Title

Test methods for electronic circuit board for high-brightness LEDs

Introductory note:

- This PAS was submitted by the Japanese National Committee. It has been reviewed by the officers of TC 91 and concluded that there are no inconsistencies between the proposed document and any other TC 91 publications or current projects.

- This PAS will be a “dual logo” publication if approved. IEC-PAS agreement for copyright has been received from JPCA which has D-liaison with TC 91.

- This document is circulated simultaneously with associated NWIP (91/929/NP), “Test methods for electronic circuit board for high-brightness LEDs”.

- Approval criteria for PAS: Simple majority of P-members voting in favour.
Test Methods for Electronic circuit board for high-brightness LEDs

JPCA–TMC–LED02T–2010

Japan Electronics Packaging and Circuits Association
JPCA Standard

Test methods for electronic circuit board for high-brightness LEDs

JPCA-TMC-LED02T

1. Scope
This standard specifies the test methods of the electronic circuit board for high-brightness LEDs (hereafter described as electronic circuit board).

Note: Reference documents to this standard are listed in Annex 1.

2. Terms and definitions
Terms and definitions applicable to this standard are given in JPCA-TD01, JIS C 60068-1 and JIC C 5603.

3. Test conditions
3.1 Standard condition
Tests shall be made unless otherwise specified in a specific standard under the standard condition specified in JIC S 60068-1, 5.3.1, Standard atmospheric condition (standard condition), temperature of 15 °C to 35 °C, relative humidity of 25% to 75% and atmospheric pressure of 86 kPa to 106 kPa. Condition specified in 3.1 shall be used in case if there is any doubt to the experimental results or required by a specific standard.

3.2 Specified condition
The specified condition as specified in JIS C 60068-1, 5.2, Standard atmospheric condition (specified condition), is temperature of 20 °C ± 2 °C, relative humidity of 60% to 70% and atmospheric pressure of 86 kPa to 106 kPa.

4. Specimen
4.1 Preparation of specimen
Specimen shall be prepared as in (1) or (2) below. Surface of a specimen shall not be contaminated by oil/grease, sweat and others.

(1) Specimen by sampling: Specimen shall be sampled from the electronic circuit boards to be used in production. The specimen shall be cut to the defined size if its shape and size are defined in a specific standard. A test coupon may used as the specimen when such coupons are prepared.

(2) Specimen using a test pattern: A specimen shall be prepared using the test pattern shown in 4.2 using the same materials and method to produce products.

4.2 Test pattern
The test pattern with the shape and dimension shown in Figures A-1 and A-2 in Annex shall be used depending on the type of the electronic circuit board.

5. Pre-conditioning
Pre-conditioning described in (1) or (2) below shall be made in accordance to the specific standard.

(1) Leave a specimen for 24 h in the standard condition
(2) Leave a specimen for 60 min in a thermostat chamber at 85 °C and then leave the specimen for 24 ± 4 h in the standard atmospheric condition.

6. Appearance, micro-sectioning and dimensions
6.1 Appearance: Appearance check shall be made by naked eyes or using a magnifying glass for
appearance of the specimen, finish and conductor pattern according to its detailed specification.

Use a micrograph of 250X to check a micro-section of a specimen by cutting it and polishing the cutting face of a specimen embedded usually in epoxy resin or polyester resin.

6.2 Micro-sectioning: Inside of a plated through-hole, conductor or electronic circuit board shall be checked by micro-sectioning to see its cross section.

(1) Equipment  Equipment for the test is a micrograph capable of measuring a thickness of plated film with an accuracy of better than 0,001 mm, or equivalent.

(2) Material  Materials needed are: release agent, embedding resin, polishing cloth (#180, #400, #1000 and alike), polishing paper (#180, #400, #1000 and alike), and polishing powder (alumina, chromium oxide, etc)

(3) Specimen  The specimen shall be cut to an appropriate size not to make any damage to the observing face and embedded in resin. The cut specimen shall be polished using polishing cloth/paper from coarse to fine particle and then polish using a rotating disc with felt cloth and polishing powder. The polished surface shall be within 85 ° to 95 ° to the board layer.

The diameter of the micro-sectioned hole for measurement of plated film on a through-hole shall be larger than 90 % of the diameter of the hole measured beforehand. If necessary, etch the polished surface to identify layer boundaries of a specimen.

(4) Test  Observe the polished surface of a specimen according to the requirement of specific standard using a micrograph of the specified magnification.

6.3 Dimension

6.3.1 Appearance

(1) Equipment  Use a slide caliper specified in JIS B 7507 or equivalent accuracy.

(2) Measurement  Measure its length and width with an accuracy of 0,01 mm.

6.3.2 Thickness

(1) Equipment  Use a micrometer specified in JIS B 7502 or equivalent accuracy.

(2) Measurement  Measure the thickness of a board or total thickness if multilayer board with an accuracy of 0,01 mm.

6.3.3 (Through-) Hole diameter

(1) Equipment  Use a magnifying glass with reading scale with an accuracy of 0,01 mm

(2) Measurement  Measure the diameter of the specified hole.

6.3.4 Hole position

(1) Equipment  Use a coordination measuring instrument or a microscope with an accuracy of 0,01 mm, or an equivalent instrument.

(2) Measurement

(a) Measurement of the position of a hole on a grid shall be made by measuring the X and Y coordinate distances by holding the specimen board in an appropriate method.

(b) Measurement of the position of a hole from an arbitrary hole shall be made by measuring the distance of the measuring hole from that reference hole by holding the specimen board in an appropriate method.

6.3.5 Conductor width and minimum conductor spacing

(1) Equipment  Use a coordination measuring instrument or a microscope with an accuracy of 0,01 mm, or an equivalent instrument.

(2) Measure the conductor width and conductor spacing by holding the specimen board in an appropriate method.

6.3.6 Conductor nick and extraneous copper

(1) Equipment  Use the equipment specified in 6.3.3 (1) or 6.3.4 (1).
(2) Measurement  Measure the size of a conductor nick or of an extraneous copper of the length and width in the direction of the conductor.

6.3.7 Land

(1) Equipment  Use the equipment specified in 6.3.4 (1).

(2) Measurement  Observe the land to be measured from above and measure its maximum size.

6.3.8 Land width

(1) Equipment  Use the equipment specified in 6.3.4 (1).

(2) Measurement  Measure the distance (w) from the edge of a land and a hole.

![Non-plated through-hole and Plated through-hole](image)

(1) Non-plated through-hole  (2) Plated through-hole

Figure 1 Land width

6.3.9 Flatness

6.3.9.1 Warpage

(1) Equipment  Use the height-gauge specified in JIS B 7517 or an equipment with better accuracy.

(2) Measurement  Place the specimen as shown in Figure 2 on a precision base with its convex face upward. Measure the warpage as the maximum gap between the board and base (h_B) to an accuracy of 0,1 mm.

6.3.9.2 Twist

(1) Equipment  Use the regular class gap gauge specified in JIS B 7524 or a height-gauge specified in JIS B 7517 or an equipment with better accuracy.

(2) Measurement  Place the specimen as shown in Figure 3 on a precision base with its convex face upward with three corners of the board in touch with the base. Measure the twist as the maximum gap between the remaining floating edge of the board and base (h_T) to an accuracy of 0,1 mm.

![Warpage and Twist](image)

Figure 2 Warpage  Figure 3 Twist

7. Electrical tests

7.1 Conductor resistance
7.1.1 Conductor
(1) Equipment  Equipment is for the voltage-drop method (Four-terminal method), or equivalent. The current used in the measurement is d.c.
(2) Specimen  The specimen shall be a conductor long and narrow as much as possible, and shall comply with the detailed specification.
(3) Pre-conditioning  The pre-conditioning shall be as specified in 5.
(4) Test  Care shall be made to avoid influences caused by contact method o probe and of heating caused by the measuring current. Measure the resistance as shown in Figure 4 to an accuracy of ±5 % using the equipment described in (1).

