

# QwikConnect

GLENAIR ■ APRIL 2008 ■ VOLUME 12 ■ NUMBER 2



## *Composite Thermoplastic:*

Lightweight, Corrosion-Free  
Interconnect Solutions From Glenair

# The Future is Here, and It's Made of Plastic

**F**or many people, “plastic” means “cheap and breakable.” But when engineers search for new ways to enhance weight savings, corrosion resistance, shock and vibration dampening and stealth they immediately turn to plastic—the only alternative material capable of meeting, and beating, the established performance levels of aluminum, brass, titanium and steel.

The name “plastic” refers to the ability to form or shape a material, or to the moldability a material adopts under forces such as pressure or heat. Engineers often use the term “polymer” when referring to plastic materials, because it more clearly describes how many (poly) chemical units (mers) form up in complex chains to create modern plastic resins. “Thermoplastics” are polymer materials that melt to a liquid when heated and form into a hard, dimensionally stable shape when cooled.

Thermoplastic polymers are created by subjecting various chemical and petroleum-based ingredients to heat and pressure in sealed vessels. Specific chemical additives control how the polymer is formed and contribute to its performance in such areas as surface hardness and flame resistance. The process of mixing base materials with chemical additives to create specific types of plastic resins is called “polymerization.” The resulting plastic materials can be classified in various ways—by chemical or physical structure, by strength or thermal performance and by optical or electrical properties.

## Resin Morphology

When polymer resins are combined with glass fibers, or other structural materials, the resultant “composite” material can deliver truly amazing levels of performance. Since over sixty thermoplastic base-resins can be used to produce composites, it is helpful to understand a little about resin chemistry and morphology as a baseline for understanding the properties of the different grades of composite plastics. Although “morphology” sounds complicated, it can simply be viewed as the orientation the molecules take when they go from the liquid to solid state during processing, such as injection molding.

A thermoplastic resin is either amorphous, having a random molecular orientation, or semi-crystalline, having ordered or crystalline regions of molecules dispersed within the random amorphous molecules. Morphology choice depends on application, as there are advantages for each material type.

The most significant structural classification for polymers has to do with their shape at the molecular level. Polymers whose long, linear shaped molecules fold tightly together into packed and ordered areas

(continued on Page 4)



*Thermoplastic polymers are created by subjecting various chemicals and petroleum-based ingredients to heat and pressure in sealed vessels. The materials shown here have been formed into shapes suitable for machining.*

The McGraw-Hill Companies

# BusinessWeek

SEATTLE, Washington — Inside Boeing Co.'s cavernous development center in Seattle, the future of its commercial jet business is taking shape. That future is plastic—and lots of it. At center stage in the tightly guarded building are three huge fuselage sections, dubbed barrels, made entirely of composites known as carbon fiber-reinforced plastic. Engineers swarm over the structures, looking for imperfections that could weaken the wafer-thin yet granite-tough material. Over in one corner, mechanics are sculpting the world's biggest composite aircraft wing.

Nothing on this scale has ever been attempted with composites, which are used in everything from golf-club shafts and tennis rackets to giant underground storage tanks. But even the latter can't measure up to what Boeing is creating—namely, the entire airframe of its upcoming 787 Dreamliner jet.



PALMDALE, Calif. — In a high-security compound where some of the world's most exotic aircraft were born, engineers and technicians are building a prototype for a new Air Force cargo plane that may change aviation.

Lockheed Martin is building the first military cargo jet in which the craft's structure will be made of fibers, resins and epoxy, replacing metals such as aluminum and titanium that have been in use in aircraft for decades.

The composites hold huge potential for saving weight a critical factor in aviation performance and fuel consumption, aviation experts say.

Jane's  
Intelligence and Insight You Can Trust

DEFENCE  
WEEKLY

LONDON, England — The Swedish Visby class corvette HSwMS Nyköping (K34) arrived at the Royal Docks Lock in the early hours of Monday morning flanked by two German minesweepers at the end of its journey to ExCeL. The ship's visit — the first by a Visby class vessel to the UK — will provide visitors to DSEi with a unique opportunity to see at first hand the vessel's radical "stealth" design and state-of-the-art combat system. A multimission, network centric-enabled surface combatant optimised for operations in the littoral, the new Visby class corvettes will become the cornerstone of the Royal Swedish Navy's future surface fleet as they enter service in the period 2009-2011. Displacing 600 tonnes at full load, the 72m corvettes are constructed almost entirely from fibre reinforced plastic material (providing high strength and rigidity, low weight, good shock resistance, low radar signature and low magnetic signature). They feature a variety of innovative signature-reduction techniques covering radar cross-section (RCS), infrared, acoustic, magnetic, hydrodynamic pressure, visual and electronic signature aspects.



<b>Amorphous and Semi-Crystalline Material Characteristics</b>		
	<b>Amorphous</b>	<b>Semi-Crystalline</b>
Low Shrinkage	<b>X</b>	
Low Warpage	<b>X</b>	
Tight Tolerances	<b>X</b>	
Toughness	<b>X</b>	
Creep Resistance	<b>X</b>	
Transparency	<b>X</b>	
Mold Flow Ease	<b>X</b>	<b>X</b>
Chemical Resistance		<b>X</b>
Response to Reinforcement		<b>X</b>
Wear Resistance		<b>X</b>

are classified as semi-crystalline. Polymers with bulkier molecular shapes not inclined to fold up into spaghetti-like crystals are classified as amorphous.

