

SECTION 1

THE BASICS



Look for this blue line in the left margin of the Design Manual documents. This line shows you where the latest update has been made.

THE BASICS

WHAT IS FIBERGLASS REINFORCED POLYMER?

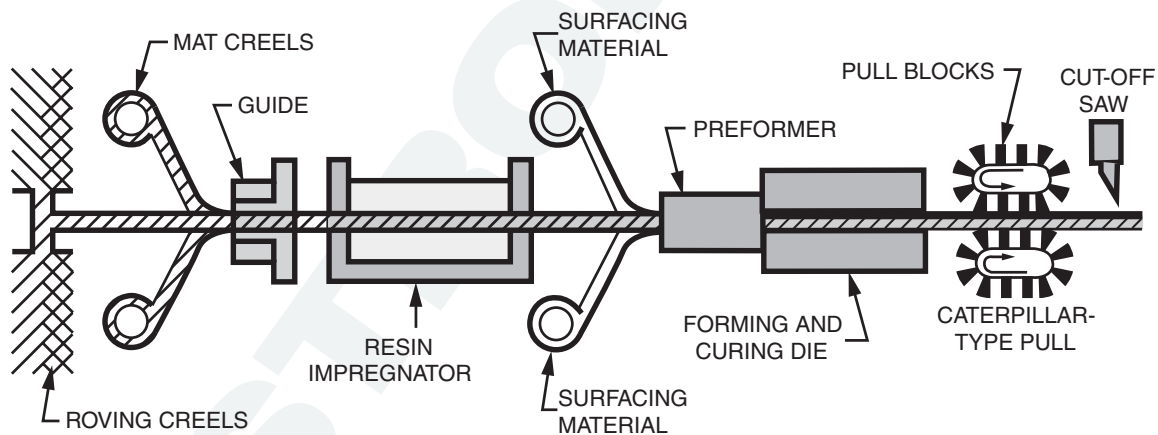
Fiberglass reinforced polymer (FRP) is most often referred to simply as “fiberglass” in practice (as in fiberglass tanks, fiberglass grating, fiberglass structural shapes, fiberglass boats, etc.). Used in this context, “fiberglass” is a composite consisting of a polymer resin matrix reinforced by embedded glass fibers. The strength of a fiberglass part is determined primarily by the type, orientation, quantity, and location of the glass fibers within the part.

The resin binds the reinforcing glass together and this resin/glass bond aids in developing stiffness in the part. The type of resin used determines corrosion resistance, flame retardance, and maximum operating temperature as well as contributing significantly to certain strength characteristics including resistance to impact and fatigue.

WHAT IS PULTRUSION?

Pultrusion is a manufacturing process for producing continuous lengths of FRP structural shapes. Raw materials include a liquid resin mixture (containing resin, fillers and specialized additives) and reinforcing fibers. The process involves pulling these raw materials (rather than pushing as is the case in extrusion) through a heated steel forming die using a continuous pulling device. The reinforcement materials are in continuous forms such as rolls of fiberglass mat or doffs of fiberglass roving. As the reinforcements are saturated with the resin mixture (“wet-out”) in the resin impregnator and pulled through the die, the gelation (or hardening) of the resin is initiated by the heat from the die and a rigid, cured profile is formed that corresponds to the shape of the die.

While pultrusion machine design varies with part geometry, the basic pultrusion process concept is described in the following schematic.



CONTINUOUS PULTRUSION

The creels position the reinforcements for subsequent feeding into the guides. The reinforcement must be located properly within the composite and controlled by the reinforcement guides.

The resin impregnator saturates (wets out) the reinforcement with a solution containing the resin, fillers, pigment, and catalyst plus any other additives required. The interior of the resin impregnator is carefully designed to optimize the “wet-out” (complete saturation) of the reinforcements.

On exiting the resin impregnator, the reinforcements are organized and positioned for the eventual placement within the cross section form by the preformer. The preformer is an array of tooling which squeezes away excess resin as the product is moving forward and gently shapes the materials prior to entering the die. In the die the thermosetting reaction is heat activated (energy is primarily supplied electrically) and the composite is cured (hardened).

