a) the charge time constant arising from the internal resistance of power supply and the resistance of the charge circuit and the capacitance of the capacitor under test;

b) the discharge time constant arising from the resistance of the discharge circuit and the capacitance of the capacitor under test;

c) the voltage to be applied during the charge period, if different from the rated voltage;

d) the number of cycles of test;

e) the duration of the charge period;

f) the duration of the discharge period;

g) the repetition rate (cycles per second);

h) temperature, if different from standard atmospheric conditions for testing.

4.27.4 Inrush current

The following information shall be given in the relevant specification:

a) the peak charge current;

b) the voltage to be applied during the charge period if different from the rated voltage;

c) the number of cycles of test;

d) the duration of the charge period in milliseconds (ms);

e) the duration of the discharge period;

f) the repetition rate;

g) the temperature if different from standard atmospheric conditions for testing.

4.27.5 Final inspection, measurements and requirements

The measurements specified in the relevant specification shall be made.

4.28 Pressure relief (for aluminium electrolytic capacitors)

Unless otherwise specified in the relevant specification, one of the following tests shall be used to test the pressure relief device of the capacitors.

4.28.1 a.c. test

Applied voltage: alternating voltage with r.m.s. value not exceeding 0.7 times the rated direct voltage.

Frequency of the applied voltage: 50 Hz or 60 Hz.

Series resistor: $R = 0.5$ times the impedance of the capacitor at the test frequency.

4.28.2 d.c. test

Applied voltage: direct voltage applied in the reverse direction, of an amplitude necessary to produce a current of 1 A to 10 A.

4.28.3 Pneumatic test

Applied pneumatic pressure: gas pressure introduced from outside shall be increased at a rate of 20 kPa/s continuously.

4.28.4 Final inspection, measurements and requirements

The measurements specified in the relevant specification shall be made.

4.29 Characteristics at high and low temperature

4.29.1 Test procedure

The capacitors shall be subjected to the procedures of the dry heat and cold test (**4.21.2** and **4.21.4**, respectively) with the following details.

The degree of severity for these tests shall be the same as for the dry heat and cold tests. Tests at intermediate temperatures may be prescribed by the relevant specification.

Measurements shall be made at each of the specified temperatures after the capacitor has reached thermal stability.

The condition of thermal stability is judged to be reached when two readings of a characteristic, taken in an interval of not less than 5 min, do not differ by an amount greater than that which can be attributed to the measuring apparatus.

4.29.2 Requirements

The capacitors shall not exceed the limits prescribed in the relevant specification.

4.30 Thermal stability test

A thermal stability test may constitute an alternative to the endurance test in accordance with **4.23.4 d**). The test to be carried out shall be specified in the detail specification.

The capacitor shall be loaded with a specified factor times the rated reactive power dissipation at the rated temperature and duration as specified in the relevant specification.

A test for thermal stability shall be made by measuring the temperature rise as a function of time over the last part of the specified duration. The temperature rise shall be within specified limits.

The measurement of the temperature rise may be made by the use of a thermocouple, thermistor, infra-red thermometer, infra-red photography, etc. Care should be taken to ensure that the error of measurement does not exceed ± 1 °C and that errors due to heat conduction along measuring connections are kept to a minimum.

The relevant specification shall specify the point at which the measurements shall be made and the method of mounting (see **JIS C 60068-2-2**, **6.4**).

4.31 Component solvent resistance

4.31.1 Initial measurements

The measurements prescribed in the relevant specification shall be made.

4.31.2 Test procedure

The components shall be subjected to **JIS C 60068-2-45**, test XA, with the following details:

a) solvent to be used: IPA (**JIS C 60068-2-45**, **3.1.2**);

b) solvent temperature: 23 °C ± 5 °C, unless otherwise specified in the detail specification;

c) conditioning: method 2 (without rubbing);

d) recovery time: 48 h, unless otherwise stated in the detail specification.

4.31.3 Final inspection, measurements and requirements

The measurements prescribed in the relevant specification shall then be made and the specified requirements be met.