Semi-crystalline polymers are characterized by very good to excellent wear resistance and the ability to withstand high heat and exposure to caustic chemicals. Semi-crystalline resins are relatively more difficult to mold and also tend to exhibit uneven mold shrinkage with elevated stress levels.

Amorphous materials are known for their excellent strength, stiffness and dimensional stability. Amorphous resins are generally easier to mold into tubular shapes and have a good “knit” or weld line strength coefficient. Amorphous resins have good dimensional stability and exhibit even mold shrinkage with lower stress levels.

Strength and thermal resistance are the most sought after characteristics in polymers used in high-performance applications. While consumer products may be produced using “commodity” plastics such as

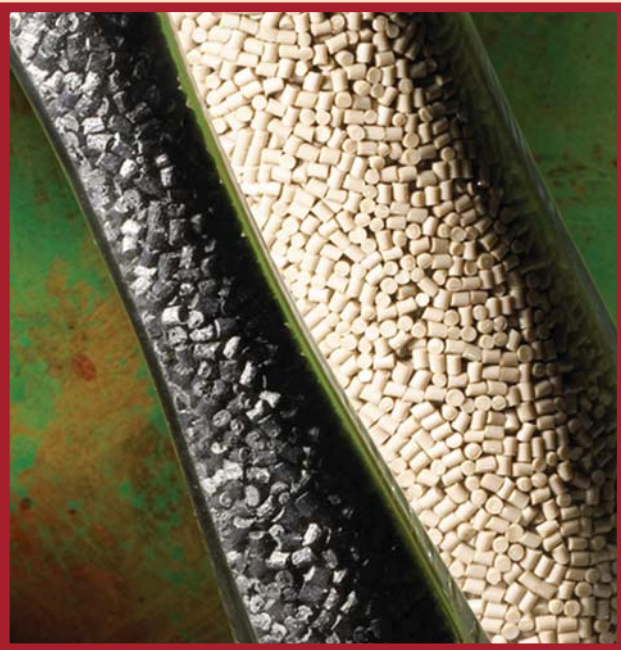
polyethylene and polypropylene, products intended for commercial and military aerospace applications, for example, must be produced using “engineering-grade plastics” or other specialized, high temperature polymers.

Engineering plastics such as polyetherimide (PEI), polyphthalamide (PPA), and polyphenylene sulfide (PPS) are formulated specifically for use in high temperature environments. Resins such as polyetheretherketone (PEEK) and various liquid crystal polymers (LCP) are also capable of withstanding extremely high temperatures. These high-performance plastics also meet stringent outgassing and flammability requirements.

Historically, “thermoplastic” resins, or those which may be melted and remelted in injection molding machinery are preferred for durable goods manufacturing over “thermoset” resins, such as epoxy, which are hardened via chemical reaction.

<b>Common Amorphous and Semi-Crystalline Material Types</b>	
<b>Amorphous</b>	<b>Semi-Crystalline</b>
Acrylic	Polypropylene
Polystyrene	Polyethylene
Styrene Acrylonitrile (SAN)	Nylon
Acrylonitrile Butadiene Styrene (ABS)	PBT Polyester
Polycarbonate	PET Polyester
Polysulfone	Acetal
Polyethersulfone (PES)	Polyphenylene Sulfide (PPS)
Polyarylsulfone (PAS)	Polyetheretherketone (PEEK)
Polyetherimide (PEI)	Liquid Crystal Polymer (LCP)

## The Role of Glass Fiber



*Glass-filled thermoplastic resins in pellet form, ready for use in injection molding applications.*

Generally, when we speak of “composites,” we refer to materials containing fibers, primarily glass, impregnated within a plastic resin or “matrix”. This combination produces strong, lightweight, corrosion-resistant and dimensionally stable materials. Such materials also provide design flexibility and high dielectric strength.

Glass fiber and resin complement each other well. Just as a metallurgist might combine tin and copper to produce bronze—a material which is much stronger than either base metal—combining glass fiber with a resin matrix results in a material that is more useful than either of the constituent components is on its own.

Certain plastics are extremely strong yet subject to cracking or other forms of stress-related damage. When the plastic matrix is augmented with glass fibers, a wide range of performance benchmarks can be achieved including improved wear-resistance, crush-resistance, and dimensional stability.

## Special Applications of Engineering Plastics: Flexible Tubing

Much of the discussion in this special composite-focused issue of *QwikConnect* is centered on products made from glass-filled thermoplastic resins, such as PEI (polyetherimide). These Glenair interconnect components—connectors, junction boxes, backshells and so on—are produced in an injection molding process that results in products that are known for their toughness, damage-resistance, dimensional stability and strength. But other formulas of engineering plastics, such as ETFE (ethylene tetrafluorethylene), are also widely applied by Glenair to produce a very different class of products: flexible convoluted tubing.

Unlike glass-filled thermoplastics that produce rigid parts, ETFE, FEP, G-Flex and other high-temperature plastics used by Glenair in tubing fabrication produce products that are known for their folding endurance, or the number of times the material can be bent or flexed before experiencing failure. Used in wire-protection applications where a rigid, jacketed cable would experience rapid failure, flexible plastic tubing delivers outstanding performance and durability.

Glenair specializes in the manufacture of ruggedized plastic tubing for shipboard, aircraft and ground applications, and offers the world's broadest range of environmental, mechanical and EMI hardened solutions. Our recently expanded convoluted tubing and conduit manufacturing facility in Glendale is a state-of-the-art plant with every step in the tubing extrusion and finishing process centralized under one roof.



