



composite dielectric tubing

**PROTECTS YOU**

from danger



# ELECTRICAL DESIGN GUIDE



*Innovation Beyond Metals™*

[polygoncomposites.com](http://polygoncomposites.com)



# ARMATURE SHAFT INSULATORS

Double Insulation Tubing

## INTRODUCTION

Since its establishment in 1949, Polygon Company has stood as one of the world's premier leaders in the development of advanced composite materials for many electrical insulative applications. Polygon's production capabilities are among the widest in the world and range from the pultrusion process to filament winding, braiding and circ-winding. In addition, Polygon is known as the world's leading fabricator of composite materials. From advanced CNC lathes, to multiple automated milling machines and tight tolerance centerless grinding, Polygon can meet a wide variety of component fabrication requirements. But Polygon's service doesn't stop at fabrication—we also provide painting, sub-assembly and contract manufacturing services.

## PRODUCT DESCRIPTION

The Polygon Tube® is the insulation sleeve that provides armatures of electric motors a secondary layer of insulation. This secondary insulation is needed to provide increased protection for operators of electrical appliances from shock. The use of the additional layer of insulation allows the appliance to be rated "Double Insulated" and the need for grounding of the appliance is eliminated. Even though an appliance is grounded by means of a three-wire power cord, it is still a good practice to provide a secondary layer of insulation. The information provided is to assist in the design and assembly of the Polygon Tube into armatures of electric motors.

## MANUFACTURING PROCESS

Polygon utilizes two bonding processes to manufacture tubes that provide optimum physical and dielectric performance. These processes capitalize upon the individual chemical and mechanical strengths of both resin chemical bond and structural interlocking of reinforcement maximizing the total strength of the Polygon Tube. These insulating composite tubes utilize their inherent modulus of elasticity to ensure a permanent press fit on the armature shaft.

Polygon Tube provides high torque strengths and is a yellow carded UL Certified material (AFW-G-10). These patented manufacturing techniques produces double insulated tubes with unparalleled physical properties and unmatched electrical insulation.

## STANDARD TOLERANCES

In comparison to conventional molding or paper tube assemblies, the implementation of the Polygon Tube into the motor assembly enables the manufacturer to reduce production costs. Standard tolerances have been established that allow these composite tubes to be press-fit into the motor laminations. The armature shaft is then pressed into the assembly, securely locking the laminations and the shaft.

## QUALITY CONTROL

To ensure each double insulated Polygon Tube surpasses all electrical insulation requirements we have implemented an uncompromising inspection process. Each tube is tested at 5000 volts to guarantee its dielectric integrity. Polygon Tube carries approval by Underwriters' Laboratories, Inc. to grade AFW-G-10. Certification and SPC controlled processing ensures "just in time" deliveries and eliminates inspection on the customer's end. The anisotropic properties composite materials are often misunderstood. Therefore, it is helpful to review some of Polygon Tube's basic material features as they relate to armature insulation.



Polygon has a long history of providing electrical insulation products.



Polygon Tube® provides double insulation in high torque motor armatures.

***"Leading the electrical industry for 60 years with over one billion tubes in production."***

## THE COMPOSITE TUBE CONSISTS OF TWO DIELECTRIC MATERIALS

### REINFORCING MATERIAL

Consisting of continuous fiber bundles of electrical grade “E-Glass” woven together at a specific helix angle with respect to the tube axis and thermoset epoxy resin, property retention (both in-dielectric and structural) electrical temps.

### EPOXY: THAT HAS A TG OF APPROXIMATELY 120°C [266°F] – OR 180°C[356°F]

Properties in the axial, hoop, and through the wall in a composite are anisotropic and are controlled with fiber orientation. The composite’s physical properties are not less consistent in ultimate strength or elasticity.

## TRANSFORMER AND DISTRIBUTION PRODUCTS

Any composite company that’s been around for over 60 years has, as part of their heritage, a family of products related to either the recreational or electrical markets, and Polygon is no exception. Polygon Company has been a major force in supplying insulating products for the electrical transformer and distribution market since the early 1950’s. Many of the applications in existence today were designed and developed by Polygon engineers.

As the originator of the fiberglass winding pin used in the production of fractional horsepower motors as an insulating turn point for the copper coils. Polygon pioneered the replacement of convolute wound fuse tubes by incorporating the braiding process, then followed closely by filament winding technology. Polygon developed a proprietary

product and process that replaced molded steel core cross bars used in 3-pole switches. This application was especially demanding because we had to match the torque requirements of the steel core while at the same time providing high voltage insulating properties with the same strength characteristics.