4.32 Solvent resistance of marking

4.32.1 Test procedure

The components shall be subjected to **JIS C 60068-2-45**, test XA, with the following details:

a) solvent to be used: IPA (**JIS C 60068-2-45**, **3.1.2**);

b) solvent temperature: 23 °C ± 5 °C;

c) conditioning: method 1 (with rubbing);

d) rubbing material: cotton wool;

e) recovery time: not applicable, unless otherwise stated in the detail specification.

4.32.2 Final inspection, measurements and requirements

After the test the marking shall be legible.

4.33 Mounting (**for surface mount capacitors only**)

4.33.1 Substrate

Surface mount capacitors shall be mounted on a suitable substrate, the method of mounting dependent on the capacitor construction. The substrate material shall normally be an epoxide woven glass fabric laminated printed board (as defined in **JIS C 6484**) with a thickness of 1.6 mm ± 0.20 mm or 0.8 mm ± 0.10 mm, or a 90 % to 98 % alumina substrate having a thickness of 0.635 mm ± 0.05 mm or more, and shall not affect the result of any test or measurement. The detail specification shall indicae which material is to be used for the electrical measurements.

The substrate shall have metallized land areas of proper spacing to permit mounting of surface mount capacitors and shall provide electrical connection to the surface mount capacitor terminals. The details shall be specified in the detail specification.

Examples of test substrates for mechanical and electrical tests are shown in figures 15 and 16, respectively.

If another method of mounting applies, the method should be clearly described in the detail specification.

4.33.1.1 Wave soldering

When the detail specification specifies wave soldering, suitable glue, details of which may be specified in the detail specification, shall be used to fasten the component to the substrate before soldering is performed.

Small dots of the glue shall be applied between the conductors of the substrate by means of a suitable device securing repeatable results.

The surface mount capacitors shall be placed on the dots using tweezers. To ensure that no glue is applied to the conductors, the surface mount capacitors shall not be moved about.

The substrate with the surface mount capacitors shall be heat-treated in an oven at 100 °C for 15 min.

The substrate shall be soldered in a wave soldering apparatus. The apparatus shall be adjusted to have a pre-heating temperature of 80 °C to 100 °C, a solder bath at 260 °C ±5 °C and a soldering time of 5 s ± 0.5 s.

The substrate shall be cleaned for 3 min in a suitable solvent (see **JIS C 60068-2-45**, **3.1.2**).

4.33.1.2 Reflow soldering

When the detail specification specifies reflow soldering, the following mounting procedure applies.

a) The solder used in preform or paste form shall be silver- bearing (2 % minimum) eutectic Sn/Pb solder together with a flux as stated in **JIS C 60068-2-20**. Alternative solders such as 60/40 or 63/37 may be used on chips whose construction includes solder leach barriers. Pb-free solder used in preform or paste form shall be Sn96.5Ag3.0Cu0.5 or derivative solder together with a flux as stated in **JIS C 60068-2-58**, or as defined in the relevant specification.

b) The surface mount capacitor shall then be placed across the metallized land areas of the test substrate so as to make contact between surface mount and substrate land areas.

