HOW To Make Composite Parts

STEP 1, how to make a mold

MOLD CONSTRUCTION
Of all the advantages offered by composite materials, their ability to be molded to complex shapes is perhaps the most popular. When a shape needs to be reproduced numerous times, it is most efficient to build a tool or mold within which the part can be fabricated. Molded parts emerge perfectly shaped every time and require little post-finishing work.

Molding or "stamping" has been used for years to shape metal products like car bodies, home appliances, and industrial fixtures. Metal stamping dies are cumbersome and cost thousands of dollars to produce. Only large companies can afford to build, operate, store, or even move these tools. Composite materials offer a cost effective way for anyone to make even large production runs of identical plastic parts in molds they can produce themselves.

This brochure will describe the steps necessary to create accurate, high-quality, low-distortion molds for producing composite parts. It is intended to help novice through intermediate builders obtain successful results with their first project. While many of the principles described are the same as large-scale industrial techniques, the suggestions offered are meant to be used in small shops, garages, or workshops to help individuals produce BIG results! For this reason, the examples listed are intended to be scaled-down, helpful industrial hints.

Types of Molds
Male and female molds are the only two fundamental types of forms, but they yield significantly different finished parts. The least time consuming and cheapest method is the male or positive mold. This is a form that mimics the final shape of the part, but the part is fabricated over its outer surface. It is true that this type of mold is quicker to construct, but each part produced will have a rough outer texture which requires laborious finishing. The part will also "grow" during lamination. Usually this is undesirable, but if the mold is intentionally made slightly smaller the part will grow into the desired finished dimensions. Male molds should be used when fewer than 5-10 parts are being produced. Larger runs usually warrant the time and cost of female molds. The remainder of this brochure will deal mostly with construction female molds, but male molds can be made using the same materials.

Female or cavity molds are generally more costly, but they offer numerous advantages for medium for medium to large production runs. Finishing time is significantly reduced because every part emerges with a smooth outer surface. Female molds also lend themselves to use with core materials because the outer skin is always a smooth regardless of how inconsistently the core is used inside the part. Either type of mold can be used for vacuum bagging, but female molds are usually easier to seal while achieving good surfacing characteristics. If more that 5-10 parts which need smooth finished are being produced, female molds are worth the extra effort.

Compression molds are sometimes made by using both a male and a female form. These "matched" molds are excellent for producing precision parts. The molds are loaded with reinforcement and resin before they are closed and tightened. Excess resin is squeezed out, voids are reduced, and parts emerge smooth on both sides. Compression molds can also be modified for use with resin infusion or injection. The key is to think about the intended use of the finished part and what type of mold will be necessary to build it. If this is considered in advance, there is no limit to the type of parts that can be produced.

Selection of Methods and Materials
Before beginning the construction of any mold, take the time to consider the desired end results. The construction of the mold will be a trade-off among the physical properties of the mold, cost of construction and time involved to build the mold. What you want in a finished part will have a direct bearing on these trade-offs. Careful consideration of these factors will enable you to incur the least expense to get the desired results.

When selecting mold-making materials and the method of construction, take into account such things as the length of the production run and the desired quality of the surface finish on the part. The time and materials put into the mold at the beginning will ultimately impact how many parts you can make and the quality of those parts. Other things to consider include technique specific modifications to the mold to aid in procedures like vacuum bagging and compression molding. Larger flanges are worth incorporating to make both these procedures easier. Locating ins along the perimeter flange should also be planned for complex molds with multiple pieces requiring precise alignment. Finally, consider how the mold will be held while in use. An egg-crate structure will add both support and manageability to molds with awkward shapes.

How you intend to release the mold from the plug and subsequent parts from the mold will also impact the overall design and construction. The first factor consider is the draft angle of the mold. This is the angle of the sides of the mold compared to its base. A mold with zero draft has flat sides perpendicular to the bottom. On a mold with positive draft, the sides are wider at the top than they are at the base. Parts will easily pop out of molds with positive draft. The sides of a mold with negative draft are tighter at the top than at the bottom. For obvious reasons parts are impossible to remove from a mold with negative draft. Shapes which have to be molded with negative draft must be made in multiple-piece molds. Each piece has positive draft for easy release, yet they all bolt together forming the negative cavity.

The point where the mold pieces join together is called the parting plane. This is the imaginary line or plane that divides the negative draft angle into two positive angles. Molds can be built with as many parting planes as needed for complete separation. The plane typically runs along the highest or widest crest of the plug. When first tackling mold building projects, it is helpful to draw the line on the plug with a felt tipped pen. This permits trial-and –error sketching until you are satisfied that it is located in the proper place. If further lessons are necessary, look at the mold seams on plastic children's toys. They are often quite exaggerated and rarely removed. Quite a bit can be learned from their examples.

Large parts and molds have difficulty separating even once their edges break free. Slight adhesion over broad areas and even static contributes to the problem. Expect the worst, and plan ahead. Drill holes through the mold and bond an air fitting to the back. Use clay to fill the hole during molding so resin does not contaminate the air line. When the part is ready to release, just hook up the compressed air and pop! Try to locate the fittings in areas that will later be trimmed and removed from the part. That way the marks from the clay won't have to be sanded and polished out.

In selecting the actual resins and fabrics, approach it from the standpoint of creating a mold for the lowest possible cost, given the application. Nearly all composite materials can be utilized in mold construction, but the part requirements often don't justify the expense of more exotic materials. For many parts, a mold constructed with general purpose polyester resin and 1.5 oz/sq ft fiberglass chopped strand mat strand mat will produce satisfactory results. Mat offers quick build-up, along with uniform strength and stiffness, in a minimum number of layers (typically 8-10 layers.) Using a good tooling gelcoat sprayed at the proper thickness will also aid greatly in achieving a top-notch mold surface.

Some parts do require an extremely rigid mold for dimensional accuracy or longevity. Epoxy surface coats and resins, which experience little to no shrinkage, can then be justified. Mat cannot be used with the epoxies because it is not compatible. That is just as well since the woven fiberglass cloths are stronger anyway. Use carbon fiber for molds, which need the highest strength and rigidity.

Plug Preparation
One of the primary keys to success in mold construction is proper preparation of the plug, which is the "original" used to create the female mold. Any imperfections in the plug surface will be transferred to the mold, and then to future parts made from the mold. Recalling what we said earlier about beginning with the end in mind, the plug needs to have a finish AT LEAST as good as the parts you wish to produce.

The preferable surface finish for the plug would be a Class "A" finish, which means it would be a polished, high-luster finish free from any porosity or scratches. In order to achieve an acceptable mold surface and a long mold life, it is far more effective to remove defects from the plug surface than attempting to remove defects from the mold surface.

After the plug has been properly shaped and sanded, finish the plug with a high quality surfacing primer, such as Duratec Surfacing Primer . These materials can be readily sanded and polished to a Class "A" finish. The brochure Plug Surface Preparation and Mold Surface Maintenance goes into this process in greater detail.

Constructing the Mold
Once the plug has been prepared to a Class "A" finish, construction of the female mold can commence. First, a mold release agent will need to be applied to the plug. This is a critical step, since it will allow you to separate the mold from the plug once the materials used to construct the mold have cured. If the mold doesn't release properly from the plug, the mold and the plug could be damaged or destroyed, so follow these procedures carefully.

