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REDLINE VERSION

INTERNATIONAL STANDARD

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BASIC SAFETY PUBLICATION

Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution

IEC 60664-3:2016-11 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 8
4 Design requirements 10
4.1 Principles 10
4.2 Application range ~~regarding~~ with regards to the environment 10
4.3 Requirements for the types of protection 10
4.4 Dimensioning procedures 10
5 Tests 11
5.1 General 11
5.2 Specimens for testing coatings 12
5.3 Specimens for testing mouldings and potting 12
5.4 Preparation of test specimens 12
5.5 Visual examination 12
5.6 Scratch-resistance test 12
5.7 Conditioning of the test specimens 13
5.7.1 General 13
5.7.2 Cold conditioning 13
5.7.3 Dry-heat conditioning 14
5.7.4 Rapid change of temperature 14
5.7.5 Damp heat, steady-state with polarizing voltage 15
5.8 Mechanical and electrical tests after conditioning and electromigration 15
5.8.1 General test conditions 15
5.8.2 Adhesion of coating 16
5.8.3 Insulation resistance between conductors 16
5.8.4 ~~AC withstand~~ Voltage test 16
5.8.5 Partial discharge extinction voltage 17
5.9 Additional tests 17
5.9.1 General 17
5.9.2 Resistance to soldering heat 17
5.9.3 Flammability 17
5.9.4 Solvent resistance 17
Annex A (normative) Test sequences 18
Annex B (normative) Decisions to be taken by the technical committees ~~' decisions~~ 21
B.1 General 21
B.2 Decisions required by technical committees 21
B.3 Optional test conditions 21
Annex C (normative) Printed wiring board for testing coatings 22
C.1 General 22
C.2 Specification of the printed wiring board 22
C.3 Arrangement of the conductors 22
C.4 Arrangement of lands 23
C.5 Connections for the tests 23

Bibliography 26

Figure 1 – Scratch-resistance test for protecting layers 13
Figure C.1 – Configuration of the test specimen 24
Figure C.2 – Configuration of lands and adjacent conductors 25

Table 1 – Minimum spacings for type 2 protection 11
Table 2 – Dry-heat conditioning 14
Table 3 – Degrees of severities for rapid change of temperature 15
Table A.1 – Test sequence 1 18
Table A.2 – Test sequence 2 additional conditioning with respect to electromigration 19
Table A.3 – Additional tests 20

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

Part 3: Use of coating, potting or moulding for protection against pollution

FOREWORD

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International Standard IEC 60664-3 has been prepared by IEC technical committee TC 109: Insulation co-ordination for low-voltage equipment.

It has the status of a basic safety publication in accordance with IEC Guide 104.

This third edition cancels and replaces the second edition published in 2003 and Amendment 1:2010. This edition constitutes a technical revision.

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

a) information added concerning interpolation;
b) provided scratch test is only for type 2 **protection**;
c) renumbered the scratch test to follow the visual examination test, since it makes more sense there;
d) separated the tables under what is now called Annex A, to make them clearer.

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

FDIS	Report on voting
109/153/FDIS	109/154/RVD

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

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

In this standard, the following types are used:

– Terms used throughout this standard which have been defined in Clause 3: **bold type**

A list of all parts in the IEC 60664 series, published under the general title *Insulation coordination for equipment within low-voltage systems*, can be found on the IEC website.

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

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

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

This part of IEC 60664 details the conditions in which the reduction of clearance and creepage distances can apply to rigid assemblies such as **printed boards** or terminals of components. **Protection** against pollution can be achieved by any kind of encapsulation such as **coating**, potting or moulding. The **protection** may be applied to one or both sides of the assembly. This standard specifies the insulating properties of the protecting material.

Between any two unprotected conductive parts, the clearance and creepage distance requirements of IEC 60664-1 ~~or IEC 60664-5~~ apply.

This document refers only to permanent **protection**. It does not cover assemblies after repair.

Technical committees ~~need to~~ should consider the influence on the **protection** of ~~overheated~~ overheating **conductors** and components, especially under fault conditions, and to decide if any additional requirements are necessary.

Safe performance of assemblies is dependent upon a precise and controlled manufacturing process for the application of the protective system. Requirements for quality control, e.g. by sampling tests, should be considered by technical committees.

INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

Part 3: Use of coating, potting or moulding for protection against pollution

1 Scope

This part of IEC 60664 applies to assemblies protected against pollution by the use of **coating**, potting or moulding, thus allowing a reduction of clearance and creepage distances as described in ~~Part 1 or Part 5~~ IEC 60664-1.

~~NOTE 1 When reference is made to Part 1 or Part 5, IEC 60664-1 or IEC 60664-5 are meant.~~

This document describes the requirements and test procedures for two methods of **protection**:

– type 1 **protection** improves the microenvironment of the parts under the **protection**;

– type 2 **protection** is considered to be similar to **solid insulation**.

This document also applies to all kinds of protected **printed boards**, including the surface of inner layers of multi-layer boards, substrates and similarly protected assemblies. In the case of multi-layer **printed boards**, the distances through an inner layer are covered by the requirements for **solid insulation** in ~~Part 1~~ IEC 60664-1.

NOTE ~~2~~ Examples of substrates are hybrid integrated circuits and thick-film technology.

This document refers only to permanent **protection**. It does not cover assemblies that are subjected to mechanical adjustment or repair.

The principles of this standard are applicable to functional, basic, supplementary and reinforced insulation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60068-2-2~~:1974~~, ~~*Basic*~~ *Environmental testing* ~~*procedures*~~ *– Part 2-2: Tests – Test~~s~~ B: Dry heat*
~~Amendment 1 (1993)~~
~~Amendment 2 (1994)~~

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

IEC 60068-2-78:~~2001~~, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

~~IEC 60249-1:1982, *Base materials for printed circuits – Part 1: Test methods* Amendment 4 (1993)~~

~~IEC 60249-2 (all parts), *Base materials for printed circuit – Part 2: Specifications*~~

IEC 60326-2:1990, *Printed boards – Part 2: Test methods*
~~Amendment 1 (1992)~~

IEC 60454-3-1:1998/AMD1:2001, *Pressure-sensitive adhesive tapes for electrical purposes – Part 3: Specifications for individual materials – Sheet 1: PVC film tapes with pressure-sensitive adhesive*

IEC 60664-1:~~1992~~ 2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*
~~Amendment 1 (2000)~~
~~Amendment 2 (2002)~~

~~IEC 60664-5: , *Insulation coordination for equipment within low-voltage systems – Part 5: A comprehensive method for determining clearance and creepage distances equal to or less than 2 mm* [1)]~~

IEC 61189-2:2006, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures*

IEC 61189-3:2007, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

IEC 61249-2 (all parts), *Materials for printed boards and other interconnecting structures – Reinforced base materials, clad and unclad*

IEC Guide 104:~~1997~~ 2010, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60664-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org
- ISO Online browsing platform: available at http://www.iso.org/obp

~~1) To be published.~~

3.1
base material
insulating material upon which a conductive pattern may be formed

Note 1 to entry: The **base material** may be rigid or flexible, or both. It may be a dielectric or an insulated metal sheet.

[SOURCE: IEC ~~60194, definition 40.1334~~ 60050-541:1990, 541-02-01]

3.2
printed board
~~general term for completely processed printed circuit and printed wiring configurations~~ **base material** cut to size containing all required holes and bearing at least one conductive pattern.

Printed boards are typically subdivided according to

– their structure (e.g., single- and double-sided, multilayers)
– the nature of the **base material** (e.g., rigid, flexible)

~~NOTE This includes single-sided, double-sided and multilayer boards with rigid, flexible, and rigid-flex base materials~~

[SOURCE: IEC ~~60194, definition 60.1485~~ 60050-541:1990, 541-01-03]

3.3
conductor (of a printed board) single conductive path in a conductive pattern

[SOURCE: IEC ~~60194, definition 22.0251~~ 60050-541:1990, 541-01-20]

3.4
protection
~~any kind of~~ measure which reduces the influence of the environment

3.5
coating
insulating material such as varnish or dry film laid on the surface of the assembly

Note 1 to entry: **Coating** and **base material** of a **printed board** form an insulating system that may have properties similar to **solid insulation**

[SOURCE: IEC 60050-212:2010, 212-11-61].

3.6
solid insulation
solid insulating material ~~interposed~~, or a combination of solid insulating materials, placed between two conductive parts or between a conductive part and a body part

~~NOTE~~ EXAMPLE In the case of a printed board with a coating, solid insulation consists of the board itself as well as the coating. In other cases, solid insulation consists of the encapsulating material.

[SOURCE: IEC 60050-903:2013, 903-04-14]

3.7
spacing
any combination of clearances, creepage distances and insulation distances through insulation

[SOURCE: IEC 60050-471:2007, 471-01-20]

4 Design requirements

4.1 Principles

The dimensioning of **spacings** between **conductors** depends on the type of **protection** used.

When type 1 **protection** is used, dimensioning of clearances and creepage distances shall follow the requirements of ~~Part 1 or Part 5~~ IEC 60664-1. If the requirements of this standard are met, pollution degree 1 applies under the **protection**.

When type 2 **protection** is used, **spacings** between conductive parts shall meet the requirements and tests for **solid insulation** of ~~Part 1~~ IEC 60664-1 and their dimensions shall not be less than the minimum clearances specified in ~~Part 1 or Part 5~~ IEC 60664-1 for homogeneous field conditions.

4.2 Application range ~~regarding~~ with regards to the environment

The design requirements are applicable in all microenvironments.

Stresses such as temperature, chemical or mechanical stresses, or those listed in ~~3.3.2.3 of Part 1~~ 5.3.2.4 of IEC 60664-1:2007 shall be taken into account when the protective material is selected.

Absorption of humidity by the protective material shall not impair the insulation properties of the parts being protected.

NOTE Absorption of humidity can be checked by an insulation resistance measurement under humid conditions.

4.3 Requirements for the types of protection

Protection is achieved in the following ways.

– Type 1 **protection** improves the microenvironment of the parts under the **protection**. The clearance and creepage distance requirements of ~~Part 1 or Part 5~~ IEC 60664-1 for pollution degree 1 apply under the **protection**. Between two conductive parts, it is a requirement that one or both conductive parts, together with all the **spacings** between them, are covered by the **protection**.

– Type 2 **protection** is considered to be similar to **solid insulation**. Under the **protection**, the requirements for **solid insulation** specified in ~~Part 1~~ IEC 60664-1 are applicable and the **spacings** shall be not less than those specified in Table 1. The requirements for clearances and creepage distances in ~~Part 1 or Part 5~~ IEC 60664-1 do not apply. Between two conductive parts, it is a requirement that both conductive parts, together with all the **spacings** between them, are covered by the **protection** so that no air gap exists between the protective material, the conductive parts and the **printed board**.

Clearance and creepage distance requirements according to ~~Part 1 or Part 5~~ IEC 60664-1 apply to all unprotected parts of the equipment.

4.4 Dimensioning procedures

For type 1 **protection**, the dimensioning requirements of ~~3.1 and 3.2 of Part 1 or Part 5~~ 5.1 and 5.2 of IEC 60664-1:2007 apply.

For type 2 **protection**, the **spacing** between the **conductors** before the **protection** is applied shall not be less than the values as specified in Table 1. These values apply to basic insulation, supplementary insulation as well as reinforced insulation. These values may also be applied to functional insulation.

NOTE In case of multi-layer boards, the **spacing** between the **conductors** at the surface of inner layers is dimensioned as specified for type 1 **protection** or type 2 **protection** depending on the result of the tests on the **protection**.

Table 1 – Minimum spacings for type 2 protection

Maximum peak value of any voltage [a] kV	**Minimum spacings** mm
≤ 0,33	0,01
> 0,33 and ≤ 0,4	0,02
> 0,4 and ≤ 0,5	0,04
> 0,5 and ≤ 0,6	0,06
> 0,6 and ≤ 0,8	0,1
> 0,8 and ≤ 1,0	0,15
> 1,0 and ≤ 1,2	0,2
> 1,2 and ≤ 1,5	0,3
> 1,5 and ≤ 2,0	0,45
> 2,0 and ≤ 2,5	0,6
> 2,5 and ≤ 3,0	0,8
> 3,0 and ≤ 4,0	1,2
> 4,0 and ≤ 5,0	1,5
> 5,0 and ≤ 6,0	2
> 6,0 and ≤ 8,0	3
> 8,0 and ≤ 10	3,5
> 10 and ≤ 12	4,5
> 12 and ≤ 15	5,5
> 15 and ≤ 20	8
> 20 and ≤ 25	10
> 25 and ≤ 30	12,5
> 30 and ≤ 40	17
> 40 and ≤ 50	22
> 50 and ≤ 60	27
> 60 and ≤ 80	35
> 80 and ≤ 100	45
[a] Transient overvoltages are disregarded since they are unlikely to degrade the protected assembly.	

