LAMINATING EPOXY

ADHESIVES

PROCESS EQUIPMENT

HANDLING GUIDE

A guide to the general handling characteristics of PRO-SET Laminating Epoxies and their use in laminating and structural applications.

PRO-SET Laminating Resins and Hardeners are combined to create different PRO-SET Epoxies, each with its own unique handling characteristics, cure schedule and physical properties. Refer to the PRO-SET Technical Data sheets for specific handling characteristics, post cure schedules and physical properties for each of the resin/hardener combinations.

PRO-SET Laminating Epoxies are recommended for use by experienced builders and fabricators. If you are new to high-strength laminating epoxies, read this guide thoroughly. If you have additional questions about the handling or use of PRO-SET Laminating Epoxies, you are encouraged to call or write the Pro-Set technical staff. We strongly recommend that you build representative panels using the proposed laminate schedule under shop conditions to fully understand working characteristics and suitability of PRO-SET Laminating Epoxy for your application. Read all safety information before using PRO-SET Laminating Epoxies.

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1. Safety

PRO-SET Epoxies can and should be used safely. To use PRO-SET epoxies safely, you must understand their hazards and take precautions to avoid them.

PRO-SET Resins may cause moderate skin irritation. PRO-SET Hardeners are corrosive and may cause severe skin irritation. Resins and hardeners are also sensitizers and may cause an allergic reaction similar to poison ivy. Susceptibility and the severity of a reaction varies with the individual. Although most people are not sensitive to PRO-SET Resins and Hardeners, the risk of becoming sensitized increases with repeated contact. For those who become sensitized, the severity of the reaction may increase with each contact. The hazards associated with resins and hardeners also apply to the sanding dust from epoxy that has not fully cured. These hazards decrease as resin/hardener mixtures reach full cure. To handle PRO-SET epoxies safely, we recommend that you observe the following precautions.

1. Avoid contact with resin, hardeners, mixed epoxy and sanding dust from epoxy that is not fully cured. Wear protective gloves and clothing whenever you handle PRO-SET Epoxies. Barrier skin creams provide additional protection. If you do get resin, hardener or mixed epoxy on your skin, remove it as soon as possible. Resin is not water soluble—use a waterless skin cleanser to remove resin or mixed epoxy from your skin. Hardener is water soluble—wash with soap and warm water to remove hardener or sanding dust from your skin. Always wash thoroughly with soap and warm water after using epoxy. Never use solvents to remove epoxy from your skin. Stop using the product if you develop a reaction. Resume work only after the symptoms disappear, usually after several days. When you resume work, improve your safety precautions to prevent exposure to epoxy, its vapors and sanding dust. If problems persist, discontinue use and consult a physician.
2. Protect your eyes from contact with resin, hardeners, mixed epoxy, and sanding dust by wearing appropriate eye protection. If contact occurs, immediately flush the eyes with water under low pressure for 15 minutes. If discomfort persists, seek medical attention.
3. Avoid breathing concentrated vapors and sanding dust. PRO-SET epoxies have low VOC content, but vapors can build up in unvented spaces. Provide ample ventilation when working with epoxy in confined spaces, such as boat interiors. When adequate ventilation is not possible, wear a NIOSH (National Institute for Occupational Safety and Health) approved respirator with an organic vapor cartridge (NIOSH Approval #TC-23C). Provide ventilation and wear a dust mask when sanding epoxy, especially uncured epoxy. Breathing uncured epoxy dust increases your risk of sensitization. Although epoxy cures quickly to a sandable solid, it may take over two weeks at room temperature, or post-curing, to cure completely.
4. Avoid ingestion. Wash thoroughly after handling epoxy, especially before eating or smoking. If epoxy is swallowed, drink large quantities of water—DO NOT induce vomiting. Because hardeners are corrosive, they can cause additional harm if vomited. Call a physician immediately. Refer to First Aid procedures on the Material Safety Data Sheet.
5. Clean up spills with a scraper, collecting as much material as possible. Follow up with absorbent towels. Use sand, clay or other inert absorbent material to contain large spills. DO NOT use saw dust or other fine cellulose materials to absorb hardeners. Clean resin or mixed epoxy residue with acetone, lacquer thinner or alcohol. Follow all safety warnings on solvent containers. Clean Hardener residue with warm soapy water. Uncontaminated resin or hardener may be reclaimed for use. DO NOT dispose of hardener in trash containing saw dust or other fine cellulose materials—spontaneous combustion can occur.
6. Dispose of resin, hardener and empty containers safely. Puncture a corner of the can and drain residue into the appropriate new container of resin or hardener. Do not dispose of resin or hardener in a liquid state. Waste resin and hardener can be mixed and cured (in small quantities) to a non-hazardous inert solid. CAUTION! Pots of curing epoxy can get hot enough to ignite surrounding combustible materials and give off hazardous fumes. Place pots of mixed epoxy in a safe and ventilated area, away from workers and combustible materials. Dispose of the solid mass only if cure is complete and the mass has cooled. Follow federal, state or local disposal regulations.
7. PRO-SET products are intended for use by professional or technically qualified persons only. Regularly updated Material Safety Data Sheets (MSDS), are available from your PRO-SET distributor. Refer to the Material Safety Data Sheets (MSDS) and product label for specific product safety information.

