higher-density foam with a bonded insert can be then bonded into the low-density foam with good success.

Vacuum Hold-down Fixtures

Since **LAST-A-FOAM®** products are closed-cell, vacuum can easily be used as a hold-down force in many applications, eliminating the need for clamps to secure parts. By drilling small holes in the tool, and pulling vacuum through them, a work-piece can be secured very well. Silicone or latex-rubber seals can be used around the part-periphery to hold vacuum; many times, masking tape can be used to accomplish the same goal.

This works particularly well for thermo-formed and compression-molded parts where it is difficult or inconvenient to used clamps to hold the part while being trimmed on a CNC-router.

Vacuum Thermo-Forming Tools, Drape-Forming tools:

Many users have found success with **LAST-A-FOAM® FR-6720** and **FR-6730/FR-3730** in vacuum-forming applications. It is possible to pull several hundred formed parts off a properly-designed vacuum- forming tool made with **LAST-A-FOAM® FR-6700/FR-3700**. Our **LAST-A-FOAM® FR-10730** will also work very well in these tooling applications.

Because our materials are machined easily, and because they cost much less than aluminum and many other substrates, a vacuum-forming tool for low-rate or prototype parts can be made without great expense. Low-cost foam tooling can be a great way to try different tooling concepts before committing to more expensive tools for high-rate production, too.

Foams in this density range have relatively low mass, and are poor conductors of heat energy. Polyurethane foams, because of their closed-cell structure, are inherently heat-insulators. This means it is difficult to get heat energy into the tooling material, and that it will absorb heat slowly. However, this also means that once heat-energy is absorbed, the foam will release it slowly as well.

The key factors in these applications are the plastic-sheet thickness, the forming temperature, and how often the tooling is "cycled" to form the part. If it is important to form a lot of parts in a short period of time using thick plastic sheets, it is likely that a great amount of heat will be transferred to the forming-tool. This presents a risk of softening the tool, if there is insufficient "cool-down" between cycles. Longer "cool-down" times between cycles will avoid this problem.

Thermo-form Tool Product Recommendations:

Since **FR-6720/FR-6730** does not begin to soften until it reaches temperatures beyond 275 degrees F, forming flexible and rigid polystyrene, ABS, PVC, and many polyolefin plastics is easily accomplished with these materials. Other plastics with higher forming temperatures may also be successfully formed on **FR-6720** and **FR-6730**, with a few precautions (good cooling of parts and tools between cycles).

LAST-A-FOAM® FR-10730 has a softening temperature above 300 degrees F, which makes it useful for forming plastics (polycarbonate, some engineering thermoplastics) at higher temperatures. Both **FR-6700** and **FR-10700** are available in generous block sizes, helping to limit the need for multiple bond-lines in large tools.

Vacuum-holes are easily drilled through these closed-cell **LAST-A-FOAM® FR-6700** and **FR-10730** materials, allowing good control of the forming process. Talcum-powder or carnauba-based waxes, worked into the tool-surface, will allow easy, clean release from the tool after forming.

Foundry and Mold Patterns:

Used as a wood-replacement, **LAST-A-FOAM®** is dimensionally stable, is easy to cut with no worries about grain-effects, and obtainable in very large block-sizes. Bond-joints in polyurethane foam patterns are not subject to failure due to humidity changes in storage, as can happen with wood patterns.

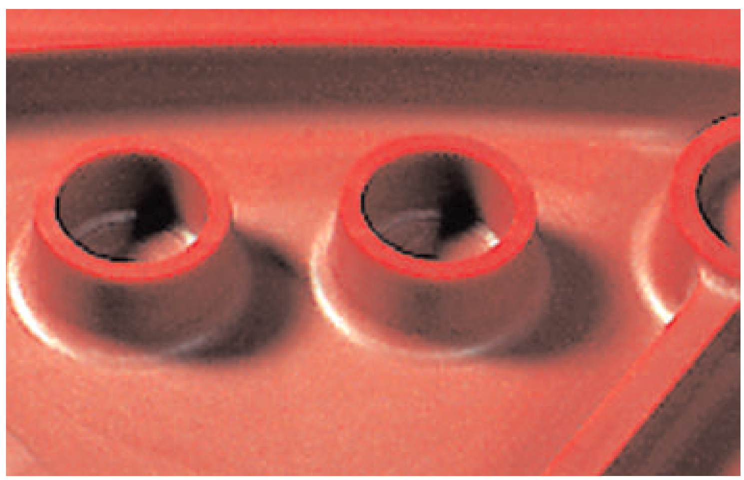
Very often, the labor-input required to "block-up" a large foundry or mold-pattern out of smaller wood pieces outweighs the cost difference between using wood, and using urethane foam as a pattern-substrate. If you can eliminate bond-joints that might later come apart, or that might cause "mark-off" on production pieces, this can be a benefit too.

