2000-11-01

ELFA

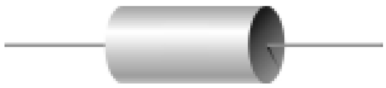
PRODUKTINFORMATION

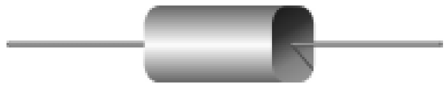
Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr		
65-445-55	Kond 0,1uF/160VDC MKP	MPW 116 3100 KB
65-445-63	Kond 0,15uF/160VDC MKP	MPW 116 3150 KB
65-445-71	Kond 0,22uF/160VDC MKP	MPW 116 3220 KB
65-445-89	Kond 0,33uF/160VDC MKP	MPW 116 3330 KD
65-445-97	Kond 0,47uF/160VDC MKP	MPW 116 3470 KD
65-446-05	Kond 0,68uF/160VDC MKP	MPW 116 3680 KG
65-446-13	Kond 1,0uF/160VDC MKP	MPW 116 4100 KG
65-449-10	Kond 0,1uF/630VDC MKP	MPW 163 3100 KG
65-449-28	Kond 0,15uF/630VDC MKP	MPW 163 3150 KG
65-449-36	Kond 0,22uF/630VDC MKP	MPW 163 3220 KJ
65-449-44	Kond 0,33uF/630VDC MKP	MPW 163 3330 KJ
65-449-51	Kond 0,47uF/630VDC MKP	MPW 163 3470 KJ
65-449-69	Kond 0,68uF/630VDC MKP	MPW 163 3680 KJ
65-449-77	Kond 1,0uF/630VDC MKP	MPW 163 4100 KJ

MPW - MPF

Metallized polypropylene film capacitor
MKP - General purpose capacitor





Main applications: Blocking, filtering, bypassing, timing, coupling, decoupling, general applications in electronics. Low pulse operation.

Dielectric	Polypropylene
Electrodes	Vacuum deposited metal layers
Coating	UL 510 / CSA TIL I-26 polyester tape wrapping; UL 94 V-0 resin end fill (flame retardant execution)
Construction	Extended metallized film (refer to general technical information). Internal series connection for Ur≥ 1000Vdc. Non inductive type
Leads	Tinned copper wire
Reference standard	IEC 60384/16, IEC 60068, CECC 30000, CECC 31200
Climatic category	55/100/56 (IEC 60068/1), FMD (DIN40040)
Operating temperature range	-55°...+105°C
Rated capacitance (Cr)	1000pF to 22µF, in compliance with IEC60063, E6 series. Refer to article table
Capacitance tolerance (at 1kHz)	±10% (code=K), ±5% (code=J) and ±20% (code=M). Other tolerances upon request
Capacitance temperature coefficient	Refer to graphs in general technical information
Long term stability (at 1kHz)	Capacitance variation≤ ±1% after a period of 2 years at standard environmental conditions
Rated voltage (Ur)	160, 250, 400, 630, 1000, 1500 Vdc (Permissible AC voltage at 60Hz: 90, 200, 220, 250, 450, 600 Vac)
Category voltage (Uc)	Uc=Ur at +85°C; Uc=0,8xUr at +100°C
Temperature derated voltage	For +85°C< T≤ +105°C, Ur must be decreased 1.25% for every °C exceeding +85°C
Self inductance	≤ 1nH/mm of capacitor and leads length used for connection
Maximum pulse rise time	Refer to article table. The pulse characteristic Ko depends on the voltage waveform. In any case the value given in the article table must not be overcome
Dissipation factor (DF), max.	(tgd x10^{-4}, measured at 25±5°C)

Freq.	Cr ≤ 0.1µF	0.1µF< Cr ≤ 1µF	Cr> 1µF
1kHz	6	6	6
10kHz	10	20	-
100kHz	30	-	-

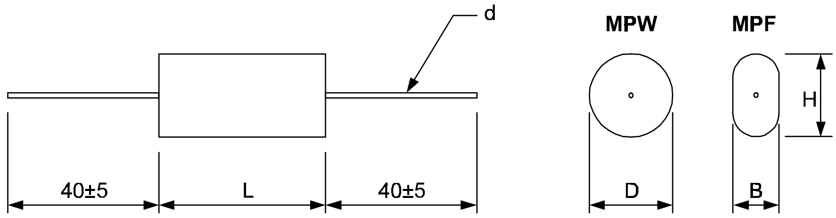
Insulation resistance (IR)	(Measured between terminals, at 25±°C, after 1 minute of electrification at 100Vdc for Ur≥ 100Vdc and 50Vdc for Ur< 100Vdc)

Cr	IR
≤ 0.33µF	≥ 100GΩ
> 0.33µF	≥ 30000s

Test voltage between terminals(Ut)	1.6xUr (DC) applied for 2s at 25±5°C (1 minute for type test)	
Damp heat test (steady state)	**Test conditions:** Temperature= +40±2°C Relative humidity= 93±2% Test Duration= 56 days	**Performance:** Capacitance change≤ ±2% DF change≤ 0.0010 at 10kHz for Cr≤ 1µF DF change≤ 0.0010 at 1kHz for Cr> 1µF IR≥ 50% of initial limit value
Endurance test	**Test conditions:** Temperature= +85±2°C Test duration= 2000h Voltage applied= 1.25 x Ur(DC)	**Performance:** Capacitance change≤ ±3% DF change≤ 0.0010 at 10kHz for Cr≤ 1µF DF change≤ 0.0010 at 1kHz for Cr> 1µF IR≥ 50% of initial limit value

MPW - MPF

Resistance to soldering heat test	**Test conditions:** Solder bath temperature= +260±5°C Dipping time (with heat screen)= 10±1s	**Performance:** Capacitance change≤ ±1% DF change≤ 0,0010 at10kHz for Cr≤ 1µF DF change≤ 0,0010 at 1kHz for Cr> 1µF IR≥ 50% initial limit value
Reliability (MIL HDB 217)	**Application conditions:** Applied voltage= 0,5xUr(DC) Temperature= +40±2°C Failure rate:≤ 3FIT (1FIT=1x10^{-9} failures / components x hours)	**Failure criteria (DIN44122):** Capacitance change> ±10% DF change> 2 x initial limit IR< 0,005 x initial limit value Short or open circuit



Dimensional tolerances (mm)

L	L±	D±	H±	B±
10,5	1,0	1,0	-	-
13,0	1,5	1,0	-	-
19,0	1,5	1,5	1,5	1,0
27,0	2,0	2,0	2,0	1,5
32,0	2,0	2,0	2,0	2,0
44,0	2,5	2,5	2,0	2,5

MPW article table (different values available upon request)

Rated voltage Vdc	Vac	Cap. value (µF)	Dimension in mm D	L	d	du/dt V/µs	Ko V²/µs	ICEL ordering code[1]
160	90	0,022	4,5	10,5	0,6	22	7040	MPW1162220*A
160	90	0,033	4,5	10,5	0,6	22	7040	MPW1162330*A
160	90	0,047	4,5	10,5	0,6	22	7040	MPW1162470*A
160	90	0,068	5	13	0,6	22	7040	MPW1162680*B
160	90	0,1	5,5	13	0,6	22	7040	MPW1163100*B
160	90	0,15	6,5	13	0,6	22	7040	MPW1163150*B
160	90	0,22	7	13	0,6	22	7040	MPW1163220*B
160	90	0,33	6,5	19	0,6	18	5760	MPW1163330*D
160	90	0,47	7,5	19	0,8	18	5760	MPW1163470*D
160	90	0,68	9,5	19	0,8	18	5760	MPW1163680*D
160	90	0,68	7,5	27	0,8	11	3520	MPW1163680*G
160	90	1	9	27	0,8	11	3520	MPW1164100*G
160	90	1,5	10,5	27	0,8	11	3520	MPW1164150*G
160	90	2,2	12,5	27	0,8	11	3520	MPW1164220*G
160	90	2,2	11,5	32	0,8	8	2560	MPW1164220*J
160	90	3,3	14	32	0,8	8	2560	MPW1164330*J
160	90	4,7	16	32	0,8	8	2560	MPW1164470*J
160	90	6,8	19	32	0,8	8	2560	MPW1164680*J
160	90	6,8	16	44	0,8	8	2560	MPW1164680*N
160	90	10	20	44	1	8	2560	MPW1165100*N
160	90	15	24	44	1	8	2560	MPW1165150*N
160	90	22	27,5	44	1	8	2560	MPW1165220*N
250	200	0,01	4,5	10,5	0,6	33	16500	MPW1252100*A
250	200	0,015	4,5	10,5	0,6	33	16500	MPW1252150*A
250	200	0,022	5	13	0,6	33	16500	MPW1252220*B
250	200	0,033	5,5	13	0,6	33	16500	MPW1252330*B
250	200	0,047	5,5	13	0,6	33	16500	MPW1252470*B
250	200	0,068	6,5	13	0,6	33	16500	MPW1252680*B
250	200	0,1	7,5	13	0,8	33	16500	MPW1253100*B
250	200	0,15	7	19	0,8	26	13000	MPW1253150*D
250	200	0,22	8	19	0,8	26	13000	MPW1253220*D
250	200	0,33	8	27	0,8	19	9500	MPW1253330*G
250	200	0,47	9	27	0,8	19	9500	MPW1253470*G
250	200	0,68	10,5	27	0,8	19	9500	MPW1253680*G
250	200	1	13	27	0,8	19	9500	MPW1254100*G
250	200	1	11	32	0,8	10	5000	MPW1254100*J
250	200	1,5	14	32	0,8	10	5000	MPW1254150*J
250	200	2,2	16,5	32	0,8	10	5000	MPW1254220*J
250	200	3,3	20	32	1	10	5000	MPW1254330*J
250	200	4,7	20	44	1	10	5000	MPW1254470*N
250	200	6,8	24,5	44	1	10	5000	MPW1254680*N
250	200	10	27,5	44	1	10	5000	MPW1255100*N

(1)Change the * symbol with the needed capacitance tolerance code: J=±5%, K=±10%, M=±20%

