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TECHNICAL REPORT

colour inside

Guidance on clearances and creepage distances in particular for distances equal to or less than 2 mm – Test results of research on influencing parameters

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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GUIDANCE ON CLEARANCES AND CREEPAGE DISTANCES IN PARTICULAR FOR DISTANCES EQUAL TO OR LESS THAN 2 mm – TEST RESULTS OF RESEARCH ON INFLUENCING PARAMETERS

FOREWORD

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IEC TR 63040, which is a Technical Report, has been prepared by IEC technical committee 109: Insulation co-ordination for low-voltage equipment.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
109/140/DTR	109/144/RVC

Full information on the voting for the approval of this Technical Report 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.

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

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- withdrawn,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

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

The contents of the corrigendum of January 2019 have been included in this copy.

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 document using a colour printer.

INTRODUCTION

This document provides information on printed board assemblies and other equivalent plane arrangements of insulation, where the clearance and the creepage distance follows the same path along the surface of solid insulation.

This document is based on German research data published in May 1989 [9], [10][1]. SC 28A, the predecessor of TC 109, began analysing this research data in November 1990.

The following points provide background information to the research.

- The research was carried out on test samples that were manufactured with the same technology being used for printed circuit boards (PCBs) with selected spacing of circuit patterns from 0,16 mm to 6,3 mm.
- Ten types of materials were used for the test samples. The influence of manufacturing operations on the surface of a material, for example moulding or machining, was not part of this research project.
- The test samples were placed in different locations, such as large city, rural, industrial, desert, sea side, and periodically exposed to a voltage stress and the data was accumulated over a long period of time.

1 Numbers in square brackets refer to the bibliography.

GUIDANCE ON CLEARANCES AND CREEPAGE DISTANCES IN PARTICULAR FOR DISTANCES EQUAL TO OR LESS THAN 2 mm – TEST RESULTS OF RESEARCH ON INFLUENCING PARAMETERS

1 Scope

This document describes test results of research on dimensioning of clearances and creepage distances, for spacing equal to or less than 2 mm for printed wiring material and other equivalent arrangements of insulation, where the clearance and the creepage distance follows the same path along the surface of solid insulation.

The information contained in this document is the result of research only and cannot be used for dimensioning the clearances and creepage distances for equipment within low-voltage systems, where IEC 60664-1 applies. However distances can be taken into account for functional reasons.

This document provides results of research related to the following criteria:

1) clearances independent from the micro-environment;
2) creepage distances for pollution degree 1, 2 and 3 which extends the use of smaller distances to products having design features similar to printed circuit boards;
3) creepage distances to avoid flashover of the insulating surface;
4) information on minimum creepage distances to maintain minimum insulation resistance.

A test method for the evaluation of the relevant water adsorption group for the surface of any insulating material which has not yet been classified is described.

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

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
inhomogeneous field
non-uniform field
electric field which does not have an essentially constant voltage gradient between electrodes

Note 1 to entry: The inhomogeneous field condition of a point-plane electrode configuration is the worst case with regard to voltage withstand capability and is referred to as case A. It is represented by a point electrode having a 30 µm radius and a plane of 1 m × 1 m.

3.2
homogeneous field
uniform field
electric field which has an essentially constant voltage gradient between electrodes

Note 1 to entry: The electric field between two spheres where the radius of each sphere is greater than the distance between them is an example of a homogeneous field (case B).

3.3
electrical breakdown
failure of insulation under electric stress when the discharge completely bridges the insulation, thus reducing the voltage between the electrodes almost to zero

Note 1 to entry: For the purposes of this document the above definition is used, as the definition in IEC 60050-212:2010, 212-11-33 [1] is broader than the scope of this document.

3.4
flashover

electrical breakdown along a surface of solid insulation located in a gaseous or liquid medium

Note 1 to entry: For the purposes of this document the above definition is used, as the definition in IEC 60050-212, 212-11-47 is broader than the scope of this document.