## Cost Comparison and Temperature Resistance

Thermal properties are extremely important when selecting plastic materials for use in high-performance applications. Composite glass transition temperature (the point at which the heated material softens) will dictate whether or not the plastic is suitable for use in high-heat applications such as adjacent to an engine or other heat source. But other properties, such as its specific gravity, hardness, refractive index, dielectric strength, conductivity, chemical resistance, UV and flame resistance are also critical in deciding which recipe of resins, fibers and additives will be selected for a particular project.

Temperature resistance can be measured in a variety of ways: melt temperature, heat deflection temperature, glass transition temperature, and continuous use temperature. The resins that offer the highest capabilities in each of these categories are often the most expensive, but typically offer the lowest lifetime cost because of enhanced durability and strength. Two of the top thermal performers, Polyetheretherketone (PEEK) and high-temperature ETFE, are high cost materials, but exceptional performers over the long run.



*The glass transition temperature, or the point at which the heated resin will soften, varies from material to material. Extremely high-heat applications, such as engine sensors, are generally considered to be ill-suited for composites.*

Additives can be used to increase flame retardancy, to improve lubricity or, in the case of pigments, simply to change the color of the final product. Again, material costs can rise with the addition of chemical compounds that contribute to improved performance. In terms of cost, thermo-plastic resins can be arranged into three basic categories:

- Low cost/commodity resins with large volume market costs of less than \$1.50/lb
- Medium cost/engineering resins that fall between \$1.50-\$3.00/lb
- High cost/high temperature resistant resins that usually cost above \$3.00/lb.

## Re-Designing for Composites

Interconnect products made of composite materials offer significant advantages over steel or aluminum. They're lighter. They don't rust. They don't loosen under vibration. They can hide from radar. Yet the ability to design composite components that take advantage of these properties while still meeting form, fit and function requirements is no simple task.

Connector accessories, no matter the material, must thread onto the back of connectors. Interconnectability with other components, whether composite or metal, is critical. Composite component design is further complicated due to the unique strengths and weakness of the material. Abrupt changes in wall thicknesses, for example, can lead to stress problems in both manufacture and use. Sharp, un-radiused angles can create stress and cause cracking. The length, shape, orientation and distribution of reinforcing fibers is also a critical concern, as is the impact of other additives, such as colorizers and flame retardants, on the behavior of the material during manufacture and use.

Interconnect systems designers continue to specify composites, despite the complications of the design and manufacturing process. The weight savings, corrosion resistance and other significant advantages of composites represent real, out-of-pocket savings in fuel consumption and lifetime system maintenance for a broad range of air, sea and space applications.

## Application Benefits of Composite Thermoplastics

The benefits of modern plastic materials have not yet led to the wholesale elimination of metal from high-performance air, sea and space applications. Aluminum, for example, is still a popular choice for most high-density connectors and accessories. But the significant advantages offered by composites, —especially reduced weight— are so beneficial that most new OEM development programs now include significant composite content.

**Corrosion Resistance:** One of the most appealing attributes of composites is their unlimited corrosion resistance as compared to conventional materials. Aluminum interconnect components, for

example, are subject to galvanic coupling which causes the metal material to be “sacrificed” to its cadmium/nickel plating. Since high-temperature plastic is not sacrificial to plating, finished products last longer, require less maintenance and directly reduce the overall cost of ownership of the system.

**Vibration Dampening:** Another major benefit of composite thermoplastics is vibration dampening. Unlike metals, polymer plastics are less subject to harmonic resonance due to their lighter weight and inherent attenuating properties. Which means threaded components made from these materials are far less likely to vibrate loose when subjected to prolonged periods of vibration and shock. Again, reduced maintenance and reduced cost of ownership are the major benefits realized by systems built from vibration dampening thermoplastics.

**Weight Reduction:** Next to their anti-corrosive capabilities, the characteristic of composites that makes them most attractive is their ability to provide increased strength and stiffness at lighter weights than metal materials. The typical weight savings for composites over aluminum is approximately 40% (depending on component design).

Weight savings versus metals such as steel and brass are even more pronounced, as their specific gravities are several times that of plastic. Composite materials directly reduce aircraft empty weights and increase fuel fractions. For the aerospace engineer, this leads directly to smaller, lower-cost aircraft that use less fuel to perform a given mission.

**Stealth:** Reduction of magnetic signatures, corrosion related magnetic signatures and acoustic signatures is critical to the development of stealth applications. Signatures are those characteristics by which systems may be detected, recognized, and engaged. The reduction of these signatures can improve survivability of military systems, leading to improved effectiveness and fewer casualties. Composite thermoplastics are at the heart of a number of advanced stealth application development projects. Forty percent of the structural weight of the F-22 is polymer composites, and other systems such as the B-2 and F-117A expanded their use of stealth technologies beyond basic shaping and material coating techniques to include the use of structural and component composite thermoplastics.

