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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

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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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CONTENTS

FOREWORD 6
INTRODUCTION 8
1 Scope 9
2 Normative references 9
3 Terms and definitions 10
4 Principles and practical application of the IEC 60664 series for insulation dimensioning of LV equipment 17
4.1 Basic principles 17
4.2 Coordination of overvoltage categories inside equipment 17
4.3 Practical use of the IEC 60664 series for the dimensioning of clearances 18
4.3.1 General 18
4.3.2 Practical use of Tables F.2 and F.7 of IEC 60664-1:2007 for the dimensioning of clearances 18
4.3.3 Practical use of Tables 2 and 3 of IEC 60664-5:2007 for the dimensioning of clearances 20
4.4 Practical use of the IEC 60664 series for the dimensioning of creepage distances 20
4.4.1 General 20
4.4.2 Practical use of Table F.4 of IEC 60664-1:2007 and Table 4 of IEC 60664-5:2007 for the dimensioning of creepage distances 21
4.4.3 Practical use of Table 5 in IEC 60664-5:2007 for dimensioning of creepage distances 22
4.4.4 Practical use of IEC 60664-1:2007 for checking the dimensioning of creepage distances with regard to time under voltage stress 22
4.4.5 Practical use of IEC 60664-3:2003 for the reduction of micro-environmental conditions for the dimensioning of creepage distances 23
4.5 Practical use of the IEC 60664 series for the dimensioning of solid insulation 23
4.5.1 General 23
4.5.2 Coordination of clearances and solid insulation 24
4.5.3 Practical information for checking the correct dimensioning of solid insulation 25
4.6 Practical use of the IEC 60664 series for designing functional insulation 31
4.6.1 General 31
4.6.2 Dimensioning and testing of functional isolation compared to basic insulation 31
4.7 Practical use of the IEC 60664 series for dimensioning with respect to the influence of the frequency of the voltage 32
4.7.1 General influence of the frequency on withstand characteristics 32
4.7.2 Influence of the frequency on the withstand characteristics of clearances 32
4.7.3 Influence of frequency on the withstand characteristics of creepage distances 32
4.7.4 Influence of frequency on the withstand characteristics of solid insulation 33
5 Four examples showing appropriate dimensioning of insulation within equipment 34
5.1 General 34
5.2 Examples for the dimensioning of clearances for class I equipment according to IEC 60664-1 36

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5.3 Examples for the dimensioning of clearances for class II equipment according to IEC 60664-1 37
5.4 Examples for the dimensioning of clearances for class II equipment according to IEC 60664-5 39
6 Practical application of the IEC 60664 series with regards to particular questions 40
6.1 General 40
6.2 Testing complete equipment in case of components bridging the basic insulation 40
6.3 Testing complete equipment in case of components bridging the functional insulation 41
6.3.1 General 41
6.3.2 Verification of clearances and creepage distances 41
6.3.3 Verification of components bridging the insulation 42
6.4 Dimensioning of insulation distances for parts of equipment which can have isolation capability 42
6.4.1 General 42
6.4.2 Dimensioning for device associated with an equipment declared suitable for isolation 42
6.4.3 Dimensioning for device associated with an equipment not declared suitable for isolation 42
6.5 Testing with respect to high-frequency voltage stress 43
6.6 Practical information in case of substitution an impulse withstand test by an AC or DC test 43
6.6.1 General 43
6.6.2 Characteristics of the a.c. voltage substituted to an impulse withstand test for dielectric test 43
6.6.3 Characteristics of the d.c. voltage substituted to an impulse withstand test for dielectric test 44
7 Examples of a dimensioning worksheet (based on case A as described in IEC 60664-1:2007) 44
7.1 Use of IEC 60664-1:2007, for circuits in equipment either directly or not directly connected to the mains supply 44
7.2 Use of IEC 60664-5:2007, for circuits in equipment either directly or not directly connected to the mains supply 45
7.3 Use of IEC 60664-4:2005, for circuits in equipment either directly or not directly connected to the mains supply 46
7.4 Examples comparing the dimensioning of clearances and creepage distances according to IEC 60664-1 and IEC 60664-5 based on case A condition (basic insulation, for equipment up to 2 000 m altitude) 48
7.4.1 Circuits not directly connected to mains supply 48
7.4.2 Circuits not directly connected to mains supply 49
7.5 Examples of dimension comparison for clearances and creepage distances according to IEC 60664-1 and IEC 60664-4 based on case A condition (basic insulation, for equipment up to 2 000 m altitude) 50
7.5.1 Circuits not directly connected to mains supply 50
7.5.2 Circuits not directly connected to mains supply 52
Annex A (informative) Overview of Clauses of IEC 60664-1 requiring decisions by technical committees, specification of options or requiring activities by the manufacturer 54
Annex B (informative) Overview of Clauses of IEC 60664-4 requiring decisions by technical committees 58

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Annex C (informative) Overview of Clauses of IEC 60664-5 requiring decisions by technical committees, specification of options or requiring activities by the manufacturer 59

