INTERNATIONAL STANDARD

IEC 60748-23-1

QC 165000-1

First edition
2002-05

Semiconductor devices –
Integrated circuits –

Part 23-1:
Hybrid integrated circuits and film structures –
Manufacturing line certification –
Generic specification

Dispositifs à semiconducteurs –
Circuits intégrés –

Partie 23-1:
Circuits intégrés hybrides et structures par films –
Certification de la ligne de fabrication –
Spécification générique

Reference number
IEC 60748-23-1:2002(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/catlg-e.htm) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/JP.htm) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

Email: custserv@iec.ch
Tel: +41 22 919 02 11
Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 60748-23-1

QC 165000-1

First edition
2002-05

Semiconductor devices –
Integrated circuits –

Part 23-1:
Hybrid integrated circuits and film structures –
Manufacturing line certification –
Generic specification

Dispositifs à semiconducteurs –
Circuits intégrés –

Partie 23-1:
Circuits intégrés hybrides et structures par films –
Certification de la ligne de fabrication –
Spécification générique

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XC

For price, see current catalogue

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES — INTEGRATED CIRCUITS –

Part 23-1: Hybrid integrated circuits and film structures – Manufacturing line certification – Generic specification

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60748-23-1 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

The text of this standard is based on the European standard EN 165000-1 and the following documents:

FDIS	Report on voting
47A/638/FDIS	47A/649/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 3.

IEC 60748-23-1 should be read in conjunction with Parts 23-2, 23-3 and 23-4.

Annex A forms an integral part of this standard.

Annex B if for information only.

The QC number that appears on the front cover of this publication is the specification number in the IEC Quality Assessment System for Electronic Components (IECQ).

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

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

INTRODUCTION

This set of specifications prescribes a set of procedures to be used by users and manufacturers for the production and delivery of high-quality, special requirement hybrid integrated circuits and film structures with a specified level of quality and reliability.

This set of specifications prescribes reference criteria for the establishment, control, maintenance and development of a certified manufacturing line and represents a manufacturing line certification methodology.

The targeted level of quality and reliability is to be achieved by using best design and manufacturing practices. Examples of quality and reliability best practices for elimination of potential failure mechanisms and achievement of a targeted quality and reliability level include: material characterization for derivation of process design rules, in-process control, continuous improvement, etc.

Assessment (estimation) of the targeted quality and reliability level may be accomplished by:

a) using data obtained from the material characterization, design and process control and improvement activities; or

b) through the use of product assessment level schedule (PALS) tests.

Part 23-2 of this set of specifications provides guidance to 'users' of hybrids in terms of the 'visual inspection standards' to be expected.

Part 23-3 of this set of specifications provides a framework for use as an assessment/audit tool to assist the suppliers, customers or an independent organization to carry out an assessment of a certified manufacturing line of a hybrid manufacturing company.

Part 23-4 of this set of specifications provides a blank detail specification, which provides guidance to 'users' of hybrids for procurement purposes.

Part 23-5 of this set of specifications provides a means of quality assessment on the basis of qualification approval.

SEMICONDUCTOR DEVICES – INTEGRATED CIRCUITS –

Part 23-1: Hybrid integrated circuits and film structures – Manufacturing line certification – Generic specification

1 Scope

This set of specifications applies to high quality hybrid integrated circuits (with films) incorporating special customer quality and reliability requirements. Hybrid integrated circuits may be fully or partly completed. Partly completed devices are those that may be supplied to customers for further processing.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050 (all parts), *International Electrotechnical Vocabulary*

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

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-2:1974, *Basic environmental test procedures – Part 2: Tests – Tests B: Dry heat*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-3:1984 (incorporating amendment 1: 1984), *Basic environmental test procedures – Part 2: Tests – Test Ca: Damp heat, steady state*
Amendment 1 (1984)

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

IEC 60068-2-7:1983, *Basic environmental testing procedures – Part 2: Tests – Test Ga and guidance: Acceleration, steady state*
Amendment 1 (1986)

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

IEC 60068-2-14:1984, *Basic environmental testing procedures – Part 2: Tests – Test N: Change of temperature*
Amendment 1 (1986)

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

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

IEC 60068-2-21:1999, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27:1987, *Basic environmental testing procedures– Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db: Damp heat, cyclic (12 + 12-hour cycle)*
Amendment 1 (1985)

IEC 60068-2-44:1995, *Environmental testing – Part 2: Tests – Guidance on Test T: Soldering*

IEC 60068-2-45:1980, *Basic environmental testing procedures – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*
Amendment 1 (1993)

IEC 60068-2-47:1999, *Environmental testing – Part 2-47: Tests – Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests*

IEC 60068-3 (all parts) E*nvironmental testing procedures – Part 3: Supporting documentation and guidance*

IEC 60068-3-4:2001, *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

IEC 60068-5 (all parts), *Environmental testing – Part 5: Guide to drafting of test methods*

IEC 60134:1961, *Rating systems for electronic tubes and valves and analogous semiconductor devices*

IEC 60191-2:1996, *Mechanical standardization of semiconductor devices*

IEC 60617 (all parts), *Graphical symbols for diagrams*

IEC 60695-2-2:1991, *Fire hazard testing – Part 2: Test methods – Section 2: Needle-flame test*
Amendment 1 (1994)

IEC 60747-1:1983, *Semiconductor devices – Discrete devices – Part 1: General* [1]
Amendment 3 (1996)

IEC 60748-1, *Semiconductor devices – Integrated circuits – Part 1: General* [2]

IEC 60748-23-2:2002, *Semiconductor devices – Integrated circuits – Part 23-2: Hybrid integrated circuits and film structures – Manufacturing line certification – Internal visual inspection and special tests*

---

1 Together with any other part of IEC 60747 or IEC 60748 relevant to the specific hybrid application, including terminology.

2 To be published.

IEC 60748-23-3:2002, *Semiconductor devices – Integrated circuits – Part 23-3: Hybrid integrated circuits and film structures – Manufacturing line certification – Manufacturers' self-audit checklist and report*

IEC 60749:1996, *Semiconductor devices – Mechanical and climatic test methods* [3]
Amendment 1 (2000)
Amendment 2 (2001)

IEC 61340-5-1:1998, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

ISO 1000:1992, *SI units and recommendations for use of their multiples and of certain other units*
Amendment 1 (1998)

ISO 9000:2000, *Quality management systems – Fundamentals and vocabulary*

ISO 2859 (all parts), *Sampling procedures for inspection by attributes*

IECQ 001002-3:1998, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure – Part 3: Approval procedures*

IECQ 001005:2000, *Register of Firms, Products and Services approved under the IECQ System, including ISO 9000*

3 Definitions

For the purpose of this part of IEC 60748, the units, graphical symbols, letter symbols and terminology given in IEC 60027, IEC 60050, IEC 60617, IEC 60747-1, IEC 60748-1 and ISO 1000, as well as the following definitions, shall apply.

3.1
added component
component added to a hybrid film integrated circuit that is not formed on the surface of the substrate

NOTE Added components are incorporated components (see 4.1.3 of IECQ 001002-3) excluding those formed on the substrate.

3.2
burn-in
non-destructive procedure designed to screen out early lifetime failures

NOTE Burn-in is an accelerated conditioning with a device under its operating electrical load at an elevated temperature, which is generally the maximum operating temperature that does not exceed the thermal rating of the device.

3.3
capability qualifying component (CQC)
test specimen used to assess, in part or in whole, a declared capability

NOTE It may be either a specially designed test specimen (process test vehicle) or a normal production circuit (qualification circuit), or a combination of both.

3 There exists a consolidated edition 2.2 (2002) that includes edition 2.0 (1996), its amendment 1 (2000) and amendment 2 (2001).

3.4
category dissipation
fraction of the rated dissipation defined in the detail specification, applicable at the upper category temperature taking account of the derating curve

NOTE Prescribed (where appropriate) in the detail specification.

3.5
certified manufacturing line
manufacturing line which is formally qualified and in which a manufacturer defines a basic technology and technology flow which can be used to produce a range of different components

NOTE The defined technology flow covers all processes from initial component design to the final completion of tested components ready for delivery.

3.6
custom designed
qualifying term for a circuit manufactured to a specific customer's requirements

3.7
electrical endurance
procedure similar to burn-in but of extended duration. Electrical endurance may be considered destructive or non-destructive dependent upon duration and severity

3.8
film circuit element
circuit element consisting of a film or films

3.9
lower category temperature (LCT)
minimum ambient temperature ($T_{amb\ min}$) at which a circuit has been designed to operate continuously

3.10
measurement uncertainty
statement of the limits of the range within which the true value of the measurement is expected to lie in relation to the recorded result, with a defined confidence level

3.11
part-finished
a film integrated circuit or hybrid film integrated circuit taken uncompleted from a production line

NOTE It cannot be completely assessed to the specification applicable in its normal finished state.

3.12
package
total or partial envelope of an integrated circuit which provides:

– mechanical protection

– environmental protection

– outline dimensions

NOTE The package may also contain or provide terminals. It contributes to the thermal characteristics of the integrated circuit.

3.13
primary stage of manufacture
production of the first film layer of a film integrated circuit on the surface of a substrate

3.14
process test vehicle (PTV)
device or test structure used to verify, analyze or monitor processes or electrical/physical attributes

3.15
product assessment level schedules (PALS)
minimum circuit process and test requirements for the different market sectors/operating environments (see annex A)

3.16
qualification circuit (QC)
circuit which is representative of circuits manufactured to declared and identical processes and used for approval tests to one of the product assessment level schedules (PALS)

3.17
repair
making good of an approved circuit which has been damaged or has become defective after release

NOTE Circuits which have been repaired should not be released under the IECQ system.

3.18
rework
reprocessing or corrective processing operation carried out on a circuit before release to the customer

3.19
screening
examination or testing applied to all products in a lot for the purpose of detecting and removing potential failures

3.20
upper category temperature (UCT)
maximum ambient temperature ($T_{amb\ max}$) at which a circuit has been designed to operate continuously at that portion of the rated dissipation which is indicated in the category dissipation

4 Standard and preferred values

Where practical, values should be selected from the following:

a) dimensions: IEC 60191-2;

b) temperatures in degrees Celsius (°C):

–65, –55, -40, –25, –10, 0, +5, +25, +40, +55, +70, +85, +100, +125, +150.

5 Marking

5.1 Circuit

The marking of the circuit shall be specified in the detail specification and provide adequate circuit identification and traceability. As space permits it shall include:

a) terminal identification (e.g. position of pin No.1);

b) type designation;

c) date code;

e) handling precautions;

f) mark of conformity;

g) manufacturer's name or trade mark;

h) serial number;

i) product assessment level schedule (PALS) number.

5.2 Despatch primary pack

The marking of the despatch primary pack shall be specified in the detail specification and shall provide adequate contents identification and traceability. It should include, as relevant, information from 5.1 and the following:

a) certificate of conformity reference number;

b) order or contract number;

c) quantity of circuits.

6 Quality assessment procedures

6.1 General

6.1.1 Eligibility for manufacturing line certification

Manufacturing line certification may be granted only to a manufacturer of film integrated circuits and/or hybrid film integrated circuits who has been granted manufacturer's approval in accordance with the requirements of ISO 9000, as detailed in clause 2 of IEC QC 001002-3. A manufacturer is eligible for manufacturing line certification if direct supervision by the designated management representative (DMR), or in the case of subcontracted processes, the local DMR, is applied to the manufacturing process including the "primary stage" of manufacture. The DMR shall ensure the proper and effective co-ordination and control of certified manufacturing line through the formation of a senior management team.

6.1.2 Subcontracting

Subcontracting shall be in accordance with the requirements of 4.2.2 of IEC QC 001002-3.

The subcontracted manufacturing processes may be either:

a) film production;

b) trimming of elements;

c) mounting of components;

d) packaging;

e) others.

Not more than two of the four named processes shall be subcontracted.

6.1.3 Control of procurement sources and incoming material

Subclause 4.2.3 of IEC QC 001002-3 applies with the following details:

6.1.3.1 Added components, part finished components, materials and subcontracted processes covered by a IECQ specification

These shall be procured using the normal IECQ release procedures. Under these conditions no other assessment is required.

6.1.3.2 Added components, part finished components, materials and subcontracted processes not covered by a IECQ specification

The DMR shall:

a) ensure the existence of a procurement specification under his control.

b) perform an evaluation programme for each procured item or family from all manufacturing sources in accordance with the relevant product assessment level schedules (PALS) for the finished circuit (see annex A).

   This evaluation programme may be carried out as part of the initial design evaluation. Each variant shall be submitted to the minimum sample size and acceptance criteria in the appropriate PALS. Structural similarity principles may be used.

c) define and institute a goods inward inspection and a continuous vendor rating system for all such items.

d) instigate such other procedures as are necessary to ensure that procurement is equivalent to any relevant IECQ release.

6.1.4 Validity of release for delivery

6.1.4.1 General

Circuits may be released under manufacturing line certification subject to the following conditions:

a) The circuits have been designed and manufactured within the manufacturer's approved capability.

b) An evaluation programme has been performed for each circuit or family in accordance with the relevant PALS for the finished circuit. These PALS, which are listed in annex A, are the minimum product release requirements of IEC 60748-23-1 to IEC 60748-23-5. Each level specifies the minimum assessment requirement and process requirements. However, customers are at liberty to add to the testing requirements or put the design evaluation requirement on a periodic product sampling basis. The structural similarity claims, where applicable for each product, are to be agreed between the customer and manufacturer. The product assessment level of release is to be clearly shown on the detail product specification and the certificate of conformity. The device screening sequence shown in each PALS is mandatory except that, when agreed by customer and manufacturer, the sequence of sealing and final electrical test may be reversed. For design evaluation there is no requirement for sequence of testing and different samples may be used for each test. The manufacturer may, however, at his risk, use the same samples for any or all of the tests in the design evaluation section. It is necessary that devices used for device sample testing or design evaluation shall have successfully completed device screening. Where a per cent defective allowable (PDA) is required for a screening sequence, the PDA is calculated at the beginning of the burn-in test. Tests performed before burn-in, or after the electrical test at T_{amb} which immediately follows the burn-in, are not subject to PDA. Where the number of defectives allowed by the PDA in any lot is not a whole number, the allowance shall be rounded up to the next whole number. In the event of a failure at PDA, if the per cent defective is found to be greater than the PDA but not greater than twice the PDA, the devices which passed may be resubmitted to burn-in once only and examined to a tightened PDA. The tightened PDAs are 10 % ⇒ 7 %, 7 % ⇒ 5 % and 5 % ⇒ 3 %.

c) The circuits, their added components, piece parts and materials are traceable to original manufacturer's lot numbers.

6.1.4.2 Release of circuits subjected to destructive or non-destructive tests

Circuits subjected to destructive (D) mechanical or environmental tests shall not be included in the lot for delivery.

Circuits subjected to non-destructive (ND) tests may be delivered, provided they meet the requirements of the detail specification.

6.1.4.3 Delayed deliveries of circuits

Circuits held for a period exceeding two years following release of the lot shall be retested to the electrical and solderability tests of the detail specification, prior to delivery, unless a longer period can be demonstrated by the manufacturer.

6.1.5 Rework

6.1.5.1 General

Rework shall only be permitted within the procedures declared in the manufacturer's declared procedures as defined in 4.7.1 of IEC QC 001002-3.

A customer may prohibit or restrict rework on circuits to be supplied to a particular contract.

6.1.5.2 General requirements

a) where circuits have been directly embedded in hard plastic encapsulants, no rework is permitted other than that specified in 6.1.5.8;
b) maximum time/temperature excursions during rework shall be specified;
c) screening, adequate to test the rework in accordance with the manufacturer's declared procedures, shall be carried out after rework.

6.1.5.3 Film conductors

Film conductors may be reworked by the attachment of conducting links provided that the number of links and methods of attachment comply with the requirements of the manufacturer’s declared procedures.

6.1.5.4 Wire bonds

Rebonding to the semiconductor die shall be attempted only once and rebonding is restricted to not more than 10 % of the wire bonds in a circuit. The rebonds shall be on at least 50 % undisturbed metallization (excluding probe marks).

Rebonding to header pins and film conductor tracks is not restricted except that each rebond is on at least 50 % undisturbed metallization.

6.1.5.5 Compound wire bonds

The placing of one wire bond on top of another wire (compound wire bond) is permitted except on the semiconductor die. The new bond shall cover at least 75 % of the original bond, and shall be attempted only once.

6.1.5.6 Added components

Added components may be replaced up to two times except for a eutectic bonded semiconductor die which may be replaced only once, unless demonstrated otherwise by the manufacturer.

6.1.5.7 Circuit packages

Assembled substrates may be removed and placed into new packages only once.

Package lids may only be replaced if the design lid/circuit clearance is maintained.

Reworked packages shall be submitted to the screening sequence of the relevant PALS.

6.1.5.8 Other permitted rework

The following processes are also permitted:

a) cleaning;
b) marking;
c) lead straightening.

6.1.5.9 Use of reworked (removed) added components

Added components may be reused provided they conform with the requirements of the relevant visual, electrical, mechanical and environmental tests and the provisions of 6.1.4.1 c).

6.2 Procedures for manufacturing line certification

6.2.1 Application for manufacturing line certification

Application shall be made to the National Authorized Institution (NAI) in accordance with IEC QC 001002-3, 4.2.4. In addition, the manufacturer shall:

a) conform with the eligibility requirements of 6.1.1;
b) carry out an audit and conform with the requirements of the appraisal checklist in IEC 60748-23-3;
c) submit the completed appraisal checklist to the National Supervising Inspectorate (NSI);
d) conform with the requirements of one or more of the product assessment level schedules (PALS) in annex A. The testing shall be performed on a circuit type or types representative of the manufacturer's claimed production capability (see 6.4.3).

6.2.2 Granting of manufacturing line certification

The manufacturer shall submit a report to the NSI covering the manufacturing line certification testing in accordance with the requirements of 6.4.4.3.

Manufacturing line certification shall be granted when the requirements of this specification have been satisfied.

6.3 Description of capability

The manufacturer shall describe his process capability to the NSI in a declared document. The scope of process capability for each qualifying component shall be stated.

6.4 Qualifying components

6.4.1 Process test vehicle (PTV)

A PTV may be either a specially designed test specimen or a standard product.

Specially designed PTVs shall be formally specified within the manufacturer's document control system and shall include details of

a) circuit materials and components,

b) process and inspection stages (including quantities),

c) acceptance criteria,

d) identification or marking.

A list of PTVs, cross-referencing the process(es) monitored, shall be incorporated in the declared procedures. This may be in tabular form.

The PTV quality standards, measurements, data collection and presentation shall be detailed in the process control documentation.

6.4.2 Qualification circuit (QC)

A circuit which is designated "qualification circuit" and used for process approval testing shall comply with the requirements of the detail specification.

More than one circuit may be needed as a qualifying circuit to approve all the permitted processes.

6.4.3 Circuit or circuits representative of the manufacturer's claimed production capability

The qualification circuit samples shall be submitted to the most severe PALS (see annex A) that is required by the manufacturer. The number of samples required is that necessary to complete the testing; tests may be sequenced at the manufacturer's risk. A report of the results conforming to the requirements of 6.4.4.3 shall be submitted to the NSI.

