



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 $\Delta C/C: \pm 5 \%$ |
| 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 $\geq 95 \%$ 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 (note 1) | 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 $\Delta C/C: \pm 5 \%$ with respect to initial measurements |
| Bump (note 1) | 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 $\Delta C/C: \pm 5 \%$ with respect to initial measurement |
| Climatic sequence: Dry heat | 4.11 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 |



Table 1 (continued)

| 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 _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 | 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 data sheet in this data handbook; at upper category temperature; U _R 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 _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 % tan δ ≤ 1.3 x stated limit 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 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 % |



Table 1 (continued)

| NON-SOLID ALUMINUM TYPES | | | | |
|----------------------------------------------------------------------|------------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME OF TEST | IEC 60384-4/ EN130300 subclause | IEC 60068-2 TEST METHOD | PROCEDURE (quick reference) | REQUIREMENTS |
| 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 \leq stated limit $\tan \delta \leq$ stated limit $\Delta C/C: \pm 10 \%$ |
| 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 data sheet in this data handbook | 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 $16 \text{ V} < U_R < 160 \text{ V}$ |
| | | 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 $\Delta C/C: \pm 10 \%$ |
| Additional tests in accordance with IEC 60384-1 and EN 130000 | | | | |
| 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 |

Notes

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

| SOLID ALUMINUM TYPES, SAL | | | | |
|-------------------------------------------------------------------------------------------------------|------------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| NAME OF TEST | IEC 60384-4/ EN130300 subclause | IEC 60068-2 TEST METHOD | PROCEDURE (quick reference) | REQUIREMENTS |
| Robustness of terminations: Tensile strength (note 1) Bending (note 1) 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 (note 2) | 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 (note 2) | 4.9 | Eb | 40 g; 2 directions; 4000 bumps total | no visible damage $\Delta C/C: \pm 5\%$ with respect to initial measurement |
| Shock (note 2) | 4.10 | Ea | 123 SAL-AG: acceleration: 29400 m/s ² 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 |



Table 2 (continued)

| SOLID ALUMINUM TYPES, SAL | | | | |
|----------------------------------|------------------------------------------------|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME OF TEST | IEC 60384-4/ EN130300 subclause | IEC 60068-2 TEST METHOD | PROCEDURE (quick reference) | REQUIREMENTS |
| Climatic sequence: Dry heat | 4.11 4.11.1 | Ba | 16 h at upper category temperature; no voltage applied | no breakdown, flashover, or harmful deformation of case no visible damage; markings legible leakage current \leq stated limit $\tan \delta$ and $Z \leq 1.2 \times$ stated limit |
| Damp heat, cyclic | 4.11.2 | Db | 1 cycle (55 °C \rightarrow 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 \pm 10 °C; atmospheric pressure: 8.5 kPa; U_R applied during last min of test | |
| Damp heat, cyclic | 4.11.5 4.11.7 | Db | 5 cycles (55 °C \rightarrow 25 °C) of 24 h each; 25 °C; RH 95 % to 100 %; no voltage applied final measurements after climatic sequence | |
| 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 \leq stated limit $\tan \delta$ and $Z \leq 1.2 \times$ stated limit $\Delta C/C: \pm 10 \%$ of initial measurement |
| Insulation resistance | 4.3.5 | | insulation sleeve: foil method | insulation resistance $\geq 100 \text{ M}\Omega$ |
| 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 data sheet in this data handbook; at upper category temperature; U_R applied (note 3) | no visible damage; markings legible leakage current \leq stated limit $\Delta C/C: \pm 10 \%$ with respect to initial measurement $\tan \delta$ and $Z \leq 1.2 \times$ stated limit axial types: insulation resistance $\geq 100 \text{ M}\Omega$; no breakdown or flashover at 1000 V |
| Endurance (additional) | | | 2000 h at 175 °C; maximum $0.63 \times U_R$ applied | leakage current \leq stated limit $\Delta C/C: \pm 20 \%$ with respect to initial measurement $\tan \delta \leq 1.5 \times$ stated limit $Z \leq 2.5 \times$ stated limit |



Table 2 (continued)

| SOLID ALUMINUM TYPES, SAL | | | | |
|---------------------------------------------------|------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| NAME OF TEST | IEC 60384-4/ EN130300 subclause | IEC 60068-2 TEST METHOD | PROCEDURE (quick reference) | REQUIREMENTS |
| Surge | 4.14 | | applied voltage source of 1.15 x U _R (note 3) 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 _R (note 3) in reverse polarity at 125 °C for 125 h, followed by U _R (note 3) 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 _R (note 3) in reverse polarity at 125 °C for 125 h, followed by U _R (note 3) 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 _R 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; (notes 4 and 5) ΔC/C: ± 20 % of the value measured in step 1 tan δ ≤ stated limit |
| Charge and discharge | 4.20 | | 10 ⁶ cycles charging to U _R for 0.5 s, and then discharging for 0.5 s | no visible damage ΔC/C: ± 5 % with respect to initial measurement |



Table 2 (continued)

| SOLID ALUMINUM TYPES, SAL | | | | |
|---------------------------------------------------------------------|------------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| NAME OF TEST | IEC 60384-4/ EN130300 subclause | IEC 60068-2 TEST METHOD | PROCEDURE (quick reference) | REQUIREMENTS |
| Additional tests in accordance with IEC 60384-1 and EN130000 | | | | |
| 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: $\leq 1.5 \times U_R \times C_R$.