Annex D (informative) Dimensioning of clearances and creepage distances for d.c. voltages above 1000 V d.c. 63

Bibliography 64

Figure 1 – Breakdown voltage of solid insulation depending upon the time of voltage stress 24

Figure 2 – Series connection of clearance and solid insulation 27

Figure 3 – Capacitive voltage divider 27

Figure 4 – Permissible field strength for dimensioning of solid insulation according to Equation (7) 34

Figure 5a – Example 1 – Simple illustration of insulation system containing functional, basic and reinforced/double insulation for a class I equipment 35

Figure 5b – Example 2 – Dimensioning of clearances for class I equipment, based on overvoltage category III 36

Figure 5c – Example 3 – Dimensioning of clearances (class II equipment) 37

Figure 5d – Example 4 – Dimensioning of clearances (class II equipment) 39

Figure 6 – Arrangement for a.c. (or d.c.) voltage test 41

Table 1 – Examples for rated voltage 100 V and 230 V and overvoltage category II 26

Table 2 – Example 2 – Dimensioning of clearances according to Table F.2 of IEC 60664-1:2007 (pollution degree 2) (see example 2 of Figure 5b) 36

Table 3 – Example 2 – Dimensioning of clearances according to Tables F.2 and F.7a of IEC 60664-1:2007, temporary overvoltages according to 5.3.3.2.3 of IEC 60664-1:2007 (U_n+1200 V) (see example 2 of Figure 5b) 37

Table 4 – Example 3 – Dimensioning of clearances according to Table F.2 of IEC 60664-1:2007 (pollution degree 2) (see example 3 of Figure 5c) 38

Table 5 – Example 3 – Dimensioning of clearances according to Tables F.2 and F.7a of IEC 60664-1:2007, temporary overvoltages according to 5.3.3.2.3 of IEC 60664-1:2007 (U_n+1200 V) (see example 3 of Figure 5c) 38

Table 6 – Example 4 – Dimensioning of clearances according to Table 2 of IEC 60664-5:2007 (see example 4 on Figure 5d) 39

Table 7 – Example 4 – Dimensioning of clearances according to Tables 2 and 3 of IEC 60664-5:2007, temporary overvoltages according to 5.3.3.2.3 of IEC 60664-1:2007 (U_n+1 200 V) (see example 4 on Figure 5d) 40

Table 8 – Relationship between influencing parameters and normative references in IEC 60664-1 44

Table 9 – Relationship between influencing parameters and normative references in IEC 60664-1 or IEC 60664-5 45

Table 10 – Relationship between influencing parameters and normative references in IEC 60664-1 or IEC 60664-4 46

Table 11 – Example for dimensioning a clearance and creepage distance following IEC 60664-1 48

Table 12 – Example for dimensioning a clearance and creepage distance following IEC 60664-5 49

Table 13 – Example for dimensioning a clearance and creepage distance following IEC 60664-1 in circuits not directly connected to mains supply 49

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IEC TR 60664-2-1:2011
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Table 14 – Example for dimensioning a clearance and creepage distance following IEC 60664-5 in circuits not directly connected to mains supply 50
Table 15 – Example for dimensioning a clearance and creepage distance following IEC 60664-1 in circuits not directly connected to mains supply 51
Table 16 – Example for dimensioning a clearance and creepage distance following IEC 60664-4 (approximately homogeneous field) 51
Table 17 – Example for dimensioning a clearance and creepage distance following IEC 60664-1 in circuits not directly connected to mains supply 52
Table 18 – Example for dimensioning a clearance and creepage distance following IEC 60664-4 (approximately homogeneous field) 53
Table A.1 – Clauses and titles of IEC 60664-1 and items to be considered by technical committees 54
Table A.2 – Clauses and titles of IEC 60664-1 and optional specifications for consideration by technical committees 56
Table A.3 – Clauses and titles of IEC 60664-1 and required manufacturer activities 57
Table B.1 – Clauses and titles of IEC 60664-4 and optional specifications for consideration by technical committees 58
Table C.1 – Clauses and titles of IEC 60664-5 and items to be considered by technical committees 59
Table C.2 – Clauses and titles of IEC 60664-5 and optional specifications for consideration by technical committees 61
Table C.3 – Clauses and titles of IEC 60664-5 and required manufacturer activities 62
Table D.1 – Rated impulse voltage for equipment 63

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IEC TR 60664-2-1:2011
https://ecommerce.sist.si/catalog/standards/sist/65c874ad-46be-41d2-9b8a-7c930f6707c6/iec-tr-60664-2-1-2011

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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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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

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.

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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.

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– 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.

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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.

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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 60664-3:2003, 3.1]

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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]

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3.11
environment
surrounding which may affect performance of a device or system

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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]

SIST Preview
(https://ecommerce.sist.si)

3.18
insulation coordination
mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and other influencing stresses

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

[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]

SIST Preview
(https://ecommerce.sist.si)
IEC TR 60664-2-1:2011
https://ecommerce.sist.si/catalog/standards/sist/6ea87dbd-c6ba-41a2-9ada-7e1b0f670ec6/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]