The circuit/circuits shall, at minimum, enable assessment of the following:

a) largest area package within 20 %, for each generic package configuration and material type;

b) each substrate material;

c) conductor/resistor/dielectric generic material types. The circuit shall be of representative density and contain the maximum number of layers. It shall contain metallization within 20 % of the minimum declared design width;

d) each temperature/time profile for deposited materials;

e) each type of trimming technique;

f) a representative sample of add-on components, at minimum assessing the maximum and minimum declared attach area and/or mass within 25 %;

g) each attachment method/material;

h) where applicable each bonding method, e.g. ultrasonic, thermo-compression;

i) each method of package sealing or encapsulation.

6.4.4 Demonstration and verification of capability

6.4.4.1 General

Electrical, visual, mechanical and environmental tests shall be in accordance with the relevant qualifying circuit detail specifications invoking one of the PALS in annex A. The process and packaging shall conform with those specified in the PALS.

Process controls and in-process inspections on process test vehicles as declared by the manufacturer shall be in accordance with the requirements of IEC 60748-23-3.

6.4.4.2 Test and inspection requirements

The test and inspection requirements for both manufacturing line certification and the maintenance of approval shall verify that the design, materials and processing are capable of producing circuits which conform with their detail specifications. This may be achieved by a combination of approved materials, incoming inspections/tests, in-process inspections/tests and qualification circuits.

a) Approved materials and/or incoming inspections/tests

   Where these methods are used, the manufacturer shall demonstrate that the subsequent processing prior to despatch of the completed circuits will not significantly change the performance of the material. The materials and validation tests shall be fully documented and referenced in the declared procedures. They may cover:

   1) solderability;
   2) package dimensions;
   3) robustness of terminations;
   4) flammability;
   5) damp heat.

b) In-process inspections

   In-process inspections, e.g. internal visual examination, may be covered by process control. The manufacturer shall demonstrate that the process capability relative to the design data and layout rules and the specific in-process inspection standards are fully documented and referenced in the declared procedures. The requirements to be validated by internal visual examination are given in IEC 60748-23-2.

c) In-process tests

   Electrical, mechanical or environmental tests to be made on the assembled circuits to verify circuit performance prior to the packaging process shall be specified in the circuit control documentation.

   Electrical, mechanical or environmental tests conducted on circuits or test vehicles which form an integral part of process control, may be used in place of quality conformance inspections provided the manufacturer demonstrates equivalence and the requirements are fully documented and referenced in the declared procedures. For example:

   1) constant acceleration (except for resin-moulded devices);
   2) sealing, gross and fine leak (except for resin-moulded devices);
   3) resistance to solder heat;
   4) component bond strengths.

6.4.4.3 Manufacturing line certification test report

A test report shall be prepared in accordance with the requirements of this clause, authenticated by the DMR and endorsed by the NSI after verifying that it meets the requirements of this specification.

A copy of the report shall be submitted to the NSI. Any other reproduction and release of the report is the sole prerogative of the manufacturer.

The test report shall be dated and conform to the following requirements:

a) Clause 1 – Front pages

The test report shall be prefaced with the following information:

1) Designation of report, i.e. "Manufacturing line certification test report";
2) Name and address of the test laboratory;
3) When relevant, the position of the test laboratory within a larger organization shall be stated;
4) If it is an IECQ approved independent test laboratory, the scope of the approval shall be stated;
5) Name and address of the NSI responsible for the supervision of the manufacturing line certification tests;
6) Name and address of the manufacturer;
7) Detailed description of the tests with reference to the specifications to be applied including revision number and date of issue;
8) In case of subcontracting of tests the identification of the assigned test laboratory;
9) Accurate identification of the test sample specified by mark of origin, date code and fabrication flowchart (lot traveller);
10) Reference number of the test report;
11) A declaration as follows signed by the DMR:

    "I certify that the requirements of the System have been met and that all specimens tested were

    a) taken from and are representative of current production;

    b) manufactured using current/intended production methods and materials";
12) The signature of the representative of the NSI;
13) Date of receipt of test item(s) and period of testing.

b) Clause 2 – Abstract of the test plan

The abstract shall show the test groups and subgroups of the whole test program and in addition the number of samples that are needed for each test group/subgroup together with the possible number of defects in each group.

The use of a flow chart is recommended.

A timetable shall display the test program sequence and a summary of actual results achieved shall be given.

c) Clause 3 – Details of the specimen

Information shall be given on the origin of the random sample with respect to how many units have been selected from each inspection/production lot and how these units have been assigned to the test groups/subgroups. The number assigned to each of these units shall be given if the test plan requires the calculation of delta limits.

The report shall detail the rules applied in cases where the report concerns structural similarity claims.

d) Clause 4 – Contents

The following details shall be given on each page of the test report:

1) The test report reference number;
2) The page number;

   NOTE The front page of the report should indicate the page number and the total number of pages of the report.

3) The test specification;
4) Test/measurement equipment:

   The test and measurement equipment used for the performance the tests shall be uniquely identified, with its calibration status shown;

5) Test methods:

   For every test the test method shall be named with reference to the corresponding standard. If a non-standard test method is used, this method shall be described in all details;

6) A description of all test conditions:

   Standard conditions for testing (ambient temperature, relative humidity, etc.);

   Type and level of the stress;

   Duration of the stress;

   Where relevant, a description of any special preconditioning or recovery of the test samples;

7) The test results shall be specified accurately, clearly and completely. The result(s) of each test sequence/sub-group shall be traceable to the individual who performed the test or measurement and shall be dated.

   If there is a large amount of test data, it is recommended that statistical methods are used so that a clear evaluation can be made;

8) The individual test requirement (specification limit) shall be stated and the measurement uncertainty associated with the test.

e) Clause 5 – Failure identification and analysis

All failures which occur during the testing shall be identified with the results of the failure analysis carried out.

6.4.5 Procedures to be followed in the event of capability qualifying component (CQC) failures

The requirements of 4.2.6.2 and 4.2.10 of IEC QC 001002-3 apply in the case of all failures, where applicable.

6.4.6 Abstract of description of capability

The manufacturer's description of his capability shall be provided to the NSI for inclusion in the certified manufacturing line listing.

The description shall be based on the following abstract of capability:

a) company name;
b) type of technology;
c) approved processes;
d) subcontracted processes;
e) packaging methods;

f) product assessment level schedules;

g) approved site address (including telecoms numbers);

h) commercial contact (telephone number).

NOTE An example abstract is given in 3.3 of IEC 60748-23-3.

6.5 Procedures following the granting of manufacturing line certification

6.5.1 Maintenance of manufacturing line certification

Manufacturing line certification is maintained by the quality conformance inspection of detail specifications and the manufacturer's quality management programme, including the annual submission to the NSI of his self-audit checklist in accordance with IEC 60748-23-3.

Manufacturing processes which have not been exercised within a two year period shall be automatically excluded from the manufacturing line certification and the manufacturer shall take action in accordance with 6.5.2.

6.5.2 Notification of changes likely to affect the validity of manufacturing line certification

A manufacturer who intends to extend his capability shall make formal application to the NSI, in accordance with 6.2.1. A manufacturer who intends to reduce his capability shall advise the NSI of the modification and amend the 'abstract of capability' accordingly.

Such modifications shall be included in the manufacturer's change control system.

The manufacturer is required to notify the NSI of the following changes and provide a plan of implementation and/or re-verification which shall, as a minimum, include the following:

NOTE All re-verification programmes are to be agreed with the NSI.

a) Change in place of manufacturer

1) breakdown of personnel transferring to the new site;
2) organization chart for the new site;
3) approvals held by the new site (if applicable);
4) details of equipment transfer and commissioning;
5) plan for re-establishing the environment;
6) re-verification of approval proposals.

b) Change of key manufacturing process

1) details of equipment and commissioning;
2) re-verification of approvals proposal.

c) Changes of materials from those declared in manufacturer's declared procedures

1) material type and composition;
2) products and/or processes affected;
3) suitability and compatibility data;
4) re-verification of approvals proposal.

NOTE Engineering data may be submitted as evidence of suitability of materials in lieu of a re-verification programme with the agreement of the NSI.

d) Change of quality personnel/organization chart

- Any change of DMR.

e) Change of test equipment or approved test house

NOTE Does not include electrical test.

1) nature of change;
2) details of equipment and commissioning;
3) change to scope of approval.

f) Reclassification of clean room area

1) extent of reclassification and areas affected;
2) implementation data.

g) Significant failures/returns

1) product types;
2) quantities against batch size;
3) failure analysis reports;
4) data relating to processes and/or other products affected.

h) Significant adverse change of process monitoring limits

1) Nature and details of change;
2) Data relating to processes and/or other products affected.

6.6 Release for delivery

6.6.1 General

Circuits conforming to the requirements of 6.1.4 may be released.

6.6.2 Quality conformance inspection requirements

6.6.2.1 General

The quality conformance inspection requirements shall be given in the detail specification. As a minimum, the tests specified in the relevant PALS shall be included (see 6.6.2.4 to 6.6.2.7 below). Tests shall be carried out in the sequence shown in the PALS.

6.6.2.2 Inspection lot

The DMR is responsible for the formation of inspection lots from production batches/lots submitted for quality conformance inspection.

Each inspection lot shall be given an inspection lot number and records shall be kept of the production batches/lots forming the inspection lot together with the test results.

6.6.2.3 Certificate of conformity

A certificate of conformity stating that the circuits conform in all respects to the specified detail specification and endorsed by an approved signatory shall accompany each shipment of circuits to a customer.

A copy of the certificate of conformity shall be filed by the manufacturer.

The certificate of conformity shall include:

a) manufacturer's name and address and certified manufacturing line registration number;
b) customer's name and address;
c) customer's contract/order number;
d) circuit type number;
e) inspection lot number;
f) detail specification number and issue;
g) number of the PALS;
h) number of circuits in shipment;
i) statement certifying traceability and conformance with the detail specification and customer's order/contract;
j) signature of approved signatory and date.

The signatories to the certificate of conformity shall be declared by the manufacturer to the NSI.

6.6.2.4 Device screening

The tests specified in the PALS shall be carried out on all devices submitted for inspection. Failed devices shall not be released. Where a percentage defective allowable (PDA) is quoted, it shall be calculated from the beginning of the burn-in test; failed lots shall not be released. Tests performed before burn-in or after the electrical test at T_{amb} which immediately follows the burn-in are not subject to PDA. Where the number of defectives allowed by the PDA in any lot is not a whole number the allowance shall be rounded up to the next whole number. In the event of a failure at PDA, if the per cent defective is found to be greater than the PDA but not greater than twice the PDA, the devices which passed may be re-submitted to burn-in once only and examined to a tightened PDA. The tightened PDAs are 10 % ⇒ 7 %, 7 % ⇒ 5 % and 5 % ⇒ 3 %.

6.6.2.5 Device sample testing

The tests specified in the PALS shall be carried out on samples taken from each inspection lot. Failed lots which fail destructive tests shall be rejected. Failed lots which fail non-destructive tests shall be subjected to 100 % testing for the failed parameters.

6.6.2.6 Design evaluation

For devices with identical build standard but with different electrical functions, structural similarity, subject to the agreement of the customer, may be claimed, except for those tests specifically excluded in the PALS given in annex A.

Except where the tests have already been done on structurally similar devices, and the detail specification states that structural similarity applies, the tests specified in the PALS shall be carried out on the initial delivery lot of each product. As these tests are of a design proving nature, failed lots shall not be shipped, and an investigation into the cause shall be carried out. Re-submission is only permitted when the fault has been corrected and a new lot has passed the inspection.

6.6.2.7 Process and packaging requirements

The requirements given in the PALS shall be applied.

6.6.3 Detail specification

6.6.3.1 Customer detail specification

The customer detail specification shall be in accordance with the requirements of IEC 60748-23-4.

The PALS number shall be stated in the customer detail specification.

The ownership rights of a customer detail specification may be vested in the customer and/or manufacturer and the contents may be held by both as confidential. A detail specification for standard catalogue circuits shall be included in the qualified products list (QPL) of IEC QC 001005.

The detail specification shall conform to the requirements of IEC 60748-23-4.

7 Test and measurement procedures

7.1 General

Test and measurement procedures are referenced to IEC and IECQ published standards which shall be used. Any qualifications or options are given in this clause. Where IEC and IECQ standards are not available, and the test methods are not detailed below, the appropriate tests, together with the conditions of measurement, shall be given in the detail specification.

Tests additional to those specified in the PALS have been included. These may be used by the manufacturer for process control and be included in the process control documentation, or requested by a customer and be included in the customer detail specification.

7.2 Standard conditions for testing

Conditions for testing shall conform to those given in

a) 5.3 of IEC 60068-1: standard atmospheric conditions for measurement and tests,

b) 5.4 of IEC 60068-1: recovery conditions.

7.2.1 Measurement uncertainty

The limits prescribed in the detail specifications are true values. When carrying out specified tests the approved manufacturer shall employ sufficient inset from the specified limits to cover the uncertainty of measurement.

A measurement uncertainty value shall be calculated for each performance requirement which relates to screening, lot-by-lot and design evaluation tests specified in the detail specification.

Each measurement uncertainty value shall be used to apply an inset of at least the uncertainty value to the values specified in the detail specification.

Where external test laboratories are utilized, measurement results are to include a stated measurement uncertainty.

7.2.2 Alternative test methods

The test and measurement methods given in the relevant specification shall not be regarded as the only methods to be used. However, the tester shall satisfy the customer and the NSI that any alternative methods will give results equivalent[4] to those obtained by the methods specified. In case of dispute, for referee and reference purposes only the specified methods shall be used. Alternative test methods shall not be shown in detail specifications.

7.2.3 Definition of axes for mechanical and other tests

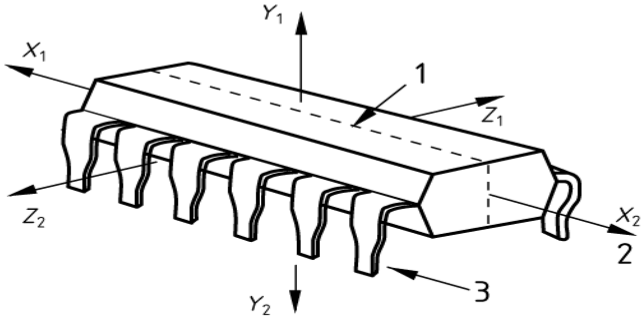
Orientation

For those methods which involve observation or the application of external forces which shall be related to the orientation of the device, such orientations and directions of forces applied shall be in accordance with figure 1. For other configurations the definitions of the axes shall be given in the detail specification.

NOTE The Y_1 force application is such that it will tend to lift the die off the substrate or the wires off the die.

---

4 By "equivalent" is meant that the value of a characteristic established by such an alternative method, and acceptable in accordance with the limits ascribed to that method, will fall within the specified limits when measured by the specified method.



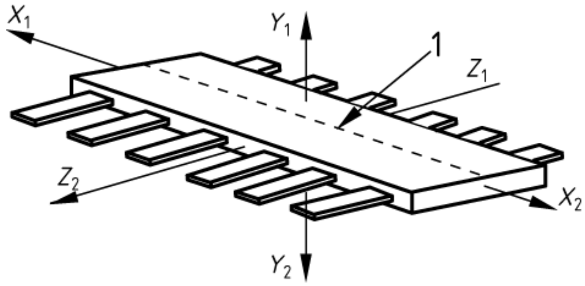
IEC 952/02

1 Major cross-section

2 Principal base substrate or mounting surface

3 Lead

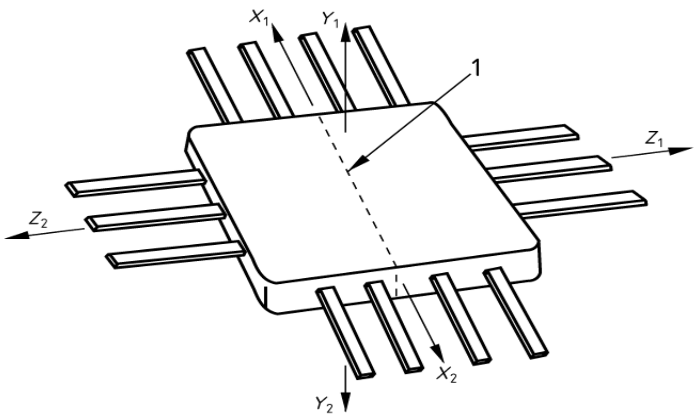
Figure 1a – Dual in-line(DIL) package



IEC 953/02

1 Major cross-section

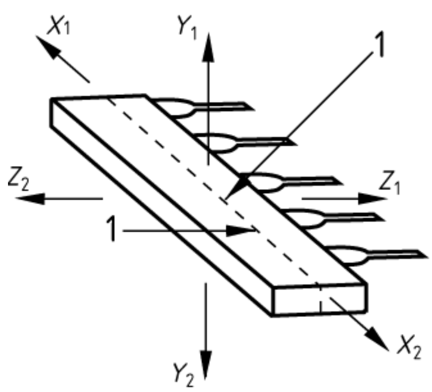
Figure 1b – Flat package



IEC 954/02

1 Major cross-section

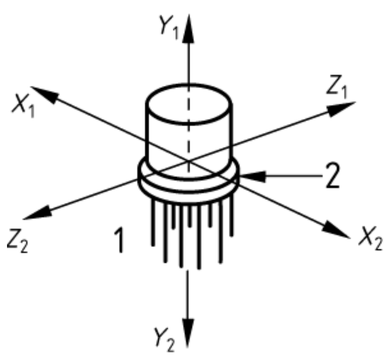
Figure 1c – Flat package with radial lead



IEC 955/02

1 Major cross-section

Figure 1d – Single in-line package



IEC 956/02

Figure 1e – Cylindrical package

Figure 1 – Definition of axes for mechanical and other tests

7.3 Visual inspections and package dimensions

7.3.1 Internal visual inspection

Internal visual inspection shall be carried out in accordance with IEC 60748-23-2.

7.3.2 External visual inspection

Unless otherwise specified, visual inspection shall be performed under approved factory lighting and normal viewing conditions. The inspections shall include:

a) marking: correctness and legibility;
b) terminations: identification, alignment, correct number;
c) embedded package: appearance, chip-outs, cracks, voids, pin holes, packaging material below seating plane;
d) cavity (metal and ceramic) package: appearance, dents, burrs, metal stressand cracks in glass/metal seals.

7.3.3 Package dimensions

The dimensions to be checked shall be specified in the detail specification and verified using methods and equipment compatible with the required tolerances.

7.4 Electrical measurement procedures

7.4.1 General

The requirements for measuring the electrical characteristics or the electrical function of the circuit shall be in accordance with the detail specification.

The requirements in 7.4.2 to 7.4.8 shall be complied with, unless stated otherwise in the detail specification.

7.4.2 Ratings

The test conditions for all measurements shall be such that the maximum ratings of the device are not exceeded (see IEC 60134).

7.4.3 Equilibrium conditions

All electrical tests shall be conducted under equilibrium conditions unless otherwise specified or unless the measurement is being carried out under pulsed conditions. When test conditions cause significant change with time of the characteristic being measured, means of compensation for such effects shall be specified; for example, the length of time that the device shall be maintained at test conditions before making a measurement.

7.4.4 Temperature

The ambient temperature shall be measured as the air temperature adjoining the film and hybrid integrated circuit in an environment of substantially uniform temperature, cooled only by natural air convection and not materially affected by reflective and radiant surfaces.

7.4.5 Precautions

The precautions should include limits on maximum instantaneous currents and applied voltages. It is recommended that devices should not be inserted into, or removed from, a test circuit while the latter is energized.

Unless the detail specification declares the circuit not to be electrostatic discharge sensitive (ESDS), circuits shall be considered to be ESDS, and precautions shall be taken in accordance with IEC 61340-5-1.

