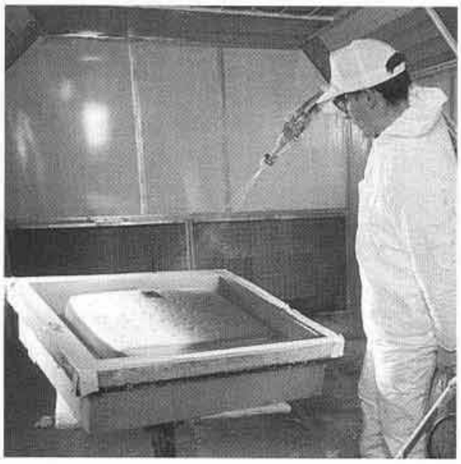

GEL COAT APPLICATION & TROUBLESHOOTING GUIDE

REFERENCE: PB-16

The key to producing quality, attractive and durable polyester parts is in the gel coat surface. Proper application of the gel coat is therefore critical. Improperly applied gel coat increases the cost of the part. The cost of a part is not only a matter of how many parts are rejected, but also how many parts require reworking or repair. Time and care in applying gel coat can pay big dividends by reducing rework time and scrapped parts. Parts can be no better than the materials and workmanship used to make them.

Familiarisation on several basic key points, is the first step towards quality application of the gel coat. These key points are the outline for this presentation.

1 GEL COATS

A gel coat is a polyester coating that is applied to the mould surface and becomes an integral part of the finished product. Its function is to protect the fibreglass from the environment and to produce cosmetically appealing surfaces that are durable, long lasting and available in a wide range of colours. Proper Gel Coat selection and application can eliminate the need for other finishes.

Gel coat vendors have many different formulations to meet the varying requirements of their customers. By proper selection of raw materials and their amounts, we arrive at a gel coat that has good spray or brush characteristics. When sprayed the gel coat will not run off the mould at 18 (± 2) mils/thou wet. The gel coat should cure in a reasonably short period of time, depending upon production requirements, and when properly cured will offer good colour retention, resistance to water, weathering and other various environments.

When properly formulated, the gel coat should provide some amount of margin to allow for production tolerances.

No matter how good the formulation, you cannot make parts of acceptable quality if using abusive and improper spray methods and/or equipment settings. Many different components make a gel coat. They influence the gel coats quality and working properties.

They are:

RESIN

The starting point for any gel coat is the polyester resin.

Its composition offers the basic properties of the cured gel coat. Good gel coats offer a good compromise between application characteristics (spray or brush) flexibility, patchability, chemical resistance, weathering characteristics and cost.

Polyester resins used to make gel coats are usually of the three types described below.

- ***ORTHO (orthophthalic anhydride)***

Orthophthalic acid is one of the raw materials used in the composition of the polyester resin. It is used in general purpose resins where superior weathering and resistance to water or other chemicals is not required.

Gel Coats based upon orthophthalic acid have been used for years, but have been replaced by more durable ISO or ISO/NPG* types by Cray Valley.

- ***ISO (isophthalic acid)***

The use of this raw material, cooked into the resin, imparts better toughness and chemical resistance, making gel coats better suited for many applications such as boats or shower stalls, for example. Replacement of orthophthalic acid with isophthalic acid produces gel coats with greater chemical and corrosion resistance, more resiliency, and better exposure properties.

- ***NPG* (neopentyl glycol)***

This is another raw material which may be cooked into the polyester resin. In the proper ratios, it can produce even better chemical resistance and weathering characteristics than the materials listed above. It is used when the greatest quality and performance is needed, such as swimming pools. Spas, and yachts for example. It is combined with isophthalic acid to produce ISO/NPG* gel coats.

PIGMENTS

Pigments influence the colour you see, and determine how that colour will look for the next several years, over a wide range of possible environments.

EXTENDERS AND FILLERS

These are used to achieve the correct spray properties. They usually lower the resin solids and will influence cured physical properties. Care in selection of extenders and fillers is taken because of the potential negative impact upon the resistance to water, colour and/or chalking.

THIXOTROPE

Most of a gel coat's viscosity comes from the thixotrope. Its purpose is to hold the gel coat on a vertical surface, yet allow easy break-up for spraying.

ACCELERATORS

Accelerators react with peroxide catalysts, necessary to cure the gel coat. They are used to regulate gel and cure characteristics of the gel coat.

2 BASIC QUALITY CONTROL TESTS

Normal Quality Control tests run on gel coats to assure they meet standards are listed below. Also see Quality Control Lab and Test Methods.

GEL TIME

With few exceptions, all Gel time tests are run at 25°C (77°F) using 1.8% of a 9.0% active oxygen MEKP catalyst.

BROOKFIELD VISCOSITY

Usually stated as RVF #4 spindle, 4 RPM, unless otherwise stated by the customer.

**NPG is a registered trademark of Eastman Chemical Co.*

THIX INDEX

$$\frac{\text{Vis. \#4 Spindle, 2 RPM}}{\text{Vis. \#4 Spindle, 20 RPM}}$$

SPRAY OUT TO CHECK

- Sag Resistance
- Colour match
- Porosity/pinholes
- Pigment/resin separation

SPECIFIC GRAVITY

(or weight gallon)

HIDE

Normally complete at 12 mils/thou wet. Exceptions to this may be found in some reds, yellows, or dark blues where the pigments will not provide complete hide at this thickness. Inquire of your Cray Valley representative whether your red, yellow or blue requires special application procedure which is increased film thickness in multiple applications.

NOTE: Apply 12 mils/thou wet, minimum.

Upon request, we will provide a thorough description of the procedures used. Since suitability can best be judged by the customer, we suggest the customer set up appropriate quality control on all products that are used.

We will supply the quality control data obtained on the products shipped to the customer, as mutually agreed to beforehand.

3 EQUIPMENT AND CALIBRATION (SPRAY)

This data assumes that the proper type of equipment is being used.

See Gel Coat Spray Equipment.

Always consult the equipment manufacturer for proper calibration of a particular type of equipment.

In calibrating either air atomized, airless or air assist airless equipment, there are two points that they all have in common:

- Material delivery rate
- The amount of catalyst being supplied to the material

Beyond these two points individual settings become specific to the equipment being used.

BATCH MIX (HOT POT)

Material Delivery Rate or Fluid Supply

For optimum spray application, it is necessary for the gel coat to flow through the spray gun at 1.5 - 2.5 pounds per minute (0.7 - 1.1 kilo per minute). To determine this, back out the fluid needle adjustment knob, allowing maximum material delivery through the gun with the trigger pulled. Into a pre-weighed container, spray the gel coat for 30 seconds, re-weigh the container and gel coat subtract the original weight of the container and multiply this by two to determine the pounds (kilo) per minute delivery. Adjustment is made by changing air pressure on the pressure pot or pump, or by changing orifice size. This must be done by weight, not by volume, as gel coat densities vary.

Atomising Air

The correct air pressure is essential for proper material break-up. Measurement is through a pressure gauge attached to the spray gun; read it when the trigger is pulled (dynamic pressure) and the fan is full open. Adjust as necessary to minimum of 60 psi. This will help produced a porosity free film.

NOTE: Long air lines, small inside diameter air lines or a number of fittings within the line can reduce the volume of air supplying the gun and can create erroneous results. Adjust as necessary for minimum of 60 psi.

Catalyst

Proper catalyst level is accomplished by accurate weighing or volumetric measurement, so calibration is exact as well as uniform. Catalysation levels should be between 1.2 to 3% by weight, with ideal recommended catalyst level being 1.8% at 25°C (77°F). Catalyst must be thoroughly mixed into the gel coat before application. Catalyst levels of less than 1.2% or more than 3% can permanently hinder the cure of the product. Always maintain catalyst levels within this range.

NOTE: Catalyst used to cure polyester resins are very reactive chemicals. Contact with many materials can cause decomposition that can present real fire hazards. Good housekeeping practices need to be maintained at all times.

CATALYST INJECTION

With most catalyst injection equipment, the peroxide catalyst is mixed externally with the gel coat. If sprayed alone, it can travel several feet or more, eventually settling onto surrounding surfaces. Accumulation of materials that can react with the catalyst have been the direct cause for fires in fibreglass shops. Cleanliness and constant removal and proper disposal of waste catalyst and contaminated materials are the only safe ways to deal with this potential hazard. Spraying only catalyst should be avoided.

Solvent, either from diluting the catalyst as required for some equipment, or from clean up operations, acts to increase the chances of an undesirable reaction.

See you catalyst supplier and the HEALTH & SAFETY section in this manual for further information.

Material Delivery rate of Fluid Supply.

Calibrate same as for batch mixing (see above).

- Air Atomised 1.5 - 2.5 pounds per minute (0.7 - 1.1 kilos per minute)
- Airless - for smaller, intricate moulds 1.5 - 3.0 pounds per minute (0.7 - 1.4 kilos per minute) for larger, open moulds 1.5 - 4.0 pounds per minute (0.7 - 1.8 kilos per minute).

Atomising Air

Calibration is the same as described for batch mixing with one exception - the catalyst has a safety valve that will only allow 80 - 100 psi static air pressure (no air flowing through the gun). The maximum pressure allowed by safety valve varies with the specific equipment. If you are at the maximum recommended static pressure, then the dynamic pressure must be adjusted by changing the inside hose diameter, using a shorter hose and/or minimising restrictions.

Airless systems have no air atomisation of material so there is no calibration of air pressure needed, or possible. Some airless systems do have air atomised catalyst which must be calibrated.

Air assist airless systems require additional atomising air. It is important that air assist air be kept as low as possible.

Catalyst

Use specific equipment manufacturers' recommendations.

Alternate calibration methods:

- The purpose is to collect some catalysed gel coat just as it leaves the gun, then timing to see how long it takes to gel. Comparing this gel time to that of a sample that has been catalysed by accurately weighing the catalyst gives a basis of comparison for adjusting catalyst settings. This should be done at two different catalyst settings.

  The procedure is to collect about 100 grams of catalysed gel coat in a small cup, recording fluid pressure setting the level of the catalyst ball (or balls), and the time. Similarly, collect sufficient material that is uncatalysed weighing 100 grams, and then weigh in the specified amount of catalyst, noting the time of catalysation. Adjust catalyser until the two times are equal, by the recommended method specific to the equipment.

  It should be noted that ball settings are only relative guides and **do not** read in % catalyst.

- After the gel coat has been calibrated, (delivery rate) turn the gel coat off. Then run delivery rate on the catalyst. Compare catalyst delivery to gel coat delivery

(% catalyst) and adjust catalyst % as required to stay in proper range.

See GEL COAT SPRAY EQUIPMENT for additional calibration information.

- Do not assume a catalyst slave pump is working properly. These can be calibrated also and should be monitored continually.

See section on 'Gel Coat Spray Equipment@ for additional calibration information

4 SPRAY OPERATOR

A spray gun should be considered to be a precision tool. It requires a skilled operator to efficiently and effectively apply the material. Many defects can be traced back to how the gel coat was applied. A poor sprayed application can be very costly, so it is in the shop's best interest to select the correct person as the spray operator and follow through with good training.

Several prerequisites of a good spray operator are:

- Conscientious
- Good co-ordination
- Desire to do good work
- Some mechanical skill
- Patience
- Good vision and no colour blindness

Good training is important because there are techniques that must be mastered correctly from the beginning, to avoid learning bad habits which may be difficult to unlearn. Costly shortcuts should also be avoided by training.

New spray operators should start out under direct supervision from competent personnel, spraying easy, noncritical parts. Progress to more difficult parts should be made in conjunction with the experience and ability of the individual.

Free literature is available from suppliers of raw materials and equipment manufacturers. Training schools are offered by many suppliers.

5 SPRAY METHODS - GENERAL

■ Check the gun and the lines for contamination such as solvent, water, or oil. Clean and correct as necessary before spraying. Drain water from pressure regulator and traps daily, more often if necessary. If water is a constant problem, a temporary solution is to leave the bleed off valve on the water extractor open slightly. Water in the air lines can lead to expensive repairs to equipment and affect the performance of the gel coat. It is best to correct the problem, (and less costly in the long run) by investing in a good drying system.

■ Check air pressures before spraying and adjust to achieve proper flow and break-up. Droplets should be no larger than 1/16 inch (1.59mm).

■ Always start spraying nearest the exhaust fan to minimise overspray that could be pulled on to the mould.

■ If catalyst injection is used, make sure catalyst is flowing properly. Do not let raw catalyst fall on the mould or sprayed gel coat.

■ Check temperatures, adjust catalyst as necessary (1.2 - 3.0%). under extremely warm conditions, working times may become very short, necessitating the addition of inhibitor to allow for enough working time. Consult your Cray Valley sales representative for what to add and the amount. Do not go below 1.2% catalyst, nor higher than 3.0%.

■ Keep the spray gun perpendicular to the mould during each stroke.

■ Hold the spray gun 18-24 inches (45-60 centimetres) from the mould when using conventional air atomised equipment, if using airless equipment, 24-36 inches (60 - 90 centimetres).

■ Do not arc the gun while spraying.

■ Keep the speed of each stroke such that a full and constant wet coat is applied.

■ The first spray pass should be a thin continuous film (5-8 mils/thou depending upon the temperature, the gel coat viscosity and the mould wax). Prevention of porosity, resin tearing, and mottling is the reason for this specific technique. About three passes are needed to achieve a total thickness of 18 (+ .2) mils/thou.

■ Overlap strokes 50%.

■ Do not reach with a stroke. Stroke length should be comfortable for the operator. Normally this is 18-36 inches (60 - 90 centimetres).

■ Start spraying near an edge in a continuous stroke towards the other side. Each spray pass should be parallel to the former, developing a uniform thickness. Subsequent spray passes should be perpendicular or diagonal to the preceding pattern to insure proper uniform coverage.

■ When practical, spray sections from one end, working continuously to the other. Overspray onto other parts of the mould is to be avoided as much as possible. Time lapse between spray passes or in spraying overlapping sections on large moulds should not be excessively delayed. Maintain a wet line, that is, covering up sprayed edges and overspray as soon as possible.

■ Do not flood the gelcoat on, or spray with the fan sideways.

■ Use a thickness gauge (mil gauge) and touch up the tested area afterward.

■ Clean the gun immediately after using it. This includes any part of the equipment that may have received overspray, such as hoses and gauges.

■ Inspect the gun regularly and replace worn parts.

■ Lubricate the gun and packing with light machine oil daily.

Do not contaminate the gel coat with oil.

■ Accidental bodily contact with gel coat or catalyst can be hazardous. In the event of contact involving body or clothing, the area needs to be cleaned immediately. See appropriate data sheets and labels for proper precautionary steps to follow.

■ Know the fire and toxic hazards of polyesters, catalyst, and the particular cleaning solvent being used.

■ Have a regular preventive maintenance programme.

■ Place only one mould in the spray booth at a time. This prevents overspray onto other moulds.

■ To achieve the best all round performance properties we recommend as ideal a wet film thickness of 18-24 mils/thou. Films with less than 12 mils/thou may not cure properly, may be hard to patch, have more print-through, and be more susceptible to water blisters. Films above 24 mils/thou, may pre-release, trap porosity, crack and are more subject to weathering discoloration. If water blisters are of a great concern (as in boat hulls) 20-24 mils/thou would perform better than a thinner film, but sag, porosity and cracking resistance could suffer. If weathering (yellowing from sunlight as on boat decks) is of great concern, then thinner films 12-16 mils/thou would perform better, but patchability, print-through and blister resistance could suffer.

■ Never reduce gel coat with a «conventional» paint or lacquer thinner.

■ Disperse catalyst thoroughly. Poor distribution causes uneven cure, colour variation, and premature release from the mould before lay-up.

■ Do not over catalyse or under catalyse. Excess catalyst plasticises the gel coat, thus degrading its water resistance and accelerating chalking and erosion. Under catalysation will result in poor cure.

A poorly cured gel coat is weak and will be degraded by weather.

Recommended Catalyst level is: 1.2% to 3.0% with 1.8% being ideal at 25°C (77°F) of MEKP (9% active oxygen).

■ Apply a minimum of 16 mils/thou of gel coat if glass fibre pattern is to be suppressed appreciably. Never apply less than 12 mils/thou, as undercure may take place.

The degree of protection against the outdoor elements is directly dependent on the amount of gel coat deposited and its quality.

■ Atomise the gel coat thoroughly when spraying. Low spray pressures will result in poor break-up and leave entrapped air in the gel coat. Entrapped air causes blistering and high water absorption.

■ Do not apply gel coat over wet Polyvinyl Alcohol (PVA) Parting Film. Residual water in film will retard cure of gel coat and also cause «alligatoring».

■ Use the catalysed gel coat within its working life with a proper allowance of time for clean up of equipment.

6 SPRAY METHODS FOR PARTICULAR PARTS

The shape and contour of each mould will dictate how it is best to apply the gel coat. This should be considered in determining a plan for where to start, where to finish and how everything between will be handled. Unfamiliar parts should be given serious thought as to how they will be sprayed before the actual application begins. Experience will show how it can be done better and more efficiently.

Below are several hints on spraying different configurations in a mould.

■ Try to spray the hardest area first and work continuously out from it.

■ Keep overspray to a minimum.

■ Use a series of passes perpendicular or diagonal to each other for more uniform thickness.

■ Keep laps (stroke) wet. Do not let a lap stay on the mould too long without covering with «fresh» lap. Alligatoring and/or resin tearing (see pictures which follow) could occur.

■ Flat Areas. These are easy to spray. Begin spraying near an edge in a continuous stroke towards the other side. Each spray pass should be parallel to the former until a uniform thickness is achieved. Subsequent spray passes should be perpendicular or diagonal to preceding pattern to insure proper uniform coverage.

■ Corners. Spray a pass down each side to the corner and work out about 12 inches (30.5 centimetres) from the corners. Use short strokes, then spray adjacent areas.

■ Gentle Curves. Spray by arcing the gun to keep it perpendicular to the working surface.

■ Channels. Spray the sides first. Most of the time, overspray will cover the bottom.

■ Deep or Narrow Channels Turn the fluid control in to cut the flow down and narrow the fan. Lower fluid and air pressure may be necessary, requiring more passes. Spray the sides first. Do not spray with the fan directly parallel to the channel. Keep the fan perpendicular to the channel or as much as is possible.

NOTES: If using catalyst injection, cutting back on material flow will change the % catalyst supplied to the gel coat. Adjusting for proper catalyst level will be necessary. Have a one quart pot gun to spray difficult areas.

■ Round or Small parts. Use a rotating spray platform.

7 TROUBLE SHOOTING

Even under the best of conditions, problems can occur due to accidents, mistakes, and unknown changes. Listed are some of the various problems that can occur and how to solve them. Also remember the gel coat is affected by the laminate, and good gel coat will not compensate for a poor laminate. To isolate and solve the problem, give consideration to the following:

- What does the defect look like?
- Where does it occur? All over, random, isolated side or section?
- Is it on all the parts, some, or just one.
- When did it first occur? Or when was it first observed?
- Does it match up to a defect in the mould?
- When were the defective parts sprayed?
- Did the problem occur on a particular shift? Or from a particular spray operator.
- Was it during a particular part of the day, maybe when it was hot, cold, damp or other?
- Did the problem occur through all spray stations or just one in particular?
- Where does it occur? In the gel, film? Against the mould? On the back side? Within the film?
- What is the code, batch number, and batch date of the gel coat from which the problem is occurring?
- Were any good parts sprayed from this batch or drum?
- Was anything done differently, such as a change in catalyst level, spray operator, method of application, or weather conditions?
- How would someone else identify or describe the defect?
- What were the weather conditions at the time the part was sprayed?
- What corrective steps were taken and were they effective?
- Check the material or laminate that was applied to or on the gel coat.

8 COMMON GEL COAT PROBLEMS AND USUAL SOLUTIONS

Below are tables of common gel coat problems and their usual solutions. This is only a partial list of defects and corrective steps. Sometimes a problem crops up that just defies any effort to take corrective action. At times such as these, outside help from the supplier (or someone not directly related to the shop area) may be the best hope.

Everyone should not be concerned about finding fault but finding solutions to problems regardless of the source.

Suppliers want their materials to be used properly and be as trouble free as possible. For the supplier to be able to come up with a solution it will be helpful for the following information to be ready when you telephone:

- Product Code
- Batch Number
- Batch Date
- Description of the problem
- When, where, and the magnitude of the problem.
- Corrective steps taken and their effect.

The following recommendations are based on what we consider typical gel coats, commonly available. Certain formulations with properties required for specific applications may not fall within the scope of all these recommendations. Always consult your Cray Valley representative for specific advice. Unless specific advice is given stating otherwise, follow the directions and recommendations in Cray Valley literature.