For additional safety information contact Pro-Set Inc., 888-377-6738.

2. Handling PRO-SET® Epoxies

This section is intended to provide an understanding of the general handling characteristics of PRO-SET Epoxies. Refer to the PRO-SET Resin/Hardener Technical Data sheets for specific handling characteristics, post cure information and cured physical properties.

Combining PRO-SET Epoxy resin and hardener starts a chemical reaction that gradually changes the mixed ingredients from a liquid to a solid. Careful measuring and thorough mixing are essential for a complete reaction to occur.

DISPENSING

Most problems related to curing of the epoxy can be traced to either inadequate mixing or the wrong ratio of resin and hardener. To simplify metering, Pro-Set Inc. recommends using calibrated pumps to dispense resin and hardener. PRO-SET Mini Pumps and Gear Pumps are calibrated to dispense the proper working ratio of most PRO-SET Resin/Hardener combinations.

Before you use the first mixture on a project, verify that the pumps are delivering the proper ratio. Refer to the verification procedure in the instructions that come with the pumps. Recheck the ratio periodically or anytime you experience problems with curing. Production facilities should check pump ratios on a regular daily or weekly basis.

To measure by weight or volume, refer to the PRO-SET Resin/Hardener Technical Data sheets or to the PRO-SET Hardener label for the correct resin-to-hardener ratio.

MIXING

Mixing epoxy with error-free results involves three separate steps:

1. Dispense the proper proportions of PRO-SET Resin and Hardener into a clean plastic, metal or paper mixing container. Don't use glass or foam containers because of the potential danger from exothermic heat buildup. Begin with a small batch if you are unfamiliar with the pot life or coverage of the epoxy.

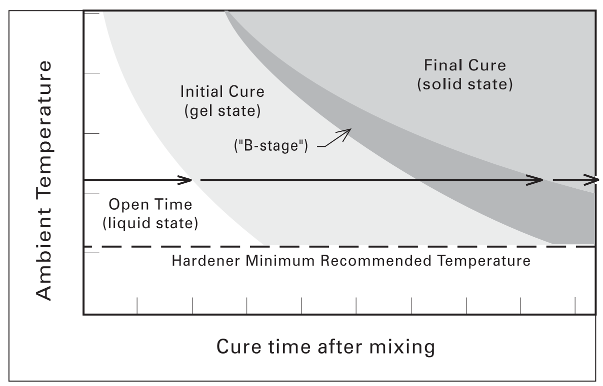
2. Stir the two ingredients together thoroughly until blended to a uniform, homogeneous consistency. Scrape the sides, bottom and inside corners of the pot as you mix. If you use a power mixer, thoroughly scrape the sides and corners of the mixing pot while mixing. Note: Resin and hardener may be dyed to assure thorough blending. *Refer to Section 4–QUALITY CONTROL CONSIDERATIONS for more information.*

3. Transfer mixture to roller pan or impregnator as soon as the resin and hardener are thoroughly mixed. Or, if required, thoroughly stir in additives, such as pigments and fillers. If you are going to be using the mixture out of a roller pan, mix it thoroughly in a mixing pot before transferring it to the roller pan. Transfer the mixture to the roller pan immediately after mixing to maximize working time.

CAUTION! Heat is generated by the chemical reaction that cures epoxy. A plastic mixing cup full of mixed epoxy will generate enough heat to melt the cup, if left to stand for its full pot life. If a pot of mixed epoxy begins an uncontrolled exotherm, quickly move it outdoors or to a safe, well ventilated area. Avoid breathing the fumes. Do not dispose of any epoxy mixture until the reaction is complete and has cooled.

