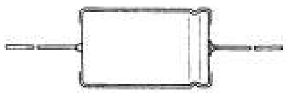
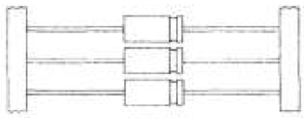
# SOLID ALUMINIUM CAPACITORS

- **Small type**
- **Axial leads; metal case**
- **Long life**
- **High reliability**
- **Industrial and military applications**





## QUICK REFERENCE DATA

| | |
|---|---|
| Nominal capacitance range (E6 series) | 2,2 to 330 $\mu$F |
| Tolerance on nominal capacitance | −20 to + 20% |
| Rated voltage range, $U_R$ (R5 series) | 6,3 to 50 V |
| Category temperature range | −55 to + 125 °C |
| Usable temperature range | −80 to + 175 °C |
| Endurance test at 125 °C | 5000 h |
| Basic specification | IEC 384-4, long-life grade |
| Climatic category, IEC 68; 6,3 V to 40 V ranges | 55/125/56 |
| Climatic category, IEC 68; 50 V range | |
| at 50 V | 55/085/56 |
| at 40 V | 55/125/56 |
| Approvals; 6,3 V to 40 V ranges | CECC 30 302-001 |
| | U.K. Post Office |
| | FOA/FTL (Sweden) |
| | Ministry of Defence DEF 59-44 |
| | SCC Arcao AR C121 (Ariane) |

Selection chart for $C_{nom}$-$U_R$ and relevant case sizes.

| $C_{nom}$ $\mu$F | $U_R$ (V) | | | | | |
|---|---|---|---|---|---|---|
| | 6,3 | 10 | 16 | 25 | 40 | 50 |
| 2,2 | | | | | 1 | 1 |
| 3,3 | | | | | 1 | |
| 4,7 | | | | 1 | 2A | 2A |
| 6,8 | | | | | 2A | 2A |
| 10 | | | 1 | 2A | 2A | |
| 15 | | 1 | 2A | | | 4 |
| 22 | 1 | | | 2A | 4 | 5 |
| 33 | | 2A | 2A | 4 | 5 | 6 |
| 47 | 2A | 2A | 4 | 5 | 6 | |
| 68 | 2A | | 5 | 6 | | |
| 100 | | 4 | 6 | | | |
| 150 | 4 | 5 | | | | |
| 220 | 5 | 6 | | | | |
| 330 | 6 | | | | | |

| case size | nominal dimensions (mm) |
|---|---|
| 1 | Ø 6,5 x 15 |
| 2A | Ø 7,5 x 20 |
| 4 | Ø 9 x 23 |
| 5 | Ø 10 x 31,5 |
| 6 | Ø 12,5 x 31,5 |

## APPLICATION

These capacitors utilize advanced technology to achieve long life, high stability, excellent reliability, very high ripple current rating and low temperature dependence. The capacitors are not subject to a limitation on charge or discharge currents and they will function in circuits where voltage reversal may occur.

## DESCRIPTION

The capacitors have etched aluminium foil electrodes separated by a layer of semiconductive material. The electrolyte is pyrolitically formed manganese dioxide. The capacitors are housed in an aluminium case with axial leads and are sealed by a ceramic disc. The cathode lead is welded to the case, which is insulated with a blue transparent plastic sleeve.

The capacitors are available in 2 styles:
style 1: axial leads, case sizes 1 to 6, in boxes;
style 2: axial leads, case sizes 1 to 6, on bandoliers on reel.

Note: A special version is available, which is partly epoxy-filled, withstanding severe shock and vibration tests; see also "Tests and requirements".

## MECHANICAL DATA

Dimensions in mm

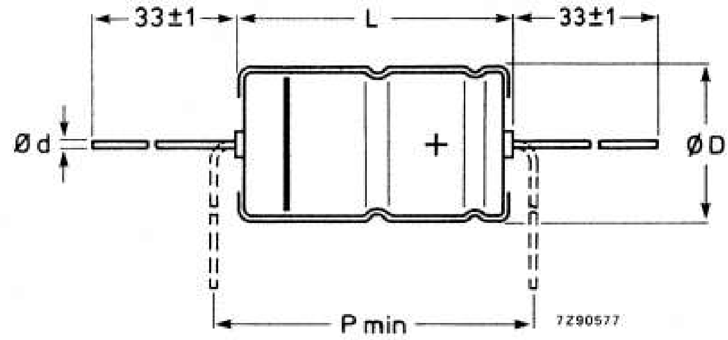



Fig. 1 Style 1; for dimensions d, D, L and P, see Table 1a.

**Table 1a**

| case size | d | $D_{nom}$ | $L_{nom}$ | $D_{max}$ | $L_{max}$ | $P_{min}$ | mass** approx. g |
|---|---|---|---|---|---|---|---|
| 1 | 0,6 (0,8)* | 6,5 | 15 | 6,7 | 15,3 (17,5)* | 17,5 (20)* | 1,2 |
| 2A | 0,6 (0,8)* | 7,5 | 20 | 7,6 | 20,4 (23,3)* | 22,5 (25)* | 2,4 |
| 4 | 0,6 (0,8)* | 9 | 23 | 9,3 (10,3)* | 23,3 | 25 | 3,3 |
| 5 | 0,8 | 10 | 31,5 | 10,3 | 32 | 35 | 4,5 |
| 6 | 0,8 | 12,5 | 31,5 | 12,9 | 32 | 35 | 6,3 |

* Dimension between brackets is valid until the middle of 1984.
** Add 10% for epoxy-filled version.

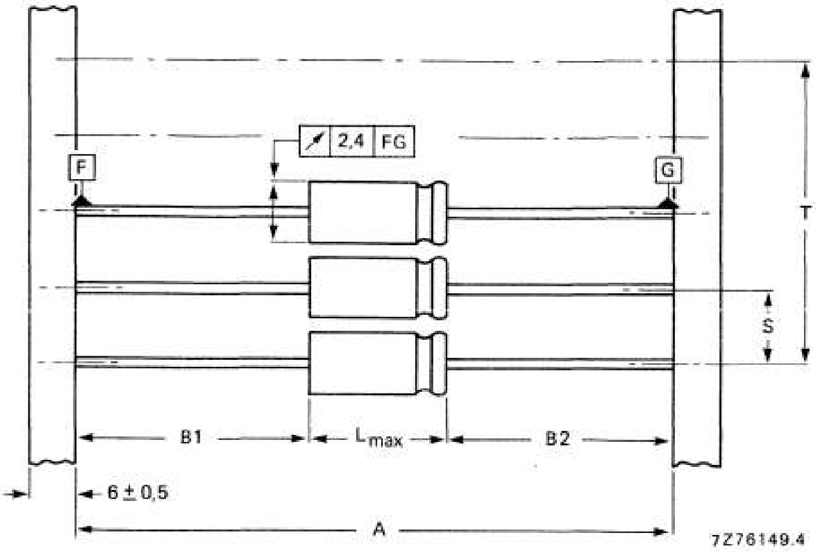



Fig. 2 Style 2 capacitors on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 1b for dimensions A, S, T and $L_{max}$.
$|B1-B2| = 1,4 + (L_{max}-L)$ mm max.

