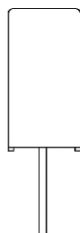
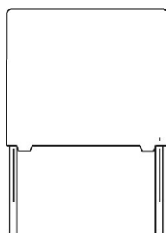


# AC and Pulse Metallized Polypropylene Film Capacitors MKP Radial Potted Type



## FEATURES

- 5 mm to 52.5 mm lead pitch; 7.5 mm bent back pitch
- Low contact resistance
- Low loss dielectric
- Small dimensions for high density packaging
- Supplied loose in box and taped on reel or ammpack
- 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

- Where steep pulses occur e.g. SMPS (switch mode power supplies)
- Electronic lighting e.g. ballast
- Motor control circuits
- High frequency and pulse operations
- Deflection circuits in TV-sets (S-correction)
- Loudspeaker crossover networks, storage, filter, timing and sample and hold circuits

## QUICK REFERENCE DATA

|                                                 |                                                                                                                                                 |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Capacitance range (E24 series)                  | 0.00047 $\mu$ F to 82 $\mu$ F                                                                                                                   |
| Capacitance tolerance                           | $\pm 5 \%$                                                                                                                                      |
| Climatic testing class according to IEC 60068-1 | 55/110/56                                                                                                                                       |
| Rated DC temperature                            | 85 °C                                                                                                                                           |
| Rated AC temperature                            | 85 °C                                                                                                                                           |
| Maximum application temperature                 | 110 °C                                                                                                                                          |
| Maximum operating temperature for limited time  | 125 °C                                                                                                                                          |
| Reference specifications                        | IEC 60384-17                                                                                                                                    |
| Dielectric                                      | Polypropylene film                                                                                                                              |
| Electrodes                                      | Metallized                                                                                                                                      |
| Construction                                    | Mono and internal serial construction                                                                                                           |
| Encapsulation                                   | Flame retardant plastic case and epoxy resin<br>UL-class 94 V-0                                                                                 |
| Leads                                           | Tinned wire                                                                                                                                     |
| Marking                                         | C-value; tolerance; rated voltage; manufacturer's type; code for dielectric material; manufacturer location; manufacturer's logo; year and week |

### Note

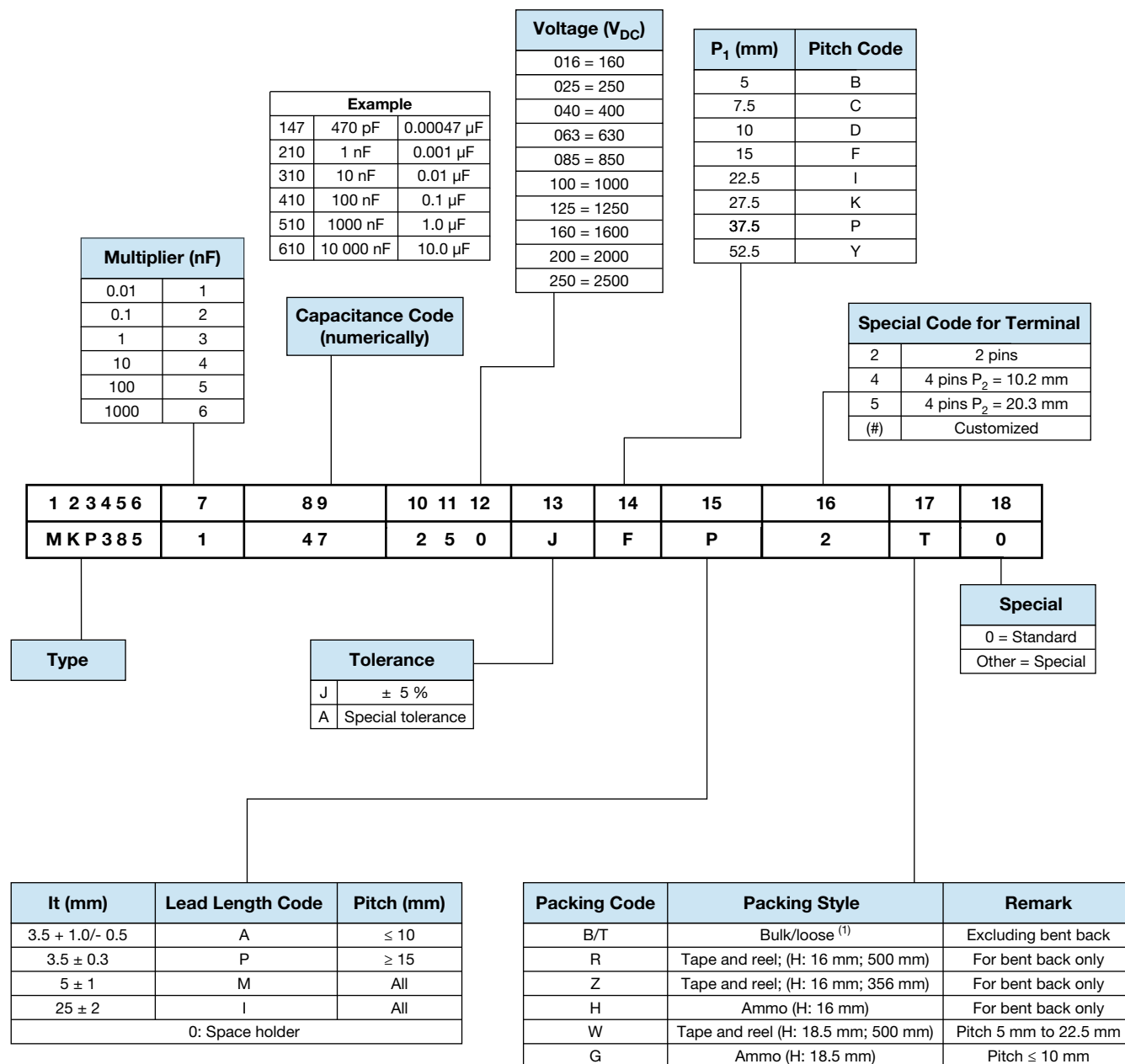
- For more detailed data and test requirements, contact [dc-film@vishay.com](mailto:dc-film@vishay.com)

## VOLTAGE RATINGS

|                            |     |     |     |     |     |      |      |      |                    |                    |
|----------------------------|-----|-----|-----|-----|-----|------|------|------|--------------------|--------------------|
| Rated DC voltage           | 160 | 250 | 400 | 630 | 850 | 1000 | 1250 | 1600 | 2000               | 2500               |
| Rated AC voltage           | 110 | 160 | 200 | 220 | 300 | 350  | 450  | 550  | 700 <sup>(1)</sup> | 900 <sup>(2)</sup> |
| Rated peak to peak voltage | 310 | 450 | 560 | 620 | 850 | 1000 | 1250 | 1600 | 2000               | 2500               |

### Notes

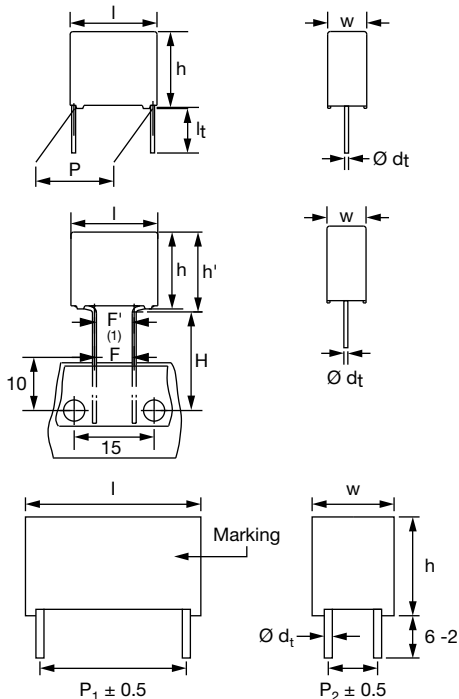
- <sup>(1)</sup> Rated AC voltage is 600 V<sub>AC</sub> for pitch  $\geq 37.5$  mm  
<sup>(2)</sup> Rated AC voltage is 800 V<sub>AC</sub> for pitch  $\geq 37.5$  mm

**COMPOSITION OF CATALOG NUMBER**

**Notes**

- For detailed tape specifications refer to packaging information [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)
- <sup>(1)</sup> Packaging will be bulk for all capacitors with pitch  $\leq 15$  mm and such with long leads ( $> 5$  mm). Capacitors with short leads up to 5 mm and pitch  $> 15$  mm will be in tray and asking code will be "T".

