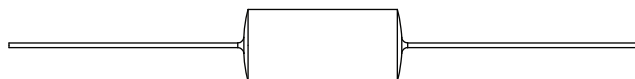


# AC and Pulse Metallized Polypropylene Film Capacitors MKP Axial Type



## FEATURES

- Supplied loose in box, taped on ammpack or reel available on request
- Material categorization:  
for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
**GREEN**  
(5-2008)

## APPLICATIONS

High current and high pulse operations

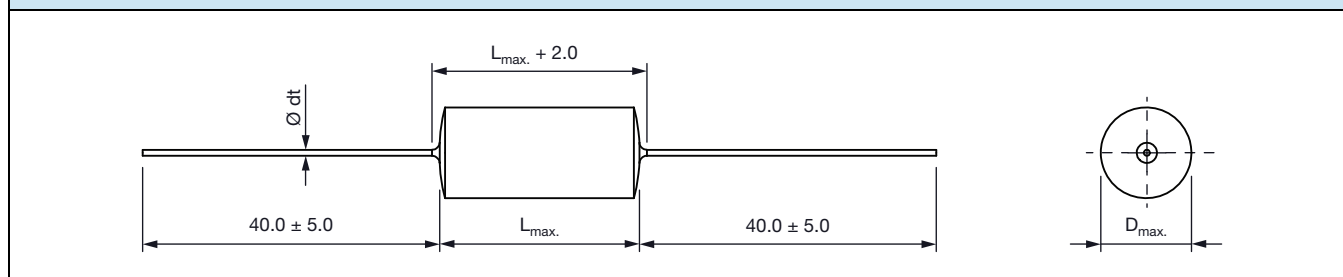
## QUICK REFERENCE DATA

|                                                 |                                                                                                                                                                                                                            |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Capacitance range (E12 series)                  | 0.1 $\mu$ F to 3.3 $\mu$ F                                                                                                                                                                                                 |
| Capacitance tolerance                           | $\pm 5\%$                                                                                                                                                                                                                  |
| Rated DC voltage                                | 630 V <sub>DC</sub> , 850 V <sub>DC</sub> , 1250 V <sub>DC</sub> , 1600 V <sub>DC</sub>                                                                                                                                    |
| Rated AC voltage                                | 300 V <sub>AC</sub> , 400 V <sub>AC</sub> , 425 V <sub>AC</sub> , 450 V <sub>AC</sub>                                                                                                                                      |
| Climatic testing class according to IEC 60068-1 | 55/110/56                                                                                                                                                                                                                  |
| Rated temperature                               | 85 °C                                                                                                                                                                                                                      |
| Maximum application temperature                 | At 85 °C: $U_C = 1.0 U_R$<br>At 110 °C: $U_C = 0.7 U_R$                                                                                                                                                                    |
| Reference standards                             | IEC 60384-17                                                                                                                                                                                                               |
| Dielectric                                      | Polypropylene film                                                                                                                                                                                                         |
| Electrodes                                      | Metallized                                                                                                                                                                                                                 |
| Construction                                    | Series construction                                                                                                                                                                                                        |
| Encapsulation                                   | Plastic-wrapped, epoxy resin sealed. Flame retardant                                                                                                                                                                       |
| Leads                                           | Tinned wire                                                                                                                                                                                                                |
| Pull test on leads                              | $\geq 20$ N in direction of leads according to IEC 60068-2-21                                                                                                                                                              |
| Bent test on leads                              | 2 bends through 90° with half of the force used in pull test                                                                                                                                                               |
| Reliability                                     | Operation life > 300 000 h<br>Failure rate < 5 FIT (40 °C and 0.5 x $U_R$ )                                                                                                                                                |
| Marking                                         | Manufacturer's logo; code for dielectric material; manufacturer's type designation;<br>C-code; rated voltage-code; tolerance-code; special n °C-value; tolerance;<br>rated voltage; year and week; manufacturer's location |

## Note

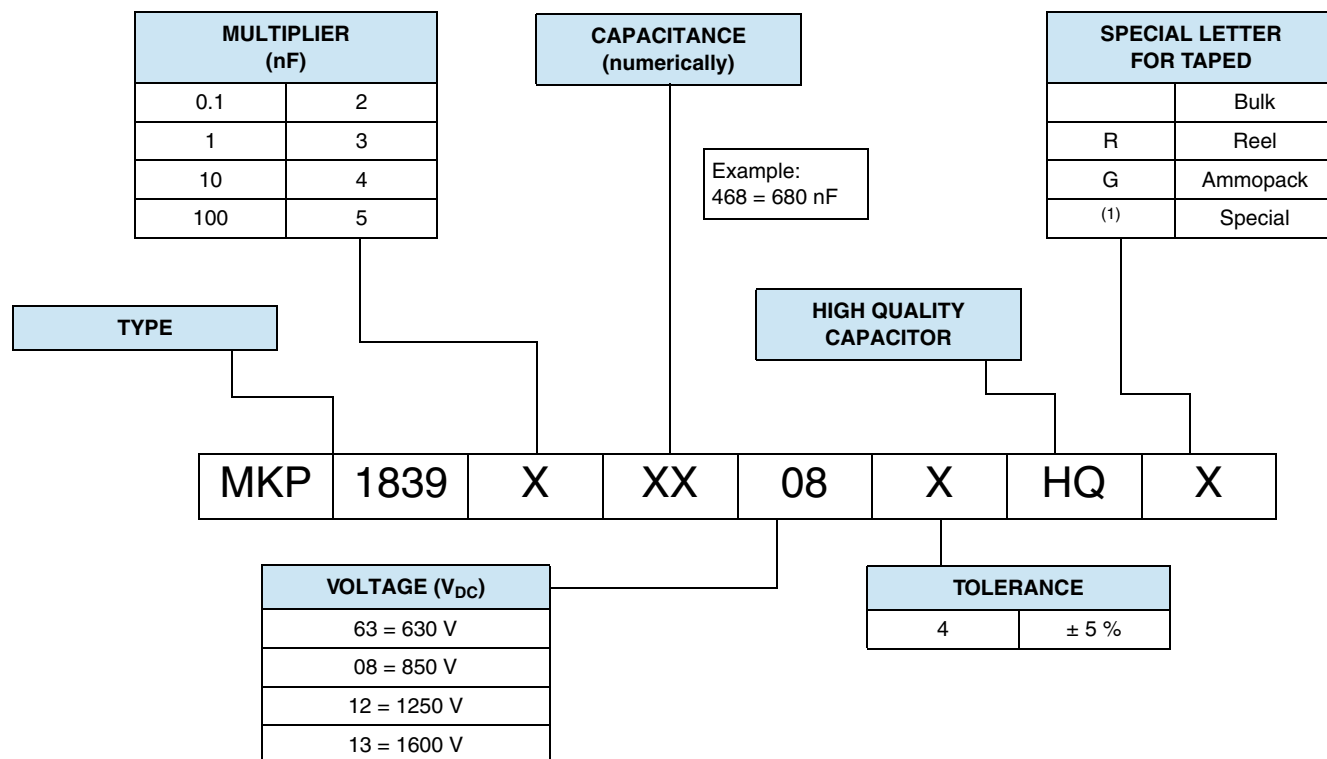
- For more detailed data and test requirements, contact [dc-film@vishay.com](mailto:dc-film@vishay.com)