Rated voltage Vdc	Vac	Cap. value (µF)	Dimension in mm D	L	d	du/dt V/µs	Ko $V^2/\mu s$	ICEL ordering code[1]
400	220[2]	0,0068	4,5	10,5	0,6	60	48000	MPW1401680*A
400	220[2]	0,01	5	13	0,6	60	48000	MPW1402100*B
400	220[2]	0,015	5,5	13	0,6	60	48000	MPW1402150*B
400	220[2]	0,022	6	13	0,6	60	48000	MPW1402220*B
400	220[2]	0,033	6,5	13	0,6	60	48000	MPW1402330*B
400	220[2]	0,047	7,5	13	0,8	60	48000	MPW1402470*B
400	220[2]	0,068	7	19	0,8	35	28000	MPW1402680*D
400	220[2]	0,1	7,5	19	0,8	35	28000	MPW1403100*D
400	220[2]	0,15	8,5	19	0,8	35	28000	MPW1403150*D
400	220[2]	0,22	8,5	27	0,8	25	20000	MPW1403220*G
400	220[2]	0,33	10,5	27	0,8	25	20000	MPW1403330*G
400	220[2]	0,47	12	27	0,8	25	20000	MPW1403470*G
400	220[2]	0,68	13	32	0,8	16	12800	MPW1403680*J
400	220[2]	1	15,5	32	0,8	16	12800	MPW1404100*J
400	220[2]	1,5	18	32	0,8	16	12800	MPW1404150*J
400	220[2]	2,2	18	44	1	16	12800	MPW1404220*N
400	220[2]	3,3	21	44	1	16	12800	MPW1404330*N
400	220[2]	4,7	26	44	1	16	12800	MPW1404470*N
400	220[2]	6,8	30	44	1	16	12800	MPW1404680*N
630	250[2]	0,001	4,5	10,5	0,6	90	113E03	MPW1631100*A
630	250[2]	0,0015	4,5	10,5	0,6	90	113E03	MPW1631150*A
630	250[2]	0,0022	4,5	10,5	0,6	90	113E03	MPW1631220*A
630	250[2]	0,0033	4,5	10,5	0,6	90	113E03	MPW1631330*A
630	250[2]	0,0047	4,5	10,5	0,6	90	113E03	MPW1631470*A
630	250[2]	0,0068	5	13	0,6	90	113E03	MPW1631680*B
630	250[2]	0,01	5,5	13	0,6	90	113E03	MPW1632100*B
630	250[2]	0,015	6,5	13	0,6	90	113E03	MPW1632150*B
630	250[2]	0,022	7,5	13	0,8	90	113E03	MPW1632220*B
630	250[2]	0,033	6,5	19	0,6	55	69300	MPW1632330*D
630	250[2]	0,047	7,5	19	0,8	55	69300	MPW1632470*D
630	250[2]	0,068	8,5	19	0,8	55	69300	MPW1632680*D
630	250[2]	0,1	8	27	0,8	37	46600	MPW1633100*G
630	250[2]	0,15	9,5	27	0,8	37	46600	MPW1633150*G
630	250[2]	0,22	11	27	0,8	37	46600	MPW1633220*G
630	250[2]	0,22	10	32	0,8	23	28900	MPW1633220*J
630	250[2]	0,33	12	32	0,8	23	28900	MPW1633330*J
630	250[2]	0,47	13,5	32	0,8	23	28900	MPW1633470*J
630	250[2]	0,68	16	32	0,8	23	28900	MPW1633680*J
630	250[2]	1	19	32	1	23	28900	MPW1634100*J
630	250[2]	1,5	19	44	1	23	28900	MPW1634150*N
630	250[2]	2,2	23	44	1	23	28900	MPW1634220*N
630	250[2]	3,3	28	44	1	23	28900	MPW1634330*N
1000	450[2]	0,015	9	19	0,8	80	160E03	MPW2102150*D
1000	450[2]	0,022	7	27	0,8	55	110E03	MPW2102220*G
1000	450[2]	0,033	8	27	0,8	55	110E03	MPW2102330*G
1000	450[2]	0,047	9	27	0,8	55	110E03	MPW2102470*G
1000	450[2]	0,068	10,5	27	0,8	55	110E03	MPW2102680*G
1000	450[2]	0,1	13	27	0,8	55	110E03	MPW2103100*G
1000	450[2]	0,1	11	32	0,8	35	70000	MPW2103100*J
1000	450[2]	0,15	13	32	0,8	35	70000	MPW2103150*J
1000	450[2]	0,22	15,5	32	0,8	35	70000	MPW2103220*J
1000	450[2]	0,33	19	32	1	35	70000	MPW2103330*J
1000	450[2]	0,47	22	32	1	35	70000	MPW2103470*J
1500	600[2]	0,001	4,5	13	0,6	170	510E03	MPW2151100*B
1500	600[2]	0,0015	5	13	0,6	170	510E03	MPW2151150*B
1500	600[2]	0,0022	5,5	13	0,6	170	510E03	MPW2151220*B
1500	600[2]	0,0033	5,5	13	0,6	170	510E03	MPW2151330*B
1500	600[2]	0,0047	6	13	0,6	170	510E03	MPW2151470*B
1500	600[2]	0,0068	6	19	0,6	100	300E03	MPW2151680*D
1500	600[2]	0,01	7	19	0,8	100	300E03	MPW2152100*D
1500	600[2]	0,015	9	19	0,8	100	300E03	MPW2152150*D
1500	600[2]	0,015	7	27	0,8	65	195E03	MPW2152150*G
1500	600[2]	0,022	8	27	0,8	65	195E03	MPW2152220*G
1500	600[2]	0,033	9,5	27	0,8	65	195E03	MPW2152330*G
1500	600[2]	0,047	11	27	0,8	65	195E03	MPW2152470*G

(1)Change the * symbol with the needed capacitance tolerance code: J=±5%, K=±10%, M=±20%
[2]Not suitable for across the line application.

Rated voltage Vdc	Vac	Cap. value (µF)	Dimension in mm D	L	d	du/dt V/µs	Ko $V^2/\mu s$	ICEL ordering code[1]
1500	600[2]	0,068	12,5	27	0,8	65	195E03	MPW2152680*G
1500	600[2]	0,068	11,5	32	0,8	45	135E03	MPW2152680*J
1500	600[2]	0,1	13,5	32	0,8	45	135E03	MPW2153100*J
1500	600[2]	0,15	16,5	32	0,8	45	135E03	MPW2153150*J
1500	600[2]	0,22	19,5	32	1	45	135E03	MPW2153220*J
1500	600[2]	0,33	23	32	1	45	135E03	MPW2153330*J

[1]Change the * symbol with the needed capacitance tolerance code: J=±5%, K=±10%, M=±20%
[2]Not suitable for across the line application.

MPF article table (different values available upon request)

Rated voltage Vdc	Vac	Cap. value (µF)	Dimension in mm B	H	L	d	du/dt V/µs	Ko $V^2/\mu s$	ICEL ordering code[1]
160	90	0,33	5	9	19	0,6	18	5760	MPF1163330*D
160	90	0,47	5,5	9,5	19	0,6	18	5760	MPF1163470*D
160	90	0,68	6,5	11	19	0,8	18	5760	MPF1163680*D
160	90	1	6,5	11	27	0,8	11	3520	MPF1164100*G
160	90	1,5	7,5	12,5	27	0,8	11	3520	MPF1164150*G
160	90	2,2	8	14	32	0,8	8	2560	MPF1164220*J
160	90	3,3	10	16,5	32	0,8	8	2560	MPF1164330*J
160	90	4,7	12	20	32	0,8	8	2560	MPF1164470*J
160	90	6,8	11,5	19,5	44	0,8	8	2560	MPF1164680*N
160	90	10	13,5	23	44	0,8	8	2560	MPF1165100*N
160	90	15	18	28	44	1	8	2560	MPF1165150*N
250	200	0,15	5	9	19	0,6	26	13000	MPF1253150*D
250	200	0,22	5,5	9,5	19	0,6	26	13000	MPF1253220*D
250	200	0,33	7	12	19	0,8	26	13000	MPF1253330*D
250	200	0,47	9	14	19	0,8	26	13000	MPF1253470*D
250	200	0,68	7	13	27	0,8	19	9500	MPF1253680*G
250	200	1	9	15,5	27	0,8	19	9500	MPF1254100*G
250	200	1,5	10,5	17	32	0,8	10	5000	MPF1254150*J
250	200	2,2	12,5	19,5	32	0,8	10	5000	MPF1254220*J
250	200	3,3	12	20	44	0,8	10	5000	MPF1254330*N
250	200	4,7	14	23,5	44	0,8	10	5000	MPF1254470*N
250	200	6,8	18,5	29	44	1	10	5000	MPF1254680*N
400	220[2]	0,068	5	8	19	0,6	35	28000	MPF1402680*D
400	220[2]	0,1	5	9	19	0,6	35	28000	MPF1403100*D
400	220[2]	0,15	6,5	10,5	19	0,6	35	28000	MPF1403150*D
400	220[2]	0,22	7,5	12,5	19	0,8	35	28000	MPF1403220*D
400	220[2]	0,33	7,5	12,5	27	0,8	25	20000	MPF1403330*G
400	220[2]	0,47	9	14	27	0,8	25	20000	MPF1403470*G
400	220[2]	0,68	9	15	32	0,8	16	12800	MPF1403680*J
400	220[2]	1	11	19	32	0,8	16	12800	MPF1404100*J
400	220[2]	1,5	10,5	18,5	44	0,8	16	12800	MPF1404150*N
400	220[2]	2,2	13	22	44	0,8	16	12800	MPF1404220*N
400	220[2]	3,3	15	25	44	1	16	12800	MPF1404330*N
630	250[2]	0,033	5	9	19	0,6	55	69300	MPF1632330*D
630	250[2]	0,047	6	10	19	0,6	55	69300	MPF1632470*D
630	250[2]	0,068	6,5	10,5	19	0,6	55	69300	MPF1632680*D
630	250[2]	0,1	7,5	12	19	0,8	55	69300	MPF1633100*D
630	250[2]	0,15	7	11	27	0,8	37	46600	MPF1633150*G
630	250[2]	0,22	8	13	27	0,8	37	46600	MPF1633220*G
630	250[2]	0,33	8	15	32	0,8	23	28900	MPF1633330*J
630	250[2]	0,47	10	17	32	0,8	23	28900	MPF1633470*J
630	250[2]	0,68	12	19	32	0,8	23	28900	MPF1633680*J
630	250[2]	1	11,5	19	44	0,8	23	28900	MPF1634100*N
630	250[2]	1,5	13,3	23,5	44	0,8	23	28900	MPF1634150*N
630	250[2]	2,2	17,5	27,5	44	1	23	28900	MPF1634220*N