**Table 1b**

| case size | A | S | T for number (n) of capacitors | | $L_{max}$ |
|---|---|---|---|---|---|
| | | | $n < 50$ | $50 < n < 100$ | |
| 1 | 73 ± 1,6 | 10 ± 0,4 | 10 (n-1) ± 2 | 10 (n-1) ± 4 | 15,3 (17,5)* |
| 2A | 73 ± 1,6 | 10 ± 0,4 | 10 (n-1) ± 2 | 10 (n-1) ± 4 | 20,4 (23,3)* |
| 4 | 73 ± 1,6 | 10 ± 0,4 | 10 (n-1) ± 2 | 10 (n-1) ± 4 | 23,3 |
| 5 | 73 ± 1,6 | 15 ± 0,75 | 10 (n-1) ± 2 | 10 (n-1) ± 4 | 32 |
| 6 | 73 ± 1,6 | 15 ± 0,75 | 10 (n-1) ± 2 | 10 (n-1) ± 4 | 32 |

## Marking

The capacitors are marked with: group number (121), capacitance, tolerance, rated and derated voltages at corresponding maximum temperatures, date code, a band to identify the negative terminal, "+" signs for the positive terminal and name of manufacturer.

## Mounting

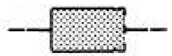
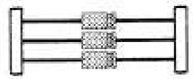
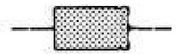
No special provisions are required for soldering to the tinned leads. (2 mm of the anode lead nearest the body are not solderable).

* Dimension between brackets is valid until the middle of 1984.

## ELECTRICAL DATA

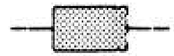
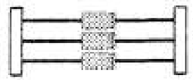
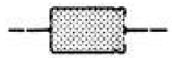
Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.
See also the corresponding paragraphs.

**Table 2**

| $U_R$ | nom. cap. | max. r.m.s. ripple current at $T_{amb}$ = 125 °C | max. leakage current at $U_R$ after 1 min* | max. tan δ | max. ESR | max. impedance at 100 kHz* | case size | catalogue number 2222 121 followed by | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | |  style 1 |  style 2 |  epoxy-filled version** |
| V | µF | mA | µA | | Ω | Ω | | | | |
| 6,3 | 22 | 60 | 12,5 | 0,18 | 16,5 | 1,2 | 1 | 13229 | 23229 | 63229 |
| | 47 | 100 | 25 | 0,18 | 7,6 | 1,0 | 2A | 13479 | 23479 | 63479 |
| | 68 | 130 | 40 | 0,18 | 5,3 | 0,75 | 2A | 13689 | 23689 | 63689 |
| | 150 | 220 | 70 | 0,18 | 2,4 | 0,4 | 4 | 13151 | 23151 | 63151 |
| | 220 | 320 | 125 | 0,18 | 1,6 | 0,3 | 5 | 13221 | 23221 | 63221 |
| | 330 | 430 | 150 | 0,18 | 1,1 | 0,2 | 6 | 13331 | 23331 | 63331 |
| 10 | 15 | 50 | 15 | 0,16 | 21,5 | 2,5 | 1 | 14159 | 24159 | 64159 |
| | 33 | 85 | 30 | 0,16 | 9,6 | 1,25 | 2A | 14339 | 24339 | 64339 |
| | 47 | 115 | 47 | 0,16 | 6,8 | 0,75 | 2A | 14479 | 24479 | 64479 |
| | 100 | 190 | 80 | 0,16 | 3,2 | 0,5 | 4 | 14101 | 24101 | 64101 |
| | 150 | 280 | 150 | 0,16 | 2,1 | 0,4 | 5 | 14151 | 24151 | 64151 |
| | 220 | 380 | 200 | 0,16 | 1,4 | 0,4 | 6 | 14221 | 24221 | 64221 |
| 16 | 10 | 45 | 16 | 0,14 | 28 | 2,5 | 1 | 15109 | 25109 | 65109 |
| | 15 | 60 | 24 | 0,14 | 19 | 1,25 | 2A | 15159 | 25159 | 65159 |
| | 33 | 105 | 53 | 0,14 | 8,4 | 0,75 | 2A | 15339 | 25339 | 65339 |
| | 47 | 140 | 75 | 0,14 | 5,9 | 0,5 | 4 | 15479 | 25479 | 65479 |
| | 68 | 200 | 109 | 0,14 | 4,1 | 0,4 | 5 | 15689 | 25689 | 65689 |
| | 100 | 270 | 160 | 0,14 | 2,8 | 0,4 | 6 | 15101 | 25101 | 65101 |

* Capacitors with lower values of max. leakage current or max. impedance are available to special order.
** Withstands severe shock and vibration.

Table 2 (continued)

