

Mylar®

polyester film

Electrical Properties

Mylar® offers unique design capabilities to the electrical industry due to the excellent balance of its electrical properties with its chemical, thermal, and physical properties. Detailed descriptions of these latter properties are included in other available bulletins. **Table 1** is a summary of some typical electrical properties; further details on these and other electrical properties are included in the remaining pages of the bulletin.

Dielectric Strength

The short-term dielectric strength test (ASTM D149) is primarily used to measure the quality of a film. This test method allows considerable freedom in the choice of electrode size, environmental conditions, etc. The following discussion of these variables is based on tests run with brass electrodes of the dimensions prescribed in ASTM D2305. In limited testing, stainless steel electrodes gave results similar to those obtained with the standard brass electrodes. The data were obtained at a frequency of 60 Hz, using a 500 V/sec rate of rise, unless otherwise noted.

Film Thickness

As with most materials, the AC Dielectric Strength of Mylar® polyester film in V/mil decreases as film thickness increases (see **Figure 1**). At 500 V/sec rate of rise, corona occurs within a few seconds, and the film begins to melt before the actual breakdown occurs. The greater the film thickness, the more the failure is due to melting and, thus, the lower the V/mil as thickness increases.

Electrode Size

Differences in dielectric strength values may result when comparing 1/4 in and 2 in diameter brass electrodes. Because of the larger film area between the electrodes, the potential for lower dielectric strength values is greater with 2-in electrodes.

Figure 1. Dielectric Strength vs. Thickness (2 in Electrode in air at 25°C [77°F])

