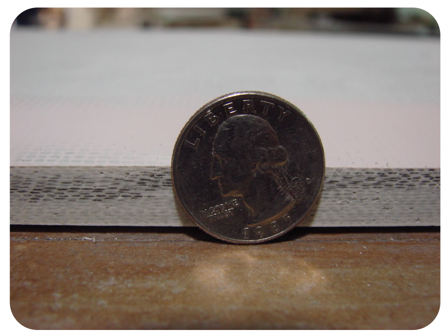
POLYMER COMPOSITES, INC. 1871 Lake Pl., Ontario, CA 91761 • (909) 673–1625 • Fax: (909) 673-1605

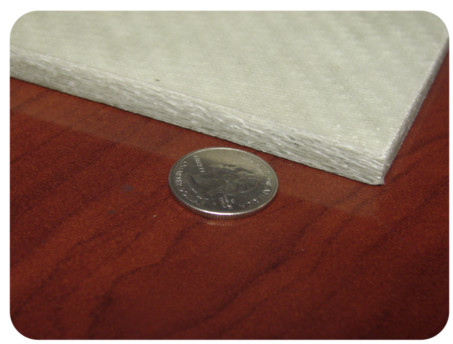
Composite Fabricating Basics

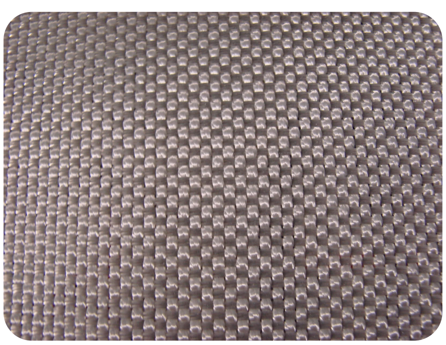
Structural Strength Composite Laminate

By resolute definition, a fabricated composite material is a manufactured collection of two or more ingredients or products intentionally combined to form a new homogeneous material that is defined by its performance that should uniquely greater than the sum of its individual parts. This method is also defined as synergistic composition.

With respect to the raw materials selection (fabric and resin), the fabricating process, and the intended composite properties, these 3 aspects must be carefully considered and in the engineering phase of the composite.







Using Reinforcing Fabric & Impregnating Resin With Our Engineered Process Will Yield a Structural Strength Composite Laminate

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www.polymercompositesinc.com
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Or call our customer service number:
877 403 8008
Monday to Friday
9:00 am to 4:00 pm PST
You can also find us on eBay at
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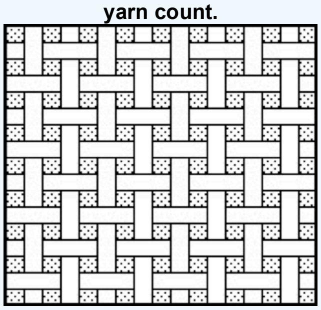
STEP ONE:
Fabric Selection

Types of Fabric Weave Style and Surface Finishing for Resin Type Compatibility

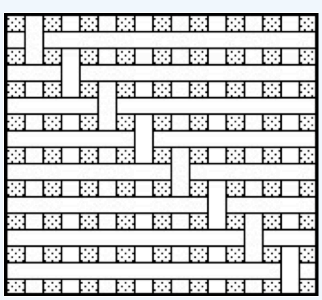
Fabrics are generally considered ”balanced” if the breaking strength is within 15% warp to fill and are best in bias applications on lightweight structures. “Unbalanced” fabrics are excellent when a greater load is required one direction and a lesser load in the perpendicular direction.

- Tow: The bundle of individual carbon filaments used to weave carbon fabric. 50k tow means there are 48-50,000 carbon filaments in the tow. Smaller tow i.e. 12k, 6k, 3k and 1k are obtained by dividing the 50k tow into smaller bundles.
- Thread Count: The number of threads (tow in carbon and yarn in Aramid) per inch. The first number is the warp count and the second is the fill count.
- Fill: The threads that run the width of the roll or bolt and perpendicular to the warp threads.
- Warp: The threads that run the length of the roll or bolt and perpendicular to the fill threads.
- Finish: The chemical treatment to fiberglass making it compatible with resin systems, therefore improving the bond between the fiber and the resin. Finishing fiberglass typically decreases the fiber strength by as much as 50%. Both Silane and Volan finishes are epoxy compatible. Historically, Volan has been considered a softer finish for a more pliable fabric, but recent advances have yielded some excellent soft Silane finishes.
- Thickness: Measured in fractions of an inch. The thicker the fabric the more resin required to fill the weave to obtain a smooth finished part.

