



# Aluminum Capacitors

## TESTS AND REQUIREMENTS

This datasheet contains an abridged version of tests and requirements given in "IEC 60384-4" or "EN130300" respectively. Correct sequence of measurement for electrical parameters in accordance with "IEC 60384-4":

1. Leakage current
2. Capacitance
3. tan δ or ESR
4. Impedance

Table 1

NON-SOLID ALUMINUM TYPES				
NAME OF TEST	IEC 60384-4/ EN130300 SUBCLAUSE	IEC 60068-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Robustness of terminations: Tensile strength	4.4	Ua	leaded types: loading force 10 N for 10 s power types: loading force 20 N for 10 s	no visible damage
Bending		Ub	leaded types: loading force 5 N two consecutive bends	no visible damage
Torsion		Uc	leaded types, axial: two successive rotations of 180° in opposite direction; 5 s per rotation	no visible damage
Torque on nut (stud)		Ud	power types/screw terminal: torque of 176 Nm gradually applied	no visible damage
Resistance to soldering heat	4.5	Tb (method 1A)	solder bath: 260 °C; 10 s	no visible damage; marking legible ΔC/C: ± 5 %
Solderability	4.6	Ta	solder bath: 235 °C; 2 s; immersed up to 2 mm from the body; non activated flux	no visible damage; marking legible ≥ 95 % tinning
Rapid change of temperature	4.7	Na	for Snap-In, DIN-PW and Screw Terminal capacitors: 5 cycles of 3 h at lower and upper category temperature  for axial, radial and SMD capacitors: 5 cycles of 30 min at lower and upper category temperature	no visible damage; no leakage of electrolyte
Vibration <sup>(1)</sup>	4.8	Fc	10 Hz to 500 Hz; 0.75 mm or 10 g (whichever is less); 3 directions; 2 h per direction form MR or ST types: 10 Hz to 55 Hz; 0.75 mm or 10 g (whichever is less); 3 directions; 2 h per direction	no visible damage; no leakage of electrolyte; marking legible ΔC/C: ± 5 % with respect to initial measurements
Bump <sup>(1)</sup>	4.9	Eb	40 g; 2 directions; 4000 bumps total  form MR: 40 g; 2 directions; 1000 bumps total	no visible damage; no leakage of electrolyte ΔC/C: ± 5 % with respect to initial measurement
Climatic sequence:	4.11			
Dry heat	4.11.1	Ba	16 h at upper category temperature; no voltage applied	no visible damage; no leakage of electrolyte
Damp heat, cyclic	4.11.2	Db	1 cycle (55 °C → 25 °C) of 24 h; RH 95 % to 100 %; no voltage applied	
Cold	4.11.3	Aa	2 h at lower category temperature; no voltage applied	no visible damage; no leakage of electrolyte



