FRP Techniques

A Comprehensive Guide. How to install and prepare fiberglass and composite bodywork for Porsches

By Mark A. Bartosh
Getty Design

IMPORTANT

We wrote this manual to help people fully understand the correct way to install and refinish fiberglass and composite parts. While everything will be explained in detailed if you read FRP TECHNIQUES, Let me summerize the important steps exactly how to go about putting a new part on a car.
Then you should consult the specific How To, chapter for your application.

1. *First check for any shipping damage.*
2. *Physically bolt the part onto the car. That means put the hinges on put all the bolts, washers and shims in place. Adjust all the clearances. In short do everything needed to come up with a perfect fit, and this includes, sanding or grinding high spots now and filling low spots later. If something is sticking up or a corner needs to be relieved, do it now. Composite parts are to be hand fit to the car and you are encouraged to take all steps necessary to do it.*
3. *Post Cure, Post Cure, Post Cure! I can't stress this enough. If you paint a part right out of the box, and omit this step when the laminate cures it will ruin the look of your fresh shiny paint job. See page 8*
4. *Aggressively sand the whole piece with at least #80 sandpaper, to remove all the print through and to block out any surface imperfections.*
5. *Above all use your head. Most of these installations should be done by professionals and if you are a service or a paint and body technician, diagnosing problems and solving them is your job. Figuring out why an engine has a misfire or how to straighten a bent chassis is a daily occurence; so applying a little bit of critical thinking when installing composite bodywork shouldn't be too difficult. Listen to what we have to say. I guarantee you we've installed and painted more fiberglass parts than you can believe. By 1993 our shops had already done over 75 full 959 rebody and paint alone. Since then we've quit counting all the numerous RS, C2, 993 and 996 conversions that we've done.*

Now let's consider how long it normally takes to properly prepare something common like a tailbase.

.5 To remove the old decklid or base.
1 To hang the new one and make the basic adjustments.
1 continue with fine tuning, the surfaces,seams, edges, etc.

Now cook it. This doesn't really require any man hours, whether its done in the sun or with the aid of a heat lamp.

1 Completely sand it with 80 grit. If it takes any longer than an hour you aren't really trying and if you try to use a finer paper like 180 or 220 its a waste of time because they won't cut print through or level surface problems.
.5 Primer
1 Sand it again. But this time go over it first filling in any little problems like pin holes first. Primer sands much easier than Gel Coat so this time it will get done faster. Step 7, page 12.
.5 Primer again.
1 Wet sand.
1 Final color coat.
1 Install.

Conservatively that is a little over 8 hours. Now consider that the factory service manual allows almost 10 hours for this operation. 2.5 to R&R and 7 to prepare and paint.

Congratulations , you have just purchased the finest,highest quality FRP/ Carbon Composite replacement part available. Proudly made in the USA by skilled technicians.

Before you begin the installation take a few minutes to read these instructions. FRP stands for , Fiber Reinforced Plastic and we've been manufacturing and installing fiberglass and composite body panels for over 15 years. Over the years photos of cars with our parts have graced the covers of over 100 magazines worldwide. When it comes to FRP body work we have a tremendous amount of experience. We know how it should be done and what it takes to do the job right.

Listening to peoples concerns, it is clear that there would be fewer problems with installation, preparation and painting if there was a source to turn to for answers. For instance it is common knowledge that when doing a brake job simply replacing brake pads when the rotor is warped or scored will not yield good results. The same type of thinking is true for bodywork. This will cover the basic do's and don'ts of fiberglass bodywork. What you should do and what you shouldn't do. We will help to take the mystery out of working with fiberglass by explaining why things are done a certain way.

PHOTO 1.
Why is this man rubbing a screwdriver on this Ducktail? Read on and we will explain.

Explanations and procedures will be geared towards getting the best possible results and these are the exact same methods that have been used in our shops for the past 15 years. Porsche's are rare and expensive automobiles and coachwork changes should be done to the highest standards. I'm reminded of the old Bell helmet ad. "If you have a $20 head get a $20 helmet." Keep this in mind when you are shopping for new bodywork.

Throughout this booklet analogies will be drawn between working with fiberglass and performing other operations on cars such as rebuilding the engine. I find that more people are comfortable or have more experience with the mechanical aspects than with hanging bodywork. Drawing these comparisons will help you understand what it really takes to install and refinish FRP bodywork.

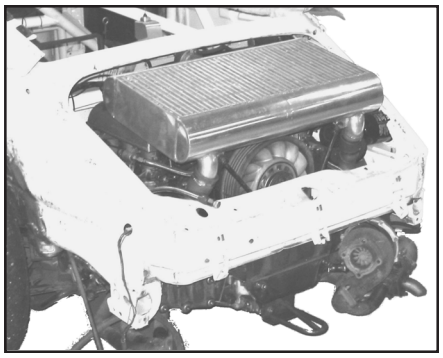


PHOTO 2
This engine costs in excess of $40,000. Doesn't it deserve to be dressed in the best bodywork?

The majority of parts end up at a professional shop for installation and whereas most shops would not hesitate to rebuild a turbo motor many hesitate to tackle bodywork. From what some shop owners tell me, part of this reluctance is because they aren't used to doing it and even worse , part may be from a previous bad experience with some poor quality parts. In reality hanging bodywork requires no special talent and is as logical as anything

mechanical. And just like tackling an engine rebuild with a hammer and crescent wrench is going to produce mixed results. It's much easier if you have the proper tools when working with FRP composites. An assortment of special tools like disc grinders , die grinders, and cutters will greatly simplify the task.

FIRST IMPRESSIONS / GETTING ACQUAINTED WITH YOUR PART

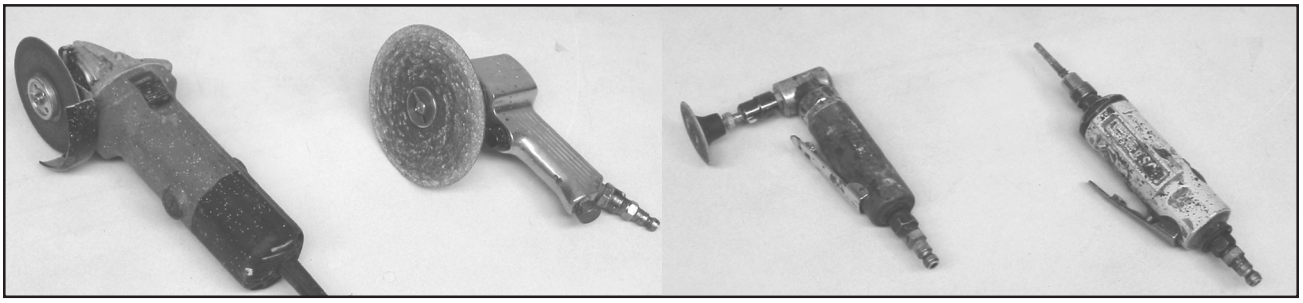


PHOTO 3
Some of the commonly used tools for fiberglass fabrication. From left to right; Makita Disc Grinder, 5" Grinder, Right Angle Grinder, Die Grinder, ...

Let's get to work and understand what we are dealing with. FIRST. Your part has been shipped in essentially a bare gel coat finish. Depending on the complexity of the piece, several hours of detailing by hand has already been done at our factory. The flanges have been ground, the parting lines sanded and imperfections have been repaired. But most importantly, it still has the original gel coat finish just as it came out of the mold and it is not camouflaged with a heavy orange peely coat of primer. There are 3 very good reasons why it is a good idea to shy away from companies that advertise all their parts as primered and ready to paint.

1. The best way to locate surface imperfections, (and every part has them), is to simply examine the surface reflections on a shiny part.

2. No professional I know is willing to guarantee his paint job on top of some mystery primer and somebody elses mistakes and when all is said and done , the perceived time savings turns out to be quite the opposite, often causing the installer to spend more time preparing a part.

3. Composite parts must be thoroughly post cured before any bodywork is started.

SHINY IS BETTER

Let's consider reason number 1. On a shiny part its easy to spot any ripples or waves or any surface imperfections that need additional work before the part is painted. And as was mentioned earlier every part has them.