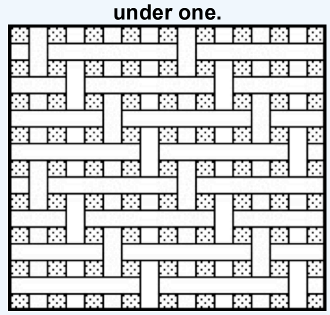
Plain Weave
The plain weave is a very simple weave pattern and the most common style. The warp and fill yarns are interlaced over and under each other in alternating fashion. Plain weave provides good stability, porosity and the least yarn slippage for a given yarn count.



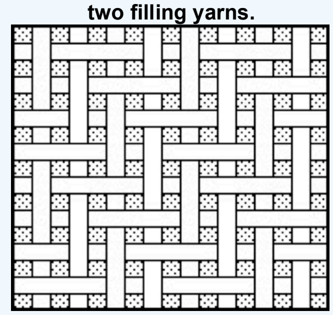
8 Harness Satin Weave
The eight-harness satin is similar to the four-harness satin except that one filling yarn floats over seven warp yarns and under one.
This is a very pliable weave and is used for forming over curved surfaces.



4 Harness Satin Weave
The four-harness satin weave is more pliable than the plain weave and is easier to conform to curved surfaces typical in reinforced plastics. In this weave pattern there is a three by one interfacing where a filling yarn floats over three warp yarns and under one.



2x2 Twill Weave
Twill weave is more pliable than the plain weave and has better drivability while maintaining more fabric stability than a four or eight harness satin weave. The weave pattern is characterized by a diagonal rib created by one warp yarn floating over at least two filling yarns.



Step One: Fabric Selection

Satin Weave Style For

These styles of fabrics are one of the easiest fabrics to use and it is ideal for laying up cowls, fuselages, ducts and other contoured surfaces with minimal distortions.

The fabric is more pliable and can comply with complex contours and spherical shapes. Because of its tight weave style, satin weaves are typically used as the surface ply for heavier and courser weaves.

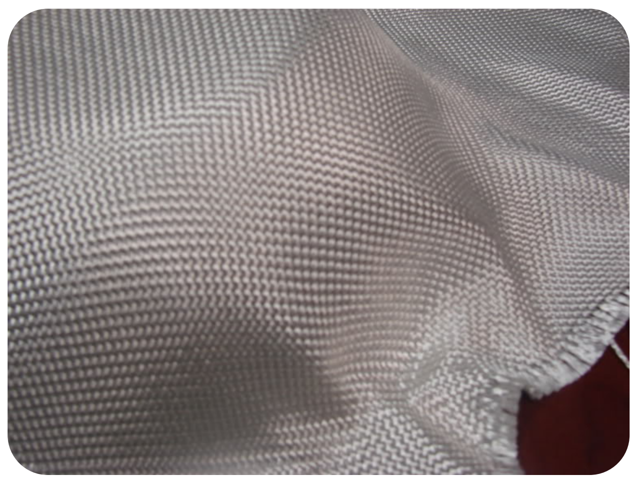
This technique helps reduce fabric print through and requires less gel coat to create a smoother surface.

Plain Weaves, Bi-axial, Unidirectional Styles For Directional High Strength Parts

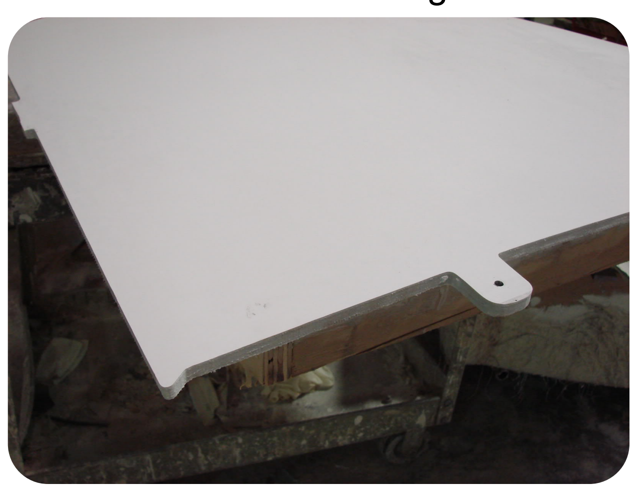
Use this weave style cloth when high strength parts are desired.