7.4.6 Measurement circuit requirements

7.4.6.1 Constant current source

A current shall be considered constant if a two-to-one increase of the effective load impedance does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement.

7.4.6.2 Current measuring device

The effective admittance of a current measuring device shall be sufficiently high so that halving its value does not significantly affect the accuracy of the measurement.

7.4.6.3 Constant voltage source

A voltage shall be considered constant if a two-to-one decrease of the effective load impedance does not produce a change in the parameter being measured that is greater than the required accuracy of measurement.

7.4.6.4 Voltage measuring device

The effective impedance of a voltage measuring device shall be sufficiently high so that halving its value does not significantly affect the accuracy of measurement.

7.4.6.5 Load impedance

The load impedance represents the equivalent input impedance of the test circuit and the device under test. For acceptance test purposes, the input impedance may be replaced by a resistor representing worst case conditions.

7.4.6.6 Power supplies

The sources of direct currents and voltages shall not have a ripple content large enough to affect the desired accuracy of measurement. Test or supply voltages or currents shall be within ±1 % of the specified value.

7.4.7 Unspecified connections to terminations

Any termination for which no conditions are specified shall be left unconnected.

7.4.8 Insulation resistance

Unless otherwise prescribed in the detail specification, a d.c. voltage of 100 V ± 15 V, shall be applied for 1 min ± 5 s. Where necessary, the polarity shall be specified in the detail specification.

7.4.8.1 Insulation between terminations (or groups of terminations)

The voltage shall be supplied between any and every combination of terminations which are electrically and functionally isolated.

7.4.8.2 Insulation between all the isolated terminations and the case

The voltage shall be applied between a metal foil tightly held in contact with the case and all the terminations of the circuit connected together (except those leads which are electrically connected to the case). The size and positioning of the foil shall not reduce the insulation paths.

Unless otherwise specified in the detail specification, a circuit fails the test if there is

a) evidence of flashover or mechanical damage.

b) any individual reading of insulation resistance less than 100 MΩ.

7.5 Environmental test procedures

The environmental tests are labelled (D) for "destructive" or (ND) for "non-destructive" according to their effect upon the circuit.

The majority of the following tests derive from IEC 60068. Some tests include guidance and this is reflected in the titles. In some cases further guidance is given as indicated by the footnotes. Some sections of IEC 60068-3 and IEC 60068-5 may also be of help.

7.5.1 Dry heat (ND)

The dry heat test shall be in accordance with:

Test Ba of IEC 60068-2-2

with the following specific requirements:

a) duration of conditioning periods is extended to include 160 h, 320 h, 640 h all with a tolerance of 8^{-0}_{+8} h, or 1 000 $^{-0}_{+24}$ h;

b) there is no electrical loading or measurement during conditioning;

c) recovery period shall be extended to 24 h maximum.

The detail specification shall prescribe:

1) the temperature of conditioning which shall be the maximum storage temperature of the circuit;
2) duration of conditioning.

7.5.2 Cold (ND)

The cold test shall be in accordance with:

Test Ab of IEC 60068-2-1

with the following specific requirements:

a) duration of conditioning periods is extended to include 160 h, 320 h, 640 h all with a tolerance of $^{-0}_{+8}$ h, or 1000 h $^{-0}_{+24}$ h;

b) there is no electrical loading or measurement during conditioning;

c) the recovery period shall be extended to 24 h maximum.

The detail specification shall prescribe:

1) the temperature of conditioning which shall be the minimum storage temperature of the circuit;
2) duration of conditioning.

7.5.3 Damp heat, steady state (D) [5]

7.5.3.1 Method 1

This damp heat, steady state test shall be in accordance with:

IEC 60068-2-3

with the following specific change:

Amend clause 1 of Test Ca to read:

"1. Object: To assess, using unsaturated damp heat, the external aspect (such as surface finish) of hybrid integrated circuits."

The detail specification shall prescribe:

a) method;
b) preconditioning procedure: none;
c) initial measurements:
   – mechanical tests: none
   – electrical tests: none
   – visual inspection;
d) state of the specimen as introduced into the chamber: prior to the introduction of the device into the chamber, the device shall be heated to a temperature greater than that of the chamber, so as to avoid condensation on the device; as an alternative, the chamber may be brought to ambient temperature prior to introduction of devices into it;
e) severities: 21 days or 56 days;
f) loading (electrical operation) during conditioning: none;
g) electrical and mechanical checks to be made during conditioning: none;
h) special precautions regarding the removal of surface moisture, if applicable;
i) recovery: upon completion of the conditioning, and prior to the final measurements, the specimens shall be subjected to standard atmospheric conditions for testing (5.3 of IEC 60068-1) for no less than 1 h and no more than 2 h, unless otherwise stated in the detail specification;
j) final measurements:
   – mechanical tests: none
   – electrical tests: none
   – visual inspection.

---

[5] Guidance for damp heat tests is given in IEC 60068-3-4.

7.5.3.2 Method 2 – Damp heat, steady-state, accelerated
(based upon Amendment 1 to IEC 60749)

7.5.3.2.1 Object

This steady-state damp heat test is performed to assess, in an accelerated manner, the resistance of non-cavity or epoxy-sealed cavity devices to degradation caused by damp heat. It is also used to assess the effect of damp heat when combined with bias. This test is not intended to assess external effects of corrosion.

7.5.3.2.2 General description

This test subjects the specimens to high levels of unsaturated damp heat for periods of 168 h to 5 000 h, depending on the severity in accordance with table 1. If specified, bias voltage is applied, as detailed below.

Degradation results from absorption of water vapour by the encapsulation materials and presence of moisture films or penetration of moisture along physical junctions.

7.5.3.2.3 Testing chamber

The chamber shall be so constructed that:

a) the temperature and humidity of the chamber are monitored by means of sensing devices located in the working space;

b) the temperature and relative humidity in the working space are uniform and maintained at ±2 °C of the specified temperature and ±5 % of the specified relative humidity;

NOTE The temperature tolerance of ±2 °C is intended to take account of absolute errors in the measurement, slow changes of temperature and temperature variations of the working space. It is necessary to keep short-term fluctuation within ± 0,5 °C to maintain the required humidity.

c) condensed water is continuously drained from the chamber and not used again until it has been re-purified;

d) condensed water cannot fall on the specimens.

The supply water shall have a resistivity not less than 500 Ωm.

Table 1 – Severities for damp heat, steady-state – Method 2

Test conditions (see note)		**Duration (h)**				
Temperature °C	**Relative humidity** %	**Severity 1**	**Severity 2**	**Severity 3**	**Severity 4**	**Severity 5**
85 ± 2	85 ± 5	168 ± 16	504 ± 48	1 000 ± 96	2 000 ± 192	5 000 ± 432
NOTE The resulting vapour pressure is of the order of 500 hPa.						

7.5.3.2.4 Bias voltage

a) When specified, the specimen shall have a voltage bias applied during exposure. Guidelines for determining the appropriate circuit configuration for bias applications are listed below in descending order of importance (see note):

   1) power as small as possible;

   2) voltage as high as possible within the operating range;

   3) voltage difference as high as possible between adjacent metallization lines on the die (for example, in the case of digital devices, adjacent inputs for the same gate would be high and low, respectively).

   NOTE The highest stress conditions correspond to zero power combined with maximum allowed voltage to the device within the operating range and maximum allowed voltage between adjacent metallization lines.

Where the dissipation of the devices cannot be reduced below 100 mW the bias voltage shall be applied intermittently. The on-off periods shall be specified, preferably 1 h on and 3 h off.

b) Bias voltage shall be applied to the specimens for a total time equal to the specified test duration.

   The total test duration, when using intermittent bias, shall be the same (that is including on and off periods) as specified for the non-intermittent test.

c) The voltage bias(es) shall continue to be applied to specimens until they have cooled to room temperature, unless it can be established, for the given device types and test conditions, that no significant change of characteristics occurs when the device is cooled with the bias removed.

7.5.3.2.5 Testing procedure

7.5.3.2.5.1 Initial measurements

Prior to exposure, the specified measurements shall be made at standard atmospheric conditions for testing or as specified.

7.5.3.2.5.2 Conditioning

The specimens under test are placed at a minimum distance of 30 mm from the chamber internal surfaces and shall not be submitted to radiant heat from the heaters.

7.5.3.2.5.3 Recovery

Upon completion of the conditioning, and prior to the final measurements, the specimens shall be subjected to standard conditions for testing (5.3 of IEC 60068-1) and normal atmospheric pressure for no less than 1 h and no more than 2 h, unless otherwise stated in the detail specification.

7.5.3.2.5.4 Final measurements

The specimen shall be visually inspected and electrically and mechanically checked as required in the detail specification.

Measurements may be initiated any time upon completion of the recovery period, but all measurements shall be completed within 8 h after the recovery period.

7.5.3.2.6 Detail specification

The detail specification shall prescribe:

a) method;
b) severity;
c) bias voltage (when specified);
d) on-off periods, if applicable;
e) initial measurements;
f) final measurements.

7.5.3.3 Method 3 – Damp heat, steady-state, highly accelerated
(based upon Amendment 1 to IEC 60749)

7.5.3.3.1 Object

This steady-state damp heat test is performed with unsaturated and pressurized vapour to assess, in a highly accelerated manner, the resistance of non-cavity devices to the degradation due to damp heat and to assess the effect of damp heat, when combined with bias. This test is not intended to assess external effects of corrosion.

7.5.3.3.2 General description

This test subjects the specimens to very high levels of unsaturated damp heat for relatively short periods. If specified, bias voltage is applied. Test severities in accordance with table 2 are determined by temperature, relative humidity and duration. Care should be taken not to reach the glass transition temperature of the encapsulating material.

Degradation results from absorption of water vapour by the encapsulation materials and presence of moisture films or penetration of moisture along physical junctions.

7.5.3.3.3 Testing chamber

The chamber shall be a humidity/pressure vessel (autoclave) so constructed that:

a) it can produce vapour pressures in excess of 1 000 hPa, without saturation and in conformance with the values given in table 2;
b) the temperature and humidity of the chamber are monitored by means of sensing devices appropriately located in the chamber;
c) the temperature and relative humidity in the working space are uniform and maintained within the tolerances given in table 2;
d) condensed water cannot fall on the specimens;
e) the water shall have a resistivity of not less than 500 Ωm.

Table 2 – Severities for damp heat, steady-state – Method 3

Variant	Test conditions		Duration (h)		
	Temperature °C	Relative humidity %	Severity 1	Severity 2	Severity 3
A	110 ±□2	85 ± 5	408	192	96
B	120 ± 2	85 ± 5	192	96	48
C	130 ± 2	85 ± 5	96	48	24

NOTE The vapour pressures are approximately 1 200 hPa, 1 700 hPa or 2 300 hPa for variants A, B and C, respectively.

7.5.3.3.4 Bias voltages

a) When specified, the specimen shall have a voltage bias applied during exposure, within the operating range, taking into account safety requirements. Guidelines for determining the appropriate circuit configuration for bias application are listed below in descending order of importance (see note):
    1) power as small as possible;
    2) voltage as high as possible;
    3) voltage difference as high as possible between adjacent metallization lines on the die (for example, in the case of digital devices, adjacent inputs for the same gate would be high and low, respectively).

NOTE The highest stress conditions correspond to zero power combined with maximum allowed voltage to the device within the operating range and maximum allowed voltage between adjacent metallization lines.

b) Where the dissipation of the specimens cannot be reduced below 100 mW, the bias voltage should be applied intermittently. The on-off periods shall be specified, preferably 1 h on and 3 h off.

c) Bias voltage shall be applied to the specimens for a total time equal to the specified test duration.

   The total test duration, when using intermittent bias, shall be the same (that is including on and off periods) as specified for the non-intermittent test.

d) The voltage bias(es) shall continue to be applied to specimens until they have cooled to room temperature, unless it can be established, for the given device types and test conditions, that no significant change of characteristics occurs when the device is cooled with the bias removed.

7.5.3.3.5 Testing procedure

7.5.3.3.5.1 Initial measurements

The specimen shall be visually inspected and electrically and mechanically checked as required in the detail specification.

7.5.3.3.5.2 Conditioning

a) The specimens under test are placed at a minimum distance of 30 mm from the chamber internal surfaces and shall not be submitted to radiant heat from the heaters.

b) The chamber is first heated to the temperature of boiling water and kept for 10 min at atmospheric pressure.

c) The chamber is then heated to the required test temperature, in such a way that the water vapour remains unsaturated.

d) The test duration shall be counted from the moment when pressure, humidity and temperature become stabilized. Heating and stabilization shall be achieved within 3 h.

e) The bias voltage is switched on after the stabilization period.

f) The sources of heat and humidity shall successively be switched off, the pressure is dropped and the specimens removed from the chamber within 2 h.

7.5.3.3.5.3 Recovery

Upon completion of the conditioning and prior to the final measurements, the specimens shall be subjected to standard conditions for testing and normal atmospheric pressure for no less than 1 h and no more than 2 h, unless otherwise stated in the detail specification.

7.5.3.3.5.4 Final measurements

The specimen shall be electrically and mechanically checked as required in the detail specification.

Measurements may be initiated any time upon completion of the recovery period, but all measurements shall be completed within 8 h after the recovery period.

7.5.3.3.6 Detail specification

The detail specification shall prescribe:

a) method;

b) variant A, B or C;

c) severity 1, 2 or 3;

d) bias voltage;
e) on-off periods (if applicable);
f) initial measurements;
g) final measurements.

7.5.4 Damp heat, cyclic (D) [6]

The damp heat, cyclic test shall be in accordance with:

IEC 60068-2-30

with the following specific requirements:

a) amend 4.2 of test Db to read
   1) upper temperature 40 °C,
      number of cycles = 21 or 56;
   2) upper temperature 55 °C,
      number of cycles = 6;
b) recovery is at standard atmospheric conditions of test (5.3 of IEC 60068-1);
c) there is no electrical loading or measurement during conditioning.

The detail specification shall prescribe:

1) severity
   – temperature,
   – number of cycles;
2) initial measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual examination;
3) variant 1 or 2;
4) intermediate measurements: none;
5) special precautions: none;
6) final measurements
   – mechanical tests: none,
   – electrical tests: as specified,

– visual examination.

7.5.5 Shock (ND)

The shock test shall be in accordance with:

IEC 60068-2-27

with the following specific requirements:

a) the conditions shall be selected from table 3, taking into consideration the mass of the device and its internal construction;

6 Guidance for damp heat tests is given in IEC 60068-3-4.

Table 3 – Preferred conditions for shock

Peak amplitude	Duration (ms)	Waveform
14 700 m/s^2 (1 500 g_n)	0,5	Half-sine
4 900 m/s^2 (500 g_n)	1,0	Half-sine
980 m/s^2 (100 g_n)	6,0	Half-sine

b) the device shall be subjected to three successive shocks, in both directions of three mutually perpendicular axes, so chosen that faults are most likely to be revealed, i.e. a total of 18 shocks;

c) the body and leads of the device shall be securely fastened during the test.

The detail specification shall prescribe:

1) mounting if not as prescribed above (reference should be made to IEC 60068-2-47);
2) severity;
3) preconditioning: none;
4) initial measurements:
   – mechanical tests: none
   – electrical tests: as specified
   – visual examination;
5) functional monitoring: none;
6) recovery: none;
7) pulse shape if not as prescribed above;
8) final measurements:
   – mechanical tests: none
   – electrical tests: as specified
   – visual examination.

7.5.6 Vibration, swept frequency (D)

The vibration, swept frequency test shall be in accordance with:

IEC 60068-2-6

with the following specific requirements:

a) the body and leads of the device are securely clamped during the test;
b) endurance by sweeping;
c) acceleration: 196 m/s^2
d) frequency range: 100 Hz to 2 000 Hz
e) number of cycles per axis: 15

The detail specification shall prescribe:

1) the severity if not as prescribed above;
2) preconditioning: none;
3) method of mounting if different from above;

4) initial measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual examination;
5) functioning and functional checks: none;
6) final measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual examination.

7.5.7 Acceleration, steady state (ND)/(D)

The acceleration, steady state test shall be in accordance with:

IEC 60068-2-7

with the following specific requirements:

a) Unless otherwise specified, the acceleration shall be applied for at least 1 min along one axis so chosen that the force is exerted in a pull direction with respect to the mounted components.
b) The severity shall be chosen from the following values:

m/s^2	**g_n**
300 000	30 000
200 000	20 000
100 000	10 000
50 000	5 000 (standard severity)
20 000	2 000
10 000	1 000
5 000	500

The detail specification shall prescribe:

1) severity if other than standard;
2) axes and directions of acceleration;
3) method of mounting;
4) duration of conditioning if other than as specified above;
5) initial measurements
   – mechanical tests: none,
   – electrical tests: as specified;
6) final measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual inspection.

7.5.8 Temperature change

The change of temperature test shall be in accordance with:

Tests Na and/or Nc of IEC 60068-2-14.

7.5.8.1 Method 1 – Test Na (two chamber method) (ND)

Test Na shall be used with the following specific requirements:

a) the use of a single test chamber that meets the specified conditions is permissible;
b) the capacity of each chamber and the loading should be such that the specified exposure temperature will be reached within 2 min after the specimens are introduced into the chamber;
c) the thermal time constant of the test specimen and its carrier shall be taken into account;
d) low temperature T_A: the minimum storage temperature of the device (see note);
e) high temperature T_B: the maximum storage temperature of the device (see note);
f) duration of the exposure t_1: 10 min if the exposure temperature has been reached by the specimen within 3 min, or 10 min after thermal equilibrium of the specimen has been reached in other cases. Thermal equilibrium of the specimen shall be reached, in any case, in not more than 20 min.

NOTE The tolerances for these temperatures should be such that the rated values are not exceeded.

The detail specification shall prescribe:

1) method;
2) the conditioning temperatures which shall be the minimum and maximum storage temperatures of the circuit;
3) number of cycles if other than 5;
4) exposure time if other than 10 min;
5) transition time if other than 2 min to 3 min;
6) initial measurements
   – mechanical tests: none,
   – electrical tests: as specified;
7) recovery: none;
8) final measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual inspection.

7.5.8.2 Method 2 – Test Nc (two liquid baths method) (D)

Test Nc shall be used with the following specific requirements:

a) Severity:

Preferred temperatures (appropriate liquids for the temperature range should be chosen):

Minimum °C	Maximum °C
–0	+100
–0	+125
–55	+125
–65	+150
NOTE Guidance on change of temperature tests is given in IEC 60068-2-33.	

b) Groups of parameters

Parameter group 1 shall be used with the minimum value of t_1 reduced to 2 min.

The detail specification shall prescribe:

1) method;
2) severity;
3) number of cycles if other than 10;
4) liquids to be used;
5) initial measurements
   – mechanical tests: sealing (if applicable),
   – electrical tests: as specified;
6) recovery: droplets of liquids shall be removed;
7) final measurements
   – mechanical tests: sealing (if applicable),
   – electrical tests: as specified,
   – visual inspection.

7.5.9 Sealing (ND)

The fine and gross leak tests for evaluating sealing shall either be in accordance with:

IEC 60068-2-17

or follow the requirements given below for corresponding tests based upon IEC 60749.

7.5.9.1 Fine leak detection: tracer gas method with mass spectrometer

This test shall be in accordance with the Test Qk, with the following specific requirements (based upon IEC 60749):

7.5.9.1.1 General

This test is applicable to cavity devices only, which are NOT filled with helium during manufacture.

