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Environmental testing –

Part 2-21:
Tests – Test U: Robustness of terminations and integral mounting devices

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ENVIRONMENTAL TESTING –

Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices

FOREWORD

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International Standard IEC 60068-2-21 has been prepared by IEC technical committee 91: Electronics assembly technology.

This sixth edition cancels and replaces the fifth edition, published in 1999, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition

– Addition of torque severity for nominal thread diameter of 8 mm in Test Ud: torque in accordance with IEC 60252-2 (see table 5)
– Modification of substrate specification and mounting method describing lead-free solder in Test Ue (see Figure 5 and 8.3.3 et al.)

– Modification of test jig and test condition in Test Ue_1: substrate bending test (see Figure 7 et al.)
– Change of pushing force from 10 N to 5 N in Test Ue_3: shear test (see 8.5.3.2)

The text of this standard is based on the following documents:

FDIS	Report on voting
91/582/FDIS	91/607/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A complete list of all parts comprising the IEC 60068 series, under the general title *Environmental testing,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

ENVIRONMENTAL TESTING –

Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices

1 Scope

This part of IEC 60068 is applicable to all electrical and electronic components whose terminations or integral mounting devices are liable to be submitted to stresses during normal assembly or handling operations.

Table 1 provides details of the applicable tests.

Table 1 – Application

Test	Type	Component	Mounted/not mounted
Ua_1	Tensile	Leaded devices	Not mounted
Ua_2	Thrust	Leaded devices	Not mounted
Ub	Bending	Leaded devices	Not mounted
Uc	Torsion	Leaded devices	Not mounted
Ud	Torque	Threaded stud or screw termination	Not mounted
Ue_1	Bending	Surface mounted devices	Mounted
Ue_2	Pull/push	Surface mounted devices	Mounted
Ue_3	Shear	Surface mounted devices	Mounted

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*
Amendment 1 (1992)

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*
Amendment 2 (1987)

IEC 60068-2-58:2004, *Environmental testing – Part 2-58: Tests – Test Td – Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-61:1991, *Environmental testing – Part 2: Tests – Test Z/ABDM: Climatic sequence*

IEC 61249-2-7:2002, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IEC 61188-5 (all parts), *Printed boards and printed board assemblies – Design and use*

IEC 61190-1-2:2002, *Attachment materials for electronic assembly – Part 1-2: Requirements for soldering pastes for high quality interconnections in electronics assembly*

IEC 61191-2:1998, *Printed board assemblies – Part 2: Sectional specification – Requirements for surface mount soldered assemblies*

ISO 272:1982, *Fasteners – Hexagon products – Widths across flats*

ISO 9453:1990, *Soft solder alloys – Chemical compositions and forms*

3 Test Ua_1: tensile

This test is applicable to all types of terminations.

3.1 Object

The purpose of this test is to verify that the terminations and attachment of the terminations to the body of the component will withstand such axial stresses as are likely to be applied during normal assembly or handling operations.

3.2 General description

With the termination in its normal position and the component held by its body, a force is applied to the termination in the direction of its axis and acting in a direction away from the body of the component. The force shall be applied progressively (without any shock) and then maintained for a period of 10 s ± 1 s.

3.3 Preconditioning

The method of preconditioning shall be as prescribed in the relevant specification.

3.4 Initial measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

3.5 Test method

Unless otherwise specified in the relevant specification, the test method shall be as follows:

Refer to Figure 2a.

3.5.1 Application

This test applies to all types of terminations. It shall be carried out on all the terminations, except where a component has more than three terminations, in which case the specification shall state the number of terminations per component to be tested. The test shall be carried out in such a manner that all the terminations of the component have an equal probability of being subjected to test.

3.5.2 Procedure

With the termination in its normal position and the component held by its body, a force with a value as stated in Table 2 shall be applied to the termination in the direction of its axis and acting in a direction away from the body of the component. The force shall be applied progressively (without any shock) and then maintained for a period of 10 s ± 1 s.

The value of the applied force is as follows:

a) Wire terminations (circular section or strip) or pins

The value of the force applied shall be that indicated in Table 2.

Insulated wires shall be stripped of the insulation at the point at which the load is applied.

Stranded wires shall be united mechanically at the point of application of the load (such as by soldering or knotting), prior to the application of the load. Where the technical features of insulated or stranded wires may give rise to difficulties during the stripping, joining or knotting operations and be liable to cause dispute for the test results, such operations shall be in accordance with the relevant specification or, where necessary, with the instructions of the component manufacturer.

Table 2 – Value of applied force for test Ua_1

Nominal cross-sectional area (*S*)[a] mm²	**Corresponding diameter (*d*) for circular-section wires** mm	**Force with tolerance of ±10 %** N
$s \leq 0{,}05$	$d \leq 0{,}25$	1
$0{,}05 < s \leq 0{,}10$	$0{,}25 < d \leq 0{,}35$	2,5
$0{,}10 < s \leq 0{,}20$	$0{,}35 < d \leq 0{,}50$	5
$0{,}20 < s \leq 0{,}50$	$0{,}50 < d \leq 0{,}80$	10
$0{,}50 < s \leq 1{,}20$	$0{,}80 < d \leq 1{,}25$	20
$s > 1{,}20$	$d > 1{,}25$	40

[a] For circular-section wires, strips or pins, the nominal cross-sectional area is equal to the value calculated from the nominal dimension(s) given in the relevant specification. For stranded wires, the nominal cross-sectional area is obtained by taking the sum of the cross-sectional areas of the individual strands of the conductor specified in the relevant specification.

b) Other terminations (tag terminations, threaded studs, screws, terminals, etc.)

The value of the force to be applied shall be given in the relevant specification.

3.6 Final measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

3.7 Information to be given in the relevant specification

	Subclause
a) Method of preconditioning	3.3
b) Initial measurements	3.4
c) Number of terminations to be tested, if more than three	3.5.1
d) Force (for oversized and other terminations)	3.5.2
e) Details of stripping, joining or knotting operations, if necessary	3.5.2
f) Final measurements	3.6

4 Test Ua_2: thrust

4.1 Object

The purpose of this test is to verify that the terminations and attachment of the terminations to the body of the component will withstand such thrusts as are likely to be applied during normal assembly or handling operations. This test applies only to specimens of small dimensions and of low mass, to the exclusion of equipment and assemblies.

NOTE This test does not apply to flexible terminations. The tests for flexible terminations are given in a) and b) of 5.1.

4.2 General description

With the termination in its normal position and the component held by its body, thrust is applied to the termination as close as possible to the body of the component, but leaving a clear 2 mm of wire between the body of the component and the nearest point of the device applying the force. The force shall be applied progressively (without any shock) and then maintained for a period of 10 s ± 1 s.

4.3 Preconditioning

The method of preconditioning shall be as prescribed in the relevant specification.

4.4 Initial measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

4.5 Test method

Refer to Figure 2b.

4.5.1 Application

The relevant specification shall state whether this test is applicable. When applicable, it shall be carried out on all the terminations, except where a component has more than three terminations, in which case the specification shall state the number of terminations per component to be tested. The test shall be carried out in such a manner that all the terminations of the component have an equal probability of being subjected to test. The relevant specification shall define the direction of applied force.

4.5.2 Procedure

With the termination in its normal position and the component held by its body, thrust shall be applied to the termination as close as possible to the body of the component, but leaving a clear 2 mm of wire between the body of the component and the nearest point of the device applying the force. The force shall be applied progressively (without any shock) and then maintained for a period of 10 s ± 1 s.