It is ideal for reinforcement, mold making, aircraft and auto parts tooling, marine and other composite lightweight applications.

Satin Weave Fiberglass



Plain Weave Fiberglass



STEP TWO:
Choose the Best Epoxy Resin System

FRP- Fiber Reinforced Plastic

The epoxy resin used in fabricating a laminate will dictate how the FRP will perform when load or pressure is implied on the part.

To choose the proper resin system consider the following factors that is crucial to a laminate's performance.

- Size and Configuration of the Part: Number or plies and contoured, flat, or profiled
- Consolidating Force: Free standing dry or hand lay-up, vacuum bag or platen press curing
- Curing Capabilities: heat cured or room-temperature cured
- Load Parameters: Shearing force, torsional and directional load, beam strength
- Environmental Exposure: The principal role of the resin is to bind the fabric into a homogeneous rigid substrate; operating temperature, ambient conditions, humidity, chemical exposure, cyclic force loading
- Material and Production Cost: Buying in bulk will always provide the best overall costs as well as doing it right the first time.

These factors will dictate the design and the composition of the part and must be carefully considered during the design and engineering phase of the fabrication.

Our Line of Epoxy Resin Systems

MAX BOND Thixotropic A/B
Marine Grade High Strength Adhesive

MAX BOND Low Viscosity A/B
Marine Grade Structural Epoxy Resin

MAX HTE A/B
High Temperature Epoxy Resin System

MAX PCR A/B
Wood Rot Repair & Protective Coating System

MAX GRE A/B
Gasoline Resistant Epoxy Resin

MAX GPE
Colored Epoxy Resin: Available in white, black, red, yellow, & blue.

MAX GPE A/B
Clear Low Cost General Purpose Epoxy Resin

MAX CLR A/B
Clear Liquid Resin System **Low Viscosity Version Extended Pot Life and Improved Flexibility

MAX CLR Fast
30% Faster Setting Version

MAX CLR-HP
High Performance Version With Higher Heat Resistance, Toughness, and Surface Hardness

MAX CLR TC
Improved Degassing and Surface Quality For Top Coat Use Only

MAX SEAL
An Aliphatic Based Top Coat Required for Outdoor and Direct Sunlight Application, Non-Yellowing Aliphatic Polyurethane Top Coat

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http://stores.ebay.com/polymerproducts/

STEP THREE:
Proper Layup Technique

Pre-Layup Tips

1. Lay out the fabric and precut to size and set aside.
2. Avoid distorting the weave pattern as much as possible.
3. For fiberglass molding, ensure the mold is clean and adequate mold release is used.
4. View our video presentation on YouTube: "MAX EPOXY RESIN MIXING TECHNIQUE".
5. **Mix the resin only when all needed materials and implements needed are ready and within reach.**
6. Mix the proper amount of resin needed and be accurate proportioning the resin and curing agent.
   - Adding more curing agent than the recommended mix ratio will not promote a faster cure.
   - Oversaturation or starving the fiberglass or any composite fabric will yield poor mechanical performance.
   - When mechanical load or pressure is applied on the composite laminate, the physical strength of the fabric should bear the stress and not the resin.
   - If the laminate is over saturated with the resin it will most likely to fracture or shatter instead of rebounding and resist damage.

Typical fabric weights regardless of weave pattern

1 yard of 8 OSY fabric at 38 inches wide weighs 224 grams

1 yard of 10 OSY fabric at 38 inches wide weighs 280 grams

Ounces per square yard or OSY is also know as aerial weight which is the most common unit of measurement for composite fabrics.