On exiting the die, the cured profile is pulled to the saw for cutting to length. It is necessary to cool the hot part before it is gripped by the pull block (made of durable urethane foam) to prevent cracking and/or deformation by the pull blocks. Strongwell uses two distinct pulling systems, one that is a caterpillar counter-rotating type and the other a hand-over-hand reciprocating type.

In certain applications an RF (radio frequency wave generator) unit is used to preheat the composite before entering the die. When in use, the RF heater is positioned between the resin impregnator and the preformer.



COMMONLY ASKED QUESTIONS BY CUSTOMERS

WHAT IS EXTREN®?

EXTREN® is a pultruded composite of fiberglass continuous strand mat, fiberglass rovings, a synthetic surfacing veil and a thermoset resin system. The three series of EXTREN® are similar in the reinforcement composition but vary in the resin matrix.

- | | |
|--------------|--|
| S-500 | Isophthalic Polyester Resin
No flame retardant, UV inhibitor added, standard color is olive green |
| S-525 | Isophthalic Polyester Resin
Flame retardant, UV inhibitor added, standard color is slate gray |
| S-625 | Premium Vinyl Ester Resin
Flame retardant, UV inhibitor added, standard color is beige |

The synthetic surfacing veil aids in weathering and corrosion resistance.

HOW DO I DESCRIBE PULTRUSION?

This is a process in which the reinforcement materials are placed at the back of the pultruder and pulled through a bath of the selected resin, then through a heated die for shaping and curing. The placement of the fiberglass is controlled by a guidance system which ensures consistent positioning throughout the cross-section.

Pultrusion is a continuous process. Length is determined by customers' needs and the ability to transport. Stock lengths are normally 20 feet long. A part must have a constant cross-section to be a candidate for pultrusion.

(For a more detailed explanation, refer to page 1-1 of the *EXTREN® Design Manual*).

HOW IS COLOR ACHIEVED?

The color of the pultrusion is the result of pigment added to the resin mixture. Therefore, color is not just on the surface but throughout the laminate.

Pigments can be obtained to meet special color requirements of the customer. Cost will be

incurred if none of the in-house colors can be utilized. The more stringent the requirement as to closeness of match will determine the end cost and lead time for customizing the color. Absolute exact matches are not achievable due to variables in the raw materials and process parameters.

Close approximations can be achieved by working with the pigment supplier and fine-tuning the process parameters. Ball park color approximations do not incorporate process controls and the range of color variation is wide. Stability of color and color retention is somewhat related to the color. Yellow, beige and orange are much more stable than gray. Colors vary from profile to profile, formula to formula, batch to batch, and set-up to set-up. Variation will occur in all product lines.

WHAT IS THE DIFFERENCE BETWEEN THERMOPLASTIC AND THERMOSET RESINS?

THERMOPLASTIC - Resins which have a defined melting point after initial cooling which means they can be heated and reshaped and this shape is retained when re-cooled; however, thermoplastics can deform (creep) under loads, even at moderate temperature.

THERMOSET - Resins which have no defined melting point, therefore cannot be heated and formed again. Once these resins have been processed with chemical cross-linking of the resin occurring, they take the shape of the die and harden upon cooling. EXTREN® is produced with thermoset resins. As the EXTREN® pultruded part is exposed to increasing temperatures, the laminate mechanical properties will fall off (maximum recommended continuous use temperature for EXTREN® Series 500 and 525 is 150°F and EXTREN® Series 625 is 200°F). When subjected to extreme heating, thermoset composites will degrade.

ARE PHENOLIC RESINS AN AVAILABLE OPTION?

Phenolic resin systems are currently available for some EXTREN® structural shapes. Phenol-formaldehyde resins are the oldest of all plastics, yet relatively new in composites/pultrusions. Phenolic composites are an option when superior fire resistance and minimum smoke emissions are required. Phenolic shapes can have “E-Glass” or carbon reinforcements; however, the higher reinforcement level makes carbon an expensive alternative. Transverse strength, pigmentation, and aesthetics are areas where phenolic profiles are not equal to standard EXTREN® shapes.

WHAT OTHER REINFORCEMENTS ARE AVAILABLE IN PLASTICS?

