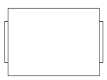
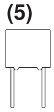
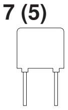
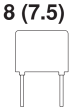
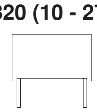
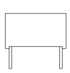
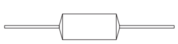
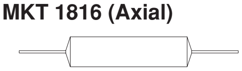
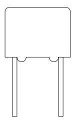
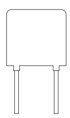
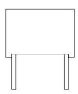
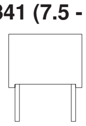
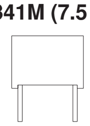
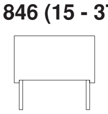
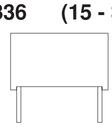
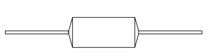
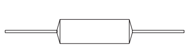
Film Capacitors
Certified Acc. to QS 9000 and ISO 9001

POLYESTER FILM CAPACITORS

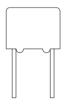
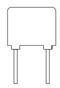
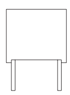
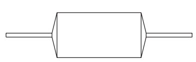
TYPE (PCM) STYLE	CAPACITANCE RANGE TOLERANCE	RATED VOLTAGE	CONSTRUCTION	STANDARDS	PAGE
MKT 1824 (SMD) 	0.01µF - 1µF ± 5% ± 10% ± 20%	40 VDC - 63 VDC	Stacked Metallized Film	IEC 60384-19 CECC 32 200	49
MKT 1826 (5) 	1000pF - 4.7µF ± 5% ± 10% ± 20%	40 VDC - 250 VDC	Stacked Metallized Film	IEC 60384-2 CECC 30 401- 059	52
MKT 1817 (5) 	1000pF - 1.0µF ± 5% ± 10% ± 20%	63 VDC - 400 VDC	Metallized Film	IEC 60384-2 CECC 30 400	35
MKT 1818 (7.5) 	1000pF - 1µF ± 5% ± 10% ± 20%	63 VDC - 630 VDC	Metallized Film	IEC 60384-2 CECC 30 400	38
MKT 1820 (10 - 27.5) 	1000pF - 15µF ± 5% ± 10% ± 20%	63 VDC - 1000 VDC	Metallized Film	IEC 60384-2 CECC 30 400	41
MKT 1822 (10 - 27.5) 	1000pF - 15µF ± 5% ± 10% ± 20%	63 VDC - 1000 VDC	Metallized Film	IEC 60384-2 CECC 30 401- 023	45
MKT 1813 (Axial) 	470pf - 22µF ± 5% ± 10% ± 20%	63 VDC - 1000 VDC	Metallized Film	IEC 60384-2 CECC 30 401- 064	29
MKT 1816 (Axial) 	680pF - 0.01µF ± 10% ± 20%	8 KVDC - 15 KVDC	Metallized Film	IEC 60384-2 CECC 30 400	33

POLYPROPYLENE FILM CAPACITORS

TYPE (PCM) STYLE	CAPACITANCE RANGE TOLERANCE	RATED VOLTAGE	CONSTRUCTION	STANDARDS	PAGE
KP 1830 (5) 	100pF - 0.033µF ± 1% ± 2.5% ± 5% ± 10%	63 VDC - 630 VDC	Film/Foil	IEC 60384-13 CECC 31 800	57
MKP 1837 (5) 	0.01µF - 0.1µF ± 1% ± 2.5% ± 5% ± 10%	160 VDC	Metallized Film	IEC 60384-16 CECC 31 200	64
MKP 1840 (5 - 37.5) 	4700pF - 10µF ± 5% ± 10% ± 20%	100 VDC - 630 VDC	Metallized Film	IEC 60384-16 CECC 31 200	69
MKP 1841 (7.5 - 37.5) 	470pF - 6.8µF ± 5% ± 10% ± 20%	160 VDC - 2000 VDC	Double-Sided Metallized Film	IEC 60384-16 CECC 31 200	72
MKP 1841M (7.5 - 37.5) 	470pF - 4.7µF	250 VDC - 2000 VDC	Double-Sided Metallized Film	IEC 60384-16 CECC 31 200	76
MKP 1846 (15 - 37.5)* 	1000pF - 0.68µF ± 5% ± 10% ± 20%	630 VDC - 2000 VDC	Double-Sided Metallized Film	IEC 60384-16 CECC 31 200	85
KP 1836 (15 - 37.5) 	100pF - 0.22µF ± 5% ± 10%	630 VDC - 2000 VDC	Film/Foil with Double-Sided Metallized Carrier Film	IEC 60384-17 Grade 12	59
MKP 1839 (Axial) 	1000pF - 10µF ± 1% ± 2.5% ± 5% ± 10%	160 VDC - 630 VDC	Metallized Film	IEC 60384-16 CECC 31 200	66
MKP 1845 (Axial) 	1000pF - 4.7µF ± 5% ± 10% ± 20%	160 VDC - 2000 VDC	Double-Sided Metallized Film	IEC 60384-16 CECC 31 200	80

*Not for new designs

POLYCARBONATE FILM CAPACITORS

TYPE (PCM)	**CAPACITANCE RANGE**	**RATED**	**CONSTRUCTION**	**STANDARDS**	**PAGE**
STYLE	**TOLERANCE**	**VOLTAGE**			
KC 1850 (5)* 	220pF - 10,000pF ± 5% ± 10% ± 20%	63 VDC - 160 VDC	Film/Foil	IEC 60384-12 CECC 31 700	91
MKC 1858 (5)* 	0.01µF - 0.33µF ± 5% ± 10% ± 20%	63 VDC - 100 VDC	Metallized Film	IEC 60384-6 CECC 30 500	94
MKC 1862 (10 - 27.5)* 	0.01µF - 10µF ± 5% ± 10% ± 20%	63 VDC - 400 VDC	Metallized Film	IEC 60384-6 CECC 30 500	99
MKC 1860 (Axial)* 	0.01µF - 10µF ± 5% ± 10%	63 VDC - 400 VDC	Metallized Film	IEC 60384-6 CECC 30 500	96

*Not for new designs

Film Capacitors

FILM CAPACITORS

Plastic film capacitors are generally subdivided into film/foil capacitors and metallized film capacitors.

FILM/FOIL CAPACITORS

Film/foil capacitors basically consist of two metal foil electrodes that are separated by an insulating plastic film also called dielectric. The terminals are connected to the end-faces of the electrodes by means of welding or soldering. Film/foil capacitors are typically manufactured in C-values ranging from 100pF to 0.01µF.

Main features: High insulation resistance, excellent current carrying and pulse handling capability and a good capacitance stability.

METALLIZED FILM CAPACITORS

The electrodes of metallized film capacitors consist of an extremely thin aluminum layer (0.02µm - 0.1µm) that is vacuum deposited either onto the dielectric film or onto a carrier film.

The dielectric film materials currently used in production range from 0.9µm to 20µm. The opposing and extended metallized film layers of the wound capacitor element are connected to one another by flame spraying different metals to the end-faces. The metal spraying process is also known as schooping. The terminals are connected to the end-faces by means of welding or soldering.

For the production of metallized film capacitors Vishay Roederstein uses both the conventionally wound film and the stacked film (multilayer) technology. Stacked film capacitors, compared with wound film capacitors, exhibit a higher pulse load.

Metallized film capacitors are typically manufactured in C-values ranging from about 1000pF to 10µF.

Main features: High volume efficiency, self-healing properties.

SPECIAL CAPACITOR DESIGNS

For high current applications Vishay Roederstein is also able to offer special designs such as capacitors with a heavy edge metallization or a double sided metallization as well as combinations that have a film/foil and a metallized film design in one unit. For high voltage applications it is furthermore possible to offer designs with dual and multiple sections.

Depending on the design these capacitors provide low losses, high current and pulse carrying capabilities, high voltages, small dimensions and good self-healing properties.

SELF-HEALING

Self-healing, also known as clearing, is the removal of a defect caused by pinholes, film flaws or external voltage transients. The heat generated by the arcing during a breakdown, evaporates the extremely thin metallization of the film around the point of failure, thereby removing and isolating the short circuit conditions.

Stacked film capacitors exhibit due to their homogeneous and their relatively low winding-pressure between the layers outstanding self-healing properties.

The self-healing process requires only µW of power and a defect is normally isolated in less than 10µs. Extensive and continuous self-healing (e.g. at misapplications) will gradually decrease the capacitance value.

DIELECTRIC MATERIALS

The electrical characteristics of plastic film capacitors are to a great extent dictated by the properties of their dielectric materials. Vishay Roederstein uses the following film materials in their production:

POLYETHYLENE TEREPHTALATE FILM OR POLYESTER FILM (PET)

Polyester film offers a high dielectric constant, and a high dielectric strength. It has further excellent self-healing pro- perties and a good temperature stability. The temperature coefficient of the material is positive.

Polyester capacitors are regarded as “general purpose capacitors”. They provide the best volume efficiency of all film capacitors at moderate cost and are preferably used for DC applications such as decoupling, blocking, bypassing and noise suppressions.

POLYPROPYLENE FILM (PP)

Polypropylene film has superior electrical characteristics. The film features very low dielectric losses, a high insulation resistance, a low dielectric absorption, and a very high dielectric strength. The film provides furthermore an excellent moisture resistance and a very good long-term stability. The temperature coefficient of the material is negative.

Polypropylene capacitors are typically used in AC and pulse applications at high frequencies (e.g. fly-back tuning and S-correction). They are further used in switched mode power supplies, electronic ballasts and snubber applications, in frequency discrimination and filter circuits as well as in energy storage, and sample and hold applications.

POLYCARBONATE FILM (PC)

Polycarbonate film exhibits low dielectric losses, and a very good long term stability. Its temperature coefficient is very low.

Polycarbonate film capacitors are preferably used in filter, timing and integrating applications.

