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PUBLICATION FONDAMENTALE DE SÉCURITÉ
BASIC SAFETY PUBLICATION

Insulation coordination for equipment within low-voltage systems –

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

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

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

FOREWORD

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International Standard IEC 60664-5 has been prepared by IEC technical committee 109: Insulation coordination for low-voltage equipment.

This second edition cancels and replaces the first edition, published in 2003 and constitutes a technical revision.

The revision of Part 1 of IEC 60664 also required a revision of Part 5 of IEC 60664, as Part 5 is closely linked to Part 1. In addition to a number of editorial improvements, the following major technical changes made in Part 1 also apply for Part 5:

- Amendment of Japanese mains conditions with regard to the rated impulse voltages, the rationalized voltages and the nominal voltages of supply systems for different modes of overvoltage control.
- Amendment of dimensioning of clearances smaller than 0,01 mm.

- Alignment of the table and the corresponding formula regarding test voltages for verifying clearances at different altitudes.
- Amendment of interpolation of the creepage distance values for functional insulation.
- Revision of the former Clause 4 "Tests and measurements" (now Clause 6) to achieve a more detailed description of the tests and their purpose, the test equipment and possible alternatives.

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

It is to be used in conjunction with IEC 60664-1.

NOTE For the purposes of this standard, all references to IEC 60664-1 are written as "to Part 1". Where a subclause is cited without reference to a Part, it is assumed that the reference is to the current Part 5.

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

CDV	Report on voting
109/61/CDV	109/63/RVC

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.

A list of all parts in the IEC 60664 series, 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 maintenance result 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.

INTRODUCTION

This part of IEC 60664 specifies humidity levels regarding the effects of humidity on creepage distances.

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

– new minimum clearances having more precise values for dimensions up to 2 mm under pollution degrees 2 and 3 than those specified in Table F.2 of Part 1;

– smaller minimum creepage distances for printed wiring boards and equivalent constructions under pollution degree 3 than those specified in Table F.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 A.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 in 1989 [1, 2]1.

The following details from this 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 the 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 B 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.

1 Figures in square brackets refer to the bibliography.

INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

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

1 Scope and object

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 6.2 of Part 1[2] (Examples 1, 5 and 11).

The dimensioning in this standard is more precise than that provided by Part 1. However, if the precision provided by this standard is not required, Part 1 may be applied instead.

This standard can only be used in its 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. In addition, this part of IEC 60664 can only be used together with Part 1.

When this Part 5 is applied to the dimensioning of clearances and creepage distances equal to or less than 2 mm, all clauses are 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 1 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 2 For minimum creepage distances to maintain adequate insulation resistance, see Table A.2.

NOTE 3 This standard is not applicable to 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.

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.

Clause 2 of Part 1 is applicable, as well as the following:

2 "Part 1" refers to IEC 60664-1.

IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

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

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities –Stationary use at weatherprotected locations*

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

IEC 60721-3-9:1993, *Classification of environmental conditions – Part 3-9: Classification of groups of environmental parameters and their severities – Microclimates inside products*

3 Terms and definitions

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

3.1
water adsorption
capability of insulating material to adsorb water on its surface

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

4 Fundamentals of clearance and creepage distance dimensioning

4.1 Introductory remark

The first publication on this subject was IEC 60664, 1980. It only covered clearances, the data being based on fundamental data of breakdown voltages. Subsequently, in 1981 IEC 60664A was published concerning creepage distances based on data obtained over many years of experience, as well as data obtained from testing printed wiring boards. In 1992, the publications were combined and published as IEC 60664-1 (Part 1). However, the revision did not change the basic data.

4.2 Basic principles

Insulation coordination implies the selection of the electric insulation characteristics of the equipment with regard to its application and in relation to its surroundings.

Insulation coordination can only be achieved if the design of the equipment is based on the stresses to which it is likely to be subjected during its anticipated lifetime.

Subclause 4.2 of Part 1 is applicable if not specified otherwise below.

4.2.5 Insulation coordination with regard to temporary overvoltage

Insulation coordination with regard to temporary overvoltages is based on the temporary overvoltage specified in Clause 442 of IEC 60364-4-44 (see 5.4.3.2.3 of this Part 5).

NOTE Currently available surge protective devices (SPDs) are not able to adequately deal with the energy associated with temporary overvoltages.

