IEC TR 60664-2-1

Edition 3.0 2026-11

TECHNICAL REPORT

BASIC SAFETY PUBLICATION

HORIZONTAL PUBLICATION

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

ICS 29.080.30

ISBN 978-2-8327-1482-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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 has been prepared by IEC technical committee 109: Insulation coordination for low-voltage equipment. It is a Technical Report and serves as an application guide for the IEC 60664 series [1].

This third edition cancels and replaces the second edition, published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– the third edition of this technical report is reconstructed to align with the structure of IEC 60664-1:2020 [2] and IEC 60664-1:2020/AMD1:2025 [3];
– reference numbers indicated in this technical report are updated in line with the changes to clause and table numbers in IEC 60664-1:2020 [2] and IEC 60664-1:2020/AMD1:2025 [3];

– references to IEC 60664-5:2007 [4], withdrawn in 2014, are deleted, and replaced, where applicable, to reference to IEC TR 63040 [5];
– explanations of the principles of IEC 60664 series [1] and examples of practical application are improved;
– Table A.1, Table A.2, and Table A.3 are combined into one table;
– Annex B, Annex C, and Annex D are deleted.

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

Draft	Report on voting
109/254/DTR	109/255/RVDTR

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.

The language used for the development of this Technical Report is English.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

It has the status of a basic safety publication in accordance with IEC GUIDE 104 [6].

This document is to be read in conjunction with IEC 60664-1:2020 [2], IEC 60664-1:2020/AMD1:2025 [3], IEC 60664-3:2016 [7] and IEC 60664-4:2005 [8].

A list of all the parts in the IEC 60664 series [1], 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, or
– revised.

INTRODUCTION

This application guide provides information relating to insulation coordination, as described in the IEC 60664 series [1], for the benefit of IEC technical committees and manufacturers of electrical equipment and components for use within low-voltage systems. It covers general information for the dimensioning of clearances, creepage distances and solid insulation for equipment within low-voltage systems.

It aims to highlight the use and understanding of the IEC 60664 series [1] when applied by technical committees and manufacturers. For the IEC 60664 series [1], the following parts are published:

a) IEC 60664-1 [9]: Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests.

b) IEC TR 60664-2-1 [10]: 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.

c) IEC 60664-3 [11]: Insulation coordination for equipment within low-voltage systems - Part 3: Use of coating, potting or moulding for protection against pollution.

d) IEC 60664-4 [12]: Insulation coordination for equipment within low-voltage systems - Part 4: Consideration of high-frequency voltage stress.

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 understanding of the IEC 60664 series [1] 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 [11] provides methods for improving the micro-environment at the creepage distance;

– the electric 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. Due to the fact that both partial discharge phenomena and dielectric losses increase in importance with voltage frequency, a dedicated standard, IEC 60664-4 [12], applies for frequencies higher than 30 kHz;

– the long-term maximum voltage stress on creepage distances to be withstood in order to avoid tracking over the surface of the insulating material;

– flashover; besides tracking, this is increasingly important with reduction of creepage distance in the presence of high humidity. IEC TR 63040 [5] provides information of 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 (thermal, X-rays, microwave, ultraviolet, etc.) can influence the performance of solid insulating materials in service. Technical committees and manufacturers are expected to consider the impacts to the solid insulation materials resulting from these other stresses following tests on equipment under particular situations.

1 Scope

This document serves as an application guide, when using the IEC 60664 series [1] for the design and verification of an insulation system of electrical equipment within low-voltage systems, in order to provide better understanding related to the:

– basic technical characteristics relevant for the design of clearances, creepage distances, and solid insulation,

– design for insulation coordination to clearances, creepage distances, and solid insulation and combinations of such,

– test and measurement of clearances, creepage distances, and solid insulation for electrical equipment and their components,

– practical examples for dimensioning of clearances, creepage distances and solid insulation.

This document is informative only and does not provide any additional requirements beyond the IEC 60664 series [1]. It provides guidance to assist better understanding of the insulation coordination requirements and avoids repeating the content of the individual parts of IEC 60664 documents. In case of conflict between this document and documents mentioned above, requirements in these documents prevail over this technical report.

This document provides a summary for technical committees in the preparation of their standards, and for manufacturers of electrical equipment and components, on specific topics, activities and options which are considered when using the IEC 60664 series [1] in their specific equipment or application. See Annex A.

This basic safety publication focusing on safety guidance related to IEC 60664 series [1] is primarily intended for use by technical committees in the preparation of safety publications in accordance with the principles laid down in IEC GUIDE 104 [6] and ISO/IEC Guide 51 [13].

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications.

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 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests*

IEC 60664-1:2020/AMD1:2025, *Amendment 1 - Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests*

IEC 60664-3:2016, *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*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60664-1:2020 , IEC 60664-1:2020/AMD1:2025 , IEC 60664-3:2016 , and IEC 60664-4:2005 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– ISO Online browsing platform: available at https://www.iso.org/obp
– IEC Electropedia: available at http://www.electropedia.org

3.2 Abbreviated terms

In addition to abbreviated terms given in IEC 60664-1:2020, IEC 60664-1:2020/AMD1:2025, the following abbreviations are used in this document.

SPD	Surge protective device connected to low-voltage power systems described in the IEC 61643-x1 series [14]
SPC	Surge protective component for low-voltage surge protective devices described in the IEC 61643-3x1 series [15]
OVC	Overvoltage category. See IEC 60664-1:2020 [2], 3.1.20.
TOV	Temporary overvoltage. See IEC 60664-1:2020 [2], 3.1.12.

4 Basic technical characteristics for insulation coordination

4.1 General

Designing each insulation part of an insulation system for electrical equipment according to the IEC 60664 series [1] is essential but it also involves careful considerations. It is important that insulation coordination is considered in the correct context.

Important parts of this consideration are:

– the purpose of insulation coordination,
– the characteristics influencing the insulation system,
– the consequences of a failure of a specific insulation within the system.

For the design of insulation coordination different parameters are considered:

a) Limits for the equipment considering the intended use:
   1) Voltages characteristics present in the intended installation or application (see IEC 60664-1:2020 [2] and IEC 60664-1:2020/AMD1:2025 [3], 4.2 to 4.4).
   2) Macro-environmental and micro-environmental conditions (humidity, temperature, altitude, pollution etc.) and their impacts on the insulation coordination including consideration about the materials used as insulators (see IEC 60664-1:2020 [2], 4.5 to 4.7).
   3) Life time consideration about conditions and duration of voltage stress (see IEC 60664-1:2020 [2], 4.6 and 4.8).
b) Operation mode of the equipment considering:

   Voltage characteristics generated by the equipment itself considering normal operating conditions, abnormal operating conditions and single fault condition (see IEC 60664-1:2020 [2] and IEC 60664-1:2020/AMD1:2025 [3], 4.2).
c) Identification of the purpose of the insulation coordination:
   1) Insulation for the purpose of the primary function of the equipment not related to any risk or increased reliability.
   2) Risk mitigation for safety aspects (for example protection against electric shock, functional safety, explosive atmosphere, fire, energy hazards).
   3) For increased reliability, for example, taking into account an effect of ageing considering the pollution degree or group of material. See 4.6.2.
   4) Insulation for the purpose of a safe function of a specific functionality inside the equipment.