COMMON GEL COAT PROBLEMS AND SOLUTIONS		
PROBLEM	**CAUSE**	**SOLUTION OR ITEMS TO CHECK FOR**
Air Bubble	**Air pockets**	**Check roll out procedures.**
Alligatoring (a wrinkling of the gel coat, that looks like alligator hide)		
Before Laminating	Raw catalyst Solvent Water 'Cured' over-spray	Check for leaks or overspray. Do not reduce with solvents. Check for contamination. Maintain a wet line.
After or during lamination, or a second application of gel coat	Thin gel coat Insufficiently cured gel coat.	Use a minimum of 12 mils/thou wet, Discontinuous gel coat film. Improper catalyst level - either too high or too low. Too long gel time. Too low temperature. Insufficient time between coats or lamination. Moisture or contamination in the mould
Bleeding (one colour shows on another)	Fresh gel coat sagging over 'cured' gel coat	Check sag resistance of 'fresh' gel coat. Spray fresh gel coat sooner. Spray this film of fresh colour over the 'wet' base coat.
Blisters Appear shortly after part is pulled, especially when put in sun.	Unreacted catalyst or undercure.	Check % catalyst, catalyst overspray, mixing and leaks.
	Solvent, water or oil.	Check air lines, material, and rollers.
	Air pockets	Check roll out.
Appear after part in field	Unreacted catalyst.	Check catalyst levels, film thickness - 18(±2) mils/thou.
	Solvent, water or oil.	Check air lines, material, and rollers.
Water Blisters	Various	See Section on Blisters and Boil Test

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PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Chalking (gel coats will oxidise/chalk over an extended period of time; degrees of chalking is directly related to the environment).		
Dry, chalk - like appearance or deposit on surface of gel coat (Premature)	Cure	Under or over catalysation giving incomplete cure. Check catalyst level, film thickness, water and sol vent.
	Contamination	Surface soil picked up from atmosphere.
	Insufficient buffing	Wipe buffed area with solvent rag, if gloss stays, it is okay. If gloss dulls down , part needs more buffing.
	Poor mould condition	Reduce sanding and buffing requirement on parts by keeping mould in good condition.
Checking (mud cracking) Single or groups of independent or crescent shaped cracks	Poor integrity of the gel coat film.	Trapped vapour or incompatible liquid which blows through the gel coat film on ageing. Check catalyst level. Check for water, solvent, etc. Chemical attack. Temperatures extremes
Craters while spraying	Large particles in the gel coat.	Dirt in the gun or material. Material old and starting to gel, rotate stock. Strain old material
	Equipment	Clogged gun. Clean. Improper atomising air setting (too low)
Cracks: Spider cracks radiating out from a central point or in circles (Reverse impact)	Impact from laminate side	Check on handling and demould procedures. Caution people about hammering on parts.
	Excessive gel coat film thickness	Use a thickness gauge. Do not go over 24 mils/thou.
	Mould mark	Defect in the mould.
Frontal Impact	Impact	Be Careful.
Stress Cracks (Cracking in parallel lines).	Stress due to flexing	Excessive gel coat thickness. Laminate too thin. Pulled too green; laminate undercured. Demoulding or handing procedures. Sticking in the mould.
	Mould mark	Defect in the mould.

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PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Delamination		
In spots	Contamination	Check for dust, solvent, moisture, catalyst getting onto gel coat surface, creating areas that will not adhere
Large area	Gel coat too fully cured	Check for high catalyst level. Letting the gel coat cure too long, such as over night. Skin coat, rather than leave on the mould for long periods of time.
	Contamination	Excess mould release wax, or wax in the gel coat.
	Unbalanced laminate	Dry fibreglass
Dimples in the gel coat surface.	Contamination	Check for water, solvent, or improperly mixed catalyst. Overspray. Seedy resin.
	Other	Excess binder on the glass mat. Thin laminate or gel coat. Very dry laminate. Pin air entrapped in laminate. Post curing of the laminate.
Dull gloss on gel coat when part is pulled	Rough mould	Polish out mould.
	Mould build-up	Wash and buff with cleaner; in most instances, what is called wax build-up is actually polystyrene build-up and should be treated as such
	Polystyrene build-up	Sand or scrub with brush and strong solvent, read precaution on solvent before using. DO NOT USE STYRENE.
	Dirt or dust on mould	Clean the mould. It is best to clean in the spray booth just prior to gel coating. Time span should be as short as possible between cleaning and gel coating. Use a tack rag.
	Solvent or water	Check for solvent or water. Drain water traps regularly.
	Raw catalyst	Start catalyst flow from gun away from the mould. Only catalysed gel coat should be sprayed in the mould.
After part is pulled	Rough PVA or wet PVA	Check spray technique. Allow longer to dry.
	Insufficiently cured gel coat or laminate.	Correct excessive or insufficient catalyst level in gel coat and laminate. Wait longer before pulling. Check for low temperature (minimum of 60°F). Check for contamination; water, oil, or solvent.

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PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Dull or soft spots, at random (continued)	Gel coat uneven	Poor break-up; use three passes.
	Catalyst poorly mixed into either gel coat and/or laminate.	Mix catalyst thoroughly or make equipment adjust ments for good catalyst mix. Equipment surging (material pump and/or atomising air). Improper catalyst settings (high or low). Gun held too close to mould.
	Trapped solvent in gel coat and/or laminate	Check cleaning procedure. Check catalyst level with equipment using solvent reduced catalyst.
	Trapped water in gel coat and/or laminate	Drain lines and correct the problem.
	Insufficient catalyst	Confirm correct catalyst concentration if using less than 9% A.O.
Fading *(also see water spotting)*	Poorly cured gel coat	Check catalyst levels and film thickness 18 ±2 mils/thou.
See section on Weathering.	Improper cleaners or chemicals	Do not use strong alkaline or acidic cleaners.
Fibre pattern in parts	Insufficient cure	Correct excessive or insufficient catalyst level in gel coat and/or laminate. Wait longer before pulling. Do not pull while laminate still has heat. Check for low temperature. Check for contamination by either water, oil or solvent.
	Transferred from mould	Refinish mould
	Glass Cloth	Too close to the gel coat. Should have 2 layers of 1.5 oz. mat or equivalent chop between gel coat and cloth.
	Woven roving	Too close to the gel coat. Should have 3 layers of 1.5 oz. mat or equivalent chop between gel coat and woven roving.
	Gel coat too thin	Use 18 (±2)mils/thou wet.
	High exotherm of laminate	Cure laminate slower. Laminate in stages. Use lower exotherm laminating resin.
Fish-eyes	Water, oil, or silicone contamination	Drain air lines. Check mould release wax. Check lubricating materials used within the equipment.
	Dust/dirt/on mould	Use tack rag.
	Gel coat film too thin	Use 18 (+2) mils/thou wet, built up in 3 passes.
	Low viscosity material	Old material - rotate stock.
Material **gelled** in container	Age	Use partially filled container first, keep covered, rotate stock.
	Storage condition	Use within storage limitations.
Pigment darting or specks	Contamination	Clean pump and lines
	Foreign particles	Strain and keep material covered. Keep overspray minimised. Be sure moulds are clean. Spray per-pendicular to mould surface.

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PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Pigment separation, (or mottling)	Pigments separate from each other	Check for contaminates such as water or solvent. Dirty equipment. Dry overspray. (Keep a wet line). Excessively applied gel coat causing sagging. Excessively high delivery rates causing a flooding onto the mould surface.
Pinholes	Insufficient atomisation	Too high gel coat delivery rate. Not enough atomising pressure.
Porosity	Entrapped air	Wrong air pressures. Too high tends to yield fine porosity; too low will produce larger surface porosity.
	Wrong catalyst	Check gel coat vendor of recommendation.
	Gel coat film thickness	Applied too thick; use 18(±2) mils/thou wet. Apply in 2-3 passes.
	Formulation	Improper viscosity and/or resin solids. Check with vendor
	Water or solvent	Check for contamination.
	Pump Cavitation	Check pump for air leaks.
	Excessive mixing	Mix once a day for 10 minutes only.
Pre-release of the gel coat;		
• ***during cure*** causing obvious surface distortion and low gloss.	High catalyst level.	Calibrate equipment and decrease catalyst.
	Low catalyst level.	Calibrate equipment and increase catalyst
	Uneven and/or too thick film	Check thickness, not to exceed 24 mils, wet. Ensure a consistent film thickness.
	Gel coat allowed too long to cure.	Gel coat should not be allowed to set on the mould for more than a few hours without laminating at least a skin coat. Varies with temperature - should be laminated within same day.
	Gel Coat Resin solids too low	Check with manufacturer. Do not add styrene without their approval.
	Uneven cure	Improperly dispersed catalyst.
	Trapped solvent	Check for contamination by such elements such as acetone, water, oil.
	Mould release	Type and amount on the mould.
• Occurring ***after cure.*** Observed by seeing a sharp distinct line (will not necessarily feel the line), with increased fibre pattern on the side of the line that pulled away - sometimes referred to as «heat» or «shrink» marks.	Too long of cure	Laminate sooner - don't tap or jar the mould.
	Laminate curing too fast. Build laminate in stages.	Check for proper catalyst level.
	Wrong type resin	Too high in exotherm. Low resin solids.
	Laminate curing uneven.	Uneven laminate thickness.
		Check resin to glass ratio. Resin drain-out or puddling.

GEL COAT APPLICATION & TROUBLESHOOTING GUIDE

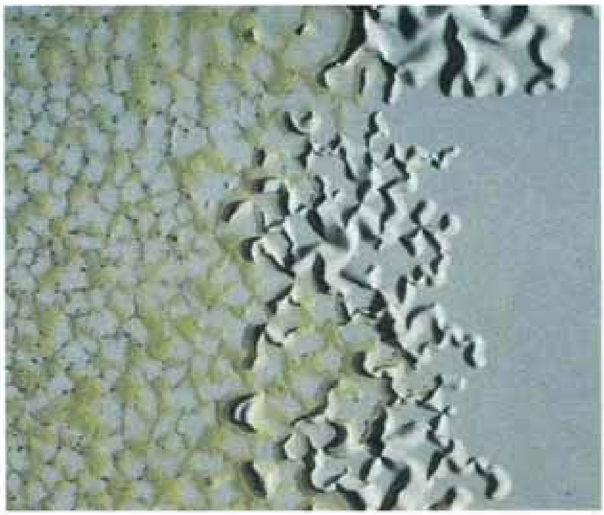
PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Resin tearing (or resin separation).	Pigments separate from resin. Application.	Check for sources of water. Improper spray techniques creating excessive overspray droplets and flooding. Can be aggravated by long gel time and sagging. Do not allow overspray to dry - keep a wet line.
Sags and runs	Excessive gel coat Spray techniques Low Viscosity Mould wax Other	Apply 18(±2) mils/thou. Wet. Atomising air is pushing and blowing the gel coat. Not enough styrene is being volatised. Check viscosity and thixotropic properties. Over-agitated. Material was reduced, but should not have been. Silicone content too high. Jarring the mould before gelation
Softness	Soft gel coat film which can be easily marred.	Incomplete cure of gel coat. Check catalyst levels, contaminants and film thickness.
Splotches after parts are sanded and buffed - also referred to as 'leathery', 'pebbly', 'chicken skin'	Overspray Not maintaining a wet line Cure	Do not allow overspray to accumulate Spray 'laps' within five minutes. The total film must cure as a total homogenous film rather than several independently cured thin films.
Water spotting (also see fading).	Usually caused by exposure with a combination of excessive heat and moisture. Poorly cured gel coat. Certain chemical treatments such as chlorine and/or cleaners. Exposure of parts to moisture too quickly after fabrication	Use only a product recommended for the particular application. Improper shrink-wrap. Use only product (and recommended procedures) applicable to gel coats. Check for both over and under catalysation. Misuse of these chemicals, Allow 1 week ambient cure before service.
Gel coat **yellowing** (gel coat yellows rapidly and unevenly when exposed to sunlight and/or heat and moisture). *See section on Weathering*	1. Polystyrene/wax build up on the mould which has transferred to the part during moulding. 2. Inadequate gel coat cure: 2.1. Improper catalysation which results in inadequate cure of the gel coat. 2.2. Contamination such as solvent, moisture or oil.	Perform a regular mould-cleaning programme. **Do not** clean mould with styrene or used/dirty/reclaimed solvent. Check catalyst (bad or old lot batch) and catalyst level. Use only a recommended catalyst and maintain the proper level of catalysation. *(See Product Data Sheet).* These contaminants will affect the gel coat's cure. Look for moisture or oil in air lines, moisture or other contaminants in solvents used to cut the catalyst or other sources of contamination.

GEL COAT APPLICATION & TROUBLESHOOTING GUIDE

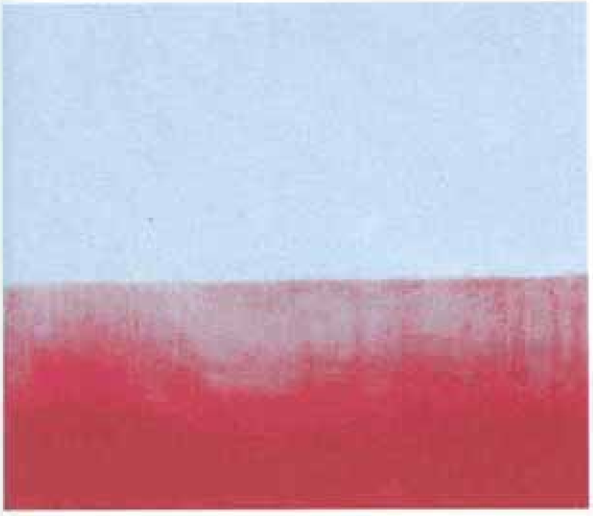
PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Gel coat **yellowing** cont	2.3. Improper or unauthorised adjustment of the gel coat.	**Do not add any material** (other than a recommended Methyl Ethyl Ketone Peroxide catalyst) to the gel coat **without the advice of a Cray Valley representative.** The addition of solvents or excessive add of styrene, inhibitors, accelerators, etc., will adversely affect the gel coat's cure and therefore its resistance to yellowing. (Contact your Cray Valley representative if adjustment seems necessary).
	2.4. Cold temperature during application.	Do not apply gel coat at temperatures below 60°f (16°C) Permanent undercure of the gel coat may result. Old material may be slow in gel and cure and will need adjustment.
	2.5. Old material	**Contact a Cray Valley representative.**
	2.6. Film cure inhibited by styrene vapours.	Provide adequate air circulation for «deep-well» areas where styrene vapours may collect.
	3. Pre-release	Most of the conditions which cause pre-release will also result in unusual gel coat yellowing; i.e., uneven gel coat thickness, uneven catalysation, uneven film gel and cure, etc. Check for and eliminate any pre-release tendencies.
	4. Excessively hot resin - rich laminates.	Good laminating techniques must be followed. This is especially true in deep well areas where the gel coat is not likely to cure adequately. Unusually 'hot' laminates at this point in the gel coat's cure may result in permanent undercure and more yellowing of the gel coat.
	5. Resin tearing	Overspray, excessive film build, flooding or contamination, all of which can result in vehicle/pigment separation. A concentration of the gel coat vehicle on the surface of the part will result in more rapid yellowing of the finished part.
	6. Uneven gel coat film thickness	Avoid flooding the gel coat or applying excessively thick gel coat. Maintain the recommended 18(±2) mils/thou wet film coverage. Excessively thick gel coat films will yellow more.
	7. Cleaning the finished part with an alkaline cleaner.	Do not use any strong alkaline cleaner (such as ammonia or other cleaner having a pH greater than 9) for cleaning a gel coat surface. A weathered gel coat can be yellowed by such cleanrers.
	8. Holding gun too close to the mould.	Maintain proper distance.
	9. Spraying in one pass	Spray in multiple passes.
	10. Insufficient atomisation.	Gel coat must be atomised to a fine particle.

GEL COAT APPLICATION & TROUBLESHOOTING GUIDE

1 - Air bulle



2 - Alligatoring
(Yellow area indicates resin)

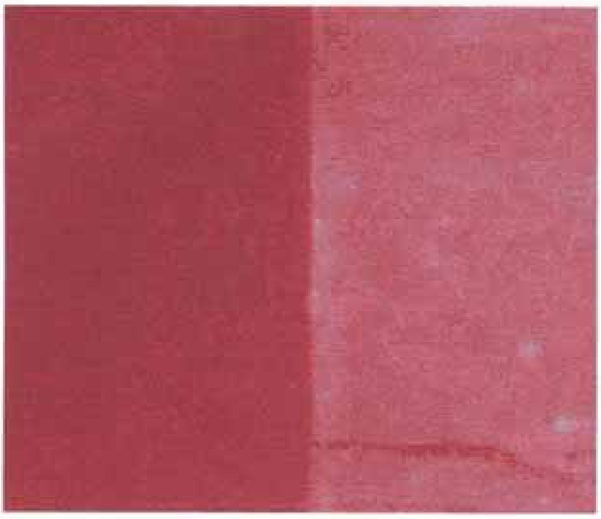


3 - Bleeding

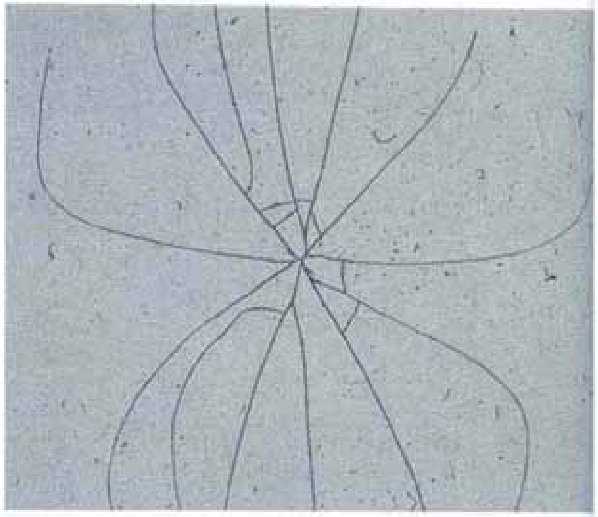
4 - Blisters - caused by catalyst drop

5 - Blisters - Osmotics
Small blisters - gel coat; large - laminate

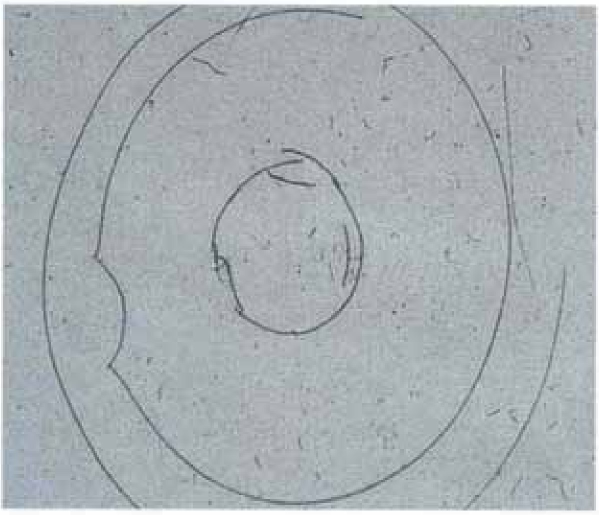
6 - Catalyst Drop Gassing
(can likely blister as in photo #4)



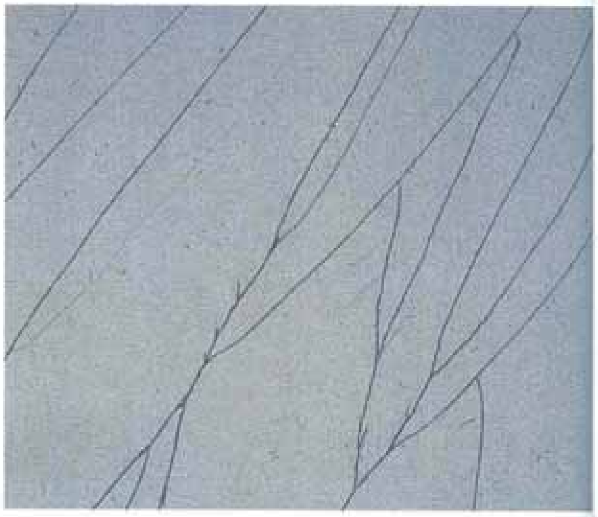
7 - Chalking



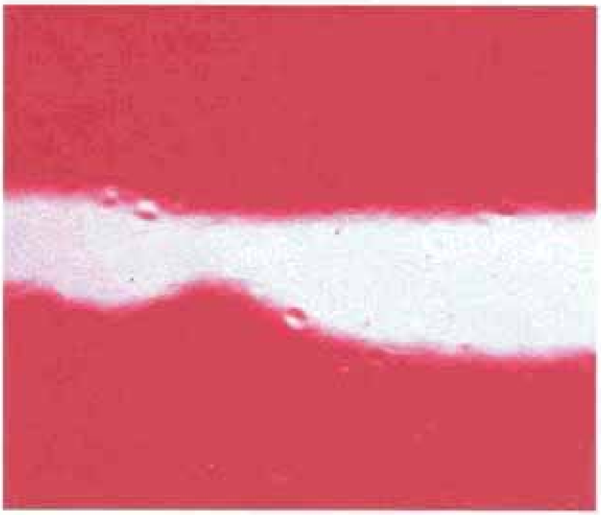
8 - Cracks - reverse impact (spider/star)