DIELECTRIC PROPERTIES (TYPICAL VALUES)

PARAMETER	PET	PP	PC
Relative Dielectric Constant	3.2	2.2	2.8
DF at 1kHz (tan δ in %)	0.5	0.02	0.1
IR (Megohm x μF)	25,000	100,000	25,000
Dielectric Absorption (%)	0.2	0.05	0.1
Capacitance Drift ΔC/C (%)	1.5	0.5	1.0
Moisture Absorption (%)	0.4	0.01	0.3
Maximum Temperature (°C)	125	100	125
TC (ppm/°C)	+ 400, ± 200	- 200, ± 100	0, ± 100

PET = Polyethylene Terephthalate (Polyester), PP = Polypropylene, PC = Polycarbonate.

DEFINITIONS

The following definitions apply to both film/foil capacitors and metallized film capacitors.

RATED VOLTAGE (U_R)

The rated voltage is the voltage for which the capacitor is designed. It is defined as the maximum DC or AC (RMS) voltage or the pulse voltage that may continuously be applied to the terminals of a capacitor up to an operating temperature of + 85°C. The rated voltage is dependent upon the property of the dielectric material, the film thickness and the operating temperature.

Above + 85°C, but without exceeding the maximum temperature, the rated voltage has to be derated in accordance to the dielectric material used. For details, please refer to the individual data sheets of this catalog.

TEST VOLTAGE OR DIELECTRIC STRENGTH

The test voltage of a capacitor is higher than the rated DC voltage and may only be applied for a limited time.

The dielectric strength is measured between the electrodes with a test voltage of 1.6 x U_R at metallized film capacitors and of 2.0 x U_R at film/foil capacitors. The time applied is typically two seconds.

The occurrence of self-healing or clearing-effects during the application of the test voltage is permitted for metallized film capacitors.

AC VOLTAGE

The AC voltage ratings in this catalog refer to clean sinusoidal voltages without transients. The capacitors in this catalog must not, therefore, be operated in mains applications (e.g. across the line). This applies also to capacitors that are rated with AC voltages ≥ 250 VAC.

Capacitors especially designed for mains operations (X- and Y-Capacitors) are listed in our catalog “RFI Suppression Capacitors”. For operations in the higher frequency range the applied AC voltage has to be derated. The derated AC voltages are provided in the graphs “Permissible AC Voltage Versus Frequency” of this catalog.

The calculations of the graphs are based on the assumption that the temperature rise measured on the surface of the capacitor under working conditions do not exceed 10°C.

$$Pd = U_{RMS}^2 * 2 * \pi * f * C * \tan\delta * 1000 \text{ (mW)}$$

$$\Delta\vartheta = \frac{Pd}{d * \beta + A * \alpha} \text{ (°C)}$$

Pd = Dissipation Power (mW)
U_{RMS} = Applied RMS-Voltage (V)
f = Frequency (Hz)
C = Capacitance (F)
tan δ = Dissipation factor at frequency (f) (For non-sinusoidal voltages the tan δ corresponding to the frequency with the steepest voltage gradient is to be applied)
$\Delta\vartheta$ = Temperature rise caused by the working conditions (°C)
β = Heat dissipation coefficient of the lead wire material [mW/(°C*mm)] (β = 7.9 for Cu)
d = Lead wire diameter (mm)
A = Surface of the capacitor body (cm^2)
α = Heat transfer coeff. [mW/(°C*cm^2)] (α = 0.96 for plastic boxes with a smooth surface)

For critical applications, please forward your voltage and current waveforms (worst case conditions) for our type proposal.

SUPERIMPOSED AC VOLTAGE

When an AC voltage is superimposed to a DC voltage, the sum of both the DC voltage (U_{DC}) and the peak value of the AC voltage (U_{PK}) must not exceed the rated DC voltage [$U_{R(DC)}$] of the capacitor.

$$U_{R(DC)} \geq U_{DC} + U_{PK}$$

PULSE VOLTAGE

The RMS value of a pulse voltage [$U_{RMS(pulse)}$] must not exceed the rated AC voltage $U_{R(AC)}$.

$$U_{R(AC)} \geq U_{RMS(pulse)}$$

The peak value of the pulse voltage (U_{PK}) must not exceed the rated DC voltage.

$$U_{R(DC)} \geq U_{PK}$$

RATED CAPACITANCE (C_R)

The rated capacitance is defined as the capacitive part of an equivalent series circuit consisting of capacitance and equivalent series resistance (ESR).

C_R is the capacitance for which the capacitor is designed. It's value is typically measured at a frequency of 1kHz ± 20%, a voltage of 0.03 x U_R (Max. 5 VAC) and a temperature of 20°C. The capacitance values in this catalog are graded to the E 6 or E 12 series (DIN IEC 60063).

The capacitance tolerance indicates the acceptable deviation from the rated capacitance at 20°C.

Since the dielectric constant of plastic film is frequency dependent, the capacitance value will decrease with increasing frequency. High relative humidity may increase the capacitance value. Capacitance changes due to moisture are reversible.

CAPACITANCE DRIFT (LONG TERM STABILITY)

In addition to reversible changes the capacitance of a capacitor is also subject to irreversible changes also known as drift.

The drift is dependent upon the dielectric material. The values shown are maximum values and refer to a period of two years and a temperature up to a maximum of 40°C. The drift decreases gradually over the time. Frequent and extreme temperature changes may exceed the catalog values.

TEMPERATURE COEFFICIENT (TC)

The temperature coefficient is the average capacitance change over a specified temperature range. It indicates how much a capacitance changes referred to 20°C, if the temperature changes by 1°C. The TC is typically expressed in ppm/°C (parts per million per °C). Depending upon the dielectric material the TC can either be positive, or negative.

$$TC = \frac{C_2 - C_1}{C_{20} * (\vartheta_2 - \vartheta_1)} \text{ (ppm/°C)}$$

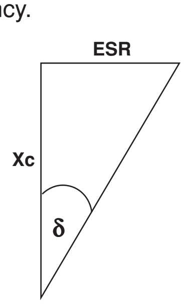
C_1 = Capacitance at temperature ϑ_1

C_2 = Capacitance at temperature ϑ_2

C_{20} = reference capacitance at 20 ± 2 °C

DISSIPATION FACTOR (TAN δ)

The dissipation factor (tan δ) is the ratio of the ESR to the capacitive reactance Xc (series capacitance) or the active power to the reactive power at a sinusoidal voltage of a specified frequency.



The tan δ reflects the polarization losses of the dielectric film and the losses caused by the contact resistance (terminals - schooping - electrodes) of the capacitor. Parallel losses can, due to the high insulation resistance of film capacitors, be neglected. The tan δ is temperature and frequency dependent.

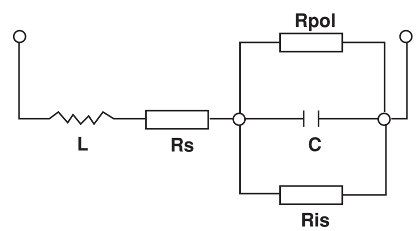
$$\tan\delta = \frac{ESR}{X_C}$$

The reciprocal value of tan δ is also known as Q-factor.

$$Q = 1/\tan\delta$$

EQUIVALENT SERIES RESISTANCE (ESR)

The ESR is the ohmic part of an equivalent series circuit. Its value assumes all losses to be represented by a single resistance in series with the idealized capacitor.



The ESR comprises the polarization losses of the dielectric material (Rpol), the losses caused by the resistance of the leads, termination and electrodes (Rs) and the insulation resistance (Ris).

$$ESR = \frac{\tan\delta}{2 * \pi * f * C} (\Omega)$$

INSULATION RESISTANCE (R_{IS}) AND TIME CONSTANT (τ)

The R_{is} is the ratio of an applied DC voltage to the resulting leakage current (flowing through the dielectric and over its body surface) after the initial charging current has ceased. The R_{is} is typically measured after one minute. ± 5 s at 20°C and a relative humidity of 50 ± 2%.

$$R_{is} = U_{DC} / I_{Leak} (\Omega)$$

The insulation resistance is determined by the property and the quality of the dielectric material and the capacitor's construction.

The R_{is} decreases with increasing temperature. A high relative humidity may decrease the insulation resistance. R_{is} changes due to moisture are reversible.

For capacitor values > 0.33µF the R_{is} is shown as time constant (τ). It is the product of insulation resistance and capacitance and is expressed in seconds or Megohm x µF

$$\tau = R_{is} \times C \text{ (Megohm x µF)}$$

INDUCTANCE (L)

The inductance of a capacitor depends upon the geometric design of the capacitor element and the length and the thickness of the contacting terminals. All capacitors shown in this catalog have an extended metallized film or foil construction and exhibit thus a very low inductance. The inductance of radial leaded capacitor types are typically measured with 2mm long lead wires. Typical values are 1.0nH/1mm lead length.

RESONANT FREQUENCY (f_r)

The resonant frequency is a function of the capacitance and the inductance of a capacitor. At resonant frequency the capacitive reactance equals the inductive reactance ($l/\omega C = \omega L$). At its lowest point of the resonant curve only the ohmic value is effective, this means the impedance equals the ESR. Above the resonate frequency the inductive part of the capacitor prevails.

IMPEDANCE (Z)

The impedance Z is the magnitude of the vectorial sum of ESR and the capacitive reactance X_C in an equivalent series circuit under consideration of the series inductance L.

$$Z = \sqrt{ESR^2 + (\omega L - 1/\omega C)^2}$$

The impedance is typically measured on capacitors (radial types) having 2mm long leads.

DIELECTRIC ABSORPTION (DA)

The DA depends upon the dielectric material and is a measure of the reluctance of a dielectric to discharge completely. After a fully charged capacitor is discharged the residual charge is expressed as a percentage of the initial charge. DA measurements are normally performed in accordance to IEC 60384-1.

$$DA = 100 * \frac{U_{resid}}{U_{initial}} \ (\%)$$

Typical DA values for film capacitors are:

KT/MKT = 0.20%, KC/MKC = 0.10%, KP/MKP = 0.05%

AMBIENT TEMPERATURE (ϑ_{amb})

The ambient temperature is the temperature in the immediante surrounding of the capacitor. It is identical to the surface temperature of an unloaded capacitor, At pulse or AC load operations the surface temperature may, due to an internal temperature increase, rise above the ambient temperature.

MAXIMUM TEMPERATURE (ϑ_{MAX})

The maximum temperature or upper category temperature is the highest temperature at which a capacitor may still be operated.

