- CAUTION AND WARNING -

- Please contact us for complete technical specification before use and confirm the appropriate condition of your application.
- If used in a specific appliance that requires an extremely high reliability directly impacting human life, please consult with us and use within the conditions designated in the specification.
- In the event of trouble with other parts on the circuit such as shorting and opening, provide proper means for preventing voltage, current or temperature exceeding the capacitor's rating from being applied to the film capacitor.
- For film capacitor for AC use, ask for our specification, and use within the specified conditions.
- Under the worst-case conditions, a film capacitor may smoke or catch fire. Therefore, as the specific application demands, we recommend that the resin part of periphery is covered with a flame-retardant material and case.

★★★ Design and specifications are subject to change without notice. Ask factory for technical specifications before purchase and/or use. Whenever a doubt about safety arises from this product, please contact us immediately for technical consultation.★★★

Web Site : http://www.pilkor.co.kr

Our technical specialists are always available to answer your questions on special applications and requirements not covered in this data book

TEL : 82-31-546-5162~5167
FAX : 82-31-217-7314~5

FILM DIELECTRICS USED IN FILM CAPACITORS

Overview

PARAMETER	DIELECTRIC[1]				UNIT
	KT	KN	KI	KP	
Dielectric constant: at 1 kHz	3.3	3.0	3.0	2.2	–
Dissipation factor at 1 kHz at 10 kHz at 100 kHz at 1 MHz	50 110 170 200	40 – – –	3 6 12 18	1 2 2 4	10^{-4} 10^{-4} 10^{-4} 10^{-4}
Volume resistivity	10^{+17}	10^{+17}	10^{+17}	10^{+18}	Ωcm
Dielectric strength	400	300	250	600	V/µm
Maximum application temperature	125	125	150	105	℃
Power density: at 10 kHz	50	40	2.5	0.6	W/cm³
Dielectric absorption	0.2	1.2	0.05	0.01	%

Note

1. In accordance with "IEC 60062": KT = polyethylene terephthalate (PETP); KN = polyethylene naphthalate (PEN); KI = polyphenylene sulfide (PPS); KP = polypropylene (PP).

Polyethylene terephthalate (PETP) and polyethylene naphthalate (PEN) films are mostly used in general purpose capacitors. These capacitors are used in applications typically with small bias DC voltages and/or small AC voltages at low frequencies.

Polyethylene terephthalate (PETP) has high capacitance per volume due to its high dielectric constant and availability in thin gauges.

Polyethylene naphthalate (PEN) is used when high temperature resistance is required compared to PET. Polyphenylene sulfide (KI) film can be used in applications where high temperature resistance is needed in combination with low dissipation factor.

Polypropylene (KP) film is used in high frequency or high voltage applications due to its very low dissipation factor and high dielectric strength. It is used in AC and pulse capacitors and interference suppression capacitors for mains applications.

Typical properties as functions of temperature or frequency are illustrated in Fig. 1 to 5.

Film Capacitor

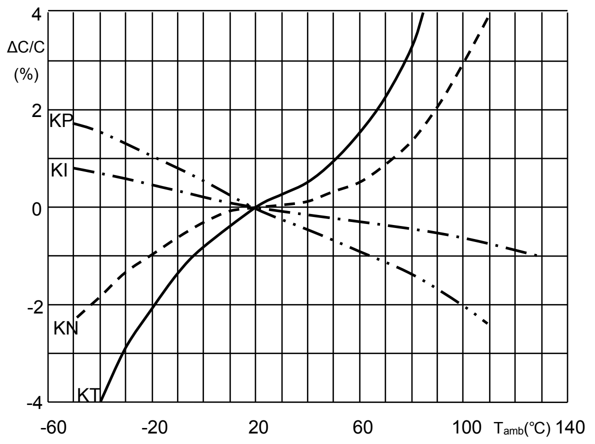


Fig.1 Capacitance change as a function of ambient free air temperature at 1 kHz; typical curves

