

**Overview**

KEMET's ESK Series of aluminum electrolytic radial capacitors are designed for high-density printed circuit boards.

**Applications**

Typical applications include general purpose coupling, decoupling, bypass and filtering.

**Benefits**

- Operating temperature of up to 85°C
- 2,000 hour operating life
- Case diameters 5 – 22 mm
- Safety vent on the capacitor base



**Part Number System**

ESK	226	M	6R3		A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)		Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63	100 = 100 160 = 160 200 = 200 250 = 250 350 = 350 400 = 400 450 = 450 500 = 500	A = Standard	See Dimension Table	See Ordering Options Table

## Ordering Options Table

Diameter	Packaging Type	Lead Type	Lead Length (mm)	Lead and Packaging Code
Standard Bulk Packaging Options				
4 – 22	Bulk (bag)	Straight	20/15 Minimum	AA
Standard Auto-Insertion Packaging Options				
4 – 5	Tape & Reel	Formed to 2.5 mm	$H_0 = 16.5 \pm 0.75$	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	KA
8	Tape & Reel	Formed to 5 mm	$H_0 = 16.5 \pm 0.75$	JA
10 – 13	Ammo	5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	EA
16	Ammo	7.5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	EA
Other Packaging Options				
4 – 8	Ammo	Formed to 5 mm	$H_0 = 16.5 \pm 0.75$	DA
10	Ammo	5 mm Lead Spacing	$H_0 = 16.5 \pm 0.75$	DA
4 – 8	Ammo	Straight	$H_0 = 18.5 \pm 0.75$	EA
4 – 5	Ammo	Formed to 2.5 mm	$H_0 = 16.5 \pm 0.75$	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	$H_0 = 16.5 \pm 0.75$	JA
4 – 5, 8 – 16	Tape & Reel	Straight	$H_0 = 18.5 \pm 0.75$	KA
Contact KEMET for other Lead and Packaging options				

## Environmental Compliance

As an environmentally conscious company, KEMET is working continuously with improvements concerning the environmental effects of both our capacitors and their production. In Europe (RoHS Directive) and in some other geographical areas like China, legislation has been put in place to prevent the use of some hazardous materials, such as lead (Pb), in electronic equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes any necessary changes in its products, whenever needed.

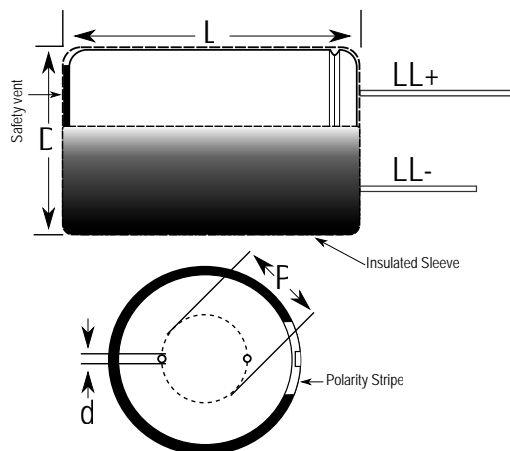
Some customer segments such as medical, military and automotive electronics may still require the use of lead in electrode coatings. To clarify the situation and distinguish products from each other, a special symbol is used on the packaging labels for RoHS compatible capacitors.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.



RoHS Compliant

## Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
C3	5	$\pm 0.5$	11	$+1.5/-0$	2	$\pm 0.5$	0.5	Nominal	20/15	Minimum
E3	6.3	$\pm 0.5$	11	$+1.5/-0$	2.5	$\pm 0.5$	0.5	Nominal	20/15	Minimum
G3	8	$\pm 0.5$	11	$+1.5/-0$	3.5	$\pm 0.5$	0.5	Nominal	20/15	Minimum
G4	8	$\pm 0.5$	15	$+2.0/-0$	3.5	$\pm 0.5$	0.5	Nominal	20/15	Minimum
H1	10	$\pm 0.5$	12	$+1.5/-0$	5	$\pm 0.5$	0.6	Nominal	20/15	Minimum
H2	10	$\pm 0.5$	16	$+2.0/-0$	5	$\pm 0.5$	0.6	Nominal	20/15	Minimum
H4	10	$\pm 0.5$	20	$+2.0/-0$	5	$\pm 0.5$	0.6	Nominal	20/15	Minimum
L3	13	$\pm 0.5$	20	$+2.0/-0$	5	$\pm 0.5$	0.6	Nominal	20/15	Minimum
L4	13	$\pm 0.5$	25	$+2.0/-0$	5	$\pm 0.5$	0.6	Nominal	20/15	Minimum
M7	16	$\pm 0.5$	25	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
M2	16	$\pm 0.5$	32	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
M3	16	$\pm 0.5$	36	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
N4	18	$\pm 0.5$	20	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
N1	18	$\pm 0.5$	32	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
N2	18	$\pm 0.5$	36	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
N3	18	$\pm 0.5$	40	$+2.0/-0$	7.5	$\pm 0.5$	0.8	Nominal	20/15	Minimum
Q3	22	$\pm 0.5$	35	$+2.0/-0$	10	$\pm 0.5$	0.8	Nominal	20/15	Minimum
Q4	22	$\pm 0.5$	40	$+2.0/-0$	10	$\pm 0.5$	0.8	Nominal	20/15	Minimum

## Performance Characteristics

Item	Performance Characteristics	
Capacitance Range	0.1 – 22,000 $\mu$ F	0.47 – 470 $\mu$ F
Capacitance Tolerance	$\pm$ 20% at 120 Hz / 20°C	
Rated Voltage	6.3 – 100 VDC	160 – 450 VDC
Life Test	2,000 hours (see conditions in Test Methods & Performance)	
Operating Temperature	-40°C to +105°C	-25°C to +85°C
Leakage Current	$I \leq 0.01 CV$ (mA) or 3 mA, whichever is greater	$I = 0.03 CV$ (mA) + 10 mA
C = rated capacitance ( $\mu$ F), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.		

## Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	Capacitance Range ( $\mu$ F)	50 Hz	120 Hz	300 Hz	1 kHz	10 to 100 kHz
6.3 – 100	0.1 – 68	0.75	1.00	1.20	1.30	1.45
6.3 – 100	100 – 680	0.75	1.00	1.10	1.15	1.25
6.3 – 100	1,000 – 22,000	0.75	1.00	1.05	1.10	1.15
160 – 450	0.47 – 220	0.80	1.00	1.25	1.40	1.40
160 – 450	330 – 470	0.80	1.00	1.10	1.13	1.15

## Compensation Factor of Ripple Current (RC) vs. Temperature

Temperature	50°C	70°C	85°C
Coefficient	1.30	1.15	1.00

## Test Method & Performance

Conditions	Load Life Test	Shelf Life Test
Temperature	85°C	85°C
Test Duration	2,000 hours	1,000 hours
Ripple Current	Maximum ripple current specified at 120 Hz 85°C	No ripple current applied
Voltage	The sum of DC voltage and the peak AC voltage must not exceed the rated voltage of the capacitor.	No voltage applied
<b>Performance</b>	<b>The following specifications will be satisfied when the capacitor is restored to 20°C:</b>	
Capacitance Change	Within $\pm$ 20% of the initial value	
Dissipation Factor	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

**Table 1 – Ratings & Part Number Reference**

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
6.3	8	22	5 x 11	22	35	ESK226M6R3AC3(1)
6.3	8	33	5 x 11	22	55	ESK336M6R3AC3(1)
6.3	8	47	5 x 11	22	75	ESK476M6R3AC3(1)
6.3	8	100	5 x 11	22	130	ESK107M6R3AC3(1)
6.3	8	220	5 x 11	22	200	ESK227M6R3AC3(1)
6.3	8	220	6 x 11	22	240	ESK227M6R3AE3(1)
6.3	8	330	6 x 11	22	260	ESK337M6R3AE3(1)
6.3	8	330	8 x 11	22	300	ESK337M6R3AG3(1)
6.3	8	470	6 x 11	22	330	ESK477M6R3AE3(1)
6.3	8	470	8 x 11	22	380	ESK477M6R3AG3(1)
6.3	8	1000	8 x 11	22	460	ESK108M6R3AG3(1)
6.3	8	1000	10 x 12	22	580	ESK108M6R3AH1(1)
6.3	8	2200	10 x 20	22	840	ESK228M6R3AH4(1)
6.3	8	2200	13 x 20	22	1050	ESK228M6R3AL3(1)
6.3	8	3300	10 x 20	22	1000	ESK338M6R3AH4(1)
6.3	8	3300	13 x 20	22	1250	ESK338M6R3AL3(1)
6.3	8	4700	13 x 20	22	1300	ESK478M6R3AL3(1)
6.3	8	4700	16 x 25	22	1700	ESK478M6R3AM7(1)
6.3	8	6800	16 x 25	22	1900	ESK688M6R3AM7(1)
6.3	8	10000	16 x 25	22	1900	ESK109M6R3AM7(1)
6.3	8	10000	16 x 32	22	2250	ESK109M6R3AM2(1)
6.3	8	15000	16 x 36	22	2500	ESK159M6R3AM3(1)
6.3	8	15000	18 x 36	22	2880	ESK159M6R3AN2(1)
6.3	8	22000	18 x 40	22	3650	ESK229M6R3AN3(1)
10	13	4.7	5 x 11	19	20	ESK475M010AC3(1)
10	13	10	5 x 11	19	35	ESK106M010AC3(1)
10	13	22	5 x 11	19	55	ESK226M010AC3(1)
10	13	33	5 x 11	19	80	ESK336M010AC3(1)
10	13	47	5 x 11	19	95	ESK476M010AC3(1)
10	13	100	5 x 11	19	180	ESK107M010AC3(1)
10	13	220	5 x 11	19	230	ESK227M010AC3(1)
10	13	220	6 x 11	19	250	ESK227M010AE3(1)
10	13	330	8 x 11	19	330	ESK337M010AG3(1)
10	13	470	6 x 11	19	360	ESK477M010AE3(1)
10	13	470	8 x 11	19	400	ESK477M010AG3(1)
10	13	680	8 x 15	19	430	ESK687M010AG4(1)
10	13	680	10 x 16	19	460	ESK687M010AH2(1)
10	13	1000	10 x 12	19	580	ESK108M010AH1(1)
10	13	1000	10 x 16	19	630	ESK108M010AH2(1)
10	13	2200	10 x 20	19	880	ESK228M010AH4(1)
10	13	2200	13 x 20	19	1100	ESK228M010AL3(1)
10	13	3300	13 x 20	19	1250	ESK338M010AL3(1)
10	13	3300	13 x 25	19	1400	ESK338M010AL4(1)
10	13	4700	13 x 25	19	1500	ESK478M010AL4(1)
10	13	4700	16 x 25	19	1800	ESK478M010AM7(1)
10	13	6800	16 x 25	19	1900	ESK688M010AM7(1)
10	13	6800	16 x 32	19	2150	ESK688M010AM2(1)
10	13	10000	16 x 36	19	2500	ESK109M010AM3(1)
10	13	10000	18 x 36	19	2500	ESK109M010AN2(1)
10	13	15000	18 x 36	19	2950	ESK159M010AN2(1)
10	13	22000	22 x 40	19	3700	ESK229M010AQ4(1)
16	20	1.0	5 x 11	16	9.3	ESK105M016AC3(1)
16	20	4.7	5 x 11	16	25	ESK475M016AC3(1)
16	20	10	5 x 11	16	40	ESK106M016AC3(1)
16	20	22	5 x 11	16	75	ESK226M016AC3(1)
16	20	33	5 x 11	16	110	ESK336M016AC3(1)
16	20	47	5 x 11	16	130	ESK476M016AC3(1)
16	20	100	5 x 11	16	185	ESK107M016AC3(1)
16	20	100	6 x 11	16	185	ESK107M016AE3(1)
16	20	220	6 x 11	16	320	ESK227M016AE3(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	RC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.

\* When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.