At pulse or AC load operations, the sum of the ambient temperature (ϑ_{amb}) and the temperature increase ($\Delta\vartheta_L$) caused by the load conditions, must not exceed the maximum temperature (ϑ_{max}).

$$\vartheta_{max} \geq \vartheta_{amb} + \Delta\vartheta_L$$

MINIMUM TEMPERATURE (ϑ_{MIN})

The minimum temperature or lower category temperature is the lowest temperature at which a capacitor may still be operated.

CLIMATIC CATEGORY

The climatic category indicates the climatic conditions which the capacitor may be operated.

According to DIN IEC 60068-1 the climatic category is expressed by a three group coding e.g. 55/100/56.

- The first group indicates the lower category temperature (- 55°C).
- The second group the upper category temperature (+100°C).
- The third group indicates the number of days (56) which the capacitor can withstand within specified limits if exposed to a relative humidity of 95% and a temperature of + 40°C. (DIN IEC 60068-1)

PULSE RISE TIME (du/dt)

The pulse rise time indicates the ability of a capacitor to withstand fast voltage changes and hence high current peaks. The du/dt value, expressed in volts per µs (V/µs), represents the steepest voltage gradient of the pulse (rise or fall time).

Its value is dependent upon the properties of the dielectric material, the film thickness and the capacitor's construction. If the applied pulse (U_p) voltage is lower than the rated voltage (U_R) higher pulse rise times are permitted.

$$du/dt_{(MAX)} = du/dt * U_R/U_P \ (V/\mu s)$$

du/dt = data sheet value

The pulse rise time (du/dt) is tested with values that are 5 to 10 times above the data sheet value.

Owing to their construction stacked film capacitors exhibit compared to wound film capacitors higher du/dt values. For film/foil capacitors the applied pulse rise time (du/dt) is not limited. At higher repetition frequencies, however, the heat generated in the capacitor during the pulse operation must not rise by more than 10°C.

PULSE LOAD AND CURRENT HANDLING CAPABILITY

The pulse load and current handling capability is the load of a non-sinusoidal AC voltage that may be applied to a capacitor. To prevent the capacitor from overheating the following operating parameters have to be considered:

- Maximum pulse voltage (Upp)
- Pulse shape
- Pulse rise or fall time (dv/dt)
- Repetition frequency of the pulse
- Ambient temperature
- Heat dissipation (cooling)

The maximum pulse current depends upon the capacitance and the permissible du/dt value.

$$I_{MAX} = C * du/dt \text{ (A)}$$

For high voltage and high current pulse loads Vishay Roederstein offers also a series of special capacitors. For example capacitors with a heavy-edge or a double-sided metallization and capacitors that combine a film/foil and a metallized film design in one unit.

For high voltage applications it is furthermore possible to offer designs with dual and multiple sections.

For critical applications, please forward your voltage and current waveforms (worst case conditions) for our type proposal.

CORONA STARTING VOLTAGE

The corona starting voltage is defined as detectable electrical discharges resulting from the ionization of air on the surface or between the capacitor layers. Its value is dependent upon the internal design of the capacitor element, the dielectric material, and the thickness of the film. The usage of series wound capacitors increases the corona voltage level.

All capacitors listed in this catalog have been designed in such a way that the corona starting voltage will be above the specified AC-voltage rating.

The corona starting voltage is typically measured with a sensitivity of 2 pC (Pico-Coulomb).

GENERAL TEST CONDITIONS

Unless otherwise specified, all electrical data listed in this catalog refer to an ambient temperature of + 23°C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of 45% to 75%. For arbitration cases measurements at 20°C and a relative humidity of 50 ± 2% are obligatory.

SOLDERING CONDITIONS

Unless otherwise specified the solderability of capacitors are tested according to DIN IEC 60068, part 2-20. The following details apply:

For Single Sided PC Boards:

At PCM ≥ 5mm and axial parts
Solder bath temperature / time: 270°C / 5 sec.

For SMD film capacitors soldering profiles are provided on the individual data sheets. The temperature and time limits for reflow and wave soldering must be strictly observed.

For Double Sided PC-Boards:

At PCM ≥ 5mm and axial parts
Solder bath temperature / time: 260°C / 5 sec.

For axial-leaded capacitors a distance of ≥ 6mm between the lead egress and the solder joint has to be kept.

SHELF LIFE OR STORAGE CONDITIONS

Film capacitors should be stored under standard atmospheric conditions as specified in IEC 60068-1 (temperature 15°C to 35°C, relative humidity 45% to 75%, atmospheric pressure 86 kPa to 106 kPa).

The following shelf-life is applicable:

Parts Supplied on Tape or Bulk:
Minimum shelf-life two years without impairing the electrical parameters. Considered has to be only the C-drift shown for the relevant series in this catalog.

SMD capacitors are supplied in moisture-proof plastic bags. After opening, the capacitors have to be assembled (soldered) under standard atmospheric conditions within 24 hours.

Parts Soldered on a PC Board:
Minimum shelf life 10 years without deterioration of quality.

NON-FLAMMABILITY

Non-flammability of capacitors is accomplished by the usage of flame-retardant materials. Non-flammability is periodically checked according to CEI IEC 60384-1 and IEC 60695-2-2. All plastic case materials used comply with UL-class 94-V-0.

CATEGORY OF FLAMMABILITY	SEVERITIES FLAME EXPOSURE TIME (s) FOR CAPACITOR VOLUME (V) (mm^3)				MAX. PERMITTED BURNING TIME (s)	ADDITIONAL REQUIREMENTS
	V ≤ 250	250 < V ≤ 500	500 < V ≤ 1750	V > 1750		
A	15	30	60	120	3	BURNING DROPLETS OR GLOWING PARTS FALLING DOWN SHALL NOT IGNITE THE TISSUE PAPER.
B	10	20	30	60	10	
C	5	10	20	30	30	

Film Capacitors

1. ALCOHOLS
Methanol
Ethanol
Propanol
Buthanol
Isopropanol

2. ESTERS
Acetic Acid Ethylester
Acetic Acid Buthylester
Methylglycolacetate
Ethylglycolacetate

3. AQUEOUS CLEANING SOLVENTS
Tests will be performed upon request

4. GLYCOLETHER
Propyleneglycolether

CLEANING PROCEDURE

The influence of high temperatures or vapor accelerates the purifying but also the destructive progress.

Please consult Vishay Roederstein if you have doubts about the usage of your cleaning solvent or if the cleaning process exceeds a solvent temperature of 40°C and a cleaning time of one minute.

NOTE: For the protection of the environment chlorinated and fluorinated hydrocarbons as well as related mixtures (e.g. Trichloroethane, Trichlorofluoroethane, Tetrachloro-hydrocarbon) shall no longer be used.

The usage of these substances in Germany and in most other countries prohibited by law !

SUITABLE CLEANING SOLVENTS

CAPACITOR VERSIONS	ITEM
Plastic Box and Epoxy End-Sealed	1, 2, 3 or 4
Plastic Molded	1, 2, 3 or 4
Plastic Wrapped and Epoxy End-Sealed (Polycarbonate Wrapping)	Non-Polar Cleaning Solvents
Plastic Wrapped and Epoxy End-sealed (Yellow or White Adhesive Tape)	1, 2, 3 or 4

Film Capacitors

GENERAL

All film capacitors listed in this catalog are manufactured in plants that have been certified to ISO 9001/ISO 9002 (EN 29001/EN 29002).

ISO 9001 is a comprehensive quality system that comprises all activities of development, material procurement, production, quality assurance and customer service. It is based on national and international standards such as DIN CECC and IEC. All quality and manufacturing procedures are described in detail in the Quality Manual of the company.

Modern quality tools such as SPC, FMEA, Zero-Defect quality programs and Q-Audits serve for the continued improvement of quality. Constant training programs make sure that all people involved in the entire process will be kept up to date with the latest production and quality procedures, thus meeting our customers requirements.

The following quality terms are alphabetically sorted.

AQL

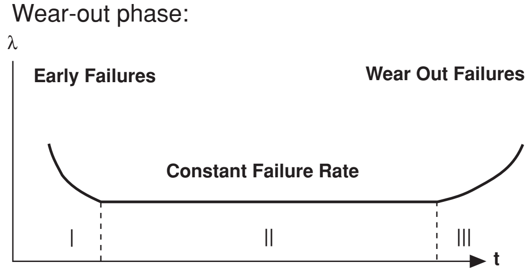
The Acceptable Quality Level represents the failure share in the test lot for all sampling instructions of a sampling plan to which a high acceptance probability is assigned. The AQL is expressed as the number of faulty components in relation to 100 components.

The sampling inspection is carried out by means of a sampling plan according to DIN ISO 2859 part 1 (identical to MIL STD 105 or IEC 60410) and is used to evaluate the test lot.

BATH TUBE CURVE

It represents the characteristic shape of the failure rate over the operation period. Its course may be divided into three time phases:

I. Early failure phase:
II. Application phase:
III. Wear-out phase:



The failure rate at phase II can be assumed to be constant.

BURN-IN

The burn-in or artificial aging of components is a measure to minimize early failure rates. In the burn-in test the components are generally subjected to an electrical and thermal stress.

CPK

Assuming a stable and normally distributed process, the process capability factor (C_{PK}) indicates the consistency of the process versus the tolerance limiting values.

$$C_{PK} = \frac{\overline{x} - LSL}{3s} \quad \text{or} \quad \frac{USL - \overline{x}}{3s}$$

(The smallest C_{PK}-value is valid)

$\overline{x}$ = Arithmetic mean value
LSL = Lower specification limit
USL = Upper specification limit
s = Standard deviation

A process is considered to be:

Bad if	$C_{PK} < 1.33$
Acceptable if	$C_{PK} \geq 1.33$
Good if	$C_{PK} \geq 1.67$
Excellent if	$C_{PK} \geq 2.00$

FAILURE

A failure means the unacceptable deviation from at least one property of a component that was without a defect at the beginning of its application. There are critical failures (e.g. short or open circuit) and failures caused by exceeding limiting values.

