a tough, high-strength material you can use eVERYDAY

material comparisons

The design migration from conventional metals to engineered thermoplastics has many times provided a brief opportunity for design solutions using fiber-reinforced thermoset composite materials. These fiber reinforced composites have offered ideal strength to weight properties but without the ultimate design flexibility of either metals or filled thermoplastics. No longer—the new line of Continuous Fiber Thermoplastics (CFT™) offers the ultimate in strength to weight properties while also providing excellent post-forming, joining and secondary attachment operations that have not been available with traditional materials until now.

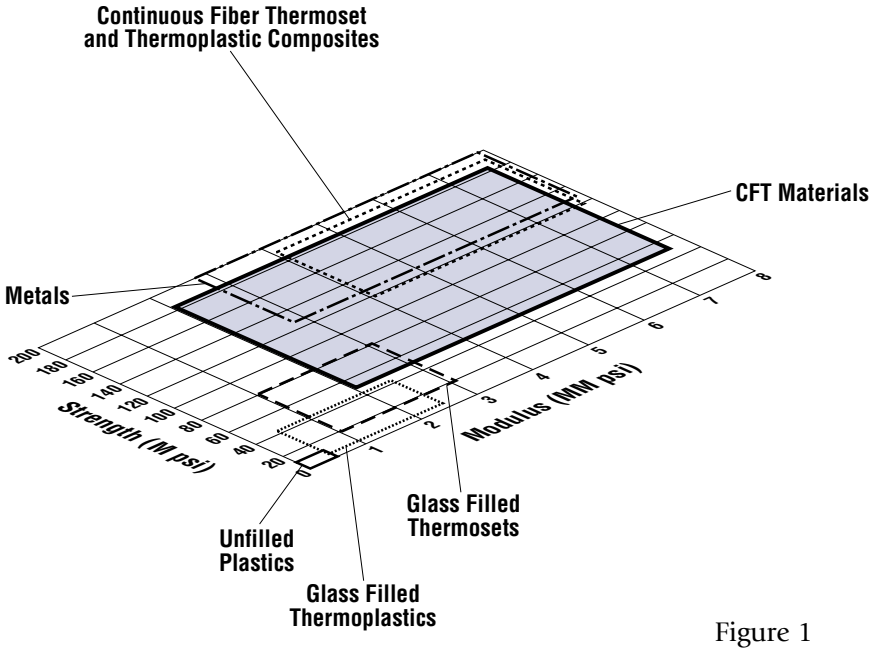


Figure 1

manufacturing processes for engineered plastic materials

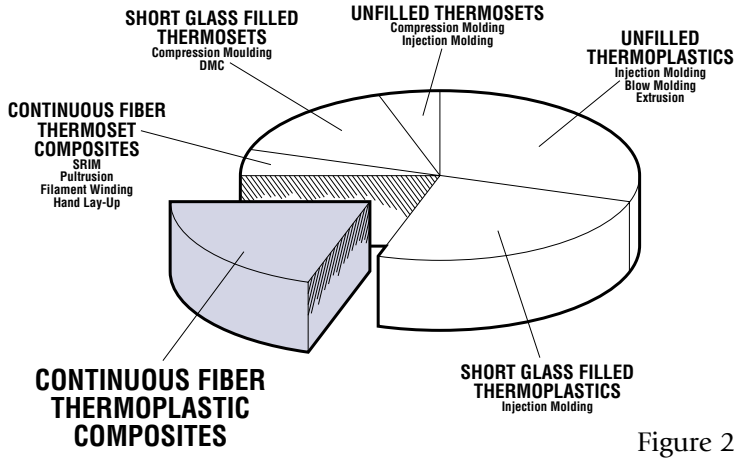
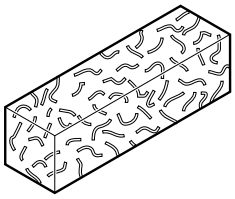


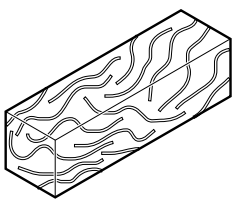
Figure 2

As with many new material families, understanding where CFT™ materials fit is important. Within the conventional engineered plastics' market-place, CFT materials bridge a gap between long fiber filled extrusions, continuous fiber thermost composite materials and conventional metals. The result is that CFT materials can bridge many application gaps in today's design engineering community.

what are continuous fiber thermoplastics?

