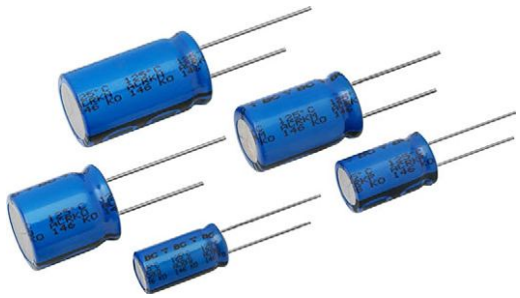
Aluminum Electrolytic Capacitors
Radial, Enhanced High Temperature, Low Impedance



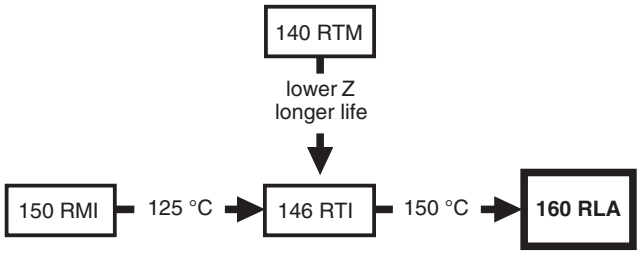


Fig. 1

FEATURES

- Useful life: up to 2000 h at 150 °C
- High stability, high reliability
- Very low ESR
- AEC-Q200 qualified
- Excellent ripple current capability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue PET sleeve
- Charge and discharge proof
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for industrial, automotive, telecommunications and military
- Smoothing, filtering and buffering

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Logo of manufacturer
- Upper category temperature (150 °C)
- Negative terminal identification
- Series number (160)

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (Ø D x L in mm)	10 x 12 to 18 x 35
Rated capacitance range, C_R	33 µF to 3300 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	16 V to 50 V
Category temperature range	-55 °C to +150 °C
Endurance test at 150 °C	1000 h to 1500 h
Useful life at 150 °C	1000 h to 2000 h
Useful life at 40 °C, 1.8 x I_R applied	200 000 h
Shelf life at 0 V, 150 °C	1000 h
Based on sectional specification	IEC 60384-4 / EN130300
Climatic category IEC 60068	55 / 150 / 56

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C_R (µF)	U_R (V)			
	16	**25**	**35**	**50**
33	→	→	→	10 x 12
47	→	→	10 x 12	10 x 12
100	→	10 x 12	10 x 16	10 x 16
220	10 x 16	12.5 x 20	12.5 x 20	10 x 20
330	10 x 20	12.5 x 25	12.5 x 25	12.5 x 20
470	12.5 x 20	16 x 25	18 x 20	12.5 x 25
680	12.5 x 25	→	16 x 31	16 x 25
1000	16 x 25	16 x 31	18 x 35	18 x 31
1500	18 x 20	18 x 31	-	-
2200	18 x 25	-	-	-
2700	18 x 31	-	-	-
3300	18 x 35	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