![Figure 4](image)

Figure 4  Electrode arrangement for resistance measurement.

7.1.2 Plated through-hole
(1) Equipment  Use the equipment specified in 7.1.1 (1).
(2) Specimen  Specimen is the specified part of a board or a test coupon or with the specified composite test pattern as shown in the Figure D in Annex.
(3) Pre-conditioning  The pre-conditioning shall be as specified in 5.
(4) Test  Care shall be made to avoid influences caused by contact method o probe and of heating caused by the measuring current. Measure the resistance as shown in Figure 5 to an accuracy of ±5 % using the equipment described in (1).

![Figure 5](image)

Figure 5  Electrode arrangement for resistance measurement of a plated through-hole.

7.1.3 Interconnection
(1) Equipment  Use the equipment specified in 7.1.1 (1).
(2) Specimen  Specimen is the specified part of a board or a test coupon or with the specified composite test pattern as shown in the Figure L in Annex.
(3) Pre-conditioning  The pre-conditioning shall be as specified in 5.
(4) Test  Care shall be made to avoid influences caused by contact method o probe and of heating
caused by the measuring current. Measure the contact resistance as shown in Figure 5 to an accuracy of ± 5 % using the equipment described in (1).

![Figure 6 Electrode arrangement for resistance measurement of interconnection measurement.](image)

7.2 Current tolerance of conductor (when specified in a detailed specification)
(1) Equipment Equipment shall be a d.c. or an a.c. power supply capable of supplying the test current specified in 7.2.4, an ammeter and a temperature measuring instrument.
(2) Specimen The specimen shall be an electronics circuit board with the specified composite test pattern (select the pattern in reference to Figure A-3).
(3) Pre-conditioning The pre-conditioning shall be as specified in 5.
(4) Test Test shall be made by supplying the specified d.c. or a.c. current to the specimen for a specified time and measure the temperature rise of the specimen (see Figure A-3 for the current). This test shall be performed only when current tolerance is required.

7.3 Current tolerance of plated through-hole
(1) Equipment Equipment shall be a d.c. or an a.c. power supply capable of supplying the test current specified in 7.2.3, and an ammeter.
(2) Specimen The specimen shall be an electronics circuit board or an test coupon with the specified composite test pattern with a plated through-hole.
(3) Pre-conditioning The pre-conditioning shall be as specified in 5.
(4) Test Test shall be made by supplying the specified current to the plated through-hole for 30 sec and check if there is any anomaly. Examples of test current are shown in Table 1.

<table>
<thead>
<tr>
<th>Hole diameter, mm</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
<th>1.3</th>
<th>1.6</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test current, A</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>14</td>
<td>16</td>
<td>20</td>
</tr>
</tbody>
</table>

This test shall be made only when current tolerance is required.

7.4 Withstanding voltage of surface layer
(1) Equipment Equipment shall be an current breaker specified in JIS C 211-2, 8.1 or equivalent.
(2) Specimen The specimen shall be the specified section of an electronics circuit board with the specified composite test pattern (as shown in Figures A-1 and A-2, E). The damaged specimen in this test such as mechanical damage, flush over, spark over or breakdown shall be used in other test.
(3) Pre-conditioning The pre-conditioning shall be as specified in 5.
(4) Test  Test shall be made by  the specified d.c. voltage or 50 H or 60 H a.c. voltage with a peak 
voltage specified in detailed specification.  The applying voltage shall be increased to the specified 
voltage in 5 sec and keep at the voltage for 1 min.  Damages such as mechanical damage, flush 
over, spark over or breakdown shall be checked.

7.5 Interlayer withstanding voltage
(1) Equipment  Equipment shall be as specified in 7.4.1.
(2) Specimen  The specimen shall be the specified section of an electronics circuit board with the 
specified composite test pattern (as shown in Figure A-2.1, M).
(3) Pre-conditioning  The pre-conditioning shall be as specified in 5.
(4) Test  Test shall be as specified in 7.4.4.

7.6 Insulation resistance of surface layer (normal and resistance to humidity (temperature-humidity cycle 
and steady state))
(1) Equipment  Equipment shall be as the insulation tester as specified in JIS C 1302, or an standard 
resistance, universal shunt and a galvanometer calibrated to an accuracy of  ± .10 %.
(2) Specimen  The specimen shall be a solder resist coated test coupon as specified in Figure A-3.1
(3) Pre-conditioning  The pre-conditioning shall be as follow for each condition.
(a) Normal  Specimen shall be left in a thermostat chamber at 85 ± 2 °C for 4 h and then leave 
it at temperature 20 ± 2 °C and relative humidity of 60 ± 10 % for 24 ± 4 h.
(b) Resistance to humidity (temperature-humidity cycle)  Specimen shall be conditioned for 10 
cycles. 9.4 and then measure the resistance in an environment of 20 ± 2 °C and relative 
humidity of 60 ± 10 % within 30 to 60 min after conditioning.
(c) Resistance to humidity (steady state)  Specimen shall be conditioned for 96 h with the 
condition of an environment of 40 ± 2 °C and relative humidity of 90 ± 95 % and then 
measure the resistance in an environment of 20 ± 2 °C and relative humidity of 60 ± 10 % 
within 30 to 60 min after conditioning.
(4) Test  Measurement shall be made for insulation resistance after applying a voltage to the specimen 
for 1 min of a voltage as specified in detailed specification of either 10 ± 1 V, 100 ± 15 V, or 500 
50 V.

7.7 Insulation resistance of inner layer (normal and resistance to humidity (temperature-humidity cycle 
and steady state))
(1) Equipment  Equipment shall be as specified in 7.6 (1).
(2) Specimen  The specimen shall be a coupon with a comb pattern as shown in Figure A-3.2.  The 
conductor spacing of the specimen shall be the minimum spacing of actual production board.
(3) Pre-conditioning  The pre-conditioning shall be as in 7.6 (4).
(4) Test  Test shall be as described in 7.6 (4).

7.8 Insulation resistance between inner layers (normal and resistance to humidity (temperature-humidity cycle 
and steady state))
(1) Equipment  Equipment shall be as specified in 7.6 (1).
(2) Specimen  The specimen shall be a coupon with a comb pattern as shown in Figure A-3.3.  The 
diameter of the hole, φ , shall be 10 mm, nominal hole diameter of through holes for 
interconnections to inner layers shall be 0.8 mm and nominal land diameter shall be 2 mm.
(3) Pre-conditioning  The pre-conditioning shall be as in 7.6 (3).
(4) Test  Measurement shall be made for insulation resistance after applying a d.c. voltage to the 
 specimen for 1 min of a voltage as specified in detailed specification of either 100 ± 15 V, or 500
7.9 Electric integrity

7.9.1 Circuit insulation

(1) Equipment  Equipment shall consist of a power supply which can supply the test voltage to a specimen, resistance meter and probes which can contact to the measuring points.

(2) Specimen  Specimen shall be a product or the specified part of a test coupon.

(3) Pre-conditioning  Preconditioning shall be as specified in 5.

(4) Test  Measurement shall be made to confirm not to exist electric contacts to unintended section of the specimen in the intended specification (art-work, computer generated test data, or detailed specification). Apply the specified test voltage to the specified part of the test pattern and measure the resistance. Insulation shall be confirmed when the resistance is above the specified minimum resistance. The applied voltage and applying time, and the minimum allowed resistance shall be specified in detailed specification.