Test Qk, as written in IEC 60068-2-17, is intended to be applicable to a number of styles of cavity packages, the mechanical robustness of which varies with size, overall wall thickness versus area ratio, material, construction, etc., precluding the standardization of a single tracer gas pressure.

As a consequence, the responsibility for adequately performing the test is shared between the specification writer, who has to state the severity he requires, and the test engineer, who has to choose the test parameters that correspond to the stated severity and also to meet the mechanical specification of the device under test (i.e. cavity volume and resistance to external pressure).

NOTE To avoid confusion between severities expressed in terms of hours and life expectancy, the severities in IEC 60068-2-17 are replaced by the actual time constant ranges, expressed in seconds, that correspond to the test conditions given here.

7.5.9.1.2 Procedure for the selection of test parameters

a) The internal cavity free volume *V* is determined or assessed and placed into one of the following ranges:

Minimum cm^3	**Maximum** cm^3
0,01	0,1
0,1	1,0
1,0	10

NOTE The internal free volume is the cavity volume that can be, by design, filled with gas. Taking into account the selected ranges, a rough assessment of it is usually adequate.

b) From the volume, the test engineer is able to determine (from previous experiments) or assess, the maximum absolute pressure the specimen is able to withstand without damage in the range 2×10^5 Pa to 8×10^5 Pa (2 bars to 8 bars). This determines in turn the immersion duration;

c) The maximum ventilation time shall be 1 h; the maximum acceptable reading on the leak rate meter is given in terms of the helium leak rate $R_{(He)}$;

d) A gross leak test shall be performed after this test – see 7.5.9.3 and 7.5.9.4.

The appropriate method, if test Qc is specified, is given in table 4.

Table 4 lists the possibilities covering most application cases for semiconductor devices.

Table 4 – Parameters for sealing test – Method 1

Volume	**Immersion**		**Measured leak rate**	**Equivalent standard leak rate**	**Required sensitivity (gross leak)**	**Actual time constant**	**Subsequent Qc method (gross leak test)**
	P_{abs}	t_1	$R_{(He)}$	L_1	L_2	θ	
cm^3	10^5 Pa	h	10^5 Pa×cm^3×s^{-1}	10^5 Pa×cm^3×s^{-1}	10^5 Pa×cm^3×s^{-1}	s	
0,01	3	4		$4,0 \times 10^{-8}$	$8,1 \times 10^{-6}$	$2,1 \times 10^5$	3
to	5	2	5×10^{-8}	to	to	to	
0,1	8	1,25		$1,4 \times 10^{-7}$	$1,1 \times 10^{-4}$	$7,0 \times 10^5$	(NOTE)
0,1	3	4		$1,8 \times 10^{-7}$	$10,0 \times 10^{-5}$	$5,0 \times 10^5$	3
to	5	2	1×10^{-7}	to	to	to	
1,0	8	1,25		$6,3 \times 10^{-7}$	$1,3 \times 10^{-3}$	$1,6 \times 10^6$	(NOTE)
1,0	3	4		8×10^{-7}	$1,5 \times 10^{-3}$	$1,3 \times 10^6$	2 or 3
to	5	2	5×10^{-6}	to	to	to	
10	8	1,25		$1,4 \times 10^{-6}$	$1,8 \times 10^{-2}$	$7,1 \times 10^6$	(NOTE)
Recommended values are underlined (105 Pa = 1 Bar).							
NOTE Recommended liquids for Test Qc method 3 are: – step 1: perfluoro-N-hexane; – step 2: perfluoro (1-methyldecaline).							

The detail specification shall prescribe:

1) the maximum acceptable leak rate;
2) any pressure restrictions imposed by the circuit package;
3) gross leak test method.

7.5.9.2 Fine leak detection – Radioactive krypton method

This test is based upon that given in IEC 60749.

7.5.9.2.1 Object

To determine the leak rate of hybrid integrated circuits by measuring the radiation level present within the device after having been pressurized in a chamber with suitable radioactive tracer gas.

This method is intended to be specified for devices which are designed to be hermetically sealed in glass, metal or ceramic (or combinations of these encapsulations) and is suitable for equivalent standard leak rates smaller than 10^{-5} bar × cm^3 × s^{-1}.

7.5.9.2.2 Equipment

Equipment for this test consists of a radioactive tracer activation tank and a counting station with sufficient sensitivity to determine the radiation level of the tracer gas inside the device.

The equipment operates with a tracer gas mixture of dry nitrogen and krypton 85, with a specified activity (minimum: 100 µCi per cm^3) under standard atmospheric conditions.

Instructions for the use of the leak testing equipment, as supplied by the manufacturer of the equipment, shall be followed in calibrating and operating the equipment. Test results obtained under non-preferred conditions can be compared with those under preferred conditions by conversion through the appropriate formula given in these instructions.

7.5.9.2.3 Procedure

a) The devices shall be placed in a radioactive tracer gas activation tank. The tank shall be evacuated to less than 50 Pa (0,5 mbar).
b) The devices shall be subjected to a minimum of 2 bar absolute pressure of krypton 85/dry nitrogen mixture for a minimum of 12 min. The actual pressure and soak time shall be determined in accordance with the activation parameters, see d).
c) The krypton 85/dry nitrogen gas mixture shall be evacuated until a pressure less than 0,5 mbar exists in the activation tank. This evacuation shall be complete in 3 min maximum.
d) The activation tank shall then be backfilled with air (air wash). The devices shall be removed from the activation tank, and their radiation levels determined within 1 h after gas exposure.
e) The wait time, as determined in the evaluation of surface sorption (see 7.5.9.2.4 c) below) shall be observed but in no case shall the time between removal from the activation chamber and test exceed 1 h.
f) If the test is to be repeated on the same specimen(s), they shall first be decontaminated in vacuum for 8 h, prior to re-pressurization.
g) The actual leak rate of the component shall be calculated with the following equation:

$$Q = \frac{(\text{actual readout in net counts per minute}) \times Q_s}{R}$$

where

Q is the actual leak rate in bar × cm^3 × s^{-1}

Q_s, and R are defined in 7.5.9.2.4.

NOTE The numerical values given are applicable for krypton 85 tracer gas (^{85}Kr) and for equivalent standard leak rate limit in the order of 5×10^{-8} bar × cm^3/s. The use of other tracer gases would require other numerical values.

A gross leak test shall be performed after this test – see 7.5.9.3 and 7.5.9.4.

7.5.9.2.4 Activation parameters

a) The activation pressure and soak time shall be determined in accordance with the following equation (see note below):

$$Q_s = \frac{R}{3\,600\, skPT}$$

where

Q_s is the maximum leak rate allowable for the devices to be tested in bar × cm^3 × s^{-1};

R is the 1 200 counts per minute above the ambient background after activation if the device leak rate were exactly equal to Q_s. This is the reject count above the background of both the counting equipment and the component if it has been through previous radioactive leak tests;

s is the specific activity, in microcuries per cm^3 of the krypton 85 gas in the activation system;

k is the overall counting efficiency of the scintillation crystal in counts per minute per one microcurie of krypton 85 in the internal cavity of the specific component being evaluated. This factor depends upon component configuration and dimensions of the scintillation crystal.

The counting efficiency shall be determined as detailed below.

P = $P_e^2 - P_i^2$, where P_e is the absolute activation pressure in bars and P_i is the original absolute internal pressure of the devices in bars. The activation pressure, P_e, may be established by specification, or if a convenient soak time, T, has been established, the activation pressure, P_e, can be adjusted to satisfy the equation defining Q_s above).

T is the soak time, i.e. the time for which the devices are placed in contact with the tracer gas under pressure, in hours.

NOTE The complete version of the equation defining Q_s contains a factor $P_0^2 - (\Delta P)^2$ in the numerator which is a correction factor for elevation above sea level. P_0 is the sea level absolute pressure, in bars, and ΔP is the difference in pressures, in bars, between the actual pressure at the test station and sea level pressure. For purposes of this test, this factor is neglected.

b) Determination of the counting efficiency (k)

The counting efficiency (k) of equation defining Q_s shall be determined as follows:

1) a representative unit of the device type to be tested shall be provided with a tube to its internal cavity and the cavity shall be backfilled through the tube with known volume and specific activity of krypton 85 tracer gas and the tube shall be sealed off;

2) the counts per minute in the shielded scintillation crystal of the counting station in which the devices are tested shall be directly read.

c) Evaluation of the surface sorption

For each type of encapsulation to be tested, the coatings and external sealants shall be evaluated for surface sorption of krypton 85 before establishing the leak test parameters. Representative samples of the devices shall be subjected to the predetermined pressure and time conditions established for the device configuration as specified in 7.5.9.2.2 and 7.5.9.2.4 a) above. The count rate of the samples shall then be noted every 10 min, until it becomes constant. The elapsed time shall be noted and is the "wait time" as specified in 7.5.9.2.3 e) above.

d) Personnel precautions

Applicable national regulations for the use of radioactive gas shall be followed.

NOTE Large packages with gross leaks may become excessively radioactive.

e) The detail specification shall prescribe:

1) method;
2) limit of leak rate;
3) gross leak test method.

7.5.9.3 Gross leak (bubble test)

This test, which is applicable to cavity devices only, shall be in accordance with the Test Qc method 2, with the following specific requirements:

The temperature of the test liquid shall be 125 °C ± 5 °C or the maximum storage temperature, whichever is the less.

The detail specification shall prescribe:

a) method;
b) the temperature of the test liquid if other than 125 °C.

7.5.9.4 Gross leak, perfluorocarbon vapour method using electronic detection apparatus

This test is based upon that given in IEC 60749.

a) Object

To determine the leak rate of a hybrid integrated circuit by measuring the amount of perfluorocarbon escaping from the device after it has been pressurized in the impregnation liquid.

This method is intended to be specified for devices which are designed to be hermetically sealed in glass, metal, or ceramic (or combination thereof) encapsulations and is suitable for equivalent standard leak rates higher than 10^{-1} Pa × cm^3 × s^{-1} (10^{-6} bar × cm^3 × s^{-1}).

This method is a variant for the Qc test method 3.

b) General description

The hybrid devices are pressurized at specified conditions, removed from the pressure chamber, and placed in a heated cell. The heated cell is connected to a detector that is sensitive to the impregnation fluid used for the pressurization cycle. If the device has leaks it will contain fluid that will vaporize, and the vapour is then detected by the test apparatus. The amount of vapour escaping per unit time is indicative of the leak rate. The test may also be used on a go/no-go basis for screening purposes.

c) Test apparatus

1) Equipment for this test consists of a vacuum/pressure chamber and a perfluorocarbon vapour detector capable of detecting the presence of 0,15 µl of the detector fluid in the volume of the test cell.

The apparatus operates using an impregnation liquid having a kinematic viscosity of the order of $0,4 \times 10^{-6}$ $m^2 \times s^{-1}$ (0,4 cSt) at room temperature, a boiling point between 75 °C and 85 °C and low heat of vaporization at boiling point so as to generate vapour quickly within the specimen when heated.

NOTE Commonly used liquids are perfluorocarbons, for example, cyclic-perfluorodipropyl-ether or perfluoro-N-hexane.

2) Precautions

The perfluorocarbon vapour detection apparatus shall be located at a minimum distance of 3 m from the pressurization chamber.

d) Test method

The devices shall be enclosed in a vacuum/pressure chamber and the pressure reduced to between 500 Pa and 600 Pa and maintained for 30 min to 45 min. A sufficient quantity of impregnation fluid shall be admitted to the pressure chamber to cover the devices. The fluid shall be admitted after the vacuum period but before breaking the vacuum. The devices shall then be pressurized to between 500 kPa and 600 kPa. The pressure shall be maintained for a period of 30 min to 45 min. If the devices will not withstand 500 kPa pressure, the pressure may be lowered to a minimum of 200 kPa and maintained at this value for 2,5 h to 3 h. Upon completion of the pressurization period, the pressure shall be released, the devices removed from the pressure chamber and retained in a bath of impregnating fluid. When the devices are removed from the fluid they may be air dried prior to the test cycle. The drying time shall be limited to 5 min maximum. The devices shall then be tested with the perfluorocarbon vapour detection system. The "preheat" time for drying the external surfaces of the device shall be in accordance with table 5. Test time shall be a minimum of 3,5 s unless the device is rejected earlier. The preheat and test chambers shall be at a temperature of 125 °C ± 5 °C.

Table 5 – Preheat times

Package with internal free volume V cm³	**Preheat time at 125 °C ± 5 °C** s
V ≤ 0,010	≤5
0,010 < V ≤ 0,4	≤9
V > 0,4	≤13
NOTE Maximum preheat time can be determined by cycling a device having a 0,5 mm to 1,5 mm hole and measuring the preheat time that can be used without permitting the device to escape detection.	

e) Requirements

Unless otherwise specified, a device that indicates a perfluorocarbon level equal to or greater than the level indicated by 0,15 µl of perfluorocarbon shall constitute a failure.

f) The detail specification shall prescribe:

1) method;

2) limit of leak rate.

7.5.10 Solderability [7]

NOTE This test is destructive unless otherwise specified in the detail specification: the criterion which may be used to identify a non-destructive operation is the absence of material alteration of the lead finish.

The solderability test shall be in accordance with either:

Test Ta, method 1 or method 3 of

IEC 60068-2-20

with the following specific requirements:

a) Where accelerated ageing is required, "ageing 1b" is preferred. Ageing 3 may be used. Ageing 1a and 2 shall not be used;
b) When Method 1 is selected:

   Terminations are subjected to the solder-bath method. Unless specified otherwise, the terminations are immersed in the bath to within 1,5 mm from the seating plane of the component;

   For flexible terminations the last 12,5 mm shall be immersed.

   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 should be specified.
c) When Method 3 is selected:

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

The detail specification shall prescribe:

1) method;
2) degreasing: none;
3) initial measurements: none;
4) ageing method: either 1b or 3 (if required);
5) avtivated flux: none;
6) immersion depth or point of application (if other than above);
7) time (if other than above);
8) thermal screen: none;
9) whether de-wetting test required;
10) if classed as non-destructive;
11) final measurements
    – mechanical tests: none,
    – electrical tests: none,
    – visual inspection.

---

7 Guidance on Test T: Soldering is given in IEC 60068-2-44.

7.5.11 Resistance to soldering heat (D) [8]

This test shall be in accordance with:

Test Tb, method 1A or method 1B of IEC 60068-2-20

with the following specific requirements:

a) If the reduced time of 5 s ± 1 s for method 1A is used, a warning shall be given to the user that special soldering precautions are necessary.
b) Immersion depth shall be to the seating plane of the device or to a point 2 mm ± 0,5 mm from the component body if no seating plane exists, unless otherwise specified.
c) A heat shield may be used where specified in the detail specification.

The detail specification shall prescribe:

1) method;
2) initial measurements;
   – mechanical tests: none,
   – electrical tests: as specified;
3) details of any heat shield;
4) immersion depth (if other than above);
5) immersion time;
6) final measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual inspection.

7.5.12 Robustness of terminations (D)

The robustness of terminations test shall be in accordance with:

Tests Ua1, Ub, Uc, or Ud of
IEC 60068-2-21

or the torque test for lead terminations, detailed below, as appropriate, with the following specific requirements:

NOTE The choice of the appropriate tests depends on the type of termination and encapsulation. Specification writers should seek guidance from IEC 60068-2-21 for those tests within that standard which are applicable.

No more than five terminations need to be tested except that every termination position shall be tested on three circuits.

7.5.12.1 IEC 60068-2-21 Test Ua_1 (tensile)

Alter 3.6 of IEC 60068-2-21 to read:

"Failure criteria

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

---

8 Guidance on Test T: Soldering is given in IEC 60068-2-44.

When examined using 3× to 10× magnification after removal of stress, any evidence of breakage (other than seal meniscus), loosening or relative motion between the termination and the device body shall be considered a device failure."

7.5.12.2 IEC 60068-2-21 Test Ub (bending) – Method 1 or Method 2

Alter 5.2 of IEC 60068-2-21 to read:

"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."

7.5.12.3 IEC 60068-2-21 Test Uc (torsion) – Method A (severity 2) or Method B

Failure criteria

When examined 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.

7.5.12.4 IEC 60068-2-21 Test Ud (torque test for studs)

Failure criteria:

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

a) the stud breaks or elongates more than one-half the thread pitch;
b) there is evidence of thread stripping or deformation of the mounting seat;
c) the device fails electrical measurements after test, if applicable.

7.5.12.5 **Torque test for leads** (based upon IEC 60749)

7.5.12.5.1 Object

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

7.5.12.5.2 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

$$1{,}4 \times 10^{-2}\ \mathrm{N} \times \mathrm{m} \pm 1{,}4 \times 10^{-3}\ \mathrm{N} \times \mathrm{m}$$

shall be applied to the termination at a distance of 3,0 mm ± 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 mm ± 0,5 mm from the point where the terminations are formed.

7.5.12.5.3 Failure criteria

When examined using 3× to 10× magnification after removal of stress, any evidence of termination breakage, loosening or relative motion between the termination and the body shall be considered a device failure.

The detail specification shall prescribe:

1) the test method(s) appropriate to the circuit;
2) preconditioning: none;
3) initial measurements;
   – mechanical tests: none;
   – electrical tests: as specified (if applicable);
4) severity (number of bends, force or weight as appropriate);
5) final measurements
   – mechanical tests: none,
   – electrical tests: as specified (if applicable),
   – visual inspection.

7.5.13 Salt mist (D)

The salt mist test shall be in accordance with:

IEC 60068-2-11

with the following specific requirements:

a) conditioning: duration = 24 h;
b) recovery: the component shall be lightly brushed and cleaned in running water;
c) failure criteria: evidence of flaking or pitting in the finish when viewed with 3× to 10× magnification.

The detail specification shall prescribe:

1) cleaning procedure;
2) initial measurements
   – mechanical tests: none,
   – electrical tests: as specified (if applicable),
   – visual inspection;
3) position of specimen;
4) recovery (if other than that specified in IEC 60068-2-11);
5) final measurements
   – mechanical tests: none,
   – electrical tests: as specified (if applicable),
   – visual inspection.

7.5.14 Burn-in (ND) – Endurance (D)

This test is destructive if the duration exceeds 1 000 h (endurance).

The test shall conform to Test Bc: Dry Heat for heat dissipating specimens with sudden change of temperature, of:

IEC 60068-2-2

with the following requirements and exceptions:

a) there is no relative humidity requirement for the air in the chamber;
b) preconditioning: no requirement;
c) initial measurement: as (if) given in the detail specification;
d) mounting and supports: these shall be adequate to ensure that the ambient or case reference point temperature is maintained within the specified limits. Where appropriate, the detail specification shall give the length of the leads between the body of the device and the test socket;
e) the electrical operating conditions shall be maintained throughout the test period. No measurements are required during the conditioning unless specified in the detail specification;
f) the temperature shall be maintained within –5 °C +0 °C of the maximum permitted by the detail specification at the power dissipation of e);
g) there is no restriction on the duration of any discontinuity of the above conditions, but any such discontinuities shall not be included as part of the duration of the conditioning period. Discontinuities shall include any period between the last time at which the conditions were measured to be within the prescribed limits and the time at which the original conditions are re-established;
h) recovery shall be under standard atmospheric conditions for recovery;
i) final electrical tests shall be carried out on completion of the conditioning;
j) the controlled area requirements given in the relevant PALS shall be maintained, if this test is used for pre-seal conditioning;
k) ESDS precautions, in accordance with IEC 61340-5-1, shall be maintained at all times.