To save on material costs, some pattern-makers will use a low-density foam armature (or "buck") under a higher-density foam working-surface. The higher-density surface can render fine-details, sharp lines, and with-stand in-use abuse, while the lower-density core lowers the overall weight of the pattern itself.

Since the mold-tool results from a pattern are only as-good as the original pattern, you should use the material that renders the best net surface needed for the intended use. You should also consider the level of fine-line and sharp-corner detail to be rendered. This may vary from project to project.

We have constructed composite and urethane-foam molds in our shop for decades using 20-lb. foam patterns. We consider this a good starting-point for material consideration, for patterns used only a few times to create a mold cavity.

LAST-A-FOAM® FR-7120 Model and Prototype Foam and **LAST-A-FOAM® FR-4520 Tooling Board** are quite suitable for this use.



If these materials are sealed and coated prior to casting in tooling resins, they can be easily removed from tool cavities. Also, if it is impossible to remove the pattern from the mold in one piece, 20-lb. foams can be broken out of a tool fairly easily as well.

For some other applications, 10-lb. or 15-lb. foams can also work just fine, if detail requirements are not high, or if a textured-skin (or some other coating) is to be applied over the pattern. **LAST-A-FOAM® FR-7110 and FR-7115 Model and Prototype Foam** and **LAST-A-FOAM® FR-4515 Tooling Board** are quite suitable in these cases.

Fiberglass Molds and Plugs:

Except for applications where a lot of detail is required, our **LAST-A-FOAM® FR-7106** is probably the best choice for this application. It is relatively low-cost, is high-strength, and has good cutting and finishing characteristics with hand tools. **LAST-A-FOAM® FR-7106** can be obtained in blocks up to 22.5 inches thick.

Because of the urethane resins used in our foam products, **FR-7106** has excellent resistance to tooling gel-coats, styrene monomer, solvents, paints and coatings used in the FRP-composite industry. All kinds of polyester resins bond well to **LAST-A-FOAM®**, as it is a close "chemical-cousin" to these materials.

Because **LAST-A-FOAM®** is flame-retardant, it presents less of a storage hazard than styrene-based foam products. The temperature-resistance of this foam is sufficient to withstand the short-term exotherm of curing unsaturated-polyester resins.

For tooling used in VARTM, SCRIMP, and other resin-infusion processes, or vacuum-bag use, **LAST-A-FOAM® FR-7106** or **FR-7110** will provide ample strength to withstand vacuum-infusion and vacuum-bag pressures.

Composite Lay-up and Autoclave-Process Tools:

All major American airframe manufacturers have used **LAST-A-FOAM®** products to build process tooling for making airworthy composite structures. The combination of ease-of-machining, large block sizes, predictable high-temperature performance, and low thermal-mass has made these products a good choice for many demanding projects.

Since many of these applications are fairly critical with regard to dimensional stability, process temperature, pre-preg resin cure cycles, autoclave pressures, thermal-expansion changes, and material property mismatch problems, constructing tools that always perform as expected can be challenging.

LAST-A-FOAM® Products and Heat:

One of the first and most common questions asked about our tooling material is, "How much heat will it take?"

In the table below, we list several of our foam formulations, and their performance under various heating conditions. These numbers are approximate and conservative, and can vary somewhat with tool geometry, material density and particular processing or environmental conditions. However, as a general guide, this information should be very useful.

This general overview may not be sufficient for all users under all circumstances. Please contact General Plastics Manufacturing Company with any specific questions you might have regarding the use of our products at elevated temperatures. We will be happy to assist you.