In case of claims the following information will be required by the manufacturer:

- Kind of defect observed
- Occurrence of the defect (e.g. incoming inspection, burn in, reliability test, field)
- Operating conditions
- Date code (on the component)
- Number of pieces rejected
- Lot size
- Lot number (on the label of the box)
- Return defect samples for failure analysis

This information will allow the manufacturer to solve the problem as quick as possible and to initiate the appropriate corrective actions.

FAILURE RATE (λ)

The failure rate is expressed in “fit” (failures in time) and indicates the number of failures per 10^9 component test hours.

1 fit = 1 x 10^{-9} / h (1 failure per 10^9 component hours)

$$\lambda_{ref} = \frac{n}{N^{*}t_b} \ \text{[fit]}$$

N = Number of components tested
n = Number of failures
t_b = Test time in hours

The calculations of the failure rates are based on CEI IEC 1709. The fit ratings provided in this catalog refer to 40°C, 0.5 x U_R and an upper confidence level of 60%.

The failure criteria are defined as follows:
Critical defect:
Short circuit or open circuit, Δ C/C > 50%
Defect by the change of limiting values:
Δ C/C > I0% (KC, MKC, MKT)
Δ C/C > 5% (KP, MKP)
Δ tan δ > 2 x initial limit (KC, MKC, MKT)
Δ tan δ > 3 x initial limit (KP, MKP)
Ris < 0.5% (MKT) of initial limit
Ris < 1.0% (MKC) of initial limit
Ris < 1.5% (KP, MKP, KC) of initial limit

Fit ratings for other voltage and temperature conditions can be converted according to CEI IEC 1709 as follows:

VOLTAGE CONVERSION FACTORS (π_U):			
Load Ratio (U/U_R)	MKT MKP	KT KP	KC MKC
100%	6	11	19
75%	2.5	3	4
50%	1	1	1
25%	0.4	0.4	0.4
10%	0.2	0.2	0.2

TEMPERATURE CONVERSION FACTORS (π_T)			
Temperature	KT MKT	KC MKC	KP MKP
≤ 40°C	1	1	1
55°C	2	3	2
70°C	5	7	5
85°C	12	18	12
100°C	33	63	33
125°C	350	—	—

$$\lambda = \lambda_{ef} * \pi_U * \pi_T$$

FMEA
The "Failure Mode and Effects Analyses" is a method that analyses systematically the potential defects as to their importance, the probability of their occurrence and the probability of detecting them (Pareto Analysis). This analysis is carried out during development and manufacturing. The results are used for a continuous improvement of quality.

Inspection by Attributes
It is a method of quality testing by means of qualitative characteristics (good or bad decision).

Inspection by Variables
It is a method of quality testing by means of quantitative characteristics (distribution of measuring values over a scale).

Operational Life
The operational life comprises operational and interruption times as well as the time for storage, testing and transportation. It refers to 40°C, 0.5 x U_R and a upper confidence level of 60%.
All film capacitors in this catalog meet an operational life of > 300.000 h.

ppm value
The ppm value is the statistically probable failure rate per million of supplied components. Its value is calculated from the accumulation of failures detected in sampling tests in relation to the sum of all the tested components. The calculation is based on EIA 554 and an upper confidence level of 90%.
A failure exists when the limiting value agreed with the customer, is exceeded. The failure rate is expressed in parts per million (PPM).

Quality
Quality means all properties and characteristics of a product or activity which relates to their suitability to comply with predetermined requirements. It is to distinguish between.

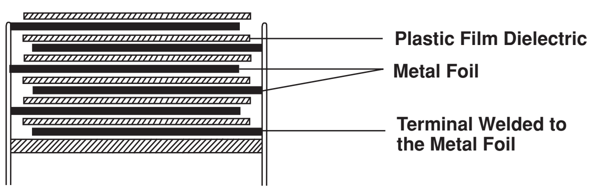
- The Zero-Hour Quality which designates the quality at the time of delivery.
- The reliability which designates the quality under predetermined user conditions during or after a predetermined operating time.

SPC
Statistical Process Control is applied to control all critical process steps. It can detect "special causes" and "common causes" of variation to eliminate and to correct process problems. SPC provides operating personnel an "early warning" when a product or process is moving out of control and will allow the application of corrective actions long before the actual defect is produced. SPC uses diagnostic tools such as frequency distribution analysis, control chart techniques, cause and effect relationships, and the application of the Pareto Analysis.

STS
Ship To Stock is a quality agreement according to which the customer performs only a reduced goods incoming inspection.

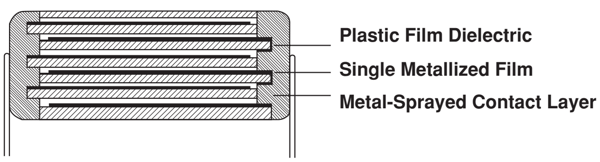
Film Capacitors

Extended Foil Design



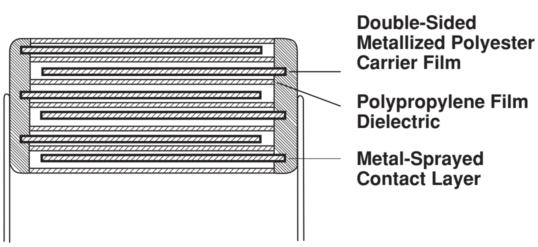
KP 1830 KC 1850

Extended Metallized Film Design



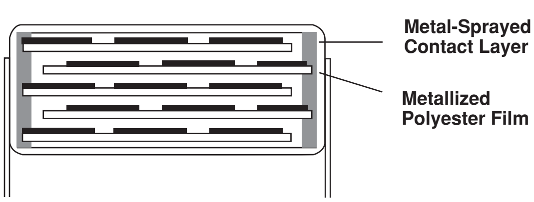
MKT 1813* MKT 1817 MKT 1818 MKT 1820
MKT 1822 MKT 1824 MKT 1826** MKP 1837**
MKP 1839* MKP 1840 MKC 1858 MKC 1860*
MKC 1862

Extended Double-Sided Metallized Carrier Film Design



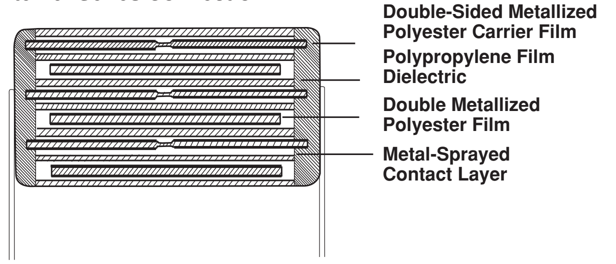
MKP 1841 (160 V, 250 V, 400 V, 630 VDC/250 VAC)
MKP 1845* (160 V, 250 V, 400 V)

Extended Metallized Film Design with Internal Series Connection



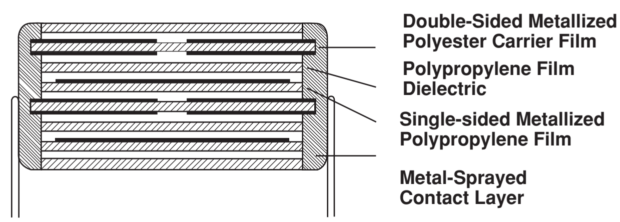
MKT 1816*

Extended Double-Sided Metallized Carrier Film Design with Internal Series Connection



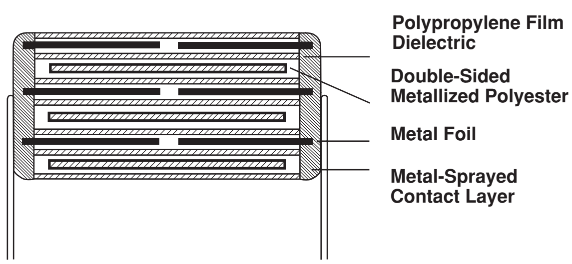
MKP 1841 (630 VDC/400 VAC - 2000 V)
MKP 1845* (630 V - 2000 V)

Extended Double-Sided Metallized Carrier Film Design with Internal Series Connection



MKP 1846

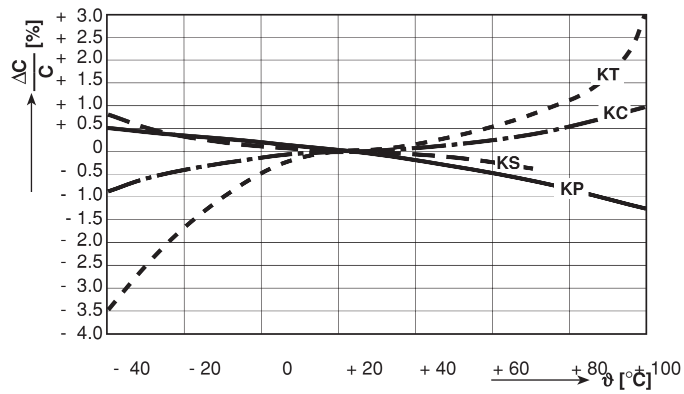
Extended Foil Design with Internal Series Connection and Double-Sided Metallized Carrier Film