The detail specification shall prescribe:

1) the duration of the test;
2) the electrical operating conditions;
3) the sequences of application and removal of the supply voltages (if applicable);
4) measurements to be taken during conditioning (if required);
5) measurements to be taken before and after conditioning (if required).

7.5.15 Resistance to cleaning solvents (ND)

The resistance to solvents test shall be in accordance with:

IEC 60068-2-45.

NOTE Additional solvents for these tests may be called up in the detail specification.

7.5.15.1 Method 1 – Marking resistance to solvents

The detail specification shall prescribe:

1) method;
2) solvent: chosen from 3.1.1 of IEC 60068-2-45;
3) temperature: 48,6 °C to 50,5 °C (boiling point);
4) rubbing material: cotton wool;

5) recovery: none;
6) final measurements
   – mechanical tests: none,
   – electrical tests: none,
   – visual inspection: the marking shall remain completely legible under normal inspection conditions.

7.5.15.2 Method 2 – Circuit resistance to solvents

The detail specification shall prescribe:

a) method;
b) initial measurements
   – mechanical tests: none,
   – electrical tests: as specified,
   – visual inspection;
c) solvent: chosen from 3.1.1 and 3.1.2 of IEC 60068-2-45;
d) temperature:

   48,6 °C to 50,5 °C for solvent chosen from 3.1.1 of IEC 60068-2-45 (boiling point)

   55 °C ± 5 °C for solvent chosen from 3.1.2 of IEC 60068-2-45;
e) severity: Immersion 5 min ± 0,5 min;
f) recovery: 1 h to 2 h at standard atmospheric test conditions;
g) final measurements:
   – mechanical tests: none
   – electrical tests: as specified
   – visual inspection.

7.5.16 Flammability (D)

The flammability test shall be in accordance with:

IEC 60695-2-2

The detail specification shall prescribe:

- the duration of the application of the flame.

7.5.17 Particle impact noise detection (PIND) (ND)

The particle impact noise detection test shall be in accordance with the description given in IEC 60748-23-2.

7.5.17.1 Object

The non-destructive detection of loose particles within a hybrid cavity package.

7.5.17.2 General description

a) The test consists of providing mechanical excitation to the hybrid device in the form of successive shocks and vibration. A sensitive transducer is used to detect transients produced by particles of sufficient mass striking the casing of the device. The test is primarily of use as a production screen and it is therefore essential that the lot acceptance criteria be followed.

b) The detail specification shall prescribe:

– test conditions.

7.5.18 Internal moisture content (D)

This test is based upon that given in IEC 60749.

7.5.18.1 Object

The purpose of this test is to measure the water vapour content and other contaminants of the gas contained in a hermetically sealed package.

7.5.18.2 General description

The package to be analyzed is placed in a suitable apparatus essentially composed of a vacuum opening chamber tightly connected to a mass spectrometer.

After pumping down the chamber, the package is pierced and its gaseous content is analyzed for determination of its water vapour content.

7.5.18.3 Test apparatus

The main features of the apparatus are as follows.

The temperature of the opening chamber shall be stabilized at 100 °C ± 5 °C. The transfer passage (between the opening chamber and the mass spectrometer), the ion source and the analyzer chamber shall be kept continuously at 125 °C ± 5 °C.

The apparatus sensitivity shall be at least ten times better than the acceptance limit specified for the package.

The apparatus calibration shall be performed at the specified moisture limit (±20 %) using a package simulator which has the capability of generating at least three different volumes of gas with a tolerance of ±10 %. The moisture content shall be established by the standard generation techniques (i.e. two pressure, divided flow, or cryogenic method).

The calibration operation shall be performed:

– every day for spectrometer measurement calibration;
– every year for the absolute moisture generator (connected to the simulator) versus the national standards.

The piercing action shall not modify the gaseous content to be analyzed.

7.5.18.4 Preconditioning

Cleanliness precautions shall be observed at all steps. Packages to be tested shall be submitted, in the following order, to:

– sealing test (see 7.5.9);
– cleaning;
– pre-baking for 12 h to 24 h at 125 °C under a vacuum equal to or less than 10 kPa (0,1 bar).

7.5.18.5 Conditioning

The package shall be taken from the pre-bake chamber and immediately put into the opening chamber. The air pressure in this chamber shall then be gradually decreased. The chamber and the package shall be heated at 100 °C ± 5 °C for a duration allowing them to reach the stabilized specified vacuum level and temperature before performing the following measurements:

1) determination of the chamber pressure increase when the gases are released. A pressure rise of less than 50 % of normal invalidates the test;
2) mass spectrum scanning to detect air constituents in the package;
3) proportions (by volume) of water vapour content and other constituents if required in the relevant specification.

7.5.18.6 Guidance

a) Piercing tools

   It is essential that point piercing tools used do not disturb the specified vacuum. Sharp-pointed tools actuated from outside the chamber wall (via a bellows to permit the movement) should be used to pierce both metal and ceramic packages. In some cases, it may be necessary to reduce the thickness of the area to be pierced.

b) Recommended cleaning sequence

   Five minutes ultrasonic cleaning in each of three successive baths:

   – trichloroethylene;
   – isopropyl alcohol;
   – acetone.

7.5.18.7 Requirements

A package that has a water vapour content or contaminant content greater than the specified maximum value shall be considered defective.

The detail specification shall prescribe:

1) gaseous constituents to be detected;
2) permissible proportion of water vapour;
3) permissible proportion of other gaseous constituents (if applicable).

7.5.19 Radiography (ND)/(D)

Radiography shall be carried out in conformity with IEC 60748-23-2.

7.5.20 Electrostatic discharge sensitivity (D)

All hybrid integrated circuits shall be considered as "Electrostatic discharge sensitive" and shall be marked with a recognized warning mark, unless otherwise declared in the detail specification.

If required, testing of devices, to prove whether or not they need to be considered to be in the above category, shall be carried out in accordance with clause 3 of Chapter IX of IEC 60747-1 (Amendment 3).

7.5.21 Wire bond strength (D)/(ND)

This test is based upon that given in IEC 60749.

7.5.21.1 Object

To measure bond strength or to determine compliance with specified bond strength requirements.

7.5.21.2 General description of the test

Six methods are described, each having its own purpose:

– methods A and B are intended for testing internal bonds of a device by a direct pulling of the connecting wire;

– method C is intended for bonds external to the device and consists of a peeling stress exerted between the lead or terminal and the board or substrate;

– method D is intended for internal bonds and consists of a shear stress applied between a die and a substrate or similar face-bonded configurations;

– methods E and F are intended for external bonds and consist of a push-off or a pull-off stress exerted between a die and the substrate.

7.5.21.3 Description of the test apparatus (for all methods)

The apparatus for this test should consist of suitable equipment for applying the specified stress to the bond, lead wire or terminal as required in the specified test method. A calibrated measurement and indication of the applied stress in newtons (N) at the point of failure should be provided by equipment capable of measuring stresses up to and including 100 mN with an accuracy of ±2,5 mN, stresses between 100 mN and 500 mN with an accuracy of ±5 mN, and stresses exceeding 500 mN with an accuracy of ±2,5 % of the indicated value.

7.5.21.4 Methods A and B

a) Purpose

   This test is intended to be applied to the wire-to-die bond, wire-to-substrate bond, or the wire-to-terminal bond inside the package of wire-connected semiconductor devices bonded by soldering, thermo-compression, ultrasonic and other related techniques.

b) General description of the test

   1) Method A: Wire pull (applied to bonds separately)

      The wire connecting the die or substrate should be cut so as to provide two ends accessible for a pull test. In the case of short wire runs, it may be necessary to cut the wire close to one termination in order to allow the pull test at the opposite termination. The wire should be gripped in a suitable device and simple pulling action applied to the wire or to the device (with the wire clamped) in such a manner that the force is applied within 5° of the normal to the surface of the die or substrate in the case of a nail-head bond, or within 5° of the parallel to the surface of the die or substrate in the case of a stitch bond.

   2) Method B: Wire pull (applied to two bonds simultaneously)

      A hook should be inserted under the lead wire connecting the die or substrate to the terminal, and a pull applied to the hook with the device clamped. The pulling force is applied approximately in the middle of the wire in a direction within 5° of the normal to the die or substrate surface or normal to a straight line between the bonds.

   3) Pulling force

      The pulling force should be progressively increased until the wire or a bond breaks or until the minimum force has been reached.

c) Failure criteria

1) For determining acceptance, the value of the pulling force at which the wire or bond breaks should be recorded and compared with that given in table 6 (see note).

2) As an alternative procedure, the pulling force is increased to the specified minimum value (see note). If neither the wire nor the bond is broken, the bond is considered to have passed the test.

NOTE The pulling force should be modified where relevant (for example, for method B) by using the information given in e) below.

d) Classification of failures

When specified, broken wires or bonds should be classified as follows:

1) wire break at neckdown point (reduction of section due to bonding process);
2) wire break at a point other than neckdown;
3) failure in bond (interface between wire and metallization) at the die;
4) failure in bond (interface between wire and metallization) at substrate, package post or any point other than at the die;
5) metallization lifted from the die;
6) metallization lifted from the substrate or package post;
7) fracture of the die;
8) fracture of the substrate.

NOTE Method B is not recommended for the purpose of measuring the absolute value of the bond strength (see e) guidance). However, it may be used for testing the bond quality on a comparative basis during the manufacturing process.

Table 6 – Minimum pulling force

Test method	**Wire composition[b] and diameter**	**Minimum pulling force *P*w [a]** mN			
		Pre-seal		**Post-seal and any other processing or screening when applicable**	
	Mm	**Normal to die**	**Parallel to die**	**Normal to die**	**Parallel to die**
A or B	Al 0,018	15	25	10	20
	Au 0,018	20	30	15	25
A or B	Al 0,025	25	35	15	25
	Au 0,025	30	40	25	35
A or B	Al 0,033	30	40	20	30
	Au 0,033	40	50	30	40
A or B	Al 0,038	35	45	25	35
	Au 0,038	50	60	35	45
A or B	Al 0,075	120	130	80	90
	Au 0,075	150	160	120	130

[a] See figure 2.

[b] Al denotes aluminium, Au denotes gold.

NOTE 1 For ribbon wire, use the equivalent round wire diameter that gives the same cross-sectional area as the ribbon wire being tested.

NOTE 2 Care should be taken not to damage the bond when opening the case for the post-seal tests.

e) Guidance

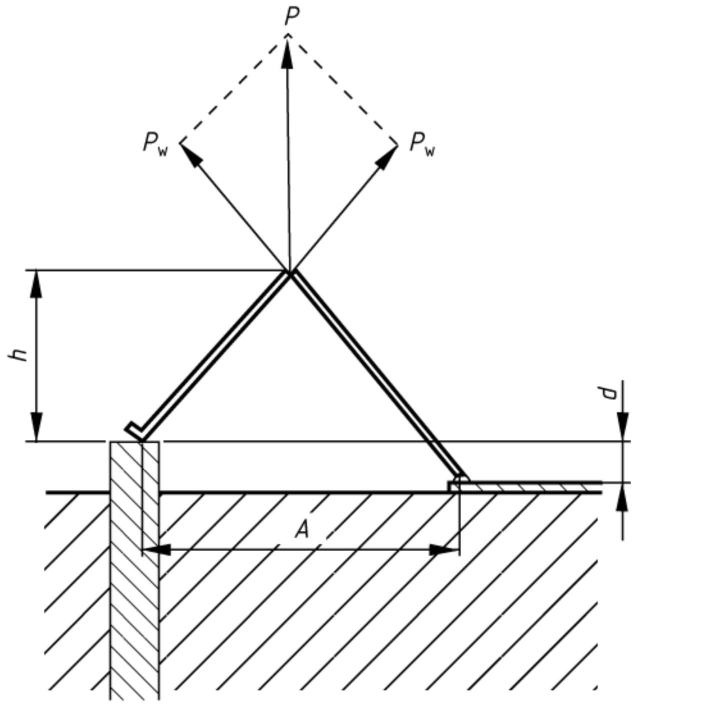
1) Method A

As general guidance, a stitch type bond should normally be submitted to a shear force, and a nail-head type bond to a pulling force.

2) Method B

The force that is actually applied to the bonds varies considerably with the length of the wire loop between bonds, that is, parameters *A* and *h* of figure 2, and with the vertical distance *d* between bonds. If the wire loop is very short, the breaking load of the wire may easily be exceeded even if the force applied to the hook is smaller than this limit. For instance, it can be seen from the formula given below that a pulling force P_W of approximately 100 mN will be exerted on a wire when a force *P* of 40 mN is applied to the hook, and $h = 0{,}1$ mm, $A = 2$ mm and $d = 0{,}2$ mm. In such a case, a gold wire of 0,025 mm diameter is likely to be broken before the bond gives way. If $d = 0$, a similar pulling force will be developed with *P* reduced to 20 mN.

This information should be used to take into consideration the typical bond geometry of the device in determining compliance with the values in table 6.



$$P_W = \frac{P}{2}\left[1 + \frac{A^2}{(2h+d)^2}\right]^{0,5}$$

Figure 2 – Pulling force for bond strength test

7.5.21.5 Method C: Bond peel

7.5.21.5.1 Purpose

This test is normally intended to be applied to bonds external to the device package.

7.5.21.5.2 General description of the test

The lead or terminal and the device package should be gripped or clamped in such a manner that a peeling stress is exerted with the specified angle between the lead or terminal and the board or substrate. Unless otherwise specified, an angle of 90⌒ should be used.

The pulling force should be progressively applied until the lead (or terminal) or the bond breaks or until the minimum force has been reached.

7.5.21.5.3 Failure criteria

For determining acceptance, the value of the pulling force at which the bond breaks should be recorded and compared with that given in table 6. The result of the test is valid only if the bond itself is the first to fail when the pulling force is applied. Only instances in which the bond itself breaks shall be counted as failures.

As an alternative procedure, the pulling force is increased to the specified minimum value. If neither the lead (or terminal) nor the bond is broken, the bond is considered to have passed the test.

7.5.21.5.4 Classification of failures

When specified, broken leads (or terminals) or bonds should be classified as follows:

i) lead (or terminal) break at a deformation point (weld affected region);

ii) lead (or terminal) break at a point not affected by the bonding process;

iii) failure in the bond interface (in the solder, or at a point of weld interface between the lead (or terminal) and the board or the substrate conductor to which the bond was made);

iv) conductor lifted from the board or substrate;

v) fracture within the board or substrate.

7.5.21.6 Method D: Bond shear (applied to flip chip)

a) Purpose

This test is normally intended to be applied to internal bonds between a semiconductor die and a substrate to which it is attached in a face-bonded configuration. It may also be used to test the bonds between a substrate and an intermediate carrier or secondary substrate, on which the die is mounted.

b) General description of the test

A suitable tool or wedge should be brought in contact with the die (or carrier) at a point just above the primary substrate and a force applied perpendicular to one edge of the die (or carrier) and parallel to the primary substrate, to cause bond failure by shear.

The force should be progressively increased until the bonds break or until the minimum force has been reached.

c) Failure criteria

For determining acceptance, the value of the force at which the bonds break should be recorded. It should be not less than 50 mN multiplied by the number of bonds. The result of the test is valid only if the bonds themselves are the first to fail when the force is applied. Only instances in which the bond itself breaks shall be counted as failures.

As an alternative procedure, the force is increased to 50 mN multiplied by the number of bonds. If neither the bonds nor the substrate or die are broken, the bonds are considered to have passed the test.

d) Classification of failures

When specified, the failures should be classified as follows:

1) failure in the bond material, or bonding pedestal, where applicable;
2) fracture of the die (or carrier) or substrate (that is, removal of a portion of the die or substrate immediately under the bond);
3) lifted metallization (that is, separation of the metallization or bonding pedestal from the die [or carrier] or substrate).

7.5.21.7 Methods E and F: Bond shear (applied to beam lead)

7.5.21.7.1 Purpose

These tests are intended for application to beam-lead devices.

Method E is normally intended to be applied to process control and is used on a sample of semiconductor die bonded to a specially prepared substrate. Therefore, it cannot be used for random sampling of production or inspection lots.

Method F is normally intended to be applied on a sample basis to beam-lead devices that have been bonded to a ceramic or other suitable substrate.

7.5.21.7.2 General description of the tests

a) Method E: Push-off test

   A metallized substrate containing a hole should be employed. The hole, appropriately centred, should be sufficiently large to provide clearance for a push tool, but not large enough to interfere with the bonding areas. The push tool should be sufficiently large to minimize device cracking during testing, but not large enough to contact the beam-leads in the anchor bond area.

   The substrate should be rigidly held and the push tool inserted through the hole. The contact of the push tool to the device should be made without appreciable impact (less than 0,25 mm per minute). The tool is forced against the underside of the bonded device at a constant rate until the specified force is attained or a failure occurs.

b) Method F: Pull-off test

   The calibrated pull-off apparatus should include a pull-off tool (for instance, an electrically heated loop of Nichrome wire) to make connection with a hard setting adhesive material (for instance, a heat-sensitive polyvinyl acetate resin glue) on the top side of the beam-lead die. Care should be taken to ensure that no adhesive flows down the beam or under the die. The substrate should be rigidly installed in the pull-off fixture and the pull-off tool should make firm mechanical connection to the adhesive material. The pulling force should be applied to the device within 5° of the normal and its value increased to at least the specified value or until the upper surface of the die is at approximately 2,5 mm above the substrate.

c) Failure criteria for both methods E and F:

   1) broken semiconductor die;
   2) beam lifting from the semiconductor die;
   3) beam broken at a bond;
   4) beam broken at the edge of the semiconductor die;
   5) beam broken between a bond and the edge of the semiconductor die;
   6) bond lifting from the substrate;
   7) metallization lifting (separation of the metallization from either the die or a bonding pad).

d) Force to be applied (both methods)

   500 mN per linear millimetre of nominal undeformed (before bonding) beam width. The bond strength should be determined by dividing the breaking force by the total of the nominal beam widths before bonding.

The detail specification shall prescribe, as applicable:

1) test method;
2) testing procedure: force to rupture or predetermined value of the applied force;
3) minimum bond strength;

4) number and selection of bonds to be tested on each device and number of devices;
5) for test method C, angle of the bond peel if other than 90° and corresponding minimum bond strength.

7.5.22 Die shear strength (D)

The following die shear strength test is based upon that given in IEC 60749.

7.5.22.1 Object

The object of the die shear strength test is to determine the integrity of materials and procedures used to attach semiconductor dies or passive elements to package headers or other substrates.

NOTE This determination is based on a measure of the force applied to the die or to the element, and, if a failure occurs, the type of failure resulting from the application of force and the visual appearance of the residual die attach media and the header/substrate metallization.

This method is not applicable for die areas greater than 10 mm^2.

7.5.22.2 Description of the test apparatus

The apparatus for this test shall consist of a load applying instrument in the form of a linear motion force-applying instrument or a circular dynamometer with a lever arm. In addition it shall have the following:

a) a contact tool which applies a uniform load to the edge of the die, perpendicular to the die mounting plane of the package or substrate (see figure 3 c)). A compliant material on the contact tool may be used to ensure that the load in applied uniformly (see figure 3 a));
b) an accuracy of 5 % of full scale or ±0,5 N, whichever is the greater tolerance;
c) a means of indicating the load applied;
d) a facility, fitted with suitable light source, to allow visual observation (e.g. at 10× magnification) of the die and contact tool during testing;
e) a fixture with rotational capability relative to the die contact tool and package/substrate holding fixture to allow line contact of the tool along the whole edge of the die from end to end (see figure 3 b)).