| $U_R$ | nom. cap. | max. r.m.s. ripple current at $T_{amb}$ = 125 °C | max. leakage current at $U_R$ after 1 min* | max. tan δ | max. ESR | max. impedance at 100 kHz* | case size | catalogue number 2222 121 followed by | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | |  style 1 |  style 2 |  epoxy-filled version** |
| V | μF | mA | μA | | Ω | Ω | | | | |
| 25 | 4,7 | 30 | 12 | 0,14 | 60 | 5 | 1 | 16478 | 26478 | 66478 |
| | 10 | 50 | 25 | 0,14 | 28 | 2,5 | 2A | 16109 | 26109 | 66109 |
| | 22 | 85 | 55 | 0,14 | 13 | 1,5 | 2A | 16229 | 26229 | 66229 |
| | 33 | 120 | 83 | 0,14 | 8,4 | 1 | 4 | 16339 | 26339 | 66339 |
| | 47 | 160 | 118 | 0,14 | 5,9 | 0,8 | 5 | 16479 | 26479 | 66479 |
| | 68 | 220 | 170 | 0,14 | 4,1 | 0,5 | 6 | 16689 | 26689 | 66689 |
| 40 | 2,2 | 20 | 9 | 0,12 | 109 | 5 | 1 | 17228 | 27228 | 67228 |
| | 3,3 | 30 | 13 | 0,12 | 73 | 5 | 1 | 17338 | 27338 | 67338 |
| | 4,7 | 35 | 19 | 0,12 | 51 | 2,5 | 2A | 17478 | 27478 | 67478 |
| | 6,8 | 45 | 27 | 0,12 | 35 | 2,5 | 2A | 17688 | 27688 | 67688 |
| | 10 | 60 | 40 | 0,12 | 24 | 1,5 | 2A | 17109 | 27109 | 67109 |
| | 22 | 100 | 88 | 0,12 | 11 | 1 | 4 | 17229 | 27229 | 67229 |
| | 33 | 150 | 132 | 0,12 | 7,3 | 0,8 | 5 | 17339 | 27339 | 67339 |
| | 47 | 200 | 188 | 0,12 | 5,1 | 0,5 | 6 | 17479 | 27479 | 67479 |
| 50 | 2,2 | 15 | 11 | 0,25 | 230 | 20 | 1 | 18228 | 28228 | 68228 |
| | 4,7 | 25 | 24 | 0,25 | 106 | 10 | 2A | 18478 | 28478 | 68478 |
| | 6,8 | 35 | 34 | 0,25 | 74 | 6 | 2A | 18688 | 28688 | 68688 |
| | 15 | 60 | 75 | 0,25 | 34 | 4 | 4 | 18159 | 28159 | 68159 |
| | 22 | 85 | 110 | 0,25 | 23 | 3,2 | 5 | 18229 | 28229 | 68229 |
| | 33 | 110 | 165 | 0,25 | 15,5 | 2 | 6 | 18339 | 28339 | 68339 |

* Capacitors with lower values of max. leakage current or max. impedance are available to special order.
** Withstands severe shock and vibration.

**Capacitance**

| | |
|---|---|
| Nominal capacitance values at 100 Hz and $T_{amb}$ = 25 °C | see Table 2 |
| Tolerance on nominal capacitance at 100 Hz | ± 20% |

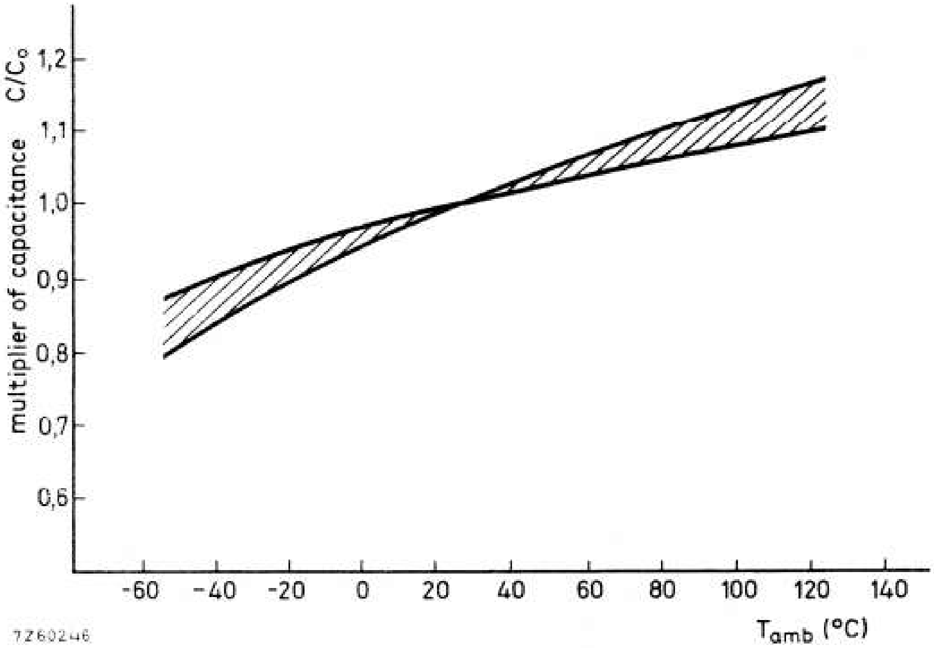



Fig. 3 Typical capacitance as a function of ambient temperature.
$C_0$ = capacitance at $T_{amb}$ = 25 °C, 100 Hz.

**Voltage**

Rated voltage

| | | |
|---|---|---|
| 6,3 V to 40 V ranges | = max. permissible voltage at $T_{amb} \leqslant 125$ °C | $U_R$ |
| 50 V range | = max. permissible voltage at $T_{amb} \leqslant 85$ °C | $U_R$* |

Derated voltage

| | | |
|---|---|---|
| 6,3 V to 40 V ranges | = max. permissible voltage at $T_{amb}$ from 125 °C to 175 °C | 0,63 x $U_R$ |
| 50 V range | = max. permissible voltage at $T_{amb}$ from 85 °C to 125 °C | 40 V |

Ripple voltage

Max. permissible a.c. voltage providing the following four conditions are met:

| | |
|---|---|
| a) Max. a.c. voltage, with negative d.c. voltage applied | 2 V |

* 63 V is permissible for max. 500 h at $T_{amb}$ = 85 °C.

b) Max. peak a.c. voltage, without d.c. voltage applied

| | $T_{amb} \leq 85\ ^oC$ | $85\ ^oC < T_{amb} \leq 125\ ^oC$* |
|---|---|---|
| at $f \leq 0,1$ Hz | $0,30 \times U_R$ | $0,15 \times U_R$ |
| at $0,1$ Hz $< f \leq 1$ Hz | $0,45 \times U_R$ | $0,22 \times U_R$ |
| at $1$ Hz $< f \leq 10$ Hz | $0,60 \times U_R$ | $0,30 \times U_R$ |
| at $10$ Hz $< f \leq 50$ Hz | $0,65 \times U_R$ | $0,32 \times U_R$ |
| at $f > 50$ Hz | $0,80 \times U_R$ | $0,40 \times U_R$ |

c) Momentary value of applied voltage, with positive d.c. voltage applied: between $U_R$ (in the positive half wave) and the limits mentioned under b) (in the negative half wave)

d) Ripple voltage limits are not applicable if the maximum ripple current is exceeded. In that case the ripple current is decisive. Whichever is in practice decisive, depends on the actual impedance of the capacitor. Table 3 should be considered as an aid only in establishing whether the ripple voltage or the ripple current is decisive.