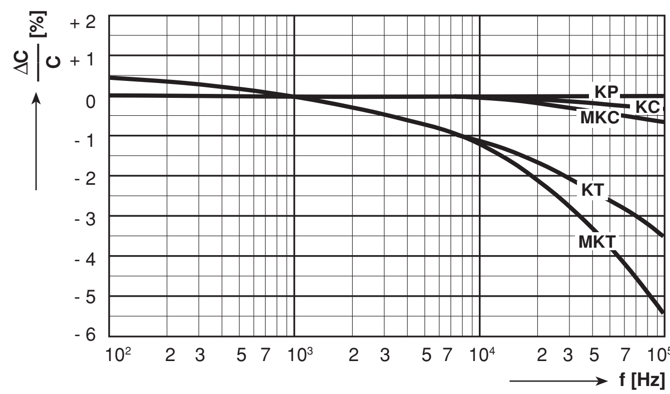
KP 1836

*Axial leads
**Stacked metallized film design

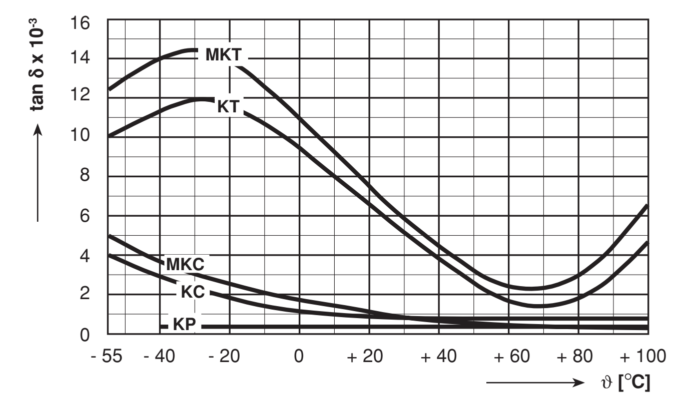
Film Capacitors



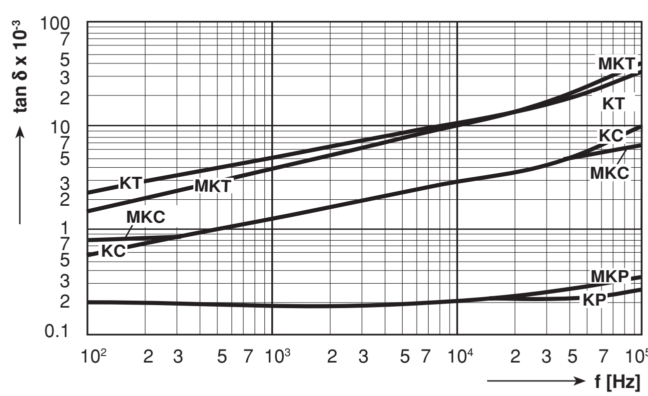
Capacitance Change versus Temperature $\frac{\Delta C}{C}$ = f (ϑ)



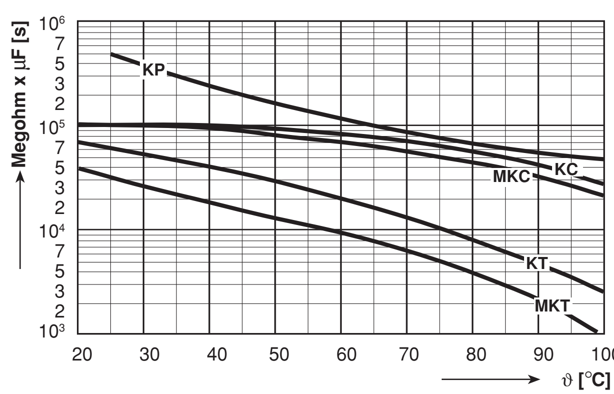
Capacitance Change versus Frequency $\frac{\Delta C}{C}$ = f (f)



Dissipation Factor versus Temperature tan ϑ = f (ϑ), measured at 1kHz

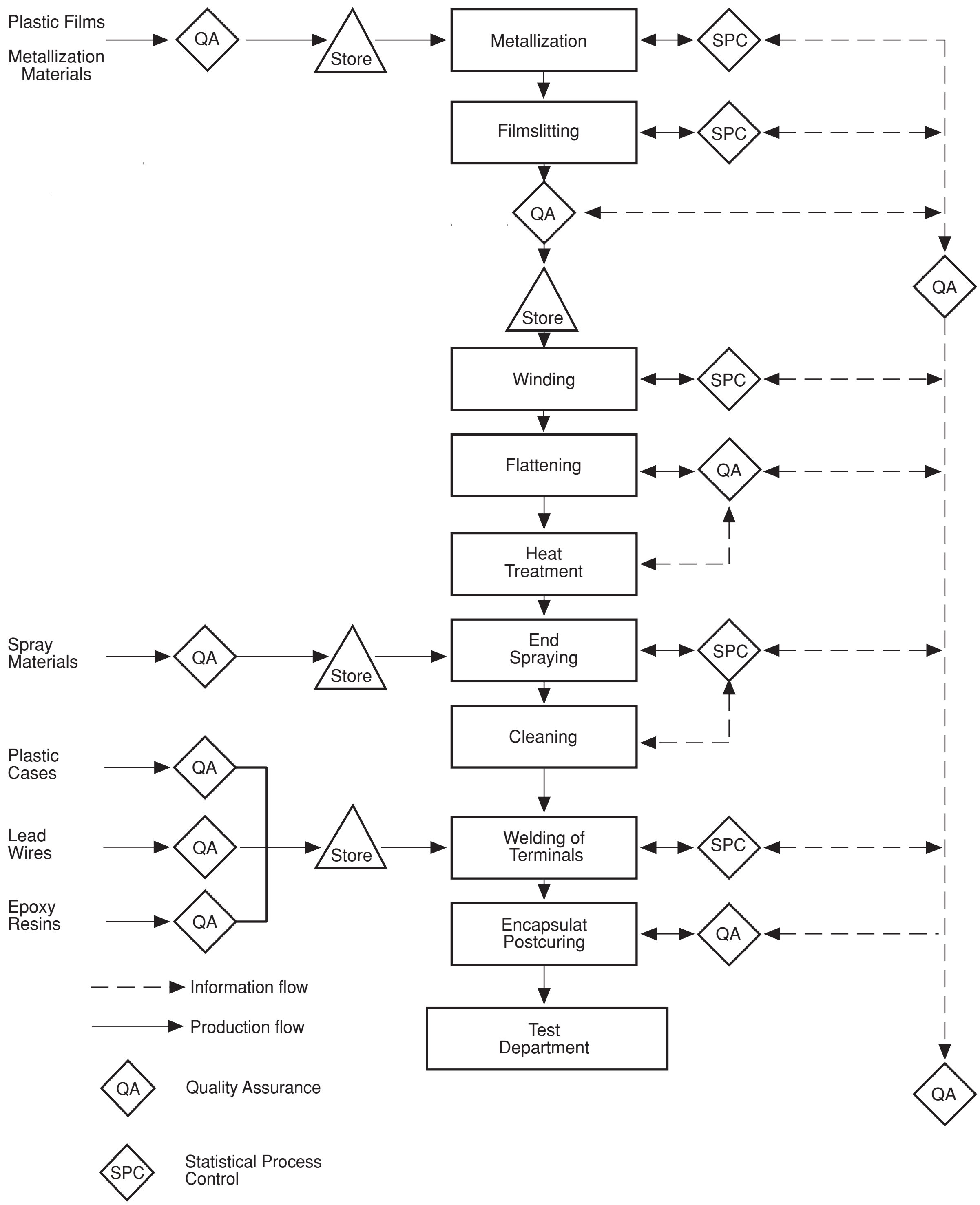


Dissipation Factor versus Frequency tan ϑ = f (f)

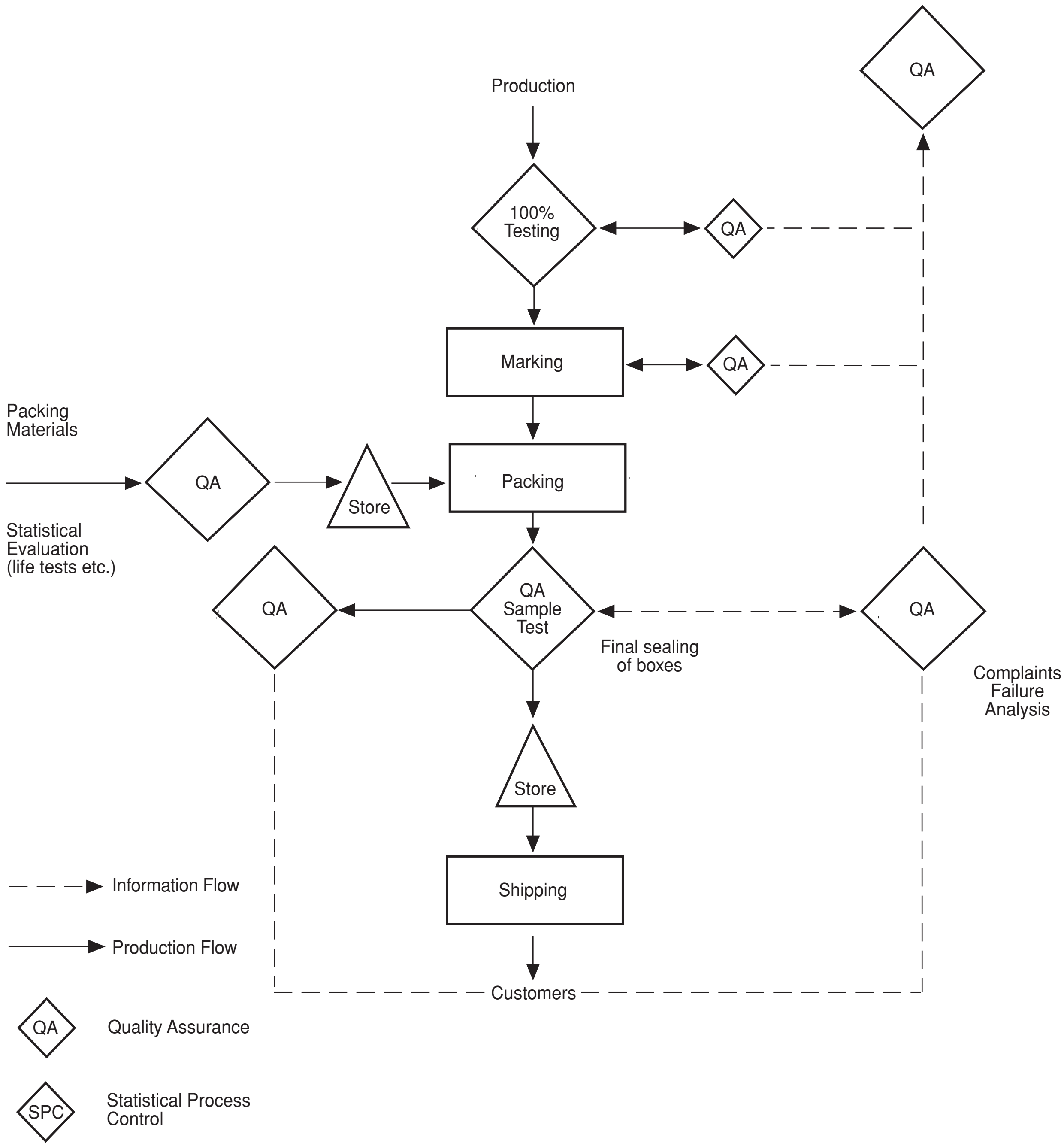


Time Constant versus Temperature τ = f (ϑ)

Metallized Plastic Film Capacitors
Radial Types



Metallized Plastic Film Capacitors Radial Types



Film Capacitors

ORDERING CODE SYSTEM:

Coded part numbers are subdivided in 6 groups comprising 14 digits to 16 digits:

MKT	1813	410	01	5	—	15 R
1	**2**	**3**	**4**	**5**		**6**

digits:

1, 2, 3	**4, 5, 6, 7**	**8, 9, 10**	**11, 12**	**13**		**14-16**
MKT	1813	410	01	5	—	15 R

GROUP 1

Two or three digits (1, 2, 3) indicate technology and dielectric:

MKT = Metallized film capacitor; dielectric polyester
KC = Film/foil capacitor; dielectric polycarbonate
MKC = Metallized film capacitor;dielectric polycarbonate
KP = Film/foil capacitor; dielectric polypropylene
MKP = Metallized film capacitor;dielectric polypropylene

GROUP 2

Four digits (4, 5, 6, 7) indicate construction, outer wrapping or case.

