

Semiconductor devices — Mechanical and climatic test methods

The European Standard EN 60749:1999, with the incorporation of amendments A1:2000 and A2:2001, has the status of a British Standard

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National foreword

This British Standard is the English language version of EN 60749:1999, including amendments A1:2000 and A2:2001. It is identical with IEC 60749:1996, Edition 2.2:2002, which comprises Edition 1.0:1996 consolidated by the incorporation of amendments 1:2000 and 2:2001. It supersedes BS 6493-3:1985 which was withdrawn on 2000-04-01.

Sidelining in this document indicates the changes made by amendments A1:2000 and A2:2001.

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductor devices, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Cross-references

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This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 April 1999

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Semiconductor devices — Mechanical and climatic test methods

(includes amendments A1:2000 and A2:2001)
(IEC 60749:1996 + A1:2000 + A2:2001)

Dispositifs à semiconducteurs —
Essais mécaniques et climatiques
(inclut les amendements A1:2000 et A2:2001)
(CEI 60749:1996 + A1:2000 + A2:2001)

Halbleiterbauelemente —
Mechanische und klimatische
Prüfverfahren
(enthält Änderungen A1:2000 und A2:2001)
(IEC 60749:1996 + A1:2000 + A2:2001)

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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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

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:

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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

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Foreword to amendment A2

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Endorsement notice

The text of amendment 2:2001 to the International Standard IEC 60749:1996 was approved by CENELEC as an amendment to the European Standard without any modification.

Contents

	Page		Page
Foreword	2	Chapter 3. Climatic test methods	
Chapter 1. General		1 Change of temperature	50
1 Scope and object	5	1.1 Rapid change of temperature: two-chamber method	50
2 Normative references	5	1.2 Rapid change of temperature: two-fluid-bath method	51
3 Terms, definitions and letter symbols	6	2 Storage (at high temperature)	51
4 Standard atmospheric conditions	6	3 Low air pressure	51
5 External visual examination and verification of dimensions	7	4A Damp heat, steady state	52
6 Electrical measurements	8	4B Damp heat, steady state, accelerated	52
Chapter 2. Mechanical test methods		4C Damp heat, steady state, highly accelerated	55
1 Robustness of terminations	10	5 Sealing	57
1.1 Tensile	10	5.1 General terms	57
1.2 Bending	10	5.2 Bomb pressure test	58
1.3 Torsion	10	5.3 Fine leak detection: radioactive krypton method	58
1.4 Torque	10	5.4 Fine leak detection: tracer gas method with mass spectrometer	61
2 Soldering	11	5.5 Gross leak, perfluorocarbon vapour method using electronic detection apparatus	63
2.1 Solderability	11	5.6 Gross leak — perfluorocarbon — bubble detection method	65
2.2 Resistance to soldering heat	12	5.5 Gross leak, perfluorocarbon vapour method using electronic detection apparatus	63
2.3 Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat	12	5.7 Test condition E, weight-gain gross-leak detection	65
3 Vibration (sinusoidal)	32	5.8 Penetrant dye gross leak detection	67
4 Shock	32	5.9 Gross leak re-tests	67
5 Acceleration, steady state	32	6 Salt mist	68
6 Bond strength test	33	7 Thermal intermittence test	68
6.1 General	33	8 Internal moisture content measurement by mass spectrometry method	69
6.2 Methods A and B See also Annex A	33	8.1 Object	69
6.3 Method C	37	8.2 General description	69
6.4 Method D	37	8.3 Test apparatus	70
6.5 Methods E and F	38	8.4 Preconditioning	70
6.6 Method G: Wire ball shear test	39	8.5 Conditioning	70
6.7 Information to be given in the relevant specification	47	8.6 Requirements	70
7 Die shear strength test	47	8.7 Information to be given in the relevant specification	71
7.1 Object	47	8.8 Guidance	71
7.2 Description of the test apparatus	47		
7.3 Test Method	47		
7.4 Failure criteria	48		
7.5 Requirements	48		
7.6 Information to be given in the relevant specification	48		

