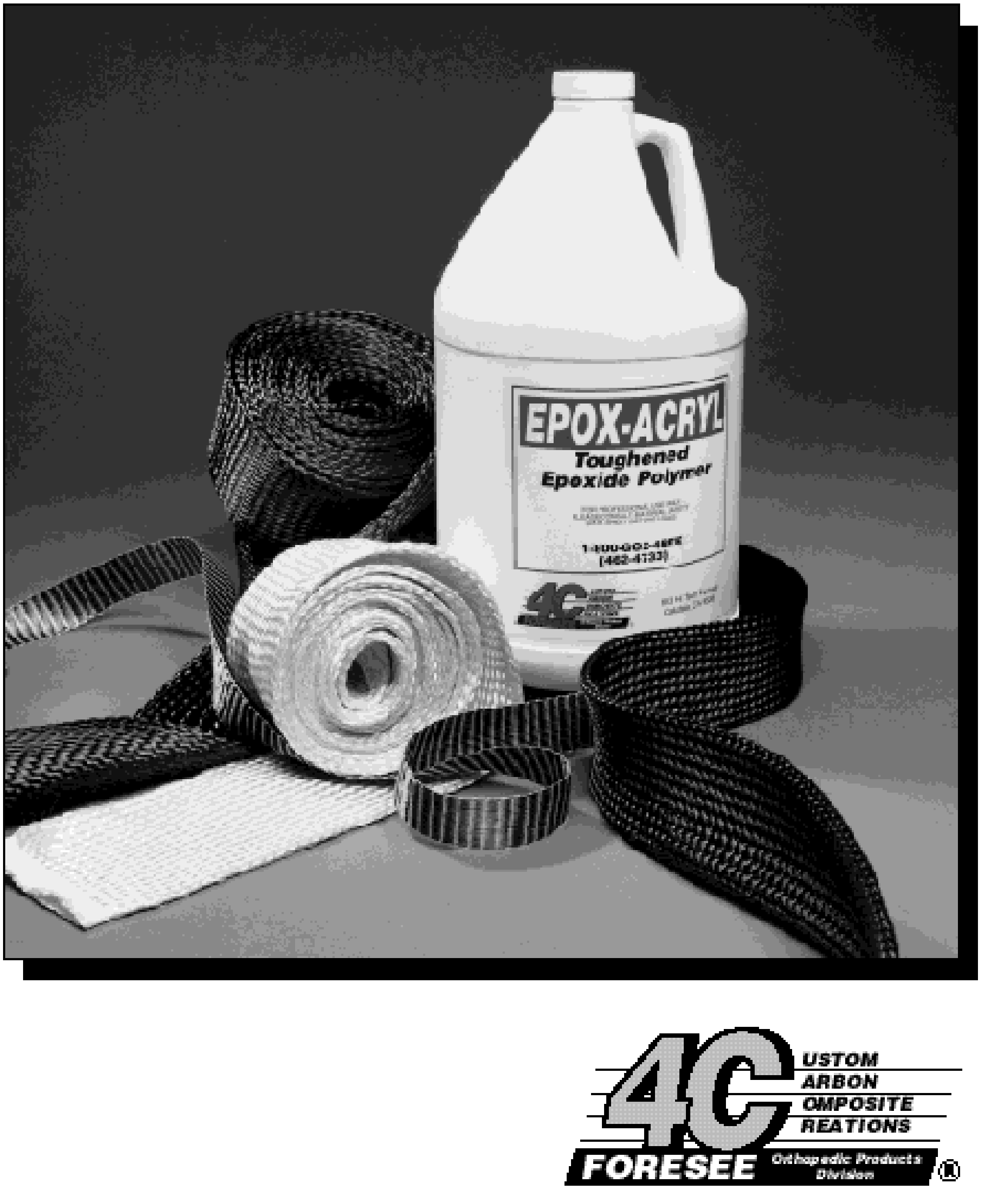
Technical Manual

FABRICATING MATERIALS



4C USTOM ARBON OMPOSITE REATIONS
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FMTM REV1