Examples:
1822
1826 Group 1 and Group 2 define
1841 the type
1862

GROUP 3

Three digits (8, 9, 10) indicate the rated capacitance. The first digit indicates the exponent x of the multiplier 10^x of the basic unit pF, the following 2 digits specify the rated C-value.

Examples:

110	≙	10×10^1pF	=	100pF
111	≙	11×10^1pF	=	110pF
215	≙	15×10^2pF	=	1500pF
310	≙	10×10^3pF	=	10,000pF
422	≙	22×10^4pF	=	0.22µF
547	≙	47×10^5pF	=	4.7µF
610	≙	10×10^6pF	=	10.0µF

GROUP 4

Two digits (11, 12) indicate the rated DC -voltage.

04	≙	40V	**75**	≙	750V
05	≙	50V	**08**	≙	800V
06	≙	63V	**10**	≙	1000V
18	≙	80V	**12**	≙	1250V
01	≙	100V	**15**	≙	1500V
02	≙	125V	**13**	≙	1600V
51	≙	150V	**20**	≙	2000V
16	≙	160V	**32**	≙	3200V
22	≙	200V	**14**	≙	4000V
25	≙	250V	**50**	≙	5000V
30	≙	300V	**80**	≙	8000V
35	≙	350V	**11**	≙	10000V
40	≙	400V	**21**	≙	12000V
52	≙	500V	**55**	≙	15000V
66	≙	600V	**61**	≙	16000V
63	≙	630V			

GROUP 5

One digit (13) indicates the capacitance tolerance:

1	≙	± 1%	(F)
2	≙	± 2%	(G)
3	≙	± 2.5%	(H)
4	≙	± 5%	(J)
5	≙	± 10%	(K)
6	≙	± 20%	(M)
7	≙	- 20%/+ 50%	
8	≙	± 3.5%	
9	≙	Special tolerance	

GROUP 6

One to three digits (number and/or letter code) indicate special customer requirements and/or type of taping (14, 15, 16).

Taping codes (letters) are listed on the data sheets of the individual types.

Examples I:

MKT 1826 - 410 / 01 5 G

1) Metallized polyester capacitor
2) Type designation
3) C-value: 0.1µF
4) Voltage: 100 VDC
5) C-tolerance: ± 10%
6) AMMO-taping with H = 18.5mm

Examples II:

MKP 1840 - 510 / 25 4 V

1) Metallized polypropylene capacitor
2) Type designation
3) C-value: 1.0µF
4) Voltage: 250 VDC
5) C-tolerance: 5%
6) REEL-taping for pcm 15 - 27.5mm

Film Capacitors

E-Series according to DIN IEC 60063

E 6 ± 20%	E 12 ± 10%	E 24 ± 5%	E 48 ± 2%	E 96 ± 1%
1.0	1.0	1.0	1.00	1.00
				1.02
			1.05	1.05
				1.07
		1.1	1.10	1.10
				1.13
			1.15	1.15
				1.18
	1.2	1.2	1.21	1.21
				1.24
			1.27	1.27
				1.30
		1.3	1.33	1.33
				1.37
			1.40	1.40
				1.43
			1.47	1.47
1.5	1.5	1.5		1.50
			1.54	1.54
				1.58
		1.6	1.62	1.62
				1.65
			1.69	1.69
				1.74
			1.78	1.78
	1.8	1.8		1.82
			1.87	1.87
				1.91
			1.96	1.96
		2.0		2.00
			2.05	2.05
				2.10
			2.15	2.15
2.2	2.2	2.2		2.21
			2.26	2.26
				2.32
			2.37	2.37
		2.4		2.43
			2.49	2.49
				2.55
			2.61	2.61
				2.67
	2.7	2.7	2.74	2.74
				2.80
			2.87	2.87
				2.94
		3.0	3.01	3.01
				3.09
			3.16	3.16
				3.24
3.3	3.3	3.3	3.32	3.32
				3.40
			3.48	3.48
				3.57
		3.6	3.65	3.65
				3.74
			3.83	3.83
	3.9	3.9		3.92
			4.02	4.02
				4.12
			4.22	4.22
		4.3		4.32
			4.42	4.42
				4.53
			4.64	4.64
4.7	4.7	4.7		4.75
			4.87	4.87
				4.99
		5.11	5.11	5.11
				5.23
			5.36	5.36
				5.49
	5.6	5.6	5.62	5.62
				5.76
			5.90	5.90
				6.04
		6.2	6.19	6.19
				6.34
			6.49	6.49
				6.65
6.8	6.8	6.8	6.81	6.81
				6.98
			7.15	7.15
				7.32
		7.5	7.50	7.50
				7.68
			7.87	7.87
				8.06
	8.2	8.2	8.25	8.25
				8.45
			8.66	8.66
				8.87
		9.1	9.09	9.09
				9.31
			9.53	9.53
				9.76

Film Capacitors

ERO production codes according to DIN 41314 and IEC 60062:

DATE CODE YEAR OF MANUFACTURE	
1980	M
1981	N
1982	P
1983	R
1984	S
1985	T
1986	U
1987	V
1988	W
1989	X
1990	A
1991	B
1992	C
1993	D
1994	E
1995	F
1996	H
1997	J
1998	K
1999	L
2000	M
2001	N
2002	P
2003	R
2004	S
2005	T
2006	U
2007	V
2008	W
2009	X
2010	A

Example: year/month coding
May, 1996 = H 5

DATE CODE MONTH OF MANUFACTURE	
January	1
February	2
March	3
April	4
May	5
June	6
July	7
August	8
September	9
October	O
November	N
December	D

Tolerance:

Capacitance tolerances are marked with digits, or a letter code.

Tolerance Marking:

± 20% = M ± 10% = K

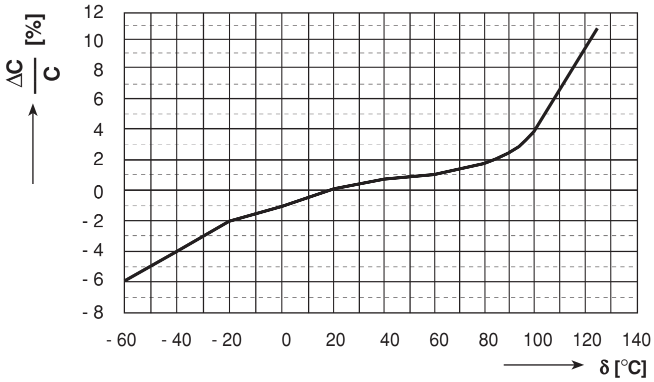
± 5% = J ± 2.5% = H

± 2% = G ± 1% = F

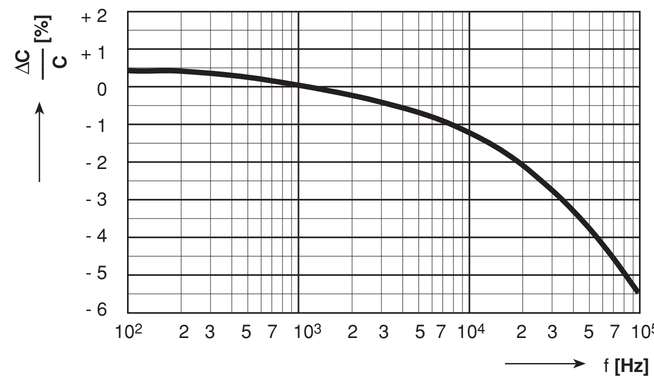
Plastic film capacitors are marked with a YEAR/WEEK production date code acc. to EIA (e.g. 9941 = 1999, week 41).

The above table showing production date codes acc. to DIN 41314 and IEC 60062 is no longer applicable but may still be used to identify production codes of older parts.