	Page		Page
Chapter 4. Miscellaneous test methods		Figure II.14 — Temperature on the body of the SMD during wave-soldering	31
1 Flammability tests of plastic-encapsulated devices	72	Figure 3 — Minimum bond pull limits (normal to die)	36
1.1 Flammability (internally induced)	72	Figure 4 — Bond shear codes	42
1.2 Flammability (externally induced)	72	Figure 5 — Minimum acceptable individual and average ball bond shear values	45
2 Permanence of marking	72	Figure 6 — Compliant interface on contact tool (plane view)	49
Annex A (normative) Guidance	74	Figure 7 — Alignment of tool with die (plane die)	49
Annex ZA (normative) Normative references to international publications with their corresponding European publications	76	Figure 8 — Choice of die edge for application of contact tool (elevation)	49
Appendix I (normative) Method of inspection by acoustic tomography	20	Figure 9 — Parallel detection circuit	69
Appendix II (informative) Details and descriptions of test method on resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat	22	Figure A.1	75
Figure 1 — Method of measuring the temperature profile of a specimen	13	Table 1 — Moisture soak conditions for dry-packed SMDs (method A)	14
Figure 2 — Method of immersion	17	Table 2 — Moisture soak conditions for dry-packed SMDs (method B)	15
Figure II.1 — Process or moisture diffusion at 85 °C, 85 % HR	23	Table 3 — Moisture soak conditions for non-dry-packed SMDs	15
Figure II.2 — Definition of resin thickness	23	Table 4 — Heating conditions for infra-red convection reflow and convection reflow soldering	16
Figure II.3 — Moisture soaking time to saturation at 85 °C as a function of resin thickness	24	Table 5 — Heating conditions for vapour-phase soldering	17
Figure II.4 — Temperature dependence of saturated moisture content of resin	24	Table 6 — Immersion conditions for wave-soldering	18
Figure II.5 — Dependence of moisture content of resin at the first interface on resin thickness under various soak conditions	25	Table II.1 — Comparison of actual storage conditions and equivalent moisture soak conditions before soldering heat	24
Figure II.6 — Dependence of moisture content of resin at the first interface on resin thickness related to method A of moisture soak	26	Table 7	32
Figure II.7 — Dependence of moisture content of resin at the first interface on resin thickness related to method B of moisture soak	27	Table 8	35
Figure II.8 — Dependence of moisture content of resin at the first interface on resin thickness related to condition B1 of method B of moisture soak	27	Table 9 — Minimum acceptable individual and average ball bond shear values for gold 4ball bond on A1/A1 alloy metallization	46
Figure II.9 — Temperature profile of infrared convection and convection reflow soldering (condition I-A)	29	Table 10	53
Figure II.10 — Temperature profile of infrared convection and convection reflow soldering (condition I-B)	29	Table 11	55
Figure II.11 — Temperature profile of vapour-phase soldering (condition II-A)	30	Table 12	62
Figure II.12 — Immersion method into solder bath	30	Table 13	64
Figure II.13 — Relation between the infrared convection reflow soldering and wave-soldering	31	Table 14 — Physical property requirements of perfluorocarbon fluids	66
		Table 15	68

SEMICONDUCTOR DEVICES – Mechanical and climatic test methods

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 60068.