The value of the applied force is as follows:

a) Wire terminations (circular-section or strip) or pins

The value of the force applied shall be as given in Table 3.

Table 3 – Value of applied force for test Ua_2

Nominal cross-sectional area (S)[a] mm^2	Corresponding diameter (d) for circular-section wire mm	Force with tolerance of ±10 % N
$s \leq 0,05$	$d \leq 0,25$	0,25
$0,05 < s \leq 0,10$	$0,25 < d \leq 0,35$	0,5
$0,10 < s \leq 0,20$	$0,35 < d \leq 0,50$	1
$0,20 < s \leq 0,50$	$0,50 < d \leq 0,80$	2
$0,50 < s \leq 1,20$	$0,80 < d \leq 1,25$	4
$s > 1,20$	$d > 1,25$	8

[a] For circular-section wires, strips or pins, the nominal cross-sectional area is equal to the value calculated from the nominal dimension(s) given in the relevant specification.

Insulated wires shall be stripped of the insulation at the point at which the load is applied.

Where the technical features of insulated wires may give rise to difficulties during the stripping, and be liable to cause dispute for the test results, such operations shall be in accordance with the relevant specification or, where necessary, with the instructions of the component manufacturer.

b) Other terminations (tag terminations, threaded studs, screws, terminals, etc.)

The value of the force to be applied shall be given in the relevant specification.

4.6 Final measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

4.7 Information to be given in the relevant specification

	Subclause
a) Method of preconditioning	4.3
b) Initial measurements	4.4
c) Indication as to whether the test is applicable	4.5.1
d) Number of terminations to be tested, if more than three	4.5.1
e) Direction of applied force	4.5.1
f) Details of stripping, if necessary	4.5.2
g) Force, for other than wire terminations or pins	4.5.2
h) Final measurements	4.6

5 Test Ub: bending

This test is applicable to pliable terminations only.

5.1 Object

The purpose of this test is to verify that pliable terminations and attachment of such terminations to the body of the component shall withstand such bending loads as are likely to be applied during normal assembly or handling operations. In order for the terminations to be considered pliable, the following conditions shall apply:

a) Test prescribed in 5.5.2.1 and 5.5.2.3

The termination shall assume, during the course of the test, a displacement of at least 30° with respect to its initial position (see Figure 3c).

b) Test prescribed in 5.5.2.2:

The termination shall be capable of being bent with the fingers.

5.2 General description

a) Bending (wire or strip terminations)

With the termination in its normal position and the component held by its body in such a manner that the axis of the termination is vertical, a mass is suspended from the end of termination. The body of the component is then inclined through an angle of approximately 90° in the vertical plane and then returned to its original position; this operation constitutes one bend.

Method 1: two or more bends in opposite directions.

Method 2: two or more bends in the same direction.

b) Bending (tag terminations)

Tag terminations, capable of being bent with the fingers, shall be bent through 45° and then returned to their initial position; this operation constitutes one bend.

Method 1: two bends in opposite directions.

Method 2: two bends in the same direction.

c) Simultaneous bending

All the terminations on one side of the component shall be held in a clamp at a point 3 mm from the seal between the termination and the body of the component. A mass shall be attached to the clamp with the terminations pointing downwards. The body of the component is then inclined through an angle of 45° and returned to its original position. This test shall be performed in two opposite directions.

5.3 Preconditioning

The method of preconditioning shall be as prescribed in the relevant specification.

5.4 Initial measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

5.5 Test method

Unless otherwise specified in the relevant specification, the test method shall be as follows:

5.5.1 Application

The relevant specification shall state whether this test is applicable. When applicable, the test shall be carried out on all the terminations, except where a component has more than three terminations, in which case the specification shall state the number of terminations per component to be tested. The test shall be carried out in such a manner that all the terminations of the component have an equal probability of being subjected to test. This limitation in the number of terminations tested does not apply to simultaneous bending (5.5.2.3), which is generally applicable to certain types of microelectronic packages with several terminations in line on one or more sides.

5.5.2 Procedure

Refer to Figure 3.

5.5.2.1 Bending (wire or strip terminations)

With the termination in its normal position and the component held by its body in such a manner that the axis of the termination is vertical, a mass applying a force of a value given in Table 3 is then suspended from the end of the termination. The body of the component is then inclined, over a period of 2 s to 3 s, through an angle of approximately 90° in the vertical plane and then returned to its original position over the same period of time; this operation constitutes one bend. The test shall be performed according to the relevant specification, stipulating one or other of the following procedures.

a) Method 1 (see Figure 3a)

One bend immediately followed by a second bend in the opposite direction, or a larger number of alternate bends where prescribed in the relevant specification.

b) Method 2 (see Figure 3b)

Two bends in the same direction without interruption, or a larger number of alternate bends where prescribed in the relevant specification. No device capable of imposing a radius of curvature shall be placed between the body of the component and the point of application of the force. Strip terminations shall be bent perpendicularly to the widest surface of the strip.

The value of the force to be applied is given in Table 4.

Table 4 – Value of applied force for test Ub

Section modulus (Z_x) mm^3	**Diameter(d) of corresponding round leads** mm	**Force with tolerance of ±10 %** N
$Z_x \leq 1{,}5 \times 10^{-3}$	$d \leq 0{,}25$	0,5
$1{,}5 \times 10^{-3} < Z_x \leq 4{,}2 \times 10^{-3}$	$0{,}25 < d \leq 0{,}35$	1,25
$4{,}2 \times 10^{-3} < Z_x \leq 1{,}2 \times 10^{-2}$	$0{,}35 < d \leq 0{,}50$	2,5
$1{,}2 \times 10^{-2} < Z_x \leq 0{,}5 \times 10^{-1}$	$0{,}50 < d \leq 0{,}80$	5
$0{,}5 \times 10^{-1} < Z_x \leq 1{,}9 \times 10^{-1}$	$0{,}80 < d \leq 1{,}25$	10
$1{,}9 \times 10^{-1} < Z_x$	$1{,}25 < d$	20

NOTE 1 For round terminations, the section modulus is given by the following formula:

$$Z_x = \frac{\pi d^3}{32}$$

where d is the lead diameter.

For strip terminations, the section modulus is given by the following formula:

$$Z_x = \frac{ba^2}{6}$$

where

a is the thickness of the rectangular strip perpendicular to the bending axis;

b is the other dimension of the rectangular strip;

Z_x is the section modulus.

NOTE 2 The section modulus is defined in ISO 31-3, item 3-21, and the derivation of the above formula can be found in standard textbooks on mechanical engineering.

5.5.2.2 Bending (tag terminations)

Tag terminations, capable of being bent with the fingers, shall be bent through 45° and then returned to their initial position; this operation shall constitute one bend (see Figure 3). The test shall be performed according to the relevant specification, stipulating one or other of the following procedures:

a) Method 1

One bend immediately followed by a second bend in the opposite direction.

b) Method 2

Two bends in the same direction, without interruption. The relevant specification may stipulate other details (such as use of pliers, place of bending, etc.).

5.5.2.3 Simultaneous bending

All terminations on one side of the component shall be clamped at the seating plane or, where it is not given, at a point approximately 3 mm from the seal between the termination and the body of the component, in a clamp with a radius of 0,1 mm at the edge where bending will occur. A mass shall be attached to the clamp with the terminations pointing downwards. This mass, which shall include the mass of the clamp, shall apply a force equal to that given in Table 4, multiplied by the number of leads clamped.

The body of the component is then inclined through an angle of 45°, taking 2 s to 3 s for the operation, and returned to its initial position over the same period of time. The test shall be performed once in one direction, and returned to the normal position, and once in the opposite direction, and again returned to the normal position (see Figure 3).