4.2.6 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 [3] 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;

– *for creepage distances*
  - air pressure,
  - pollution,
  - relative humidity,
  - condensation;

– *for solid insulation*
  - temperature,
  - relative humidity.

4.3 Voltages and voltage ratings

4.3.1 General

Subclause 4.3.1 of Part 1 is applicable.

4.3.2 Determination of voltage for long-term stresses

4.3.2.1 General

Subclause 4.3.2.1 of Part 1 is applicable.

4.3.2.2 Voltage for dimensioning basic insulation

4.3.2.2.1 Equipment energized directly from the low-voltage mains

The nominal voltages of the low-voltage mains have been rationalized according to Tables F.3a and F.3b of Part 1 and these voltages are the minimum to be used for the selection of creepage distances. They may also be used for the selection of rated insulation voltages.

For equipment having several rated voltages so that it may be used at different nominal voltages of the low-voltage mains, the voltage selected shall be appropriate for the highest rated voltage of the equipment.

Technical committees shall consider whether the voltage is to be selected

– based on line-to-line voltage, or
– based on line-to-neutral voltage.

In the latter case the technical committee shall specify how the user is to be informed that the equipment is for use on neutral-earthed systems only.

4.3.2.2.2 Systems, equipment and internal circuits not energized directly from the low-voltage mains

Subclause 4.3.2.2.2 of Part 1 is applicable.

4.3.2.3 Voltage for dimensioning functional insulation

Subclause 4.3.2.3 of Part 1 is applicable.

4.3.3 Determination of rated impulse voltage

4.3.3.1 General

Subclause 4.3.3.1 of Part 1 is applicable.

4.3.3.2 Overvoltage categories

4.3.3.2.1 General

Subclause 4.3.3.2.1 of Part 1 is applicable.

4.3.3.2.2 Equipment energized directly from the supply mains

Subclause 4.3.3.2.2 of Part 1 is applicable.

4.3.3.2.3 Systems and equipment not energized directly from the low-voltage mains

Subclause 4.3.3.2.3 of Part 1 is applicable.

4.3.3.3 Selection of rated impulse voltage for equipment

Subclause 4.3.3.3 of Part 1 is applicable.

4.3.3.4 Impulse voltage insulation coordination within equipment

4.3.3.4.1 Parts or circuits within equipment significantly influenced by external transient overvoltages

Subclause 4.3.3.4.1 of Part 1 is applicable.

4.3.3.4.2 Parts or circuits within equipment specifically protected against transient overvoltages

For such parts are not significantly influenced by external transient overvoltages, the impulse withstand voltage required for basic insulation is not related to the rated impulse voltage of the equipment but to the actual conditions for that part or circuit. Application of the preferred series

of impulse voltage values as introduced in 4.2.3 of Part 1 is, however, recommended to permit standardization. In other cases, interpolation of Table 2 values of this Part 5 is allowed.

4.3.3.5 Switching overvoltage generated by the equipment

Subclause 4.3.3.5 of Part 1 is applicable.

4.3.3.6 Interface requirements

Subclause 4.3.3.6 of Part 1 is applicable.

4.3.4 Determination of recurring peak voltage

Subclause 4.3.4 of Part 1 is applicable.

4.3.5 Determination of temporary overvoltage

4.3.5.1 General

Subclause 4.3.5.1 of Part 1 is applicable.

4.3.5.2 Fault voltage

Subclause 4.3.5.2 of Part 1 is applicable.

4.3.5.3 Stress due to temporary overvoltages

The magnitude and duration of a temporary overvoltage in low-voltage equipment due to an earth fault in the high-voltage system are given in 5.4.3.2.3.

4.4 Frequency

Subclause 4.4 of Part 1 applies.

4.5 Time under voltage stress

Not applicable.

4.6 Pollution

4.6.1 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. 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 4.6.4. The influence of the water adsorption characteristics on the surface of insulation is identified by the water adsorption groups specified in 4.8.6.

4.6.2 Degrees of pollution in the micro-environment

Subclause 4.6.2 of Part 1 applies.

4.6.3 Conditions of conductive pollution

Not applicable.

4.6.4 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 defined:

- 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.

4.6.5 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

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

4.7 Information supplied with the equipment

Subclause 4.7 of Part 1 is applicable.

4.8 Insulating material

4.8.1 General

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

The electric strength characteristics as well as the thermal, mechanical, chemical and water adsorption characteristics of insulating material shall be considered by the technical committees. Regarding the requirements for solid insulation, 5.4 of this Part 5 applies.