

# AC and Pulse Metallized Polypropylene Film Capacitors MKP Axial Type



## FEATURES

- Precision capacitor, tolerance 1 % and 2 %. Intermediate values are available of the E96 series
- 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

- Pulse operations
- SMPS and thyristor circuits
- Storage, filter, timing and sample and hold circuits

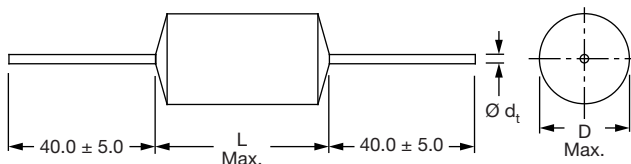
## QUICK REFERENCE DATA

|                                                 |                                                                                                                                                         |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Capacitance range (E12 series)                  | 47 pF to 22 $\mu$ F                                                                                                                                     |
| Capacitance tolerance                           | $\pm 10 \%$ , $\pm 5 \%$ , $\pm 2.5 \%$ , $\pm 2 \%$ , $\pm 1 \%$                                                                                       |
| Climatic testing class according to IEC 60068-1 | 55/100/56                                                                                                                                               |
| Maximum application temperature                 | 100 °C                                                                                                                                                  |
| Reference standards                             | IEC 60384-16                                                                                                                                            |
| Dielectric                                      | Polypropylene film                                                                                                                                      |
| Electrodes                                      | Metallized                                                                                                                                              |
| Construction                                    | Mono construction                                                                                                                                       |
| Encapsulation                                   | Plastic-wrapped, epoxy resin sealed. Flame retardant                                                                                                    |
| Leads                                           | Tinned wire                                                                                                                                             |
| Marking                                         | C-value; tolerance; rated voltage; manufacturer's type; code for dielectric material; manufacturer location, year and week; manufacturer's logo or name |
| Rated DC voltage                                | 160 V <sub>DC</sub> , 250 V <sub>DC</sub> , 400 V <sub>DC</sub> , 630 V <sub>DC</sub>                                                                   |
| Rated AC voltage                                | 100 V <sub>AC</sub> , 160 V <sub>AC</sub> , 220 V <sub>AC</sub> , 250 V <sub>AC</sub>                                                                   |
| 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                                                                                            |

## Note

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

## DIMENSIONS in millimeters



| LEAD DIAMETER<br>$d_t$ | D          | L           |
|------------------------|------------|-------------|
| $0.6 \pm 0.06$         | $\leq 9.0$ | $\leq 19.0$ |
| $0.8 \pm 0.08$         | $< 16.5$   | $> 26.5$    |
| $1.0 \pm 0.1$          | $> 16.5$   | $> 26.5$    |

**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>C ≤ 0.1 μF<br>0.1 μF < C ≤ 1.0 μF<br>C > 1.0 μF                         |                                                     | at 1 kHz              | at 10 kHz                      | at 100 kHz            |
|                                                                                                   |                                                     | 4 x 10 <sup>-4</sup>  | 6 x 10 <sup>-4</sup>           | 40 x 10 <sup>-4</sup> |
|                                                                                                   |                                                     | 4 x 10 <sup>-4</sup>  | 6 x 10 <sup>-4</sup>           | -                     |
|                                                                                                   |                                                     | 10 x 10 <sup>-4</sup> | -                              | -                     |
| CAPACITOR LENGTH<br>(mm)                                                                          | MAXIMUM PULSE RISE TIME (dU/dt) <sub>R</sub> [V/μs] |                       |                                |                       |
|                                                                                                   | 160 V <sub>DC</sub>                                 | 250 V <sub>DC</sub>   | 400 V <sub>DC</sub>            | 630 V <sub>DC</sub>   |
| 11                                                                                                | 240                                                 | 300                   | 515                            | 700                   |
| 14                                                                                                | 175                                                 | 220                   | 380                            | 510                   |
| 19                                                                                                | 100                                                 | 125                   | 200                            | 280                   |
| 26.5                                                                                              | 60                                                  | 75                    | 120                            | 160                   |
| 31.5                                                                                              | 45                                                  | 60                    | 95                             | 120                   |
| 41.5                                                                                              | 30                                                  | 40                    | 65                             | 85                    |
| If the maximum pulse voltage is less than the rated voltage higher dU/dt values can be permitted. |                                                     |                       |                                |                       |
| R between leads, for C ≤ 0.33 μF at 100 V, 1 min                                                  |                                                     |                       | > 100 000 MΩ                   |                       |
| RC between leads, for C > 0.33 μF at 100 V, 1 min                                                 |                                                     |                       | > 30 000 s                     |                       |
| R between leads and case, 100 V, 1 min                                                            |                                                     |                       | > 30 000 mΩ                    |                       |
| Withstanding (DC) voltage between leads and wrapped film (1.4 x U <sub>RAC</sub> + 2000)          |                                                     |                       | 2840 V, 1 min                  |                       |
| Withstanding (DC) voltage (cut off current 10 mA), rise time 100 V/s                              |                                                     |                       | 1.6 x U <sub>RDC</sub> , 1 min |                       |
| Maximum application temperature                                                                   |                                                     |                       | 100 °C                         |                       |