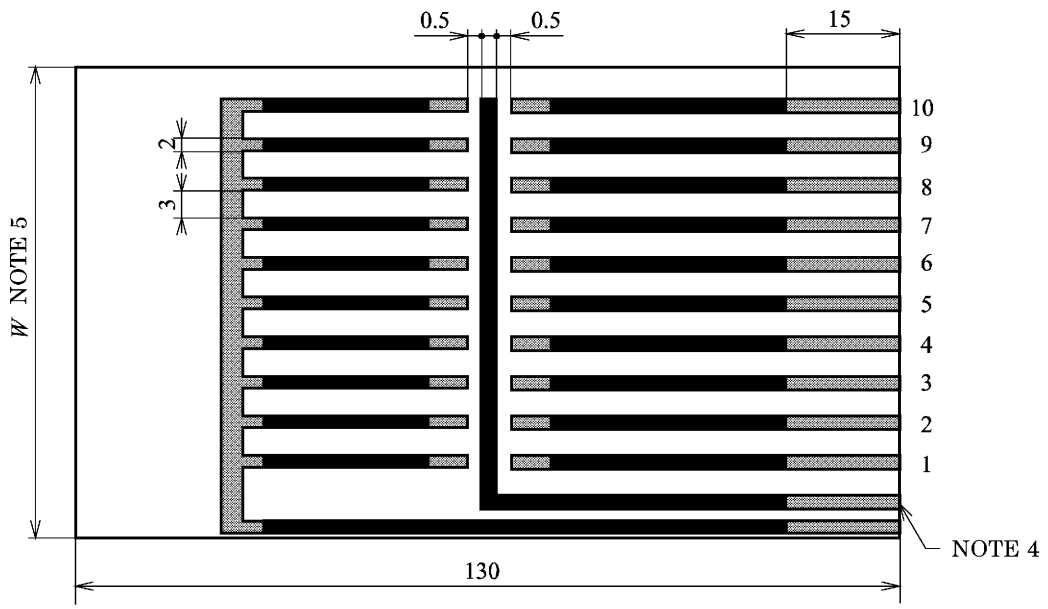
c) The substrate shall then be placed in or on a suitable heating system (molten solder, hot plate, tunnel oven, etc.). The temperature of the unit shall be maintained between 215 °C and 260 °C, until the solder melts and reflows forming a homogeneous solder bond, but for not longer than 10 s.

NOTE 1 Flux should be removed by a suitable solvent (see **JIS C 60068-2-45**, **3.1.2**). All subsequent handling should be such as to avoid contamination. Care should be taken to maintain cleanliness in test chambers and during post test measurements.

NOTE 2 The detail specification may require a more restricted temperature range.

NOTE 3 If vapour phase soldering is applied, the same method may be used with the temperatures adapted.

Unit: mm



Material: epoxide woven glass
Thickness: 1.6 mm ± 0.2 mm, or 0.8 mm ± 0.1 mm

NOTE 1 Solderable areas
Non-solderable areas (covered with non-solderable lacquer)

NOTE 2 All dimensions are in millimetres. Tolerances: medium.

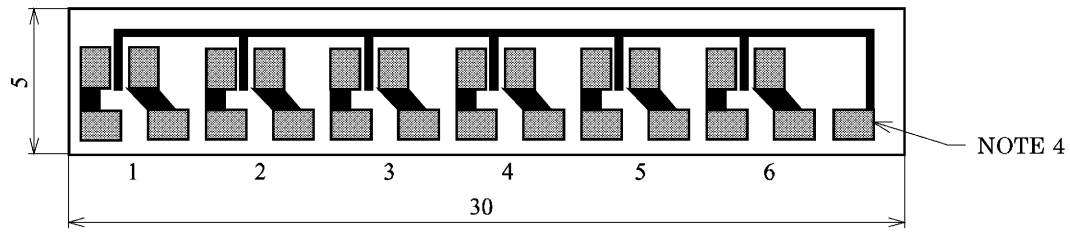
NOTE 3 Dimensions not given should be chosen according to the design and size of the specimens to be tested.

NOTE 4 This conductor may be omitted or used as a guard electrode.

NOTE 5 Dimension *W* is dependent on the design of the test equipment.

Figure 15 Suitable substrate for mechanical tests (may not be suitable for impedance measurements)

Unit: mm



Material: 90 % to 98 % alumina substrate
Thickness: 0.635 mm ± 0.05 mm, or more

NOTE 1 Solderable areas
Non-solderable areas (covered with non-solderable lacquer)

NOTE 2 All dimensions are in millimetres. Tolerances: medium.

NOTE 3 Dimensions not given should be chosen according to the design and size of the specimens to be tested.

NOTE 4 This conductor may be omitted or used as a guard electrode.