7.5.22.3 Test method

A force sufficient to shear the die from its mounting or equal to twice the minimum specified shear strength, whichever is the smaller, shall be applied to the die using the apparatus detailed above with the following provisions.

a) When a linear motion force-applying instrument is used, the direction of the applied force shall be parallel with the plane of the header or substrate and perpendicular to the die being tested.
b) When a circular dynamometer with a lever arm is employed to apply the force required for testing, it shall be pivoted about the lever arm axis and the motion shall be parallel with the plane of the header or substrate and perpendicular to the edge of the die being tested. The contact tooling attached to the lever arm shall be at a proper distance to ensure an accurate value of applied force.
c) The die contact tool shall load against an edge of the die which most closely approximates a 90° angle with the base of the header or substrate to which it is bonded (see figure 3 c)).

d) After initial contact with the component edge and during the application of force, the contact tool shall not move vertically with respect to the component such that contact is made with the header/substrate or attach media. If the tool rides over the component, a new component may be substituted or the component may be re-positioned, provided that there is conformance with the requirements of item 3) above.

7.5.22.4 Failure criteria

The strength of attachment of a component shall be considered to have failed the test on the basis of any of the following criteria:

a) unless otherwise specified, component separation at a force not greater than the following:
   1) 4,1 $mm^2 \leq$ attach area $\leq$ 10 mm^2 : 25 N,
   2) attach area < 4,1 mm^2 : 6,1 N per mm^2 of attach area,
   3) attach area > 10 mm^2 : not applicable;

b) separation at a force less than 1,25 times that in a) above and evidence of less than 50 % adhesion of the attach medium to the component;

c) separation at a force less than 2 times that in i) above and evidence of less than 10 % adhesion of the attach medium to the component.

NOTE Residual material attached in discrete areas of the component attach medium should be considered as evidence of such adhesion.

7.5.22.5 Requirements

When specified, the force required to achieve separation and the category of the separation shall be recorded.

Categories of separation:

a) shearing of component with residual material remaining;
b) separation of component from attach medium;
c) separation of component and attach medium from package.

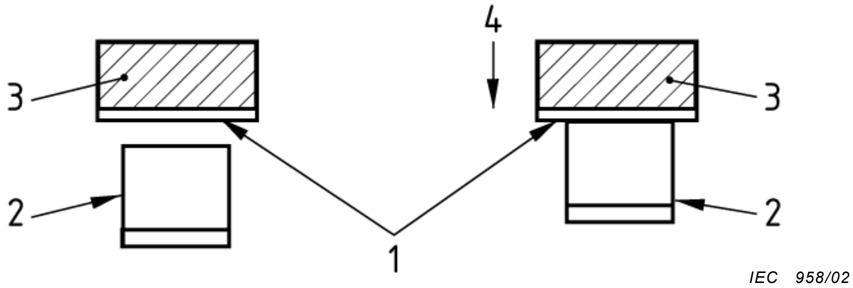
The detail specification shall prescribe:

1) minimum component attach strength if other than that given in d;
2) number of devices to be tested and acceptance criteria;
3) requirements for data recording, when applicable.

7.5.23 Radiation hardness assessment

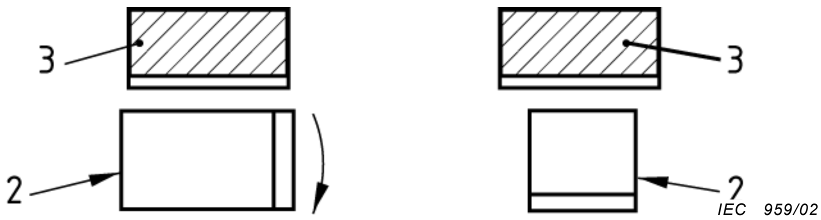
No test is specified as no standards yet exist. It should be noted that assessing this property of a circuit involves many variables and that great variation in arrangements may be encountered.

Users requiring such a test therefore need to specify their requirements fully in the detail specification.



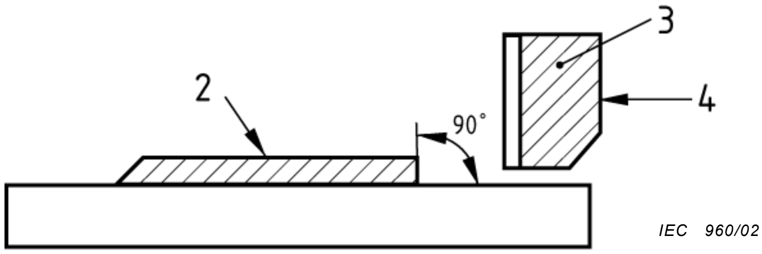
NOTE A compliant interface on the contact tool distributes the load to the irregular edge of the die.

Figure 3a – Compliant interface on the contact tool (plan view)



NOTE The die contact tool or the device may be rotated to ensure parallel alignment.

Figure 3b – Alignment of tool with die (plan view)



NOTE The contact tool is loaded against the edge of the die which is perpendicular in the header/substrate.

Figure 3c – Choice of die edge for application of contact tool (elevation)

Key

1 Solder or glue
2 Die
3 Contact tool
4 Direction of motion

Figure 3 – Apparatus requirements for the added component bond strength destructive test

Annex A
(normative)

Product assessment level schedules (PALS)

PRODUCT ASSESSMENT LEVEL SCHEDULE 1

Applicability

This assessment schedule is intended for use with solder assembled and/or bare die, non-hermetic encapsulated, unencapsulated, cavity or non-cavity devices, which are for use in benign mechanical and temperature environments.

Device screening 100 %		**IEC 60748-23-1**
1 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified for screening)		7.4
2 External visual inspections		7.3.2
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical test. All specified parameters at T_{min} and T_{max}*.		7.4
2 Dimensions		7.3.3
Minimum sample 3. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Robustness of terminations	(D)	7.5.12
4 Flammability	(D)	7.5.16
5 Resistance to solvents	(ND)	7.5.15
* Structural similarity rules do not apply.		
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 ESD precautions (where applicable) to IEC 61340-5-1		
4 Pre-cap visual at IL S4 AQL 0,4 % minimum		7.3.1

PRODUCT ASSESSMENT LEVEL SCHEDULE 2

Applicability

This assessment schedule is intended for use with solder assembled and/or bare die, non-hermetic encapsulated, unencapsulated, cavity or non-cavity devices, which are for use in benign mechanical and temperature environments.

Device screening 100 %		**IEC 60748-23-1**
1 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified for screening)		7.4
2 External visual inspection		7.3.2
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical endurance 1000 h. Release after 160 h *		7.5.14
2 Electrical test All specified parameters at T_{min} and T_{max} *		7.4
3 Dimensions		7.3.3
Minimum sample 3. Accept on 0 failures		
1 Resistance of circuits to solder heat.	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Robustness of terminations	(D)	7.5.12
4 Flammability	(D)	7.5.16
5 Resistance to solvents	(ND)	7.5.15
* Structural similarity rules do not apply		
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 ESD precautions (where applicable) to IEC 61340-5-1		
4 Pre-cap visual at IL S4 AQL 0,4 % minimum		7.3.1

PRODUCT ASSESSMENT LEVEL SCHEDULE 3

Applicability

This assessment schedule is intended for use with solder assembled, and/or bare die, non-hermetic encapsulated, unencapsulated, cavity or non-cavity devices. These hybrids are for use in benign mechanical environments but with demonstration of extreme temperature and humidity operation.

Device screening 100 %		**IEC 60748-23-1**
1 Change of temperature. 10 cycles		7.5.8 .1
2 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified for screening), T_{min} and T_{max}. Those tests in the detail specification		7.4
2 Electrical tests which define circuit functionality		7.4
3 External visual inspection		7.3.2
Design evaluation		
Minimum sample 8. Accept on 0 failures.		
1 Electrical endurance 1000 h. Release after 160 h *		7.5.14
2 Dimensions		7.3.3
3 Damp heat cyclic or steady state		7.5.4, 7.5.3
4 Change of temperature *		7.5.8 .2
Minimum sample 3. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Robustness of terminations	(D)	7.5.12
4 Flammability	(D)	7.5.16
5 Resistance to solvents	(ND)	7.5.15
* Structural similarity rules do not apply		
Process and packaging requirements		**IEC 60748-23-1**
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 ESD precautions (where applicable) to IEC 61340-5-1		
4 Pre-cap visual at IL S4 AQL 0,4 % minimum		7.3.1

PRODUCT ASSESSMENT LEVEL SCHEDULE 4

Applicability

This assessment schedule is intended for use with solder assembled and/or bare die, non-hermetic encapsulated, unencapsulated, cavity or non-cavity devices, which are for use in non-benign mechanical and temperature environments. It is intended to give a high level of assurance on this type of build standard.

Device screening 100 % PDA = 10 %		**IEC 60748-23-1**
1 Change of temperature. 10 cycles		7.5.8 1
2 Electrical tests at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
3 Burn-in. 160 h		7.5.14
4 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
5 Electrical tests at T_{min} and T_{max}. Those tests in the detail specification which define circuit functionality		7.4
6 External visual inspection		7.3.2
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified in item 2 of screening)		7.4
Design evaluation		
Minimum sample 8. Accept on 0 failures.		
1 Electrical endurance 2 000 h. Release after 1000 h *		7.5.14
2 Dimensions		7.3.3
3 Damp heat cyclic or steady state		7.5.4, 7.5.3
4 Change of temperature *		7.5.8 .2
Minimum sample 5. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Resistance to solvents	(ND)	7.5.15
4 Acceleration	(ND/D)	7.5.7
5 Shock and/or vibration (as specified in detail specification)	(ND/D)	7.5.5, 7.5.6
Minimum sample 3. Accept on 0 failures		
1 Robustness of terminations	(D)	7.5.12
2 Flammability	(D)	7.5.16
* Structural similarity rules do not apply.		
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 ESD precautions (where applicable) to IEC 61340-5-1		
4 Pre-cap visual at 100 %		7.3.1

PRODUCT ASSESSMENT LEVEL SCHEDULE 5

Applicability

This assessment schedule is intended for use with solder assembled, and/or bare die, non-hermetic encapsulated, unencapsulated, cavity or non-cavity devices which are for use in non-benign mechanical and temperature environments. It is intended to give the highest level of assurance on this type of product.

Device screening 100 % PDA = 10 %		**IEC 60748-23-1**
1 Change of temperature. 10 cycles		7.5.8 .1
2 Electrical tests at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
3 Acceleration. (5 000 g_n or at design limit)		7.5.7
4 Burn-in 160 h		7.5.14
5 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
6 Electrical tests at T_{min} and T_{max}. Those tests in the detail specification which define circuit functionality		7.4
7 External visual inspection		7.3.2
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified in item 2 of screening)		7.4
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical endurance 2000 h. Release after 1000 h*		7.5.14
2 Dimensions		7.3.3
3 Damp heat cyclic or steady state		7.5.4, 7.5.3
4 Change of temperature*		7.5.8 .2
* Structural similarity rules do not apply.		
Minimum sample 5. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Resistance to solvents	(ND)	7.5.15
4 Acceleration	(ND/D)	7.5.7
5 Shock and/or vibration (as specified in the detail specification)	(ND/D)	7.5.5 , 7.5.6
Minimum sample 3. Accept on 0 failures		
1 Robustness of terminations	(D)	7.5.12
2 Flammability	(D)	7.5.16
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 ESD precautions (where applicable) to IEC 61340-5-1		
4 Pre-cap visual at 100 %		7.3.1

PRODUCT ASSESSMENT LEVEL SCHEDULE 6

Applicability

This assessment schedule is intended for use with bare die, hermetic cavity devices. This assessment is also intended for use with substrates containing solder attached added components all of which are individually hermetic. These devices are for use in benign mechanical environments but with demonstration of extreme temperature operation. The assessment is intended where lower levels of assurance are adequate.

Device screening 100 %		**IEC 60748-23-1**
1 Change of temperature. 10 cycles		7.5.8 .1
2 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
3 Sealing fine and gross		7.5.9
4 External visual inspection		7.3.2
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified for screening)		7.4
2 Electrical tests at T_{min}, T_{max} and T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical endurance 1 000 h. Release after 160 h *		7.5.14
2 Dimensions		7.3.3
Minimum sample 3. Accept on 0 failures		
1. Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Robustness of terminations	(D)	7.5.12
4 Resistance to solvents	(ND)	7.5.15
5 Damp heat steady state 56 days or salt mist (as specified in the detail specification)	(D)	7.5.3 , 7.5.13
* Structural similarity rules do not apply.		
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 Temperature controlled, monitored and relative humidity 30 % to 65 % prior to hermetic sealing stage		
4 ESD precautions (where applicable) to IEC 61340-5-1		
5 Pre-cap visual at 100 %		7.3.1
6 Hermetic packaging in glass, metal, ceramic or combinations of these; no adhesive or polymeric materials used for lid attach and no flux used in the final sealing process		

PRODUCT ASSESSMENT LEVEL SCHEDULE 7

Applicability

This assessment schedule is intended for use with bare die, hermetic cavity devices. This assessment is also intended for use with substrates containing solder attached added components all of which are individually hermetic. These devices are for use in benign mechanical environments but with demonstration of extreme temperature operation. The assessment with the addition of the burn-in requirement is intended to give a medium level of assurance.

Device screening 100 % PDA = 10 %		**IEC 60748-23-1**
1 Change of temperature. 10 cycles		7.5.8 .1
2 Burn-in 160 h		7.5.14
3 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality.		7.4
4 Sealing fine and gross		7.5.9
5 External visual inspection		7.3.2
Device sample testing – IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified for screening)		7.4
2 Electrical tests at Tmin, Tmax and T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical endurance 1 000 h. Release after 160 h		7.5.14
2 Dimensions		7.3.3
Minimum sample 3. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Robustness of terminations	(D)	7.5.12
4 Resistance to solvents	(ND)	7.5.15
5 Damp heat steady state 56 days or salt mist (as specified in the detail specification)	(D)	7.5.3, 7.5.13
* Structural similarity rules do not apply.		
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 Temperature monitored and controlled, relative humidity 30 % to 65 % prior to hermetic sealing stage.		7.3.1
4 ESD precautions (where applicable) to IEC 61340-5-1		
5 Pre-cap visual at 100 %		
6 Hermetic packaging in glass, metal, ceramic or combinations of these; no adhesive or polymeric materials used for lid attach and no flux used in the final sealing process		

PRODUCT ASSESSMENT LEVEL SCHEDULE 8

Applicability

This assessment schedule is intended for use with bare die, hermetic cavity devices. This assessment is also intended for use with substrates containing solder attached added components all of which are individually hermetic. These devices are for use in non-benign mechanical and temperature environments. The assessment is intended to give a high level of assurance for these devices for use in extreme environment applications.

Device screening 100 % PDA = 7 %		**IEC 60748-23-1**
1 Change of temperature. 10 cycles		7.5.8.1
2 Acceleration (5 000 g_n or at design limit)		7.5.7
3 Electrical tests at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
4 Burn-in 160 h		7.5.14
5 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
6 Electrical tests at T_{min} and T_{max}. Those tests in the detail specification which define circuit functionality		7.4
7 Sealing fine and gross		7.5.9
8 External visual inspection		7.3.2
Device sample testing, IL S4 AQL 0,4 %		
1 Electrical test at T_{amb} (other than those specified in item 3 of screening)		7.4
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical endurance 2 000 h. Release after 1000 h *		7.5.14
2 Dimensions		7.3.3
3 Shock and/or vibration (as specified in the detail specification)	(ND/D)	7.5.5, 7.5.6
4 Acceleration	(ND/D)	7.5.7
Minimum sample 5. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Resistance to solvents	(ND)	7.5.15
4 Damp heat steady state 56 days or salt mist as specified in the detail specification	(D)	7.5.3, 7.5.13
Minimum sample 3. Accept on 0 failures		
1 Robustness of terminations	(D)	7.5.12
* Structural similarity rules do not apply.		
Process and packaging requirements		
1 Substrate fabrication = class 100 000		
2 Substrate assembly (bare die) = class 100 000		
3 Pre-cap visual = class 10 000		
4 Temperature monitored and controlled, relative humidity 30 % to 65 % prior to sealing stage		
5 ESD precautions (where applicable) to IEC 61340-5-1		7.3.1
6 Pre-cap visual at 100 %		
7 Hermetic packaging in glass, metal, ceramic or combinations of these; no adhesive or polymeric materials used for lid attach and no flux used in the final sealing process		

PRODUCT ASSESSMENT LEVEL SCHEDULE 9

Applicability

This assessment schedule is intended for use with bare die, hermetic cavity devices, which are for use in non-benign mechanical and temperature environments. It is intended to give a very high level of assurance for these devices for use in applications where reliability is paramount.

Device screening 100 % PDA = 5 %		IEC 60748-23-1
1 Change of temperature. 10 cycles		7.5.8.1
2 Acceleration (5 000 g_n or at design limit)		7.5.7
3 Particle impact noise detection		7.5.17
4 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
5 Burn-in 160 h		7.5.14
6 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
7 Electrical tests at T_{min} and T_{max}. Those tests in the detail specification which define circuit functionality		7.4
8 Sealing fine and gross		7.5.9
9 External visual inspection		7.3.2
Device sample testing. IL S4 AQL 0,4 %		
1 Electrical tests at T_{min}, T_{max} and T_{amb} (other than those specified in item 4 of screening)		7.4
2 Electrical endurance 2 000 h		7.5.14
Design evaluation		
Minimum sample 8. Accept on 0 failures		
1 Electrical endurance 2 000 h. Release after 1 000 h *		7.5.14
2 Dimensions		7.3.3
3 Acceleration	(ND/D)	7.5.7
4 Shock (as specified in the detail specification)	(ND/D)	7.5.5
5 Vibration (as specified in the detail specification)	(ND/D)	7.5.6
* Structural similarity rules do not apply.		
Minimum sample 5. Accept on 0 failures		
1 Resistance of circuits to solder heat state	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Resistance to solvents	(ND)	7.5.15
4 Damp heat steady 56 days or salt mist (as specified in the detail specification)	(D)	7.5.3, 7.5.13
Minimum sample 3. Accept on 0 failures		
1 Robustness of terminations	(D)	7.5.12
2 Internal moisture content 5 000 × 10^{-6} water *	(D)	7.5.18
* Structural similarity rules do not apply.		

PRODUCT ASSESSMENT LEVEL SCHEDULE 9 (continued)

Process and packaging requirements

1 Die storage and pre-cap product storage = class 1 000	
2 Substrate fabrication = class 10 000	
3 Substrate assembly (bare die) = class 10 000	
4 Pre-cap visual = class 1 000	
5 Temperature monitored and controlled, relative humidity 30 % to 65 % prior to hermetic sealing stage	
6 ESD precautions (where applicable) to IEC 61340-5-1	
7 Pre-cap visual at 100 %	7.3.1
8 Hermetic packaging in glass, metal, ceramic or combinations of these; no adhesive or polymeric materials used for lid attach and no flux used in the final sealing process	
9 Destructive bond pull and element shear evaluation on customer product	7.5.21, 7.5.22

PRODUCT ASSESSMENT LEVEL SCHEDULE 10

Applicability

This assessment schedule is intended for use with bare die, hermetic cavity devices, which are for use in non-benign mechanical and temperature environments. It is intended to give a very high level of assurance for these devices for use in applications where reliability is paramount.

