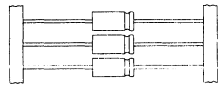
SOLID ALUMINIUM CAPACITORS

- **Small type**
- **Axial leads; metal case; ceramic seal**
- **Very long life**
- **High reliability**
- **Industrial and military applications**



QUICK REFERENCE DATA

Nominal capacitance range (E6 series)	2,2 to 330 μF
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 +200 °C
Endurance test	
at T_{amb} = 125 °C	5000 h
at T_{amb} = 150 °C	2000 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
DIN 40040	EHC/JQ/TW
NF C20-600	434
Approvals; 6,3 V to 40 V ranges	CECC 30 302-001 U.K. : Post Office; Ministry of Defence DEF 59-44 Sweden: FOA/FTL ESA : SCC Arcao AR C121 (Ariane) France : Liste LNZ 44-04 COS-A

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

C_{nom} μF	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 22,5
5	Ø 10 x 31,5
6	Ø 12,5 x 31,5

* ± 10% to special order.

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.

The taped versions are suitable for automatic insertion and for cutting and forming equipment.

DESCRIPTION

The capacitors have etched aluminium foil electrodes separated by a layer of glassfabric and filled with solid semiconductive, pyrolitically formed manganese dioxide. The capacitors are housed in an aluminium case with soldered-copper 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 supplied on bandoliers in boxes and on reels.

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

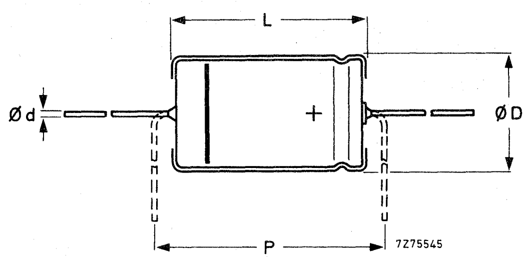


Fig. 1 For dimensions d, D, L and P, see Table 1a.

Table 1a

case size	d*		D_{nom}	L_{nom}	D_{max}	L_{max}	P_{min}	mass** approx. g
1	0,6	+0,06	6,5	15	6,7	15,3	20	1,2
2A	0,6		7,5	20	7,6	20,4	22,5	2,4
4	0,6	−0,05	9	22,5	9,3	23,3	25	3,3
5	0,8	+0,08	10	31,5	10,3	32	35	4,5
6	0,8	−0,05	12,5	31,5	12,9	32	35	6,3

* Tolerance according to IEC 301; not applicable to a length of 2 mm from the lead ends, which is covered by the bandoliers.

** Add 10% for epoxy-filled version.

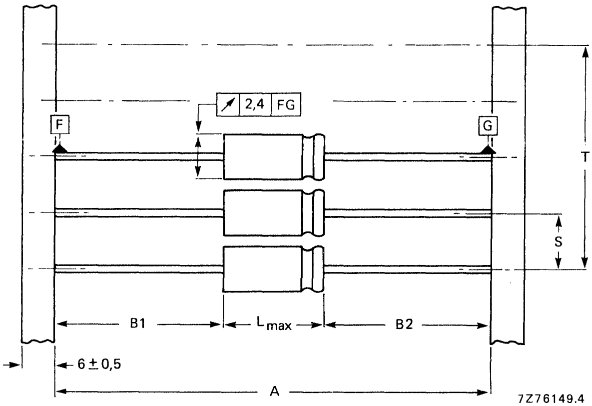


Fig. 2 Capacitors on bandoliers; the bandolier to which the negative capacitor terminals are connected is blue. See Table 1b for dimensions A, S, T and L_{max}.
$|B1-B2| = 1,4 + (L_{max}-L)$ mm max.

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
2A	73 ± 1,6	10 ± 0,4	10 (n-1) ± 2	10 (n-1) ± 4	20,4
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.

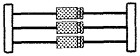
Mounting

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

ELECTRICAL DATA

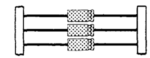
Unless otherwise specified all electrical values in Table 2 apply at an ambient temperature of 20 to 25 °C, a frequency of 100 Hz, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75%.
See also the corresponding paragraphs.

