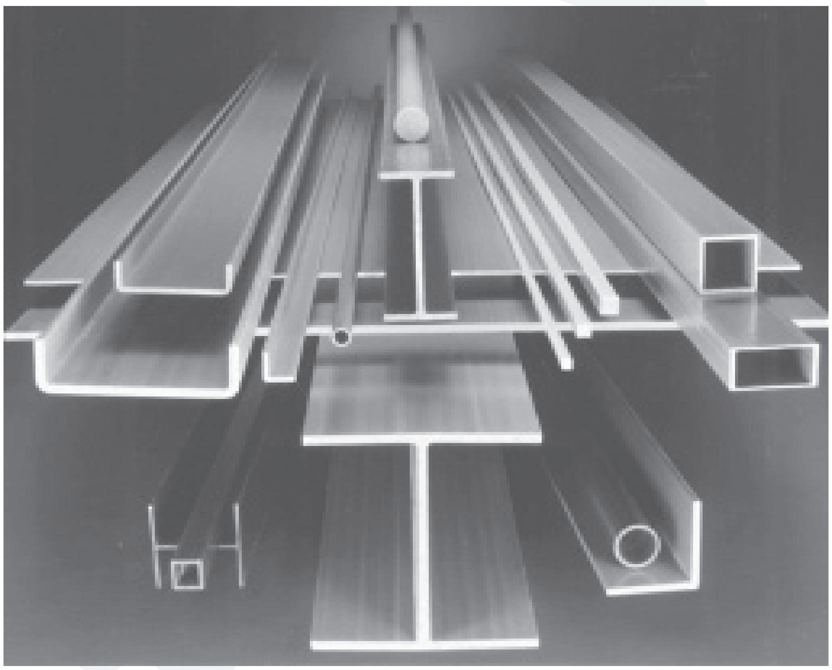
SECTION 2

INTRODUCTION TO EXTREN®



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INTRODUCTION TO EXTREN®

WHAT IS EXTREN®?

EXTREN® is the registered trade name for a proprietary line of **standard pultruded fiberglass structural shapes** produced by Strongwell. The **EXTREN®** line consists of more than 100 different fiberglass shapes, each with a very specific, proprietary composite design.

Types of glass reinforcements used in EXTREN®

Continuous strand mat:	Long glass fibers intertwined and bound with a small amount of resin called a binder. The mat provides multi-directional strength properties.
Continuous strand roving:	Each strand contains 800-4,000 fiber filaments. Many strands are used in each pultruded profile. The rovings provide strength in the longitudinal (pultruded) direction.

Resins used in EXTREN®

Isophthalic polyester:	A general duty resin which provides excellent corrosion resistance in many applications.
Vinyl ester:	A premium grade resin which has higher strength properties, retains strength better at elevated temperatures, and provides a wider range of corrosion resistance than isophthalic polyester.

Surfacing Veil

All **EXTREN®** has a surfacing veil of polyester non-woven fabric which encases the glass reinforcement and adds a layer of resin to the surface. This combination of fabric and resin provides greater protection against corrosives and also eliminates “fiber blooming” (the occurrence of glass fibers on the surface) which was prevalent in early pultruded shapes in outdoor applications.

THE FEATURES OF EXTREN®

EXTREN® structural shapes have numerous features that engineers might use individually or in combination to solve structural problems.

- **HIGH STRENGTH** — Stronger than structural steel on a pound-for-pound basis (in the 0° direction), **EXTREN®** has been used to form the superstructures of multi-story buildings, walkways, sub-floors and platforms.
- **LIGHTWEIGHT** — Weighing 80% less than steel, and 30% less than aluminum, **EXTREN®** structural shapes are easily transported, handled and lifted into place. Total structures can often be preassembled and shipped to the job site ready for installation.
- **CORROSION RESISTANT** — **EXTREN®** will not rot and is impervious to a broad range of corrosive environments. This feature makes it a natural selection for indoor or outdoor structures in pulp and paper mills, chemical plants, water and sewage treatment plants, or other corrosive environments.
- **NON-CONDUCTIVE** — An excellent insulator, **EXTREN®** has low thermal conductivity and is electrically non-conductive.
- **ELECTRO-MAGNETIC TRANSPARENCY** — **EXTREN®** is transparent to radio waves, microwaves, and other electromagnetic frequencies.
- **DIMENSIONAL STABILITY** — The coefficient of thermal expansion of **EXTREN®** shapes is slightly less than steel in the 0° direction and significantly less than aluminum.