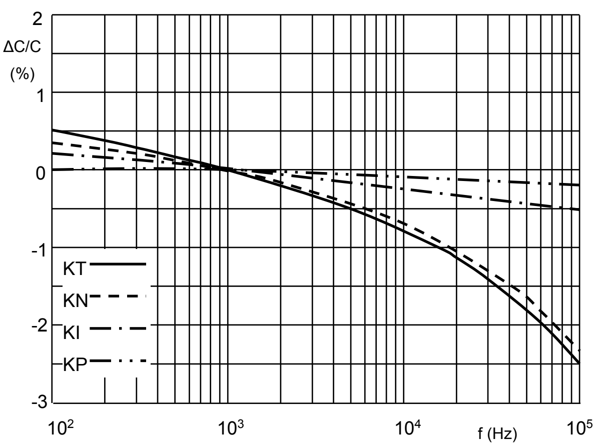


Fig.4 Capacitance change as a function of frequency; typical curves

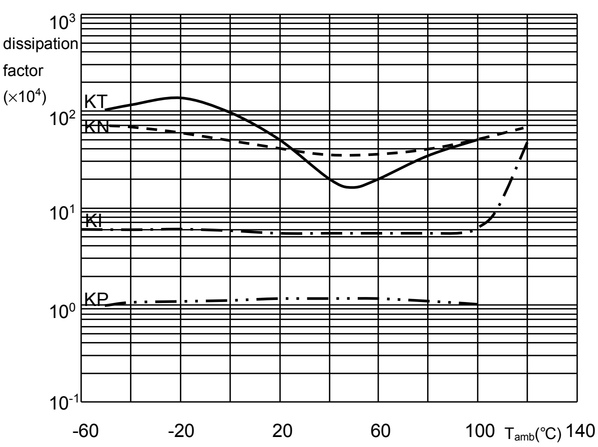


Fig.2 Dissipation factor as a function of ambient free air temperature at 1 kHz; typical curves

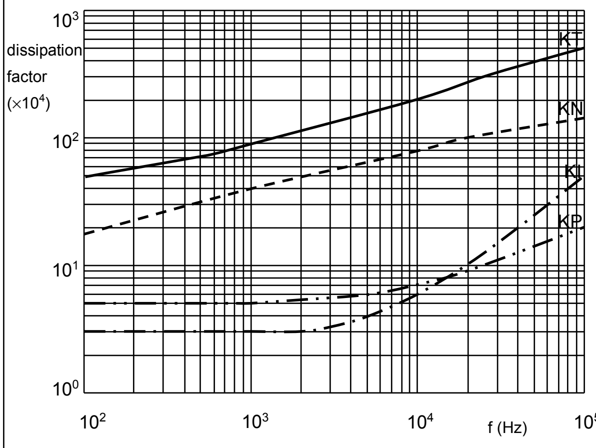


Fig.5 Dissipation factor as a function of frequency at 20°C; typical curves

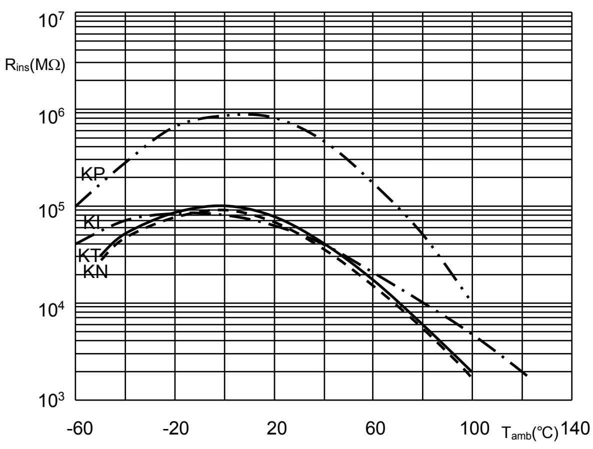


Fig.3 Insulation resistance as a function of ambient free air temperature; typical curves

CONSTRUCTION OF THE CAPACITOR CELL

The type of electrode used determines whether the capacitor is a metallized film or film/foil type.