## DIMENSIONS in millimeters





## COMPOSITION OF CATALOG NUMBER



## Note

(1) For detailed tape specifications refer to packaging information: [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139) or end of catalog

| SPECIFIC REFERENCE DATA                                                                                                                                        |                         |                          |                          |                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------------|--------------------------|-----------------------|
| DESCRIPTION                                                                                                                                                    | VALUE                   |                          |                          |                       |
| Tangent of loss angle:<br>0.1 $\mu\text{F} < C \leq 0.47 \mu\text{F}$<br>0.47 $\mu\text{F} < C \leq 1 \mu\text{F}$<br>1 $\mu\text{F} < C \leq 3.3 \mu\text{F}$ | 1 kHz                   | 10 kHz                   | 100 kHz                  |                       |
|                                                                                                                                                                | $\leq 3 \times 10^{-4}$ | $\leq 5 \times 10^{-4}$  | $\leq 40 \times 10^{-4}$ |                       |
|                                                                                                                                                                | $\leq 3 \times 10^{-4}$ | $\leq 8 \times 10^{-4}$  | $\leq 60 \times 10^{-4}$ |                       |
|                                                                                                                                                                | $\leq 3 \times 10^{-4}$ | $\leq 15 \times 10^{-4}$ | -                        |                       |
| Rated voltage pulse slope<br>(dU/dt) <sub>R</sub> at U <sub>RDC</sub>                                                                                          | 630 V <sub>DC</sub>     | 850 V <sub>DC</sub>      | 1250 V <sub>DC</sub>     | 1600 V <sub>DC</sub>  |
|                                                                                                                                                                | 500 V/ $\mu\text{s}$    | 1000 V/ $\mu\text{s}$    | 1000 V/ $\mu\text{s}$    | 1000 V/ $\mu\text{s}$ |
| U <sub>P-P</sub> peak-to-peak voltage                                                                                                                          | 700 V                   | 1130 V                   | 1400 V                   | 1600 V                |
| R between leads,<br>for C $\leq 0.33 \mu\text{F}$ at 500 V, 1 min                                                                                              | > 100 G $\Omega$        |                          |                          |                       |
| RC between leads,<br>for C > 0.33 $\mu\text{F}$ at 500 V, 1 min                                                                                                | > 30 000 s              |                          |                          |                       |
| R between interconnecting and<br>wrapped film at 500 V, 1 min                                                                                                  | > 100 G $\Omega$        |                          |                          |                       |
| Withstanding (DC) voltage (cut off<br>current 10 mA), rise time 100 V/s                                                                                        | 1008 V                  | 1360 V                   | 2000 V                   | 2560 V                |
|                                                                                                                                                                | 1 min                   |                          |                          |                       |
| Withstanding (DC) voltage between<br>leads and wrapped film<br>(1.4 x U <sub>RAC</sub> + 2000)                                                                 | 2840 V, 1 min           |                          |                          |                       |
| Maximum application temperature                                                                                                                                | 110 °C                  |                          |                          |                       |



