Example of using Fig.9 and Fig.10

A capacitor with a dielectric of metallised PETP film and a value of 1 μF should be used at an a.c. voltage of 130 V, a frequency of 1 kHz and an ambient temperature of 50 °C. The R_sC-product is $7,5 \times 10^{-7}$ ΩF (from Fig. 9), so that the power to be dissipated

$$P = (R_sC)\, C\omega^2\, V_{ac}^2$$

$$= 7,5 \times 10^{-7} \times 10^{-6} \times 4\pi^2 \times 1000^2 \times 130^2 = 500 \text{ mW}$$

Fig. 10 shows that at 50 °C capacitors with curve numbers 8 to 11 can be used, thus a minimum size of 10,4 x 23,5 x 14,4 mm. It can be seen from the tables that the 1 μF/250 V capacitor can be chosen.

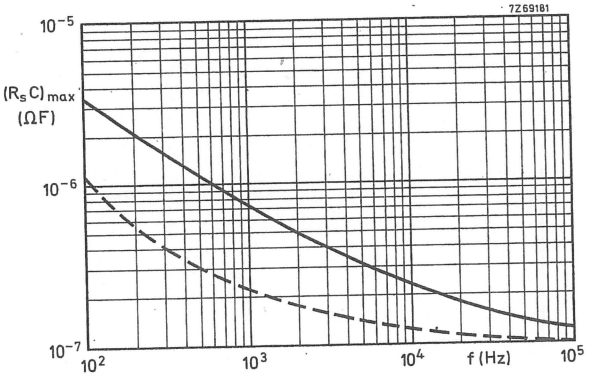


Fig. 9. Maximum product of series resistance and capacitance as a function of frequency
—— metallised PETP film dielectric
---- metallised polycarbonate film dielectric

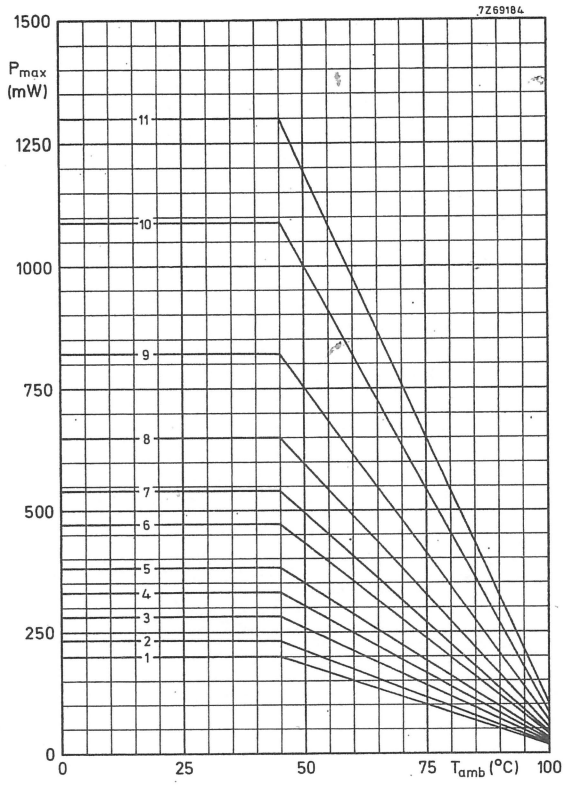


Fig. 10. Maximum permissible power dissipation as a function of temperature

curve	dimension (mm)		
	T_{max}	L_{max}	H_{max}
1	4,7	14,5	8,7
2	5,5	14,5	9,4
3	6,5	14,5	10,4
4	6,5	18	10,4
5	7,6	18	11,5
6	7,4	23,5	11,5
7	8,7	23,5	12,8
8	10,4	23,5	14,4
9	10,4	31	14,6
10	12,4	31	19,5
11	15	31	22