Table 2

U_R	nom. cap.	max. r.m.s. ripple current at T_{amb} = 125 °C, no d.c. voltage applied	max. d.c. 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		
										
V	μF	mA	μA		Ω	Ω		in box	on reel	epoxy-filled version**
6,3	22	60	10	0,18	16,5	1,2	1	13229	23229	63229
	47	100	21	0,18	7,6	1,0	2A	13479	23479	63479
	68	130	30	0,18	5,3	0,75	2A	13689	23689	63689
	150	220	66	0,18	2,4	0,4	4	13151	23151	63151
	220	320	97	0,18	1,6	0,3	5	13221	23221	63221
	330	430	146	0,18	1,1	0,2	6	13331	23331	63331
10	15	50	11	0,16	21,5	2,5	1	14159	24159	64159
	33	85	23	0,16	9,6	1,25	2A	14339	24339	64339
	47	115	33	0,16	6,8	0,75	2A	14479	24479	64479
	100	190	70	0,16	3,2	0,5	4	14101	24101	64101
	150	280	105	0,16	2,1	0,4	5	14151	24151	64151
	220	380	154	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	1,25	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. d.c. 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, no d.c. voltage applied	max. d.c. 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 		
V	µF	mA	µA		Ω	Ω		in box	on reel	epoxy-filled version**
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	2,5	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	7,5	1	17228	27228	67228
	3,3	30	13	0,12	73	7,5	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	2,5	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. d.c. 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%; ± 10% to special order

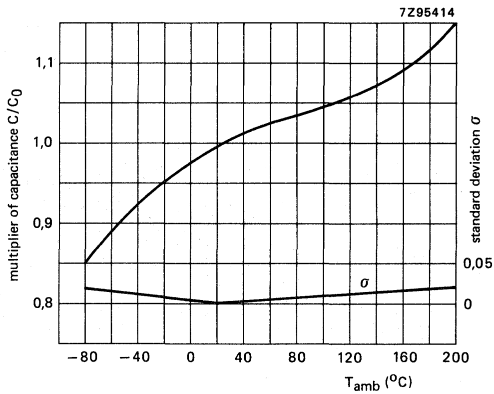


Fig. 3 Typical multiplier of capacitance as a function of ambient temperature.
C_0 = capacitance at T_{amb} = 25 °C, 100 Hz.

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 200 °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 x U_R	0,15 x U_R
at $0{,}1\ Hz < f \leq 1$ Hz	0,45 x U_R	0,22 x U_R
at $1\ Hz < f \leq 10$ Hz	0,60 x U_R	0,30 x U_R
at $10\ Hz < f \leq 50$ Hz	0,65 x U_R	0,32 x U_R
at $f > 50$ Hz	0,80 x U_R	0,40 x 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 x U_R	
50 V range	= max. permissible voltage for max. 500 h	63 V	45 V

* For 50 V range, U_R = 40 V.

Reverse voltage		$T_{amb} \leqslant 85\ ^oC$	$85\ ^oC < T_{amb} \leqslant 125\ ^oC$
6,3 V to 40 V ranges	= max. d.c. voltage continuously (2000 h) applied in the reverse polarity,		
	at $T_{amb} \leqslant 85\ ^oC$	0,30 x U_R	
	at $85\ ^oC < T_{amb} \leqslant 125\ ^oC$	0,15 x 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

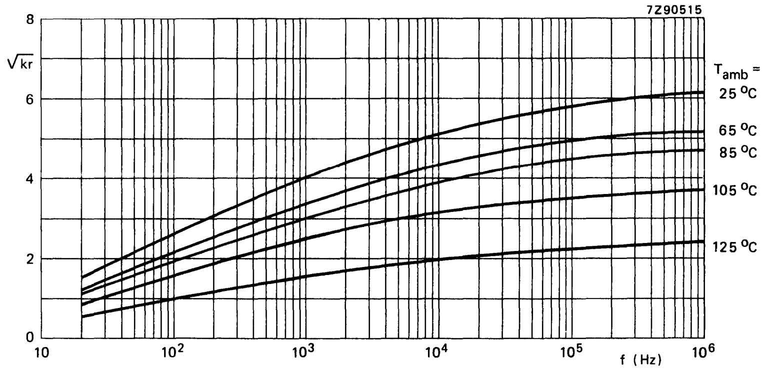


Fig. 4 Combined temperature/frequency multiplier of ripple current ($\sqrt{kr}$) as a function of frequency. $I_{r\,max} = I_{r0}\sqrt{kr}$.