Compliance is checked by measurement of the **spacing** before applying the **protection**.

5 Tests

5.1 General

The suitability of **protection** is evaluated by carrying out all the tests described in 5.8 after the conditioning described in 5.7.

The suitability of **protection** is evaluated after the visual examination test described in 5.5, the scratch-resistance test described in 5.6 and the subsequent conditioning described in 5.7.

Six specimens are used unless otherwise specified by technical committees. In addition, technical committees may specify the additional tests of 5.9, each of which is carried out on a separate new specimen.

These tests are designed for type testing. Technical committees should consider if any of the tests shall be specified for routine or sampling tests.

The sequence of tests is shown in Annex A.

No failure of any specimen under test is permitted.

Annex B lists the decisions required to be taken by technical committees when referring to this standard.

5.2 Specimens for testing coatings

Test specimens may be:

– test specimens according to Annex C, which specifically applies for printed wiring boards; the specimen used for testing shall have the same minimum distances as those from production;
– specimens from production; or
– any **printed board**, as long as the test specimens are representative of those from production.

5.3 Specimens for testing mouldings and potting

Production specimens shall be used, or they shall be representative of those from production.

5.4 Preparation of test specimens

Printed boards shall be cleaned and coated using the normal procedure of the manufacturer. The soldering procedure is carried out but without the components being in place. Moulded and potted specimens shall be tested without further preparation.

5.5 Visual examination

The specimens shall be visually examined according to test ~~1b in 5.1.2 of IEC 60326-2~~ 3V02 in 6.2 of IEC 61189-3:2007.

The specimens shall show no

– blistering,
– swelling,
– separation from the **base material**,
– cracks,
– voids,
– areas with adjacent unprotected conductive parts, with the exception of lands,
– electromigration (following electromigration conditioning),

following the test sequence criteria given in the tables within Annex A.

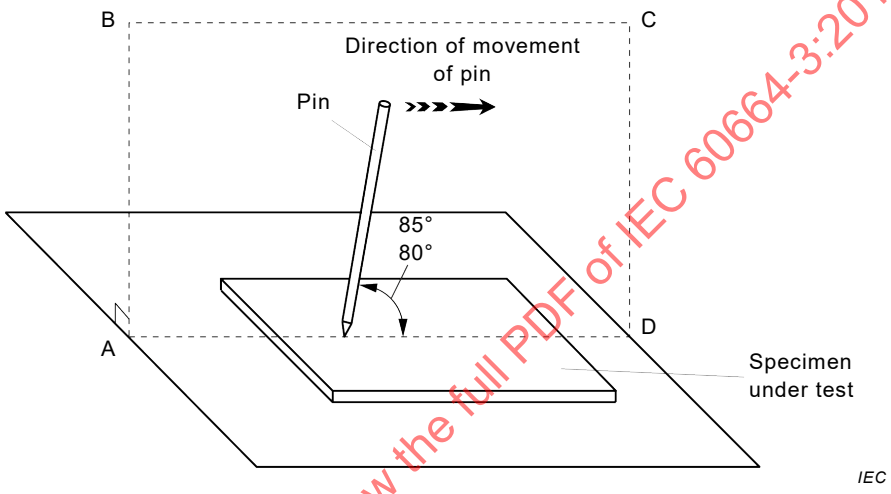
5.6 Scratch-resistance test

The scratch-resistance test is only carried out for type 2 **protection**. Prior to the sequence of tests for type 2 **protection**, the test samples shall be subjected to the scratch-resistance test.

NOTE In some cases, the scratch-resistance test cannot be applied to assemblies protected against pollution by the use of potting or moulding. In such cases, considerations for any alternative or additional tests can be necessary.

Scratches shall be made across five pairs of conducting parts and the intervening separations at points where the ~~separations~~ insulation will be subject to the maximum ~~potential gradient during the tests~~ electric field strength between **conductors**.

Protective layers shall be scratched by means of a hardened steel pin, the end of which has the form of a cone with an angle of 40°. Its tip shall be rounded and polished, with a radius of 0,25 mm ± 0,02 mm. The pin shall be loaded so that the force exerted along its axis is 10 N ± 0,5 N. The scratches shall be made by drawing the pin along the surface in a plane perpendicular to the **conductor** edges of the protective layer at a speed of approximately 20 mm/s as shown in Figure 1. Five scratches shall be made at least 5 mm apart and at least 5 mm from the edges.



NOTE The pin is in the plane ABCD which is perpendicular to the specimen under test.

Figure 1 – Scratch-resistance test for protecting layers

5.7 Conditioning of the test specimens

5.7.1 General

The conditioning methods are suitable for the majority of applications. For particular applications, a modification of the parameters specified for the conditioning may be appropriate and should be considered by technical committees.

NOTE The climatic sequence from 5.7.2 to 5.7.5 is intended to simulate ageing.

5.7.2 Cold conditioning

The cold conditioning (simulation of storage and transportation) is carried out according to test Ab of IEC 60068-2-1. The severities shall be specified by the technical committees and selected from the following temperatures:

– −10 °C
– −25 °C
– −40 °C
– −65 °C

The duration of the test is 96 h.

5.7.3 Dry-heat conditioning

The dry-heat conditioning is carried out according to test Bb of IEC 60068-2-2. However, the conditioning time and conditioning temperature corresponds to the composition of the **printed board** and the working surface temperature shown in Table 2. Interpolation of Table 2's maximum working surface temperatures and corresponding conditioning temperature values is allowed.

Table 2 – Dry-heat conditioning

Resin/base material	Maximum working surface temperature °C	Conditioning temperature °C	Conditioning time h
Epoxide/cellulose paper	105	165	1 000
	75	125	1 000
Epoxide/woven glass surfaces/cellulose paper core	140	175	1 000
	100	125	1 000
	75	95	1 000
Epoxide/woven glass surfaces/ non-woven glass core	140	175	1 000
	100	125	1 000
	75	95	1 000
Epoxide/woven glass	140	175	1 000
	100	125	1 000
	75	95	1 000
Polyester/glass mat	160	200	1 000
	100	130	1 000
	75	100	1 000
Phenolic/cellulose paper (with defined flammability – vertical burning test) [a)]	110	155	1 000
	75	110	1 000
Phenolic/cellulose paper	125	170	1 000
	100	140	1 000
	75	110	1 000

a) For defined flammability, refer to ~~IEC 60249-1, subclause 4.3.4~~ 8.6 of IEC 61189-2:2006 and the relevant part of IEC ~~60249-2~~ 61249-2.

5.7.4 Rapid change of temperature

The rapid change of temperature conditioning is in accordance with test Na of IEC 60068-2-14. The temperatures are in accordance with Table 3, where the degree of severity shall be specified by the relevant technical committee.

Table 3 – Degrees of severities for rapid change of temperature

Degree of severity	Minimum temperature °C	Maximum temperature °C
1	−10	125
2	−25	125
3	−40	125
4	−65	125

The conditioning is carried out as follows:

– duration of one cycle: 1 h (30 min ± 2 min at each temperature)
– rate of change of temperature: within 30 s
– number of cycles: ~~5~~ 50

When a protected assembly is likely to be subjected to many variations of temperature during its service life, the technical committee may specify an increased number of cycles.

5.7.5 Damp heat, steady-state with polarizing voltage

5.7.5.1 General conditioning

The test specimens shall be placed in the humidity chamber for 96 h under conditions ~~according to~~ defined in test Cab of IEC 60068-2-78 as follows:

– temperature: 40 °C ± 2 °C
– relative humidity: $93\,\%^{+2\,\%}_{-3\,\%}$

A DC voltage of 100 V is applied between **conductors** and adjacent lands. When a test specimen ~~according to~~ as defined in Annex C is used, the positive pole of the supply shall be connected to the "common".

The test result is assessed according to 5.6, 5.8.3, 5.8.4 and 5.8.5.

5.7.5.2 Additional conditioning with respect to electromigration

When equipment can be expected to be subject to abnormally severe conditions of pollution or humidity for significant periods during its service life, technical committees may specify a longer DC voltage test under damp heat conditions.

In order to minimize the overall testing time, this test should be carried out on six new test specimens which have been subjected to the soldering process (see 5.4), scratch-resistance test (only for type 2 **protection**) (see 5.6) and visual examination (see 5.5) only. The test is carried out according to 5.7.5.1. Preferred durations are 10 days, 21 days or 56 days.

5.8 Mechanical and electrical tests after conditioning and electromigration

5.8.1 General test conditions

The tests are carried out in a room having a temperature of between 15 °C to 35 °C and a relative humidity of between 45 % and 75 %.

For the tests of 5.8.3, 5.8.4 and 5.8.5, the specimens are placed in a chamber having a temperature of 40 °C ± 2 °C and a relative humidity of $93\%^{+2\%}_{-3\%}$ in accordance with

IEC 60068-2-78 for 48 h. The test in 5.8.3 shall be conducted while the specimens are in the humidity chamber. The tests in 5.8.4 and 5.8.5 shall be conducted within one hour after removing the specimens from the humidity chamber.

5.8.2 Adhesion of coating

The tested area shall contain portions of metalization and **base material**.

The specimen shall be cleaned with a suitable organic solvent and allowed to dry.

Non-transferable transparent pressure-sensitive tape, in accordance with IEC 60454-3-1, is used. The tape shall have a minimum width of 13 mm. A suitable tape is IEC 60454-3-1-5/F-PVCP/90x. A new piece of tape shall be used for each test.

A 50-mm length of the tape is applied to the test specimen. Air bubbles are excluded by using means such as finger pressure, a hand roller or an eraser.

Within 10 s, the tape is removed by a snap pull applied approximately perpendicular to the surface of the test specimen.

NOTE A minimum achievable pull force ~~may~~ can be specified by technical committees.

After the test, the **coating** shall not have loosened and there shall be no material transferred to the tape that is visible to the naked eye. In order to assess whether there has been any transfer of material, the tape may be placed on a sheet of white paper or card. If a white or light-coloured **coating** is being tested, a suitably contrasting coloured paper or card is used instead.

5.8.3 Insulation resistance between conductors

The test shall be carried out according to ~~6.4.1 of IEC 60326-2~~ 10.3 of IEC 61189-3:2007, the voltage specified for test ~~6a~~ method 3E03 being as close to the working voltage as possible.

The minimum value for the insulation resistance between the **conductors** shall be 100 MΩ, unless otherwise specified by technical committees.

5.8.4 ~~AC withstand~~ Voltage test

With a type 1 **protection** the impulse voltage test shall be carried out according to 6.1.2.2.1 of IEC 60664-1:2007.

NOTE 1 Because there is no relation between pollution degree and the Uimp withstand, a conductive layer, applied on the surface of the **protection** to perform the test, is not necessary.

With a type 2 **protection**, the electrical tests on the protected specimen shall be carried out according to ~~4.1.2.3 of Part 1~~ 6.1.3.4 of IEC 60664-1:2007 with the exception that the test voltage is either as specified in ~~3.3.3.2.2 of Part 1~~ 5.3.3.2.3 of IEC 60664-1:2007 or 0,707 times the relevant rated impulse voltage according to Table F.1 of ~~Part 1~~ IEC 60664-1:2007, whichever is the higher value. If the assembly is subjected to pollution degree 3 or 4, the withstand voltage test shall be carried out with a conductive layer on the surface of the **protection** to simulate the pollution degree.

NOTE 2 The conductive layer is not connected to the test generator or to one of the lands.

Reinforced insulation shall be tested with twice the test voltage required for basic insulation.

5.8.5 Partial discharge extinction voltage

The partial discharge test is only carried out for type 2 **protection**. The partial discharge extinction voltage and the test method are specified in ~~4.1.2.4 of Part 1~~ 6.1.3.5 of IEC 60664-

1:2007. The partial discharge test voltage is 700 V peak or the peak value of the working voltage multiplied by the relevant factors described in ~~4.1.2.4 of Part 1~~ 6.1.3.5 of IEC 60664-1:2007, whichever is higher. If the assembly is subjected to pollution degree 3 or 4, the measurement of the partial discharge extinction voltage shall be carried out with a conductive layer on the surface of the **protection**.

The partial discharge extinction voltage is reached when the magnitude of the discharge does not exceed 5 pC.

5.9 Additional tests

5.9.1 General

Technical committees may require one or more of the~~se~~ tests in 5.9.2, 5.9.3 and 5.9.4 to be carried out.