The electrode used for the metallized film capacitor is a thin metal layer deposited on the plastic film with thickness of approximately 30 to 50 nm. The electrode of the film/foil capacitor is discrete metal foil with thickness of approximately 5 to 10㎛.

In some products a double side metallized plastic film is used as electrode.

Due to their construction, film/foil capacitors can carry higher currents than metallized ones, but are larger in volume.

Metallized film capacitors have a self-healing property as an intrinsic characteristic.

Depending on the AC voltage, single or series constructions are used. Single section capacitors are normally used for products with an AC rating up to 275 V (AC). Series constructions are used for higher AC voltages.

GENERAL DEFINITIONS

Rated DC voltage (V_{Rdc})

The maximum direct voltage or peak value of pulse voltage which may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature.

Category voltage (V_C)

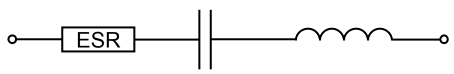
The maximum voltage which may be applied continuously to a capacitor at its upper category temperature.

Rated AC voltage (V_{Rac})

The maximum RMS voltage (in V) at specified frequency (mostly 50 Hz) which may be continuously applied to the terminations of a capacitor at any temperature between the lower category temperature and the rated temperature.

Capacitance

The capacitance of a capacitor is the capacitive part of the equivalent circuit composed of capacitance, equivalent series resistance (ESR) and inductance.



Simplified equivalent circuit.

Rated capacitance

The designed capacitance value usually indicated on the capacitor.

Capacitance tolerance

The percentage of the allowed deviation of the capacitance from the rated capacitance measured at a free air ambient temperature of 23 ±1℃ and RH of 50 ±2%.

Tolerance coding in accordance with "*IEC 60062*"

CAPACITANCE TOLERANCE	LETTER CODE
±1.0%	F
±2.0%	G
±3.0%	H
±3.5%	A
±5.0%	J
±10.0%	K
±20.0%	M

A letter "A" indicates that the tolerance is defined in the type specification or customer detail specification.

Temperature coefficient and cyclic drift of capacitance

The terms characterizing these two properties apply to capacitors of which the variations of capacitance as a function of temperature are linear or approximately linear and can be expressed with a certain precision.

TEMPERATURE COEFFICIENT OF CAPACITANCE

The rate of capacitance change with temperature, measured over the specified temperature range. It is normally expressed in parts per million per Kelvin (10^{-6}/K).

TEMPERATURE CYCLIC DRIFT OF CAPACITANCE

The maximum irreversible variation of capacitance observed at room temperature (20 ±2℃) during or after the completion of a number of specified temperature cycles. It is normally expressed in percent.

Rated voltage pulse slope (dV/dt)

The maximum voltage pulse slope that the capacitor can withstand with a pulse voltage equal to the rated voltage. For pulse voltages other than the rated voltage, the maximum voltage pulse slope may be multiplied by V_{Rdc} and divided by the applied voltage.

The voltage pulse slope multiplied by the capacitance gives the peak current for the capacitor.

Dissipation factor

The dissipation factor or tangent of loss angle ($\tan\delta$) is the power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage of specified frequency.

Equivalent series resistance (ESR)

The resistive part of the equivalent circuit composed of capacitance, series resistance and inductance.

Insulation resistance (R_{ins})

The applied DC voltage divided by the leakage current after defined time.

Time constant

The product of the insulation resistance and the capacitance, normally expressed in seconds.

Ambient temperature

The ambient temperature is the temperature of the air surrounding the component.

Climatic category

The climatic category code (e.g. 50/100/56) indicates to which climatic category a film capacitor type belongs. The category is indicated by a series of three sets of digits separated by oblique strokes corresponding to the minimum ambient temperature of operation, the maximum temperature of operation and the number of days of exposure to damp heat (Steady state - test Ca), respectively.

Category temperature range

The range of ambient temperatures for which the capacitor has been designed to operate continuously; this is given by the lower and upper category temperature.

Upper category temperature

The maximum ambient temperature for which a capacitor has been designed to operate continuously.

Lower category temperature

The minimum ambient temperature for which a capacitor has been designed to operate continuously.