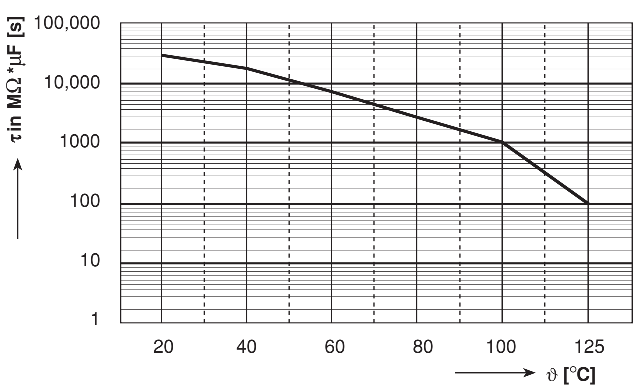
Metallized Polyester Film Capacitors



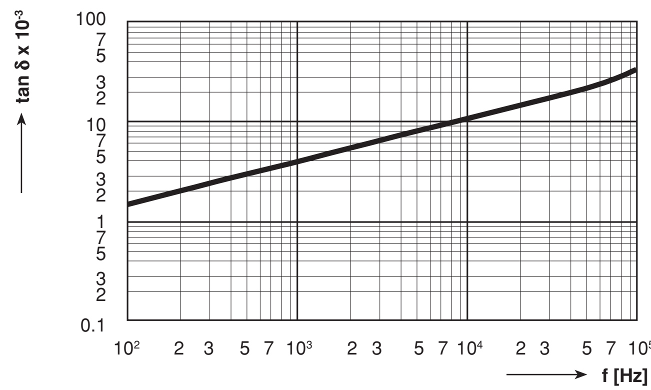
Capacitance versus Temperature $\Delta C/C = f(\vartheta)$



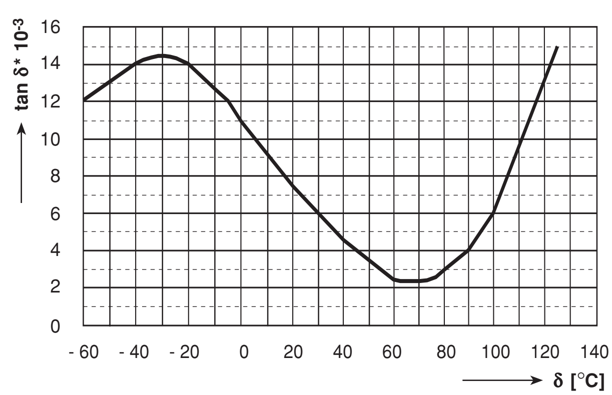
Capacitance Change versus Frequency $\frac{\Delta C}{C} = f(f)$



Time constant versus temperature $\tau = f(\vartheta)$

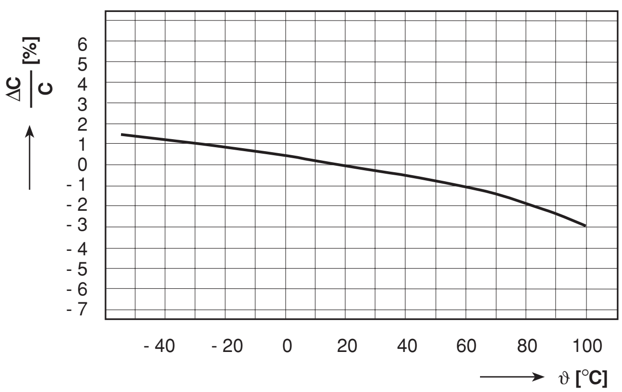


Dissipation Factor versus Frequency $\tan \delta = f(f)$

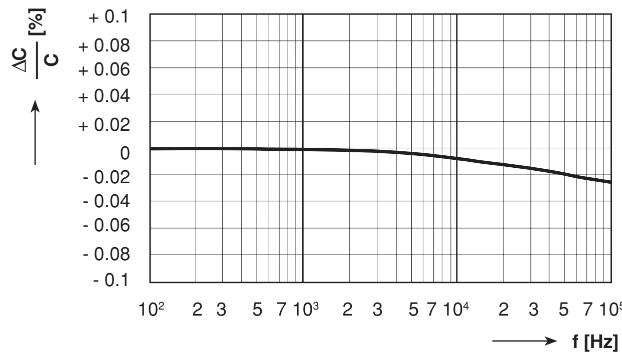


Dissipation Factor (1kHz) versus temperature $\tan \delta = f(\vartheta)$

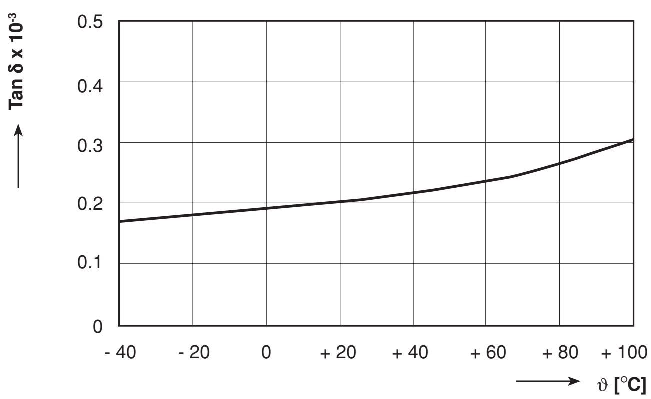
Polypropylene Film Capacitors



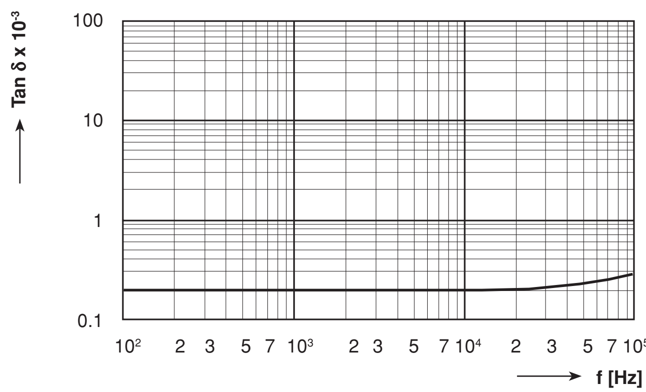
Capacitance Change versus Temperature $\frac{\Delta C}{C}$ = f (ϑ)



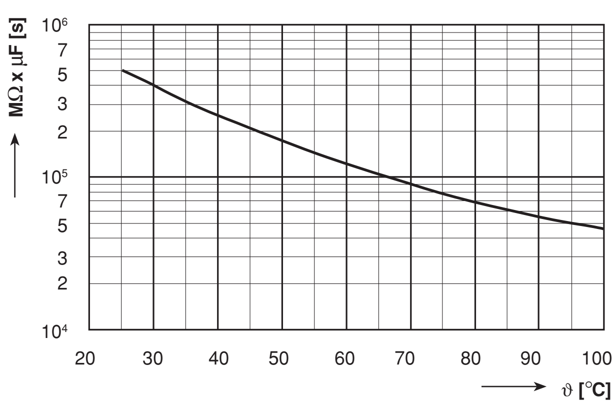
Capacitance Change versus Frequency $\frac{\Delta C}{C}$ = f (f)



Dissipation Factor versus Temperature tan δ = f (ϑ), measured at 100kHz

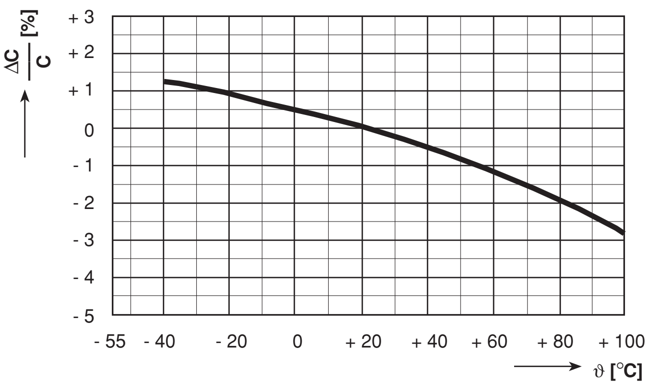


Dissipation Factor versus Frequency tan δ = f (f)

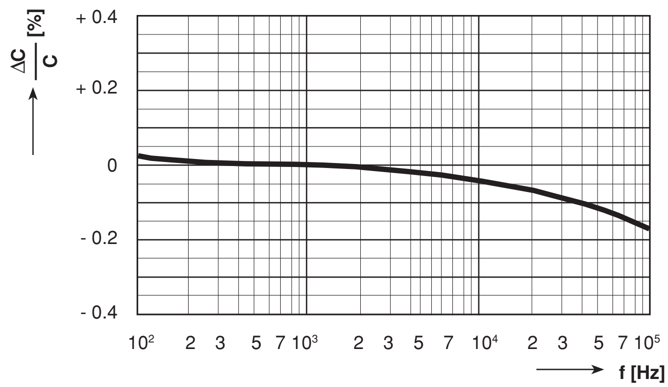


Time Constant versus Temperature τ = f (ϑ)

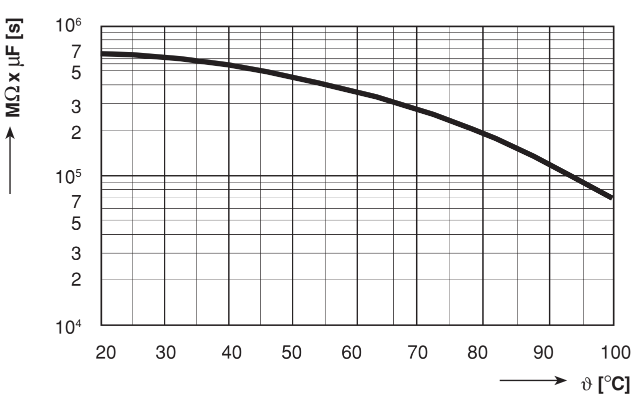
Metallized Polypropylene Film Capacitors



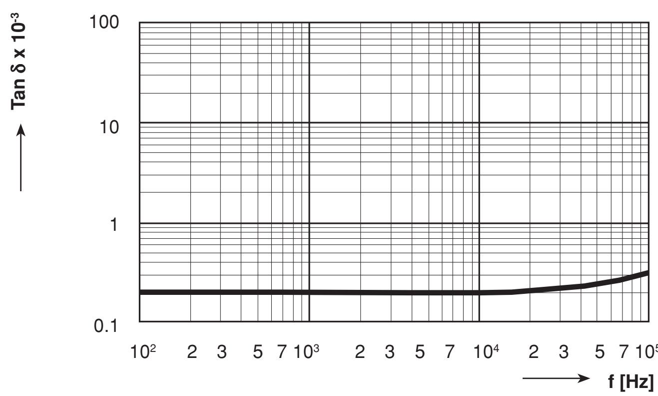
Capacitance Change versus Temperature $\frac{\Delta C}{C} = f(\vartheta)$