7.9.2 Conduction

(1) Equipment  Equipment shall consist of a power supply which can supply the test current to a specimen, resistance meter and probes which can contact to the measuring points.

(2) Specimen  Specimen shall be the specified part of a product.

(3) Pre-conditioning  Preconditioning shall be as specified in 5.

(4) Test  Measurement shall be made to confirm not to exist electric contacts to unintended section of the specimen in the intended specification (art-work, computer generated test data, or detailed specification). Apply the specified test voltage to the specified part of the test pattern and measure the resistance. Insulation shall be confirmed when the resistance is above the specified minimum resistance. The applied voltage and applying time, and the minimum allowed resistance shall be specified in detailed specification.

8. Mechanical tests

8.1 Peel strength of conductor

(1) Equipment  The instrument shall be a testing machine which can keep the pulling speed of the cross head to 50 mm/min. The accuracy of shall be within ± 1 % of the indication within its effective measuring range and the pulling force shall be within 15 % to 85 % of the capability of the testing machine. Use a jig to hold the specimen to keep the peeling angle to 90 ° to the specimen surface.

(2) Specimen  The specimen shall have a straight conductor band with an appropriate length and uniform width (e.g. Figures 1 to 2, G). A specimen with a conductor band of 0,8 mm width shall not be used in the test.

(3) Pre-conditioning  Preconditioning shall be as specified in 5.

(4) Test  Test shall be made in standard environmental condition. One end of the conductor shall be lift off for about 10 mm from the board and fastened to the peeling machine. The conductor shall be peeled from the board at 90 ° to the surface of the board at 50 mm/min for more than 25 mm. The minimum force per unit width, N/cm, in this peeling shall be the peel strength. Repeat the test if the conductor is cut in peeling of less then 25 mm.

8.2 Peeling strength of a land with non-plated hole

(1) Equipment  Equipment shall be as specified in 8.1.1 and 10.3.1.

(2) Specimen  Specimen shall have an round land (e.g. Figure A-1, J) with a hole to solder a lead wire as specified in Table 2. A lead wire and the land shall be pre-soldered using the solder specified in 10.3.2 using the equipment specified in 10.3.1 within 3 sec. In case other dimensions are to be
used, use the condition specified in detailed specification.

Table 2  Land, hole and lead wire

<table>
<thead>
<tr>
<th>Land diameter</th>
<th>Hole diameter</th>
<th>Diameter of lead wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1,3</td>
<td>0,9 to 1,0</td>
</tr>
<tr>
<td>2</td>
<td>0,8</td>
<td>0,6 to 0,7</td>
</tr>
</tbody>
</table>

(3) Preconditioning  Preconditioning shall be as specified in 5.

(4) Test

(a) Insert a lead wire to the hole of the land of a specimen and solder it to the land at the surface without bending the tip of the wire in the back. The tip of the soldering iron (diameter of the tip shall be 5,0 ± 0,1 mm) shall have a temperature of 270 ± 10 °C. Solder the wire without touching the tip to the land within 3 to 5 sec. Cool the specimen in room temperature for more than 30 min. Pull the soldered wire using the testing machine to the peeling of the land with a peeling speed of 50 mm/min and measure the force when the wire is pulled off from the land. Repeat the test if the wire is cut by pulling, or pulled off from the land.

(b) In case peeling strength of a land is measured after repeated soldering of a wire to the land, use a specimen prepared as described in (a) and remove the wire in the same manner as to solder it to the land, and solder a wire again to the land of the specimen in the same way. Repeat soldering and removing of a wire for a number of times as specified in detailed specification. Cool the specimen each time for more than 30 min at room temperature. Pull the soldered wire using the testing machine to the peeling of the land with a peeling speed of 50 mm/min and measure the force when the wire is pulled off from the land. Repeat the test if the wire is cut by pulling, or pulled off from the land.

8.3 Peeling strength of Plated through-hole

(1) Equipment  Equipment shall be as specified in 8.1.1.

(2) Specimen  An example of the test pattern is shown in Figure A-1.1 and Figure A-2.1. Remove the land in case the plated through-hole is connected to a land before test. A lead wire which can pass through the hole freely shall be pre-soldered to the plated through-hole and the end of the wire shall project more than 15 mm from the hole. The projected end of the wire shall not be bent.

(3) Preconditioning  Preconditioning shall be as specified in 5.

(4) Test  Insert a lead wire to the plated through-hole of the land of a specimen extruding more than 15 mm from the land and solder it to the plated through-hole. The tip of the soldering iron (diameter of the tip shall be 5,0 ± 0,1 mm) shall have a temperature of 270 ± 10 °C. Solder the wire without touching the tip to the land within 3 to 5 sec. Cool the specimen in room temperature for more than 30 min. Pull the soldered wire using the testing machine to the peeling of the land from the board with a peeling speed of 50 mm/min and measure the force when the wire is pulled off from the land. Repeat the test if the wire is cut by pulling, or pulled off from the land.

8.4 Peeling strength of footprint

(1) Equipment  Equipment shall be as specified in 8.1.1 and 10.3.1.

(2) Specimen  The specimen shall be an isolated footprint. The size and the lead wire to be used shall be specified in detailed specification. Pre-solder the wire and the footprint using appropriate solder flux and solder using the equipment described in 10.3.1 and the solder specified in 10.3.2.

(3) Preconditioning  Preconditioning shall be as specified in 5.

(4) Test
(a) Solder the lead wire vertically to the center of the specimen. The tip of the soldering iron (diameter of the tip shall be 5.0 ± 0.1 mm) shall have a temperature of 270 ± 10 °C. Solder the wire without touching the tip to the land within 3 to 5 sec. Cool the specimen in room temperature for more than 30 min. Pull the soldered wire using the testing machine to the peeling of the foot print from the board with a peeling speed of 50 mm/min and measure the force when the foot print is pulled off from the board. Repeat the test if the wire is cut by pulling, or pulled off from the foot print.

(b) In case peeling strength of a foot print is measured after repeated soldering of a wire to a foot print, use a specimen prepared as described in (a) and remove the wire in the same manner as to solder it to the foot print, and solder a wire again to the foot print of the specimen in the same way. Repeat soldering and removing of a wire for a number of times as specified in detailed specification. Cool the specimen each time for more than 30 min at room temperature. Pull the soldered wire using the testing machine to the peeling of the foot print with a peeling speed of 50 mm/min and measure the force when the wire is pulled off from the foot print. Repeat the test if the wire is cut by pulling, or pulled off from the foot print.

8.5 Adhesivity of plated film
(1) Material used in the test  The material to be used in the test shall be the transparent adhesive tape (hereafter stated as tape) with a width of 12 mm specified in JIS Z 1522.
(2) Specimen  An example of the test pattern to be used in specimen is shown in Figures A-1 and 2, K.
(3) Preconditioning  Preconditioning shall be as specified in 5.
(4) Test  Test shall be made by adhering the new adhesive face of the adhesive tape to the specimen for a length of more than 50 mm by finger pressing or another appropriate way not to leave a bubble between the tape and the specimen. Pull the tape off rapidly after about 10 sec to the direction perpendicular to the surface. The adhered area shall be no less than 100 mm². Peeling, floating, or attach to plated film to the adhesive tape shall be checked by a naked eye or using a magnifying glass. The plated film exfoliated from the overhang of the conductor shall not be the target of the test.