Polygon Company has designed and made fuse tubes, transformer fuse tubes, draw out tubes, lightning arrester tubes, fuse holders, stand offs, stabbers and various other products longer than most composite manufacturing companies have been in existence. We stand alone in our ability to manufacture products for the electrical industry using the processes of filament winding, pultrusion, braiding or combinations of all three. We are a true manufacturer, not just a fabricator or distributor of electrical products. This allows us to control both our raw material inputs as well as the finished products. Most of our competitors must rely on outside sources to make their composite or laminates that they then fabricate. This additional step creates a hidden supply chain issue that contributes to quality problems or extends lead times. We make the composites, and then finish them to print, which can also include secondary processing such as metallic end attachments, painting, certification or any type of subassembly that might be required.

Polygon Company is very diverse in product size range offerings as well. Making a variety of electrical products, from products that require a magnifying glass to visualize to tubing structures that an individual could actually crawl through. We create, manufacture and produce tubes, rods, solids, sheets and even electrical torque products. Our depth of knowledge in the electrical market is unsurpassed.

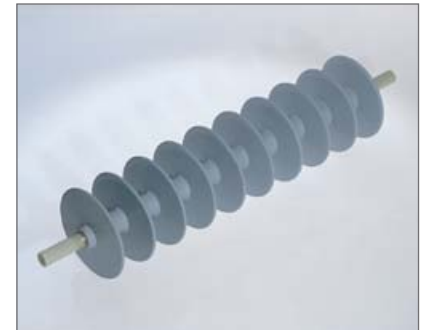
## GENERAL SPECIFICATION OF POLYGON TUBE®

### STANDARD TOLERANCES

Concentricity Standard	TIR	0.004" (0.10mm)
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### PHYSICAL PROPERTIES

Compressive Strength		20,000 psi
Tensile Strength		20,000 psi
Shear Strength		6,500 psi
Water Absorption	2 hours	0.12%
Water Absorption	24 hours	0.16%
Specific Gravity		1.8



Polygon has supplied insulating products for the electrical transformer and distribution market since the early 1950’s.

***“We are a true manufacturer,  
not just a fabricator or distributor,  
of electrical products.”***

## GENERAL SPECIFICATION OF POLYGON TUBE® (CONTINUED)

### ELECTRICAL PROPERTIES

Insulation Resistance	ohm/8" length	$2.38 \times 10^{12}$
Volume Resistivity	ohm/cm	$2.41 \times 10^{18}$
Surface Resistivity	ohms	$3.93 \times 10^{15}$
Time, volts/mil		400
Dielectric Constant	60 cps	4.15
Dissipation Factor	60 cps	0.0094

## PG-P-560 ALL COMPOSITE CROSS BAR

### PRODUCT DESCRIPTION

The all composite cross bar from Polygon utilizes an engineered composite structure that results in excellent retention of mechanical and physical properties at elevated temperatures. This all-composite cross bar eliminates the need for traditional metallic cross bars that are a combination of a metallic shaft encapsulated with epoxy impregnated glass fabric.

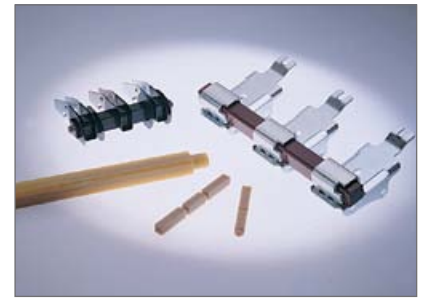
### GENERAL SPECIFICATION OF PG-P-560

Tensile Strength (Axial)	175 KSI
Compressive Strength (Axial)	175 KSI
Compressive Modulus (Axial)	6.1 MSI
Shear Strength	7.0 KSI
Shear Modulus	0.5 MSI
Modulus of Elasticity (Axial)	6.1 MSI
Poisson's Ratio	0.28
Young's Modulus	$5.5 \times 10^6$ PSI
Yield strength	100,000 PSI
Thermal Conductivity	2.0 BTU/hr./sq.ft./°F/in.
Specific Heat	0.26 BTU/lb./°F
Dielectric Strength	400 volts/mil
Material Composition	Epoxy/Fiberglass
Listed Under UL Number	PG-P-560

#### CREEP:

100°C with 14 lbs. Load—deflection	None at 12 days
80°C with 5 lbs. Load—deflection	None at 5 days
65°C with 14 lbs. Load—deflection	None at 14 days

*“Why have a metallic strength member in an electrical insulating product?”*



Composite cross bars are rigid and insulate through the entire material, not just via a layer of laminate.