CFT™





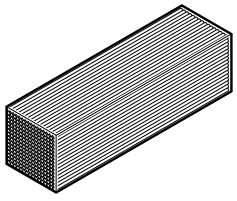


Figure 3

Unlike either short or long filled thermoplastic resins, CFT™ materials have 100% of their fibers continually connected throughout the axial direction of any profile. This means that CFT materials have no break in the fiber architecture. As a result they can fully optimize the design advantages of a traditional composite material with the processing and product advantages of thermoplastic extrusions.

product CAPABILITIES

Impact Tolerance: Thermoplastic resins are known for their better impact resistance when compared to thermoset resins. In Polygon's line of CFT™ materials this greater impact resistance is translated into the final product as demonstrated on the test curves (see Figure 4). The upper curve depicts the increased impact resistance of Polygon's CFT material. The area under both curves can be roughly equated to energy absorption and damage resistance from impact. The "shattering" associated with conventional fiberglass products is no longer an issue. Polygon's CFT line of thermoplastic products brings new design options to applications where impact concerns and damage tolerance are present.

load-displacement curves for high-speed impact*

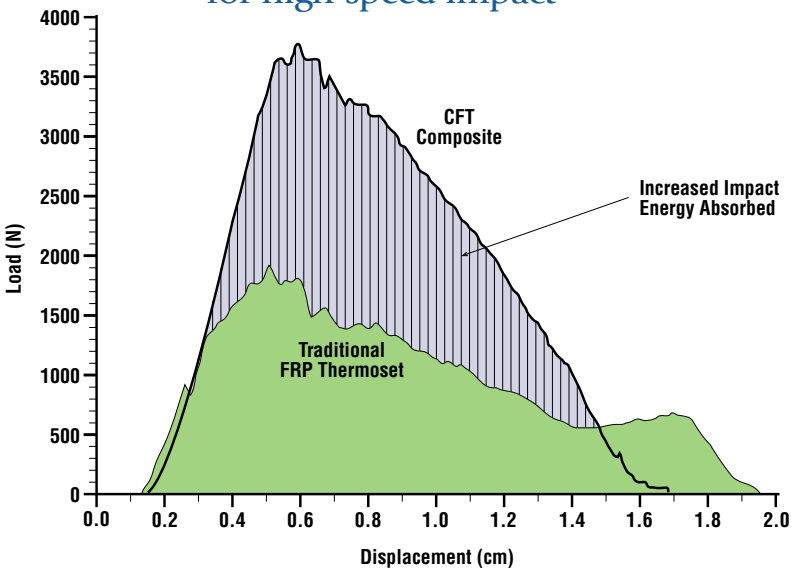
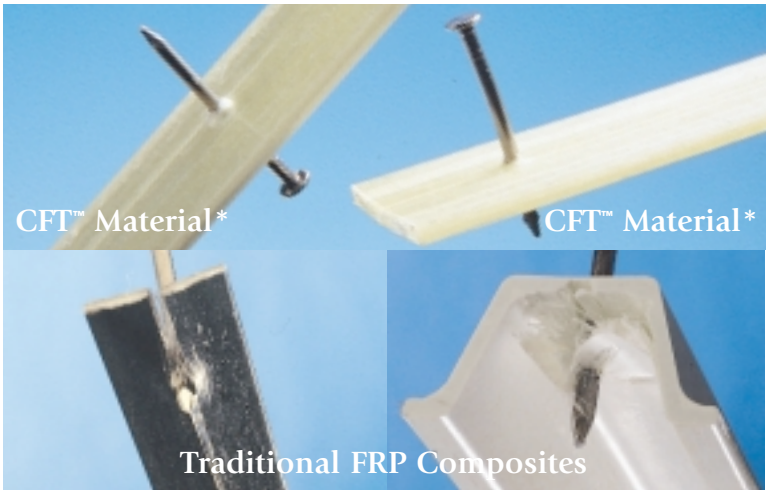