Name of test	Procedure (quick reference)	Requirements
Pulse load	10 000 cycles of charge and discharge at 25 °C, pulse steepness 1,5 x initial requirements	Δ tanδ ≤ 20 x 10^{-4} at 10 kHz
Additional tests		
Flammability	Bore of gas jet: ϕ 0,5 ± 0,1 mm Fuel: butane Test duration: 20 s	After removal of the flame the capacitor must not continue to burn for more than 15 s, no burning particles should drip from the capacitor
Solvent resistance	According to MIL-STD-202 E, method 215	No damage
Storage	1000 h at 100 °C	ΔC/C ≤ 3% Tan δ and insulation resistance (at ≤ 10 V d.c.) shall meet initial requirements
	10 000 h at 25 °C	ΔC/C ≤ 1% Tan δ and insulation resistance (at ≤ 10 V d.c.) shall meet initial requirements
Soldering test for mounting on printed-wiring boards	Board thickness: 1,6 mm, hole diameter: 1,3 mm; non-metallised holes Bath temp.: 250 ± 10 °C; dipsolder time: 5 ± 0,5 s	No damage, good tinning; ΔC/C ≤ 1%

ADDITIONAL INFORMATION

Power dissipation

The rated a.c. voltage has been specified for 50 Hz and at 20 °C. This voltage value must also never be exceeded at other frequencies. This permissible a.c. voltage may further be limited by the following requirements:
1) The power dissipation must not exceed the specified limit P_{max}.
2) The steepness of the a.c. voltage must not exceed the specified limit.

Ad 1.

The power dissipated by a capacitor is a function of the voltage over the series resistance (R_s) or of the current through the series resistance and is expressed by

$$P = \frac{V_{R_s}^2}{R_s} = I^2 R_s \qquad (1)$$

$$V_{R_s}^2 = \frac{R_s^2}{R_s^2 + 1/\omega^2 C^2} V_{ac}^2 \qquad (2a)$$

As for these capacitors $\tan\delta = R_s \omega C$ = always < 0,1, the formula (2a) can be simplified to

$$V_{R_s}^2 = \frac{R_s^2}{1/\omega^2 C^2} V_{ac}^2 = R_s^2 \omega^2 C^2 V_{ac}^2 \qquad (2b)$$

Thus $P = R_s \omega^2 C^2 V_{ac}^2$ (3a)

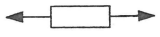
or $P = (R_s C)\, C \omega^2 V_{ac}^2$ (3b)

The term $R_s C$ can be found from Fig. 9. C (in farads), $\omega = 2\pi f$ and V_{ac} are assumed to be known.

The maximum permissible value of power dissipation (P_{max}), which depends on the dimensions of the capacitor and on the ambient temperature, can be found from Fig. 10. Thus, when the actual power has been calculated with formula (3b), Fig. 10 gives the minimum size of capacitor which can dissipate this power.

May be two or three capacitors having this size can be chosen, namely with different rated voltages.

TESTS AND REQUIREMENTS

IEC 68-2 test method	Name of test	Procedure (quick reference)	Requirements
Ua	Tensile strength of terminations	Loading weight in axial direction, for d = 0,8 mm: 10 N, 10 s for d = 1 mm: 20 N, 10 s 	No damage
Ub	Bending of terminations	Loading weight, for d = 0,8 mm: 5 N, for d = 1 mm: 10 N, two consecutive bends	No damage
Fc	Vibration	10 to 55 Hz, amplitude 0,75 mm or 10 g (whichever is the less), 2 h in 3 directions; capacitors mounted on printed-wiring boards	No damage, no open or short circuit. $\Delta C/C \leq 0,5\%$
Eb	Bumping	40 g, 3 directions, 4000 bumps per direction, capacitors horizontally mounted on printed-wiring boards; 10 g, 3 directions, 4000 bumps per direction, capacitors vertically mounted on printed-wiring boards	No damage, no open or short circuit. $\Delta C/C \leq 0,5\%$
T3.2	Soldering (solder bath)	Solderability: 230 °C, 2 s	No damage, good tinning; $\Delta C/C \leq 0,5\%$
		Resistance to heat: 350 °C, 3 s Capacitors immersed up to 3,5 mm from the body	No damage; $\Delta C/C \leq 0,5\%$
→ Na	Rapid change of temperature	5 cycles of 1 h at −55 °C and 1 h at +100 °C	No damage, no leakage; $\Delta C/C \leq 2\%$ Tan δ and insul. resistance shall meet initial requirements