NOTE For the testing of short terminations, the clamp should be so designed that its upper surface will not touch the body of the component during the bending (which would cause a tensile stress on the terminations). See Figure 1 below:

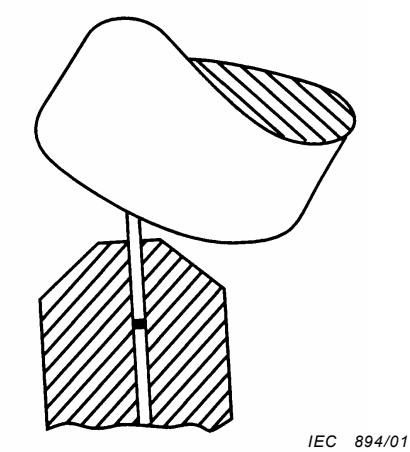


Figure 1 – Clamp for the testing of short terminations

5.6 Final measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

5.7 Information to be given in the relevant specification

	Subclause
a) Method of preconditioning	5.3
b) Initial measurements	5.4
c) Indication as to whether the test is applicable	5.5.1
d) Number of terminations to be tested, if more than three	5.5.1
e) Method and number of bends, if more than two	5.5.2.1
f) Method and particular details of application	5.5.2.2
g) Final measurements	5.6

6 Test Uc: torsion

6.1 Object

The purpose of this test is to verify that the terminations and attachment of the terminations to the body of the component will withstand torsional forces such as are likely to be applied during normal assembly or dismantling operations.

6.2 Preconditioning

The method of preconditioning shall be as prescribed in the relevant specification.

6.3 Initial measurements

The specimen shall be visually inspected and electrically and mechanically checked as required by the relevant specification.

6.4 Test method

Unless otherwise specified in the relevant specification, the test method shall be as follows:

Refer to Figure 4.

6.4.1 Application

The relevant specification shall state whether this test is applicable. When applicable, the test shall be carried out on all the terminations, except where a component has more than three terminations, in which case the specification shall state the number of terminations per component to be tested. The test shall be carried out in such a manner that all the terminations of the component have an equal probability of being subjected to test.

6.4.2 Procedure

Each termination shall be bent through 90° at a point 6 mm to 6,5 mm from the point of emergence of the termination. The radius of curvature of the bend shall be approximately 0,75 mm (see Figure 4a). The free end of the termination shall be clamped to a point 1,2 mm ± 0,4 mm from the bend (see Figure 4b). The body of the component shall then be rotated, as specified below, about the original axis of the termination at a rate of one rotation per 5 s. Successive rotations shall be in alternate directions. The test shall be performed in accordance with one of the following procedures, and one of the following severities as required by the detail specification.

a) Method 1

Component body clamped:

– Severity 1: three rotations of 360°;

– Severity 2: two rotations of 180°.

b) Method 2

Both wire terminations clamped (see Figure 4c):

– Severity: two rotations of 180°.

NOTE Method 2 is primarily intended for components with a body unsuitable for clamping (e.g. having a diameter less than 4 mm) and with axial terminations of the same kind at each end.

6.5 Final measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

6.6 Information to be given in the relevant specification

	Subclause
a) Method of preconditioning	6.2
b) Initial measurements	6.3
c) Indication as to whether this test is applicable	6.4.1
d) Number of terminations to be tested, if more than three	6.4.1
e) Test procedures and severities	6.4.2
f) Final measurements	6.5

7 Test Ud: torque

7.1 Object

The purpose of this test is to verify that the terminations, the attachment of the terminations to the body of the component and integral mounting means shall withstand torque forces such as are likely to be applied during normal assembly or handling operations.

7.2 General description

For terminations with threaded studs or screws, the torque given in Table 5 below is applied to the screw or to each of the nuts normally fitted to each terminal for a period of 10 s to 15 s, according to the severity prescribed in the relevant specification. During this test, a washer or metal plate with a normal clearance hole for the screw threads shall be placed between the screw head and the surface on to which it is tightened. For other types of termination the relevant specification shall give the method required.

7.3 Preconditioning

The method of preconditioning shall be as prescribed in the relevant specification.

7.4 Initial measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

7.5 Test method

Unless otherwise specified in the relevant specification, the test method shall be as follows:

7.5.1 Application

The relevant specification shall state whether this test is applicable. When applicable, the test shall be carried out on all the terminations, except where a component has more than three terminations, in which case the specification shall state the number of terminations per component to be tested. The test shall be carried out in such a manner that all the terminations of the component have an equal probability of being subjected to test.

7.5.2 Procedure

7.5.2.1 Terminations with threaded studs or screws

With the component held by its normal fixing devices, the torque given in Table 5 shall be applied without shock to the screw or to each of the nuts normally fitted to each termination, for a period of 10 s to 15 s, according to the severity prescribed by the relevant specification. During this test, a washer or metal plate with a normal clearance hole for the screw threads shall be placed between the screw head and the surface on to which it is tightened. The thickness of the washer or metal plate shall be approximately equal to six times the nominal pitch of the stud. All parts shall be clean and dry. The nut width shall be equal to approximately 0,8 times the nominal stud diameter, as stated in ISO 272.

Table 5 – Torque severity

Nominal thread diameter mm		**2,6**	**3,0**	**3,5**	**4,0**	**5.0**	**6,0**	**8,0**
Torque	Severity 1	0,4	0,5	0,8	1,2	2,0	2,5	5,0
Nm	Severity 2	0,2	0,25	0,4	0,6	1,0	1,25	2,5

For some components, such as semiconductor devices, very different torque values may be needed. Where necessary, these shall be prescribed in the relevant specification. For diameters greater than 8 mm, the torque values shall be specified in the relevant specification. The nuts or screws shall be capable of being loosened afterwards.

7.5.2.2 Other types of terminations

The relevant specification shall give the methods required.

7.6 Final measurements

The specimen shall be visually inspected and electrically and mechanically checked, as required by the relevant specification.

7.7 Information to be given in the relevant specification

	Subclause
a) Method of preconditioning	7.3
b) Initial measurements	7.4
c) Indication as to whether this test is applicable	7.5.1
d) Number of terminations to be tested, if more than three	7.5.1
e) Severity	7.5.2.1

f) Different torque values for thread diameters greater than 8 mm, or if necessary for other reasons 7.5.2.1

g) Test method for other types of terminations 7.5.2.2

h) Final measurements 7.6

8 Test Ue: robustness of terminations for SMD in the mounted state

8.1 Object

The purpose of this test is to assess the mechanical robustness of surface mounting device (SMD) terminations mounted on a substrate using a specified method. The terminations consist of metallized portions on non-conductive parts of the component or of short, partly flattened metallic parts.

8.2 General description

Test Ue contains three separate test methods and relevant specifications shall state which is applicable. These methods are as follows:

– test Ue_1: substrate bending test;

– test Ue_2: pull-off and push-off test;

– test Ue_3: shear (adhesion) test.

Unless otherwise prescribed by the relevant specification, the test shall be conducted on a specimen (device) mounted by its normal means on one of the following substrates.

a) Test Ue_1:

Epoxide woven glass fabric copper-clad laminated sheet, general purpose grade (61249-2-7 IEC-EP-GC-Cu), with foil bonded to one side and a nominal thickness of the sheet, including the metal foil, of 1,6 mm with a tolerance of ±0,20 mm or of 0,8 mm with a tolerance of ±0,10 mm. The choice of the thickness of substrate shall be prescribed in the relevant specification. The copper foil shall have a thickness of 0,035 mm ± 0,010 mm.

b) Test Ue_2 and Test Ue_3:

Alumina ceramic, with a purity of 90 % to 98 %, a thickness of 0,635 mm ± 0,05 mm or more with fired-on metallized pads of a material which is difficult to peel off (e.g. copper, or silver palladium) or epoxide glass board as for test Ue_1. Where the push-off method of Ue_2 is to be applied, a hole shall be made in the substrate with dimensions as given in Figure 8, as an example. Where the pull-off method of Ue_2 is to be applied, a substrate without holes may be used.