5.9.2 Resistance to soldering heat

The test shall be carried out according to test ~~19c of 9.2.3 of IEC 60326-2~~ 3N02 of 11.2 of IEC 61189-3:2007.

The floating time shall be 20 s. After the test, the test specimen shall be assessed according to 5.6.

5.9.3 Flammability

The test shall be carried out according to test ~~16b of 8.4.2 of IEC 60326-2~~ 3C02 of 8.2 of IEC 61189-3:2007. The temperature shall be specified by the relevant technical committee.

The test shall be carried out on protected and unprotected assemblies. The results of the test shall not be adversely affected by the **protection**.

5.9.4 Solvent resistance

This test shall be carried out according to test 17a of 8.5 of IEC 60326-2:1990.

~~The solvent used is dichlor-methane (methylene chloride) unless otherwise specified by the technical committee.~~

The test shall be carried out using such organic solvent as agreed between user and manufacturer and as appropriate to the application.

During the handling of the organic solvent, appropriate personal protective equipment should be used.

After the test, the solvent shall be removed and the test specimen shall be assessed according to 5.6.

Annex A
(normative)

Test sequences

The following flow-chart Table A.1, Table A.2 and Table A.3 shows the order in which the tests of Clause 5 have to be carried out. No failure of any specimen under test is permitted.

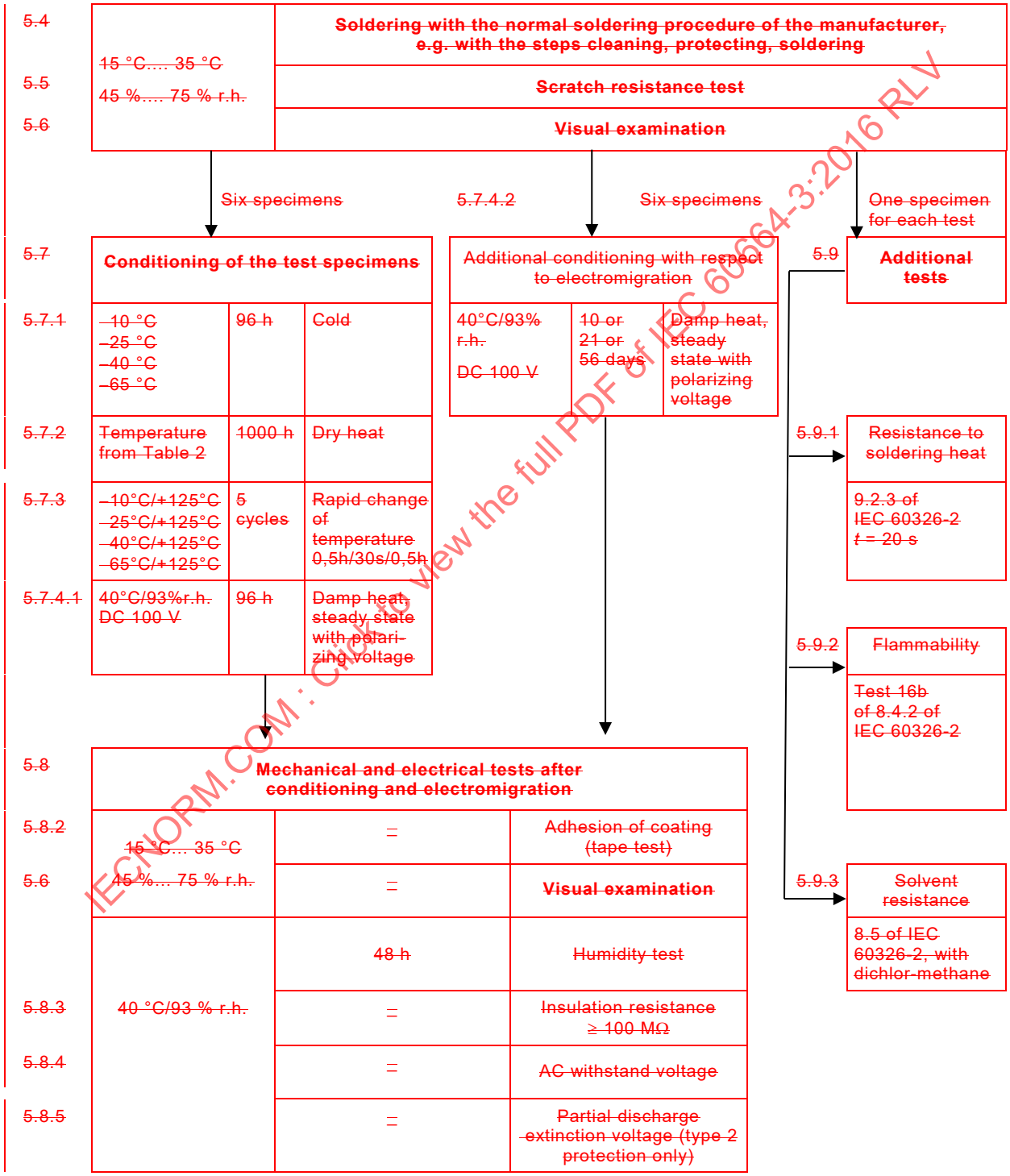


Table A.1 – Test sequence 1

Reference	Test/conditioning requirements (six specimens)		
5.4	Soldering with the normal soldering procedure of the manufacturer, e.g. with the steps cleaning, protecting, soldering		
5.6	Scratch resistance test (type 2 **protection** only)		
5.5	Visual examination		
5.7	**Conditioning of the test specimens**		
	Temperature/Humidity	**Time**	**Condition**
5.7.2	−10 °C −25 °C −40 °C −65 °C	96 h	Cold
5.7.3	Temperature from Table 2	1 000 h	Dry heat
5.7.4	−10 °C/+125 °C −25 °C/+125 °C −40 °C/+125 °C −65 °C/+125 °C	50 cycles	Rapid change of temperature 0,5 h/30 s/0,5 h
5.7.5.1	40 °C/93 % r.h. DC 100 V	96 h	Damp heat, steady state with polarizing voltage
5.8	**Mechanical and electrical tests after conditioning and electromigration**		
5.8.2	Adhesion of **coating** (tape test)		
5.5	**Visual examination**		
5.8.1	40 °C/93 % r.h	48 h	Humidity conditioning
5.8.3	Insulation resistance ≥ 100 MΩ		
5.8.4	Voltage test		
5.8.5	Partial discharge extinction voltage (type 2 **protection** only)		

Table A.2 – Test sequence 2 additional conditioning with respect to electromigration

Reference	Test/conditioning requirements (six specimens)		
5.4	Soldering with the normal soldering procedure of the manufacturer, e.g. with the steps cleaning, protecting, soldering		
5.6	Scratch resistance test (type 2 **protection** only)		
5.5	Visual examination		
5.7	**Conditioning of the test specimens**		
	Temperature/Humidity	**Time**	**Condition**
5.7.5.2	40 °C/93 % r.h. DC 100 V	10 or 21 or 56 days	Damp heat, steady state with polarizing voltage
5.8	**Mechanical and electrical tests after conditioning and electromigration**		
5.8.2	Adhesion of **coating** (tape test)		
5.5	**Visual examination**		
5.8.1	40 °C/93 % r.h	48 h	Humidity conditioning
5.8.3	Insulation resistance ≥ 100 MΩ		
5.8.4	Voltage test		
5.8.5	Partial discharge extinction voltage (type 2 **protection** only)		

Table A.3 – Additional tests

Reference	Test/conditioning requirements (one specimen for each test)	Reference
5.9.2	Resistance to soldering heat	11.2 of IEC 61189-3:2007 t = 20 s
5.9.3	Flammability	Test 3C02 of 8.2 of IEC 61189-3:2007
5.9.4	Solvent resistance	Solvent as agreed between user and manufacturer

Annex B
(normative)

Decisions to be taken by the technical committees~~' decisions~~

B.1 General

When referring to the standard, technical committees are required to decide on the severity levels for some of the tests and are allowed to vary some of the test conditions.

B.2 Decisions required by technical committees

The following severities have to be specified:

5.7.2	Cold	Severity temperature
5.7.4	Rapid change of temperature	Degree of severity
5.9.3	Flammability	Test temperature (if the test is specified)

B.3 Optional test conditions

The following test conditions may be varied:

5	Tests	Number of specimens specifying routine tests
5.7	Conditioning of the test specimens	Modification of the parameters
5.7.4	Rapid change of temperature	Number of cycles
5.7.4.2	Additional conditioning with respect to electromigration	Duration of damp heat test
5.8.2	Adhesion of **coating**	Specifying the pull force
5.8.3	Insulation resistance between **conductors**	Minimum value for insulation resistance
5.9	Additional tests	Specifying which additional tests are necessary
5.9.4	Solvent resistance	Specifying the solvent

Annex C
(normative)

Printed wiring board for testing coatings

C.1 General

The printed wiring board described in this annex is suitable for assessing **coatings** that have to be tested in accordance with this standard.

C.2 Specification of the printed wiring board

In order to take into account the most unfavourable conditions, the following criteria have to be considered in order to provide a standard test specimen:

– the **base material**;
– the **coating** material;
– the **conductor** material;
– the mutual adhesion of the materials;
– the thickness of the **coating** material;
– the thickness, width and shape of the **conductor**;
– the **coating** pattern (e.g. size and shape of the access holes) in relation to the conductive pattern (e.g. lands); and
– the electrical field configuration.

The standard test specimen shall incorporate the same materials and shall use the same processing procedures as the **printed boards** for production. For instance, the standard test specimen has to be subjected to all processes (e.g. cleaning and soldering) to which the **printed boards** are exposed to in the specific application.

The size of the standard test specimen shown in Figure C.1 allows for **conductor spacings** up to 0,5 mm and **conductor** widths up to 2 mm. For larger **conductor spacings** or larger **conductor** widths, it may be necessary to use a larger board than that shown in Figure C.1.

The standard test specimen shall have the configurations as shown in Figure C.1 and Figure C.2.

C.3 Arrangement of the conductors

Ten pairs of parallel **conductors**, each **conductor** having a length of 100 mm, are terminated alternatively at the edge board contacts on either side of the **printed board**, as shown in section C of Figure C.1.

– The **spacing** between the first five pairs of **conductors** is equal to the minimum **spacing** that will be used in production. These **conductors** are shown as section A in Figure C.1.
– The **spacing** between the other five pairs of **conductors** is equal to the **spacing** used in production where the highest electrical stress occurs. These **conductors** are shown as section B in Figure C.1.

The **conductors** terminating on the left-hand side of the **printed board** (side X) have equal width. This width is equivalent to the minimum width used in production.

The **conductors** terminating on the right-hand side of the **printed board** (side Y) under section A in Figure C.1 have a width progressively increasing in five steps from the smallest

to the largest used in production. This configuration is repeated for the **conductors** terminating under section B in Figure C.1.

Conductor width is an important parameter regarding the adhesion of the **coating**. Therefore, the intermediate widths shall, as far as possible, represent the widths used in production.

The ends of the **conductors** opposite to the edge board contacts shall be formed as follows:

– enlarged to 1 mm in diameter, for **conductors** less than 1 mm in width;

– semi-circular, for **conductors** having a width of 1 mm or greater.

The **spacing** between adjacent pairs of **conductors** is at least five times the **spacing** between the **conductor** pair.

The part of the **printed board** covered by section C in Figure C.1 is coated, with the exception of the edge board contacts.

C.4 Arrangement of lands

Eighty-four (84) lands shall be arranged in six groups, each group comprising two rows of seven lands, as shown in section L of Figure C.1. The lands shall be surrounded on three sides by **conductors**, as shown in Figure C.2.

The **spacing** between the lands and **conductors** for three of the groups is equal to the minimum **spacing** used in production, shown as section M in Figure C.1.

The **spacing** between the lands and **conductors** for the other three groups is equal to the **spacing** used in production where the highest electrical stress occurs, shown as section N in Figure C.1.

The dimensions of the lands, together with the dimensions and arrangement of **conductors**, shall be representative of those used in production. Examples of different lands and arrangements of **conductors** are shown in Figure C.2.

All lands in each group are connected together and terminate at an edge board contact on the right-hand side of the **printed board** (side Y). All **conductors** in each group are connected together and terminate at an edge board contact on the left-hand side of the board (side X).

The part of the **printed board** covered by section L in Figure C.1 is coated, with the exception of the edge board contacts. In addition, the lands are not coated if this is the case in production.

C.5 Connections for the tests

The measurements required in 5.8.3, 5.8.4 and 5.8.5 are made between an edge board contact X and the corresponding edge board contact Y.