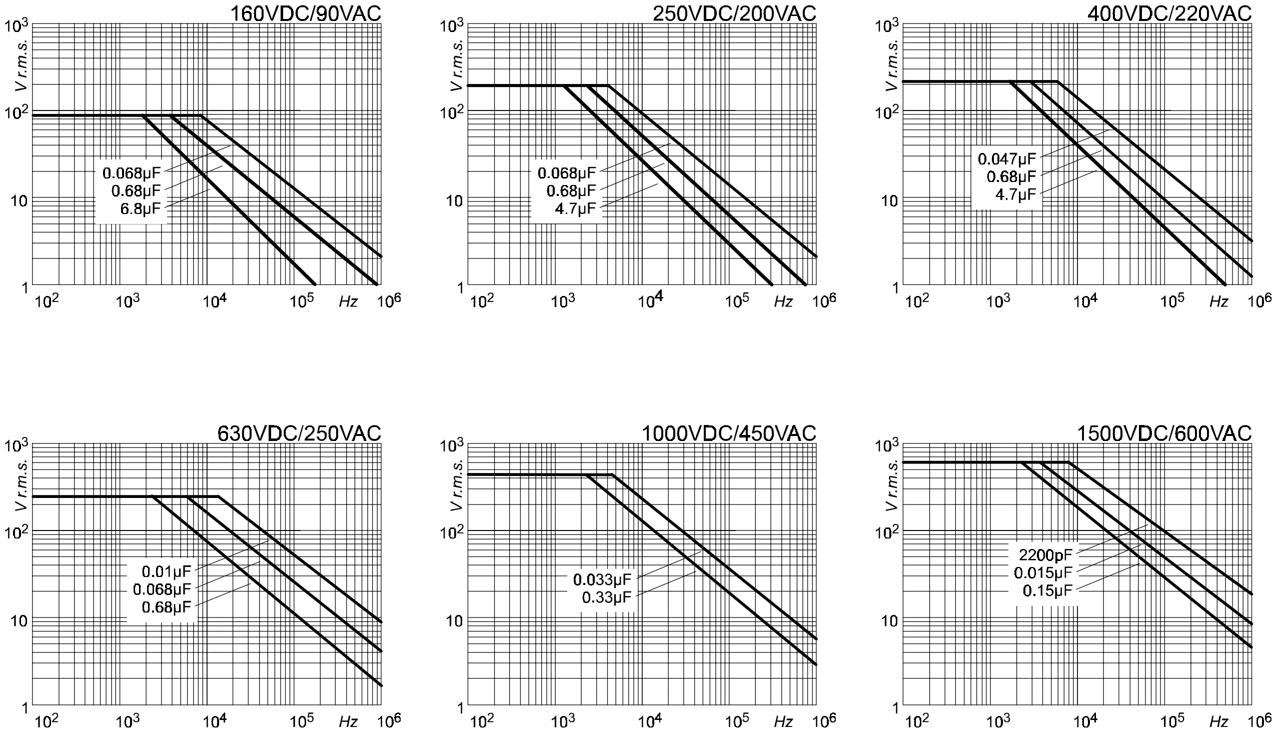
[1]Change the * symbol with the needed capacitance tolerance code: J=±5%, K=±10%, M=±20%
[2]Not suitable for across the line application.

MPW - MPF

Rated voltage		Cap.	Dimension in mm				du/dt	Ko	ICEL ordering code[1]
Vdc	Vac	value (µF)	B	H	L	d	V/µs	V^2/µs	
1000	450[2]	0,047	6	10	27	0,6	55	110E03	MPF2102470*G
1000	450[2]	0,068	7,5	12,5	27	0,8	55	110E03	MPF2102680*G
1000	450[2]	0,1	8	12	32	0,8	35	70000	MPF2103100*J
1000	450[2]	0,15	9,5	16	32	0,8	35	70000	MPF2103150*J
1000	450[2]	0,22	12	18,5	32	0,8	35	70000	MPF2103220*J
1000	450[2]	0,33	13,5	23,5	32	0,8	35	70000	MPF2103330*J
1500	600[2]	0,01	5	9	19	0,6	100	300E03	MPF2152100*D
1500	600[2]	0,015	6	10	19	0,6	100	300E03	MPF2152150*D
1500	600[2]	0,022	7	11	19	0,8	100	300E03	MPF2152220*D
1500	600[2]	0,033	9	13,5	19	0,8	100	300E03	MPF2152330*D
1500	600[2]	0,033	6	10,5	27	0,6	65	195E03	MPF2152330*G
1500	600[2]	0,047	8	13	27	0,8	65	195E03	MPF2152470*G
1500	600[2]	0,068	9	15,5	32	0,8	45	135E03	MPF2152680*J
1500	600[2]	0,1	9,5	16,5	32	0,8	45	135E03	MPF2153100*J
1500	600[2]	0,15	12,5	18,5	32	0,8	45	135E03	MPF2153150*J
1500	600[2]	0,22	14	23,5	32	0,8	45	135E03	MPF2153220*J

[1]Change the * symbol with the needed capacitance tolerance code: J=±5%, K=±10%, M=±20%
[2]Not suitable for across the line application.

Permissible AC voltage versus frequency (sinusoidal waveform)



Warning

This specification must be completed with the data given in the "General technical information" chapter

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A-Capacitor design and construction

Plastic film capacitors can be subdivided into two main groups in function of their construction: film-foil capacitors and metallized film capacitors.
The combination of these two technologies brings to a third main group of capacitors, which gets the advantages of both the other groups.

A1- Film-foil capacitors

Typical film-foil capacitor consists of two metal foil electrodes with a plastic film between them, used as dielectric.
Metal foils thickness is typically 5 to 9µm and the plastic film must be thick enough to guarantee the necessary capacitor reliability in terms of voltage withstanding and long term behaviour.
Film-foil capacitors, being not able to self-heal (refer to related paragraph) usually need a dielectric thickness higher than the equivalent metallized film capacitors one, having the same ratings.
It means that, considering the same dielectric type, capacitance and voltage rating, the typical dimensions of film-foil capacitors are larger than the metallized film capacitors ones.
The presence of metal foil electrodes ensures high insulation resistance, very good capacitance stability, low losses even at high frequency and excellent pulse handling capability.
Film-foil capacitors don't have self healing properties.

A2- Metallized film capacitors

In metallized film capacitors, the metal electrodes are vacuum deposited directly onto the dielectric film surface.
The outstanding advantage of metallized film capacitor technology is the self-healing property.
The extremely thin metal layer obtained (typical thickness 0.02 to 0.05µm) and the availability of low thickness dielectric films allow the production of capacitors having small dimensions.
The contacting of metallized film capacitors is made by spraying metal alloys onto windings face ends and then welding the leads on these metal sprayed areas.
This ensures low inductance and low loss characteristics.
Metallized film capacitors do not typically guarantee high pulse withstanding capability.
Nevertheless, a medium-high pulse handling capability can be reached with metallized film technology, using special films having metallization with reinforced contact edges and particular metal alloys, or with inner series connection design.

A3- Self-healing

Self-healing (or clearing) process consists in the removal of imperfections, pin holes and dielectric film flaws which can cause permanent voltage breakdowns when voltage is applied to the capacitor.
The electric arc which takes place with breakdown, evaporates and changes the characteristics of the metallized area around the fault, insulating the defect: the capacitor instantaneously regains its full operation ability.
The time necessary for self-healing process is usually less than 10µs and the electric arc occurs only if the necessary energy is available either as charge energy or as external energy.
The capacitor design (film metallization characteristics and dielectric film thickness) ensures that the self-healing occurs only occasionally even when the maximum voltage allowed is continuously applied to the capacitor at the higher temperature limit.
Moreover, only fractions of the total energy stored in the capacitor are dissipated during the self-healing process, therefore the corrispondent voltage drop remains low.
When prescribed by approval normatives, self-healing characteristic is indicated by the presence of "SH" or "#" symbol in the capacitors printing.

A4- Mixed film-foil and metallized film capacitor technology

The mixing of film-foil and metallized film technology combines the advantages of the two above described types, obtaining self-healing property, high current and pulse capability and low losses with extended frequency ranges.
As a function of the foreseen application and needed capacitors characteristics, double side metallized films can be used in substitution to metal foil electrodes and some types also cover high voltage ranges thanks to a particular inner structure design.
Also this kind of capacitor is conventionally classified among metallized film capacitors.

A5- Dielectrics

Many different materials and plastic films may be used as a dielectric.
The dielectrics used in ICEL products are:

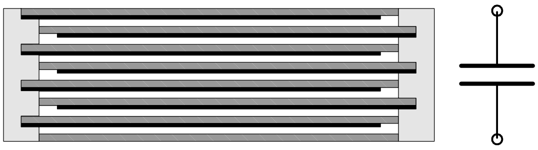
Polyester
Polypropylene
Polycarbonate

The use of different dielectrics gives to capacitors different characteristics and behaviour: dielectric types are choosen in function of design needs and foreseen capacitors application characteristics.
A comparison of the main characteristics of the above mentioned plastic films is shown in the following table

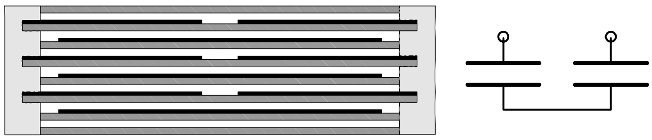
Comparative table of plastic film dielectric characteristics (typical values)				
Characteristic	Polyester	Polycarbonate	Polypropylene	Polystyrene
Relative dielectric costant (25°C, /1kHz)	3.3	2.8	2.2	2.5
Max. working temperature (°C)	125	125	105	70
Loss factor (x10^{-4}, 1kHz/100kHz)	50/180	10/100	2/3	2/3
Insulation resistance (MΩ x µF, +20°C)	30	50	300	300
Temperature coefficient (ppm/°C)	-	+150	-200	-150
Dielectric strenght (V/µm)	250	180	350	150
Water absorption (% in weight)	0.2	0.3	<0.01	0.1
Density (g/cm^3)	1.39	1.21	0.91	1.05

A6- Capacitors winding

Capacitive elements are obtained rolling together a stated number of different types of films and / or foils, having characteristics, arrangement and sequence function of design targets, obtaining cylindrical rolls called windings.

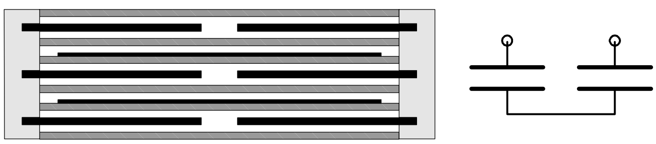


Extended metallized film design

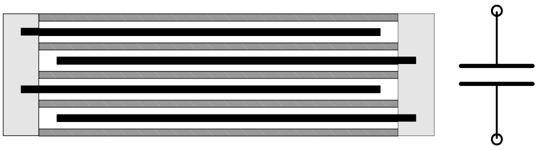


Extended metallized film design
with internal series connection
(series connection of 2 elements)

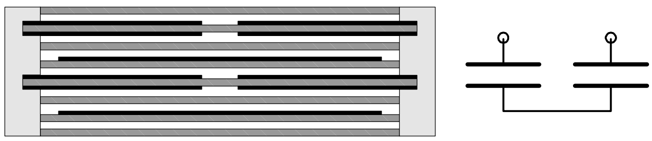
Extended double side metallized
carrier film design



Extended foil design with internal series
connection and metallized film
(series connection of 2 elements)



Extended foil design



Extended double side metallized carrier
film design with internal series
connection and metallized film
(series connection of 2 elements)

A7- Capacitors assembly and testing

The windings (the original cylindrical shape of the windings can be changed into flat one by pressing them, in order to obtain axial or dipped units having specified dimensions or to be sealed in box) are submitted to thermal treatments, heads contact spraying and submitted to 100% clearing and electrical parameters pre-testing.
After the leads welding to capacitive elements, the units are finished in accordance with specifications using protecting tapes, boxes and sealing resins or by dipping in resin process and curings.
Additional 100% or statistical checks are foreseen at different points of the production cycle in order to guarantee the materials and capacitors conformity with specifications.
Then capacitors are submitted to 100% final tests, printing and packing.

B-Technical terms (reference standards: IEC, CECC, EN and DIN normatives) and general technical data

B1- Rated Capacitance (Cr)

It is the capacitance value for which the capacitor has been designed.
If not differently specified, it is typically measured at 1kHz ±20% at a max. testing voltage 3% of the rated voltage or 5V (whichever is the lowest), at 20°±5°C.
Capacitance rated values are typically graded in accordance with E series (refer to E series table).

