DuPont Teijin Films

Mylar® - Electrical Properties

Insulated with Mylar®

Mylar® A offers unique design capabilities to the electrical industry due to the excellent balance of its electrical properties with its chemical, thermal and physical properties. 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.

Table 1
Typical Electrical Properties of Mylar® Polyester Film

Film Properties	Unit	Typical Values	Test Method
DC breakdown voltage25°C			
A/23	kV	10	6mm upper electrode, flat plate lower electrode, 500V/sec rate of rise
A/250	kV	24	
AC breakdown voltage 25°C, 50Hz			
A/23	kV	6.4	ASTM D149. ASTM D2305, 500V/sec rate of rise
A/250	kV		
Dielectric Constant			
25°C - 50Hz		3.3	ASTM D150
25°C - 1KHz		3.25	
25°C - 1MHz		3.0	
25°C - 1GHz		2.8	
150°C - 50Hz		3.7	
Dissipation Factor			
25°C - 50Hz		0.0025	ASTM D150
25°C - 1KHz		0.005	
25°C - 1MHz		0.0	
25°C - 1GHz		0.008	
150°C - 50Hz		0.004	
Volume Resistivity			
25°C	Ω/□	10^{18}	ASTM D257, ASTM D2305
Surface Resistivity			
23°C - 30% R.H.	Ω/□	10^{16}	
23°C - 80% R.H.	Ω/□	10^{12}	

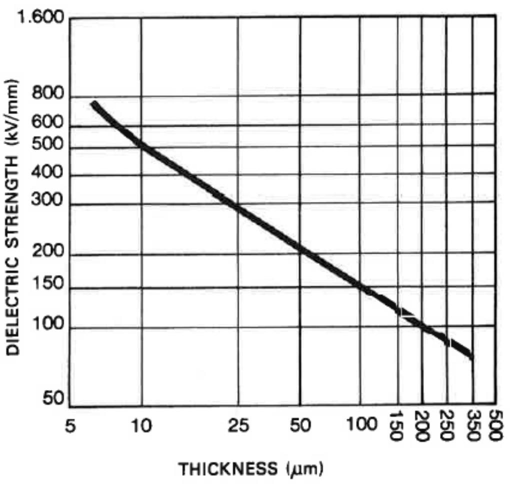
1. **Dielectric Strength**

The short-term dielectric strength test (ASTM D 149) 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 D 2305. The results were obtained at a frequency of 50Hz, using a 500 V/sec rate of rise, unless otherwise noted. Differences in dielectric strength values may result when comparing different electrode sizes because of different active area and/or electrical field geometries.

1.1. **Film Thickness**

The dielectric strength of Mylar® polyester film as a function of film thickness is shown in Figure 1. As with most materials, the AC dielectric strength in kV/mm decreases as the film thickness increases. For instance, 6 µm Mylar® film has a dielectric strength of over 600 kV/mm while 350µm Mylar® has a dielectric strength of about 80 kV/mm at 25°C.

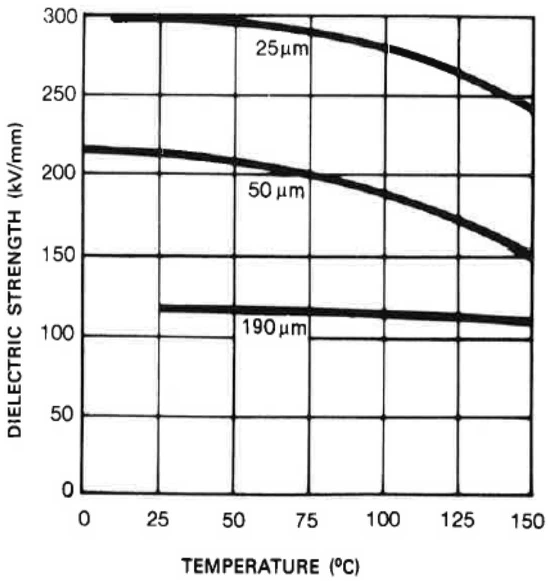
Figure 1
Dielectric Strength vs. Thickness
(50 mm electrode in air at 25°C)



1.2. **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.