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 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-3:1985, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*

IEC 60068-2-7:1983, *Environmental testing – Part 2: Tests – Test Ga and guidance: Acceleration, steady state*

IEC 60068-2-11:1981, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-13:1983, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-17:1994, *Environmental testing – Part 2: Tests – Test Q: Sealing*

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

IEC 60068-2-21:1983, *Environmental testing – Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-45:1980, *Environmental testing – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*

IEC 60068-2-47:1982, *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 60068-2-48:1982, *Environmental testing – Part 2: Tests – Guidance on the application of the tests of IEC Publication 68 to simulate the effects of storage*

IEC 60653:1979, *General considerations on ultrasonic cleaning*

IEC 60695-2-2:1991, *Fire hazard testing – Part 2: Test methods – Section 2: Needle-flame test*

IEC 60747-1:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 1: General*

IEC 60748-1:1984, *Semiconductor devices. Integrated circuits – Part 1: General*

3 Terms, definitions and letter symbols

Reference is made to IEC 60068, IEC 60747 and IEC 60748.

4 Standard atmospheric conditions

Reference: IEC 60068-1.

Unless otherwise specified, all tests and recoveries shall be carried out under standard atmospheric conditions for testing, as defined in IEC 60068-1, 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 1060 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 1060 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 1060 mbar).

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.

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

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.

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.

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 5.1.6.2 b).

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 60747 or IEC 60748; 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 60747 or IEC 60748.

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.

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 60068-2-21.

1.1 Tensile

This test shall be in accordance with Test Ua₁, 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:

Method

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

Failure criteria

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 Ud₂)

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 $30^\circ \pm 10^\circ$ 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 $3,0 \pm 0,5$ 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 $3,0 \pm 0,5$ mm from the point where the terminations are formed.

1.4.2.3 Final measurements

After test, examine under $3\times$ to $10\times$ 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 60068-2-20.

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.

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.

- 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 of soldering-iron application shall be $3,5 \pm 0,5$ s.

- 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 $10\times$ 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

Method 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 mount 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 into SMDs 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.

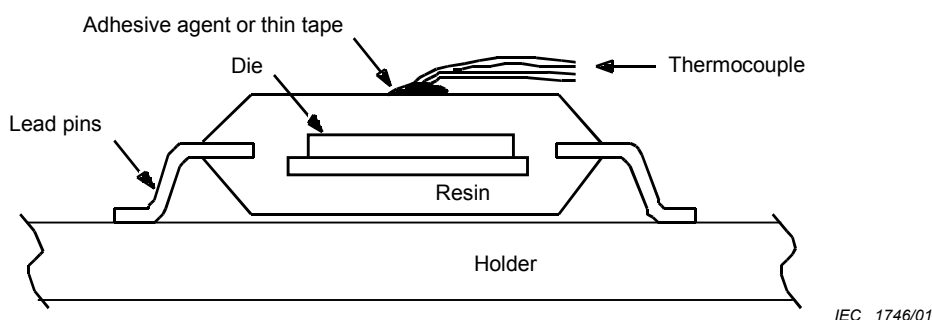
2.3.3 Test apparatus and materials

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

The infra-red convection, the convection and the vapour-phase 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 top surface of the specimen while it is undergoing the soldering heat process, measured as shown in figure 1.



NOTE The adhesive agent or thin tape should have good thermal conductivity.

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

c) Holder

Unless otherwise detailed in the relevant specification, any board material, such as epoxy fibreglass or polyimide, may be used for the holder. The specimen shall be placed on the holder by the usual means and in a position as shown in figure 1. If the position of the specimen, as shown in figure 1, necessitates changing the shape of terminations and results in subsequent electrical measurement anomalies, a position that avoids changing the shape of terminations may be chosen, and this shall be specified in the relevant specification.

d) Wave-soldering apparatus

The wave-soldering apparatus shall comply with conditions given in item d)3) of 2.3.4. Molten solder shall usually be flowed.

e) Solvent for vapour-phase reflow soldering

Perfluorocarbon (perfluoroisobutylene) shall be used.

f) Flux

Unless otherwise detailed 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 60068-2-20.

g) Solder

Solder of composition as specified in appendix B of IEC 60068-2-20 shall be used.