Composite Thermoplastic Versus Common Metal Materials		
Weight Savings		
Material	Specific Gravity	Density (lbs. Inch <sup>3</sup> )
Composite	1.27 - 1.51	.055
Aluminum	2.55 - 2.80	.098
Titanium	4.51 - 4.62	.162
Stainless Steel	7.70 - 7.73	.284
Brass	8.40 - 8.70	.305
Corrosion Protection		
Material	Plating	Salt Spray
Composite	Nickel	2000+ Hrs
Aluminum	Nickel	48-96 Hrs
Aluminum	Zinc Colbalt	350-500 Hrs
Aluminum	Cadmium Nickel	500-1000 Hrs
Aluminum	Zinc Nickel	500-1000 Hrs
Titanium	Nickel	500-1000 Hrs
Stainless Steel	Nickel	500-1000 Hrs
Brass	Nickel	500-1000 Hrs

## Glenair Composites: Tooled and Ready for Production

**G**lenair is the recognized leader in composite thermoplastic research and development for the interconnect accessory industry. In fact, no one else has tooled even a small fraction of the composite thermoplastic accessories available today from Glenair. The product line includes circular and rectangular connectors and accessories, cable junction boxes, conduit, conduit fittings, protective covers, shielding, shielding support rings, and more. It is an ongoing goal at Glenair, largely achieved at this point, to be able to offer equivalent function composite thermoplastic interconnect components for the complete range of interconnect products we produce in metal.

Glenair composite components are produced in injection molded and, in certain cases, machined versions ideally suited for use in harsh environments where resistance to high temperatures, outgassing, corrosive fluids, fire, and shock and vibration is required. Glenair composites are ASTM E595 space rated, and are qualified to the shock, vibration, thread strength and bend moment requirements of MIL-DTL-38999 and SAE AS85049. The materials also meet stringent EMI/RFI/HIRF and indirect lightning strike performance specifications.

Glenair has the largest and most experienced staff of composite engineers and manufacturing

experts in the interconnect accessory industry. Their combined expertise insures Glenair composite products mate correctly with both metal and composite connectors and meet the customer's most stringent performance requirements. All Glenair designs provide a dimensionally stable and cadmium-free alternative to plated aluminum and brass.



Glenair composite material options include Ultem® (PEI), Amodel® (PPA), Ryton® (PPS), Torlon® (PAI), PEEK, Siltem and LCP. Base materials can be augmented with conductive and non-conductive additives and reinforcing fibers to meet specific functional specifications. As mentioned, each composite material has its own specific structural properties. The following is



a brief introduction to the most common materials used by Glenair:

Ultem® (PEI) is an amorphous thermoplastic available in extruded bars for machining and pellets for injection molding. The material combines high performance with good processing characteristics and offers high heat resistance, high strength



modulus and broad chemical resistance. Ultem 2300 is a 30 percent glass filled thermoplastic which displays excellent property retention and resistance to environmental stress. Ultem can be further reinforced with conductive fibers, or plated, for EMI resistance. Ultem performs in operating environments up to 378° F long term and 410° F short term. Ultem meets ASTM E595 outgassing, 14 CFR Part 25 flammability, and zero halogen outgassing requirements.

Ryton® (PPS) is a high temperature, injection molded material. It has good mechanical properties and excellent chemical resistance at elevated temperatures. Different grades are available including glass filled and glass/mineral filled versions. Ryton R4-XT is a 40 percent glass filled version engineered for improved knit-weld line characteristics. As a semi-crystalline material, Ryton exhibits excellent resistance to prolonged exposure to high temperatures, up to 500° F. Ryton also provides outstanding resistance to a broad spectrum of aggressive chemicals and has very stable dielectric and insulating properties. Ryton meets ASTM E595 outgassing requirements and UL94 flammability tests.

Glenair's G-FLEX polymer (polyetherimide-siloxane) is a high-temperature material used primarily to produce annular convoluted tubing. The material is offered in a broad range of operating temperatures, has exceptional flexibility and good crush resistance. In certain applications, G-FLEX is a suitable alternative to costlier halogen-free composite polymers such as PEEK (polyetheretherketone). PEEK is a semi-crystalline thermoplastic that operates at extremely high temperatures—500°F long-term and 600°F short term. An extrudable material, PEEK offers one of the lightest strength to weight ratios available in a composite.

Please consult the factory for information on additional material types used in Glenair products.

*QwikConnect*

*April 2008 Centerfold*





Nickname: *Swing-Arm*

Vital Statistics: *627 -122*

Likes: *vibration, shock and long salt water baths*

Dislikes: *non-standard tools*

Orientation: *straight, right and 45°*

Mates with: *both Military and civilian interconnects*

Status: *available in selected 'X' platings*

Lifestyle: *low-smoke and halogen free*

# Composite Thermoplastic Glossary

**Additive:** A material used to modify the properties of polymer resins. Examples include plasticizers, initiators, light stabilizers and flame-retardants.

**Alloy:** In plastics, a blend of polymers or copolymers blended with other polymers or elastomers under select conditions.

**Antioxidant:** Substance that, when added in small quantities to resin, prevents oxidation and degradation while maintaining the resin's properties.

**Antistatic Agents:** Agents added to a molding material or applied to the surface of a molded object to make it more conductive and prevent the fixation of dust or buildup of electrical charge.

**Bearing Strength:** The maximum amount of stress that can be sustained.

**Bearing Stress:** Applied load in pounds divided by the bearing area. Maximum bearing stress is the number of pounds that can be sustained, divided by the original bearing area.

**Bi-directional:** Reinforcing fibers arranged in two directions, usually at right angles.

**Binder:** Coating which is applied to the surface of a chopped glass mat or preform and then cured to hold bundles or ends together in a stable form during the roving operation.