To determine how much resin is needed to adequately impregnate the fiberglass, use the following equation:

(Total Weight of Fabric divided by 60%) X(40%)= weight of mixed resin needed

OR

fw= fabric weight

rc= target resin content

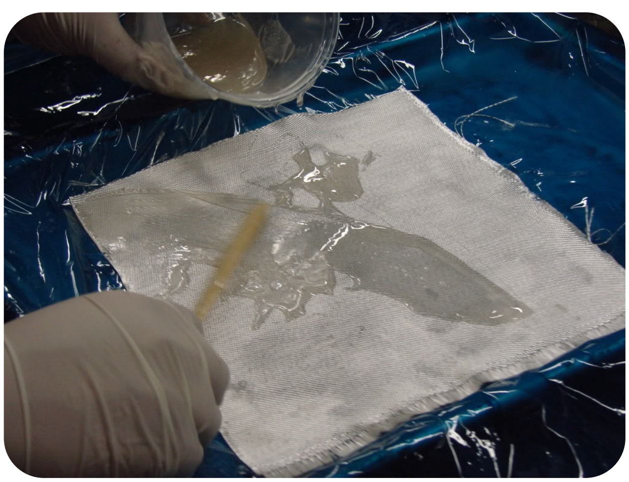
rn=resin needed

STEP THREE:
Proper Layup Technique

Don't how much resin to use to go with the fiberglass?

A good rule of thumb is to maintain a minimum of 30 to 35% resin content by weight. This is the optimum ratio used in high performance prepreg (or pre-impregnated fabrics) typically used in aerospace and high performance structural application.

For general hand lay-ups, calculate using 60% fabric weight to 40% resin weight as a safe factor. This will ensure that the fabricated laminate will be below 40% resin content depending on the waste factor accrued during fabrication. Place the entire precut fiberglass to be used on a digital scale to determine the fabric to resin weight ratio. Measuring by weight will insure accurate composite fabrication and repeatability, rather than using OSY data.



Master Equation

(fw/60%)x(40%)=rn
FOR EXAMPLE
1 SQUARE YARD OF 8-OSY FIBERGLASS FABRIC WEIGHS 224 GRAMS
(224 grams of dry fiberglass / 60%) X 40% = 149.33 grams of resin needed
So for every square yard of 8-ounce fabric, It will need 149.33 grams of mixed resin.
Computing for resin and curing agent requirements based on
149.33 grams of resin needed
MIX RATIO OF RESIN SYSTEM IS 2:1
OR
50 PHR (per hundred resin)
2 = 66.67% (2/3)
+
1 = 33.33%(1/3)
=
(2+1)=3 or (66.67%+33.33%)=100% or (2/3+1/3)= 3/3
149.33x 66.67%= 99.56 grams of Part A RESIN
149.33x 33.33%= 49.77 grams of Part B Curing Agent

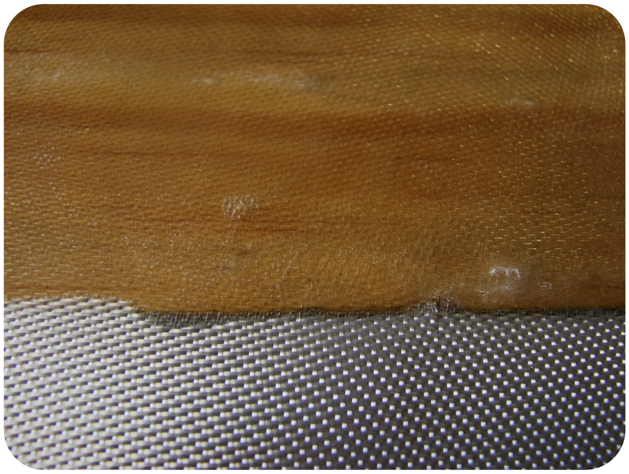
Common Factors Of 100% Solids

(Zero volatiles and unfilled epoxy resin)
1 gallon of resin = 4239 grams (1.12 g/cc)
1 gallon = 128 fluid ounces
1 gallon of resin = 231 cubic inches
1 fluid ounce of resin = 33.17 grams

Step Three:
Proper Layup Technique

Application

1. Apply the mixed resin onto the surface.
2. Lay the fabric and allow the resin to saturate through the fabric, **NOT THE OTHER WAY AROUND.**
   - This is one of the most common processing errors that yield sub-standard laminates.
   - By laying the fiberglass onto a film of resin, less air bubbles are entrapped during the wetting-out stage. Air is pushed up and outwards instead of forcing the resin through the fabric, which will entrap air bubbles.
   - This technique will displace air pockets unhindered and uniformly disperse throughout the fiberglass with minimal mechanical agitation or spreading.