LAST-A-FOAM® Thermal Properties

Foam Formulation	Glass Transition Temperature (TG)	Heat Distortion Temperature	Continuous Service Temperature
FR-10100	305 degrees F	295 degrees F	275 degrees F
FR-10700	290 degrees F	280 degrees F	260 degrees F
FR-3700/FR6700	280 degrees F	270 degrees F	250 degrees F
FR-4305, FR-4310, FR-4315	215 degrees F	205 degrees F	185 degrees F
FR-7104, FR-7106	255 degrees F	245 degrees F	225 degrees F
FR-7107 to FR-7112	235 degrees F	225 degrees F	205 degrees F
FR-7115 to FR-7135	245 degrees F	235 degrees F	215 degrees F
TR Series Marine Foam	235 degrees F	225 degrees F	205 degrees F
FR-4500 Tooling Foam	225 degrees F	215 degrees F	195 degrees F

We define these heating conditions as follows:

Glass Transition Temperature (Tg): Above this temperature, the material will become "rubbery", and can exhibit plastic deformation under (fairly low) mechanical or autoclave-pressure loads.

Heat Distortion Temperature: At this temperature, when exposure times exceed approximately 4 hours, the material will begin to "creep" under load. Normally, short-term exposure of 1-3 hours (as in a cure cycle or secondary heating operation) is allowable up to the heat distortion temperature, under low pressure or mechanical loads.

If vacuum-bag or autoclave-cure processes are to be used, it is important to test the tooling material under process conditions to assure it is suitable and stable.

Continuous Service Temperature: This is the maximum continuous service temperature in a "protected" condition (painted, laminated, protected from UV and moisture).

Please note: Most problems with our materials used in elevated-temperature curing of composites result from the tooling board being subjected to thermal conditions slightly beyond what it can withstand for an extended period of time. Success can be ensured if users adequately assess actual curing-temperature conditions within the cure-vessel (oven or autoclave) through mapping with thermocouples placed in various locations throughout the vessel. In addition, providing an ample margin between cure-temperature and tooling material heat-distortion temperature limits can prevent high-temperature "creep" from becoming a factor.

Dimensional Stability, Vacuum-bag and Autoclave Pressures:

The stability of tooling substrates is a key consideration in advanced-composite tooling applications where heat-cures and laminate-consolidation pressures are applied to the work-piece.

All tooling-grade **LAST-A-FOAM®** products are put through a stress-relieving process after manufacture, to eliminate as much internal stress as possible. Subsequent machining operations on a piece of **LAST-A-FOAM®** can induce further stresses which may be observable at room temperature, or which may only become apparent on heating.

Solid bonds to tooling-plates will help restrain the material under heating conditions, and very often, that heating can allow lower-density **LAST-A-FOAM®** to "creep-relax" into its new configuration without damage. Unsupported thin cross-sections of tooling material should be avoided, since heat-soaking at high temperature may cause unpredictable movement.

The **Heat Distortion Temperature** limits of various **LAST-A-FOAM®** formulations (shown above) apply most strongly when using them in vacuum- bag or autoclave-cure applications. While rigid urethanes are usually quite stable at high temperature, they will "creep" under mechanical loading, given sufficient time and pressure at or near their **Heat Distortion Temperature**. *It is important to test tooling materials at their intended use temperature and pressure conditions to assure success.*

With that understanding, several of our customers have had excellent autoclave-cure and vacuum-bag-cure process results using our tooling materials at (or near) the **Continuous Service Temperature** limits shown on the previous page. Even at autoclave pressures of 80-90 psi in 4-hour (at peak temperature levels) cure cycles, **FR-6730/FR-3730** has done very well in the production of fly-away parts for major airframe builders.