The two most common release agents employed are the traditional combination of parting wax and PVA release film, and the newer one-step, water-based release agents such as FibRelease . When working with parting wax and PVA, generally four coats of wax are applied with an hour wait in between the second and third coats of wax. After the final application has dried and been buffed, the PVA can be sprayed onto the plug. For best results, the PVA should be sprayed in three thin mist coats and allowed to dry for 30-45 minutes. In that time it should cure into a thin smooth film. 70 to 90 psi air pressure will help to fully atomize the PVA for a smoother finish. FibRelease, on the other hand, dispenses with the multiple coats of wax and PVA . The FibRelease is merely wiped or misted onto the surface and allowed to dry to a film-like state. After about a half hour, FibRelease is usually sufficiently dry to begin construction.

Before starting the lay-up of the mold, parting flanges or dams must be added to the plug along all the parting planes previously described. This is the form, which divides the mold segments during construction. This form is removed once one side has been molded. Like the plug itself, these parting flanges are constructed of the lest expensive materials that will support the curing fiberglass later. Clay, masonite, waxed posterboard, thin sheetmetal, and playing cards have all been known to work. Typically, a "snake" of clay is rolled in the palm of the hands and pressed onto the plug along the parting plane. When the symmetry is simple, a silhouette cut-out can be made from masonite and attached with the clay. It is easier to use the posterboard, or playing cards on plugs with complicated shapes. Scissors can quickly cut the contours necessary before the dam is inserted into the clay. Use a mixing stick to scrape away the excess clay on the side that will be molded first. More elaborate fixtures can be constructed to do the same job, however this method will provide repeatable results.

At this point, any locating keys or dowels for re-aligning the segments of a multiple-piece mold should be added to the parting flange. If the flange is made of clay, these key-ways can simply be imbedded in the soft material. Masonite is also easy to add them to because it provides plenty of support for holding the dowels. When using a paper or metal dam, simply make a key from clay and stick it to the surface. The key-way will be molded first, then remove the clay and the other mold section will be made with the matching key. Regardless of the materiel used to make the parting dam, spray or gently wipe o one final coat of release agent.

Once these steps have been completed, it's time to begin applying the surface coat. The polyester tooling gel coat is easily distinguished by its bright orange color. Although the surface coat can be applied with a brush, a more uniform result will be achieved by spraying it. Gel coats and other surface coat materials are too thick to be sprayed with normal automotive spay equipment, so a special gravity-feed “cup” gun must be utilized. Typically, cup guns accept disposable cups holding up to a quart of material. After mixing the proper amount of catalyst, you’re ready to spray the surface coat. Once you start spraying, keep the material flowing; don’t start and stop at the end of each pass like when spraying paint through regular siphon equipment. Exercise caution, though, or too much material will build up too quickly. Using a gel coat thickness gauge for testing, apply a uniform thickness of 20-25 mils over the plug. This is best achieved in three passes of 7-8 mils each. DO NOT allow any initial pass to tack-up before adding the next layer. All 20-25 mils must cure as a single film for best results. Epoxy surface coats be brushed on, and if mixed correctly are trouble free.

Once the surface coat has been applied, it’s critical to stabilize it with the first layer of reinforcement within 1.5 to 5 hours. This will help prevent the surface coat from shrinking or lifting off the surface of the plug. The first layer of reinforcement is also the most critical layer in the mold to lay down without trapping air bubbles. All air pockets directly beneath the surface coat are prone to cracking. When the chips fall out after producing a part or two, the whole mold surface will become cratered and need resurfacing.

With the stabilizing layer in place, the mold could sit in that condition for days before being completed. The main advice here is to avoid spraying your surface coat just before bed and expecting it to perfect when you return in the morning. You will be time and money ahead if you wait and begin the process when the surface coat can be stabilized within the 5-hour window of opportunity. This advice may seem overly cautious to some, but it always works.

This also helps prevent heat distortion in polyester molds. After an hour the gel coat is cool to the touch. One layer of 1.5 oz/sq. ft mat and resin will heat slightly while curing, but not enough to distort the delicate surface coat. When the first reinforcement layer is cool to the touch, it can be sanded in preparation for more mat. The remaining layers can be added fairly quickly to this stabilized surface without much fear of thermal distortion.

If chopped strand mat is used, tear (don’t cut) the mat into manageable chunks. The frayed edges blend well with one another without trapping air like sharp scissor - cut edges do. The flange areas will need some strips cut to the proper width to butt into the corner of the parting dam to exclude air. However, this is about the only area where they are needed. If coarse woven fabrics are used, they will lay easier over severe contours when they are cut off the roll on a 45-degree bias. Pre-cut much of the reinforcement so 2-3 layers can be added at a time before the resin starts to gel.

Using a natural bristle brush, pre-wet the surface with properly catalyzed resin, then place the mat on the plug. The reinforcement will soak up much of the resin, but white spots indicate more is needed. Once again, begin by butting pre-cut strips into the angles where the parting dam meets the plug. Then apply frayed patches on the main surface overlapping nicely onto the flange. A milled glass putty can also be spread into those types of corners to keep out air.

Roll the air out of the laminate at least every other layer. Begin using a bristle roller which will pop many bubbles within the mat. Next, switch to a grooved saturation roller to compact the laminate. Be sure to use a roller which contacts the entire surface. There are many shapes to choose from for this reason.

Most Molds using chopped strand mat utilize about 8-10 layers. Heavier fabrics such as woven roving or tooling fabric can be added after the third layer of mat to more rapidly increase the build-up and strength of the mold. Consider alternating the fabric weave patterns between 0/90 and 45/45 degrees so the strength remains uniform. Do not apply more than 3-4 layers at a time so that heat generation, or exotherm, is kept to a minimum.

Once all of the layers are in place and have properly cured, the parting dam can be stripped of f the back of the new flange and discarded. Use clean rags to wipe away any excess clay that might remain on the surface. Take care not to scratch the plug while doing this. Apply fresh mold release agent to the newly exposed flange, as this will be the form against which its mate will be constructed. Once again, follow the sequence described above from surface coat to final reinforcement until all the segments of the mold have been built.

If eggcrate support structures need to be added, now is the time. Most are made from plywood or some other inexpensive flat stock. Make paper templates of the mold contour where the panel is to attach so miscuts are reduced. Cut the wood to shape so it fits well against the mold and any other pieces of the framework itself. Use the resin and reinforcement to bond it to the back of the mold. Join all other similar pieces to the mold in the same way, and attach them to each other as designed. Once cured, this will add even greater rigidity to the mold.

When all the portions are complete and cured, it is time to trim the mold and drill any final clamping holes for bolts. Drill the holes first so that if any part of the mold pre-releases while trimming everything will still line up later. Trimming is actually best achieved with a saw. Grit edge jig saw blades cut faster and with less effort than most air die grinders. With the perimeter entirely trimmed, construction is complete.

