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SIST EN 60749:2002 + A1:2002

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Semiconductor devices - Mechanical and climatic test methods (IEC 60749:1996)

Semiconductor devices - Mechanical and climatic test methods

Halbleiterbauelemente - Mechanische und klimatische Prüfverfahren

Dispositifs à semiconducteurs - Essais mécaniques et climatiques

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Semiconductor devices — Mechanical and climatic test methods

(includes amendment A1:2000)
(IEC 60749:1996 + A1:2000)

Dispositifs à semiconducteurs —
Essais mécaniques et climatiques
(inclut l'amendement A1:2000)
(CEI 60749:1996 + A1:2000)

Halbleiterbauelemente —
Mechanische und klimatische Prüfverfahren
(enthält Änderung A1:2000)
(IEC 60749:1996 + A1:2000)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the International Standard IEC 60749:1996, prepared by IEC TC 47, Semiconductor devices, was submitted to the formal vote and was approved by CENELEC as EN 60749 on 1999-01-01 without any modification.

The following dates were fixed:

— latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2000-04-01

— latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2000-04-01

Annexes designated "normative" are part of the body of the standard.

In this standard, Annex A and Annex ZA are normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60749:1996 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 47/1477/FDIS, future amendment 1 to IEC 60749:1996, prepared by IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60749:1999 on 2000-09-01.

The following dates were fixed:

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Endorsement notice

The text of amendment 1:2000 to the International Standard IEC 60749:1996 was approved by CENELEC as an amendment to the European Standard without any modification.

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Chapter 1. General

1 Scope and object

This International Standard lists test methods applicable to semiconductor devices (discrete devices and integrated circuits) from which a selection may be made. However, additional test methods may be required for non-cavity devices.

NOTE A non-cavity device is a device in which enclosing or encapsulating material is in intimate contact with all exposed surfaces of the active element, and no void space is included in the device design.

This standard has taken into account, wherever possible, IEC 68.

The object of this standard is to establish uniform preferred test methods with preferred values for stress levels for judging the environmental properties of semiconductor devices.

In case of contradiction between this standard and a relevant specification, the latter shall govern.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 68-1:1988, *Environmental testing — Part 1: General and guidance.*

IEC 68-2-3:1985, *Environmental testing — Part 2: Tests — Test Ca: Damp heat, steady state.*

IEC 68-2-6:1995, *Environmental testing — Part 2: Tests — Test Fc and guidance: Vibration (sinusoidal).*

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IEC 68-2-7:1983, *Environmental testing — Part 2: Tests — Test Ga and guidance: Acceleration, steady state.*

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IEC 68-2-11:1981, *Environmental testing — Part 2: Tests — Test Ka: Salt mist.*

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IEC 68-2-13:1983, *Environmental testing — Part 2: Tests — Test M: Low air pressure.*

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IEC 68-2-14:1984, *Environmental testing — Part 2: Tests — Test N: Change of temperature.*

IEC 68-2-17:1994, *Environmental testing — Part 2: Tests — Test Q: Sealing.*

IEC 68-2-20:1979, *Environmental testing — Part 2: Tests — Test T: Soldering.*

IEC 68-2-21:1983, *Environmental testing — Part 2: Tests — Test U: Robustness of terminations and integral mounting devices.*

IEC 68-2-45:1980, *Environmental testing — Part 2: Tests — Test XA and guidance: Immersion in cleaning solvents.*

IEC 68-2-47:1982, *Environmental testing — Part 2: Tests — Mounting of components, equipment and other articles for dynamic tests including shock (Ea), bump (Eb), vibration (Fc and Fd) and steady-state acceleration (Ga) and guidance.*

IEC 68-2-48:1982, *Environmental testing — Part 2: Tests — Guidance on the application of the tests of IEC Publication 68 to simulate the effects of storage.*

IEC 653:1979, *General considerations on ultrasonic cleaning.*

IEC 695-2-2:1991, *Fire hazard testing — Part 2: Test methods — Section 2: Needle-flame test.*

IEC 747-1:1983, *Semiconductor devices — Discrete devices and integrated circuits — Part 1: General.*

IEC 748-1:1984, *Semiconductor devices. Integrated circuits — Part 1: General.*

3 Terms, definitions and letter symbols

Reference is made to IEC 68, IEC 747 and IEC 748.

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4 Standard atmospheric conditions

Reference: IEC 68-1.

Unless otherwise specified, all tests and recoveries shall be carried out under standard atmospheric conditions for testing, as defined in IEC 68-1, subclause **5.3**:

temperature:	15 °C to 35 °C;
relative humidity:	45 % to 75 %, where appropriate;
air pressure:	86 kPa to 106 kPa (860 mbar to 1 060 mbar).