Thermal Expansion Characteristics:

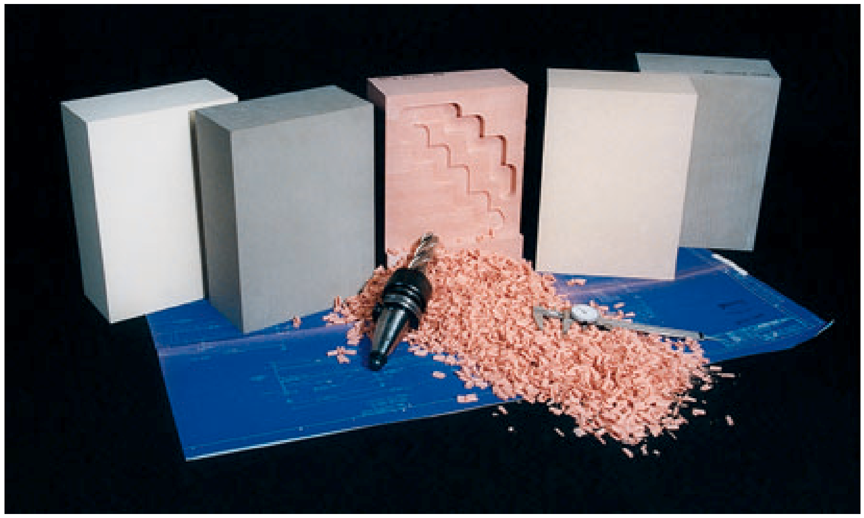
Like other tooling materials, **LAST-A-FOAM®** products change in dimension with changes in temperature.

Because **LAST-A-FOAM®** products are made with polyurethane resins, their thermal expansion characteristics are typical of most urethane resin products. The **Coefficient of Thermal Expansion (CTE)** for these resins is generally in the range of 3.0-5.0 x 10-5 in/in/degree F. Slight differences in formulation can cause individual products to have expansion rates at one end or the other of this range.

The impact of this expansion can be dramatic, especially in the case of larger objects. For example, if you have an unrestrained beam of **LAST-A-FOAM®** FR-6720 (20-lb. per cubic foot) that is exactly 120.00 inches long at 75 degrees F, it will be approximately 120.315 inches long at 150 degrees F, and 120.735 inches long at 250 degrees F. On cooling to 75 degrees, the material will return to its original dimension, but this expansion can still be critical if it exceeds that of other dimensional allowances in the project.

This information becomes important in considering the dimensional changes a tool might have between its room-temperature state, and its condition at work-piece curing temperatures. Other factors with influence on this data would include the CTE for other materials bonded or fastened to the tool, the allowable dimensional tolerance for the finished work-piece, and the relative CTE behavior of the work-piece itself.

Generally speaking, CTE data for **LAST-A-FOAM®** relates directly to the behavior of the polymer over a range of foam densities, and a range of temperature environments. Higher-density materials may exhibit slightly less expansion/contraction due to temperature, than lower-density materials. The presence of filler materials and changes in foam processing or formulation might also affect CTE rates.



For reference purposes, here are some Coefficient of Thermal Expansion data for other materials commonly used with our tooling materials.

Coefficient of Thermal Expansion for some tooling and process materials

Material	Temperature Range	CTE Range
LAST-A-FOAM® FR-6700/FR-3700	-45°F to +250°F	$3.0\text{-}5.0 \times 10^{-5}$
Cured Tooling-Grade Epoxies	Upper limit +200°F	$2.8\text{-}4.4 \times 10^{-5}$
Aluminum-filled Tooling Epoxies	Upper limit +340°F	$2.8\text{-}6.3 \times 10^{-5}$
Steel		0.67×10^{-5}
Aluminum		1.31×10^{-5}
ABS (Acrylonitrile Butadiene Styrene)		5.3×10^{-5}
PVC (Polyvinyl Chloride)		6.1×10^{-5}
Acrylic		7.0×10^{-5}
Polycarbonate		3.9×10^{-5}

From this data it can be seen that **LAST-A-FOAM® FR-6700/FR-3700** materials are quite compatible with tooling-grade and lamination epoxies, and many other polymer materials used in tooling applications. Other **LAST-A-FOAM®** products have CTE properties in the same range, and are equally compatible with these resins.

Using Low-Temperature-Curing Pre-Pregs with Urethane Tooling Materials:

In the past few years, several new, low-temperature-curing epoxy pre-preg formulations have entered the marketplace. These new materials allow users to accomplish an initial cure at temperatures in the range of 140-150 degrees F, with ultimate strength obtained in a post-cure at higher temperatures (250+ degrees F).

These materials have greatly simplified the manufacture of some composite items, and reduced the cost and complexity of tooling for those items. However, there is a trade-off in all of this.