8.6 Adhesivity of solder resist and symbol mark
8.6.1 Tape peeling strength
(1) Material used in the test  The material to be used in the test shall be as specified in 8.5.1.
(2) Specimen  Specimen shall be an electronic circuit board with solder resist or symbol mark.
(3) Preconditioning  Preconditioning shall be as specified in 5.
(4) Test  Test shall be made by adhering the new adhesive face of the adhesive tape to the specimen for a length of more than 50 mm by finger pressing or another appropriate way not to leave a bubble between the tape and the specimen. Pull the tape off rapidly after about 10 sec to the direction perpendicular to the surface. Peeling, floating, or attach to plated film of solder resist or symbol mark to the adhesive tape shall be checked by a naked eye or using a magnifying glass.

8.6.2 Grid line test (see JIS K 5600, 5 and 6)
(1) Material used in the test  The material to be used in the test shall be the tape as specified in 8.5.1 and a cutter knife specified in the following section. The cutter knife to cut a coating surface shall have the shape and dimension illustrated in Figure 7, and made of the material SK2 specified in JIS G 4401 with a hardness of HV 820 ± 30. A new sharp edge of a blade shall be used by taking off an old edge and held the blade in a holder as shown in Figure 8.
(2) Specimen  Specimen shall be as specified in 8.6.1 (2).
(3) Pre-conditioning  Pre-conditioning shall be as specified in 5. The pre-conditioning shall be
specified in detailed specification in case doing the grid line test for adhesivity after performing other
tests.

(4) Test Cut the specimen surface using a cutter knife to cut through the coated film or printed pattern
spending about 0.5 sec for each line of total of 11 parallel lines in each direction with a separation of 1
mm to obtain 100 small squares in an area of 100 mm². Clean the surface using a soft brush and
test the adhesivity of the coating using the test method described in 8.6.1 (4).

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8.6.3 Scratch test using pencil

(1) Material used in the test The material to be used in the test shall be the pencil specified in JIS SS
6006. Types of the pencils are: 9H, 8H, 7H, 6H, 5H, 4H, 3H, 2H, H, F, B, 2B, 3B, 4B, 5B and 6B.
Use the pencils produced by the same manufacturer. Cut the wood of a pencil to expose about 3
mm of the lead and then sharpen the lead using #400 lapping paper placed on a hard plate as to the
lead is perpendicular to the lapping paper and a sharp edge is obtained at the end of the lead.
Pencil shall be newly sharpened each time used to scratch the specimen surface.

(2) Specimen Specimen shall be as specified in 8.6.1 (2).

(3) Pre-conditioning Pre-conditioning shall be as specified in 5. The pre-conditioning shall be
specified in detailed specification in case doing the pencil scratch test is made after performing other
tests.

(4) Test Place the specimen horizontally and apply a the hardest pencil as shown in Figure 9 with an
angle of 45 °. Push the pencil forward and write a line to form a scratch to the surface. Change
the pencil to a softer pencil until the pencil does not form a scratch to the surface to obtain the most
hard pencil not to make a scratch to the surface of a specimen.
8.7  Resistance to bending

(1) Equipment  The equipment for this test shall be the test machine for bending as shown in Figure 10.
(a) The holder to apply the force can move to the vertical direction to the rotating axis of the test
machine. The face to hold a specimen is on the same plane to the rotating axis. It is possible
to apply a tension of 0 N to 14,7 N to a specimen. The distance from the holder to the rotating
axis shall be 50 mm to 70 mm.
(b) The bending machine has a parallel and smooth bending faces and placed symmetric positions.
The bending machine has a holding device which can bend a specimen to $135^\circ \pm 5^\circ$ from the
non-bending position. Each of the bending face shall have the radius of curve of less than 19
mm. The spacing of bending faces shall be larger than the thickness of the specimen but shall
not exceed 0,25 mm to the thickness of unbend specimen.
(c) There shall be a driving scheme to give a specified rotating movement to the bending machine.
(d) There shall be an indicator of the number of bending.

(2) Specimen  Prepare a minimum number of specimens of 6 of flexible wiring board, test coupons, or
specimen with the test pattern specified in Figure A5 and the cover-lay.

(3) Pre-conditioning  Pre-conditioning shall be as specified in 5..

(4) Test  Apply a weight equivalent to the tension to be applied to the plunger to specimen. Hold a
specimen to the instrument as to the specimen is in a plane and not to touch to the holding face of
the machine. The specimen shall be handled at both ends but not to touch to the bending face.
Loose the holding screw of the plunger and apply the load to the specimen. Adjust the weight
indicator if its reading changes when a load is applied by adjusting the adjustment screw to adjust the
reading of the indicator to the value shown when a load is applied. Bend the specimen with a
tension of 4,9 N at 175 bending per minute until the specimen breaks. Register the number of
bending to breakage.
9. Environmental tests

9.1 Temperature cycle

(1) Equipment  The equipment shall be the high temperature and low temperature chambers to realize the temperature shown in Table 3.

(2) Specimen  Specimen shall be test coupons, coupons with composite test patterns (e.g. Figures A-1 and 2, D, E or Figure A-2.1 L)

(3) Test  Test shall be made for the specimen for the items specified in detailed specification and then test shall be made selecting the temperature condition from the Table 3 depending on the detailed specification for steps 1 to 4 for the specified cycles in the detailed specification. The number of cycles shall be five (5) if the number is not specified in detailed specification.

Table 3  Temperature cycle conditions

<table>
<thead>
<tr>
<th>Step</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp., °C</td>
<td>Time, Min</td>
<td>Temp., °C</td>
</tr>
<tr>
<td></td>
<td>-65 ± 3</td>
<td>30</td>
<td>-65 ± 3</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>20 ± 15</td>
<td>10 to 15</td>
<td>20 ± 15</td>
</tr>
<tr>
<td>3</td>
<td>125 ± 3</td>
<td>30</td>
<td>100 ± 2</td>
</tr>
<tr>
<td>4</td>
<td>20 ± 15</td>
<td>10 to 15</td>
<td>20 ± 15</td>
</tr>
</tbody>
</table>

9.2 Thermal shock (low and high temperatures) (see JIS C 0225)

(1) Equipment  Equipment shall be thermostat chambers which can realize the temperatures shown in Table 4.

(2) Specimen  Specimen shall be prepared as described in 9.1.2.
(3) Test  Characteristics of a specimen specified in detailed specification shall be measured first. The specimen shall then be held in the chambers at temperature selected from Table 4 according to the condition specified in detailed specification for step 1 to step 2, then return step 2 to step 1 within 30 sec for the cycles specified in detailed specification. The number of cycles shall be 5 when the number is not specified in detailed specification.

Table 4  Thermal shock conditions

<table>
<thead>
<tr>
<th>Step</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>Condition 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time, min</td>
<td>Time, min</td>
<td>Time, min</td>
<td>Time, min</td>
</tr>
<tr>
<td>Step 1</td>
<td>-65 ± 3</td>
<td>-65 ± 3</td>
<td>-65 ± 3</td>
<td>-55 ± 3</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Step 2</td>
<td>175 ± 3</td>
<td>125 ± 3</td>
<td>100 ± 2</td>
<td>100 ± 2</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

9.3 Thermal shock (immersion in high temperature)

(1) Equipment  Equipment shall satisfy the following conditions.
(a) A container to contain enough silicone oil to immerse a specimen in the oil and keep the temperature to 260 ±5/-0 °C.
(b) A container to contain enough organic solvent to immerse a specimen in the oil and keep the temperature to 20 ±15 °C.

(2) Specimen  Specimen shall be prepared as described in 9.1.2.

