

REPORT

2001 / 1

NEWS ABOUT

EPOXY
CHEMISTRY,COMPOSITE
PROCESSES &

FABRICATORS

Confidence and Credibility*Robert Monroe, President
Gougeon Brothers, Inc.*

For the past fifteen years, PRO-SET epoxy products have been the workhorse resin systems for a wide array of boat builders and composite manufacturers. The products in the PRO-SET line were developed originally to meet the needs of our own composites manufacturing plant and have been constantly updated as manufacturing processes and composite engineering have changed. From aircraft to infrastructure, PRO-SET products offer value and performance in demanding applications and an evolving regulatory environment.

We believe that our credibility and customer confidence is no accident. PRO-SET epoxy products draw on thirty years of epoxy formulating, boat building and composite manufacturing at Gougeon Brothers, Inc. We are proud of that experience base, but we recognize that expertise comes from all over and it starts with the customer. We are keenly aware of an increased sophistication on the part of our customers and the demand for seamless quality and performance on the part of our customers' customers.

Meeting these demands is an iterative process. We review application, design and process requirements to see if a standard or custom formulation fits the customer's needs. We offer responsive materials testing as needed. We work shoulder to shoulder with builders as they refine their shop processes. We measure success and when necessary, we repeat the process. We are committed to superior value resin systems — they have to work for the customer.

While our focus is epoxy, we seek out opportunities for cooperative projects with other materials suppliers. We believe that a systems approach works best. The correct choices and proper integration of resin, fabric, reinforcements, core, gelcoat or finishing system define the success of any project. Quality and longevity are the targets. We know that the end customer demands value and performance, both at delivery and in twenty years.

Starting with this premier issue of our *PRO-SET Report*, we want to highlight products, processes and customer projects that we believe will be of interest to our broad customer base. We hope these articles document the vitality and inventiveness that mark the constant change and growth of the composites industry. ■

Resin Thixotropy*Chris Maples, R & D Chemist
Gougeon Brothers, Inc.*

One of the most important criteria for an epoxy laminating resin is the ability to wet out and saturate fiber bundles in a laminate stack. A common misconception is that a very low viscosity* system is the best candidate for such an application, but this is not necessarily the case. Although a low viscosity system would penetrate the fiber bundle quickly, the possibility of resin drain out may offset this benefit. The drain out effect will be most pronounced on vertical surfaces and can lead to dry areas in the laminate, especially in a contact molded part. If the viscosity is increased to prevent drain out, the system will be more difficult to mix and apply and may not wet out the fiber bundle properly. In laminating operations,

the ideal system would be one which has a low viscosity at high shear, such as when mixing and wetting out fabric, and a high viscosity at low shear, when the resin system is at rest on the surface.

We have developed a PRO-SET custom resin that fits the above criteria. Our custom XR99-097-31B resin evolved from numerous rheological* tests that were performed to find the right balance of high shear to low shear viscosity. Even with high resin to fiber ratios and a thick laminate stack, the resin system has excellent resistance to drain out while still wetting out the fiber bundle aggressively.

One of the tools used to predict the wet out performance of a resin system is the Thixotropic (Thix) Index. The data obtained from this test is a ratio of low shear to high shear viscosity. Most resin systems are Newtonian liquids. At a given temperature, they will have the same

*Editor
Kay Harley**Design
Jennifer L. Jones*

viscosity at low and high shear and will have a Thix Index of 1.0. A resin system with a Thix Index greater than 1.0 will have a lower viscosity at high shear. This tool was used as an initial screening for various formulations aimed at reducing drain out. Once several candidates were identified, we used a simple yet revealing wet out/drain out test to isolate the final candidates. We tested the resin systems using XM1508 (± 45 biaxial fiberglass with stitched 3/4oz mat) on a vertical surface. The fabric was wet out with a specific amount of mixed epoxy required to give a 60% resin content by weight. Observations were then made regarding the ease of wetting the fabric and the degree of drain out. This test indicated that the XR99-097-31B resin has an ideal balance of wet out capability and drain out resistance.

Because manufacturers rarely build in laboratory conditions, we conducted further tests using the vertical surface method at an elevated temperature. To mimic a typical laminating scenario, 8 layers of XM1508 fiberglass were wet out on a vertical surface

at 90°F. After five hours in these conditions, the XR99-097-31B specimen showed no signs of drain out from initial lay up until the epoxy resin hardener combination had completely cured. The excellent elevated temperature performance of the XR99-097-31B was also demonstrated in the recent construction of a 140' carbon/Kevlar™ high-speed motor yacht in Florida where shop conditions often require a thixotropic resin.

As with all PRO-SET® products, mechanical and physical properties for this resin are appropriate for most FRP composite applications. This product is just one of the custom resins we are producing for very specific applications. Call us if you would like to discuss your projects to determine if a custom resin or hardener would make your manufacturing process more cost effective.

* viscosity = resistance to flow

* rheology = the study of the deformation and flow of matter ■

Product Update

Volume and Weight Change

Gougeon Brothers, Inc.

Due to requests from customers, the amount of PRO-SET resins and hardeners in the dash 3, drum unit sizes is being changed. In the past, the amount of resin contained in each drum has been determined by identifying the amount of hardener that will fit in the hardener drums, and then, based on the mix ratio, calculating the amount of resin that can be reacted with the hardener. In essence, kit amounts are being provided so that when the hardener is gone, the resin will run out at the same time. However, as resins and hardeners have been added to the PRO-SET product line, this has become more and more difficult. Containers with as little as 390 pounds of resin (117LV for example) are shipped to customers.

Most customers are using multiple PRO-SET resins and hardeners in their plants, so the resin and hardener from a kit do not run out at the same time. To simplify inventory management for these folks, the amount of resin or hardener in a container will become the same for all resins and all hardeners. The dash 3 size of resins will now contain 500 pounds of product, and the dash 3 hardener containers will contain 115 pounds of material. The enclosed table describes the weight change.

This change will take effect on August 1, 2001. After that date, drum units will be shipped with the new product weights. New price information will be available reflecting the quantity modification. In the case of some products, the unit price will increase significantly, not because of a large increase in price per pound, but simply because more pounds are in the containers.

The weight change is intended to reduce confusion and simplify inventory management for professional fabricators. It is critical that everyone involved in purchasing and inventory management in your plant be notified of this change. The smaller sizes of PRO-SET resins and hardeners will remain packaged as kits. This will allow purchase of smaller quantities for individual projects.

An additional size has been created for large quantity users. There is now a dash 4 size. The resins will be packaged in 2250 pound totes, and the hardeners will be packaged in 425 pound drums. These sizes are not included on the price list; if you are interested, call us to discuss supply in this larger size. ■

Comparison of old / new weights and volumes of PRO-SET dash 3 sizes.

Product	Old Weight (Pounds)	Old Volume (Gallons)	New Weight (Pounds)	New Volume (Gallons)
117LV	390	40.83	500	53.98
125	414	42.83	500	52.97
135	500	51.65	500	51.65
145	417	42.83	500	51.35
226	119.6	14.27	115	13.73
229	116.9	14.27	115	14.04
237	116.5	14.5	115	14.31
239	114	14.4	115	14.64



Carroll Marine, builder of the Farr 40's, will be featured in a future Fabricator's Profile.

Post Cure Basics

Tom Pawlak, Technical Services
Gougeon Brothers, Inc.

It is fairly well known among composites professionals that epoxy formulations benefit from post cure, that is, a controlled elevated temperature cure following gelation. Many epoxy formulations require a post or elevated temperature cure in order to achieve meaningful physical properties. Without the post cure, these epoxy formulations do not cure sufficiently, leading to less than optimum mechanical properties and potential problems for the structure. Generally speaking, the higher the post cure temperature, the higher the cured physical properties will be.

There are a number of epoxies that are formulated as “room temperature cure” products. These products do not require post cure to achieve acceptable physical properties, but may benefit from exposure to a higher temperature cure. The improved properties can range from higher heat resistance to higher toughness as measured by Izod impact testing. Properties are enhanced because elevated temperatures allow the epoxy’s resin and hardener molecules to continue cross-linking to a higher degree of cure.

Even low temperature post cures of 110°F for several hours can produce dramatic results for some epoxy products. An example would be PRO-SET® 125 resin and 226 hardener. This combination has a tensile strength of 7,960 psi when cured at room

temperature for two weeks. After exposure to 110° F for eight hours, the tensile strength improves to 10,592 psi. That’s a 33% improvement. The flexural strength for the 125/226 combination is 12,760 psi for room temperature cure and 18,087 psi for samples post cured at 110°F, a 41% gain. An additional benefit to post curing a part is that the thermal properties increase along with the mechanical properties. This translates to better resistance to print through once the part is in service and better stability at elevated use temperatures. In many cases, very good room temperature cured properties are improved dramatically with exposure to a little heat and time through post curing.

In determining the appropriate post cure schedule, it is important to understand temperature and time. A lower cure temperature for a longer time can sometimes be as effective as a higher temperature for a shorter time. For example, 110°F for 24 hours will provide similar properties to a cure at 140°F for 8 hours with most resin and hardener combinations. You can choose the post cure temperature based on available heating equipment or tooling constraints and choose the time to optimize properties at that target temperature.

Post cure techniques can range from low cost and simple enclosures made of plastic and heated with propane space heaters to exotic ovens with computer-based controls. Even if you assemble ovens temporarily for a single project, you can post cure safely. The next *PRO-SET Report* will describe several post cure methods. ■

Physical Property	Test Method	Room Temp.* x 2 weeks	RT x 15 hr + 110°F x 8hr	RT x 15 hr + 140°F x 8hr	RT x 15 hr + 180°F x 4hr	RT x 15hr + 180°F x 8hr
Tensile Strength (psi)	ASTM D-638	7,960	10,592	10,386	10,172	11,071
Flexural Strength (psi)	ASTM D-790	12,760	18,087	19,086	18,298	19,077
Onset Glass Transition Temperature (°F)**		134	139	157	N/A	184

Typical physical properties table from the technical data sheet for 125/226.

*Room Temperature (70°F-75°F)
**Determined using a Differential Scanning Calorimeter (DSC). Value reported is the onset of the glass transition.

Fabricator Profile:

Scaled Composites LLC

Joe Parker, Product Manager
Gougeon Brothers, Inc.

In each *PRO-SET Report*, we will introduce readers to a composites manufacturer who is using PRO-SET Epoxy products. This issue features Scaled Composites LLC in Mojave, CA founded in 1982 by Burt Rutan. If you are interested in aircraft, you already know of Burt and Scaled Composites as the designers, engineers, and builders of *Voyager*, the first aircraft to fly non-stop around the world. Scaled is well known in the aerospace industry for their air vehicle design, tooling and manufacturing abilities. They currently employ over 100 people and have developed and prototyped some of the most innovative composite aircraft in the last 20 years.

Scaled Composites have been using PRO-SET products since early 1996 for their composite aircraft. Primarily, they use carbon and PRO-SET 125/229 Laminating Epoxy. All of their recent projects use PRO-SET.

One recent project is *Proteus* (back page), a true multi-purpose aircraft designed for high altitude operation. The plane recently set three world altitude records, with a sustained altitude record of 61,919 feet and a maximum altitude record of 62,786 feet. To put this in perspective, the aircraft has flown nearly 12 miles up, very near the limit of the earth’s atmosphere. One of the folks involved in the project said that at these altitudes, the sky is dark outside the plane, even in broad daylight.

The modular design of *Proteus* allows for configuration changes quickly. It will be used as a wireless telecommunications satellite over large cities, as a launch vehicle for unmanned satellites, and for atmospheric research. Once the aircraft has completed certification, Scaled Composites will begin production with an initial run of about 100 aircraft.

The *Vantage* is another project using PRO-SET®. Designed as a six passenger, cost effective business or private jet, this all composite structure allows rapid construction and its light weight permits the use of fuel efficient engines. The talented design,

tooling and manufacturing teams at Scaled were able to create the prototype in just eight months, rolling out the plane to a perfect test flight.

The *Adams M-309* plane was developed for Adams Aircraft Industries as a twin engine, 6 passenger private aircraft. Again, Scaled brought their resources to bear on the project and produced the prototype in a mere ten months with the first flight in April 2000.

Scaled Composites continues to use PRO-SET products because of the high quality of the formulations. They depend on the consistency and quality control exercised by Gougeon Brothers employees. As Bob Marks, Purchasing Manager for Scaled Composites said, “on behalf of the crew of *Proteus* and everyone at Scaled Composites, I’d like to thank everyone at Gougeon Brothers for making such an excellent product. That excellence is enhanced by the great service and support that the people at Gougeon provide.”

Words like that make us proud to be part of Gougeon Brothers and remind us that our attention to detail is what keeps customers, and sometimes just planes, boats, and whatever returning. For more information about Scaled Composites and their composites projects, visit their web site at www.scaled.com. ■

All photos courtesy of Scaled Composites LLC



Proteus under construction.



Vantage



Adams M-309



Proteus in flight.

www.prosetepoxy.com

- process equipment
- adhesives
- laminating epoxies



Gougeon Brothers, Inc.
P.O. Box 908
Bay City, MI 48707