## ELECTRICAL DATA AND ORDERING INFORMATION

| U <sub>RDC</sub><br>(V) | CAP.<br>(μF) | VOLTAGE<br>CODE | V <sub>AC</sub> | DIMENSIONS<br>(mm) |                   | d <sub>t</sub><br>± 0.08 mm<br>(mm) | MASS<br>(g) | SPQ <sup>(1)</sup><br>(pieces) |
|-------------------------|--------------|-----------------|-----------------|--------------------|-------------------|-------------------------------------|-------------|--------------------------------|
|                         |              |                 |                 | D <sub>max.</sub>  | L <sub>max.</sub> |                                     |             |                                |
| 630                     | 0.10         | 63              | 300             | 7                  | 26.5              | 0.8                                 | 0.9         | 2000                           |
|                         | 0.15         |                 |                 | 8                  | 26.5              |                                     | 1.2         | 1750                           |
|                         | 0.18         |                 |                 | 8.5                | 26.5              |                                     | 1.4         | 1500                           |
|                         | 0.22         |                 |                 | 9.5                | 26.5              |                                     | 1.6         | 1250                           |
|                         | 0.27         |                 |                 | 10                 | 26.5              |                                     | 1.9         | 1000                           |
|                         | 0.33         |                 |                 | 11                 | 26.5              |                                     | 2.3         | 900                            |
|                         | 0.39         |                 |                 | 10.5               | 31.5              |                                     | 2.6         | 900                            |
|                         | 0.47         |                 |                 | 11                 | 31.5              |                                     | 3.0         | 750                            |
|                         | 0.56         |                 |                 | 12                 | 31.5              |                                     | 3.5         | 650                            |
|                         | 0.68         |                 |                 | 13                 | 31.5              |                                     | 4.2         | 500                            |
|                         | 0.82         |                 |                 | 14                 | 31.5              |                                     | 5.1         | 1000                           |
|                         | 1.00         |                 |                 | 16                 | 31.5              |                                     | 6.1         | 900                            |
|                         | 1.50         |                 |                 | 19                 | 31.5              | 1.0                                 | 9.0         | 600                            |
|                         | 2.20         |                 |                 | 23                 | 31.5              |                                     | 13.1        | 450                            |
|                         | 3.30         |                 |                 | 28                 | 31.5              |                                     | 19.5        | 300                            |
| 850                     | 0.10         | 08              | 400             | 8.5                | 31.5              | 0.8                                 | 1.6         | 1500                           |
|                         | 0.15         |                 |                 | 10                 | 31.5              |                                     | 2.3         | 1000                           |
|                         | 0.18         |                 |                 | 11                 | 31.5              |                                     | 2.7         | 850                            |
|                         | 0.22         |                 |                 | 11.5               | 31.5              |                                     | 3.2         | 750                            |
|                         | 0.27         |                 |                 | 13                 | 31.5              |                                     | 3.9         | 1000                           |
|                         | 0.33         |                 |                 | 14                 | 31.5              |                                     | 4.6         | 1000                           |
|                         | 0.39         |                 |                 | 15                 | 31.5              |                                     | 5.4         | 1000                           |
|                         | 0.47         |                 |                 | 16.5               | 31.5              |                                     | 6.5         | 1000                           |
|                         | 0.56         |                 |                 | 15                 | 31.5              |                                     | 5.4         | 1000                           |
|                         | 0.68         |                 |                 | 16.5               | 31.5              |                                     | 6.5         | 1000                           |
|                         | 0.82         |                 |                 | 18                 | 31.5              | 1.0                                 | 7.8         | 750                            |
|                         | 1.00         |                 |                 | 19.5               | 31.5              |                                     | 9.4         | 600                            |
|                         | 1.50         |                 |                 | 24                 | 31.5              |                                     | 13.9        | 400                            |
|                         |              |                 |                 |                    |                   |                                     |             |                                |
| 1250                    | 0.10         | 12              | 425             | 8.5                | 31.5              | 0.8                                 | 1.6         | 1500                           |
|                         | 0.15         |                 |                 | 10                 | 31.5              |                                     | 2.3         | 1000                           |
|                         | 0.18         |                 |                 | 11                 | 31.5              |                                     | 2.7         | 1000                           |
|                         | 0.22         |                 |                 | 11.5               | 31.5              |                                     | 3.2         | 800                            |
|                         | 0.27         |                 |                 | 13                 | 31.5              |                                     | 3.9         | 650                            |
|                         | 0.33         |                 |                 | 14                 | 31.5              |                                     | 4.6         | 500                            |
|                         | 0.39         |                 |                 | 15                 | 31.5              |                                     | 5.4         | 1000                           |
|                         | 0.47         |                 |                 | 16.5               | 31.5              |                                     | 6.5         | 900                            |
|                         | 0.56         |                 |                 | 18                 | 31.5              | 1.0                                 | 7.7         | 750                            |
|                         | 0.68         |                 |                 | 20                 | 31.5              |                                     | 9.2         | 600                            |
|                         | 0.82         |                 |                 | 21.5               | 31.5              |                                     | 11.1        | 500                            |
|                         | 1.00         |                 |                 | 23.5               | 31.5              |                                     | 13.4        | 400                            |
|                         |              |                 |                 |                    |                   |                                     |             |                                |
|                         |              |                 |                 |                    |                   |                                     |             |                                |
| 1600                    | 0.10         | 13              | 450             | 12                 | 31.5              | 0.8                                 | 2.7         | 1000                           |
|                         | 0.15         |                 |                 | 14                 | 31.5              |                                     | 3.9         | 600                            |
|                         | 0.18         |                 |                 | 15                 | 31.5              |                                     | 4.6         | 500                            |
|                         | 0.22         |                 |                 | 16.5               | 31.5              |                                     | 5.5         | 500                            |
|                         | 0.27         |                 |                 | 17.5               | 31.5              |                                     | 6.7         | 900                            |
|                         | 0.33         |                 |                 | 20                 | 31.5              |                                     | 8.1         | 750                            |
|                         | 0.39         |                 |                 | 21.5               | 31.5              | 1.0                                 | 9.5         | 600                            |
|                         | 0.47         |                 |                 | 23.5               | 31.5              |                                     | 11.3        | 500                            |
|                         | 0.56         |                 |                 | 25.5               | 31.5              |                                     | 13.4        | 400                            |
|                         | 0.68         |                 |                 | 28                 | 31.5              |                                     | 16.2        | 350                            |
|                         |              |                 |                 |                    |                   |                                     |             |                                |
|                         |              |                 |                 |                    |                   |                                     |             |                                |

## Note

(1) SPQ = Standard Packing Quantity

## MOUNTING

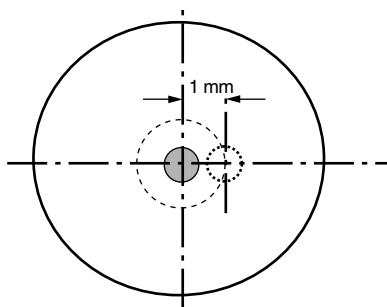
### Normal Use

The capacitors are designed for mounting on printed-circuit boards. The capacitors packed in bandoliers are designed for mounting in printed-circuit boards by means of automatic insertion machines.

### Specific Method of Mounting to Withstand Vibration and Shock

In order to withstand vibration and shock tests, it must be ensured that the capacitor body is in good contact with the printed-circuit board.