(3) Test  Characteristics of a specimen specified in detailed specification shall be measured first. The specimen shall then be held in the chambers at temperature selected from Table 5 according to the condition specified in detailed specification for step 1 to step 4 for the cycles specified in detailed specification. The number of cycles shall be 5 when the number is not specified in detailed specification. The specimen shall be left for a sufficient time to bring it to a stable state and then perform following specified tests.

Table 5  Test condition

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Step</th>
<th>Temperature, °C</th>
<th>Time, min</th>
<th>Immerse in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>260 ±5/-0</td>
<td>3 to 5</td>
<td>silicone oil</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20 ±15</td>
<td>≤15</td>
<td>transfer</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>20 ±15</td>
<td>20</td>
<td>organic solvent</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>20 ±15</td>
<td>≤15</td>
<td>transfer</td>
</tr>
</tbody>
</table>

9.4 Resistance to humidity (temperature/humidity cycle) (see JIS C 60068-2-38)

(1) Equipment  Equipment shall satisfy the following conditions.
(a) A container shall be able to realize the temperature/humidity cycles illustrated in Figure A-6.
(b) The resistance of water shall be larger than 500 Ωm in case the water is directly sprayed to humidify the chamber.
(c) Water condensated on the wall or ceiling of the chamber shall not drop on or near the specimen.

(2) Specimen  Specimen shall be a product or coupon with the test pattern (Figures A-1, -2 E, Figure A-2.1 J).

(3) Test  Characteristics of a specimen specified in detailed specification shall be measured first. The specimen shall then be held in the chambers for the humidity exposure cycles specified in detailed
specification. The number of cycles shall be 10 when the number is not specified in detailed specification. The specimen shall be left for a sufficient time to bring it to a stable state and then perform following specified tests.

Subject the specimen for 24 h with the procedure step a to g given in Figure A-6 as one cycle. Procedure at the final cycle, g, (measurement at high temperature, measurement right after taking the specimen out of the chamber, and measurement after drying) shall be as stated in detailed specification. The specimen shall be used for the test(s) specified in detailed specification. The damaged specimen in this test such as mechanical damage, flush over, spark over or breakdown shall be used in other test.

9.5 Resistance to humidity (steady state) (see JIS C 6006-2-78)

(1) Equipment Equipment shall satisfy the following conditions.
   (a) A container shall be able to keep its temperature and relative humidity in the chamber to 40 ± 2 °C and 90 to 95 %.
   (b) The resistance of water shall be larger than 500 Ωm in case the water is directly sprayed to humidify the chamber.
   (c) Water condensed on the wall or ceiling of the chamber shall not drop on or near the specimen.

(2) Specimen Specimen shall be prepared as described in 9.4.2.

(3) Test Characteristics of a specimen specified in detailed specification shall be measured first. The specimen shall then be held in the chamber at 40 ± 2 °C and 90 to 95 %. It is desirable to preheat the specimen before setting it in the chamber as not to condensate water vapour on the specimen. The specimen shall be left for a specified time in detailed specification. The time shall be 240 h unless it is not specified in detailed specification. The specimen shall be taken out of the chamber and measure the items specified in detailed specification. Care shall be made to wipe water vapour on the specimen if there is any. The damaged specimen in this test such as mechanical damage, flush over, spark over or breakdown shall be used in other test.

10. Other tests

10.1 Flammability

(1) Equipment Equipment shall satisfy the following conditions
   (a) A stand with a holding arm
   (b) A burner with the length of the tube of 100 ± 10 mm with opening diameter of Ø = 9,5 ± 0,3 mm using methane gas or natural gas with heat capacity of approximately 38 MJ/m³.
   (c) A stop-watch or a timer.
   (d) Cotton.
   (e) Desiccator with dry potassium chloride.
   (f) A test chamber capable of realizing 23 ± 2 °C and 50 ± 5 %.
   (g) A test chamber capable of realizing 70 ± 2 °C.

(2) Specimen Specimen shall be a test board without conductor to be cut to a length of 125 ± 0,5 mm and width of 13 ± 0,5 mm and the cut surfaces are smoothly made.

(3) Number of specimen The number of specimen used in the test shall be 20.

(4) Pre-conditioning Specimens are to be treated (a) and (b) stated below for pre-conditioning.
   (a) Leave 5 specimens in a test chamber at 23 ± 2 °C and 50 ± 5 % for 48 h.
   (b) Five specimens are heated to 70 ± 2 °C die 168 h and then cool them more than 4 h in a desiccator with dry potassium chloride.

(5) Test A specimen shall be clamped vertically to the holder at 6 mm from the top in a room without air flow and place a burner as the tip of the upper end of the burner is 10 ± 1 mm below the lower end of
the specimen. Place a cotton pad 300 ± 10 mm below the specimen and lit the burner to the blue flame with the flame height to 20 ± 2 mm. Burn the specimen with the burner flame for 10 ± 0.5 sec. Leave the burner more than 150 mm from the specimen and measure the flaming time of the specimen (time the specimen burns with flame). After the flaming of the specimen, the burner is again brought to the same position of the specimen for 10 ± 0.5 sec. Leave the burner more than 150 mm from the specimen and measure the flaming time and the glowing time (time the specimen is in red but not flaming) of the specimen. Observe if there is any fire in the cotton below caused any hot falling from the specimen.

![Flammability test diagram](image)

Figure 10  Flammability test (mm).

10.2 Resistance to chemical solvent

1) Equipment  Equipment shall be a container is solvent resistant and can heat it to a specified temperature with protection from over heating.

2) Specimen  Specimen shall be electronic circuit board with solder resist and/or symbol mark.

3) Pre-conditioning  Pre-conditioning shall be as specified in 5.

4) Test  Dip the specimen into boiling solvent for 1 min. Check if there is any damage to the specimen by naked eyes. Confirm there is no peeling of solder resist or symbol mark with the test as described in 8.6 by naked eyes.

10.3 Solderability

1) Equipment  Equipment shall be a soldering equipment which is capable of either dip soldering, flow soldering or swing type soldering (1) and can keep its temperature to 235 ±5/0 °C. Note (1) Swing type instrument described in JIS C 60068-2-20, 6.Specimen

2) Solder  Unless otherwise specified in detailed specification, the solder to be used in the test shall be H 60A or H 63A specified in JIS Z 3283.

3) Specimen  Unless otherwise specified in detailed specification, specimen shall be a test coupon or a coupon with the test pattern (see Figures A-1 and A-2, A or H).

4) Pre-conditioning  Pre-conditioning shall be as specified in 5.

5) Test  Coat soldering flux to the surface of a specimen. Flux shall be one of (1) to (3) specified below unless specified in detailed specification. Remove flux after soldering at the temperature and
time specified in detailed specification. If not specified in detailed specification, soldering shall be made at 235 ±5/0 °C for 3 ±1/0 sec.

Flux (1) Mixture of 25 % rosin (JIS K 5902) in weight and 75 % propyl alcohol (JIS K 8839) or ethyl alcohol (JIS K 8101).

Flux (2) Flux (1) with added diethyl ammonium chloride to a chlorine content of 0.2 % weight % (as free chlorine to rosin content).

Flux (3) Flux with chlorine content of 0.5 % as specified in flux (2)

Check the soldered surface using a magnifying glass under sufficient illumination
(a) Solder wetting and gloss
(b) Repel and pin-holes
(c) Filling of solder in through-hole and wetting

10.4 Resistance to soldering heat

10.4.1 Solder float method
(1) Equipment  Equipment shall be a soldering bath which is heated by electric heater and can keep it to a specified temperature.
(2) Solder  Unless otherwise specified in detailed specification, the solder is specified in 10.3.2.
(3) Specimen  Use specimen specified in detailed specification. Unless otherwise specified, specimen shall be as illustrated in Figure A-7.
(4) Pre-conditioning  Pre-conditioning shall be as specified in 5.
(5) Test  Coat soldering flux to the surface of a specimen. Flux shall be Mixture of 25 % rosin (JIS K 5902) in weight and 75 % propyl alcohol (JIS K 8839) or ethyl alcohol (JIS K 8101). unless otherwise specified in detailed specification. Float the specimen on the molten solder and then taken out of the bath and check for swelling or peel. The temperature and time for this test shall be 260 ±5/0 °C for 10 ±1/0 sec unless otherwise specified in detailed specification. Use the micro-sectioning specified in 6.2 to check peeling inside of a specimen.