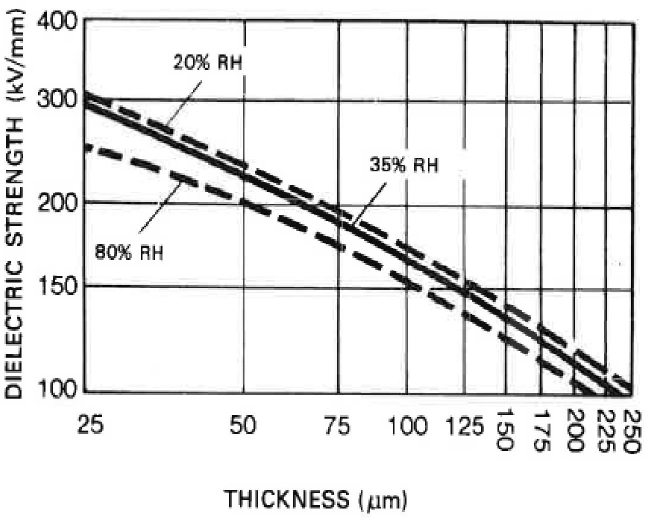
Figure 2
Dielectric Strength vs. Temperature



1.3. **Humidity**

The dielectric strength of Mylar® is just slightly sensitive to the humidity of the surrounding air as shown in Figure 3. For films above 50µm thick, the effect of varying the relative humidity from 20% to 80% causes a maximum change in the dielectric strength of less than ±10% from the value obtained at 35% R.H. 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 Levels of Humidity



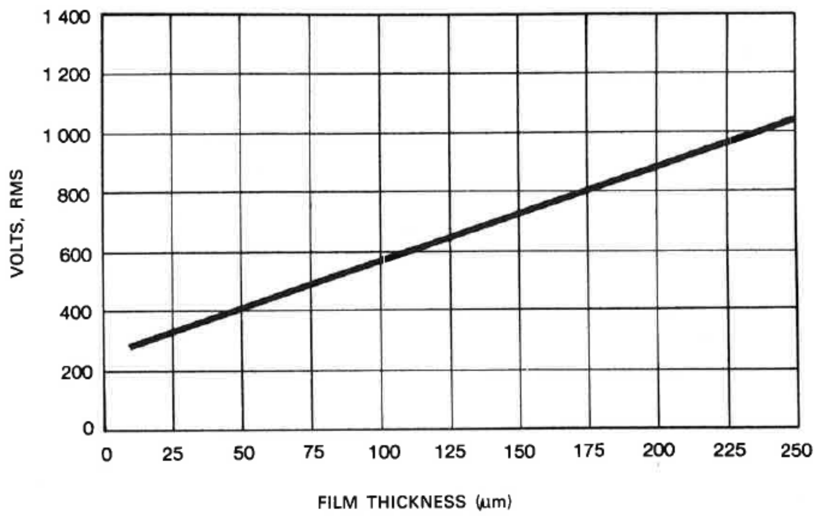
1.4. **Frequency and wave form**

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 x 40 microsecond 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 75µm Mylar® and 26 kV for 250µm Mylar® when the samples were tested in air. The DC dielectric strength of 25µm Mylar® varied from 14.000 volts at 25°C to 12.000 volts at 90°C, 8.000 volts at 150°C, and 5.500 volts at 200°C. These data were obtained with a 6mm upper electrode and a flat plate lower electrode using a 500 volts/second rate of rise.

2. **Corona Threshold Voltage**

AC corona, an ion bombardment which 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 50Hz. Most AC systems are designed so that corona is not continuously present. However, the corona resistance of Mylar® polyester film 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 overvoltage 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.