THE THREE EXTREN® SERIES

EXTREN® shapes are produced in three standard resin systems which comprise the three series of **EXTREN®**.

EXTREN® SERIES 500
Resin — Isophthalic Polyester
Standard Color — Olive Green
UV Inhibitor — Yes
Purpose – General Use

EXTREN® SERIES 525
Resin — Isophthalic Polyester with Flame Retardant Additive
Standard Color — Slate Gray
UV Inhibitor — Yes
Purpose — General Use when flame retardancy is required

EXTREN® SERIES 625
Resin — Vinyl Ester with Flame Retardant Additive
Standard Color — Beige
UV Inhibitor — Yes
Purpose — Structures where the environment is highly corrosive

E23
Any Series 500, 525 and 625 EXTREN® product can be manufactured upon request to meet the mechanical and physical properties, as well as the dimensional and visual requirements of BS EN 13706 (E23) European standards.

Flame retardant properties of Series 525 and 625 can be found in Section 3 — **PROPERTIES OF EXTREN®**.

If the service environment is corrosive, refer to Section 23— **CORROSION RESISTANCE GUIDE** to **EXTREN®**. If the applicable corrosives are not listed, consult with Strongwell.

NOTE:
In addition to **EXTREN®** products, Strongwell manufactures custom pultrusions. These pultrusions vary from **EXTREN®** in either shape, resin type, or reinforcement (type, amount, location and/or orientation). Designers may choose to vary one or all of these parameters to improve strength, temperature resistance, corrosion resistance, machinability or some other characteristic. See Section 18 — **CUSTOM PULTRUSIONS**. Consult Strongwell with specific needs or questions.

EXTREN® VS. CONVENTIONAL MATERIALS

Designing with **EXTREN®** using this manual is not much different than designing with other materials. The designer should, however, keep the following primary differences in mind:

Relatively Low Modulus of Elasticity
The modulus of elasticity of **EXTREN®** is approximately one-tenth that of steel. As a result, deflection is often a controlling design factor.

Anisotropic
Pultruded composites are not homogeneous or isotropic; therefore, the mechanical properties of **EXTREN®** are directional. When designing with **EXTREN®**, it is important to consider stresses in both the transverse and longitudinal directions.

Relatively Low Shear Modulus
The shear modulus of pultruded fiberglass shapes is low compared to metals. Accordingly, the designer should be aware that shear stresses add deflection to loaded beams above the classical flexural deflection. Refer to Section 8 — **FLEXURAL MEMBERS** for more detailed information and design examples.

The Effect of Temperature
EXTREN® structural shapes are more susceptible to property degradation at high temperatures than are metals. The designer should keep this in mind where the design temperature is above 150° F for polyester and 200° F for vinyl ester. Contrary to intuitive thinking, **EXTREN®** shapes become stiffer in cold temperatures. See "Temperature Effects" in Section 3 — **PROPERTIES OF EXTREN®** for expanded discussion of the effects of temperature.

Corrosion Resistance
EXTREN® shapes are often placed in corrosive environments. Generally **EXTREN®** shapes offer superior corrosion resistance when compared to conventional building materials. See Section 23 — **CORROSION RESISTANCE GUIDE** to **EXTREN®** for guidance.

EXTREN® Structural Tube is Not Pipe
EXTREN® tubes have been designed for structural applications such as columns and handrails and not as fluid carrying pipe. **EXTREN®** may be used to carry fluids if there is no internal pressure. The end-user should consult Section 23 — **CORROSION RESISTANCE GUIDE** to **EXTREN®** to confirm the suitability of the resin to handle the fluid being considered and should also test the **EXTREN®** tube to confirm its ability to carry the fluid without leaking.

EXTREN® VS. OTHER PULTRUDED PRODUCTS

Referring to the previous discussion of "What is Fiberglass Reinforced Polymer", the designer should be aware that two pultruded shapes with identical external dimensions can vary dramatically in physical properties depending on the resin formulation and the amount and type of reinforcement. **This manual should not be used for fiberglass shapes other than EXTREN®.**

The key word in describing **EXTREN®** is "standard". **EXTREN®** is a product line of standard shapes with standard mechanical properties. If the pultruded product is not **EXTREN®**, we refer to it as a "custom pultrusion", as described in the next section.