The after market fiberglass/composite parts business for Porsche is relatively small. Parts runs number in the tens or hundreds only. This small number of parts sold and their relative complexity rules out any

type of automated production. So the vast majority of bodywork is made by hand. There isn't anything wrong with this. Indy cars are built by hand, F1 cars are built by hand, heck even the space shuttle is built by hand. All this does is open the process up to normal human error. Errors in molding the original part, in making the mold and in laminating the new part. So over the years I have seen thousands of different parts and I can't think of many that would not have benifited from sanding with at least some 80 grit and filling with a little Bondo and that includes factory originals.

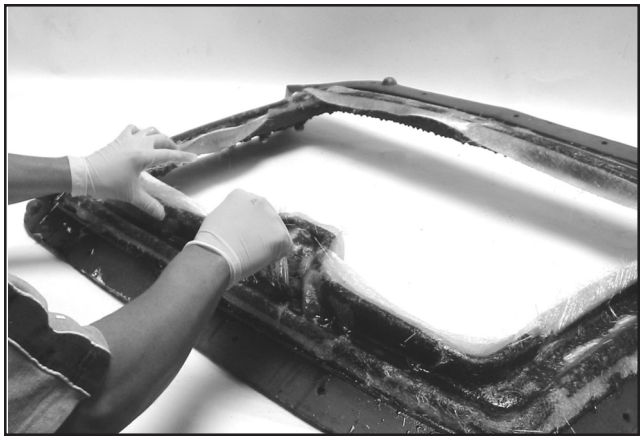


PHOTO 4
Hand laminating a Decklid Liner
In this photo the laminater is "wetting out" mat and cloth. Forming it to the contours of the liner mold section.

A certain amount of prep work is necessary. Before I got into the bodywork end of this business I worked as a Porsche mechanic for about 15 years. In that time I'd built hundreds of Porsche engines and I knew there was a right way to do things and a wrong way. If I was putting a new set of pistons into a race motor they weren't just going to go straight out of the box into the motor and off to the track. No, the pistons were going to be checked and balanced, deburred, test fit on the rods, the skirt clearances were checked, the piston to head clearance was checked, the piston to valve clearance was checked, the actual compression ratio was measured and then before assembly everything would be carefully oiled, the rings staggered and then the barrels would be installed. By the way do you know that rings rotate in a running engine. Its slow something on the order of a few RPM but this is getting away from the point, which is there is a correct way to go about mechanical things and the same is true for bodywork.

PHOTO 5
Example of a poorly made bumper.
Notice how the top edge of this bumper is severly warped. This is an example of part that should be returned as unsatisfactory. The amount of time and energy needed to repair the warping exceeds the initial cost.

On a well made high quality part a small amount of sanding/filling will fix almost any problem. A cheap poorly made part may require hours and hours of hand work and still be unsatisfactory. One of the goals of this book is to help the user distinguish between parts that require normal prep work and those that are beyond hope and should be returned to the seller. Once you are familar with high quality parts, you won't go back to trade hours of reworking for a budget price. Afterall time is still money!

So the fact is every part is going to have some surface problems that have to be addressed before painting. Whether they are big or small the absolute best way to locate them is to carefully examine the surface of a highly reflective part.

Consider this real world scenario. Say you want to update an early chassis with some late model doors. A guy has a nice set at the swap meet and the price is right. The only problem is while the drivers door has the nice original paint the passenger door has been completely shot with primer. How does this affect the preparation process? Well the left door is a gift. Bolt it on the car, make all the shim adjustments, wipe it off and check the surface for any dents , dings or waves. Even the slightest imperfections stand out on a nice shiny surface.

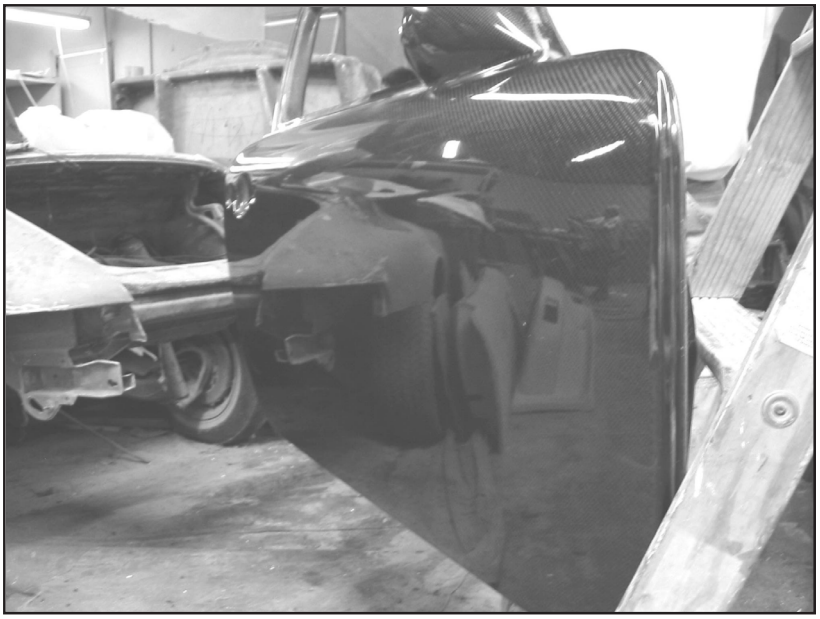


PHOTO 6
Highly reflective door surface.

The right door is another story, it's going to take a lot of work just to figure out how much sanding its going to need. My first impression would be 'why the primer, what's it hiding'? Since you can't see any but the biggest problems under a flat coat of paint they will have to be felt. Rubbing your hand over a super smooth surface is an excellent way to detect problems but it doesn't work all that well over rough primer, so it's time to go back to basics. That means sanding and buffing the surface back to a mirror surface.

PHOTO 7
Block sanding a door
Using a long board file to hand sand a door to remove dents and waves

The first thing I would do is start block sanding with an #80 grit paper on a long board file. As the primer is sanded off the various problems underneath will reveal themselves as high or low spots. Areas where the board sanded off the high spots or glided over and didn't touch the low spots. After dry sanding with #80 it's time to block it again with #220 wet, and then with #400 wet. Now it's smooth enough to buff and shiny enough to bolt on the car and check just like we did with the first door. Finally after all that work you can check the reflections to see just how much more sanding might be needed. Whew! I've sanded hundreds of doors and trust me it's a lot easier when you can just see the problems right off the bat.

Take for example our hoods, they are far and away the best on the market. With vacuum bagged

urethane cores and compression bonded liners these are excellent ,high quality parts. They are light and stiff and hold their shape at speed and won't ' oil can' like some others. In fact where as little as 10 pounds of pressure will deform most plain Jane fiberglass hoods ours will support up to 50lbs. The complicated aerospace style manufacturing process we use generates an exotherm and this shows up as a slight print through on the surface, but, the point is it's easy to see and a little sanding with #80 on a DA and it's gone.

YOU CAN'T TRUST ANYONE THESE DAYS

Number two is important because it goes to the heart of human nature. In our shop, if a part is going to be painted the lowest guy on the totem pole is assigned the task of completely sanding the the entire surface with #80 grit. This is because it doesn't require any particular skill, and is a perfect job for someone just learning. Give him a piece of 80 and come back in 30 or 60 minutes and most anything from hoods to tailbases can be completely sanded. But here's the rub, when I come back to check, (and the only way to do this is by carefully wiping the part down with a solvent), there are always a few areas that are still shiny and have to be redone. This is a major problem if the sanding isn't done conscientiously because the new primer or paint won't adhere properly to the surface.

PHOTO 8
Initial sanding.
In this photo a 996 Tailbase that has already been Post Cured and checked for air bubbles is being sanded with #80 grit paper . This will remove the print through and any small ripples and imperfections.

You see when a part comes out of a mold, (in the business they are referred to as tools), its outer surface, the gel coat, is covered with the mold release, the wax used to prevent the part from bonding to the inside of the tool. Normal mold release contains a lot of silicone ! Kind of like automotive paste wax on steroids. Some of the newer chemical releases are even worse. If this contamination is not removed before any primer or bondo or paint whole sections of the finished paint job can peel off. Did you ever see a cheap respray that you could strip off with a razor blade? I've seen dozens. They 're always the ones where they failed to properly prepare the original surface. Instead of aggressively sanding the original paint base to provide a good mechanical grip for the primer , it was just wiped down or sanded very lightly with too fine a paper. Result, catastrophic paint failure.