CURING

The transition period of an epoxy mixture from a liquid to a solid is generally labeled the **cure time**. It can be divided into three phases–open time or wet lay-up time (liquid state), initial cure (gel state) and final cure (solid state). The speed of the reaction (and the length of these phases and the total cure time) varies relative to the ambient temperature *(Figure 1)*.



Figure—1
All PRO-SET Epoxies go through the same three phases of cure. The higher the ambient temperature, the shorter each of the phases and overall cure.

1. OPEN TIME

Open time (wet lay-up time) describes the working life of the epoxy mixture. It is the portion of the cure time, after mixing, that the resin/hardener mixture will remain in a **liquid state** and be workable or suitable for application. The end of the open time (wet lay-up time) marks the last opportunity to apply clamping pressure to a lay-up or assembly and obtain a dependable bond.

2. INITIAL CURE PHASE

The open time is over when the mixture passes into an initial or partial cure phase and has reached a **gel state**. It may be hard enough to be shaped with files or planes, but too soft to dry sand. Post-cure heating may begin once the mixture has reached an initial cure. The epoxy mixture will continue to harden and at the end of the initial cure phase, it will enter a "B-stage" and may exhibit a degree of brittleness (depending on the resin/hardener combination and ambient temperature). At this point the epoxy will have cured enough to remove vacuum clamping pressure. Handle components carefully until the epoxy cures through its "B" stage. PRO-SET Epoxy mixtures will temper (toughen) over the next few days at room temperature. Post-curing is necessary to pass some resin/hardener combinations through their "B-stage". *(See PRO-SET Resin/Hardener Technical Data)*

3. FINAL CURE PHASE
   In the final cure phase the epoxy mixture has cured to a tempered **solid state** and will continue to cure over the next couple of weeks at room temperature. Post-curing at elevated temperatures will shorten the final cure phase of PRO-SET Epoxies, and is required for some resin/hardener combinations.

CONTROLLING CURE TIME

The selection of a resin/hardener combination may be based on the length of its overall cure time or on its "pot life."

Pot life is a term used to compare the relative rate of reaction of various resin/hardener combinations. By definition, it is the amount of time a given mass of mixed resin and hardener will remain in the liquid state at a specific temperature. For comparison, we determine the pot life of an individual resin/hardener combination based on a 100g-mass mixture in a standardized container, at 72°F (22°C). Pot life is not directly equivalent to actual working life or assembly time of a resin/hardener combination. Several important factors affect the length of open time and overall cure time of an epoxy mixture:

1. TYPE OF HARDENER
   Each resin/hardener combination will go through the same cure phases, but at different rates. Choose the hardener that gives you adequate working time for the job you are doing at the temperature and conditions you are working under. Some PRO-SET Hardeners may also be mixed to provide a custom blend with an intermediate open and cure time. *Refer to the PRO-SET Resin/Hardener Technical Data to compare the curing and handling characteristics of blended hardeners.*
2. MIXED QUANTITY
   Mixing resin and hardener together creates an exothermic (heat producing) reaction. A larger quantity of mixed epoxy will generate more heat and yield a shorter open time and overall cure time. Smaller batches of epoxy generate less heat than larger batches and have longer open and cure times. Therefore, a thicker joint or layer of epoxy will cure sooner than a thin layer.
3. CONTAINER SHAPE
   Heat generated by a given quantity of resin/hardener mixture can also be dissipated by pouring the mixture into a container with greater surface area (a roller pan, for example), thereby extending the open time. Since the mixed epoxy will cure at a faster rate while it's in the mixing pot, the sooner the mixture is transferred or applied, the more of the mixture's useful open time will be available for lay-up or assembly.
4. TEMPERATURE
   Heat can be applied or removed from the epoxy to shorten or extend open and cure times. Moderate heat applied to the resin and hardener before mixing will shorten the epoxy's open time. A cooler box is designed to draw heat from a roller pan and extend open time in hand wet out operations (contact Pro-Set for information about building cooler boxes). For larger operations, impregnating machines with water cooled rollers are available. After the epoxy is applied, a fan can be used to draw heat from the lay-up or application and extend the epoxy's open time. The tooling itself can be designed to both extend open time and shorten cure time. It is possible to build tooling with copper or plastic tubing imbedded. During the lay-up, cool water pumped through the mold draws heat from the lamination, extending the open mold time. When the lay-up is complete, hot water or steam pumped through the mold will speed the cure of the laminate. These techniques, when used together, are especially beneficial when laminating very large or complicated components that required maximum open time and minimum cure time. Be sure you fully understand the effects of heating and cooling on the mold.