**Bond Strength:** Amount of adhesion between bonded surfaces. The stress required to separate a layer of material from the base to which it is bonded, as measured by load/bond area.

**Braid/Braider:** A narrow tubular or flat fabric produced by intertwining a single set of yarns according to a definite pattern.

**Carbon Fiber:** Fiber produced by the pyrolysis of organic precursor fibers, such as rayon, polyacrylonitrile (PAN), and pitch, in an inert environment.

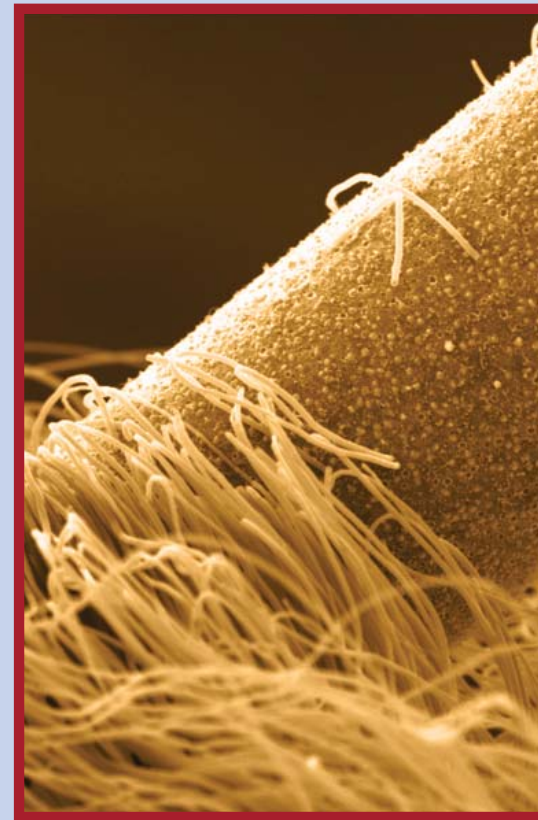
**Casting:** Process of pouring resin, fillers and/or fibers into a mold vs. building up layers through lamination. Casting results in physical properties that are different than those resulting from lamination.

**Catalyst (Hardener):** A substance that markedly speeds up the cure of a compound by decomposing in the presence of a promoter to release an active oxygen radical.

**Cavity:** Space inside a mold in which a resin or molding compound is poured or injected. The female portion of the mold. That portion of the mold that encloses the molded article (often referred to as the die). Depending on the number of such depressions, molds are designated as a single cavity or multiple cavity.

**Coefficient of Thermal Expansion:** How much a material's shape will change per each degree of temperature fluctuation.

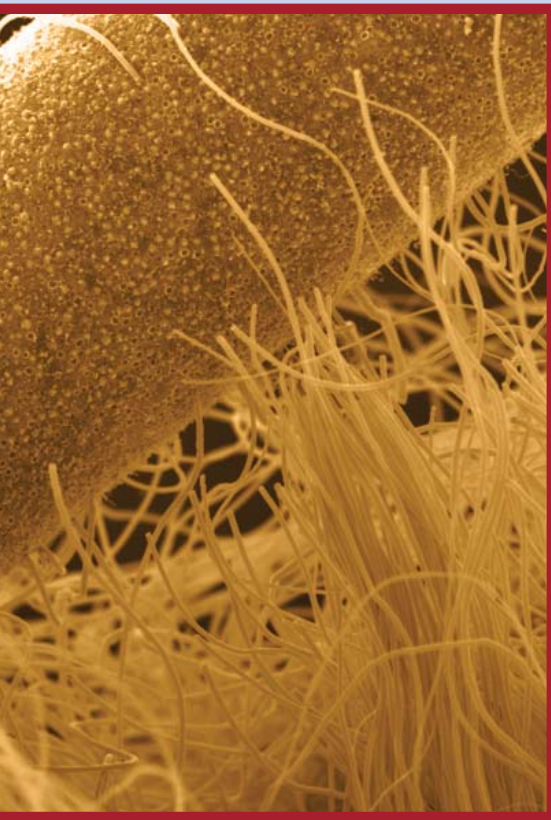
**Cold Flow:** Distortion that occurs in a material under continuous load within its working temperature range and without a phase or chemical change.



**Compatibility:** The ability of two or more substances to be combined in order to form a homogeneous composition of useful plastic properties; for example, the suitability of a sizing or finish for use with certain general resin types.

**Composite:** Chemical or mechanical bonding of dissimilar materials such as glass fiber and polyester resin, whose cumulative properties are superior to the individual materials.

**Compression Molding:** An open molding process in which material is introduced and shaped by the pressure of closing and by heat.



**Conductivity:** Reciprocal of volume resistivity. The electrical or thermal conductance of a material (conductivity per unit volume).

**Continuous Heat**

**Resistance:** Maximum temperature to which material should be

subjected in a continuous application. Below this temperature, the material is acceptable. At temperatures above the maximum, the material may decompose, melt, or otherwise fail.

**Corrosion Resistance:** A material's ability to withstand ambient natural factors or those of a particular artificially created atmosphere, without

degrading or changing in properties.

**Crazing:** Cracking of gel coat or resin due to stress. Region of ultra-fine cracks, which may extend in a network on or under the surface of a resin or plastic material. May appear as a white band. Often found in a filament-wound pressure vessel or bottle.