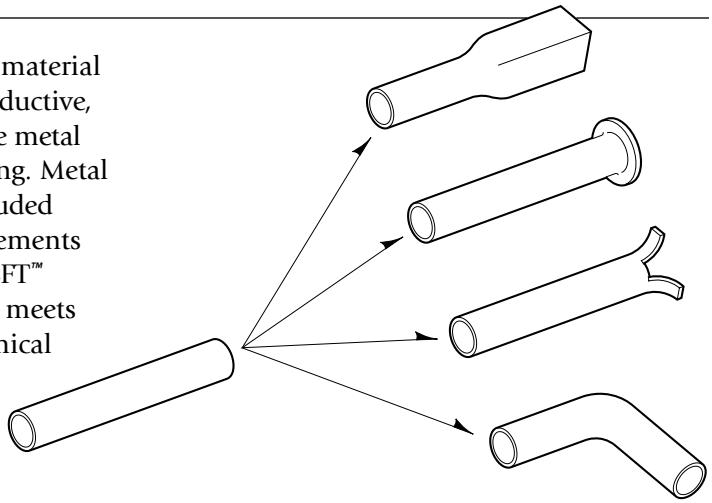
Figure 4



Toughness: Producers of highway sign posts and delineator posts have for some time sought a material that is high strength and more damage tolerant than current metal, fiberglass and plastic products. CFT™ products take advantage of the high strength, impact resistance, flexibility and ability to "spring" back into position. Door manufacturers can now look at ways of improving impact resistance and energy absorption of current door systems by strategically placing a reinforcing bar of Polygon's CFT composite on the interior of the door panel.

* Graphs and photos provided by Dow Plastics.

Post-Formable: Surgical medical devices require a tubing material that offers good chemical resistance, high strength, non-conductive, and can form flared ends. Traditional tubing materials include metal (stainless steel) and a variety of extruded thermoplastic tubing. Metal tubing does not meet the need of being non-conductive. Extruded thermoplastic tubing does not meet the high strength requirements for the product. Polygon's CFT™ tubing is the only answer. It meets all the requirements of chemical resistance, high strength, non-conductivity, and ability to be post formed.



material COMPARISONS

CFT™ materials combine the best of engineered thermoplastics with the design stability of metallic materials. The typical material and processing capabilities innate in plastic extrusion is combined with the superb mechanical and physical properties only fiber-reinforced pultrusions have been able to attain.

CFT™ product advantages

- **Post-formable**
- **Impact resistance**
- **Toughness/durability**
- **Secondary attachment capacity**
- **Joining capability**
- **Recyclable**
- **Light weight**
- **Corrosion resistance**
- **Good insulating qualities**

**	Thermoplastic Composites via CFT™ Technology	Thermoset Composites	Steel	Aluminum	Wood	Thermo-plastics
Strength	+++	+++	+++	++	+	+
Strength to Weight	+++	+++	-	+	+++	++
Recyclability	+++	-	+++	+++	++	+++
Corrosion Resistance	+++	+++	+	++	+	+++
Mechanical Properties	+++	+++	+++	++	+	+
Formability	+++	-	+++	+++	+	+++

typical mechanical properties of thermoplastic composites using CFT™ COMPOSITES tECHNOLOGY

The typical mechanical properties of CFT™ materials are provided on this table. As can be seen, the transverse strength of the CFT materials are significantly better than conventional FRP composite materials. As a result of this, many applications areas that have traditionally been serviced only by expensive composite materials are now open to more effective CFT materials.