B2- Capacitance Tolerance

It is the maximum admitted deviation from rated capacitance value, measured at 20±5°C.
It is typically expressed in % or with correspondent letter codes.
Preferred tolerance values and correpondent letter codes are:

±1%= F
±1.25%= A
±2%= G
±2.5%= H
±5%= J
±10%= K
±20%= M (may not appear in units printing. In this case capacitance tolerance is assumed as ±20%)

B3- Temperature Coefficient (α)

Applies to capacitors of which the reversible variation of capacitance as function of temperature is linear or approximately linear and can be expressed with a certain precision.
It is the rate of change with temperature measured over a specified temperature range within the category temperature range.
a is normally expressed in parts per million per degree celsius (10^{-6}/°C) and shall be calculated as follows:

$$\alpha_i = \frac{C_i - C_0}{C_0(\theta_i - \theta_0)}$$

C_0 = capacitance measured at 20±2°C
θ_0 = 20±2°C
C_i = capacitance measured at θ_i
θ_i = temperature measured on test

B4- Long Term Stability

It is the maximum irreversible capacitance change after a period of 2 years at standard environmental conditions (refer to "Storage conditions / Standard environmental conditions" paragraph).

B5- Rated Voltage (Ur)

The rated voltage is the voltage for which the capacitor has been designed.
It is the maximum direct voltage or the maximum r.m.s. alternating voltage or peak value of pulse voltage which may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature (unless other declared limitations or otherwise stated in reference specifications).

B6- Category Voltage (Uc)

It is the maximum voltage which may be applied continuously to a capacitor at its upper category temperature.

B7- Temperature Derated Voltage

For any temperature between the rated temperature and the upper category temperature, the temperature derated voltage is the maximum voltage that may be applied to a capacitor.

B8- Superimposed AC Voltage

When alternating voltage is present, the working voltage of the capacitor is the sum of the direct voltage and the peak alternating voltage. This sum shall not exceed the rated voltage value.

B9- Permissible AC Voltage up to 60Hz

It is the pure sine wave voltage that may be applied to the capacitor at a frequency up to 60Hz.
For operation at higher frequencies, correspondent dissipated power and currents must be taken in consideration.
The AC rated voltages stated for each series refer to an operating frequency of 50÷60Hz and sinusoidal waveforms (no transient voltages).
The permissible AC voltage at frequency over 60Hz, under sinusoidal waveforms, can be obtained from the AC voltage versus frequency graphs of each capacitor series.
Warning: even if the permissible AC voltage covers the lines voltage range, standard film capacitors are basically not suitable for operation in direct connection to public power networks.

B10- Test Voltage between leads (Ut)

It is the specified voltage value that may be applied for a specified time to the capacitor in order to test its dielectric strength.
The occurrence of self-healing during the application of test voltage is permitted for metallized film capacitors.

Warning: the test of many capacitors connected in parallel or the test of a self-healing capacitor in parallel with other capacitive elements is not admitted if adequate limiting discharging devices are not used in order to prevent the rapid dissipation of the complete energy of the capacitors bank at the breakdown / clearing point, when a self-healing takes place, with probable damage or distruction of the self-healing capacitor.
This must be taken in consideration when making voltage proofs and high voltage tests prescribed by relevant normatives on equipments where many capacitors are used.

B11- Test Voltage between leads and case (Utc)

It is the specified voltage value (insulation voltage) that may be applied for a specified time to the capacitor between its leads and case in order to test insulation characteristics of its external protection.
The occurrence of breakdown or discharge during the application of test voltage is not admitted.

B12- Non Recurrent Surge Voltage (Upk)

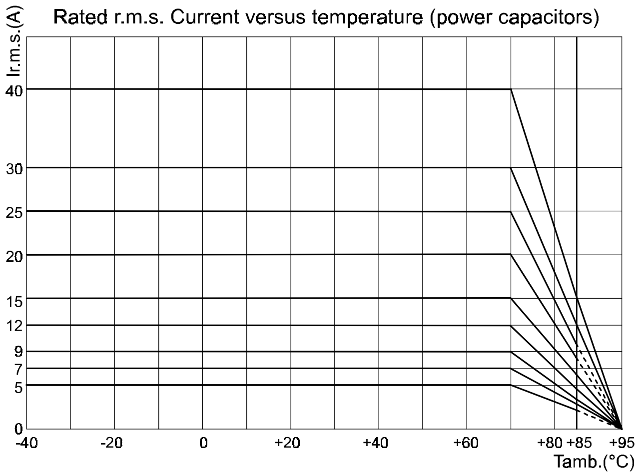
It is the maximum non recurrent peak DC voltage that may be applied to the capacitor for a limited number of times and for a short period.
The application of voltage higher than Upk may result in premature dielectric failure.

B13- Rated Ripple Current (Ir)

It is the r.m.s. current value of the maximum allowable alternating current of a specified frequency at which the capacitor may operate continuously at a specified temperature.

B14- Rated r.m.s. Current (Irms)

It is the highest permissible r.m.s. value of the continuous current flowing through the capacitor at the specified max. case temperature (typically +70°C for power capacitors).
The rated Irms of power series (PHC, PHB, PMC, PPS, PHS, PMS, PPA, PSB, PMB) must be derated taking in account the ambient temperature (for derating due to skin effect in case of short duration of peak current refer to correspondent graph) according to the following graph



B15- Max. Repetitive Peak Current (Ipeak)

It is the maximum value of the repetitive peak current that may be applied to the capacitor.
Refer to "Pulse Rise Time (du/dt) and waveform Energy Content (Ko)" paragraph.

B16- Max. Non Repetitive Peak Current (Ipk)

It is the maximum non recurrent peak current that may be applied to the capacitor for a limited number of times and for a short period. The application of peak currents higher than Ipk may result in permanent capacitor damage.

B17- Category Temperature Range

It is the range of temperature for which the capacitor has been designed to operate continuously.
It is defined by the temperature limits of the appropriate category.

B18- Lower / Upper Category Temperature

It is the minimum / maximum ambient temperature for which the capacitor has been designed to operate continuously.

B19- Rated Temperature

It is the maximum ambient temperature at which the rated voltage may be continuously applied.

B20- Ambient Temperature (θamb)

It is the temperature in the immediate surrounding of the capacitor and it is identical with the body surface temperature of the unloaded capacitor.

B21- Pulse Rise Time (du/dt) and Waveform Energy Content (Ko)

The pulse rise time is the slope of voltage wave shape during charging or discharging of the capacitor and it is expressed in V/µs.
The maximum pulse rise time value is typically referred to the rated voltage of the capacitor.

The current loading correspondent to the pulse rise time value is:

Ipeak= Cr x du/dt

Ipeak in A, Cr in µF, du/dt in V/µs.

The peak current flowing through the capacitor, causes a localized heating of the contact area in the capacitor, due to contact resistance between leads - metal sprays on the winding heads - electrodes of the winding (winding film contact edges or metal foils).
Note: the contacts localized heating may extend to the entire capacitor body, when the pulse stress is repetitive and constantly applied.

The energy W involved in the heating can be obtained by the formula

$$W = \int I_{peak}^2 \cdot R_i \cdot dt$$

R_i = inner resistance

The content of energy of the waveform applied to the capacitor is defined as follows

$$Ko = \int_0^t (du/dt)^2 \cdot dt$$

t = pulse width

Ko is expressed in V^2/µs.

At low voltage / medium-low pulse levels, when working at lower voltage Ua than the rated voltage Ur, capacitors may be operated at a pulse rise time= du/dt at specification x Ur / Ua.
In any case, correspondent Ipeak must be ≤ Ipk (max. non repetitive peak current admitted) and maximum Ko values stated in specifications must not be exceeded in order to avoid a dangerous overheating of the capacitors.

B22- Power Dissipation

The heat to be dissipated by the capacitor can be calculated as follows

$$P = \sum_1^n {}_i Vrms_i^2 \cdot 2\pi f_i \cdot C \cdot tg\delta(f_i)$$

P = dissipation in Watt
$Vrms_i$ = r.m.s. voltage of the i^{th} armonic in Volt
f_i= frequency of the i^{th} armonic in Hz
C = capacitance in Farad
$tg\delta(f_i)$ = dissipation factor at the frequency of the i^{th} armonic
n = number of significant harmonics

In case of sinusoidal waveforms, (n=1) the formula is

$$P = Vrms^2 \cdot 2\pi f \cdot C \cdot tg\delta(f)$$

This formula may be also used to approximate the capacitor dissipation when submitted to non sinusoidal or pulse conditions, where

P = dissipation in Watt
Vrms = r.m.s. value of the AC voltage
f = repetition frequency of the pulse waveform
C = capacitance in Farad
tgδ = dissipation factor at the frequency of the steepest pulse part (pulse frequency=1/pulse width)

The maximum power dissipation admitted for a capacitor under normal conditions, depends on many different factors like the execution, design, shape, dimensions, materials and so on.
An extimated value of the dissipable power may be calculated with the following formula

Pd= K x S x ΔT

K= 1÷2.2 (mW/°C x cm^2)

K may assume different values in function of different types, design and executions of the capacitors.
As a general consideration, lower K values should be considered for general purpose metallized film capacitors and capacitors having shape and construction not favourable for heat dissipation; higher K values could be considered for film foil capacitors and capacitors having double side metallized film electrodes or units having design, shape and construction favourable for heat dissipation.
The choice of lower K values will ensure high safety margin in Pd extimation.

S= case surface (cm^2)

Parts of capacitors surface not able to adequately dissipate the heat because of capacitor position or other limitations, like the radial – box capacitors face laying on PCB surface, should not be taken in consideration.

ΔT (°C)= difference between the hot spot case temperature of the capacitor in stationary working conditions and the ambient temperature (as an example, assuming an ambient temperature= +50°C, if the hot spot case temperature of the working capacitor has to be mantained ≤ +70°C, a maximum ΔT of 20°C must be considered).

Warning: in any case, the max. assumed ΔT must be ≤ 40°C, whichever is the type of capacitor taken in consideration and a max. ΔT of 20°C is suggested for general purpose metallized film capacitors (capacitors not having metal foil or double side metallized electrodes and not designed for power applications).
Moreover, at +85°C ambient temperature the max. assumed ΔT must be ≤ 10°C, whichever is the type of capacitor taken in consideration and a max. ΔT of 5°C is suggested for general purpose metallized film capacitors (capacitors not having metal foil or double side metallized electrodes and not designed for power applications).
Avoid operation conditions which cause sensible power dissipation at ambient temperatures over +95°C, even in case of capacitors having higher rated upper category temperature.

During stationary operation, the capacitor temperature must be always ≤ max. operating temperature stated for the capacitor.
Mantaining a safe temperature margin, avoiding the reaching of the max. temperature limit, encreases the capacitors reliability and expected life.

