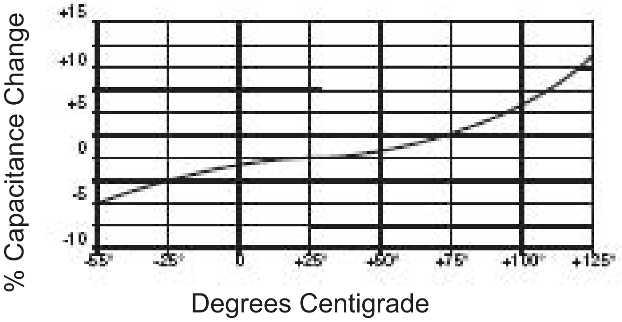
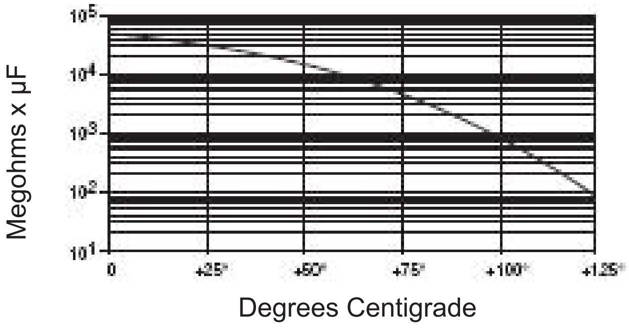
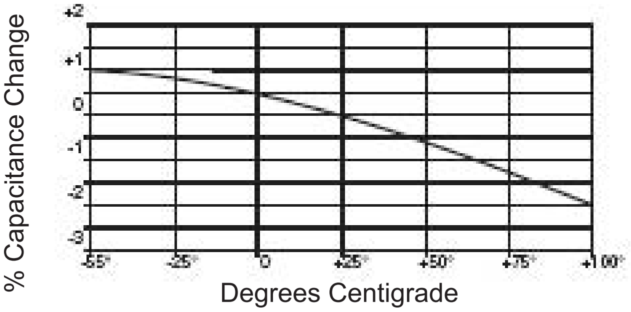
Capacitance Change vs. Temperature   Insulation Resistance vs. Temperature

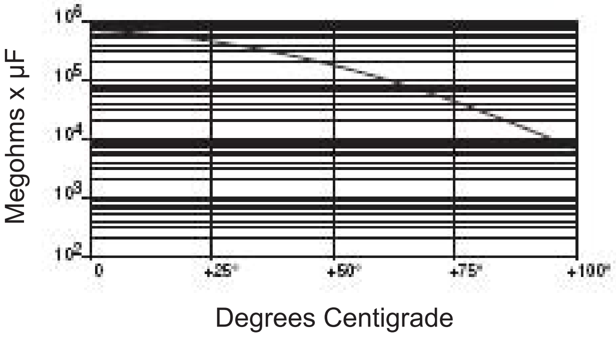
Polyester Typical Characteristics at 1 kHz



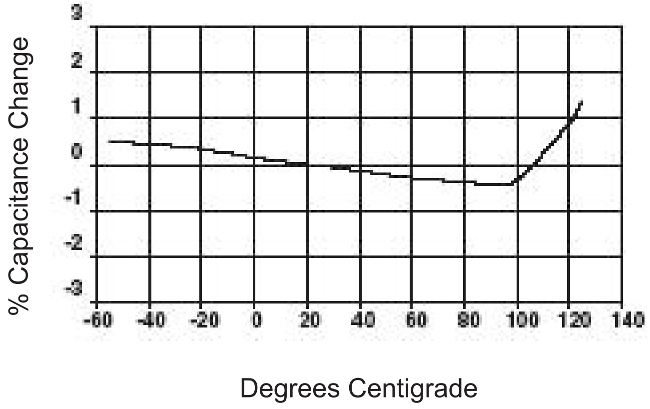


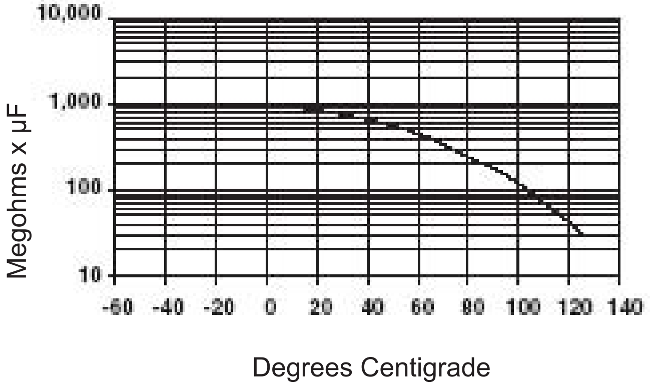
Polypropylene Typical Characteristics at 1 kHz