IEC 68-2 test method		Name of test	Procedure (quick reference)	Requirements	
Climatic sequence	→ Ba	Dry heat	16 h at +100 ± 2 °C, no voltage applied	No damage, no leakage; $\Delta C/C \leq 2\%$ (polycarbonate), $\leq 7\%$ (PETP) at 100 °C. Insulation resistance at 100 °C for $C_R \leq 0,33$ μF: > 50 MΩ (100 V version), > 100 MΩ (other versions); for $C_R > 0,33$ μF: RC > 16 s (100 V version), > 33 s (other versions).	
	D	Accelerated damp heat, first cycle	24 h at 55 ± 2 °C and R.H. 95 to 100%; no voltage applied		
	Aa	Cold	2 h at −55 ± 3 °C; no voltage applied	$\Delta C/C \leq -3\%$ (polycarbonate), $\leq -8\%$ (PETP) at −55 °C	
	M	Low air pressure	1 h at 25 ± 5 °C, at atmospheric pressure of 85 mbar	During and after the test there shall be no breakdown or flashover	
	D	Accelerated damp heat, remaining cycles	5 cycles of 24 h at 55 °C and R.H. 90 to 100%, no voltage applied	$\Delta C/C \leq 3\%$ Tan δ shall meet initial requirement. Insulation resistance ≥ 0,5 x initial requirements	
Ca		Damp heat, steady state	56 days at 40 °C and R.H. 90 to 95%; 6 V applied (continuously)	$\Delta C/C \leq 3\%$ Tan δ shall meet initial requirements Insulation resistance ≥ 0,5 x initial requirements	
–		Endurance	1000 h at 85 °C, 1,5 x U_R applied ($U_R \leq 630$ V) 1,2 x U_R ($U_R > 630$ V)	$\Delta C/C \leq 3\%$	$\Delta \tan\delta \leq 30 \times 10^{-4}$ at 10 kHz. Insulation resistance meets initial requirements
			1000 h at 100 °C, 1,5 x U_c applied ($U_R \leq 630$ V) 1,2 x U_c ($U_R > 630$ V)	$\Delta C/C \leq 5\%$	
			1000 h at 85 °C, rated a.c. voltage applied	$\Delta C/C \leq 15\%$ (L = 14,5 mm) $\leq 10\%$ (L = 18 mm) $\leq 7\%$ (L = 23,5 mm) $\leq 5\%$ (L = 31 mm)	

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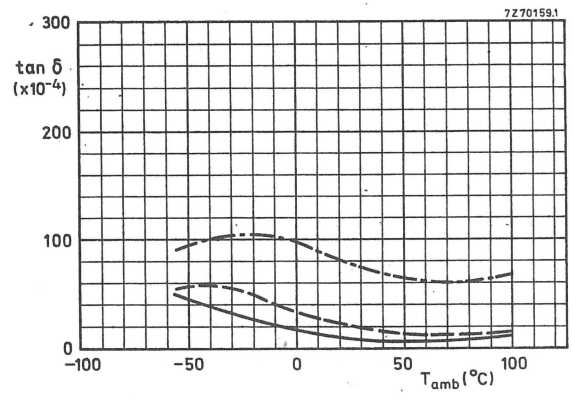


Fig. 8. Tan δ as a function of temperature; typical curves.
Metallised polycarbonate film dielectric.
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 μF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 μF, measured at 100 kHz, 0,3 V.

Power dissipation

Maximum permissible power dissipation — see chapter "Additional information"

Note - If the requirement for the maximum permissible power dissipation is satisfied, a check must be made to ascertain that the maximum permissible pulse steepness is not exceeded.

Pulse steepness

rated voltage	max. pulse steepness (V/μs)			
(V)	L = 14,5 mm	L = 18 mm	L = 23,5 mm	L = 31 mm
100	10	7	4	3
250	20	10	7	5
400	30	20	10	8
630	45	30	15	10
1000		45	30	20
1600	200	90	50	30

Note - If the pulse steepness requirement is satisfied, a check must be made to ascertain that the maximum permissible power dissipation is not exceeded.