NON-SOLID ALUMINUM TYPES				
NAME OF TEST	IEC 60384-4/ EN130300 SUBCLAUSE	IEC 60068-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Low air pressure	4.11.4	M	5 min at 25 °C ± 10 °C; at atmospheric pressure of 8.5 kPa; U <sub>R</sub> applied during last min	no visible damage; no evidence of breakdown or flashover
Damp heat, cyclic	4.11.5	Db	5 cycles (55 °C → 25 °C) of 24 h each; RH 95 % to 100 %; no voltage applied	no continuous chain of bubbles no visible damage; no leakage of electrolyte; marking legible leakage current ≤ stated limit tan δ ≤ 1.2 x stated limit ΔC/C: ± 10 %
Sealing	4.11.6	Qc	1 min in water at 90 °C	
	4.11.7		final measurement after climatic sequence	
Insulation resistance	4.3.5		insulation sleeve: foil method	insulation resistance ≥ 100 MΩ
Voltage proof	4.3.6		insulation sleeve: foil method; 1000 V for 1 min	no breakdown or flashover
Damp heat, steady state	4.12	Ca	56 d at 40 °C; RH 90 % to 95 %; no voltage applied	no visible damage; no leakage of electrolyte; marking legible leakage current ≤ stated limit tan δ ≤ 1.2 x stated limit insulation resistance > 100 MΩ; no breakdown or flashover below 1000 V ΔC/C: ± 10 %
Endurance	4.13		for test duration, refer to the relevant datasheet in this data book; at upper category temperature; U <sub>R</sub> applied	no visible damage; no leakage of electrolyte; marking legible leakage current ≤ stated limit insulation resistance > 100 MΩ; no breakdown or flashover below 1000 V U <sub>R</sub> ≤ 6.3 V; ΔC/C: + 15 %/- 30 %; 6.3 V < U <sub>R</sub> < 200 V; ΔC/C: ± 15 %; U <sub>R</sub> ≥ 200 V; ΔC/C: ± 10 % tan δ ≤ 1.3 x stated limit impedance ≤ 2 x stated limit
Surge	4.14		from source of 1.15 x U <sub>R</sub> for U <sub>R</sub> ≤ 315 V or 1.1 x U <sub>R</sub> for U <sub>R</sub> > 315 V RC = 0.1 s ± 0.05 s 1000 cycles of 30 s on, 330 s off, at upper category temperature	no visible damage; no leakage of electrolyte leakage current ≤ stated limit tan δ ≤ stated limit ΔC/C: ± 15 %
Reverse voltage	4.15		1 V in reverse polarity followed by U <sub>R</sub> in forward polarity, both for 125 h at upper category temperature	leakage current ≤ stated limit tan δ ≤ stated limit ΔC/C: ± 10 %
Pressure relief (only for types with vent)	4.16		DC voltage applied in reverse direction producing a current of 1 A to 10 A	pressure relief opens prior to danger of explosion or fire



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Storage at upper category temperature	4.17	Ba	test duration 500 h at upper category temperature; for longer test duration (shelf life), refer to the relevant datasheet in this data book	no visible damage; no leakage of electrolyte leakage current $\leq 2 \times$ stated limit $\tan \delta \leq 1.2 \times$ stated limit $\Delta C/C: \pm 10 \%$
Storage at low temperature	4.18	Ab	72 h at the lower category temperature	no visible damage; no leakage of electrolyte leakage current $\leq$ stated limit $\tan \delta \leq$ stated limit $\Delta C/C: \pm 10 \%$
Characteristics at high and low temperatures	4.19		step 1: reference measurement of impedance at 20 °C and 100 Hz	
		Aa	step 2: measurement at lower category temperature	impedance at 100 Hz: $\leq 7 \times$ value of step 1 for $U_R \leq 6.3 \text{ V}$ or $U_R > 160 \text{ V}$ ; $\leq 5 \times$ value of step 1 for $6.3 \text{ V} < U_R \leq 16 \text{ V}$ ; $\leq 4 \times$ value of step 1 for $16 \text{ V} < U_R \leq 160 \text{ V}$
		Ba	step 3: measurement at upper category temperature	leakage current: $\leq 10 \times$ stated limit at 125 °C; $\leq 8 \times$ stated limit at 105 °C; $\leq 5 \times$ stated limit at 85 °C; $\leq 3 \times$ stated limit at 70 °C
Charge and discharge	4.20		for $U_R \leq 160 \text{ V}$ : $10^6$ cycles of 0.5 s charge to $U_R$ ( $RC = 0.1 \text{ s}$ ) and 0.5 s discharge ( $RC = 0.1 \text{ s}$ ); for $U_R > 160 \text{ V}$ : under consideration	no visible damage; no leakage of electrolyte $\Delta C/C: \pm 10 \%$
<b>Additional tests in accordance with IEC 60384-1 and EN130000</b>				
Solvent resistance	4.31	Xa	immersion: 5 min $\pm$ 0.5 min with or without ultrasonic at 55 °C $\pm$ 0.5 °C  solvents: demineralized water and/or calgonite solution (20 g/l)	visual appearance not affected
Passive flammability	4.38	IEC 60695-2-2	needle flame test	category of flammability: B

**Note**

For vibration and bump testing, the components shall be mounted by their terminations (with mounting accessories where applicable). The following capacitors shall also be clamped by their body:

- (a) Radial types:  $\varnothing D_{nom} \geq 12.5 \text{ mm}$ ;  $L_{nom} \geq 15 \text{ mm}$
- (b) Axial types:  $\varnothing D_{nom} \geq 12.5 \text{ mm}$ ;  $L_{nom} \geq 30 \text{ mm}$



Table 2

<b>SOLID ALUMINUM TYPES, SAL</b>				
<b>NAME OF TEST</b>	<b>IEC 60384-4/ EN130300 SUBCLAUSE</b>	<b>IEC 60068-2 TEST METHOD</b>	<b>PROCEDURE (quick reference)</b>	<b>REQUIREMENTS</b>
Robustness of terminations: Tensile strength <sup>(1)</sup> Bending <sup>(1)</sup> Torsion (axial types)	4.4	Ua  Ub  Uc	loading force; 10 N for 10 s  loading force; 5 N; two consecutive bends  two successive rotations of 180° in opposite direction; 5 s duration per rotation	no visible damage  no visible damage  no visible damage
Resistance to soldering heat	4.5	Tb (method 1A)	radial types: solder bath: 260 °C; 10 s	no visible damage; markings legible
		Tb (method 1B)	axial types: solder bath 350 °C for 3.5 s	$\Delta C/C$ : $\pm 5\%$ with respect to initial measurement
Solderability	4.6	Ta (method 1)	solder bath: 235 °C; 2 s immersed up to 2 mm from the body; non activated flux	no visible damage; marking legible  $\geq 95\%$ tinning
Rapid change of temperature	4.7	Na	5 cycles of 30 min at lower and upper category temperature	no visible damage  leakage current $\tan \delta$ and $Z \leq$ stated limit
Vibration <sup>(2)</sup>	4.8	Fc	10 Hz to 500 Hz; 0.75 mm or 10 g (whichever is less severe); in 3 directions; 2 h per direction	no visible damage; markings legible  $\Delta C/C$ : $\pm 5\%$ with respect to initial measurement
			128 SAL-RPM: 10 Hz to 2000 Hz; 1.5 mm or 20 g (whichever is less severe); in 3 directions; 2 h per direction	no visible damage; markings legible  $\Delta C/C$ : $\pm 5\%$ with respect to initial measurement
Bump <sup>(2)</sup>	4.9	Eb	40 g; 2 directions; 4000 bumps total	no visible damage  $\Delta C/C$ : $\pm 5\%$ with respect to initial measurement
Shock <sup>(2)</sup>	4.10	Ea	123 SAL-AG: acceleration: 29 400 m/s <sup>2</sup> or 3000 g; duration of pulse: 0.2 ms; total number of shocks: 18	no visible damage  $\Delta C/C$ : $\pm 5\%$ with respect to initial measurement



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Climatic sequence:	4.11			
Dry heat	4.11.1	Ba	16 h at upper category temperature; no voltage applied	no breakdown, flashover, or harmful deformation of case
Damp heat, cyclic	4.11.2	Db	1 cycle (55 °C → 25 °C) of 24 h; RH 95 % to 100 %; no voltage applied	
Cold	4.11.3	Aa	2 h at lower category temperature; no voltage applied	
Low air pressure	4.11.4	M	5 min at 25 °C ± 10 °C; atmospheric pressure: 8.5 kPa; U <sub>R</sub> applied during last min of test	
Damp heat, cyclic	4.11.5 4.11.7	Db	5 cycles (55 °C → 25 °C) of 24 h each; 25 °C; RH 95 % to 100 %; no voltage applied final measurements after climatic sequence	
				no visible damage; markings legible leakage current ≤ stated limit tan δ and Z ≤ 1.2 x stated limit
				axial types: ΔC/C: ± 5 % with respect to initial measurement
				radial types: ΔC/C: ± 10 % with respect to initial measurement
Damp heat, steady state	4.12	Ca	56 d at 40 °C: RH 90 % to 95 %; no voltage applied	no visible damage; markings legible leakage current ≤ stated limit tan δ and Z ≤ 1.2 x stated limit ΔC/C: ± 10 % of initial measurement
Insulation resistance	4.3.5		insulation sleeve: foil method	insulation resistance ≥ 100 MΩ
Voltage proof	4.3.6		insulation sleeve: foil method; 1000 V for 1 min	no breakdown or flashover
Endurance	4.13		for test duration, refer to the relevant datasheet in this data book; at upper category temperature; U <sub>R</sub> applied <sup>(3)</sup>	no visible damage; markings legible leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ 1.2 x stated limit axial types: insulation resistance ≥ 100 MΩ; no breakdown or flashover at 1000 V
Endurance (additional)			2000 h at 175 °C; maximum 0.63 x U <sub>R</sub> applied	leakage current ≤ stated limit ΔC/C: ± 20 % with respect to initial measurement tan δ ≤ 1.5 x stated limit Z ≤ 2.5 x stated limit