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 β = heat transfer coefficient, taken as 9,0 W/m²K;

S = capacitor outer surface;

ΔT = 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.

D.C. leakage current

Maximum d.c. leakage current 1 min after application of U_R, at T_{amb} = 25 °C	see Table 2 (max. 0,1 CU)
D.C. 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
D.C. 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

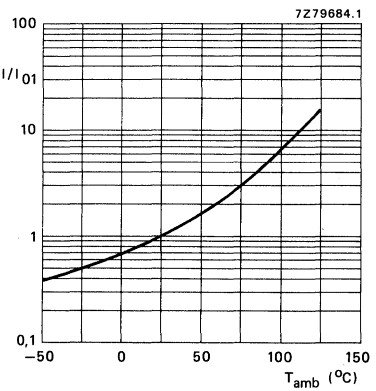


Fig. 5 Multiplier I/I_{01} as a function of ambient temperature. I_{01} = d.c. leakage current during continuous operation at U_R, T_{amb} = 25 °C.

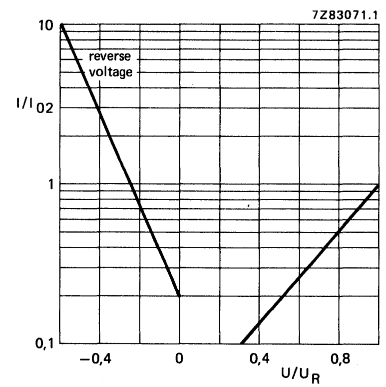


Fig. 6 Multiplier I/I_{02} as a function of U/U_R. I_{02} = d.c. leakage current at U_R at a discrete constant temperature.

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

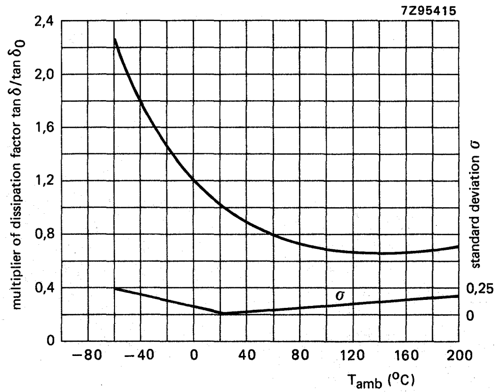


Fig. 7 Multiplier of dissipation factor as a function of ambient temperature; tan δ_0 = dissipation factor at 25 °C, 100 Hz.

Equivalent series resistance (ESR = tan $\delta/\omega C$)

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

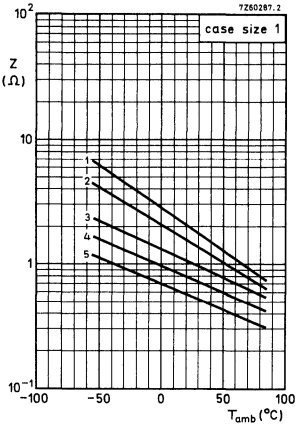


Fig. 8 Typical impedance as a function of temperature at 100 kHz.

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.

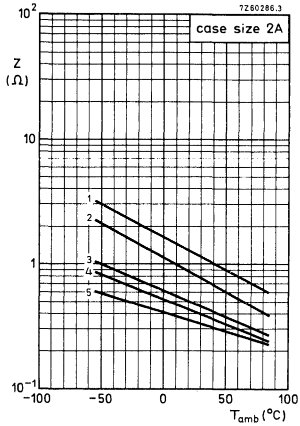


Fig. 9 Typical impedance as a function of temperature at 100 kHz.

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.