**Table 3**

| frequency | decisive factor | |
|---|---|---|
| | at $T_{amb} \leq 85\ ^oC$ | $T_{amb} > 85\ ^oC$ |
| $f \leq 50$ Hz | voltage | voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low |
| $50$ Hz $< f \leq 1$ kHz | voltage, if actual capacitor impedance is high; current, if actual capacitor impedance is low | current |
| $f > 1$ kHz | current | current |

Surge voltage

| | | $T_{amb} \leq 85\ ^oC$ | $85\ ^oC < T_{amb} \leq 125\ ^oC$ |
|---|---|---|---|
| 6,3 V to 40 V ranges | = max. permissible voltage for short periods (see also "Tests and requirements") | $1,15 \times U_R$ | |
| 50 V range | = max. permissible voltage for max. 500 h | 63 V | 45 V |

* For 50 V range, $U_R = 40$ V.

| | | $T_{amb} \leq 85\ ^oC$ | $85\ ^oC < T_{amb} \leq 125\ ^oC$ |
|---|---|---|---|
| Reverse voltage | | | |
| 6,3 V to 40 V ranges | = max. d.c. voltage continuously (2000 h) applied in the reverse polarity, | | |
| | at $T_{amb} \leq 85\ ^oC$ | $0,30 \times U_R$ | |
| | at $85\ ^oC < T_{amb} \leq 125\ ^oC$ | $0,15 \times U_R$ | |
| 50 V range | = max. d.c. voltage applied in the reverse polarity at the maximum category temperature for short periods (see also "Tests and requirements") | 7,5 V | 6 V |

**Ripple current**

Maximum permissible r.m.s. ripple current at 100 Hz and $T_{amb} = 125\ ^oC$ — see Table 2

Maximum permissible r.m.s. ripple current at other frequencies, temperatures and conditions — see Table 4 to 6, and Fig. 4

**Table 4** Temperature multiplier of ripple current ($\sqrt{k}$), at 100 Hz

| $T_{amb}$ $^oC$ | $\sqrt{k}$ |
|---|---|
| 25 | 2,6 |
| 35 | 2,5 |
| 45 | 2,4 |
| 55 | 2,25 |
| 65 | 2,2 |
| 70 | 2,15 |
| 75 | 2,1 |
| 80 | 2,05 |
| 85 | 2,0 |
| 90 | 1,9 |
| 95 | 1,8 |
| 100 | 1,7 |
| 105 | 1,6 |
| 110 | 1,45 |
| 115 | 1,35 |
| 120 | 1,2 |
| 125 | 1,0 |

**Table 5** Frequency multiplier of ripple current ($\sqrt{r}$) at 25 $^oC$

| frequency kHz | $\sqrt{r}$ |
|---|---|
| 0,05 | 0,8 |
| 0,1 | 1,0 |
| 0,2 | 1,2 |
| 0,5 | 1,4 |
| 1 | 1,55 |
| 2 | 1,70 |
| 5 | 1,80 |
| 10 | 1,95 |
| 20 | 2,05 |
| 50 | 2,15 |
| 100 | 2,20 |
| 200 | 2,25 |
| 500 | 2,30 |
| 1000 | 2,35 |

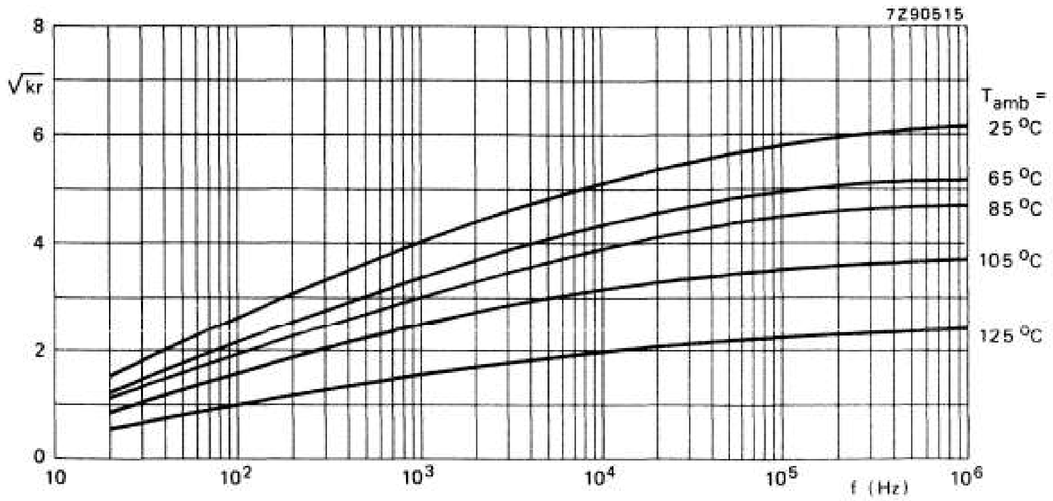



Fig. 4 Combined temperature/frequency multiplier of ripple current ($\sqrt{kr}$) as a function of frequency. $I_{r\,max} = I_{r0}\sqrt{kr}$.

**Table 6** Multiplier of ripple current for various application conditions

| condition | multiplier |
|---|---|
| A. Capacitor insulated with a blue sleeve, mounted horizontally on a thermally non-conducting printed-circuit board, in free flowing air and in a surrounding that allows the absorption of radiation heat. | 1,0 |
| B. As under A but capacitor is not insulated | 0,9 |
| C. As under A but capacitor is mounted vertically. | 0,7 |
| D. As under A but capacitor is mounted on a good thermally conducting printed-circuit board. | 1,25 |
| E. As under A but the surrounding walls etc. have a temperature higher than 125 °C and therefore prevent the absorption of heat by radiation. | 0,6 |
| F. Capacitor has an ESR value lower than the maximum ESR. | $\sqrt{\frac{ESR_{max}}{ESR_{actual}}}$ |
| G. As under A but capacitor is epoxy-filled (for severe shock and vibration resistance). | 1,05 |
| H. As under G but capacitor is mounted on a good thermally conducting printed-circuit board. | 1,5 |

Note: Neither the maximum permissible ripple current nor the maximum permissible ripple voltage values are to be exceeded. Refer to Table 3 to find whichever factor will be decisive.

*Calculation of ripple currents*

The maximum permissible ripple current ($I_{r\ max}$) is a function of temperature and frequency:

$I_{r\ max} = I_{r0}\sqrt{kr}$,

where $I_{r0}$ = max. ripple current at 100 Hz and 125 °C (see Table 2);

$\sqrt{k}$ = temperature multiplier (neglecting the frequency dependence) = $\sqrt{P_{max}/P_{125}}$;

$\sqrt{r}$ = frequency multiplier (neglecting the temperature dependence) = $\sqrt{ESR_{100}/ESR_{max}}$;

(for $\sqrt{k}$ and $\sqrt{r}$, see Tables 4 and 5, for $\sqrt{kr}$, see Fig. 4);

while $P_{max}$ = max. permissible power dissipation, temperature dependent;

$P_{125}$ = max. permissible power dissipation at 125 °C = $I^2_{r0}\ ESR_{100}$;

$ESR_{max}$ = max. equivalent series resistance, frequency dependent;

$ESR_{100}$ = max. equivalent series resistance at 100 Hz.