Rated temperature

The maximum ambient temperature at which the rated voltage may be continuously applied.

Maximum application temperature

The equivalent of the upper category temperature.

Temperature characteristic of capacitance

The maximum reversible variation of capacitance produced over a given temperature range within the category temperature range, normally expressed as a percentage of the capacitance related to a reference temperature of 20℃.

> NOTE The term characterizing this property applies mainly to capacitors of which the variations of capacitance as a function of temperature, linear or non-linear, cannot be expressed with precision and certainty.

Storage temperature

The temperature range from -25℃ to 40℃, a RH of maximum 80% without condensation at which the initial characteristics can be guaranteed for at least 2 years.

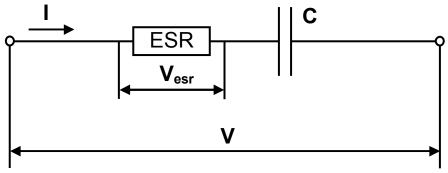
Self-healing

The process by which the electrical properties of the capacitor, after a local breakdown of the dielectric, are rapidly and essentially restored to the values before the breakdown.

Maximum power dissipation

The power dissipated by a capacitor is a function of the voltage (V_{esr}) across or the current (I) through the equivalent series resistance ESR and is expressed by:

$$P = \frac{V_{esr}^2}{ESR} = ESR \times I^2$$



Simplified equivalent circuit.

$$V_{esr}^2 = \frac{ESR^2}{ESR^2 + 1/\omega^2 C^2} \times V^2$$

Given that for film capacitors $\tan\delta = \omega \times C \times ESR \ll 0.1$ the formula can be simplified to:

$$V_{esr}^2 = ESR^2 \times \omega^2 \times C^2 \times V^2$$

With $ESR = \tan\delta/\omega C$, the formula becomes:

$$P = \omega \times C \times \tan\delta \times V^2 = \frac{\tan\delta}{\omega \times C} \times I^2$$

For the $\tan\delta$ we take the typical value found in the specification, C is in farads and $\omega = 2\pi f$. V or I are assumed to be known.

In applications where sinewaves occur, we have to take for V the RMS-voltage or for I the RMS-current of the sinewave.

In applications where periodic signals occur, the signal has to be expressed in Fourier-terms:

$$V = V_0 + \sum_{k=1}^{\infty} V_k \times \sin(k\omega t + \phi_k) \qquad I = \sum_{k=1}^{\infty} I_k \times \sin(k\omega t + \phi_k)$$

with V_0 (the DC voltage), V_k and I_k (the voltage and current of the k-th harmonic, respectively) the formula for the dissipated power becomes:

$$P = \sum_{k=1}^{\infty} I_k \times \omega \times C \times \tan\delta_k \times \frac{V_k^2}{2} \qquad P = \sum_{k=1}^{\infty} \frac{\tan\delta_k \times I_k^2}{2 \times k \times \omega \times C}$$

and $\tan\delta_k$ is the $\tan\delta$ at the k-th harmonic.

TEST INFORMATION

Robustness of terminations

TENSILE (Ua_1) (LOAD IN LEAD AXIS DIRECTION)

Lead diameter 0.5, 0.6 and 0.8 mm: load 10 N, 10 s
Lead diameter 1.0 mm: load 20 N, 20 s

BENDING (Ub)

Lead diameter 0.5, 0.6 and 0.8 mm: load 5 N, 4 × 90°
Lead diameter 1.0 mm: load 10 N, 4 × 90°

TORSION (Uc) (FOR AXIAL CAPACITORS ONLY)

Severity 1: three rotations of 360°
Severity 2: two rotations of 180°

Rapid change of temperature (Na)

The rapid change of temperature test is intended to determine the effect on capacitors of a succession of temperature changes and consists of 5 cycles of 30 minutes at lower category temperature and 30 minutes at higher category temperature.

Dry heat (Ba)

This test determines the ability of the capacitors to be used or stored at high temperature. The standard test is 16 hours at upper category temperature.