Polyphenylene Sulfide Typical Characteristics at 1 kHz

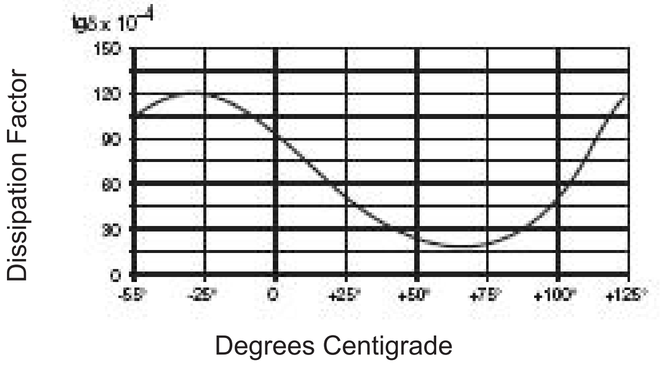


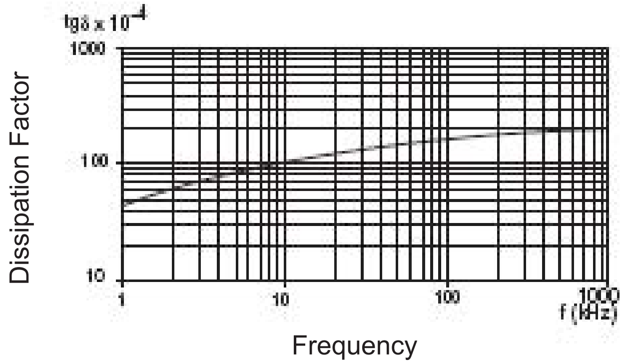


Dissipation Factor vs. Temperature

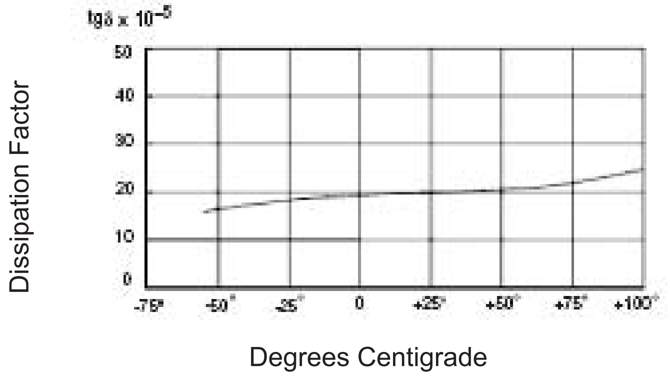
Dissipation Factor vs. Frequency

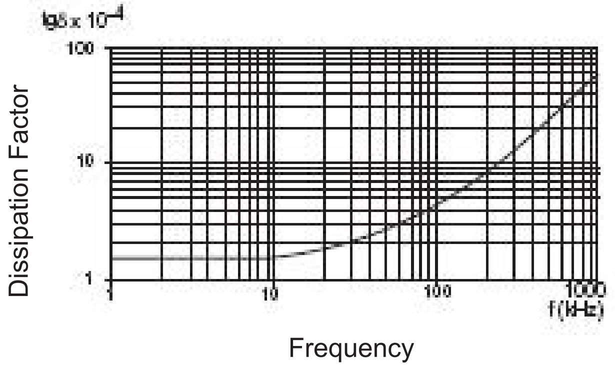
Polyester Typical Characteristics



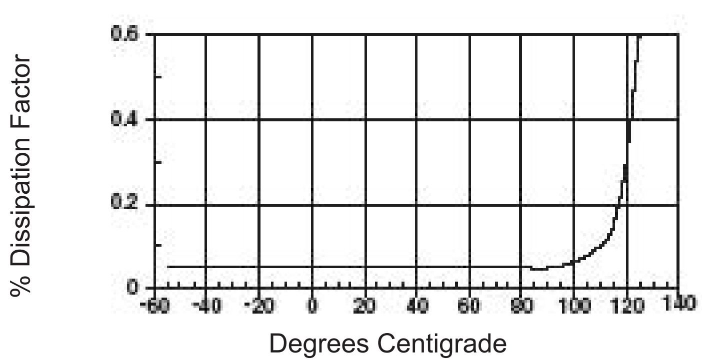


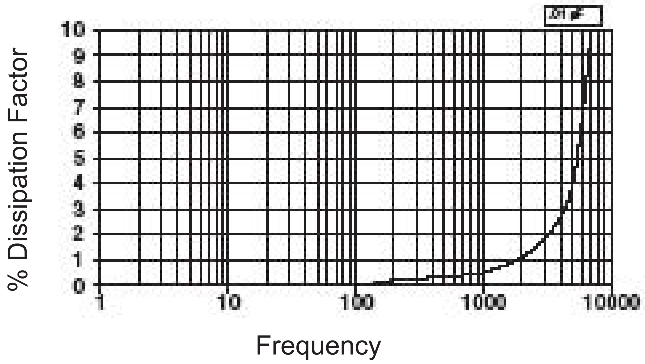
Polypropylene Typical Characteristics





Polyphenylene Sulfide Typical Characteristics





Capacitance is within tolerance when measured at 1 kHz ±20 Hz (120 Hz for polyester if C >1 µF) and 25 °C ±5 °C. Standard tolerance is ±10%.

Dissipation Factor or tan σ is the ratio of the capacitor's ESR to its reactance. It's no more than specified when measured at 1 kHz ±20 Hz (120 Hz for polyester if C>1 µF) and 25 ±5 °C.

Insulation Resistance changes from a minimum resistance capacitance product (MΩ•µF) to a minimum resistance (MΩ) for rated capacitances above 0.25 to 0.5 µF, depending on the capacitor type. It is no less than the lesser of the RC product or the R specified, when measured at 100 Vdc after 2 minutes and at 25 ±5 °C.

Rated Voltage is the maximum continuous voltage for actual use up to the rated maximum operating temperature.

Dielectric Strength is the maximum peak voltage that the capacitor is rated to withstand at room temperature. Test by applying the specified multiple of rated voltage for one minute through a current limiting resistance of 100 Ω per volt. As an illustration, to test a Type DPM capacitor rated 250 Vdc and 175% dielectric strength, apply 438 Vdc through a 43.8 kΩ or higher value resistor.

Life Test: Subject capacitors to rated maximum temperature ±3 °C with the specified multiple of rated voltage applied for 500 or 1,000 (+72, -2) hours as specified. There will be no visual damage and the capacitance will not have changed more than ±5%. Insulation resistance will not decrease to less than 50% of initial limit. Dissipation factor will not increase to more than initial limit.