- For  $L \leq 19$  mm capacitors shall be mechanically fixed by the leads
- For larger pitches the capacitors shall be mounted in the same way and the body clamped
- The maximum diameter and length of the capacitors are specified in the dimensions table
- Eccentricity as shown in the drawing below:



### Soldering Conditions

For general soldering conditions and wave soldering profile, we refer to application note:

“Soldering Guidelines for Film Capacitors”: [www.vishay.com/doc?28171](http://www.vishay.com/doc?28171)

### Storage Temperature

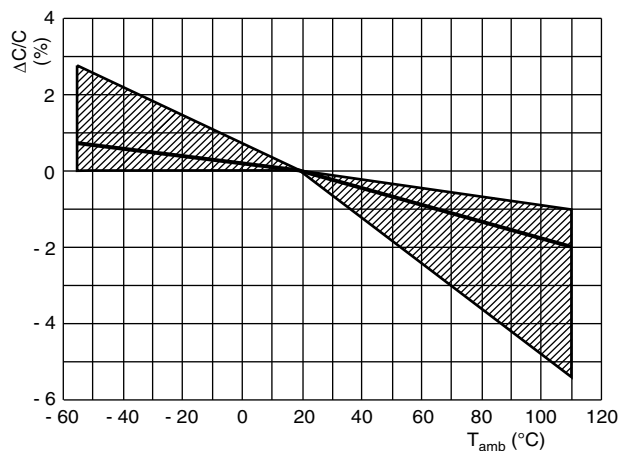
$T_{stg} = -25\text{ °C to }+35\text{ °C}$  with RH maximum 75 % without condensation

### Ratings and Characteristics Reference Conditions

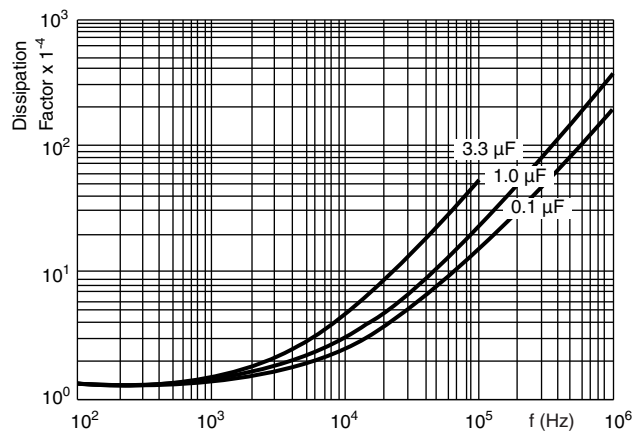
Unless otherwise specified, all electrical values apply to an ambient free air temperature of  $23\text{ °C} \pm 1\text{ °C}$ , an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of  $50\% \pm 2\%$ .

For reference testing, a conditioning period shall be applied over  $96\text{ h} \pm 4\text{ h}$  by heating the products in a circulating air oven at the rated temperature and a relative humidity not exceeding 20 %.

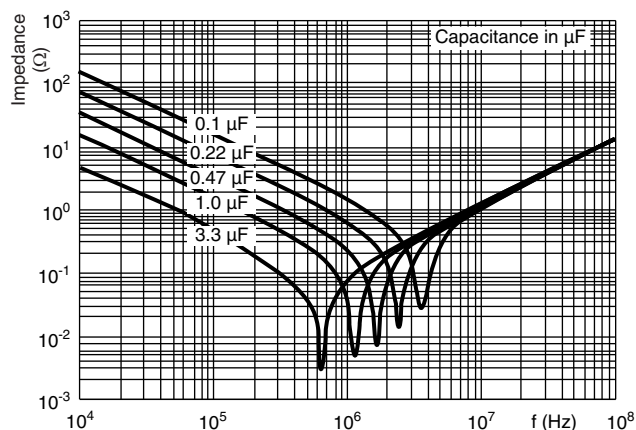
## CHARACTERISTICS



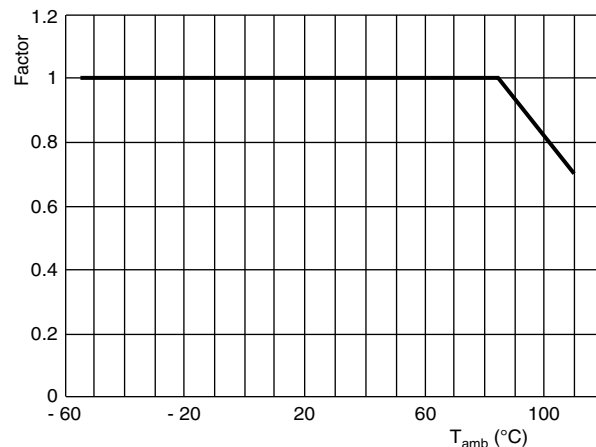
Capacitance as a function of ambient temperature (typical curve)



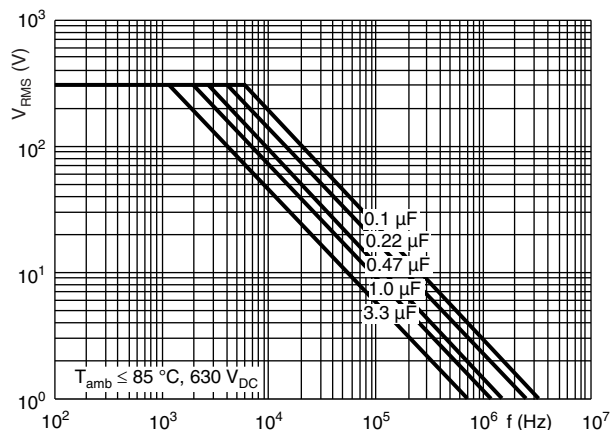
Tangent of loss angle as a function of frequency (typical curve)



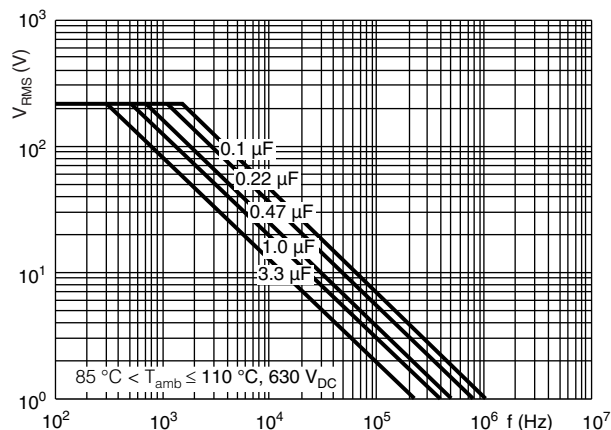
Impedance as a function of frequency (typical curve)