3.5
humidity level
HL
level defining the expected humidity influences in the micro-environment and expressed numerically

3.6
water adsorption
capability of an insulating material to adsorb water on its surface

3.7
critical relative humidity
value of the relative humidity when the impulse withstand voltage of a creepage distance has dropped to 95 % of the value which was measured at 70 % humidity

3.8
water adsorption group
group characterizing the extent of the dependence of the critical relative humidity upon the creepage distance

3.9
working voltage
highest r.m.s. value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

Note 2 to entry: Both open-circuit conditions and normal operating conditions are taken into account.

3.10
rated insulation voltage
r.m.s. withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified (long-term) withstand capability of its insulation

Note 1 to entry: The rated insulation voltage is not necessarily equal to the rated voltage of equipment which is primarily related to functional performance.

3.11
rated voltage
value of voltage assigned by the manufacturer, to a component, device or equipment and to which operation and performance characteristics are referred

Note 1 to entry: Equipment may have more than one rated voltage value or may have a rated voltage range.

4 Fundamental aspects and phenomena of clearance and creepage distances

4.1 Mutual correlation of insulation characteristics with regard to environmental conditions

The micro-environmental conditions for the insulation depend primarily on the macro-environmental conditions in which the equipment is located and in many cases the environments are identical. However the micro-environment can be better or worse than the macro-environment where, for example, enclosures, heating, ventilation or dust influence the micro-environment.

NOTE Protection by enclosures provided according to the degrees of protection specified in IEC 60529 [4] can increase or decrease the humidity of the micro-environment.

The most important environmental parameters are the following.

– For clearances:
  - air pressure;
  - temperature, if it has a wide variation.
– For creepage distances:
  - pollution;
  - relative humidity;
  - condensation.
– For solid insulation:
  - temperature;
  - relative humidity.

4.2 Pollution

4.2.1 General

Pollution does not only impair insulation with regard to long-term r.m.s voltage stress causing tracking but also impairs it with regard to peak voltages and water adsorption, causing reduced impulse withstand capability in case of short distances and thus flashover may occur along the insulation surface.

The influence of humidity on the surface of insulation is identified by the humidity levels. These levels also apply to a macro-environment having the same humidity as the micro-environment.

The influence of the water adsorption characteristics on the surface of insulation is identified by the water adsorption categories.

4.2.2 Humidity level (HL)

For the purpose of evaluating creepage distances with regard to flashover along the surface, respectively minimum insulation resistance, the following three levels in the micro-environment are established.

- Humidity level 1 (HL 1):

  The relative humidity at the insulation never reaches a level where condensation occurs on the insulation.

  Therefore, the flashover is not influenced by humidity. Humidity Level HL 1 is considered to be pollution degree 1.

- Humidity level 2 (HL 2):

  The relative humidity at the insulation is such that condensation on the insulation occurs only occasionally during transient changes in the micro-environment.

  Therefore, the flashover is influenced by humidity.

- Humidity level 3 (HL 3):

  The relative humidity at the insulation is such that condensation on the insulation may occur frequently.

  Therefore, the flashover is strongly influenced by humidity.

4.2.3 Relation of humidity levels to macro-environment

Macro-environmental conditions are specified in IEC 60364-5-51, in IEC 60721-3-3, IEC 60721-3-7, and IEC 60721-3-9. The relation of humidity levels to defined macro-environmental classes is shown in Table 1.

Table 1 – Relation of the humidity levels to macro-environments

Standard specifying climatic classes	Climatic (macro-environmental) classes			Humidity levels
IEC 60721-3-9 --- IEC 60721-3-3 --- IEC 60721-3-7 --- IEC 60364-5-51	Y2 --- 3K1 --- --- ↓	Y3 --- 3K3 --- 7K1 --- AB5 ↓	Y4 --- 3K6 --- 7K3 --- AB7 ↓	
	=	(–)	(–)	→ HL 1
	(+)	=	(–)	→ HL 2
	(+)	(+)	=	→ HL 3

Key

= micro-environment has the same humidity as the macro-environment

(–) micro-environment is less humid than the macro-environment

(+) micro-environment is more humid than the macro-environment

NOTE In IEC 60721-3-9 different expressions of climatic classes are used.