

Insulation coordination for equipment within low-voltage systems —

**Part 5: A comprehensive method for
determining clearances and creepage
distances equal to or less than 2 mm**

The European Standard EN 60664-5:2003 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 60664-5:2003. It is identical with IEC 60664-5:2003.

The UK participation in its preparation was entrusted to Technical Committee GEL/109, Insulation coordination for low voltage equipment, which has the responsibility to:

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

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**Insulation coordination for equipment within low-voltage systems
Part 5: A comprehensive method for determining clearances
and creepage distances equal to or less than 2 mm
(IEC 60664-5:2003)**

Coordination de l'isolement des matériels
dans les systèmes (réseaux)
à basse tension
Partie 5: Méthode détaillée
de détermination des distances
d'isolement dans l'air et des lignes de fuite
inférieures ou égales à 2 mm
(CEI 60664-5:2003)

Isolationskoordination für elektrische
Betriebsmittel in Niederspannungsanlagen
Teil 5: Ein umfassendes Verfahren zur
Bemessung der Luft- und Kriechstrecken
für Abstände gleich oder unter 2 mm
(IEC 60664-5:2003)

This European Standard was approved by CENELEC on 2003-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 109/32/FDIS, future edition 1 of IEC 60664-5, prepared by IEC TC 109, Insulation co-ordination for low-voltage equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60664-5 on 2003-10-01.

This standard shall be read in conjunction with EN 60664-1:2003.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2004-07-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2006-10-01

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

Annexes designated "informative" are given for information only.

In this standard, annexes G and ZA are normative and annexes A to F and H and I are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60664-5:2003 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

This part of IEC 60664 can only be used together with Part 1.

This part applies to printed wiring boards and equivalent constructions, where the clearance and the creepage distance are identical and are along the surfaces of solid insulation, such as the paths described in example 1, example 5 and example 11 of Part 1, Subclause 4.2.

This part specifies the humidity levels regarding the effects of humidity on creepage distances.

This part introduces the following dimensioning criteria which have to be taken into account together:

- new minimum clearances having more precise values for dimensions up to 2 mm under pollution degrees 2 and 3 than those specified in Table 2 of Part 1;
- smaller minimum creepage distances for printed wiring boards and equivalent constructions under pollution degree 3 than those specified in Table 4 of Part 1;
- a specification of minimum creepage distances to avoid flashover of the insulating surfaces, the values being based on the water adsorption characteristics of the material;
- a specification of minimum creepage distances to ensure adequate insulation resistance under humid conditions.

NOTE Table F.2 provides information on the dimensioning of creepage distances in order to maintain adequate insulation resistance for r.m.s. voltages up to 10 000 V, corresponding to creepage distances up to 250 mm.

The information in this standard is based on research data published 1989.

The following details from the research provide background information:

- the research was carried out on test samples that were manufactured using the same process as for printed wiring boards with spacing of circuit patterns from 0,16 mm to 6,3 mm;
- ten different materials were used for the test samples. The influence of manufacturing process on the surface of the material, e.g., moulding or machining, was not part of the research project;
- the test samples were placed in different locations, such as city, rural, industrial, desert, and coastal.
- the samples were periodically exposed to a voltage stress and the data accumulated over a long period of time.

Annex G specifies a water adsorption test method for allocating unclassified insulating material to the relevant water adsorption group.

This annex will be reviewed when further experience is gained using the test method for different materials.

INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

Part 5: A comprehensive method for determining clearances and creepage distances equal to or less than 2 mm

1 General

1.1 Scope

This part of IEC 60664 specifies the dimensioning of clearances and creepage distances for spacings equal to or less than 2 mm for printed wiring board and equivalent constructions, where the clearance and the creepage distance are identical and are along the surface of solid insulation, such as the paths described in example 1, example 5 and example 11 of 4.2 of Part 1.

The dimensioning is more precise than that provided by Part 1¹.

NOTE 1 If the precision provided by this standard is not required, Part 1 may be applied instead.

This standard can only be used as an entirety. It is not permitted to select one or more clauses from this standard and to use them in place of the corresponding clauses of Part 1.

When this standard is applied to the dimensioning of clearances and creepage distances, all clauses shall be used in place of the corresponding clauses given in Part 1. For clearances and creepage distances larger than 2 mm and for solid insulation in general, Part 1 applies.

NOTE 2 The limitation to distances equal to or less than 2 mm applies to basic or supplementary insulation. The total distance of a reinforced or double insulation may be larger than 2 mm.

This standard is based on the following criteria for dimensioning:

- minimum clearances independent of the micro-environment (see Table 2);
- minimum creepage distances for pollution degrees 1, 2 and 3 to avoid failure due to tracking (see Table 4);
- minimum creepage distances to avoid flashover across the insulating surface (see Table 5).

NOTE 3 For minimum creepage distances to maintain adequate insulation resistance, see Table F.2.

NOTE 4 This standard is not applicable for micro-environmental conditions worse than pollution degree 3 or humidity level 3.

A test method is specified for allocating unclassified insulating material to the relevant water adsorption group.

¹ "Part 1" refers to IEC 60664-1.

1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Subclause 1.2 of Part 1 is applicable, as well as the following:

IEC 60364-5-51:2001, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

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

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*
Amendment 1 (1995)
Amendment 2 (1996)

IEC 60721-3-7:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 7: Portable and non-stationary use*
Amendment 1 (1996)

IEC 60721-3-9:1993, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 9: Microclimates inside products*
Amendment 1 (1994)

1.3 Definitions

For the purposes of this document, the following definitions apply in addition to those given in Part 1.