CARBON FIBERS (GRAPHITE) -Carbon fibers are selected to achieve a high modulus (stiffer) composite. The carbon also makes the part electrically conductive. Strongwell regularly produces composites with carbon fibers in both vinyl ester and epoxy resins. Carbon fiber reinforcements are 10 to 100 times as expensive as standard glass reinforcements depending on the grade used.

POLYESTER FIBERS -Low modulus synthetic fiber to produce a flexible composite. Useful in high bending/low strength applications.

KEVLAR -Aramid fibers that offer high strength and have achieved recognition as being bullet-proof. These reinforcements have been successfully processed at Strongwell in pultrusion, but are difficult to process and expensive.

WHAT IF CUSTOMER NEEDS PROPERTIES DIFFERENT FROM THOSE PUBLISHED?

Variations in physical and mechanical properties can be achieved by altering the composite of the standard product. A change in reinforcement selection can produce higher or lower longitudinal or transverse strengths. A change in the resin can affect the strength and/or performance of the part (Ex: epoxy resins give better flexural fatigue performance). Additives to the resin, such as fillers, can affect the part appearance, pultrudeability, etc.

HOW DOES EXTREN® COMPARE TO TRADITIONAL MATERIALS?

When EXTREN® is being considered as an alternate to “traditional” materials, the significant product features are: lightweight, corrosion resistance and thermal/electrical non-conductivity.

In comparing EXTREN® versus structural timber, aluminum and steel, be very careful about generalizations. The design using a particular material has its own unique set of parameters. With these cautions in mind, the following general rules of thumb apply:

A shape in EXTREN® would require a thickness three times that of steel to achieve the same tensile strength, rigidity and flexural strength.

The same shape in comparison to aluminum would require one to one-half times the thickness.

EXTREN® is stronger and more rigid than structural timber.

EXTREN® weighs 80% less than steel.

HOW DOES EXTREN® PRICING COMPARE WITH STEEL

Generally speaking the price of EXTREN® is 2 to 3 times higher than steel. However, EXTREN® offers special benefits such as:

- Corrosion Resistance
- Non-Conductive - thermally and electrically
- Lightweight - weighs 80% less than steel
- High Strength
- Dimensional Stability
- Low Maintenance
- Custom Colors

The price of EXTREN® is generally less than the price of stainless steel.

WHAT ARE THE CAUTIONS FOR EXTREN® IN ELECTRICAL APPLICATIONS?

It is the electrical non-conductivity which allows EXTREN® to compete in the electrical market. The composite of resin and glass assures that an electrical current will meet the level of resistance as stated in our literature. However, moisture absorption from unsealed ends could provide a possible area for electrical failure. It is therefore recommended that all cut ends and holes be coated with resin of equal quality to the resin in the part.

WHAT DATA SHOULD I COLLECT FOR DECISIONS ON CORROSION ENVIRONMENTS?

When discussing corrosion problems with your customer you need to find out the chemicals, their concentration on contact with EXTREN®, the loads that EXTREN® will see, and the operating temperature. Strongwell's *CORROSION RESISTANCE GUIDE* will answer most of your questions utilizing the above information.

Should you have an environment not listed in our guide, call Strongwell. We will ask the above questions as well as the type of maintenance program the application most likely will receive, and how existing materials withstand the environment.

HOW LONG WILL EXTREN® LAST IN THE OUTDOORS WITHOUT PROTECTION?

There is no definite answer on how long the composite will last because that depends on its location; South Florida is more severe than Minnesota.

All EXTREN® products have a synthetic surfacing veil. This prevents the phenomena of “Fiber Blooming” which is the eruption of the glass fibers through the surface. NOTE: Rod and bar are all roving parts and have different properties from EXTREN® products. Rod and bar do not have a synthetic surfacing veil.

The exposure to ultraviolet rays causes a noticeable fading or washing out of color. This is not a degradation of the physical integrity of the section.

It is recommended that all parts which will experience long-term exposure be coated with a polyurethane or epoxy paint. This can prolong the life of a part for many years.

WHAT AGENCIES HAVE APPROVED EXTREN® MATERIALS?

EXTREN® will not meet the strict requirements of the agencies (USDA) protecting the public for consumable contact because of pigments and/or flame retardants in EXTREN®.

We have received USDA approval for a limited selection of raw material components for use in incidental food contact without sacrificing the structural integrity of our products. You may special order this product (produced only in white) priced on mill run quantities. A broader approval is being pursued.