Foresee Orthopedic provides the highest quality composite laminating materials available to the Orthotics and Prosthetics industry. In order to achieve the maximum benefit from these products, it is very important to have a basic understanding of the science behind the function of these materials as well as a knowledge of proper fabricating techniques. In other words, it is important to not only know **WHAT** to do, but also **WHY** you are doing it. This manual has been prepared to share information with our customers in hopes of allowing them to produce lighter, stronger and less expensive products. While we have tried to include all relevant information, issues can and will arise that are not covered in this manual. In these cases we welcome your technical questions by phone. We can be reached at **1-800-462-4733** or (209) 845-2930 (7:00 - 5:00 PST)

EPOX-ACRYL
Toughened Epoxide Polymer

In a lamination, the resin serves to transmit shear loads between the fibers, therefore, it is very important for the bond between the fibers and resin to be a strong one. First, one must be concerned with whether or not the fibers and resin are compatible. Fibers are generally treated to be most effective with a particular type of resin.

Epox-Acryl is a high performance thermosetting laminating resin that offers unsurpassed strength and ease of use to the Prosthetic and Orthotic industry. This material was designed to provide very high fracture toughness without sacrificing rigidity. This unique property allows the designer to create laminates that are very thin, yet strong and durable.

Epox-Acryl gives you all of these favorable characteristics while retaining an ease of use that meets or exceeds currently used resins. In order to achieve the properties outlined above it is recommended you follow the instructions outlined in this manual.

Gel Time

Epox-Acryl is designed to have an estimated gel time of 12-15 minutes when combined with 3% hardener by weight. It is recommended that you use a scale when adding the hardener in order to achieve consistent results. To attain the fastest possible cure, up to 5% hardener can be used.

Adding the hardener in amounts less than 3% can cause a delayed cure and should be avoided. If, for some reason, less than 3% hardener is used, heat can be used to accelerate the cure.

Cure Time

Epox-Acryl is an epoxy based resin, therefore, there is some volume sensitivity to the cure rate. This means that a large amount of resin will cure faster than a small amount. While this effect has been all but eliminated, you may find the thinner portions of your laminate take a few minutes longer to cure than the thicker portions. When properly catalyzed, Epox-Acryl will achieve very high strength within 35-60 minutes, however, it will continue to get even stronger for up to 24 hours.

Laminating

When laminating with Epox-Acryl you can use an outer bag vacuum up to 28 in Hg. This vacuum assures a very thin, well consolidated, void free laminate. Lower vacuum can be used to achieve a smoother finish lamination. Always make sure all your reinforcing fiber are completely wet out. This can be accomplished by stringing a generous amount of resin down past your trim lines followed by stringing excess resin back up and out of your laminate. To achieve best results, you will want to laminate over as dry a cast as possible. If it is not possible to have a dry cast, it is recommended you put a couple coats of lacquer on your cast and then a coat of paste wax.

FORESEE SAMPLE LAY-UPS

The following lay-up suggestions are based on the principles already outlined in this manual. They can all be modified to accommodate different patient weights, activity levels, and socket geometries.

I. Standard lay-up for Transtibial socket

1 1/2 oz Dacron Felt
1 Foresee Carbon Fiber Sleeve
2 Nyglass
1 Foresee Carbon Fiber Sleeve
2 Finish Stockinette

- For the thinnest and lightest lamination use 22-28 inches of vacuum
- For a smoother finish use 8-14 inches of vacuum
- A layer of thin sheer nylon over the carbon fiber will prevent any small black fibers from showing up on the outside of the socket

II. Ultra Light lay-up

1 1/2 oz Dacron Felt (this layer can be replaced by a nylon layer if the socket will require little modification)
1 Foresee Carbon Fiber Sleeve
2 Nyglass
1 Foresee Carbon cloth around the proximal portion of the socket
2 Finish Stockinette

III. Hybrid lay-up

1 1/2 oz Dacron Felt
1 Foresee Carbon Fiber Sleeve
2 Nyglass
1 Foresee Fiberglass Sleeve
2 Finish Stockinette

- The advantage to this lay-up is the white glass on the outside of the socket makes it easier to pigment. The glass also makes this socket slightly more flexible and damage tolerant than the all carbon socket, however, it will weigh slightly more than the socket outlined in lay-up I.