**	CFT™ Composite 45v% Glass	CFT™ Composite 55v% Glass
Tensile Strength [MPa] [psi x 10^3]		980 142
Tensile Modulus [GPa] [psi x 10^6]		43 6.24
Longitudinal Flexural Strength [MPa] [psi x 10^3]	1080 157	1340 194
Longitudinal Flexural Modulus [GPa] [psi x 10^6]	35 5.08	44 6.38
Transverse Flexural Strength [MPa] [psi x 10^3]	122 17.7	151 21.9
Compressive Strength [MPa] [psi x 10^3]	430 62.4	
Compressive Modulus [GPa] [psi x 10^6]	35 5.08	

[1] Typical property values, not to be construed as sales specifications.

*Nylon 6,6 data are highest values quoted in Modern Plastics Encyclopedia 1998.

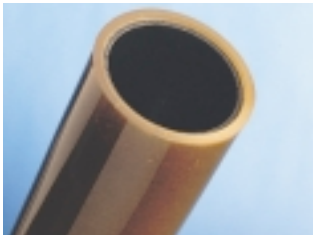
** Charts and photo provided by Dow Plastics.

typical mechanical properties of rEGROUND COMPOSITE STRIP[1]

In addition to the previous design advantages of CFT™ materials, they are also completely and fully recyclable materials. Testing has been completed that shows CFT materials can be reground,processed, and successfully used in many conventional engineering thermoplastic applications. The continuous fiber architecture of the regrind material also offers a genuinely unique material option.

**	Recycled Composite From CFT™ Technology (Blended to 40% Glass)	40% Virgin LGF PA 6,6* (Dry as Molded)	33% Virgin LGF PA 6,6* (Dry as Molded)	33% Virgin LGF PA 6,6* (Conditioned)
Tensile Strength [MPa] [psi]	142 20,600	227 32,900	190 27,600	140 20,300
Elongation at Break [%]	2.4	2.5	2.0	3.7
E Modulus [GPa] [psi x 10^3]	10.0 1450	12.3 1790	9.5 1380	7.5 1090
Flexural Strength [MPa] [psi]	223 32,300	338 49,100	276 40,000	200 29,000
Flexural Modulus [GPa] [psi x 10^3]	11.0 1600	11.0 1600	10.0 1450	5.5 800
Izod Notch Impact [J/m] [ft-lb/in]	216 4.0	370 6.9	86 1.6	162 3.0

problems and SOLUTIONS



Material Handling Rollers

Design Problem:
Today's material handling systems use metal rollers that are loud, heavy, and energy inefficient. They require noise abatement systems that add overall system cost.

CFT™ Solution:
The CFT material increases the overall roller durability, increases the rollers ability to handle repeated impact loading, has inherent abrasion resistance, lowers the moment of inertia for the roller system, and reduces the energy required to move packages.

Tool Handle

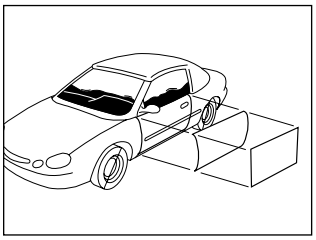
Design Problem:
Conventional FRP tool handles are not ideal solutions for the tool handle market—they degrade due to UV exposure, have poor cosmetics and shatter upon impact or repeated stresses.

CFT™ Solution:
CFT materials offer significantly increased toughness and durability (twice the transverse strength of FRP pultrusions), they eliminate UV degradation issues, are able to be post-formed for ergonomics, can have attachments joined, and can have co-extruded handle materials.

High Performance Tent

Design Problem:
High performance tent applications require materials that have excellent spring retention, are durable and can be easily fastened and joined. Many tent and recreational equipment designers resort to traditional FRP materials that are not durable and have poor fastening/joining capability.