The substrate pattern of Figures 5, 6 or 8 is preferred but not required.

NOTE These patterns are basically applicable to two-terminal devices.

The relevant specification shall prescribe all additional details, including whether the specimen may be a non-operative device.

The test shall be made under the standard atmospheric conditions for measurement and tests as given in 5.3 of IEC 60068-1.

The tests are destructive because mounted specimens are required and cannot be reused. Different specimens will be required for each test.

8.3 Mounting

8.3.1 Dimensions

The dimensions for the soldering lands on the substrate shall be prescribed by the IEC 61188-5 series or the relevant specifications.

8.3.2 Possible mounting methods

For the mounting of the specimen on the test substrate, the relevant specification shall prescribe the method to be selected, preferably from the following list, with all the necessary details (see also 8.3.3):

a) solder wave, single or double;

b) reflow soldering with heating by one of the following means:
   - oven or conveyor oven (forced convection),
   - hot gas jet,
   - vapour phase (condensation),
   - laser soldering.

8.3.3 Mounting method for substrate bending, pull-off, push-off and shear

When the details of mounting are not prescribed by the relevant specification, the method of mounting shall be as follows:

a) Choice of solder paste

   1) Solder paste for this test shall be one of the followings.

      i) A lead-free solder paste shall be in accordance with c) of 7.1.2.1 of IEC 60068-2-58.

      ii) A solder paste, made from solder as specified in Appendix B of IEC 60068-2-20 (see note 1 below) or 63 % tin and 37 % lead may be used and mildly activated flux (see note 2 below) as specified in Appendix C of IEC 60068-2-20. Silver (2 weight % or more) can be added in accordance with the relevant specification. The contamination limits of the solder shall comply with ISO 9453.

      NOTE 1 The solder has the following composition: tin 59 % to 61 %; antimony 0,5 % maximum; copper 0,1 % maximum; arsenic 0,05 % maximum; iron 0,02 % maximum; remainder lead.

      NOTE 2 The activated flux has the following composition: colophony 25 g; 2 propanol (iso-propanol) or ethyl alcohol 75 g; diethylammonium chloride 0,39 g.

   2) When solder paste is of the type described in i) of 8.3.3 a) 1), the viscosity of the solder paste shall be used as described in c) of 7.1.2.1 of IEC 60068-2-58. When solder paste is of the type described in ii) of 8.3.3 a) 1), the viscosity of the solder paste shall be in accordance with the relevant specification.

   3) The particle size of the each solder paste shall be symbol 3 as specified in Table 2 of IEC 61190-1-2.

   4) The footprints shall be covered with solder deposit. The thickness of the solder deposit shall be between 100 µm and 250 µm; the thickness shall be specified in the relevant specification.

b) Preparation of the specimen

   1) The specimen surface to be tested shall be in the "as received" condition and shall not be touched by fingers or otherwise contaminated.

   2) The specimen shall not be cleaned prior to the test. If required by the relevant specification, the specimen may be immersed in an organic solvent at room temperature for preconditioning.

3) Preconditioning

Specimens which need preconditioning shall be pretreated in accordance with the relevant specification.

c) Positioning of the specimen

– The specimen shall be placed symmetrically on its footprint.

d) Preheating

When solder paste is of the type described in i) of 8.3.3 a), the substrate with the mounted specimen shall be preheated in accordance with the relevant specification. When solder paste is of the type described in ii) of 8.3.3 a), the substrate with the mounted specimen shall be preheated for 60 s to 120 s at 150 °C ± 10 °C, unless otherwise specified.

e) Soldering

1) Soldering shall be performed immediately after preheating.

2) As long as the soldering conditions do not lead to a thermal load, which exceeds the SMD specification, any kind of reflow oven or vapour phase soldering oven may be used.

3) When solder paste is of the type described in i) of 8.3.3 a), the solder temperature shall be performed in accordance with the relevant specification. If solder paste is of the type described in ii) of 8.3.3.a) of 8.3.3, the solder temperature shall be between 215 °C and 235 °C and the time at the peak temperature shall not exceed 10 s, and during soldering the total time above 185 °C shall be 45 s minimum.

NOTE 3 The solder temperature for solder paste of the type descried in i) of 8.3.3 a) is described as 235 °C to 250 °C in Table 1 of IEC 60068-2-58.

4) Care shall be taken that complete wetting is achieved.

5) The soldered area of the substrate shall be cleaned using 2-propanal (iso-propanol) or water to remove surplus flux. If necessary, the details of the cleaning method shall be specified in the relevant specification.

6) The solder fillet shall comply with the minimum requirements for the relevant joint given in IEC 61191-2.

8.4 Initial measurements

Visual inspection of the specimen shall be made with a magnification of at least 10× under adequate light (e.g. 2 000 lx). If specified in the relevant specification, electrical and/or mechanical characteristics shall be measured. The strength of the solder weakens with time and this will influence the test results.

Unless otherwise specified in the relevant component specification, the test shall be performed after 24 h ± 6 h .

8.5 Test methods

8.5.1 Test Ue_1: substrate bending test

This test is suitable for all devices except those intended for mounting on rigid substrates only (see 8.5.2)

NOTE It is the responsibility of the manufacturer or supplier of the device to indicate whether it is intended for mounting on rigid substrates only.

8.5.1.1 Object

The purpose of this test is to verify that pliable terminations and attachment of these terminations to the body of the component shall withstand such bending loads as are likely to be applied during normal assembly or handling operations.

8.5.1.2 Test method

The specimen shall be mounted on the test substrate (see Figure 5) according to 8.3. The geometry of the specimen should be taken into account when selecting its position on the substrate and, therefore, when defining the dimensions of the solder lands.

The test substrate with the specimen is placed in the bending jig (see Figure 7) and gradually bent to a depth, D, of 1 mm, 2 mm, 3 mm or 4 mm with a speed of 1,0 mm/s ± 0,5 mm/s. The value of *D*, and its tolerance shall be prescribed in the relevant specification. The substrate shall be maintained in the bent state for 20 s ± 1 s, unless another time is prescribed in the relevant specification. The relevant specification shall prescribe, where necessary, a critical (electrical) parameter to be monitored throughout the period during which the specimen remains bent under test. The bending force shall then be relaxed. Unless otherwise specified in the relevant specification, the number of bends shall be one.

NOTE 1 As an alternative, the stepwise bending methods may be applied to decide the required values of the relevant specification or to seek the limit. When the stepwise bending methods are applied, the test method should be specified in the relevant specification.

NOTE 2 If the radius of the bending tool is applied and is other than 5 mm, the radius should be specified in the relevant specification.

8.5.2 Test Ue_2: Pull-off and push-off test

This test is suitable for SMDs intended for mounting on rigid substrates.

8.5.2.1 Object

The purpose of this test is to evaluate the adhesion strength at the interface between the terminations of an SMD and its body.

8.5.2.2 Test methods

Unless otherwise specified in the relevant specification, the test method shall be as follows:

The specimen shall be mounted on the substrate, as shown in Figure 8.