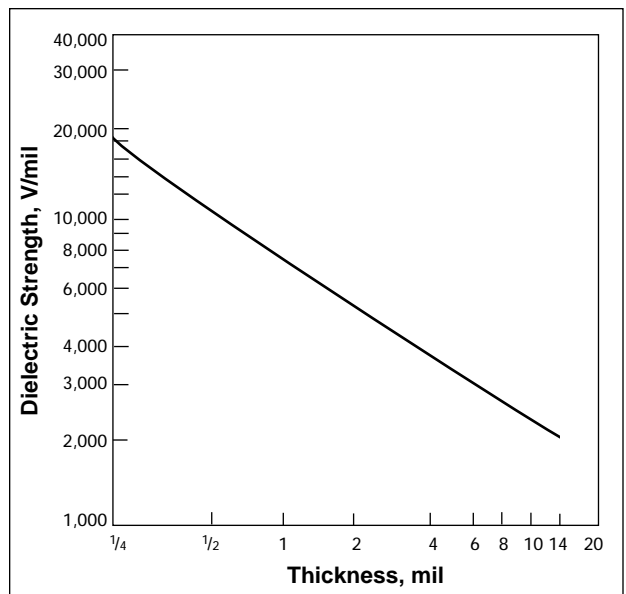


Table 1
Typical Electrical Properties of Mylar® Polyester Film

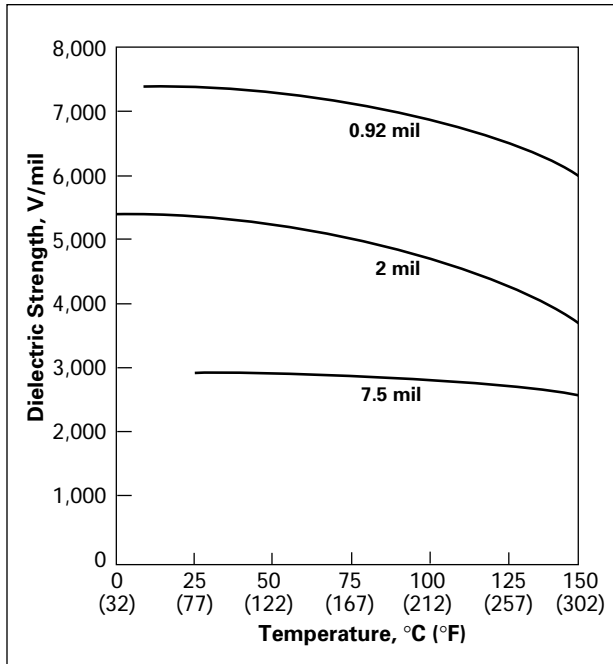
Property	Value	Test Method	
DC Dielectric Strength 25°C (77°F)	Typical Value for Mylar® 92 EL/C* 11.0 kV/mil	1/4 in upper electrode and flat plate lower electrode. 500 V/sec rate of rise	
Gauge and Type at 25°C (77°F)	Minimum Values for Mylar® C Film		
6C	0.225 kV	Minimum average voltage of 20 film-foil capacitors, 0.5 µF each 100 V/sec rate of rise	
7C	0.300 kV		
8C	0.320 kV		
10C	0.490 kV		
12C	0.650 kV		
14C	0.825 kV		
20C	1.500 kV		
24C	2.000 kV		
32C	3.100 kV		
40C	4.100 kV		
48C	4.900 kV		
75C	5.500 kV		
92C	6.000 kV		
AC Dielectric Strength 25°C (77°F)	Typical Value for Mylar® 92 EL/C* 7.0 kV/mil		ASTM D149 and ASTM D2305 60 Hz 500 V/sec rate of rise
Gauge and Type at 25°C (77°F)	Minimum Values for Mylar® EL Film		
48EL	2.8 kV	ASTM D149 and D2305, Minimum average voltage of 10 sheet samples 60 Hz 500 V/sec rate of rise	
75EL	3.5 kV		
92EL	4.0 kV		
142EL	5.5 kV		
200EL	7.7 kV		
300EL	10.0 kV		
500EL	13.5 kV		
750EL	17.5 kV		
900EL	18.4 kV		
1000EL	19.0 kV		
1400EL	20.0 kV		
Dielectric Constant 25°C (77°F)—60 Hz 25°C (77°F)—1 kHz 25°C (77°F)—1 MHz 25°C (77°F)—1 GHz 150°C (302°F)—60 Hz	Typical Value for Mylar® 92 EL/C* 3.3 3.25 3.0 2.8 3.7		ASTM D150
Dissipation Factor 25°C (77°F)—60 Hz 25°C (77°F)—1 kHz 25°C (77°F)—1 MHz 25°C (77°F)—1 GHz 150°C (302°F)—60 Hz -269°C (-452°F)—1 kHz (in Helium)	Typical Value for Mylar® 92 EL/C 0.0025 0.0050 0.016 0.008 0.004 0.0002		ASTM D150
Volume Resistivity 25°C (77°F) 150°C (302°F) (Type C Film)	Typical Value for Mylar® 92 EL/C 10 ¹⁸ ohm-cm 10 ¹³ ohm-cm		ASTM D257 and D2305
Surface Resistivity 23°C (73°F)—30% RH 23°C (73°F)—80% RH	10 ¹⁶ ohm/sq 10 ¹² ohm/sq		
Insulation Resistance 35°C (95°F)—90% RH	10 ¹² ohm		
Capacitor Insulation Resistance 100°C (212°F) 125°C (257°F) 150°C (302°F)	Typical Value for Mylar® 92 C 30,000 MΩ-µF 1,000 MΩ-µF 100 MΩ-µF	Based on 0.5 µF film-foil capacitor sections, using single layer, 92 Mylar®C	

*Data relevant for other types of Mylar®

Temperature

The effect of film temperature on the dielectric strength of Mylar® polyester film is shown in **Figure 2**; there is a slight decrease in dielectric strength from room temperature up to 150°C (302°F).