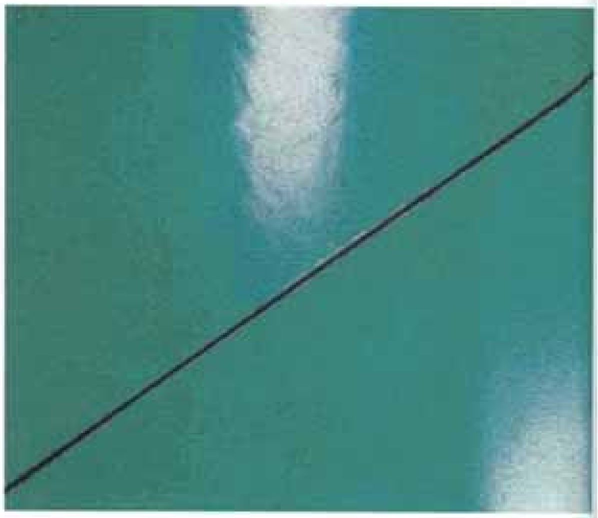
9 - Cracks - frontal impact



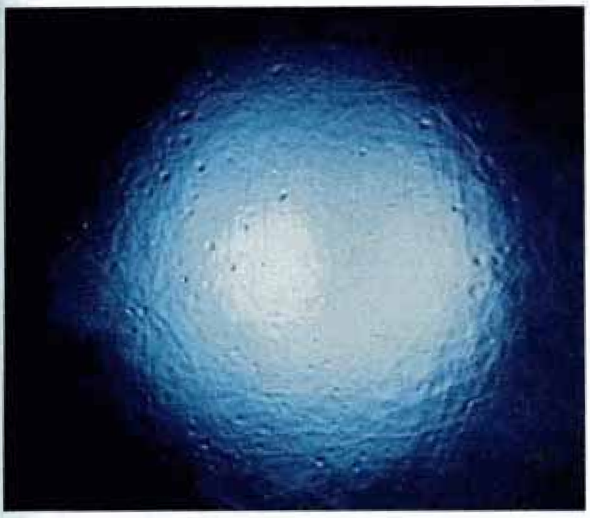
10 - Cracks - stress



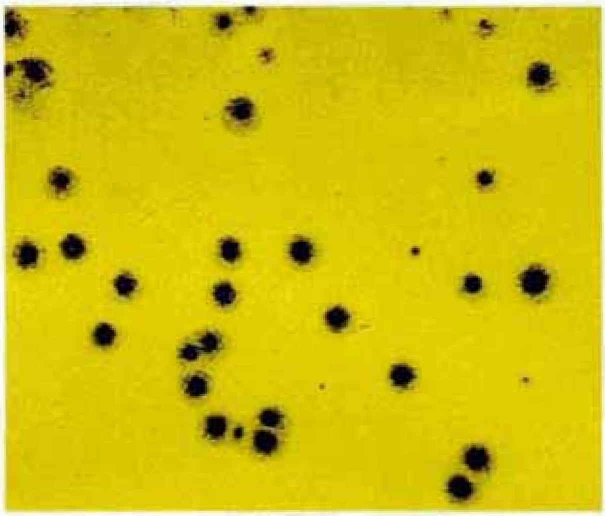
11 - Dimples



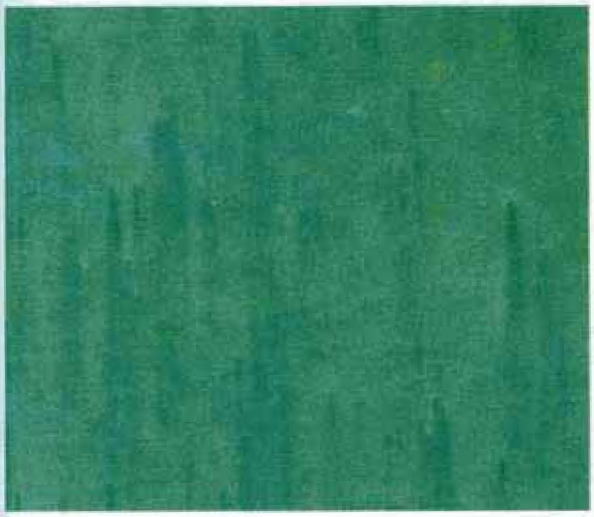
12 - Distortion - top panel shows distortion



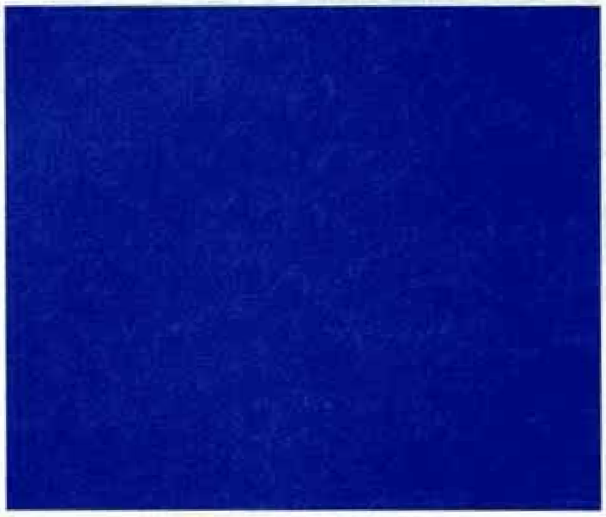
13 - Fiber Pattern & Distortion
(Note: also exhibits dimples)



14 - Fisheyes



15 - Pigment Darting



16 - Pigment/Color Separation

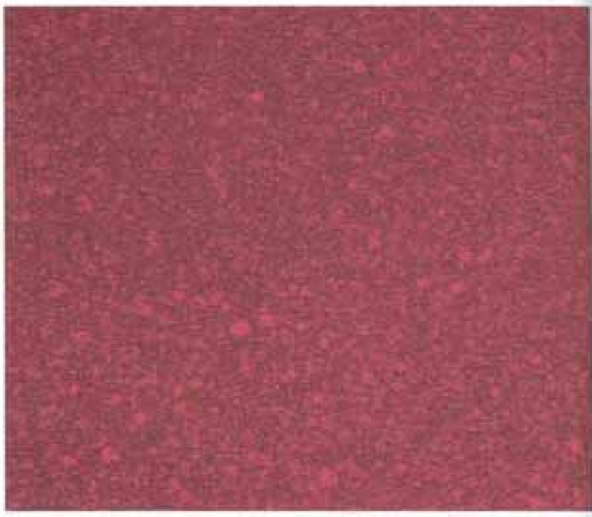
17- Pinholes

18 - Porosity (magnified 10x)

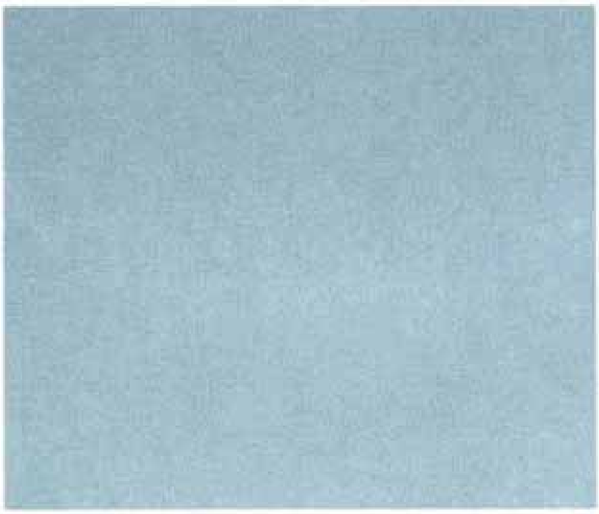
19 - Pre-Release
(Gel coat, before lamination)

20 - Pre-Release
(Gel coat, during or after lamination)

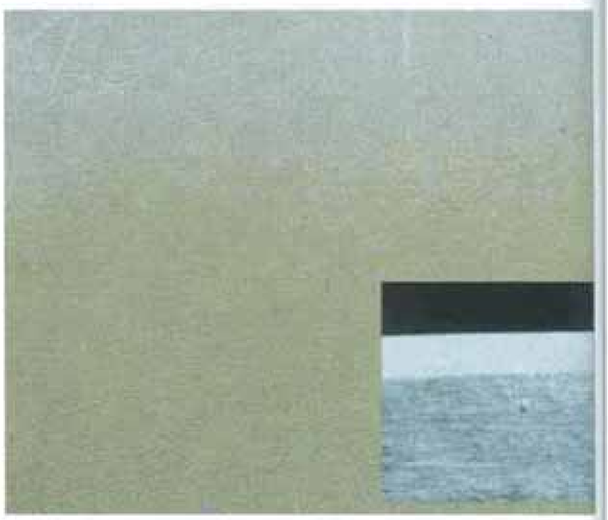
21 - Reasing Tearing



22 - Solvent Contamination



23- Water Spotting



24 - Yellowing caused by thick gel coat
(inset shows 55 mil thickness of white gel coat)

REFERENCE: PB-20

This section is a general overview of laminate construction.

While several methods of laminate construction are covered, most of the discussion is about contact moulding.

We discuss all the components of lamination and the methods used. We hope this section will help provide a good background for your understanding of FRP lamination.

1 GENERAL DISCUSSION

After the gel coat has been applied and cured, it is reinforced (laminated). This consists of bonding fibreglass with a polyester laminating resin to the gel coat for structural properties.

The fibreglass can be applied as either a mat, chopped glass, woven, or a combination of all three. This process is generally referred to as contact moulding. The resin can be applied by brushing, rolling, or spraying. The resin is worked in (the air in the laminate is worked out) with either a brush, a roller or a squeegee, depending on the part's shape, size and method of fabrication. This process is called "consolidating".

This process requires no more than atmospheric pressure and most curing is done at room temperature (minimum of 60°F, 15.5°C).

Although high production moulding is done by such methods as matched die moulding, compression moulding, centrifugal casting, filament winding, resin transfer moulding and other processes, most beginners are introduced through the contact moulding process. This method accounts for a high percentage of all FRP usage.

Certain products can be made only by contact moulding.

HAND LAY-UP

Hand lay-up is the process of applying the material, resin and fibreglass by hand. Brushes, rollers and wet-out guns can be used to apply the resin. The reinforcing glass will be consolidated materials such as mat, cloth, or woven roving to consolidate the shape.

SPRAY-UP

In spray-up moulding, chopped roving is sprayed simultaneously or alternately with catalysed resin onto the gel coat surface and then compacted.

This versatile process has reduced the cost of many contact moulded parts and has opened up numerous new uses for reinforced plastics in fabrication and maintenance.

There is no limit to the size of the products which can be

LAMINATE CONSTRUCTION

made by contact moulding where other processes are limited by the opening and size of the presses or other equipment used. Normally, contact moulding is used for short production runs of 1,000 parts or less, and on large parts where steel tooling is too expensive.

2 RESINS

All resins used in FRP contact moulding are thermosetting. This means that the liquid resin hardens irreversibly into a hard mass when heated or catalysed to cure at ambient conditions.

Both epoxy and polyester resins have been used with good results in contact moulding.

EPOXY

This resin is about 2 ½ times the cost of polyesters, but does not contribute proportionally higher strengths to the laminate. Its shrinkage factor is considerably lower than polyester so that close tolerance laminates, such as tooling, are available with epoxy. Also, where highest strengt to weight ratios are required, as in aircraft parts, epoxies are used.

Epoxy resins require an intimate mixing of resin and hardener and have not generally been effective in use with external mix spray equipment. Special precautions must be taken to protect the operator from inhalation of vapours or exposure of the sprayed epoxy resin and hardener to the skin. These precautions include barrier skin creams, protective clothing, spray booths and, in confined spaces, a mask with independent air supply.

See "Health and Safety" in Cray Valley's Applications Manual.

POLYESTER

The resin used in the wet-out process must be thixotropic (drain-resistant), have a moderately low exotherm (heat build-up from the chemical reaction), must wet out quickly and must cure moderately fast after the laminating is finished.

Polyesters used in contact moulding should have good gel time stability, good wetting characteristics, low exothermic heat development and, for inclined surfaces, some thixotropy. A pigment is sometimes used in the resin in low concentrations to assist in gauging laminate thickness. Gel time of the sprayed resin is not normally more than half an hour, and is often reduced to as short an interval as the roll-out operation will allow.

Remember, gel coats must be applied with separate spray equipment, such as catalyst atomisation dual nozzle guns or single nozzle spray guns.

All these factors contribute to fast mould turnover. The pot life (working time before gelation occurs) must be controllable over a wide time range and predictable by taking into consideration the temperature and humidity.

High humidity and lower temperatures extend the pot life or gel time.

A 15 degree Fahrenheit lower temperature will extend the gel time two fold.

Check individual data sheets for minimum and maximum catalyst levels to be used to ensure a complete cure.

Ambient temperatures should never be below 60°F (15.5°C) for proper cures.

VINYL ESTER

Vinyl ester resins, cousins to polyester resins, technically are a special class of polyester resins. The distinction is based upon what raw materials are used to cook them. Very few, if any, of the major ingredients, except styrene, are common to both polyesters and vinyl esters. Vinyl esters offer specific advantages in physical properties. These include: higher heat distortion temperatures; more elongation; greater resistance to fatigue; and better chemical resistance. Exterior durability is poor, which limits where it can be used. Cost is another strong consideration of where it is used, generally it is 2-3 times that of polyester. Styrene monomer is used to reduce the vinyl ester resin, just like a polyester. This results in similar working properties.

HYBRIDS

These resins are the most recent development in polymers for the fibreglass industry. They combine two or more differing polymer chemistries to provide a unique set of properties. They normally have extremely good elongation, toughness, physical strengths (with and without glass), low styrene emissions and fast cycle times.

Cray Valley has developed polyester/urethane hybrid resins for RTM and room temperature lay-up. These systems are developed for use with or without glass.

3 FIBREGLASS REINFORCEMENT

VEIL (HAND AND SPRAY-UP)

This is a thin (usually 10 mil/thou) layer of fine, soft fibreglass or synthetic fibre that is used next to the gel coat. It is used to reduce the transfer of fibre pattern through the gel coat from the coarser glass mats. It is also used in corrosion work as the last layer next to exposed surfaces.

MAT (HAND LAY-UP)

This is available in weights from 200 to 800 grams per square metre and is a rolled form of fibreglass. It is the weakest (structurally in the laminate), but has multi-directional strength rather than the bi-directional strength of woven material. It is made up of chopped strands up to 2" (5cm) long held together with a binder.

Some binders used in FRP glass are soluble in polyesters

Excess binder can cause a dimpling of the gel coat surface. Tear the mat and inspect it for the particles, (small and crystalline, like salt). Normally, there is more binder on one side of the mat than the other. Some mats are made with an insoluble binder and cannot be used in the hand lay-up process. Mat is used to inexpensively build up bulk (stiffness).

CHOPPED ROVING (SPRAY-UP)

Roving is a strand of glass fibres called ends (usually 60) wound up into a cylindrical package weighing about 35 pounds (16 kilogram). It is the cheapest form of fibreglass. It is used mostly in the spray-up process where the roving is chopped and fed into converging streams of catalysed resin by special equipment (chopper guns) onto the mould surface.

Sometimes the continuous roving is used to wrap around (for circumferential strength), in special configurations such as a fishing rod, vaulting poles, stiffening ribs. Roving is available with one red strand (out of 60) called a tracer, to help gauge the uniformity of thickness. The glass fibres become transparent when wet with resin.

The ideal roving for use in spray-up has good compatibility with the resin, good cutting characteristics, easy roll-out, and freedom from static electricity. Handling properties vary notably to the extent that the binder of the rovings renders it "hard" or "soft". Hard rovings cut well and have good strand integrity. Soft rovings tend to filamentise (i.e. open up) when cut. But they can be compacted into sharp corners, such as the strakes of boat hulls, without spring back.

WOVEN ROVING

(Hand and Spraying)

This material costs about the same or a little less than mat, but is twice as strong in tensile and flexural strength, so most structural laminates have some woven roving in their makeup. It is a coarse weave of the roving previously mentioned and is available in weights from 350 to 700 grams per square metre;. It is easy to place and conforms to contours better than mat or cloth. However, its coarse weave can be objectionable since its outline is sometimes seen through the gel coat when it is put too close behind it. This is called "print-through".

It is best to have at least 3/16 inches, (4.76 millimetres) of cured mat or chopped roving between the woven roving and gel coat minimise the print-through. Its strength is bi-directional like cloth, so that multiple plies are laid at different angles to each other. Isotropic mat is used between plies.

CLOTH (Hand and Spray-up)

Cloth is the most expensive form of fibreglass and the strongest woven material on an equivalent weight basis. It comes in weights from 50 to 1000 grams per square metre. Although most production parts utilise 100 to 250 gram material, the heavier weights such as 1000 gram cloth, can be used in tooling to build up strength and thickness quickly. It comes in different types of weaves such as twill, crowfoot and satin style where the satin is stronger and conforms more easily to compound curves.

Cloth is used principally as a finishing layer (for better appearance) or a skin layer (just behind the gel coat) for extra strength. It will "telegraph" through the gel coat as does the woven roving, but with less "profile".

CORE MATERIALS

When the fabricator needs to build in stiffness and strength without significant increases in weight...."core materials" are sandwiched between the layers of fibreglass. These "core materials" may be metal or paper honeycomb, cardboard, wood, foam, composites of hollow bubbles and fibreglass, or combinations thereof. Also, core material can be in sprayable form. Consideration must be given to the resin demand of core materials, their impact on cure and subsequent print/distortion. Their placement in order of construction must also be studied for optimum results for all aspects. The angles, ribs and tie-ins created during sandwiching add sturdiness, stiffness, strength and bulk to the FRP structure..

APPLICATION

The reinforcement is usually specified by the type of material, weight per unit area, and location in the laminate.

The first layer is important in that it must reinforce the gel coat and prevent air pockets from forming behind the gel coat. Reinforcing is best ensured by a thin layer (skin coat) of binder-free glass.

Studies have shown that laminate construction has an important effect on the performance of the gel coat.

To reduce cracking, blisters and crazing gel coats, the best results are obtained by using a thin coat of properly calibrated chopped glass and resin behind the gel coat; then continue with 450 gram glass mat lay-up.

LAMINATE CONSTRUCTION

The next layer or two should be a heavier mat, or chopped roving depending on the ultimate thickness desired. This provides for fast laminate build-up where strength is not critical. Another advantage of starting the laminate with mat layers is that it puts the fabric layers, which show a predominant pattern, further from the surface.

The third or fourth layer, if it is the final layer, can be woven roving or cloth. Woven roving should be used where strength is critical. Otherwise 6 or 10 ounce cloth is used for a better finished surface (than the mat) and a little extra strength. Another advantage of cloth as a final layer is that the laminator can squeegee hard on the surface to remove trapped air bubbles and excess resin.

Succeeding layers should be alternating mat and woven roving for best strength. It is not usually good practice to face two woven layers because of a poorer interlaminate bond and a higher chance for porosity (air bubbles entrapped in the cloth or woven roving usually extending the entire thickness of the fabric).

Nine total ounces of mat per square foot will result in a 1/4 inch laminate (at 30% glass content). Glass content is usually specified to prevent resin-rich areas (too low a glass content) which would crack and craze, or resin-starved areas (too high a glass content) which would cause porosity. An all-mat or chop laminate should have a tolerance of 30% glass (low) to 35% (maximum) for best results. When woven roving is used in conjunction with mat, the range of glass content can be as high as 80% for the ultimate in strength. Bag moulded parts should have a glass content of 60-65%.

LAMINATE THICKNESS VERSUS LAYERS OF GLASS REINFORCEMENT

The table on the following page is offered as an aid in estimating approximate laminate thickness of various glass reinforcing materials and typical laminating reins. The values given are averages and will carry according to application technique. It is noteworthy that a material's multiple layer thickness is not in direct proportion to its single layer thickness.

LAMINATE THICKNESS VERSUS LAYERS OF GLASS

REINFORCEMENT	NUMBER OF LAYERS	LAMINATE THICKNESS	% GLASS CONTENT
1.5 oz mat [1]	1	.041" 1mm	36
	2	.070" 1.8mm	34
	3	.107" 2.7mm	33
7.5oz cloth[2]	1	.017" 0.4mm	41
	2	.031" 0.8mm	40
	3	.045" 1.1mm	43
24oz Woven roving[3]	1	.043" 1.1mm	54
	2	.069" 1.8mm	55
	3	.092" 2.3mm	59
Alternating layers of	3(m,c,m)	.106" 2.7mm	30
mat & cloth	5(m,c,m,c,m)	.145" 3.7mm	34
	7(m,c,m,c,m,c,m)	.207" 5.3mm	31
Alternating layers	3(m,r,m)	.100" 2.8mm	36
of mat & woven roving	5(m,r,m,r,m)	.163" 4.1mm	42
	7(m,r,m,r,m,r,m)	.226" 5.7mm	44

DRY GLASS THICKNESS

1	1.5oz. mat (450g/m2)	0.022"	.58mm.
2	7.5oz. cloth (2250g/m2)	0.11"	2.9mm.
3.	24.0oz woven cloth (7200g/m2)	.024"	.60mm.

4 METHODS

HAND LAY-UP

Hand lay-up generally refers to pre-catalysing the resin in a pail and then pre-wetting the cured gel coat by using a brush, nap roller or wet-out gun. The pre-cut "sheet" of mat or woven product is placed onto the resin wetted gel coat and is wet-out again.

Compaction of the glass/resin and removal or air voids is accomplished by one of two methods.

- If the laminate is "mat only", roller and brush are used.
- If the laminate contains a woven product, the fabric is put behind the mat and then a squeegee is used.

SPRAY-UP

In the spray-up process, short glass fibres and resin are deposited simultaneously with catalysed resin onto the cured gel coat. This is done by a hand-operated chopper gun that chops glass roving and sprays catalysed resin so that the two merge and are directed by the operator onto the mould.

This process uses the least expensive raw materials and requires the least amount of labour (since there is no need for hand tailoring of glass or hand application of resin), but is more difficult to maintain tolerances in laminate thickness.A coloured trace strand is advisable in the glass roving to check the evenness of deposition. A transparent laminate is best to make inspections for variation in thickness and entrapped air bubbles or voids.

Highly contoured parts rather than large flat surfaces are more economically "sprayed up" unless thickness tolerances are critical. Glass content and strengths similar to an all-mat laminate results from this process. In Spray-up, workmanship is an important factor to the integrity of the product and means of inspection must be assured (transparent laminate, pressure tests, etc.).

Separate controls on the chopper gun allow the operator to spray the catalysed resin and glass simultaneously or independently of one another.