For the tests of 5.7.5.1 and 5.7.5.2, the edge board contacts of side Y are connected together by means of a short-circuit connector. The test voltage is applied between the common edge board contact on side X and all the other edge board contacts are connected together.

Dimensions in millimetres

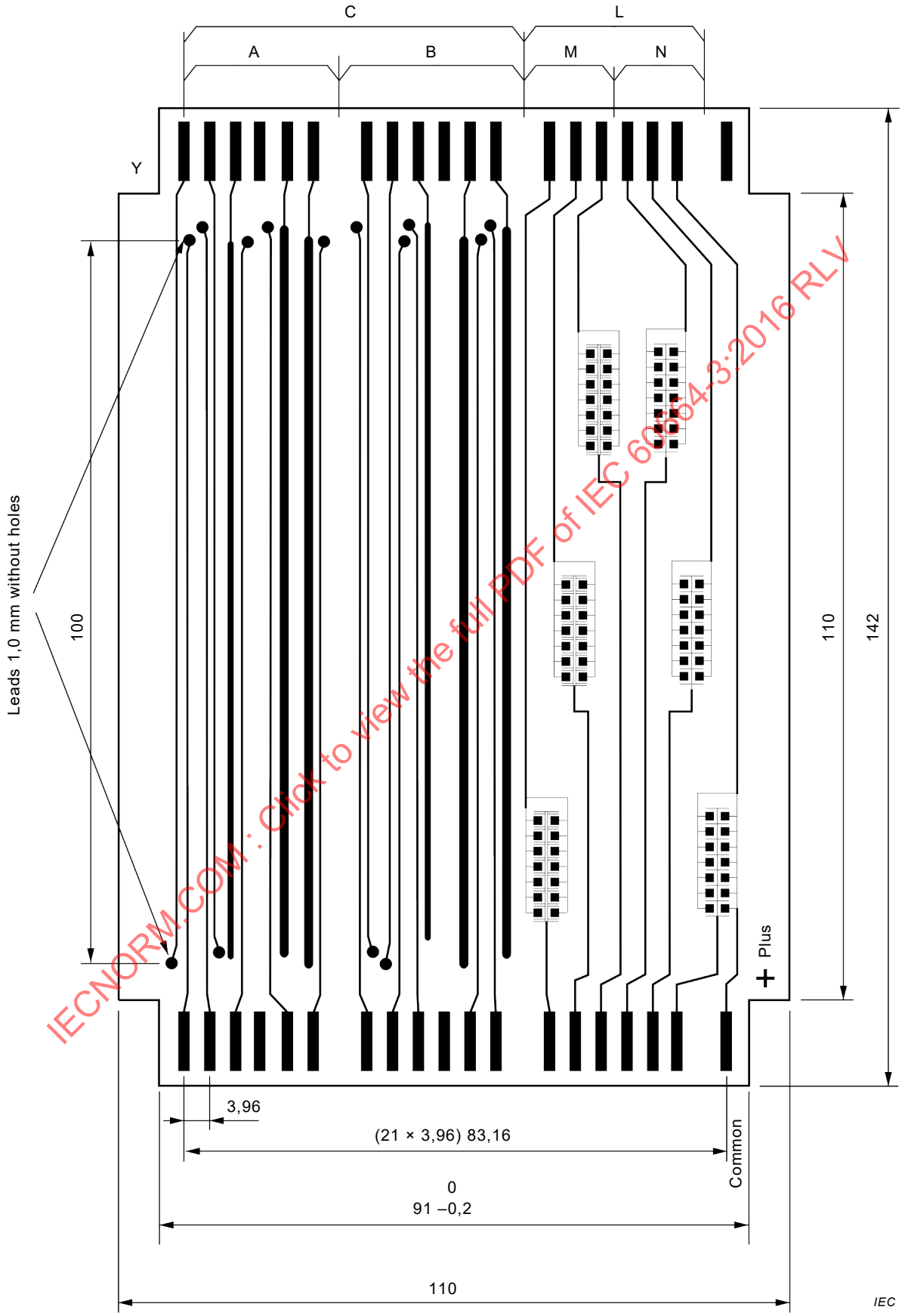


Figure C.1 – Configuration of the test specimen

Dimensions in millimetres

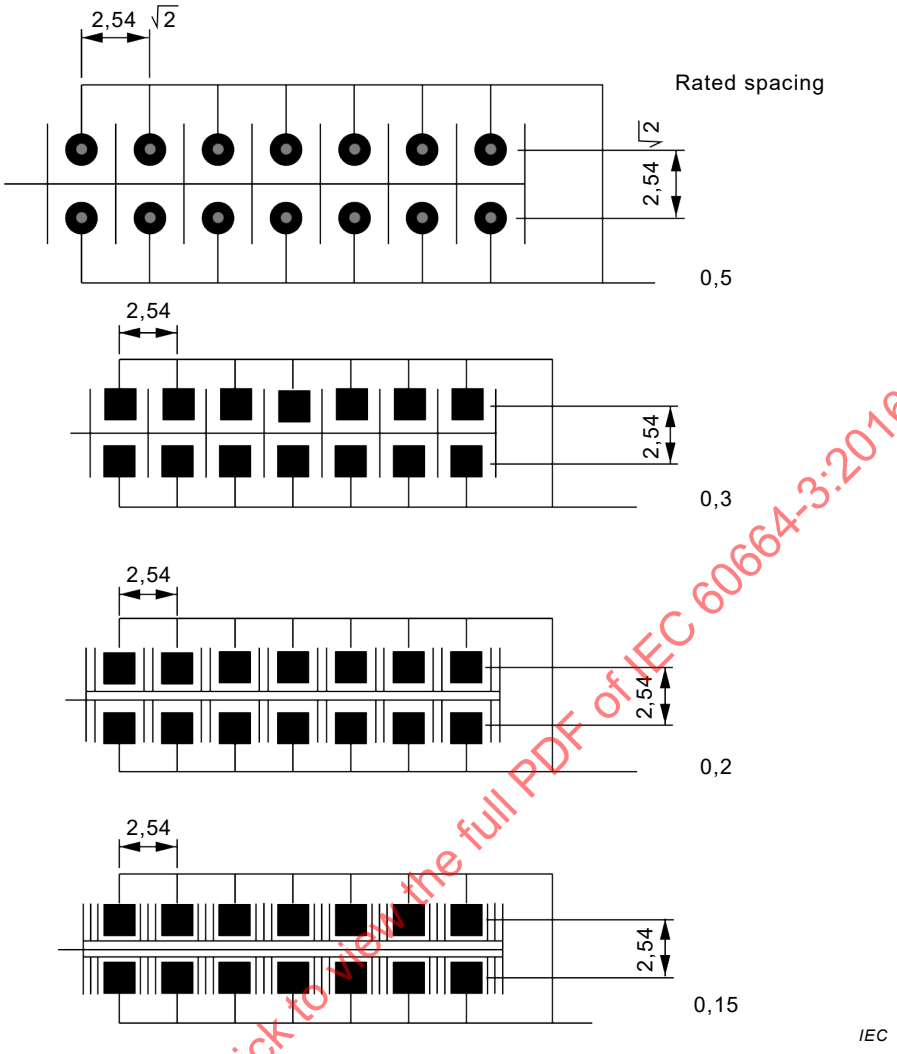


Figure C.2 – Configuration of lands and adjacent conductors

Bibliography

IEC 60194:~~1999~~ 2006, *Printed board design, manufacture and assembly – Terms and definitions*

IEC 60664-3

Edition 3.0 2016-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution

Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution

IEC 60664-3:2016-11(en-fr)

CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 8
4 Design requirements 9
4.1 Principles 9
4.2 Application range with regards to the environment 9
4.3 Requirements for the types of protection 10
4.4 Dimensioning procedures 10
5 Tests 11
5.1 General 11
5.2 Specimens for testing coatings 11
5.3 Specimens for testing mouldings and potting 12
5.4 Preparation of test specimens 12
5.5 Visual examination 12
5.6 Scratch-resistance test 12
5.7 Conditioning of the test specimens 13
5.7.1 General 13
5.7.2 Cold conditioning 13
5.7.3 Dry-heat conditioning 13
5.7.4 Rapid change of temperature 14
5.7.5 Damp heat, steady-state with polarizing voltage 15
5.8 Mechanical and electrical tests after conditioning and electromigration 15
5.8.1 General test conditions 15
5.8.2 Adhesion of coating 15
5.8.3 Insulation resistance between conductors 16
5.8.4 Voltage test 16
5.8.5 Partial discharge extinction voltage 16
5.9 Additional tests 16
5.9.1 General 16
5.9.2 Resistance to soldering heat 17
5.9.3 Flammability 17
5.9.4 Solvent resistance 17
Annex A (normative) Test sequences 18
Annex B (normative) Decisions to be taken by the technical committees 20
B.1 General 20
B.2 Decisions required by technical committees 20
B.3 Optional test conditions 20
Annex C (normative) Printed wiring board for testing coatings 21
C.1 General 21
C.2 Specification of the printed wiring board 21
C.3 Arrangement of the conductors 21
C.4 Arrangement of lands 22
C.5 Connections for the tests 22
Bibliography 25

Figure 1 – Scratch-resistance test for protecting layers 13
Figure C.1 – Configuration of the test specimen 23
Figure C.2 – Configuration of lands and adjacent conductors 24

Table 1 – Minimum spacings for type 2 protection 10
Table 2 – Dry-heat conditioning 14
Table 3 – Degrees of severities for rapid change of temperature 14
Table A.1 – Test sequence 1 18
Table A.2 – Test sequence 2 additional conditioning with respect to electromigration 19
Table A.3 – Additional tests 19

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

Part 3: Use of coating, potting or moulding for protection against pollution

FOREWORD

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International Standard IEC 60664-3 has been prepared by IEC technical committee TC 109: Insulation co-ordination for low-voltage equipment.

It has the status of a basic safety publication in accordance with IEC Guide 104.

This third edition cancels and replaces the second edition published in 2003 and Amendment 1:2010. This edition constitutes a technical revision.

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

a) information added concerning interpolation;
b) provided scratch test is only for type 2 **protection**;

c) renumbered the scratch test to follow the visual examination test, since it makes more sense there;

d) separated the tables under what is now called Annex A, to make them clearer.

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

FDIS	Report on voting
109/153/FDIS	109/154/RVD

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

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

In this standard, the following types are used:

– Terms used throughout this standard which have been defined in Clause 3: **bold type**

A list of all parts in the IEC 60664 series, published under the general title *Insulation coordination for equipment within low-voltage systems*, can be found on the IEC website.

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

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

INTRODUCTION

This part of IEC 60664 details the conditions in which the reduction of clearance and creepage distances can apply to rigid assemblies such as **printed boards** or terminals of components. **Protection** against pollution can be achieved by any kind of encapsulation such as **coating**, potting or moulding. The **protection** may be applied to one or both sides of the assembly. This standard specifies the insulating properties of the protecting material.

Between any two unprotected conductive parts, the clearance and creepage distance requirements of IEC 60664-1 apply.

This document refers only to permanent **protection**. It does not cover assemblies after repair.

Technical committees should consider the influence on the **protection** of overheating **conductors** and components, especially under fault conditions, and to decide if any additional requirements are necessary.

Safe performance of assemblies is dependent upon a precise and controlled manufacturing process for the application of the protective system. Requirements for quality control, e.g. by sampling tests, should be considered by technical committees.

INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

Part 3: Use of coating, potting or moulding for protection against pollution

1 Scope

This part of IEC 60664 applies to assemblies protected against pollution by the use of **coating**, potting or moulding, thus allowing a reduction of clearance and creepage distances as described in IEC 60664-1.

This document describes the requirements and test procedures for two methods of **protection**:

– type 1 **protection** improves the microenvironment of the parts under the **protection**;

– type 2 **protection** is considered to be similar to **solid insulation**.

This document also applies to all kinds of protected **printed boards**, including the surface of inner layers of multi-layer boards, substrates and similarly protected assemblies. In the case of multi-layer **printed boards**, the distances through an inner layer are covered by the requirements for **solid insulation** in IEC 60664-1.

NOTE Examples of substrates are hybrid integrated circuits and thick-film technology.

This document refers only to permanent **protection**. It does not cover assemblies that are subjected to mechanical adjustment or repair.

The principles of this standard are applicable to functional, basic, supplementary and reinforced insulation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60326-2:1990, *Printed boards – Part 2: Test methods*

IEC 60454-3-1:1998/AMD1:2001, *Pressure-sensitive adhesive tapes for electrical purposes – Part 3: Specifications for individual materials – Sheet 1: PVC film tapes with pressure – sensitive adhesive*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 61189-2:2006, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures*

IEC 61189-3:2007, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

IEC 61249-2 (all parts), *Materials for printed boards and other interconnecting structures – Reinforced base materials, clad and unclad*

IEC Guide 104:2010, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60664-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
base material
insulating material upon which a conductive pattern may be formed

Note 1 to entry: The **base material** may be rigid or flexible, or both. It may be a dielectric or an insulated metal sheet.

