

# TECHNICAL REPORT

## RAPPORT TECHNIQUE



BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

**Insulation coordination for equipment within low-voltage systems –  
Part 2-1: Application guide – Explanation of the application of  
the IEC 60664 series, dimensioning examples and dielectric testing**

**Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse  
tension –**

**Partie 2-1: Guide d'application – Explication de l'application de la série  
CEI 60664, exemples de dimensionnement et d'essais diélectriques**



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IEC TR 60664-2-1:2011

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

### Part 2-1: Application guide – Explanation of the application of the IEC 60664 series, dimensioning examples and dielectric testing

## FOREWORD

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IEC/TR 60664-2-1, which is a technical report, serves as an application guide for the IEC 60664 series and 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 1997, and constitutes a technical revision.



The main changes with respect to the previous edition are listed below:

- the previous edition was only an application guide for IEC 60664-1. This second edition takes into account not only IEC 60664-1 but also the other parts IEC 60664-3, IEC 60664-4, and IEC 60664-5 and their interrelation;
- principles of the IEC 60664 series for insulation dimensioning of LV equipment are explained and examples of practical application are provided together with some background information;
- Annex A provides an overview of clauses of IEC 60664-1 requiring decisions by technical committees, or specification of options, or requiring activities of the manufacturer;
- Annex B provides an overview of such clauses of IEC 60664-4;
- Annex C provides an overview of such clauses of IEC 60664-5;
- Annex D amends the tables of Annex F of IEC 60664-1:2007 with rated impulse voltages for voltages line to neutral derived from nominal d.c. voltages up to and including 1 500 V.

The text of this application guide is based on the following documents:

Enquiry draft	Report on voting
109/82/DTR	109/83/RVC

Full information on the voting for the approval of this application guide 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.

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

A list of all the 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 amendment and the base 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.

The contents of the corrigendum of October 2011 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 application guide provides information relating to insulation coordination, as described in the IEC 60664 series, for the benefit of IEC technical committees and manufacturers. It covers general information for the dimensioning of clearances, creepage distances and solid insulation for equipment.

It aims to highlight the use and understanding of the IEC 60664 series when applied by technical committees and manufacturers.

Insulation coordination for equipment implies the assessment of the minimum necessary dimensioning for clearances, creepage distances and solid insulation in order to allow safe use of the equipment during its lifetime, taking into consideration the foreseeable environmental conditions.

The main parameters to be taken into account for the understanding of the IEC 60664 series include:

- the maximum voltage stress to be withstood in order to avoid flashover across clearances;
- the characteristics of the solid insulating material and the environmental conditions regarding tracking. IEC 60664-3 provides methods for improving the micro-environment at the creepage distance;
- the electrical field stress through solid insulation as it relates to the risk of partial discharge and dielectric loss causing a risk of breakdown due to excessive heating. In particular, technical committees and manufacturers should consider a partial discharge test if the maximum peak voltage across the insulation material exceeds 700 V and the peak value of the field strength exceeds 1 kV/mm. Due to the fact that both partial discharge phenomena and dielectric losses increase in importance with voltage frequency, a dedicated standard, IEC 60664-4, applies for frequencies higher than 30 kHz;

NOTE IEC 60664-4 provides information concerning clearances, creepage distances, solid insulation and testing for frequencies above 30 kHz.

- the long-term maximum voltage stress to be withstood in order to avoid tracking over the surface of the insulation material;
- flashover; besides tracking, this is increasingly important with reduction of creepage distance in the presence of high humidity. IEC 60664-5 introduces humidity levels classifying the effects of humidity on creepage distances equal to or less than 2 mm.

Other stresses such as heat, vibration, mechanical shocks, radiation, etc. may influence the performance of solid insulating materials in service. Technical committees and manufacturers should consider the risks related to these stresses when specifying conditions for testing equipment to be used under particular situations.

## INSULATION COORDINATION FOR EQUIPMENT WITHIN LOW-VOLTAGE SYSTEMS –

### Part 2-1: Application guide – Explanation of the application of the IEC 60664 series, dimensioning examples and dielectric testing

#### 1 Scope

This part of IEC 60664, which is a technical report, serves as an application guide for technical committees and manufacturers specifying dimensioning requirements for products in accordance with the IEC 60664 series.

The significant items for consideration are as follows:

- a) nominal system voltage(s) or rated insulation voltage(s);
- b) overvoltage category of the products (OV cat.);
- c) any type of overvoltages;
- d) frequency of the voltage;
- e) characteristics of the solid insulating material;
- f) pollution degree and humidity levels.

#### 2 Normative references

[IEC TR 60664-2-1:2011](https://standards.iteh.ai/catalog/standards/sist/65e874ad-46ba-41d2-9b8a-7a930878746/iec-60664-2-1-2011)

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

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*  
Amendment 1 (2009)

IEC 60216 (all parts), *Electrical insulating materials – Properties of thermal endurance*

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

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

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60664-5:2007, *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*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE All definitions can be found in the various parts of the IEC 60664 series, as indicated below.

#### 3.0

##### **apparent charge**

$q$

electric charge which can be measured at the terminals of the specimen under test

NOTE 1 The apparent charge is smaller than the partial discharge.

NOTE 2 The measurement of the apparent charge requires a short-circuit condition at the terminals of the specimen under test.

[IEC 60664-1:2007, 3.18.1]

#### 3.1

##### **approximately homogeneous field**

for frequencies exceeding 30 kHz the field is considered to be approximately homogeneous when the radius of curvature of the conductive parts is equal or greater than 20 % of the clearance

[IEC 60664-4:2005, 3.1]

#### 3.2

##### **base material**

insulating material upon which a conductive pattern may be formed

NOTE The base material may be rigid or flexible, or both. It may be a dielectric or an insulated metal sheet.