A few things happen with these so called ' ready to paint parts'. First , the primer is sprayed on so thick and full of orange peel, that the sander has to use at least #80 grit just to cut through it. Then since you can't see the surface problems that need to be fixed, they have to be felt. But you can't really feel the

ones that make paint jobs look bad without sanding with at least #400 wet. Then once you figure out where the problems are its time to go back and resand with coarse paper to remove the problem or provide a base for some filler. More like a total waste of time than a time saver.
And if the paint job blisters because the first coat of primer was applied incorrectly over a poorly sanded surface , instant comeback!

Some pistons come preinstalled in the cylinders. Would you ever consider taking one of these out the box, sliding the piston down just far enough to slip the wrist pin on the rod and then install it for the first and last time ? Well I wouldn't either.

ARE YOU READY TO DO SOME COOKING?

The third reason why you should stay away from primered parts has to do with a little bit of resin chemistry and a very important process called, 'post curing'. Not being aware of this phenomenon can spell the difference between show quality paint and a botched job the customer refuses to pay for.

This all boils down to the fact that fiberglass shrinks as it cures. A laminate shrinks up to about 5% in all directions as it cures and there are TWO distinct cure cycles for FRP.

PHOTO 9
Waxing molds.
Wax is one type of release agent that prevents parts from sticking to the tool.

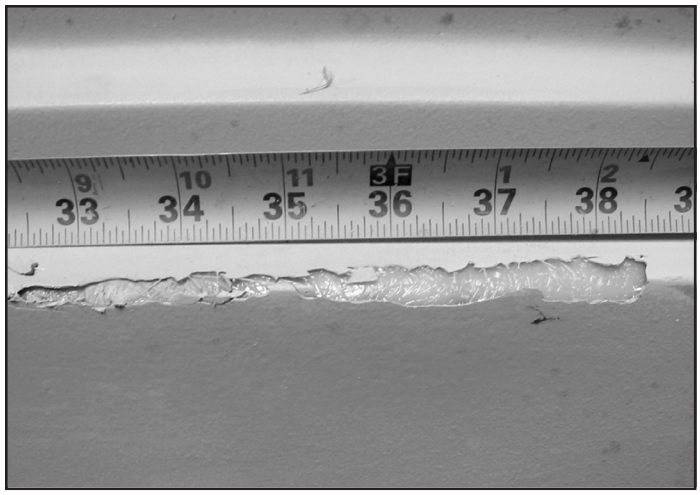


PHOTO 10
Air Bubbles
Remember Photo 1? Conscientiously rubbing the round shaft of a screwdriver over all the seams and edges of a part will break out any air bubbles that are just beneath the Gel Coat. In this case this large air bubble was found on a supposedly " primered, ready to paint", part. Imagine what this would have looked like if it broke after the bumper was painted. Ultimately this is the installers responsibility to check for any hidden flaws.

The first is the room temperature cure that occurs in the tool , when the catalyzed resin kicks off and the laminate hardens. The second and more important cure happens after the part is removed from the tool and subjected to a much higher temperature. This is the post cure. Post curing has a dramatic effect on

the part. As the temperature increases so to does the molecular activity and polymerization becomes complete with the ester molecules, (remember polyester resin), cross linking and forming a strong resin matrix.

Under controlled conditions the temperature can be ramped up gradually, only 5-10 degress an hour until the upper limit is reached. The maximum temperature used during a post cure is refered to as the 'HDT, the heat distortion temperature .' This figure is determined by the resin manufacturer, with a good HDT of about 200 degrees F for a quality polyester resin.

Post curing will actually make a stronger part with better high temperature characteristics.

Also during the 'cooking' process the laminate is expanding as it heats up and volatile organic compounds are evaporated. The resin, which expands many more times than the glass reinforcement, when its heated pushes the fibers out toward the surface. The resin also is shrinking as it loses some bulk. Combine the two and you get 'print through'. That ripply surface appearance where you can plainly see the texture of the material underneath. Either the random cross hatching of chopped strand fiberglass mat or the regular patterns of woven fabric like carbon cloth. This is also refered to as the surface profile. A high profile exhibits a lot of print through while a low profile surface is relatively smooth.

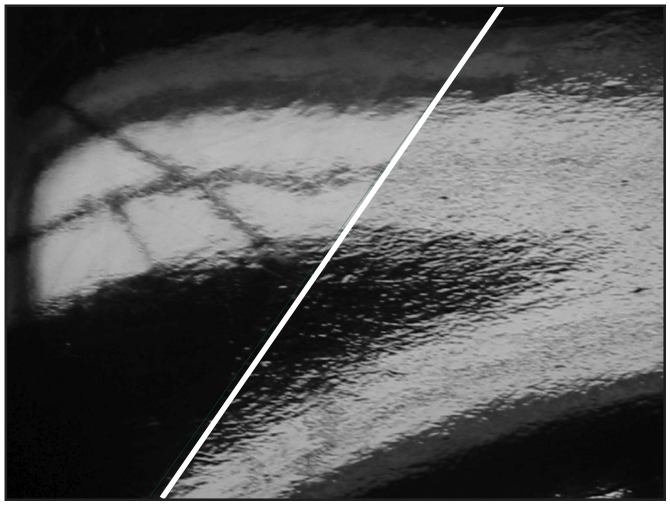


PHOTO 11
Print Through
This picture shows the effects of a thorough Post Cure. The right side of this section of a BMW hood was cured in the sun for several hours, reaching a temperature of 180 degrees, while the left side was covered. The difference in surface textures is dramatic! Imagine what the surface finish would look like if the part post cures after its been painted.

The thickness of the gel coat will help control print through. Gel coat is also a polyester based resin that has several uses. It protects the mold surface. It forms the smooth outer color layer of the part and it helps reduce print through. Gel coat is applied to a thickness of 20 mils or more . Compare that to regular paint which is sprayed on at only 2-3 mils.

During the normal process of lamination many small air bubbles are trapped in the resin/glass matrix. They are usually small, less than the size of a pin head but if they were at the outer surface it would be tedious to continually fill them in each time the surface is sanded and more are uncovered. The gel coat acts as a barrier layer pre-

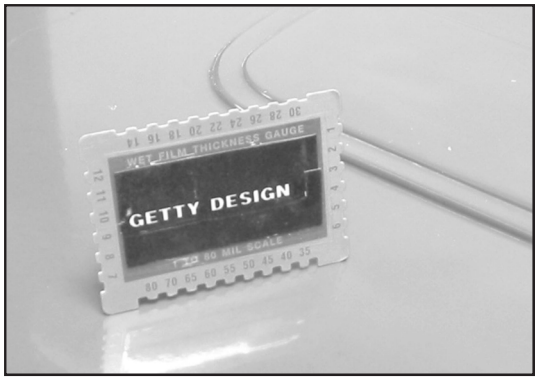


PHOTO 12
Mil. thickness gauge
The coarse notches on the perimeter of the guage measure the thickness of the applied Gel Coat.

venting potential blisters and other surface defects from surfacing.

If the gel coat is sanded and primered before the part is post cured the laminate will print right through the primer. The preparer will then have to resand with a coarse paper, something on the order of at least 80 grit and then its back to the beginning, refill the pinholes, reprimer etc,etc.

Until parts have been thoroughly post cured they should all be considered prime candidates to exhibit nasty print through at any time the surface temperature gets hot enough. Even months and years later. Time is not the answer. An elevated temperature post cure is. Skipping this step has caused more ruined paint jobs.

Now while the correct laboratory method of post curing is to slowly increase the temperature hour by hour that is not very practical in the real world. Fortunately you can achieve a very good post cure and induce print through as easily as letting the part cook outside in the sun or inside with the help of a heat lamp. Just follow these guidelines.

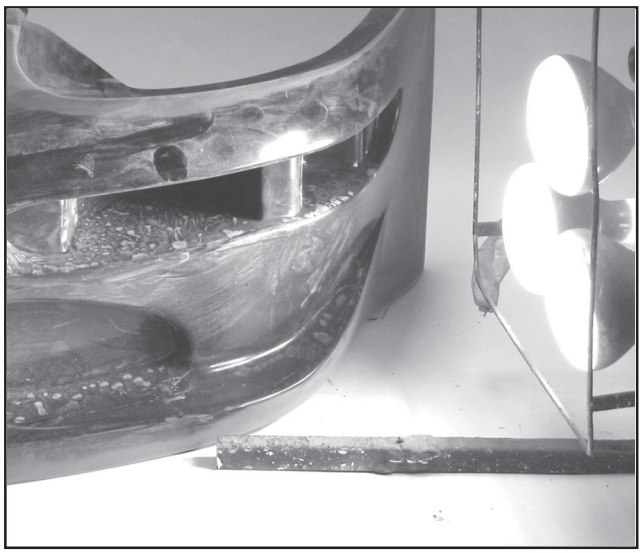


PHOTO 13
Cooking
This photograph shows a part being heated with a small heat lamp When possible it is always best to post cure parts in place on the car. This way as the heat releases any internal stress they conform to where they are held in place.