Either a pull-off or push-off test method may be used. The choice of the method shall be prescribed in the relevant component specification. In general, the pull-off method is used as the first choice. The push-off method is used when it is too difficult to attach a pulling wire to the specimen. When required by the relevant specification, the time between soldering and testing shall be specified. The strength of the solder weakens with time and this will influence the test results. The test shall be performed after 24 h ± 6 h.

8.5.2.2.1 Pull-off test

A suitable pulling tool shall be attached to the centre of the specimen by clamping or by means of a wire fastened perpendicularly to the top of the specimen mounted on its substrate, as shown in Figure 9.

NOTE If necessary, the clamping and adhesion methods of the specimen should be prescribed in the relevant specification.

With the substrate firmly held, a pulling force of 10 N shall be applied to the specimen. The force shall be applied gradually at a constant rate. The maximum force shall be reached within 5 s and maintained constant for 10 s ± 1 s and the force shall be applied along an axis within 5° to the normal (see Figure 9).

8.5.2.2.2 Push-off test

Fix the substrate and apply the push-load through the hole in the substrate, on the centre of the specimen by means of a pushing tool, as shown in Figure 10. The pushing tool shall be chamfered with a radius of 0,5 mm. The pushing tool shall be brought, without shock, into contact with the lateral surface of the specimen. Unless otherwise specified in the relevant specification, a pushing force of 10 N shall be applied to the specimen. The force shall be applied gradually at a constant rate. The maximum force shall be reached within 5 s and maintained constant for 10 s ± 1 s and the force shall be applied along an axis within 5° to the normal.

8.5.3 Test Ue_3: shear test

Unless otherwise specified in the relevant specification, the test method shall be as follows:

This test is suitable for SMDs intended for mounting on rigid substrates.

8.5.3.1 Object

The purpose of this test is to evaluate the shear strength at the interface between the terminations of an SMD and its body.

8.5.3.2 Test method

The method is used for SMDs with comparatively large heights, such as electrolytic capacitors, connectors, switches and ceramic-based SMDs. When permitted by the type and geometry of the specimen, a force shall be applied by means of an appropriate pushing tool. A pushing tool chamfered with a radius of 0,5 mm shall be used. The thickness of the pushing tool shall be larger than the height of the relevant contact surface of the specimen to be tested; however, the width of the pushing tool is not specified (see Figure 11). The force shall be applied parallel to the substrate and perpendicular to the specimen lateral surface, as shown in Figure 11. The point of contact between the specimen and the pushing tool shall be prescribed by the relevant specification.

The pushing tool shall be brought, without shock, into contact with the lateral surface of the specimen. A pushing force of 5 N shall be applied to the specimen. gradually and at a constant rate. The maximum force shall be reached within 5 s and maintained constant for 10 s ± 1 s. When required by the relevant specification, the time between soldering and testing shall be specified. The strength of the solder weakens with time and this will influence the test results. The test shall be performed after 24 h ± 6 h.

If prescribed by the relevant specification, a suitable critical parameter shall be monitored throughout the period during which the force is applied.

8.6 Final measurements

8.6.1 Recovery

Components which need recovery treatment shall be treated in accordance with the relevant specification.

8.6.2 Visual examination of terminations

Visual inspection of the specimen shall be made under adequate light (for example 2 000 lx), with a magnification of at least 10×. The joints between the specimen terminations and the specimen body shall be inspected. There shall be no visible evidence of rupture or cracking. The termination shall remain secured to the specimen. Defects of the solder joint and substrate shall not be considered in assessing the specimen.

8.6.3 Electrical characteristics

Electrical measurements shall be performed in accordance with the relevant specification. The relevant specification shall provide the criteria upon which the acceptance or rejection of the specimen is to be based.

8.6.4 Hidden defect

In many cases the damage caused by testing cannot be assessed by visual inspection or electrical measurements. In order to develop and reveal hidden faults, it is recommended that the test should be immediately followed by the climatic sequence in IEC 60068-2-61 or by other appropriate mechanical and/or electrical conditioning as prescribed by the relevant specification.

8.7 Information to be given in the relevant specification

When this test is included in a relevant specification, it shall be stated which elements are applicable as well as which are mandatory.

			Subclause
	a)	Applicable test method	8.2
	b)	Indication as to whether the tested specimen is operative or non-operative	8.2
*	c)	Type and dimensions (thickness and additional detail) of the substrate	8.2
*	d)	Shape and dimensions of the solder lands on the substrate	8.3.1
	e)	Method of mounting if other than given in 8.3.2 and 8.3.3	8.3.2, 8.3.3
	f)	Type of solder alloy	8.3.3a)
	g)	Use of solder paste with the addition of silver	8.3.3a) 1-2)
	h)	Viscosity and the method of measurement	8.3.3a) 2)
	i)	Conditions of preconditioning the specimen	8.3.3b) 3)
	j)	Preheating	8.3.3d)
	k)	Soldering method and condition of soldering if other than as specified in 8.3.3 e) 3)	8.3.3e) 3)
	l)	Method of cleaning	8.3.3e) 5)
*	m)	Initial measurements	8.4
	n)	Dwell time between soldering and testing	8.4, 8.5.2.2, 8.5.3.2
	o)	If the bending test (Ue_1) is specified, the depth of the bend and time of remaining bent, if other than 20 s, and any required monitoring	8.5.1.2
	p)	The stepwise bending methods (if applied)	8.5.1.2
	q)	Radius of bending tool, if other than 5 mm, for test Ue_1	8.5.1.2
*	r)	Test method for test Ue_2 (pull-off or push-off)	8.5.2.2
	s)	Method of attachment of the wire for test Ue_2 (pull-off)	8.5.2.2.1
	t)	Loading condition (pulling or pushing force and direction) if other than as specified in 8.5.2.2.1 and 8.5.2.2.2	8.5.2.2.1 8.5.2.2.2
	u)	Radius of pushing tool, if other than 0,5 mm, for test Ue_2 (push-off)	8.5.2.2.2

* Mandatory information.

v) The pushing tool, point of contact between the specimen and pushing tool and the type of contact, for test Ue_3 (shear test) 8.5.3.2

w) Pushing force if other than 5 N, for test Ue_3 (shear test) 8.5.3.2

x) Critical parameter to be monitored during application of force, for test Ue_3 (shear test) 8.5.3.2