*“Polygon is universally known as the most vertically integrated supplier in the electrical market.”*

## HIGH TEMPERATURE FUSE TUBING

### PRODUCT DESCRIPTION

This product has been designed to provide excellent performance at elevated temperatures. With a glass transition temperature of over 200°C this epoxy filament wound tube exhibits superb performance over extended exposure to elevated temperatures.

### ELECTRICAL PROPERTIES\*\*

Insulation Resistance (ohm/8" length)	2.38 x 10 <sup>12</sup>
Volume Resistivity (ohm/cm)	2.41 x 10 <sup>15</sup>
Surface Resistivity (ohms)	2.92 x 10 <sup>15</sup>
Dielectric Strength, Short Time (volts/mil)Minimum	500
Dielectric Constant (60 cps)	4.15
Dissipation Factor (60 cps)	0.0094
Impulse (11/2 -40u Wave (Axial) volts/mil)	400 to 550
<b>POWER FACTOR AT 60 cps (100v pct mx)</b>	
As Received	5.0
at 100°C	10.0
After 24 hours at 100°F at 98% rel. hum.	10.0

### PHYSICAL PROPERTIES\*\*

All calculations based on an 89° wind angle

Hoop Strength (Fy x 10 <sup>3</sup> )	120
Tensile Strength (Ft x 10 <sup>3</sup> PSI)	20
Flexural Strength, Axial (Fbx x 10 <sup>3</sup> PSI)	20
Poisson's Ratio, Axial	0.08
Shear Modulus (Gxy x 10 <sup>6</sup> PSI)	0.6
Elastic Modulus (Ex x 10 <sup>6</sup> PSI)	1.6
Elastic Modulus, Transverse (Ey x 10 <sup>6</sup> PSI)	5.0

### THERMAL PROPERTIES\*\*

Thermal Conductivity (BTU/hr/sq ft/°F/in)	1.8 to 2.3
Specific Heat (BTU/lb/°F)	0.27
Coefficient of Thermal Expansion (in/in/°F)	5.0 to 7 x 10 <sup>6</sup>
Heat Resistance, Continuous	200°C

\*\*Note: These are typical properties. Specific properties may vary, depending on the composite design for each application



High temperature fuse tubing remains stable through prolonged heat.



Composite materials combine structural strength with dielectric capability.



Provides insulation in high temperature motor applications.

## PG-P-6001 EPOXY FIBERGLASS FILAMENT WOUND GENERAL PURPOSE FUSE TUBING

### PRODUCT DESCRIPTION

PG-P-6001 designates a general "E" glass fiber reinforced composite tubing material, with an epoxy resin as matrix.

### PHYSICAL PROPERTIES\*\*

All calculations based on an 40° wind angle

Hoop Strength ( $F_y \times 10^3$ )	60
Tensile Strength ( $F_t \times 10^3$ PSI)	60
Flexural Strength, Axial ( $F_{bx} \times 10^3$ PSI)	55
Poisson's Ratio, Axial	0.3
Shear Modulus ( $G_{xy} \times 10^6$ PSI)	0.8
Elastic Modulus ( $E_x \times 10^6$ PSI)	2.5
Elastic Modulus, Transverse ( $E_y \times 10^6$ PSI)	1.8

### THERMAL PROPERTIES\*\*

Thermal Conductivity (BTU/hr/sq ft/°F/in)	1.8 to 2.3
Specific Heat (BTU/lb/°F)	0.27
Coefficient of Thermal Expansion (in/in/°F)	$5.0 \text{ to } 7 \times 10^{-6}$
Heat Resistance, Continuous	200°C

### ELECTRICAL PROPERTIES\*\*

Insulation Resistance (ohm/8" length)	$2.38 \times 10^{12}$
Volume Resistivity (ohm/cm)	$2.41 \times 10^{15}$
Surface Resistivity (ohms)	$2.92 \times 10^{15}$
Dielectric Strength, Short Time (volts/mil) Minimum	500
Dielectric Constant (60 cps)	4.15
Dissipation Factor (60 cps)	0.0094
Impulse (11/2 -40u Wave (Axial) volts/mil)	400 to 550
<b>POWER FACTOR AT 60 cps (100v pct mx)</b>	
As Received	5.0
at 100°C	10.0
After 24 hours at 100°F at 98% rel. hum.	10.0



Available in a variety of standard and custom sizes.

*"Filament winding, braiding, pultrusion and fabrication— all in one organization."*





MEDICAL



BEARINGS



CYLINDERS



ELECTRICAL

*Innovation Beyond Metals™*

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