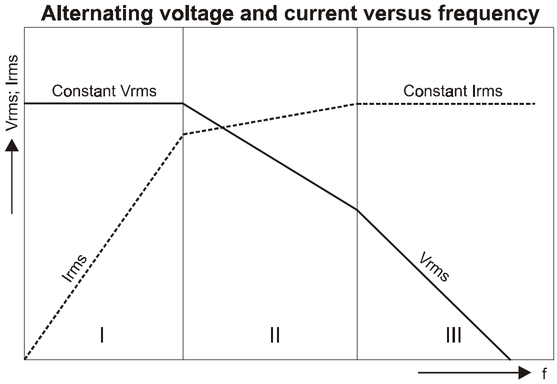
Therefore P must be ≤ Pd.

If the above condition is not respected, possible actions are:

Reduction of ambient temperature
Forced air cooling
Parallel connection of many capacitors
Use of different type of capacitors or capacitors having better dissipation characteristics

Note: nevertheless the extimated theorical Pd, always consider the max. voltage and the max. current withstandable by the capacitor and particularly the current capability allowed by leads type.
Infact, a theorically obtained Pd value may correspond to voltage values higher than permissible Urms voltage (over ionization level at midium-low frequencies) or to current values not tolerable by the capacitor and its leads (at midium-high frequencies).
The typical capacitors Urms and Irms (sinusoidal waveform) withstanding capability in function of frequency is as follows

Alternating voltage and current versus frequency



I: voltage limited by ionization
II: voltage and current limited by power dissipation and tgδ
III: current limited by leads

Following indicative max. current values, in function of leads type, shape and section could be taken in consideration for power capacitor series (up to +70°C max):

Tinned copper wire leads or cables, 0.7mm diameter / approx. 0.385mm^2 section= about 5.5A
Tinned copper wire leads or cables, 0.8mm diameter / approx. 0.50mm^2 section= about 7A
Tinned copper wire leads or cables, 1.0mm diameter / approx. 0.785mm^2 section= about 9A
Tinned copper wire leads or cables, 1.2mm diameter / approx 1.13mm^2 section= about 12A
Lugs used for axial units (MPHL type)= approx. 20A
Other lugs types= 30÷35A

Important factors when estimating the capacitors leads-contacts current capability, are the leads welding mode, the contacts welded surface, the units heads spraying type and thickness and the capacitor working temperature.
For this reason the above listed data must be considered as approximative and indicative.
Always refer to capacitors specifications in order to obtain max. currents withstandable.

If needed data are not present in capacitors specification and in case of severe application with complex voltage and current waveforms which may cause sensible power dissipation and capacitor heating, ICEL Technical Office shall be contacted in order to ensure the use of the correct kind of capacitor for the application.
Moreover, since the above given data are based on very generalized assumptions, they do not allow absolute correct deductions in case of critical cases: a pratical test in the particular application should always be made in order to verify the correctness of the theorical assumptions.

B23- Equivalent Series Resistance (E.S.R.)

It is the resistive part of the equivalent series circuit.
It is due to the resistivity of electrodes, internal connections and dielectric losses and it is frequency and temperature dependent.
The E.S.R. is related to the capacitive reactance and dissipation factor of the capacitor by the formula

$$ESR = \frac{tg\delta}{\omega \cdot C}$$

C = capacitance in Farad
ω = 2πf
f = frequency in Hz

B24- Dissipation Factor (tgδ)

It is the power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage of a specified frequency.
The reciprocal value of the dissipation factor is known as the Q factor.

$$tg\delta = \frac{1}{Q}$$

B25- Impedance (Z)

It is the magnitude of the vectorial sum of the E.S.R. and the capacitive reactance in an equivalent series circuit, under consideration of series inductance

$$|Z| = \sqrt{ESR^2 + \frac{1}{(\omega \cdot C)^2}}$$

B26- Self Inductance (Ls) and Resonant Frequency (fo)

Self inductance depends on the inductance of connecting leads and of the winding.
Thanks to metal spraying by which all windings turns are connected, the self inductance is typically extremely low.
Since the inductance can be reduced but never completely eliminated, at a certain frequency (fo) the capacitive and inductive reactances are equal.

$$\frac{1}{\omega_0 \cdot C} = \omega_0 \cdot L \quad \text{where } \omega_0 = 2\pi f_0$$

f_0 is called resonant frequency and at frequencies > f_0 the inductive component of the capacitor prevails.
The inductance values indicated in the specifications are typical and referred to resonant frequency, at 20±5°C.

B27- Insulation Resistance (IR) and Time Constant (s)

Insulation resistance consists of the insulation resistance of the dielectric (layer/layer) and that of layer and case, which is determined by the quality of the insulating materials (insulating tapes, plastic boxes, sealing resins and so on).
IR is the ratio of an applied DC voltage to the current flowing after a specified time.
It is dependent on temperature, voltage and time.

The time constant (s) of a capacitor is the product of IR and capacitance

s= MΩ x µF

B28- Test Categories (reference: IEC 60068)

Capacitors can be graded in accordance with stated test categories which result from the test conditions according to which capacitors have been tested.
The test categories comprise three parameters

Test	Preferred values			
A (cold, °C)	-65	-55	-40	-25
B (dry heat, °C)	+70	+85	+100	+125
C (damp heat, days)	04	10	21	56

Example:
test A= -40°C; test B= +85°C, test C= 56 days.
Test category= 40/085/56

B29- Permitted Temperature and Humidity

They are dependent on capacitor type and are identified in accordance with DIN40040

Permitted temperature and humidity in accordance with DIN 40400				
1st code letter	E	F	G	H
Minimum temperature (°C)	-65	-55	-40	-25
2nd code letter	S	P	M	K
Maximum temperature (°C)	+70	+85	+100	+125
3rd code letter humidity category	G	F(E[3])	D	C
Average relative humidity	≤65%	≤75%	≤80%	≤95%
30 days per year, continuosly [1]	-	95%	100%	100%
60 days per year, continuosly	85%	-	-	-
For the remaining days, occasionally[2]	75%	85%	90%	100%

[1] These days should suitably be spread evenly out over the year.
[2] Keeping the annual average.
[3] For humidity category E, rare and slight dew precipitations additionally permitted.

B30- Solder conditions for capacitors on printed circuits boards

Solder bath temperature and soldering time:

270±5°C 5s for single sided PCBs
260±5°C 5s for double sided PCBs

Capacitors with radial leads must rest on the PCBs.
For axial leads capacitors, a necessary soldering distance of min. 6mm between the capacitor body and the solder connection has to be kept.

For vertical mounting a min. 1.5mm distance has to be maintained.

Warning: the permissible heat exposure on film capacitors is limited by upper category temperature. Long exposure to temperature levels above this limit may cause irreversible changes of the capacitor characteristics or its damage.
In addition to solder bath temperature and the soldering process time, thermal load applied to the capacitor is also affected by pre-heating and post soldering temperature.
Since the soldering heat is mainly transmitted in the units through the leads, the process is more critical for small size capacitors.
For critical capacitors soldering, in addition to checks of the process effect on the capacitors, particular care is required; the keeping of maximum possible distance from solder bath, the use of solder resistent coatings and the forced ventilation cooling is suggested.
Moreover, if pre-heating cannot be avoided, the soldering process conditions should be possibly readjusted.

B31- Dimensions and tolerances

Dimensions and materials may be subjected to reasonable variations due to available raw materials and normal fluctuations in the manufacturing process.
Moreover, high stress working conditions, like operation at maximum ratings at the max. rated temperature, may cause dimensional variations which should be taken in account when designing capacitors placement in equipments and on PCBs.

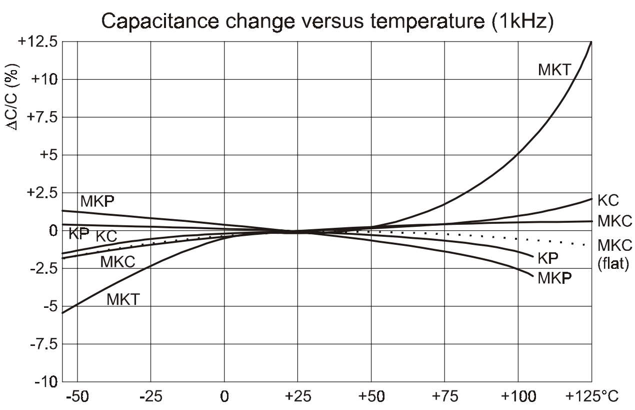
Tolerances on dimensions are usually specified for every type in series specifications.
For capacitors in box, following tolerances on nominal box dimensions declared must be taken in consideration, unless otherwise specified:

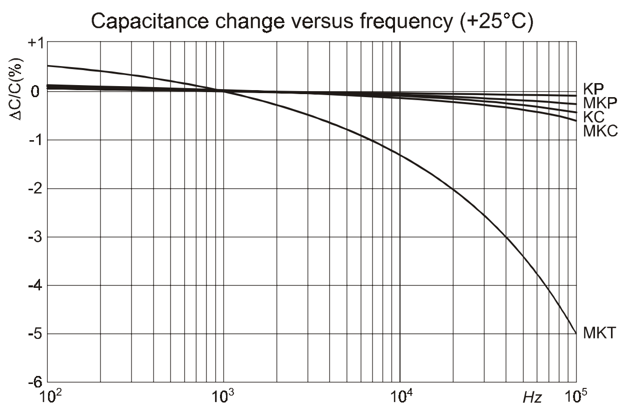
±0.25mm on dimensions Bd ≤ 10mm
±0.35mm on dimensions 10mm < Bd ≤ 18mm
±0.45mm on dimensions 18mm < Bd ≤ 32mm
±0.55mm on dimensions 32mm < Bd ≤ 42.5mm
±0.75mm on dimensions Bd > 42.5mm

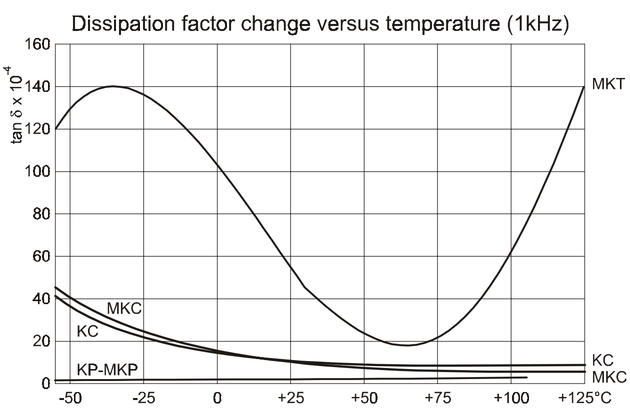
B32- Standard Environmental Conditions for Test

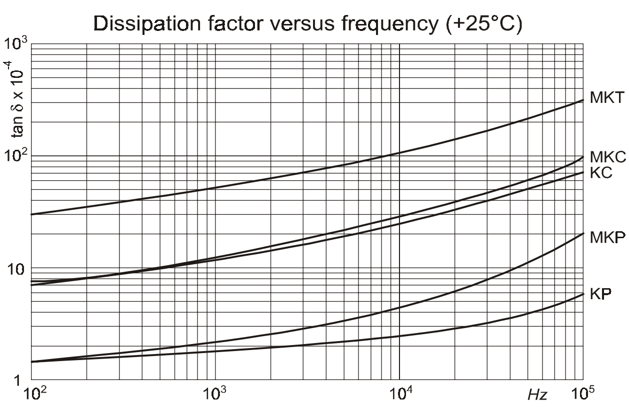
Unless otherwise specified, all the electrical data stated in specifications are referred to a temperature of +15÷35°C, an atmospheric pressure of 86÷106kPa (860÷1060 mbar) and a relative humidity of 45÷75%.