The curing mechanism in many of these pre-preg resins relies on a specific chemistry that can be inhibited by the presence of certain metals. If these metals are available at the working surface of the tool, the resin in the pre-preg will not cure, and a “gooey-mess” will ensue.

Every manufacturer producing urethane-resin based tooling materials uses chemical compounds containing metals in their production process, and even though they are used in very small quantities, they are sufficiently present at the surface of the material to cause resin-cure inhibition. This phenomenon is not limited to urethane-resin products—PVC-foam materials also show the same inhibition potential. High relative-humidity exacerbates this problem.

As a consequence, it is very important to test the compatibility of tooling materials to avoid this difficulty. In many cases it may be necessary to coat the surface of a urethane tool with a tooling-grade epoxy compatible with these pre-preg resins to avoid the “gooey mess” problem.

Large-Mass Tools in High-Temperature Curing Cycles:

Because many **LAST-A-FOAM®** products are available in large, single-piece blocks, it is often very attractive (from a cost standpoint) to make large, monolithic tools. Under most circumstances, this practice presents few problems. Many resin cure-cycles are relatively short, and the low thermal-mass of tooling made from lower-density (20lb-30lb) boards prevents the absorption of a lot of heat-energy into the mass of the tool. In these cases, there is usually not a large temperature (and CTE-effect) difference between the inside core of the tool and the outside of the tool.

However, when large-mass tooling is subjected to high-temperature, long-duration autoclave cure-cycles (e.g., 350°F for 6+ hours at peak temperature), the potential for heat-soaking the entire mass of the tool is quite high, and there can be problems, especially on cool-down.

A large ΔT (temperature-difference) between the outside of the tool and the inside of the tool can result in a large difference in thermal-expansion effects, incurring possibly severe stresses within the tool. Sometimes, these stresses can exceed the strength of the tooling material, and cracking or shearing of the tool will result.

Similar stresses can be incurred during rapid heating of a tool, where a quick ramp-up in autoclave or oven temperature can cause the outside of tooling to heat much more rapidly than the tool core.

BONDING RIGID LAST-A-FOAM®:

The best adhesive materials to use in bonding rigid **LAST-A-FOAM®** foam products are **room-temperature curing, reactive adhesives, i.e., adhesives which reach full cure within the bond joint.**

These adhesives can be one-component, no-mix, or two-component adhesives requiring accurate dispensing and mixing.

The following adhesive types are considered to be “reactive adhesives”:

• Epoxies • Polyurethanes • Cyanoacrylates ("superglue") • Methacrylate Adhesives

If you are using **LAST-A-FOAM®** in a way that involves finish-sanding across a bond-line, it is helpful to use an adhesive with a cured-hardness similar to the material surrounding the bond-line. Adhesives that are harder than the surrounding material will leave a ridge when sanded; adhesives that are softer will cause a depression around the bond-line.

We publish **Shore D hardness** data on all our foam products, which should be useful for comparison to the cured hardness of adhesives you might select for your application.

We cannot make specific recommendations for your particular adhesive need, as it should be based on your specific design and application. Keep in-mind the environment the bonded assembly will have to withstand, including use-temperature, bond-line gap filling capability, chemical exposure, mechanical loads, thermal-expansion characteristics, and ease of application and cure.

Generally, the **single-component urethane adhesives** (Pro-Bond“, Gorilla Glue“, Excel One“) cure to a consistency and hardness very close to that of our foam products at densities of 20 pounds per cubic foot, or less. These adhesives can be sanded easily, and can be filled and finished to very closely match the surrounding foam material. A light spray of water on one side of the bond-line will help speed the complete reaction of these adhesives, which rely on ambient water-vapor to cure.

All of these adhesives expand in the bond-line upon cure, which helps to fill gaps and any voids. It is important that pieces to be bonded be clamped together while the adhesive cures, because of this expansion attribute. Clamping pressure requirements can be as high as 100-125 psi. The reward for this is a clean, neat bond-line that will blend with the rest of the foam material around it.

