IEC 60071-1

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INTERNATIONAL STANDARD

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Insulation co-ordination – Part 1: Definitions, principles and rules

Coordination de l'isolement – Partie 1: Définitions, principes et règles

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Insulation co-ordination – Part 1: Definitions, principles and rules

Coordination de l'isolement – Partie 1: Définitions, principes et règles

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INSULATION CO-ORDINATION –

Part 1: Definitions, principles and rules

FOREWORD

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International Standard IEC 60071-1 has been prepared by IEC technical committee 99: Insulation co-ordination and system engineering of high voltage electrical power installations above 1,0 kV AC and 1,5 kV DC.

This ninth edition cancels and replaces the eighth edition published in 2006 and Amendment 1:2010. This edition constitutes a technical revision.

It has the status of a horizontal standard in accordance with IEC Guide 108.

The main changes from the previous edition are as follows:

a) all references are updated to current IEC standards, and the bibliography is deleted;
b) some definitions are clarified in order to avoid overlapping and ensure clear understanding;
c) letter symbols are changed and corrected in order to keep the consistency with relevant IEC standards;
d) some titles are changed to clarify understanding (see Clauses A.2, A.3 and Annex B).

The text of this International Standard is based on the following documents:

CDV	Report on voting
99/199/CDV	99/227/RVC

Full information on the voting for the approval of this International 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 60071 series, published under the general title *Insulation co-ordination*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendments 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- withdrawn,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.

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INSULATION CO-ORDINATION –

Part 1: Definitions, principles and rules

1 Scope

This part of IEC 60071 applies to three-phase AC systems having a highest voltage for equipment above 1 kV. It specifies the procedure for the selection of the rated withstand voltages for the phase-to-earth, phase-to-phase and longitudinal insulation of the equipment and the installations of these systems. It also gives the lists of the standard withstand voltages from which the rated withstand voltages are selected.

This document describes that the selected withstand voltages are associated with the highest voltage for equipment. This association is for insulation co-ordination purposes only. The requirements for human safety are not covered by this document.

Although the principles of this document also apply to transmission line insulation, the values of their withstand voltages can be different from the standard rated withstand voltages.

The apparatus committees are responsible for specifying the rated withstand voltages and the test procedures suitable for the relevant equipment taking into consideration the recommendations of this document.

NOTE In IEC 60071-2, all rules for insulation co-ordination given in this document are justified in detail, in particular the association of the standard rated withstand voltages with the highest voltage for equipment. When more than one set of standard rated withstand voltages is associated with the same highest voltage for equipment, guidance is provided for the selection of the most suitable set.

This horizontal standard is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 108.

One of the responsibilities of a technical committee is, wherever applicable, to make use of horizontal standards in the preparation of its publications. The contents of this horizontal standard will not apply unless specifically referred to or included in the relevant 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 60038, *IEC standard voltages*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-2, *Insulation co-ordination – Part 2: Application guidelines*

IEC 60099-4, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

3 Terms and definitions

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

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

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

3.1
insulation co-ordination
selection of the dielectric strength of equipment in relation to the operating voltages and overvoltages which can appear on the system for which the equipment is intended, and taking into account the service environment and the characteristics of the available preventing and protective devices

Note 1 to entry: By "dielectric strength" of the equipment, is meant here its rated insulation level (3.36) or its standard insulation level (3.37).

[SOURCE: IEC 60050-614:2016, 614-03-08, modified – Note 1 to entry has been added]

3.2
external insulation
distances in atmospheric air, and the surfaces in contact with atmospheric air of solid insulation of the equipment which are subject to dielectric stresses and to the effects of atmospheric and other environmental conditions from the site, such as pollution, humidity, vermin, etc.

Note 1 to entry: External insulation is either weather protected or non-weather protected, designed to operate outside or inside closed shelters, respectively.

[SOURCE: IEC 60050-614:2016, 614-03-02, modified – Note 1 to entry has been added]

3.3
internal insulation
internal distances of the solid, liquid, or gaseous insulation of equipment which are protected from the effects of atmospheric and other external conditions

[SOURCE: IEC 60050-614:2016, 614-03-03]

3.4
self-restoring insulation
insulation which completely recovers its insulating properties within a short time interval after a disruptive discharge

Note 1 to entry: Insulation of this kind is generally, but not necessarily, external insulation.