   Moderate heat (hot air gun or heat lamp) applied to the lay-up will shorten the epoxy's cure time. Heat can be applied as soon as the lay-up or assembly is completed, but most often heat should be applied after the epoxy has reached its initial cure *(See Post-curing, below)*. Heating epoxy that has not reached its initial cure will lower its viscosity, allowing the epoxy to run or sag on vertical surfaces more easily. In vacuum bag procedures, it can lower the resin content of the laminate. In addition, heating uncured epoxy that has been applied to porous materials (wood or low density core material) can cause the substrate to "out-gas". When air in the porous material expands and passes through the curing epoxy, it can leave bubbles or pinholes in the cured epoxy.

   Regardless of what steps are taken to control the cure time, thorough planning of the application and assembly will allow you to make maximum use of the working life of the mixture.

POST-CURING

Some resin/hardener combinations reach an acceptable degree of cure for certain applications with only a room temperature cure. Resin/hardener combinations with 145 Resin or 237 and 239 Hardener require an elevated temperature post-cure to cure beyond the "B" Stage and achieve useful physical properties.

Post-curing is the controlled heating of an epoxy laminate—after it has reached or passed its initial cure stage—to improve the physical strength and thermal properties of the cured epoxy. Each PRO-SET Resin/Hardener combination has potential maximum cured physical properties that can only be achieved by post-curing the laminate above a minimum target temperature.

For each resin/hardener combination there is a range of target temperatures (above the minimum target temperature) that will allow the laminate to reach 100% of its potential cured physical properties. Each target temperature within the range has a corresponding minimum hold time. Higher target temperatures require shorter hold times—lower target temperatures require longer hold times.

Maximum physical properties will not be reached if the actual post-cure temperature is below the minimum temperature in the range. However, even with post-cure temperatures below the minimum target temperature, most resin/hardener combinations will achieve increased physical properties that are useful for many applications.

The post-cure temperature you select for a resin/hardener combination may be determined by the physical properties desired for the component or by the limits of the available equipment to reach or hold a target temperature. To avoid the potential of inducing flaws in the laminate from thermal shock, increase the temperature slowly and do not exceed a maximum target temperature of 180°F (82°C).

Note: Avoid air pockets or voids in the tooling and laminate that can expand when heated and deform the tooling and laminate.

Refer to the PRO-SET Resin/Hardener Technical Data for optimum post-cure temperatures post-cured physical properties. Refer to Section 3 for information on post-cure schedules and techniques.

3. Application Techniques

The following application information is designed to provide general guidelines for using PRO-SET Epoxies in laminating applications.

PRIMARY BONDING/WET LAY-UP

PRO-SET Epoxies are designed for primary bonding of composite materials like glass, carbon, aramid and various core materials. Fabrics may be wet out by standard hand wet out techniques or by roller type impregnating machines. Since each resin/hardener combination will have a different viscosity, it is recommended that you test a combination for its suitability with a particular fabric, impregnating machine and impregnating machine setup.

Fabrics recommended for use with PRO-SET Epoxies should be classified as epoxy compatible. Avoid fabrics with styrene soluble binders or that are compatible only with polyester resins.

Vacuum Bag Laminating

Vacuum bagging is an excellent clamping method for composite construction using PRO-SET Epoxies. Regulating the amount of vacuum pressure permits control of the resin/fiber ratio and can produce a more dense laminate, with a higher fiber volume. Generally, the higher the vacuum pressure, the lower the resin content. The optimum resin/fiber ratio for a particular component will be between 30% and 50%. A lower ratio will result in a lighter composite. A higher ratio will be heavier, but yield higher moisture exclusion effectiveness. Various bleeder and absorber materials used in vacuum bag laminating can also influence the resin/fiber ratio. Building test panels is recommended to determine the proper vacuum bagging material schedule and vacuum pressure for a particular component.

Detailed information about vacuum bagging equipment, molds and procedures can be found in the manual VACUUM BAGGING TECHNIQUES (Catalog No. 002-150), published by West System Inc.