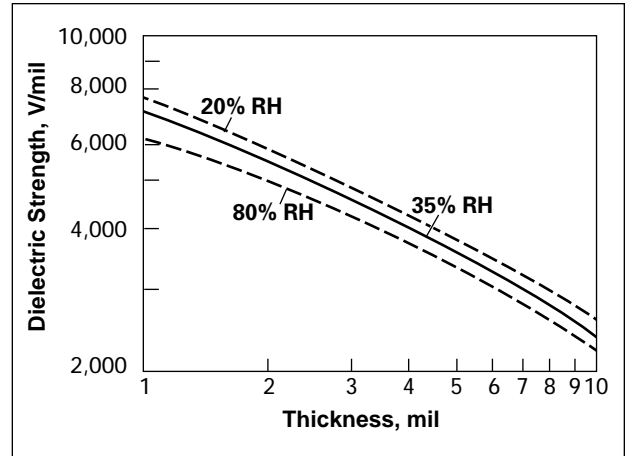
Figure 2. Dielectric Strength vs. Temperature



Humidity

While the dielectric strength of Mylar® is much less sensitive to the humidity of the surrounding air than cellulosic materials, there is a slight effect as shown in **Figure 3**. For films above 2 mil thick, the effect of varying the relative humidity from 20 to 80% causes a maximum change in the dielectric strength of less than $\pm 10\%$ from the value obtained at 35% RH. The absolute differences in dielectric strength as a result of humidity changes appear to be independent of electrode size.

Figure 3. Dielectric Strength at Various Humidities



Frequency and Wave Form

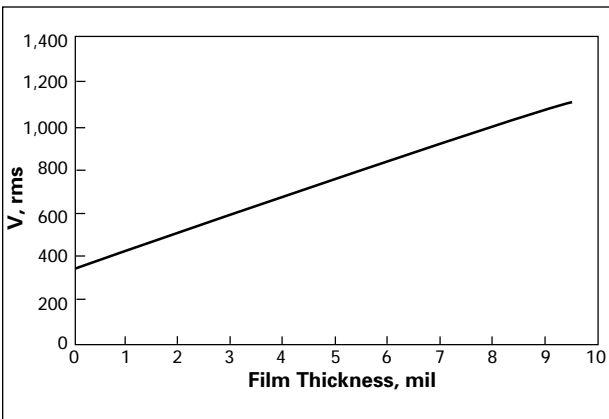
The DC dielectric strength of Mylar® 92 EL varied from 14,000 V at 25°C (77°F) to 12,000 V at 90°C (194°F), 8,000 V at 150°C (302°F), and 5,500 V at 200°C (392°F). These data were obtained with a $\frac{1}{4}$ in upper electrode and a flat plate lower electrode using a 500 V/sec rise.

Deviations from a sinusoidal wave form can have marked effects on the measured dielectric strength at power frequencies. To simulate the effect of transients, impulse strength tests were run using $1.5 \times 40 \mu\text{sec}$ square wave forms and subjecting specimens to five pulses at each voltage. (The voltage was increased by several hundred volts between each set of pulses.) The average impulse strengths were 22 kV for Mylar® 300 EL polyester film and 26 kV for Mylar® 1000 EL when the samples were tested in air.

Corona Threshold Voltage

AC corona, an ion bombardment that causes erosion of a material, is not observed with Mylar® polyester film at AC voltages under the curve of corona threshold voltages plotted in **Figure 4**. In this case, threshold voltage means the level below which corona is not observed at all—either as a starting or extinction voltage. These values were obtained with unimpregnated systems in air, with sharp edge electrodes, at 60 Hz. Most AC systems are designed so that corona is not continuously present. However, the corona resistance of Mylar® is one of the highest of all plastic films. This makes it capable of withstanding the corona that may occur during the short surges of overvoltages common to many electrical systems.

Figure 4. AC Corona Threshold Voltage



In DC systems, corona is seldom of any practical concern. For systems involving both AC and DC, such as a capacitor with a DC bias and an AC component, it is primarily the AC that governs corona. That is, whatever the DC working voltages may be, AC voltages approximately equal to those shown in the curve must be added to the DC before corona is observed.