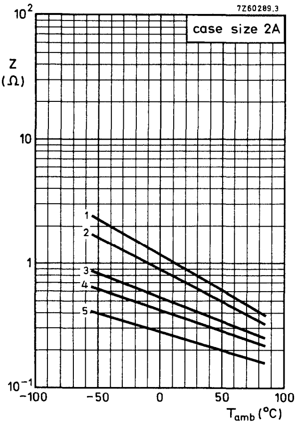


Fig. 10 Typical impedance as a function of temperature at 100 kHz.

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.

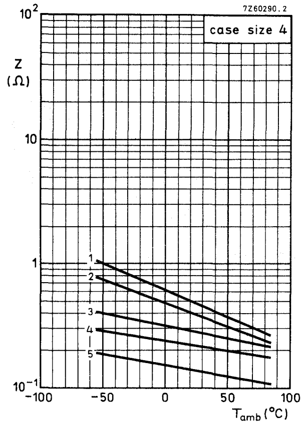


Fig. 11 Typical impedance as a function of temperature at 100 kHz.

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.

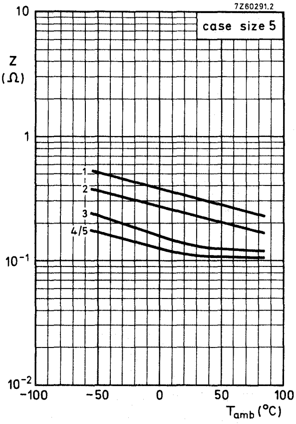


Fig. 12 Typical impedance as a function of temperature at 100 kHz.

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.

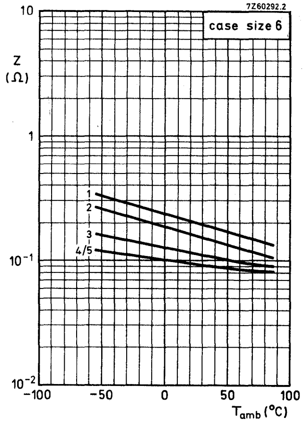


Fig. 13 Typical impedance as a function of temperature at 100 kHz.

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.

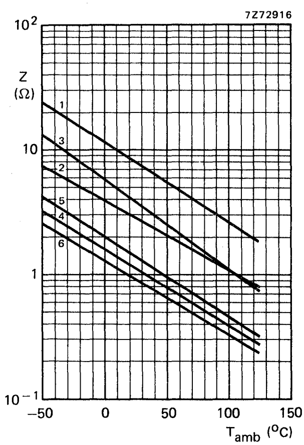


Fig. 14 Typical impedance as a function of temperature at 100 kHz.

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.

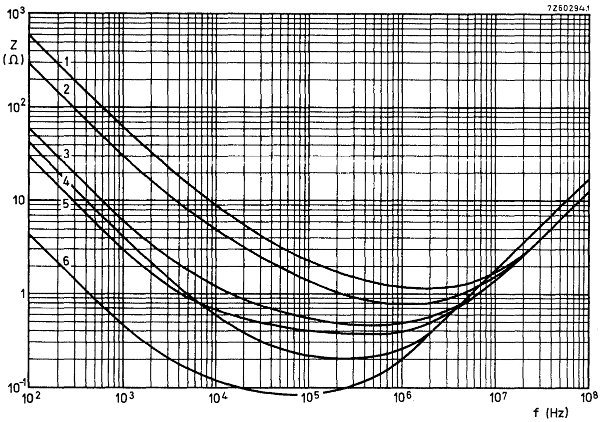


Fig. 15 Typical impedance as a function of frequency at T_{amb} = 25 °C.

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.

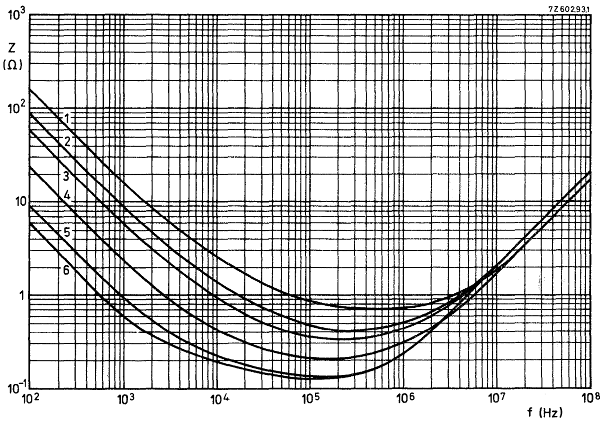


Fig. 16 Typical impedance as a function of frequency at T_{amb} = 25 °C.