| ELECTRICAL DATA         |              |                     |                 |                    |            |      |
|-------------------------|--------------|---------------------|-----------------|--------------------|------------|------|
| U <sub>RDC</sub><br>(V) | CAP.<br>(μF) | CAPACITANCE<br>CODE | VOLTAGE<br>CODE | V <sub>AC</sub>    | DIMENSIONS |      |
|                         |              |                     |                 |                    | D          | L    |
| 160                     | 0.033        | 333                 | 16              | 100                | 5.0        | 11.0 |
|                         | 0.047        | 347                 |                 |                    | 5.5        | 11.0 |
|                         | 0.068        | 368                 |                 |                    | 6.0        | 11.0 |
|                         | 0.10         | 410                 |                 |                    | 6.5        | 14.0 |
|                         | 0.15         | 415                 |                 |                    | 7.5        | 14.0 |
|                         | 0.22         | 422                 |                 |                    | 7.0        | 19.0 |
|                         | 0.33         | 433                 |                 |                    | 8.0        | 19.0 |
|                         | 0.47         | 447                 |                 |                    | 9.0        | 19.0 |
|                         | 0.68         | 468                 |                 |                    | 8.5        | 26.5 |
|                         | 1.0          | 510                 |                 |                    | 10.5       | 26.5 |
|                         | 1.5          | 515                 |                 |                    | 12.0       | 26.5 |
|                         | 2.2          | 522                 |                 |                    | 13.0       | 31.5 |
|                         | 3.3          | 533                 |                 |                    | 15.5       | 31.5 |
|                         | 4.7          | 547                 |                 |                    | 15.5       | 41.5 |
|                         | 6.8          | 568                 |                 |                    | 18.5       | 41.5 |
|                         | 10           | 610                 |                 |                    | 22.0       | 41.5 |
|                         | 15           | 615                 |                 |                    | 24.5       | 41.5 |
|                         | 22           | 622                 |                 |                    | 28.5       | 41.5 |
| 250                     | 0.010        | 310                 | 25              | 160                | 5.0        | 11.0 |
|                         | 0.015        | 315                 |                 |                    | 5.0        | 11.0 |
|                         | 0.022        | 322                 |                 |                    | 5.0        | 11.0 |
|                         | 0.033        | 333                 |                 |                    | 5.5        | 11.0 |
|                         | 0.047        | 347                 |                 |                    | 6.0        | 14.0 |
|                         | 0.068        | 368                 |                 |                    | 6.5        | 14.0 |
|                         | 0.10         | 410                 |                 |                    | 7.5        | 14.0 |
|                         | 0.15         | 415                 |                 |                    | 7.0        | 19.0 |
|                         | 0.22         | 422                 |                 |                    | 8.5        | 19.0 |
|                         | 0.33         | 433                 |                 |                    | 8.0        | 26.5 |
|                         | 0.47         | 447                 |                 |                    | 9.0        | 26.5 |
|                         | 0.68         | 468                 |                 |                    | 11.0       | 26.5 |
|                         | 1.0          | 510                 |                 |                    | 12.5       | 26.5 |
|                         | 1.5          | 515                 |                 |                    | 13.0       | 31.5 |
|                         | 2.2          | 522                 |                 |                    | 16.0       | 31.5 |
|                         | 3.3          | 533                 |                 |                    | 19.0       | 31.5 |
|                         | 4.7          | 547                 |                 |                    | 19.5       | 41.5 |
|                         | 6.8          | 568                 |                 |                    | 23.0       | 41.5 |
|                         | 10           | 610                 |                 |                    | 22.0       | 41.5 |
|                         | 15           | 615                 |                 |                    | 24.5       | 41.5 |
|                         | 22           | 622                 |                 |                    | 28.5       | 41.5 |
| 400                     | 0.0068       | 268                 | 40              | 220 <sup>(1)</sup> | 5.0        | 11.0 |
|                         | 0.0082       | 282                 |                 |                    | 5.0        | 11.0 |
|                         | 0.010        | 310                 |                 |                    | 5.5        | 11.0 |
|                         | 0.015        | 315                 |                 |                    | 6.0        | 11.0 |
|                         | 0.022        | 322                 |                 |                    | 6.5        | 14.0 |
|                         | 0.033        | 333                 |                 |                    | 7.0        | 14.0 |
|                         | 0.047        | 347                 |                 |                    | 8.0        | 14.0 |
|                         | 0.068        | 368                 |                 |                    | 8.5        | 19.0 |
|                         | 0.10         | 410                 |                 |                    | 9.0        | 19.0 |
|                         | 0.15         | 415                 |                 |                    | 8.0        | 26.5 |
|                         | 0.22         | 422                 |                 |                    | 9.5        | 26.5 |
|                         | 0.33         | 433                 |                 |                    | 11.5       | 26.5 |
|                         | 0.47         | 447                 |                 |                    | 13.5       | 26.5 |
|                         | 0.68         | 468                 |                 |                    | 14.0       | 31.5 |
|                         | 1.0          | 510                 |                 |                    | 17.0       | 31.5 |
|                         | 1.5          | 515                 |                 |                    | 20.5       | 31.5 |
|                         | 2.2          | 522                 |                 |                    | 21.0       | 41.5 |