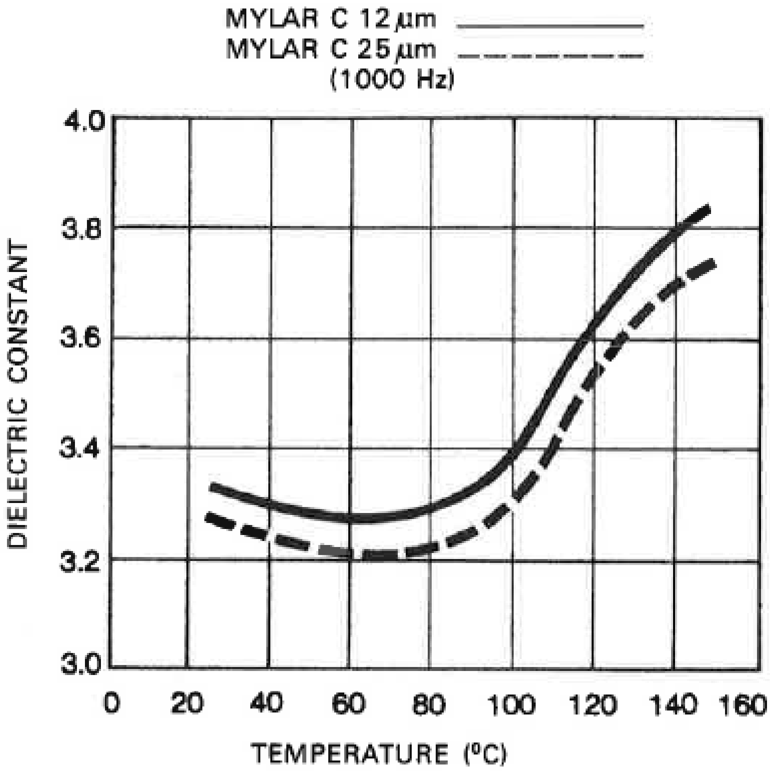
Impregnation is required for insulation systems that are to be operated continuously at AC voltages above their corona threshold in air. Porous materials, such as paper and cloth, usually require impregnation to attain suitable corona levels. Mylar®, however, requires no impregnation at all, unless continuous 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 insulated with 75µm Mylar® film.

3. **Dielectric Constant**

3.1. **Temperature**

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

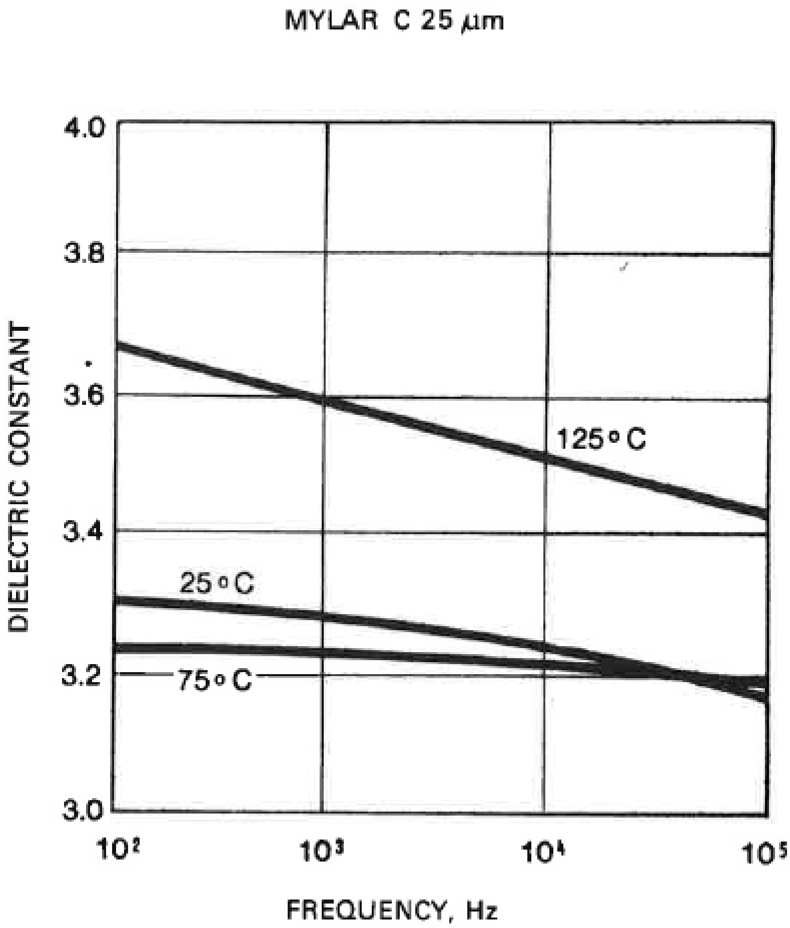
Figure 5
Dieelctric Constant vs. temperature Mylar® C is available 2.5µm to 12µm and Mylar® A in 23µm to 500µm.