10.4.2 Reflow soldering
(1) Equipment  Use the equipment specified in detailed specification.
(2) Specimen  Use specimen specified in detailed specification. Unless otherwise specified, specimen shall be as illustrated in Figure A-7.
(3) Pre-conditioning  Pre-conditioning shall be as specified in 5.
(4) Test  Reflow solder the specimen with the temperature profile specified in detailed specification for 1 to 3 times. If the temperature profile is not specified in detailed specification, use the temperature profile given in Figure A-8. Check for swelling or peel after reflow soldering by naked eyes. Use the micro-sectioning specified in 6.2 to check peeling inside of a specimen.

10.5 Resistance to heat of solder resist and symbol mark

10.5.1 Solder floating method
(1) Equipment  Use the equipment specified in 10.4.1 (1).
(2) Specimen  Use specimen specified in detailed specification. Unless otherwise specified, specimen shall be as illustrated in Figure A-7.
(3) Pre-conditioning  Pre-conditioning shall be as specified in 5.
(4) Test  Float the specimen on the molten solder and then taken out of the bath and check for swelling, peel or colour change of symbol mark by naked eyes. The temperature and time for this test shall be 260 ±5/0 °C for 10 ±1/0 sec unless otherwise specified in detailed specification. Check if there is any peeling by performing the test specified in 8.6 as a peeling.

10.5.2 Reflow soldering method
(1) Equipment  Use the equipment specified in 10.4.1 (1).
(2) Specimen Use specimen specified in detailed specification. Unless otherwise specified, specimen shall be as illustrated in Figure A-7.

(3) Pre-conditioning Pre-conditioning shall be as specified in 5.

(4) Test Process the specimen with the temperature profile given in 10.4.2 (4), then float the specimen on the molten solder and then taken out of the bath and check for swelling, peel or colour change of symbol mark by naked eyes. Check if there is any peeling by performing the test specified in 8.6 as a peeling.

10.6 Thermal conductivity
10.6.1 Measurement of thermal resistance on the plane

(1) Equipment Use the equipment specified in EIA/JEDEC STD 51-2 (Integrated Circuits Thermal Test Method – Environment Conditions – Natural convection (still air)), or an equivalent. The equipment shall have a set of a specimen and a thermo-couple at the center of a cubic chamber of 30 cm a side length. Schematic diagram of the equipment is shown in Figure A-1.

(2) Specimen Use specimen specified in detailed specification. Unless otherwise specified, specimen shall be as illustrated in Figure A-2. A heater of a size of 5 mm x 5 mm with a temperature measuring sensor is used as a heat source and wire bonded to specimen board.

(3) Pre-conditioning Pre-conditioning shall be as specified in 5.

(4) Test Specimen shall be fixed in the chamber that is equipped with a heater with a temperature measuring sensor whose temperature coefficient has already been obtained. Heat the heater with temperature sensor with a heat of W. Electricity is supplied in this standard by connecting power supply directly to the specimen through electricity is supplied using a card-edge connector in EIA/JEDEC STD 51-2. Hold the specimen horizontally in the chamber and the board and the supporting jig is thermally isolated. The heat, W, from the heater with temperature sensor depends on the thermal resistance, Rp, on the plane shall be selected from Table 6. Measure the temperature of the temperature sensor, Ts, and the temperature of the air in the chamber, Ta, after the temperature of the sensor reached to a stable state. Thermal resistance on the plane, Rp, shall be calculated from the following equation.

\[ Rp = \frac{(Ts - Ta)W}{W} \quad (\text{K/W}) \]

Heat transfer parameter, he, shall be calculated from the following equation using Rp.

\[ he = \frac{1}{Rp \times 0.025} \]
Table 6  Heating of specimen

<table>
<thead>
<tr>
<th>Load heat (W)</th>
<th>Thermal resistance Range of Rp(K/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>3000&lt;R</td>
</tr>
<tr>
<td>0.2</td>
<td>2000&lt;R&lt;300</td>
</tr>
<tr>
<td>0.3</td>
<td>1500&lt;R&lt;200</td>
</tr>
<tr>
<td>0.4</td>
<td>1000&lt;R&lt;150</td>
</tr>
<tr>
<td>0.75</td>
<td>600&lt;R&lt;100</td>
</tr>
<tr>
<td>1.0</td>
<td>300&lt;R&lt;600</td>
</tr>
<tr>
<td>2.0</td>
<td>200&lt;R&lt;300</td>
</tr>
<tr>
<td>3.0</td>
<td>150&lt;R&lt;200</td>
</tr>
<tr>
<td>5.0</td>
<td>50&gt;R&lt;150</td>
</tr>
<tr>
<td>10.0</td>
<td>R&lt;5</td>
</tr>
</tbody>
</table>

10.6.2  Thermal conductivity in the direction of thickness

(1) Equipment  Equipment shall consists of a metal block (aluminum or copper) which can hold the specimen specified in 10.6.1 (2) and a cooling system to keep the temperature of the metal block. An illustration of the equipment is shown in Figure A-11.

(2) Specimen  Specimen shall be as specified in 10.6.1 (2).

(3) Pre-conditioning  Pre-conditioning shall be as specified in 5.

(4) Test  Specimen with a heater with a temperature measuring sensor whose temperature coefficient has already been obtained shall be fixed to the metal block with screws. Thermal conductive material such as thermal grease shall be inserted between the specimen and block to reduce thermal resistivity between them. Cut a groove of a depth larger than 1 mm to the block to install a thermocouple on the top plane of the block touching to the specimen. The tip of the thermocouple when buried in the block shall be at the center of the back surface of the heater. The metal block is fixed to the cooling system. The cooling system shall be water-cooled as illustrated in Figure A-11 and keep the water temperature constant. Heat to the heater, W, shall be selected from Table 7 depending on the thermal resistance to the direction of the thickness, Rt. Measure the temperature of the temperature sensor, Ts, and the temperature of the air in the chamber, Ta, after the temperature of the sensor reached to a stable state. Thermal resistance on the thickness, Rt, shall be calculated from the following equation.

\[ Rt = (Ts - Ta)W (K/W) \]

Thermal conductivity parameter, \( k_e \), shall be calculated from the following equation using Rt.

\[ k_e = \frac{t}{Rt \times 2.5 \times 10^{-5}} (W/mK) \]

\( t \): thickness  \( 2.5 \times 10^{5} \): area of temperature measuring sensor
Table 7  Heating of specimen

<table>
<thead>
<tr>
<th>Load heat (W)</th>
<th>Thermal resistance Range of Rp(K/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,1</td>
<td>300&lt;R</td>
</tr>
<tr>
<td>0,2</td>
<td>200&lt;R&lt;300</td>
</tr>
<tr>
<td>0,3</td>
<td>150&lt;R&lt;200</td>
</tr>
<tr>
<td>0,4</td>
<td>100&lt;R&lt;150</td>
</tr>
<tr>
<td>0.75</td>
<td>60&lt;R&lt;100</td>
</tr>
<tr>
<td>1,0</td>
<td>30&lt;R&lt;60</td>
</tr>
<tr>
<td>2,0</td>
<td>20&lt;R&lt;30</td>
</tr>
<tr>
<td>3,0</td>
<td>15&lt;R&lt;20</td>
</tr>
<tr>
<td>5,0</td>
<td>5&lt;R&lt;15</td>
</tr>
<tr>
<td>10,0</td>
<td>R&lt;5</td>
</tr>
</tbody>
</table>

10.7  Reflectivity
The test method of reflectivity shall be agreed between user and supplier. An example of a test method is described in Annex B of this document for information.