I always recommend cooking parts only after they have been installed on the car. It makes sense on many levels. Remember one of the first things that should be done after unpacking the box with the new part is to check that it is what was ordered and more importantly, that it will fit the car. There is no better way to do that than by actually bolting it in place. Instead of being more work, actually bolting parts on first not only is the correct way but it turns out to be a big time saver.

Take for example a pair of doors. Hinges have to installed and the shim packs determined. The latches, the door handles, and maybe the window frames need to be installed. That means the doors will probably be off and on several times while the hinges and shims are sorted out. Holes will have to be cut for the latches, some amount of grinding will be necessary to fit the frames and once the doors are on and latching the best way to even up the seam around the perimeter is to run a thin disc grinder around the outside, grinding the edge of the door to perfectly match the surrounding bodywork. It takes about an hour to hang a door for the first time and you certainly don't want to try all that experimentation on a fresh paint job.

When you first start to cook some parts try to moderate the temperature for the first hour or so to something that you can just keep your hand on. Make sure all the surfaces get cooked and periodically check the surface profile in the surface reflections to monitor the post curing.

COLOR MAKES A DIFFERENCE

One very important thing to keep in mind is that surface temperature is color dependent and it is always a good idea to paint FRP parts light colors. The reason most recreational boats or sail planes are painted white is that light colors keep the surface temperature low and low temperatures keep the laminate as strong as possible.

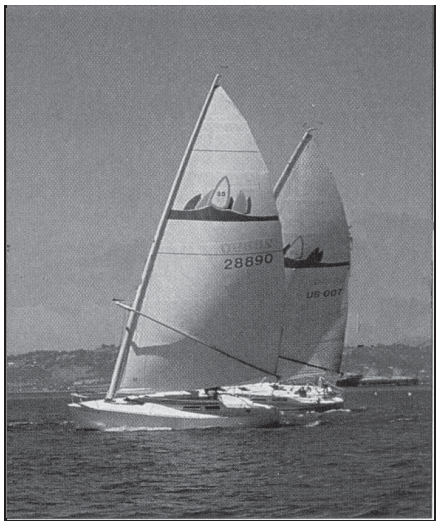


PHOTO 14
Sailboats
The white hull surface of the FRP watercraft helps to maintain a low surface temperature.

While a black part in the summer sun might see surface temperatures as high as 200 degrees F, a white one will only be 120 degrees F. This is definitely something to consider. At 200 degrees many resins are at or near their heat distortion temperatures and some cheap resins are well beyond, already losing some physical properties and becoming weaker. So it's always a good idea to stick with light colors.

PHOTO 15
Infrared detector
One simple way to check on surface temperatures is with an infrared pyrometer, the same one you would use for checking tire temperatures. Temperatures in the 180-200 degree range will post cure most common composites.

Experienced installers can use heat to their benefit. Some pieces that may have taken a set, say from improper storage , will relax enough at high temperatures to be easier to install. Fenders are a perfect example . The best way to store FRP fenders is to have them lay on a shelf with the vertical pointing straight up. Unfortunately it is not always convenient and they often end up leaning against a wall with the vertical being twisted. When the vertical flange is bolted there will be a lot of stress as you try to reverse the twist. Judicious application of a heat lamp will relax this stress. Caveat..... This assumes that the tool produces a part that is correct in the first place . A little bit of sun or a heat lamp is not going to turn a sows ear into a silk purse. So read on and lets find out how to tell the difference between the two so you won't feel embarrassed by your cars appearance when you take it to the ball.

SURPRISE, POP QUIZ

Quick, what are the correct steps to take a part from out of the box to finish paint? Don't worry, this is an open book test so let's review.

1. Carefully unpack the box and check for any damage from shipping. If a box arrives and it looks

like its been really crunched it might be best to refuse delivery. If the part has been damaged in shipping then some companies expect the customer to file a claim with the shipping company and those are very hard to collect on. Make sure to write on the freight bill that the package has been damaged.

2. Ensure that what you ordered is what has been sent.

3. Make sure it fits your car. That means bolting it in place, making all the shim adjustments just as if it was going on for the final time.

4. Post cure the part , in place, on the car if possible.

5. Check the edges and the seams for voids. Carefully examine all the surfaces to determine how much sanding will be needed.

6. Sand and prep as needed , prior to primering.

7. Apply a nice even coat of a high quality catalysed primer. After the primer drys go over the surface looking for small imperfections or pin holes. If the gel coat was sanded off in spots chances are there will be a lot of pin holes that the primer won't fill. Now is the time to fill these in using a small amount of filler and a razor blade as a squeegee. It only takes a few minutes and you want to do it first before any sanding dust gets in and obscures the holes.

8. Next resand and primer as needed. Check and fill any pin holes one more time.

9. Paint.

ARE YOU READY TO GET STICKY?

What's the easiest way to tell a good part from a bad part? Simple become an educated consumer and that doesn't mean by reading ad copy. Probably the most overworked phrase in the business is 'These parts fit'. From what I've seen that can mean anything from "30 minutes of your time and simple hand tools and it's on", to "all you have to do is, chop it in half, remove an inch from each side, and then glass it back together again".

People who have been in the business long enough have seen way too much of the latter and too little of the former. The basic problem is that fiberglass manufacturing is deceptively simple in concept but far more difficult in execution. Let's see what it takes to construct a simple mold and a part and in so doing see how a reputable company can add quality and value during the manufacturing process. We will also demonstrate how disreputable companies can cut corners and pump out shoddy, inferior goods.

FIBERGLASS 101

"Good morning class. Todays project will be to make a light weight version of an aluminum rear bumper blade. The aluminum blade on 74-89 911's weighs about 20 lbs. We hope to save almost 15

lbs with an FRP substitute."

This is an introductory course so those of you with no fiberglass experience will not be at a disadvantage. Now gather around and that includes some of you fly by night companies whose junky pieces give fiberglass such a bad name. Pay attention, you might learn something.

First we are going to prepare the plug and make a simple female tool. Then we will prep the mold and make a rear bumper blade.

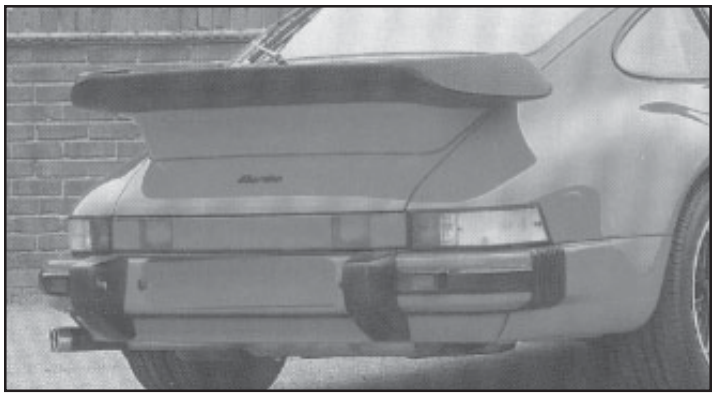


PHOTO 16
Rear Bumper Blade
The aluminum bumper blade on the back of the 74-83 911 SC's weighs over 20lbs.

The bumper plug is first secured to a stand on the table and then the shape is examined to determine if it has enough draft angle for the tool to pull back off the plug after it has been laminated. This blade has a simple 'U' cross section and no returns on either end that would necessitate a multi piece mold with parting lines. In practice most tooling is much more complex than our simple bumper. The tools most be be built in many sections that bolt together. Parting lines are small vertical fences that are attached to the plug to surround small sections so that they can be laminated separately. You can see these lines in the gel coat and they are also referred to as the parting lines. It is not uncommon for poor quality parts to have a big step in the surface between the parting lines. This occurs because the various mold sections don't line up with each other.

PHOTO 17
Bumper blade on stand
The bumper blade has been mounted on a stand to make it easier to work on.

STEP 1. Clean and prepare the plug for gel coat. In this case the mounting holes will be covered with tape and 2-3 coats of a quality mold release are applied.