**Table 1 – Ratings & Part Number Reference cont'd**

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
16	20	220	8 x 11	16	320	ESK227M016AG3(1)
16	20	330	8 x 11	16	360	ESK337M016AG3(1)
16	20	470	8 x 11	16	400	ESK477M016AG3(1)
16	20	470	10 x 12	16	470	ESK477M016AH1(1)
16	20	680	10 x 16	16	560	ESK687M016AH2(1)
16	20	1000	10 x 16	16	630	ESK108M016AH2(1)
16	20	1000	10 x 20	16	790	ESK108M016AH4(1)
16	20	2200	13 x 20	16	1100	ESK228M016AL3(1)
16	20	2200	13 x 25	16	1350	ESK228M016AL4(1)
16	20	3300	13 x 25	16	1400	ESK338M016AL4(1)
16	20	3300	16 x 25	16	1700	ESK338M016AM7(1)
16	20	4700	16 x 25	16	1800	ESK478M016AM7(1)
16	20	4700	16 x 32	16	2100	ESK478M016AM2(1)
16	20	6800	16 x 36	16	2200	ESK688M016AM3(1)
16	20	6800	18 x 36	16	2500	ESK688M016AN2(1)
16	20	10000	18 x 36	16	2700	ESK109M016AN2(1)
16	20	15000	22 x 40	16	3150	ESK159M016AQ4(1)
16	20	22000	22 x 40	16	3800	ESK229M016AQ4(1)
25	32	4.7	5 x 11	14	30	ESK475M025AC3(1)
25	32	10	5 x 11	14	50	ESK106M025AC3(1)
25	32	22	5 x 11	14	90	ESK226M025AC3(1)
25	32	33	5 x 11	14	115	ESK336M025AC3(1)
25	32	47	5 x 11	14	135	ESK476M025AC3(1)
25	32	100	6 x 11	14	200	ESK107M025AE3(1)
25	32	220	8 x 11	14	290	ESK227M025AG3(1)
25	32	220	10 x 12	14	340	ESK227M025AH1(1)
25	32	330	8 x 15	14	380	ESK337M025AG4(1)
25	32	330	10 x 12	14	420	ESK337M025AH1(1)
25	32	330	10 x 16	14	420	ESK337M025AH2(1)
25	32	470	10 x 12	14	460	ESK477M025AH1(1)
25	32	470	10 x 16	14	540	ESK477M025AH2(1)
25	32	1000	10 x 20	14	760	ESK108M025AH4(1)
25	32	1000	13 x 20	14	950	ESK108M025AL3(1)
25	32	2200	13 x 25	14	1300	ESK228M025AL4(1)
25	32	2200	16 x 25	14	1550	ESK228M025AM7(1)
25	32	3300	16 x 25	14	1660	ESK338M025AM7(1)
25	32	3300	16 x 32	14	1950	ESK338M025AM2(1)
25	32	4700	16 x 32	14	1950	ESK478M025AM2(1)
25	32	4700	18 x 36	14	2360	ESK478M025AN2(1)
25	32	6800	18 x 36	14	2550	ESK688M025AN2(1)
25	32	10000	22 x 40	14	2800	ESK109M025AQ4(1)
25	32	15000	22 x 40	14	3200	ESK159M025AQ4(1)
35	44	4.7	5 x 11	12	35	ESK475M035AC3(1)
35	44	10	5 x 11	12	60	ESK106M035AC3(1)
35	44	22	5 x 11	12	95	ESK226M035AC3(1)
35	44	33	5 x 11	12	120	ESK336M035AC3(1)
35	44	47	5 x 11	12	120	ESK476M035AC3(1)
35	44	47	6 x 11	12	140	ESK476M035AE3(1)
35	44	100	6 x 11	12	200	ESK107M035AE3(1)
35	44	100	8 x 11	12	230	ESK107M035AG3(1)
35	44	220	8 x 11	12	290	ESK227M035AG3(1)
35	44	220	10 x 12	12	370	ESK227M035AH1(1)
35	44	330	10 x 12	12	420	ESK337M035AH1(1)
35	44	330	10 x 16	12	490	ESK337M035AH2(1)
35	44	470	10 x 16	12	480	ESK477M035AH2(1)
35	44	470	10 x 20	12	510	ESK477M035AH4(1)
35	44	470	13 x 20	12	640	ESK477M035AL3(1)
35	44	1000	13 x 20	12	950	ESK108M035AL3(1)
35	44	1000	13 x 25	12	1100	ESK108M035AL4(1)
35	44	2200	16 x 25	12	1600	ESK228M035AM7(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	RC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.

\* When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.

**Table 1 – Ratings & Part Number Reference cont'd**

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
35	44	2200	16 x 32	12	1800	ESK228M035AM2(1)
35	44	3300	16 x 36	12	1970	ESK338M035AM3(1)
35	44	3300	18 x 36	12	2220	ESK338M035AN2(1)
35	44	4700	18 x 36	12	2400	ESK478M035AN2(1)
35	44	6800	22 x 40	12	2600	ESK688M035AQ4(1)
50	63	0.1	5 x 11	10	1	ESK104M050AC3(1)
50	63	0.22	5 x 11	10	2	ESK224M050AC3(1)
50	63	0.33	5 x 11	10	3	ESK334M050AC3(1)
50	63	0.47	5 x 11	10	5	ESK474M050AC3(1)
50	63	1	5 x 11	10	10	ESK105M050AC3(1)
50	63	2.2	5 x 11	10	23	ESK225M050AC3(1)
50	63	3.3	5 x 11	10	35	ESK335M050AC3(1)
50	63	4.7	5 x 11	10	40	ESK475M050AC3(1)
50	63	10	5 x 11	10	65	ESK106M050AC3(1)
50	63	22	5 x 11	10	100	ESK226M050AC3(1)
50	63	33	6 x 11	10	125	ESK336M050AE3(1)
50	63	47	6 x 11	10	140	ESK476M050AE3(1)
50	63	47	8 x 11	10	150	ESK476M050AG3(1)
50	63	100	8 x 11	10	230	ESK107M050AG3(1)
50	63	100	10 x 12	10	250	ESK107M050AH1(1)
50	63	220	10 x 12	10	360	ESK227M050AH1(1)
50	63	220	10 x 16	10	440	ESK227M050AH2(1)
50	63	330	10 x 16	10	490	ESK337M050AH2(1)
50	63	330	10 x 20	10	580	ESK337M050AH4(1)
50	63	470	10 x 20	10	610	ESK477M050AH4(1)
50	63	470	13 x 20	10	760	ESK477M050AL3(1)
50	63	1000	13 x 25	10	1100	ESK108M050AL4(1)
50	63	1000	16 x 25	10	1350	ESK108M050AM7(1)
50	63	2200	16 x 36	10	1850	ESK228M050AM3(1)
50	63	2200	18 x 36	10	2090	ESK228M050AN2(1)
50	63	3300	18 x 36	10	2170	ESK338M050AN2(1)
50	63	3300	18 x 40	10	2400	ESK338M050AN3(1)
50	63	4700	22 x 35	10	2500	ESK478M050AQ3(1)
50	63	4700	22 x 40	10	2500	ESK478M050AQ4(1)
63	79	0.47	5 x 11	9	5	ESK474M063AC3(1)
63	79	1.0	5 x 11	9	10	ESK105M063AC3(1)
63	79	2.2	5 x 11	9	29	ESK225M063AC3(1)
63	79	3.3	5 x 11	9	40	ESK335M063AC3(1)
63	79	4.7	5 x 11	9	45	ESK475M063AC3(1)
63	79	10	5 x 11	9	70	ESK106M063AC3(1)
63	79	22	6 x 11	9	115	ESK226M063AE3(1)
63	79	33	6 x 11	9	130	ESK336M063AE3(1)
63	79	33	8 x 11	9	140	ESK336M063AG3(1)
63	79	47	6 x 11	9	190	ESK476M063AE3(1)
63	79	47	8 x 11	9	190	ESK476M063AG3(1)
63	79	100	10 x 12	9	300	ESK107M063AH1(1)
63	79	220	10 x 16	9	410	ESK227M063AH2(1)
63	79	220	10 x 20	9	490	ESK227M063AH4(1)
63	79	330	10 x 20	9	540	ESK337M063AH4(1)
63	79	330	13 x 20	9	680	ESK337M063AL3(1)
63	79	470	13 x 25	9	880	ESK477M063AL4(1)
63	79	1000	16 x 25	9	1310	ESK108M063AM7(1)
63	79	1000	16 x 32	9	1550	ESK108M063AM2(1)
63	79	2200	18 x 40	9	2200	ESK228M063AN3(1)
63	79	3300	22 x 40	9	2500	ESK338M063AQ4(1)
100	125	1.0	5 x 11	8	21	ESK105M100AC3(1)
100	125	2.2	5 x 11	8	30	ESK225M100AC3(1)
100	125	3.3	5 x 11	8	45	ESK335M100AC3(1)
100	125	4.7	5 x 11	8	50	ESK475M100AC3(1)
100	125	10	6 x 11	8	75	ESK106M100AE3(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	RC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.