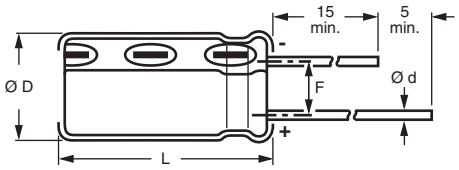


Fig. 2 - **Form CA**: Long leads

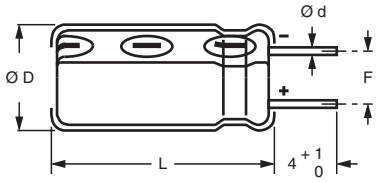


Fig. 3 - **Form CB:** Cut leads

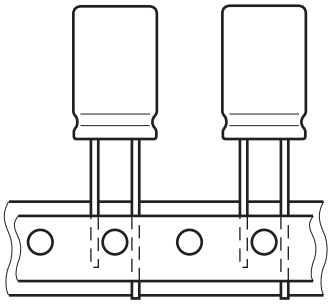


Fig. 4 - **Form TFA**: Taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø $D_{max.}$	$L_{max.}$	F	MASS (g)	PACKAGING QUANTITIES		
							FORM CA	FORM CB	FORM TFA
10 x 12	14	0.6	10.5	13.5	5.0 ± 0.5	≈ 1.6	1000	500	800
10 x 16	15	0.6	10.5	17.5	5.0 ± 0.5	≈ 1.9	500	500	800
10 x 20	16	0.6	10.5	22.0	5.0 ± 0.5	≈ 2.2	500	500	800
12.5 x 20	17	0.6	13.0	22.0	5.0 ± 0.5	≈ 4.0	500	500	500
12.5 x 25	18	0.6	13.0	27.0	5.0 ± 0.5	≈ 5.0	250	250	500
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	250	250	250
16 x 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	100	100	250
18 x 20	1820	0.8	18.5	22.0	7.5 ± 0.5	≈ 8.0	100	100	250
18 x 25	1825	0.8	18.5	27.0	7.5 ± 0.5	≈ 10.0	100	100	250
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	100	100	250
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C_R	Rated capacitance at 100 Hz, tolerance ± 20 %
I_R	Rated RMS ripple current at 100 kHz, 150 °C
I_{L2}	Maximum leakage current after 2 min at U_R
tan δ	Maximum dissipation factor at 100 Hz
Z	Maximum impedance at 100 kHz

Note

- Unless otherwise specified, all electrical values in Table 2 apply at T_{amb} = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %

ORDERING EXAMPLE

Electrolytic capacitor 160 RLA series

470 µF / 25 V; ± 20 %

Nominal case size: Ø 16 mm x 25 mm; Form TFA

Ordering code: MAL216036471E3

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION										
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 kHz 150 °C (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	Z 100 kHz +20 °C (Ω)	Z 100 kHz -40 °C (Ω)	ORDERING CODE MAL2160.....		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
16	220	10 x 16	300	38	0.14	0.075	0.450	55221E3	65221E3	35221E3
	330	10 x 20	400	56	0.14	0.065	0.390	55331E3	65331E3	35331E3
	470	12.5 x 20	600	78	0.14	0.048	0.288	55471E3	65471E3	35471E3
	680	12.5 x 25	700	112	0.14	0.040	0.240	55681E3	65681E3	35681E3
	1000	16 x 25	800	163	0.16	0.029	0.174	55102E3	65102E3	35102E3
	1500	18 x 20	750	243	0.16	0.035	0.210	55152E3	65152E3	35152E3
	2200	18 x 25	1200	355	0.18	0.028	0.168	55222E3	65222E3	35222E3
	2700	18 x 31	1600	435	0.18	0.025	0.150	55272E3	65272E3	35272E3
	3300	18 x 35	2000	531	0.20	0.023	0.132	55332E3	65332E3	-
25	100	10 x 12	250	28	0.12	0.120	0.750	56101E3	66101E3	36101E3
	220	12.5 x 20	600	58	0.12	0.048	0.288	56221E3	66221E3	36221E3
	330	12.5 x 25	700	86	0.12	0.040	0.240	56331E3	66331E3	36331E3
	470	16 x 25	800	121	0.12	0.029	0.174	56471E3	66471E3	36471E3
	1000	16 x 31	1000	253	0.12	0.027	0.162	56102E3	66102E3	36102E3
	1500	18 x 31	1600	378	0.14	0.025	0.150	56152E3	66152E3	36152E3
35	47	10 x 12	250	19	0.10	0.120	0.750	50479E3	60479E3	30479E3
	100	10 x 16	400	38	0.10	0.075	0.450	50101E3	60101E3	30101E3
	220	12.5 x 20	600	80	0.10	0.048	0.288	50221E3	60221E3	30221E3
	330	12.5 x 25	700	119	0.10	0.040	0.240	50331E3	60331E3	30331E3
	470	18 x 20	750	168	0.10	0.035	0.210	50471E3	60471E3	30471E3
	680	16 x 31	1000	241	0.10	0.027	0.162	50681E3	60681E3	30681E3
	1000	18 x 35	1200	353	0.10	0.024	0.144	50102E3	60102E3	-
50	33	10 x 12	160	20	0.10	0.380	2.280	51339E3	61339E3	31339E3
	47	10 x 12	180	27	0.10	0.360	2.160	51479E3	61479E3	31479E3
	100	10 x 16	270	53	0.10	0.260	1.560	51101E3	61101E3	31101E3
	220	10 x 20	360	113	0.10	0.170	1.020	51221E3	61221E3	31221E3
	330	12.5 x 20	400	168	0.10	0.115	0.690	51331E3	61331E3	31331E3
	470	12.5 x 25	600	238	0.10	0.095	0.570	51471E3	61471E3	31471E3
	680	16 x 25	700	343	0.10	0.069	0.414	51681E3	61681E3	31681E3
	1000	18 x 31	1000	503	0.10	0.062	0.372	51102E3	61102E3	31102E3

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 0.5$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01\ C_R \times U_R + 3\ \mu A$
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	Typ. 16 nH
	Case Ø D ≥ 12.5 mm	Typ. 18 nH
Resistance		
Equivalent series resistance (ESR)	Calculated from tan $\delta_{max.}$ and C_R (see Table 2)	ESR = tan $\delta/2\ \pi\ f\ C_R$