METALLISED POLYESTER AND POLYCARBONATE FILM CAPACITORS

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Temperature

Rated temperature	85 °C
Category temperature range	−55 to + 100 °C
Storage temperature range	−55 to + 100 °C
Climatic category, IEC 68	55/100/56

PACKING

250 pieces per box, for capacitors with $H_{max} \leq 11,5$ mm
200 pieces per box, for capacitors with $H_{max} > 11,5$ mm

Insulation resistance

The insulation resistance is measured after a voltage has been applied for 1 min ± 5 s, the voltage being 100 ± 15 V for the 100 V, 250 V and 400 V versions and 500 ± 50 V for the 630 V, 1000 V and 1600 V versions.

	ambient temperature	
	20 °C	100 °C
→ R between terminations		
for $C_R \leq 0,33$ µF, 100 V version	> 15 000 MΩ	> 50 MΩ
250 V to 1600 V versions	> 30 000 MΩ	> 100 MΩ
→ RC between terminations		
for $C_R > 0,33$ µF, 100 V version	> 5 000 s	> 16 s
250 V to 1600 V versions	> 10 000 s	> 33 s

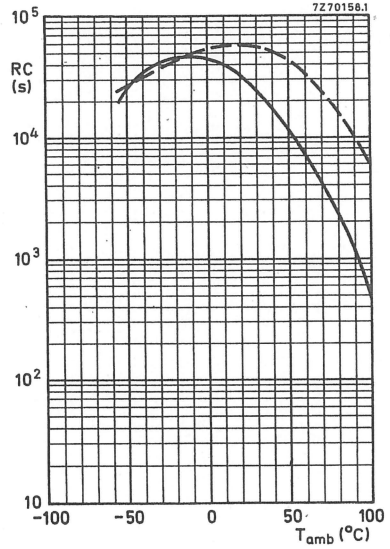


Fig. 5. Insulation resistance as a function of temperature; typical curves.
—— Metallized PETP film dielectric.
--- Metallized polycarbonate film dielectric.

Tan δ (tangent of the loss angle)

Tan δ at 10 kHz

metallised PETP film dielectric	≤ 150 x 10^{-4} (typ. 100 x 10^{-4})
metallised polycarbonate film dielectric	≤ 75 x 10^{-4} (typ. 20 x 10^{-4})

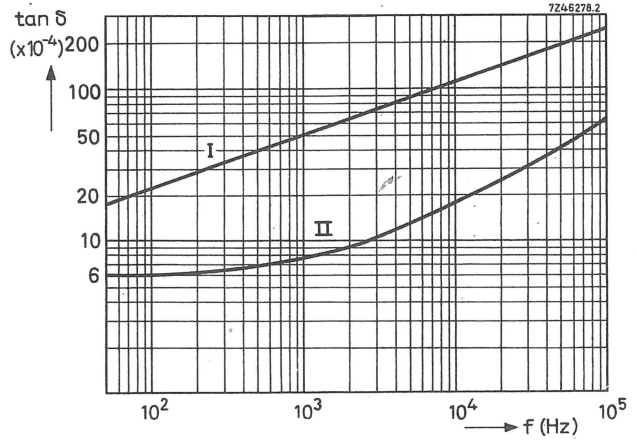


Fig. 6. Tan δ as a function of frequency; typical curves.
I = Metallised PETP film dielectric
II = Metallised polycarbonate film dielectric

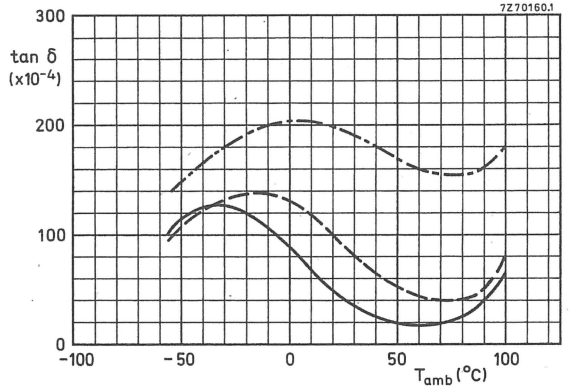


Fig. 7. Tan δ as a function of temperature; typical curves.
Metallised PETP film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 µF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 µF, measured at 100 kHz, 0,3 V.

ELECTRICAL DATA

Unless otherwise specified all electrical values apply at an ambient temperature of 20 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Capacitance

Rated capacitance values (C_R) at 1 kHz	see Tables 1 to 7
Tolerance on rated capacitance	± 10% and ± 20%

Fig. 2.

