# Aluminum Capacitors

## TESTS AND REQUIREMENTS

This datasheet contains an abridged version of tests and requirements given in "*IEC 60384-4*" or "*EN 130300*" 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/ EN 130300 SUBCLAUSE** | **IEC 60068-2 TEST METHOD** | **PROCEDURE (quick reference)** | **REQUIREMENTS** |
| Robustness of terminations: | 4.4 | | | |
| Tensile strength | | Ua | Leaded types:<br>loading force 10 N for 10 s<br>Power types:<br>loading force 20 N for 10 s | No visible damage |
| Bending | | Ub | Leaded types: loading force 5 N<br>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 1.76 Nm gradually applied | No visible damage |
| Resistance to soldering heat | 4.5 | Tb (method 1A) | Solder bath: 260 °C; 10 s | No visible damage;<br>marking legible<br>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;<br>marking legible<br>≥ 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<br><br>For axial, radial, and SMD capacitors: 5 cycles of 30 min at lower and upper category temperature | No visible damage;<br>no leakage of electrolyte |
| Vibration [1] | 4.8 | Fc | 10 Hz to 500 Hz; 0.75 mm or 10 *g* (whichever is less); 3 directions; 2 h per direction<br>Form MR or ST types: 10 Hz to 55 Hz;<br>0.75 mm or 10 *g* (whichever is less);<br>3 directions; 2 h per direction | No visible damage;<br>No leakage of electrolyte;<br>marking legible<br>ΔC/C: ± 5 % with respect to initial measurements |
| Bump [1] | 4.9 | Eb | 40 *g*; 2 directions; 4000 bumps total<br><br>Form MR:<br>40 *g*; 2 directions; 1000 bumps total | No visible damage;<br>no leakage of electrolyte<br>ΔC/C: ± 5 % with respect to initial measurement |
| Climatic sequence: | 4.11 | | | |
| Dry heat | 4.11.1 | Ba | 16 h at upper category temperature;<br>no voltage applied | No visible damage;<br>no leakage of electrolyte |
| Damp heat, cyclic | 4.11.2 | Db | 1 cycle (55 °C → 25 °C) of 24 h;<br>RH 95 % to 100 %; no voltage applied | |
| Cold | 4.11.3 | Aa | 2 h at lower category temperature;<br>no voltage applied | No visible damage;<br>no leakage of electrolyte |

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| Low air pressure | 4.11.4 | M | 5 min at 25 °C ± 10 °C; at atmospheric pressure of 8.5 kPa; $U_R$ 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 | |
| Sealing | 4.11.6 | Qc | 1 min in water at 90 °C | No continuous chain of bubbles |
| | 4.11.7 | | Final measurement after climatic sequence | No visible damage; no leakage of electrolyte; marking legible<br>Leakage current ≤ stated limit<br>tan δ ≤ 1.2 x stated limit<br>ΔC/C: ± 10 % |
| 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<br>Leakage current ≤ stated limit<br>tan δ ≤ 1.2 x stated limit<br>Insulation resistance > 100 MΩ; no breakdown or flashover below 1000 V<br>ΔC/C: ± 10 % |
| Endurance | 4.13 | | For test duration, refer to the relevant datasheet; at upper category temperature; $U_R$ applied | No visible damage; no leakage of electrolyte; marking legible<br>Leakage current ≤ stated limit<br>Insulation resistance > 100 MΩ; no breakdown or flashover below 1000 V<br>$U_R$ ≤ 6.3 V; ΔC/C: + 15 %/- 30 %; 6.3 V < $U_R$ < 200 V; ΔC/C: ± 15 %; $U_R$ ≥ 200 V; ΔC/C: ± 10 %<br>tan δ ≤ 1.3 x stated limit<br>Impedance ≤ 2 x stated limit |
| Surge | 4.14 | | From source of 1.15 x $U_R$ for $U_R$ ≤ 315 V or 1.1 x $U_R$ for $U_R$ > 315 V<br>RC = 0.1 s ± 0.05 s<br>1000 cycles of 30 s on, 330 s off, at upper category temperature | No visible damage; no leakage of electrolyte<br>Leakage current ≤ stated limit<br>tan δ ≤ stated limit<br>ΔC/C: ± 15 % |
| Reverse voltage | 4.15 | | 1 V in reverse polarity followed by $U_R$ in forward polarity, both for 125 h at upper category temperature | Leakage current ≤ stated limit<br>tan δ ≤ stated limit<br>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 |
| 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 | No visible damage; no leakage of electrolyte<br>Leakage current ≤ 2 x stated limit<br>tan δ ≤ 1.2 x stated limit<br>ΔC/C: ± 10 % |

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| Storage at low temperature | 4.18 | Ab | 72 h at the lower category temperature | No visible damage;<br>no leakage of electrolyte<br>Leakage current ≤ stated limit<br>tan δ ≤ stated limit<br>ΔC/C: ± 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:<br>≤ 10 x value of step 1 for $U_R$ ≤ 6.3 V; ≤ 8 x value of step 1 for 6.3 V < $U_R$ ≤ 16 V;<br>≤ 6 x value of step 1 for 16 V < $U_R$ ≤ 160 V<br>≤ 10 x value of step 1 for $U_R$ > 160 V |
| | | Ba | Step 3: measurement at upper category temperature | Leakage current:<br>≤ 15 x stated limit at 150 °C;<br>≤ 10 x stated limit at 125 °C;<br>≤ 8 x stated limit at 105 °C;<br>≤ 5 x stated limit at 85 °C;<br>≤ 3 x stated limit at 70 °C |
| Charge and discharge | 4.20 | | For $U_R$ ≤ 160 V: $10^6$ cycles of 0.5 s charge to $U_R$ (RC = 0.1 s) and 0.5 s discharge (RC = 0.1 s);<br>For $U_R$ > 160 V: under consideration | No visible damage;<br>no leakage of electrolyte<br>ΔC/C: ± 10 % |
| **Additional tests in accordance with IEC 60384-1 and EN 130000** | | | | |
| Solvent resistance | 4.31 | Xa | Immersion: 5 min ± 0.5 min with or without ultrasonic at 55 °C ± 0.5 °C<br>Solvents: demineralized water and / or calgonite solution (20 g/l) | Visual appearance not affected |
| Passive flammability | 4.38 | IEC 60695-11-5 | Needle flame test | Category of flammability: B |

**Note**

(1) 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 or glued by their body:
(a) THT types: Ø $D_{nom.}$ ≥ 12.5 mm
(b) SMD types: Ø $D_{nom.}$ ≥ 8.0 mm