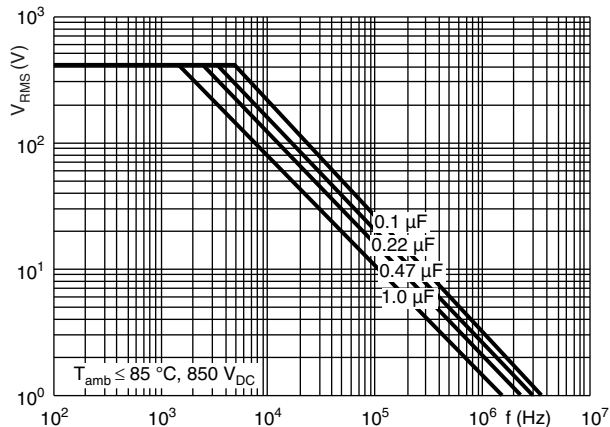
Max. DC and AC voltage as a function of temperature



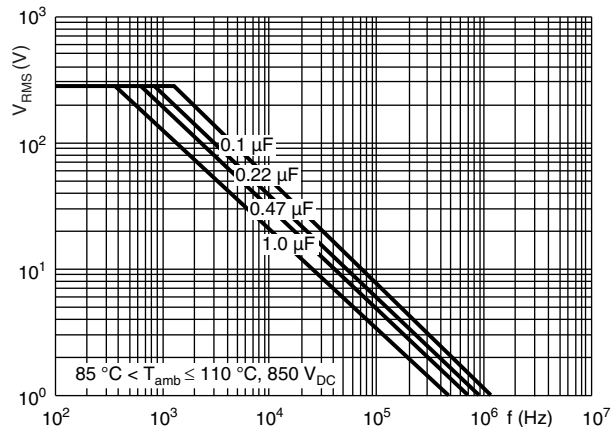
Max. RMS voltage (sinewave) as a function of frequency



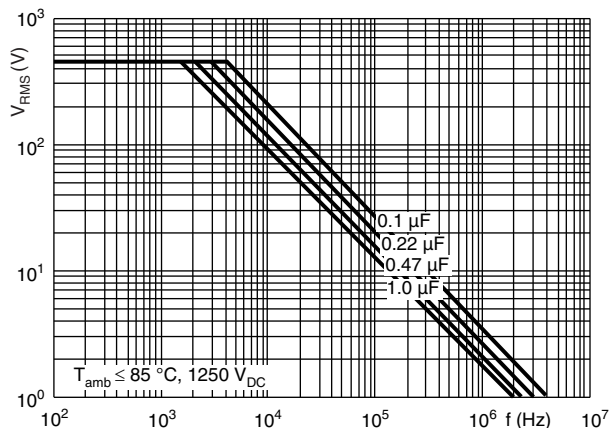
Max. RMS voltage (sinewave) as a function of frequency



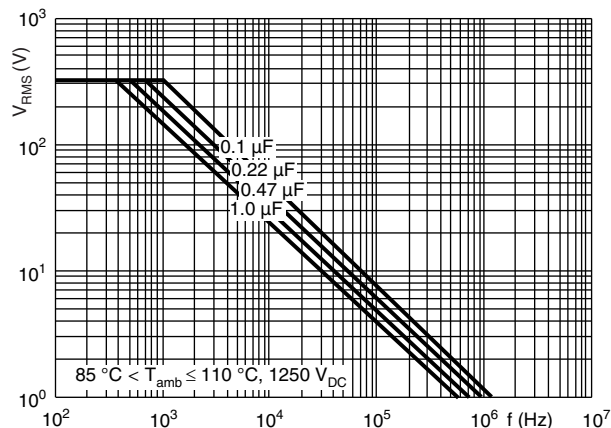
Max. RMS voltage (sinewave) as a function of frequency



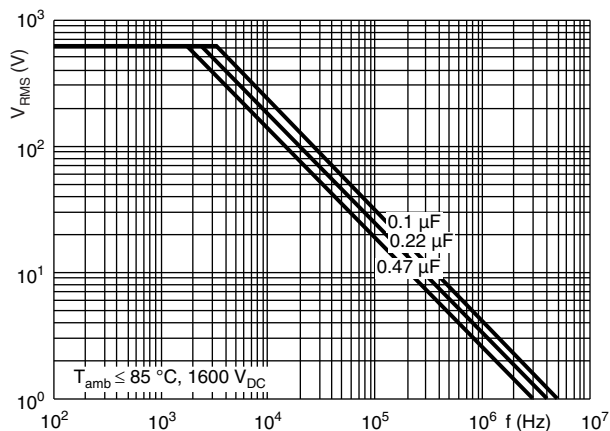
Max. RMS voltage (sinewave) as a function of frequency



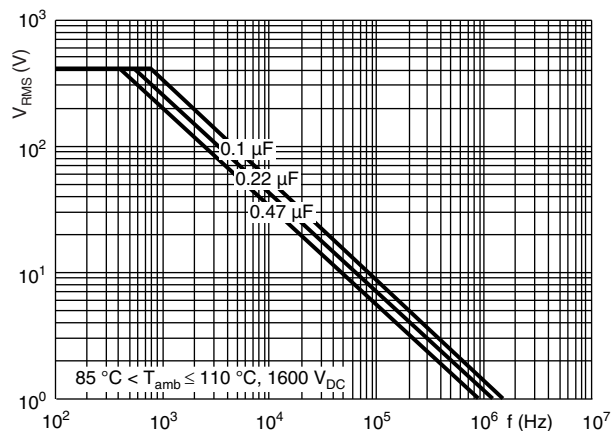
Max. RMS voltage (sinewave) as a function of frequency



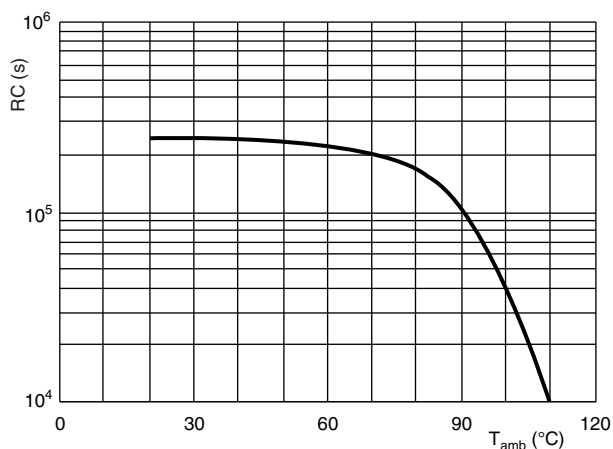
Max. RMS voltage (sinewave) as a function of frequency