**CTE:** see Coefficient of Thermal Expansion

**Cure:** Cross-linking or total polymerization of a resin's molecules that alters a material's properties, changing it from a liquid to a solid.

**Curing Agent:** A catalytic or reactive agent that, when added to a resin, causes polymerization. Also called hardener.

**Damping:** The decay with time of the amplitude of free vibrations of a specimen.

**Deflashing:** A finishing technique used to remove excess, unwanted material (flashing) on a plastic molding.

**Deflection Temperature under Load:** Temperature at which a simple beam has deflected a given amount under load (formerly called heat distortion temperature).

**Dielectric:** A nonconductor of electricity. A material's ability to resist the flow of electrical current.

**Dielectric Strength:** An electrical property indicating how well a material acts as an electrical insulator. It describes how much of an electrical voltage can be built up on one side of the material before it is communicated to the other side. Units are measured in volts per mil of thickness (volts/mil). Higher numbers indicate materials with better insulation properties.

**Dimensional Stability:** A plastic part's ability to retain the precise shape to which it was molded, cast, or otherwise fabricated.

**Distortion:** Change in shape from that which is intended. Symptomatic of laminating difficulties,

curing problems, tooling problems or resin shrinkage.

**Elasticity:** A material's ability to recover its original size and shape after the force deforming it has been removed.

**Elastic Limit:** The greatest stress a material can sustain without permanent strain after the stress has been completely released. A material is said to have passed its elastic limit when the load is sufficient to initiate plastic, or non-recoverable, deformation.

**Elastomer:** A material that substantially recovers its original shape and size at room temperature after a deforming force is removed.

**Epoxy:** A polymerizable thermoset polymer containing one or more epoxide groups cured by its reaction with amines, alcohols, phenols, carboxylic acids, acid anhydrides, and mercaptans. An important matrix resin in composites and structural adhesive.

**Extruder:** Machine that pushes molten plastic through small holes to form fibers.

**Fiber:** The major reinforcement material component in a composite matrix. Often, fiber is used synonymously with filament.

**Fiber Orientation:** Fiber alignment in a non-woven or a mat laminate where the majority of fibers are in the same direction, resulting in greater strength in that direction.

**Filament:** A single, threadlike fiber of glass.

**Fire Retardants:** Chemicals that reduce a resin's tendency to burn.

**Flammability:** How fast a plastic material will burn when subjected to a particular ASTM test. In this test, a flame is applied to one end of a strip of material. When the material starts burning the flame is removed and the time to consume a given amount of material is measured. Units are measured in inches per minute (in/min.). Higher

numbers indicate that the material will burn faster under this particular test's conditions.

**Flash:** Portion of the charge that flows or is extruded from the mold cavity during the molding. Also refers to extra plastic attached to a molding along the parting line that must be removed before the part is considered finished.

**Gate:** Point at which molten thermoplastic enters the injection molding tool cavity.

**Glass Content:** Percentage of glass in the compound.

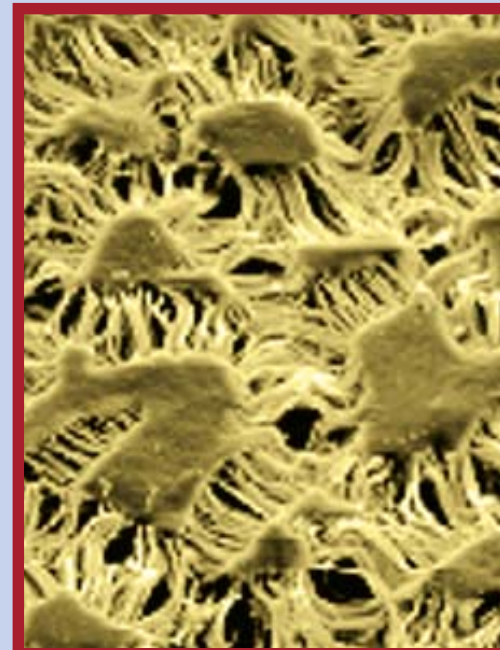
**Green Strength:** That ability of the material, while not completely cured, to undergo removal from the mold and handling without tearing or permanent distortion.

**Hardener:** A substance or mixture added to a plastic composition to promote or control curing by taking part in it.

**Heat Resistance:** The ability of plastics and elastomers to resist deterioration due to elevated temperatures.

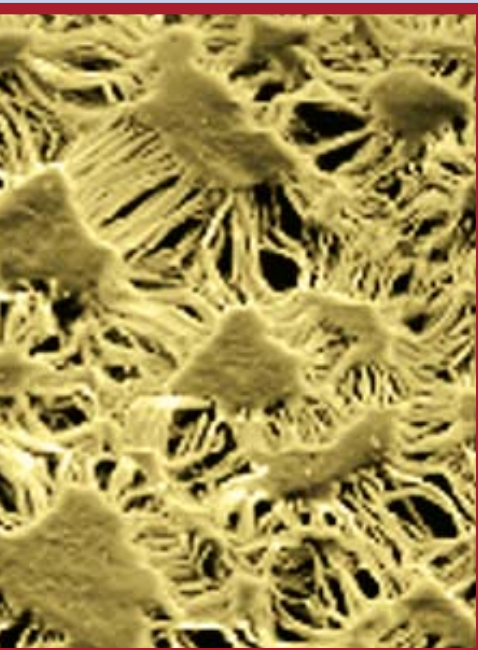
**Injection Molding:** Method of forming plastic to the desired shape by forcing a heat-softened thermoplastic polymer into a relatively cool cavity under pressure or thermosetting polymer into a heated mold.