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Surge	4.14		applied voltage source of 1.15 x U <sub>R</sub> <sup>(3)</sup> at 125 °C; 1000 cycles; 30 s on, 330 s off	no visible damage leakage current ≤ stated limit tan δ ≤ stated limit
				axial types: ΔC/C: ± 5 % with respect to initial measurement
				radial types: ΔC/C: ± 10 % with respect to initial measurement
Reverse voltage	4.15		0.15 x U <sub>R</sub> <sup>(3)</sup> in reverse polarity at 125 °C for 125 h, followed by U <sub>R</sub> <sup>(3)</sup> in forward polarity at 125 °C for 125 h	leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ stated limit
Reverse voltage (additional): Radial types			0.30 x U <sub>R</sub> <sup>(3)</sup> in reverse polarity at 125 °C for 125 h, followed by U <sub>R</sub> <sup>(3)</sup> in forward polarity at 125 °C for 125 h	leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ stated limit
Reverse voltage (additional): Axial types			0.30 x U <sub>R</sub> in reverse polarity at 125 °C for 2000 h	leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement tan δ and Z ≤ stated limit
Storage at upper category temperature	4.17	Ba	500 h at upper category temperature	no visible damage leakage current ≤ stated limit ΔC/C: ± 10 % with respect to initial measurement
Long storage ≥ 1 year (additional)			at ambient temperature	leakage current ≤ stated limit
Characteristics at high and low temperature	4.19		step 1: reference measurement at 20 °C of capacitance, tan δ and impedance at 100 Hz	
			step 2: measurement at - 55 °C; tan δ and impedance at 100 Hz	ΔC/C: ± 20 % with respect to value in step 1 impedance ratio (100 Hz) ≤ 2 x the value of step 1 tan δ ≤ 2 x the stated limit
			step 3: measurement at 125 °C capacitance, leakage current and tan δ	leakage current ≤ 15 x the stated limit; <sup>(4)</sup> / <sub>(5)</sub> ΔC/C: ± 20 % of the value measured in step 1 tan δ ≤ stated limit
Charge and discharge	4.20		10 <sup>6</sup> cycles charging to U <sub>R</sub> for 0.5 s, and then discharging for 0.5 s	no visible damage ΔC/C: ± 5 % with respect to initial measurement



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<b>Additional tests in accordance with IEC 60384-1 and EN130000</b>				
Solvent resistance	4.31	Xa	immersion: 5 min ± 0.5 min with or without ultrasonic at 55 °C ± 0.5 °C  solvents: demineralized water and/or calgonite solution (20 g/l)	visual appearance not affected
Passive flammability	4.38	IEC 60695-2-2	needle flame test	category of flammability: B

**Notes**

- (1) SPECIAL PLIERS MUST BE USED TO PROTECT THE CELL BODY AND CONSEQUENTLY KEEP THE BENDING LOCATION UNDER CONTROL.
- (2) Axial capacitors shall be mounted by clamping both the body and the leads.
- (3)  $U_R$  at 125 °C is 25 V for 35 V and 40 V versions.
- (4) For radial types, 40 V version: < 8 x the stated limit
- (5) Leakage current for axial types:  $\leq 1.5 \times U_R \times C_R$