The formula is derived for any temperature and frequency as follows:

$$I^2_{r\ max} = P_{max}/ESR_{max}$$
$$= kr\ P_{125}/ESR_{100}$$
$$= kr\ I^2_{r0}\ ESR_{100}/ESR_{100}$$

Thus $I_{r\ max} = I_{r0}\sqrt{kr}$.

The values of the temperature multiplier $\sqrt{k}$ and of P125 have been calculated allowing a capacitor temperature of 138 °C and assuming the values of $ESR_{max}$ at 138 °C to be 0,8 times the $ESR_{max}$ at 25 °C at all frequencies.

The values of the frequency multiplier $\sqrt{r}$ have been measured at 25 °C assuming it to be the same at all temperatures.

The power dissipation ($P_{max}$) has been calculated assuming it to be governed by the simplified relation:

$P_{max} = \beta \times S \times \Delta T$,

where $\beta$ = heat transfer coefficient, taken as 9,0 W/m²K;

S = capacitor outer surface;

$\Delta T$ = temperature difference between capacitor surface and the ambient atmosphere, taken as 13 °C at $T_{amb}$ = 125 °C.

**Charge and discharge current**

The capacitors may be charged from a source without internal resistance and they may be discharged by short-circuiting. If the capacitors are charged and discharged continuously at a rate of several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The r.m.s. value of these currents should be determined and the value thus found must not exceed the applicable limit.

**Leakage current**

| | |
|---|---|
| Maximum leakage current 1 min after application of $U_R$, at $T_{amb}$ = 25 °C | see Table 2 (max. 0,1 CU) |
| Leakage current during continuous operation at $U_R$, | |
| at $T_{amb}$ = 25 °C | approx. 0,5 x value stated in Table 2 |
| at $T_{amb}$ = 85 °C | approx. 2 x value stated in Table 2 |
| at $T_{amb}$ = 125 °C | approx. 7 x value stated in Table 2 |
| Leakage current during continuous operation at 40 V, $T_{amb}$ = 125 °C (only applicable to 50 V range) | approx. 2 x value stated in Table 2 |

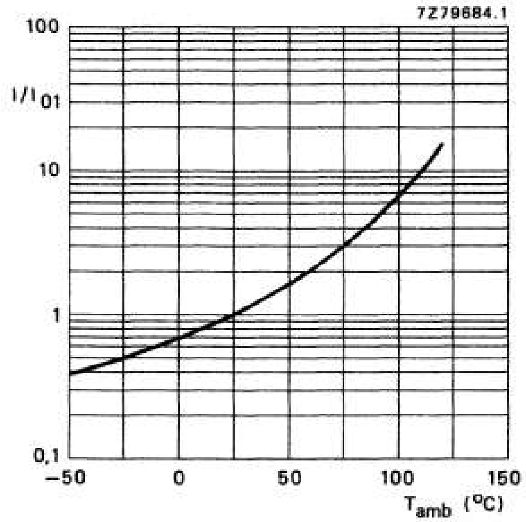



Fig. 5 Multiplier $I/I_{01}$ as a function of temperature. $I_{01}$ = leakage current during continuous operation at $U_R$, $T_{amb}$ = 25 °C.

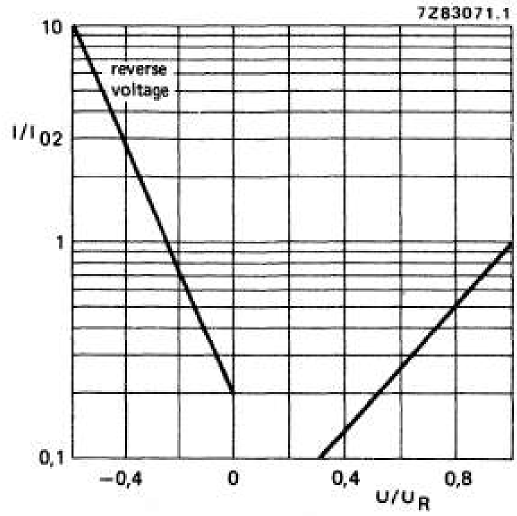



Fig. 6 Multiplier $I/I_{02}$ as a function of $U/U_R$. $I_{02}$ = leakage current at $U_R$ at a discrete constant temperature.

**Tan δ (dissipation factor)**

| | |
|---|---|
| Maximum tan δ at 100 Hz and $T_{amb}$ = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) | see Table 2 |
| Typical tan δ at 100 Hz and $T_{amb}$ = 25 °C | approx. 0,6 x value stated in Table 2 |

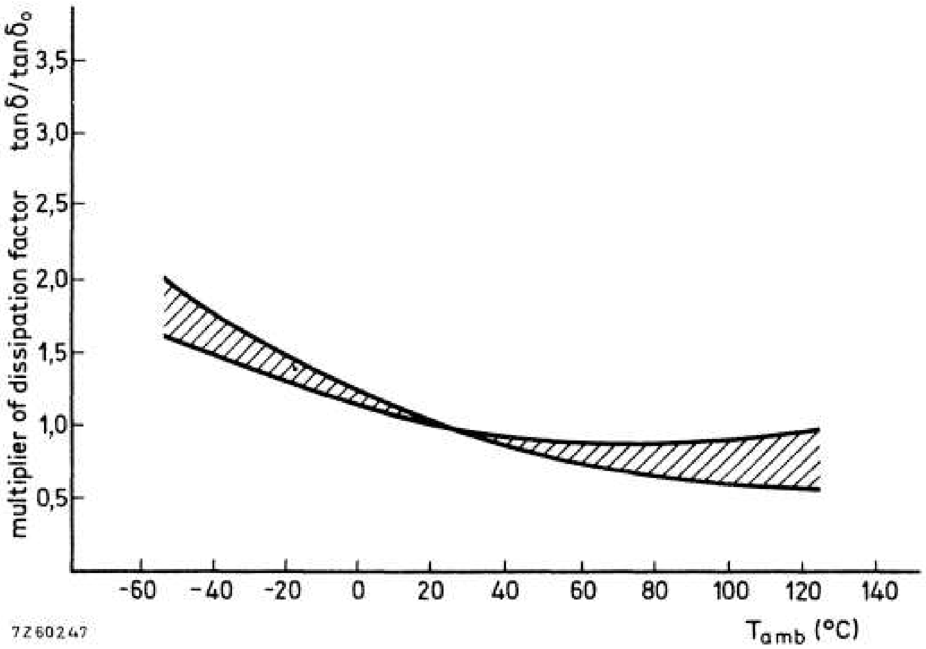



Fig. 7 Multiplier of dissipation factor as a function of ambient temperature; tan $\delta_0$ = dissipation factor at 25 °C, 100 Hz.