**Liquid-Crystal Polymer:** A newer thermoplastic polymer that is melt process capable and develops high orientation in molding, resulting in tensile strength and high-temperature capability.



**Mat:** A fibrous material for reinforced plastic consisting of randomly oriented chopped filaments, short fibers (with or without a carrier fabric) or swirled filaments loosely held together with a binder.

**Matrix:** The resin component of a polymer composite. Both thermoplastic and thermoset resins may be used, as well as metals, ceramic and glasses.



**Mold:** The cavity or matrix into or on which the plastic composition is placed and from which it takes form. The tool used to fabricate the desired part shape.

**Plastic:** Material of which an essential ingredient is an organic polymer of large molecular weight and also

contains hardeners, fillers and reinforcements; is solid in its finished state; and has been shaped by flow during some stage of its manufacture or processing. A plastic may be either thermoplastic or thermoset.

**Polymer:** Chain molecule composed of many identical groups commonly found in plastics.

**Polymerization:** Chemical bonding of polymer molecules during the curing reaction.

**Resin:** Solid or pseudo-solid organic material, usually of high molecular weight, that tends to flow when subjected to stress. Most resins are polymers.

In reinforced plastics, the material used to bind together the reinforcement material. See Matrix and Polymer.

**Runner:** The channel through which thermoplastic material moves through a mold.

**Shore Hardness:** A material's resistance to indentation from a spring-loaded indenter. Higher numbers indicate materials with greater resistance.

**Shrinkage:** The relative change in dimension between the length measured on the mold when it is cold and the length of the molded object 24 hours after it has been taken out of the mold.

**Specific Gravity:** A material's weight in relation to the weight of an equal volume of water. For example, a material with a Specific Gravity of 2.0 weighs twice as much as an equal volume of water. Because specific gravity is a ratio of values for two materials, there are no units. Higher numbers indicate heavier materials.

**Thermoplastic:** Capable of being repeatedly softened by an increase of temperature and hardened by a decrease in temperature. Applicable to those materials whose change upon heating is substantially physical rather than chemical and that in the softened stage, they can be shaped by flow into articles by molding or extrusion.

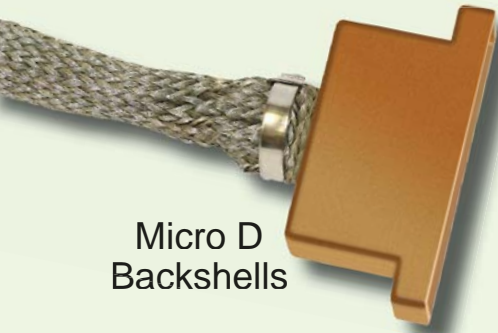
**Thermoset:** A material that undergoes a chemical reaction caused by heat, catalyst or other condition, which results in the formation of a solid. Once it becomes a solid, it cannot be reformed.

**UV Stabilizer:** Chemical compound which improves resistance to degradation from ultraviolet radiation.

**Viscosity:** Measure of a liquid's resistance to flow.

**Yarn:** Generic term for a continuous strand of textile fibers, filaments or material in a form suitable for knitting, weaving or intertwining to form a textile fabric.

# The World's Largest Selection of *Tooled* Composite Thermoplastic Interconnect Components



Micro D  
Backshells



Composite EMI  
Shielding



Strain Relief  
Backshells



Band-in-a-Can  
Backshells



Fiber Optic  
Banding Backshells



Ultra-Light Banding  
Strain Relief



Dual Banding  
Backshells



5015 Type  
Connectors



Knit-Braid  
EMI/RFI  
Backshells



Series 390  
Environmental



Junction Boxes

D38999  
Type  
Connectors



Overmolded Cable  
Adapters



Extender  
Backshells





Convolved Tubing and Fittings



Swing Arm Strain Relief Clamps



Protective Covers



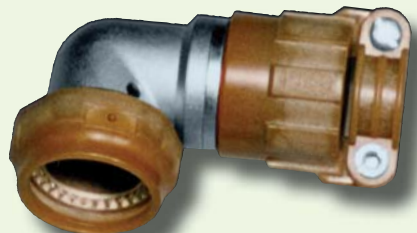
Swing Arm with Shield Sock



Qwik-Ty Strain-Relief



Ultra Low-Profile Banding Backshell



Series 360 Strain Relief



Feed-Thru Fittings



Split Rings



EMI Lamp Base Thread Backshells



EMI/RFI Backshell



Low Profile Strain-Relief



Cone and Ring Style EMI/RFI Backshells



EMI/RFI Shield Socks



Environmental Backshells



Series 620 Strain Relief Clamps



Fiber Optic Backshells



# Glenair Composites: Proven Performance Applications

## **Composite Knit-Braid Strain-Reliefs**

Glenair EMI/RFI “Knit-Braid” composite accessories are ideally suited for use in harsh environments where resistance to high temperatures, outgassing, corrosive fluids, fire, shock and vibration is required. The products also deliver extremely fast assembly and reliable termination of EMI shielding. These composite connector accessories are qualified to the shock, vibration, thread strength and bend moment requirements of MIL-DTL-38999 and SAE AS85049. The materials used to produce the parts also meet stringent EMI/RFI/HIRF and indirect lightning strike performance specifications.