**ELECTRICAL DATA** (For Detailed Ratings go to [www.vishay.com/doc?28182](http://www.vishay.com/doc?28182))

| $U_{RDC}$<br>(V) | CAP.<br>( $\mu$ F)        |
|------------------|---------------------------|
| 160              | 0.011 min.<br>82 max.     |
| 250              | 0.010 min.<br>62 max.     |
| 400              | 0.0043 min.<br>27 max.    |
| 630              | 0.0015 min.<br>15 max.    |
| 850              | 0.001 min.<br>10 max.     |
| 1000             | 0.00047 min.<br>6.8 max.  |
| 1250             | 0.00047 min.<br>5.1 max.  |
| 1600             | 0.00047 min.<br>2.7 max.  |
| 2000             | 0.00047 min.<br>1.6 max.  |
| 2500             | 0.00047 min.<br>0.68 max. |

**DIMENSIONS** in millimeters

**Note**

- $|F - F'| < 0.3 \text{ mm}$   
 $F = 7.5 \text{ mm} + 0.6 \text{ mm} / - 0.1 \text{ mm}$   
 $\varnothing d_t \pm 10 \% \text{ of standard diameter specified}$

## MOUNTING

### Normal Use

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

For detailed tape specifications refer to “Packaging Information” [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)

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

In order to withstand vibration and shock tests, it must be ensured that the stand-off pips are in good contact with the printed-circuit board:

- For original pitch = 15 mm the capacitors shall be mechanically fixed by the leads
- For larger pitches the capacitors shall be mounted in the same way and the body clamped

### Space Requirements on Printed-Circuit Board

The maximum length and width of film capacitors is shown in the drawing:

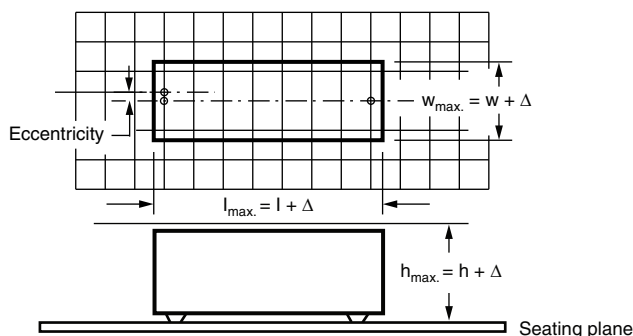
For products with pitch  $\leq 15$  mm,  $\Delta w = \Delta l = 0.3$  mm and  $\Delta h = 0.1$  mm

For products with  $15 \text{ mm} < \text{pitch} \leq 27.5$  mm,  $\Delta w = \Delta l = 0.5$  mm and  $\Delta h = 0.1$

For products with pitch = 37.5 mm  $\Delta w = \Delta l = 0.7$  mm and  $\Delta h = 0.5$  mm

For products with pitch = 52.5 mm,  $\Delta w = \Delta l = 1$  mm and  $\Delta h = 0.5$  mm

Eccentricity as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.



## SOLDERING CONDITIONS

For general soldering conditions and wave soldering profile we refer to the document “Soldering Conditions Vishay Film Capacitors”: [www.vishay.com/doc?28171](http://www.vishay.com/doc?28171)

## STORAGE TEMPERATURE

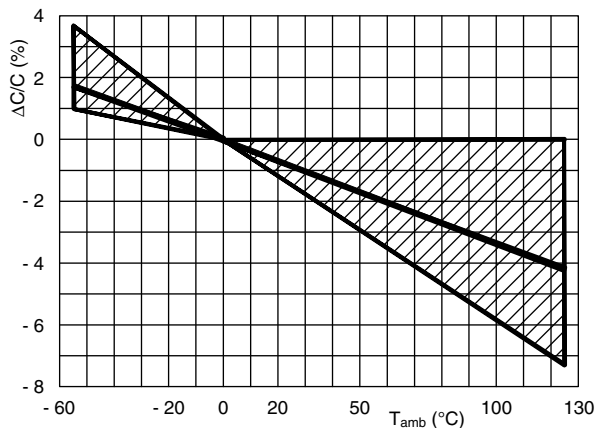
Storage temperature:  $T_{stg} = -25$  °C to  $+35$  °C with RH maximum 75 % without condensation.

## RATINGS AND CHARACTERISTICS REFERENCE CONDITIONS

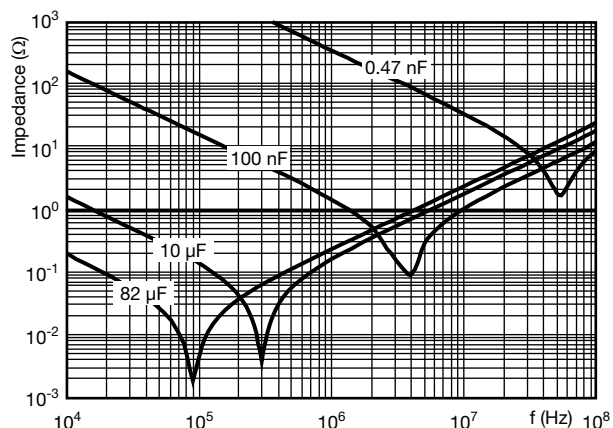
Unless otherwise specified, all electrical values apply to an ambient free temperature of  $23$  °C  $\pm 1$  °C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of  $50$  %  $\pm 2$  %.

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

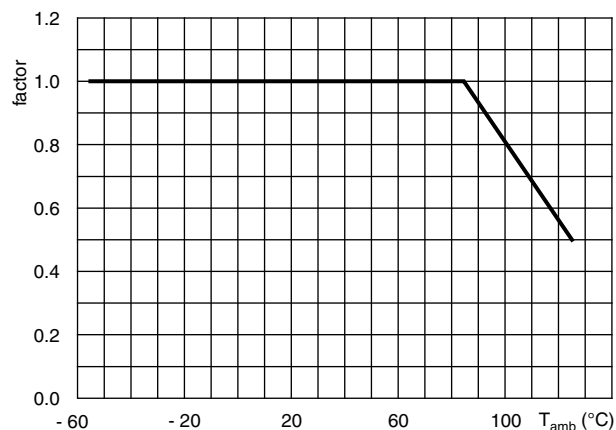
## CHARACTERISTICS



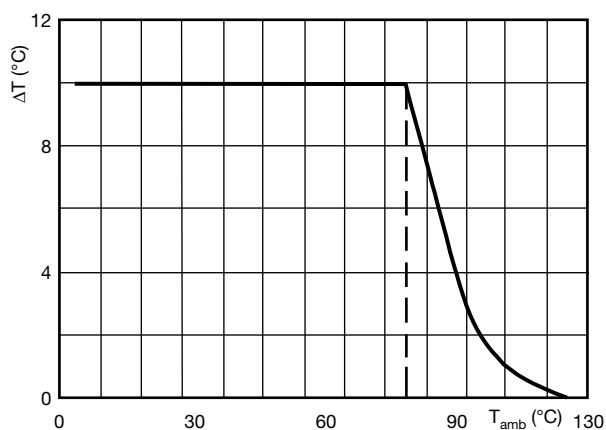
Capacitance as a function of ambient temperature (typical curve)  
(1 kHz)



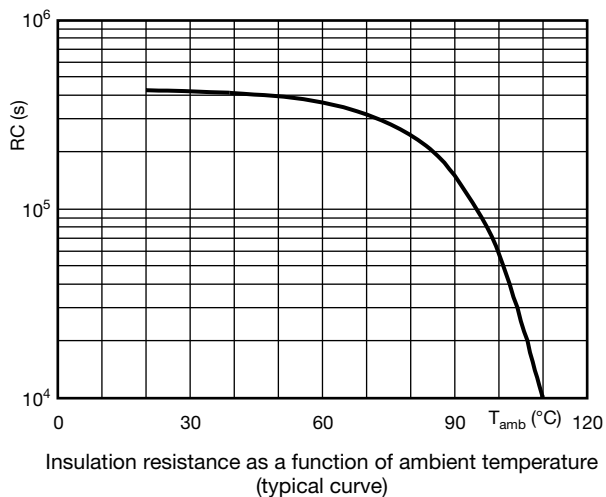
Impedance as a function of frequency (typical curve)