All electrical measurements, as well as recoveries followed by measurements, shall, however, be carried out under the atmospheric conditions:

temperature:	(25 ± 5) °C;
relative humidity:	45 % to 75 %, where appropriate;
air pressure:	86 kPa to 106 kPa (860 mbar to 1 060 mbar).

Referee tests shall be carried out under the following standard atmospheric conditions:

temperature:	(25 ± 1) °C;
relative humidity:	48 % to 52 %;
air pressure:	86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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Before the measurements are made, the specimens shall be stored until temperature equilibrium is reached. The ambient temperature during the measurements shall be stated in the test report.

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During measurement, the specimens shall not be exposed to draughts, illumination or other influences likely to cause error.

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5 External visual examination and verification of dimensions

5.1 External visual examination

5.1.1 *Purpose*

To verify that the physical appearance of the materials, design, construction, markings and workmanship of the device are in accordance with the applicable detail specification.

5.1.2 *Scope*

This test is intended for the outgoing inspection from the device manufacturer's facility or as an incoming user inspection. Additional requirements for the optical systems of optoelectronic devices need to be specified where applicable.

5.1.3 *Definition*

Chip out: a void in the package material caused by an unintentional breakage.

5.1.4 *Test apparatus*

Apparatus used in this test shall be capable of demonstrating device conformance to the applicable requirements, which may include optical equipment capable of magnification between 3× and 10× and a relatively large and accessible field of view such as an illuminated ring magnifier.

5.1.5 *Test method*

The device shall be examined under a magnification of between 3× and 10× (unless otherwise specified) with a field of view sufficiently large to contain the entire device in accordance with the requirements of the applicable specification and the criteria listed in **5.1.6**. Where adherence of foreign material is in question, devices may be subjected to a clean filtered air (ionized if devices are electrostatic sensitive) stream (suction or expulsion) of 27 m/s maximum, and reinspected.

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5.1.6 *Defect criteria*

Devices shall be considered defective if they exhibit any of the following:

5.1.6.1 Device design, termination identification, markings (content, placement, and legibility), materials, construction, and workmanship not in accordance with the applicable specification.

5.1.6.2 Defects or damage resulting from manufacturing, handling, or testing, including the following:

a) Broken packages, voids or cracks in the packages. Cracks, scratches, openings, bubbles and other defects on the surface shall not be cause for failure unless they affect the performance of the package or violate other criteria stated herein, such as markings, finish, etc.

b) Any chip out dimension that exceeds 1,5 mm in any direction on the surface or has a depth which exceeds 0,2 mm, unless otherwise specified, for example for very small packages.

c) Any chip out that exposes either sealing glass (not exposed prior to the chip out) or any internal material such as lead frame or conductive layer, that is not intended to be exposed by design.

5.1.6.3 Visible evidence of corrosion, contamination or breakage, broken leads, cracked seals (except glass meniscus), defective (peeling, flaking, or blistering) or damaged plating. Discoloration of the finish shall not be cause for failure unless there is evidence of flaking, pitting, or corrosion. In the case of very small packages, more stringent requirements may be called for in the relevant specification.

5.1.6.4 Leads that are not intact, or aligned in their normal location, or free of sharp or unspecified lead bends, or (for ribbon leads) free of twist outside the normal lead plane.

5.1.6.5 Leads that are not free of foreign material such as paint or other adherent deposits.

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5.1.7 *Information to be given in the relevant specification*

The following details shall be specified in the applicable document:

a) Requirements for marking and the lead or pin identification (see **5.1.6.1**).

b) Detailed visual requirements specified in drawings.

c) Chip out dimensions if other than those specified in **5.1.6.2b**).

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5.2 Verification of dimensions

Dimensions given in the relevant specification shall be verified.

6 Electrical measurements

6.1 For environmental testing, the characteristics to be checked shall be selected from the chapter "Acceptance and reliability" of the relevant part of IEC 747 or IEC 748; they are specified for each device category.

6.2 Measurement conditions: see table "Conditions for the endurance tests" in the chapter "Acceptance and reliability" of the relevant part of IEC 747 or IEC 748.

6.3 Initial measurements

If upper specification limit and/or lower specification limit criteria are required only, it is left to the discretion of the manufacturer whether initial measurements are made or not. Initial measurements shall be made where individual values for an individual device are a criterion.

6.4 Measurements monitored during environmental testing

To be stated, where appropriate.