We can suggest that you investigate the potential of these bonding products listed below. These adhesives have been used successfully by our own fabrication facility and/or by our customers:

Epoxy Adhesives	Contact Cements	Methacrylate Adhesives
#2216 B/A, #1838 B/A, #3501 B/A (3M Company)	**Fastbond™ 10** (3M Co.)	**#330 Depend®** (Henkel Loctite)
#320, #363 (Lord Corporation)	**#80 Aerosol, Super 77 Aerosol** (3M Co.)	**#324 Superbonder** (Henkel Loctite)
Triggerbond 10-3003, 10-3012 (Epoxies Etc.)	**ScotchGrip™ 1357** (3M Co.)	**#661/6, #662/6, #663/6** (Lord Corp.)
WB 400/WH150 (Resin Services Co.)	**#7132C + Boscodur 24** (Bostik)	**MA200, MA320, AO420** (ITW Plexus)
Epi-Tech 260A (Adhesive Tech.)		
DURABOND E20HP (Henkel Loctite)		
Polyurethane Adhesives	Foam Surface Sealants	Cyanoacrylate Adhesives
#3532 B/A, #3535 B/A (3M Company)	**#21 Sprayable Polyester** (CASS Polymers-Adtech)	**#454 Gel, #409 QuickGel®** (Henkel Loctite)
#7542, #7545, #7546, #7610 (Lord Corporation)	**MV85LE Mold Sealant + Release** (Meguiar's USA)	**Pronto Gel CA-50 Instant Adhesive** (3M Co.)
EXCEL ONE® (The Ambel Corporation)	**ZYVAX Sealer GP** (ZYVAX Inc.)	**Hot Stuff Special T** (Satellite City)
DURABOND 605/610 (Henkel Loctite)	**DURATEC Polyester Sealer** (Hawkeye Industries)	**Zap Gel** (Pacer Technology)
PL Premium Polyurethane Construction Adhesive (OSI)	Sanding Sealer for wood products (various manufacturers)	(**Note:** It is good to use activators for all cyanoacrylate bonds)
ProBond Polyurethane Glue (Borden Co.)	Concrete sealers (both water and solvent-based types)	Surface Fillers
Titebond Polyurethane Glue (Franklin)	**Varathane®** ***Diamond Finish*** (Flecto Company)	Lightweight Auto Body Fillers Drywall Compound
Gorilla Glue® (The Gorilla Group)		**#18 Pattern Filler** (CASS Polymers-Adtech)

Sealing rigid LAST-A-FOAM® products:

A variety of materials can be used to seal the surface of **LAST-A-FOAM®** products. Since the materials are resins that are expanded with carbon-dioxide gas, the role of a sealant is to fill the voids created when gas-bubbles at the surface are opened-up by either sanding or cutting into the foam. Higher-density **LAST-A-FOAM®** products will have smaller cells, and hence will be easier to fill and seal.

It has been found that most sanding sealers (whether varnish or lacquer types) will work well to plug surface cells and small voids in the foam. More than one coat may be required. Best results have been achieved by spray-applying at least 4 (four) thin coats of sealer, with light sanding between coats.

Even water-based polyurethane finishes (such as Flecto Company's Varathane® *Diamond Finish®*) will work well with our products, and VOC problems are thereby avoided.

Generally speaking, lower density (3-to-20-lb. per cubic foot) **LAST-A-FOAM® FR-6700** and **FR-7100** and **FR-4500** Tooling Board products will need more coats of sealing material to attain a smooth surface.

You should make sure to use a sealant material that will be compatible with the mold-release or surface-coating materials you wish to use to complete the tool. There are some material-combinations that may not work well together. Consulting with the manufacturer(s) of the products you are using may be advisable if you are unsure about a combination, or you are trying something new.

Additional light sanding can then prepare the surface for finish coatings of your choice. On higher density **LAST-A-FOAM®** materials, only a paint primer may be necessary to provide a good surface for a final finish.

Hawkeye Industries' **DURATEC©** products work very well as FRP-compatible surface coatings on our tooling foams. **Resin Services, PTM&W,** and **CASS Polymers-Adtech** make products to satisfy similar needs for the advanced composites industry. Several of our distributors carry these complementary product lines.