Infusion

Several PRO-SET Laminating Epoxy combinations can be used for resin infusion techniques. Choose the resin/hardener combination that will provide low viscosity and proper gel time for the part. 125/229 works well for smaller parts, particularly those with thin skins on a low density core. 117LV is formulated specifically for resin infusion processes. 117LV/229 is useful for smaller parts that permit a shorter open time. 117LV/237 and 117LV/239 are formulated for the fabrication of large parts. Because of the many variables involved, this technique requires testing to determine the most suitable procedure and the proper resin/hardener combination for each part.

RELEASE FABRIC

In areas where secondary bonding or additional coating will be necessary, use a release fabric such as peel ply over the lay-up. Release fabric is used primarily in vacuum bag laminating, but it is very useful in standard wet lay-up applications as well. When you peel it from the cured or partially cured laminate, the surface will be left finely textured and free of contaminates and amine blush. The laminate surface will be ready for bonding after a laminate reaches its initial cure and the release fabric is removed. This technique eliminates the normal washing and sanding step required to prepare for secondary bonding. A laminate may be built up in several continuing lay-ups over a period of days. Use release fabric after each day's lay-up and remove it prior to continuing the lay-up. When complete, the built up layers of laminate can be post-cured together.

Not all release fabrics have an epoxy compatible coating or a texture suitable for secondary bonding with epoxy. Before building a part, test for the ability to bond to a surface prepared with the intended release fabric at the proposed post-cure temperature .

POST-CURE SCHEDULES

During the post-cure, the temperature of the laminate is slowly raised to the post-cure target temperature, held for a period of time, then slowly lowered to room temperature. Post-cure schedules vary depending on the resin/hardener combination, the desired laminate physical properties, and the capability of the post-cure equipment to reach and maintain a target temperature.

Elevated temperature cure may begin as soon as the laminate is laid up, but with precautions. Keep in mind that as the uncured epoxy warms, it becomes more fluid and has the potential to drain from vertical laminates or result in a reduced resin to fiber ratio in vacuum bag lay-ups. In addition, in thicker laminations, the heat of the post-cure added to the exothermic heat generated by a large mass of curing epoxy may be high enough to damage the laminate or mold. For these reasons, a typical post-cure begins after the epoxy reaches a partial cure at room temperature.

The target temperature is usually determined by the mechanical or thermal properties desired, but may also be determined by limitations of the post-cure equipment, or the ability of core materials or the mold to withstand high temperatures. Although minimum recommended post-cure temperatures may be lower, 140°–180°F (60°–82°C) is the most effective range for post-curing. The target temperature determines the maximum potential physical properties a resin/hardener combination can reach. Higher target temperatures result in higher potential physical properties. The length of time at the target temperature determines how close the resin/hardener combination gets to the maximum potential physical properties determined by the target temperature. The highest gain in physical properties occurs within 8 hours, with diminishing gain up to 16 hours. Use the Physical Property/Cure Schedule charts on the Resin/Hardener technical data sheets as a guide for determining cure schedules.

The laminate thickness will determine the rate of temperature increase. A thick laminate may require a hold cycle to allow the temperature to normalize throughout the laminate. A core can insulate a portion of the laminate, causing that portion to lag behind the average temperature rise. Use thermocouples to monitor the temperature at various locations on the component during post-cure.

Increase the laminate temperature **slowly** so the Heat Deflection Temperature (HDT) is not exceeded. As the laminate is heated, it will continue to cure, pushing the HDT above the laminate temperature. If the post-cure temperature exceeds the HDT of the room-temperature cured composite, the epoxy will soften and may cause print through or distortion of the laminate.

Observe the following guidelines to avoid thermal shock during the post-cure cycles:

1. Increase the temperature from room temperature at a rate of 15°–20°F (8°–11°C) per hour.

2. At every 40°F (22°C) increase in temperature, hold that temperature for an extra hour to allow interior laminate temperatures to equalize. Resume the temperature increase of 15°–20°F (8°–11°C) per hour.

3. Continue this cycle until the post cure target temperature is reached.

4. Hold the target temperature for a minimum of eight hours. The physical properties of the component will continue to improve until 100% of the potential physical properties are reached. Lower target temperatures require longer post cure times to reach 100%.