FDA approval has not been sought for our finished products but we can supply parts made from materials that are approved by the FDA.

EXTREN® Series 500 structural shapes and plate have passed the necessary requirements for listing under NSF (National Sanitation Foundation) Standard 61 for drinking water components. The NSF International Official Listing certifies the EXTREN® Series 500 shapes to a maximum water contact surface area of 250 sq. in./L. This allows EXTREN® Series 500 to be sold into potable water applications in the USA. The certification does not include other EXTREN® series.

The NSF mark/logo will be applied to all EXTREN® Series 500 products produced for drinking water applications. Due to special manufacturing and labeling requirements, orders for NSF product must be produced as custom orders.

NEMA - While EXTREN® has been used in numerous applications where GPO-1, GPO-2, GPO-3 and GPO-10 were called for, EXTREN® does not meet all the specification requirements for these grades. GPO applications should be referred to Customer Service for review.

WHAT MILITARY SPECIFICATIONS APPLY TO EXTREN®?

There is no single military specification written that is exclusively designed for fiberglass reinforced pultruded structural shapes. There are several commonly referenced specifications which EXTREN® represents.

MIL R 7575 - The resin Series 500 and Series 525 conform to this specification. The requirement specifies a polyester resin.

MIL P 25421 (This specification has been superseded by NAVSEA Dwg. 803-5000903 Rev. C) Strongwell manufactures no product which meets this military specification. It is for a glass cloth reinforced epoxy round tube. We can certify to some of the mechanical properties of this specification, and this has been acceptable to several of the Naval Shipyards. The product has a special glass orientation; therefore, is a custom, not a shelf item.

NAVSEA Dwg. 803-5000903, Rev. C (Replaces MIL P 25421) - Is a specification for specially reinforced round tubes with higher crosswise properties and a higher full section modulus than standard EXTREN®. Certifications can be provided. Sizes offered are 1-1/2", 1-3/4", 2" and 2-1/2" round tubes with 1/4" wall. Contact the Customer Service Department for more information.

MIL P 17549C, GRADE 3 - This is a specification for flat sheet that EXTREN® does not meet. EXTREN® meets the mechanical properties of Table 1, in the lengthwise direction, but not in the crosswise direction; therefore, we cannot certify.

IN WHAT APPLICATIONS IS EXTREN® MOST COMMONLY USED?

- Platforms, Stairways and Walkways near chemical manufacturing/storage facilities
- Water/Wastewater Treatment Facilities
- Chemical Manufacturing/Storage Plants - structural components
- Pulp and Paper Plants
- RFI/EMI Compliance Buildings - structural components
- Greenhouses - High humidity areas
- Circuit Board Plating Facilities - Computer Industry
- Trade Show Booths - especially multi-level
- Electrical Switch Gear
- Flue Gas Desulfurization and Cooling Tower Components
- Offshore Platforms - structural and miscellaneous components
- RF Transparency Applications (Ex: Sun Bank Building)
- Airport Instrument Landing System (ILS) components
- Structural and miscellaneous components near salt water
- Applications of structurals functioning in water; both salt and fresh water
- Electrical Equipment Housing
- Cable Tray Components

HOW EASY IS EXTREN® TO FABRICATE?

Fabricating EXTREN® is very similar to fabricating structural timber. Standard woodworking saws and drills can be used. Carbide tipped or diamond coated blades and bits are an essential in saws. Connections can be made with fasteners such as stainless steel bolts and rivets or FIBREBOLT®. An epoxy used in combination with the fasteners will produce the strongest connections. Fasteners alone can be used if later disassembly is required. Refer to Strongwell's Fabrication and Repair Manual for details on how to fabricate EXTREN®.

WHY DO THE SQUARE AND ROUND TUBES NOT TELESCOPE?

The tolerances to which EXTREN® is produced and inspected can allow overlapping. The sizes advertised are nominal dimensions and not controllable to the point that telescoping can be guaranteed.

There is one exception in the 2 x 1/8" square tube and 1-3/4 x 1/4" square tube. These will telescope, upon request.

Other products can be made to telescope with the customer purchasing a mandrel for the outer tube with dimensions allowing sufficient clearance.