Impregnation is required for insulation systems that are to be operated continuously at AC voltages above their corona threshold in air. Porous materials, such as paper and cloth, usually require impregnation to attain suitable corona levels. Mylar®, however, requires no impregnation at all, unless

continuous operation is contemplated at AC voltages above those shown in **Figure 4**. In such cases suitable impregnation, by gas or liquid, can result in substantial increases in the AC corona threshold voltages. For example, values as high as 4,000 V rms have been attained with an oil impregnated capacitor that was insulated with 3-mil Mylar®.

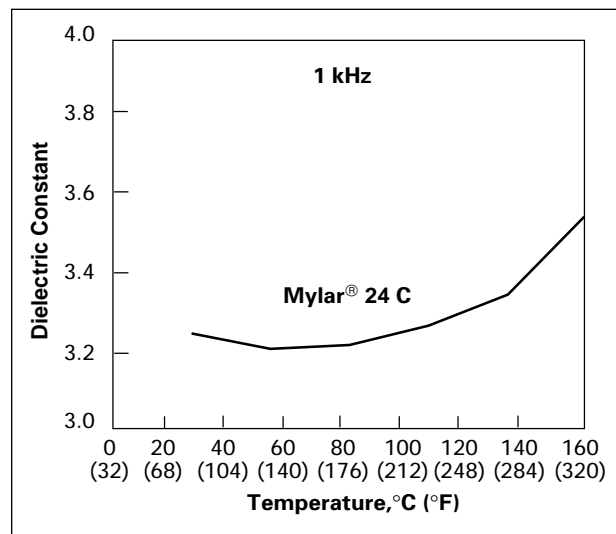
Dielectric Constant

There is no significant difference in dielectric constant between Type EL and Type C films.

Temperature

At a constant frequency, the dielectric constant increases as temperature of the film increases above 65°C (149°F) as shown in **Figure 5**.

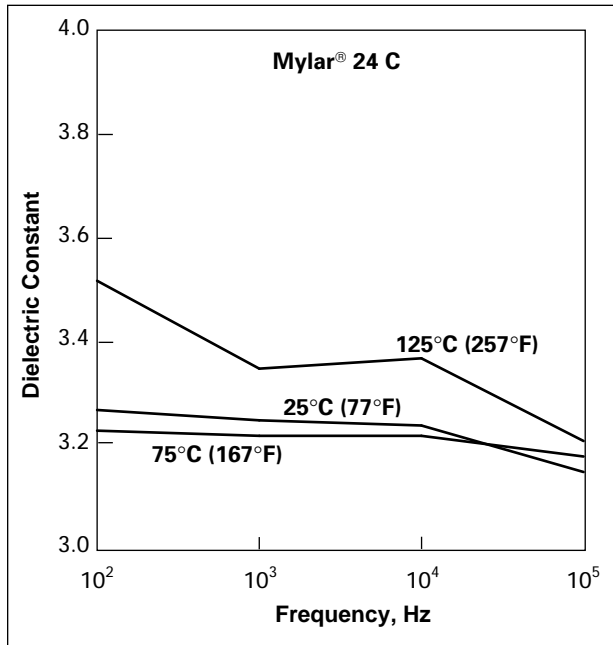
Figure 5. Dielectric Constant vs. Temperature



Frequency

At a constant temperature, the dielectric constant decreases as the frequency increases, as shown in Figure 6.

Figure 6. Dielectric Constant vs. Frequency



Humidity

Tests on flat sheets and unencapsulated capacitors showed that the dielectric constant (at 100 Hz and 1 kHz) of Mylar® polyester film increased by 3% as the relative humidity at 23°C (73°F) increased from 20 to 80%. Suitable encapsulation can greatly reduce the variation of capacitance due to daily fluctuations of humidity.

Dissipation Factor

There is no significant difference in the dissipation factor between Type EL and Type C films.