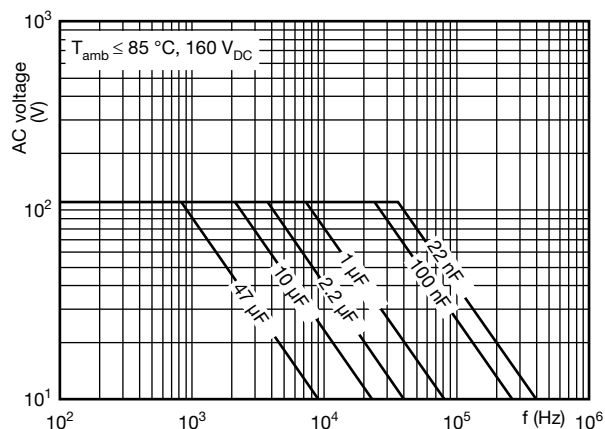
Max. DC and AC voltage as function of temperature



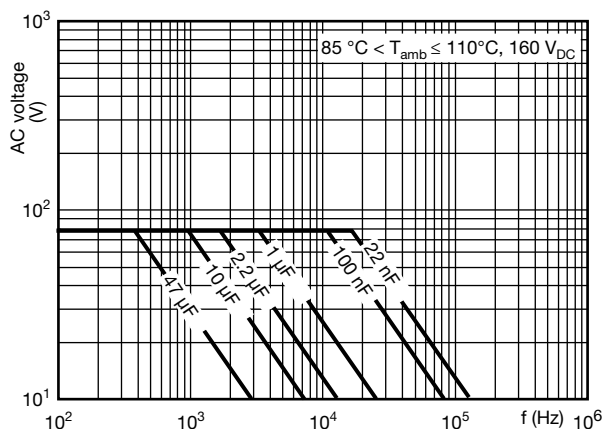
Maximum allowed component temperature rise ( $\Delta T$ )  
as a function of ambient temperature ( $T_{amb}$ )



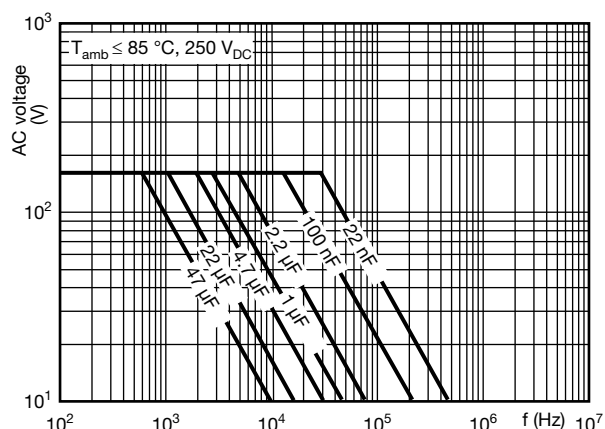
Insulation resistance as a function of ambient temperature  
(typical curve)



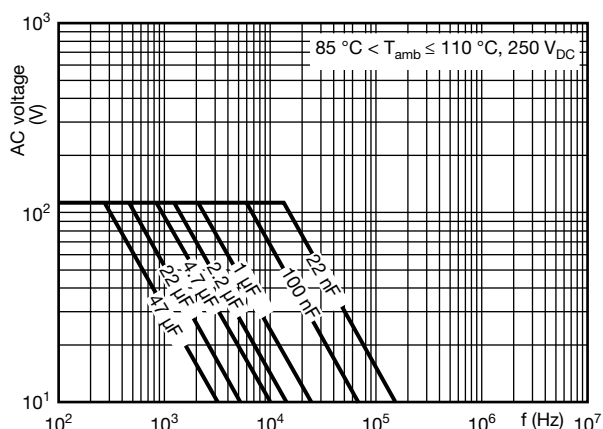
Max. RMS voltage as function of frequency (160 V)



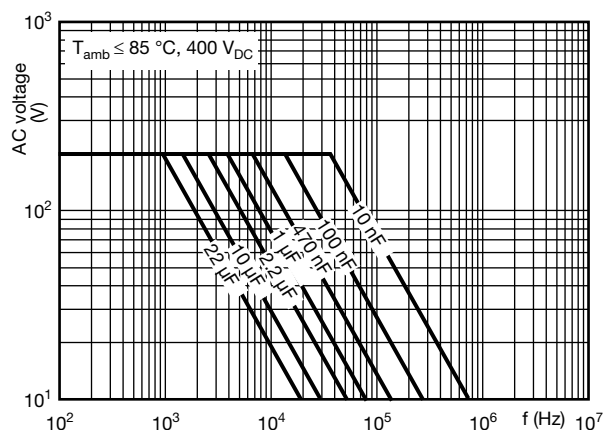
Max. RMS voltage as function of frequency (160 V)



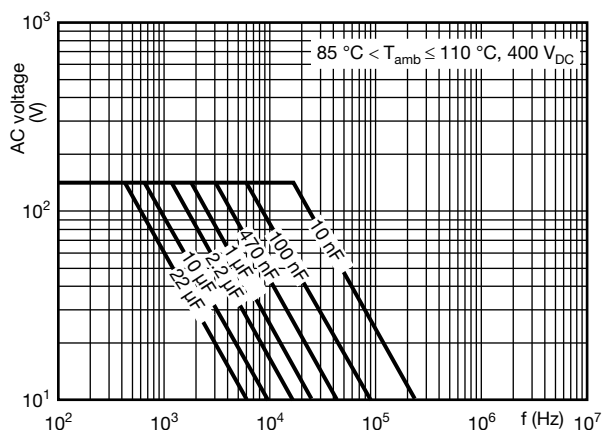
Max. RMS voltage as function of frequency (250 V)



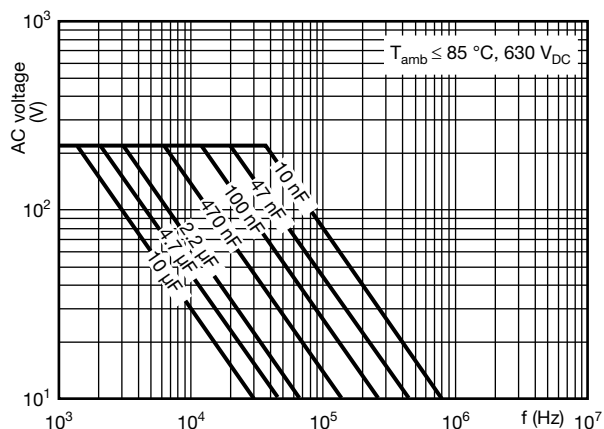
Max. RMS voltage as function of frequency (250 V)



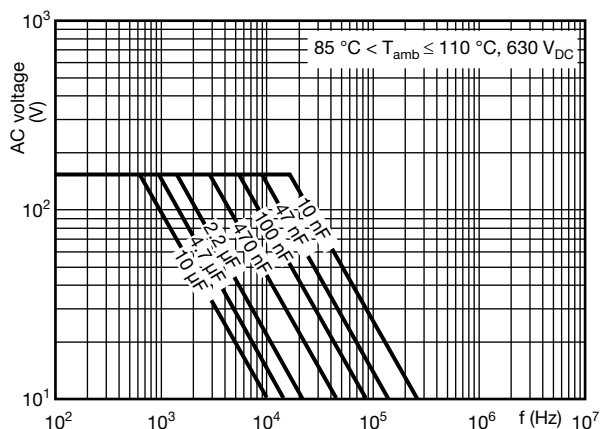
Max. RMS voltage as function of frequency (400 V)



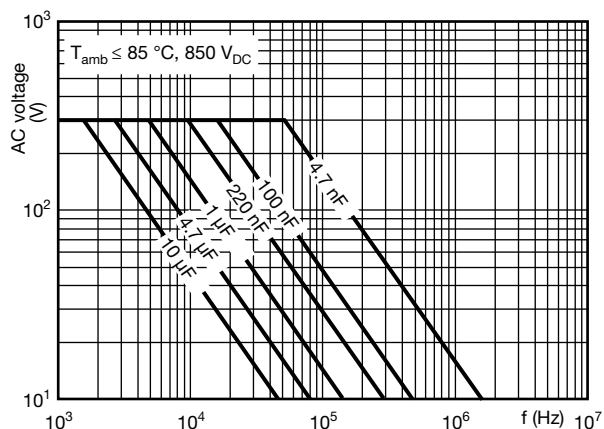
Max. RMS voltage as function of frequency (400 V)