* y) Recovery condition 8.6.1

* z) Types of defect 8.6.2

aa) Electrical measurement 8.6.3

ab) Acceptance/rejection criteria 8.6.3

* ac) Indication as to whether the climatic sequence test should be used 8.6.4

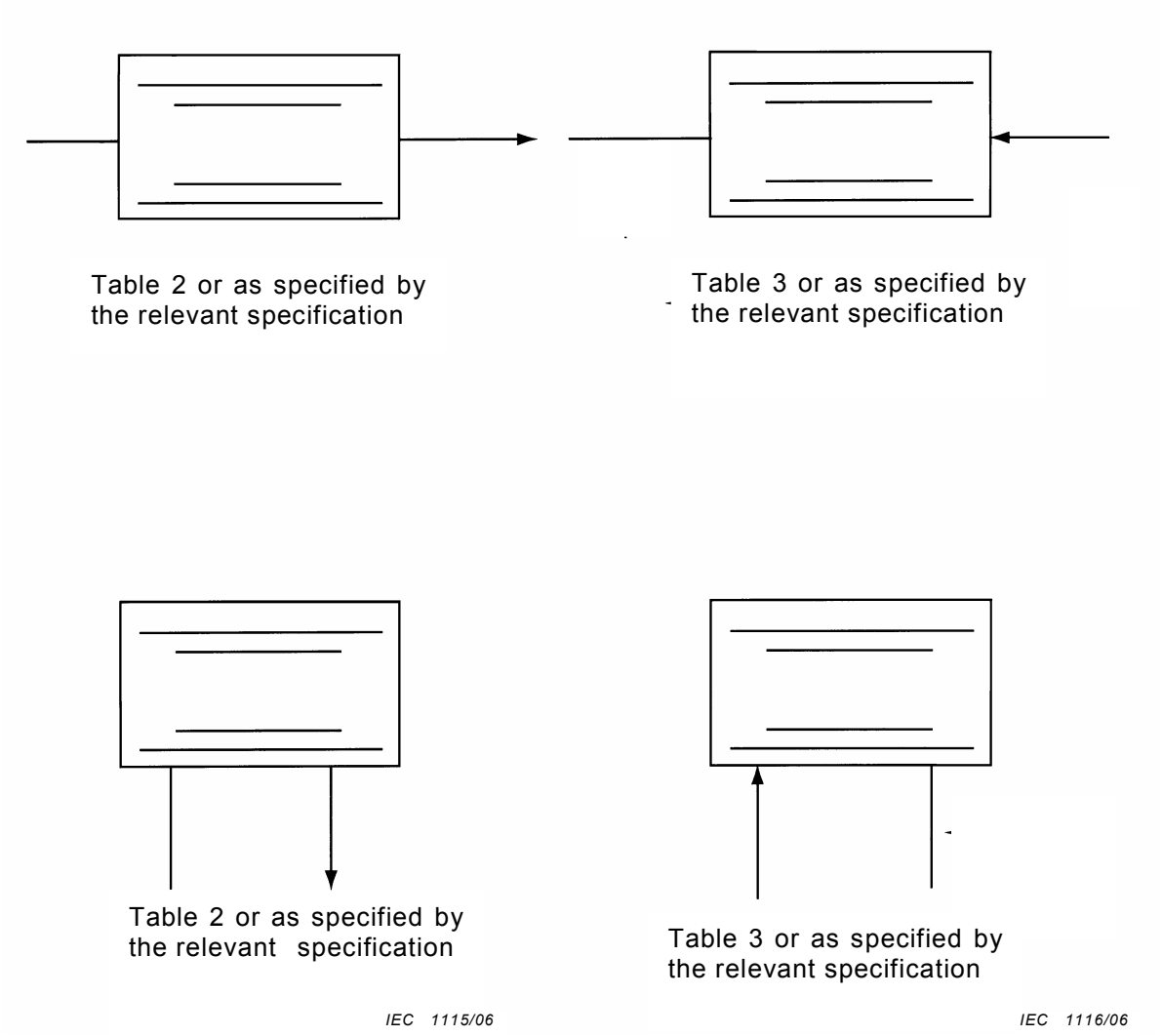


Figure 2a – Test Ua_1

Figure 2b – Test Ua_2

Figure 2 – Sketches showing direction by arrow heads of application of forces Test Ua_1: tensile and test Ua_2: thrust

* Mandatory information

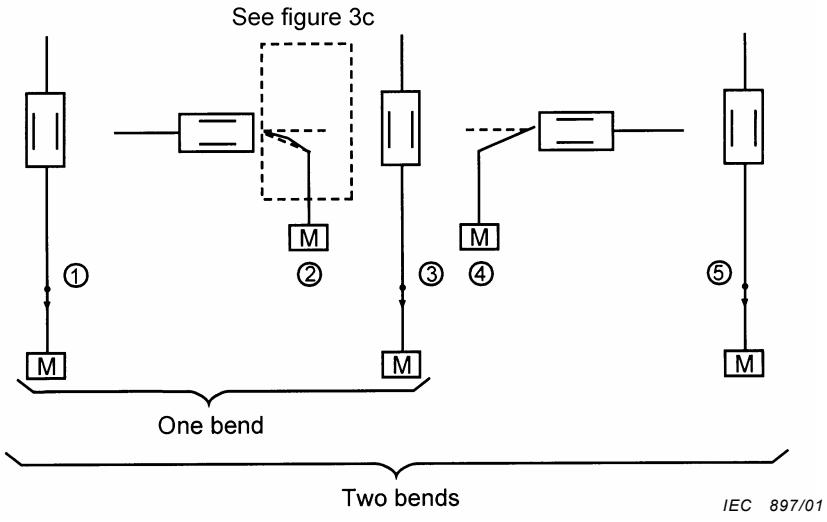


Figure 3a – Method 1: test Ub

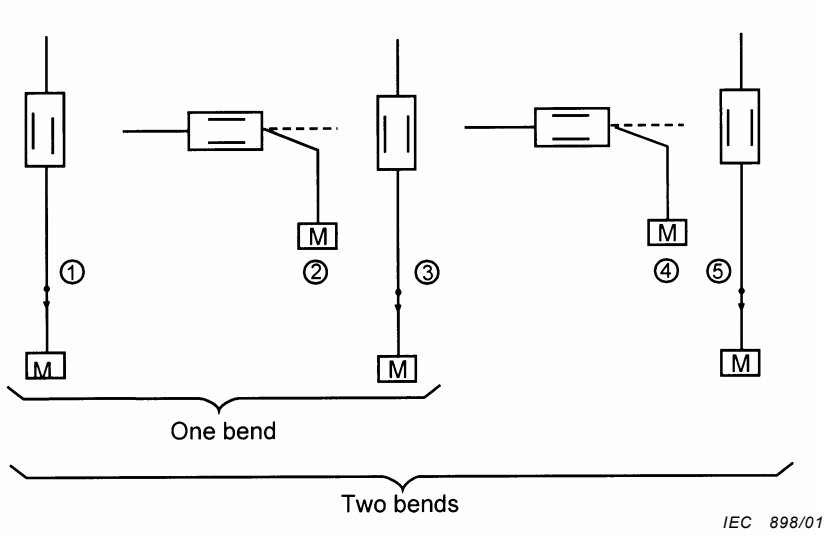


Figure 3b – Method 2: test Ub

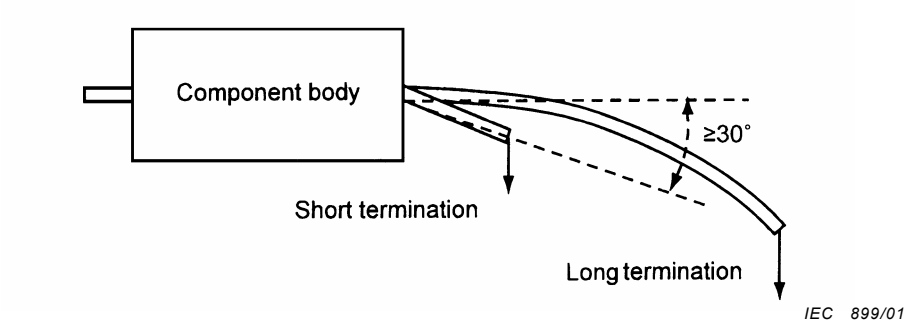


Figure 3c – Detail sketch showing angle of displacement for pliable terminations

Figure 3 – Sketches showing test procedure for test Ub: bending (see 5.5.2.1 and 5.5.2.3)