Figure 16 Suitable substrate for electrical tests

4.34 Shear test

4.34.1 Test procedure

The surface mount capacitors shall be mounted as described in **JIS C 60068-2-21**, test *U*.

The capacitors shall be subjected to **JIS C 60068-2-21**, Test U_{e3}, under the following condition.

A force shall be applied to the surface mount capacitor body progressively, without shock, and shall be maintained for a period of 10 s ± 1 s. Unless otherwise specified in the relevant specification, a force shall be selected from 1 N, 2 N, 5 N or 10 N.

4.34.2 Final inspection, measurements and requirements

The surface mount capacitors shall be visually examined in the mounted state. There shall be no visible damage.

4.35 Substrate bending test

4.35.1 Test procedure

The surface mount capacitor shall be mounted on a epoxide woven glass printed board as described in **4.33**.

a) The capacitance of the surface mount capacitor shall be measured as specified in **4.7** and in the relevant sectional specification.

b) The capacitor shall be subjected to **JIS C 60068-2-21**, test U_e, using the conditions as prescribed in the relevant specification for the deflection *D* and the number of bends.

NOTE : Figure 16A shows an example of bending jig.

c) The capacitance of the surface mount capacitors shall be measured as specified in **a**) with the board in the bent position. The change of capacitance shall not exceed the limits prescribed by the relevant specification.

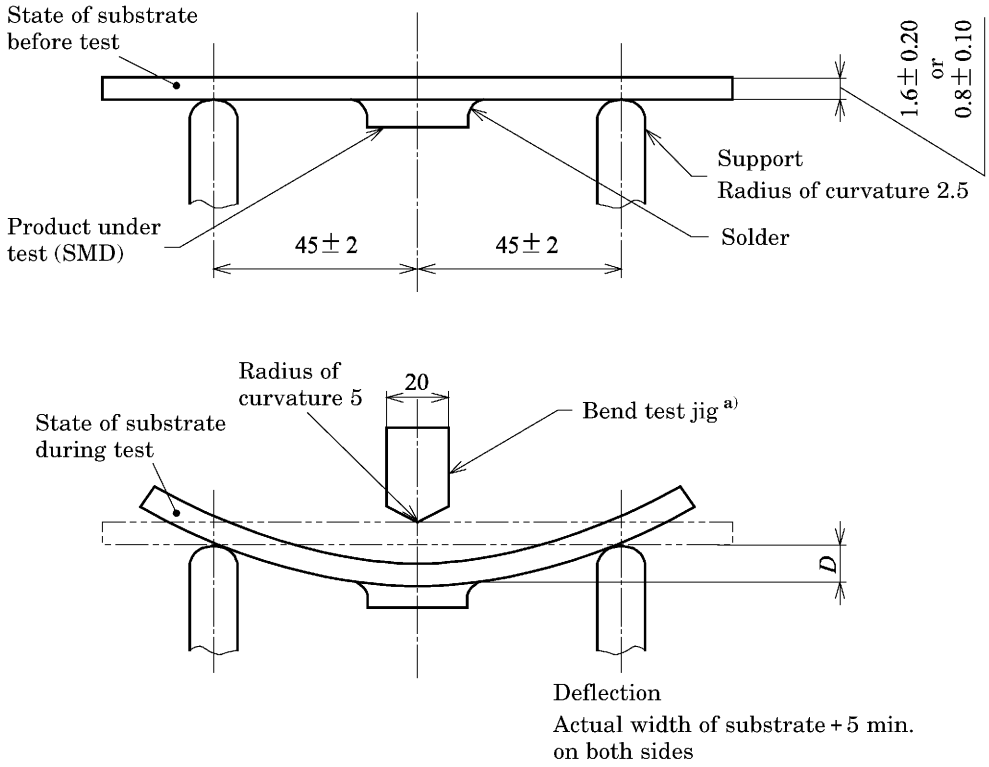
4.35.2 Recovery

The printed board shall be allowed to recover from the bent position and then removed from the test jig.