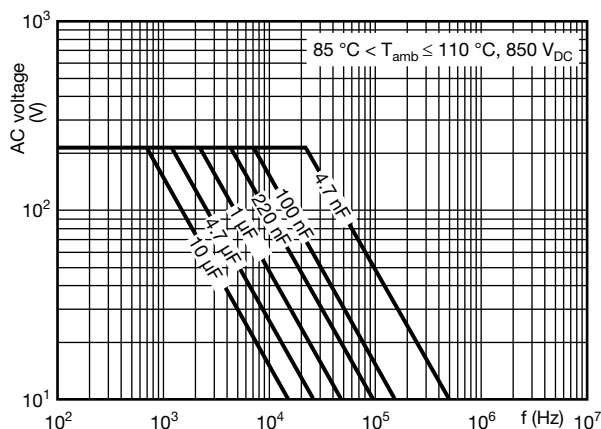
Max. RMS voltage as function of frequency (630 V)



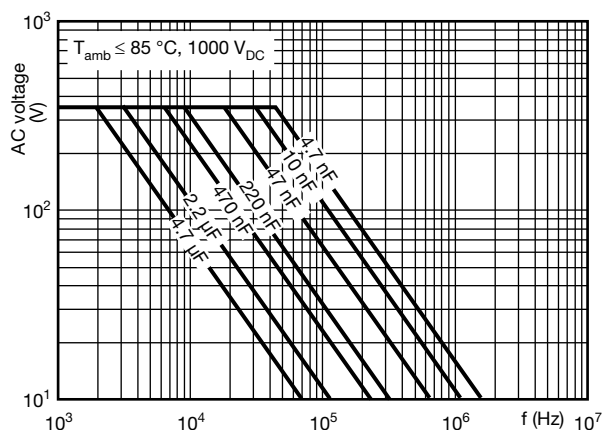
Max. RMS voltage as function of frequency (630 V)



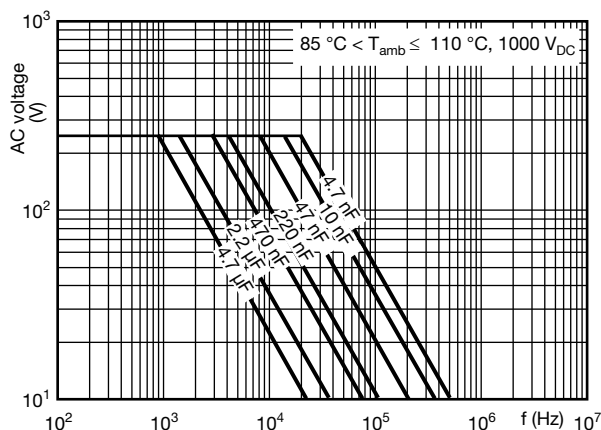
Max. RMS voltage as function of frequency (850 V)



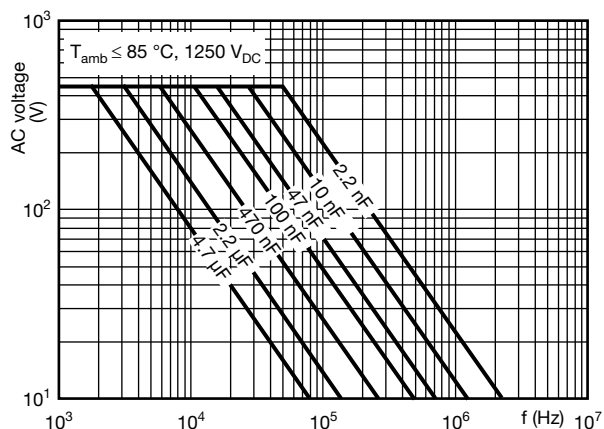
Max. RMS voltage as function of frequency (850 V)



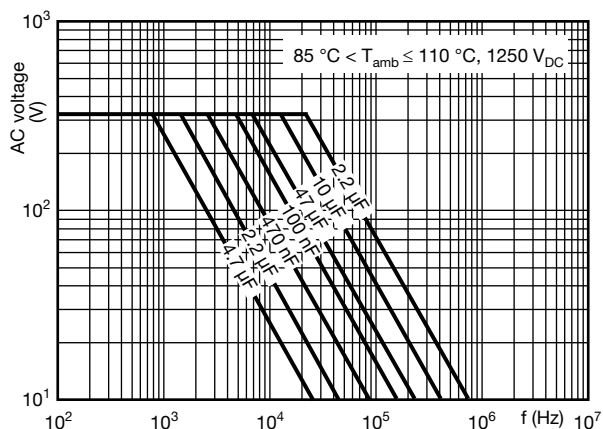
Max. RMS voltage as function of frequency (1000 V)



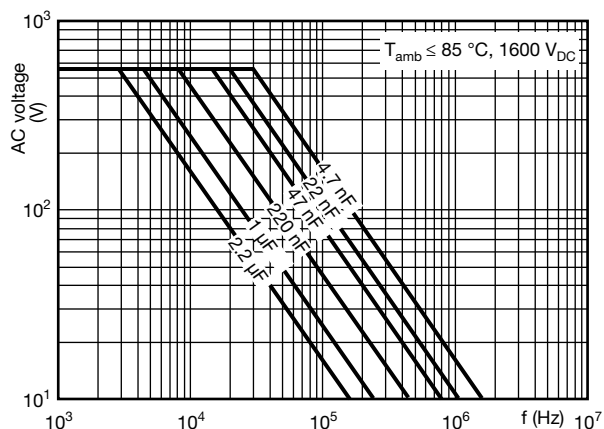
Max. RMS voltage as function of frequency (1000 V)



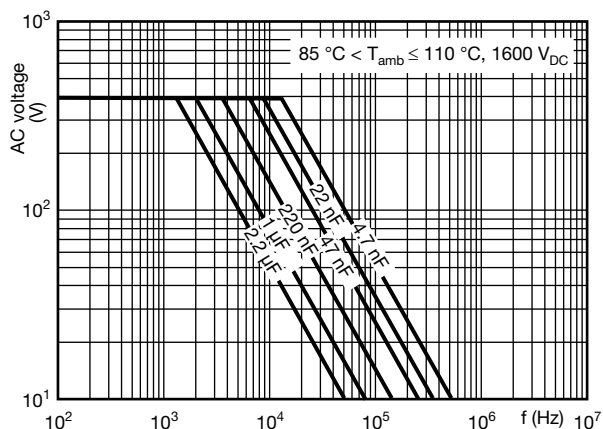
Max. RMS voltage as function of frequency (1250 V)



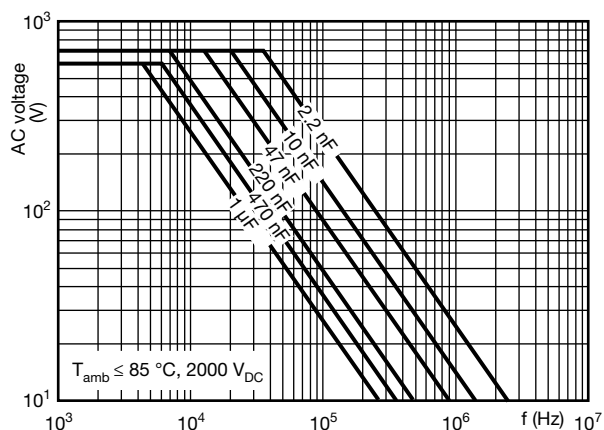
Max. RMS voltage as function of frequency (1250 V)