By regulating air pressure in the lines to the spray head and chopper, the operator is able to pre-set within certain limits the ratio of glass to resin that has been simultaneously deposited.Typical line pressures would be 30 to 40 pounds psi for the resin and 90 to 120 psi for the chopper motor depending on whether one or more rovings were being used.

After the mould has been prepared and gel coated, an undercoating of catalysed resin is sprayed over a limited area of the back of the gel coat.This is followed by a simultaneous deposition of glass and catalysed resin. Following behind the spray applicator are two or more assistants who roll out the deposited resin and glass.At high rates of output, more roll-out assistants are needed.

Aluminium or plastic rollers are suitable for roll out.

Typical rates of output of spray-up equipment currently available range from 2.7 - 13.6 kilograms of finished laminate per minute/high output is obtained by large volume resin pumps and by passing two or more rovings through the chopper. There has been some success in spraying up large pieces of simple configuration by combining more than one chopper and spray head in a single assembly.

EQUIPMENT

The equipment required to apply polyester resins can be as simple as a paint brush or as complex as an automatic unit programmed to automatically select, meter and mix the right amounts of material as required. For hand lay-ups, pre-cut sections of fibreglass fabric of the proper weight and weave are impregnated with polyesters resin to form a product. With "spray-up" a fibreglass " chopper" is used by feeding fibreglass strand (or "roving") through this device.

The glass fibres are sprayed along with the resin and catalyst spray to fabricate a laminate.

Spray-up equipment for fibreglass and polyester, available at moderate to low cost, consists of an air-powered roving chopper mounted together with a dual or single nozzle resin spray head. One or more rovings are led to the chopper where they are passed between two tangent rollers.

When set in motion by the pull of the trigger, these rollers propel the roving towards the mould surface as chopped strands. The cutting is accomplished by razor-like blades mounted in one of the rollers at an interval providing the desired strand length. The chopped strands converge with the streams of resin where they are partially wet out before reaching the mould surface. The resin spray head and glass cutter are suspended from a carrying boom to allow the operator freedom of movement.

The rovings are lead from spools along the boom to the cutter and the resin is supplied; 1) from two pressurised tanks of equal volume, one containing catalysed and the other promoted resin, or 2) by a single promoted resin using a catalyst injector. An air compressor of 5 h.p. or more is used to maintain line pressures up to 100 pounds psi. As the cost of continuous roving is considerably less than that of mat, the spray-up process offers an advantage in lower material cost. The cost is further reduced by the elimination of waste in batch mixing and trimming of reinforcements, which amounts to more than the over spray lost by an experienced spray-up applicator. Additional savings are realised in spray-up from reduced labour costs through the elimination of the mixing and tailoring operations, and faster deposition of resin and reinforcement on some contoured pieces.

In some applications, spray-up replaces hand lay-up; and in others, the two processes are being used in conjunction with one another. Complexity of shape often favours spray-up over hand lay-up. But small and deep drafted parts cannot as a rule be produced by this method. Physical properties of sprayed parts depend heavily on the applicator's skill in spraying uniform thickness'.

Properties of well constructed spray moulded parts compare favourably with those of mat laminates, but the problems of quality control become less critical when the sprayed glass is used together with a woven reinforcement, such as woven roving. Typical mat laminates have glass ratios of 30 - 35%. (When comparing glass ratios of mat with chopped glass, allow for the resinous binder in the mat which constitutes 4-5% of the weight of medium weight mat.)

An outstanding virtue of spray-up process is its versatility. Reinforced plastic laminations can be sprayed on overhead surfaces and on inflatable surfaces, cardboard and other temporary moulds. Glass and resin can be sprayed and rolled out on carrier fabrics such as cheesecloth, and wrapped wet on mandrels or other forms. Products that lend themselves to spray-up include items such as temporary shelters, ventilation ducts, boats, tanks, housings, machine guards, bath-tub and showers. Surface laminations for water-proofing and maintenance have been successfully field-tested on tanks, pools, conduits, grain elevators, roofs, gutters and freight cars.

The two most commonly used types of equipment are discussed in the following section:

▪ *"Split Batch" or Double Nozzle Spray Gun System*

Two equal volume individual quantities of resin are premixed as follows: One quantity has enough catalyst added to effect a cure for both quantities, gelation would take many hours or days without being mixed with the second quantity. The second quantity has a promoter, or accelerator added.

The two quantities are delivered separately, but in equal volumes, to a spray gun and are atomised in such a way that the two materials intermix; the intermixing may occur internally or externally. The promoter rapidly decomposes the catalyst and the cure takes place a short time later.

• *Advantages*

Large volumes of material can be dispensed at one time with adequate mix, no small catalyst nozzle to plug, limited calibration of equipment is required, and greater gel/cure time flexibility is possible.

• *Limitations*

The premixing and pre-catalysed side of the system must be used or removed within its "pot life" and it is more labour intensive than an injection-type system

▪ *Catalyst Injection System*

A catalyser (small pressure vessel with flowmeter) injects a measured quantity of catalyst (normally MEK Peroxide) into the atomising air supply of the spray gun. Resin is supplied to the spray gun with standard material handling equipment. During the atomisation of the resin, the catalyst is mixed into the material to initiate the cure cycle.

• *Advantages*

Good mix, dilution of catalyst by user not required, and spray gun can be calibrated.

• *Limitations*

Special air hose and fittings are required.

5 SPRAY-UP CALIBRATION

Calibration of a chopper gun is important to ensure maximum laminate strength and proper cure. When calibrating a chopper gun, the two main areas to be concerned with are resin/glass ratio and catalyst content.

▪ Resin/Glass Ratio

The resin/glass ratio is the amount of resin (by weight) versus the amount of glass (by weight) in the total laminate. These ratios ideally are 67% resin and 33% glass.

Normally, these figures can vary somewhat, but should stay within 70/30% to 65/35%. If there is too little glass, the laminate will be brittle and crack easily. If the glass content is too high, the laminate will be dry and hard to roll out. The laminate will cure dry and porous and not rigid enough to prevent cracking problems.

Total laminate output of chopper guns will vary - anywhere from 2.7 - 13.6 kilograms per minute. Chopper gun output considerations are generally based on:

- Size of part
- Number of "roll out people" available to roll; (the thicker the laminate the harder it is to remove air bubbles).
- Laminate thickness desired (skin coat versus 2nd and 3rd layer)
- Gel Time of the resin.

To figure calibration of resin/glass ratio you will need to know;

Resin weight per minute = R.
Glass weight per minute = G.

Total laminate weight per minute = T.

Example :

if R. = 7.75

G. = 3.50

T. = 11.25

To find the % resin or % glass :

divide (R.) by (T.) = .6889 or* 68.89% resin

divide (G.) by (T.) = .311 or* 31.1% glass

*Move decimal point two places to the right to read in percent. Resin/glass would be rounded to 69/31

Procedure for running resin/glass ratio is :

- Select and install correct fluid nozzle in chopper gun.
- Adjust air to resin pump **slowly** just until pump starts to pump; stop and check for leaks. Adjust pump pressure to "ballpark" area, i.e., high or low laminate out put. If high output, 30 pounds (13.6 kilograms) of laminate is desired, 67% of this is 20 pounds (9 kilograms) of resin, then high pressure on the pump would be required. If low output desired, 7 pounds (3.2 kilograms) of laminate, 67% of this is 4.7 pounds (2.1 kilograms), or low pressure on the pump is all that is necessary.
- After pump is adjusted to a close approximation, run a flow rate on the resin, by:
  - Weigh an empty container on a balance or scale.
  - Spray resin into the container for 30 seconds, weigh this collected material, subtract the containers weight and multiply the difference by 2, this is Resin weight per minute.
  - If the weight is close to you "ballpark", turn off pump and bleed pressure. If not, adjust pump as required and redo, then turn off pump and bleed the pressure.
- Run a flow rate of the glass per above procedures to obtain the glass weight per minute.
- Add R. (Resin), and G. (Glass) to determine T. (Total):

  R. divided by T. = Resin %

  G. divided by T. = Glass %
- If the ratio is not between 70/30 and 65/35, adjust resin or chopper as required, i.e., increasing resin or glass would increase total, decreasing resin or glass would decrease the total.

CATALYST CONTENT

After resin/glass ratio is checked, catalyst content needs to be determined. Resins normally are formulated to use 1.5% (at 25°C) of a 9.0% Active Oxygen Methyl Ethyl Ketone Peroxide catalyst. A minimum of 1.0% can be used when the weather is warm and as much as 2.4% can be used when temperatures are cold. Catalyst content within this 1.0% to 2.4% range must be insured.

To determine how much catalyst is required, multiply % Catalyst Desired (CD) times Resin, (R.).

Examples :

R. Is 7.75 pounds, convert this to grams.

There are 454 grams per pound, so 454 times 7.75 pounds = 3.518 grams

(R.) 3.518 x (CD) 1.2% = 42.22 grams of catalyst required.

Procedure for running catalyst content is :

- Turn off resin supply and chopper motor, then bleed air pressures.
- Adjust catalyst ball to close approximation, (high output - "high catalyst ball", low output "low catalyst ball") per recommended equipment Manufacturer's procedure, (see also "Gel Coat Spray Equipment" in this manual, regarding calibration as related to different catalyst atomizing equipment).
- Run flow rate on catalyst (the catalyst can be weighed or collected by volume) per procedures outlined in resin/glass calibration. Adjust the catalyst ball until the flow rate is ±2 grms/cc's of catalyst required.
- To double check the catalyst calibration:

  Run a control gel time by catalysing 100 grams (not cc's) of resin with the same catalyst and % that was used above.

  Check gel time.

  Turn resin supply on (leave chopper off) spray catalysed resin onto a panel, collect approximately 100 grams into a cup and check the gel time. The gun gel time should be ±2 minutes of the control gel time. If not, recheck figures and redo.
- Turn chopper motor on and make laminate.

6 MATERIALS FOR MAKING PARTS AND MOULDS

LAMINATE COMPONENTS

- Tooling Gel Coat
- Tooling Lay-up Resin
- MEK Peroxide Catalyst
- Lay-up or Spray-up Resin for Product
- Solvent
- Gel Coat for Product
- Fibreglass

LAMINATE CONSTRUCTION

■ EQUIPMENT NEEDED
(Spray Process)

- Spray booth with filter, exhaust fan, metal lined sliding doors, ample walking space around moulds, good ligh-ting.
- Air compressor. Don't skimp on size - specify an air drier; use accumulators with large water extractors.

It is recommended that all hand tools be air operated for operating costs and for safety reasons (nonsparking).

- Cutting table for glass reinforcement, not needed for spray-up gun, 60 inches, 152 cm, wide rack on one end for mounting rolls of glass - 2 rolls.
- Spray Equipment :
  - Pressure pot or pumps to accommodate volume of gel coat being sprayed; need high volume (larger orifice), high atomisation tip and cap.
  - Or catalyst injection gun, pumps - air atomised or airless.
- Monorail and hoists for heavy parts, like boats and shower stalls.
- Dollies or conveyor track for moving moulds around plant.
- Air hose, additional water traps, connectors, air regulators..
- Chopper gun for resin and glass.
- Air powered gear driven mixer for mixing resin and gel coat.
- Storage bins - heated or dehumidified for glass materials.
- Fire extinguishers around plant; consult your insurance carrier and local safety officials for proper type and location.
- Scales for weighing ingredients (ounces and gram).

■ TOOLS NEEDED

- Large scissors for cutting table and smaller ones for individual tailoring during lay-up.
- Paint brushes - 3 inch (8cm) and 4 inch (10 cm) (Solvent - resistant).
- Rollers - wool, plastic, and aluminium 1 inch x 3 inch (2.5 x 8 cm) and 2 inch x 7 inch (5 x 18 cm) with refills.
- Squeegee material.
- Hand grinders for smoothing exposed surface and edges.
- Buffers for applying rubbing compound, cleaner and glaze.
- Putty knives for bonding, filling, repairing.
- Air powered drills for hardware, trim, other attachments.
- Linoleum knives for trimming edges of part in mould.
- Wrenches for bolting moulds together.
- Clamps for holding inserts to wet laminate while curing.
- Measuring container for measuring catalyst.

■ AUXILIARY SUPPLIES

- Sandpaper - 80 to 600 grit, wet or dry.
- Solvent for clean-up.
- Covering for floors under laminating area.
- Cans - 1 gallon (4 litre) and 5 gallon (20 or 25 kilo) for resin and solvent of appropriate type.
- Sponges for washing moulds.
- Mould cleaner, mould sealer and mould wax.
- Wash basins - for clean-up.
- Solvent dispenser can.
- Rags

7 TROUBLE SHOOTING GUIDE FOR CONTACT MOULDING

Since the technique used in assembling the glass and resin properly is a deciding factor in the integrity of the part, particular attention must be paid to workmanship. The most important considerations of workmanship are :

■ UNIFORMITY OF RESIN DISTRIBUTION

Since application of resin by spray, roller, or brush is sometimes haphazard, special attention must be made to distributing the resin after it is applied. Resin-starved areas will be weak, whereas, resin-rich areas become hot during curing and will warp and crack. The finished part will be "brittle".

■ UNIFORMITY OF GLASS DISTRIBUTION

Any lack of uniformity depends entirely on the technique of the spray operator. The only non-uniform prepared glass reinforcement is glass mat, which has a 10% variation in weight. So for ultimate thickness uniformity, specify cloth and woven roving.

■ RESIN-GLASS RATIO

Not only resin distribution, but also the ratio of resin to glass will determine the likelihood of resin-starved or resin-rich areas. Specifying percentage of glass content can minimise these problems.

MINIMUM AIR VOIDS

It is impossible to remove all air bubbles by contact moulding, but their size and distribution is important. Large air voids give a whitish appearance when using clear resin. Since the most critical area is directly behind the gel coat, it is advisable to specify a light cloth, mat or chop for the first layer. Surface pits also must not be predominant.

MEDIUM HEAT BUILD-UP

Since the polymerisation or hardening reaction of the resin generates heat, it is important that the reaction be controlled.This is done by keeping the concentration of catalyst to an allowable minimum, allowing a few layers of laminate to cool to room temperature before continuing with additional layers, also excess resin should be prevented from collecting.

Low exotherm resins should be specified for thick laminates (over 1/8", or 3.175 mm).

For best consideration of mould life, part temperature should not exceed 160°F (71°C).

REDUCTION OF DELAMINATION POSSIBILITIES

Delamination occurs when two or more layers of glass reinforcement separate. Since glass mat is homgeneous in nature, multiple plies of this material almost never delaminate. Carelessness in compacting the multiple layers during lay-up can result in delamination. The placement of mat between layers of woven roving or cloth increases the shear strength between layers since the loose mat fibres link the fabric layers more effectively, giving better shear strength.

The laminate is the major portion of any fibreglass part. It provides the physical strength of the part. Problems which arise in the laminate not only affect the strength of the part, but many times show up in the gel coat surface. The gel coat, being only a thin surface film, will not compensate for or hide a poor laminate. Some defects can be caused by either gel coat or laminate. *(See "Gel Coat Trouble Shooter's Guide" and "Equipment Trouble Shooting Bulletin" in the section "Gel Coat Spray Equipment" in this Application's Manual.)*

Listed below and on the following pages are some of the more common laminate problems, although other problems can occur. It is impossible to list or foresee every plant circumstance that can cause problems.

8 TROUBLE SHOOTING LAMINATES

PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Glass **pattern** or **waviness** in gel coat found a) **When** part is pulled .	Resin shrinkage or heat	Check catalyst level, temperature, use lower exotherm resin, avoid resin puddling, thin gel coat, under-cured gel coat.
	Thin gel coat	Use a minimum 16 mils. (Thou)
	Under-cured gel coat	Use a minimum of 1.2% MEKP. Temperature should be at least 60°F (15.5°C)
	Laminating process	Too much laminate at one time, (use a skin coat); woven roving or cloth too close to gel coat.
b) **After** part is pulled	Post cured	Too low a catalyst level, temperature too low, liquid contaminate, resin exotherm too low, demoulding too soon, gel coat too thin.
Soft Spots	Unmixed catalyst	Check equipment, catalyst and resin sides for clogs, surging, drips, purge catalyst line.
	Water, solvent or oil (May appear as whitish areas)	Check air lines and solvent, rollers must be free of solvent.
Hot spots	Over-catalysing	Check equipment, catalyst and resin sides for clogs, surging drips, purge catalyst line.
	Resin-rich areas	Reduce resin content
	Unbalanced laminate	Check thickness of different areas.

LAMINATE CONSTRUCTION

PROBLEM	CAUSE	SOLUTION OR ITEMS TO CHECK FOR
Colour variation in laminate	Hot/cold laminate	Mix in catalyst well, reduce percentage of catalyst, resin puddles, moist glass.
Low impact strength or **cracking**	Insufficient glass	Check glass to resin ratio
	Demoulding	Rough demoulding, too much twisting and flexing.
	Part too thin/weak resins	Increase thickness check grade and physicals of resin.
Cure time - long or short	Various	Check percentage of catalyst and type, temperature, laminate thickness, gel time, contamination.
Delamination a) From gel coat	Contamination	Dust on gel coat, gel coat cured too long, mould release build-up dissolved by gel coat, used top coat instead of gel coat
b) Between laminates	Application	Poor impregnation, resin rich
	Resin	Too much wax in resin, weak resin, check grade and physicals.
	Cloth from Cloth	Use mat or chopped glass between plies
	Uncured	Check percentage of catalyst, temperature, pulling green
Dimples in gel coat	Particles in laminate	Check for excessive binder on mat - one side may be worse than the other
		Contaminants between gel coat and laminate, gel particles in resin.
Drain out a) No dry glass	Resin-rich	Reduce resin-to-glass ratio, avoid "after wet"
b) Dry glass	Resin too thin	Use higher thixotropig resin.
	Long gel time	Increase catalyst where allowed, check temperature
Gel time - long or short	Various	Check percentage of catalyst and type, temperature, lami nate thickness, gel time, contamination
Glass pick-up on roller	Rolling near gelation	Adjust gel time
	Styrene evaporation	Dip roller in styrene or fresh catalysed resin Keep air movement across laminate to the minimum
	Rolling too fast	More deliberate rolling.
	Too high % of glass	Increase resin.
	Dirty rollers	Correctly clean roller
Resin crack	Pulling too soon	Do not pull under-cured parts.
	Too hot	Resin puddles, excessive catalyst, resin too high in exotherm.
Poor wetting	Viscosity too high	Check viscosity, cold resin, moisture contamination.
	Glass type or wetting properties	Check type and grade of glass.
Voids (air bubbles)	Entrapped air	Poor roll out, slow wetting glass, resin starved areas, resin viscosity high, filler level high, resin drain out.
Warpage of parts	Unbalanced laminate	Use symmetrical lay-up, back spray laminate with gel coat or top coat.

9 EQUIPMENT TROUBLE SHOOTING

The majority of polyesters used today are sprayed or pumped through semi-automatic equipment.The care and operation of this equipment will determine whether or not the polyester will achieve its maximum properties and performance.

Gelcoaters (people who spray gel coat) and chopper operators must be trained in how to use and maintain their equipment.This can save or cost you money. Anyone who uses spray equipment should have and read all the literature available from the manufacturer of the equipment,. This includes parts diagrams, set-up instructions, operating instructions, maintenance requirements, safety and trouble shooting guides.

If you do not have this information, or have a question, call or write to both the people from whom you purchased the equipment and the manufacturers of the equipment. They will help because they want you to use the equipment efficiently, correctly and safely.Also, they have general literature on spraying, and technical service people to help you.

Always remember you have an investment in your equipment and it was purchased to do an important job. If you do not maintain it and replace worn parts, you will lose your investment and it will not do the job for which you bought it.

A way to determine if a cure related problem is caused by material or equipment is to make a small test part where the catalyst is weighed in. If the part made without the equipment does not have the problem, then the cause is more likely in the equipment or operator.

Another way to check is to use a different batch of material through the equipment; however, this could generate bad parts making the first test method preferred.

Listed below are some of the more common problems that can occur with spray equipment. Since there are many different types of equipment in use, we cannot cover each one individually, or list all problems or solutions.You should see the manufacturer's literature for the particular type of equipment you are using or contact the manufacturer.

EQUIPMENT TROUBLESHOOTING - SUGGESTED CAUSES AND REMEDIES	
PROBLEM - GEL COAT/SPRAY	**SUGGESTED CAUSES AND REMEDIES**
Atomisation poor (large droplets)	Check air pressure, length of hose, hose diameter (which may be too small), clogged or worn nozzle or air cap, stuck check valves, too much fluid flow, regulator not working properly.
Balls in the catalyst flowmeter drop	Bottom needle valve almost closed and vibrates, filter plugged, not enough CFM's.
Balls in the catalyst flowmeter overshoot	Top valve wide open, turn 1 ½ turns in - (Binks injector)
Catalyst ball goes out of sight when pressured.	Catalyst level too low - insert special gasket with .013 hole over delivery tube (Binks injector), air in flow tube.
Catalyst valve - burst of catalyst	Weak sprung due to ageing. If Binks, use Plug Groove valve at the gun. If hose within a hose, check for broken catalyst line.
Cavitating pump - sucks air	Remove siphon tube, put pump directly into resin - if pumps okay - cavitating due to siphon system leak, pump too small, cold or high viscosity.
Check stuck ball	Residue after flushing, vapour lock. Use piece of wood to free ball or tap side of pump.
Chopper will not run or runs slowly	Loss of air, insufficient CFM's; regulator not on; rubber roller adjusted too tight.