Pulse Capability is peak-current Capability. The ability of the capacitor to withstand current transients is set largely by the integrity of the lead connections and is indicated by the dV/dt rating, the maximum permitted rate of change of voltage in V/µs. The peak current rating in amps is the rated capacitance in µF times the dV/dt rating:

$$\text{Ipk} = C(dV/dt)$$

Marking includes part number, capacitance in µF, tolerance in %, manufacturer and rated voltage in Vdc and Vac. Small units may include only Type, CD, capacitance in pF and a tolerance code. Example: "DLMCD" and "682K" means Type DLM, 6800 pF ("2" is the number of zeroes) and 10%.

When used, tolerance codes are:

F = ± 1%
G = ± 2%
H = ± 6%
I = ± 3%
J = ± 5%
K = ±10%
M = ±20%

Metallized vs. Film/Foil Construction. Here's how to choose. For a metallized film capacitor, the capacitor plates are aluminum sprayed onto the dielectric film by thin-film vacuum deposition. Compared to making the capacitor with separate foil and film sheets, metallizing enables smaller size, lighter weight, lower cost per microfarad and self-healing, but it also engenders lower current capability. Smaller size and cost is especially striking in high capacitance ratings.

Self healing refers to an internal short circuit from an overvoltage transient or a fault in the film which clears in microseconds by vaporizing the aluminum metallizing at the fault site. There is a glitch in the applied voltage, but the capacitor suffers no permanent damage save a negligible reduction in capacitance. The advantages make CDE metallized film capacitors the correct high-value choice for all applications except four:

- low capacitance, less than .01 µF, where size difference is not significant and the film/foil material cost is less,

- high continuous current as in a resonant circuit,

- high-transient current as in a snubber circuit, and

- low noise where self clearing is a problem with its attendant, albeit rare, volts of noise.