[SOURCE: IEC 60050-541:1990, 541-02-01]

3.2
printed board
base material cut to size containing all required holes and bearing at least one conductive pattern.

Printed boards are typically subdivided according to

– their structure (e.g., single- and double-sided, multilayers)
– the nature of the **base material** (e.g., rigid, flexible)

[SOURCE: IEC 60050-541:1990, 541-01-03]

3.3
conductor (of a printed board) single conductive path in a conductive pattern

[SOURCE: IEC 60050-541:1990, 541-01-20]

3.4
protection
measure which reduces the influence of the environment

3.5
coating
insulating material such as varnish or dry film laid on the surface of the assembly

Note 1 to entry: **Coating** and **base material** of a **printed board** form an insulating system that may have properties similar to **solid insulation**

[SOURCE: IEC 60050-212:2010, 212-11-61].

3.6
solid insulation
solid insulating material, or a combination of solid insulating materials, placed between two conductive parts or between a conductive part and a body part

EXAMPLE In the case of a printed board with a coating, solid insulation consists of the board itself as well as the coating. In other cases, solid insulation consists of the encapsulating material.

[SOURCE: IEC 60050-903:2013, 903-04-14]

3.7
spacing
any combination of clearances, creepage distances and insulation distances through insulation

[SOURCE: IEC 60050-471:2007, 471-01-20]

4 Design requirements

4.1 Principles

The dimensioning of **spacings** between **conductors** depends on the type of **protection** used.

When type 1 **protection** is used, dimensioning of clearances and creepage distances shall follow the requirements of IEC 60664-1. If the requirements of this standard are met, pollution degree 1 applies under the **protection**.

When type 2 **protection** is used, **spacings** between conductive parts shall meet the requirements and tests for **solid insulation** of IEC 60664-1 and their dimensions shall not be less than the minimum clearances specified in IEC 60664-1 for homogeneous field conditions.

4.2 Application range with regards to the environment

The design requirements are applicable in all microenvironments.

Stresses such as temperature, chemical or mechanical stresses, or those listed in 5.3.2.4 of IEC 60664-1:2007 shall be taken into account when the protective material is selected.

Absorption of humidity by the protective material shall not impair the insulation properties of the parts being protected.

NOTE Absorption of humidity can be checked by an insulation resistance measurement under humid conditions.

4.3 Requirements for the types of protection

Protection is achieved in the following ways.

– Type 1 **protection** improves the microenvironment of the parts under the **protection**. The clearance and creepage distance requirements of IEC 60664-1 for pollution degree 1 apply under the **protection**. Between two conductive parts, it is a requirement that one or both conductive parts, together with all the **spacings** between them, are covered by the **protection**.

– Type 2 **protection** is considered to be similar to **solid insulation**. Under the **protection**, the requirements for **solid insulation** specified in IEC 60664-1 are applicable and the **spacing**s shall be not less than those specified in Table 1. The requirements for clearances and creepage distances in IEC 60664-1 do not apply. Between two conductive parts, it is a requirement that both conductive parts, together with all the **spacings** between them, are covered by the **protection** so that no air gap exists between the protective material, the conductive parts and the **printed board**.

Clearance and creepage distance requirements according to IEC 60664-1 apply to all unprotected parts of the equipment.

4.4 Dimensioning procedures

For type 1 **protection**, the dimensioning requirements of 5.1 and 5.2 of IEC 60664-1:2007 apply.

For type 2 **protection**, the **spacing** between the **conductors** before the **protection** is applied shall not be less than the values as specified in Table 1. These values apply to basic insulation, supplementary insulation as well as reinforced insulation. These values may also be applied to functional insulation.

NOTE In case of multi-layer boards, the **spacing** between the **conductors** at the surface of inner layers is dimensioned as specified for type 1 **protection** or type 2 **protection** depending on the result of the tests on the **protection**.

Table 1 – Minimum spacings for type 2 protection

Maximum peak value of any voltage [a)] kV	Minimum spacings mm
≤ 0,33	0,01
> 0,33 and ≤ 0,4	0,02
> 0,4 and ≤ 0,5	0,04
> 0,5 and ≤ 0,6	0,06
> 0,6 and ≤ 0,8	0,1
> 0,8 and ≤ 1,0	0,15
> 1,0 and ≤ 1,2	0,2
> 1,2 and ≤ 1,5	0,3
> 1,5 and ≤ 2,0	0,45
> 2,0 and ≤ 2,5	0,6
> 2,5 and ≤ 3,0	0,8
> 3,0 and ≤ 4,0	1,2
> 4,0 and ≤ 5,0	1,5
> 5,0 and ≤ 6,0	2
> 6,0 and ≤ 8,0	3
> 8,0 and ≤ 10	3,5

Maximum peak value of any voltage [a] kV	**Minimum spacings** mm
> 10 and ≤ 12	4,5
> 12 and ≤ 15	5,5
> 15 and ≤ 20	8
> 20 and ≤ 25	10
> 25 and ≤ 30	12,5
> 30 and ≤ 40	17
> 40 and ≤ 50	22
> 50 and ≤ 60	27
> 60 and ≤ 80	35
> 80 and ≤ 100	45
a) Transient overvoltages are disregarded since they are unlikely to degrade the protected assembly.	

Compliance is checked by measurement of the **spacing** before applying the **protection**.

5 Tests

5.1 General

The suitability of **protection** is evaluated by carrying out all the tests described in 5.8 after the conditioning described in 5.7.

The suitability of **protection** is evaluated after the visual examination test described in 5.5, the scratch-resistance test described in 5.6 and the subsequent conditioning described in 5.7. Six specimens are used unless otherwise specified by technical committees. In addition, technical committees may specify the additional tests of 5.9, each of which is carried out on a separate new specimen.

These tests are designed for type testing. Technical committees should consider if any of the tests shall be specified for routine or sampling tests.

The sequence of tests is shown in Annex A.

No failure of any specimen under test is permitted.

Annex B lists the decisions required to be taken by technical committees when referring to this standard.

5.2 Specimens for testing coatings

Test specimens may be:

– test specimens according to Annex C, which specifically applies for printed wiring boards; the specimen used for testing shall have the same minimum distances as those from production;

– specimens from production; or

– any **printed board**, as long as the test specimens are representative of those from production.

5.3 Specimens for testing mouldings and potting

Production specimens shall be used, or they shall be representative of those from production.

5.4 Preparation of test specimens

Printed boards shall be cleaned and coated using the normal procedure of the manufacturer. The soldering procedure is carried out but without the components being in place. Moulded and potted specimens shall be tested without further preparation.

5.5 Visual examination

The specimens shall be visually examined according to test 3V02 in 6.2 of IEC 61189-3:2007.

The specimens shall show no

– blistering,
– swelling,
– separation from the **base material**,
– cracks,
– voids,
– areas with adjacent unprotected conductive parts, with the exception of lands,
– electromigration (following electromigration conditioning),

following the test sequence criteria given in the tables within Annex A.

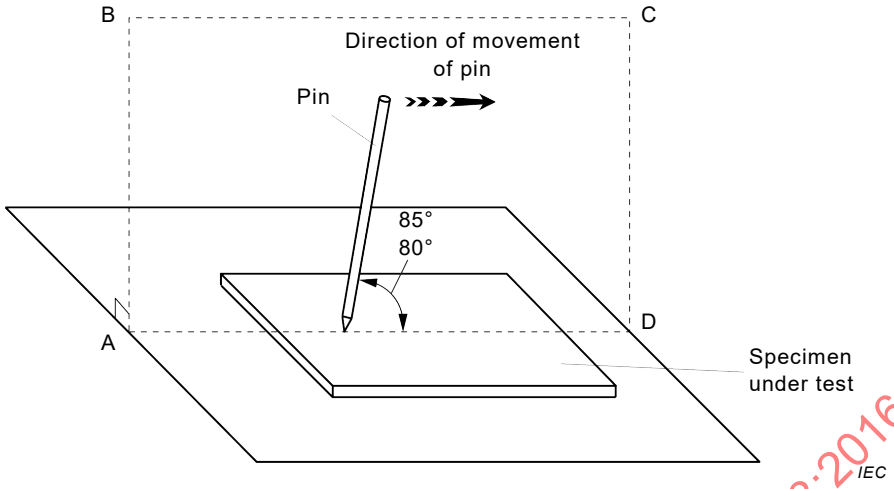
5.6 Scratch-resistance test

The scratch-resistance test is only carried out for type 2 **protection**. Prior to the sequence of tests for type 2 **protection**, the test samples shall be subjected to the scratch-resistance test.

NOTE In some cases, the scratch-resistance test cannot be applied to assemblies protected against pollution by the use of potting or moulding. In such cases, considerations for any alternative or additional tests can be necessary.

Scratches shall be made across five pairs of conducting parts and the intervening separations at points where the insulation will be subject to the maximum electric field strength between **conductors**.

Protective layers shall be scratched by means of a hardened steel pin, the end of which has the form of a cone with an angle of 40°. Its tip shall be rounded and polished, with a radius of 0,25 mm ± 0,02 mm. The pin shall be loaded so that the force exerted along its axis is 10 N ± 0,5 N. The scratches shall be made by drawing the pin along the surface in a plane perpendicular to the **conductor** edges of the protective layer at a speed of approximately 20 mm/s as shown in Figure 1. Five scratches shall be made at least 5 mm apart and at least 5 mm from the edges.



NOTE The pin is in the plane ABCD which is perpendicular to the specimen under test.

Figure 1 – Scratch-resistance test for protecting layers

5.7 Conditioning of the test specimens

5.7.1 General

The conditioning methods are suitable for the majority of applications. For particular applications, a modification of the parameters specified for the conditioning may be appropriate and should be considered by technical committees.

NOTE The climatic sequence from 5.7.2 to 5.7.5 is intended to simulate ageing.

5.7.2 Cold conditioning

The cold conditioning (simulation of storage and transportation) is carried out according to test Ab of IEC 60068-2-1. The severities shall be specified by the technical committees and selected from the following temperatures:

– −10 °C
– −25 °C
– −40 °C
– −65 °C

The duration of the test is 96 h.

5.7.3 Dry-heat conditioning

The dry-heat conditioning is carried out according to test Bb of IEC 60068-2-2. However, the conditioning time and conditioning temperature corresponds to the composition of the **printed board** and the working surface temperature shown in Table 2. Interpolation of Table 2's maximum working surface temperatures and corresponding conditioning temperature values is allowed.

Table 2 – Dry-heat conditioning

Resin/base material	Maximum working surface temperature °C	Conditioning temperature °C	Conditioning time h
Epoxide/cellulose paper	105	165	1 000
	75	125	1 000
Epoxide/woven glass surfaces/cellulose paper core	140	175	1 000
	100	125	1 000
	75	95	1 000
Epoxide/woven glass surfaces/ non-woven glass core	140	175	1 000
	100	125	1 000
	75	95	1 000
Epoxide/woven glass	140	175	1 000
	100	125	1 000
	75	95	1 000
Polyester/glass mat	160	200	1 000
	100	130	1 000
	75	100	1 000
Phenolic/cellulose paper (with defined flammability – vertical burning test) [a)]	110	155	1 000
	75	110	1 000
Phenolic/cellulose paper	125	170	1 000
	100	140	1 000
	75	110	1 000

[a)] For defined flammability, refer to 8.6 of IEC 61189-2:2006 and the relevant part of IEC 61249-2.

5.7.4 Rapid change of temperature

The rapid change of temperature conditioning is in accordance with test Na of IEC 60068-2-14. The temperatures are in accordance with Table 3, where the degree of severity shall be specified by the relevant technical committee.

Table 3 – Degrees of severities for rapid change of temperature

Degree of severity	Minimum temperature °C	Maximum temperature °C
1	−10	125
2	−25	125
3	−40	125
4	−65	125

The conditioning is carried out as follows:

– duration of one cycle: 1 h (30 min ± 2 min at each temperature)
– rate of change of temperature: within 30 s
– number of cycles: 50

When a protected assembly is likely to be subjected to many variations of temperature during its service life, the technical committee may specify an increased number of cycles.