2.3.4 Procedure

a) Initial measurements

1) Visual inspection

Visual inspection, as specified in clause 5 of chapter 1, shall be performed before the test. Special attention shall be paid to external cracks and swelling, which will be looked for under a magnification of 40×.

2) Electrical measurement

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

3) Internal inspection by acoustic tomography

Unless otherwise detailed in the relevant specification, internal cracks and delamination in the specimen shall be inspected by acoustic tomography in accordance with appendix I.

b) Drying

Unless otherwise detailed in the relevant specification, the specimen shall be baked at 125 °C ± 5 °C for at least 24 h.

c) Moisture soak

Unless otherwise detailed in the relevant specification, moisture soak conditions shall be selected on the basis of the packing method of the specimen (see II.1.1 of appendix II). If baking the specimen before soldering is detailed in the relevant specification, the specimen shall be baked instead of being subject to moisture soak.

1) Moisture soak for dry-packed SMDs

Moisture soak conditions for dry-packed SMDs may be used as specified in method A, table 1, or method B, table 2. Moisture soak conditioning for dry-packed SMDs consists of two stages. The first stage of conditioning is intended to simulate moisturizing SMDs before opening the dry pack/dry cabinet. The second stage of conditioning is to simulate moisturizing SMDs during storage after opening the dry pack for soldering (floor life). Moisture soak conditioning for dry-packed SMDs shall be selected from method A or B. Method A shall be used when the relative humidity in the dry pack or dry cabinet is specified by the manufacturer as being between 10 % and 30 %. Method B shall be used when the relative humidity in the dry pack or dry cabinet is specified by the manufacturer as being below 10 %.

i) Method A

Unless otherwise detailed in the relevant specification, the first stage of conditioning A1, as shown in table 1, shall be performed. Subsequently, the second stage of conditioning A2, as shown in table 1, shall be performed within 4 h of finishing the first stage of conditioning (see II.1.2.2 of appendix II).

Table 1 – Moisture soak conditions for dry-packed SMDs (method A)

Condition		Moisture soak conditions	Permissible storage conditions in the dry pack and the dry cabinet	Condition of floor life
First-stage conditioning	A1	$(85 \pm 2) ^\circ\text{C}$, $(30 \pm 5) \% \text{ RH}$, $168 \begin{smallmatrix} 24 \\ -0 \end{smallmatrix} \text{ h}$	$<30 ^\circ\text{C}$, 30 % RH, 1 year	–
Second-stage conditioning	A2	$(30 \pm 2) ^\circ\text{C}$, $(70 \pm 5) \% \text{ RH}$, $168 \begin{smallmatrix} 24 \\ -0 \end{smallmatrix} \text{ h}$	–	$<30 ^\circ\text{C}$, 70 % RH, 168 h
RH: Relative humidity.				

NOTE 1 The first stage of conditioning represents storage conditions in the dry pack and the dry cabinet, as well as increasing relative humidity in the dry pack, by repacking the SMDs at the distributor's facility and the user's inspection facility. When condition A1 is applied, the SMDs must be packed into a moisture-proof bag with IC trays and desiccants within a few weeks of drying. They may then be subjected to multiple temporary openings of the moisture-proof bag (for several hours at a time). Repack and inspection of SMDs are possible while the humidity indicator in the dry pack indicates less than 30 % RH since SMDs will recover the initial condition of absorbed moisture within a few days of repacking. In this case, the moisture content measurement of SMDs (see clause II.2 of appendix II) is not needed as a moisture control of the dry pack. A check of the moisture indicator is sufficient for moisture control.

NOTE 2 When moisture soak of the first-stage conditioning does not result in saturation, the soak time is extended to 336 h, because SMDs in a dry pack or dry cabinet will become saturated with moisture during long-term storage. When moisture soak of the first stage of conditioning reaches saturation, the soak time is shortened.

ii) Method B

The condition of moisture soak conditioning shall be selected from table 2 in accordance with the condition of the floor life detailed in the relevant specification (see II.1.2.3 of appendix II).