Polyester Dielectric: Just as metallized is usually the CDE construction of choice, so too, polyester is usually the dielectric film material of choice. Of the three CDE dielectrics, polyester has the highest dielectric constant and delivers the lowest cost, smallest size capacitors with the bonus of being able to operate to 125 °C at half rated voltage. However, with a DF hovering at 1% at higher temperatures, power dissipation prevents its choice for high current or high-frequency AC voltage applications, and with about a 5% capacitance change from –55 °C to 0 °C and from 50 °C to 125 °C, polyester is not the choice for precision capacitance at temperature extremes. But notice that capacitance changes only ±1% from 0 °C to 50 °C.

Polypropylene Dielectric with its low dissipation factor empowers CDE capacitors for high-current DC, high-voltage AC and high-frequency AC applications. And its high insulation resistance and low dielectric absorption are a fit for precision DC capacitors. It would displace polyester in many applications except its low dielectric constant and unavailability of thin-gauge films produces larger case sizes and prices. A slight handicap — its maximum operating temperature is 105 °C.

Polypropylene fits many of the applications polyester misses. It even complements polyester in wide temperature applications: capacitance decreases with temperature at about the same rate as capacitance increases for polyester capacitors, so a polypropylene capacitor in parallel with a polyester spawns a temperature-compensated capacitor.

Polyphenylene Sulfide is for precision capacitance and wide temperature applications. Able to operate from –55 °C to 125 °C and hold capacitance change to less than 1% over all but the extremes of the range, polyphenylene sulfide is the preferred precision-capacitor dielectric and is the dielectric film in FCP chip capacitors.

AC Voltage Operation: You can use all CDE film capacitors with either AC or DC voltages or a combination of the two. The rules for successful application are: 1) don't exceed the dielectric's voltage capability; 2) keep the capacitor cool, and 3) don't operate with corona. As a practical matter, here's how you do those three rules.

Limit the voltage peaks to the rated DC voltage. Limit the current peaks to the rated capacitance times the dV/dt rating. For high-frequency operation limit the power dissipated so that the case-temperature rise is no more than 15 °C and at high temperatures the case temperature no greater than the maximum operating temperature. The maximum high frequency sine wave voltage for a 15 °C rise may be calculated using the following formulas:

Round cases:

$$V_{RMS} = \sqrt{\frac{11(.5\pi D^2 + \pi DL)}{2\pi f C \bullet DF(\%)}}$$

Oval cases:

$$V_{RMS} = \sqrt{\frac{21(TH + TL + HL)}{2\pi f C \bullet DF(\%)}}$$

D, T, H, and L are dimensions taken from the ratings dimensions chart.

DF is dissipation factor in percent at operating frequency taken from the DF vs. Frequency charts which appear two pages back.

And for rule 3, limit the applied voltage to the maximum AC rating listed for each type to avoid corona.

Corona is partial breakdown of the dielectric by sparking across air voids in the insulation system. It occurs with the application of AC voltage because the effective "capacitance" of the voids is lower than the surrounding dielectric material. Like low-value capacitors connected in series with high-value ones, the voids get higher voltage gradients and they break down. Corona is to be avoided because the sparking tends to carbonize the dielectric which converts it to conductive material and eventually a carbon track can short the capacitor.

Comparison of Dielectrics

Dielectric	Best Tolerance	Change –25 to 85 ºC	Change/ Year	Typical DF	Typical DA*	IR	Size 1 μF/100 V
Polyester, Metallized	±5%	+5%	0.40%	0.50%	0.40%	30 GΩ	0.09 in^{3}
Polypropylene, Metallized	±1%	–3%	0.10%	0.10%	0.05%	100 GΩ	0.13 in^{3}
Polyphenylene Sulfide (PPS), Metallized	±2%	±0.5%	<1%	0.20%	0.08%	3 GΩ	0.09 in^{3}
Polyester, Film/Foil	±5%	+5%	0.40%	0.50%	0.35%	100 GΩ	0.40 in^{3}
Polypropylene, Film/Foil	±1%	–3%	0.20%	0.05%	0.03%	200 GΩ	0.71 in^{3}

* Dielectric absorption — a measure of energy stored in the dielectric. Needs to be low for sample-and-hold circuit applications to avoid voltage rebound