LAMINATE CONSTRUCTION

PROBLEM - GEL COAT/SPRAY	SUGGESTED CAUSES AND REMEDIES
Drips (Gun):	
Fluid	Worn, clogged, or bent needle, seating adjustment of needle, over spray on gun, worn packing or seals, loose connection
Catalyst	Worn seat or seals, damaged air valve, trigger out of adjustment, over spray on gun, loose connection, clogged valve or seat, gun head not aligned to gun body, fan control may trap catalyst in dead air apace and drip catalyst out of air horns.
Solvent.	Clogged or worn valve, worn seals, sticking needle or button
Gelled hose	Bad fluid nozzle, bad seat.
Glass (chopped) not uniform in length	Worn or damaged blades; worn rubber roller; incorrect roller adjustment.
Glass pattern narrow	Chopper angle wrong; chopper air too low.
Glass off to one side	Chopper out of alignment; fluid nozzle worn or clogged.
Glass to resin ratio varies	Chopper air not regulated; pressure dropping before compressor kicks on - install regulator and set below the compressor's kick-on pressure; pre-wetting and extra wetting not accounted for.
Hot Spots	Catalyst or resin surging, purge catalyst line before starting, catalyst drops.
Housing (chopper) packs with glass	Motor speed too slow; blower air too low; static electricity; overspray in motor; dirty glass.
Material (none on downstroke)	Foot valve, spring, spring retainer, or foot valve ball worn or dirty.
Material (none on upstroke)	Piston cups, piston ball or pump cylinder worn.
Pattern of spray off to one side	Partial clogged air cap, damaged nozzle, worn nozzle or air cap, bent or worn fluid needle.
Plugged filter screen	Seedy or partial gelled batch, trash from material falling off pump when placed in new drum; due to normal build-up, screens and pumps must be cleaned periodically.
Pump cycles when gun is not in use	Worn piston cups, bottom check ball not seating.
Shaft of pump drops an inch or two - shudders	Starved pump - check filters or worn internal packing. Check for worn packing by stopping pump at top of stroke - if with no material flow shaft creeps down, packing is worn.
Shaft of pump (material coming up around)	Loose or worn seals - clean and tighten, stop pump in down position when system not in use, worn shaft.
Siphon kit jumps	Dirt on check ball in pump.
Slow gel time and/or cure	Check catalyst and material flow, oil or water contamination. Check gun trigger for proper activation. If slave pump, check for air bubbles.

PROBLEM - GEL COAT/SPRAY	SUGGESTED CAUSES AND REMEDIES
Surging:	
Material	Inconsistent or low air pressure on pump, worn or loose pump packing, out of material, sucking air through loose connection, balls not seating in pump (dives on down stroke - bottom ball; fast upward stroke - top ball; flush pump), filter plugged, siphon line has air leak, screens plugged, too much material flow, cold or high viscosity, plug ged surge chamber.
Catalyst	Inconsistent or low air pressure, out of catalyst, check valve sticking in gun or catalyser, loose connection, screen plugged. If Binks equipment install Plug-Groove valve at the gun, keep hoses straight rather than coiled.
Tails (airless)	
Material	Pump pressure too low, worn tip, too large a tip, viscosity too high.
Catalyst	Worn tip, low pressure, wrong tip, viscosity too high, too large a fan.
Tips splitting or trigger will not shut off	Worn seat or worn needle or weak spring, check packing.
Trigger stiff	Bent needle, bent trigger, worn needle guide.
Water in air lines	No extractor, extractor too close to compressor - should be no closer than 25 ft, all take off's from main line should come off the top.
Worn packings	Pump overheating from being undersized, high pressure or pumping without any material, do not let pumps jackhammer - no more than 1 cycle (both strokes) per second - use glass reinforced Teflon™ packings. Keep idle pump shaft in down position to keep dried material from damaging packings.

10 FILLED LAMINATING RESIN

Some industries use a filled resin system to achieve certain special reduced burning rates of polyester. The filler is normally hydrated alumina mixed with a special viscosity laminating resin (Cray Valley may be able to supply you such resin, ready-to-use). This resin is normally filled 10 - 50% by weight with hydrated alumina. The hydrated alumina filler should be slowly mixed in with the pre-measured special resin. The more hydrated alumina used, the more effect there is on viscosity (higher), and cure time (longer), gel time may be slightly longer.

Because of the longer cure time in filled state, especially at the 50/50 level and higher, handling should be minimised until fully cured. This is especially true when laminating to acrylic sheet, where delamination may occur if the part isn't fully cured.

Due to the viscosity when filled, a lower glass content is used - around 15 - 21%, depending upon amount of filler. Further, laminating should be limited, in area to approximately 3 feet x 3 feet (1 metre x 1 metre) to a first thickness of around 1/16 inches (1.6 mm).

Over 1/16 inch (1.6 mm), there is more air entrapment due to increased difficulty to roll out. Styrene evaporation from the surface becomes the factor limiting the area which can be laminated at one time as it creates a stickier, harder-to-roll laminate.

11 VACUUM BAG MOULDING

This process is similar to hand lay-up in that the material is applied to the mould by hand, but the compaction and air removal steps are replaced by a final vacuum operation that ensures a high glass content, high laminate strength, elimination of voids and more control over resin mixing and glass-to-resin ratio. A clear plastic sheet is placed over the laminate and sealed to the edge of the mould. A vacuum pump then draws the air out from between the bag and the mould.Air is drawn from the laminate through bleeders, such as felt strips.

This process is used for almost all aircraft parts because of the high percentage of glass obtained (65 - 70%) and the reduction of air pockets. This process is particularly suited to sandwich construction where pressure is needed to compact the laminate and excess resin must be eliminated. It should be specified for integral sandwich constructions, where strength and weight are very important and where reliability is an important factor.

The human element (or workmanship factor) is minimised in this process because the material is usually pre-cut, pre-impregnated and only a minimum of handwork is needed to compact the laminate and remove air.

12 COLD MOULDING AND RESIN TRANSFER MOULDING (RTM)

Cold moulding is a low pressure, room temperature, moulding process utilising polyester resin, glass mat or cloth and relatively inexpensive matched moulds of metal, epoxy, or fibreglass.

The glass fibre reinforcement, pre-cut to the required shape, preformed or formed with thermoformable glass, is placed on one-half of the mould with its edges extending into the flash area. Resin is then onto the glass and the mould closed until low pressure (10 - 150 psi) OR - resin is injected into a closed mould until it appears at the pinch-off area or bleed ports.

Once the part is cured (5 - 30 minutes), it is removed from the mould.

Cold moulding is a process which economically fits between hand lay-up (500 to 1,000 parts) and match metal die moulding (10,000 parts).

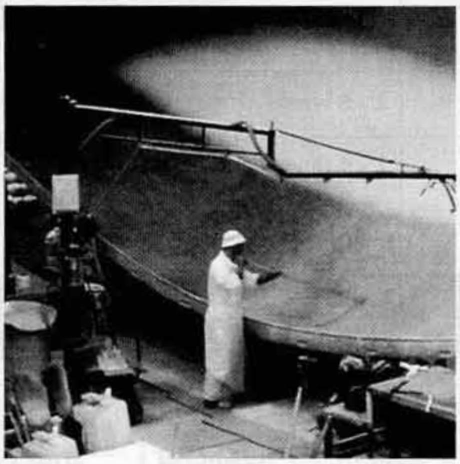
Example: 5 square foot areas, 3 pounds of laminate, fibreglass mould, room temperature, pressure to 10 psi, gel time 4.5 minutes, demould time 12 minutes.

TWO PART MIX			ONE PART MIX
Accelerated side		**Catalysed side**	
Resin	75.0 parts	Resin 100.0 parts	RTM resin (pre-promoted) 96.3 parts
Internal mould release	.2 parts	BPO-paste 3.7 parts	Internal mould release .2 parts
Styrene	10.0 parts		
Pigment	7.0 parts		Pigment 3.5 parts
DMA*	1 parts		Catalyst (MEKP) 1.25 parts

**(DMA is a hazardous material. Follow all precautions as listed on to label, data sheet and Material Safety Data Sheet)*

2 CONTACT MOULDING, COLD MOULDING/RTM, AND MATCHED METAL DIE MOULDING COMPARISONS

	CONTACT MOULDING	COLD MOULDING/RTM	MATCH METAL
Number of parts up	Less than 1,000	500 - 10,000	10,000 and up
Part size	Any size	Currently 30 sq. ft. 2.8 sq. Metres to 400 sq. Ft, 37.16 sq. metres	Any size limited only by press.
Cure :			
a) Temperature	Room temperature	Up to 200°F(93°C), cooling may be necessary.	250 - 350°F(121 -177°C)
b) Time	2 - 4 hours	5 - 30 minutes	1 - 15 minutes
Parts per 8 hour shift per mould	Generally one	16 - 90	30 - 400
Moulds	FRP	FRP or metal	Metal
Mould lead-time	2 - 4 weeks	2 - 6 weeks	4 months
Mould cost (approx.)		2 - 4 times contact moulding	5 - 10 times contact moulding
Press cost (approx.)		£1250 and up	Over £25,000
Part surface	One smooth, other rough	Both sides smooth	Both sides smooth
Part-to-part consistency	Fair - depends on operator	Good	Good
Tolerances	Depends on operator	Good	Good
Resin-to-glass ratio	Depends on operator	Good	Good
Use of filler	Yes	Yes - low level	Yes
Resin	Standard laminating	Special low viscosity - fast gel and cure	Special
Glass	Fabric or chopped	Continuous strand mat	Continuous strand mat, sheet moulding compound, bulk moulding
Mould release	External	External and internal	Internal
Compaction	Hand roll out	10 - 50 psi	500 - 3,000 psi
Pinch off or Flange areas	Not necessary	Yes, to help develop pressure	Yes



DISTORTION FIBRE PATTERN PRINT - THROUGH

REFERENCE: PB-56

A gel coat defect that has long plagued the FRP industry is fibre pattern print-through, and distortion. Several causes of distortion can be cited and all relate directly to post-cure of the laminate. There is no prevention method for post-cure. The objective is to minimise or mask the resin shrinkage which would limit the distortion.

Fibreglass fabricators should avoid the following, which maximise distortion:

- Heavy gel coat orange peel.
- Air bubbles in the laminate
- High or low catalyst levels
- Pulling parts too soon
- Laminating woven roving or cloth too close to the gel coat
- Shop temperatures below 70°F (21°C)

Another factor that maximises distortion, but is difficult to avoid, is dark gel coat colours. The reason is two fold: a dark surface reflects light better, revealing the fibre prominence more than light surface coats and dark gel coats increase distortion by achieving higher post cure temperatures.

EFFECT OF COLOUR CHOICE ON SURFACE TEMPERATURE UNDER SUNLIGHT*		
SURFACE TEMPERATURE °F (°C)		
PANEL COLOUR	**UNBACKED**	**FOAM BACKED**
White	120 (49)	127 (53)
Light Blue	127 (53)	137 (58)
Medium Blue	137 (58)	157 (69)
Dark Blue	144 (62)	174 (79)
Medium Red	128 (53)	142 (61)
Dark Red	137 (58)	169 (76)
Black	148 (64)	173 (78)

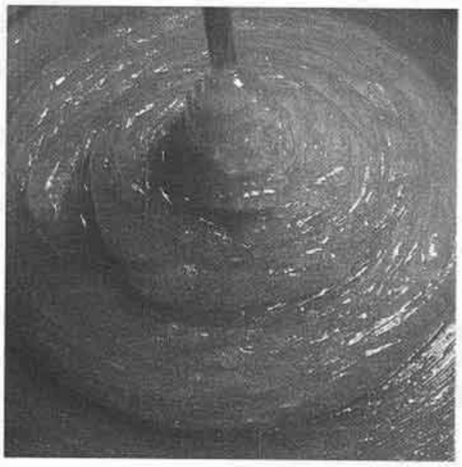
** These panels were exposed to outdoor sunlight with unrestricted ventilation of 100°F (38°C) air.*

Special precautions can be taken to mask the shrinkage.

Fibreglass fabricators can use:

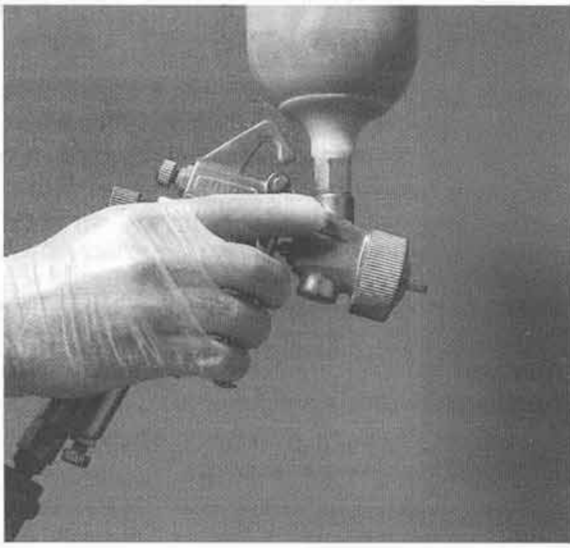
- A thicker gel coat film (no more than 24 mils(thou) wet).
- A back-up gel coat or hybrid.
- A laminate skin coat first, then multi-stage laminate build up.
- A high-heat distortion ISO laminating resin
- A special low-shrinkage resin

NOTE: Distortion on parts can sometimes be traced to the mould. If so, the mould should be refinished and/or use moulds with a thick laminate average 3/8 to ½ inches (9.52 - 12.7 millimetres).0



REFERENCE: PB-2

This section is designed as a guide for repairing a fibreglass part.
No matter how much care is taken in making fibreglass parts, some of them will have to be repaired. Some of these defects are caused by defects in the mould, operator error, contamination, rough demoulding, impacts during handling, storage or use.
The first thing that should be done when a defect is found is to try and determine what caused it. Then, if possible, eliminate the cause.



1 GENERAL WORKING CONDITIONS.

Fibreglass repairs should be made with the same type of gel coat and/or laminating resin used to make the original part. The same chemical reactions that gel and cure the materials used to make the original part take place during repair. Considerations of safety, temperature, catalyst levels, and calibration to make a good part are also important to achievement of a good repair. In fact, they are more critical since additional heat from other steps is not available, and the repair does not set up for hours in the mould until sanded and buffed.

SAFETY

Many of the materials used in fibreglass are hazardous. Therefore, before any repairs are started, obtain and read all MSDS's on ALL materials (gel coats, resin, catalysts, solvents, etc.). make sure all safety requirements are met before proceeding.

CURE

• **Temperature** - Repairs should not be attempted when material, ambient, or substrate temperature is below 60°F (16°C) as poor cure any results. Poor cure can cause the repair to change colour, be dull and/or prematurely fail. Note that at 60°F (16°C) repairs will be slow and will have long cure times.

It is best to have temperatures above 75°F (24°C) since small masses of materials (thin films of gel coat) are being used. Air and part temperatures are critical as cold air, or draft, and cold parts will greatly influence small masses of materials. If this happens, poor cure can result.

• **Catalyst** – Since small amounts of gel coats are used and additional heat from the laminate is not available, the catalyst levels should be kept on the high side, normally 2% but no more that 3%. Normally Polycor gel coats are controlled with Peroxid Chemie LA3. Therefore LA3 is the recommended catalyst for gel coat patching. Butanox LA, Peroximon K12, Luperox DHD and Andonox LCR-S are suitable alternatives.

To achieve good cure, the ratio of catalyst to material should be calibrated (measured) to be within proper limits.

Many repairs are small and require small amounts of patching materials. One method of catalysing is to use the 'drop' method (example: for 2% catalyst level for a teaspoon of gel coat, add 4 – 6 drops of catalyst). This method can work, but the margin of error is great because of the small amounts used. A better method is to use larger amounts (50 grams at a minimum) and measure material and catalyst using grams. Even if 95% of catalysed material is discarded, it is cheaper than redoing a repair due to error in using small amounts of materials. It is less costly in the long run if the materials are accurately measured.

The next best method is to measure by volume (50 ml or cc of gel coat, 1 ml or cc of catalyst).

Low cost measuring devices can be purchased from scientific apparatus suppliers.

VISIBILITY

Most repairs are done on areas that are visible. It is necessary the repair area be well lighted to insure the defect is removed, to see what is being done, and to make sure the repair is acceptable.

MIXING

To assure uniformity, all materials must be mixed before use.

NOTE: Material used in repair is taken from larger production containers. The larger container must be mixed before repair supplies are obtained.

2 MINOR SURFACE REPAIRS - SPOT PATCHING

The following procedure is recommended for areas which have damage to the gel coat only or have a blemish (hole, gouge, or scratch) that is deep enough to penetrate through the gel coat to the fibreglass, but not deep enough to go completely through the laminate.

- Rough up the surface of the damaged area using a hand held router, power drill with burr bit attachment, or coarse sandpaper. Feather the edge surrounding the blemish with finer grit sandpaper. Do no undercut this edge.

- Be sure that the area to be patched is clean and dry, and free of wax, oil or other contaminants.

Solvents (see Warning under Helpful Hints 7) such as Ethyl Acetate and Methyl Ethyl Ketone are suitable for this purpose.

- Place an ample amount of gel coat in a suitable container lid such as ½ litre tin lid. By adding 5% by weight of Cray Valley's wax solution to the gel coat a good surface cure can be obtained.

NOTE: Always make the patch with the same batch of gel coat that used to make the original part. Failure to comply with this rule will almost certainly result in an off-colour patch.

Thoroughly mix the proper amount of MEK Peroxide into the gel coat. The addition of 2.0% (4 to 6 drops) catalyst to a teaspoon mass of gel coat should give a working time of about 15-20 minutes at 77°F (25°C).

- Work the catalysed gel coat into the damaged area with a knife or spatula. Slightly overfill the blemish, including the area around and above, to allow for shrinkage. Puncture and eliminate any air bubbles that may be entrapped within the gel coat.

- If Cray Valley Wax Solution was not added to the gel coat, cover the repaired area with cellophane, waxed paper, or parting film (PVA) while the patch cures.

CAUTION:

Spray the PVA so that the mist is almost dry when it hits the patch because wet PVA could inhibit the cure.

- Let the patch cure thoroughly before doing anything further to it - approximately 2 - 3 hours. The patch has not cured sufficiently if a thumb-nail will leave an impression in the gel coat.

- Sand the patched area with 220 grit wet or dry sandpaper. Change to 320 or 400 grit, then to 600 grit wet or dry paper. If the patch shrinks to a point where the surface is not level with the adjoining area. Repeat the preceding process. Complete the finishing process by buffing with rubbing compound to a smooth surface. Then wax and buff the surface to a high gloss. See section 6, "Finishing Techniques".

If this spot patch does not match in colour, double check to see if the same batch of gel coat was used in the patch as was used for the original part. It might be necessary to make a spray patch (see following directions) over this spot patch or over an entire section.

As with body work on cars, it is sometimes necessary to spray patch an entire section at a time using edges or corners as boundaries for difficult-to-match situation.

3 AREA PATCHING - SPRAY PATCHING

■ Sand the area to be patched using 220 grit sandpaper. Feather the edges using finer grit paper in hard-to-match situations.

■ Clean the surface with a suitable solvent as described under 1.2 of "Minor Surface Repairs," for spot patching.

■ Add 5% Cray Valley's wax solution by weight (up to 10% can be added for better sprayability) and 1.2 - 3% MEK Peroxide to the gel coat used for patching.

MIX THOROUGHLY!! ALWAYS MAKE THE PATCH WITH THE SAME BATCH OF GEL COAT THAT WAS USED TO MAKE THE ORIGINAL PART.

Failure to comply with this rule will almost certainly result in an off colour patch. If an aerosol can sprayer is used, up to 5% solvent may be added to the patching gel coat to get better sprayability. Use high purity ethyl acetate or methyl ethyl ketone.

CAUTION:

If solvent is used, do not spray the patch too wet or too thick. Retained solvent will retard the cure of the gel coat and can create porosity or change the colour and lower the gloss.

Example:

100g gel coat

5 - 10 g wax solution

1.2 - 3.0g catalyst.

■ Using a Binks 115 type spray gun, spray the catalysed gel coat over the entire sanded and feathered area. Thickness should be approximately 8 - 12 mils (thou) for good cure. If spraying an area where gel coat has been completely removed, thickness must be at least 12 mils(thou) for good hide.

■ Let the patch cure thoroughly.

■ Sand the patched area with 320 grit wet or dry sandpaper; change to 400 grit, then to 600 grit wet or dry paper. Buff with rubbing compound, then wax and buff to a high gloss for the final finish. See 6., "Finishing Techniques."

4 HOLES OR CRACKS IN THE GEL COAT REQUIRING A PUTTY PATCH

There are two aspects to putty patching. If you want a "thick" gel coat only, use about 2.0% fumed silica. If you want a reinforcing or strengthening putty, use 1.0% fumed silica and about 10.0% of a glass filler such as milled fibres, micro glass, or glass bubbles.

Preparation and procedure are the same as those given for minor surface repairs. Normally, spray patches have to follow a putty patch because air bubbles are entrapped in the patch or there is a slight colour change due to the filler added. Reinforcing putty should be used to resist patch cracking if the laminate is weak or flexible.

Coarse sandpaper, such as 100 grit, can be used to level the putty patch. Masking tape can be placed alongside the patch to keep from sanding the surrounding gel coat.

Finish with a spray patch.

5 PATCHING OF HOLES, PUNCTURES & BREAKS

The following repair method is used for damage which penetrates completely through or deeply into the entire laminate:

■ Prepare the affected area by cutting away the fractured portion of laminate to the sound part of the laminate.