5.7.5 Damp heat, steady-state with polarizing voltage

5.7.5.1 General conditioning

The test specimens shall be placed in the humidity chamber for 96 h under conditions defined in test Cab of IEC 60068-2-78 as follows:

– temperature: 40 °C ± 2 °C

– relative humidity: $93\,\%^{+2\,\%}_{-3\,\%}$

A DC voltage of 100 V is applied between **conductors** and adjacent lands. When a test specimen as defined in Annex C is used, the positive pole of the supply shall be connected to the "common".

The test result is assessed according to 5.6, 5.8.3, 5.8.4 and 5.8.5.

5.7.5.2 Additional conditioning with respect to electromigration

When equipment can be expected to be subject to abnormally severe conditions of pollution or humidity for significant periods during its service life, technical committees may specify a longer DC voltage test under damp heat conditions.

In order to minimize the overall testing time, this test should be carried out on six new test specimens which have been subjected to the soldering process (see 5.4), scratch-resistance test (only for type 2 **protection**) (see 5.6) and visual examination (see 5.5) only. The test is carried out according to 5.7.5.1. Preferred durations are 10 days, 21 days or 56 days.

5.8 Mechanical and electrical tests after conditioning and electromigration

5.8.1 General test conditions

The tests are carried out in a room having a temperature of between 15 °C to 35 °C and a relative humidity of between 45 % and 75 %.

For the tests of 5.8.3, 5.8.4 and 5.8.5, the specimens are placed in a chamber having a temperature of 40 °C ± 2 °C and a relative humidity of $93\%^{+2\%}_{-3\%}$ in accordance with IEC 60068-2-78 for 48 h. The test in 5.8.3 shall be conducted while the specimens are in the humidity chamber. The tests in 5.8.4 and 5.8.5 shall be conducted within one hour after removing the specimens from the humidity chamber.

5.8.2 Adhesion of coating

The tested area shall contain portions of metalization and **base material**.

The specimen shall be cleaned with a suitable organic solvent and allowed to dry.

Non-transferable transparent pressure-sensitive tape, in accordance with IEC 60454-3-1, is used. The tape shall have a minimum width of 13 mm. A suitable tape is IEC 60454-3-1-5/F-PVCP/90x. A new piece of tape shall be used for each test.

A 50-mm length of the tape is applied to the test specimen. Air bubbles are excluded by using means such as finger pressure, a hand roller or an eraser.

Within 10 s, the tape is removed by a snap pull applied approximately perpendicular to the surface of the test specimen.

NOTE A minimum achievable pull force can be specified by technical committees.

After the test, the **coating** shall not have loosened and there shall be no material transferred to the tape that is visible to the naked eye. In order to assess whether there has been any transfer of material, the tape may be placed on a sheet of white paper or card. If a white or light-coloured **coating** is being tested, a suitably contrasting coloured paper or card is used instead.

5.8.3 Insulation resistance between conductors

The test shall be carried out according to 10.3 of IEC 61189-3:2007, the voltage specified for test method 3E03 being as close to the working voltage as possible.

The minimum value for the insulation resistance between the **conductors** shall be 100 MΩ, unless otherwise specified by technical committees.

5.8.4 Voltage test

With a type 1 **protection** the impulse voltage test shall be carried out according to 6.1.2.2.1 of IEC 60664-1:2007.

NOTE 1 Because there is no relation between pollution degree and the Uimp withstand, a conductive layer, applied on the surface of the **protection** to perform the test, is not necessary.

With a type 2 **protection**, the electrical tests on the protected specimen shall be carried out according to 6.1.3.4 of IEC 60664-1:2007 with the exception that the test voltage is either as specified in 5.3.3.2.3 of IEC 60664-1:2007 or 0,707 times the relevant rated impulse voltage according to Table F.1 of IEC 60664-1:2007, whichever is the higher value. If the assembly is subjected to pollution degree 3 or 4, the withstand voltage test shall be carried out with a conductive layer on the surface of the **protection** to simulate the pollution degree.

NOTE 2 The conductive layer is not connected to the test generator or to one of the lands.

Reinforced insulation shall be tested with twice the test voltage required for basic insulation.

5.8.5 Partial discharge extinction voltage

The partial discharge test is only carried out for type 2 **protection**. The partial discharge extinction voltage and the test method are specified in 6.1.3.5 of IEC 60664-1:2007. The partial discharge test voltage is 700 V peak or the peak value of the working voltage multiplied by the relevant factors described in 6.1.3.5 of IEC 60664-1:2007, whichever is higher. If the assembly is subjected to pollution degree 3 or 4, the measurement of the partial discharge extinction voltage shall be carried out with a conductive layer on the surface of the **protection**.

The partial discharge extinction voltage is reached when the magnitude of the discharge does not exceed 5 pC.

5.9 Additional tests

5.9.1 General

Technical committees may require one or more of the tests in 5.9.2, 5.9.3 and 5.9.4 to be carried out.

5.9.2 Resistance to soldering heat

The test shall be carried out according to test 3N02 of 11.2 of IEC 61189-3:2007.

The floating time shall be 20 s. After the test, the test specimen shall be assessed according to 5.6.

5.9.3 Flammability

The test shall be carried out according to test 3C02 of 8.2 of IEC 61189-3:2007. The temperature shall be specified by the relevant technical committee.

The test shall be carried out on protected and unprotected assemblies. The results of the test shall not be adversely affected by the **protection**.

5.9.4 Solvent resistance

This test shall be carried out according to test 17a of 8.5 of IEC 60326-2:1990.

The test shall be carried out using such organic solvent as agreed between user and manufacturer and as appropriate to the application.

During the handling of the organic solvent, appropriate personal protective equipment should be used.

After the test, the solvent shall be removed and the test specimen shall be assessed according to 5.6.

Annex A
(normative)

Test sequences

The following Table A.1, Table A.2 and Table A.3 show the order in which the tests of Clause 5 have to be carried out. No failure of any specimen under test is permitted.

Table A.1 – Test sequence 1

Reference	Test/conditioning requirements (six specimens)		
5.4	Soldering with the normal soldering procedure of the manufacturer, e.g. with the steps cleaning, protecting, soldering		
5.6	Scratch resistance test (type 2 **protection** only)		
5.5	Visual examination		
5.7	**Conditioning of the test specimens**		
	Temperature/Humidity	**Time**	**Condition**
5.7.2	−10 °C −25 °C −40 °C −65 °C	96 h	Cold
5.7.3	Temperature from Table 2	1 000 h	Dry heat
5.7.4	−10 °C/+125 °C −25 °C/+125 °C −40 °C/+125 °C −65 °C/+125 °C	50 cycles	Rapid change of temperature 0,5 h/30 s/0,5 h
5.7.5.1	40 °C/93 % r.h. DC 100 V	96 h	Damp heat, steady state with polarizing voltage
5.8	**Mechanical and electrical tests after conditioning and electromigration**		
5.8.2	Adhesion of **coating** (tape test)		
5.5	**Visual examination**		
5.8.1	40 °C/93 % r.h	48 h	Humidity conditioning
5.8.3	Insulation resistance ≥ 100 MΩ		
5.8.4	Voltage test		
5.8.5	Partial discharge extinction voltage (type 2 **protection** only)		

Table A.2 – Test sequence 2 additional conditioning with respect to electromigration

Reference	Test/conditioning requirements (six specimens)		
5.4	Soldering with the normal soldering procedure of the manufacturer, e.g. with the steps cleaning, protecting, soldering		
5.6	Scratch resistance test (type 2 **protection** only)		
5.5	Visual examination		
5.7	**Conditioning of the test specimens**		
	Temperature/Humidity	**Time**	**Condition**
5.7.5.2	40 °C/93 % r.h. DC 100 V	10 or 21 or 56 days	Damp heat, steady state with polarizing voltage
5.8	**Mechanical and electrical tests after conditioning and electromigration**		
5.8.2	Adhesion of **coating** (tape test)		
5.5	**Visual examination**		
5.8.1	40 °C/93 % r.h	48 h	Humidity conditioning
5.8.3	Insulation resistance ≥ 100 MΩ		
5.8.4	Voltage test		
5.8.5	Partial discharge extinction voltage (type 2 **protection** only)		

Table A.3 – Additional tests

Reference	Test/conditioning requirements (one specimen for each test)	Reference
5.9.2	Resistance to soldering heat	11.2 of IEC 61189-3:2007 t = 20 s
5.9.3	Flammability	Test 3C02 of 8.2 of IEC 61189-3:2007
5.9.4	Solvent resistance	Solvent as agreed between user and manufacturer

Annex B
(normative)

Decisions to be taken by the technical committees

B.1 General

When referring to the standard, technical committees are required to decide on the severity levels for some of the tests and are allowed to vary some of the test conditions.

B.2 Decisions required by technical committees

The following severities have to be specified:

5.7.2	Cold	Severity temperature
5.7.4	Rapid change of temperature	Degree of severity
5.9.3	Flammability	Test temperature (if the test is specified)

B.3 Optional test conditions

The following test conditions may be varied:

5	Tests	Number of specimens specifying routine tests
5.7	Conditioning of the test specimens	Modification of the parameters
5.7.4	Rapid change of temperature	Number of cycles
5.7.4.2	Additional conditioning with respect to electromigration	Duration of damp heat test
5.8.2	Adhesion of **coating**	Specifying the pull force
5.8.3	Insulation resistance between **conductors**	Minimum value for insulation resistance
5.9	Additional tests	Specifying which additional tests are necessary
5.9.4	Solvent resistance	Specifying the solvent

Annex C
(normative)

Printed wiring board for testing coatings

C.1 General

The printed wiring board described in this annex is suitable for assessing **coatings** that have to be tested in accordance with this standard.

C.2 Specification of the printed wiring board

In order to take into account the most unfavourable conditions, the following criteria have to be considered in order to provide a standard test specimen:

– the **base material**;
– the **coating** material;
– the **conductor** material;
– the mutual adhesion of the materials;
– the thickness of the **coating** material;
– the thickness, width and shape of the **conductor**;
– the **coating** pattern (e.g. size and shape of the access holes) in relation to the conductive pattern (e.g. lands); and
– the electrical field configuration.

The standard test specimen shall incorporate the same materials and shall use the same processing procedures as the **printed boards** for production. For instance, the standard test specimen has to be subjected to all processes (e.g. cleaning and soldering) to which the **printed boards** are exposed to in the specific application.

The size of the standard test specimen shown in Figure C.1 allows for **conductor spacing**s up to 0,5 mm and **conductor** widths up to 2 mm. For larger **conductor spacings** or larger **conductor** widths, it may be necessary to use a larger board than that shown in Figure C.1.

The standard test specimen shall have the configurations as shown in Figure C.1 and Figure C.2.

C.3 Arrangement of the conductors

Ten pairs of parallel **conductors**, each **conductor** having a length of 100 mm, are terminated alternatively at the edge board contacts on either side of the **printed board**, as shown in section C of Figure C.1.

– The **spacing** between the first five pairs of **conductors** is equal to the minimum **spacing** that will be used in production. These **conductors** are shown as section A in Figure C.1.
– The **spacing** between the other five pairs of **conductors** is equal to the **spacing** used in production where the highest electrical stress occurs. These **conductors** are shown as section B in Figure C.1.

The **conductors** terminating on the left-hand side of the **printed board** (side X) have equal width. This width is equivalent to the minimum width used in production.

The **conductors** terminating on the right-hand side of the **printed board** (side Y) under section A in Figure C.1 have a width progressively increasing in five steps from the smallest

to the largest used in production. This configuration is repeated for the **conductors** terminating under section B in Figure C.1.

Conductor width is an important parameter regarding the adhesion of the **coating**. Therefore, the intermediate widths shall, as far as possible, represent the widths used in production.

The ends of the **conductors** opposite to the edge board contacts shall be formed as follows:

– enlarged to 1 mm in diameter, for **conductors** less than 1 mm in width;

– semi-circular, for **conductors** having a width of 1 mm or greater.

The **spacing** between adjacent pairs of **conductors** is at least five times the **spacing** between the **conductor** pair.

The part of the **printed board** covered by section C in Figure C.1 is coated, with the exception of the edge board contacts.

C.4 Arrangement of lands

Eighty-four (84) lands shall be arranged in six groups, each group comprising two rows of seven lands, as shown in section L of Figure C.1. The lands shall be surrounded on three sides by **conductors**, as shown in Figure C.2.

The **spacing** between the lands and **conductors** for three of the groups is equal to the minimum **spacing** used in production, shown as section M in Figure C.1.

The **spacing** between the lands and **conductors** for the other three groups is equal to the **spacing** used in production where the highest electrical stress occurs, shown as section N in Figure C.1.

The dimensions of the lands, together with the dimensions and arrangement of **conductors**, shall be representative of those used in production. Examples of different lands and arrangements of **conductors** are shown in Figure C.2.