**Equivalent series resistance (ESR = tan δ/ωC)**

| | |
|---|---|
| Maximum ESR at 100 Hz and $T_{amb}$ = 25 °C (calculated from maximum tan δ and 0,8 x nominal capacitance) | see Table 2 |

**Impedance**

| | |
|---|---|
| Maximum impedance at 100 kHz, and $T_{amb}$ = 25 °C, measured by means of a four-terminal circuit (Thomson circuit) | see Table 2 |
| Typical impedance at 100 kHz, and $T_{amb}$ = 25 °C | approx. 0,5 x value stated in Table 2 |

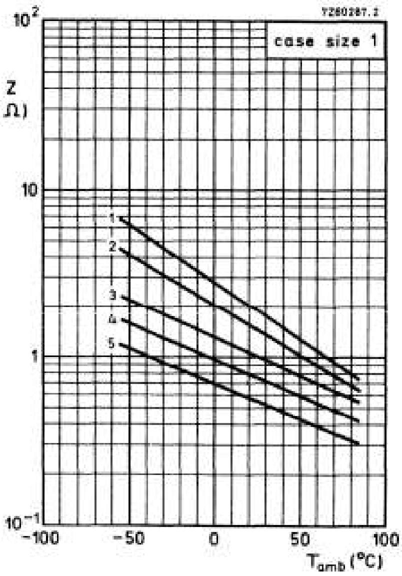



Fig. 8 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 2,2 μF, 40 V;
curve 2 = 4,7 μF, 25 V;
curve 3 = 10 μF, 16 V;
curve 4 = 15 μF, 10 V;
curve 5 = 22 μF, 6,3 V.

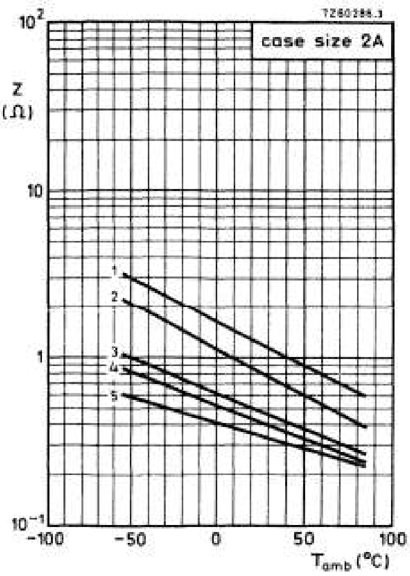



Fig. 9 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 4,7 μF, 40 V;
curve 2 = 10 μF, 25 V;
curve 3 = 15 μF, 16 V;
curve 4 = 33 μF, 10 V;
curve 5 = 47 μF, 6,3 V.

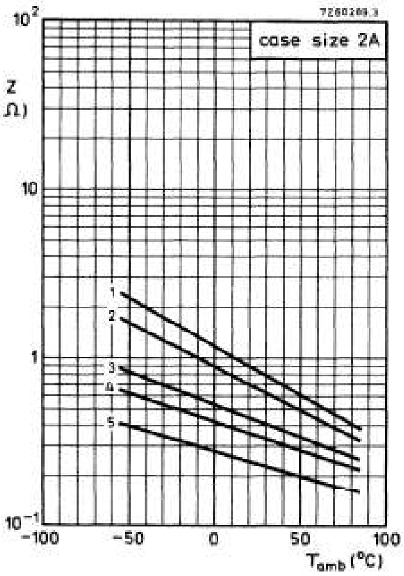



Fig. 10 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 10 μF, 40 V;
curve 2 = 22 μF, 25 V;
curve 3 = 33 μF, 16 V;
curve 4 = 47 μF, 10 V;
curve 5 = 68 μF, 6,3 V.

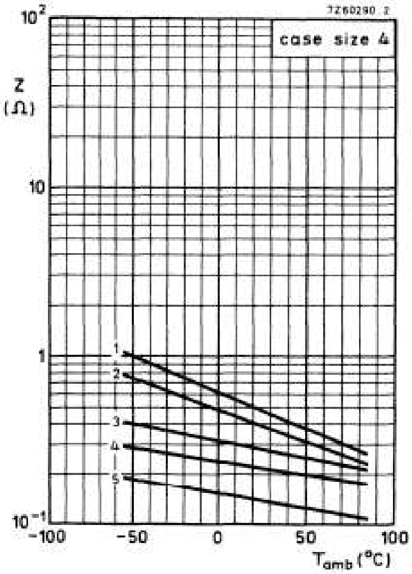



Fig. 11 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 22 μF, 40 V;
curve 2 = 33 μF, 25 V;
curve 3 = 47 μF, 16 V;
curve 4 = 100 μF, 10 V;
curve 5 = 150 μF, 6,3 V.

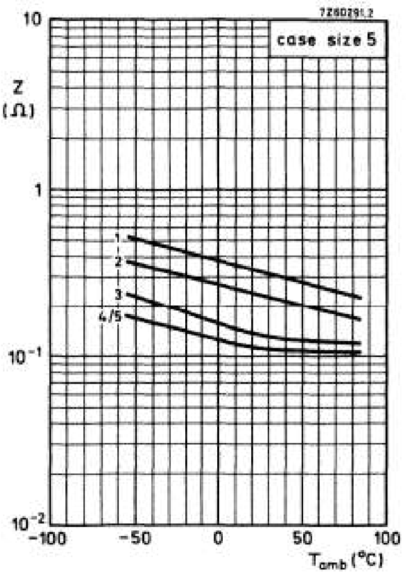



Fig. 12 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 33 μF, 40 V;
curve 2 = 47 μF, 25 V;
curve 3 = 68 μF, 16 V;
curve 4 = 150 μF, 10 V;
curve 5 = 220 μF, 6,3 V.

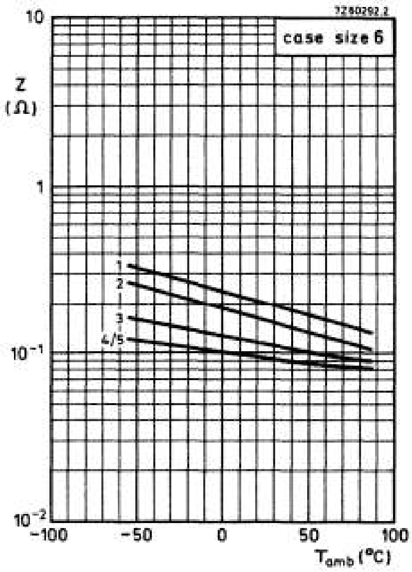



Fig. 13 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 47 μF, 40 V;
curve 2 = 68 μF, 25 V;
curve 3 = 100 μF, 16 V;
curve 4 = 220 μF, 10 V;
curve 5 = 330 μF, 6,3 V.