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.

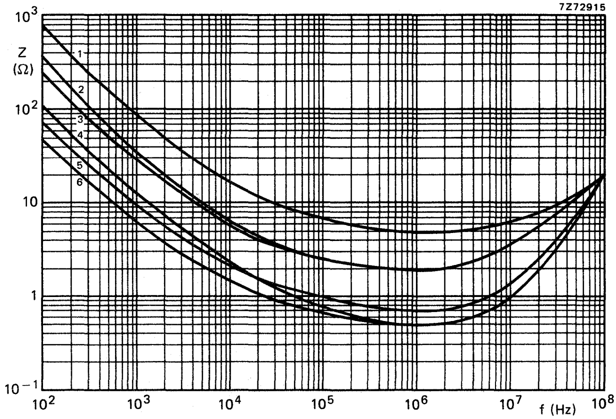


Fig. 17 Typical impedance as a function of frequency at T_{amb} = 25 °C.

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	30 nH	15 to 23 nH
case size 2A	25,4 mm	30 nH	16 to 24 nH
case size 4	27,9 mm	35 nH	20 to 27 nH
case size 5	35,6 mm	40 nH	26 to 33 nH
case size 6	35,6 mm	55 nH	41 to 49 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 + 200 °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 x 10^{-9}/h
Typical parameter change after endurance test at T_{amb} = 125 °C	see Figs. 18, 19 and 20

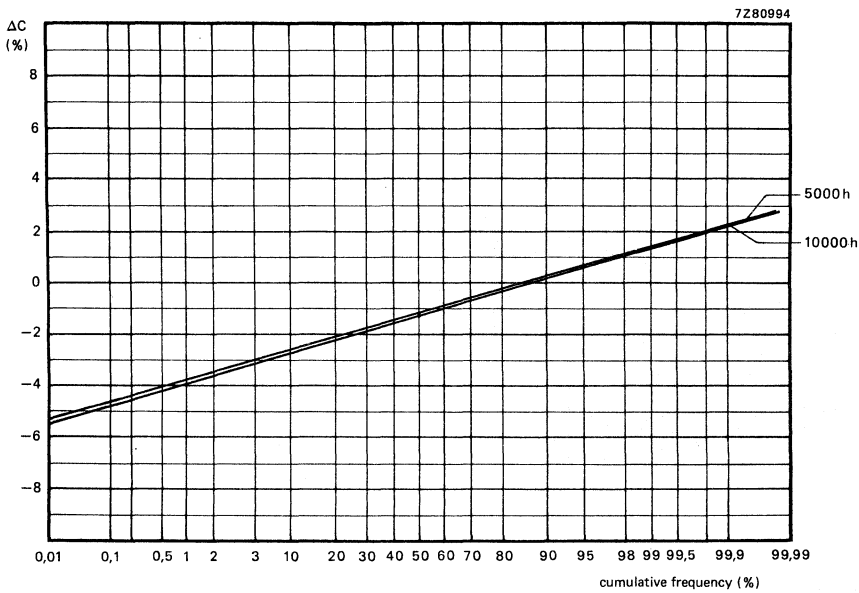


Fig. 18 Change of capacitance after endurance test.