## **Composite Shield-Sock Backshells**

Glenair’s composite shield sock backshells provide lightweight and corrosion free termination of EMI/RFI cable shielding. Made from high-temperature composite thermoplastic, these rugged assemblies offer easy installation, long term performance, and outstanding weight and cost reduction. Performance tested to stringent AS85049 mechanical and electrical standards.

## **Composite Fiber Optic Connectors**

Glenair’s close-tolerance MIL-DTL-38999 Series III Style Composite Fiber Optic Connector is built to ensure precise optical alignment of optical fibers. Connector polarization keys and keyways are manufactured to tighter tolerances than required by the MIL-DTL-38999 specification to reduce radial misalignment and insertion loss.

Glenair’s composite swing arm strain relief backshell provides lightweight and corrosion free termination of EMI/RFI cable shielding. This innovative backshell is quickly becoming the standard shield termination device for both military and commercial aerospace applications. Made from high-temperature composite thermoplastic, these rugged assemblies offer easy installation, long term performance, and outstanding weight and cost reduction. Performance tested to stringent AS85049 mechanical and electrical standards.

## **Composite MIL-C-5015 Type Harsh Environment Connectors**

Glenair’s line of 5015 Type Harsh Environment Connectors is designed to provide outstanding corrosion resistance and rugged performance. These composite thermoplastic plugs and receptacles are ideally suited for severe environments such as geophysical exploration, mining and other settings where resistance to mechanical abuse, extreme temperatures, salt spray and caustic chemicals is a critical requirement.





### **Composite Convoluted Tubing**

Glenair's PEEK (polyetheretherketone) polymer convoluted tubing provides an extremely rugged, lightweight enclosure for wiring systems deployed in harsh application environments. The crush-resistant material provides exceptional flexibility and crush resistance, and can be combined with Glenair composite end-fittings and transition-fittings to meet almost any installation configuration. The low-outgassing polymer far outperforms other plastics and has a V-O flammability rating down to 0.057 inches without the use of additives, making PEEK tubing an ideal choice for a broad range of aerospace, marine, military and commercial applications.

### **Composite EMI/RFI Braiding**

For many applications, the braided cable shield is the most important element in controlling EMI. Unfortunately, metal shielding—especially when applied in multiple layers—can be extremely heavy. The opportunity to provide robust EMI shielding at a fraction of the weight is the principal advantage of composite thermoplastic composite braid. Glenair composite EMI/RFI shielding is available in 100% plated composite or in hybrid blends combined with NiCu. The material is supplied as expandable sleeving or as spooled strands for direct overbraiding of multi-branch cable assemblies.

### **Composite Micro and D-Sub Backshells**

Glenair's line of rectangular backshells is the largest in the industry. The composite thermoplastic versions provide outstanding environmental and EMI protection for rectangular connectors used in harsh or severe operating environments. Our D-Subminiature and Micro-D versions are both available in top, side and 45° entry configurations together with the full range of conductive and nonconductive finishes. Jackpost hardware is CRES/passivated stainless steel. All backshell designs meet the exact dimensional requirements for the specified connector series and provide equivalent performance to metal versions

### **Composite EMI/RFI “CostSaver” Junction Boxes**

Glenair's Composite EMI/RFI Junction Boxes are ideally suited for use in harsh environments where resistance to EMI, corrosive fluids, high temperatures, shock and vibration is a critical requirement. The boxes are designed to meet the shock and vibration requirements of MIL-S-901D and MIL-STD-167SHIPS. Box materials also meet stringent EMI/RFI/HIRF and indirect lightning strike performance specifications.

## Mind the Gap

Faithful readers of *QwikConnect* know exactly what we mean when we say we follow a “No Gaps” strategy at Glenair: if we see a gap in a product line—something our customers want that we don’t yet make—we fill it. We think it makes good business sense to be able to tell our customers we can supply every line-item on their list—not just the ones we consider convenient or desirable to make.

We have been making composite parts at Glenair for over 25 years, and we boast a huge assortment including connectors, convoluted tubing, EMI/RFI braided shielding, junction boxes and dozens of connector accessory types and styles. In the last few years, we have accelerated our development and tooling of new part numbers such that we are now in close reach of being able to claim “No Gaps” status when it comes to composite interconnect solutions. This is particularly true for our line of composite backshells and connector accessories: we now can offer our customers a composite solution for almost every connector accessory requirement!

The subtitle of our new *Composite Thermoplastic Connector Accessory* catalog, which will roll-out later in 2008, shows just where we’re headed: “The World’s Largest Selection!” And we are perfectly serious: we believe we have more composite accessories, connectors, conduit systems, junction boxes and other solutions in production than the rest of our industry combined. You’ll find plenty of new products in this expanded catalog, including new versions of our composite swing-arm series, new configurations of banding and shrink-boot adapters, new junction box designs and more. We even have a new flavor of composite convoluted tubing called “G-Flex.” G-Flex (polyetherimide-siloxane) is ideal for harsh environment applications that require a lightweight, halogen-free material with exceptional flexibility and crush resistance.

I sometimes find myself in London during my business travels to and from our UK facility in Mansfield. And like most foreigners, my attention is easily drawn to the automated female voice in London’s underground rail system that warns travelers to “mind the gap” between the station platform and the train. Of course when I hear this warning, I can’t help but think about product line “gaps”, and chuckle to myself that the “mind the gap” lady would fit right in at Glenair.

Christopher J. Toomey  
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