\* When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.

**Table 1 – Ratings & Part Number Reference cont'd**

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
100	125	22	8 x 11	8	130	ESK226M100AG3(1)
100	125	33	8 x 11	8	140	ESK336M100AG3(1)
100	125	33	10 x 12	8	170	ESK336M100AH1(1)
100	125	47	10 x 12	8	190	ESK476M100AH1(1)
100	125	47	10 x 16	8	230	ESK476M100AH2(1)
100	125	100	10 x 20	8	400	ESK107M100AH4(1)
100	125	220	13 x 25	8	710	ESK227M100AL4(1)
100	125	330	13 x 25	8	720	ESK337M100AL4(1)
100	125	330	16 x 25	8	860	ESK337M100AM7(1)
100	125	470	16 x 25	8	1100	ESK477M100AM7(1)
100	125	1000	16 x 32	8	1350	ESK108M100AM2(1)
100	125	1000	18 x 40	8	1680	ESK108M100AN3(1)
100	125	2200	22 x 40	8	2300	ESK228M100AQ4(1)
160	200	0.47	5 x 11	15	12	ESK474M160AC3(1)
160	200	1.0	5 x 11	15	17	ESK105M160AC3(1)
160	200	2.2	6 x 11	15	26	ESK225M160AE3(1)
160	200	3.3	6 x 11	15	30	ESK335M160AE3(1)
160	200	3.3	8 x 11	15	35	ESK335M160AG3(1)
160	200	4.7	6 x 11	15	32	ESK475M160AE3(1)
160	200	4.7	8 x 11	15	40	ESK475M160AG3(1)
160	200	10	8 x 11	15	50	ESK106M160AG3(1)
160	200	10	10 x 12	15	65	ESK106M160AH1(1)
160	200	22	10 x 16	15	110	ESK226M160AH2(1)
160	200	33	10 x 20	15	150	ESK336M160AH4(1)
160	200	47	13 x 20	15	180	ESK476M160AL3(1)
160	200	100	13 x 25	15	250	ESK107M160AL4(1)
160	200	100	16 x 25	15	300	ESK107M160AM7(1)
160	200	220	16 x 32	15	450	ESK227M160AM2(1)
160	200	220	16 x 36	15	510	ESK227M160AM3(1)
160	200	330	18 x 36	15	540	ESK337M160AN2(1)
160	200	330	18 x 40	15	600	ESK337M160AN3(1)
160	200	470	22 x 40	15	900	ESK477M160AQ4(1)
200	250	0.47	5 x 11	15	14	ESK474M200AC3(1)
200	250	1.0	5 x 11	15	19	ESK105M200AC3(1)
200	250	2.2	6 x 11	15	22	ESK225M200AE3(1)
200	250	2.2	8 x 11	15	27	ESK225M200AG3(1)
200	250	3.3	6 x 11	15	30	ESK335M200AE3(1)
200	250	3.3	8 x 11	15	37	ESK335M200AG3(1)
200	250	4.7	8 x 11	15	36	ESK475M200AG3(1)
200	250	4.7	10 x 12	15	45	ESK475M200AH1(1)
200	250	10	10 x 12	15	57	ESK106M200AH1(1)
200	250	10	10 x 16	15	70	ESK106M200AH2(1)
200	250	22	10 x 16	15	120	ESK226M200AH2(1)
200	250	33	10 x 20	15	160	ESK336M200AH4(1)
200	250	47	13 x 20	15	160	ESK476M200AL3(1)
200	250	47	13 x 25	15	190	ESK476M200AL4(1)
200	250	100	16 x 25	15	330	ESK107M200AM7(1)
200	250	220	18 x 32	15	600	ESK227M200AN1(1)
200	250	220	18 x 36	15	600	ESK227M200AN2(1)
200	250	330	18 x 36	15	800	ESK337M200AN2(1)
200	250	330	18 x 40	15	800	ESK337M200AN3(1)
200	250	470	18 x 40	15	1000	ESK477M200AN3(1)
250	300	0.47	5 x 11	15	14	ESK474M250AC3(1)
250	300	1.0	6 x 11	15	19	ESK105M250AE3(1)
250	300	2.2	6 x 11	15	24	ESK225M250AE3(1)
250	300	2.2	8 x 11	15	30	ESK225M250AG3(1)
250	300	3.3	8 x 11	15	30	ESK335M250AG3(1)
250	300	3.3	10 x 12	15	38	ESK335M250AH1(1)
250	300	4.7	8 x 11	15	36	ESK475M250AG3(1)
250	300	4.7	10 x 12	15	45	ESK475M250AH1(1)
<b>VDC</b>	<b>VDC Surge</b>	<b>Rated Capacitance</b>	<b>Case Size</b>	<b>DF</b>	<b>RC</b>	<b>Part Number</b>

(1) Insert packaging code. See Ordering Options Table for available options.

\* When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.