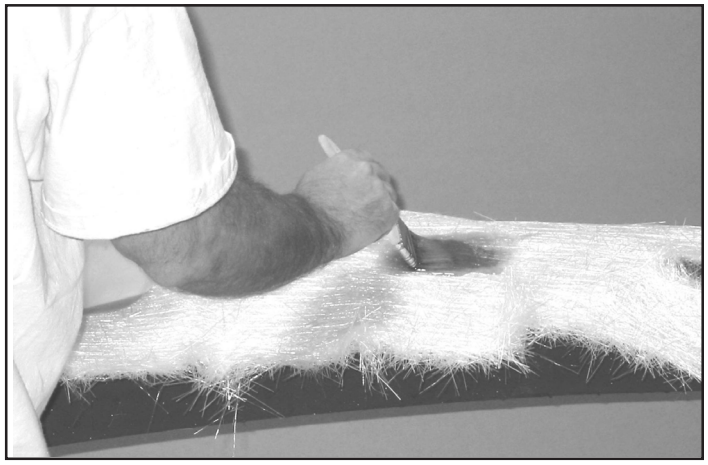


PHOTO 18
Laminating the Plug.
After the plug has been Gel Coated, the first layers of fiberglass mat are applied

STEP 2. The first layer of gel coat can now be applied. Gel coat can be sprayed on with special equipment or in the case of small molds, it can be brushed on in two coats. A special tooling gel coat is used for molds. It is harder and more durable than what is commonly used for parts. As was mentioned before, gel coat is basically a polyester resin with added color pigments and some other special-

ized properties. It is catalylzed at about 1.5% with MEKP, (Methyl Ethyl Ketone Peroxide), and should be ready to be "layed up' in about an hour.

One of the reasons gel coat is always applied to a tool before laminating is to protect the tool surface. Styrene is a chemical that makes up a substantial percentage of most resins and it will attack and degrade the mold surface over time . Also, all the brushing and squeegeeing can remove some of the mold release causing the part to bond directly to the mold . Once a part sticks the mold is usually severly damaged while trying to get the two apart. Cleaning and waxing molds is an extremely important job but it often falls to the lower paid guys. Its similar to the job of sanding the part after its been post cured. It requires someone who is conscientious for there are consequences of a poorly done job. In a production shop it can be a thankless job. Imagine waxing your car over and over again , 8 hours a day, 5 days a week.

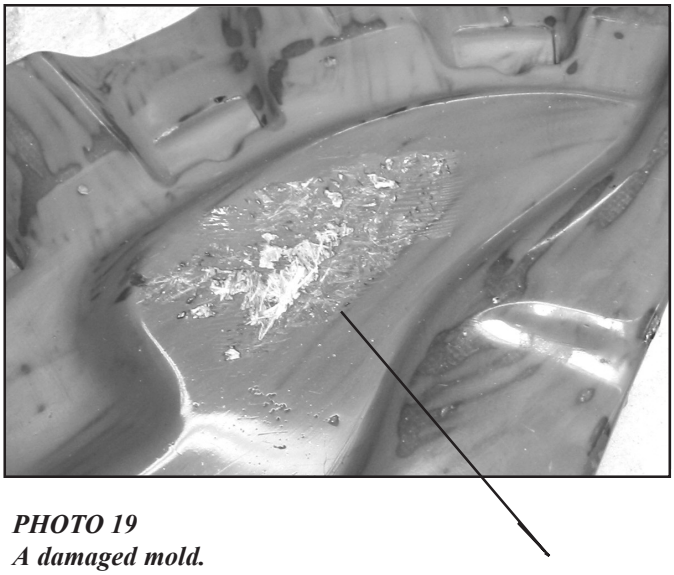


PHOTO 19
A damaged mold.
A problem with the mold release has caused this portion of a part to chemically bond with the tools surface. This could be from any number of reasons but results are a severely damaged tool.

STEP 3. Once the surface tacks up enough the first layers of material can be applied. For a simple mold like this we will be using a standard polyester resin, suitable for parts and molds. Determine how big an area can be laminated at one time before the resin kicks off and cut the material for this section. This little plug can be layed up in one shot and the first layer of material will be ordinary chopped strand mat with a layer of cloth on top

Estimate how much resin it will take to 'wet out' the mat and then mix the resin with about 1.5% MEKP in a plastic pail.

A word of caution. When handling chemicals be sure to follow all the manufacturers safety guidelines. You should wear protective clothing such as gloves, an apron or overalls, safety glasses and a respirator. Provide plenty of ventilation and do not work in confined areas.

Notice that the mat is stiff and doesn't want to bend over the corners almost as if it's been starched. That's almost the case. During the manufacturing process a binder is applied to hold all the randomly oriented glass fibers together. As the resin is brushed on the binder dizzolves allowing the fibers to be molded to the shape of the plug. Once the mat is saturated lay the cloth over the top and start smoothing it out. The idea is to remove all the air bubbles from the laminate and to remove excess resin at the same time, so there is 50% resin to 50% glass. Using your hands, the brush and a small flexible squeegee the wet laminate is worked over the mold.

This is where the laminating process really starts and we separate the men from the boys. Anyone can wet out some mat and slop it in place with a brush. But to do it correctly is a lot harder than it looks. The best laminators are artists and they work for years learning the craft. It's kind of like painting. I can

dab some paint on a canvas but that doesn't make me Rembrandt.

It is easy to see how talented a laminator is by looking at how well the cloth is applied to a mold or part. By how elegantly the pieces are cut and laminated around some of the shapes found in complex molds. Some parts are so poorly made that they only use mat. These parts aren't nearly as strong as mat/cloth composites and they also exhibit many of the other signs of poorly trained or inexperienced laminators. Resin drain out , where small puddles of resin pool up at the low areas, is a sure sign that the laminator undercatylzed the resin because he wasn't fast enough to finish the section normally. These parts end up with low physical properties. Soft or thin spots . These occur because without cloth on top the short glass fibers can easily be displaced with clumsy brush strokes. Since squeegeeing the cloth is the only way to control resin content, mat only parts usually have very poor resin to glass ratios. Making them brittle and more susceptible to warping.

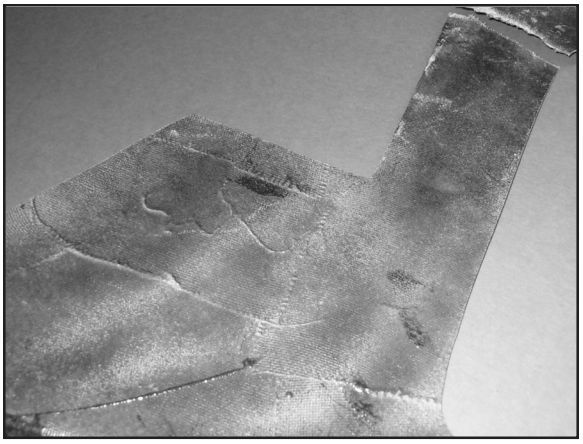


PHOTO 21
Cloth mosaic.
Here is a very strange example of a lower spoiler which was laminated with dozens of tiny square pieces of light weight cloth. I can only imagine that this was the work ofa really poor laminator who couldn't manipulate material that was more than a few inches square. Note fracture. This part wasn't even strong enough to survive shipping.

PHOTO 20
Mat only construction.
Note the puddle of resin pooled into this low spot on this part made only with chopped strand mat

Take for example the section of a Turbo S spoiler shown in PHOTO 21. This whole spoiler is made up of a patchwork quilt of small scrap pieces of a cloth that are much too lightweight for automotive use; especially considering its working environment which is under the front edge of the bumper. So I am left wondering, what kind of company would intentionally produce such a poor quality part? It's too thin to stand up to everyday driving, let alone shipping. Notice the part is broken in the top right corner. The cloth isn't there to help control the resin to glass ratio because you can't squeegee small pieces. They just slide around on top of the mat. Lastly and this is one of my favorites, it's one of those "primered ready to paint", parts, but the primer is heavy and rough. It feels like 80 grit sandpaper and if that isn't enough of a problem it dizzolves when you wipe it off with acetone. This means it is a very low quality primer and there is a good chance the normal solvents in the color coat could cause it to lift off the surface, ruining the paint job. This is another example of something that should be returned to the so called manufacturer as substandard. Keeping this piece of junk just encourages them to make more shoddy parts.