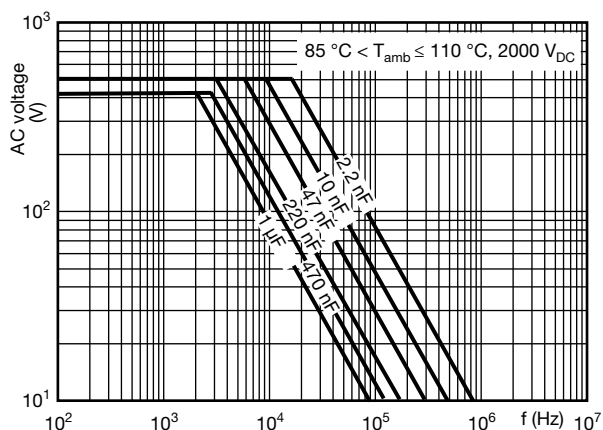
Max. RMS voltage as function of frequency (1600 V)



Max. RMS voltage as function of frequency (1600 V)

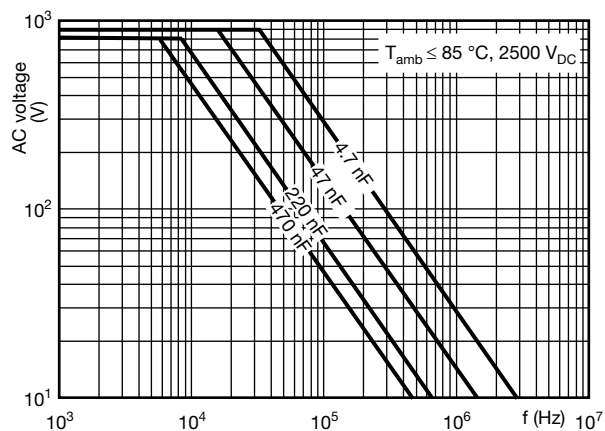


Max. RMS voltage as function of frequency (2000 V)

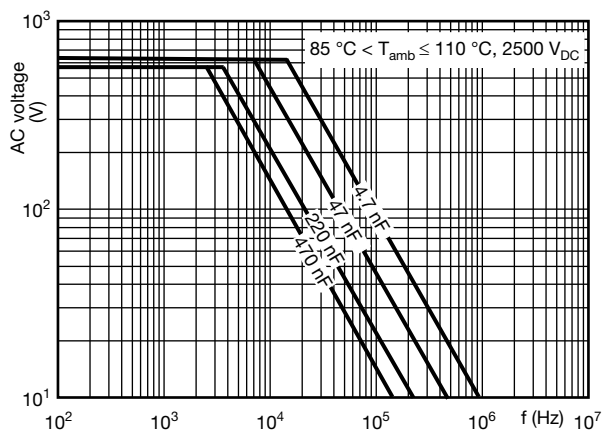


Max. RMS voltage as function of frequency (2000 V)

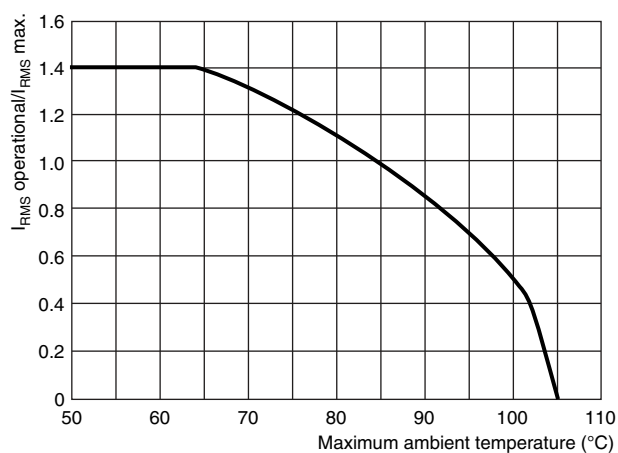


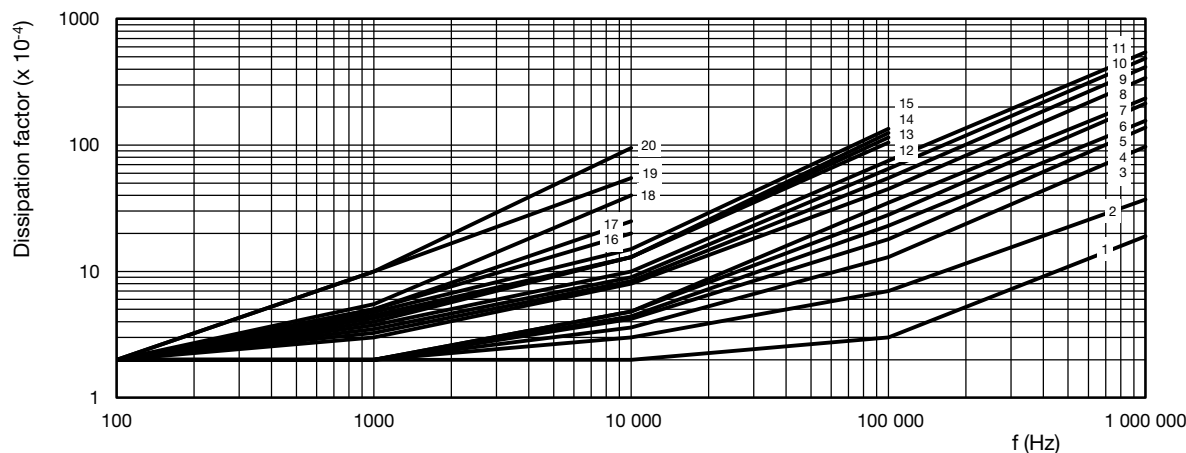


Max. RMS voltage as function of frequency (2500 V)



Max. RMS voltage as function of frequency (2500 V)


Maximum  $I_{RMS}$  current in function of the ambient temperature



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

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>160 V:</b><br>$C \leq 0.018 \mu\text{F}$ , curve 1<br>$0.018 < C \leq 0.12 \mu\text{F}$ , curve 2<br>$0.12 < C \leq 0.16 \mu\text{F}$ , curve 5<br>$0.16 < C \leq 0.33 \mu\text{F}$ , curve 6<br>$0.33 < C \leq 0.47 \mu\text{F}$ , curve 7<br>$0.47 < C \leq 0.91 \mu\text{F}$ , curve 10<br>$0.91 < C \leq 1.1 \mu\text{F}$ , curve 11<br>$1.1 < C \leq 1.6 \mu\text{F}$ , curve 12<br>$1.6 < C \leq 2.4 \mu\text{F}$ , curve 13<br>$2.4 < C \leq 3 \mu\text{F}$ , curve 14<br>$3 < C \leq 5.6 \mu\text{F}$ , curve 15<br>$5.6 < C \leq 43 \mu\text{F}$ , curve 18<br>$43 < C \leq 82 \mu\text{F}$ , curve 20 | <b>250 V:</b><br>$C \leq 0.043 \mu\text{F}$ , curve 2<br>$0.043 < C \leq 0.091 \mu\text{F}$ , curve 3<br>$0.091 < C \leq 0.11 \mu\text{F}$ , curve 5<br>$0.11 < C \leq 0.43 \mu\text{F}$ , curve 6<br>$0.33 < C \leq 0.47 \mu\text{F}$ , curve 7<br>$0.43 < C \leq 0.91 \mu\text{F}$ , curve 10<br>$0.91 < C \leq 3.3 \mu\text{F}$ , curve 12<br>$3.3 < C \leq 5.6 \mu\text{F}$ , curve 13<br>$5.6 < C \leq 33 \mu\text{F}$ , curve 18<br>$33 < C \leq 62 \mu\text{F}$ , curve 20 | <b>400 V:</b><br>$C \leq 0.010 \mu\text{F}$ , curve 1<br>$0.010 < C \leq 0.036 \mu\text{F}$ , curve 2<br>$0.036 < C \leq 0.043 \mu\text{F}$ , curve 3<br>$0.043 < C \leq 0.18 \mu\text{F}$ , curve 4<br>$0.18 < C \leq 0.43 \mu\text{F}$ , curve 8<br>$0.43 < C \leq 0.75 \mu\text{F}$ , curve 10<br>$0.75 < C \leq 3.0 \mu\text{F}$ , curve 11<br>$3.3 < C \leq 15 \mu\text{F}$ , curve 17<br>$15 < C \leq 27 \mu\text{F}$ , curve 19 | <b>630 V:</b><br>$C \leq 0.018 \mu\text{F}$ , curve 1<br>$0.018 < C \leq 0.024 \mu\text{F}$ , curve 2<br>$0.024 < C \leq 0.043 \mu\text{F}$ , curve 3<br>$0.043 < C \leq 0.11 \mu\text{F}$ , curve 4<br>$0.11 < C \leq 0.24 \mu\text{F}$ , curve 7<br>$0.24 < C \leq 2.4 \mu\text{F}$ , curve 9<br>$2.4 < C \leq 8.2 \mu\text{F}$ , curve 16<br>$8.2 < C \leq 15 \mu\text{F}$ , curve 19 |
| <b>850 V:</b><br>$C \leq 0.0091 \mu\text{F}$ , curve 1<br>$0.0091 < C \leq 0.051 \mu\text{F}$ , curve 2<br>$0.051 < C \leq 0.12 \mu\text{F}$ , curve 3<br>$0.12 < C \leq 0.68 \mu\text{F}$ , curve 4<br>$0.68 < C \leq 1.3 \mu\text{F}$ , curve 6                                                                                                                                                                                                                                                                                                                                                                  | <b>1000 V:</b><br>$C \leq 0.015 \mu\text{F}$ , curve 1<br>$0.015 < C \leq 0.056 \mu\text{F}$ , curve 2<br>$0.056 < C \leq 0.10 \mu\text{F}$ , curve 3<br>$0.1 < C \leq 0.91 \mu\text{F}$ , curve 4                                                                                                                                                                                                                                                                                | <b>1250 V:</b><br>$C \leq 0.033 \mu\text{F}$ , curve 1<br>$0.033 < C \leq 0.091 \mu\text{F}$ , curve 2<br>$0.091 < C \leq 0.68 \mu\text{F}$ , curve 3                                                                                                                                                                                                                                                                                  | <b>1600 V:</b><br>$C \leq 0.0091 \mu\text{F}$ , curve 1<br>$0.0091 < C \leq 0.27 \mu\text{F}$ , curve 2<br>$0.27 < C \leq 0.36 \mu\text{F}$ , curve 3<br>$0.36 < C \leq 1 \mu\text{F}$ , curve 5                                                                                                                                                                                         |
| <b>2000 V:</b><br>$C \leq 0.018 \mu\text{F}$ , curve 1<br>$0.018 < C \leq 0.22 \mu\text{F}$ , curve 2<br>$0.22 < C \leq 1 \mu\text{F}$ , curve 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>2500 V:</b><br>$C \leq 0.082 \mu\text{F}$ , curve 1<br>$0.082 < C \leq 0.39 \mu\text{F}$ , curve 2<br>$0.39 < C \leq 0.68 \mu\text{F}$ , curve 4                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                          |