**Table 1 – Ratings & Part Number Reference cont'd**

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
250	300	10	10 x 12	15	70	ESK106M250AH1(1)
250	300	10	10 x 16	15	70	ESK106M250AH2(1)
250	300	22	10 x 20	15	130	ESK226M250AH4(1)
250	300	33	13 x 20	15	140	ESK336M250AL3(1)
250	300	33	13 x 25	15	160	ESK336M250AL4(1)
250	300	47	13 x 25	15	210	ESK476M250AL4(1)
250	300	100	16 x 32	15	310	ESK107M250AM2(1)
250	300	220	18 x 40	15	600	ESK227M250AN3(1)
350	400	0.47	5 x 11	20	14	ESK474M350AC3(1)
350	400	1.0	6 x 11	20	19	ESK105M350AE3(1)
350	400	2.2	8 x 11	20	33	ESK225M350AG3(1)
350	400	3.3	8 x 11	20	33	ESK335M350AG3(1)
350	400	3.3	10 x 12	20	39	ESK335M350AH1(1)
350	400	4.7	10 x 12	20	39	ESK475M350AH1(1)
350	400	4.7	10 x 16	20	45	ESK475M350AH2(1)
350	400	10	10 x 16	20	70	ESK106M350AH2(1)
350	400	22	13 x 20	20	130	ESK226M350AL3(1)
350	400	33	13 x 25	20	170	ESK336M350AL4(1)
350	400	47	16 x 25	20	220	ESK476M350AM7(1)
350	400	100	18 x 36	20	360	ESK107M350AN2(1)
400	450	0.47	6 x 11	20	14	ESK474M400AE3(1)
400	450	1.0	6 x 11	20	19	ESK105M400AE3(1)
400	450	1.0	8 x 11	20	19	ESK105M400AG3(1)
400	450	2.2	8 x 11	20	26	ESK225M400AG3(1)
400	450	2.2	10 x 12	20	33	ESK225M400AH1(1)
400	450	3.3	10 x 12	20	40	ESK335M400AH1(1)
400	450	4.7	10 x 16	20	45	ESK475M400AH2(1)
400	450	10	10 x 20	20	56	ESK106M400AH4(1)
400	450	10	13 x 20	20	70	ESK106M400AL3(1)
400	450	22	13 x 25	20	110	ESK226M400AL4(1)
400	450	22	16 x 25	20	130	ESK226M400AM7(1)
400	450	33	16 x 25	20	170	ESK336M400AM7(1)
400	450	33	18 x 20	20	130	ESK336M400AN4(1)
400	450	47	16 x 25	20	180	ESK476M400AM7(1)
400	450	47	16 x 32	20	220	ESK476M400AM2(1)
400	450	100	18 x 36	20	360	ESK107M400AN2(1)
450	500	0.47	6 x 11	20	14	ESK474M450AE3(1)
450	500	1.0	8 x 11	20	19	ESK105M450AG3(1)
450	500	2.2	10 x 12	20	33	ESK225M450AH1(1)
450	500	3.3	10 x 16	20	42	ESK335M450AH2(1)
450	500	4.7	10 x 16	20	50	ESK475M450AH2(1)
450	500	10	13 x 20	20	60	ESK106M450AL3(1)
450	500	10	13 x 25	20	75	ESK106M450AL4(1)
450	500	22	16 x 25	20	130	ESK226M450AM7(1)
450	500	33	16 x 32	20	160	ESK336M450AM2(1)
450	500	33	16 x 36	20	180	ESK336M450AM3(1)
450	500	47	18 x 40	20	230	ESK476M450AN3(1)
450	500	47	18 x 36	20	200	ESK476M450AN2(1)
450	500	100	22 x 40	20	370	ESK107M450AQ4(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	RC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.

\* When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.

## Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which causes electrolysis. The oxygen produced by electrolysis will regenerate the dielectric layer but, at the same time, the hydrogen released may cause the internal pressure of the capacitor to increase. The overpressure vent (safety vent) ensures that the gas can escape when the pressure reaches a certain value. All mounting positions must allow the safety vent to work properly.

## Installing

- A general principle is that lower-use temperatures result in a longer, useful life of the capacitor. For this reason, it should be ensured that electrolytic capacitors are placed away from heat-emitting components. Adequate space should be allowed between components for cooling air to circulate, particularly when high ripple current loads are applied. In any case, the maximum category temperature must not be exceeded.
- Do not deform the case of capacitors or use capacitors with a deformed case.
- Verify that the connections of the capacitors are able to insert on the board without excessive mechanical force.
- Verify the correct polarization of the capacitor on the board.
- Verify that the space around the pressure relief device is according to the following guideline:

Case Diameter	Space Around Safety Vent
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 mm	> 3 mm
> 40 mm	> 5 mm

It is recommended that capacitors always be mounted with the safety device uppermost or in the upper part of the capacitor.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with  $V_R \leq 160$  V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in series, a suitable voltage sharing must be used.  
In the case of balancing resistors, the approximate resistance value can be calculated as:  $R = 60/C$

KEMET recommends, nevertheless, to ensure that the voltage across each capacitor does not exceed its rated voltage.

## Application and Operation Guidelines

### Electrical Ratings: Capacitance (ESC)

Capacitance is measured by applying an alternate voltage of  $\leq 0.5$  V at a frequency of 120 or 100 Hz and 20°C.

### Temperature Dependence of the Capacitance

Capacitance of an electrolytic capacitor depends upon temperature: with decreasing temperature the viscosity of the electrolyte increases, thereby reducing its conductivity.

Capacitance will decrease if temperature decreases. Furthermore, temperature drifts cause armature dilatation and, therefore, capacitance changes (up to 20% depending on the series considered, from 0 to 80°C). This phenomenon is more evident for electrolytic capacitors than for other types.

### Frequency Dependence of the Capacitance

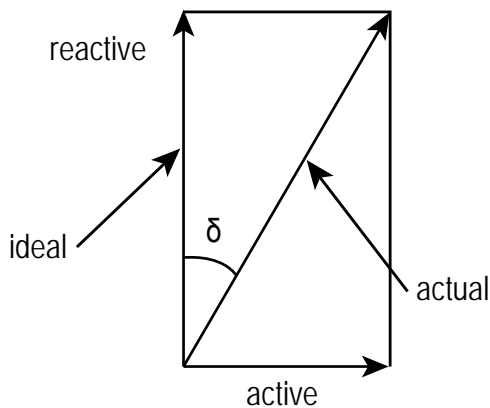
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

$C$  = Capacitance (F)  
 $f$  = Frequency (Hz)  
 $Z$  = Impedance ( $\Omega$ )

### Dissipation Factor $\tan \delta$ (DF)

Dissipation Factor  $\tan \delta$  is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.



$\tan \delta$  is measured with the same set-up used for the series capacitance ESC.

$\tan \delta = \omega \times \text{ESC} \times \text{ESR}$  where:

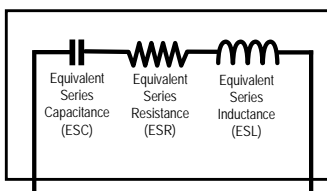
ESC = Equivalent Series Capacitance

ESR = Equivalent Series Resistance

### Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



## Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the  $\tan \delta$  by the following equation:

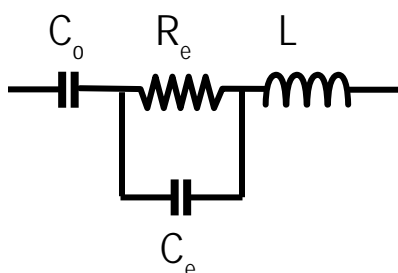
$$ESR = \frac{\tan \delta}{2\pi f ESC}$$

$ESR$  = Equivalent Series Resistance ( $\Omega$ )  
 $\tan \delta$  = Dissipation Factor  
 $ESC$  = Equivalent Series Capacitance (F)  
 $f$  = Frequency (Hz)

Tolerance limits of the rated capacitance must be taken into account when calculating this value.