Temperature

The effect of temperature on the dissipation factor of Mylar® 24 C polyester film at three frequencies is shown in Figure 7.

Frequency

The effect of frequency on the dissipation factor at six different temperatures is shown in Figure 8.

Although it is beyond the range of these figures, at temperatures below 60°C (140°F) the dissipation factor begins to decrease at very high frequencies. For example at 3,000 megacycles (3 GHz), the dissipation factor of Mylar® polyester film is the same as that shown at 60 Hz at 25°C (77°F).

Figure 7. Dissipation Factor vs. Temperature

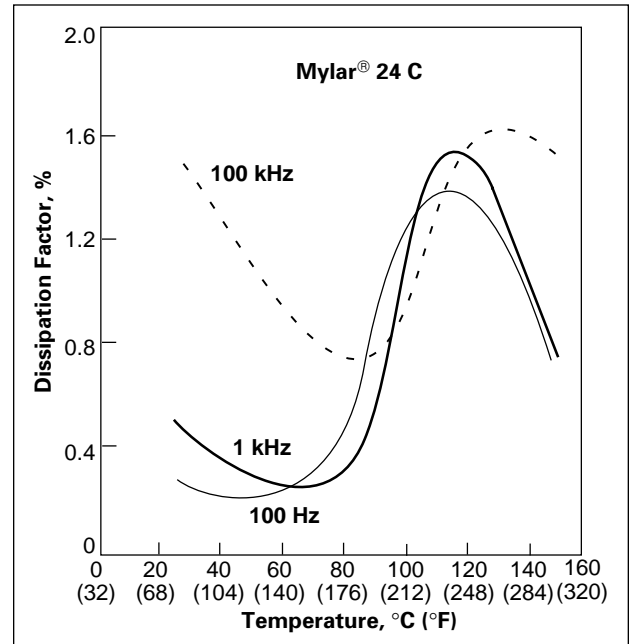
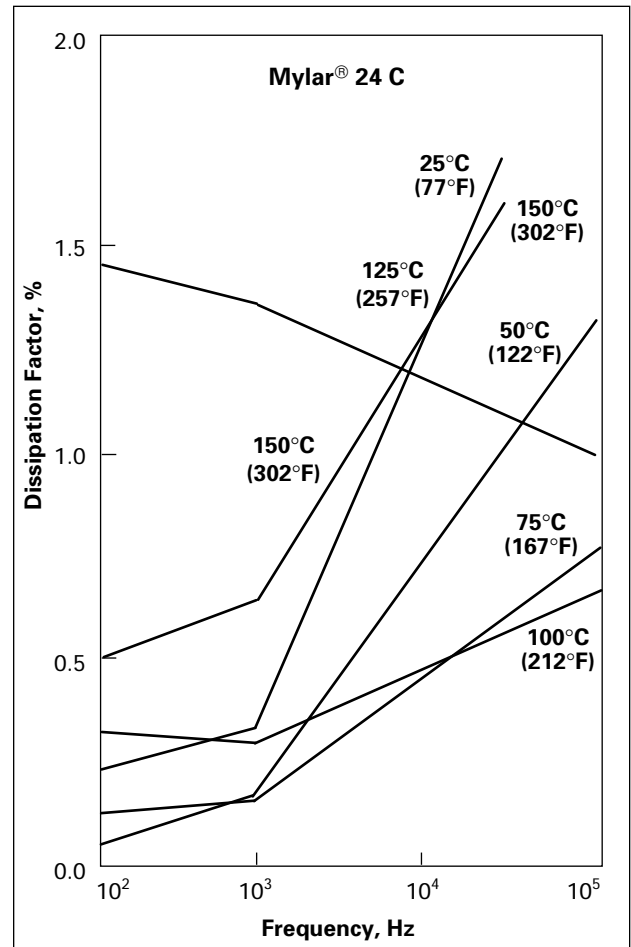