A keyhole or sabre saw works well to cut away these ragged edges.

■ Rough up the inside edges of the affected area using a power grinder. Feather out the backside at least half the diameter of the hole to be patched.

■ Clean the surface and remove all paint or foreign substances as previously described in spot patching.

■ Use a template to give "shape" to the part. Tape cellophane in place over a piece of cardboard or aluminium large enough to completely cover the affected area with cellophane towards the inside of the part. Aluminium is used when contour is present.

■ Cut glass fabric and mat to the shape of the hole and one half diameter larger than the hole. Materials are total thickness should approximate that of the part you are repairing.

PATCHING

■ Mix an ample amount of resin with the appropriate amount of catalyst. Apply this onto the glass mat and thoroughly wet it out. Wet-out the fabric in a similar manner. Apply the mat first against the cellophane over the inside of the hole. Then apply the fabric.

■ Roll out or squeegee out all air bubbles. Allow the area to cure well. Build this laminate up to the same thickness of greater than the thickness of the original laminate.

■ If you cannot get to the backside (blind hole), then a template will not be used. Cut a piece of cardboard slightly larger than the hole. Then cut the fibreglass mat and cloth along the same outline as the cardboard inset, only larger. Thread a wire or wires through the centre of the cardboard insert, follow with the fibreglass.

Wet-out the fibreglass with catalysed resin. Force the plug through the hole. (Don't worry about neatness - your first concern is a structurally sound repair). Use the wire to pull back and secure the plug until the resin cures.
When cured, check adhesion of the plug and proceed.

■ When laminate has cured, remove the cellophane and backing from the outside of the hole and rough-up from outside, feathering the edge with a powder grinder.

■ Mask the area with tape and paper to protect the remainder of the laminate. Then repeat Steps in 4 if a large void is present. Smaller voids could be patched with putty material.

■ Using 80 grit sandpaper, smooth and blend the patch into the surrounding surface.

■ Follow previous Steps for spray patching to complete the patch and obtain a high gloss colour matching patch.

6 FINISHING TECHNIQUES

The frequency of complaints related to cosmetic finish problems has increased in the past 4 - 5 years. These defects are most often referred to as pits or comet tails. We feel that this coincides with increased customer demand for contact moulded FRP parts and a general movement to higher quality finishes.

Production process techniques in some high production countries have changed to help manufacturers keep up with increased customer demands. We have seen that moulds are run in poor condition and turned faster to meet production demands. This in turn caused more sanding and buffing to remove mould defect on productic parts caused by over use.

Parts may not be allowed to sit in the mould as long an are not well cured when sanded and buffed, compoundir this problem. Dual action sanders are replacing hand sar ding. These sanders are fast but the sanding area is a min mum of 4 inches (10cm) regardless of the size of th defect. Polishing is accomplished with 10 inch (25cm) bu fers which further increases the size of the finish area. Fin shers often stop sanding with 320 grit DA paper and us high speed electric buffers along with coarse buffing com pound to take out the scratches. High rpm's (more thai 3000) and "excessive" buffing pressure can cause excessiv heat build up. Buffing should not be such as to heat the ge coat more than "just warm". Rough handling of the gel coa creates "comet tails", burns the gel coat, and causes th resin to post cure producing print through. Higher rpn buffers in conjunction with heavy pressure can definitel induce finishing problems.

Sanding to the finest possible grit is strongly recommended so that the least amount of buffing is required.

When buffing compound has been consumed in an area, dc not continue buffing with a dry pad. The dry pad will heat up the gel coat and it is at this point that pits often develop.

Always pre-condition a new/clean pad by pre-buffing at low rpm so to "wet" the fibres of the pad. Using plenty of compound to lubricate and cool the gel coat is recommended. Spur the buffing pad when it starts to glaze over or change to a clean pad. When sanding scratches are removed and gloss is nearly back, change the pad and use a fine glazing compound to bring up the gloss.

Recommended Procedures

■ Sand out all patched or DA areas to 15 to 20 micron (the equivalent to 1200 DA) or 600 grit wet.

■ Buff out sanded area with a medium duty compound.

■ Change buffing pad and apply a final glaze.

Important:

Ideal buffing speeds are from 1700 rpm to 3000 rpm

7 HELPFUL HINTS

■ To speed up the patching process and for patching in cold working conditions, use heat lamps, heat guns, space heaters or prebuff before sanding.

CAUTION:

Overheating may cause blistering and poor colour matching. Patching materials are flammable be careful.

■ Spray patches generally match better than spot or putty patches.

■ Different colours behave differently in patching.

■ Additional additive to the gel coat may cause a colour change.

■ As a general rule, keep any patch as small as possible.

■ If the patch is not cured thoroughly on the surface, wiping with suitable fast evaporating solvent will clean the surface sufficiently to allow sanding without clogging the paper.

■ Check technical literature for the correct catalyst levels on all materials used.

WARNING:

Acetone and many other fast evaporating solvents are highly flammable and can be toxic. Consult literature such as the book of "Dangerous Properties of Industrial Materials" published by Reinhold Publishing Corporation, New York, for physical hazards of these materials. You may also consult your supplier.

■ Do not use excessive buffing pressure. Excessive pressure creates heat, this heat may cause print through and distortion. This heat and pressure can actually abrade the cured film of gel coat down to the laminate.

■ Our experience has shown that one of the biggest factors that contributes to patching problems is lack of a method for measuring gel coat, patching aid and catalyst.

We have developed a method that is quick, accurate, and inexpensive for mixing patching material in the shop. The effort required to accurately measure gel coat, patch aid and catalyst is often the difference between a patch matching or having to start over again.

- Apply mould release in 3 or 5 ounce (9 or 15 cl) cups to be used for moulds.

NOTE: DO NOT USE PARAFFIN LINED CUPS, THE PARAFFIN CAN BE SCRAPED LOOSE DURING MIXING AND CONTAMINATE YOU BATCH.

- Obtain samples of white or light coloured gel coat and dark gel coat to make castings. An 80:20 ratio is best for light colours and a 70:30 for dark colours. Catalyse enough gel coat to make two castings

  Catalyse gel coat at 0.5% so that castings are less likely to get too hot and crack.

  Weigh catalysed gel coat into waxed cups, and put on a level surface to cure.

- If you are using 5 ounce cups (15cl) a 100 gram standard patch mix will allow plenty of room for mixing. For white, use 100 grams in one cup and 80 grams in the other.

  For dark colours, use 100 grams in one cup and 70 grams in the other. Allow the casting to cure and cool then remove from the cups.

- When a patch is to be made, use the appropriate set of castings to mark lines in the mix cup. Gel coat should be filled to the bottom line then patching aid to the top line. Stir patching aid and gel coat together thoroughly and then catalyse at 2.0% for best cure.

  A 10cc graduated cylinder should be used to measure catalyst. For a 100 gram mix, use 2 cc's of catalyst.

PATCHING

8 TROUBLESHOOTING GUIDE

PROBLEM	ITEM TO CHECK
Colour does not match	Wrong batch used for patching; fillers added; too many accelerators added; catalyst level off; patch undercured; trapped solvent; dirty spray gun; buffer developed too much heat.
Patch is dull	Undercured; catalyst level off; low temperature; sanding too quickly; trapped solvent; PVA sprayed too wet.
Comet Tails	Too coarse a sandpaper used on last sanding; buffing too hard; dry pad.
Low Gloss	Excessive buffing pressure; coarse compound.
Sand marks	Too coarse a sandpaper or rubbing compound used in last step - work up through 600 wet; undercured.
Ring around patch (halo)	Edges not feathered; not sanded properly; porosity in original gel coat may have to overspray; uncured patch. Improper level of patching aid.
Crack re-appears	Crack was not fully ground out; weak laminate.
Patch is glossy, part dull	Original gel coat undercured; buffer developed too much heat. Too much patching aid.
Porosity or void in patch	Not sprayed or levelled properly; filler not mixed in properly; trapped solvent air not worked out.
Patch is depressed/shallow	Patch will shrink – allow for this by overfilling. Do not sand and finish until patch is cured. 'Hot' buffing can cause the patch to shrink. Condition the patch by prebuffing before sanding.

POLYCOR® TOPCOATS

REFERENCE: PB-53

Polycor Topcoats are very similar to gel coats except they cure tack-free. Topcoats are used like paint - to seal and hide a substrate. Normally topcoats are used as interior finishes or to cover a laminate to give a coloured surface. Topcoats cannot be used as a gel coat, because they do cure tack-free, and delamination could result.

Cray Valley has formulated a complete line of coloured Polycor Topcoats. These multi-mil surface coatings are formulated for use in boat and camper shell interiors, over masonry blocks, wood, masonite or hardboard and metals providing they are not subjected to flexing or bending and are properly primed when necessary.

Topcoats should not be used for water immersion service.

Polycor Topcoats produce a hard, tough, durable, flat finish when applied correctly.

1 SURFACE PREPARATION

■ Fibreglass laminates such as boat and camper shell interiors.

Polycor Topcoats should be sprayed after the laminate has cured and while it has a tacky surface. Beware of glossy laminates where topcoats may separate, sag, and give poor adhesion.

While still wet, the Polycor® Topcoat can be flecked or cob webbed.

On laminates containing a "wax surface" or "mould release" this should be removed before coating with Polycor® Topcoat. Sand with rough sandpaper to remove all indications of wax or mould release, then wash with solvent.

In all cases; before applying Polycor® Topcoat to any surface ... be sure the surface is clean, dry and freed from asphalt, dirt, dust, grease, oil, form oil, soap or cleaning agents, disinfectants and deodorants.

2 APPLICATION

Topcoats should NOT be applied to surfaces when the temperature is below 70°F (21°C). At temperatures below 70°F (21°C), inadequate cure can result. Equipment, settings, and techniques for spraying gel coats are the same for Enamels.

We recommend a delivery rate of no more than 2.5 pounds (1.1 kg) a minute with conventional air atomised equipment, and no more than 4 pounds (1.8 kg) a minute with airless equipment.

Batch mixing is recommended to achieve the best catalysts mix and cure because even with the equipment properly calibrated, potential problems can occur due to; poorly atomised catalyst, surging problems (topcoat or catalyst), poor tip alignment (catalyst to top coat mix), contamination, and poor application procedures which will quickly negate all benefits of calibration. The equipment (and application procedures), must be monitored on a routine basis to ensure proper cure and application of the topcoat. Inquire of and adhere to all equipment manufacturer's recommendation.

Equipment, pot pressure, temperature, and length of hoses will vary the spraying; therefore, you should adjust your equipment to obtain a good spray surface.

POLYCOR® TOPCOATS

One gallon of Polycor® Topcoat will cover approximately 75 to 100 square feet (6.9 to 9.3 m2) ... depending on the film thickness of the coating. A wet film thickness of 18 ± 2 mils (thou) is recommended for proper hiding, cure and performance properties. A film below 12 mils (thou) may not cure properly. Excessive millages above 24 mil(thou), may pre-release, are more prone to cracking and tend to trap porosity. If a "fleck coat" of topcoat is desired over the base coat of enamel, it may be applied while the base topcoat is wet.

3 CURE

It is recommended that gel time be checked in the customer's plant as age, temperature, humidity and catalyst will produce varied gel times. Gel time/cure data refers to 9.0% active oxygen MEKP. Recommended catalysts should be used with Cray Valley Topcoat.

The catalyst level should not exceed 3% or fall below 1.2% for proper cure. Recommendation range is 1.2% to 3.0% with 1.8% at 77°F(25°C) being ideal. Cure characteristics are dependent on material temperature, room temperature, humidity, air movement, and catalyst concentration. Special fast-cure versions are available but must be requested. These products offer lay-up times of 30 minutes or less depending on gel times. Fast cure products have shorter stability and should not be inventoried over 45 days.

These products (standard or fast cure) should not be used when temperature conditions are below 70°F (21°C) as curing may be adversely affected.

4 AVAILABILITY

Polycor® Topcoats are available in a wide range of colours as well as clears, white and black.

Special colours are available upon request.

5 CLEAN UP

Clean all equipment upon completion of the application, as it is impossible to clean equipment if the Polycor® Topcoats sets up and is allowed to cure in the hoses and gun.

6 STORAGE LIMITATIONS

Uncatalysed Polycor® Topcoats have a usage life of three months from date of manufacture when stored at 73°F (23°C) or below in a closed, factory sealed opaque container, and out of direct sunlight.

POLYCOR® CONDUCTIVE SANDING GEL COATS

REFERENCE: PB-41

This chapter describes Cray Valley conductive sanding gel coats and their application in the following sections:

1 DESCRIPTION
2 APPLICATION

1 DESCRIPTION

Cray Valley conductive sanding gel coats have been used for several years in composite construction to enable electrostatic post painting of FRP parts. They are offered for both open mould and RTM processes. They may also be used as a gel coated surface to facilitate static electricity drain off (with proper grounding provided).

These products are available only in black. Conductivity comes from carbon particles which are black. The liquid material will normally yield a maximum resistance of 0.10 megohms when tested by an ITW Ransburg #70357 meter. Parts should register 100 to 165+ on the ITW Ransburg #8333 Spray Ability meter. Users should determine that the product's conductivity meets the intended use.

These conductive sanding gel coats are made from resilient isophthalic polymers to meet normal flexing/fitting demands after paint bake, and ingredients for quick powdering-sanding surface preparation. They exhibit good chemical resistance and are considered very serviceable in a salt water environment.

While the gel coat is only part of the composite/laminate structure, it must participate in the processing and service conditions of the total composite. These conductive gel coats can withstand temperature elevations to 180°F (82°C) but normal operating temperature range is considered 0°F to 120°F (-18°C to 49°C). The gel coat will endure the lower temperatures of this range but can crack if stressed significantly. Temperatures as high as 325°F (162°C) for 30 minutes are endured but customers should expect some pinhole blowing and accompanying spew from trapped air pockets within the sanded composite.

These gel coats are ready to use and require only the addition of an appropriate methyl ethyl ketone peroxide (MEKP) to cure.

These gel coats will chalk when exposed to direct sunlight and are not designed (nor recommended) for constant water immersion parts.

Conductive surface coats (or enamels) can be made from these products by incorporating 5% by weight of a 10% wax solution.

2 APPLICATION

Conductive sanding gel coats are generally formulated for both airless and conventional spray application. Brushing or rolling is not recommended. Refer to the chapters on 'Gel Coat Application' and 'Gel Coat Spray Equipment', for additional specific recommendations.

Pits, pinholes, and porosity are, of course, very detrimental in a sanding gel coat which is to be post painted. It is important not to spray any of these defects into the film. Keeping the equipment properly calibrated (gel coat delivery/atomisation and catalyst delivery/atomisation) is important as is maintaining a minimum temperature of 70°F (21°C) (material, mould and ambient) and applying the gel coat in at least three smoothly sprayed 6 mil coats using the appropriate spray distance.

Cray Valley recommends a gel coat delivery rate of no more than 2.5 pounds per minute (1.1 kg/min) with conventional air-atomised equipment, and a rate of no more than 4 pounds per minute(1.8 kg/min) with airless equipment.

Batch mixing is recommended to achieve the best catalyst mix and cure. Even with the equipment properly calibrated, potential problems can occur due to:

- poorly atomised catalyst,
- surging problems (gel coat or catalyst),
- poor tip alignment (catalyst to gel coat mix),
- contamination,
- poor application procedures, which will quickly negate all benefits of calibration.

POLYCOR® CONDUCTIVE SANDING GEL COATS

The equipment (and application procedures) must be monitored on a routine basis to ensure proper application and cure of the gel coat. Ask about – and adhere to – all equipment manufacturers' recommendations.

For best overall end performance properties, a wet film thickness of 18 + 2 mils is recommended as ideal. Films less than 12 mils will have less conductivity, may not cure properly, may be hard to patch, have more print-through, and are more susceptible to water blisters. Films above 24 mils may pre-release, trap porosity and crack

Proper mould maintenance is important. Although conductive gel coats have excellent patching properties, minimal repair work is always desirable.

PAINTING POLYESTER GEL COATS

REFERENCE: PB-47

1 DESCRIPTION

2 SURFACE PREPARATION

3 OTHER SYSTEMS

1 DESCRIPTION

If painting of a gel coat part is desired, the most durable paint system to employ is a catalysed urethane.

In general, two-component acrylic urethane or polyester urethane enamels have very good gloss and colour retention when subjected to prolonged and severe atmospheric conditions. They will normally cure at ambient temperatures to a very tough, abrasion-resistant film with exceptionally high gloss.

2 SURFACE PREPARATION

When re-coating (painting) a polyester gel coat, it is very important that the surface be clean and free from mould release agents, oil, grease, and other surface contaminants.

Follow the coatings manufacturer's directions for surface preparation, mixing, reducing, sweat-in, pot life, application coverage, film thickness, drying time, clean-up, physical data, precaution and safety, and other aspects.

If using for water immersion service (boats, baths, showers, pools, spas, etc.), be sure that the paint is recommended for such use.

- In the absence of surface preparation instructions, a minimum surface preparation is to wash thoroughly PRIOR TO and AFTER sanding with CLEAN rags and V.M. & P. Naphtha (or coating manufacturer's recommendations) to remove all contaminants.
- Sand all gel coat surfaces with a medium grit sandpaper such as #120, #220, or #320 to roughen the surface. Follow with an overall fine sanding to a smooth surface using #400 grit sandpaper.

3 OTHER SYSTEMS

Other paint systems can be used but may not have the exterior durability of catalysed urethane. Match desired durability with paint quality. See paint manufacturer's recommendations.

BLISTERS AND BOIL TESTS

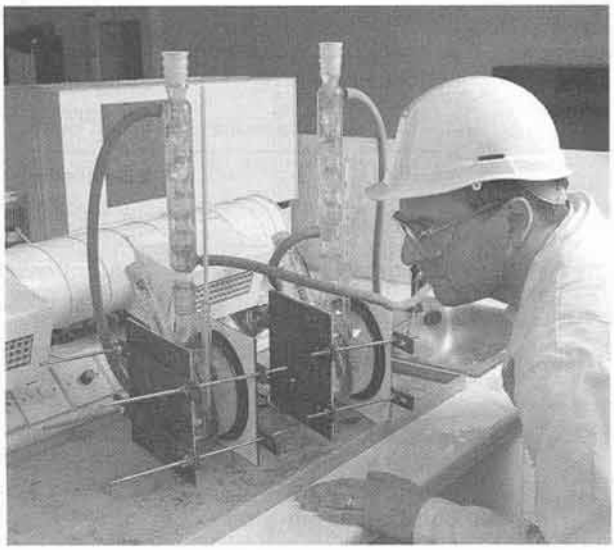
REFERENCE: PB-24

If you make fibreglass parts, sooner or later you will run into blisters. In this article we will cover many types of blisters and their causes. An audio/visual presentation on blisters is available for viewing through your Cray Valley representative.

A blister is a raised surface area behind which there is either a hollow area (generally referred to as an air bubble) or a liquid area (solid swelling).

Blisters normally appear on the surface of the part. They very seldom are caused by the gel coat. If you look at an old car, many times you note rusted areas around which the paint has blistered. A lot of these blisters are not due to the paint failing, but rather to rusting of the metal.

When you are looking for the source of blisters, consider not only the gel coat, but all the ingredients that make up the total laminate.



1 CAUSES OF BLISTERING

2 BOIL TESTS

3 TROUBLE SHOOTING BLISTERS

4 REFERENCE MANUAL

1 CAUSES OF BLISTERING

AIR POCKETS

Air, trapped beneath the gel coat, can cause a blister to form when the surface is heated enough to cause the entrapped air to expand. A part in sunlight can reach temperatures greater than 150°F (66°C). The darker the colour of the part, the higher the temperature.

If the surface above the air void is weaker than the force generated by expansion, a blister will form. These voids can also serve as collecting points for liquids, such as water or residues.

An air pocket is the most common cause of blistering and is sometimes easily located by tapping the part with a plastic or wood stick. They usually are indicated by a difference in sound. Usually they sound dead or muffled. Air pockets such as these are usually caught and repaired in the plant. They vary in size and are more commonly found in radii, (corners).

Most of these are caused by poor roll out, too much glass and/or filler, or poor wet out of the glass or glass spring back. Some air pockets are caused by debris that has fallen into a mould trapping air or affecting bonding between layers due to contamination. These voids, however formed, will also cause the gel coat to more easily crack.

ENTRAPPED LIQUIDS

Entrapped liquids are another common cause of blisters. An entrapped liquid can expand with heat. Heat can cause some materials to form a gas or become a corrosive liquid.

These blisters can show up a few hours after the part is pulled and placed in the sun. Some of them will take longer to appear. Bubbles of entrapped liquids are generally random and about the size of a penny or smaller. If they are punctured, they are sticky and contain fluid.

Any non-reacted liquid, such as catalyst can be self-sealing or encapsulated. The outer edge of the drop will react with the polyester to form a tight gelled skin that entraps the rest of the un-reactive catalyst. The catalyst can cause a blister by simple expansion or by breaking down to form gases and/or solvent like material that slowly weakens the surrounding area.

An entrapped solvent can also expand, change into a gas, and weaken the area around it.

Uncatalysed resin entrapped between cured layers can cause blisters.

Listed below are some of the more common entrapped liquids plus some of the characteristics of each.