1.3.1

water adsorption

capability of insulating material to adsorb water on its surface

1.3.2

critical relative humidity

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

2 Fundamentals of clearance and creepage distance dimensioning

2.1 Introduction

The first publication on this subject was IEC 664, 1980. It only covered clearances, the data being based on fundamental data of breakdown voltages. Subsequently in 1981 IEC 664A was published concerning creepage distances based on data obtained over many years of experience, and on data obtained from testing printed wiring boards. In 1992, the publications were combined and published as Part 1. However, the revision did not change the basic data.

2.1.1 Basic principles

Subclause 2.1.1 of Part 1 is applicable.

2.1.2 Insulation coordination with regard to environmental conditions

The micro-environmental conditions for the insulation shall be taken into account. They 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 may increase the humidity of the micro-environment.

The main environmental parameters are as follows:

- for clearances,
 - air pressure,
 - temperature, if it has a wide variation (see 4.1.1.2.1.2 of Part 1),
- for creepage distances,
 - pollution,
 - relative humidity,
 - condensation;
- for solid insulation,
 - temperature,
 - relative humidity.

2.2 Voltages and voltage ratings

Subclause 2.2 of Part 1 is applicable.

2.3 Frequency

Subclause 2.3 of Part 1 is applicable.

2.4 Time under voltage stress

Not applicable.

2.5 Pollution

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. Pollution causes reduced impulse withstand capability of short distances and thus flashover may occur across the insulation surface.

The influence of humidity on the surface of insulation is identified by the humidity levels specified in 2.5.3. The influence of the water adsorption characteristics on the surface of insulation is identified by the water adsorption groups specified in 2.7.5.

2.5.1 Degrees of pollution in the micro-environment

Subclause 2.5.1 of Part 1 applies.

2.5.2 Conditions of conductive pollution

Not applicable.

2.5.3 Humidity levels

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

- humidity level 1 (HL 1): the relative humidity at the insulation surface never reaches a level where condensation occurs. Therefore flashover is not influenced by humidity;
- humidity level 2 (HL 2): the relative humidity at the insulation surface is such that condensation occurs occasionally during transient changes in the micro-environment. Therefore flashover is influenced by humidity;
- humidity level 3 (HL 3): the relative humidity at the insulation surface is such that condensation may occur frequently. Therefore flashover is strongly influenced by humidity.

2.5.4 Relation of humidity levels to the macro-environment

Macro-environmental conditions are specified in IEC 60364-5-51, IEC 60721-3-3, IEC 60721-3-7 and IEC 60721-3-9.

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

The relationship between humidity levels of the micro-environment and the defined macro-environmental classes is shown in Table 1.

Table 1 – Relation between the humidity levels and macro-environmental classes

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

2.6 Information supplied with the equipment

Subclause 2.6 of Part 1 is applicable.

2.7 Insulating material

Insulating material shall be classified into groups according their CTI values.

The electric strength characteristics, the thermal, the mechanical, the chemical and the water adsorption characteristics of insulating material shall be considered by the technical committees. Regarding the requirements for solid insulation, 3.3 of Part 1 applies.

2.7.1 Comparative tracking index (CTI)

Subclause 2.7.1 of Part 1 is applicable.

2.7.2 Electric strength characteristics

Subclause 2.7.2 of Part 1 is applicable.

2.7.3 Thermal characteristics

Subclause 2.7.3 of Part 1 is applicable.

2.7.4 Mechanical and chemical characteristics

Subclause 2.7.4 of Part 1 is applicable.

2.7.5 Water adsorption characteristics

Water adsorption is a surface-related phenomenon that depends on the characteristics of the insulating material. With regard to the effect of water adsorption on voltage withstand capability, insulating materials are allocated to a water adsorption group according to the test procedure in Annex G as follows:

- water adsorption group WAG 1 (negligible influence);
- water adsorption group WAG 2 (weak influence);
- water adsorption group WAG 3 (medium influence);
- water adsorption group WAG 4 (strong influence).

NOTE 1 The classification of materials with respect to water adsorption groups may be influenced by fillers, additives, and manufacturing procedures.

NOTE 2 The classification of various insulating materials with respect to water adsorption groups is given in 3.2.1.2.4.

3 Requirements and dimensioning procedures

Clearances shall be dimensioned to withstand the transient overvoltages in accordance with 3.1.1.1. The associated creepage distance shall fulfil the requirements of 3.2.1.2.2 and 3.2.1.2.3.

3.1 Dimensioning of clearances

Clearances shall be dimensioned to withstand the required impulse withstand voltage. For equipment directly connected to the low-voltage mains, the required impulse withstand voltage is the rated impulse voltage established on the basis of 2.2.2.2 of Part 1. If a steady-state r.m.s. voltage, a temporary overvoltage or a recurring peak voltage requires larger clearances than required for the impulse withstand voltage, the corresponding values of Table 3 shall be used. The largest clearance shall be selected, resulting from consideration of impulse withstand voltage, steady-state r.m.s. voltage, temporary overvoltages and recurring peak voltages.

NOTE Dimensioning for steady-state r.m.s. or recurring peak voltage leads to a situation in which there is no margin to breakdown with the continuous application of these voltages. Technical committees should take this into account.

3.1.1 Dimensioning criteria

Clearances shall be selected taking into account the following influencing factors:

- impulse withstand voltage according to 3.1.4 of Part 1 for functional insulation and 3.1.5 for basic, supplementary and reinforced insulation;
- steady-state withstand voltages and temporary overvoltages (see 3.1.1.2);
- recurring peak voltages (see 3.1.1.2);
- electric field conditions (see 3.1.2);
- altitude. The clearance dimensions specified in Table 2 and Table 3 give withstand capability for equipment for use in altitudes up to 2 000 m. For equipment for use in higher altitudes, 3.1.3 applies.

Larger clearances may be required in the case of mechanical influences such as vibration or applied forces.