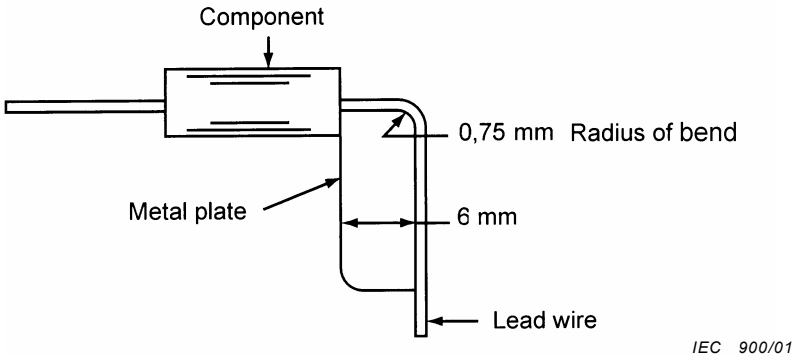


Figure 4a – Method of bending wire leads for the torsion test

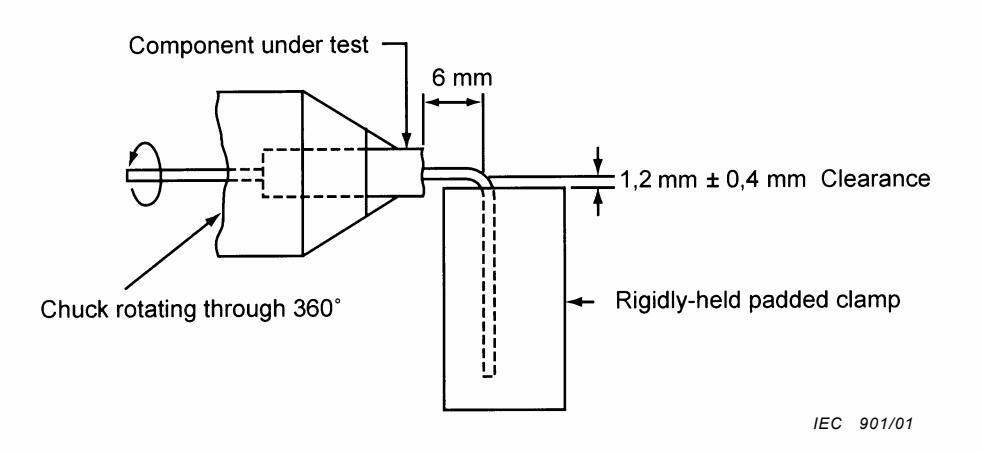


Figure 4b – Method of twisting wire leads for the torsion test

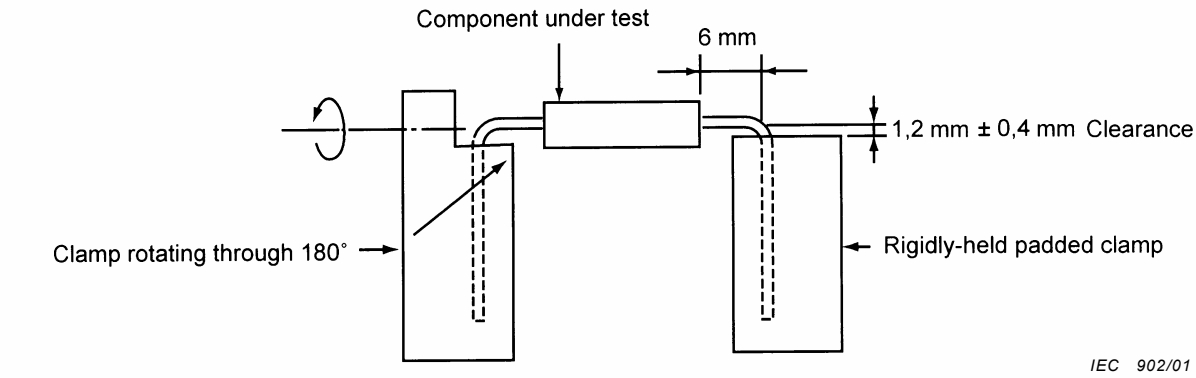


Figure 4c – Method of twisting wire leads on component body unsuitable for clamping

Figure 4 – Diagrams showing test procedure for test Uc: torsion test for wire terminations

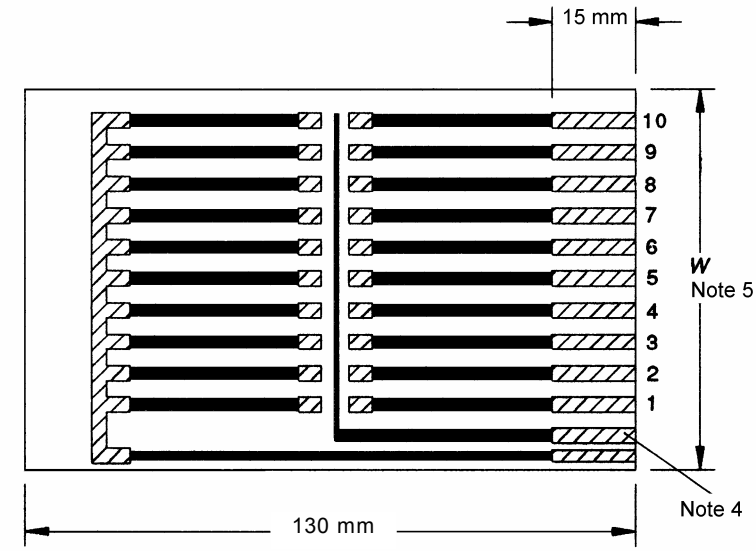


Figure 5 – Example of substrate for test method Ue_1 (also suitable for electrical test)

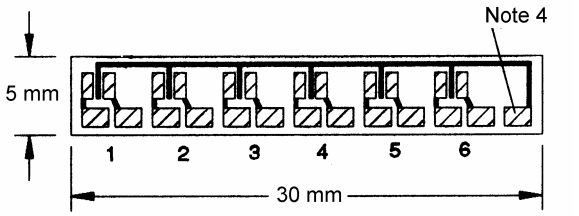


Figure 6 – Example of substrate for test methods Ue_2 and Ue_3 (also suitable for electrical test)

NOTE 1 Solderable areas

Non-solderable areas (covered with non-solderable lacquer)

NOTE 2 Material:

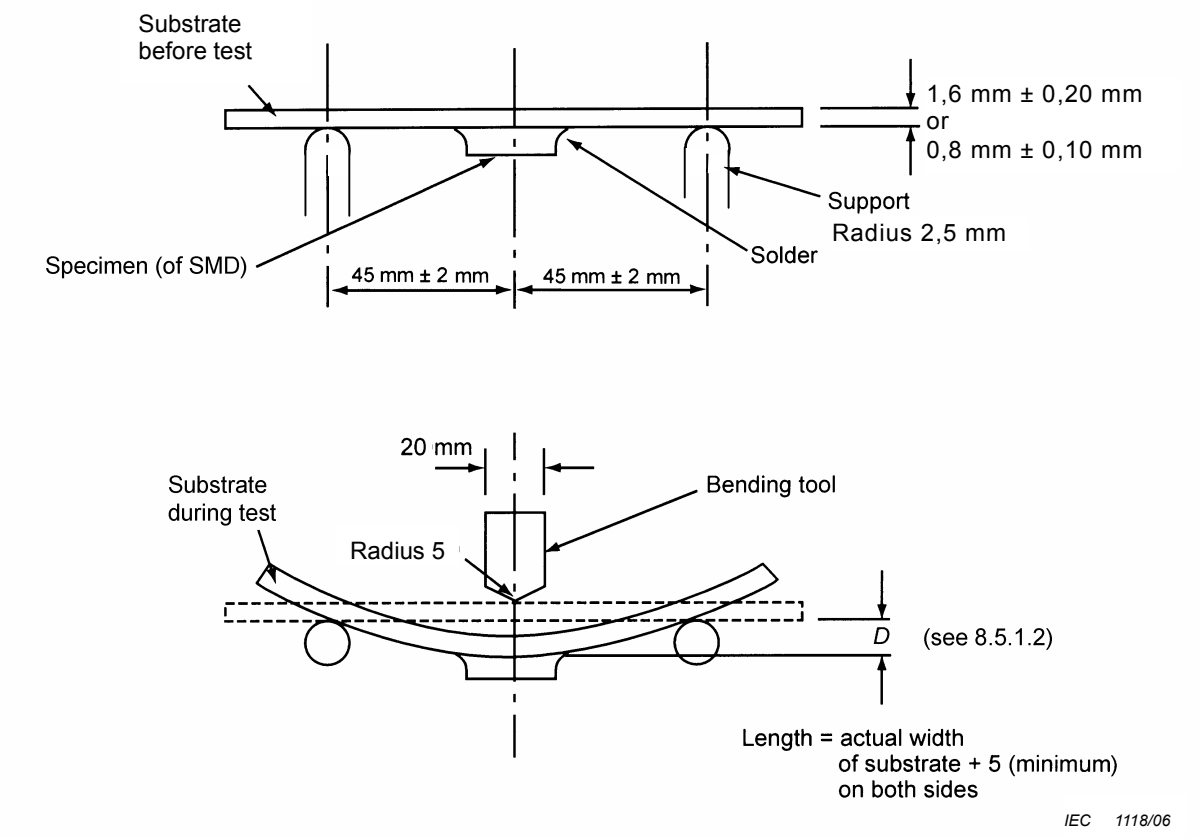
Figure 5: epoxide woven glass, thickness 1,6 mm ± 0,20 mm or 0,8mm ± 0,10mm

Figure 6: 90 % 98 % Alumina ceramic, thickness: 0,635 mm ± 0,05 mm or over

NOTE 3 When board is designed to mount more than 2 specimens, take sufficient space between specimens so as to have no influence on test result. Dimensions not given shall be chosen according to design and size of the specimen to be tested.

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

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



NOTE All sharp edges of the bending tool should be removed.

Figure 7 – Bending jig for test Ue_1

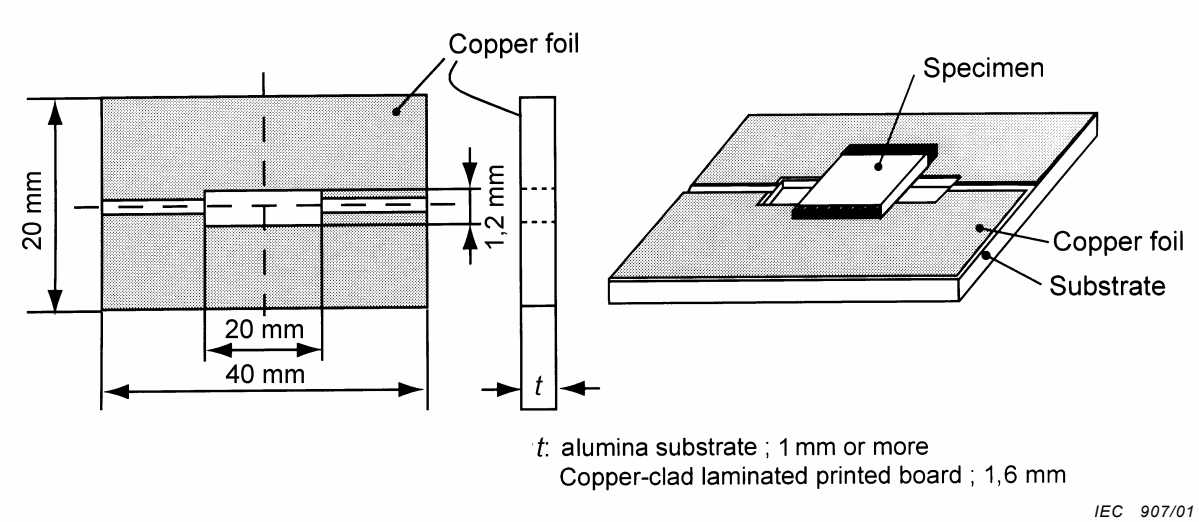


Figure 8 – Example of a push-off test substrate

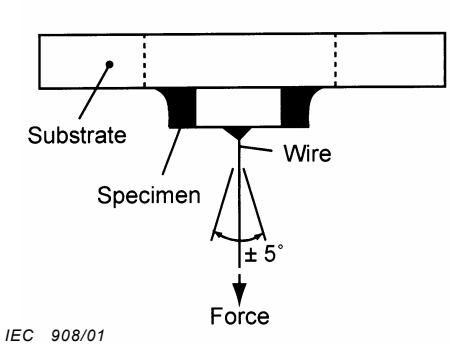


Figure 9 – Force test Ue_2 – pull-off

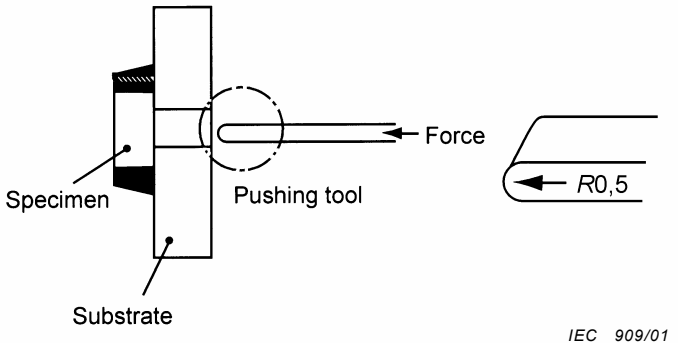
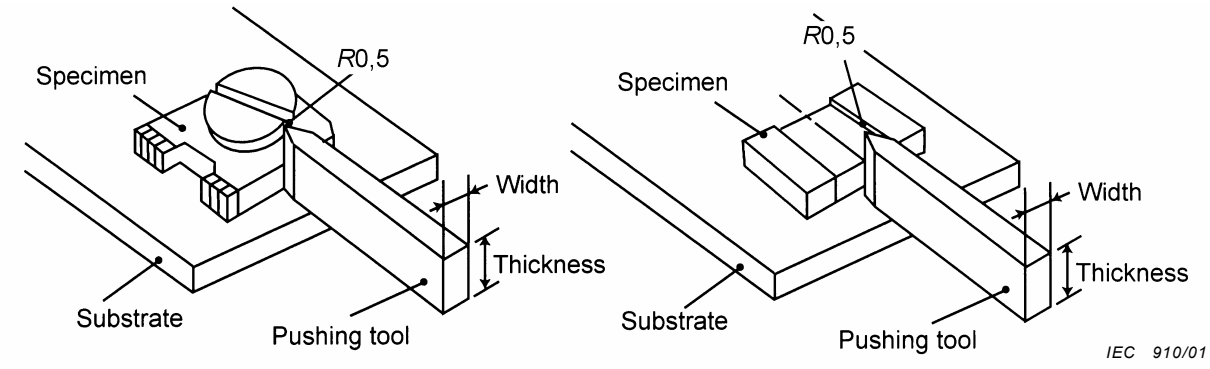


Figure 10 – Example of a force application pushing tool for test Ue_2 – push-off



NOTE When the length of the specimen is 2,0 mm or less, the radius of the pushing tool should be 0,2 mm.

Figure 11 – Example of the shear (adhesion) test – Ue_3

Bibliography

ISO 31-3:1992, *Quantities and units – Part 3: Mechanics*

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