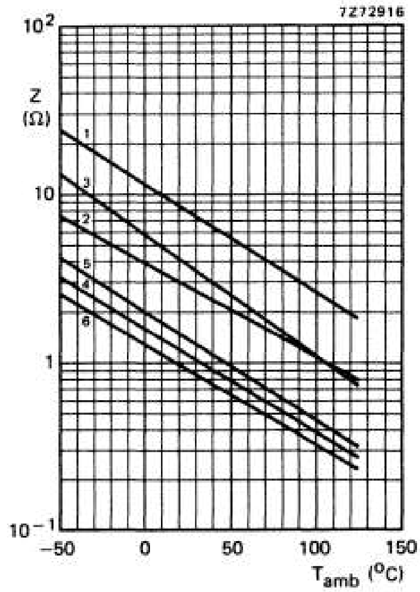



Fig. 14 Typical impedance as a function of temperature at 100 kHz.

Curve 1 = 2,2 μF, 50 V;
curve 2 = 4,7 μF, 50 V;
curve 3 = 6,8 μF, 50 V;
curve 4 = 15 μF, 50 V;
curve 5 = 22 μF, 50 V;
curve 6 = 33 μF, 50 V.

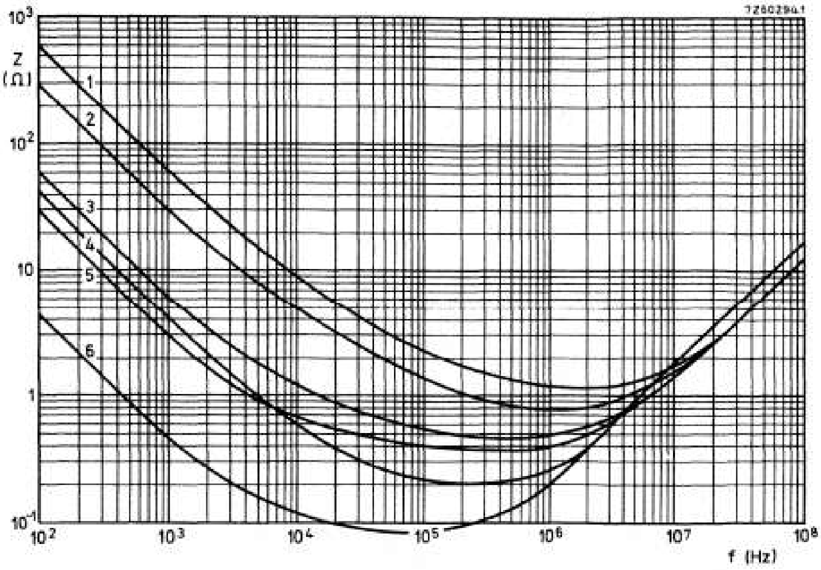



Fig. 15 Typical impedance as a function of frequency at $T_{amb}$ = 25 °C.

Curve 1 = 2,2 μF, 40 V;
curve 2 = 4,7 μF, 40 V;
curve 3 = 22 μF, 6,3 V;
curve 4 = 47 μF, 40 V;
curve 5 = 47 μF, 6,3 V;
curve 6 = 330 μF, 6,3 V.

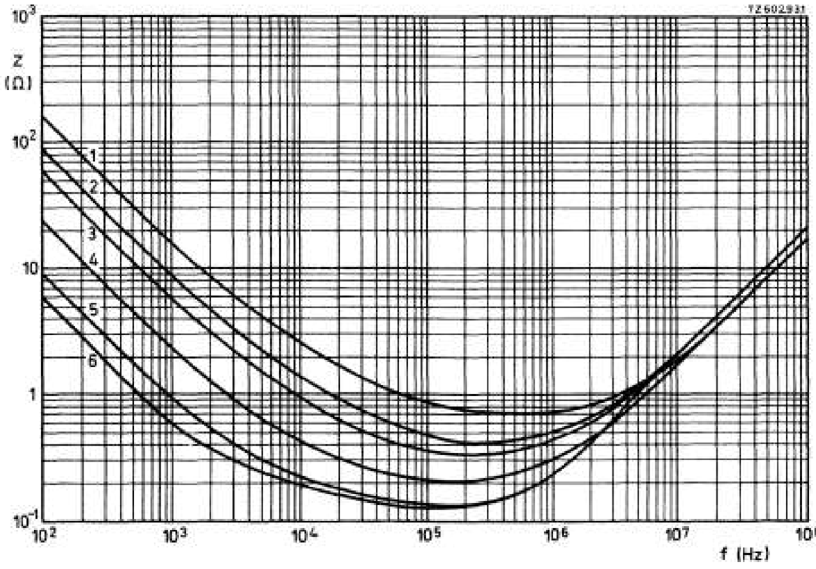



Fig. 16 Typical impedance as a function of frequency at $T_{amb}$ = 25 °C.

Curve 1 = 10 μF, 40 V;
curve 2 = 22 μF, 40 V;
curve 3 = 33 μF, 40 V;
curve 4 = 68 μF, 6,3 V;
curve 5 = 150 μF, 6,3 V;
curve 6 = 220 μF, 6,3 V.

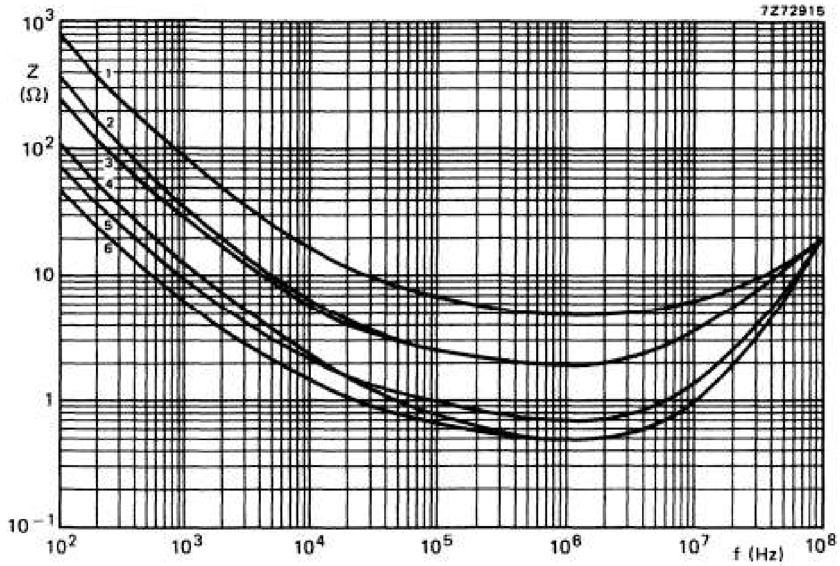



Fig. 17 Typical impedance as a function of frequency at $T_{amb}$ = 25 °C.
Curve 1 = 2,2 μF, 50 V;
curve 2 = 4,7 μF, 50 V;
curve 3 = 6,8 μF, 50 V;
curve 4 = 15 μF, 50 V;
curve 5 = 22 μF, 50 V;
curve 6 = 33 μF, 50 V.