IV. Econo lay-up

1 1/2 oz Dacron Felt
1 Foresee Fiberglass Sleeve
2 Nyglass
1 Foresee Fiberglass Sleeve
2 Finish Stockinette

Lay-ups for Transfemoral sockets will generally start out the same as those outlined above with the addition of some localized reinforcement. An example might go as follows:

V. AK Retainer with anterior and posterior window

1 1/2 oz Dacron Felt
1 Foresee Carbon Fiber Sleeve
1 or 2 Unidirectional Carbon Tape running length of medial and lateral strut of socket
2 pieces of Fiberglass cloth on proximal posterior medial side of socket
2 Nyglass
1 or 2 Unidirectional Carbon Tape running length of medial and lateral strut of socket
1 Unidirectional Carbon Tape around proximal brim
2 Finish Stockinette

Often times the way components attach to a socket can require special consideration as far as lay-ups are concerned. For instance, sockets that have a hemispherical contour fabricated onto the distal end for the components to attach to (Delta series, Pyramid Plus, etc.) may require extra material in this area. This can consist of Unidirectional tape on the bottom of the socket in the AP and ML. One layer after the first Fiber Sleeve and one before the second Fiber Sleeve.

While the following lay-ups have proven to be effective we cannot guarantee their use for a particular application as we have no control over various manufacturing parameters.

BRAIDED CARBON SLEEVE FABRICATION TIPS

- Always push sleeve onto cast as opposed to pulling it on.
- Place the sleeve over the cast before it is cut from the roll. This can eliminate waste.
- If the sleeve is very tight around the proximal portion of the cast, either remove any excess plaster from the posterior build up or on the anterior above the trim lines.
- Trim the sleeve on the anterior and the posterior above the trim lines and then pull the sleeve down on the medial and lateral sides or use a larger size sleeve.
- Ideally, the finished part will have a + or - 45 degree fiber orientation on both medial and lateral ears.

BRAIDED CARBON SLEEVES (circumferences)

BCF2 - maximum circumference 9 - 9 1/2 inches in diameter

BCF4 - maximum circumference 15 - 15 1/2 inches in diameter

BCF5 - maximum circumference 20 -20 1/2 inches in diameter

BCF6 - maximum circumference 25-25 1/2 inches in diameter

BCF8 - maximum circumference 33-33 1/2 inches in diameter

- Take measurement at or under posterior brim of the cast or socket.
- Measurement can also be taken at the proximal area as well.

NOTES

COMPOSITE THEORY

Composites are defined as two or more materials with different properties, and when mixed, they retain their individual identities, but act in concert to achieve different and often times more useful properties. When we are talking about composites, what we really mean are Fiber Reinforced Plastics (FRP's). These products are characterized by high strength fibers impregnated with a resin matrix. When FRP's are properly combined, their strength to weight ratios can be several times greater than steel.

Fiber Types

There are many different varieties of fibers available with each one having very different properties. It is important to realize that none of these fibers are inherently good or bad, but just different. In selecting the proper fiber or fibers for a particular laminate you must decide what properties you desire the finished product to have and then select the fiber that will give you those properties. The major physical qualities that we need to be concerned about are tensile strength, modulus and density. Tensile strength is a measure of how hard you can pull on a fiber before it will break (Table 1). Modulus is a measure of the rigidity of a fiber or how much it will stretch at a given load (Table 2). Density tells you the weight of a material at a given volume (Table 3). All of the fibers that are commonly used have vastly different values for each of these measures. If you are trying to make a laminate with maximum rigidity and/or minimum thickness you would want to look toward the higher modulus fibers. If you are designing something that requires more flexibility, the lower modulus fibers might be more appropriate.