Figure 8. Dissipation Factor vs. Frequency



Humidity

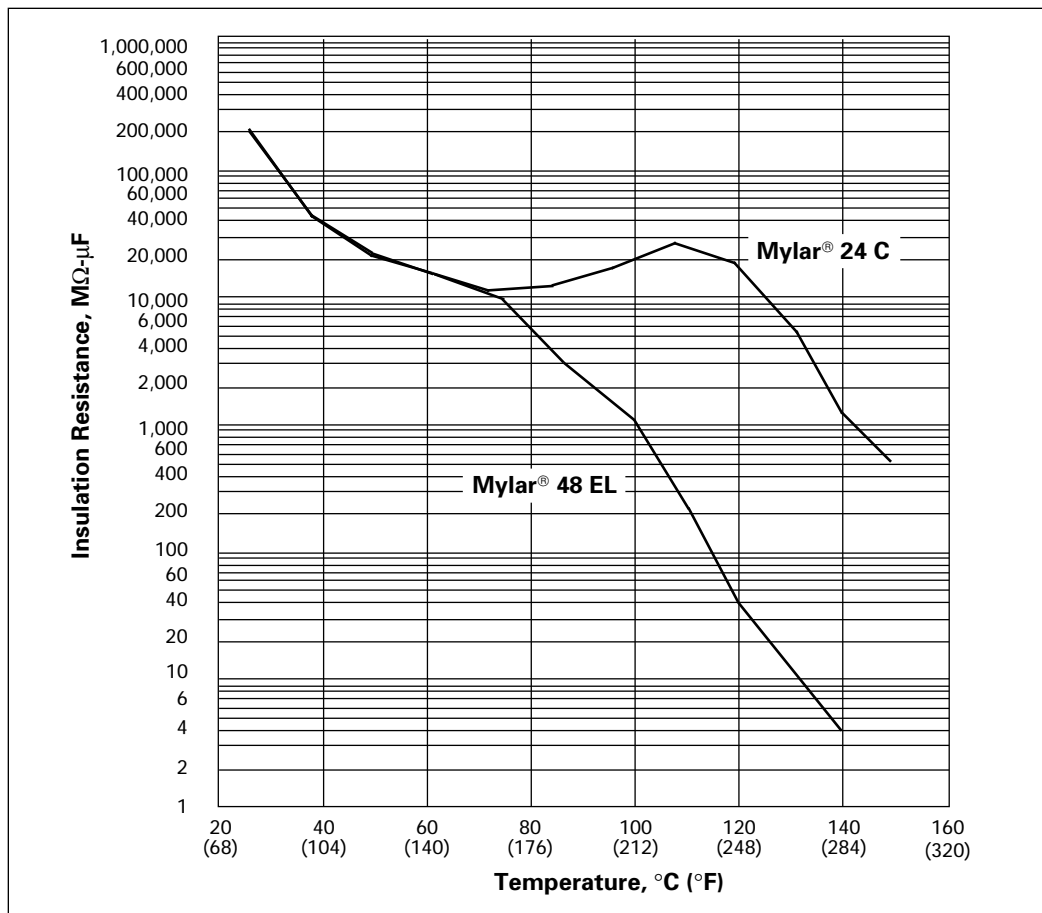
An increase in relative humidity from 20 to 80% at 23°C (73°F) caused an increase in the dissipation factor of 12% at 1 kHz and 40% at 100 Hz.

Insulation Resistance

One of the outstanding properties of Mylar® Type C polyester film is its high insulation resistance over a wide temperature range. Of the commonly used

dielectrics, only polystyrene and polyethylene exhibit a higher resistivity, but their use is limited by a relatively low softening temperature. The effect of temperature on the insulation resistance of Mylar® is shown in **Figure 9**. This study was made using 0.5 μF film-foil capacitors wound with Mylar® 24 C as the dielectric material and measured 100 V DC.