## Impedance (Z)

Impedance of an electrolytic capacitor results from a circuit formed by the following individual equivalent series components:



$C_o$  = Aluminum oxide capacitance (surface and thickness of the dielectric)

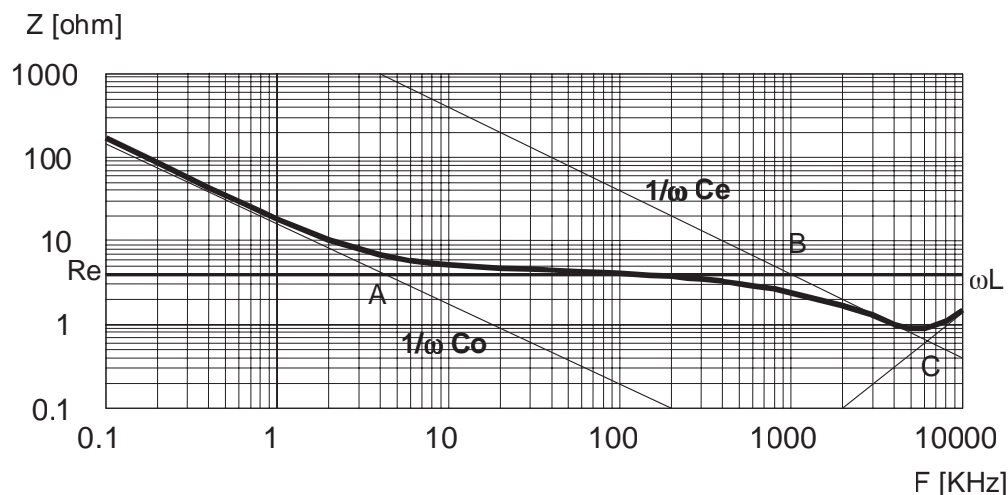
$R_e$  = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)

$C_e$  = Electrolyte soaked paper capacitance

$L$  = Inductive reactance of the capacitor winding and terminals

Impedance of an electrolytic capacitor is not a constant quantity that retains its value under all conditions; it changes depending on frequency and temperature.

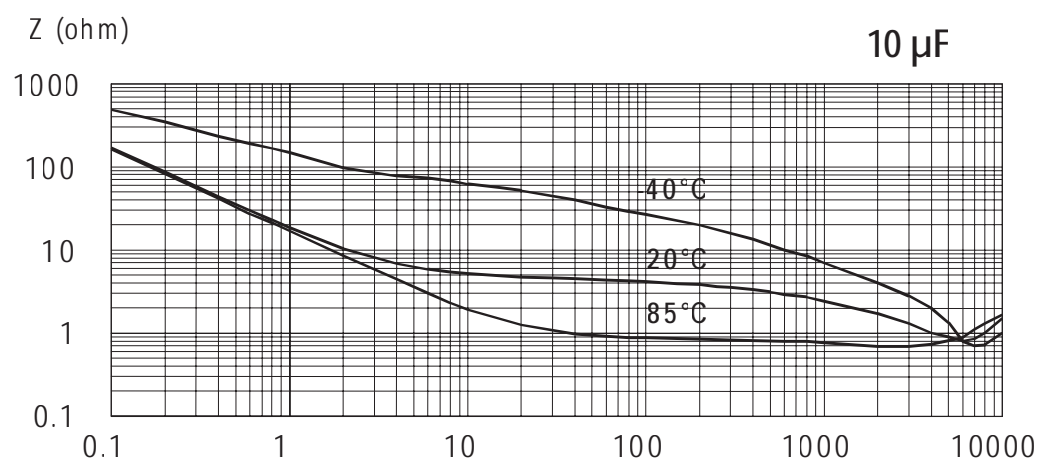
Impedance as a function of frequency (sinusoidal waveform) for a certain temperature can be represented as follows:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance  $X_c = 1/\omega C_0$  decreases until it reaches the order of magnitude of electrolyte resistance  $R_e$  (A)
- At even higher frequencies, resistance of the electrolyte predominates:  $Z = R_e$  (A - B)
- When the capacitor's resonance frequency is reached ( $\omega_0$ ), capacitive and inductive reactance mutually cancel each other  $1/\omega C_e = \omega L$ ,  $\omega_0 = C\sqrt{1/LC_e}$
- Above this frequency, inductive reactance of the winding and its terminals ( $X_L = Z = \omega L$ ) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that  $C_e \approx 0.01 C_0$ .

Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



$R_e$  is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range,  $R_e$  must be as little as possible. However,  $R_e$  values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

### Leakage Current (LC)

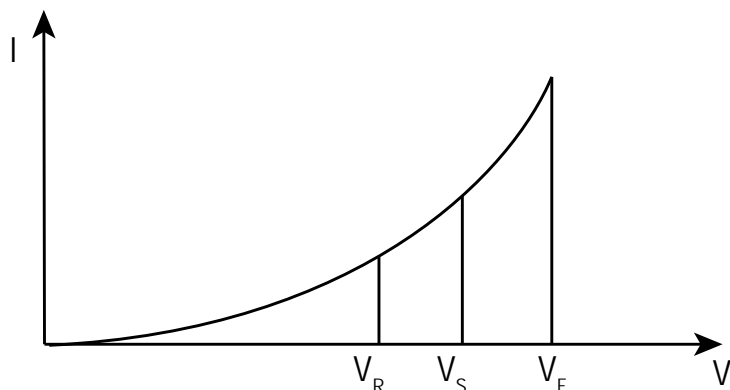
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after prolonged storage without any applied voltage. In the course of continuous operation, the leakage current will decrease and reach an almost constant value.

After a voltage-free storage the oxide layer may deteriorate, especially at high temperature. Since there are no leakage currents to transport oxygen ions to the anode, the oxide layer is not regenerated. The result is that a higher than normal leakage current will flow when voltage is applied after prolonged storage.

As the oxide layer is regenerated in use, the leakage current will gradually decrease to its normal level.

The relationship between the leakage current and voltage applied at constant temperature can be shown schematically as follows:



Where:

$V_F$  = **Forming voltage**

If this level is exceeded, a large quantity of heat and gas will be generated and the capacitor could be damaged.

$V_R$  = **Rated voltage**

This level represents the top of the linear part of the curve.

$V_S$  = **Surge voltage**

This lies between  $V_R$  and  $V_F$ . The capacitor can be subjected to  $V_S$  for short periods only.