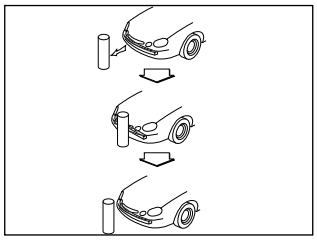
CFT™ Solution:
A CFT profile can offer a design engineer the optimal combination of strength, durability and toughness as well as the ability to complete basic post-forming and joining techniques not currently available to FRP materials.



Car Door Systems

Design Problem:
Today's car door materials require complicated molding systems that fall short on the ultimate material expectations that today's automotive engineers would like to have.

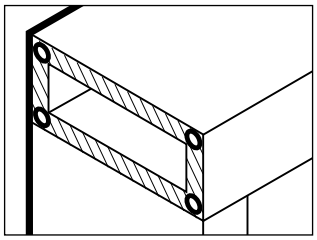
CFT™ Solution:
CFT materials offer integrated post-forming capability, excellent impact resistance, and perhaps most importantly, a continuous manufacturing process (not batch), that is more cost effective than traditional FRP molding systems.



Energy Management Systems

Design Problem:
Today's engineered thermoplastic materials offer poor energy absorption, and rely on complex mechanical energy management systems to meet today's government impact standards.

CFT™ Solution:
The next generation of CFT materials can be easily incorporated into large molded parts such as bumpers that traditionally have average impact resistance and marginal room for improvement. By adding CFT stiffeners the finished bumper offers increased impact resistance, energy absorption and an ability to lower the overall system cost.

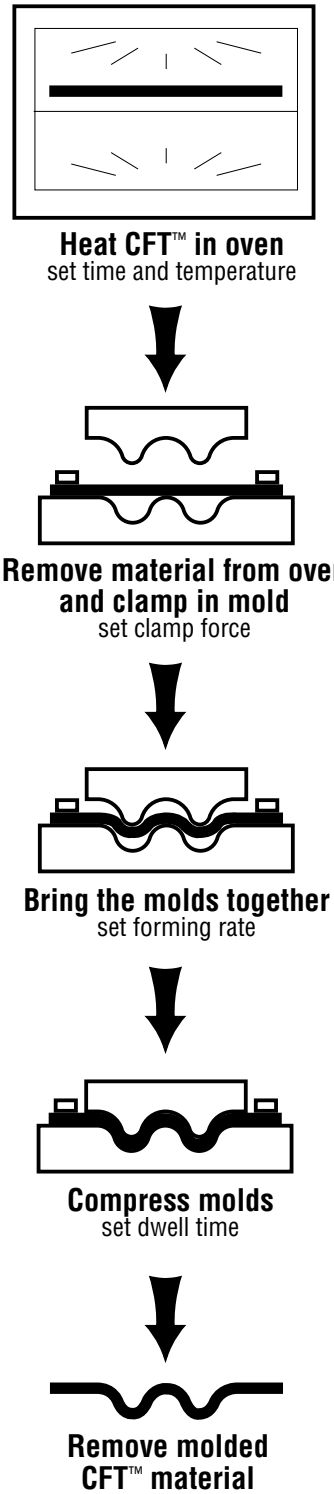


Stiffeners

Design Problem: *Strategically embedding CFT™ reinforcements into an extrusion wall can improve both the performance and lower the overall cost of existing parts.*

CFT™ Solution: *In a rectangular profile (2"x 4"x 0.160") where stiffness and cost reduction of the parts are analyzed, four 0.070" diameter CFT rod reinforcements are placed in the corners of the profile. While maintaining the same 0.160" wall thickness, the CFT reinforcements will increase the stiffness of the profile by 30-45% with minimal increase in cost. With this increase in performance, it is then possible to look at decreasing the wall thickness of the PVC wall to evaluate cost savings. While maintaining the same stiffness of the original PVC extrusion, the CFT stiffeners can reduce the weight of PVC used. In the rectangular profile, PVC usage can be decreased over 35%, maintaining the same part stiffness!*