3.2. **Frequency**

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

Figure 6
Dielectric constant vs. frequency



3.3. **Humidity**

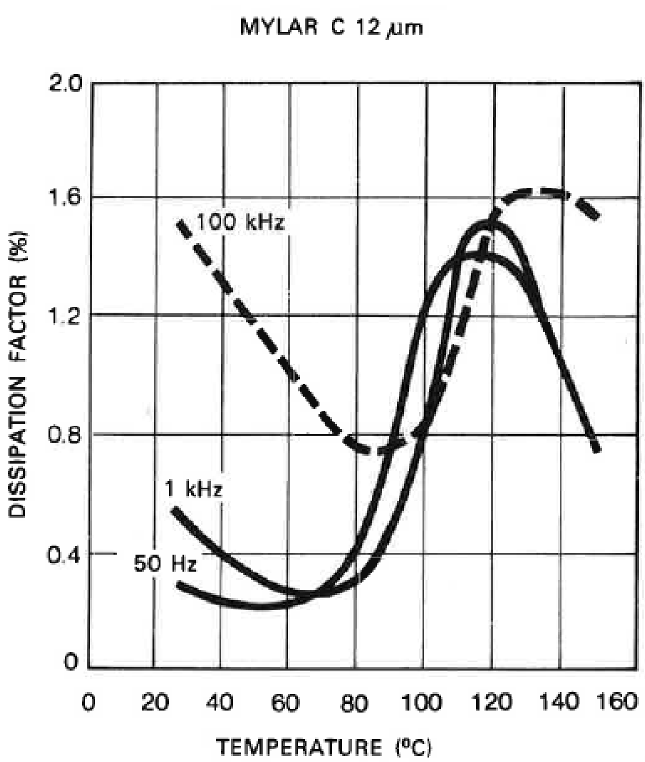
Test on flat sheets and unencapsulated capacitors showed that the dielectric constant (at 100Hz and 1 kHz) of Mylar® polyester film increased by 3% as the relative humidity at 23°C increased from 20% to 80%. Suitable encapsulation can greatly reduce the variation of capacitance due to daily fluctuations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

4. **Dissipation Factor**

4.1. **Temperature**

The effect of temperature on the dissipation factor of Mylar® polyester film in 12µm at three frequencies is shown in Figure 7.

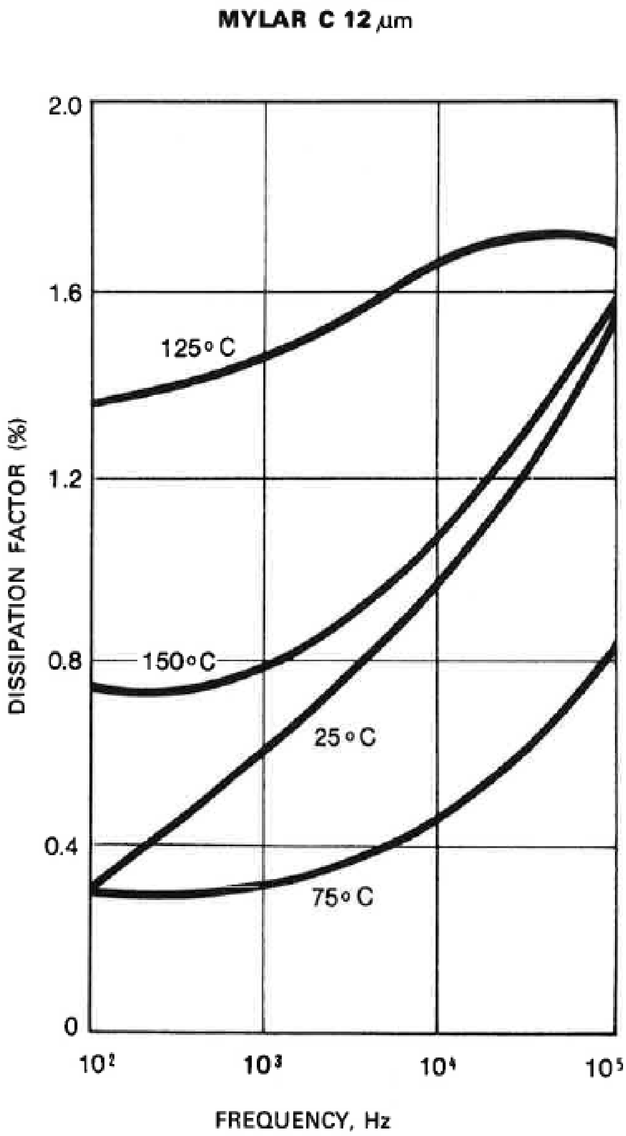
Figure 7
Dissipation factor vs. temperature