All lands in each group are connected together and terminate at an edge board contact on the right-hand side of the **printed board** (side Y). All **conductors** in each group are connected together and terminate at an edge board contact on the left-hand side of the board (side X).

The part of the **printed board** covered by section L in Figure C.1 is coated, with the exception of the edge board contacts. In addition, the lands are not coated if this is the case in production.

C.5 Connections for the tests

The measurements required in 5.8.3, 5.8.4 and 5.8.5 are made between an edge board contact X and the corresponding edge board contact Y.

For the tests of 5.7.5.1 and 5.7.5.2, the edge board contacts of side Y are connected together by means of a short-circuit connector. The test voltage is applied between the common edge board contact on side X and all the other edge board contacts are connected together.

Dimensions in millimetres

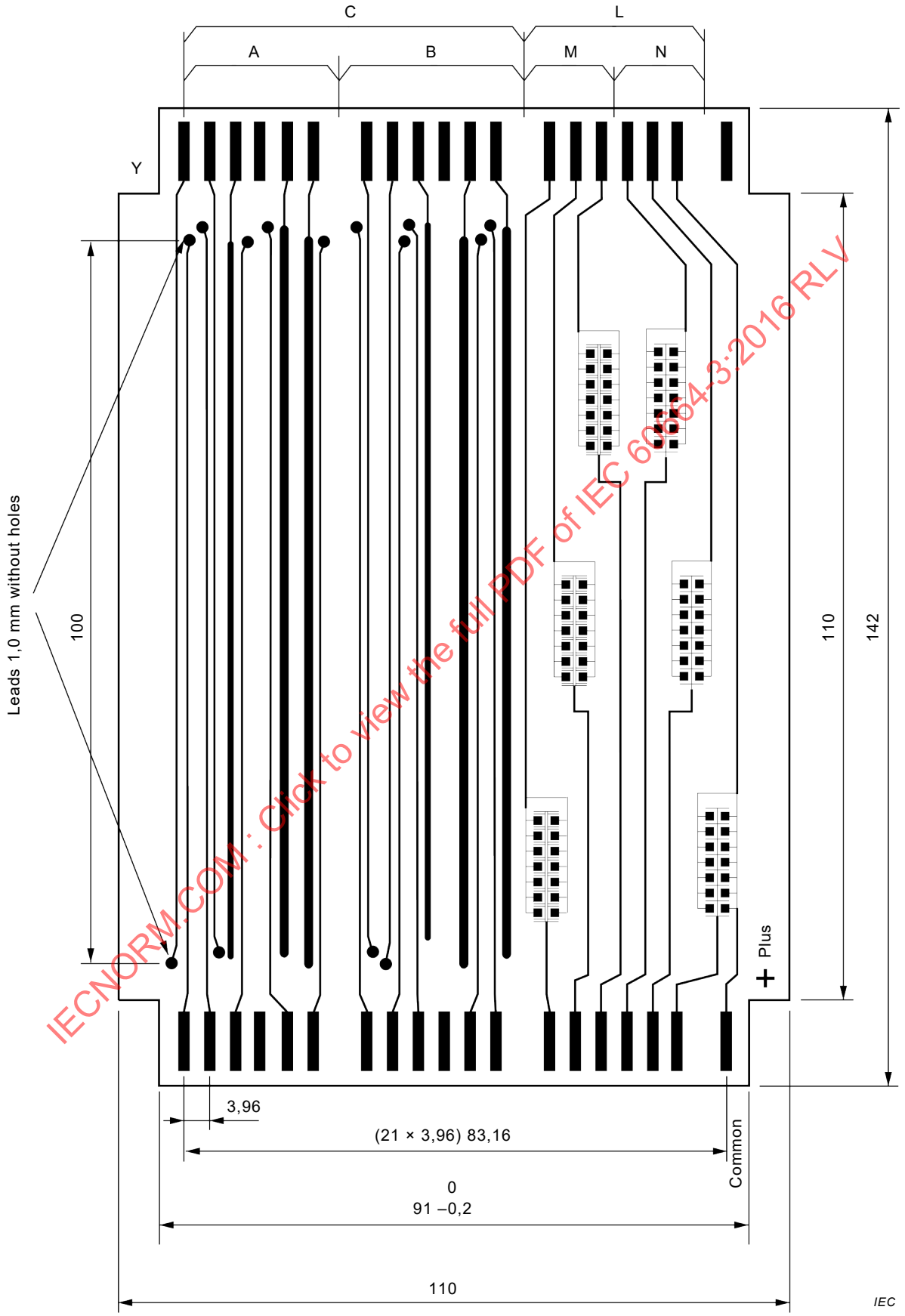


Figure C.1 – Configuration of the test specimen

Dimensions in millimetres

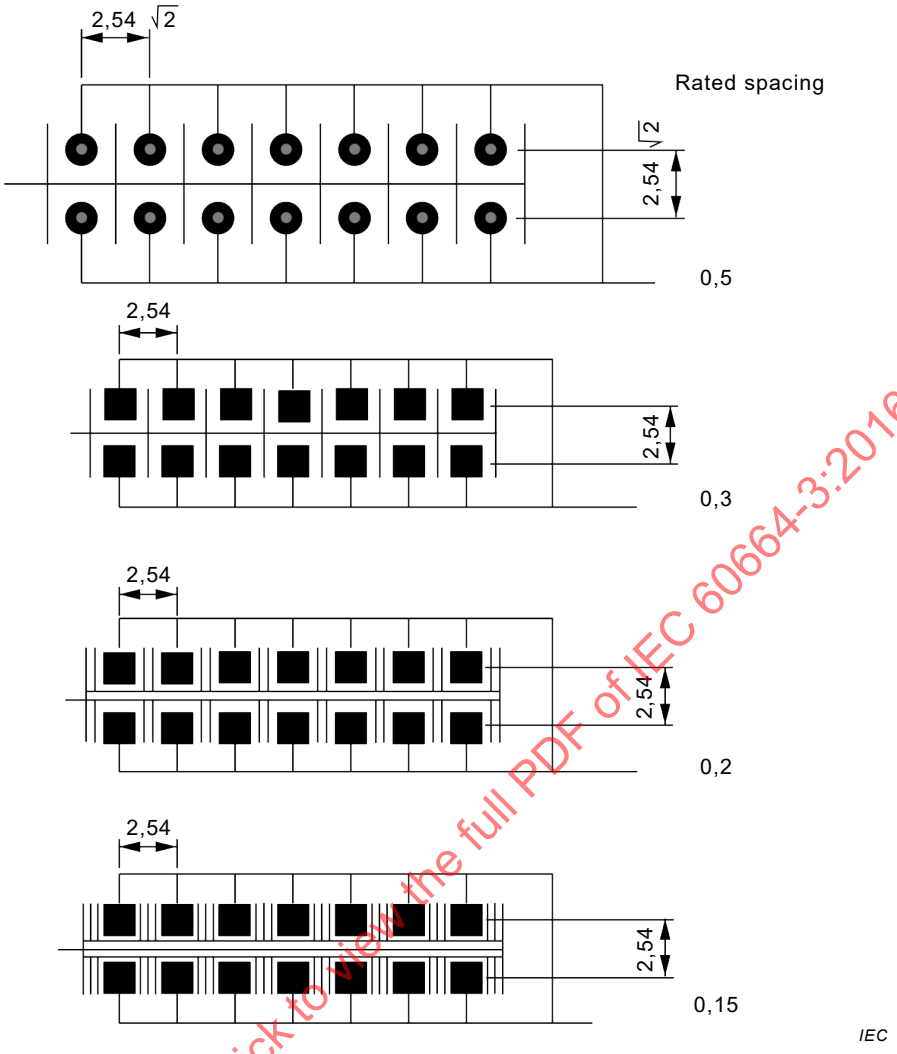


Figure C.2 – Configuration of lands and adjacent conductors

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SOMMAIRE

AVANT-PROPOS 28
INTRODUCTION 30
1 Domaine d'application 31
2 Références normatives 31
3 Termes et définitions 32
4 Exigences de conception 33
4.1 Principes 33
4.2 Plage d'application concernant l'environnement 33
4.3 Exigences relatives aux types de protections 34
4.4 Procédures de dimensionnement 34
5 Essais 35
5.1 Généralités 35
5.2 Echantillons destinés aux essais de revêtements 36
5.3 Echantillons destinés aux essais des moulages et de l'empotage 36
5.4 Préparation des échantillons d'essai 36
5.5 Examen visuel 36
5.6 Essai de résistance aux éraflures 36
5.7 Conditionnement des échantillons d'essai 37
5.7.1 Généralités 37
5.7.2 Conditionnement froid 37
5.7.3 Conditionnement de chaleur sèche 37
5.7.4 Variation rapide de température 38
5.7.5 Essai continu de chaleur humide avec tension de polarisation 39
5.8 Essais mécaniques et électriques après conditionnement et électromigration 39
5.8.1 Conditions générales d'essai 39
5.8.2 Adhérence du revêtement 39
5.8.3 Résistance d'isolement entre conducteurs 40
5.8.4 Essai de tension 40
5.8.5 Tension d'extinction de décharge partielle 40
5.9 Essais additionnels 41
5.9.1 Généralités 41
5.9.2 Résistance à la chaleur de brasage 41
5.9.3 Inflammabilité 41
5.9.4 Résistance au solvant 41
Annexe A (normative) Séquences d'essai 42
Annexe B (normative) Décisions des comités d'études 44
B.1 Généralités 44
B.2 Décisions exigées de la part des comités d'études 44
B.3 Conditions d'essai facultatives 44
Annexe C (normative) Cartes à câblage imprimé pour revêtements d'essai 45
C.1 Généralités 45
C.2 Spécification de la carte à câblage imprimé 45
C.3 Disposition des conducteurs 45
C.4 Disposition des pastilles 46
C.5 Connexions pour les essais 46
Bibliographie 50

Figure 1 – Essai de résistance aux éraflures pour couches de protection 37
Figure C.1 – Configuration de l'échantillon d'essai 48
Figure C.2 – Configuration des pastilles et des conducteurs adjacents 49

Tableau 1 – Espacements minimaux pour la protection de type 2 35
Tableau 2 – Conditionnement de chaleur sèche 38
Tableau 3 – Degrés de sévérité des variations rapides de température 38
Tableau A.1 – Séquence d'essai 1 42
Tableau A.2 – Séquence d'essai 2 conditionnement additionnel concernant l'électromigration 43
Tableau A.3 – Essais additionnels 43

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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COORDINATION DE L'ISOLEMENT DES MATÉRIELS DANS LES SYSTÈMES (RÉSEAUX) À BASSE TENSION –

Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution

AVANT-PROPOS

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La Norme internationale IEC 60664-3 a été établie par le comité d'études 109 de l'IEC: Coordination de l'isolement pour le matériel à basse tension.

Elle a le statut d'une publication fondamentale de sécurité conformément au Guide IEC 104.

Cette troisième édition annule et remplace la deuxième édition parue en 2003 et l'Amendement 1:2010. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) des informations concernant l'interpolation ont été ajoutées;

b) l'essai de résistance aux éraflures est destiné uniquement aux **protections** de type 2;

c) l'essai de résistance aux éraflures a été renuméroté et placé à la suite de l'essai d'examen visuel, ce qui est plus pertinent;

d) le tableau de l'annexe désormais désignée comme l'Annexe A a été divisé en plusieurs tableaux, pour plus de clarté.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
109/153/FDIS	109/154/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Dans la présente norme, les caractères suivants sont utilisés:

– Termes utilisés tout au long de la présente norme qui sont définis à l'Article 3: **caractères gras**

Une liste de toutes les parties de la série IEC 60664, publiées sous le titre général *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

INTRODUCTION

La présente partie de l'IEC 60664 précise les conditions dans lesquelles la réduction des distances d'isolement dans l'air et des lignes de fuite peut s'appliquer aux ensembles rigides tels que les **cartes imprimées** ou les bornes des composants. La **protection** contre la pollution peut être obtenue par tous types d'encapsulages, tels que le **revêtement**, l'empotage ou le moulage. La **protection** peut être appliquée sur une face ou sur les deux faces de l'ensemble. La présente norme spécifie les propriétés isolantes du matériau de protection.

Entre deux parties conductrices quelconques non protégées, les exigences relatives aux distances d'isolement et aux lignes de fuite de l'IEC 60664-1 s'appliquent.

Le présent document fait uniquement référence à une **protection** permanente. Elle n'englobe pas les ensembles après réparation.

Il convient que les comités d'études examinent les implications pour la **protection** des **conducteurs** et composants surchauffés, en particulier dans des conditions de défaut, et qu'ils décident si des exigences additionnelles sont nécessaires.