10.8  Wire bond strength
The test method of wire bond strength shall be agreed between user and supplier. An example of a test method is described in Annex C of this document for information.

References
JIS B 7502  Micrometer
JIS B 7507  Slide Caliper
JIS B 7513  Precision Base Plate
JIS B 7517  Height Gauge
JIS B 7524  Gap Gauge
JIS C 60068-1  Environmental test – Electricity and electronics – General
JIS C 60068-2-78  Environmental test – Electricity and electronics – 2-78 High temperature/high humidity test (steady state)
JIS C 0025  Environmental test – Electricity and electronics – Temperature variation
JIS C 0028  Environmental test – Electricity and electronics – Temperature/humidity cycle test
JIS C 0050  Environmental test – Electricity and electronics – Soldering test
JIS C 1302  insulation resistance meter
JIS C 2110-2  Solid electric insulation materials – Test method of insulation breakdown – Part 2 : Applying d.c. voltage
JIS C 5603  Terminology in printed wiring boards
JIS G 4401  Carbon steel for tools
JIS K 5600-5-4  Paint – Test methods – Part 5: Mechanical strength of painted film – Scratch test (pencil)
JIS K 5600-5-6  Paint – Test methods – Part 5: Mechanical strength of painted film – Scratch test (cross-cut)
JIS K 5902  Rosin
JIS K 8101  Ethyl alcohol
JIS K 8839  2-propyl alcohol
JIS R 6252  Lapping paper
JIS S 6006  Pencils, colour pencils and leads used in them
JIS Z 1522  Cellophane adhesive tape
JIS Z 3282  Solders – Chemical compositions and shapes
EA/JEDEC STD 51-2  Integrated circuits thermal test method - environment condition
                 - natural convection (still air)
Annex A  Figures

* Not plated holes

Note: Specimens B, C, and D are not used for single-sided boards
<table>
<thead>
<tr>
<th>Specimen</th>
<th>Applicable test</th>
<th>Test Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Solderability (plated through-hole and land)</td>
<td>10.3</td>
</tr>
<tr>
<td>B</td>
<td>Pulling strength of plated though-hole</td>
<td>8.3</td>
</tr>
<tr>
<td>C</td>
<td>Thickness of plated copper of plated through-hole</td>
<td>6.2</td>
</tr>
<tr>
<td>D</td>
<td>Conductance of plated through-hole</td>
<td>7.1, 9.1, 9.2, 9.3</td>
</tr>
<tr>
<td>E</td>
<td>Surface breakdown voltage and insulation resistance</td>
<td>7.4, 7.6, 9.1to 9.5</td>
</tr>
<tr>
<td>F</td>
<td>Conductor width, spacing, nick, extraneous copper</td>
<td>6.3.5, 6.3,6</td>
</tr>
<tr>
<td>G</td>
<td>Peeling strength of conductor</td>
<td>8.1</td>
</tr>
<tr>
<td>H</td>
<td>Solderability (conductor surface)</td>
<td>10.3</td>
</tr>
<tr>
<td>J</td>
<td>Pulling strength of un-plated land</td>
<td>8.2</td>
</tr>
<tr>
<td>K</td>
<td>Adhesivity of plated film</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Figure A-1.1  Composite test pattern for single- and double-sided electronic board (front surface)
Note: See Figure A-1.1 for dimensions.

Figure A-1.2  Composite test pattern for double-sided electronic board (back surface).
Note: This figure shows arrangement test patterns in a complex test pattern and does not show the arrangement in the first layer. The meshed parts show the arrangement in X-th layer of specimens A, B, D, G and L. See Figure A-2.4 for the arrangement in X-th layer for specimens C and M.
<table>
<thead>
<tr>
<th>Specimen</th>
<th>Test item</th>
<th>Nominal hole diameter mm</th>
<th>Nominal land diameter mm</th>
<th>Applicable section</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Solderability (plated through-hole and land)</td>
<td>0.8</td>
<td>1.8</td>
<td>10.3</td>
</tr>
<tr>
<td>B</td>
<td>Pulling strength of plated through-hole</td>
<td>1.0</td>
<td>—</td>
<td>8.3</td>
</tr>
<tr>
<td>C</td>
<td>Adhesivity of plated film, micro-section and internal shorts</td>
<td>1.3</td>
<td>2.5</td>
<td>8.5, 6.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.8</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Conductivity of plated through-hole</td>
<td>0.8</td>
<td>2</td>
<td>7.1.2</td>
</tr>
<tr>
<td>E</td>
<td>Surface withstanding voltage, surface insulation resistance</td>
<td>0.8</td>
<td>2.5</td>
<td>7.4, 7.6</td>
</tr>
<tr>
<td>F</td>
<td>Conductor width, space, nick, extraneous copper</td>
<td>—</td>
<td>—</td>
<td>6.3.5, 6.3.6</td>
</tr>
<tr>
<td>G</td>
<td>Peeling strength of conductor, inter-layer peeling</td>
<td>—</td>
<td>—</td>
<td>8.1</td>
</tr>
<tr>
<td>H</td>
<td>Solderability (conductor surface)</td>
<td>—</td>
<td>3</td>
<td>10.3</td>
</tr>
<tr>
<td>J</td>
<td>Insulation resistance of inner layer</td>
<td>0.8</td>
<td>2</td>
<td>7.7, 9.4, 9.5</td>
</tr>
<tr>
<td>K</td>
<td>Adhesivity of plated film</td>
<td>—</td>
<td>—</td>
<td>8.5</td>
</tr>
<tr>
<td>L</td>
<td>Interconnection resistance of inner layers</td>
<td>0.8</td>
<td>1.8</td>
<td>7.1.3, 9.1, 9.2, 9.3</td>
</tr>
<tr>
<td>M</td>
<td>Interlayer withstanding voltage, and insulation resistance</td>
<td>0.8</td>
<td>2</td>
<td>7.5, 7.8</td>
</tr>
</tbody>
</table>

Figure A-2.1  Complex test patterns of multi-layer electronics board (perspective.)
Figure A-2.2  Electrode patterns of each specimen (Part 1).
Figure A-2.2  Electrode patterns of each specimen (Part 2).
Figure A-2.2 Electrode patterns of each specimen (Part 3).
Figure A-2.2  Electrode patterns of each specimen (Part 4)
Figure A-2.2 Electrode patterns of each specimen (Part 5).

Specimen E
First layer and sixth layer

Specimen F
First layer, Second layer
Third layer, Fourth layer
Fifth layer, Sixth layer

Specimen H
First layer and sixth layer

Specimen K
First layer and sixth layer

Six conductors and five spaces 0.50 mm
Space of two group 2 mm
Six conductors and five spaces 0.25 mm

Ten conductors and nine spaces 0.50 mm
Space of two group 2 mm
Ten conductors and nine spaces 0.25 mm

Second layer, Third layer, Fourth layer, Fifth layer

No copper foil for second layer, third layer, fourth layer, fifth layer and sixth layer of specimen E and X
No copper foil for Xth layer of specimen F and H
Figure A-2.2 Electrode patterns of each specimen (Part 6).