Releasing the Mold from the Plug

It is time for the moment of truth – releasing the mold from the plug! Release wedges can be used to help coax the mold off the plug. These plastic wedges should be used in place of screwdrivers and putty knives because they will not chip the mold surface. Why perform all these tedious tasks just to ruin it now? Insert the wedges around the perimeter of the mold and gently tap them into place, progressing evenly around the edges. Special air-injection release wedges , which attach to an air compressor, can also be used for stubborn parts. The pillow of air that is shot between the plug and the mold provides pressure where no wedge can ever reach. Slowly the two should separate. If problems still persist, light blows with a rubber mallet can send vibrations through the mold causing separation. Don’t get carried away. Heavy pounding can actually fracture the mold itself. These combined hints will safely release the mold sections.

Preparing the Mold for Use
Once the mold is separated from the plug, clean and inspect its surface. The residue of PVA mold release agent can be washed off with warm water. Dry the surface, and look for any serious defects. Critical problems will actually have to be ground out and resurfaced. Hinges, air injection ports, and any other accessories should be attached at this time if they are needed. If the directions were followed and nothing was damaged during release, the surface should already be very smooth. Typically, the mold release agents leave a slight texture behind, but this can be quickly removed while achieving a class “A” surface. Begin by wet sanding with 400 grit sandpaper, eventually moving to 600 grit, then 1000 grit paper. Rinse the bucket and the mold surface before moving to the next grade of paper, so any remaining grit from the previous sandpaper is removed. Once the sanding is completed, buff the mold surface with an appropriate polishing compound. Fibre Glast recommends a two stage polishing process for best results. For more detailed information on mold surface preparation and maintenance, see our brochure Plug Surface Preparation and Mold Surface Maintenance .

The final step before use is the application of he desired release agent. This is just as straightforward as it has been during the mold construction process. An unseasoned mold is often given an extra coat or two of the system just to be sure of its effectiveness. In fact, the first few parts made in a mold are sometimes constructed thin enough to be broken out in the event of a major failure. However, if the mold was designed correctly, there shouldn’t be any problems.

Congratulations are in order for all those who made it this far. You are now prepared to embark on projects, which can truly open the doors to new creations, even new careers. Following these simple instructions, accurate, high quality, distortion-free molds can be constructed for producing composite parts. This information combined with a bright idea offers the freedom to build structures many would consider impossible. Then, if the idea takes off, produce as many as necessary to fill demand. Hopefully, this brochure has instilled enough confidence and enthusiasm to get you started on your first project. Even if you start small, you can get BIG results!

Step 2A, Molding Fiberglass

MOLDING FIBERGLASS
Composites offer tremendous possibilities for part fabrication once a few basic concepts are understood. The key lies in understanding the different materials available, their applications, and the best ways to handle them.

This brochure is intended to be a general overview of composite fabrication, with an emphasis placed on the fabrication of parts in molds. The broad scope of this brochure limits the amount of detail included about basic fundamentals and mold construction. Fibre Glast Developments offer brochures, which delve into specific aspects of these areas in more detail.

Terminology
The best place to start when learning about composites is an understanding of the vocabulary used in this field. The following terms are often used in describing the composite fabrication process:

Piece: The finished product, which you are making.

Plug: The actual item to be duplicated in fiberglass or other composite materials, which is used to construct the mold. The plug can be the actual part or a custom-fabricated shape, made from virtually any type of material.

Mold: The item from which the piece will be made. There are two main types of molds, male and female. A male mold is identical to the item being duplicated, and the piece is made over the mold. A female, or cavity, mold is the reverse of the item to be duplicated, and the piece is made inside the mold. The word can also be used to describe the composite fabrication process: Molding a part.

Laminate: A solid part constructed from a combination of resin and reinforcing fabric. This term can also be used to describe the process of laying up a part: Laminating a part.

Gel Coat (or Surface Coat): The term gel coat is often used generically to describe any resin-based surface coating, but the term technically applies to polyester-based materials. The term surface coat can be used to describe either epoxy or polyester materials. Surface coats are specially formulated, thickened versions of resins which can be applied to the surface of a mold or piece to serve as a cosmetic and protective coating.

Release Agent: Any of a number of materials applied to the mold surface before part fabrication, in order to aid in the release of the piece from the mold. These could be waxes, oils or specialty release coatings such as PVA .

Flange/Parting Dam: A temporary fixture attached to the plug when building multiple-piece molds. This generally creates a surface for materials to be molded against, perpendicular to the parting plane of symmetry. The flange aids in clamping or bolting the mold sections together, as well as serving as a mounting point during vacuum bagging operations.

Materials
Once you know the “key words” of composites, the next step is learning about the different resin and reinforcement options available when working with composites. The fist portion of this section deals with the three main resins used for most composite structures, while part two deals with the most common reinforcements.

Part 1: Resins

A composite structure consists of a thermosetting resin used in conjunction with some type of reinforcement, such as woven fiberglass cloth. The three main types of room-temperature-curing resins used in composite fabrication are polyester, vinyl ester and epoxy resins.

Polyester resin is a general-purpose resin suitable for a wide variety of applications. Methyl Ethyl Ketone Peroxide (MEKP) must be used as the catalyst to begin the curing process. Catalyzation rates can be varied with polyester resins, environmental conditions. In thin laminations or when gel coat is sprayed as a topcoat, the surface may remain tacky and not cure properly if left exposed to the air. To get a complete cure, thin laminations or top coats must contain either styrene wax solution of have a coat of polyvinyl alcohol (PVA) solution sprayed over them to seal out the air. With the former, the wax “floats” to the surface as the resin cures, acting as a barrier to the air. Styrene wax must be sanded off after curing, but PVA can be rinsed off with warm water.

Epoxy resins are not as forgiving in their measurement as polyester resins, but epoxies provide a greater part strength and dimensional stability. They also adhere to other materials better than polyester resins. Epoxy hardener rations can’t be varied, and adequate temperatures (at least 70 degrees F) must be maintained during the curing process. Epoxy resin systems tend to cost more than polyester resins, but they are a virtual necessity in some repair applications, such as with Sheet Molded Compound (SMC). Epoxy resins are also highly recommended for use with Kevlar® and carbon fiber.

The third type of resin, vinyl ester , possesses qualities that fall between polyester and epoxy resins for the most part. It excels above both, however, in the areas of corrosion resistance, temperature resistance (it’s good to 300 degrees F), and toughness. Common uses include boat hull repair, full tank construction and chemical storage tank linings. Like polyester resin, it is catalyzed with MEKP, but vinyl ester has as shorter three-month shelf life.

Part 2: Fabrics

There are many reinforcing fabrics available that are used with the resins discussed. The three types of reinforcing fabrics most commonly used are fiberglass, Kevlar® (Aramaids) and carbon fiber (graphite). Each possesses different qualities and advantages. All three are usually available at tows or rovings, veil mats and woven fabrics. Additionally, fiberglass is available as a chopped strand mat, which consists of short, randomly oriented fibers held together by a binder.

Carbon fibers costs the most to purchase, but it offers exceptionally high strength and stiffness, in combination with extremely lightweight. Kevlar® also offers lightweight, along with excellent abrasion resistance. It is, however, difficult to cut and wet out with resin. For finishing purposes, fabricators often use a surface layer of lightweight fiberglass cloth in Kevlar® laminates, because Kevlar ® is virtually impossible to sand once cured.