| ELECTRICAL DATA         |              |                     |                 |                    |            |      |
|-------------------------|--------------|---------------------|-----------------|--------------------|------------|------|
| U <sub>RDC</sub><br>(V) | CAP.<br>(μF) | CAPACITANCE<br>CODE | VOLTAGE<br>CODE | V <sub>AC</sub>    | DIMENSIONS |      |
|                         |              |                     |                 |                    | D          | L    |
| 630                     | 0.000047     | 047                 | 63              | 250 <sup>(1)</sup> | 5.0        | 11.0 |
|                         | 0.000051     | 051                 |                 |                    | 5.0        | 11.0 |
|                         | 0.000056     | 056                 |                 |                    | 5.0        | 11.0 |
|                         | 0.000062     | 056                 |                 |                    | 5.0        | 11.0 |
|                         | 0.000068     | 068                 |                 |                    | 5.5        | 11.0 |
|                         | 0.000075     | 075                 |                 |                    | 5.5        | 11.0 |
|                         | 0.000082     | 082                 |                 |                    | 5.5        | 11.0 |
|                         | 0.000091     | 091                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00010      | 110                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00011      | 111                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00012      | 112                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00013      | 113                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00015      | 115                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00016      | 116                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00018      | 118                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00020      | 120                 |                 |                    | 6.0        | 11.0 |
|                         | 0.00022      | 122                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00024      | 124                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00027      | 127                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00030      | 130                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00033      | 133                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00036      | 136                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00039      | 139                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00043      | 143                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00047      | 147                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00051      | 151                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00056      | 156                 |                 |                    | 5.5        | 11.0 |
|                         | 0.00062      | 162                 |                 |                    | 5.5        | 11.0 |
|                         | 0.00068      | 168                 |                 |                    | 5.5        | 11.0 |
|                         | 0.00075      | 175                 |                 |                    | 5.5        | 11.0 |
|                         | 0.00082      | 182                 |                 |                    | 5.0        | 11.0 |
|                         | 0.00091      | 191                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0010       | 210                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0011       | 211                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0012       | 212                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0013       | 213                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0015       | 215                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0016       | 216                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0018       | 218                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0020       | 220                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0022       | 222                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0024       | 224                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0027       | 227                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0030       | 230                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0033       | 233                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0036       | 236                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0039       | 239                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0043       | 243                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0047       | 247                 |                 |                    | 5.0        | 11.0 |
|                         | 0.0062       | 262                 |                 |                    | 5.5        | 11.0 |
|                         | 0.0068       | 268                 |                 |                    | 5.5        | 11.0 |
|                         | 0.0082       | 282                 |                 |                    | 6.0        | 11.0 |
|                         | 0.010        | 310                 |                 |                    | 5.5        | 14.0 |
|                         | 0.015        | 315                 |                 |                    | 6.5        | 14.0 |
|                         | 0.022        | 322                 |                 |                    | 7.5        | 14.0 |
|                         | 0.033        | 333                 |                 |                    | 7.0        | 19.0 |
|                         | 0.047        | 347                 |                 |                    | 8.0        | 19.0 |