Table 2 – Moisture soak conditions for dry-packed SMDs (method B)

Condition	Moisture soak conditions	Total conditions from baking to dry packing and temporary opening of the dry pack	Condition of floor life
B1	(30 ± 2) °C, (60 ± 5) % RH, 192 ⁺²⁴ ₋₀ h	<30 °C, 60 % RH, 24 h	<30 °C, 60 % RH, 168 h
B2	(30 ± 2) °C, (60 ± 5) % RH, 96 ⁺²⁴ ₋₀ h	<30 °C, 60 % RH, 24 h	<30 °C, 60 % RH, 72 h
B3	(30 ± 2) °C, (60 ± 5) % RH, 72 ⁺²⁴ ₋₀ h	<30 °C, 60 % RH, 24 h	<30 °C, 60 % RH, 48 h
B4	(30 ± 2) °C, (60 ± 5) % RH, 48 ⁺²⁴ ₋₀ h	<30 °C, 60 % RH, 24 h	<30 °C, 60 % RH, 24 h
B5	(30 ± 2) °C, (60 ± 5) % RH, 6 ⁺²⁴ ₋₀ h	–	<30 °C, 60 % RH, 6 h
RH: Relative humidity.			

NOTE 3 Moisture soak conditions from B1 to B4 consist of the first-stage conditioning (30 °C, 60 % RH, 24 h) and the second-stage conditioning (floor life).

NOTE 4 Contents in the dry pack of SMDs, IC trays and other materials, should be fully dried just before packing into the moisture-proof bag and the desiccant must be completely dry. This is because moist materials and degraded desiccants give off water vapour, causing the relative humidity in the dry pack to exceed 10 %. The relative humidity in the dry pack should be verified by the humidity indicator and the moisture content measurement of the SMDs, as shown in clause II.2 of appendix II.

NOTE 5 Storage of SMDs in a dry cabinet instead of a dry pack is not permitted because very low relative humidity cannot be obtained in a dry cabinet.

NOTE 6 The individual conditions of method B shall cover total storage condition from baking the SMDs to soldering them, and this should include the duration time of room storage from baking the SMDs to packing them into the dry pack, temporary opening of the dry pack and the floor life.

2) Conditions for non-dry-packed SMDs

The moisture soak condition shall be selected from table 3, in accordance with the permissible limit of actual storage (see II.1.2.1 of appendix II).

Table 3 – Moisture soak conditions for non-dry-packed SMDs

Condition	Temperature °C	Relative humidity %	Duration time h	Permissible limit on actual storage
C	85 ± 2	85 ± 5	168 ± 24	<30 °C, 85 % RH
D	85 ± 2	60 ± 5	168 ± 24	<30 °C, 60 % RH
RH: Relative humidity.				

d) Soldering heat

Unless otherwise detailed in the relevant specification, the specimen shall be subjected to soldering heat within 4 h of finishing the moisture soak or baking. 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. Whichever method is chosen, the soldering heat cycles shall be a minimum of one and a maximum of three. Unless otherwise detailed in the relevant specification, one cycle of soldering heat shall be used. If more than one cycle is selected, the specimen shall be cooled down to below 50 °C before the second, and subsequent, soldering heat.

NOTE 7 If the specimen is not affected by moisture soak and drying, which takes place during room storage of over 4 h, a storage time exceeding 4 h following the completion of moisture soak or the baking may be detailed in the relevant specification.

1) Method of heating by infra-red convection or convection reflow soldering

i) Preparation

The specimen shall be put on the holder.

ii) Preheating

Unless otherwise specified in the relevant specification, the specimen shall be preheated at a temperature from 100 °C to 160 °C for 1 min to 2 min in the reflow soldering apparatus.

iii) Solder heating

Following preheating, the temperature of the specimen shall be raised to peak temperature and then lowered to room temperature. The heating condition shall be selected from table 4 in accordance with the relevant specification.