Most general-purpose applications utilize fiberglass cloth. Although it lacks the light weight and strength of carbon fiber or Kevlar®, it is considerably cheaper to purchase. Fiberglass cloth comes in a wide variety of styles and weights, making it ideal for many applications. High-strength weave styles are available, and these could be considered cost effective alternatives to the more advanced fabrics.

Mold Construction

The first step in mold making consists of plug construction and/or preparation. The plug may be constructed of nearly anything, as long as its surface can be finished well enough to give a suitable mold surface. As stated previously, the plug can either be an existing item or something fabricated specifically for the mold-making process. Some of the materials commonly used in plug construction include wood, plaster, metal and polyurethane foam. The latter comes either as pre-formed sheets or as a two-part “mix and pour” system that chemically reacts to form the foam. The “mix and pour” foam will conform to the shape of any cavity into which the ingredients are poured.

The surface of the plug must be finished at least as well as the desired surface on the part to be produced. In most applications, the preferred plug surface would be a perfectly smooth and polished class “A” finish. If a particular texture or pattern is desired on the finished part, it can be incorporated into the plug surface. A high quality, sandable surfacing primer such as the Duratec Grey Surfacing Primer (#1041-B), works well as the finish coat on the plug. Incorporate flanges and any necessary parting dams onto the plug at this point (see “Special Mold Construction Considerations.)

Before beginning construction of the mold, a release agent must be applied to the plug. This is the most important step in the process, because if the release agent fails to perform, the mold can’t be removed without damaging it and the plug. A little extra effort at this point is better than hours spent trying to correct damage to the plug and mold. The release agent can either be a combination of parting wax and PVA, or a one-step release agent such as FibRelease .

When using wax, apply four coats, waiting one hour between the second and third coats. After the final wax coat has been buffed, spray three thin mist coats of PVA and allow it to dry for 30-45 minutes. FibRelease can be wiped or misted onto the plug, and allowed to dry for 30 minutes. Be sure to apply the release agent to the surface of any flanges and parting dams.

For most molds, polyester resin and 1.5 oz/sq. ft chopped strand mat yield satisfactory results. Mold strength and thickness can be built up more rapidly by adding woven roving or tooling fabric. With polyester molds, the first step in making the mold is the application of the tooling gel coat, which is distinguishable by its bright orange color. Prior to its application, be sure to catalyze the gel coat at the proper ratio. For best results, the tooling gel coat should be sprayed onto the plug with a gel coat cup gun in three passes of seven to eight mils each, building to a total thickness of 20-25 mils.

The surface coat should be stabilized with an initial layer of mat within one and a half to five hours, in order to prevent the gel coat from shrinking or lifting off the plug surface. Apply a coat of resin to the surface and lay the mat into the resin. Using a bristle brush, apply the resin to the mat, coaxing the mat into the various contours of the plug. A dabbing motion is much more effective than a painting motion, as long strokes tend to pull the mat around.

All trapped air pockets must be worked out so that the mat is tight against the plug surface, and it must be uniformly saturated with resin. Air bubbles and dry areas will appear milky against the tooling gel coat . Use a bristle roller to work air pockets out of the mat and a grooved saturation roller to help compact the laminate. Watch for bridging (lifting) of the fibers across sharp corners and in textured areas. Any air bubbles remaining after the resin gels must be carefully cut out with a sharp utility knife and a match patch laminated in place.

Once the initial layer has cured, lightly sand it in preparation for additional layers, following the same procedure as with the initial layer. Most molds utilize 8-10 layers, but do not apply more than three to four layers at a time to minimize heat generation (exotherm). After the third layer of mat, a layer of woven roving or tooling fabric can be added t more rapidly build thickness. In general, a mold should be a minimum of twice the thickness of the part it is to produce.

Allow the completed mold to cure for at least 24 hours before attempting removal. Any support structures should be laminated to the back of the mold prior to releasing it from the plug. Release wedges can be inserted around the perimeter of the mold, between the mold and the plug, and gently driven into place in a progressive fashion. Air injection wedges, which attach to an air compressor, can be used to coax stubborn sections apart.

Once the mold is released, wash off any residue from the release agent with warm water and inspect the surface. Any imperfections must be ground out and repaired. You’re then ready to begin prepping the mold for part production.

Mold Maintenance

Before any part can be made in a new mold, it must be wet sanded and polished to a Class “A” finish. Wet sand the mold in a progressive manner, using 400, 600, and finally 1000-grit sandpaper. Be sure to change the water in your buck and rinse the mold surface when changing to a finer paper to insure none of the coarser grit remains. For polishing Fibre Glast Development Co. recommends using a two step polishing compound and a high-speed buffer. The first stage removes the sanding scratches, while the second polishes the surface to the desired finish.

After polishing the mold, apply a release agent to it, following the procedures outlined for prepping the plug. A new mold is often given an extra coat of the release agent as added insurance.

In the event a part doesn’t release properly and damages the mold, repair will be necessary. Any loose or damaged material must be removed by sanding or grinding, and new tooling gel coat applied to that area. A coat of PVA or wax paper placed over the repair will be necessary for proper curing. Once cured, the repair can be sanded and buffed as previously described.

Special Mold Construction Considerations

Part 1: Multiple Piece Molds

In some instances, the shape of the plug may require a multiple-piece mold so that the mold can be removed from the plug and subsequent parts removed from the mold. When making a multiple piece mold, start by constructing a temporary dam on the plug, along the desired parting line. This dam may be constructed of masonite or a similar material, and held in place with clay. A sharp corner without a radius must be maintained on the portion to be molded first. Any locating keys or dowels for realignment of the mold pieces should be added to the parting dam. With multiple piece molds, construct the entire mold before releasing any part of the mold, in order to avoid realignment problems. After the first portion of the mold cures, remove the temporary dam and use the completed portion of the flange to form the parting dam for the next half. Apply release agent to this surface before continuing the mold construction.

Part 2: Alternate Construction Methods

If durability and dimensional stability are important factors in mold construction, epoxy resin can be used in place of polyester resin . The procedure for this is much the same as with polyester resin, except that mat cannot be used with epoxy, as the binder that holds the mat together is not compatible with epoxy resins. Start with two or four ounce fabric to minimize prints through of the weave pattern. Then switch to a 7-10 ounce fabric. Be sure to place some layers on a 45-degree angle for good stiffness. Epoxy surface coats should be brushed onto the plug for best results. Because epoxies are less prone to shrinkage than polyester materials, immediate application of a stabilizing reinforcement layer over the surface coat isn’t critical.

If exceptionally rigid molds are required, carbon fiber can be used in place of fiberglass cloth. We recommend using epoxy resin with carbon fiber, and a flexible rubber squeegee works best for distributing resin through the fabric.

MOLDING PARTS: SELECTING MATERIALS

Once the mold has been properly polished and coated with a release agent, you can begin making parts! The first stage in the process of molding parts is determining which resin and reinforcements will be used. Having previously discussed the merits of the three main resins, we will concentrate here on the specifics of reinforcement selection.

After choosing the type of reinforcement to be used, the biggest factor becomes choosing the style (weave) and weight of fabric best suited to a given application. The three main fabric styles are plain weave, twill weave, and satin weave. In addition, fiberglass is available in ounces per square yard, with the exception of mat, which is expressed in ounces per square foot.