The basic premise of resin/fiber composites, is that resin, (usually refered to as the matrix), is only there to hold the fibers in place. It is the job of the fibers, whether they are glass, carbon, Kevlar, or whatever, to carry most of the load. If there is an abundance of resin between the reinforcements then the resin will fracture long before the fibers can do their job. This is a weak laminate.

A TRUE COMPOSITE LAMINATE

A real world example would be particle board. I would compare an ordinary cheap piece of particle board to a part made only with chopped mat. Here the wood chips or glass fibers are just glued together and pieces can be easily broken off with a pair of pliers. This is considered a short fiber laminate and not very strong unless its thick and heavy. Think about a cheap particle board bookshelf. Don't they always seem to be sagging in the middle with the weight of the books? That's because there really isn't anything to take up the strain.

In a laminate, during bending the outer layers are subjected to the highest tensile and compressive loadings. In particle board, just like in a cheap mat only part, the short fibers don't do a good job of The stronger the laminate has to be the greater the percentage of woven fabrics. Something simple like shower stalls are comprised entirely of chopped mat. The hulls of pleasure boats, which might be more than half an inch thick, to stand up to the pounding of the waves, are mainly constructed using a very heavy cloth type material called woven roving. Chopped mat is only used between the layers to help

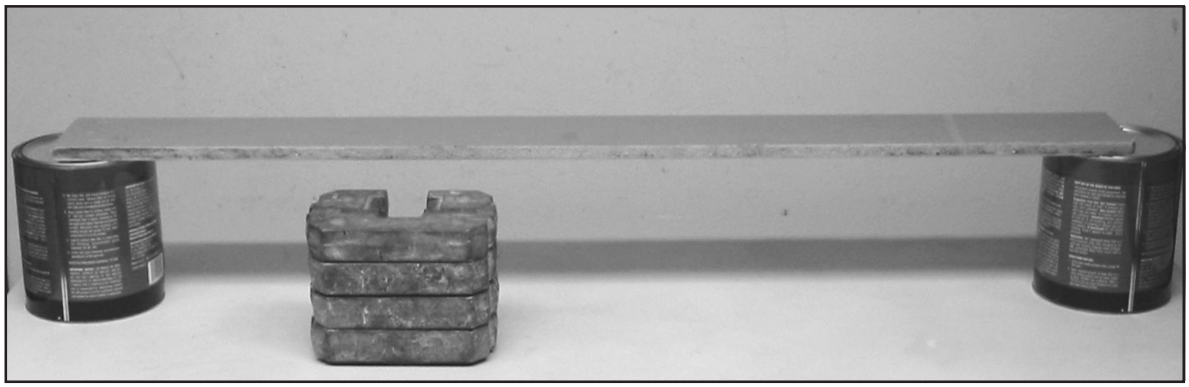


PHOTO 22
Particle board demonstration

PHOTO 23
Particle board demonstration.
Notice how far this common piece of 5/8 inch particle board sags under only 10lbs.

fill in voids. Top of the line race car parts are laminated with only fabrics, usually carbon and Kevlar. They don't use mat at all.

After the first layer has been applied we will let it set up over night and come back tomorrow to add resisting bending forces. Technically this would be considered a low modulus part. Modulus is a measure of a materials ability to resist deflection, or how stiff it is. A high modulus laminate is much better. A stiff part that holds up under pressure. Compare the particle board to a piece of plywood where the long grain outer layers contribute more to the stength of the laminate. In this case both products are made of the same material, wood but in the plywood the fiber type and orientation result in enhanced properties. The same is true with fiberglass. A mat and cloth composite is superior to just mat.

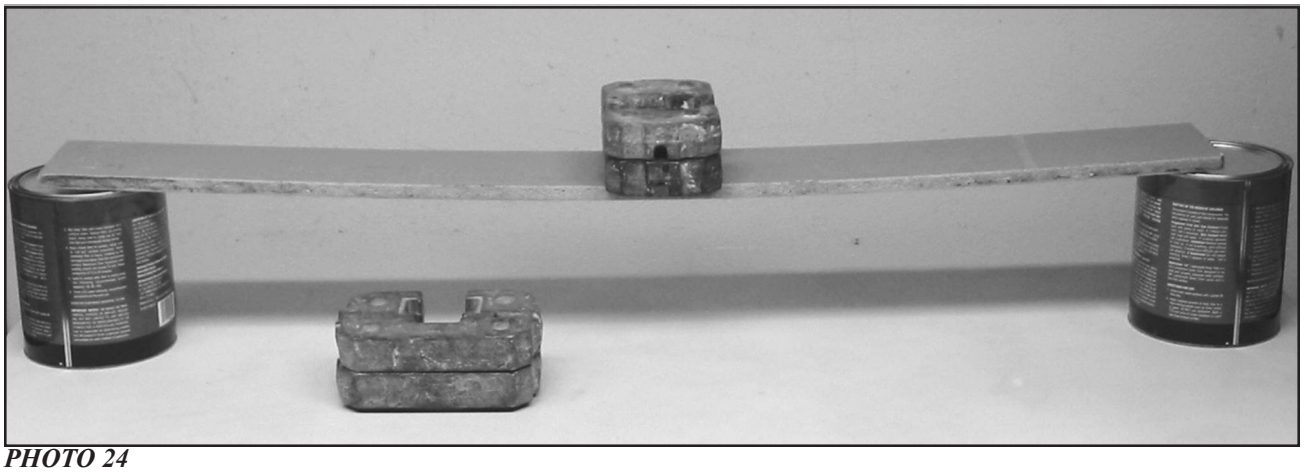


PHOTO 24
Particle board demonstration.
With twenty LBS of weight the particle board is really beginning to bend

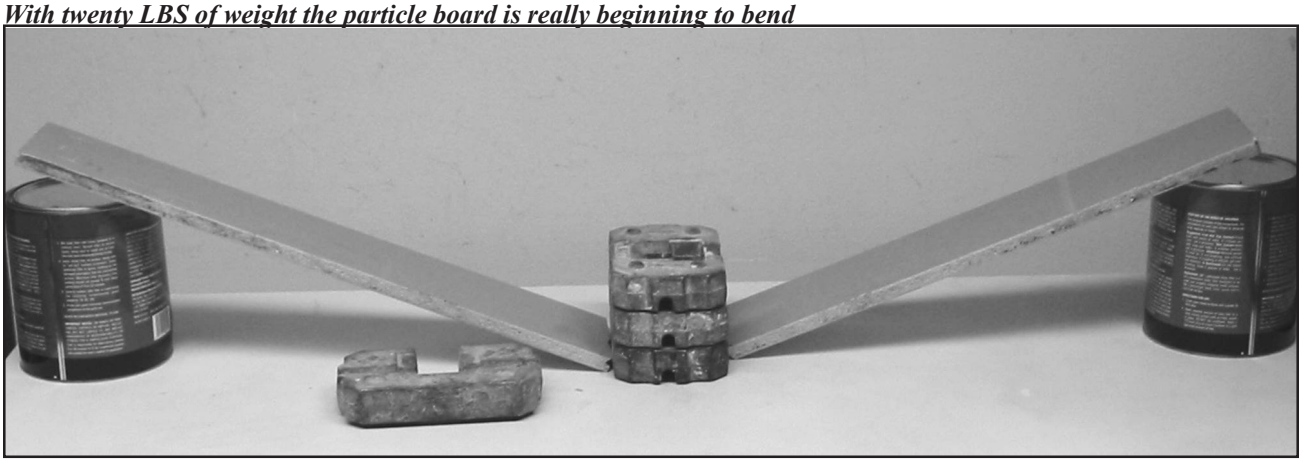


PHOTO 25
Particle board demonstration.
30 LBS is too much for the weak particle board to handle and it snaps in half

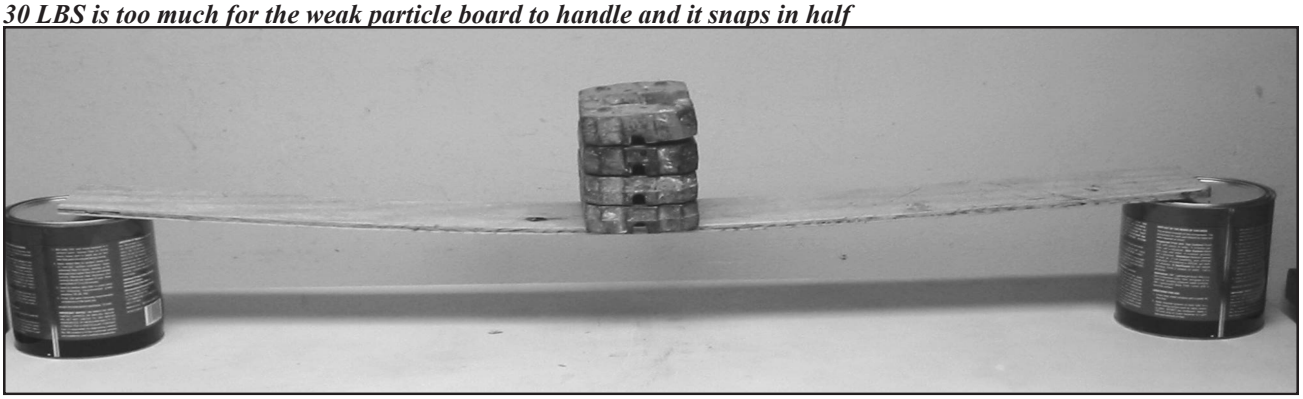


PHOTO 26
Plywood.
Here a thinner and lighter piece of plywood easily supports more weight than the thicker and heavier particle board.

more material. There will be a total of 4 layers on this mold and it will be about four times as thick as a part.