Device screening 100 % PDA = 5 %		IEC 60748-23-1
1 Dry heat 500 h		7.5.1
2 Change of temperature. 10 cycles		7.5.8.1
3 Acceleration (5 000 g_n or at design limit)		7.5.7
4 Particle impact noise detection		7.5.17
5 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
6 Burn-in 160 h		7.5.14
7 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
8 Electrical tests at T_{min} and T_{max}. Those tests in the detail specification which define circuit functionality		7.4
9 Sealing fine and gross		7.5.9
10 External visual inspection		7.3.2
Device sample testing. IL S4 AQL 0,4 %		
1 Electrical tests at T_{min}, T_{max} and T_{amb} (other than those specified in item 5 of screening)		7.4
2 Electrical endurance 2 000 h		7.5.14
3 Shock (as specified in the detail specification)	(ND)	7.5.5
4 Vibration (as specified in the detail specification)	(D)	7 .5.6
Design evaluation		
Minimum sample 13. Accept on 0 failures		
1 Electrical endurance 2 000 h. Release after 1000 h *		7.5.14
2 Dimensions		7.3.3
3 Acceleration	(ND/D)	7.5.7

* Structural similarity rules do not apply.

Minimum sample 5. Accept on 0 failures		
1. Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Resistance to solvents	(ND)	7.5.15
4 Damp heat steady state 56 days or salt mist (as specified in the detail pecification)	(D)	7.5.3, 7.5.13
Minimum sample 3. Accept on 0 failures		
1 Robustness of terminations	(D)	7.5.12
2 Internal moisture content 5 000 × 10^{-6} water, 100 × 10^{-6} other contaminants *	(D)	7.5.18

* Structural similarity rules do not apply.

PRODUCT ASSESSMENT LEVEL SCHEDULE 10 *(continued)*

Process and packaging requirements	
1 Die storage and pre-cap product storage = class 1 000	
2 Substrate fabrication = class 10 000	
3 Substrate assembly (bare die) = class 10 000	
4 Pre-cap visual = class 1 000	
5 Temperature monitored and controlled, relative humidity 30 % to 65 % prior to hermetic sealing stage	
6 ESD precautions (where applicable) to IEC 61340-5-1	
7 Pre-cap visual at 100 %	7.3.1
8 Hermetic packaging in glass, metal, ceramic or combinations of these; no adhesive or polymeric materials used for lid attach and no flux used in the final sealing process	
9 100 % Non-destructive bond pull testing	7.5.21
10 Destructive bond pull and element shear evaluation on customer product	7.5.21, 7.5.22

PRODUCT ASSESSMENT LEVEL SCHEDULE 11

Applicability

This assessment schedule is intended for use with bare die, hermetic cavity devices, which are for use in non-benign mechanical, temperature and radiation environments. It is intended to give the maximum level of assurance for these devices for use in applications such as space where reliability is paramount.

Device screening 100 % PDA = 5 %		**IEC 60748-23-1**
1 Dry heat 500 h		7.5.1
2 Change of temperature. 10 cycles		7.5.8.1
3 Acceleration (5 000 g_n or at design limit)		7.5.7
4 Particle impact noise detection		7.5.17
5 Radiography		7.5.19
6 Electrical tests at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
7 Burn-in 160 h		7.5.14
8 Electrical test at T_{amb}. Those tests in the detail specification which define circuit functionality		7.4
9 Electrical tests at T_{min} and T_{max}. Those tests in the detail specification which define circuit functionality		7.4
10 Sealing fine and gross		7.5.9
11 External visual inspection		7.3.2
Device sample testing. IL S4 AQL 0,4 %		
1 Electrical tests at T_{min}, T_{max} and T (other than those required in item 6 screening)		7.4
2 Electrical endurance 2000 h		7.5.14
3 Shock (as specified in the detail specification)	(ND)	7.5.5
4 Vibration (as specified in the detail specification)	(D)	7.5.6
Design evaluation		
Minimum sample 13. Accept on 0 failures		
1 Electrical endurance 8 000 h. Release after 1000 h *		7.5.14
2 Dimensions		7.3.3
3 Acceleration	(ND/D)	7.5.7
* Structural similarity rules do not apply		
Minimum sample 5. Accept on 0 failures		
1 Resistance of circuits to solder heat	(D)	7.5.11
2 Solderability	(ND/D)	7.5.10
3 Resistance to solvents	(ND)	7.5.15
4 Damp heat steady state 56 days or salt mist (as specified in the detail specification)	(D)	7.5.3, 7.5.13
5 Radiation hardness assessment	(D)	7.5.23
Minimum sample 3. Accept on 0 failures		
1 Robustness of terminations	(D)	7.5.12
2 Internal moisture content. 3 000^{-6} water 100^{-6} other contaminants *	(D)	7.5.18
* Structural similarity rules do not apply		

PRODUCT ASSESSMENT LEVEL SCHEDULE 11 (continued)

Process and packaging requirements	
1 Die storage and pre-cap product storage = class 1 000	
2 Substrate fabrication = class 10 000	
3 Substrate assembly (bare die) = class 10 000	
4 Pre-cap visual = class 1 000	
5 Temperature monitored and controlled, relative humidity 30 % to 65 % prior to hermetic sealing stage	
6 ESD precautions (where applicable) to IEC 61340-5-1	
7 Pre-cap visual at 100 %	7.3.1
8 Hermetic packaging in glass, metal, ceramic or combinations of these; no adhesive or polymeric materials used for lid attach and no flux used in the final sealing process	
9 100 % non-destructive bond pull testing	7.5.21
10 Destructive bond pull and element shear evaluation on customer product	7.5.21, 7.5.22

Annex B
(informative)

Customer information – Application of these specifications with particular reference to produce assessment level schedules (PALS)

B.1 Customer information

This part of IEC 60748 applies to a high quality approval system for hybrid integrated circuits and film structure.

B.1.1 How to use this specification

This specification is part of the IECQ quality assessment system which provides arrangements for the specification, manufacturing line certification, inspection and release of hybrid integrated circuits of assessed quality. This comprehensive scheme is more effective than individual standards, allowing the approved manufacturer to work to consistent, defined requirements and gives the customer a clear view of exactly what component quality will be received. Because hybrids are used in a variety of applications, it is important for the customer to be able to choose a manufacturer who can supply to those needs. This specification is designed to meet a large cross-section of these applications (such as automotive, military, space, telecommunications, professional).

To gain approval to this specification the manufacturer shall:

– meet the requirements of ISO 9001 or ISO 9002;
– carry out an audit and comply with the detailed technical process requirements of the checklist shown in IEC 60748-23-3;
– test a representative product against the requirements of one of the product assessment level schedules (PALS) detailed herein.

Having completed the approval, the manufacturer can release customer circuits for that particular technology against a PALS for which he is approved. The level of quality and reliability may be estimated:

a) from data obtained from the materials characterization, manufacturing process design rules and control. It may be augmented by performing additional reliability testing;
b) by performing the negotiated level of inline screening and/or end of line PALS tests.

PALS are used to give more confidence to the customer concerning hybrid products with special requirements, especially as it relates to the quality and reliability of the product. PALS are very useful when sufficient information about quality and reliability cannot be obtained from the material's characteristics, process design rules and control or product design activities.

The type of inline screening or PAL schedule agreed to does not necessarily determine the actual product quality (parts per million (ppm)) or reliability (FITS).

B.1.2 Customer/manufacturer interface

A customer, when entering into negotiation with a potential supplier of hybrid circuits released to this specification, needs to be aware of the various manufacturer/customer interfaces. At the design and layout stage, the two parties need to agree whether the manufacturer will be responsible for the complete design against an electrical, mechanical and environmental specification and whether the customer may contribute to the layout. In this latter case, the manufacturer has to ensure that the layout complies with his design rules. Although the test requirements of each PALS is clearly defined, the customer and manufacturer have a responsibility to ensure that the customer detail specification clearly reflects the requirements of the customer without exceeding the capabilities of the manufacturer. In particular, any test or test sequence which allows a choice shall have that choice agreed and documented. The customer detail specification requires that the physical dimensions of the hybrid be stated. Some of these dimensions are essential for interchangeability requirements. These need to be agreed and toleranced since the manufacturer will inspect the finished product to these requirements.

The customer detail specification also requires information on the performance and design of the circuit and the conditions under which it can be used, as well as derating data, all of which needs to be agreed between customer and manufacturer. Further mutually agreed information in the customer detail specification can include circuit diagrams, curves, drawings and explanatory notes.

Electrical testing needs very careful specification and agreement between customer and manufacturer. This minimizes incorrect testing, tests which damage the circuit, tests being omitted and redundant testing. The PALS refer to "those tests which define circuit functionality" and the remainder. The tests defining circuit functionality are those which prove that the device performs its prime function. These tests tend to be part of screening and are also used as post-test end-points. The remainder are more peripheral and, either for reasons of cost of test or perceived lack of importance, tend to be examined on a sampling basis. The customer and manufacturer need to agree which electrical tests are required and which are considered to "define circuit functionality". Where testing is performed at T_{min} and T_{max}, or where burn-in and electrical endurance are concerned, the manufacturer and the customer need to be aware that some devices dissipate heat during operation and this may raise the junction temperature much higher than that of the ambient. The control and definition of temperature and its reference point (e.g. T_{amb}, T_{case}) can cause problems and needs to be discussed by the manufacturer and the customer in advance of the detail specification being agreed.

Further agreement needs to be reached over testing and structural similarity considerations. Where structural similarity is applicable, design evaluation testing can be omitted since the manufacturer has already demonstrated assurance at his initial approval stage. Such omissions can only be permitted if both customer and manufacturer are confident of the correctness of such a decision.

For the first delivery, the customer's circuit has to be tested against all aspects of the PALS (device screening, device sample testing and design evaluation) as well as any other requirements which are mutually agreed between manufacturer and customer. For subsequent deliveries, circuits are tested against the requirements of device screening, device sample testing and those tests from design evaluation which are mutually agreed. The circuits may have some or all of the design evaluation tests performed under any mutually agreed sampling plan, together with any other agreed testing. Tests additional to those specified in the PALS do not change the release of the product assessment level schedule number. The full requirements are agreed between customer and manufacturer and are documented in the customer detail specification.

B.1.3 Product assessment level schedules (PALS)

B.1.3.1 Derivation of the product assessment level schedules

Every hybrid manufacturer specializes in a number of technologies with respect to substrate type, metallization, method of add-on component attachment and encapsulation. Dependent upon the market for which this product is designed (high volume, high reliability, military, consumer, etc.) the manufacturer will offer a number of tests which may be adopted 100 %, used on a sampling basis or performed once only purely as a means of design evaluation. These variants may be classified as a series of product assessment level schedules.

Table B.1 shows five PALS based on solder-attached or chip or wire components which are either unencapsulated or non-hermetically encapsulated. It can be seen that as the PALS number increases so does the amount of testing done on the hybrid. Similarly table B.2 shows six PALS based on hermetic assembly. Once again, the amount of testing increases as the PALS number increases.

A manufacturer who has completed an assessment against a PALS can release a product of that same technology to customers. The manufacturer who is approved to a PALS may offer that PALS or a lower one in the same technology series.

Customers who purchase hybrid circuits may require them for a wide variety of uses. These may include military or aerospace applications, medical or safety, telecommunications, automotive, commercial, professional or consumer applications. Each of these applications is driven by a diversity of requirements, such as cost, quality, reliability, ability to withstand extremes of temperature, mechanical or humidity environment, etc. By examining the PALS as displayed in tables 1 and 2, the customer is able to choose the PALS which most equates to his requirements and is thus able to choose a manufacturer who can release to this particular PALS. Where there is a requirement for testing in excess of that stipulated by a particular PALS, the customer and manufacturer may agree to this but release is still to that PALS.

Purely as guidance, the eleven PALS against which a manufacturer can release his product can be used in the following applications.

B.1.4 Indication of applications for the product assessment level schedules

Each of the PALS is characterized by a different assessment level, but not necessarily by a different application level. A device procured against PALS 1 or PALS 2 is not tested for its ability to withstand acceleration, although it may well withstand the test. The difference between the same device procured against PALS 1 and an identical device tested to PALS 4 or 5 is that in the latter case the ability to meet acceleration, amongst other requirements, is demonstrated and, importantly, it is paid for.

A hybrid used in consumer applications, such as toys or audio-visual applications, may need to be cheap and thus have less testing demonstrated. An overall quality of product is, nevertheless, implicit as a result of the enhanced processing requirements, which is ensured by compliance with the audit against the checklist of IEC 60748-23-3. It is impossible to give any firm guidance on which PALS is required for a specific application, except to advise that the cost of procurement rises from PALS 1 through to PALS 5 (which are essentially solder-attached components without hermetic encapsulation) and from PALS 6 through to PALS 11 (which are hermetic cavity devices, probably containing bare dies).

PALS 1 contains no mechanical, thermal or climatic testing and is thus assessed for benign mechanical and temperature environments. It is the cheapest schedule to perform and this would probably be suitable for commercial or consumer applications.

PALS 2 is identical except that design evaluation requires electrical endurance to be performed for 1 000 h, this giving some confidence of the life time capability of the device. The applications would be similar to those suggested for PALS 1.

PALS 3 contains damp heat testing, temperature cycling and measurement of essential electrical parameters at T_{min} and T_{max}. It thus demonstrates capability to withstand extremes of temperature and humidity but only for a benign mechanical environment. It could be suitable for certain telecommunications and computer-based applications as well as commercial and consumer.

PALS 4 introduces burn-in and electrical endurance up to 2 000 h, whilst adding acceleration and shock and/or vibration testing. For this type of build standard it gives a good assessment of the device's capability of withstanding non-benign mechanical and climatic conditions as well as the removal of early life failures. This level of testing makes the device suitable for those applications indicated for PALS 3 and possibly for automotive use and certain non-critical military applications.

PALS 5 gives the highest level of assurance for this hybrid build standard, including acceleration in the screening sequence and a limit on the percentage of defectives allowed (PDA) during screening. Its applications would be similar to those indicated for PALS 4.

PALS 6 is intended for non-critical applications but nevertheless includes electrical endurance testing and assessment at extremes of temperature. It could be used for consumer or commercial requirements where hermeticity is important, or perhaps telecommunication and computer requirements where demonstrations of life time is not required.

PALS 7 could be used for applications similar to PALS 6 but introduces burn-in and PDA. giving more confidence of screening and slightly greater applicability for telecommunication and computer use.

PALS 8 includes acceleration in the screening sequence, shock and/or vibrations in the design evaluation and a tighter PDA. It gives confidence that the device can survive harsh environmental and mechanical conditions and could be used for certain military applications.

PALS 9 contains particle impact noise detection (PIND) testing, endurance to 2 000 h and residual gas analysis. This level of testing and screening (PDA 5 %) is generally only used where a very high level of assurance and reliability is required. One example of its application would be used in military systems.

PALS 10 exceeds the requirements of PALS 9 by the addition of dry heat testing and shock and vibration testing during device sampling. Other than use in space applications, this schedule gives the highest level of quality and reliability assurance.

PALS 11 includes radiation hardness assessment and radiography. Testing to this schedule will be expensive and is only recommended for aerospace applications.

Table B.1 – Product assessment level schedules for solder or chip and wire (non-hermetic) assembly

TEST	PAL 1	PAL 2	PAL 3	PAL 4	PAL 5
Device screening (100 %)					
Electrical test at T_{amb}	*	*	*	*	*
Change of temperature (10 cycles)			*	*	*
Acceleration (5 000 g_n)					*
Burn-in 160 h				*	*
PDA (%)				10	10
Electrical test at T_{max}, T_{min}, T_{amb}				*	*
External visual inspection				*	*
Device sample testing (IL=S4, AQL=0,4 %)					
Electrical test at T_{amb}	*	*	*	*	*
External visual inspection	*	*	*		
Electrical test at T_{min}, T_{max}			*		
Design evaluation					
Min sample size (accept on 0 failures)	8	8	8	8	8
Dimensions	*	*	*	*	*
Electrical test at T_{min}, T_{max}	*	*			
Endurance 1000 h		*	*	*	*
Endurance 2 000 h				*	*
Damp heat cyclic / steady state			*	*	*
Change of temperature			*	*	*
Min sample size (accept on 0 failures)	3	3	3	5	5
Resistance to solder heat	*	*	*	*	*
Solderability	*	*	*	*	*
Resistance to solvents	*	*	*	*	*
Acceleration				*	*
Shock and/or vibration				*	*
Min sample size (accept on 0 failures)	3	3	3	3	3
Robustness of terminations	*	*	*	*	*
Flammability if applicable	*	*	*	*	*

Table B.2 – Product assessment level schedules for chip and wire (hermetic) assembly

TEST	PAL 6	PAL 7	PAL 8	PAL 9	PAL 10	PAL 11
Device screening (100 %)						
Electrical test at T_{amb}	*	*	*	*	*	*
Change of temperature (10 cycles)	*	*	*	*	*	*
Acceleration (5 000 g_n)			*	*	*	*
Burn-in 160 h		*	*	*	*	*
PDA (%)		10	7	5	5	5
Sealing (fine and gross)	*	*	*	*	*	*
External visual inspection	*	*	*	*	*	*
Electrical test at T_{max}, T_{min}, T_{amb}			*	*	*	*
PIND				*	*	*
Dry heat (500 h)					*	*
Radiography						*
Device sample testing (IL=S4, AQL=0,4 %)						
Electrical test at T_{amb}	*	*	*			
Electrical test at T_{max}, T_{min}, T_{amb}	*	*		*	*	*
Endurance 1000 h				*	*	*
Endurance 2 000 h				*	*	*
Shock					*	*
Vibration					*	*
Design evaluation						
Min sample size (accept on 0 failures)	8	8	8	8	13	13
Dimensions	*	*	*	*	*	*
Acceleration				*	*	*
Endurance 1000 h	*	*	*	*	*	*
Endurance 2 000 h			*	*	*	*
Endurance 8 000 h						*
Shock and/or vibration			*	*		
Min sample size (accept on 0 failures)	3	3	3	3	5	5
Resistance to solder heat	*	*	*	*	*	*
Solderability	*	*	*	*	*	*
Resistance to solvents	*	*	*	*	*	*
Damp heat steady state / Salt mist	*	*	*	*	*	*
Radiation hardness assessment						*
Min sample size (accept on 0 failures)	3	3	3	3	3	3
Robustness of terminations	*	*	*	*	*	*
Internal moisture content				*	*	*

B.1.5 Test requirements of PALS and their applicability to real life application

B.1.5.1 Origin of inspection requirements

The test procedures detailed in the inspection requirements of the PALS have largely been derived from National Standards for discrete transistors and integrated circuits. Although a film hybrid can contain many diverse add-on components and be considerably bulkier than those devices envisaged by these earlier standards, the test procedures have needed little modification to encompass the changes in technology dictated by hybrids.

The origins of inspection requirement test procedures can be traced back to the basic reasons for testing a product. Probably the most fundamental reason is to reveal weaknesses, potential or otherwise, before the shipment. The PALS divide inspection requirements into screening, sample testing and design evaluation.

Screening tests are performed on every device of every lot. They are non-destructive, electrical, mechanical or short-term endurance tests which are employed to assess the principal characteristics of the component and whether it is capable of meeting its fundamental requirements.

Sample tests (which may be electrical, medium term endurance or mechanical, such as shock and vibration) are carried out on each lot but only a representative sample is examined. These tests are generally non-destructive, but in order to minimize the cost of testing an acceptable level of quality is assured by sample testing.