6.5 Final measurements

When the test is called for in the relevant specification as part of a sequence (sub-group) of tests, measurements are required only at the end of the sequence. For certain tests, such as solderability or lead fatigue, electrically defective devices may be used.

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Chapter 2. Mechanical test methods

The choice of the appropriate tests depends on the type of devices and of the encapsulation. The relevant specification shall state which tests are applicable.

1 Robustness of terminations

Reference: IEC 68-2-21.

1.1 Tensile

This test shall be in accordance with Test Ua_1, with the following specific requirements:

In **2.6**, read:

After test, examine under 3× to 10× magnification.

The device shall be rejected if there is breakage (other than seal meniscus), loosening or relative motion between the lead or terminal and the device body.

1.2 Bending

This test shall be in accordance with Test Ub, with the following specific requirements:

In **4.2**, Method 2 is recommended only for dual-in-line and similar packages, where the configuration of the body makes it difficult or impracticable to use Method 1.

1.3 Torsion

This test shall be in accordance with Test Uc, with the following specific requirements:

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Method

Method A (severity 2) or Method B shall be used.

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Failure criteria

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When examining using 10× to 20× magnification after removal of the stress, any evidence of breakage, other than in the seal meniscus, loosening, or relative motion between the terminal lead and the device body shall be considered as a device failure.

1.4 Torque

1.4.1 *Torque test for studs*

This test shall be in accordance with Test Ud, with the following specific requirements:

The device shall be considered as a failure if any of the following occurs:

— the stud breaks or elongates more than one-half the thread pitch;

— there is evidence of thread stripping or deformation of the mounting seat;

— the device fails electrical measurements after test, if applicable.

1.4.2 *Torque test for leads — New test (called Ud_2)*

1.4.2.1 *Object*

To determine the ability of a termination to withstand twisting which may be applied during inspection or servicing after installation.

1.4.2.2 *Test method*

The component shall be held rigidly and a torque or twist shall be applied slowly to the termination being tested until the twist angle reaches 30 ± 10° or the specified torque is achieved, whichever condition occurs first.

The termination is then returned to its original position. A torque of $1,4 \times 10^{-2} \pm 1,4 \times 10^{-3}$ N·m shall be applied to the termination at a distance of 3,0 ± 0,5 mm from the body or within 1 mm from the end of the termination, if it is shorter than 3 mm.

The torque shall be applied in each direction.

When the component has terminations which are formed close to the body, the torque may be applied 3,0 ± 0,5 mm from the point where the terminations are formed.

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1.4.2.3 *Final measurements*

After test, examine under 3× to 10× magnification. The component shall be rejected if there is any evidence of termination breakage, loosening or relative motion between the termination and the body.

1.4.2.4 *Information to be given in the relevant specification*

Number and selection of terminations to be tested.

2 Soldering

Reference: IEC 68-2-20.

2.1 Solderability

This test shall be in accordance with Test Ta, with the following specific requirements:

— Ageing:

Where accelerated ageing is required by the relevant specification, "ageing 1b" is preferred. Ageing 3 may be used. Ageing 1a and 2 shall not be used.

— Dewetting: (as per **4.9** of Test Ta):

This test shall not be considered mandatory except when it is required in the relevant specification.

— When Method 1 is selected:

Terminals are subjected to the solder-bath method. The terminals are immersed in the bath to within 1,5 mm or other distance, as specified in the relevant specification, from the seating plane of the component.

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NOTE When the immersion distance is closer than 1,5 mm to the seating plane of the device, then alternative failure criteria may apply and shall be specified.

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— When Method 2 is selected:

Terminals are subjected to the soldering-iron method, using the soldering-iron bit size A. The distance of the soldering-iron application from the body of the component shall be as specified in the relevant specification; the time or soldering-iron application shall be 3,5 ± 0,5 s.

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— When Method 3 is selected:

Terminals are subjected to the solder globule method. The terminals are tested at a point 5 ± 1 mm from the body of the component. The wire shall be wetted with solder within 2,5 s.

Criteria for good wetting

When observed under 10× magnification, the dipped surface shall be covered with a smooth and bright solder coating, with no more than traces (approximately 5 %) of scattered imperfections such as pin-holes or non-wetted areas. These imperfections shall not be concentrated in one area.

2.2 Resistance to soldering heat

This test shall be in accordance with Test Tb, with the following specific requirements:

Method

Methods 1A with an immersion time of 10 ± 1 s, or Method 1B shall be used.

2.3 Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat

2.3.1 *Object*

This subclause provides a test method for assessing the resistance to soldering heat of plastic encapsulated surface mounted devices (SMDs). This test is destructive.