TIME TO GET ITCHY

STEP 4. Once all the layers have been added it's time to pop the mold off the plug and detail it. Special plastic wedges are inserted around the perimeter slowly getting the mold to release . It is always a little more difficult to get the mold off the first time. As was mentioned before the laminate shrinks a little bit and the tool is gripping the plug a little harder. The plastic wedges won't mar the tool surface and can be hammered into the gaps.

It is very important not to hammer directly on the tool surface. The tooling gel coat is very brittle and hammer blows will transfer through the laminate causing hairline fractures that can't be repaired. Even on laminates as much as one half an inch thick indiscriminate pounding will cause star like cracks in the surface coat.

Each time a part comes out of the mold these transfer cracklines will show up in the gel coat. Though they may look disconcerting, almost as if the part is broken, these lines are strictly cosmetic and can be easily sanded out along with the print through. One way to tell the difference between these imprint lines and true cracks is by examining the laminate on the underside. Cracks will show through as white areas or lines where the laminate has been damaged More on this later but if real cracks are present then a die grinder must be used to grind out all the problems. Then the area must be correctly refilled or the cracks will just come back right through the primer and paint. You see a lot of these star cracks on race car fenders where the thin material is fractured from stones thrown up by the tires.

PHOTO 27
Popping a part out of the mold.
The plastic wedges and hammer are used to separate the new part from the mold without damaging the tool surface.

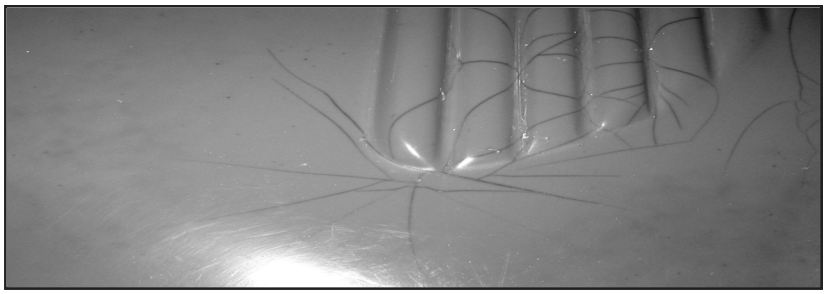


PHOTO 28
Transfer lines.
These star like lines,which are cracks in the tool surface are transfered to the parts Gel Coat as fine ridges.

With the mold off it's time to cut or grind off all the rough flashing around the edges and to prepare the mold surface. The mold will

be waxed a few times with a high quality mold release and then gel coated in anticipation of laying up a part.

STEP 5. The tool is now ready to laminate. This is a typical bumper mold and a little bit more difficult to lay up than the plug . Since we are adding material to the inside, gravity wants to pull the pieces off the sides and it takes a little more finesse to keep everything in place.

PHOTO 29
Laminating.
Laminating inside the confined areas of a small tool is much more difficult than applying layers to the outside of a tool.

For a nice light weight part the laminate schedule will be one layer of 2oz mat with one layer of cloth on top. A bit more material can be added inside around the mounting holes for some added reinforcement. As the material is wet out air bubbles become trapped under the fiberglass and must be worked out with the squeegee. There are several reasons for this. A large enough air bubble near the surface will cause a blister under the paint as it heats up in the sun. Air bubbles left in corners always seem to break open after the part has been painted. And most importantly, air entrained laminates are weak.

In the marine industry they call it bubble busting and the laminators use long handled rollers to roll out many square yards of material at a time. They don't so much remove the bubbles as they merely break them down into smaller bubbles. Automotive parts require a much more precise effort to remove most of this air and a skilled laminator makes all the difference. One thing that helps is to laminate against a black gel coat. Here the air bubbles appear whitish so they stand out better than if the background was white gel coat.

Once the part is layed up and kicks off the edges can be trimmed with a knife, facilitating the detailing. It will be ready to pop after sitting overnight .

STEP 6. Using the wedges, pop the part out of the tool. Now detail as needed. Grind it to the rough dimensions. Check all the corners and and edges to make sure there aren't any air bubbles. The best way to do this is by rubbing the round shaft of a screwdriver over all the corners and edges. Use a firm pressure on the screwdriver and any voids under the gel coat will break open. These need to be repaired first, prior to any sanding. Air bubbles are a fact of life. What's important is that they be found and filled before the part is painted.

When you are checking all the edges and corners with the screwdriver shaft, think of it as a quick kind of magnafluxing for composites.. It is simply a precautionary step that should never be overlooked.

You certainly wouldn't take a chance on building a cylinder head if it was cracked. The correct solution would be to send it out and have it welded first, then go ahead and assemble it.

The same thinking is true for composite parts, let's find any potential problems before we go to all the trouble of prepping and painting something. There are 2 ways parts should be examined. I have mentioned checking for air bubbles a couple of times but there is another area that is equally important and that is the parting lines or seams.

Back around 1994 there was a change in the type of parts that were starting to be manufactured. The factory began making many more new and complex tailbases and wings that required different manufacturing techniques. Where previously we had simple shapes like ducktails that could basically be laminated in one shot in simple female tools, now a new generation of tailbases was emerging like the 3.8 RSR and the 993 twin Turbo. All of a sudden we were dealing with multi piece tools. Instead of a simple 2 piece ducktail there were now 4, 5, 6 and more separate mold sections. So the tools became more complicated and the parts are much more complicated and this means that detailing the parts also requires a little bit more attention to prepare them properly. It takes many more hours to rebuild a 911 engine than it does a 914 and if you make a mistake on the 911 it is going to be alot more expensive to fix. Same with FRP stuff. You might be able to get away with some sloppy detail and prep work on a bumper that's hanging half under the car but make the same mistake on a tailbase that's right out in the open and everyone will notice.

PHOTO 30
Multi piece tools.

So after conscientiously checking for air bubbles the next step is to check the seams along the parting lines. We mentioned before the parting lines are where the different tool sections are joined together as it's laminated. Each individual tool section is laminated then it is trimmed around the edges and then bolted to it's neighbor . Problems can arise because after a section has been trimmed mold release is applied to the edge of the mold that was scraped with the trim knife. This is to prevent the two sections from bonding together where the original mold release was removed. In effect what happens sometimes is that the outermost edges of the part at the surface don't always get bonded together. This can happen if mold release gets on the edges or if they fit so tight that resin doesn't get in. Whatever the reason, you the detailer, are often left with a hairline crack that looks OK but will show up once its painted. Paint will not fill in the crack, wicking off to the sides leaving a very noticeable line. Kind of like fish eyes, the paint will not fill in across the problem area.

The easy way to fix this is to check the part first carefully squeezing all the sides. It's not tough , it's not rocket science and it doesn't take alot of time or energy. What I am saying is, this is another area for potential problems and needs to be checked conscientiously. As far as time, it takes all of 5,(as in only

five), minutes to run the screwdriver on all of the outside corners and to squeeze check the seams. I wouldn't bat an eye at spending an extra couple of hours setting up 2 dial indicators on a 911 race engine to physically check the cam lobe centers so the cams could be set up based on what they actually are vs what they are supposed to be. It is never a waste of time to do things the best way you know how. Fiberglass doesn't enjoy the best of reputations and some of the blame rests with the many fly by night companies that could care less about quality and some of it rests with inexperienced installers who aren't familiar with the right techniques.