NOTE 8 If the SMDs are thick and large, condition I-B should be selected, since the temperature of thick and large SMDs having a large heat capacitance will not reach 220 °C during actual reflow soldering (see II.3.1 of appendix II).

NOTE 9 Following preheating, the temperature of the specimen should follow the values as indicated in the profile given in figure II.9 or figure II.10 of appendix II.

Table 4 – Heating condition for infra-red convection reflow and convection reflow soldering

Condition	Time s	Range of peak temperature °C
I-A	10 ± 1	235 to 240
I-B	10 ± 1	220 to 225

2) Method of heating by vapour-phase reflow soldering

i) Preparation

The specimen shall be put on the holder.

ii) Preheating

Unless otherwise specified in the relevant specification, the specimen shall be preheated at a temperature from 100 °C to 160 °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 ± 4 s as shown in table 5 (refer to II.3.2 of appendix II).

Table 5 – Heating condition for vapour-phase soldering

Condition	Temperature °C	Time s
II-A	215 ± 5	40 ± 4

3) Method of heating by wave-soldering

i) Preparation

The bottom surface of the specimen shall be fixed to the holder by an adhesive agent specified in the relevant specification. Unless otherwise detailed in the relevant specification, flux shall not be applied to the specimen and holder.

NOTE 10 If flux is applied, vaporization of solvent in the flux could affect the temperature rise of the specimen. Flux should not, therefore, be applied to the body of the specimen and should only be applied to lead pins as sparingly as possible.

NOTE 11 Where SMDs have a stand-off (height between the bottom of the SMD body and the bottom of the lead pin) of less than 0,5 mm (except lower thermal resistance SMDs with a heat sink and whose body thickness exceeds 2,0 mm), they should be tested by soldering heat of condition I-A. SMDs whose body thickness exceeds 3,0 mm are tested by soldering heat by condition I-B. Wave-soldering of conditions III-A and III-B should be omitted because conditions I-A and I-B are more severe than conditions III-A and III-B for these SMDs (refer to II.3.3 of appendix II).

ii) Preheating

Unless otherwise detailed in the relevant specification, the specimen shall be preheated at a temperature of 80 °C to 140 °C for 30 s to 60 s in the soldering apparatus.

iii) Solder heating

Following preheating, the specimen and the holder shall be immersed into flowing molten solder, as shown in figure 2. The immersion condition shall be selected from table 6.

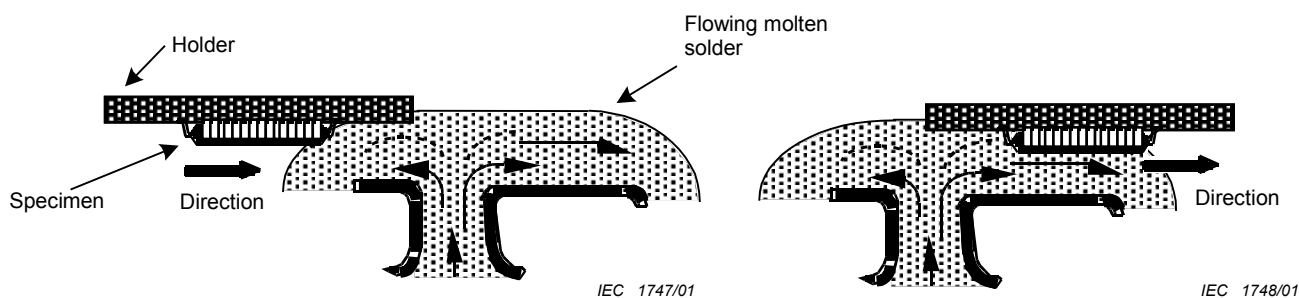
**Figure 2a – Start of immersion****Figure 2b – End of immersion****Figure 2 – Heating by wave-soldering**