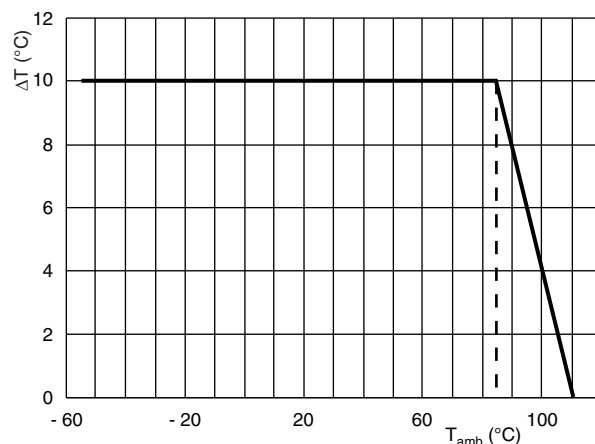
Max. RMS voltage (sinewave) as a function of frequency



Max. RMS voltage (sinewave) as a function of frequency



Insulation resistance as a function of ambient temperature  
(typical curve)



Max. allowed component rise ( $\Delta T$ ) as a function of the  
ambient temperature ( $T_{amb}$ )

### HEAT CONDUCTIVITY (G) AS A FUNCTION OF CAPACITOR BODY THICKNESS IN mW/°C

| DIAMETER<br>(mm) | HEAT CONDUCTIVITY (mW/°C) |               |
|------------------|---------------------------|---------------|
|                  | PITCH 26.5 mm             | PITCH 31.5 mm |
| 7.0              | 8                         | -             |
| 8.0              | 10                        | -             |
| 8.5              | 11                        | 12            |
| 9.5              | 12                        | -             |
| 10.0             | 13                        | 15            |
| 10.5             | -                         | 16            |
| 11.0             | 15                        | 17            |
| 11.5             | -                         | 18            |
| 12.0             | -                         | 19            |
| 12.5             | -                         | 20            |
| 13.0             | -                         | 21            |
| 13.5             | -                         | 22            |
| 14.0             | -                         | 23            |
| 15.0             | -                         | 25            |
| 16.0             | -                         | 28            |
| 16.5             | -                         | 29            |
| 18.0             | -                         | 32            |
| 19.0             | -                         | 34            |
| 19.5             | -                         | 36            |
| 20.0             | -                         | 37            |
| 21.5             | -                         | 40            |
| 23.0             | -                         | 44            |
| 23.5             | -                         | 45            |
| 24.0             | -                         | 47            |
| 25.5             | -                         | 51            |
| 28.0             | -                         | 57            |

## POWER DISSIPATION AND MAXIMUM COMPONENT TEMPERATURE RISE

The power dissipation must be limited in order not to exceed the maximum allowed component temperature rise as a function of the free air ambient temperature.

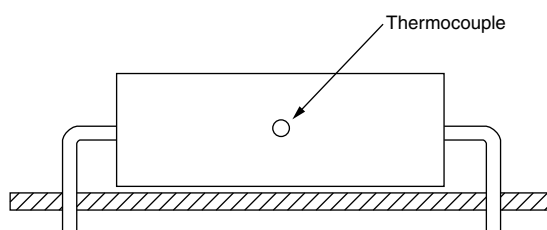
The power dissipation can be calculated according type detail specification “HQN-384-01/101: Technical Information Film Capacitors with the typical  $t_{gd}$  of the curves”.

The component temperature rise ( $\Delta T$ ) can be measured (see section “Measuring the component temperature” for more details) or calculated by  $\Delta T = P/G$ :

- $\Delta T$  = Component temperature rise ( $^{\circ}\text{C}$ )
- $P$  = Power dissipation of the component (mW)
- $G$  = Heat conductivity of the component ( $\text{mW}/^{\circ}\text{C}$ )

## MEASURING THE COMPONENT TEMPERATURE

A thermocouple must be attached to the capacitor body as in:



The temperature is measured in unloaded ( $T_{\text{amb}}$ ) and maximum loaded condition ( $T_{\text{C}}$ ).

The temperature rise is given by  $\Delta T = T_{\text{C}} - T_{\text{amb}}$ .

To avoid radiation or convection, the capacitor should be tested in a wind-free.

## APPLICATION NOTE AND LIMITING CONDITIONS

These capacitors are not suitable for mains applications as across-the-line capacitors without additional protection, as described hereunder. These mains applications are strictly regulated in safety standards and therefore electromagnetic interference suppression capacitors conforming the standards must be used.

To select the capacitor for a certain application, the following conditions must be checked:

1. The peak voltage ( $U_{\text{P}}$ ) shall not be greater than the rated DC voltage ( $U_{\text{RDC}}$ ).
2. The peak-to-peak voltage ( $U_{\text{P-P}}$ ) shall not be greater than the maximum ( $U_{\text{P-P}}$ ) to avoid the ionization inception level.
3. The voltage pulse slope ( $dU/dt$ ) shall not exceed the rated voltage pulse slope in an RC-circuit at rated voltage and without ringing. If the pulse voltage is lower than the rated DC voltage, the rated voltage pulse slope may be multiplied by  $U_{\text{RDC}}$  and divided by the applied voltage.

For all other pulses following equation must be fulfilled:

$$2 \times \int_0^T \left( \frac{dU}{dt} \right)^2 \times dt < U_{\text{RDC}} \times \left( \frac{dU}{dt} \right)_{\text{rated}}$$

$T$  is the pulse duration.

4. The maximum component surface temperature rise must be lower than the limits (see figure Max. Allowed Component Temperature Rise).
5. Since in circuits used at voltages over 280 V peak-to-peak the risk for an intrinsically active flammability after a capacitor breakdown (short circuit) increases, it is recommended that the power to the component is limited to 100 times the values mentioned in the table “Heat conductivity”.
6. When using these capacitors as across-the-line capacitor in the input filter for mains applications or as series connected with an impedance to the mains the applicant must guarantee that the following conditions are fulfilled in any case (spikes and surge voltages from the mains included).