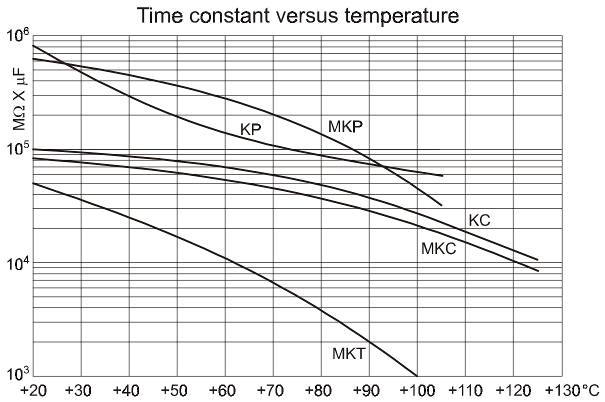
B33- Typical curves











MKT: metallized polyester
KP: film-foil polypropylene
MKP: metallized polypropylene
KC: film-foil polycarbonate
MKC: metallized polycarbonate

B34- Reference Reliability and Failure Rate (λ)

The reference reliability states a component type fraction failure under a defined load / operating condition.
This fraction failure will not be exceeded within a specified operating time.
The reference operating condition is typically +40°C at 30% relative humidity with 0.5 x Ur (DC) continuously applied to the capacitor.

Failure rate λ is the fraction failure divided by a specified operating time and it is expressed in fit (failure in time), as follows:

1 fit= 1 x 10^{-9} / h (1 failure per 10^9 component hours)

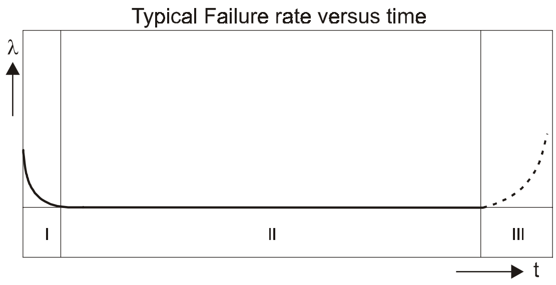
Failure rate, when available, is referred to failure rate criteria like short or open circuit, main electrical parameters variation limits and so on, declared in each series specification.

In order to extimate the expected failure rate in function of load / operation characteristics different from the one taken as a reference for nominal failure rate, following conversion factors (CF) may be used:

Working Voltage (Uw/Ur)	CF
1	x 20
0,75	x 4
0,5	x 1
0,25	x 0,4
0,1	x 0,2

Working Temperature(°C)	CF
≤ +40	x 1
+55	x 2,5
+70	x 6
+85	x 15
-	-

Typical components failure rate curve in function of time, shows three characteristic periods in the components life: a first period (I), when early failures occur, a second period (II) during which the failure rate can be considered approximatively constant and a third period (III) when failures increase due to aging wear.
Failure rates data at specifications are typically referred to the second period (II).



Warning: figures stated about expected life and failure rates are mainly based on application experience and accelerated ageing tests; they are referred to average production conditions and must be considered as mean values, based on statistical expectations for a large number of lots of identical capacitors.

B35- Life expectancy (Le)

The Life Expectancy of power capacitors series is referred to a reference nominal voltage Un and to the hot spot temperature of the capacitor case (+70°C).
The Life Expectancy may be improved derating the operating voltage and / or the operating temperature.

Life Expectancy in function of operating voltage can be approximately obtained with the following formula

$Lw = Le\ (Un / Uw)^{E}$

Lw (h)= life expectancy at the operating voltage Uw
Le (h)= life expectancy at the voltage Un (given in specifications)
Un (V)= reference voltage to which Le is referred
Uw (V) = operating voltage (Uw ≤ Un)
E = 8 (typical value)

Warning: a good approximation of the capacitor behaviour can be obtained at Uw values narrow to Un reference only. At Uw >Un the “E” value significatively encreases (up to double or more). Do not operate capacitors over the allowed voltage

Life Expectancy in function of the hot spot temperature of the capacitor case can be approximately obtained with the following formula

$Lw = Le \times 2^{(T-Ths) / Ac}$

Lw (h)= life expectancy at the operating temperature
Le (h)= life expectancy at the reference temperature T (given at specification)
T (°C)= reference temperature (+70°C)
Ths (°C)= hot spot case temperature at stationary working conditions (≤ +70°C)
Ac (Arrhenius coefficient expressed in °C)= 7 (typical)

Warning: the above formula is derived from Arrhenius equation which describes the ageing of organic dielectrics in function of the temperature.
It gives a good approximation of the capacitor behaviour only if the temperature range taken in consideration is not too large.

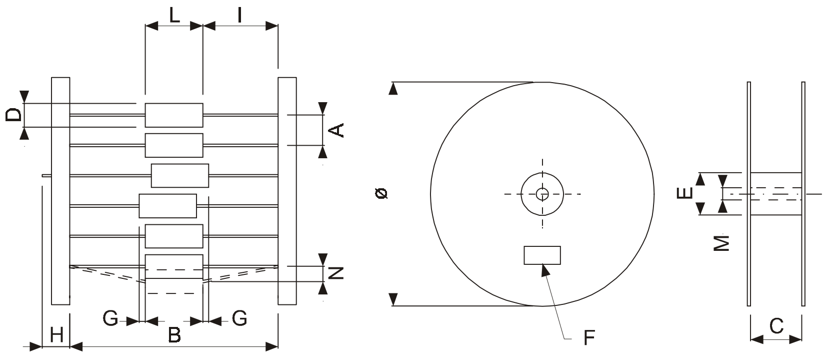
B36- EN60252 normative Life Expectancy Classes

The following Life Expectancy Classes are used to rate the capacitors approved in conformity with EN60252 normative:

Class A: 30000 hours
Class B: 10000 hours
Class C: 3000 hours
Class D: 1000 hours

The Life Expectancy Class is referred to an operating voltage, frequency, temperature and duty cycle correspondent to the EN60252 approval obtained.
The Life Expectancy Class code is printed in EN60252 approved capacitors markings.

B37- Taping specification for axial capacitors



Description	Symbol	Dimensions (mm)
Capacitor diameter	D	4.5 ÷ 19.5
Capacitor length	L	10.5 ÷ 32.0
Component pitch	A*	See table I
Reel core diameter	E	60
Arbor core diameter	M	16
Reel diameter	ø	340+5
Marking	F	See table II
Tape width	H	6±0.5
Body location (lateral deviation)	G	≤0.8
Body location (longitudinal location)	N	≤1.2
Tape spacing	B	See table III
Lead length from the capacitor body to the adhesive tape	I	≥20
Distance between reel flanges	C	See table III
* Cumulative pitch tolerance does not exceed 1.5mm over six consecutive components.		

Table I	
D (mm)	A (mm)
<5	5
5 ÷ 9.5	10
9.6 ÷ 14.7	15
14.8 ÷ 19.5	20

Table II (reel marking)
- Manufacturer's name - Capacitor type and code - Electrical values - Component quantity - Date

Table III		
L (mm)	B±2 (mm)	C (mm)
≤13.0	53	75
19.0	63	86
>19.0	73	95

Typical capacitor quantity per reel	
D	pieces per reel
≤5	2000
5 ÷ 10	500 ÷ 1000
10,1 ÷ 19,5	125 ÷ 350
Allowed number of lacking piecs: 2 per 1000 pieces	

B38- E series according to DIN41426 and IEC 60063 (preferred capacitance values)

Available = x

E series according to DIN 41426 and IEC 63 (preferred capacitance values).											
Values	E96 (±1%)	E48 (±2%)	E24 (±5%)	E12 (±10%)	E6 (±20%)	Values	E96 (±1%)	E48 (±2%)	E24 (±5%)	E12 (±10%)	E6 (±20%)
1.00	x	x	x	x	x	3.30			x	x	x
1.02	x					3.32	x	x			
1.05	x	x				3.40	x				
1.07	x					3.48	x	x			
1.10	x	x	x			3.57	x				
1.13	x					3.60			x		
1.15	x	x				3.65	x	x			
1.18	x					3.74	x				
1.20			x	x		3.83	x	x			
1.21	x	x				3.90			x	x	
1.24	x					3.92	x				
1.27	x	x				4.02	x	x			
1.30	x		x			4.12	x				
1.33	x	x				4.22	x	x			
1.37	x					4.30			x		
1.40	x	x				4.32	x				
1.43	x					4.42	x	x			
1.47	x	x				4.53	x				
1.50	x		x	x	x	4.64	x	x			
1.54	x	x				4,70			x	x	x
1.58	x					4.75	x				
1.60			x			4.87	x	x			
1.62	x	x				4.99	x				
1.65	x					5,10			x		
1.69	x	x				5.11	x	x			
1.74	x					5.23	x				
1.78	x	x				5.36	x	x			
1.80			x	x		5.49	x				
1.82	x					5,60			x	x	
1.87	x	x				5.62	x	x			
1.91	x					5.76	x				
1.96	x	x				5.90	x	x			
2.00	x		x			6.04	x				
2.05	x	x				6.19	x	x			
2.10	x					6,20			x		
2.15	x	x				6.34	x				
2.20			x	x	x	6.49	x	x			
2.21	x					6.65	x				
2.26	x	x				6,80			x	x	x
2.32	x					6.81	x	x			
2.37	x	x				6.98	x				
2.40			x			7.15	x	x			
2.43	x					7.32	x				
2.49	x	x				7.50	x	x	x		
2.55	x					7.68	x				
2.61	x	x				7.87	x	x			
2.67	x					8.06	x				
2.70			x	x		8,20			x	x	
2.74	x	x				8.25	x	x			
2.80	x					8.45	x				
2.87	x	x				8.66	x	x			
2.94	x					8.87	x				
3,00			x			9.09	x	x			
3.01	x	x				9.10			x		
3.09	x					9.31	x				
3.16	x	x				9.53	x	x			
3.24	x					9.76	x				

C-Application notes, operation and safety conditions

Because of the many different types of capacitors and the many factors involved, it is not possible to cover, by simple rules, installation and operation in all possible cases.
The following information, in addition to single series specifications and to the data up to now listed in “General Technical Information” chapter, are given with regard to more important points to be considered.