Capacitance as a function of frequency; typical curves.
—— Metallised PETP film dielectric
--- Metallised polycarbonate film dielectric
From 100 Hz to 1 kHz the curve is valid for all capacitance values (measuring voltage 1 V).
From 1 to 10 kHz the curve is valid for capacitance values ≤ 1 µF (measuring voltage 1 V).
From 10 to 100 kHz the curve is valid for capacitance values ≤ 0,1 µF (measuring voltage 0,3 V).

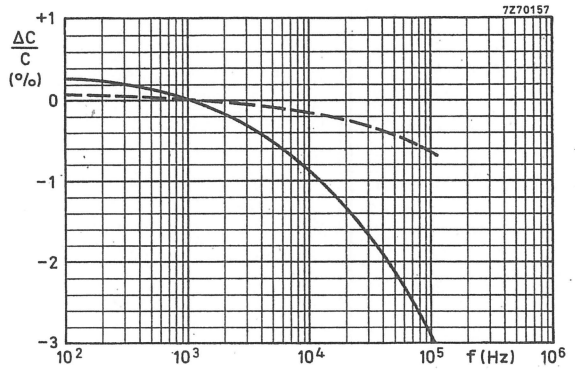
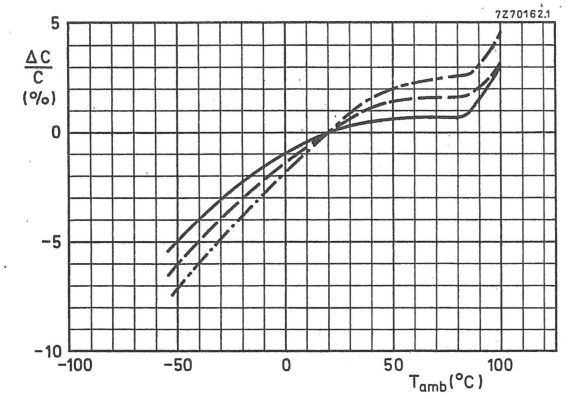


Fig. 3.

Capacitance as a function of temperature; typical curves. Metallised PETP film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 µF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 µF, measured at 100 kHz, 0,3 V.



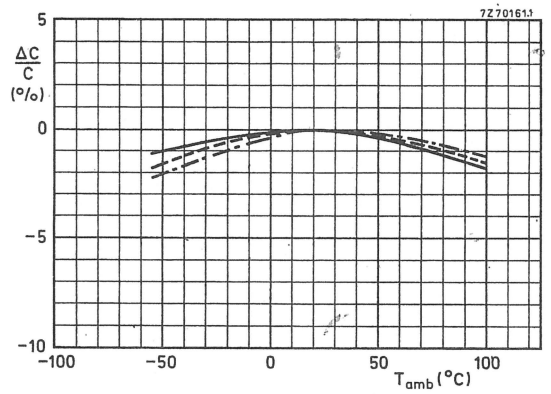


Fig. 4. Capacitance as a function of temperature; typical curves. Metallised polycarbonate film dielectric
—— For all capacitance values, measured at 1 kHz, 1 V.
--- For capacitance values ≤ 1 µF, measured at 10 kHz, 1 V.
-·- For capacitance values ≤ 0,1 µF, measured at 100 kHz, 0,3 V.

Voltage

Rated d.c. voltage U_R	100 V, 250 V, 400 V, 630 V, 1000 V, 1600 V
Rated a.c. voltage, 50-60 Hz [1]	
100 V version	63 V
250 V version	160 V
400 V version	220 V
630 V version	220 V
1000 V and 1600 V version	250 V
Category voltage U_C	0,8 x U_R (derating of 1,25%/°C)
Overvoltage for 1 min/h	
100 V and 250 V versions	≤ 40% of U_R
400 V, 630 V, 1000 V and 1600 V versions	≤ 25% of U_R
Test voltage (d.c.) for 1 min	
between terminals	1,6 x U_R
between interconnected terminals and coating	2 x U_R (minimum 1000 V)

Notes - The sum of the d.c. voltage and the peak value of the superimposed a.c. voltage must be ≤ U_R.
- It is recommended that the capacitors are not used in low-impedance circuits where the resistive current through the capacitors can exceed 400 mA in the event of an internal breakdown of the dielectric; so direct operation from the mains should not be applied

[1]) For higher frequencies see "Additional information".