Damp heat cyclic (Db)

This test determines the suitability of capacitors for use and storage under conditions of high humidity combined with cyclic temperature changes and, in general, producing condensation on the surface of the capacitor.
One cycle consists of 24 hours exposure to 55℃ and 95 to 100% relative humidity (RH).

Cold (Aa)

This test determines the ability of the capacitors to be used or stored at low temperature. The standard test is 2 hours at the lower category temperature.

Damp heat steady state (Ca)

This test determines the suitability of capacitors for use and storage under conditions of high humidity.
The test is primarily intended to observe the effects of high humidity at constant temperature over a specified period.
The capacitors are exposed to a damp heat environment which is maintained at a temperature of 40℃ and a RH of 90 to 95% for the number of days specified by the third set of digits of the climatic category code.

Soldering

With regard to the resistance to soldering heat and the solderability, our products comply with “IEC60384-1” and the additional type specifications.

Solvent resistance of components

Soldered capacitors may be cleaned using appropriate cleansing agents, such as alcohol, fluorohydro-carbons or their mixtures. Solvents or cleansing agents based on chlorohydrocarbons or ketones should not be used, as they may attack the capacitor or the encapsulation.
After cleaning it is always recommended to dry the components carefully and completely.

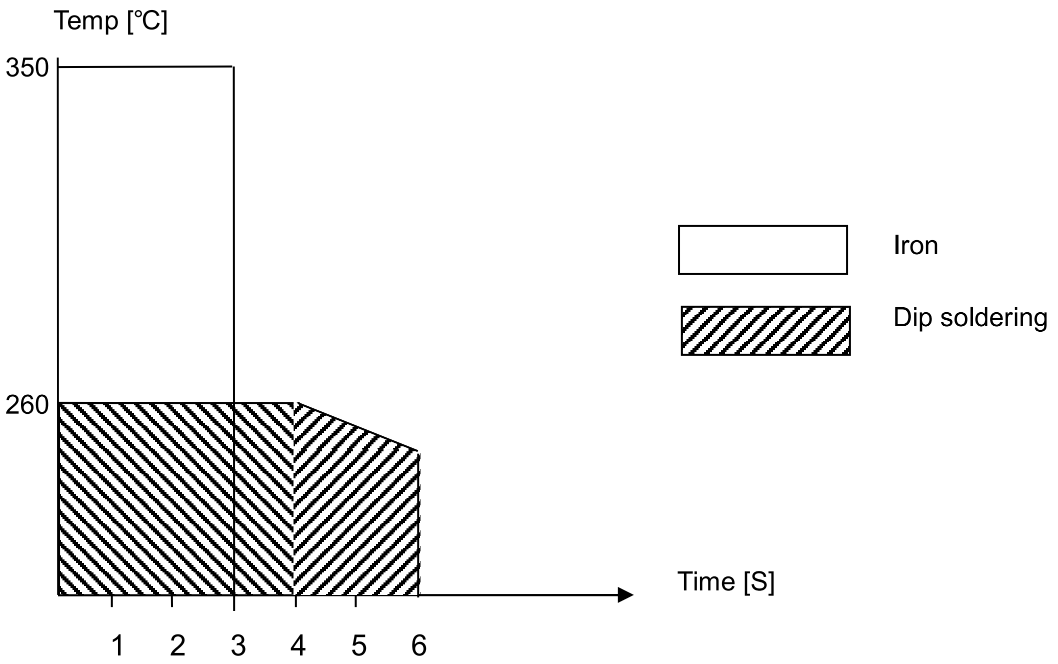
OTHER CAUTIONS

Soldering conditions

- Heat resisting temperature
  MKT : 160℃ KP/MKP : 110℃

  When mounting, set the soldering temperature so that the capacitor inside peak temperature is to be lower than the given above heat resisting temperature.

- Preheating temp : Max 110℃, 1min



[If dipping a capacitor into solder twice, the second dipping shall be carried after the capacitor itself has returned to normal temperature]

Not passing through adhesive curing oven in order to fix the SMD parts in combination with leads parts.
- Not reflow soldering by combine the lead parts with SMD parts.