Filling voids in rigid LAST-A-FOAM® products:

Larger voids can be filled with putties, such as automotive "bondo" compounds, or paste-grade epoxies. Many of these compounds can be found by visiting shops that deal in fiberglass resin and repair products. Using these materials in several thin-layer applications to fill voids is better than a one-shot filling operation, since these fillers often shrink on cure, leaving gaps and cracks. Polyester-resin based fillers shrink more than epoxy-based resins.

We know of a pattern shop that has used common drywall compound as a quick filler and surface finisher for large **LAST-A-FOAM®** surfaces. By using thin coats and wet-sanding techniques, they have found this material to be an excellent substrate over which to apply subsequent finishes. It dries quickly, sands easily, accepts most common finishes, is widely available, and is very inexpensive.

Sometimes the addition of powders (colloidal silica, alumina powder) to a surface-coating resin can also be useful in making fillers for larger voids.

LAST-A-FOAM® products used as Mold Tooling:

When using **LAST-A-FOAM® F-7100, FR-6700** and **FR-4500 Tooling Board for low-cost molds**, users can effectively seal the surface of these materials with mold-sealant compounds made for filling micro-porosities in metal molds.

We have found the **Zyvax** and **Meguiar's** products listed above effective for getting a surface-seal important to good "release" from our polyurethane tooling materials. In these cases it is important to follow the manufacturer's instructions carefully to get good results. We found the **FR-4530 Tooling Board, FR-4540 Tooling Board,** and **FR-4550 Tooling Board** best when used with these sealants, though we had acceptable results with **FR-4520 Tooling Board** as well.

Another method for gaining a good "release" from a **LAST-A-FOAM®** mold involves rubbing several coats of a carnauba-wax-based mold release into the mold surface. This method has been effective in our own shop in treating low-cost tools for molding polyurethane-foam shapes.

Painting and Finishing rigid LAST-A-FOAM® Products:

Typically, automotive or wood-working grade finishes can be used with great success when applied to our urethane board products. Customers have been able to duplicate almost any surface devised by man or found in nature by creative application of finish coatings to **LAST-A-FOAM®**.

We have seen examples exactly duplicating wood, metal, rock, fish-skin, feathers, and reflective mirror finishes. Customers in the automotive, sign-making, entertainment, amusement park, and prototype modeling industries create many convincing effects through finish coatings.

For outdoor use, an acrylic-latex paint or enamel is quite sufficient to protect **LAST-A-FOAM** products from UV-effects and weathering. A primer can be used to improve surface quality, but is probably unnecessary to improve adhesion or surface-sealing.

If a plated-metal surface is desired, our foams can be plated using an electroless-plating process. We have design-model-making customers in the bathroom/kitchen fixture business using this method, and the results are indistinguishable from the "real thing" (until you pick up the model).

As in any paint or finishing process, proper surface preparation is the best start toward good final finish. As there are virtually no solvents that can irreversibly damage **LAST-A-FOAM**, you have great freedom in selecting finishing materials. If you follow the finish manufacturer's instructions, we feel confident you can attain the results you desire from the use of **LAST-A-FOAM** as the basis for your project.

Bonding flexible LAST-A-FOAM® grades:

Any of the **contact cements** listed above will work for bonding flexible **LAST-A-FOAM®** products. *Foam Adhesive 45NF* and *Super 74 Foam Fast Adhesive* from 3M will also work well for many bonding applications. Additionally, **polysulfide** adhesives will bond to flexible **LAST-A-FOAM®**, but will require clamps and fixtures be used because of their extended cure times. Please note: All flexible **LAST-A-FOAM®**® grades are **open-celled** foams, and are solvent and vapor permeable.

Material Handling, Storage, and Safety Considerations:

When storing and handling rigid **LAST-A-FOAM®**, it should be treated as you would any possibly combustible organic solid. Storage precautions for wood are fully adequate when used with **LAST-A-FOAM®**. Scrap and waste **LAST-A-FOAM®** materials are inert and can be disposed of as you would ordinary solid waste.

Rigid **LAST-A-FOAM®** products are essentially chemically inert, as the ingredients used to make them react completely during the manufacturing process. However, cutting, planing, shaping, routing and sanding **LAST-A-FOAM®**produces dust. The inhaling of foam dust, as with any dust, should be avoided. Safety equipment appropriate for use in avoiding dust inhalation should be used when working with **LAST-A-FOAM®**.

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