**VOLTAGE CONDITIONS FOR 6 ABOVE**

| ALLOWED VOLTAGES                           | $T_{amb} \leq 85\text{ °C}$ | $85\text{ °C} < T_{amb} \leq 110\text{ °C}$                                |
|--------------------------------------------|-----------------------------|----------------------------------------------------------------------------|
| Maximum continuous RMS voltage             | $U_{RAC}$                   | See "Maximum AC voltage as a function of temperature par. characteristics" |
| Maximum temporary RMS-overvoltage (< 24 h) | $1.25 \times U_{RAC}$       | $0.875 \times U_{RAC}$                                                     |
| Maximum peak voltage ( $V_{O-P}$ ) (< 2 s) | $1.6 \times U_{RDC}$        | $1.1 \times U_{RDC}$                                                       |

**INSPECTION REQUIREMENTS****General Notes**

Sub-clause numbers of tests and performance requirements refer to the "Sectional Specification, Publication IEC 60384-17 and Specific Reference Data".

**GROUP C INSPECTION REQUIREMENTS**

| SUB-CLAUSE NUMBER AND TEST                          | CONDITIONS                                                                                                            | PERFORMANCE REQUIREMENTS                                                                                                                                                                     |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1</b> |                                                                                                                       |                                                                                                                                                                                              |
| 4.1 Dimensions (detail)                             |                                                                                                                       | As specified in chapter "General Data" of this specification                                                                                                                                 |
| 4.3.1 Initial measurements                          | Capacitance<br>Tangent of loss angle at 100 kHz                                                                       |                                                                                                                                                                                              |
| 4.3 Robustness of terminations                      | Tensile: load 30 N; 10 s<br>Bending: load 15 N; 90°                                                                   | No visible damage                                                                                                                                                                            |
| 4.4 Resistance to soldering heat                    | No pre-drying<br>Method: 1A<br>Solder bath: 280 °C ± 5 °C<br>Duration: 10 s                                           |                                                                                                                                                                                              |
| 4.4.2 Final measurements                            | Visual examination                                                                                                    | No visible damage<br>Legible marking                                                                                                                                                         |
|                                                     | Capacitance                                                                                                           | $ \Delta C/C  \leq 2\%$ of the value measured initially                                                                                                                                      |
|                                                     | Tangent of loss angle                                                                                                 | Increase of $\tan \delta$ :<br>for $C \leq 470\text{ nF} \leq 0.001 (10 \times 10^{-4})$<br>for $C > 470\text{ nF} \leq 0.0015 (15 \times 10^{-4})$<br>Compared to values measured initially |
|                                                     | Insulation resistance                                                                                                 | $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                                                                                                     |
| 4.14 Solvent resistance of the marking              | Isopropylalcohol at room temperature<br>Method: 1<br>Rubbing material: cotton wool<br>Immersion time: 5 min ± 0.5 min | No visible damage<br>Legible marking                                                                                                                                                         |
| <b>SUB-GROUP C1B PART OF SAMPLE OF SUB-GROUP C1</b> |                                                                                                                       |                                                                                                                                                                                              |
| 4.6.1 Initial measurements                          | Capacitance<br>Tangent of loss angle at 100 kHz                                                                       |                                                                                                                                                                                              |
| 4.6 Rapid change of temperature                     | $qA = -55\text{ °C}$<br>$qB = +110\text{ °C}$<br>5 cycles<br>Duration $t = 30\text{ min}$                             |                                                                                                                                                                                              |
|                                                     | Visual examination                                                                                                    | No visible damage                                                                                                                                                                            |



| GROUP C INSPECTION REQUIREMENTS                                            |                                                                                                                                                                                                                               |                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SUB-CLAUSE NUMBER AND TEST                                                 | CONDITIONS                                                                                                                                                                                                                    | PERFORMANCE REQUIREMENTS                                                                                                                                                                                                |
| <b>SUB-GROUP C1B PART OF SAMPLE OF SUB-GROUP C1</b>                        |                                                                                                                                                                                                                               |                                                                                                                                                                                                                         |
| 4.7 Vibration                                                              | Mounting:<br>see section "Mounting" of this specification<br>Procedure B4<br>Frequency range: 10 Hz to 55 Hz<br>Amplitude: 0.75 mm or<br>Acceleration 98 m/s <sup>2</sup><br>(whichever is less severe)<br>Total duration 6 h |                                                                                                                                                                                                                         |
| 4.7.2 Final inspection                                                     | Visual examination                                                                                                                                                                                                            | No visible damage                                                                                                                                                                                                       |
| 4.9 Shock                                                                  | Mounting:<br>see section "Mounting" for more information<br>Pulse shape: half sine<br>Acceleration: 490 m/s <sup>2</sup><br>Duration of pulse: 11 ms                                                                          |                                                                                                                                                                                                                         |
| 4.9.3 Final measurements                                                   | Visual examination                                                                                                                                                                                                            | No visible damage                                                                                                                                                                                                       |
|                                                                            | Capacitance                                                                                                                                                                                                                   | $ \Delta C/C  \leq 2\%$ of the value measured initially                                                                                                                                                                 |
|                                                                            | Tangent of loss angle                                                                                                                                                                                                         | Increase of $\tan \delta$ :<br>for $C \leq 470 \text{ nF} \leq 0.001 (10 \times 10^{-4})$<br>for $C > 470 \text{ nF} \leq 0.0015 (15 \times 10^{-4})$<br>Compared to values measured initially                          |
|                                                                            | Insulation resistance                                                                                                                                                                                                         | $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                                                                                                                                |
| <b>SUB-GROUP C1 COMBINED SAMPLE OF SPECIMENS OF SUB-GROUPS C1A AND C1B</b> |                                                                                                                                                                                                                               |                                                                                                                                                                                                                         |
| 4.10 Climatic sequence                                                     |                                                                                                                                                                                                                               |                                                                                                                                                                                                                         |
| 4.10.2 Dry heat                                                            | Temperature: 110 °C<br>Duration: 16 h                                                                                                                                                                                         |                                                                                                                                                                                                                         |
| 4.10.3 Damp heat cyclic<br>Test Db, first cycle                            |                                                                                                                                                                                                                               |                                                                                                                                                                                                                         |
| 4.10.4 Cold                                                                | Temperature: -55 °C<br>Duration: 2 h                                                                                                                                                                                          |                                                                                                                                                                                                                         |
| 4.10.6 Damp heat cyclic<br>Test Db, remaining cycles                       |                                                                                                                                                                                                                               |                                                                                                                                                                                                                         |
| 4.10.6.2 Final measurements                                                | Voltage proof = $U_{RDC}$ for 1 min within<br>15 min after removal from testchambers                                                                                                                                          | No breakdown or flashover                                                                                                                                                                                               |
|                                                                            | Visual examination                                                                                                                                                                                                            | No visible damage<br>Legible marking                                                                                                                                                                                    |
|                                                                            | Capacitance                                                                                                                                                                                                                   | $ \Delta C/C  \leq 3\%$ of the value measured initially                                                                                                                                                                 |
|                                                                            | Tangent of loss angle                                                                                                                                                                                                         | Increase of $\tan \delta$ :<br>for $C \leq 470 \text{ nF} \leq 0.001 (10 \times 10^{-4})$<br>for $C > 470 \text{ nF} \leq 0.0015 (15 \times 10^{-4})$<br>Compared to values measured in<br>4.3.1 or 4.6.1 as applicable |
|                                                                            | Insulation resistance                                                                                                                                                                                                         | $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                                                                                                                                |