STEP FOUR:
Proper Curing

- Allow the lay-up to cure for a minimum of 24 to 36 hours before handling.
- Optimum cured properties can take up to 7 days depending on the ambient cure condition.
- The ideal temperature cure condition of most room temperature epoxy resin is 22 to 27 degrees Celsius at 20% relative humidity.
- Higher ambient curing temperatures will promote faster polymerization and development of cured mechanical properties.
- Improving mechanical performance via post heat cure.
- A short heat post cure will further improve the mechanical performance of most epoxy resins. Allow the applied resin system to cure at room temperature until for 18 to 24 hours and if possible, expose heat cure it in an oven or other source of radiant heat (220°F to 250°F) for 45 minutes to an hour. You can also expose it to direct sunlight but place a dark colored cover, such as a tarp or cardboard to protect it from ultraviolet exposure.
- In general room temperature cured epoxy resin has a maximum operating temperature of 160°F or lower
- A short heat post cure will ensure that the mixed epoxy system is fully cured.
- A room temperature cured system can take up to 7 days to achieve 100% cure.
- Some darkening or yellowing of the epoxy resin may occur if over exposed to high temperature (>250 F).

AMINE BLUSH

The affinity of an amine compound (curing agent) to moisture and carbon dioxide creates a carbonate compound and forms what is called amine blush.

Amine blush is a wax-like layer that forms as most epoxies cure. If the epoxy system is cured in extreme humidity (>70%), it will be seen as a white and waxy layer that must be removed by physical sanding of the surface followed by an acetone wipe.

Although we have formulated the MAX CLR, MAX BOND and MAX GPE product line to be resistant to amine-blush, it is recommended not to mix any resin systems in high humidity conditions, greater than 60%.

Always make sure that the substrate or material the epoxy resin system is being applied to is as dry as possible to ensure the best cured performance.

STEP FOUR: PROPER CURING
Other Types of Epoxy Resin Cure Mechanisms

LATENT CURING SYSTEMS

Latent epoxy resins are systems that are mixed together at room temperature and will begin polymerization but it will not achieve full cure unless it is exposed to a heat cure cycle. In general, these are high performance systems that demonstrate exceptional performance under extreme conditions such as high mechanical performance under heat and cryogenics temperatures, chemical resistance or any environment that epoxy room temperature system perform marginally or poorly.

Upon the mixing of the resin and curing agent polymerization will begin and will only achieve partial cure. Some resins may appear cured or dry to the touch, this state is called 'B-Stage Cure', but upon application of force will either be gummy or brittle almost glass-like and will dissolve in most solvents. The semi-cured resin must be exposed to an elevated temperature for it to continue polymerization and achieve full cure.

UV CURING SYSTEMS

Similar to "addition cure" or catalytic polymerization, Ultraviolet Curing is another method that has gained popular use in the polymer adhesives and coatings application. It offers a unique curing mechanism that converts a liquid polymer into a solid plastic upon exposure to UV radiation. The two common commercially significant methods are "FREE RADICAL INITIATION" and CATIONIC REACTION. In both reactions, polymerization occurs via decomposition of a photoiniator blended within the resin system. Upon exposure to adequate wavelength of ultraviolet energy, the photoinitator degrades and causes a ring opening or cleavage of the photoinitiator molecule and induces rapid polymerization or cross linking.

The polymerization reaction can be either free radical or cationic and occurs almost instantaneous creation of a polymer network.

HEAT ACTIVATED CURING SYSTEMS

This type of epoxy system will not polymerize unless it is exposed to the activation temperature of the curing agent, which can be as low as 200°F and as high as 400°F.

If an oven is not available to provide the needed thermal post cure, exposing the assembled part to the sun for a period will provide enough heat cure for the part to be handled.

Other heat curing such as infrared heat lamps can be used if a heat chamber or oven is not available.

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