Table 5- U_R = 630 V; dielectric: metallised polycarbonate film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010	4,7	14,5	8,7	0,8	40	1,0	103
0,015	5,5	14,5	9,4			1,1	153
0,022	6,5	14,5	10,4			1,4	223
0,033	6,5	18	10,4			1,7	333
0,047	7,6	18	11,5			2,0	473
0,068	7,4	23,5	11,5			2,5	683
0,10	8,7	23,5	12,8			3,2	104
0,15	10,4	23,5	14,4			4,0	154
0,22	10,4	31	14,6	1,0	50	5,5	224
0,33	12,4	31	19,5			8,0	334
0,47	15	31	22			10,5	474

Table 6- U_R = 1000 V; dielectric: metallised polycarbonate film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010	6,5	18	10,4	0,8	40	1,7	103
0,015	7,6	18	11,5			2,0	153
0,022	7,4	23,5	11,5			2,5	223
0,033	8,7	23,5	12,8			3,2	333
0,047	10,4	23,5	14,4			4,0	473
0,068	10,4	31	14,6	1,0	50	5,5	683
0,10	12,4	31	19,5			8,0	104
0,15	15	31	22			10,5	154

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

Table 7- U_R = 1600 V; dielectric: metallised polycarbonate film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,0010	5,5	14,5	9,4	0,8	40	1,1	102
0,0015	6,5	14,5	10,4			1,4	152
0,0022	6,5	18	10,4			1,7	222
0,0033							332
0,0047	7,6	18	11,5			2,0	472
0,0068	7,4	23,5	11,5			2,5	682
0,010							103
0,015	8,7	23,5	12,8			3,2	153
0,022	10,4	23,5	14,4			4,0	223
0,033	10,4	31	14,6	1,0	50	5,5	333
0,047	12,4	31	19,5			8,0	473
0,068	15	31	22			10,5	683

Marking

The marking is impressed as follows:
1st line: rated capacitance [2], tolerance [3] and rated voltage
2nd line: 5th, 6th and 7th digit of the catalogue number, code for dielectric [4] and production code
The outer film connection is marked with a stroke on the body.

Mounting

The capacitors are suited for horizontal or vertical mounting on printed-wiring boards and for point to point wiring.

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

[2] in pF (without pF unit symbol), for $C < 0,010$ μF
in μF (without μF unit symbol), for $C \geq 0,010$ μF and < 1 μF
in μF (with μF unit symbol), for $C \geq 1$ μF

[3] 10 = ± 10%, 20 = ± 20%, K = ± 10%, M = ± 20%.

[4] MA = metallised PETP, MC = metallised polycarbonate.

Table 3- U_R = 250 V; dielectric: metallised PETP film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010 0,015 0,022 0,033 0,047	4,7	14,5	8,7	0,8	40	1,0	103 153 223 333 473
0,068 0,10	5,5	14,5	9,4			1,1	683 104
0,15 0,22	6,5	18	10,4			1,7	154 224
0,33 0,47	7,4	23,5	11,5			2,5	334 474
0,68	8,7	23,5	12,8			3,2	684
1,0	10,4	31	14,6	1	50	5,5	105
1,5 2,2	12,4	31	19,5			8,0	155 225

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

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Table 4- U_R = 400 V; dielectric: metallised polycarbonate film and metallised PETP film.

rated capacitance [1] (μF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010 0,015 0,022	4,7	14,5	8,7	0,8	40	1,0	103 153 223
0,033	5,5	14,5	9,4			1,1	333
0,047	6,5	14,5	10,4			1,4	473
0,068	6,5	18	10,4			1,7	683
0,10	7,6	18	11,5			2,0	104
0,15	7,4	23,5	11,5			2,5	154
0,22	8,7	23,5	12,8			3,2	224
0,33	10,4	23,5	14,4			4,0	334
0,47	10,4	31	14,6	1,0	50	5,5	474
0,68	12,4	31	19,5			8,0	684
1,0	15	31	22			10,5	105

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

MECHANICAL DATA

Dimensions in mm

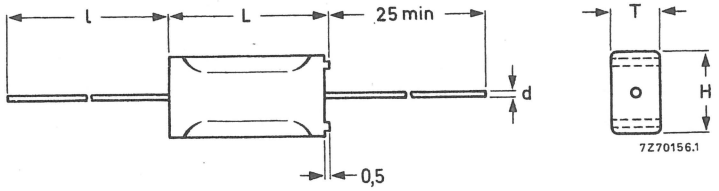


Fig. 1

For dimensions T, L, H, d and l, see tables below.