**Equivalent series inductance (ESL)**

Equivalent series inductance, measured by means of a four-terminal circuit (Thomson circuit), at 10 MHz; the capacitor leads bent to the pitch as indicated

| | pitch | max. ESL | typ. ESL |
|---|---|---|---|
| case size 1 | 20,3 mm | 35 nH | 18 to 28 nH |
| case size 2A | 25,4 mm | 35 nH | 18 to 28 nH |
| case size 4 | 27,9 mm | 40 nH | 23 to 33 nH |
| case size 5 | 35,6 mm | 40 nH | 24 to 34 nH |
| case size 6 | 35,6 mm | 55 nH | 37 to 47 nH |

## OPERATIONAL DATA

| | |
|---|---|
| Category temperature range, 6,3 V to 40 V ranges | −55 to + 125 °C |
| Category temperature range, 50 V range | |
| for rated voltage | −55 to + 85 °C |
| for derated voltage (40 V) | −55 to + 125 °C |
| Usable temperature range | −80 to + 175 °C |
| Typical life time, 6,3 V to 40 V ranges | |
| at $T_{amb}$ = 125 °C and $U_R$ | > 20 000 h |
| at $T_{amb}$ = 150 °C and $U_R$ | > 5 000 h |
| at $T_{amb}$ = 175 °C and $U_R$ | > 2 000 h |
| Typical life time, 50 V range | |
| at $T_{amb}$ = 85 °C and $U_R$ | > 10 000 h |
| at $T_{amb}$ = 125 °C and derated voltage (40 V) | > 10 000 h |
| Field failure rate | $< 1 \times 10^{-9}$/h |

## PACKING

Capacitors of style 1 are supplied in boxes, those of style 2 are on bandoliers on reels.
The number of capacitors per box or per reel is shown in Table 7.

**Table 7**

| case size | number of capacitors | |
|---|---|---|
| | style 1 per box | style 2 per reel |
| 1 | 100 | 1000 |
| 2A | 100 | 1000 |
| 4 | 100 | 500 |
| 5 | 100 | 500 |
| 6 | 100 | 400 |

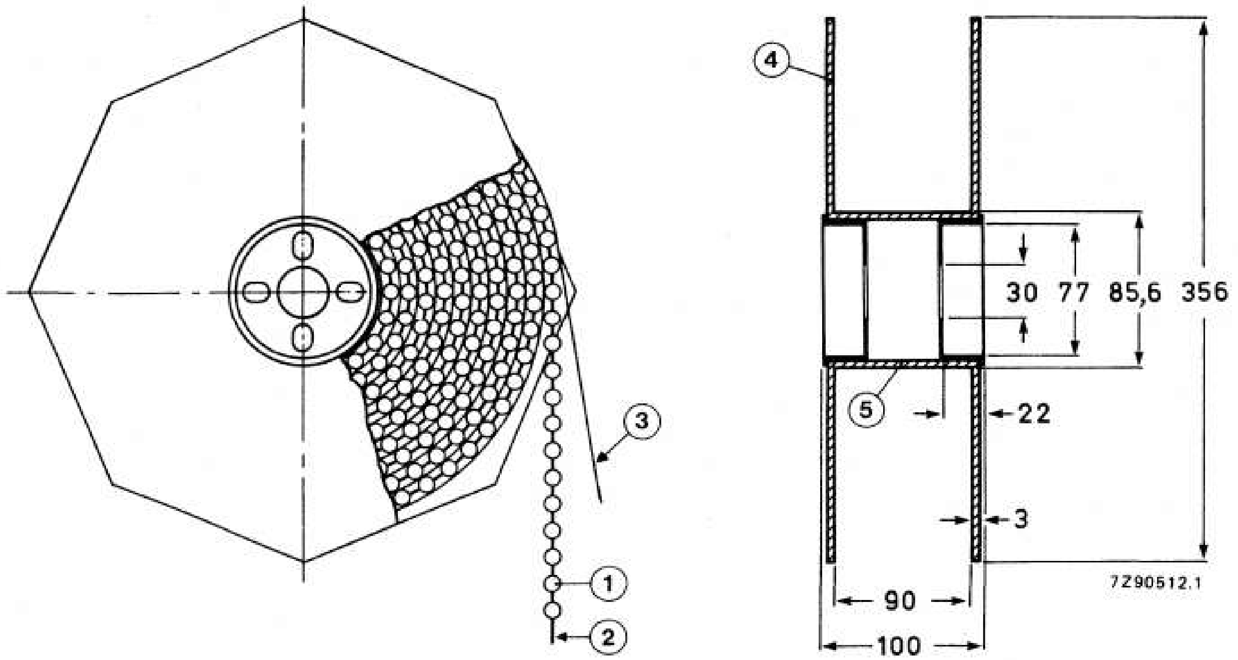



Fig. 18 Style 2 capacitors on banboliers on reel.

1 = capacitor
2 = bandolier
3 = paper
4 = flange
5 = cylinder

## TESTS AND REQUIREMENTS

See Introduction, section 9, under solid aluminium capacitors, with the addition of the following tests.

*Severe rapid change of temperature test*: 100 cycles of 15 min at −40 °C and + 125 °C.

Requirements: leakage current ⩽ stated limit,
tan $\delta \leqslant$ 1,6 x stated limit,
impedance ⩽ 1,6 x stated limit,
$\Delta C/C \leqslant$ 10%.

*Severe shock test (for expoxy-filled version only)*: 10 000g, 0,1 ms.

Requirements: leakage current ⩽ stated limit,
tan $\delta \leqslant$ 1,2 x stated limit,
$\Delta C/C \leqslant$ 10%,
typical capability ⩾ 100 000g.

*Severe vibration test (for epoxy-filled version only)*: 50 to 2000 Hz, 50g, 125 °C, 1 octave/min, 2 directions (longitudinal and transversal), 3 sweeps per direction.

Requirements: leakage current ⩽ stated limit,
tan $\delta \leqslant$ 1,2 x stated limit,
$\Delta C/C \leqslant$ 10%,
typical capability: up to 80g (also at 125 °C).