4.2. **Frequency**

The effect of frequency on the dissipation factor at four different temperatures is shown in Figure 8. Although it is beyond the range of these figures, at temperatures below 60°C, the dissipation factor begins to decrease at very high frequencies. For example, at 3000 MHz ($3x10^9$ Hz), the dissipation factor of Mylar® polyester film is the same as that shown at 50Hz at 25°C.

Figure 8
Dissipation factor vs frequency



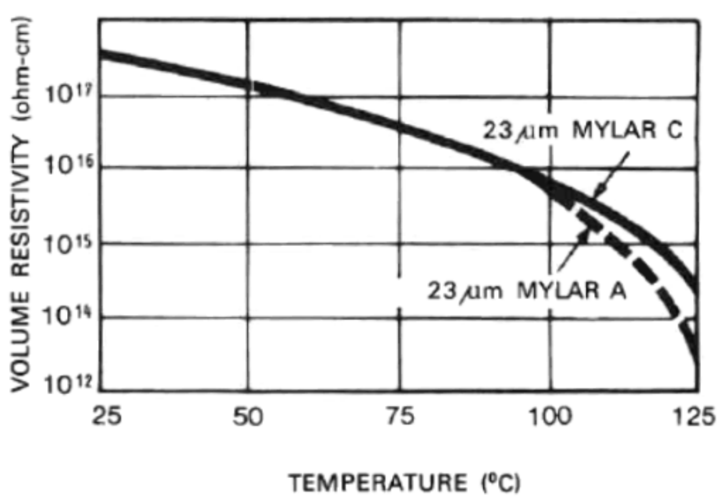
4.3. **Humidity**

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

5. **Volume Resistivity**

The volume resistivity of Mylar® was determined by ASTM D257, using 90-100V DC, three minutes electrification time and 25mm diameter sprayed silver electrodes. As can be seen from Figure 9, the volume resistivity decreases as the temperature increases. At 125°C, Mylar® Type C has about one order of magnitude higher volume resistivity (10^{15} ohm-cm) than type A (10^{14} ohm-cm).

Figure 9
Volume resistivity vs. temperature



6. **Tracking Resistance**

Although dry Mylar® polyester film does not track, liquid contaminants can result in a tracking erosion of the film. ASTM test method D 2303 was used to measure tracking resistance as determined by the "time to track" 25mm 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 minutes for 125µm Mylar® A and less than 2 minutes for polypropylene film.

7. **Arc Resistance**

Arc resistance tests (ASTM D 495) showed that Mylar® film 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 times of 73 to 94 seconds as determined by the noticeable change in sound which 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).

The arc resistance tests indicate that Mylar® polyester film 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.

8. The effect of Coatings and Potting Compounds

Some insulation suppliers have developed coatings that result in an improvement of the electrical properties of Mylar® polyester film. 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® polyester film. Therefore, care should be taken that adequate evaluation of a coating is made before it is used.

9. Further Information

In addition to above information, the Underwriters Laboratory has undertaken a number of tests of Mylar® A in order to certify specific properties of the film.
Information on these results can be found on the UL website (http://www.ul.com/) under our UL number: UL File 93687.

We have benchmarked Mylar® A against other polyester films available in the market and the results, showing best in class properties, are available in our *Electrical Insulation* brochure on our website: http://europe.dupontteijinfilms.com/

Please contact your DuPont Teijin Films representative or contact us through the website for more information about the individual Mylar® products.

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