Table 1- U_R = 100 V; dielectric: metallized polycarbonate film and metallized PETP film.

rated capacitance [1] (µF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,047							473
0,068	4,7	14,5	8,7			1,0	683
0,10							104
0,15	5,5	14,5	9,4			1,1	154
0,22	6,5	14,5	10,4			1,4	224
0,33	6,5	18	10,4	0,8	40	1,7	334
0,47	7,6	18	11,5			2,0	474
0,68	7,4	23,5	11,5			2,5	684
1,0	8,7	23,5	12,8			3,2	105
1,5	10,4	23,5	14,4			4,0	155
2,2	10,4	31	14,6			5,5	225
3,3	12,4	31	19,5	1	50	8,0	335
→ 4,7 [2]	12,4	31	19,5			10,5	475
→ 4,7 [3]	15	31	22			10,5	475

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

[2] Metallized polycarbonate film dielectric.

[3] Metallized PETP film dielectric.

Table 2- U_R = 250 V; dielectric: metallised polycarbonate film.

rated capacitance [1] (µF)	T_{max} (mm)	L_{max} (mm)	H_{max} (mm)	d (mm)	l_{min} (mm)	weight (g)	capacitance code
0,010							103
0,015							153
0,022	4,7	14,5	8,7			1,0	223
0,033							333
0,047							473
0,068	5,5	14,5	9,4			1,1	683
0,10	6,5	14,5	10,4	0,8	40	1,4	104
0,15	6,5	18	10,4			1,7	154
0,22	7,6	18	11,5			2,0	224
0,33	7,4	23,5	11,5			2,5	334
0,47	8,7	23,5	12,8			3,2	474
0,68	10,4	23,5	14,4			4,0	684
1,0	10,4	31	14,6			5,5	105
1,5	12,4	31	19,5	1	50	8,0	155
2,2	15	31	22			10,5	225

[1] Capacitance values of the E6 series as quoted are preferred; intermediate capacitance values of the E12 series are available to special order.

METALLISED POLYESTER AND POLYCARBONATE FILM CAPACITORS
moulded type ("mepolesco")

QUICK REFERENCE DATA	
Rated capacitance range (E12 series)	0,82 nF to 5,6 μF
Tolerance on rated capacitance	± 10% and ± 20%
Rated voltage U_R (d.c.)	100 V, 250 V, 400 V, 630 V, 1000 V, 1600 V
Rated temperature	85 °C
Climatic category, IEC 68	55/100/56

APPLICATION

For general purpose and industrial use in electronic equipment, e.g. for coupling and decoupling applications.

DESCRIPTION

These capacitors consist of a low-inductive winding of metallised polyethyleneterephthalate (PETP) or polycarbonate film and axial leads of tinned copper wire.
The winding is moulded in yellow flame retardant polypropylene.
One end of the capacitor is provided with two stand-off ridges to allow removal of solder flux etc., when cleaning the printed-wiring board.

Composition of the catalogue number

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code for rated voltage, capacitance tolerance and dielectric material — code for capacitance, see tables 1 to 7

28 = 100 V; ±20%	metallised polycarbonate film	60 = 630 V; ±20%	26 = 100 V; ±20%	metallised PETP film
29 = 100 V; ± 10%		61 = 630 V; ± 10%	27 = 100 V; ± 10%	
48 = 250 V; ±20%		70 = 1000 V; ±20%	88 = 250 V; ±20%	
49 = 250 V; ± 10%		71 = 1000 V; ± 10%	89 = 250 V; ± 10%	
58 = 400 V; ±20%		80 = 1600 V; ±20%	54 = 400 V; ±20%	
59 = 400 V; ± 10%		81 = 1600 V; ± 10%	55 = 400 V; ± 10%	

For ordering purposes please quote the 12-digit catalogue number.