Table 6 – Immersion conditions for wave-soldering

Condition	Temperature of solder °C	Immersing time s	Actual soldering method
III-A	260 ± 5	5 ± 1	Single-wave
III-B	260 ± 5	10 ± 1	Double-wave

iv) Cleaning

If the flux is applied, it shall be removed by a cleaning method detailed in the relevant specification.

e) Recovery

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

NOTE 12 Wave-soldering is not commonly available to the semiconductor manufacturer. Where the manufacturer does not have access to such equipment, the method should be specified only by agreement between the manufacturer and the customer.

f) Final measurements

1) Visual inspection, as specified in clause 5 of chapter 1, shall be performed after the test. Special attention shall be paid to external cracks and swelling which will be looked for under a magnification of 40×.

2) Electrical measurement

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

3) Internal inspection by acoustic tomography

Unless otherwise specified in the relevant specification, internal cracks and delamination in the specimen shall be inspected by acoustic tomography in accordance with appendix I.

2.3.5 Information to be given in the relevant specification

	Subclause
	2.3.3
a) Material of holder	item c)
b) Position of specimen on the holder	item c)
c) Composition of flux	item f)
d) Number of test specimens	2.3.4
e) Item and failure criteria for initial measurement	item a)
f) Preconditioning	item b)
g) Method of moisture soak	item c)
h) Conditions of drying	item b)
i) Baking conditions instead of the moisture soak	item c)
j) Method of moisture soak for dry packed SMDs	item c)1)
k) Period between the stages of moisture soak conditioning	item c)1)i)
l) Conditions of first-stage and second-stage conditioning and whether another condition is needed	item c)1)i)
m) Soak time of the first-stage conditioning if 168 h of soak time is insufficient	item c)1)i)
n) Moisture soak conditions for SMDs stored in completely dried dry pack	item c)1)ii)
o) Moisture soak conditions for non-dry-packed SMDs	item c)2)
p) Period between finish of moisture soak and soldering heat	item d)
q) Method and condition of soldering heat	item d)
r) Number of cycles of soldering heat	item d)
s) Preheat conditions for infra-red convection and convection reflow soldering	item d)1)
t) Heating conditions for infra-red convection and convection reflow soldering	item d)1)
u) Preheat conditions for vapour-phase reflow soldering	item d)2)
v) Adhesion method	item d)3)
w) Preheat conditions for wave-soldering	item d)3)
x) Cleaning method for flux	item d)3)
y) Recovery conditions	item e)
z) Item and failure criteria for final measurement	item f)

Appendix I (normative)

Methods of inspection by acoustic tomography

I.1 Object

Inspection by acoustic tomography is required by 2.3.4 in order to inspect the specimen's initial internal integrity and internal integrity anomalies subsequent to solder heating.

I.2 Equipment

An acoustic tomography unit capable of operating in the C-Scan (plane image) mode within the 10 MHz to 75 MHz frequency range with an accuracy of 0,5 mm² or more in the area of plane image.

I.3 Procedure of inspection

I.3.1 Select the highest usable ultrasonic frequency, subject to the limitations imposed by the media thicknesses and acoustic characteristics, specimen configuration and transducer availability, to address the interfaces to be inspected (attenuation of the signal with depth).

I.3.2 Complete transducer calibration and optimization in accordance with the manufacturer's recommended procedure.

I.3.3 Bake all specimens suspected or known to have absorbed water through external cracks for the period and temperature required to remove all moisture.

I.3.4 Place the specimens in the acoustic tomography apparatus. Unless otherwise detailed in the relevant specification, the sides, top and bottom of the specimen shall be inspected.

I.3.5 Unless otherwise detailed in the relevant specification, the focus of the ultrasonic beam shall be adjusted to the first interfaces (for example the surface of the die for the top-side inspection and the bottom surface of the die pad for the bottom-side inspection). If any integrity anomalies remote from the first interfaces are detected, the focus shall be changed accordingly.