All Xth layers

Figure 2.4 shows the difference pattern between even layer and odd layer.

Figure A-2.2 Electrode patterns of each specimen (Part 6).
Figure A-2.2 Electrode patterns of each specimen (Part 7).

<table>
<thead>
<tr>
<th>Construction</th>
<th>6th layer</th>
<th>Exceeding 7 layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>First layer</td>
<td>8-10-12-14-16-18-20-22, etc</td>
<td>Number of underlined layers are recommended</td>
</tr>
<tr>
<td>Second layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sixth layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of layers</td>
<td>6</td>
<td>8-10-12-14-16-18-20-22, etc</td>
</tr>
<tr>
<td>Total layer thickness</td>
<td>1.6±0.2 mm</td>
<td>Depends on detailed specification</td>
</tr>
<tr>
<td>Stacked layer</td>
<td>Thickness</td>
<td>公称 0.2 mm 以上</td>
</tr>
<tr>
<td>Copper foil</td>
<td>Copper 35 μm for both sides</td>
<td></td>
</tr>
<tr>
<td>Insulation layer</td>
<td>Thickness</td>
<td>Minimum 0.1 mm</td>
</tr>
<tr>
<td>Number of pre-preg</td>
<td>Minimum 2</td>
<td></td>
</tr>
<tr>
<td>Hole</td>
<td>Plate all through-holes</td>
<td></td>
</tr>
<tr>
<td>Surface finish</td>
<td>Specified in detailed specification</td>
<td></td>
</tr>
<tr>
<td>Notes</td>
<td>These patterns shall be properly arranged according to the specified arrangement. The odd number layer such as X1, X3, X5 and even number layers such as X2, X4, X6 shall be arranged as shown for construction of layers above 7 layers. A sufficient space shall be formed outside of a pattern for fiducial purpose.</td>
<td></td>
</tr>
</tbody>
</table>
Figure A-3  Temperature rise according to conductor thickness, width and current.
Figure A-4.1  Insulation resistance (normal, resistance to humidity-temperature/humidity cycle and steady state)

Figure A-4.2  Insulation resistance of inner layers (normal, resistance to humidity-temperature/humidity cycle and steady state).
Figure A-4.3  Insulation resistance between inner layers (normal, resistance to humidity-temperature/humidity cycle and steady state).

Figure 5  Specimen for resistance to bending test
Figure 6  Temperature – humidity cycle.

*: The permissible limits at this time point are ± 5 min.
Figure 7  Test pattern for resistance to soldering heat test (for information only).

Figure A-8  Temperature profile of reflow furnace (for information only)
Figure A-9  Illustration of thermal conductivity test (for information). Arrange as to the heating TEG (test equipment group) to the center of the cabinet.

Figure A-10  Surface layer specimen pattern for thermal conductivity test.
Figure A-11  Test equipment for thermal resistance to the thickness direction.
### Annex B  Reflectivity

| **Equipment** | UV and visible light spectrophotometer, V-570, by Nihon-Bunko  
Integration cube for wave length range of 360 to 740nm, ISN-470  
Spectro-colour meter, CM-2600d, by KONICA MINOLTA |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specimen</strong></td>
<td>Use a board fully laminated copper foil of about 23μm thick.</td>
</tr>
<tr>
<td><strong>Pre-conditioning</strong></td>
<td>—</td>
</tr>
</tbody>
</table>
| **Test** | (1) Spectro-reflectivity  
  - Wave length range: 300 to 800nm  
  - Wave length range: 360 to 740nm  
  
  Measurement after SR curing  
  
  (2) Measurement of Y (calculation of ΔE)  
  Measured value right after curing of solder resist is taken as the initial value.  
  Measure Y after the following treatment and calculate ΔE:  
  
  Example of treatment to white solder resist  
  1) Reflow: Solder in air at peak temperature of 265°C for 0, 1, 3 or 5 times  
  2) UV illumination: illuminate using metal-halide lamp for 0, 50, 100 or 200 J/cm²  
  3) Heating: 120 or 150°C for 0, 250, 500, 750, and 1000 h  
  4) Super UV  
  
  (3) Reflectivity change by heating  
  
  Condition: 160°C for 0, 24, 48, 72, 96 and 120 h  
  Measurement: Reflectivity for each heating condition  
  
  (4) Reflectivity in UV range  
  
  Condition: 0, 25, 50, 75 and 100 passes at 3J/cm² per 1 pass (Curing machine for resist)  
  Measurement: Reflectivity for each heating condition |
| **Remarks** | (1) Evaluation of colour change shall be agreed between user and supplier  
(2) Other types of board may also be measured.  
(3) Generally available test equipment may be used. |

### Annex C  Connection strength of wire bonding

Refer to EIAJ ED-4703/K112 and K113
Additional Information to JPC-A –TMC-LED02T-2010, Test methods for electronic circuit board for high-brightness LEDs

I. Procedure of the preparation of this document

CO$_2$ reduction is one of the most serious environmental issues. LEDs are of high interest in illumination for their high efficiency of nearly ten times and long life compared to incandescent lamps. Incandescent lamps are being switched recently to LEDs very rapidly in public facilities, offices, homes, automobiles and any possible places. Standardization especially for thermal management of substrates used for LED installation is a keen interest of the industry for further applications of LEDs of high luminance and high power in lighting applications.

JPCA has organized the Standardization Committee of Electronic Circuit Board for High-Brightness LEDs with Chair of Prof. Suzuki of Yamaguchi-Tokyo University of Science and had its first meeting in December 2, 2009. 65 members from 62 companies joined the Committee in areas of design, electronic circuit board, equipment, materials, metal plating and users. It was confirmed at the first meeting the necessity of preparing standard documents not only in Japan but to prepare international documents by submitting drafts to IEC as to the industry around world would be encouraged to develop the technology. It was also proposed to submit documents prepared by JPCA to IEC TC91 – Electronics Assembly Technology – as PASs (publicly available standard) as official IEC documents by means of D-liaison relations of JPCA with IEC TC91 for publication of documents within three months after submission if approved by the member countries of TC91. The committee drafted two documents, “JPCA-TMC-LED01S Electronic circuit board for high-brightness LEDs” and “JPCA-TMC-LED02TTest methods for electronic circuit board for high-brightness LEDs”. The present will be submitted to IEC TC91 as a PAS and also as an NP (new work proposal) as an international standard.

II. Additional information of some items of this document

This document has been prepared referring to the existing Japanese standard for resin type boards, JIS C 5012 – Test methods of printed wiring board, adding necessary items for tests of substrates used for high-brightness LEDs.

1. Thermal conductivity (11.1)
This test is included in this document to select proper materials used for high brightness LEDs. Temperature rise is measured by assembling a heat source to a specimen of specified size. Experimental data were gathered using specimens provided by some member companies to decide specified values as a detailed specification in JPCA-TMC-LED02T.

2. Reflectivity (Annex B)
Substrate used for high brightness LEDs used in illumination applications is often coated with a white paint to enhance light reflection and/or silver plating on the LED mounting position. Measurement of reflectivity is now made by different methods in various companies now. An example of test method is given in Annex B for reference.

3. Interconnection strength of wire bonding (Annex C)
JEITA (Japan Electronics and Information Technology Association) standard, ED-4703 – Interconnection reliability test in semiconductor device preparation, prepared by EIAJ (Electronics Industry Association of Japan, the former organization of JEITA) as the test method for the interconnection strength of wire bonding to silver plated place is referred for “K-112 – Wire bonding strength” and “K-118 – Wire bonding (ball share)” in this document.