EXTREN® VS. TRADITIONAL MATERIALS (PROPERTY COMPARISON)

		EXTREN 500/525 SHAPES①	EXTREN 625 SHAPES①	THERMAL CURE ROD & BAR①	CARBON STEEL (M1020)	316 STAINLESS STEEL	HASTELLOY C-276 (ANNLD.)
MECHANICAL							
Tensile Strength	LW	30	30	100	60	80	100
($x10^3$ psi)	CW	7	7	—	60	80	100
Tensile Modulus	LW	2.5	2.6	6	30	28	26
($x10^6$ psi)	CW	.8	.8	—	30	28	26
Flexural Strength	LW	30	30	100	60	80	100
($x10^3$ psi)	CW	10	10	–	60	80	—
Flexural Modulus	LW	1.6	1.6	6	30	28	26
($x10^6$ psi)	CW	.8	.8	—	30	28	26
Izod Impact	LW	25	25	40	N/A	8.5-11	—
(ft-lb/in)	CW	4	4	—	N/A	—	—
Specific Gravity		1.7	1.7	2	7.8	7.92	8.96
PHYSICAL							
Density (lbs/in^3)		.062-.07	.062-.07	.072-.076	.284	.29	.324
Thermal Conductivity (BTU/SF/HR/F°/in)		4	4	5	260-460	96-185	71
Coefficient of Thermal Expansion (10^{-6} in/in/°F)		7	7	5	6-8	9-10	

① Values Are Minimum Ultimate Properties From Coupons.

FIBERGLASS PULTRUSION THICKNESS RELATIVE TO STEEL, ALUMINUM OR WOOD②

FIBERGLASS PULTRUSION CONSTRUCTION	*STEEL Tensile Strength	*STEEL Rigidity	*STEEL Flexural Strength
50% Mat & Roving (**EXTREN®**)③	2.5	2.15	1.82
70% Roving only (Thermal Cure Rod & Bar)	1.0	1.71	1.12

* Copied from *Engineered Materials Handbook*, Vol. 1, "Composites", pg. 541

② As an example, a 50% mat & roving fiberglass pultrusion would need to be 1.16 times as thick as an aluminum part to achieve the same 'flexural strength'.

③ Values refer to non-plate EXTREN® profiles.

EXTREN® VS. TRADITIONAL MATERIALS (PROPERTY COMPARISON)

		ALUMINUM 6061-T61 T651	PONDEROSA PINE	RIGID PVC	RIGID PVC 10% GLASS	FIBERGLASS COMPRESSION MOLDING (SMC)	SPRAY-UP (30-50% GLASS)
MECHANICAL							
Tensile Strength	LW	45	.42	6.2	7.8	8-20	9-18
($x10^3$ psi)	CW	45	–	6.2	7.8	8-20	9-18
Tensile Modulus	LW	10	–	.39	.47	1.6-2.5	.8-1.8
($x10^6$ psi)	CW	10	–	.39	.47	1.6-2.5	.8-1.8
Flexural Strength	LW	45	15.4	11	11.7	18-30	16-28
($x10^3$ psi)	CW	45	9.4	11	11.7	18-30	16-28
Flexural Modulus	LW	10	1	.35	.45	1.3-1.8	1-1.2
($x10^6$ psi)	CW	10	–	.35	.45	1.3-1.8	1-1.2
Izod Impact	LW	–	–	1.6	1.6	10-20	4-12
(ft-lb/in)	CW	–	–	1.6	1.6	10-20	4-12
Specific Gravity		2.5	.52	1.38	1.39	1.5-1.7	1.4-1.6
PHYSICAL							
Density (lbs/in³)		.092	.019	.052	.052	.054-.061	.05-.059
Thermal Conductivity (BTU/SF/HR/F°/in)		1200	.08	1.3	–	1.3-1.7	1.2-1.6
Coefficient of Thermal Expansion (10^{-6} in/in/°F)		13.5	1.7	37	23	10-18	12-20

FIBERGLASS PULTRUSION THICKNESS RELATIVE TO STEEL, ALUMINUM OR WOOD②

FIBERGLASS PULTRUSION CONSTRUCTION	*ALUMINUM			*WOOD		
	Tensile Strength	Rigidity	Flexural Strength	Tensile Strength	Rigidity	Flexural Strength
50% Mat & Roving (**EXTREN**®)③	1.0	1.49	1.16	.25	.79	.45
70% Roving only (Thermal Cure Rod & Bar)	.4	1.19	.71	.10	.63	.27

* Copied from *Engineered Materials Handbook*, Vol. 1, "Composites", pg. 541

② As an example, a 50% mat & roving fiberglass pultrusion would need to be 1.16 times as thick as an aluminum part to achieve the same 'flexural strength'.

③ Values refer to non-plate EXTREN® profiles.