You would not believe some of the stories I hear on the phone. Not too long ago someone called up complaining that the doors I sent him were an inch off from the quarter panels. " What the heck was I doing. These things are an inch too big". Well to make a long story short it turns out he was trying to install the doors with the metal hinges that bolt to the front hinge post turned around backwards. OOOPS.

PHOTO 31
Checking for open seams.
You should always check parts for seam integrity before sanding. It only takes a few minutes per part to carefully squeeze all the areas that might have a problem.

The next logical question is , if the seam opens when I'm squeezing does that mean the part is broken? Good question and that depends on which company is making the part. At Getty Design we have been well aware of the problem for many years and take special precautions to insure each part is structurally sound. Unlike the majority of companies that simply slop some radius putty between the 2 tool halfs, stick them together and hope for the best; we laminate layers of material ,bridging the seam . See Photo 32. Putty is hard and brittle and doesn't always bond well. So some of these poorly constructed pieces split wide open when you check them. They are junk and shouldn't be used. I've seen this happen with ultra expensive carbon parts from

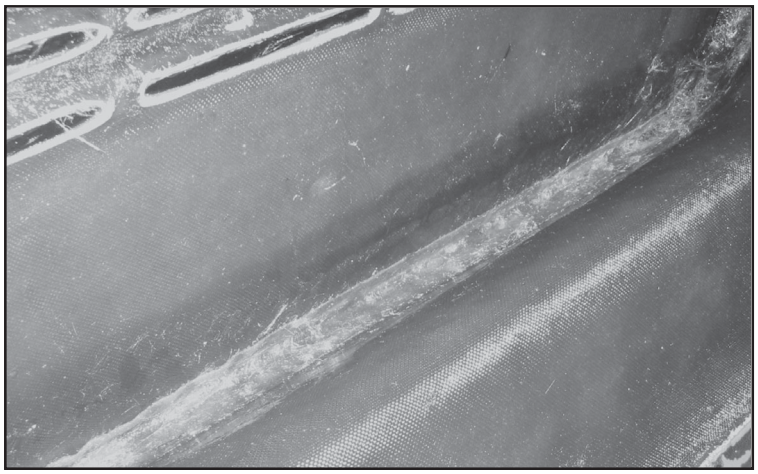


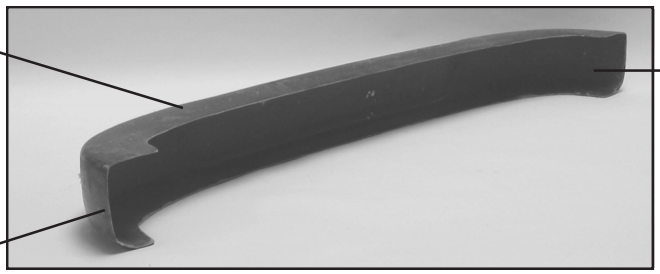
PHOTO 32
Reinforcing the seams.
Here,2 layers of mat are being used to reinforce the back seam on a 3.8 Tailbase.

Germany and with cheap junk made in China and Mexico.

If there is an open seam it must be fixed correctly and this means the edges must be cleaned so the repairing material will bond. One way to do this is to lightly run the cutoff wheel of a Makita along the split being careful to only cut down through the Gel Coat and barely into the material underneath. This way new clean material is exposed and it's easy to apply a small amount of filler to fix the problem.

BRAND X BUMPER

Flimsy, single layer top edge is prone to warping.



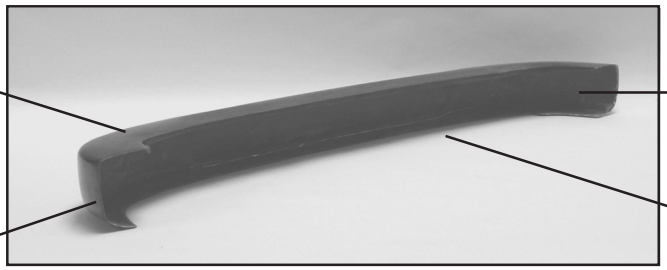
Cheap mat only construction.

Poor surface quality.

PHOTO 33
Basic bumper blade.
Flimsy unflanged top, cheap mat only laminate and a rough surface.

GETTY DESIGN BUMPER

Top flange adds strength and reduces warping



Composite mat and cloth consturction.

Superior surface finish.

Bottom flange adds strength and reduces warping

PHOTO 34
Getty Design bumper blade.
Flanged for strength,not warped,cloth and mat construction and a superior surface finish.

But we are getting off the subject a little bit. The new bumper blade is out of the mold but how do we tell if it's a good part or a bad part? We need something to compare it to. This was just a normal run of the mill mold that most any company would produce. Compare this to a typical Getty Design tool for the same part and you can see many important differences.

We add important flanging that dramatically increases the rigidity of the bumper. The part comes out of our mold with with a cleaner finish because we spent much more time preparing the original. And the most important difference is that our part is nice and straight while the demonstration blade we did is severely warped. How many times have you seen bumpers and other parts all warped with sides sucked down making them hard to use? Getty uses a proprietary technique that minimizes this warping resulting in superior pieces.

All 3 reasons why our bumper is superior to the demonstration bumper are a result of Getty Design's commitment to excellence. Sure it would be cheaper and easier to produce shoddy goods like alot of the other companies out there but that isn't where we want to be. It isn't about making the cheapest parts , it's about making the best. Adding that simple top flange to the bumper mold means that it takes

about 30% more time to laminate than if it didn't have it.

What's the one thing everyone says about working with fiberglass? I don't like like working with it I get itchy. Well that happens to me too but it is usually because I'm in a hurry to do something and don't take the time to put the proper clothing on.

The reason you get itchy is because the fiberglass particles get into your skin. The two most common ways are from particles coming off cutting or grinding wheels and from rubbing up against dusty and gritty parts.

It never fails to amaze me that after working with composites for 20 years , that I should know by now that if I pick up a Makita to cut a small notch in something and I don't put on a coat first the little bit of stuff coming off the wheel is going to get on my arms and irritate the skin. Unfortunately when you are in a hurry you don't always think.

The cutting and grinding wheels are the worst. A cutoff disc spinning at 10,000 RPM is spraying abrasive dust particles at well over 100 miles per hour. So if you are using one of these tools with bare arms you are going to get itchy.

The same is true for leaning or rubbing up against parts, like when fitting body panels and you are leaning across to tighten fastners or hold 2 things together. Do it in shirtsleeves and the embedded dust will cause irritation.

So the simple solution is to always wear proper clothing. An ordinary sweatshirt works fine for me, for small jobs. For bigger jobs requiring extended grinding I prefer to use a one piece Tyvek overall with an attached hood and a clear plastic face shield. These precautionary steps will help to eliminate 90% of the problems. But what do you do if you start to get irritated?

If you happen to get some dust into your skin and it is uncomfortable the best thing to do is to wash it off with soap and water , soaking a little bit longer than normal. Some people prefer cold water and some swear by warm or hot water. I really don't care. The real trick after you are done washing is to liberally apply a good hand or body moisturizing lotion. Really slop it on. The dryer your skin is the more the dust will irritate you.

The one other thing that is annoying about fiberglass is splinters. Handle raw fiberglass pieces for any length of time and you will get splinters. So any time I'm out in the shop there is a good pair

PHOTO 35
Proper attire.
A tyvek suit,a respirator, eye protection and gloves.

of leather work gloves in my back pocket. It never fails, grab a part to spin it around and look at with out gloves on and Ouch, it's an instant splinter. What makes fiberglass splinters so wonderful is that they are really sharp and usually clear which makes them impossible to find. Be smart use your gloves.

So the important thing about working with FRP parts is to wear the proper clothing,all the time.

This pretty much covers the basics of fiberglass. We've covered a little bit about the material itself. How to laminate with it, how to make sure it is cured. How to protect yourself when working with it. We have talked about parts, what makes a good part and what makes a bad part. And we've covered some of the necessary steps to perform before a part is ready to be painted.

The next few chapters will focus in detail on how to install certain pieces of bodywork. How to work with bondo and some tips on fastening methods.

Remember always try to work with the best parts available and keep an open mind when it comes to fitting problems. 911's for the most part were hand built cars with many subtle differences from car to car.