When fabrics are woven, the fibers are bundled into yarns running a 0 (warp yarn) and 90 (fill yarn) degrees. Plain weaves use an “over-under” pattern, while in a satin weave one filling yarn floats over three to seven warp threads before being stitched under another warp thread, and twill weaves are a “2x2” pattern. Plain weaves are the least expensive and are good general purpose fabrics, but they don’t offer the strength of satin and twill weave fabrics, but it is equally strong in all directions.

The lighter the fabric weight, the easier it will drape over contours and the less resin it will take to wet it out. Lightweight fabrics are most commonly used for surfacing and radio-control (R/C) hobby applications. Medium weight fabrics are most commonly used in repair and fabrication work. The heaviest fabrics are generally used for rapid thickness build up, such as in boat hulls and mold making.

Fabrics are sold by the running yard, generally in widths of 38, 50 and 60 inches, although not every fabric will be available in all of those widths. For a given project, choose a width that most closely approximates the width of the part to be made. The idea is to use as few separate pieces of fabric as possible per layer. The amount of resin needed will depend on the weight of the fabric selected. Fabric to resin ratios for most woven fiberglass and Kevlar® are about 50:50, while carbon fiber is 60:40. Fiberglass mat will require about twice as much resin as woven fiberglass for proper saturation.Extra strength can be built into parts by means of sandwich core construction. This process involves utilizing a core material, such as end grain balsa wood , polyurethane foam, vinyl foam, or honeycomb, between to laminate skins. Some core materials come in a variety of thickness, depending on the needs of a particular application. The strength and stiffness of a part can be increased significantly, with very little extra weight added to the part.

MOLDING PARTS: THE FABRICATION PROCESS

With the fabric and resin selected, you’re ready to begin molding the part. As stated previously, when using a mold for the first time, add an extra coating of release agent to insure a proper release. While the release agent is drying, take the time to cut the reinforcement to the proper size and number of pieces and stack the pile near your work area. If using mat, tear it into workable sized pieces instead of cutting it. The frayed edges of the pieces will intermix as they are placed in the mold, giving a stronger bond than when two cut edges are butted together. With woven fabrics, determine where the part’s strength needs to be the greatest and orient the fibers accordingly. With plain weave fabrics, a more uniform strength can be achieved by alternating the fiber orientation between 0/90 and 45/45 degrees.

The part fabrication process is similar to the steps followed in making the mold. When working with a female mold, start by applying the appropriate surface coat to the mold surface. This step isn’t absolutely necessary when fabricating parts, but a much better cosmetic appearance for the finished part will be achieved if it is used. Applying the first layer of resin and fabric directly to the mold surface can result in surface irregularities, pinholes, and print-through of the fabric weave pattern if a heavier fabrics is used. These blemishes can be corrected once the part is removed from the mold, but it will require tedious sanding and filling. Use of a lightweight fabric, such as two-ounce or four-ounce, as the first layer can minimize these problems if a gel coat or surface coat isn’t used. As an alternative to gel coat, Duratec Surfacing Primer can be sprayed into the mold, providing a durable surface finish.

Polyester gel coats come in either white or clear form, which is pigmented to a variety of colors. Clear gel coats reproduce colors very accurately, while white gel coats yield pastel colors. Epoxy surface coat is white in color, and can also be pigmented.

When applying gel coat to the mold, the best results will be achieved by spraying unthinned gel coat with a cup gun , in much the same manner as tooling gel coatis applied in mold construction. Slowly build up the gel coat in three passes, to a thickness of 15-20 mils. A gel coat thickness gauge is the best tool to use for determining the thickness. Check in several locations on the part to make certain an even coat is being applied. Too much of too little in some areas can cause wrinkling or distortion when the gel coat cures. When using an epoxy surface coat, it should be brushed into the mold.

Adhering to the guidelines in the mold construction section of the brochure, follow the gel coat with an initial stabilizing layer of reinforcement. If you’ve pigmented the gel coat and want the same color throughout the part, the resin can also be pigmented to match.

When laying up the reinforcement, try to utilize a single, uncut piece of fabric for each layer. Unfortunately, this is not always possible. Sometimes a part is too large to be covered by as single piece of fabric, so two or more pieces must be used. When two separate pieces must be joined together in a mold, it is best to overlap the pieces by one-half to one inch, as opposed to butting the pieces tougher. Butt two pieces together to form a seam only when maintaining constant thickness is necessary.

The contours and shapes of a part may also make it difficult to get good adhesion using a single piece of fabric. Indentations and sharp angles, in particular, present this kind of problem. Composites can be formed into many shapes, but it is very difficult to achieve sharp angles (90 degrees or sharper) with continuous pieces of fabric. The fabric will tend to life tin these areas, resulting in air bubbles and weak spots in the laminate. If a sharp angle is required in a part, the best way to approach it is by butting two cut pieces of fabric together at the turn. For added strength at these butt joints, mix a small amount of resin with milled glass fibers to form structural putty filler. Apply this to the joint before lying in the fabric. With indentations, it’s better to cut a smaller piece of fabric to fit the indentation rather than trying to force a larger piece of fabric down into it.

As with mold construction, use rollers and squeegees to thoroughly saturate the fabric, work air pockets out of the laminate and compacts the layers as much as possible. This will help avoid weak spots and delamintion problems into the finished part. As the layers of reinforcement fit into the mold, pay attention to the orientation of the fibers if using woven cloth, alternating the orientation by layer to increase part strength.

If a sandwich core construction is going to be utilized, determine which type of core material best suits the application. Polyurethane foam is very rigid and doesn’t conform will to contours, whereas vinyl foam can be heated ad formed to a variety of shapes. Balsa, which generally consists of small end grain blocks held together by a scrim of fabric, can conform to mild curves. Honeycomb core materials are very flexible and will bend to a variety of shapes.

Several steps must be taken to prep core material, in order to get a strong piece. After cutting and shaping the core material to the contours of the part, bevel the edges of the core’s perimeter to a 45-degree angle to smooth fabric transition. Mix a portion of resin with glass microspheres to a slurry consistency, and use this to fall any gaps, as well as splice multiple pieces or core material together. Pretreat open-celled foams and honeycomb cores with this slurry mix, in order to fill the open cells with something lighter than pure resin. Once these steps are completed, the core can be bonded in place.

When dealing with multiple-piece molds, almost always assemble the pieces of the mold before laying up a part. Laying up a part and then assembling the mold pieces will make it difficult to get a good bond between the pieces and a smooth cosmetic finish. The exception to this rule would be an enclosed item, such as a fuel tank, which would be impossible to lay up if the mold was assembled in advance.

If a compression mold is being used, the other half of the mold can be clamped to the first half once all of the reinforcing layers are in place. If a compression mold is not being used, but a smooth surface is desired on both sides of the part, a surface coat can be applied over the final layer of reinforcement. When the laminate reaches the “leathery” semi-cured stage, trim the edges with a sharp utility knife. Doing this now will significantly reduce finishing time and dust generation down the road.

Once the part has cured, remove it from the mold in much the same manner as the mold was removed from the plug. Any residue from the release agent can be rinsed off the part, and it can be finished in whatever manner is necessary. Finishing usually involves sanding down any seams and sanding the edges of the part.

Inspect the mold for any damage or dulling of the mold surface. If everything is fine, reapply the release agent when you’re ready to build the next part. If repairs or buffing and necessary, carry out those operations as previously described.