BLISTERS AND BOIL TESTS

LIQUID	COMMON SOURCE	DISTINGUISHING CHARACTERISTICS
Catalyst (main cause)	Overspray, drips due to leaks or malfunctioning valves	Usually when punctured, the blister has a vinegar-like odour; the area around it, if in laminate, is browner or burnt in colour.
Water	Air lines, improperly stored material, perspiration.	No real odour when punctured; area around blister is whitish or milky.
Solvents	Leaky solvent flush system, overspray and carried in by wet rollers.	Odour, area sometimes white.
Oil	Compressor seals leaking	Very little odour, fluid feels slick and does not evaporate.
Uncatalysed resin	Malfunctioning gun or ran out of catalyst.	Styrene odour and sticky.

■ ATTACK BY A CHEMICAL

This is when a corrosive agent literally breaks up from the outside or from within.

When polyesters are attacked by a chemical, the first signs are swelling and blisters. Alligatoring of undercured gel coat is an example of chemical attack. The styrene from the next polyester layer attacks the film.

The general types of materials that can break up polyester are : alkaline materials (like caustic, trisodium phosphate); certain solvents (like acetone, ethyl acetate, methyl ethyl ketone, if in contact long enough before evaporation); chlorinated liquids (methylene chloride).

If you suspect chemical attack, check for signs of attack on metal fittings, trim and wood attachments. This agent can be from airborne or water sources.

■ CREATION OF AN OSMOTIC PRESSURE CELL

Osmosis is a very common natural phenomenon. This mechanism involves water penetration, normally by immersion. A pure liquid, such as water, can pass through a membrane in order to combine with a salt. In the case of FRP the membrane is a thin film of gel coat, and the salt is any material that can be dissolved fully or partially in water.

NOTE: This process can occur in all coatings such as epoxies, urethanes, alkyds and latex.

As the water passes through the gel coat and combines with the salts present, it becomes higher in density therefore, it does not exit as quickly as it entered. This continued absorption of liquid causes an expansion within some part of the laminate that is seen on the outside gel coated surface - a blister is formed. This pressure build-up cannot only lead to a blister, but can also cause the gel coat to crack open.

A very simple example of osmotic pressure is when you boil a hot dog. It is one size before you put it in the water. As it boils, the water passes through the skin and dissolves part of the salts in the hot dog. Because the "salted" water cannot get out as fast as it comes in, the hot dog swells up in size and eventually will split apart.

The osmotic mechanism regarding gel coat blisters is greatly affected by: quality and thickness of the gel coat; how well the system (gel coat and laminate) is cured; the quality and compatibility of the resin and glass in the laminate with the gel coat and other materials. This affects the rate water penetrates the part. The amount and type of "salt" affects the rate of penetration and whether blisters will occur or not.

Normally we are talking about large amounts of "salts" and a weakened membrane. For the source and types of salts that can be involved, see the section on what affects boil test results.

2 BOIL TEST (ANSI WATER RESISTANCE TEST)

A boil test concerns exposing a surface to boiling water - 100°C for 100 continuous hours. Caution must be used when interpreting the results of this test.

This test is one section of ANSI Z124 standard for fibreglass plastic bath tub units. It was developed to set up a material standard for shower and tubs. The rating is in five separate areas:

- Blister size and number
- Change in surface profile (Fibre prominence)
- Cracks
- Loss of visible gloss
- Colour change

The rating scale for each area is subjective. The scale is "0 to 5" with "0" being no change and "5" being the maximum change possible. Values 1, 2, 3 and 4 are increasing gradations of change. A laminated panel is rated by three experienced people, independently. A panel is failed if any one area has a rating over 4 or the total of all area averages is over 9. The ANSI standard lowers the severity of the test for thermoplastic sheet material by lowering the test temperature to 82°C. One should note that the occurrence of blisters by itself does not indicate failure, it is a combination of factors.

Many question whether the boil test can be related to actual use. The main reasons for questioning this are:

- There are different test temperatures for different materials.
- The thickness of gel coat and type of substrate is not specified, but both are major influences on the success or failure of the specimen,
- The conditions are extremely severe and are not found in normal field applications.
- Some materials which fail this test have been used successful for years in certain field applications.
- Test results are very dependent on types of glass and resin and their application

This test, if performed with proper controls, can be a help in choosing and/or comparing materials.

There are many extreme tests for FRP laminates that have no direct field correlation. Elongation at break tests are generally accepted as valuable tests but in actual use an FRP part would not be subjected to a similar force. Boiling water tests are like wise extreme and no one in actual practice boils their FRP parts. But the test is valuable in comparing different, but similarly constructed laminates.

Since the boil test is required by the shower stall industry and is referred to by other segments of the FRP industry, a good understanding of what affects this test is a must.

The boil test attacks the gel coat in two ways: The high temperature water causes a softening of the gel coat and chemical attack (corrosive); the hot water produces a high hydrostatic pressure (water penetration) that can set up osmosis.

PERFORMANCE FACTORS

The following factors affect the performance of gel coats on boil tests;

Type of Resin Used in Gel Coat

The most resistance the gel coat has to the attack of water and to permitting water passage through it, the better the test results. In general, we have found gel coat systems rank as follows:

1) ORTHO System (poorest). Failure starts in 20 - 40 hours.

2) ORTHO/NPG Systems (poor)

3) Straight ISO Systems (good).

4) ISO/NPG Systems (good)

Water Resistance of Other Gel Coat Components

Gel coats are not just resins. All the other components need to be selected and tested to ensure the gel coats performance. (Also see "Fillers").

Cure of the Gel Coat

If the gel coat is undercured, it will have poorer water resistance. The major factors affecting cure are:

- ***Temperature***

If parts are made below 60°F (16°C), poor cure will result.

- ***Percent Catalyst***

If the catalyst is too low or too high, undercure can occur. Too high appears to be worse than too low because excess catalyst remains that can act as an osmotic agent. It can simultaneously chemically attack the gel coat and weaken it further.

- ***Type and Grade of catalyst***

Different brands and types of catalyst have different ratios of ingredients and produce different cures.

- ***Thickness***

If a gel coat is less than 12 mils(thou), undercure is possible due to insufficient mass and to excessive styrene loss due to surface evaporation.

- ***Unreactive contaminants***

This consists of agents such as water and solvent.

Thickness of Gel Coat

The thicker the gel coat, the better the results are. This is due to the slower water penetration (thicker membrane). But gel coat which is too thick can create other problems.

Quality of the Laminating Resin

In general, ORTHO resin gives poorer results than ISO resin or vinyl esters.

BLISTERS AND BOIL TESTS

- ***Filler***

Certain fillers can increase/decrease blistering and colour change.

- ***Laminate Cure***

The cure of the laminate is important because it also affect the gel coat.

- ***Type and Sizing of Glass (layer next to the gel)***

  • A layer of surfacing veil gives good results when used as a skin coat for either chopped glass or mat.

  • Cloth gives better results than mat or chopped glass

NOTE: Layers of cloth next to each other do show sporadic large blisters due to poor bonding between layers.

  • Roving (Chopped laminate), in general, gives better results than chopped mat.

NOTE: there is a difference between types and brands of roving. Some give poorer results than mat, others better. It appears this may be related to the type of glass, binder and sizing.

  • Mat is generally worse than other types of fibreglass.

- ***Lay Up Time***

The longer one waits past lay up readiness, the poorer the boil-blister resistance due to weaker bonding between gel coat and laminate.

As you can see, there are many factors that affect this test. If you are using this test to compare gel coats or other materials used in making a part, you must make sure that nothing else over-rides the material being tested.

For example, if you want to compare two gel coats, you should make sure of the following:

  • Maintain proper temperature above 60°F (16°C), preferably 77°F (25°C).

  • Use the proper amount and type of catalyst. See data sheet on each product.

  • Try to achieve the same thickness - try a normal film thickness (18 ± 2) mil/thou and a higher film thickness (25-35 mils) thou. Side by side drawdown comparison is most accurate

  • Use a high quality laminating resin and glass with proper amount of catalyst.

3 TROUBLE SHOOTING BLISTERS

When you run into blisters, do not assume a particul[ar] cause.

Do the following:

EXAMINE THE BLISTERED PART

  • Where does the blister occur on the part?

  • What is the number of and size of each blister?

  • Was water and/or heat involved?

  • How soon did it develop after demould?

PUNCTURE AND OBSERVATION OF BLISTERS

Make cross section cut and note the following:

  • How deep is the blister or where did it occur (ge[l] coat, first skin, bulk laminate or between layers)?

  • Does it contain a different colour?

  • Does it have a different colour?

  • Does it have an odour? Compare the odour to wha[t] you think it is.

NOTE: Decomposed catalyst does not smell like pure catalyst.

  • Is there any discoloration around or near the bliste[r] on wood or metal fittings? What colour?

SELECTION OF MOST PROBABLE BLISTER MECHANISM

Select the most probable mechanism and list materials equipment and procedures that are involved.

Now comes the hard part: Try to determine what material process, or combination caused the blister.

Sometimes it is simple and other times it requires testing.

It is impossible to guarantee that even one of your parts will never develop blisters. There are too many materials, types of equipment and people involved. However, we can recommend how to reduce the possibility of blisters.

  • Apply proper type of gel coat - see data sheets.

NOTE: Some gel coats, such as ORTHO'S and some ORTHO/NPG's develop blisters within themselves that cause failure regardless of laminate construction.

  • Apply the proper type of gel coat. We recommend Cray Valley's ISO or ISO/NPG gel coats.

• Apply with proper equipment and procedures, see 'Equipment Selection' section. If catalyst injection equipment is used, make sure it is properly calibrated.

• Use proper catalyst and amount. Make sure temperature is above 60°F (16°C).

• Avoid contaminants in any part of the system.

• Use high-quality laminating resin.

• Use the right catalyst and its proper amount in the laminating resin. See laminating resin data sheet.

• Make sure the laminate is applied and cured properly, especially the skin coat.

• Choose a good suitable glass. See data sheet on the glass.

• Make sure the part is properly cured.

If you are unsure if a material is suitable ask your supplier and run your own tests.

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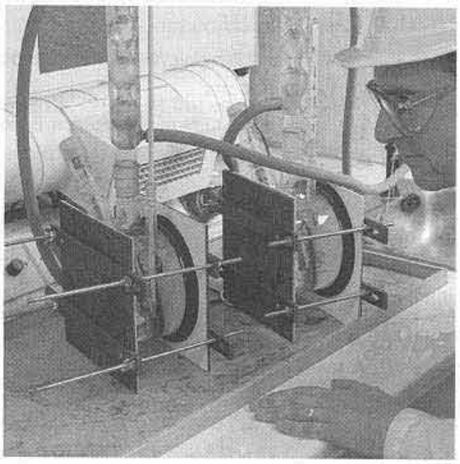


BLACK PLAGUE/COLOUR CHANGE PROBLEMS

REFERENCE: PB-36

This section deals with two problems encountered with FRP, parts exposed to water and chemicals which "treat" water. The look, feel, durability and strength of fibreglass makes this unique material an ideal candidate for the construction of boats, swimming pools, spas and saunas. With proper selection of materials and good workmanship by the manufacturer, and with reasonable maintenance by the consumer, a fibreglass unit will give many years of trouble free service. However, if these rules are not followed, problems affecting the appearance of the fibreglass unit can be encountered, problems such as blistering stained and colour fading can occur after unit has been placed in service for only a short period of time.

1 MATERIAL SELECTION
2 APPLICATION
3 OWNER MAINTENANCE

1 MATERIAL SELECTION

Swimming pools are exposed to continuous water contact of 50 to 100°F (10 - 38°C), spas and therapy tubs see intermittent water contact at temperatures of 90 - 105°F (32 to 41°C), and saunas will be operated in high humidity near 165° to 200°F (74 to 93°C). These conditions, coupled with the use of a variety of chemicals in the treatment of pool and spa water, provide for severe operating conditions.

It is important that the proper materials have been selected for these demanding applications.

Standard gel coats and colours cannot be used. Contact your Cray Valley representative for specific gel coat (type and colour) recommendations.

Each of the materials used in constructing a fibreglass unit has an influence on the performance of the finished product. This includes the laminating resin, reinforcement glass, gel coat, and catalyst. The manufacturer should carefully select all materials and then test the entire system by a suitable test method. One such test method is the 100 hour boiling water test (ANSI Z124.1 and .2 1987, Section 6.3).

(See the section "Blisters and Boil Tests")

A major concern of proper material selection should be the avoidance of gel coat blistering. The blistering is a severe cosmetic problem, expensive to repair, that can also lead to another problem unique to pools and spas. That problem is "Black Plague".

Black Plague is a black or brown staining of the gel coat surface and will form around a blistered area.

Chemically, the source of Black Plague appears to be a reaction of the cobalt accelerator found in all room-temperature cured polyesters and the chlorine compounds used in treating pool water. To prevent Black Plague, preventing blistering is essential.

(See Blister section)

Blistering is best prevented by using ISO/NPG gel coats with ISO laminating resin. The gel coat must be applied to at least 18 mils (thou) wet film thickness and good spray procedures should be followed.

Glass selection must also be carefully considered. Because of the wide variety of reinforcement glass which is available, (i.e. the glass type, sizing and binders used), a specific recommendation is not given here. Generally a chopped glass laminate is superior to a mat laminate. Some surfacing veils can be used to improve a mat laminate's resistance to blistering. However, not all surfacing veils, and glass mats (or even roving) will give the same blistering resistance. Therefore, the manufacturer is encouraged to test the complete resin, glass, gel coat and catalyst system before entering production.

2 APPLICATION

Proper application is necessary for good field performance of the finished unit. Even if the best materials are used, poor application techniques can result in an inferior unit. One important manufacturing concern is proper catalysation. Improper catalysation can lead to poor gloss, blistering, and colour fading.

Gel coat colour fading in particular can be extreme if the unit is exposed to unusual chemical treatment by the owner. Some colour fading of the gel coat surface is expected over a period of time. Also, certain colours are more prone than others to fading. The colour fade is usually slow and not to a degree which is objectionable to the unit owner. This fade can be accelerated to the point of being objectionable when any two of three factors exist.

They are:

- Over catalysation of the gel coat during application.
- Excessive use of chlorine compounds in water treatment.
- Elevated temperatures.

If all three factors are present, the fade will occur most rapidly.

Excessive use of chlorine compounds in water treatment can attack the gel coat even if properly applied. But the discoloration will be increased if good manufacturing techniques are ignored. Over catalysation is known to accelerate the gel coat colour fading. The manufacturer can encounter units which have faded in spots, patches or even stripes. These are usually over catalysed areas.

The white splotches that sometimes occur are caused by excess catalyst drops from poorly atomised catalyst. Poor catalyst/gel coat tip alignment can cause this also, which will be evidence by a "spray pattern" in the gel coat surface.

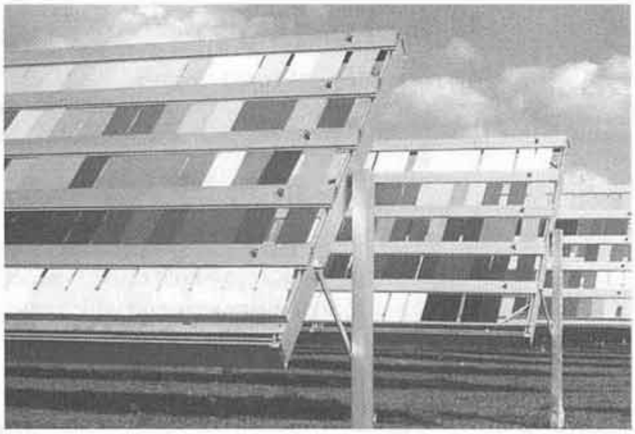
3 OWNER MAINTENANCE

Owner care of the unit is the least controllable factor in assuring good field performance and yet mistreatment by the owner may be the source of many field failures. A variety of chemicals are used in pool/spa water treatment and marine cleaning. When used in excess, especially the chlorine compounds or acid cleaners, these chemicals can cause colour fading

The unit manufacturer should select gel coat colours which are resistant to fading in a chlorine environment. Remember that chlorine is a bleaching agent and that no pigmentation system is completely resistant to chemical attack.

The unit manufacturer should offer recommendations for water treatment. Those guidelines normally listed on the pool chemical containers are for standard concrete pool construction and may not be applicable for fibreglass units.

REFERENCE: PB-50



Fibreglass parts have a shiny finish when new, but eventually the gel coat can dull and fade regardless of quality. Then the basic question is, what has happened and what can be done about it? The following is an explanation of what has happened, how it can be prevented or slowed down, and what can be done to restore the gel coat. Gel coats have been developed over many years of research and they provide very durable, water and environment resistant surfaces. Normally, gel coats are applied 10 times the typical thickness of paints. Even though these surfaces are very durable, they are not indestructible.

Synthetic and natural materials, when placed outside, slowly deteriorate.

The part is exposed to sunlight, heat/cold, water, wind, dust and chemicals in the air. The only way to prevent deterioration totally would be to put the part in a vacuum that is dust free and not exposed to light; this is not realistic.

When something is used, it will start to show wear and tear. How much wear and tear depends on how you treat the product and how you maintain it. If you let a car go without waxing and washing, its surface deteriorates and has a poor appearance. If you let a product deteriorate, then you have a very high expense of trying to do all the maintenance repair at once. It's easier and cheaper in the long run to do a little maintenance periodically.

Aside from the quality of material used in initial production and careful procedures to make the fibreglass part, the only secret in keeping fibreglass looking like new is maintenance.

1 WEATHERING PROBLEMS

THE RESULTS OF WEATHERING PROBLEMS ARE :

1. **Chalk**
2. **Fade**
3. **Yellowing**
4. **Loss of Gloss**

Chalk

Chalk is a result of the top surface being broken down into an extremely fine powder. When this happens, the colour whitens. The chalk that is developed is strictly on the surface. Most house paints are designed to chalk and then wash clean when it rains. Unfortunately, gel coat chalk does not simply wash off.

Fade

Fade means that the colour has changed uniformly.

There are three main causes of fading:

- Chalk makes the gel coat look lighter.
- Pigments used in the system have actually changed in colour. In this case, you have a high gloss but the colour has changed.
- The gel coat is bleached or stained by something.

Yellowing

Yellowing is when the gel coat has actually started to pick up a yellow cast. This can be uniform, or it can be streaked. Usually yellowing that is uniform can be related to how it was applied. Streaks generally are caused by chemical stains, residues, or by a covering that was left on the gel coated surface which, therefore, shielded the surface from the environment.

Gloss

Gloss refers to how shiny the gel coat is. Any change in the surface, be it a light sanding, chalk, or dirt will change the gloss.

We find that parts whose surfaces are restored after weathering loose gloss faster upon re-exposure than the new surface weathered the first time.

Most of the changes that you see are cosmetic. They appear on the surface of the gel coat and do not affect its strength. The surface is sound, but does not look as it did originally.

GEL COAT WEATHERING

Once a part is made, it begins to change because it is attacked by the environment.

The Causes of Weathering problems

The attack on gel coat is from :

1. Light
2. Water
3. Pollutants
4. Temperature

There are strong forces which cause wooden boat owners to repaint almost every year, and which cause cars to rust, vinyl to crack, and virtually every synthetic material to need repainting.

A fibreglass laminate must be protected by a "thick" coating to prevent the fibres from protruding through the surface (fibre bloom). In most cases, the protection is a gel coat. If this was all that was required, gel coats would be much easier to make and use. But more is required. They must also retain their original colour and gloss as along as possible.

Light

Light is a form of energy. The energy in light is made up of different components or wavelengths. A rainbow shows light separated by wavelengths. Some of these are stronger than others.

The ultraviolet (UV) is considered the most destructive one for weathering; but, you cannot ignore the others. The energy in light attacks materials by breaking down their molecular or polymer structure (degradation). This energy can cause a chemical reaction to take place. This is oxidation, or chain splitting or atomic extraction and is noticed as colour change (yellowing or bleach fading).

Water

Water is called the universal solvent. It will dissolve more things than any other chemical.

Water attacks parts by dissolving or reacting with them. It penetrates materials and leeches out impurities or degraded materials. It can also contribute pre-dissolved chemicals causing stains or degradation. It can change non-corrosive material into corrosive material.

Pollutants

We do not live in a sterile environment. The atmosphere contains many foreign materials. Some of these are harmless, some stain, and some, when they land upon an object, attack it.

Temperature

Sunlight generates heat. It will raise the temperature of a part. How much depends on colour. White reflects most of the sunlight and warms up only slightly (e.g., in 100°F (38°C) air, white can be 120 - 130°F (49 - 54°C)).

While dark colours absorb more sunlight and warm up more (e.g., in 100°F (38°C) air, black can be 150 - 170°F (66 - 76°C)). *See table below.*

As the part warms up, three things happen:

- the material softens slightly;
- additional cure can take place;
- chemical attack and water penetration rates are increased.

EFFECT OF COLOUR CHOICE ON SURFACE TEMPERATURE UNDER SUNLIGHT

SURFACE TEMPERATURE °F(°C)		
PANEL COLOUR	**UNBACKED**	**FOAM BACKED**
White	120 (49)	127 (53)
Light Blue	127 (53)	137 (58)
Medium Blue	137 (58)	157 (69)
Dark Blue	144 (62)	174 (79)
Medium Red	128 (53)	142 (61)
Dark Red	137 (58)	169 (76)
Black	148 (64)	173 (78)

* These panels were exposed to outdoor sunlight with unrestricted ventilation of 100°F (38°C) air.

2 WEATHERING TESTING

The only way to evaluate the gel coat, is to test it. The best test is outdoor exposure. The ideal location should have lots of sun, moisture and warm temperature. There are many testing facilities located in Southern Florida, USA because it has this climate. The only problem is time; usually it takes one year or more to get results.