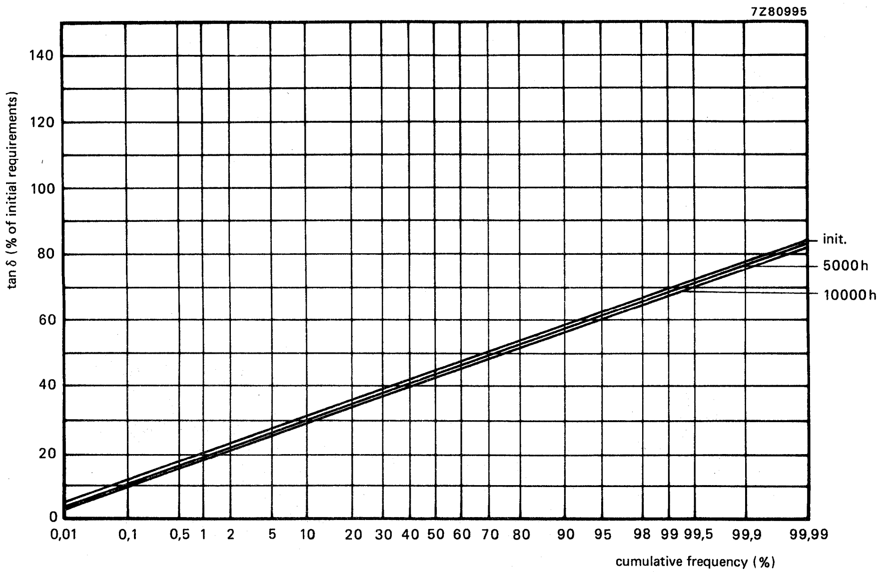


Fig. 19 Tan δ after endurance test.

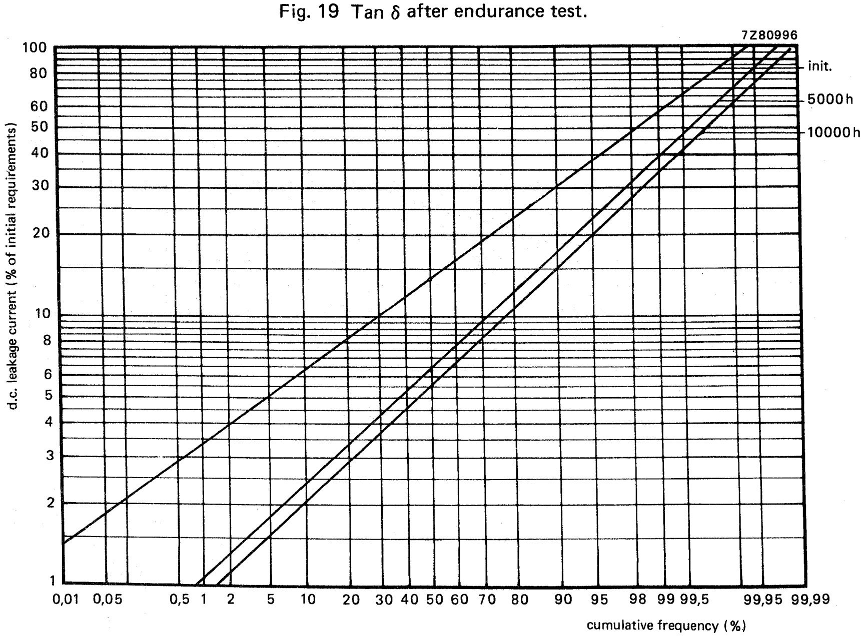


Fig. 20 D.C. leakage current after endurance test.

PACKING

The capacitors are supplied on bandoliers in boxes or on reels, (according to IEC 286-1).
The number of capacitors per box or per reel is shown in Table 7.

Table 7

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

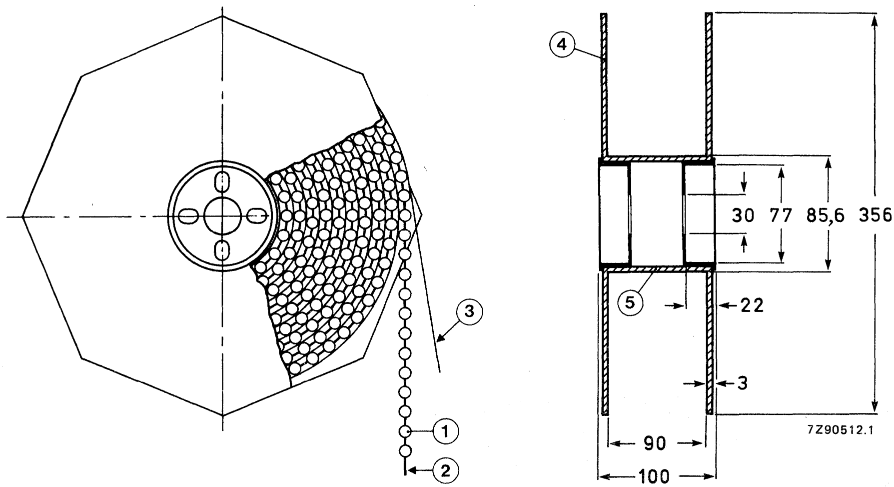


Fig. 21 Capacitors on bandoliers on reel.