By carefully following the guidelines in this and our other brochures, you can produce molds and finished parts that meet or exceed your expectations. If something does go wrong, nearly any damage or problems can be repaired. Remember that working with composites is like any other new skill you learn: the more you work at it and practice honing your abilities, the better the results will be. Once you have mastered the basics, and then refined those skills, nearly anything is possible.

< in started 2B,Getting>

GETTING STARTED IN COMPOSITES
The exciting thing about composites is that an ordinary person can make things that they have never been able to make before, such as bathtubs, a boat, or a motorcycle! Race car bodies, canoes, airplanes, model aircraft, jet skis, boats, sculpture, as well as traditional industrial molding and modelmaking have taken on a new dimension as fiberglass becomes less of a mystery, easier to use, and easier to buy!

The materials that are used are easiest to understand when you think about something like a boat. A boat is hard, it doesn't bend, and it certainly doesn't take in water. Most people think of a boat as being made of "fiberglass".

Fiberglass is actually a textile. It comes on a bolt like a big, white bedsheet. The stuff that makes it hard (like a boat) is the resin. Resin is a liquid and is applied as a coating to the fiberglass. Unlike most household coatings, the resin requires a hardener. The hardener is also a liquid which, when added to the resin, causes a reaction which allows the resin to cure. When the resin (plastic) hardens in and on the fiberglass (reinforcement,) you have a reinforced plastic (like a boat.) Fiberglass is only one type of reinforcement used in composite work.

When the resin and fiberglass harden, they bond mechanically and chemically, forming a composite material. For most purposes, the terms "reinforced plastics", "composites", and "fiberglass" can be used interchangeably.

It takes several layers of fiberglass and resin to make a structure like a boat. The process can get more complicated as you try to reduce the weight of your structure and take advantage of the natural properties of composites. But the techniques and refinements are not all that tricky. Keep reading and enjoy! It's not as hard as you think!

Sometimes it is easiest to learn by watching. You might consider some of our videos in our catalog.

Reinforcements

The first step in choosing materials is to select a reinforcement. Glass fabrics, Kevlar®, and graphite (carbon) range significantly in both strength and cost. (Kevlar® is a registered trademark of the E.I. DuPont deNemours Company.)

E-glass:
E-glass ranges in cost dramatically. Low cost Chopped Strand Mats are ideal for rapid buildup whereas Woven Fabrics can be used for surfacing or weight critical applications.

Aerospace Fabrics:
The natural properties of fiberglass make it the ideal reinforcement for many applications where weight is critical. These are superior weaves and types which offer a natural balance between tensile, flexural, and compressive strengths.

Kevlar® and Aramid Fabrics:
Synthetic aramid fibers offer extraordinary impact resistance, which makes them ideal for canoes and high-performance boats.

Resins
The second step in choosing materials is to choose either epoxy or polyester resin. You may also want to consider a surface or gel coat.

Epoxies:
Epoxies offer high strength, high adhesion and impact resistance. They are temperamental and require temperatures around 75 degrees.

Polyesters:
Polyester resins are naturally resistant to ultraviolet light and are used more widely than any other type of resin. They are less troublesome than epoxies, but also require careful mixing and ambient temperatures.

Vinyl Esters:
Vinyl Ester Resins are typically used in applications requiring corrosion resistance including building and repairing chemical storage tanks. Vinyl Esters are often described as a cross between polyester and epoxy as it falls between them in both price and handling characteristics.

Gel Coats:
Gel coats are special polyester resins which are generally used on both part and mold surfaces. Gel coats are best used in a mold and are not recommended for surface repairs where paint would be suitable. Similar epoxy materials are generally called Surface Coats.

Tools & Accessories
Fiberglass work is very labor intensive! You want to make the job as easy as possible by making sure you have plenty of mixing containers, measuring tools, applicators, safety equipment, and accessories!

Applicators:
Applying the resin to a surface is best accomplished with mohair rollers or a brush. Working the resin into the reinforcement requires saturation rollers or squeegees. Spraying is usually recommended for gel coats and large jobs.

Mixing and Measuring:
It is important to measure the correct amounts of resin and hardener. Tacky surfaces are a common problem when the resin and hardener are not measured or mixed correctly.

Accessories:
Proper safety and hygiene equipment, thickness, and temperature measurement are all considerations. As well, advanced techniques, such as vacuum bagging, require additional equipment and supplies. We carry a full line of useful books and videos which will help you choose the accessories you will need for your project.

Applications
Aircraft:
Military, homebuilt, experimental, and commercial aircraft have used composite materials for years.

Art:
Stage sets, amusement parks, museums, and zoos find fiberglass easy to use and able to withstand outdoor environments when necessary.

Automotive:
Beyond simple repair, car and motorcycle racing have used composites extensively. Buses, trucks, and bicycles have found increasing use for composites.

Industrial:
The unique corrosion resistance, strength-to-weight, electrical conductivity, and formability of composites lend themselves to an increasing variety of industrial applications.

Marine:
Boats, jet skis, paddles, canoes, kayaks, and buoys are a wide variety of examples where the ability to withstand prolonged exposure to water, salt, gasoline, chlorine, and ultraviolet light is critical.

Radio Control:
Radio controlled aircraft, boats, and cars use composites extensively to obtain the critical reduction of weight.

Techniques
Laminating:
The advantages of applying a protective fiberglass layer over another substrate such as wood are primarily waterproofing and extension of life. Thin layers of resin are sometimes difficult to cure and special attention is required to make laminations turn out as expected. Careful application can result in a surface where substrate is complete opaqued or beautifully highlighted.

Molding:
The most common fiberglass technique is molding, which allows making several identical parts. The most critical step is in construction of a flawless plug which will result in a flawless mold. Construction of a mold is quite time-consuming, but a good mold will result in numerous perfect parts. Most fiberglass materials are developed to be molded, and exposure to air can actually damage and inhibit the performance if they are not molded!

Sculpting:
By sanding a block of polyurethane foam to any shape, a colored, smooth, and durable form can be created by laminating the foam with fiberglass. Often, the fiberglassed form is painted for detail. Additionally, casting of clear polyester resin enables a long life clear casting, which is difficult to obtain with other materials.

Vacuum Bagging:
By adding pressure to a laminate, excess resin can be eliminated which will reduce overall weight and optimize strength. To add pressure without crushing the part, vacuum bagging is used. By placing the part in a bag, a sealed area is created into which vacuum can be run. The resulting vacuum pressure squeezes out excess resin. A vacuum pump is required and the process is usually conducted while the part is in a mold.

< Core Sandwhiching for Guild 3,>

GUIDELINES FOR SANDWICH CORE CONSTRUCTION
The rising demand for new materials with higher strength to weight ratios has created a dramatic growth in sandwich composite technology. Sandwich construction employs a lightweight core that has a flexural strength and flexural modulus far exceeding that of the skin laminates alone.

The normal method of building a composite sandwich is to laminate the outer skin by conventional means in a mold then lay the core material into the wet laminate. The inner skin is laminated onto the top of the core material effectively sealing it. Sandwich core laminates of this type are used to stiffen various composite applications such as boat hulls, automobile hoods, molds, and aircraft panels. By increasing the core thickness, you can increase the stiffness of the sandwich without substantially increasing weight and cost.