2.3.2 *General description*

Package cracking and electrical failure in plastic encapsulated SMDs can result when soldering heat raises the vapour pressure of moisture which has been absorbed during storage. These problems are assessed. In this test method, SMDs are evaluated for heat resistance after being soaked in an environment which simulates moisture being absorbed while under storage in a warehouse or dry pack.

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2.3.3 *Test apparatus and materials*

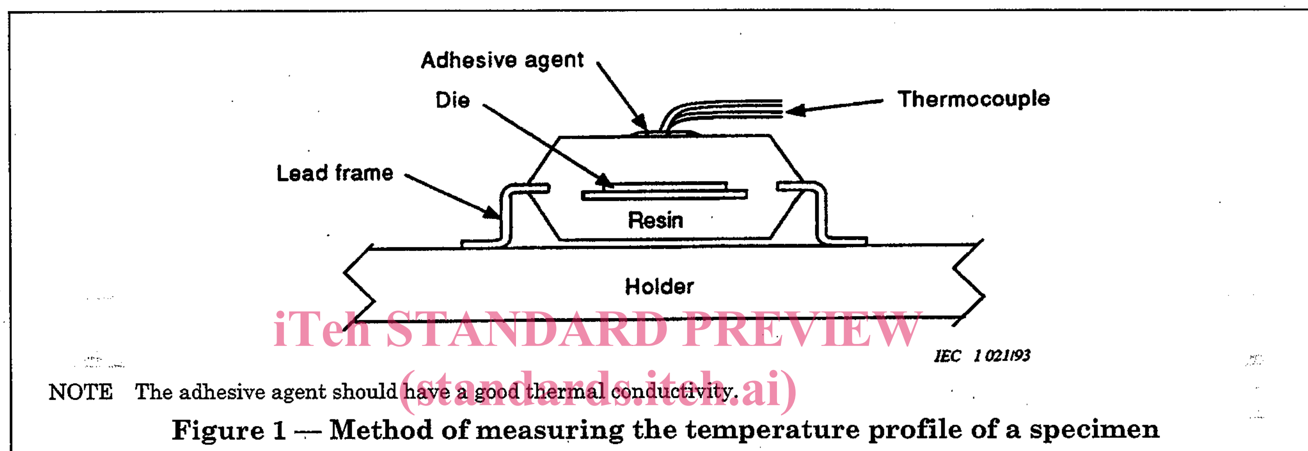
a) Humidity chamber

The humidity chamber shall provide an environment complying with the temperature and relative humidity defined in item c) of **2.3.4**.

b) Reflow soldering apparatus

Vapour phase soldering apparatus and infrared reflow soldering apparatus shall provide temperature profiles complying with the conditions of soldering heat defined in items d)1) and d)2) of **2.3.4**.

The settings of the reflow soldering apparatus shall be adjusted by temperature profiling of the surface of the package while it is undergoing the soldering heat process, measured as indicated in Figure 1.



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NOTE The adhesive agent should have a good thermal conductivity.

Figure 1 — Method of measuring the temperature profile of a specimen

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c) Holder

Unless otherwise specified in the relevant specification, any board material, such as an alumina, epoxy fibreglass or polyimide, or a wire net may be used for the holder. The specimen shall be mounted on the board by the usual means and in a position as given in Figure 1.

d) Solder bath

The solder bath shall comply with the condition of soldering heat given in item c) of **2.3.4**.

e) Solvent for vapour phase soldering

Perfluorocarbon (perfluoroisobutylene) shall be used.

f) Flux

Unless otherwise specified in the relevant specification, the flux shall consist of 25 % by weight of colophony in 75 % by weight of isopropyl alcohol, both as specified in Appendix C of IEC 68-2-20.

g) Solder

Solder of composition as specified in Appendix B of IEC 68-2-20 shall be used.

2.3.4 *Procedure*

a) Initial measurements

1) Visual inspection

Visual inspection shall be performed as specified in clause **5** of chapter 1 of the present standard.

2) Electrical measurement

Electrical testing shall be performed as required by the relevant specification.

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b) Preconditioning

The specimen shall be baked at 125 °C ± 5 °C or at its maximum rated temperature if this is lower.

NOTE The preconditioning may need to be longer than 6 h if the temperature is lower.

c) Moisture soaking

In accordance with **2.3.6.1**, the moisture soaking shall be performed at 85 °C ± 2 °C; relative humidity and soaking time shall be selected from Table 1.

Table 1

Method	Temperature °C	Relative humidity %	Soaking time h
A	85 ± 2	30 ± 5	168 ± 24
B	85 ± 2	65 ± 5	168 ± 24
C	85 ± 2	85 ± 5	24 ± 2

d) Soldering heat

Unless otherwise specified in the relevant specification, the specimen shall be subjected to the soldering heat within 24 h of finishing the moisture soaking.