Screening, sample testing and design evaluation testing are also performed by the manufacturer during the initial approval exercise on product or products representative of the scope of capability to the highest PALS selected. This shall be done to the satisfaction of the National Supervising Inspectorate (NSI).

Design evaluation testing is performed on the initial delivery lot of each individual customer product for the full set of design evaluation tests unless structural similarity rules apply and they are mutually agreed by manufacturer and customer. The tests performed during design evaluation comprise long term electrical endurance, mechanical and environmental tests: in some cases they are destructive and, quite often, expensive. The tests are meant to provide a check on the overall design of the hybrid rather than a periodic check on quality. Because of this, the manufacturer and customer may agree not to repeat the design evaluation tests on subsequent delivery lots.

B.1.5.2 Electrical tests

The electrical tests required by the PALS are subdivided into

a) those tests at ambient temperature which define circuit functionality,

b) those test at ambient temperature other than a) above,

c) those tests which define circuit functionality at T_{min} and T_{max},

d) those tests other than a), above, at T_{min} and T_{max},

e) burn-in,

f) electrical endurance.

Item a) is sometimes known as major static and dynamic characteristics and b) as minor static and dynamic characteristics, but the difference between them is not clear cut. The differentiation between a) and b) needs to be agreed between the manufacturer and the customer when the detail specification is drawn-up but the tests at a) are those which the customer perceives as a measure of whether the circuit is functioning properly.

Tests performed at T_{min} and T_{max} (whether they are those tests which define circuit functionality or other criteria) are necessary if the circuit is required to meet its specification at extremes of temperature. Unless otherwise specified, devices shall be considered to be T_{amb} rated, whereby they will function at the maximum specified air temperature (T_{max}) without the need for further thermal management considerations. Devices which generate significant amounts of heat during operation should be T_{case} rated, whereby the responsibility for the thermal management of the devices is placed on the customer, with the manufacturer providing the required thermal management data.

Burn-in is a non-destructive test designed to screen out infant mortalities or early lifetime failures. It is assumed that by placing the device under its operating electrical load at an elevated temperature (generally the maximum operating temperature without exceeding the thermal rating of the device) the life of the device will be accelerated. The value of this test and the extension of it to electrical endurance up to 8 000 h need to be examined in the light of its derivation. 8 000 h endurance testing of a transistor-transistor logic (TTL) device at 125 °C can be roughly equated to 50 years life under normal operating conditions at 70 °C. If failure rate with time of such a discrete device is assumed to obey the classical bathtub curve, successful completion of the 8 000 h test is an indication that the end of life wear-out phase has not yet begun. Similarly, accelerated operation of the discrete device for 160 h simulates avoidance of early failure (infant mortalities) whereas 2 000 h is an assessment of the medium term life or flat portion of the bathtub curve. Thus, with a discrete device it is possible to gain a degree of insight into the short, medium and long term life expectancy. With a film hybrid, the complexity and variety of components make any such calculation much more difficult but, nevertheless, the burn-in and electrical endurance tests provide some confidence as to reliability of the manufacturer's hybrids.

The post test end-points may need to be relaxed or otherwise modified after burn-in or electrical endurance testing. Such changes (delta values) shall be agreed between customer and manufacturer in advance and be included in the customer detail specification.

B.1.5.3 Other screening tests

B.1.5.3.1 General

Certain of the PALS contain a screening sequence designed to stress the device mechanically by temperature cycling (generally between the storage temperature limits) followed first by an electrical check and then either a leak test or exposure to damp heat cyclic. The sequence may also contain acceleration. The philosophy of the test sequence is that the required minimum of 10 complete temperature cycles, whilst not representing the device life, will turn a latent defect into a patent failure.

The test is intended to stress die bonds, wire bonds, package seals and, where applicable, the integrity of leads through package walls. Any damage to the circuit within the package is then obvious when the device is electrically tested. Where the temperature cycling has resulted in damage to the package hermeticity, the fault can be recognized for a cavity package by leak detection.

B.1.5.3.2 Acceleration test

The acceleration test is intended to assess the satisfactory performance of components when subjected to forces produced by steady acceleration environments (other than gravity) such as occur in moving vehicles, especially flying vehicles, rotating parts and projectiles. The standard levels of test quoted in IEC 60068 range from 3 g_n to 50 000 g_n (30 m/s² to 500 000 m/s²) which are put into context when it is realized that the maximum acceleration achieved by a space rocket is only in the order of 500 g_n (although this can produce associated ringing and flexing transients up to and above a higher order). Nevertheless, the acceleration test still offers a range of standard severities between 10 g_n and 30 000 g_n, not to simulate life but to apply an artificial stress on wire bonds, die bonds and other attachments. If a stress level of 20 000 g_n is considered on a wire bond, the associated force is somewhere in the order of 1 g whereas in the case of a large semiconductor chip the force is about 0,5 kg for the same acceleration. If applied to a large (say 64 lead) chip carrier, the force rises to about 40 kg. For wire bonds and chip adhesion, the forces involved are really only testing for the poorest quality of bond and thus provide a useful back-up check once the lid has been sealed on. The situation is different for large components such as the chip carrier, since although the solder joints should comfortably bear the 20 000 g_n and its associated 40 kg force, the acceleration could cause flexing, bowing and even cracking of the mounting board which would result in premature joint fracture. It is, therefore, essential for both manufacturer and customer to set a realistic value of acceleration. The normal screening level for non-destructive acceleration testing is set at 5 000 g_n.

B.1.5.3.3 Leak test

The leak test is performed in two steps called fine and gross. The commonest form of fine leak test consists of placing the device in a chamber which is evacuated, back-filled with a specified pressure of helium and left for a period of time. It is assumed that, for a given pressure and time, the helium will pass through any holes or cracks into the main cavity of the package at a rate proportional to the size of the hole or crack. On removal from the helium "bomb", the helium flows back into the atmosphere and the rate at which it does so is again proportional to the size of the hole or crack. If this flow rate is between certain limits, the helium can be detected by the mass spectrometer of a commercial leak detector. This particular test is sensitive to leak rates between 10^{-8} atm. cm^3/s and 10^{-5} atm. cm^3/s (10^{-3} Pa cm^3/s and 1 Pa cm^3/s). It is generally assumed that a device with a leak rate of better than 10^{-8} atm. cm^3/s is "hermetic". Where the leakage path is very large, the helium forced into the package flows out very quickly and by the time the device is in the mass spectrometer it may well have disappeared, giving the appearance of a pass. It is, therefore, essential to complement fine leak testing with a gross leak test. In essence, this is done by placing the device in a hot liquid which causes the gas in the package to expand and bubble out through any hole or crack. The presence of bubbles coming from the package signifies a failure. Leak testing is not performed on non-cavity plastic encapsulated devices or plastic sealed devices.

B.1.5.3.4 Particle impact noise detection (PIND) test

Particle impart noise detection (PIND) is used to detect loose particles (such as fragments of dies) within cavity packaged hybrids. The test is labour-intensive and is normally only performed where the highest level of quality and reliability are required. The test consists, essentially, of a vibration shaker and driver assembly capable of producing a sinusoidal signal to the device under test and a shock mechanism or tool able to produce shock pulses of 1 000 g_n peak to the device. Any loose particle activated by the shock and vibration strikes the case and activates a transducer whose signal is amplified. The device under test is bonded acoustically to the transducer and is subjected to a series of shocks and vibrations in accordance with the test specification.

B.1.5.3.5 Dry heat test

The dry heat test is designed simply to verify that the hybrid is capable of being stored at elevated temperatures. It is not intended to assess the hybrid's ability to withstand variations in temperature nor is it meant to demonstrate the hybrid's capability under electrical load. In keeping with possible worst case conditions the test called for by this standard requires the device to be taken from ambient and placed directly into the oven at test temperature, allowing no time for gradual increase in temperature. The temperature chosen for the test should be the maximum that the device will see in normal life. The test will act as a screen for devices whose electrical parameters drift out of specification during storage at elevated temperature or are subject to thermally induced failures such as loss of hermeticity or bonding separation.

B.1.5.3.6 Radiographic inspection

Radiography is the use of X-ray equipment to detect defects within a packaged device. The radiographic inspection is made in one or more of the axes of the device depending upon the package size and individual requirements. It is an expensive test (both in terms of equipment and time required) and is only used where the highest levels of quality and reliability are required. The test is capable of detecting foreign or extraneous material, either loose or attached, excessive semiconductor die or substrate bonding material or voids in the bonding material, cracks, splits or chips, inadequate clearance (e.g. bond wire to lid), etc. It is predominantly used to detect defects which have occurred after the package sealing process since most other defects (apart from voids in attach material) would have been eliminated during pre-cap visual inspection.

B.1.5.4 Device sample testing

In order to keep device testing to a realistic minimum, some tests on each lot produced by the manufacturer are carried out only on a sample. This is achieved using statistical methods to ensure that the sample reflects the quality of the whole lot.

Apart from electrical testing and endurance testing, sample testing in this standard, in IEC 60748-23-2, in IEC 60748-23-3 and in IEC 60748-23-4 is confined to shock and vibration, and then only where a high degree of assurance is required.

The shock test is designed to simulate the effects of relatively infrequent, non-repetitive shocks likely to be encountered by equipment in service or during transportation. In other words, the test is not designed to prove components which are required to exist in an environment of repeated shocks and jolts. The shock tester is, in essence, a simple machine. The sample is securely fixed to a table which can be allowed to fall under gravity along rods or runners. On the underside of the table is a hammer which, at the end of the fall, impacts on to a bed of material (or anvil) with absorbent properties (usually rubber, lead or a metallic honeycomb). The combination of table height above the bed, hammer geometry and properties of the bed material define the shock experienced by the component on the table. The requirement of this standard, together with IEC 60748-23-2, IEC 60748-23-3 and IEC 60748-23-4 is for the shock to have a half sine pulse shape with a choice of severities. Most manufacturers offer a peak acceleration of 15 000 m/s^2 with a 0,5 ms pulse or 1 000 m/s^2 with a 6 ms pulse which is measured by attaching a storage oscilloscope to the shock tester.

Vibration testing is performed using vibration swept frequency, where sub-samples are vibrated in each of three mutually perpendicular axes for 2 h, one sub-sample per axis. For small components such as most of those covered by this specification, a resonance search is not considered necessary and is not called for by the test. The severity of the test can be chosen from a list given in this specification. The frequency range 100 Hz to 2 000 Hz is generally considered to be representative of frequencies found in a real life environment (such as rail transport, tanks, aircraft, etc.) and, except for large packages, is offered by most manufacturers. Again, except for large packages, most manufacturers offer the maximum severity of vibration amplitude which is associated with a corresponding value of acceleration amplitude. This is 1,5 mm and 20 g_n (200 m/s^2). The sweep rate is set at approximately one octave per minute which, for the full duration of the test, gives something in the order of one million reversals.

B.1.5.5 Design evaluation testing

B.1.5.5.1 General

The purpose of design evaluation testing is to show that the customer's design is capable of meeting certain environmental and mechanical conditions. Where the design and materials are kept constant, as demonstrated by the manufacturer's in-house controls, repetition of the design evaluation testing is considered to be unnecessary.

There is, however, no compulsion to accept this proposition and customers may request that some or all of the design evaluation tests are repeated on all lots or periodically. In all cases where a choice of the amount of testing exists, a balance shall be struck between the assurance acquired through the testing and the cost of the extra tests.

The design evaluation tests listed in the PALS contain dimensional measurements which are primarily included to ensure that device pins fit into motherboards and overall dimensions to ensure that the device is not too wide or high. Apart from the electrical test, electrical endurance tests, change of temperature, acceleration, shock and vibration, the list contains damp heat, resistance to solder heat, solderability, robustness of terminations, flammability, resistance to solvents, salt mist, residual gas analysis and radiation hardness assessment.

B.1.5.5.2 Damp heat cycling test

The damp heat cycling test, in conjunction with a subsequent electrical test, is designed to detect flaws in encapsulations. This test may also be used where the sealing test is inappropriate (e.g. plastic encapsulations). The requirement may be for 6 cycles (which is designed to detect faulty devices), whereas the 56 day test gives a degree of confidence that the device possesses an acceptable life in any kind of climate (other than shipborne above deck). The actual conditions of the test are approximately 95 % RH and cycling between 25 °C and 40 °C or 55 °C. Meteorological measurements made over many years have shown that a relative humidity of more than 95 % combined with a temperature above 30 °C does not occur in free air conditions over long periods, except in regions of extreme climate. However, these conditions can occur in confined spaces such as vehicles, tents and aircraft cockpits. Thus, although the test has an accelerated element it is not entirely divorced from a possible worst case situation. The cyclic element of the test also tends to cause cracks to flex, thus assisting moisture penetration.

B.1.5.5.3 Damp heat, steady-state test

The damp heat, steady-state tests of this standard, together with IEC 60748-23-2, IEC 60748-23-3 and IEC 60748-23-4 are used either for hermetic assemblies or non-hermetic and non-cavity encapsulations. A choice of three test methods is available. The test performed at 40 °C, 93 % relative humidity is used to assess the external aspects of the device, such as corrosion resistance. The resistance of non-cavity or epoxy-sealed devices to degradation can be assessed in an accelerated manner by performing the test at 85 °C, 85 % relative humidity with bias. Alternatively, the damp heat test may be performed with unsaturated and pressurized vapour for assessment in a highly accelerated manner with bias. This method is not intended to assess external effects of corrosion for non-cavity devices.

B.1.5.5.4 Solderability test

The solderability test, performed under controlled conditions quite simply assesses whether the terminations of the hybrid can be soldered by dipping them into solder. Upon completion of the test, the terminations are assessed for wetting, porosity, voiding and the presence of foreign material. Resistance to solder heat is designed to ensure that the whole device can withstand the temperatures produced during the soldering process. The device terminations are immersed up to a specified level in molten solder at a specified temperature for a specified time.

B.1.5.5.5 Termination robustness test

The check on termination robustness offers a choice of test methods dependent upon the actual termination. The test is designed to demonstrate that the device is capable of withstanding the potential rough handling which may result when, for example, the units are inserted into boards.

B.1.5.5.6 Resistance to solvents test

The resistance to solvents test is basically a measure of how well the plastic encapsulation (solid or cavity) can stand up to exposure to various solvents.

B.1.5.5.7 Flammability test

Flammability is applicable to plastic packages and is a check on the flammability of the plastic. The test is performed by holding the packaged device in a standard flame.

B.1.5.5.8 Change of temperature test

Change of temperature (two bath method) involves placing the plastic encapsulated devices alternately into liquids at, for example, 0 °C and +100 °C through 10 complete cycles to ensure no mechanical or electrical damage occurs.

B.1.5.5.9 Salt mist test

The salt mist test is designed to examine a hybrid's capability of withstanding shipborne (above deck) and other marine environments. It is a severe test. The specimen is placed in a chamber which is conditioned to a temperature of 35 °C. A salt mist prepared from a standard salt solution is blown through the chamber but not directly over the specimens throughout the duration of the test. The test is primarily a test of the metal parts of a hybrid, such as the solder seal, pins, header, lid and plating. The corrosive nature of the test readily detects inadequate plating on pins and the wrong material being used for headers or lids. The duration of the test may range from 16 h to 4 weeks.

B.1.5.5.10 Internal moisture content

Internal moisture content measurement by mass spectrometer is a check on hermetic cavity packages after sealing to ensure that the moisture content (and sometimes the quantity of other gases) is sufficiently low in the package atmosphere to prevent any corrosion of the hybrid elements. It is a destructive and expensive test and is normally only carried out where the highest level of assurance is required. The test is performed by puncturing the package and drawing off the atmosphere through a mass spectrometer. The normal limit for water vapour contact is $5\,000 \times 10^{-6}$. The process controls needed to meet the requirements of this test include drying and outgassing the hybrid before sealing, sealing the package under vacuum or with dried gas and ensuring that the package is truly hermetic.

B.1.5.5.11 Radiation hardness assessment

Radiation hardness assessment is performed on devices which may be susceptible to various forms of radiation. The tests are applicable to devices which are used not only in a military environment but to those that are designed to spend long periods in space where the levels of radiation are much less severe but where, nevertheless, radiation is an ever present hazard. The tests are extremely expensive.

B.1.5.6 AQLs, inspection levels and sampling plans

The number of hybrids examined during the lot-by-lot or periodic testing and the number of failures permissible without condemnation of the lot is defined by the stated AQL and inspection level of the sampling plan. The definitions of these terms and the operation of the sampling plan is explained in ISO 2859. Acceptable quality level (AQL) is defined as the maximum percent defective (or the maximum number of defects per hundred units) that, for the purposes of the sampling inspection, can be considered satisfactory as a process average. Because the majority of tests performed during design evaluation are destructive and because the hybrids may be expensive, the sampling levels are comparatively low. In order to give a high level of confidence in the ability of the device to meet the individual tests an "Acceptance on 0 failures" criterion is applied throughout.

Bibliography

ISO 9001: 2000, *Quality management systems – Requirements*

ISO 9002: 1994, *Quality systems – Model for quality assurance in production, installation and servicing*

Standards Survey

The IEC would like to offer you the best quality standards possible. To make sure that we continue to meet your needs, your feedback is essential. Would you please take a minute to answer the questions overleaf and fax them to us at +41 22 919 03 00 or mail them to the address below. Thank you!

Customer Service Centre (CSC)

International Electrotechnical Commission
3, rue de Varembé
1211 Genève 20
Switzerland

or

Fax to: **IEC**/CSC at +41 22 919 03 00

Thank you for your contribution to the standards-making process.

Nicht frankieren
Ne pas affranchir

Non affrancare
No stamp required

A Prioritaire

RÉPONSE PAYÉE

SUISSE

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
1211 GENEVA 20
Switzerland

Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: *(e.g. 60601-1-1)*

....

Q2 Please tell us in what capacity(ies) you bought the standard *(tick all that apply).* I am the/a:

- purchasing agent ❑
- librarian ❑
- researcher ❑
- design engineer ❑
- safety engineer ❑
- testing engineer ❑
- marketing specialist ❑
- other...

Q3 I work for/in/as a: *(tick all that apply)*

- manufacturing ❑
- consultant ❑
- government ❑
- test/certification facility ❑
- public utility ❑
- education ❑
- military ❑
- other...

Q4 This standard will be used for: *(tick all that apply)*

- general reference ❑
- product research ❑
- product design/development ❑
- specifications ❑
- tenders ❑
- quality assessment ❑
- certification ❑
- technical documentation ❑
- thesis ❑
- manufacturing ❑
- other...

Q5 This standard meets my needs: *(tick one)*

- not at all ❑
- nearly ❑
- fairly well ❑
- exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

- standard is out of date ❑
- standard is incomplete ❑
- standard is too academic ❑
- standard is too superficial ❑
- title is misleading ❑
- I made the wrong choice ❑
- other ....

Q7 Please assess the standard in the following categories, using the numbers:
(1) unacceptable,
(2) below average,
(3) average,
(4) above average,
(5) exceptional,
(6) not applicable

timeliness ....
quality of writing....................................
technical contents...................................
logic of arrangement of contents ....
tables, charts, graphs, figures...............
other ....

Q8 I read/use the: *(tick one)*

- French text only ❑
- English text only ❑
- both English and French texts ❑

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

....
....
....
....
....
....
....
....
....
....
....
....

ISBN 2-8318-6306-6

9 782831 863061

ICS 31.200

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND