

Pre-preg vs. Wetpreg Technology

Composite boats are built using one of three methods: 'wetpreg', resin infusion [one acronym being SCRIMP] or 'prepreg' technology. Goetz Custom Boats has successfully employed all three methods, and has spent many hours of research and development perfecting our construction techniques. Here's a brief description of each process, and the reason a prepreg boat will be stronger and lighter than the same boat built with wetpreg or resin infusion.

The technique for the traditional or wetpreg method consists of impregnating the reinforcing material (such as E-glass, S-glass, Kevlar, or Carbon Fiber) with a room temperature cure epoxy and applying the wet material to the boat plug. A vacuum bag is then spread over the laminate and pressure is maintained until the resin cures. Once the whole structure is complete, the boat should be post-cured in an oven at 60 degrees Celsius. This 'cooking' process tempers the epoxy and increases the strength of the resin.

Wetpreg technology produces very sound boats and represents the process we used to construct boats prior to 1992, including the 85' Maxi boat World Champion *Matador 2*. However, the resin content of the laminate is between 50-55% even under a very good vacuum bag and excess resin translates into excess weight with no benefit.

Resin infusion uses a process of drawing or sucking resin into a laminate consisting of reinforcing materials such as glass or carbon, and core such as balsa or foam. The resin is introduced into ports which line the perimeter of the vacuum-bagged part. Once the resin is introduced the ports are shut and the pressure is maintained until the resin cures. Once again, after the whole structure is complete, the boat should be post-cured in an oven at 60 degrees Celsius.

Because resin must be drawn into the fabric, the fabrics used in infusion are coarse weave materials. Woven materials are weaker than the unidirectional tapes typically used in prepreg laminates due to the crimping and handling of the weaving process. This results in lower fatigue life for the boat using these goods. Even in sails there is huge emphasis on unidirectional fibers for the best strength/weight ratio.

Resin infusion is a process that is mostly used on series production boats such as 'J Boats'. The advantages are: the laminate and core is thoroughly wet by the resin, the weight from one boat to the other is very similar which is important for class boats and the emissions are reduced, increasing worker safety. The down side is that the resulting boat is heavier than that achieved by either 'wetpreg' or 'prepreg' due the flowing of the resin into every nook and cranny. Again, excess resin translates into excess weight with no benefit.

Beginning with the 1992 America's Cup boats, Goetz Custom Boats incorporated the latest aerospace prepreg technology into full scale racing boats. For prepreg the reinforcing material is pre-impregnated by an outside supplier to a prescribed resin ratio (about 35% for most laminates), and then frozen to keep the epoxy in the uncured stage.

The material is shipped to the builder packed in dry ice and then applied to the boat plug and put under a vacuum bag. The whole hull or deck is then baked at 90-105 degrees Celsius (depending on the rating rule, if any) to cure the resin. Prepreg's elevated cure temperature eliminates the need for post-cure. In fact, the prepreg resin is inherently much stronger than the resin used in 'wetpreg' or infusion by 18% in tensile, and 17% in compression strength.

	Resin Type	
	<u>Prepreg</u>	<u>Wetpreg / Infusion</u>
Tensile Strength	11,500 psi	9,770 psi
Compression Strength	17,000 psi	14,500 psi

We used prepreg technology on the nine America's Cup boats we have built, along with fourteen IMS racing boats, three Whitbread/Volvo 60's, four cruising boats from 63-78', a 102' motoryacht, over eighty rowing shells, and a radar test-site dish for Lockheed Aerospace. There are no other builders in North America or worldwide with this level of experience in large aerospace-grade prepreg composites.

The two major benefits from the use of prepregs in boat construction are lighter weight and greater strength. Plus, prepreg is the most environmentally and worker friendly system since no wet resin is used.

Weight is controlled by regulating the amount of resin in the laminate. Each boat is designed with a fixed laminate schedule for the cloth, but the actual resin content in a wetpreg boat is a variable depending on application technique, temperature, and humidity. Using prepreg materials results in a consistent laminate with the correct (minimum) amount of resin already applied. More resin, which is inevitable in a wetpreg or infused boat, simply gives you more weight, not a stronger boat.

As a result, the fiber/resin ratio of prepregs is greater than wetpregs by an average of 15% for a glass or carbon laminate, and 10% for a Kevlar laminate. This ratio means less weight for the same amount of reinforcing. In fact, with the equivalent amount of material and core, the prepreg laminate will weigh about 20% less than the wetpreg laminate and over 22% less than resin-infused!

WEIGHT COMPARISON

Grams per Square Meter	REINFORCEMENT	CORE	RESIN	TOTAL
PREPREG	4500	650	2100	7250
WETPREG	4500	650	3525	8675
INFUSED	4500	650	3725	8875

LAMINATE =4500 grams of uni-carbon, 130 kg core @ 50mm

At 330 square meters for the hull shell of a 106 foot sailing yacht, and 260 square meters for the deck, this translates into a weight savings of over 840 kilos compared to wetpreg, and 958 kilos compared to infused. The projected weights for the boat 'off the mold' are:

Prepreg:	4,277.5 kg	(9,410 lbs.)
Wetpreg:	5,118.25 kg	(11,260 lbs.)
Infused:	5,236.25kg	(11,519 lbs.)

Reducing the resin content of the laminate also actually increases the interlaminar shear properties due to better fiber-to-fiber contact. This shear strength advantage results in greater stiffness of the laminate as well as the total structure of the boat. The shear strength increase is also a safety factor as it rates heavily in impact situations.

Prepreg laminates are also less porous than those of wetpreg laminates. This factor results in less moisture pick-up, which can be significant over the life of the boat. Boats that don't accumulate moisture over their lifetime will weigh less and be faster than their wetpreg counterparts.

An additional benefit to using prepreg is cosmetic; a boat that has been baked at 100 degrees C (212 degrees F) will remain stable in the hot summer sun, where dark painted topsides can reach 150 degrees F. This means that the topsides of a prepreg boat will be smoother and fairer, and require less maintenance than a boat cured at a lower temperature.

As we have seen, prepreg has a clear advantage over wetpreg or infused laminates in both performance and safety considerations – no wonder aerospace composites are exclusively built with prepreg! Prepreg's only disadvantage is a slightly higher material and labor application cost, resulting in a price premium of about 15% compared to wetpreg.