C1- Voltage applied and ionization effects

Voltage values higher than the rated voltage applied to the capacitor may cause permanent damage like the dielectric perforation, short circuit or, in case of metallized film capacitors, a progressive decrease of the IR and capacitance drop, with decrease of reliability and expected life.
If the capacitor may be subjected to higher voltages than the rated one, due to particular conditions like equipment malfunction, equipment test conditions or else, it migth be adeguately protected.
Rated voltage can be applied at temperature ≤ rated temperature.
At temperatures higher than the rated one, a voltage derating must be applied in conformity with each series specifications.
In order to guarantee an high reliability and long term life expectancy, power application capacitors should not be operated at maximum permissible voltage and maximum operating temperature contemporaneously: this should be considered an emergency operating condition, for short periods of time.
Capacitors rated voltage is usually specified DC.
For AC application it is suggested to refer to series specifically designed for this kind of usage (do check the foreseen main applications at specifications and the “Capacitors selection guide”).
If a DC rated capacitor is used in AC applications, do not use AC voltages higher than the one stated at specification.
With the exception of series designed for power applications, the AC voltages stated at specifications are referred to sinusoidal waveform.
If DC rated capacitors are used in an application with waveforms not sinusoidal or different from what specified at catalogue, ICEL Technical Office must be contacted before the use of the capacitor.

At high working voltage, ionization may cause a destructive process in the capacitor, often having consequences at medium-long term.
The ionization phenomenon (also called corona effect) is due to air contained in the dielectric, bewteen the winding layers of the capacitor and present at the face ends of the capacitive element.

If the electric field in the capacitor exceeds the air dielectric rigidity, micro-discharges might take place in the winding, damaging film metallization and / or the film itself.
This usually causes capacitance drop and may cause overheating due to IR drop, up to short circuit in case of persistent ionization.
The voltage at which ionization phenomenon overcomes a reference limit is called corona on-set or corona off-set voltage in function of its taking place at the rising or at the decreasing of the voltage applied to the capacitor.
The grade of the phenomenon and the damage that ionization is able to cause depends on many different factors like the amount of air trapped in the capacitor, the type of dielectric and electrodes, the design and construction, the accuracy of manufacturing process and working conditions.
In order to minimize potentially dangerous ionization effects, do always respect the voltage ratings and if possible, choose capacitors having voltage ratings higher than the foreseen application ones, in order to guarantee an enough high safety margin and better reliability.

In particular do ensure the respect of following condition

Vpp (peak to peak voltage) $\leq 2 \times \sqrt{2} \times U_r$ (AC)

C2- Pulse applications

In case of pulse applications, it is necessary to take in account the following main capacitor characteristics and application data (to be considered as the minimum conditions to be satisfied in order to prevent capacitors damages):

Vmax. (max. voltage) $\leq U_r$ (DC)

Vpp (peak to peak voltage) $\leq 2 \times \sqrt{2} \times U_r$ (AC)

du/dt or Ipeak ≤ specifications value

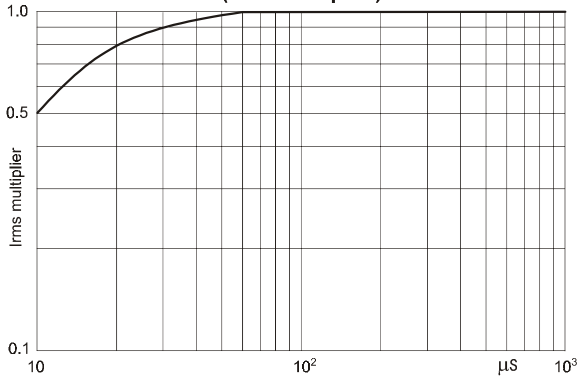
Ko ≤ specifications value

Ur.m.s., Ir.m.s. and waveform / pulse frequency (1/T): refer to permissible AC voltage versus frequency graphs.

Upk and Ipk ≤ specifications value

Moreover, in case of short current pulse duration, also the skin effect in the contacts should be taken in account, in accordance with the following graph

Rated rms current value versus pulse current duration
(Irms multiplier)



C3- Noises produced by capacitors

During pulse stresses or when submitted to complex waveforms having high frequency distorsion rate, capacitors might produce buzzing noises due to coulomb forces generated between opposite poles electrodes.
This noise is usually proportional to the size of the stress and its characteristics and may be different with different capacitor constructions.
It is not dangerous for the capacitor and does not typically relate to any damage of the capacitor.

C4- Permissible current

The main effect produced by the current flowing through the capacitor is its overheating.
This overheating in addition to the ambient temperature, must be maintained lower than the maximum operating temperature for which the capacitors have been designed.
An excessive heating reduces capacitors reliability and might cause capacitors deterioration up to a short or open circuit, body deformation and melting with smoke emission or fire danger, even if components are protected by flame retardant materials.
The fact that dissipation factor may encrease at temperature exceeding the max. rated temperature, causes a further dangerous heating effect which brings to a fast encrease of the risk of severe damage of the capacitor.

In addition to current linked with pulse operation (please refer to the related paragraphs), the effective currents (Ir.m.s.) due to periodic waveforms cause the entire capacitor body heating.
The combined effect of pulse and r.m.s. currents must be taken in consideration when evaluating the capacitor overheating.

Capacitors designed for high current operation show max. Ir.m.s. values at specification.
In any case, the maximum Ipeak and Ir.m.s. stated at specification must not be overcome.
Please contact ICEL Technical Office for support in case of any doubt about application of capacitors subjected to high pulse and r.m.s. currents or particular waveforms.

C5- Operating temperature

A capacitor used in AC applications is submitted to heating due to currents flowing through it.
The working conditions and the correct choice of the capacitor must ensure that the capacitor working temperature, like all the other parameters, remains within the limits stated in specification.
Operating temperature in excess to the max. admitted or very rapid changes from hot to cold and viceversa may accelerate electrochemical dielectric degradation and cause physical damage to protecting materials(accelerated ageing , their breaking and detouching one from the other and so on).

The direct test of the capacitor overheating shall be made at load conditions equivalent to the real operating one, but also simulating the worst working conditions foreseen in the application.
The capacitor temperature must be measured at the hottest part of its body (typically in correspondence with contacts / near heads areas).
The dissipation factor (and the related E.S.R.) of the capacitor under evaluation should be measured and compared with specification data, taking in consideration the typical range of values that different units of the same lot and different lots of the same type may reasonably have.
In addition to working conditions in terms of electrical parameters, particular attention must be paid to the correct installation of the capacitor and its position on PCB and in the equipment.
Capacitors shall be placed where there is adequate dissipation by convection and radiation of the heat produced by capacitor losses.
The ventilation of the environment and the placement of the capacitor units shall provide good air circulation around each unit.
This is particularly important for units mounted in rows, one above the other.
Extra heating, even localized on parts of the capacitor body, could be caused by other components or parts in the immediate surroundings either as a consequence of their heating or as a consequence of strong magnetic fields inducing alternating magnetization and currents in metal parts.
Capacitors should be situated at a safe distance from heavy current conductors.
The influence of other components near to the capacitor under operating conditions must be always carefully evaluated.

C6- Components fitting on PCBs and arrangement in equipments layout

Dimensional tolerances must be taken in consideration when designing capacitors fitting on PCBs and in the equipments.

The fitting of capacitors on PCBs and their arrangements in equipments lay-outs with touching bodies or body faces in contact one with the other must be absolutely avoided, expecially if capacitors are positioned in rows, one above the other.
Inadequate distance between units would not allow the correct capacitors heat dissipation and cooling, expecially in case of power applications and in equipments where components are submitted to sensible heating.
The contact between capacitors body may also cause phisical damage in case of mechanical stresses (vibrations, shocks) and small settlements of the units body which may occur at high temperature or in particular ambient conditions.

As a general indication, the suggested minimum distance between side by side elements should be at least about 1/12 of the diameter or thickness in case of axial leads components and at least about 1/8 of the thickness in case of radial leads capacitors and capacitors in box with lug terminals.

C7- Vibrations and mechanical shocks

Capacitor fixing method is very important in order to minimize detrimental effects due to vibrations.
In particular, when foreseen application will submit capacitors to mechanical stresses, axial leaded capacitors shall be adequately fixed to PCBs and capacitors having lug terminals should be positioned in order to guarantee additional body support against vibrations, shocks and mechanical sollecitations, (elastic silicon gluing, fixing bands etc.), expecially for units having big size and weigth.
Radial in box capacitors must rest onto PCBs surface (capacitor mounted on PCB with its supporting area in contact with PCB surface).
If not differently declared or stated by normatives taken as a reference in series specifications, the vibrations withstanding for radial in box capacitors is in accordance with IEC 62-2-6 (test Fc, sinusoidal vibration):

f= 10÷500Hz for leads pitch $P \leq 22.5$mm
f= 10÷55Hz for leads pitch $P > 22.5$mm

3 x 2 hours with 0.75mm amplitude (below 57.6Hz) or 98m/s^2 (above 57.6Hz), applied in three orthogonal axis
No visible damage, no open or short circuit admitted.

C8- Connections

The current leads into the capacitors (expecially when they are high section lugs, blades and so on) are capable to dissipating heat from the unit but they could possibly transfer heat generated in outer connections into the capacitor.
For this reason it is necessary to keep the connections leading to the capacitors cooler than the capacitor itself.

Special care is necessary when designing circuits with capacitors connected in parallel or in series.
In parallel connections, the current splitting depends on slight differences of resistances and inductances in the current paths, then one of the capacitors may be easily overloaded.
Moreover, when one capacitor fails by short-circuit or simply self-heal, the complete energy of the bank will be rapidly dissipated at the breakdown / clearing point with possible distruction of the unit.
In series connections, because of variations in the circulation resistances of units, the correct voltage division between capacitors should be ensured by resistive voltage dividers.
The insulation voltage of the single units shall be appropriate for the series arrangement.

C9- Across the line and interference suppression applications

This type of capacitors is permanently submitted to mains voltage and additional surge or high pulse stress typical of this kind of application.
For this reason, the capacitor must have an high safety margin, in conformity with related reference standards (EN134200, IEC60384-14 etc.).
For safety reasons the use of approved components in conformity with the above mentioned standards is suggested.
In case of across the line application with pulses having Vpp exceeding 630V (for up to 275Vac rated capacitors) the use of additional surge suppressors in parallel to the capacitor is suggested.

C10- Special working conditions

Following special working conditions must be carefully evaluated before using a capacitor in the application.

Humid ambient: a capacitor used for a long time in a humid ambient might absorb humidity with gradual electrodes oxidation and medium-long term capacitor damage or failure.
Moreover, the capacitor gradually modifies its characteristics according to environmental operating conditions.
The size of modifications and the speed of the process depends on the kind of dielectric, design and protecting materials; a certain capacitance variation takes place as a consequence of air humidity (the capacitance value typically encreases with the encrease of the environment humidity).
This should be taken in account when units are supposed to be used in tropical countries.

Sealing resins: chemical and thermal effects due to capacitors embedding in resins and curing process must be taken into account. Solvents contained in the resin migth cause capacitor characteristics deterioration and phisical damage to protection materials.
The heat generated in the resin mass during polymerization process may bring to high temperatures and the resin shrinking during hardening might also cause leads breaks or physical damage to the capacitor.

Adhesive curing: the resin used to glue SMD components might cause damage to capacitors dielectric (in particular to polypropylene film) if they are cured in the same oven, expecially when long curing time is combined with the heat necessary for the curing process.
When polypropylene capacitors are used with SMD components, they must be fit after the SMD gluing process.