CAPACITANCE (C)

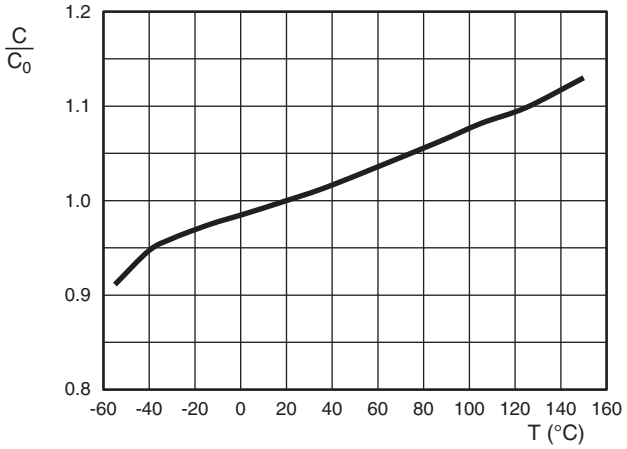


Fig. 5 - Typical multiplier of capacitance at 100 Hz as a function of temperature (C_0 = C at 20 °C)

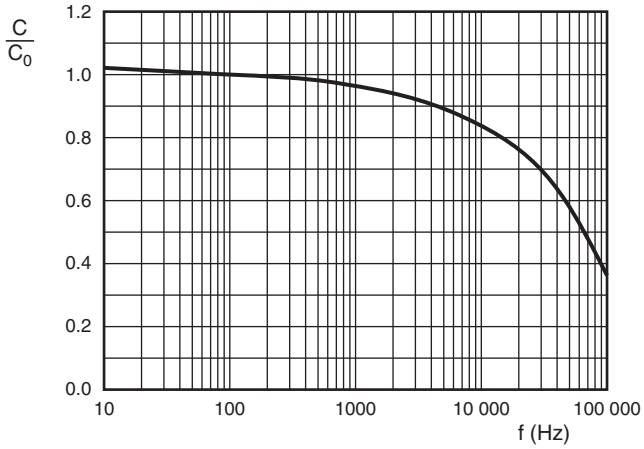


Fig. 6 - Typical multiplier of capacitance as a function of frequency at 20 °C (C_0 = C at 100 Hz)

EQUIVALENT SERIES RESISTANCE (ESR)

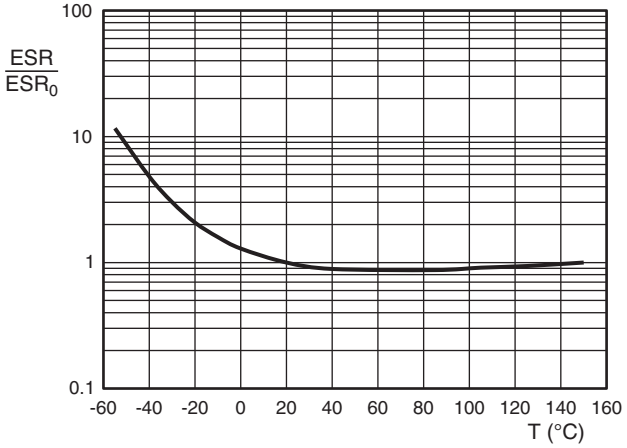


Fig. 7 - Typical multiplier of ESR at 100 Hz as a function of temperature (ESR_0 = ESR at 20 °C)

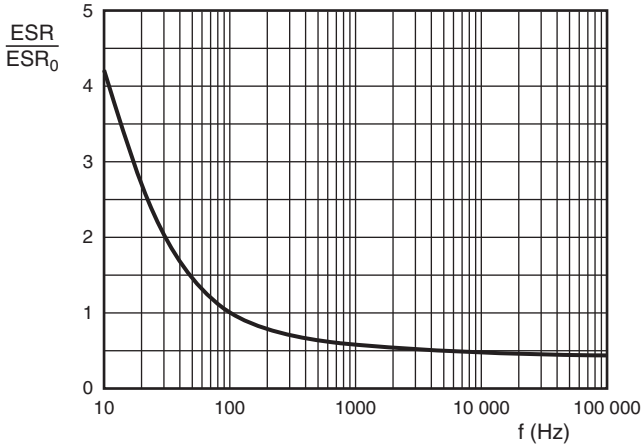


Fig. 8 - Typical multiplier of ESR at 20 °C as a function of frequency (ESR_0 = ESR at 100 Hz)