HOW DO I SELL EXTREN® VS. OTHER FIBERGLASS SHAPES?

Strongwell and its distributors compete with numerous smaller companies that offer some of our shapes. Some of these companies attempt to identify their product with EXTREN® by using series numbers similar to EXTREN® in order to get their product used when EXTREN® is specified.

We suggest selling on the following basis which has enabled Strongwell to establish team relationships with the nation's best fabricators and distributors:

- **QUALITY**

Strongwell is widely recognized for consistently high quality parts. Reliable quality is assured by a strong ongoing statistical process control program which covers the entire range of EXTREN® shapes. Additionally, a series of physical property tests (First Article Testing) is performed on each production run of every item.

- **SERVICE**

Strongwell has a commitment to provide superior, unmatched service. Supporting this commitment are three plants with pultrusion operations covering over 600,000 square

feet of manufacturing space, and an EXTREN® inventory of nearly \$2,000,000 from which shipments can be made within 24 to 48 hours.

- **SIZE AND AVAILABILITY**

EXTREN® is now available in nearly 150 standard shapes with many of these available from stock for immediate shipment. Strongwell offers the most comprehensive range of shapes and the largest sizes available in the industry. In addition, Strongwell is continually expanding the size range and the number of different profiles in various EXTREN® shapes to keep pace with the expanding market demand.

- **PRODUCT DEVELOPMENT**

Strongwell is widely considered the world's leader in pultrusion technology and is constantly investigating and evaluating new raw materials and potential process improvements. The resulting product improvements are incorporated into EXTREN® well in advance of competitive products.

- **EXTREN® DESIGN MANUAL**

Strongwell offers the most comprehensive, up-to-date Design Manual for use with EXTREN® shapes. This Design Manual, widely recognized as the “Bible” for designing with EXTREN® fiberglass shapes, has been developed from theoretical computations made by Strongwell's licensed engineers and from empirical data generated from extensive testing of the latest EXTREN® composites. Data from this Design Manual should be used only in conjunction with EXTREN® shapes.

GLOSSARY - COMMON TERMS IN THE PLASTICS INDUSTRY

BLISTER - A rounded elevation of the pultruded surface with boundaries that may be more or less sharply defined.

BOW - A conditional longitudinal curvature in pultruded parts.

CRACK - A visual separation that occurs internally or penetrates down from the pultruded surface to the equivalent of one full ply or more of reinforcement.

CRAZE, HAIRLINE - Multiple fine pultrusion surface separation cracks that exceed ¼” in length and do not penetrate in depth to the equivalent of a full ply of reinforcement.

CRAZE, RESIN - Multiple fine separation cracks at the pultruded surface not penetrating into the reinforcement.

DELAMINATION - The separation of two or more layers or plies of reinforcing material within a pultrusion.

DIE-PARTING LINE - A lengthwise flash or depression on the surface of a pultruded plastic part. It is only at the surface and does not weaken the part.

FIBER PROMINENCE - A visible and measurable pattern of the reinforcing material on the surface of a pultruded plastic part.

FIBER BLOOMING - A pultrusion surface condition exhibiting a fiber prominence or fiber show that usually has a white or bleached color and a sparkling appearance. This condition usually is the result of surface degradation by 'UV' on a pultruded part where a synthetic surfacing veil was not used.

FRP - Fiberglass Reinforced Plastic

GROOVING - Long, narrow grooves or depressions in a surface of a pultrusion parallel to its length.

INCLUSION - Any foreign matter of particles that are either encapsulated or imbedded in the pultrusion.

INSUFFICIENT CURE - A pultrusion abnormality created by lack of, or incomplete, cross-linking of the resin.

POROSITY - The presence of numerous pits or pin holes beneath or on the surface of a pultruded surface.

RESIN - Polymer, generally dissolved in styrene, which embodies the chemical, temperature and fatigue properties of the composite.

SAW BURN - Blackening or carbonization of a cut surface of a pultruded section. Fiberglass parts do not dissipate heat as quickly as metal, so the speed of cutting fiberglass must be controlled to prevent saw burns.

SCALE - A condition wherein unreinforced, cured resin particles exit the die on the surface of the part.

TWIST - A condition of longitudinal progressive rotation found in pultruded parts.