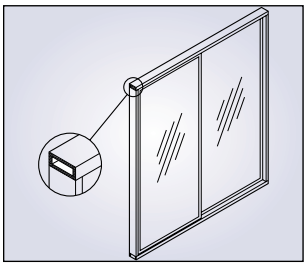
suggested post-forming technique



application iDEAS

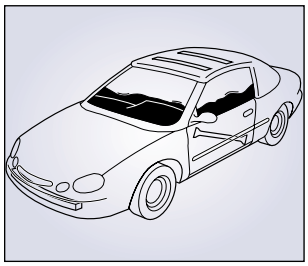
potential applications for CFT™ products

Before the advent of CFT™ materials, when design engineers were faced with a problem where metals or engineered thermoplastics were not sufficient, no obvious other alternative presented itself. That is no longer the case—today, CFT materials bridge the gap in many application areas where neither conventional metals or plastics can meet the need. Typical applications where this occurs are areas where strength-to-weight ratios, corrosion resistance, post-forming, joining, or fastening are not currently optimal.



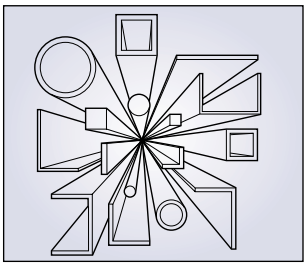
extrusion stiffeners

Using CFT™ materials as stiffeners within the wall of conventional thermoplastic extrusions is an ideal use of the CFT's excellent strength-to-weight ratios, stiffness and durability.



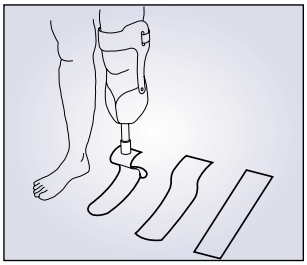
impact management systems

The durability, toughness, impact tolerance and energy dissipation of CFT™ materials are ideal for use in designs where the need to combine impact management and conventional strength requirements is a primary design driver.



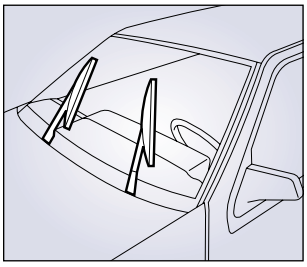
shapes

CFT™ materials are available not only in simple rod and tube shapes, but also more complex non-symmetrical shapes that are typically produced with complicated FRP pultrusions and metal or plastic extrusions.



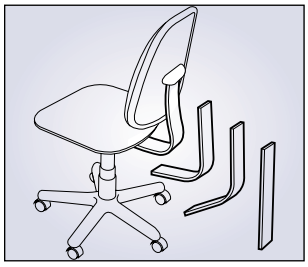
prosthetics

Unlike expensive composite materials currently on the market today, CFT™ materials offer the potential to create similar near net-shape preforms with better overall mechanical performance and cost-benefit advantages. The ability to post-form materials and have simple secondary attachment techniques are significant competitive advantages as well.



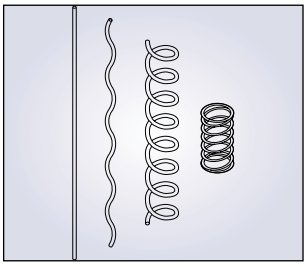
windshield wipers

Conventional short and long fiber filled injection molded thermoplastics offer design flexibility for windshield wiper systems, but are not acceptable with respect to long term strength and spring retention. CFT™ materials offer the pricing and performance advantages of thermoplastic materials along with the ability to post-form to the windows contours.