Capacitance Change versus Frequency $\frac{\Delta C}{C} = f(f)$

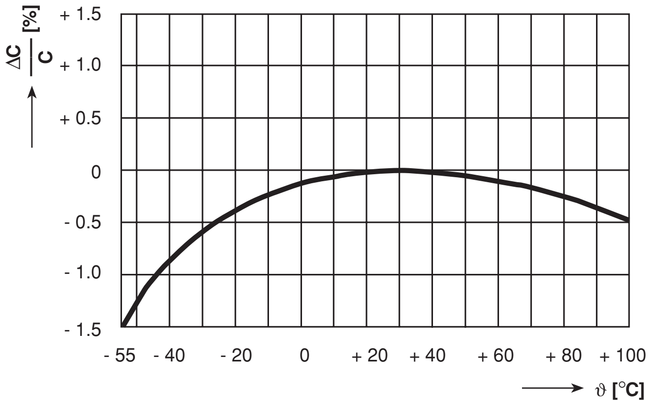


Time Constant versus Temperature $\tau = f(\vartheta)$

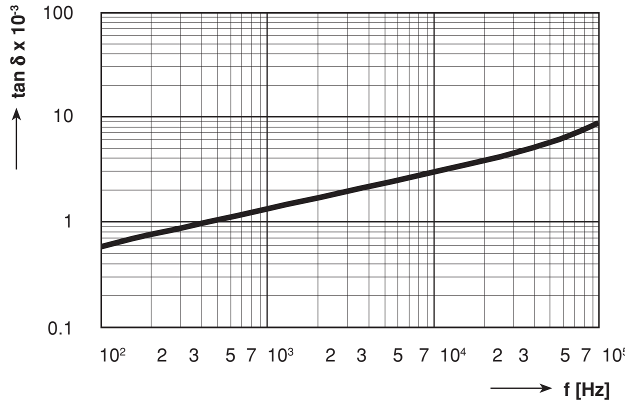


Dissipation Factor versus Frequency $\tan \delta = f(f)$

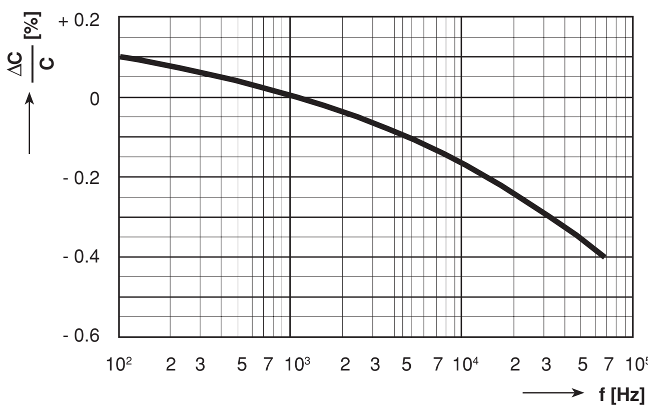
Polycarbonate Film Capacitor



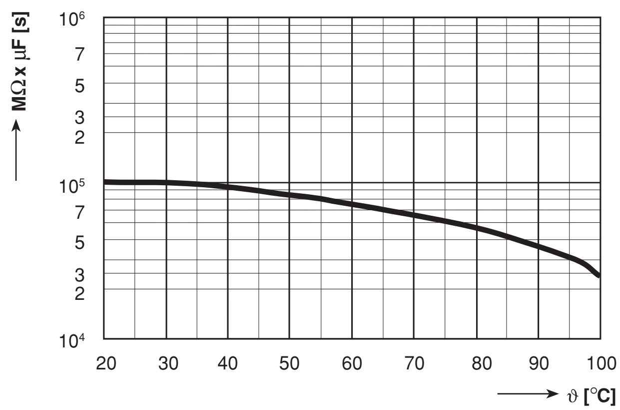
Capacitance Change versus Temperature $\frac{\Delta C}{C}$ = f (ϑ)
(Only for flat capacitors)



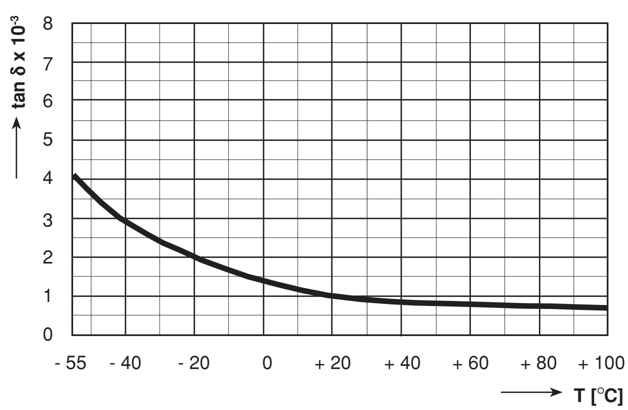
Dissipation Factor versus Frequency tan δ = f (f)



Capacitance Change versus Frequency $\frac{\Delta C}{C}$ = f (f)

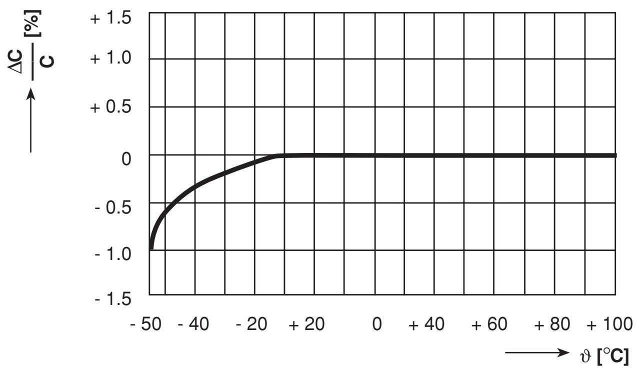


Time Constant versus Temperature τ = f (ϑ)

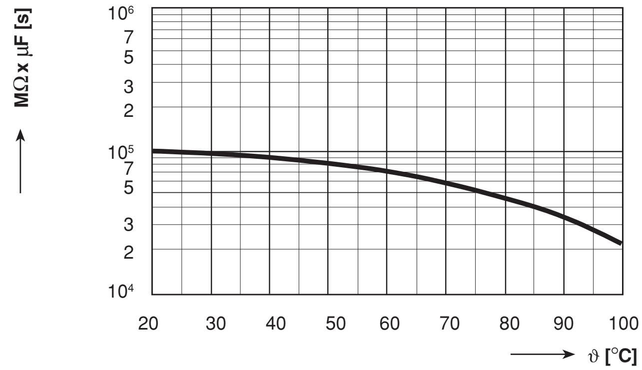


Dissipation Factor versus Temperature tan δ = f (ϑ),
measured at 1kHz

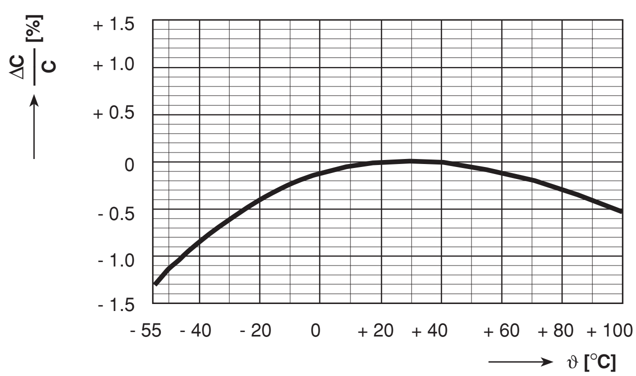
Metallized Polycarbonate Film Capacitor



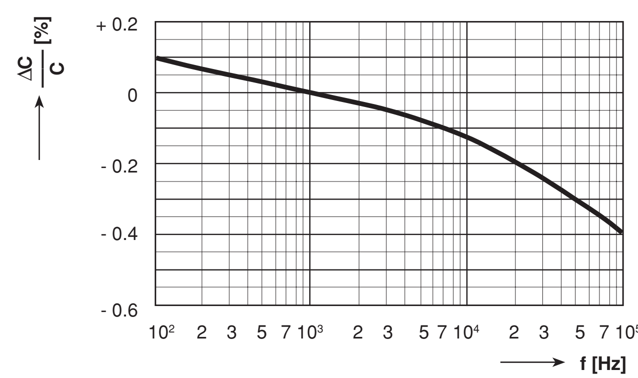
Capacitance Change versus Temperature $\frac{\Delta C}{C}$ = f (ϑ)
(Only for tubular capacitors)



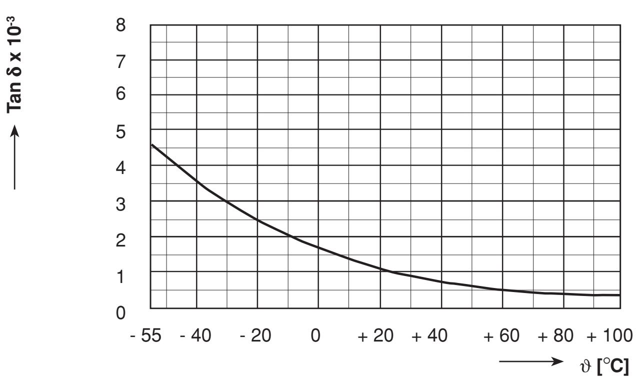
Time Constant versus Temperature τ = f (ϑ)



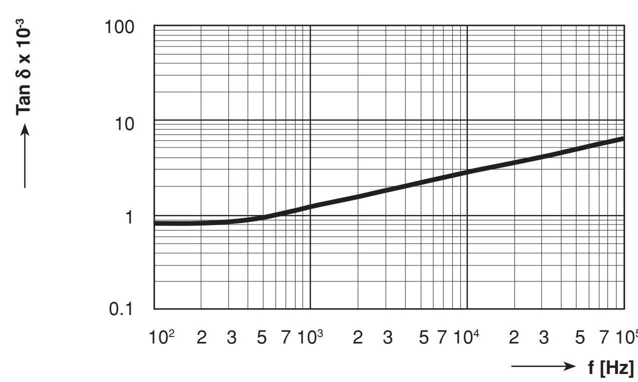
Capacitance Change versus Temperature $\frac{\Delta C}{C}$ = f (ϑ)
(Only for flat capacitors)



Capacitance Change versus Frequency $\frac{\Delta C}{C}$ = f (f)



Dissipation Factor versus Temperature tan δ = f (ϑ),
measured at 1kHz



Dissipation Factor versus Frequency tan δ = f (f)