5. Decrease the temperature at a rate of 20°F (11°C) per hour.

6. Hold at 95°F (35°C) for two hours to allow for normalization.

7. Turn off heat and allow to cool to room temperature.

This schedule is recommended when curing a lighter laminate. The temperature ramp speed should be decreased for molds, plugs and heavy laminates. We recommend building test panels of the finished laminate schedule to determine the ideal post-cure cycle. Thermocouple wires imbedded in the test laminate will measure the temperature lag experienced during the post-cure.

Heating Methods

Post-cure heating techniques vary depending on the size of the component and mold, the number of components being built or on the resources available for space and equipment. If resources are available, a fully insulated oven with electric or vented gas or oil heaters provides the greatest control over post-cure variables. A crude but effective (and economical) post-curing method is to simply cover or tent the component with black plastic and let it sit in the sun.

Catalytic heaters that generate long wave infrared radiation can be used to heat the component without the use of an enclosure. This type of post-cure technique is often used on large components, when space is limited or when a limited production does not justify the cost of an enclosure. Temperature is monitored by surface mounted thermometers and the heaters are repositioned over the component as necessary to provide an overall post-cure. **Warning!** It is difficult to accurately control the rate of temperature change and maintain a uniform target temperature with radiant heating. This may result in laminate that does not have uniform physical properties and can cause localized weak spots. This technique may also result in more print through of the laminate.

Post Curing In Molds

Generally, components are post-cured in the mold in which they were laminated. Molds that are subject to repeated use should be post-cured at higher temperatures than the finished component. This allows the part to be post-cured in the mold at a temperature below the mold's HDT, avoiding distortion of the mold, mold surface or the component during the component post-cure.

Plugs used to build molds should be post-cured at higher temperatures than the mold to avoid distortion of the plug or plug surface while the mold is being post-cured. Check plugs for fairness after post-curing and fair as necessary before the mold is laid up.

SECONDARY BONDING

Secondary bonding operations include the bonding of bulkheads, blocking or additional fabric reinforcing, coating, fairing or filleting to a previously cured or existing component. Once the component has cured to a solid state, a new application of epoxy will not chemically link with it, so the surface of the component must be washed and sanded (if it was not prepared with release fabric) to provide the proper surface for mechanical secondary bond.

PRO-SET Adhesive is a two-part, thixotropic epoxy adhesive designed for secondary bonding and assembly of laminated components. It cures fully at room temperature and it can be post-cured if parts are to be assembled before they are post-cured. For tabbing or taping, a high-quality room-temperature cure epoxy, such as WEST SYSTEM Epoxy, may be used after the components are post cured. Use PRO-SET Laminating Epoxy for tabbing and taping prior to post-curing. High density fillers, such as WEST SYSTEM 406 Colloidal Silica or 404 High Density Filler, should be used when it is necessary to thicken WEST SYSTEM or PRO-SET Epoxies.

Surface Preparation

The success of a secondary bonding application depends not only on the strength of the epoxy, but also on the ability of the epoxy to mechanically "key" into the surface of the material rather than chemically bond to it. If you are bonding to a surface that has not been properly prepared with release fabric, the following three steps of surface preparation are a critical part of any secondary bonding operation:

1. CLEANING

   Surfaces must be free of any contaminants such as grease, oil, wax or mold release. Clean contaminated surfaces with the appropriate solvent. A silicone and wax remover such as DuPont Prep-Sol™ 3919S or acetone works well on many contaminants. Wipe the surface with clean paper towels before the solvent dries. Clean surfaces *before* sanding to avoid sanding the contaminant into the surface. **CAUTION!** Provide plenty of ventilation and follow all safety precautions when working with solvents.

   REMOVING AMINE BLUSH

   Special preparation may be required for epoxy surfaces. Amine blush can appear as a wax-like film on epoxy surfaces. It is a byproduct of the epoxy curing process and may begin to form during the initial cure phase. The blush is water soluble and can easily be removed, but can clog sandpaper and inhibit subsequent bonding if not removed. To remove the blush, wash the surface with clean water and an abrasive pad. We use and recommend 3-M Scotch-brite™ 7447 General Purpose Hand Pads. Dry the surface with plain white paper towels to remove the dissolved blush before it dries on the surface. After washing with the abrasive pad, the surface should appear dull. Sand any remaining glossy areas with 80-grit sandpaper. If a release fabric is used, amine blush is removed when the release fabric is removed.