Electrolytic capacitors are subjected to a reforming process before acceptance testing. The purpose of this preconditioning is to ensure that the same initial conditions are maintained when comparing different products.

### Ripple Current (RC)

The maximum ripple current value depends on:

- Ambient temperature
- Surface area of the capacitor (heat dissipation area)
- tan  $\delta$  or ESR
- Frequency

The capacitor's life depends on the thermal stress.

### Frequency Dependence of the Ripple Current

ESR and, thus, the tan  $\delta$  depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

### Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

## Expected Life Calculation

Expected life depends on operating temperature according to the following formula:  $L = L_o \times 2^{(T_o - T)/10}$

Where:

- L: Expected life
- L<sub>o</sub>: Load life at maximum permissible operating temperature
- T: Actual operating temperature
- T<sub>o</sub>: Maximum permissible operating temperature

This formula is applicable between 40°C and T<sub>o</sub>.

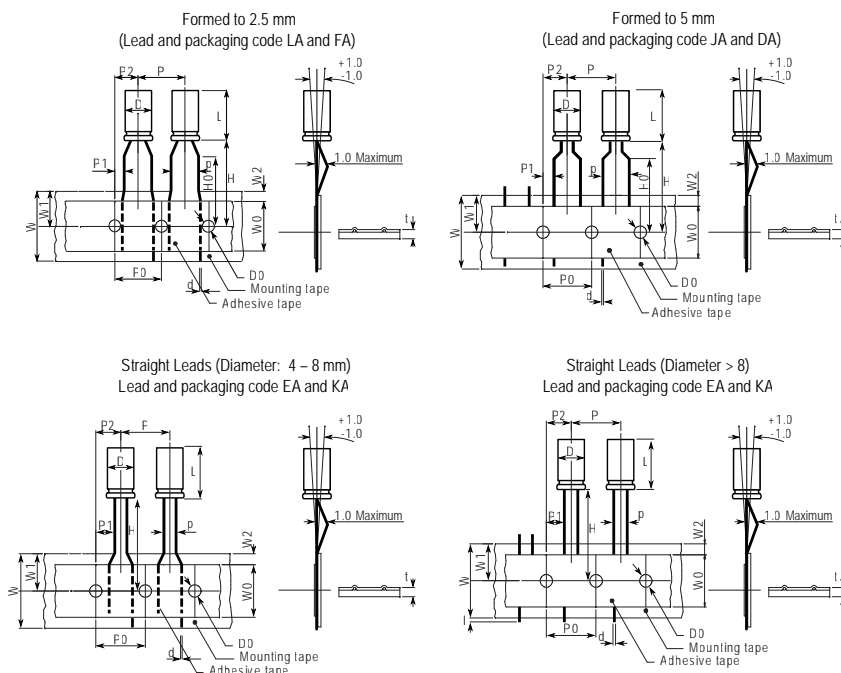
## Packaging Quantities

Size Code	Diameter (mm)	Length (mm)	Bulk Standard Leads	Cut Leads	Auto-insertion	
					Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G4	8	15	5000	5000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
N4	18	20	800	1000		
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		
Q3	22	35	400			
Q4	22	40	300	400		

## Standard Marking for Radial Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: white line
- Date code

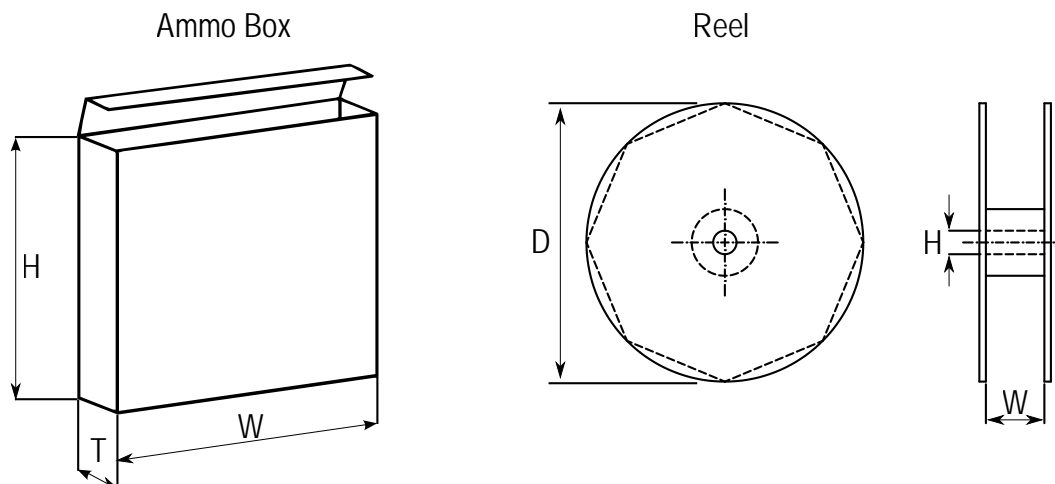
## Taping for Automatic Insertion Machines



Dimensions (mm)	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H0	H1	I	D0	t
Tolerance	+0.5		+0.8/-0.2	±0.05	±1.0	±0.3	±0.7	±1.3	+1/-0.5	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5-7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5	≤7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
		>7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
Formed to 5 mm	4	5-7	5	0.45	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	5	≤7	5	0.45	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	6	≤7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	8	≤7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7		
Straight leads	4	5-7	1.5	0.45	12.7	12.7	5.6	6.35	18	12	11	3	18.5			4	0.7
	5	≤7	2	0.45	12.7	12.7	5.35	6.35	18	12	11	3	18.5			4	0.7
		>7	2	0.5	12.7	12.7	5.35	6.35	18	12	11	3	18.5			4	0.7
	6	≤7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	18.5			4	0.7
		>7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	18.5			4	0.7
	8	≤7	3.5	0.5	12.7	12.7	4.6	6.35	18	12	11	3	18.5			4	0.7
		>7	3.5	0.5	12.7	12.7	4.6	6.35	18	12	11	3	18.5			4	0.7
	10	12-25	5	0.6	12.7	12.7	3.85	6.35	18	12	11	3	18.5		1	4	1
	12	15-25	5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
13	5		0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1	
	5		0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1	
16	7.5		0.8	30	30	3.75	7.5	18	12	11	3	18.5		1	4	1	
18	7.5		0.8	30	30	3.75	7.5	18	12	11	3	18.5		1	4	1	