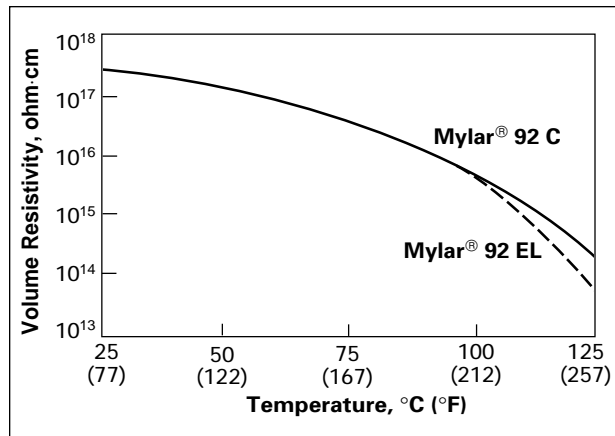
Figure 9. Insulation Resistance vs. Temperature



Volume Resistivity

The volume resistivity of Mylar® was determined by ASTM D257 using 90–100 V DC, 3 min electrification time and 1 in diameter sprayed silver electrodes. As can be seen from **Figure 10**, the volume resistivity decreases as the temperature increases. At 125°C (257°F), Mylar® Type C has about one order of magnitude higher volume resistivity (10^{15} ohm-cm) than Type EL film (10^{14} ohm-cm).

Figure 10. Volume Resistivity vs. Temperature



Tracking Resistance

Although dry Mylar® polyester film does not track, liquid contaminants can result in a tracking erosion of the film. ASTM D2303 was used to measure tracking resistance as determined by the “time to track” 1 in up from the lower of two electrodes. A 0.1% NH_4Cl solution was fed at a rate of 0.1 cc/min along the surface of the film with 1600 V between the electrodes. Under these conditions the “time to track” was 10 min for Mylar® 500 EL and less than 2 min for polypropylene film.

Arc Resistance

Arc resistance tests (ASTM D495) showed that Mylar® did not fail due to the formation of narrow tracks on the surface, but rather by melting with the subsequent formation of a conductive carbonaceous fluid. Mylar® had arc resistance time of 73 to 94 sec as determined by the noticeable change in sound that occurs when the arc disappears from the surface into the material. (This test is designed to indicate the ability of an insulating material to resist high voltage-low current arcs close to the surface of the material. It may not be indicative of the relative arc resistance under other types of arcs such as low voltage-high current arcs, etc.)

The arc resistance tests indicate that Mylar® should have an advantage over materials that track, because momentary overloads of a few seconds would be noncumulative in their effect on Mylar®, provided that there was sufficient time for cooling between arcs.

The Effects of Coatings and Potting Compounds

Some insulation suppliers have developed coatings that result in improvement of the electrical properties of Mylar®. Properties that have been significantly improved by such coatings include: resistance to high temperature aging; cut-through temperature; corona resistance; and reduced variation of insulation resistance, dielectric breakdown strength, capacitance, and dissipation factor due to changes in humidity. However, some varnishes and potting compounds have been found to cause a severe reduction in the dielectric breakdown strength and the resistance to high temperature aging of Mylar®. Therefore, care should be taken that adequate evaluation of a coating is made before it is used.

DuPont Teijin Films
1 Discovery Drive (P.O. Box 411)
Hopewell, VA 23860
Product Information: (800) 635-4639
Fax: (804) 530-9867

These values are typical performance data for Mylar® polyester film; they are not intended to be used as design data. We believe this information is the best currently available on the subject. It is offered as a possible helpful suggestion in experimentation you may care to undertake along these lines. It is subject to revision as additional knowledge and experience is gained. DuPont Teijin Films makes no guarantee of results and assumes no obligation or liability whatsoever in connection with this information. This publication is not a license to operate under, or intended to suggest infringement of, any existing patents.

CAUTION: Do not use in medical applications involving permanent implantation in the human body. For other medical applications, see "DuPont Teijin Films Medical Caution Statement," H-50102-1-DTF.