**HEAT CONDUCTIVITY (G) AS A FUNCTION OF (ORIGINAL) PITCH AND CAPACITOR BODY THICKNESS IN mW/°C**

| W <sub>max</sub><br>(mm) | HEAT CONDUCTIVITY (mW/°C) |                 |                |                |                  |                  |                  |                  |
|--------------------------|---------------------------|-----------------|----------------|----------------|------------------|------------------|------------------|------------------|
|                          | PITCH<br>5 mm             | PITCH<br>7.5 mm | PITCH<br>10 mm | PITCH<br>15 mm | PITCH<br>22.5 mm | PITCH<br>27.5 mm | PITCH<br>37.5 mm | PITCH<br>52.5 mm |
| 3                        | -                         | 4               | -              | -              | -                | -                | -                | -                |
| 3.5                      | 3                         | -               | -              | -              | -                | -                | -                | -                |
| 4                        | -                         | 5               | 6.5            | -              | -                | -                | -                | -                |
| 4.5                      | 4                         | -               | -              | -              | -                | -                | -                | -                |
| 5                        | -                         | 6               | 7.5            | 10             | -                | -                | -                | -                |
| 6                        | 5.5                       | 7               | 9              | 11             | 19               | -                | -                | -                |
| 7                        | -                         | -               | -              | 12             | 21               | -                | -                | -                |
| 8.5                      | -                         | -               | -              | 16             | 25               | -                | -                | -                |
| 9                        | -                         | -               | -              | -              | -                | 31               | -                | -                |
| 10                       | -                         | -               | -              | 18             | 28               | -                | -                | -                |
| 11                       | -                         | -               | -              | -              | -                | 36               | -                | -                |
| 12                       | -                         | -               | -              | -              | 34               | -                | -                | -                |
| 13                       | -                         | -               | -              | -              | -                | 42               | -                | -                |
| 14.5                     | -                         | -               | -              | -              | -                | -                | -                | -                |
| 15                       | -                         | -               | -              | -              | -                | 48               | -                | -                |
| 18                       | -                         | -               | -              | -              | -                | 57               | -                | -                |
| 18.5                     | -                         | -               | -              | -              | -                | -                | 89               | -                |
| 21                       | -                         | -               | -              | -              | -                | 68               | -                | -                |
| 21.5                     | -                         | -               | -              | -              | -                | -                | 102              | -                |
| 24                       | -                         | -               | -              | -              | -                | -                | 116              | -                |
| 25                       | -                         | -               | -              | -              | -                | -                | -                | 152              |
| 30                       | -                         | -               | -              | -              | -                | -                | 134              | 181              |
| 35                       | -                         | -               | -              | -              | -                | -                | -                | 197              |

**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.

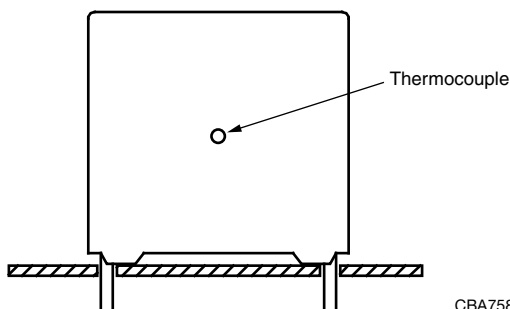
The power dissipation can be calculated according type detail specification “HQN-384-01/101: Technical information film capacitors with the typical tgδ of the curves.”.

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 (°C)
- P = power dissipation of the component (mW)
- G = heat conductivity of the component (mW/°C)

**MEASURING THE COMPONENT TEMPERATURE**

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



CBA758

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

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

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

## APPLICATION NOTE AND LIMITING CONDITIONS

For capacitors connected in parallel, normally the proof voltage and possibly the rated voltage must be reduced. For information depending of the capacitance value and the number of parallel connections contact: [dc-film@vishay.com](mailto:dc-film@vishay.com)

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 ( $U_p$ ) shall not be greater than the rated DC voltage ( $U_{RDC}$ )
2. The peak-to-peak voltage ( $U_{p-p}$ ) shall not be greater than the maximum ( $U_{p-p}$ ) to avoid the ionization inception level
3. The voltage peak 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  $U_{RDC}$  and divided by the applied voltage.

For all other pulses following equation must be fulfilled:

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

T is the pulse duration

4. The maximum component surface temperature rise must be lower than the limits (see graph "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                            | $T_{amb} \leq 85^\circ\text{C}$ | $85^\circ\text{C} < T_{amb} \leq 110^\circ\text{C}$ | $110^\circ\text{C} < T_{amb} \leq 125^\circ\text{C}$ |
|---------------------------------------------|---------------------------------|-----------------------------------------------------|------------------------------------------------------|
| Maximum continuous RMS voltage              | $U_{RAC}$                       | $0.7 \times U_{RAC}$                                | $0.5 \times U_{RAC}$                                 |
| Maximum temporary RMS-over voltage (< 24 h) | $1.25 \times U_{RAC}$           | $0.875 \times U_{RAC}$                              | $0.625 \times U_{RAC}$                               |
| Maximum peak voltage ( $V_{o-p}$ ) (< 2 s)  | $1.6 \times U_{RDC}$            | $1.1 \times U_{RDC}$                                | $0.8 \times U_{RDC}$                                 |

### EXAMPLE

C = 4n7 - 1600 V used for the voltage signal shown in next drawing.

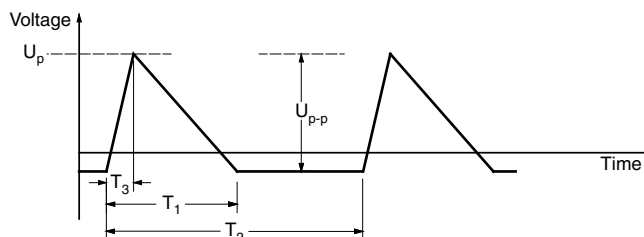
$U_{p-p} = 1000\text{ V}$ ;  $U_p = 900\text{ V}$ ;  $T_1 = 12\text{ }\mu\text{s}$ ;  $T_2 = 64\text{ }\mu\text{s}$ ;  $T_3 = 4\text{ }\mu\text{s}$

The ambient temperature is  $80^\circ\text{C}$ . In case of failure, the oscillation is blocked.

Checking the conditions:

1. The peak voltage  $U_p = 900\text{ V}$  is lower than  $1600\text{ V}_{DC}$
2. The peak-to-peak voltage  $1000\text{ V}$  is lower than  $2\sqrt{2} \times 550\text{ V}_{AC} = 1600\text{ V}_{p-p}$
3. The voltage pulse slope ( $dU/dt$ ) =  $1000\text{ V}/4\text{ }\mu\text{s} = 250\text{ V}/\mu\text{s}$   
This is lower than  $4000\text{ V}/\mu\text{s}$  (see specific reference data for each version)
4. The dissipated power is  $35\text{ mW}$  as calculated with fourier terms and typical tgδ.  
The temperature rise for  $W_{max} = 6\text{ mm}$  and pitch =  $15\text{ mm}$  will be  $35\text{ mW}/9\text{ mW}/^\circ\text{C} = 3.9^\circ\text{C}$   
This is lower than  $10^\circ\text{C}$  temperature rise at  $80^\circ\text{C}$ , according graph.
5. Oscillation is blocked
6. Not applicable

### VOLTAGE SIGNAL



## 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”.

| <b>GROUP C INSPECTION REQUIREMENTS</b>              |                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>SUB-CLAUSE NUMBER AND TEST</b>                   | <b>CONDITIONS</b>                                                                                                                                                | <b>PERFORMANCE REQUIREMENTS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1</b> |                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 4.1 Dimensions (detail)                             |                                                                                                                                                                  | As specified in Chapters “General data” of this specification                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 4.3.1 Initial measurements                          | Capacitance<br>Tangent of loss angle:<br>$C \leq 1 \mu\text{F}$ at 100 kHz<br>$1 \mu\text{F} < C \leq 10 \mu\text{F}$ at 10 kHz<br>$C > 10 \mu\text{F}$ at 1 kHz |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 4.3 Robustness of terminations                      | Tensile: load 10 N; 10 s<br>Bending: load 5 N; 4 x 90°                                                                                                           | No visible damage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 4.4 Resistance to soldering heat                    | Method: 1 A<br>Solder bath: 280 °C ± 5 °C<br>Duration: 10 s                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 4.14 Component solvent resistance                   | Isopropylalcohol at room temperature<br>Method: 2<br>Immersion time: 5 min ± 0.5 min<br>Recovery time:<br>min. 1 h, max. 2 h                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 4.4.2 Final measurements                            | Visual examination<br><br>Capacitance<br><br>Tangent of loss angle                                                                                               | No visible damage<br>Legible marking<br><br>$\Delta C/C_i \leq 1 \%$ of the value measured initially.<br><br>Increase of $\tan \delta$ :<br>$\leq 0.0005$ for: $C \leq 100 \text{ nF}$ at 100 kHz<br>$\leq 0.0010$ for: $100 \text{ nF} < C \leq 470 \text{ nF}$ at 100 kHz<br>$\leq 0.0015$ for: $470 \text{ nF} < C \leq 1 \mu\text{F}$ at 100 kHz<br>$\leq 0.0015$ for: $1 \mu\text{F} < C \leq 10 \mu\text{F}$ at 10 kHz<br>$\leq 0.0015$ for: $C > 10 \mu\text{F}$ at 1 kHz<br>Compared to values measured in 4.3.1 |
| 4.6.1 Initial measurements                          | Capacitance<br>Tangent of loss angle:<br>$C \leq 1 \mu\text{F}$ at 100 kHz<br>$1 \mu\text{F} < C \leq 10 \mu\text{F}$ at 10 kHz<br>$C > 10 \mu\text{F}$ at 1 kHz |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 4.15 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 4.6 Rapid change of temperature                     | $\theta A = -55 \text{ °C}$<br>$\theta B = +110 \text{ °C}$<br>5 cycles<br>Duration $t = 30 \text{ min}$                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |



| GROUP C INSPECTION REQUIREMENTS                                            |                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SUB-CLAUSE NUMBER AND TEST                                                 | CONDITIONS                                                                                                                                                                                                                                        | PERFORMANCE REQUIREMENTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1</b>                        |                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4.7. Vibration                                                             | Visual examination<br>Mounting: see section "Mounting" for more information<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. | No visible damage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 4.7.2 Final inspection                                                     | Visual examination                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4.9 Shock                                                                  | Mounting: 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<br><br>Capacitance<br><br>Tangent of loss angle<br><br><br><br>Insulation resistance                                                                                                                                           | No visible damage<br><br><br><br><br><br><br><br><br><br><br>Increase of tan $\delta$ :<br>$\leq 0.0005$ for: $C \leq 100$ nF at 100 kHz<br>$\leq 0.0010$ for: $100$ nF $< C \leq 470$ nF at 100 kHz<br>$\leq 0.0015$ for: $470$ nF $< C \leq 1$ $\mu$ F at 100 kHz<br>$\leq 0.0015$ for: $1$ $\mu$ F $< C \leq 10$ $\mu$ F at 10 kHz<br>$\leq 0.0015$ for: $C > 10$ $\mu$ F at 1 kHz<br>Compared to values measured in 4.6.1<br><br>As 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 test chamber<br><br>Visual examination<br><br>Capacitance<br><br>Tangent of loss angle<br><br><br><br>Insulation resistance                                               | No breakdown or flashover<br><br>No visible damage<br>Legible marking<br><br><br><br><br><br><br><br><br><br><br>Increase of tan $\delta$ :<br>$\leq 0.0005$ for: $C \leq 100$ nF at 100 kHz<br>$\leq 0.0010$ for: $100$ nF $< C \leq 470$ nF at 100 kHz<br>$\leq 0.0015$ for: $470$ nF $< C \leq 1$ $\mu$ F at 100 kHz<br>$\leq 0.0015$ for: $1$ $\mu$ F $< C \leq 10$ $\mu$ F at 10 kHz<br>$\leq 0.0015$ for: $C > 10$ $\mu$ F at 1 kHz<br>Compared to values measured in 4.3.1<br>or 4.6.1<br><br>$\geq 50$ % of values specified in section<br>"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     | 56 days; 40 °C; 90 % to 95 % RH<br>no load                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                      |
| 4.11.1 Initial measurements     | Capacitance<br>Tangent of loss angle at 1 kHz                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                      |
| 4.11.3 Final measurements       | Voltage proof = $U_{RDC}$ for 1 min within<br>15 min after removal from test chamber                                                                                                      | No breakdown or flashover                                                                                                                                                                                                                                                                                                                                            |
|                                 | Visual examination                                                                                                                                                                        | No visible damage<br>Legible marking                                                                                                                                                                                                                                                                                                                                 |
|                                 | Capacitance                                                                                                                                                                               | $I\Delta C/CI \leq 2\%$ of the value measured in<br>4.11.1.                                                                                                                                                                                                                                                                                                          |
|                                 | Tangent of loss angle                                                                                                                                                                     | Increase of $\tan \delta$<br>$\leq 0.0005$ for: $C \leq 100$ nF at 100 kHz<br>$\leq 0.0010$ for: $100$ nF $< C \leq 470$ nF at 100 kHz<br>$\leq 0.0015$ for: $470$ nF $< C \leq 1$ $\mu$ F at 100 kHz<br>$\leq 0.0015$ for: $1$ $\mu$ F $< C \leq 10$ $\mu$ F at 10 kHz<br>$\leq 0.0015$ for: $C > 10$ $\mu$ F at 1 kHz<br>Compared to values measured in 4.11.1.    |
|                                 | Insulation resistance                                                                                                                                                                     | $\geq 50\%$ of values specified in section<br>"Insulation resistance" of this specification                                                                                                                                                                                                                                                                          |
| <b>SUB-GROUP C3A</b>            |                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                      |
| 4.12.1 Endurance                | Duration: 2000 h<br>Temperature: 85 °C<br>Voltage: $1.25 \times U_{RAC} V_{RMS}$ , 50 Hz or<br>Duration: 2000 h<br>Temperature: 110 °C<br>Voltage: $0.875 \times U_{RAC} V_{RMS}$ , 50 Hz |                                                                                                                                                                                                                                                                                                                                                                      |
| 4.12.1.1 Initial measurements   | Capacitance<br>Tangent of loss angle<br>$C \leq 1$ $\mu$ F at 100 kHz<br>$1$ $\mu$ F $< C \leq 10$ $\mu$ F at 10 kHz<br>$C > 10$ $\mu$ F at 1 kHz                                         |                                                                                                                                                                                                                                                                                                                                                                      |
| 4.12.1.3 Final measurements     | Visual examination                                                                                                                                                                        | No visible damage<br>Legible marking                                                                                                                                                                                                                                                                                                                                 |
|                                 | Capacitance                                                                                                                                                                               | $I\Delta C/CI \leq 5\%$ for $C > 10$ nF<br>$I\Delta C/CI \leq 8\%$ for $C \leq 10$ nF<br>Compared to values measured in 4.12.1.1                                                                                                                                                                                                                                     |
|                                 | Tangent of loss angle                                                                                                                                                                     | Increase of $\tan \delta$ :<br>$\leq 0.0005$ for: $C \leq 100$ nF at 100 kHz<br>$\leq 0.0010$ for: $100$ nF $< C \leq 470$ nF at 100 kHz<br>$\leq 0.0015$ for: $470$ nF $< C \leq 1$ $\mu$ F at 100 kHz<br>$\leq 0.0015$ for: $1$ $\mu$ F $< C \leq 10$ $\mu$ F at 10 kHz<br>$\leq 0.0015$ for: $C > 10$ $\mu$ F at 1 kHz<br>Compared to values measured in 4.12.1.1 |
|                                 | Insulation resistance                                                                                                                                                                     | $\geq 50\%$ of values specified in section<br>"Insulation resistance" of this specification.                                                                                                                                                                                                                                                                         |



| GROUP C INSPECTION REQUIREMENTS                                                        |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SUB-CLAUSE NUMBER AND TEST                                                             | CONDITIONS                                                                                                                                                                   | PERFORMANCE REQUIREMENTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>SUB-GROUP C3B</b>                                                                   |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 4.12.2 Endurance test at 50 Hz alternating voltage                                     | Duration: 500 h<br>Voltage: $1.25 \times U_{RDC}$ 110 °C                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 4.12.2.1 Initial measurements                                                          | $0.625 \times U_{RAC}$ at 125 °C<br>Capacitance<br>Tangent of loss angle:<br>$C \leq 1 \mu F$ at 100 kHz<br>$1 \mu F < C \leq 10 \mu F$ at 10 kHz<br>$C > 10 \mu F$ at 1 kHz |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 4.12.2.3 Final measurements                                                            | Visual examination<br><br>Capacitance<br><br>Tangent of loss angle<br><br><br>Insulation resistance                                                                          | No visible damage<br>Legible marking<br><br>$I\Delta C/CI \leq 10 \% + 100 \text{ pF}$ compared to values measured in 4.12.2.1<br><br>Increase of $\tan \delta$ :<br>$\leq 0.0005$ for: $C \leq 100 \text{ nF}$ at 100 kHz<br>$\leq 0.0010$ for: $100 \text{ nF} < C \leq 470 \text{ nF}$ at 100 kHz<br>$\leq 0.0015$ for: $470 \text{ nF} < C \leq 1 \mu F$ at 100 kHz<br>$\leq 0.0015$ for: $1 \mu F < C \leq 10 \mu F$ at 10 kHz<br>$\leq 0.0015$ for: $C > 10 \mu F$ at 1 kHz<br>Compared to values measured in 4.12.2.1<br><br>$\geq 50 \%$ of values specified in section "Insulation Resistance" of this specification. |
| <b>SUB-GROUP C4</b>                                                                    |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 4.2.6 Temperature characteristics<br>Initial measurements<br>Intermediate measurements | Capacitance<br>Capacitance at -55 °C<br>Capacitance at 20 °C<br>Capacitance at +125 °C                                                                                       | For -55 °C to +20 °C:<br>$+1 \% \leq I\Delta C/CI \leq 3.75 \%$ or<br>for 20 °C to 105 °C:<br>$-7.5 \% \leq I\Delta C/CI \leq 0 \%$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Final measurements                                                                     | Capacitance<br><br>Insulation resistance                                                                                                                                     | As specified in section "Capacitance" of this specification<br><br>As specified in section "Insulation Resistance" of this specification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 4.13 Charge and discharge                                                              | 10 000 cycles<br>Charged to $U_{RDC}$ discharge resistance:<br>$R = \frac{U_{RDC}}{2.5 \times C (dU/dt)}$                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 4.13.1 Initial measurements                                                            | Capacitance<br>Tangent of loss angle:<br>$C \leq 1 \mu F$ at 100 kHz<br>$1 \mu F < C \leq 10 \mu F$ at 10 kHz<br>$C > 10 \mu F$ at 1 kHz                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 4.13.3 Final measurements                                                              | Capacitance<br><br>Tangent of loss angle<br><br>Insulation resistance                                                                                                        | $I\Delta C/CI \leq 1 \%$ compared to values measured in 4.13.1.<br><br>Increase of $\tan \delta$ :<br>$\leq 0.0005$ for: $C \leq 100 \text{ nF}$ or<br>$\leq 0.001$ for: $100 \text{ nF} < C \leq 470 \text{ nF}$ or<br>$\leq 0.0015$ for: $C > 470 \text{ nF}$<br>Compared to values measured in 4.13.1<br><br>$\geq 50 \%$ of values specified in section "Insulation Resistance" of this specification.                                                                                                                                                                                                                     |





| GROUP C INSPECTION REQUIREMENTS                                                        |                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SUB-CLAUSE NUMBER AND TEST                                                             | CONDITIONS                                                                                                                              | PERFORMANCE REQUIREMENTS                                                                                                                                                                                                                                                                                                                                          |
| SUB-GROUP ADD1                                                                         |                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                   |
| A.1 Ignition of lamp test<br>Only for 1600 V and 2000 V series<br>(Cap. value < 33 nF) | Capacitance                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                   |
| A.1.1 Initial measurements                                                             | Tangent of loss angle at 100 kHz<br>Temperature: 85 °C                                                                                  |                                                                                                                                                                                                                                                                                                                                                                   |
| A.1.2 Ignition of lamp test                                                            | 10 000 cycles: 1 s ON 29 s OFF:<br>Frequency: 60 kHz<br>Voltage:<br>1600 V type: 2800 V <sub>pp</sub> 2000 V type: 3000 V <sub>pp</sub> |                                                                                                                                                                                                                                                                                                                                                                   |
| A.1.3 Final measurements                                                               | Visual examination                                                                                                                      | No visible damage                                                                                                                                                                                                                                                                                                                                                 |
|                                                                                        | Capacitance                                                                                                                             | $I\Delta C/C_I \leq 5\%$ of the value measured in A.1.1                                                                                                                                                                                                                                                                                                           |
|                                                                                        | Tangent of loss angle                                                                                                                   | Increase of $\tan \delta$ :<br>$\leq 0.0005$ for: $C \leq 100$ nF at 100 kHz<br>$\leq 0.0010$ for: $100$ nF < $C \leq 470$ nF at 100 kHz<br>$\leq 0.0015$ for: $470$ nF < $C \leq 1$ $\mu$ F at 100 kHz<br>$\leq 0.0015$ for: $1$ $\mu$ F < $C \leq 10$ $\mu$ F at 10 kHz<br>$\leq 0.0015$ for: $C > 10$ $\mu$ F at 1 kHz<br>Compared to values measured in A.1.1 |
|                                                                                        | Insulation resistance                                                                                                                   | $\geq 50\%$ of values specified in section<br>“Insulation Resistance” of this specification                                                                                                                                                                                                                                                                       |



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