Rapid mould growth, corrosive atmosphere and ambients with an high degree of pollution: carefully evaluate operating conditions which may cause capacitors damage or accelerated ageing.

Operating Altitude: capacitors used at big altitudes are subjected to special operating conditions. For power capacitors the maximum allowable altitude is 2200 meters.

Following further unusual service conditions and misapplications may cause failures: superimposed radiofrequency voltages (units not suitable for radio interference suppression), unusual vibrations, bumps of mechanical shocks, abrasive particles, corrosive substances, explosive or conducting dust in cooling air and oil or water vapours, explosive gas or substances, radioactivity, rapid or excessive humidity or temperature changes of working ambient, unusual transportation or storage temperature and environmental conditions.

D-Storage conditions / Standard environmental conditions

In order to minimize the units ageing and electrical parameters variation before the units real use in the application, it is suggested to avoid capacitors storage where environmental conditions are different from the following (standard environmental conditions):

Temperature: +15°C ÷ +35°C (ideal), up to +5°C ÷ +50°C admitted.
Humidity (+25°C): average per year≤ 60%, 30 days random distributed throughout the year≤ 80%, other days≤ 70%, dew not admitted.
These humidity levels should be reduced at ambient temperatures≥ +25°C, of about 15% for every 5°C of ambient temperature increase, up to +50°C max.

Note: service life must be considered as the sum of operating hours, operating breaks, storage and testing time at users / customers facility and transport times.

E-Printing

If not otherwise stated by reference normatives or approvals related to capacitors series, typical printing data shown on capacitor body are:

- ICEL trade mark or name
- Series or type
- Rated capacitance and measuring unit
- Tolerance on capacitance (shown in % or with correspondent code)
- Rated voltage
- Manufacturing date codes according to DIN41314 and IEC60062:

Year code:				Month code:			
1995=	F	2001=	N	January=	1	July=	7
1996=	H	2002=	P	February=	2	August=	8
1997=	J	2003=	R	March=	3	September=	9
1998=	K	2004=	S	April=	4	October=	O
1999=	L	2005=	T	May=	5	November=	N
2000=	M	2006=	U	June=	6	December=	D

(example: capacitors manufactured in June 99 code= L6)

In addition to above listed data, following additional printing are typically shown on approved series:

- Operating temperature range or climatic class
- Self-healing property
- Protection class
- Expected life class
- Operating frequency
- Approval references and approval Marks

Some of the above mentioned data may be lacking when capacitors dimensions or available printing surfaces do not allow a complete data marking.

Warning: the printing is usually made on capacitors body with dark ink, resistant to the main part of common solvents (like alcohol, fluorhydro-carbons and their mixtures) used for PCBs washing and flux residues removal.
Particularly aggressive solvents and cleaning agents based on chloroydro-carbons or ketones must not be used since they may damage the capacitors and their coating materials.
In particular, any substance containing ketones will cause printing melting.
Moreover also some kind of protecting and tropicalizating varnishes may cause printing melting and capacitors damage.
For this reason, before applying any varnish or protecting liquid or solvent onto capacitors surface, do test its effect on markings and coating materials. It is recommended to carefully dry the components after the cleaning.

F-General Warning

Not respecting specifications and parameters limits, improper installation, use or application of ICEL products might cause damage to the components, their characteristics modification and a decrease of their reliability and expected life.
This could bring to dangerous failures which may cause the destruction of the components and of the equipments where they are used, smoke, fire and explosion danger.

Before using ICEL products in any application, please read carefully the related specifications and all the information included in this catalogue.
Information and data contained in the chapter "General technical information", must be considered as a completing part of the single series specifications.

Overstressing and overheating shorten the life of a capacitor, therefore the operating conditions (like temperature, voltage, installation, operation and so on) should be strictly controlled.
Be sure that the component is proper for your application, that the application parameters do not overcome the limits stated at related specification and that all Warnings and instructions for use are correctly followed.
Do check in the intended application and operating conditions of the component before using it in any product or equipment, to ensure that the component is proper for your application.

In case of doubt about service conditions and correspondent capacitors characteristics and performances, or in case of application not foreseen or working parameters not stated at capacitors specifications, ICEL Technical Office must be consulted (refer to "Application data questionnaire").

Products manufactured by ICEL are made with maximum attention to quality, in order to be free from difects in design, materials and workmanship, following related series specifications and applicable national and international normatives.

A main aim of ICEL Q.A. system is the prevention of defects occuring.
Cooperation between ICEL and customers is foundamental in order to solve any problem or failure occurring.
In particular, the tempestive communication of following main information will help ICEL to quickly respond to any complaint you may have:

- detailed description of failure / problem
- when and how the failure / problem was detected
- operating conditions and application description
- operating time before the failure / problem occurring
- number of defectives and their percentage on total quntity used / supplied
- original supplied lots data (production date, delivery date, qty. etc.)
- any additional information about particular conditions which may have been associated with failure / problem occurring

Samples of defectives, if available, should be sent to ICEL for analisys, clearly identified and possibly separated by other "good" units or units damaged for other reasons, packed in order to prevent any additional damage different from the originally detected failure / problem.

ICEL liability shall be limited to replacement or repair free of charge, provided that notification of failures or difects is given to ICEL immediately when the same becoming apparent and after that returning conditions have been agreed with the customer or buyer and ICEL has analized the defectives and authorized the returning of goods.
ICEL liability is limited to a period of 12 months from the date of shipment to the customer or buyer.
ICEL is not responsible for any possible damages to persons or things, of any kind, derived from improper installation, use or application of ICEL products.
ICEL shall not be liable for any defect which is due to accident, fair wear and tear, negligent use, tampering, improper handling, improper use, operation or storage or any other default on the parts of any person other then ICEL.
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In case of any product liability claim from third parties against ICEL, not falling within ICEL liability in accordance with above statements, customer or buyer shall hold ICEL harmless.

G-Updating and validity of product specifications

Being given for general information, all drawings, descriptions, characteristics, materials and performance data given by ICEL are as accurate as possible but are not binding on ICEL, unless specifically agreed in writing.

Unless otherwise stated, dimensions and materials may be subjected to reasonable variations due to available raw materials or normal manufacturing process tolerances.

Data and characteristics shown in this catalogue are subjected to modifications without notice.
Refer to ICEL web site information for updated characteristics and last revision specifications available.

General technical information

H-Application Data Questionnaire

In order to help ICEL Technical Office to correctly individuate the component suitable for your needs, please fill this questionnaire, giving us all the available information about the application and the working conditions.

Capacitance (1kHz): Tolerance (%):

Resistor value (Ω, for RC networks only): Resistor power (W, for RC networks only):

Rated DC voltage (Vdc): Operating DC voltage (Vdc):

Rated AC voltage (Vac): Operating AC voltage (Vac):

Repetitive Peak voltage (Vdc): Non Repetitive Peak voltage (Vdc):

Operating frequency (Hz):

Irms max.(A): , at frequency= Hz, at temperature= °C

Max. Pulse Rise Time (V/µs): Max. Repetitive Peak Current (A):

Max. Non Repetitive Peak Current (A):

Pulse width (s): Pulse repetition frequency (Hz):

Max. Dissipation Factor (x10^{-4}): tgd= at frequency= Hz; tgd= at frequency= Hz

Max. E.S.R.(mΩ): at frequency= Hz; at frequency= Hz

Insulation Resistance at+25°C (MΩ): after1 minute at Vdc

Operation: continuous |_| Intermittent |_| with Cycle duration / Duty cycle:

Test voltage between leads: Vdc |_| / Vac |_|, for s, notes:

Test voltage between leads and case: Vdc |_| / Vac |_|, for s, notes:

Max. rated operating temperature (°C): Min. rated operating temperature (°C):

Max. ambient temperature (°C): Min. ambient temperature (°C):

Cooling: natural |_|; forced |_|, notes:

Climatic category (IEC60068-1 cold test / heat test / damp heat duration): / /

Ambient operating humidity conditions:

Other critical operating conditions:

Expected life (h): Failure rate (x10^{-9} component hours):

Reference conditions: voltage applied= ; temperature= ; others=

Failure modes:

Preferred execution: axial cylindrical |_|, axial flat |_|, radial dipped |_|, radial in box |_|, radial with lugs |_|, other |_|

Notes:

Diameter (mm): , tolerance± mm Thickness (mm): , tolerance± mm

Heigth (mm): , tolerance± mm Length (mm): , tolerance± mm

Leads type: Leads dim. (mm): , tolerance± mm

Printing requirements:

Approvals:

Reference Normatives:

Packing requirements:

Reference / presently used components:

Additional technical information (please enclose drawings, schematic circuit diagram, voltage and current waveforms and application description if available):

Needed quantity: Foreseen order frequency:

Delivery terms: Target price:

Notes:

List of enclosed documents:

I-Capacitors selection guide

ICEL Capacitors Selection Guide	APPLICATIONS (X= recommended, O= possible choice)																			
	Blocking	Coupling and Decoupling (low pulse)	Bypassing	Filtering and frequency discrimination	Timing and oscillation	Deflection monitor circuits	High DC voltage operation and voltage multipliers	General purpose AC voltage operation	Motor running	High frequency ripple filtering	High current operation	High frequency operation	High pulse and pulse coupling / decoupling	Snubber in power semiconductor circuits	Clamper for IGBT and MOSFET	Resonance (low power)	Resonance (medium power)	Interference suppression	Audio	Measurement and high stability circuits
MWR-MWF	X	X	X	X	O				O*										X	
MSR	X	X	X	X	O														X	
MSM-MTB-MSB	X	X	X	X	O				O*										X	
MWS						X	X													
PW					O							X	X							X
PWS						X	O				O	X	X	X					O	
MPW-MPF	X	X	X	X	X														X	
MPB	X	X	X	X	X														X	
MPL	O	O	O	X	X															X
MPH	X*	X*	X*	X*						X	X	X			X	X			X	
PHC	X*	X*	X*	X*				O	O	X	X	X			X				X	
PHB	X*	X*	X*	X*				O	O	X	X	X			X	X			X	
PMC	X*	X*	X*							X	X	X			X		X			
PPS	X°	X°	X°	X°			O	X	O	X	X	X	O	O	X				X	
PHS	X°	X°	X°	X°			O	X	O	X	X	X	O	O	X	X			X	
PMS	X°	X°	X°							X	X	X	O	O	X		X			
PPA	X^	X^	X^			X	O	O		O	X	X	X	X	X					
PSB	X^	X^	X^			X	O	O		O	X	X	X	X	X	X				
PMB	X^	X^	X^							O	X	X	X	X	X		X			
PPB	X^	X^	X^			X	O	O		O	O	X	X	X	O					
CW					O							X	X							X
MCW-MCF	O	O	O	X	X															O
MCB	O	O	O	X	X															O
MCL	O	O	O	X	X															X
MAB								X	X	O					O			O		
XMB								O										X		
N1-N3														O				X		

Notes:
X*= high frequency applications
X°= high frequency / medium-high pulse applications
X^= high frequency / high pulse applications
O*= very low AC voltage and high Cap. value