| GROUP C INSPECTION REQUIREMENTS                                                       |                                                                                                                              |                                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SUB-CLAUSE NUMBER AND TEST                                                            | CONDITIONS                                                                                                                   | PERFORMANCE REQUIREMENTS                                                                                                                                                                                                                         |
| <b>SUB-GROUP C2</b>                                                                   |                                                                                                                              |                                                                                                                                                                                                                                                  |
| 4.11 Damp heat steady state                                                           | Capacitance                                                                                                                  |                                                                                                                                                                                                                                                  |
| 4.11.1 Initial measurements                                                           | Tangent of loss angle at 1 kHz                                                                                               |                                                                                                                                                                                                                                                  |
|                                                                                       | Visual examination                                                                                                           | No visible damage<br>Legible marking                                                                                                                                                                                                             |
| 4.11.3 Final measurements                                                             | Voltage proof = $U_{RDC}$ for 1 min within 15 min after removal from testchamber                                             | No breakdown or flashover                                                                                                                                                                                                                        |
|                                                                                       | Capacitance                                                                                                                  | $ \Delta C/C  \leq 3\%$ of the value measured in 4.11.1.                                                                                                                                                                                         |
|                                                                                       | Tangent of loss angle                                                                                                        | Increase of $\tan \delta$ :<br>for $C \leq 470 \text{ nF} \leq 0.001 (10 \times 10^{-4})$<br>for $C > 470 \text{ nF} \leq 0.0015 (15 \times 10^{-4})$<br>Compared to values measured in 4.11.1                                                   |
|                                                                                       | Insulation resistance                                                                                                        | $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                                                                                                                                                         |
| <b>SUB-GROUP C3 A</b>                                                                 |                                                                                                                              |                                                                                                                                                                                                                                                  |
| 4.12.1 Endurance test at 50 Hz alternative voltage                                    | Duration: 2000 h<br>$1.0 \times U_{RAC}$ at $85^\circ\text{C}$<br>$0.875 \times U_{RAC}$ at $110^\circ\text{C}$              |                                                                                                                                                                                                                                                  |
| 4.12.1.1 Initial measurements                                                         | Capacitance<br>Tangent of loss angle at 100 kHz                                                                              |                                                                                                                                                                                                                                                  |
| 4.12.1.3 Final measurements                                                           | Visual examination                                                                                                           | No visible damage<br>Legible marking                                                                                                                                                                                                             |
|                                                                                       | Capacitance                                                                                                                  | $ \Delta C/C  \leq 5\%$ compared to values measured in 4.12.1.1                                                                                                                                                                                  |
|                                                                                       | Tangent of loss angle                                                                                                        | Increase of $\tan \delta$ :<br>for $C \leq 470 \text{ nF} \leq 0.001 (10 \times 10^{-4})$<br>for $C > 470 \text{ nF} \leq 0.0015 (15 \times 10^{-4})$<br>Compared to values measured in 4.12.1.1                                                 |
|                                                                                       | Insulation resistance                                                                                                        | $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                                                                                                                                                         |
| <b>SUB-GROUP C4</b>                                                                   |                                                                                                                              |                                                                                                                                                                                                                                                  |
| 4.2.6 Temperature characteristics<br>Initial measurement<br>Intermediate measurements | Capacitance<br>Capacitance at $-55^\circ\text{C}$<br>Capacitance at $20^\circ\text{C}$<br>Capacitance at $110^\circ\text{C}$ | For $-55^\circ\text{C}$ to $20^\circ\text{C}$<br>$0\% \leq  \Delta C/C  \leq 2.75\%$ or<br>for $20^\circ\text{C}$ to $110^\circ\text{C}$ :<br>$-5.5\% \leq  \Delta C/C  \leq 0\%$<br>As specified in section "Capacitance" of this specification |
| 4.13 Charge and discharge                                                             | 10 000 cycles<br>Charged to $U_{RDC}$<br>Discharge resistance:<br>$R = \frac{U_n(V_{DC})}{2.5 \times C(dU/dt)}$              |                                                                                                                                                                                                                                                  |
| 4.13.1 Initial measurements                                                           | Capacitance<br>Tangent of loss angle at 100 kHz                                                                              |                                                                                                                                                                                                                                                  |
| 4.13.3 Final measurements                                                             | Capacitance                                                                                                                  | $ \Delta C/C  \leq 3\%$ of the value measured in 4.13.1                                                                                                                                                                                          |
|                                                                                       | Tangent of loss angle                                                                                                        | Increase of $\tan \delta$ :<br>for $C \leq 470 \text{ nF} \leq 0.001 (10 \times 10^{-4})$<br>for $C > 470 \text{ nF} \leq 0.0015 (15 \times 10^{-4})$<br>Compared to values measured in 4.13.1                                                   |
|                                                                                       | Insulation resistance                                                                                                        | $\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                                                                                                                                                         |



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