(IEC 60194, definition 40.1334)

[IEC TR 60664-2-1:2011](https://standards.iteh.ai/catalog/standards/sist/65c874ad-46be-41d2-9b8a-7c930f6707c6/iec-tr-60664-2-1-2011)

[IEC 60664-3:2003, 3.1]

<https://standards.iteh.ai/catalog/standards/sist/65c874ad-46be-41d2-9b8a-7c930f6707c6/iec-tr-60664-2-1-2011>

#### 3.3

##### **basic insulation**

insulation of hazardous-live-parts which provides basic protection

NOTE The concept does not apply to insulation used exclusively for functional purposes.

(IEV 826-12-14)

[IEC 60664-1:2007, 3.17.2]

#### 3.4

##### **clearance**

shortest distance in air between two conductive parts

[IEC 60664-1:2007, 3.2]

#### 3.5

##### **coating**

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

NOTE Coating and base material of a printed board form an insulating system that may have properties similar to solid insulation.

[IEC 60664-3:2003, 3.5]

#### 3.6

##### **conductor**

single conductive path in a conductive pattern

(IEC 60194, definition 22.0251)

[IEC 60664-3:2003, 3.3]

### 3.7

#### **creepage distance**

shortest distance along the surface of a solid insulating material between two conductive parts

(IEV 151-15-50)

[IEC 60664-1:2007, 3.3]

### 3.8

#### **double insulation**

insulation comprising both basic insulation and supplementary insulation

(IEV 826-12-16)

[IEC 60664-1:2007, 3.17.4]

### 3.9

#### **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

[IEC 60664-1:2007, 3.20]

### 3.10

#### **electrical field strength**

$E$

voltage gradient per unit length usually expressed in kV/mm

[IEC 60664-4:2005, 3.7]

### 3.11

#### **environment**

surrounding which may affect performance of a device or system

NOTE Examples are pressure, temperature, humidity, pollution, radiation, vibration.

(IEV 151-16-03, modified)

[IEC 60664-1:2007, 3.12]

### 3.12

#### **flashover**

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

[IEC 60664-1:2007, 3.20.2]

### 3.13

#### **functional insulation**

insulation between conductive parts which is necessary only for the proper functioning of the equipment

[IEC 60664-1:2007, 3.17.1]

### 3.14

#### **homogeneous field**

electric field which has an essentially constant voltage gradient between electrodes (uniform field), such as that between two spheres where the radius of each sphere is greater than the distance between them

NOTE The homogeneous field condition is referred to as case B.

[IEC 60664-1:2007, 3.14]

### 3.15

#### **impulse withstand voltage**

highest peak value of impulse voltage of prescribed form and polarity which does not cause breakdown of insulation under specified conditions

[IEC 60664-1:2007, 3.8.1]

### 3.16

#### **inhomogeneous field**

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

NOTE 1 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.

NOTE 2 For frequencies exceeding 30 kHz the field is considered to be inhomogeneous when the radius of curvature of the conductive parts is less than 20 % of the clearance.

[IEC 60664-1:2007, 3.15, modified, and IEC 60664-4:2005, 3.2]

### 3.17

#### **insulation**

that part of an electrotechnical product which separates the conducting parts at different electrical potentials

(IEV 212-01-05)

[IEC 60664-1:2007, 3.17]

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### 3.18

#### **insulation coordination**

mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and other influencing stresses

[IEC 60664-1:2007, 3.1, modified]

### 3.19

#### **macro-environment**

environment of the room or other location in which the equipment is installed or used

[IEC 60664-1:2007, 3.12.1]

### 3.20

#### **micro-environment**

immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

[IEC 60664-1:2007, 3.12.2]

### 3.21

#### **overvoltage**

any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

[IEC 60664-1:2007, 3.7]

### 3.22

#### **overvoltage category**

numeral defining a transient overvoltage condition

[IEC 60664-1:2007, 3.10, modified]

**3.23****partial discharge**

PD

electric discharge that partially bridges the insulation

[IEC 60664-1:2007, 3.18]

**3.24****partial discharge inception voltage** $U_i$ 

lowest peak value of the test voltage at which the apparent charge becomes greater than the specified discharge magnitude when the test voltage is increased above a low value for which no discharge occurs

NOTE For a.c. tests the r.m.s. value may be used.

[IEC 60664-1:2007, 3.18.4]

**3.25****pollution**

any addition of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

[IEC 60664-1:2007, 3.11]

**3.26****pollution degree**

numeral characterizing the expected pollution of the micro-environment

[IEC 60664-1:2007, 3.13]

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[IEC TR 60664-2-1:2011](https://standards.iteh.ai/catalog/standards/sist/65c874ad-46be-41d2-9b8a-7c930f6707c6/iec-tr-60664-2-1-2011)

<https://standards.iteh.ai/catalog/standards/sist/65c874ad-46be-41d2-9b8a-7c930f6707c6/iec-tr-60664-2-1-2011>

**3.27****printed board**

general term for completely processed printed circuit and printed wiring configurations

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

(IEC 60194, definition 60.1485)

[IEC 60664-3:2003, 3.2]

**3.28****protection**

any kind of measure which reduces the influence of the environment

[IEC 60664-3:2003, 3.4]

**3.29****r.m.s. withstand voltage**

highest r.m.s. value of a voltage which does not cause breakdown of insulation under specified conditions

[IEC 60664-1:2007, 3.8.2]

**3.30****rated impulse voltage**

impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages

[IEC 60664-1:2007, 3.9.2]