Un fonctionnement performant en toute sécurité des ensembles dépend d'un procédé de fabrication précis et contrôlé pour l'application du système de protection. Il convient que les exigences relatives au contrôle de la qualité, par exemple par des essais par prélèvement, soient prises en considération par les comités d'études.

COORDINATION DE L'ISOLEMENT DES MATÉRIELS DANS LES SYSTÈMES (RÉSEAUX) À BASSE TENSION –

Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution

1 Domaine d'application

La présente partie de l'IEC 60664 est applicable aux ensembles protégés contre la pollution au moyen de **revêtement**, d'empotage ou de moulage, permettant ainsi une réduction des distances d'isolement et des lignes de fuite décrites dans l'IEC 60664-1.

Le présent document décrit les exigences et procédures d'essai pour deux méthodes de **protection**:

– la **protection** de type 1 améliore le microenvironnement des parties sous **protection**;

– la **protection** de type 2 est considérée comme similaire à l'**isolation solide**.

Le présent document s'applique également à toutes sortes de **cartes imprimées** protégées, y compris la surface de couches internes de cartes multicouches, de substrats et d'ensembles protégés de manière similaire. Dans le cas de **cartes imprimées** multicouches, les distances à travers une couche interne sont couvertes par les exigences relatives à l'**isolation solide** dans l'IEC 60664-1.

NOTE Les circuits intégrés hybrides et la technologie à couches épaisses sont des exemples de substrats.

Le présent document fait uniquement référence à une **protection** permanente. Elle n'englobe pas les ensembles soumis à une mise au point mécanique ou à des réparations.

Les principes de la présente norme sont applicables à l'isolation fonctionnelle, principale, supplémentaire et renforcée.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-1, *Essais d'environnement – Partie 2-1: Essais – Essai A: Froid*

IEC 60068-2-2, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

IEC 60068-2-14, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

IEC 60326-2:1990, *Cartes imprimées – Partie 2: Méthodes d'essai*

IEC 60454-3-1: 1998/AMD1:2001, *Rubans adhésifs sensibles à la pression à usages électriques – Partie 3: Spécifications pour matériaux particuliers – Feuille 1: Rubans en PVC avec un adhésif sensible à la pression*

IEC 60664-1, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

IEC 61189-2:2006, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures* (disponible en anglais uniquement)

IEC 61189-3:2007, *Méthodes d'essai pour les matériaux électriques, les cartes imprimées et autres structures d'interconnexion et ensembles – Partie 3: Méthodes d'essai des structures d'interconnexion (cartes imprimées)*

IEC 61249-2 (toutes les parties), *Matériaux pour circuits imprimés et autres structures d'interconnexion – Matériaux de base renforcés, plaqués et non plaqués*

IEC Guide 104:2010, *The preparation of safety publications and the use of basic safety publications and group safety publications* (disponible en anglais uniquement)

ISO/IEC Guide 51, *Aspects liés à la sécurité – Principes directeurs pour les inclure dans les normes*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60664-1, ainsi que les suivants, s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
matériau de base
matériau isolant sur lequel peut être réalisée une impression conductrice

Note 1 à l'article: Le **matériau de base** peut être rigide et souple, ou encore les deux. Il peut s'agir d'un diélectrique ou d'une feuille de métal isolée.

[SOURCE: IEC TR 60664-2-1:2011, 3.2]

3.2
carte imprimée
matériau de base découpé aux dimensions demandées, percé de tous les trous prescrits, et portant au moins une impression conductrice.

Les **cartes imprimées** sont divisées en plusieurs types selon:

– leur structure (c'est-à-dire simple face, double face, multicouches)
– la nature du **matériau de base** (c'est-à-dire: rigide, souple)

[SOURCE: IEC 60050-541:1990, 541-01-03]

3.3
conducteur (d'une carte imprimée)
piste conductrice individuelle d'une impression conductrice

[SOURCE: IEC 60050-541:1990, 541-01-20]

3.4
protection
mesure qui réduit l'influence de l'environnement

3.5
revêtement
matériau isolant tel que vernis ou film sec posé sur la surface de l'ensemble

Note 1 à l'article: Le **revêtement** et le **matériau de base** d'une **carte imprimée** forment un système isolant qui peut avoir des propriétés similaires à l'**isolation solide**.

3.6
isolation solide
matériau isolant entièrement constitué d'un solide

Note 1 à l'article: Dans le cas d'une **carte imprimée** à **revêtement**, l'**isolation solide** est constituée de la carte elle-même ainsi que du **revêtement**. Dans les autres cas, l'**isolation solide** est constituée du matériau d'encapsulation.

[SOURCE: IEC 60050-212:2010, 212-11-02]

3.7
espacement
toute combinaison de distances d'isolement, de lignes de fuite et des distances à travers l'isolation

[SOURCE: IEC TR 60664-2-1:2011, 3.41]

4 Exigences de conception

4.1 Principes

Le dimensionnement des **espacements** entre les **conducteurs** dépend du type de **protection** utilisé.

Lorsque la **protection** de type 1 est utilisée, le dimensionnement des distances d'isolement et des lignes de fuite doit suivre les exigences de l'IEC 60664-1. Si les exigences de cette norme sont respectées, le degré 1 de pollution s'applique sous la **protection**.

Lorsque la **protection** de type 2 est utilisée, les **espacements** entre les parties conductrices doivent satisfaire aux exigences et aux essais relatifs à l'**isolation solide** de l'IEC 60664-1 et leurs dimensions ne doivent pas être inférieures aux distances d'isolement minimales spécifiées dans l'IEC 60664-1 pour des conditions de champ homogènes.

4.2 Plage d'application concernant l'environnement

Les exigences de conception sont applicables dans tous les microenvironnements.

Les contraintes de température, chimiques, mécaniques, ou bien celles énumérées en 5.3.2.4 de l'IEC 60664-1:2007, doivent être prises en compte lors du choix du matériau de protection.

L'absorption d'humidité par le matériau de protection ne doit pas affecter les propriétés d'isolation des parties protégées.

NOTE L'absorption d'humidité peut être vérifiée par une mesure de la résistance d'isolement dans des conditions humides.

4.3 Exigences relatives aux types de protections

La **protection** est obtenue des manières suivantes.

– La **protection** de type 1 améliore le microenvironnement des parties sous **protection**. Les exigences relatives à la distance d'isolement et aux lignes de fuite de l'IEC 60664-1 pour le degré 1 de pollution s'appliquent sous la **protection**. Entre deux parties conductrices, il est exigé qu'une partie conductrice ou les deux, ainsi que tous les **espacements** entre elles, soient couverts par la **protection**.

– La **protection** de type 2 est considérée comme similaire à l'**isolation solide**. Sous la **protection**, les exigences relatives à l'**isolation solide** spécifiées dans l'IEC 60664-1 sont applicables et les **espacements** ne doivent pas être inférieurs à ceux qui sont spécifiés dans le Tableau 1. Les exigences relatives aux distances d'isolement et aux lignes de fuite de l'IEC 60664-1 ne s'appliquent pas. Entre deux parties conductrices, il est exigé que les deux parties conductrices soient couvertes par la **protection**, de même que tous les **espacements** entre elles, de sorte qu'il n'existe aucun entrefer entre le matériau de protection, les parties conductrices et la **carte imprimée**.

Les exigences relatives à la distance d'isolement et aux lignes de fuite conformément à l'IEC 60664-1 s'appliquent à toutes les parties non protégées des matériels.

4.4 Procédures de dimensionnement

Pour la **protection** de type 1, les exigences de dimensionnement de 5.1 et 5.2 de l'IEC 60664-1:2007 s'appliquent.

Pour la **protection** de type 2, l'**espacement** entre les **conducteurs** avant d'appliquer la **protection** ne doit pas être inférieur aux valeurs spécifiées dans le Tableau 1. Ces valeurs s'appliquent à l'isolation principale, à l'isolation supplémentaire, ainsi qu'à l'isolation renforcée. Ces valeurs peuvent également être appliquées à l'isolation fonctionnelle.

NOTE Dans le cas des cartes multicouches, l'**espacement** entre les **conducteurs** à la surface des couches internes est dimensionné comme spécifié pour la **protection** de type 1 ou la **protection** de type 2 en fonction du résultat des essais sur la **protection**.

Tableau 1 – Espacements minimaux pour la protection de type 2

Valeur de crête maximale de toute tension [a)] kV	Espacements minimaux mm
≤ 0,33	0,01
> 0,33 et ≤ 0,4	0,02
> 0,4 et ≤ 0,5	0,04
> 0,5 et ≤ 0,6	0,06
> 0,6 et ≤ 0,8	0,1
> 0,8 et ≤ 1,0	0,15
> 1,0 et ≤ 1,2	0,2
> 1,2 et ≤ 1,5	0,3
> 1,5 et ≤ 2,0	0,45
> 2,0 et ≤ 2,5	0,6
> 2,5 et ≤ 3,0	0,8
> 3,0 et ≤ 4,0	1,2
> 4,0 et ≤ 5,0	1,5
> 5,0 et ≤ 6,0	2
> 6,0 et ≤ 8,0	3
> 8,0 et ≤ 10	3,5
> 10 et ≤ 12	4,5
> 12 et ≤ 15	5,5
> 15 et ≤ 20	8
> 20 et ≤ 25	10
> 25 et ≤ 30	12,5
> 30 et ≤ 40	17
> 40 et ≤ 50	22
> 50 et ≤ 60	27
> 60 et ≤ 80	35
> 80 et ≤ 100	45

[a)] Les surtensions transitoires sont ignorées étant donné qu'elles sont peu susceptibles de dégrader l'ensemble protégé.

La conformité est vérifiée par mesure de l'**espacement** avant d'appliquer la **protection**.

5 Essais

5.1 Généralités

L'aptitude à la **protection** est évaluée en effectuant tous les essais décrits en 5.8 après le conditionnement décrit en 5.7.

L'aptitude à la **protection** est évaluée après l'examen visuel décrit en 5.5, l'essai de résistance aux éraflures décrit en 5.6 et le conditionnement qui s'ensuit, décrit en 5.7. Sauf indication contraire de la part des comités d'études, six échantillons sont utilisés. De plus, les comités d'études peuvent spécifier les essais additionnels de 5.9, dont chacun est effectué sur un nouvel échantillon séparé.

Ces essais sont conçus pour les essais de type. Il convient que les comités d'études examinent si des essais doivent être spécifiés pour les essais individuels de série ou par prélèvement.

La séquence des essais est présentée à l'Annexe A.

Aucune défaillance de l'échantillon en essai n'est admise.

L'Annexe B énumère les décisions devant nécessairement être prises par les comités d'études en se référant à la présente norme.

5.2 Echantillons destinés aux essais de revêtements

Les échantillons d'essai peuvent être:

– des échantillons d'essai conformes à l'Annexe C, qui s'appliquent spécifiquement aux cartes à câblage imprimé; les échantillons utilisés pour les essais doivent avoir les mêmes distances minimales que ceux issus de la production;

– des échantillons issus de la production; ou

– toute **carte imprimée**, tant que les échantillons d'essai sont représentatifs de ceux issus de la production.

5.3 Echantillons destinés aux essais des moulages et de l'empotage

Les échantillons de production doivent être utilisés ou ils doivent être représentatifs de ceux issus de la production.

5.4 Préparation des échantillons d'essai

Les **cartes imprimées** doivent être nettoyées et revêtues en utilisant la procédure normale du fabricant. La procédure de brasage est réalisée, mais sans que les composants soient en place. Les échantillons moulés et empotés doivent être soumis aux essais sans préparation supplémentaire.

5.5 Examen visuel

Les échantillons doivent être examinés visuellement conformément à l'essai 3V02 en 6.2 de l'IEC 61189-3:2007.

Les échantillons ne doivent présenter aucun des phénomènes suivants:

– cloquage,

– gonflement,

– séparation du **matériau de base**,

– fissures,

– vides,

– zones à parties conductrices adjacentes non protégées, à l'exception des pastilles,

– électromigration (à la suite du conditionnement pour l'électromigration),

d'après les critères des séquences d'essai donnés dans les tableaux de l'Annexe A.

5.6 Essai de résistance aux éraflures

L'essai de résistance aux éraflures est uniquement effectué pour la **protection** de type 2. Avant la séquence d'essais destinés à la **protection** de type 2, les échantillons d'essai doivent être soumis à l'essai de résistance aux éraflures.

NOTE Dans certains cas, l'essai de résistance aux éraflures ne peut pas être appliqué aux ensembles protégés contre la pollution au moyen d'empotage ou de moulage. Dans de tels cas, il peut être nécessaire d'envisager des essais autres ou supplémentaires.