| ELECTRICAL DATA         |              |                     |                 |                    |            |      |
|-------------------------|--------------|---------------------|-----------------|--------------------|------------|------|
| U <sub>RDC</sub><br>(V) | CAP.<br>(μF) | CAPACITANCE<br>CODE | VOLTAGE<br>CODE | V <sub>AC</sub>    | DIMENSIONS |      |
|                         |              |                     |                 |                    | D          | L    |
| 630                     | 0.068        | 368                 | 63              | 250 <sup>(1)</sup> | 9.0        | 19.0 |
|                         | 0.10         | 410                 |                 |                    | 8.5        | 26.5 |
|                         | 0.15         | 415                 |                 |                    | 10.5       | 26.5 |
|                         | 0.22         | 422                 |                 |                    | 12.0       | 26.5 |
|                         | 0.33         | 433                 |                 |                    | 14.5       | 26.5 |
|                         | 0.47         | 447                 |                 |                    | 15.0       | 31.5 |
|                         | 0.68         | 468                 |                 |                    | 18.0       | 31.5 |
|                         | 1.0          | 510                 |                 |                    | 18.0       | 41.5 |
|                         | 1.5          | 515                 |                 |                    | 22.0       | 41.5 |

**Notes**

- Pitch = L + 3.5 mm

<sup>(1)</sup> Not suitable for mains applications

| RECOMMENDED PACKAGING |                         |                       |                           |   |
|-----------------------|-------------------------|-----------------------|---------------------------|---|
| PACKAGING<br>CODE     | TYPE OF<br>PACKAGING    | REEL DIAMETER<br>(mm) | ORDERING CODE<br>EXAMPLES |   |
| G                     | Ammo                    | -                     | MKP1839422403G            | x |
| R                     | Reel                    | 350                   | MKP1839422403R            | x |
| -                     | Bulk<br>for L > 31.5 mm | -                     | MKP1839522403             | x |

**Note**

- For detailed tape specifications refer to packaging information: [www.vishay.com/doc?28139](http://www.vishay.com/doc?28139)

**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.

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 capacitors body is in good contact with the printed-circuit board.

- For L < 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

**Space Requirements on Printed-Circuit Board**

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

- Eccentricity as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.
- Product height with seating plane as given by IEC 60717 as reference:  $h_{max.} \leq h + 0.4 \text{ mm}$  or  $h_{max.} \leq h' + 0.4 \text{ mm}$



## 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

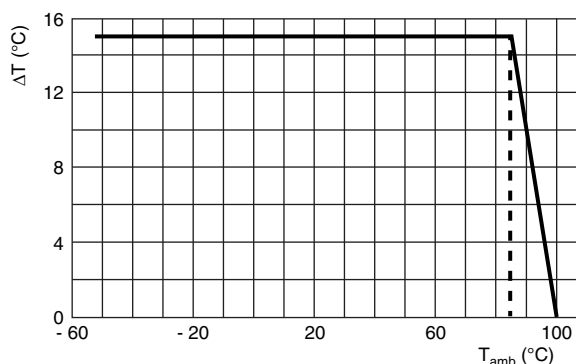
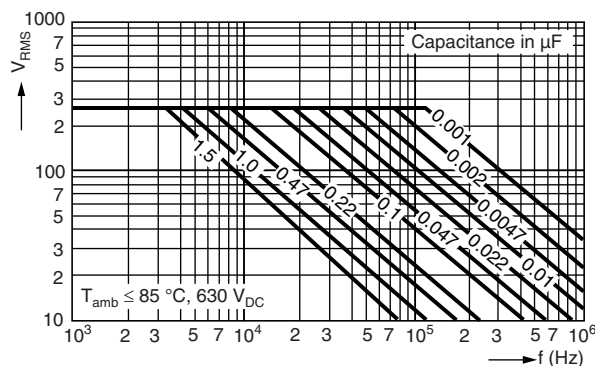
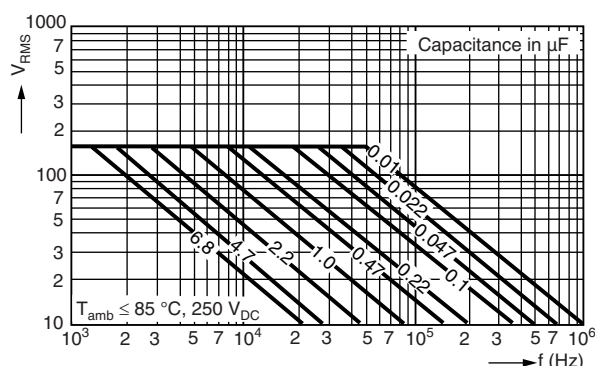
## Ratings and Characteristics Reference Conditions

Unless otherwise specified, all electrical values apply to an ambient 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

### MAX. RMS VOLTAGE AS A FUNCTION OF FREQUENCY



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

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

| DIAMETER<br>(mm) | HEAT CONDUCTIVITY (mW/°C) |           |           |             |             |             |
|------------------|---------------------------|-----------|-----------|-------------|-------------|-------------|
|                  | L = 11 mm                 | L = 14 mm | L = 19 mm | L = 26.5 mm | L = 31.5 mm | L = 41.5 mm |
| 5.0              | 2                         | 3         | 4         | 5           | 6           | 8           |
| 5.5              | 3                         | 3         | 4         | 6           | 7           | 9           |
| 6.0              | 3                         | 4         | 5         | 7           | 8           | 10          |
| 6.5              | 3                         | 4         | 5         | 7           | 9           | 11          |
| 7.0              | 4                         | 5         | 6         | 8           | 9           | 12          |
| 7.5              | 4                         | 5         | 7         | 9           | 10          | 13          |
| 8.0              | 4                         | 5         | 7         | 10          | 11          | 15          |
| 8.5              | 5                         | 6         | 8         | 10          | 12          | 16          |
| 9.0              | 5                         | 6         | 8         | 11          | 13          | 17          |
| 9.5              | 6                         | 7         | 9         | 12          | 14          | 18          |
| 10.0             | 6                         | 7         | 10        | 13          | 15          | 19          |
| 10.5             | 7                         | 8         | 10        | 14          | 16          | 20          |
| 11.0             | 7                         | 8         | 11        | 14          | 17          | 21          |
| 11.5             | 8                         | 9         | 12        | 15          | 18          | 23          |
| 12.0             | 8                         | 10        | 12        | 16          | 19          | 24          |
| 12.5             | 9                         | 10        | 13        | 17          | 20          | 25          |
| 13.0             | 9                         | 11        | 14        | 18          | 21          | 26          |
| 13.5             | 10                        | 11        | 14        | 19          | 22          | 28          |
| 14.0             | 10                        | 12        | 15        | 20          | 23          | 29          |
| 14.5             | 11                        | 13        | 16        | 21          | 24          | 30          |
| 15.0             | 11                        | 13        | 16        | 21          | 25          | 31          |
| 15.5             | 12                        | 14        | 17        | 22          | 26          | 33          |
| 16.0             | 12                        | 14        | 18        | 23          | 27          | 34          |
| 16.5             | 13                        | 15        | 19        | 24          | 28          | 35          |
| 17.0             | 14                        | 16        | 20        | 25          | 29          | 37          |
| 17.5             | 14                        | 17        | 20        | 26          | 30          | 38          |
| 18.0             | 15                        | 17        | 21        | 27          | 31          | 39          |
| 18.5             | 15                        | 18        | 22        | 28          | 32          | 41          |
| 19.0             | 16                        | 19        | 23        | 29          | 34          | 42          |
| 19.5             | 17                        | 19        | 24        | 30          | 35          | 43          |
| 20.0             | 17                        | 20        | 25        | 31          | 36          | 45          |
| 20.5             | 18                        | 21        | 25        | 32          | 37          | 46          |
| 21.0             | 19                        | 22        | 26        | 33          | 38          | 48          |
| 21.5             | 20                        | 22        | 27        | 35          | 39          | 49          |
| 22.0             | 20                        | 23        | 28        | 36          | 41          | 50          |
| 22.5             | 21                        | 24        | 29        | 37          | 42          | 52          |
| 23.0             | 22                        | 25        | 30        | 38          | 43          | 53          |
| 23.5             | 23                        | 26        | 31        | 39          | 44          | 55          |
| 24.0             | 23                        | 27        | 32        | 40          | 46          | 56          |
| 24.5             | 24                        | 27        | 33        | 41          | 47          | 58          |
| 25.0             | 25                        | 28        | 34        | 42          | 48          | 59          |
| 25.5             | 26                        | 29        | 35        | 44          | 49          | 61          |
| 26.0             | 27                        | 30        | 36        | 45          | 51          | 62          |
| 26.5             | 27                        | 31        | 37        | 46          | 52          | 64          |
| 27.0             | 28                        | 32        | 38        | 47          | 53          | 66          |
| 27.5             | 29                        | 33        | 39        | 48          | 55          | 67          |
| 28.0             | 30                        | 34        | 40        | 50          | 56          | 69          |
| 28.5             | 31                        | 35        | 41        | 51          | 57          | 70          |

## 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 ( $^{\circ}\text{C}$ )
- $P$  = 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 ( $T_C$ ).

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

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

## 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 ( $U_P$ ) 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 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  $U_{\text{RDC}}$  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 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                                  | $T_{\text{amb}} \leq 85^{\circ}\text{C}$ | $85^{\circ}\text{C} < T_{\text{amb}} \leq 100^{\circ}\text{C}$ |
| Maximum continuous RMS voltage                    | $U_{\text{RAC}}$                         | $U_{\text{RAC}}$                                               |
| Maximum temperature RMS-overvoltage (< 24 h)      | $1.25 \times U_{\text{RAC}}$             | $1.25 \times U_{\text{RAC}}$                                   |
| Maximum peak voltage ( $V_{\text{O-P}}$ ) (< 2 s) | $1.6 \times U_{\text{RDC}}$              | $1.1 \times U_{\text{RDC}}$                                    |

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

Sub-clause numbers of tests and performance requirements refer to the “Sectional Specification, Publication IEC 60384-16 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 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 and bending                                                                                                                                                                                                                                | No visible damage                                                                                                                                                                       |
| 4.4 Resistance to soldering heat                          | Method: 1A<br>Solder bath: 280 °C ± 5 °C<br>Duration: 5 s                                                                                                                                                                                          |                                                                                                                                                                                         |
| 4.14 Component solvent resistance                         | Isopropylalcohol at room temperature<br>Method: 2<br>Immersion time: 5 min ± 0.5 min<br>Recovery time: 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  \leq 2\%$ of the value measured initially<br><br>Increase of $\tan \delta \leq 0.002$<br>Compared to values measured in 4.3.1 |
| <b>SUB-GROUP C1B OTHER PART OF SAMPLE OF SUB-GROUP C1</b> |                                                                                                                                                                                                                                                    |                                                                                                                                                                                         |
| 4.6.1 Initial measurements                                | Capacitance<br>Tangent of loss angle:<br>For $C \leq 1 \mu\text{F}$ at 10 kHz<br>For $C > 1 \mu\text{F}$ 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                           | $\theta A$ = Lower category temperature<br>$\theta B$ = Upper category temperature<br>5 cycles<br>Duration $t = 30$ min                                                                                                                            |                                                                                                                                                                                         |
| 4.7 Vibration                                             | Visual examination<br>Mounting:<br>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                                                                                                                                                                                                                                 | No visible damage                                                                                                                                                                       |



| GROUP C INSPECTION REQUIREMENTS                                            |                                                                                                                                                      |                                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SUB-CLAUSE NUMBER AND TEST                                                 | CONDITIONS                                                                                                                                           | PERFORMANCE REQUIREMENTS                                                                                                                                                                                                                                                                  |
| <b>SUB-GROUP C1B OTHER PART OF SAMPLE OF SUB-GROUP C1</b>                  |                                                                                                                                                      |                                                                                                                                                                                                                                                                                           |
| 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<br><br>Capacitance<br><br>Tangent of loss angle<br><br>Insulation resistance                                                      | No visible damage<br><br>$ \Delta C/C  \leq 2\%$ of the value measured in 4.6.1<br><br>Increase of $\tan \delta \leq 0.002$<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: Upper category temperature<br>Duration: 16 h                                                                                            |                                                                                                                                                                                                                                                                                           |
| 4.10.3 Damp heat cyclic<br>Test Db, first cycle                            |                                                                                                                                                      |                                                                                                                                                                                                                                                                                           |
| 4.10.4 Cold                                                                | Temperature: Lower category temperature<br>Duration: 2 h                                                                                             |                                                                                                                                                                                                                                                                                           |
| 4.10.6 Damp heat cyclic<br>Test Db, remaining cycles                       | Visual examination                                                                                                                                   | No visible damage<br>Legible marking                                                                                                                                                                                                                                                      |
| 4.10.6.2 Final measurements                                                | Capacitance<br><br>Tangent of loss angle<br><br>Insulation resistance                                                                                | $ \Delta C/C  \leq 3\%$ of the value measured in 4.4.2 or 4.9.3<br><br>Increase of $\tan \delta \leq 0.003$<br>Compared to values measured in 4.3.1 or 4.6.1<br><br>$\geq 50\%$ of values specified in section "Insulation Resistance" of this specification                              |
| <b>SUB-GROUP C2</b>                                                        |                                                                                                                                                      |                                                                                                                                                                                                                                                                                           |
| 4.11 Damp heat steady state                                                | Capacitance                                                                                                                                          |                                                                                                                                                                                                                                                                                           |
| 4.11.1 Initial measurements                                                | Tangent of loss angle at 1 kHz                                                                                                                       |                                                                                                                                                                                                                                                                                           |
| 4.11.3 Final measurements                                                  | Visual examination<br><br>Capacitance<br><br>Tangent of loss angle<br><br>Insulation resistance                                                      | No visible damage<br>Legible marking<br><br>$ \Delta C/C  \leq 3\%$ of the value measured in 4.11.1.<br><br>Increase of $\tan \delta \leq 0.001$<br>Compared to values measured in 4.11.1<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                                                                                                        |
| <b>SUB-GROUP C3</b>                                                                                   |                                                                                                                               |                                                                                                                                 |
| 4.12 Endurance DC                                                                                     | Duration: 2000 h<br>1.25 x $U_{RDC}$ at 85 °C<br>0.875 x $U_{RDC}$ at 100 °C                                                  |                                                                                                                                 |
| 4.12.1 Initial measurements                                                                           | Capacitance<br>Tangent of loss angle:<br>For $C \leq 1 \mu F$ at 10 kHz<br>For $C > 1 \mu F$ at 1 kHz                         |                                                                                                                                 |
| 4.12.5 Final measurements                                                                             | Visual examination                                                                                                            | No visible damage<br>Legible marking                                                                                            |
|                                                                                                       | Capacitance                                                                                                                   | $ \Delta C/C  \leq 3 \%$ compared to values measured in 4.12.1                                                                  |
|                                                                                                       | Tangent of loss angle                                                                                                         | Increase of $\tan \delta \leq 0.002$<br>Compared to values measured in 4.12.1                                                   |
|                                                                                                       | 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<br>Intermediate measurements | Capacitance<br>Capacitance at lower category temperature<br>Capacitance at 20 °C<br>Capacitance at upper category temperature | For - 55 °C to + 20 °C:<br>$0 \% \leq  \Delta C/C  \leq 2 \%$ or<br>for 20 °C to 85 °C:<br>$- 3 \% \leq  \Delta C/C  \leq 0 \%$ |
| Final measurements                                                                                    | Capacitance<br>Tangent of loss angle:<br>For $C \leq 1 \mu F$ at 10 kHz<br>For $C > 1 \mu F$ at 1 kHz                         | As specified in section "Capacitance" of this specification                                                                     |
|                                                                                                       | Insulation resistance                                                                                                         | As specified in section "Insulation Resistance" of this specification                                                           |
| 4.13 Charge and discharge                                                                             | 10 000 cycles<br>Charged to $U_{RDC}$<br>Discharge resistance:<br>$R = \frac{U_{RDC}}{2.5 \times C(dU/dt)}$                   |                                                                                                                                 |
| 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 $\tan \delta \leq 0.003$<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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