4.35.3 Final inspection, measurements and requirements

The surface mount capacitors shall be visually examined and there shall be no visible damage.

Unit: mm



Note a) The edge of bend test jig shall be chamfered.

Figure 16A Example of bending jig

4.36 Dielectric absorption

4.36.1 Test procedure

The capacitor under test shall be placed in a screened enclosure to reduce the effect of electric fields.

For the measurement of the voltage an electrometer or other suitable instrument having an input resistance of minimum 10 000 MΩ shall be used.

The resistance of any jigs, switches etc. used shall not affect the input resistance of the measuring system.

The capacitor shall then be charged at the d.c. voltage rating for 60 min ± 1 min. The initial surge current shall not exceed 50 mA.

At the end of this period the capacitor shall be disconnected from the power source and shall be discharged through a 5 Ω ± 5 % resistor for 10 s ± 1 s, unless the specified du/dt value is exceeded.

The discharge resistor shall be disconnected from the capacitor at the end of the 10 s discharge period. The voltage remaining or regained on the capacitor (recovery voltage) shall be measured.

NOTE : The recovery voltage is the maximum voltage occurring across the capacitor terminations within a 15 min period.

The dielectric absorption shall be calculated from the following formula:

$$d = \frac{U_1}{U_2} \times 100 \times \frac{C_X + C_0}{C_X}$$

where, d : the dielectric absorption (%);

U_1 : the recovery voltage;

U_2 : the charging voltage;

C_X : the capacitance of capacitor under test;

C_0 : the input capacitance of measuring system.

If C_0 is less than 10 % of C_X, the above formula can be simplified to:

$$d = \frac{U_1}{U_2} \times 100$$

4.36.2 Requirement

The dielectric absorption calculated shall not exceed the limit specified in the detail specification

4.37 Accelerated damp heat, steady state (for multilayer ceramic capacitors only)

4.37.1 Mounting of capacitors

The capacitors shall be mounted so that each capacitor is connected in series with a resistor. Half of the capacitors shall be connected in series with resistors of 100 kΩ ± 10 % and half in series with resistors of 6.8 kΩ ± 10 %.

4.37.2 Initial measurement

The capacitors, mounted as in **4.37.1**, shall be measured for insulation resistance with a voltage of 1.5 V ± 0.1 V applied across the capacitor and resistor in series.

The insulation resistance shall meet the requirements given in the relevant specification.

4.37.3 Test procedure

The capacitors with associated resistors shall be subjected to conditioning at (85 ± 2) °C, (85 ± 3) % RH for a duration to be specified in the relevant specification. Those capacitors connected to 100 kΩ resistors shall have a voltage of (1.5 ± 0.1) V applied, and those connected to 6.8 kΩ resistors shall have (50.0 ± 0.1) V or U_R, whichever is the lower, applied. In both cases the voltage shall be applied across the capacitor/resistor combination.

Care shall be taken to avoid condensation of water on to the capacitors or substrates. Condensation may happen if the door is opened during the test before the humidity is lowered.

4.37.4 Recovery

The applied voltage shall be disconnected and the capacitors and resistors shall be removed from the test chamber and allowed to recover for 4 h to 24 h in standard atmospheric conditions for testing.

4.37.5 Final inspection, measurements and requirements

The capacitors, mounted as in **4.37.1**, shall be measured for insulation resistance as in **4.37.2** above.

The insulation resistance shall be greater than 0.1 times the initial limit.

4.38 Passive flammability

4.38.1 Test procedure

The test shall be made according to **JIS C 60695-11-5**.

The capacitor under test shall be held in the flame in the position which best promotes burning (if this position is not given in the detail specification it shall be evaluated by pretesting). Each specimen shall be exposed only once to the flame.

The smallest, a medium (in the case of more than four case sizes), and the biggest case size shall be tested. Of each case size, three specimens of the maximum and three specimens of the minimum capacitance shall be tested, resulting in six specimens per case size.