When cleaning right after soldering, make sure the capacitor surface temperature is lower than 50℃

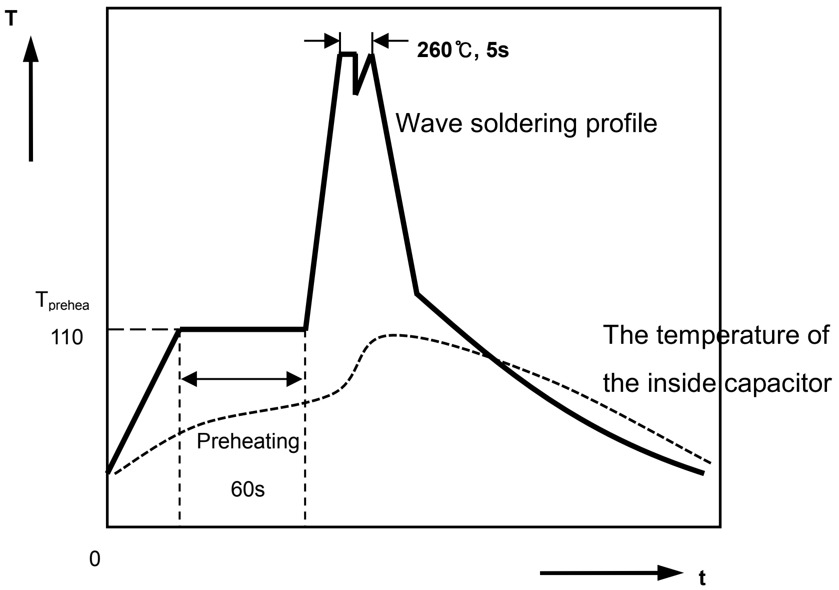
General notes on soldering

Long exposure to temperatures above this type-related temperature limit can lead to changes in the plastic dielectric and thus change irreversibly a capacitor's electrical characteristics. For short exposures (as in practical soldering processes) the heat load (and thus the possible effects on a capacitor) will also depend on other factors like:

- Pre-heating temperature and time
- Forced cooling immediately after soldering
- Terminal characteristics: diameter, length, thermal resistance, special configurations
- Height of capacitor above solder bath
- Shadowing by neighboring components
- Additional heating due to heat dissipation by neighboring components
- Use of solder-resist coatings

The overheating associated with some of these factors can usually be reduced by suitable countermeasures. For example, if a pre-heating step cannot be avoided, an additional or reinforced cooling process may possibly have to be included.

Recommended wave soldering profile

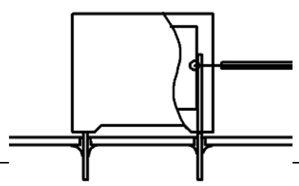


1. The maximum set-up temperature of the soldering process

Maximum preheat temperature	Maximum peak soldering temperature
110℃	260℃

2. The maximum temperature of the inside capacitor:
   Set the temperature so that inside the element the maximum temperature is below the limit:-

Maximum temperature measured inside the element
110℃



Changes in capacitance value over time

The capacitor characteristics change depending on its ambient conditions and environmental conditions. In natural conditions, there is a certain capacitance change due to permeation of humidity in the air. The degree of such capacitance changes varies with the dielectric material, coating material, and structure.

Buzz noise

Any buzz noise produced by the film capacitor is caused by the vibration of the film due to the Coulomb force that is generated between the electrodes with opposite polarity. Buzz noise becomes louder if the applied voltage waveform presents distortion and/or high frequency harmonics. Buzz noise does not affect the capacitor structure, nor its electrical characteristics or reliability.

Selection guide for across the line

The approved series by UL, ENEC, CQC, KC and so on should be selected for across the line, line bypass or antenna coupling purpose in the circuit.

Legal notice

These described information given by PILKOR are as accurate as possible
but, being given for general and typical information.

PILKOR shall not be liable for any defect which is due to accident, improper handling, improper use, improper operation or any other default on the part of any person other than PILKOR.

These described products in this data book, are not designed for use in medical, life-saving,
or life-sustaining applications.