2. DRYING

   Bonding surfaces must be as dry as possible for good adhesion. If necessary, accelerate drying by warming the bonding surface with hot air guns, hair dryers or heat lamps. Use fans to move the air in confined or enclosed spaces. Watch for condensation when working outdoors or whenever the temperature of the work environment changes.

3. SANDING

   Sand hardwoods and non-porous surfaces (metal, FRP laminate, cured epoxy, etc.) thoroughly to obtain an abraded surface. 80-grit aluminum oxide paper will provide a good texture for the epoxy to "key" into. Be sure the surface to be bonded is solid.

Remove any flaking, chalking or blistering before sanding. Wear a dust mask! Remove all dust after sanding. Laminate surfaces can be textured by using release fabric during the lay-up, eliminating the need for additional sanding.

GELCOATS

We have had good results with various in-mold polyester gelcoats. Because of their superior resistance to ultraviolet degradation, polyester gelcoats are preferred over epoxy gelcoats for exterior finish applications above the waterline. The adhesion of these gelcoats is enhanced by using a chemical tie coat. These products will chemically bond with the polyester gelcoat and allow the epoxy to bond mechanically without any further preparation. Check with your polyester gelcoat supplier for a recommended tie coat.

Success has been reported with a mechanical tie coat as well. A layer of chopped strand mat and polyester resin is applied to the back of the gelcoat. While the resin is still wet, a layer of chopped cotton fiber is sprinkled on the surface. Once the resin has cured, the excess cotton is removed and an epoxy laminate can be applied to the surface. A mechanical bond is formed on both sides of the cotton fibers.

Below the waterline, apply bottom paint directly over epoxy. The use of a polyester gelcoat below the waterline is not recommended. Any moisture finding its way through the gelcoat will be trapped against the epoxy laminate and may cause blistering or debonding of the gelcoat.

An epoxy gelcoat is sometimes preferred for plugs and molds. You can make your own gelcoat using PRO-SET Epoxy. Use WEST SYSTEM 423 Graphite Powder as a pigment and 404 High-Density Filler to modify the viscosity. If a high temperature gelcoat is necessary, add WEST SYSTEM 420 Aluminum Powder to the mixture.

We recommend that each brand of gelcoat and tie coat technique be tested for suitability in a specific application. If you have any questions about testing, call the Pro-Set technical staff.

PAINT SYSTEMS

PRO-SET Epoxies provide an excellent base for most paint systems. Linear polyurethane paints have proven to be the most durable protection over epoxy. Regardless of the paint system used, thorough preparation of the surface is essential for good paint adhesion and a smooth finish.

1. Allow the epoxy to cure thoroughly, especially if the component was cured at room temperature.
2. Remove all traces of mold release by washing the surface thoroughly with a wax and silicone remover such as DuPont Prep-Sol™ 3919S or acetone. Wipe the surface dry with paper towels.
3. Wet-sand the surface to remove any flaws and provide a texture for the paint to "key" into. If you are using a filling or sandable primer, use 100 grit paper. Use 220-320 grit paper if no primer is used. The thinner the paint film thickness, the finer the grit of sandpaper needed. Rinse the surface with clean water and dry thoroughly. Rinse water should sheet without beading up or "fisheyeing", which could be a sign of local contamination. Re-wash with solvent if necessary and wet-sand. Allow the surface to dry thoroughly.
4. Follow the application instructions of the paint manufacturers for coating.

4. Quality Assurance Considerations

This section offers quality control measures that can be employed by builders, large and small, to assure consistent high performance of PRO-SET Laminating Epoxy.

COMMON PROBLEMS

The vast majority of problems encountered when working with an epoxy system can be traced to two problems, improper mix ratio and insufficient mixing of the two components. If care is taken to meter the two components at the proper mix ratio and to thoroughly blend them together, you can ensure consistent, high-quality results.

To a lesser extent, problems may also arise from not properly compensating for changes in temperature. It is important to understand how changes in temperature can effect the cure characteristics of a resin system and how to counteract those effects.

Proper Mix Ratio

CHECKING PUMP RATIOS–Pro-Set offers pumps which are designed to meter the correct ratio of resin and hardener for most PRO-SET combinations. However, the pumps are built for an average shop temperature of approximately 70°F (21°C) and it has been found that changes in the viscosity of the resin and the hardener due to changes in temperature can cause internal slippage resulting in poor ratio control. With any metering system, a frequent check of the pump ratio is recommended. You can use graduated containers to check the metered volume or a scale to check the ratio by weight. If the ratio is not within the acceptable range for the products you are using, corrective action must be taken. Recheck the ratio anytime you experience problems with curing. Production facilities should check pump ratios on a regular daily or weekly basis.