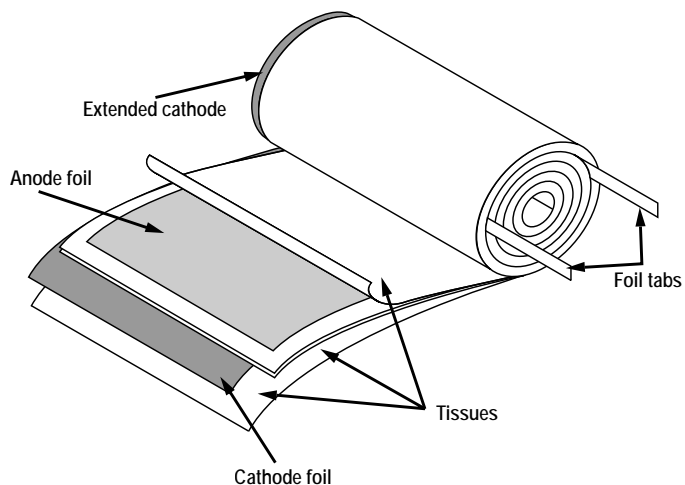
## Lead Taping & Packaging



Case Size (mm)	Ammo			Reel		
	H	W	T	D	H	W
		Maximum	Maximum	±2	±0.5	+1/-0.1
4	230	340	42	350	30	50
5 x 5 – 7	230	340	42			
6 x 5 – 7	275	340	42			
8 x 5 – 9	235	340	45			
5 x 11	230	340	48			
6 x 11	270	340	48			
8 x 11	235	340	48			
8 x 14 – 20	240	340	57			
10 x 12	250	340	52			
10 x 15 – 19	256	340	57			
10 x 22 – 25	250	340	60			
12	270	340	57			
13	285	340	62			
16	265	340	62			

## Construction

The manufacturing process begins with the anode foil being electrochemically etched to increase the surface area and then “formed” to produce the aluminum oxide layer. Both the anode and cathode foils are then interleaved with absorbent paper and wound into a cylinder. During the winding process, aluminum tabs are attached to each foil to provide the electrical contact.



The deck, complete with terminals, is attached to the tabs and then folded down to rest on top of the winding. The complete winding is impregnated with electrolyte before being housed in a suitable container, usually an aluminum can, and sealed. Throughout the process, all materials inside the housing must be maintained at the highest purity and be compatible with the electrolyte.

Each capacitor is aged and tested before being sleeved and packed. The purpose of aging is to repair any damage in the oxide layer and thus reduce the leakage current to a very low level. Aging is normally carried out at the rated temperature of the capacitor and is accomplished by applying voltage to the device while carefully controlling the supply current. The process may take several hours to complete.

Damage to the oxide layer can occur due to variety of reasons:

- Slitting of the anode foil after forming
- Attaching the tabs to the anode foil
- Minor mechanical damage caused during winding

A sample from each batch is taken by the quality department after completion of the production process.

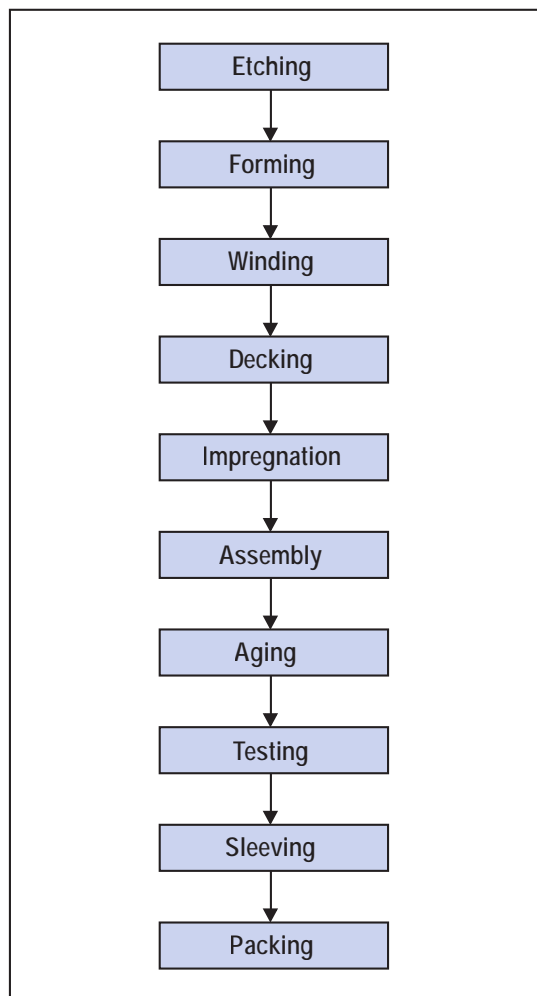
The following tests are applied and may be varied at the request of the customer. In this case the batch, or special procedure, will determine the course of action.

### Electrical:

- Leakage current
- Capacitance
- ESR
- Impedance
- Tan Delta

### Mechanical/Visual:

- Overall dimensions
- Torque test of mounting stud
- Print detail
- Box labels
- Packaging, including packed quantity



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*Note: KEMET reserves the right to modify minor details of internal and external construction at any time in the interest of product improvement. KEMET does not assume any responsibility for infringement that might result from the use of KEMET Capacitors in potential circuit designs. KEMET is a registered trademark of KEMET Electronics Corporation.*

## Other KEMET Resources

Tools	
Resource	Location
Configure A Part: CapEdge	<a href="http://capacitoredge.kemet.com">http://capacitoredge.kemet.com</a>
SPICE & FIT Software	<a href="http://www.kemet.com/spice">http://www.kemet.com/spice</a>
Search Our FAQs: KnowledgeEdge	<a href="http://www.kemet.com/keask">http://www.kemet.com/keask</a>
Electrolytic LifeCalculator	<a href="http://www.kemet.com:8080/elc">http://www.kemet.com:8080/elc</a>

Product Information	
Resource	Location
Products	<a href="http://www.kemet.com/products">http://www.kemet.com/products</a>
Technical Resources (Including Soldering Techniques)	<a href="http://www.kemet.com/technicalpapers">http://www.kemet.com/technicalpapers</a>
RoHS Statement	<a href="http://www.kemet.com/rohs">http://www.kemet.com/rohs</a>
Quality Documents	<a href="http://www.kemet.com/qualitydocuments">http://www.kemet.com/qualitydocuments</a>

Product Request	
Resource	Location
Sample Request	<a href="http://www.kemet.com/sample">http://www.kemet.com/sample</a>
Engineering Kit Request	<a href="http://www.kemet.com/kits">http://www.kemet.com/kits</a>

Contact	
Resource	Location
Website	<a href="http://www.kemet.com">www.kemet.com</a>
Contact Us	<a href="http://www.kemet.com/contact">http://www.kemet.com/contact</a>
Investor Relations	<a href="http://www.kemet.com/ir">http://www.kemet.com/ir</a>
Call Us	1-877-MyKEMET
Twitter	<a href="http://twitter.com/kemetcapacitors">http://twitter.com/kemetcapacitors</a>

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