The most common types of core materials are:

Nomex® Honeycomb
Vinyl Sheet Foam
End Grain Balsa
Polyurethane Foam
Mix and Pour Polyurethane Foam
Nomex® Honeycomb

Honeycomb is a series of cells, nested together to form panels similar in appearance to the cross-sectional slice of a beehive. In its expanded form, honeycomb is 90-99 percent open space. Nomex honeycomb is fire retardant, flexible, lightweight, and has good impact resistance. It offers the best strength to weight ratio of the core materials. Nomex honeycomb is used primarily for structural applications in the aerospace industry.

Vinyl Sheet Foam

Vinyl sheet foam is one of the most versatile core materials on the market. It is a rigid, closed cell material that resists hydrocarbons, alkalis, dilute acids, methyl alcohol, sea water, gasoline, diesel oil, and it is self extinguishing. It has been used extensively in aircraft and performance automotive structures, but it can be applied anywhere that high properties and easy handling are needed. Vinyl foam can be thermoformed in an oven or with a heat gun while applying gentle pressure. For ultimate peel strength, use a perforation roller to increase the surface area of the foam. The peel strength will increase an additional 15-20% after perforation.

End-Grain Balsa

End-grain balsa is the most widely used core material. It is both a relatively high strength core and less expensive than vinyl or honeycomb. It achieves its high compression strength because on a microscopic level it has a honeycomb type of structure yet is quite dense. It is easy to cut and bevel and is available in 29x49 inch sheets. The individual small blocks of end grain balsa are bonded to a light scrim fabric which makes the sheet quite flexible.

Polyurethane Sheet Foam

This sheet foam is a rigid, closed cell material with excellent thermal insulation and flotation properties. This core has been at the heart of the marine industry for decades and is fairly inexpensive when a lower property cored laminate is needed. It is compatible with both polyester and epoxy resin systems.

Mix and Pour Polyurethane Foam

This foam is a rigid, closed cell material with excellent thermal and floatation properties. While it is not generally suited to the classic sandwich core laminate described in this brochure, it can be poured into any closed cavity to stiffen the structure. The free rise density is 2 lbs. per cubic foot, but closed mold techniques can increase the density when required. Small amounts of this foam may be added to the Nomex honeycomb to fill the cells. The filled honeycomb is then much easier to bevel and shape.

Practical Guide to Handling the Core Materials

To maintain the effectiveness of the sandwich structure three conditions must be met. First, the core must be strong enough to withstand the compressive or crushing load placed on the panel. If the core collapses, the mechanical stiffness advantage is lost. Second, the load bearing skins must form a rigid bond to the core surfaces so the skins don't creep or peel during use. This interface is called the BOND LINE. Finally the core must resist the shear forces involved. If the core shears, the skins shift and the mechanical advantage is again lost.

Once the proper core material has been selected based upon compressive and shear strengths, the skills of the fabricator become critical in determining the quality of the bond line. Here are some helpful hints for maximizing the strength of the bond line.

Increase the Surface Area
Increase the Pressure
To guide the fabricator through real world production obstacles care should be taken to:

Carefully bevel the edge of the core
Reinforce all holes cut or drilled through the core

< Surface Mold and Preparation Plug 4,>

PLUG SURFACE PREPARATION AND MOLD SURFACE MAINTENANCE
The majority of current composite applications focus on molding for rapid part reproduction and maximization of the material properties themselves. Regardless of the type of mold used, female cavity or male plug, the mold surface is critical. This brochure describes the techniques necessary to achieve a Class 'A' mold surface finish as well as the steps required to maintain it.

The mold surface affects three important areas of the molding process. First, the quality of the mold's cosmetic finish will be reproduced in every part. Regardless of whether it affects the physical performance of the part, every customer will judge your work by the surface quality. It is much easier to perform the steps one time on the mold surface than to touch-up every part after it is finished. Second, the mold surface affects the release characteristics of the mold. Any imperfections can contribute to adhesion problems. When a part sticks in a mold, extreme measures are often used to force the release. These can lead to broken flanges and mold edges, gouges on the surface itself, and destroyed parts or molds. Finally, the mold surface coat is the protective barrier to the rest of the mold. Just as boats and other fiberglass structures can deteriorate due to exposure, a porous mold surface permits water, chemicals or other harmful agents to enter into the structural laminae below. For these three reasons, all molds will benefit from the procedures described below.

What is a Class 'A' Surface Finish?
A Class 'A' finish is a perfectly polished high luster surface free of porosity and scratches of any kind. The term originated in the marine and automotive industries. Examples of such a finish can be found on high quality boat hulls and automobiles. However, those finishes are achieved through two different procedures. Cars have primers and paint systems sprayed over medium quality metal surfaces. The paint flows into a self-leveling thin film and requires polishing to achieve a true Class 'A' surface. The boat hull, however, receives its finish directly from the mold itself. If the mold has a Class 'A' finish all the parts produced in it will also have the same high quality surface. Construction of quality molds can decrease final finishing time and increase overall part quality.

A Quality Mold Surface Begins At the Plug Stage
Final plug preparation directly influences the quality of the mold surface. Every detail, good or bad, will be reproduced in the mold. Do not expect to remove defects or flaws after they have been transferred to the new mold surface. While it is true that many irregularities can be removed or smoothed by sanding the mold surface and repolishing, those operations increase porosity and reduce the thickness of the tooling coat. The tooling coat was applied in the proper thickness

originally for a number of reasons. Generally, the less the tooling coat is sanded the longer its service life will be. Also, even light sanding of the mold surface can change the dimensions of the finished parts. This is unacceptable for many close tolerance molding applications.

The steps to creating the Class 'A' finish on the plug are the same as for the mold surface and will be described below. However, there are some differences between materials which are worth noting.

1) Seal the Plug
The plug must be sealed in a material which is heavy enough to hide the multiple shaping compounds used below and durable enough to be sanded and polished to a mirror-like luster. Few primer/ sealers are able to do both. Varnish, lacquer primers, paint and gelcoat have been used to seal wood, metal, plaster, plastic, foam and fiberglass shaping compounds for years. Varnish, paint and primers often don't hide completely and are too porous to polish adequately. Gelcoat is certainly heavy enough to hide the underlying substrate, but it is difficult to spray evenly and can require back breaking sanding efforts to polish smoothly.

2) Duratec Surfacing Primer
Duratec Surfacing Primer is gaining widespread acceptance as the plug surfacing compound of choice for the marine, automotive, and patternmaking industries. It is a polyester based primer which has numerous advantages over all the products used in the past. First, it can be sprayed though conventional automotive type siphon or HVLP guns which offer the best control and delivery of any system on the market. The more evenly the primer is applied the less sanding is necessary to achieve a smooth finish. Second, it is a high build material which fills many surface imperfections and effectively hides all the layers beneath it. Third, it sands easily. Begin with 220 grit if necessary and proceed through 1000 grit before buffing. Finally, it is specially formulated to develop and maintain a highly polished finish. When sprayed at correctly at 35-50 psi, the surfacing primer has very little porosity to interfere with the luster.