TABLE 1

Tensile Strength

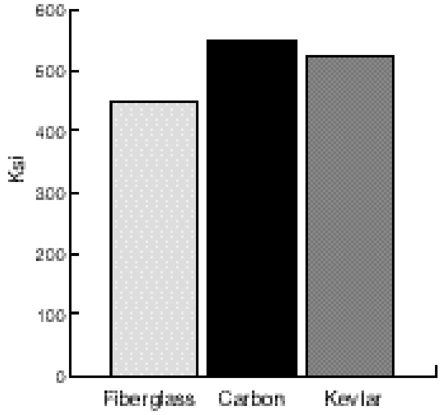


TABLE 2

Modulus of Elasticity

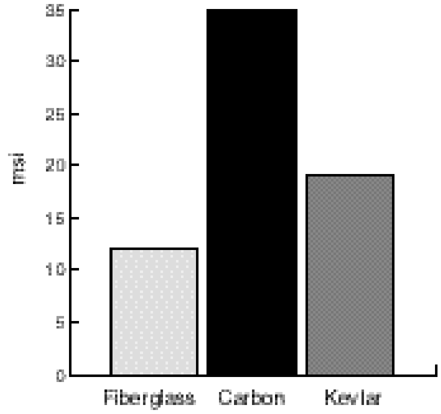
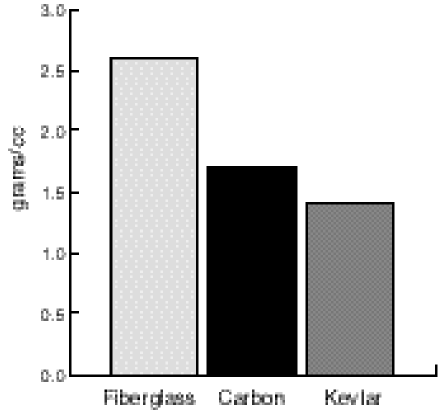


TABLE 3

Fiber Density



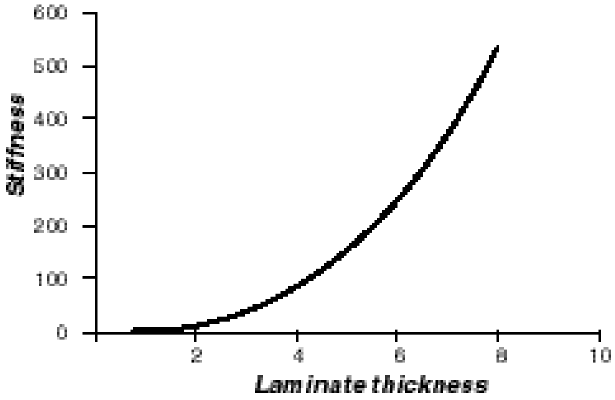
LAMINATE DESIGN

The main issues that need consideration when designing a laminate are fiber type, fiber orientation and stacking sequence. Fiber orientation is a very important consideration because the strength and rigidity of a FRP will change drastically as the direction of the fibers change. The maximum strength is achieved when the fibers are running in the same direction as the loads. When the loads are at 90 degrees to the fibers the minimum strength is attained. This fact can be very helpful when the direction of the loads can be easily determined. In this case, you would want the majority of the fibers running in that direction. A more common situation is where you have loads in many directions. Here, you would want to have fibers running in several directions to accommodate the forces that are present.

All laminates are made up of several layers of fibers. The stacking sequence refers to the fiber orientation and type of fiber in each layer. This sequence can effect material properties. For instance, a lamination consisting of a carbon-glass-glass-carbon will be more rigid than a glass-carbon-carbon-glass even though they contain the exact same material in the same orientation. The reason for this is because fibers which are farther from the center or neutral axis of a laminate are required to do more work than fibers near the center. Having the higher modulus fibers on the outside will maximize rigidity. This concept explains why it is generally a waste to have carbon in the center of a laminate. The high rigidity of this fiber cannot be realized in that configuration. This brings up another issue on how the thickness of a material will effect its rigidity. The interesting fact here is that an increase in thickness will increase the rigidity exponentially. This means that a small increase in thickness can cause a large increase in stiffness as seen to the right in Table 4.

This concept can be very useful when trying to create a localized area of strength and rigidity. For instance, when fabricating an ischial containment socket we will often end up with a thin piece of plastic on the medial side of the socket encapsulating the ishium. In order to prevent any increase in the skeletal ML of the socket this piece of plastic needs to be very rigid. This can be accomplished by adding a couple layers of extra lay-up material in this area. These layers should be feathered to prevent any build up of stress. You can do this by cutting the first layer about one inch larger in each direction than the second piece. Always try to avoid creating an area in a laminate that has greatly different properties than the area next to it. Try to create gradual changes as much as possible.

TABLE 4



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