For time of exposure to flame and burning time, see table 7. If applicable, the detail specification shall specify the category of passive flammability.

4.38.2 Final inspection, measurements and requirements

The burning time of any specimen shall not exceed the time specified in table 7.

Burning droplets or glowing parts falling down shall not ignite the tissue paper.

Table 7 Severities and requirements

Category of flammability	Severities Flame exposure time, in seconds, for capacitor volume ranges				Maximum burning time s
	Volume ≤ 250 mm^3	250 mm^3 < volume ≤ 500 mm^3	500 mm^3 < volume $\leq 1\,750$ mm^3	Volume $> 1\,750$ mm^3	
A	15	30	60	120	3
B	10	20	30	60	10
C	5	10	20	30	30

4.39 High surge current test

4.39.1 Initial measurements

Not required.

4.39.2 Test procedure

The test shall be carried out at a temperature of (23 ± 3) °C.

The test circuit is shown in figure 17. The switch may be mechanical or electronic but is preferably electronic. With the switch in position A, the capacitor under test is charged for 1 s from a low-impedance electrolytic capacitor of capacitance at least 20 000 μF to the rated voltage of the capacitor under test ($U_R \pm 2$ %) from a regulated

power supply capable of delivering 10 A. The impedance of the circuit through which the capacitor under test is charged shall meet the requirements of **4.39.3**.

After the 1 s charging time the capacitor under test shall be discharged for 1 s with the switch in position B through a circuit whose resistance is greater than 0.05 Ω but less than 0.2 Ω.

The voltage across the capacitor under test shall be monitored. Four further chargings and dischargings of the capacitor under test shall be carried out under the same conditions.

Capacitors may be tested in parallel provided that

a) their total capacitance is less than 2 % of the capacitance of the reservoir capacitor, and

b) all the conditions specified above are met for each capacitor under test.

The fuse may be a wire fuse designed to blow between 0.5 A and 2.0 A or an electronic circuit designed to trip in the same current range.

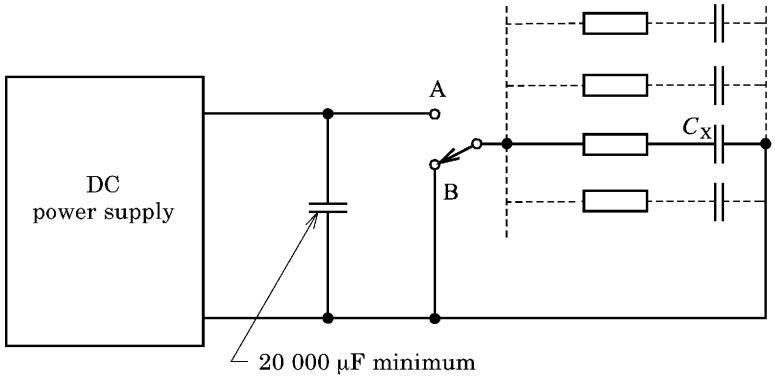


Figure 17 High surge current test

4.39.3 Requirements for the charging circuit

The test procedure of **4.39.2** shall be carried out with a capacitor of 47 µF ± 10 %, 35 V in the test position, or in every one of the test positions if provision is made for testing capacitors in parallel. The monitoring of the voltage across the capacitor under test shall demonstrate that the peak voltage across the capacitor during charging is $U_R {}^{+5}_{-2}$ %, and that 90 % of the measured peak voltage is achieved within 60 µs from the time of closure of the switch and without unwanted transients due to switch bounce or circuit inductance. Where there is provision for testing capacitors in parallel, this requirement shall be verified for each capacitor under test.

NOTE : It is unlikely that this requirement will be met unless the d.c. resistance of the charging circuit including wiring, fuse, fixtures, and the series resistance of the tank capacitor is less than 0.5 Ω.

4.39.4 Nonconforming items

A capacitor shall be considered a nonconforming item if the fuse blows or the electronic circuit trips at any single charging or discharging of the capacitor.