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: d.c. leakage current ⩽ stated limit,
tan δ ⩽ 1,6 x stated limit,
impedance ⩽ 1,6 x stated limit,
ΔC/C ⩽ 10%.

Solvent resistance tests:

Severity 1, according to MIL-STD-202, method 215, including brushing of all portions of the specimens.

Solvents:
- deionized water (50 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixture of 25 vol.% 2-propanol (isopropanol) and 75 vol.% mineral spirits.

Severity 2, according to IEC 68-2-45, and IEC 653, test XA with the following details and additions.

Conditions: immersion time of samples 5 min., at ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz).

Solvents:
- deionized water (50 ± 5 °C);
- calgonite solution (20 g/l, 70 ± 5 °C), a dishwasher detergent;
- mixture of 4,5% 2-butoxyethanol, 4,5% 2-amino-ethanol, and 91% water (70 ± 5 °C);
- 1.1.1. trichloro-ethane;
- mixtures of 1.1.2-trichloro- 1.2.2-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon:
  - 2-propanol (isopropanol), 25%: 75% (Arklone K*); up to the ratio 35%: 65%;
  - ethanol, 4,5%: 95,5% (e.g. Arklone A*, Freon TE**);
  - methanol and nitromethane, 5,7%: 0,3%: 94% (Freon TMS**).

Requirement: visual appearance not affected.

Note: Tests are carried out using non-contaminated solvents.

* Trade mark of I.C.I.

** Trade mark of Dupont de Nemours.

Severe vibration tests (for epoxy-filled version only): according to IEC68-2-6 and MIL-STD-202, method 204, letters E and F, with the following details and additions.

a. Method of mounting: clamping both the body and the leads.

b. Severity:
1. frequency range : 10 - 3000 Hz;
temperature : 20 - 25 °C;
2. frequency range : 50 - 2000 Hz;
temperature : 125 °C.
1 and 2. vibration amplitude: 50g or 3,5 mm, whichever is less.

c. Direction and duration motion:

Severity 1 : 1 octave/min, 3 directions (mutually perpendicular), 20 sweeps per direction (total 60 sweeps or 18 h);

Severity 2: 1 octave/min, 2 directions (longitudinal and transversal), 3 sweeps per direction (total 6 sweeps or 1 h).

d. Functioning:

	severity 1	: rated voltage applied;
	severity 2	: no voltage applied.

e. Requirements:

	$\Delta C/C$	: $\leqslant$ 10%
	tan δ	: $\leqslant$ 1,2 x stated limit
	impedance	: $\leqslant$ 1,4 x stated limit
	d.c. leakage current	: $\leqslant$ stated limit
	general	: no intermittent contacts; no indication of breakdown; no open circuiting; no evidence of mechanical damage.

f. Typical capability: up to 80g at 10 to 3000 Hz (also at 125 °C).

Severe shock tests (for epoxy-filled version only): according to IEC68-2-27 and MIL-STD-202, method 213, letter F, with the following details and additions.

a. Method of mounting: clamping both the body and the leads.

b. Pulse shape: half-sine or sawtooth.

c. Severity:
1. 1500g, 0,5 ms (MIL-STD-202, method 213, letter F);
2. 3000g, 0,2 ms;
3. 10000g, 0,1 ms;

d. Direction and number of shocks:

severity 1 and 2: 3 successive shocks in each direction of 3 mutually perpendicular axes (total 18 shocks);

severity 3: 1 shock, any direction.

e. Functioning: rated voltage applied.

f. Requirements: see "Severe vibration tests" par. e.

g. Typical capability: $\geqslant$ 100000g; these shock tests can be preceded by severe vibration tests on the same samples.