I.3.6 Optimize the signal-to-noise response of the acoustic system and units under evaluation.

I.3.7 Complete inspection for all specimens specified in 2.3.4.

I.4 Failure criteria

I.4.1 Unless otherwise detailed in the relevant specification, the following internal integrity anomalies shall be unacceptable.

- a) Delamination of any area on the top surface of the die.
- b) Internal resin cracking that intersects a bond wire, ball bond, or wedge bond.
- c) Internal resin cracking extended to any internal feature (for example, from die pad to lead finger).
- d) Internal resin cracking extending more than two-thirds of the distance from any internal feature to the outside of the specimen. These additional internal integrity anomalies shall be unacceptable if the area and location of the delamination or crack are specified in the relevant specification.
- e) Wide delamination of any internal feature that intersects a bond wire, ball bond, or wedge bond.
- f) Wide delamination or wide internal crack that degrades an electrical or thermal specification.

NOTE 1 If internal resin cracks of b), c), d) and f) above are suspected (based on acoustic tomography), polished cross-sections must be made to verify the suspected sites.

NOTE 2 Internal integrity anomalies in this subclause are specified in order to avoid failures such as external cracks, electrical and thermal failures in the population of the specimens. Other integrity anomalies that may generate reliability failures must be checked by other reliability tests as stated in I.4.2.

I.4.2 Unless otherwise detailed in the relevant specification, internal integrity anomalies other than a), b), c), d), e) and f) detailed in I.4.1 may be listed as grounds for rejection.

NOTE Some internal integrity anomalies in this subclause may need to be assessed by alternative reliability tests such as the climatic test of chapter 3.

I.5 Information to be given in the relevant specification

	Subclause
a) Side to be inspected if different from specification	I.3.4
b) Focus of ultrasonic beam if different from specification	I.3.5
c) Area and location of delamination	item e) of I.4.1
d) Area and location of delamination or crack	item f) of I.4.1
e) Additional internal integrity anomalies to be judged as unacceptable	I.4.2

Appendix II (informative)

Details and descriptions of test method on resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat

II.1 Description of moisture soak

II.1.1 Guidance for moisture soak

Method A and method B of moisture soak of item c) of 2.3.4 are intended to be used for dry-packed SMDs, whereas conditions C and D in table 3 are intended for use with non-dry-packed SMDs which have been stored under room conditions.

Where package cracking is generated by soldering heat after the moisture soak of condition C or D, it is recommended that devices be dry-packed or stored in a dry atmosphere.

If the cracking is generated by solder heating after the moisture soak of method A and method B, it is recommended that SMDs are pre-baked before being soldered on to the PCBs.

II.1.2 Considerations on which the condition of moisture soak is based

II.1.2.1 General description of moisture soak

The presence of moisture in SMDs is caused by diffusion of water vapour into the resin. The moisture content of the resin needs to be examined, since package cracking during soldering emanates from near the die pad or the die. Examples of characteristics for moisture soak at 85 °C, 85 % relative humidity, are shown in figure II.1. In the case where the resin thickness from the bottom surface of the package to the die pad is 1 mm, figure II.1 indicates that over 168 h are needed for saturation to take place.

Moisture soak characteristics, such as that of resin A in figure II.3, show a slow moisture soak speed which is nevertheless considered significant. Figure II.1 and figures II.4 to II.8 represent moisture soak characteristics of resin A.

Saturation is needed for soldering heat tests in order to simulate long-time storage of, for example, one year which occurs when SMDs are dry-packed or warehoused. The diffusion speed of water vapour into resin depends only on temperature. Given the resin thickness as defined in figure II.2, saturating moisture time at 85 °C depends on the resin thickness as shown in figure II.3. It would appear that, for a normal SMD whose resin thickness is from 0,5 mm to 1,0 mm, 168 h of moisture soak time are required.