A properly shaped plug covered in a coating of highly polished Duratec Surfacing Primer is the perfect starting point for molding. Follow the next steps to transfer the Class 'A' plug finish to the final mold surface.

The 5 Steps to Developing a Class 'A' Mold Finish
1) Start with a Class 'A' finish on the plug. As stated above, this step cannot be overlooked. It is perhaps the most significant factor in the mold surface preparation process. Steps two thorough five need to be followed to prepare the Class 'A' plug surface as well as the mold surface.

2) Follow the manufacturers recommendations for mixing, catalyzing and applying the tooling coat exactly. Excessive catalyst or thinning agents can drastically reduce the performance of many surfacing agents.

3) Sand the mold surface and edges using 400 grit or finer wet/dry sandpaper. If a significantly coarser paper is needed for leveling the surface, something went seriously wrong with either step 1 or 2. If this is the case, proceed to the repair section of this brochure for instructions before going any further.

Continue sanding the mold surface with finer grit paper. Follow the 400 grit with 600 and then 1000 grit. Remember to change the water and rinse the mold surface when switching to the finer paper as minute sanding particles the size of the previous grit will otherwise remain on the surface. These particles will leave scratches coarser than the new paper is able to remove.

4) Wash, dry, and inspect the surface. If any scratches remain, back up and sand using the finest paper which will remove the texture.

5) Use a quality polishing compound and buffing wheel to polish the surface to a high luster. Again, follow the manufactures recommendations for the products used. If there are two compounds available, use them in their intended sequence. Do not plan on skipping one of the two and still getting the desired results.

Clean excess polishing compound from the pad frequently. Large clumps of compound can actually scratch or streak the surface again requiring more removal work. If a high speed buffing wheel is used, do not work in one area too long or the compound may burn through the tooling coat. Move quickly at first to prevent problems until experience is gained.

Areas which cannot be reached using the buffing wheel must be polished by hand. Apply the needed amount of compound to a clean terrycloth towel, diaper or cheesecloth. Be sure the fabric is soft and will not scratch the mold surface. Remove rings, watches or other jewelry which could scratch the mold surface. Some people even clip their fingernails. It may be difficult to achieve the same luster, but hand polish the surface until it resembles the areas which were machine buffed.

Wipe the surface with a clean rag to remove any remaining polishing compound.

Condition the surface for release following the instructions provided by the manufacturer of the release agent.

If these five steps have been followed, the resulting molds will have a Class 'A' surface finish. The parts produced in them will require very little post finishing and the molds will actually last longer than poorly finished types.

How Long Will the Gloss Last?

Every mold and release system functions differently, but some generalizations do exist. Well conditioned polyester molds can often produce 20-40 parts before needing attention. Epoxy tooling coats are even more durable. Since release agents provide the only barrier between the mold and the part, they do help preserve the surface finish. Selecting a quality release agent will maximize the gloss retention of the mold. If the surface finish is extremely critical it should be inspected following the cleaning procedure and before the next production run.

Mold Surface Maintenance
Proper maintenance of the Class 'A' finish can significantly increase the lifespan of the mold. A Mold Maintenace Program usually consists of regular inspections of the surface and the structural elements of the mold. When the surface dulls, it is time to clean and repolish the mold.

All molds are slightly affected by the heat generated during the cure cycle. Additionally, styrene can build up on molds used to make polyester parts. It makes the surface appear cloudy or chalky white. Epoxy molding does not usually leave residues but the molds will still benefit from periodic polishing.

Before polishing can begin the mold release must be stripped from the surface. Use wax and grease remover or other recommended product to wipe the release agent from the mold. Evaluate the condition of the mold surface. If deep scratches are evident, use 600 or 1000 grit paper to remove them. Otherwise, follow the same polishing schedule that was used to develop the original Class 'A' finish.

Mold Repair
Mold repair can be categorized into two types: structural or resurfacing. Structural damage is usually obvious, but subtle cracks in the mold surface are often due to structural damage below. To fix the cracks, the mold may need extra reinforcement followed by resurfacing. If the structural damage is severe, it is often cheaper to remake the entire mold than to refurbish it. If no pattern exists or the structural damage is relatively minor the repair can be performed like any other structural repair.

Structural repair is beyond the scope of this brochure, however we do offer a complete guide on this subject. A variation specific to mold repair is worth noting. Specifically, it will be necessary to clamp or support the mold so it is not distorted while curing.

Mold resurfacing is a realistic option to mold replacement if only the surface has deteriorated. Once again, the Duratec Surfacing Primers are the products of choice for upgrading polyester tools. However, the surfacing primer can be sprayed on epoxy molds once the surface has been properly prepared. For strong adhesion of the surfacing materials, remove enough of the existing gel coat so that all contaminants and porosity are eliminated. The older and more porous the mold, the greater the amount of gel coat that must be removed. Begin by sandblasting or sanding the surface with 80 grit paper. If only a portion needs to be recoated, mask off the remaining areas thoroughly. Apply 10-15 mils of Duratec Surfacing Primer to seal the exposed gelcoat porosity and provide a surface barrier. When cured, block sand the surface up to a 180-grit finish and wait overnight for it to fully cure. Develop the final contours by sanding the primer with 180-220 grit paper. This sanding operation is important because the final top coat is relativly thin and will not hide imperfections.

The addition of 15% Duratec Hi-Gloss Gelcoat Additive to polyester tooling gelcoat will yield a blend that is easily sprayed to form the final mold surface. Use conventional automotive spray equipment to apply a fine mist coat. Wait 2 minutes for the solvents to flash off, then continue building wet coats to 6-10 mils or thicker if desired. Spray pressures should be 35-50 psi. There is no need to inhibit the cure using styrene wax as the Hi-Gloss tooling blend will air cure to a hard, glossy finish in 4-6 hours. Wet sand beginning at 220-grit to 1000-grit finish and wait overnight for the surface to fully cure. Remove any remaining scratches with the polishing compound.

Mold Storage
How a mold is stored between uses is an important aspect of mold maintenance. Here are a few tips:
1) Always put the molds away clean. Begin by scraping resin build-up from the edges and flanges. Use compressed air to blow debris off the mold surface. If an air source is not available, wipe cautiously so the surface coat is not scratched. Finally, remove excess release agents remaining on the mold. Follow the suggestions of the release agent supplier if more than soap and water are necessary.
2) Inspect the surface for defects. Pull the mold from the production schedule if any serious problems are detected. It is usually cheaper and quicker to correct a flaw before it becomes a major problem.
3) Store the molds on their support structures if they were constructed with them. Assemble multiple piece molds or store them in such a way that supports each component evenly so distortion is not a problem. If possible, store molds with the cavity side down so dust does not collect within them.
4) If molds are to be stored for extended periods, spray a heavy coat of PVA over the surface. This can keep paint mists and other overspray often found in the shop environment from settling and sticking to the mold surface. Rinse away PVA before reusing the mold.

Conclusion
If these procedures are followed, your plugs and molds will achieve the highly desirable Class 'A ' surface finish. The parts produced in the molds will have a better surface quality, require less finishing time, and the molds will have a longer service life. Proper storage and maintenance procedures should be followed to minimize downtime of the molds. Finally, Duratec surfacing products reduce the effort and cost of refurbishing mold surfaces. This can extend the life cycle of the mold significantly.