IMPEDANCE (Z)

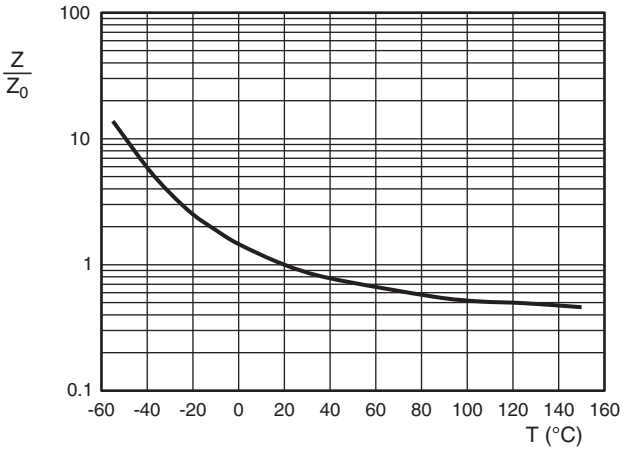


Fig. 9 - Typical multiplier of impedance at 100 kHz as a function of temperature (Z_0 = Z at 20 °C)

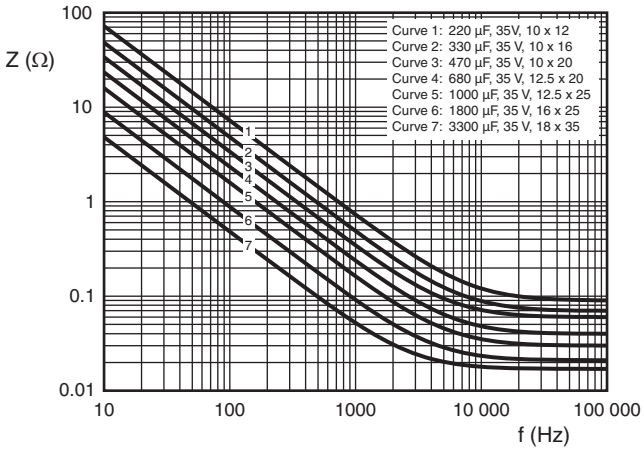


Fig. 10 - Typical impedance Z at 20 °C as a function of frequency

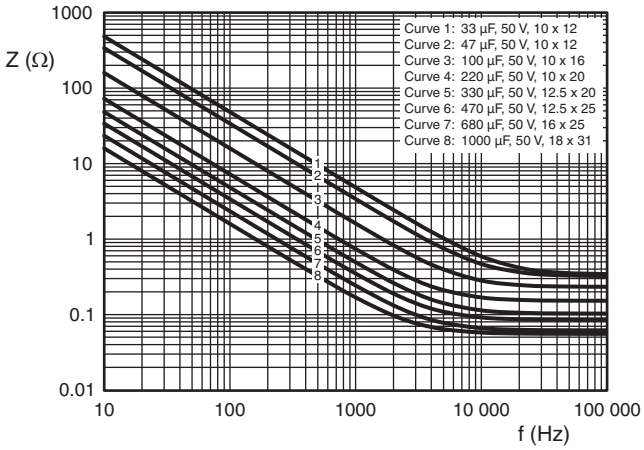


Fig. 11 - Typical impedance Z at 20 °C as a function of frequency

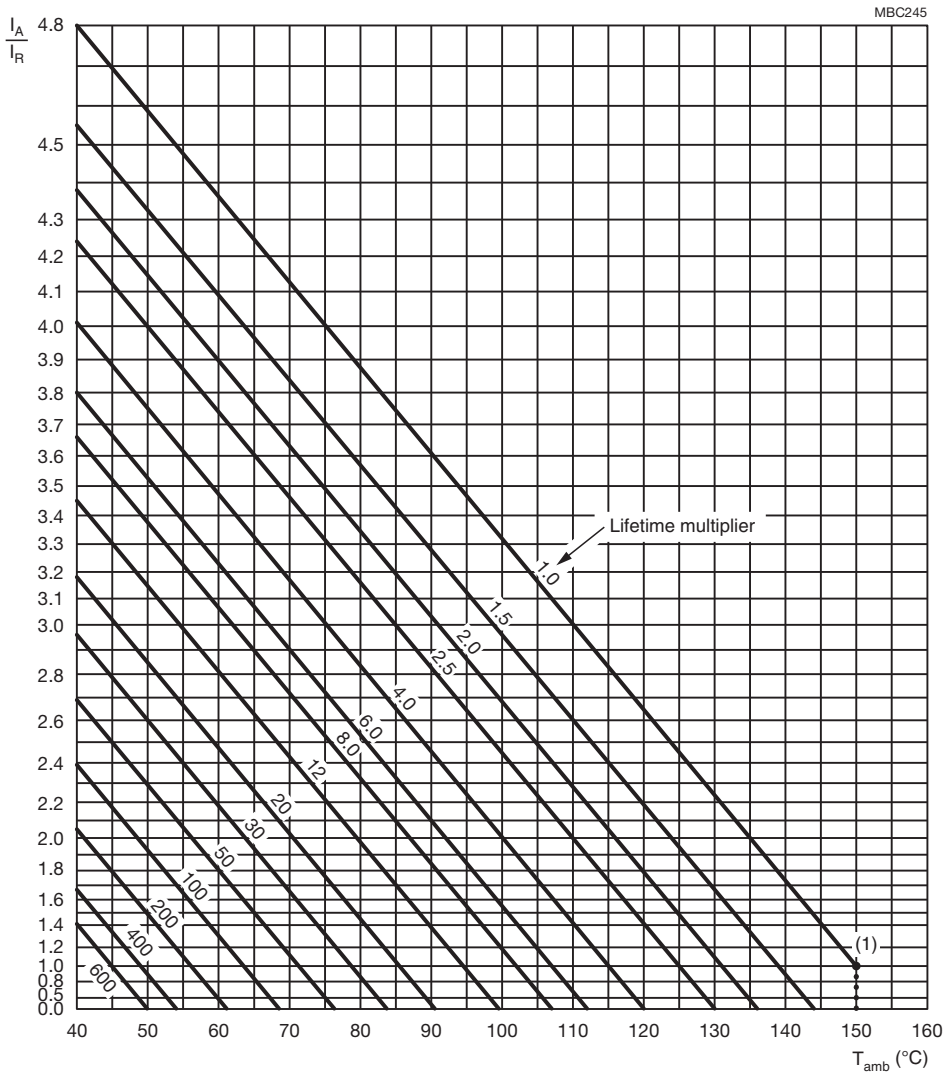
RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE AS A FUNCTION OF CASE SIZE			
NOMINAL CASE SIZE Ø D x L (mm)	**CASE CODE**	**ENDURANCE AT 150 °C (h)**	**USEFUL LIFE AT 150 °C (h)**
10 x 12	14	1000	1000
10 x 16	15	1000	1000
10 x 20	16	1000	1000
12.5 x 20	17	1000	1000
12.5 x 25	18	1000	1000
16 x 25	19	1500	2000
16 x 31	20	1500	2000
18 x 20	1820	1500	2000
18 x 25	1825	1500	2000
18 x 31	1831	1500	2000
18 x 35	22	1500	2000

Note

- Multiplier of useful life code: MBC245



I_A = Actual ripple current at 100 kHz

I_R = Rated ripple current at 100 kHz, 150 °C

(1) Useful life at 150 °C and I_R applied; see Table 4

Fig. 12 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY							
U_R (V)	FREQUENCY (Hz)						
	50	100	300	1000	3000	10 000	100 000
	I_R MULTIPLIER						
6.3	0.60	0.70	0.85	0.90	0.95	1.00	1.00
10	0.60	0.70	0.85	0.90	0.95	1.00	1.00
16	0.60	0.70	0.85	0.90	0.95	1.00	1.00
25	0.60	0.70	0.85	0.90	0.95	1.00	1.00
35	0.50	0.65	0.80	0.85	0.90	0.95	1.00
50	0.35	0.50	0.65	0.80	0.90	0.90	1.00
63	0.35	0.50	0.65	0.80	0.90	0.90	1.00

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		**PROCEDURE (quick reference)**	**REQUIREMENTS**
NAME OF TEST	**REFERENCE**		
Endurance	IEC 60384-4 / EN130300 subclause 4.13	T_{amb} = 150 °C; U_R applied; for test duration see Table 3	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit I_{L2} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 150 °C; U_R and I_R applied; for test duration see Table 3	ΔC/C: ± 30 % tan δ ≤ 3 x spec. limit I_{L2} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life	IEC 60384-4 / EN130300 subclause 4.17	T_{amb} = 150 °C; no voltage applied; 1000 h after test: U_R to be applied for 30 min, 24 h o 48 h before measurement	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit I_{L2} ≤ spec. limit

Statements about product lifetime are based on calculations and internal testing. They should only be interpreted as estimations. Also due to external factors, the lifetime in the field application may deviate from the calculated lifetime. In general, nothing stated herein shall be construed as a guarantee of durability.

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