The coatings industry has been looking for a good accelerated weathering test that simulates natural conditions for years. One of the first ones was the carbon arc weatherometer (1918).

This testing device exposes a panel to a timed cycle of light and dark, heat, and water. The latter is sprayed on the front of the panel during the cycle. Panels are usually exposed for 1,000 hours and are checked every 250 hours. The actual time to complete the test is 80 hours/week or three months.

Other modifications have been tried, for example, Dew Cycle W.O. exposure, 100 hours, checks every 20 hours. The latest entry has been QUV Weatherometers.

The Dew Cycle W.O. is okay for some colours, but does not correlate well with exterior for others.

The QUV does not correlate for some resin systems (polyesters and thermoplastics). QUV will not affect some systems while actual outdoor exposure will. QUV may degrade others, but outdoor exposure will not.

Here's a brief chart comparing Weatherometer features for unsaturated polyesters:

	CARBON ARC	DREW CYCLE	QUV
Light/dark cycles	Yes	Yes	Yes
Moisture	Sprayed on front	Sprayed on back	In a pan
Light type	Most like natural	Similar to natural light	High in selected UV wave-lengths
Time	1,000 hrs	100 hrs	Varying
Correlation to out doors for polyester	Good	Poor to fair	Poor

Of these tests, only the old standard carbon arc weatherometer has shown consistent correlation with actual outdoor exposure for polyesters. Xenon Weatherometers show promise, but must be confirmed.

From experience with carbon arc W.O., we do not expect to see any major change in most gel coats until after 250 hours. The majority of colour change is between 500 and 750 hours. Between 750 and 1,000 hours, the samples appear to reverse themselves and recover. This is not really true; what really happens is a chalk forms making the sample appear lighter and less yellow. As a sample is exposed, two factors must be measured:

- Colour change and
- Gloss change.

COLOUR

It is hard to describe colour and to remember what a sample looks like. We have to use a colorimeter or spectrophotometer to indicate what has changed and how much.

This instrument used the fact that all colours can be described (verbally and mathematically) in three ways.

- Is it white or black? - L scale of (+)lightness/(-) darkness.
- Is it green or red? - the a, or RG scale of (+) red/(-) green.
- Is it blue or yellow? - the b, or YB scale of (+) yellow/(-) blue.

Once you have control readings, you can then calculate the change on each scale and total difference (DC or DE).

GLOSS CHANGE

You measure loss of gloss by measuring how much light is reflected back at different angle. Typically, the measurements are taken at a 20°, 60° and/or 85° angle from the light source.

The 20° and 60° angle show the most change and the 85o the least.

Degradation Index (D.I.) is determined by dividing total colour difference (DE) by percent of gloss retention.

3 INFLUENCES ON WEATHERING

When a change has been noticed, the owner of a fibreglass product may ask the following questions :

- Does my part have a structural problem?
- Have the light stabilisers been left out?
- Why is my part faded and yellow?

The answer to the first question is,"no", if the proper application procedure was used in making the part. Fading and yellowing happen on the surface and do not affect structural strengths. A good cleaning may restore the finish.

Light stabilisers are not normally used in Cray Valley pigmented gel coat. The coloured pigment itself and resin are the materials which determine the light stability of a system.

The addition of a costly light stabiliser to a pigmented gel coat has not been found to significantly improve weathering of gel coats. Light stabilisers are necessary in clear gel coats because there are no pigments to provide protection.

Well, what does happen?

Yellowing is caused by the reaction of light, water, air pollutants and temperature with any reactive sites in the gel coat which can include unpolymerised maleic or styrene or by-products. Some of these 'sites' always exist. Achieving a good cure is necessary to reduce these to a minimum.

Fading and chalking are the breakdown of the surface resin and pigment on a microscopic level. They also are caused by light, water, etc.

This breakdown is so fine it appears to be white in colour.

Keeping these causes in mind, let us look at the different types of gel coats.

GEL COAT TYPES

GENERAL

Resins

The weather and water resistance of polyesters can be related to the resin type used. Certain glycol's and acids impart better yellowing and chalking resistance to a polymer than do others.

Other Ingredients

The other ingredients used in gel coats can improve or reduce the weathering characteristics of the base resin. You have to balance application, weathering, and blister resistance.

a) Fillers - type and amount.

b) Pigments.

c) Additives.

CLEARS

Clear gel coats are the most susceptible to yellowing because of the absence of pigment. Because of this, light stabilisers are necessary in clears. Light stabilisers work by absorbing the harmful sunlight and converting it into non-destructive energy. Light stabilisers eventually are used up. They only slow down and even out yellowing. These parts will change in colour with time.

The use of light stabilisers in clears is a compromise. They add to the initial yellow colour of the clear (as the better light stabilisers are yellow themselves), but this is balanced against slower yellowing upon ageing.

Clears, because they do not have any pigments, do retain their gloss better.

METAL FLAKES

A metal flake system is a clear backed by the metal flake in clear. The weathering on the surface is the same as a clear, but now we must consider how the environment effect the flake itself.

Some metal flake is made by coating an aluminium foil or aluminiumised mylar sheet with a dyed epoxy.

The aluminium reflects the light back through the dyed epoxy coating giving it the colour of the dye. If the epoxy is not properly cured and the gel coat not cured, the aluminium can be eaten away and the colour is changed.

NOTE: These systems are used in America on "bass boats" and are not common in most European countries.

WHITE AND OFF-WHITE GEL COATS

The weathering of whites and off-whites is partly controlled by the amount and grade of titanium dioxide (TiO_2) used. High exterior durability grades of TiO_2 are the best and most expensive.

Whites are very forgiving as they do not show up changes in gloss easily, but they will yellow. White gel coats are highly pigmented and will chalk more than clears. The chalk is not as noticeable because you have white on white, but gloss will suffer. Chalk is more noticeable on dark colours.

COLOURED GEL COATS

A wide variety of pigment types are used to make colours. All pigments do not weather equally. Normally, colours do not yellow, but will chalk and fade.

Colour pigment must be checked out carefully, colours that weather well in paints may not work in polyesters.

Accelerated weathering must be compared against actual outdoor exposure, i.e., some colours look good in the weatherometer, but after six months in Florida will fade badly. Many pigments will bleach out when subjected to either acids or bases.

Blues and greens fade in colour, while yellows and reds turn brown or go darker.

NOTE: the durability, cost and hide of bright yellows, maroons and reds are changing due to regulations. Lead, chromate and other heavy metal pigments are being discontinued by pigment manufacturers.

DEEP COLOURED GEL COATS

Blacks, blues, reds, burgundies and greens chalk as they weather. They may do so at the same rate as other colours, but the whitish chalk is more visible. This is due to the fact that deep colours highlight any chalk making it stand out. Some colours absorb more sunlight becoming warmer and weathering faster.

In general, clears, whites and off-whites yellow as they weather, colours fade, and black and deep colours chalk. We have seen how different gel coats weather, now let's look at how the application of the gel coat affects weathering.

■ *FABRICATION*

The durability of a part is related to the care in making it.

Good materials used poorly produce a poor part.

Poor materials used well produce a poor part.

Today's increased production rates leave very little margin for error. Training and tight controls are a must.

Beware of making parts fast and fixing them later. Repairs are costly and take away from the ultimate quality of the part. Think of it as "building quality in" rather than "adding it on".

Moulds and equipment will get dirty and war quickly; good maintenance is a must to produce a quality part.

The weathering of gel coats can be degraded before the gel coat is applied. Yellowing, fading and chalking can be built in.

■ *Moulds*

Weathering takes place at the surface of the part which mirrors the mould. If your mould has any dirt, dust or a build-up on it, some will be transferred to the part. Polystyrene slowly builds up on the moulds. Polystyrene yellows badly. If the moulds are not properly cleaned, the polystyrene is transferred to the part and will yellow.

Do not use styrene to clean a mould for three reasons:

- The fumes can cause more polystyrene to form.
- It can leave a thin residue of polystyrene on the mould.
- The styrene may contain polystyrene leaving it on the mould. Pure styrene starts to form polystyrene in a container after only 30 days. Styrene, as it ages, will turn yellow, and thicken, eventually gelling. Excessive wax left on the moulds can also be transferred to the part which may yellow later.

Also see "Polyester Tooling" under Section 6 "Mould Maintenance" in this Applications Manual.

■ *ADDITIONS TO GEL COAT*

If the gel coat is modified before spraying, its weathering properties can be changed.

Do not thin the gel coat without authority from your gel coat supplier.

Do not add anything except catalyst without your supplier's permission, as the initial colour and weathering can suffer.

■ *CALIBRATION*

Inadequate calibration will affect the weathering of your parts.

Too high (or too low) catalyst levels can cause parts to prematurely yellow or chalk. See product data sheet for type and amount.

Poorly atomised gel coat will retain more monomer, resulting in more yellowing.

■ *TECHNIQUE*

The gel coat must be applied as evenly as possible because gross differences in film thickness will cause non uniform weathering. Also, gel coat should be applied in at least two passes.

One pass spraying of thick films will cause yellowing. Thinner films yellow less than thicker films. Thickness' of 12 - 16 mils might be considered for high visibility areas such as boat decks, but print through and blister resistance would be lessened.

■ *CURE*

Poorly mixed catalyst will make various sections of a part weather differently. Overcatalysed parts or areas will bleach, fade and chalk worse than an undercatalysed part.

Plant ambient and mould temperatures must be 60°F (15.5°C) or above to ensure proper cure.

■ MAINTENANCE

Weathering can be affected by how the finished part is cared for.

Weathering starts immediately and does not depend on whether the part is immediately sold or sits at a dealer. FRP parts need to be washed, waxed and taken care of like a car. They do not need repainting each year like wooden boats, but they do need care. A car dealer will wash his cars once a week to keep them looking good. A professional fibreglass dealer should also do this.

Chemicals and dirt can collect during storage. The gel coat can be attacked or stained when chemicals combine with rain or dew. They then can attack or stain the gel coat.

The following are some general instructions, which will help keep your fibreglass part looking almost like new. For further information, contact your manufacturer or suppliers of cleaning materials.

- Wash monthly or more frequently, if needed. Wash with mild soap such as dishwashing soap, avoid using strong alkaline cleaners or abrasives.
- Wax the part once or twice a year with a good grade paste wax formulated for gel coat surfaces.
- Cover the parts surface with an appropriate breathable material when not in use of shelter the article from sunlight when not in use.

For parts that have weathered and have chalked:

- Wash.
- Try a little wax in one area to see if this is sufficient to restore its lustre. If not, use a fine rubbing compound, followed by wax.

If the part has weathered for some time and has developed

GEL COAT WEATHERING

a very severe chalk, rubbing compound alone may not be strong enough to remove the chalk. You will then need to go to a light sanding of 600 (or finer) wet or dry paper, followed by fine rubbing compound and wax. Use finer paper or preferably use finest compound to remove bad chalk.

▪ *CLEANERS*

Polyester gel coats are very resistant to water and other chemicals, but it is surprising the harshness of the cleaners that are available on the market. You want to avoid any strong alkaline (such as tri-sodium phosphate) or highly acidic cleaners. Avoid bleach and ammonia. These material, if left in contact with polyester, may attack or change the colour. Any cleaner that is used should be in contact the minimum amount of time required to do the job.

All cleaners are meant to attack dirt and remove it. The longer they remain in contact, the more they attack the dirt and the finish. It is best to use mild detergents such as hand dishwashing soap, which will work for a majority of stains and dirt accumulations.

If you are unsure about using cleaner, do two things:

- Read the label and instructions. Also, look at the precautions. We found one material, recommended for fibreglass, that casually mentioned "keep off of aluminium parts". The reason for this statement was that the material contained HCl, more commonly known as hydrochloric acid. Read the label to see if the product is recommended for specific surfaces only. Using them on surfaces other than those intended could be damaging. Cleaners normally used for wood or teak may not be appropriate for fibreglass either.
- Run a test spot. Try it in an inconspicuous spot, if it discolours, or dulls this area, do not use it.

▪ *SANDING AND BUFFING*

The technique of sanding/compounding a new part surface may cost you 3-6 months of finish life. For weatherability's sake, it is to your advantage to operate with defect-free, high gloss moulds so that minimal finishing is required on the part.

The reason for this reduction in weatherability is that sanding and compounding removes the thin, resin rich surface which protects the part's gloss.

Glazes give gel coat glossy appearance when first applied. This is a temporary shine that will disappear as it wears or evaporates. We may be deceived with this false gloss and fooled into thinking the gel coat is rapidly losing gloss when it is really fugitive glaze. Again, the best approach is to build the gloss into the part through the mould surface finish.

▪ *RUBBING COMPOUNDS*

There are a wide variety of rubbing compounds. Some are faster cutting (more abrasive), some are slower. A rubbing compound is a fine, gritty material that is used to take off part of the top surface. Compounds come in a number of different types of grits, like sandpaper. The coarser grits are faster cutting compounds, have larger particles and remove more of the surface quicker. You want to stay with the fine grits. These grits are carried in a variety of liquids (lacquer, mineral spirits, water and other vehicles).

General tips are:

- Read directions on use.
- Do not use in direct sunlight. This makes the rubbing compound dry out.
- Use clean pads to apply. Apply rubbing compound liberally. Do a small area, usually 3 feet x 3 feet at a time. If you are using a power buffer, use a low RPM buffer, 1,700 to 3,000 rpm range. Keep the buffer moving at all times. Do not apply heavy pressure. Heavy pressure will make the rubbing compound cut quicker, but also leaves gouges, pits, scratches and swirl marks and produces heat. If using the power buffer, keep the buffing pad wet with material. Do not allow the pad to dry out.

Gradually lighten up the pressure as a high gloss appears. Several applications may be necessary. If the pad dries out, coarser particles scratch rather than cut. After a rubbing compound has been used, you must wax the part.

▪ *WAXES*

There are a number of waxes on the market. You should try to use one specifically designed for fibreglass.

Put down a thin coat of waxes:

- Read the directions on the can
- Do not use in direct sunlight
- Use clean cloths
- Work a small area, 3 feet x 3 feet at a time.

Normally, the harder the wax in the can, the higher wax content it has. The softer waxes have a higher proportion of silicones and solvents in them. If a power buffer is used, use at a low RPM with light pressure. Keep it moving at all times to prevent heat build up. Waxes formulated specifically for gel coat/fibreglass surfaces are handled by many boat dealers, shower stall dealers, and automotive houses.

▪ *SEALANTS*

While "Sealants" may give a wet lustre or slick surface when applied to a new or sanded/compound exposed gel coat surface, we have not found them to significantly extend the gloss or colour retention life of that surface. If applied frequently during the use of the FRP item it will make the surface look better during the use; however, a one time application will not protect or add durability to the gloss or colour of the surface. Waxes designed for exterior surfaces perform similar benefits as sealants.

One system may last longer than another before re-application is needed to again achieve a slick feel and lustre. Again neither has been found to be a one time application solution to weathering.

■ *STAINS*

Many fibreglass parts, as they age and are used, eventually pick up stains. These stains can come from dust, dirt accumulation, road tar, plant sap and pollen, rust from fittings, material that has leaked out from caulking or sealing compounds, covers, other fittings, and accessory parts.

Materials which stain can be broken down into two very general type substances. Soluble and non-soluble in water. The majority will be water soluble. Stains can be difficult to remove. It requires a lot of trial and error to determine the fastest and easiest method to remove the stain.

The best practice is to begin with the easiest method and then work up to the more complicated. Before you try to remove stains, the materials used should be pre-tested in an inconspicuous area. Some materials not only remove the stain, but also deteriorate the gel coat or change its colour.

The majority of stains will be from water soluble materials. Pre-wet the area and wash with a mild detergent. Beginning with a small spot, a cleanser can be used, making sure it is a fine abrasive as it will also remove some of the surface. You may then have to come back with rubbing compound and wax to restore the lustre. If the soap and water solution doesn't remove the stains, then a solvent might be necessary.

Water soluble materials are often organic based substances. There are two general classes. One is called aliphatic, and the other is aromatic. It is a general rule in chemistry that, "like dissolves like". Before using any solvent read directions and warning label.

CAUTION:

If you are using cleaning solvents, contact must only be for a very short period of time. Leaving a solvent soaked rag on the part can cause deterioration of the gel coat. Also, many solvents are flammable. The procedure is to put a small amount of solvent on the area that is being cleaned, and then wipe it dry. Repeat if necessary; do not soak an area. Different types of solvents can be used...test areas are recommended.

The most common removers for aliphatic are acetone, methyl ethyl ketone (NOT CATALYST, which is methyl ethyl ketone peroxide), ethyl acetate, and rubbing alcohol. Acetone is a prime ingredient in fingernail polish remover and is also found in lacquer thinners. Lacquer thinners also contain some alcohol's and other solvents. To remove aromatics, try xylene or toluene. These are commonly used as paint thinners. If these materials do not remove the stains, or if the stain has gone deeper in the material, then surface abrasion will be necessary.

In mild cases, rubbing compound works for a small spot. If this does not remove the stain, then you would need to use 400 to 600 sandpaper, followed by rubbing compound, then waxing.

■ *SCRATCHES AND NICKS*

Scratches can occur with normal use. On scratches, use the simplest method first. Keep the area that you are working on as small as possible. The first thing to try is a little rubbing compound. This may not completely remove the scratch but may make it hardly noticeable.

If rubbing compound does not take it out, then you need to go to the wet sandpaper. Again, both these procedures have to be followed by waxing to get the original sheen.

If the scratch has gone all the way through the gel coat, then a repair will have to be done. For instructions on repairs, see the "Patching" section of this manual or contact the manufacturer of the part. Minor repairs can be done easily if you have the knowledge of how to work with polyesters. A good repair is almost invisible. Major repairs should be done by a professional.

In cases where there is extensive damage, it may be necessary to paint or refinish the fibreglass part. In all cases, read the coatings manufacturer's literature and directions on the can. Recommendations should be read and followed. Two-component, polyester or acrylic urethanes find best acceptance.

■ *SHRINK-WRAP*

Boat manufacturers, marinas and dealers are being encouraged to "shrink-wrap" boats by those who sell the wrap and heat guns. This practice is suggested to keep boats clean during storage and transit. As a manufacturer of gel coats for the marine and fibreglass industry, we feel it important that we alert you to the complications and risks associated with this practice.

We, of course, favour clean boats over dirty boats. We also would ask anyone who shrink-wraps a boat to consider the possible adverse "side effects" and viable alternatives.

Our concern centres on two major issues:

- Heat applied to the laminate
- Moisture trapped next to the gel coat.

Shrink-wrapping involves heat being applied against a plastic film. The heat causes a reaction and the film shrinks to "fit". This heat if/when applied to a laminate can have an adverse effect. Heat can bring about fibre print and post-cure distortion.

These wraps may not "breathe". If these films trap water or condensed moisture next to the gel coat surface for pro-

GEL COAT WEATHERING

longed periods, the possibility of blistering or colour fading is likely. Boats are obviously constructed to sit in water. However, lakes, rivers, oceans, etc., have moderate temperatures compared to heat trapped inside plastic. It's somewhat analogous to rolling up the window of your car on a hot day - it's hotter in the car with the sun beating through the window than on the outside. The length of time and the temperature at which the FRP article is stored with the plastic wrap, as well as the colour of the gel coat and the shrink-wrap, are major factors influencing the severity of this possible problem.

Breathable materials which would allow moisture to escape are preferred. Less heat is preferred to more heat and no heat is the best option when covering a fibreglass part.

If it is your decision to continue the shrink-wrap practice with the full knowledge of the risk involved, we encourage you to adopt certain techniques which can reduce the severity of these potential problems:

- Use white or light coloured shrink-wrap for less heat transmission.
- Taping of shrink-wrap to rails or to the white or off-white gel coat surface or an area not affected by the moisture, will place the condensed moisture in an area less sensitive to these problems.
- Seal or tape the shrink-wrap to a position of the hull such that collected moisture does not rest against an area that is highly visible.
- Place a barrier of foam or fabric between the plastic film-tape and the gel coat surface to prevent heat released plasticisers from reacting with the gel coat surface.

Removal of the discoloration depends on severity. Mild cases have been removed to a limited extent by use of a heat gun. The techniques must be done cautiously and at lower heat settings to avoid heat discoloration as well as laminate print.

Now that we have seen what causes a part to weather, we can answer the question, how can the effects of weathering be minimised?

Here is a method in 10 easy steps:

1. Keep the moulds in good condition
   - Do not let polystyrene, wax or dirt accumulate on them and pay particular attention to radi and non-skid areas.
   - Do not clean the moulds with styrene.
2. Choose a material optimised for durability and application.
3. Choose your colours with weathering in mind.
4. Do not thin gel coats.
5. See Gel Coat Manufacturer before any addition.
6. Calibrate the gel coat equipment.
7. Use the proper type and amount of catalyst with complete mixing.
8. Keep the film thickness as uniform as possible and not excessively thick.
9. Clean and wax the finished part at least twice per year.
10. Send a "care" package of instructions on how to care for your fibreglass part. *(See your Cray Valley representative for assistance on a "care" package.*

4 ARTICLES FOR FURTHER READING

- Some thoughts on weathering of plastics:

JMJ Estevey
The Plastics Institute
Transactions and Journal,
June, 1965, p.89

- Correlation between outdoors:

Performance and Laboratory Accelerated Testing for Light Stability of RP Panels.
John L. Scott
Reinforced Plastics/Composite Institute
SPI, 41st Annual Conference, 1986

- Instruments for Measuring Product Appearance:

P. Barnes
Industrial Finishing, Volume 43, p.13
May. 1988