The method and condition of soldering heat shall be selected from items d)1) to d)3) of this subclause according to the relevant specification.

Each test, whichever method is chosen, shall consist of one cycle.

1) Method of heating by vapour phase soldering

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i) Preparation

The specimen shall be mounted on the holder.

ii) Preheating

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Unless otherwise specified, the specimen shall be preheated at a temperature of 150 °C ± 10 °C for 1 min to 2 min in the vapour phase soldering apparatus.

iii) Solder heating

The temperature of the specimen shall be raised after preheating.

When the temperature of the specimen has reached 215 °C ± 5 °C, it shall be maintained for 40 s ± 3 s (refer to **2.3.8.1**).

2) Method of heating by infrared reflow soldering

i) Preparation

The specimen shall be mounted on the holder.

ii) Preheating

Unless otherwise specified, the specimen shall be preheated at a temperature of 150 °C ± 10 °C for 1 min to 2 min in the infrared reflow soldering apparatus.

iii) Solder heating

Following preheating, the temperature of the specimen shall be raised to 240 °C maximum and then lowered to room temperature (see **2.3.8.2**).

Following preheating, the temperature of the specimen will follow the values as indicated in the profile given in Figure 9 of **2.3.8.2**.

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3) Method of heating by solder bath

i) Dipping into flux

The terminations of the specimen shall be dipped into the flux at room temperature.

ii) Solder cleaning

The surface of the molten solder shall be wiped off with a spatula made of stainless steel or equivalent.

iii) Immersion in the solder bath (where applicable)

Unless otherwise specified in the relevant specification, the specimen shall be immersed to a depth of 10 mm ± 5 mm in the molten solder as shown in Figure 2. The speed of immersion and withdrawal shall be 25 mm/s ± 2,5 mm/s. In accordance with the actual condition of soldering process, the temperature and the immersion time shall be selected from Table 2.

iv) Removal of residual flux

After immersion into the solder bath, the residual flux shall be removed.

Table 2

Method	Temperature of molten solder °C	Immersion time s	Remarks
A	245 ± 5	5 ± 1	Single wave
B	260 ± 5	5 ± 1	Single wave
C	260 ± 5	10 ± 1	Double wave

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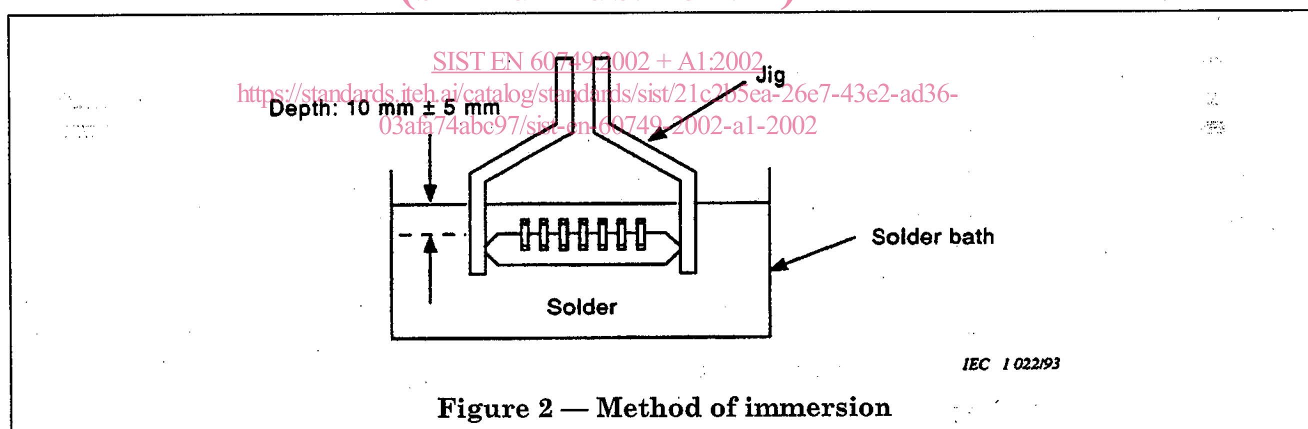

Figure 2 — Method of immersion

e) Recovery

If recovery is specified in the relevant specification, the specimen shall be stored under standard atmospheric conditions for the time given in the specification.

f) Final measurements

1) Visual inspection

Visual inspection shall be performed after the test as specified in clause 5 of chapter 1.

2) Electrical measurement

Electrical testing shall be performed as required by the relevant specification.