EPOXY RATIO AND HARDNESS

Each resin/hardener combination will achieve optimum working, cure and mechanical properties at a specific mix ratio. Refer to the Technical Data section for the acceptable range for the resin/hardener combination you have chosen. The optimum mix ratio is the mid point of the acceptable range. If the actual mix ratio deviates from the optimum mix ratio, the physical properties of the resin system will decline as the ratio deviates from the optimum ratio.

To check the cure of the epoxy we use the ASTM D-2240 method for Rubber Property - Durometer Hardness. This method is recommended for quality control purposes and not for establishing specifications. The test is performed using a Type D Shore Durometer, where an indentor needle is pressed into the cured epoxy sample and the resistance is recorded on an indicator. The Shore D Durometer is available from Shore Instrument and Manufacturing Company of Freeport, New York. Any instrument meeting the ASTM D-2240 requirements can be substituted. Some resin manufacturers specify Barcol hardness readings. However, we feel the Shore D Durometer is more sensitive than the Barcol tester and is more appropriate for epoxy testing. Unfortunately, there is no direct conversion from the Shore D scale to Rockwell or Barcol scales.

It is often a good idea to prepare a special quality control sample for testing and to keep quality control samples of cured epoxy for future reference. It can be as easy as pouring a portion of the mixed epoxy you are using into a mold or suitable container (we often use a plastic lid, as from a coffee can). Label this sample and cure it under the same conditions as your project. It may be sufficient to check the hardness right on the part you are building, as long as there is a flat area large enough to use the durometer.

A fully cured sample of epoxy will usually show a Shore D hardness of 80-85. A sample that has not had sufficient time to cure will have a lower hardness. However, if the hardness does not increase after a reasonable amount of time, there are several possible causes which should be investigated. The temperature may be too low to allow the epoxy to cure properly, the epoxy may have been mixed at the wrong ratio, or it may have not been mixed thoroughly, resulting in localized areas of off-ratio material.

Thorough Mixing

If a mechanical mixer is being used with large batches of mixed epoxy, it is crucial to scrape the sides and bottom of the container to assure thorough mixing.

DYED RESINS AND HARDENERS

We suggest using dyed resins and hardeners as a visual control of mixing thoroughness. By using a yellow dye in the resin and a blue dye in the hardener, a proper ratio of resin/hardener that is thoroughly mixed will result in a consistent shade of green. Streaking due to insufficiently mixed resin and hardener is very apparent. Pro-Set has dye available to mix on-site. Instructions are provided to mix the dye at the proper ratio. If you are purchasing larger quantities of resin, we can premix dyes at our plant before shipment.

COMPENSATING FOR TEMPERATURE EFFECTS ON EPOXY CURING

The minimum recommended curing temperatures and pot-life information for PRO-SET resin/hardeners are shown in the Technical Data section.

Low temperatures can increase open time, time to full cure and resin viscosity. It may be more difficult to thoroughly mix a very thick resin and hardener batch. It may also be more difficult to wet-out the fabric with very thick resins. The extended cure time can leave the epoxy vulnerable to damage if clamping pressure is removed too early.

Higher temperatures can reduce open time, cure time and resin viscosity. The builder should carefully evaluate the working conditions, size of job and number of workers in choosing the correct resin/hardener combination.

For more detailed information refer to *Strategies For Successful Cold Temperature Bonding and Sealing with Epoxy (Catalog No. 002-915)*, available from West System Inc.

QUALITY CONTROL WORKER/EPOXY SPECIALIST

In large shops, we recommend that a responsible person be designated an “epoxy specialist." The primary job should be training of new workers regarding safety and effective use of epoxy in the construction of an epoxy composite structure. Other job areas might include:

1. Inventory and quality control of epoxy (including monitoring shelf life and expiration dates) and safety supplies.
2. Monitoring pump ratios, shop heating and relative humidity.
3. Checking the epoxy cure/hardness of sensitive or critical jobs.
4. Taking quality control samples of epoxy.

If you have any questions about PRO-SET Epoxies or laminating procedures, write or call the Pro-Set technical staff.

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