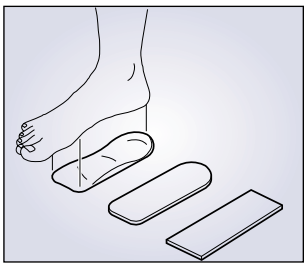
chair support

Metals are not ideal for many applications where repeated application of stress and strain can result in the support material losing its spring and no longer maintaining the same level of back support. CFT™ materials reduce the overall support weight, are easily post-formable, and can be readily adapted to the fastening and machining requirements for this type of application.



springs

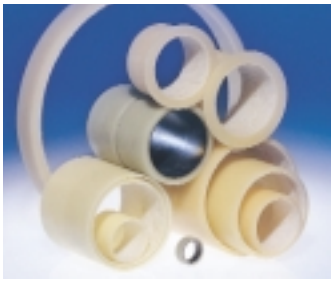
The post-forming capability of CFT™ materials allow a conventional all longitudinal material to be formed into a spring shapes, utilizing the durability and toughness of the CFT material. Application possibilities include less dramatic spring shapes such as leaf springs for automotive and golf-car systems as well as vibratory bowl-feeders and compound bow limbs.



orthotic inserts

CFT™ materials offer an optimized strength capacity, spring retention, and durability along with an ability to easily post-form the materials in question for customized use by orthotic specialists.

other Polygon ADVANTAGES



Bearings: Polygon PolyLube™ composite bearings and bushings are ideal for any high load, low speed application. Superior load bearing capabilities make these composites the perfect choice for use in industrial equipment such as scissor lifts, cherry picker booms, work platforms and material handling equipment. Agricultural applications include combines, sprayers, hay bailers and bulk feeders. Because Polygon bearings are non- corrosive, they work well in waste water treatment valves, outboard motors, boat trailers, and moving parts for offshore oil drilling rigs.

Double Insulation: These filament woven composite tubes have set a precedent for electrical insulation with their superior dielectric properties. The Polygon Tube™ is being used today in millions of hand-held power tools, appliance motors and other electrical equipment throughout the world. Polygon utilizes two bonding processes to manufacture Polygon Tubes that provide optimum physical and dielectric performance. These insulating composite tubes utilize their inherent modulus of elasticity to ensure a permanent press fit on the armature shaft. Polygon's patented manufacturing techniques have resulted in double insulated tubes that exhibit unparalleled physical properties and unmatched electrical insulation.

Cylinder Tubing: Polygon Company's cylinder tubing is a superior replacement for conventional metal tubing in such applications as pneumatic actuators for valves, hydraulic actuators for aircraft and flow control mechanisms for waste water treatment plants. Polyslide™ tubing offers proven high-strength, corrosion resistance and thermal stability.

about the Polygon COMPANY

Since 1949 Polygon Company has remained an innovative leader in composite materials. Polygon has grown to an international company with facilities and sales offices throughout the world. At Polygon you will find more manufacturing capabilities, products and development activities than anyone in the composites industry.

Polygon's reputation is based on a long history of experience that, among others, includes being the first commercial pultruder in North America, and holding over 60 patents on proprietary composite processes and applications. The first composite golf shafts, molded door panels, as well as the first ever patented composite self-lubricating bearings stand out as well-known applications from Polygon.

CFT™ CONTINUOUS FIBER THERMOPLASTICS

FULCRUM

•FULCRUM Thermoplastic Composites Technology is a trademark of The Dow Chemical Company and Dow Plastics. Dow is a leading science and technology company that provides innovative chemical, plastic and agricultural products and services to many essential consumer markets. The FULCRUM technology is specifically designed to help customers achieve higher strength, greater output rates and more finishing versatility for structural reinforcement applications. For more information on the FULCRUM technology, visit www.dowfulcrum.com

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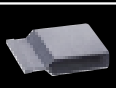
CFT Web site: polygon-cft.com


SELF-LUBRICATING BEARINGS


THRUST WASHERS

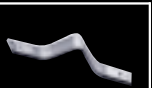

FILAMENT WOUND TUBING


TUBING AND RODS


PULTRUDED SHAPES


INSULATIVE MATERIALS


MEDICAL COMPOSITES


CONTINUOUS FIBER THERMOPLASTICS

POLYGON®