Note 2 to entry: This definition applies only when the discharge is caused by the application of a test voltage during a dielectric test. However, discharges occurring in service may cause a self-restoring insulation to lose partially or completely its original insulating properties.

[SOURCE: IEC 60050-614:2016, 614-03-04]

3.5
non-self-restoring insulation
insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge

Note 1 to entry: This definition applies only when the discharge is caused by the application of a test voltage during a dielectric test. However, discharges occurring in service may cause a self-restoring insulation to lose partially or completely its original insulating properties.

[SOURCE: IEC 60050-614:2016, 614-03-05]

3.6
insulation configuration terminal
any of the terminals between any two of which a voltage that stresses the insulation can be applied

Note 1 to entry: The types of terminal are:

a) phase terminal, between which and the neutral is applied in service the phase-to-neutral voltage of the system;

b) neutral terminal, representing, or connected to, the neutral point of the system (neutral terminal of transformers, etc.);

c) earth terminal, always solidly connected to earth in service (tank of transformers, base of disconnectors, structures of towers, ground plane, etc.).

3.7
insulation configuration
complete geometric configuration of the insulation in service, consisting of the insulation and of all terminals and including all elements (insulating and conducting) which influence its dielectric behaviour

Note 1 to entry: The insulation configurations defined in 3.7.1 to 3.7.4 are identified.

3.7.1
three-phase insulation configuration
insulation configuration having three phase terminals, one neutral terminal and one earth terminal

3.7.2
phase-to-earth insulation configuration
three-phase insulation configuration where two phase terminals are disregarded and, except in particular cases, the neutral terminal is earthed

3.7.3
phase-to-phase insulation configuration
three-phase insulation configuration where one phase terminal is disregarded. In particular cases, the neutral and the earth terminals are also disregarded

3.7.4
longitudinal insulation configuration
insulation configuration having two phase terminals and one earth terminal, the phase terminals belonging to the same phase of a three-phase system temporarily separated into two independently energized parts (e.g. open switching devices)

Note 1 to entry: The four terminals belonging to the other two phases are disregarded or earthed. In particular cases one of the two phase terminals considered is earthed.

3.8
nominal voltage of a system
U_n
suitable approximate value of voltage used to designate or identify a system

[SOURCE: IEC 60050-601:1985, 601-01-21, modified – A symbol has been added.]

3.9
highest voltage of a system
U_s
highest value of the phase-to-phase operating voltage (RMS value) which occurs under normal operating conditions at any time and at any point in the system

[SOURCE: IEC 60050-601:1985, 601-01-23, modified – Clear meaning on the voltage has been added.]

3.10
highest voltage for equipment
U_m
highest value of phase-to-phase voltage (RMS value) for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards

Note 1 to entry: Under normal service conditions specified by the relevant apparatus committee, this voltage can be applied continuously to the equipment.

[SOURCE: IEC 60050-614:2016, 614-03-01]

3.11
isolated neutral system
system where the neutral point is not intentionally connected to earth, except for high impedance connections for protection or measurement purposes

[SOURCE: IEC 60050-601:1985, 601-02-24]

3.12
solidly earthed neutral system
system whose neutral point(s) is(are) earthed directly

[SOURCE: IEC 60050-601:1985, 601-02-25]

3.13
impedance earthed (neutral) system
system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents

[SOURCE: IEC 60050-601:1985, 601-02-26]

3.14
resonant earthed (neutral) system
system in which one or more neutral points are connected to earth through reactances which approximately compensate the capacitive component of a single-phase-to-earth fault current

Note 1 to entry: With resonant earthing of a system, the residual current in the fault is limited to such an extent that an arcing fault in air is usually self-extinguishing.

[SOURCE: IEC 60050-601:1985, 601-02-27]

3.15
earth fault factor
k
at a given location of a three-phase system, and for a given system configuration, the ratio of the highest RMS phase-to-earth power-frequency voltage on a healthy phase during a fault to earth affecting one or more phases at any point on the system to the RMS phase-to-earth power-frequency voltage which would be obtained at the given location in the absence of any such fault

[SOURCE: IEC 60050-614:2016, 614-03-06, modified – A symbol has been added and description on voltage has been modified.

3.16
continuous voltage
power-frequency voltage, considered having constant RMS value, continuously applied to any pair of terminals of an insulation configuration

3.17
overvoltage
voltage:

– between one phase conductor and earth or across a longitudinal insulation having a peak value exceeding the peak of the highest voltage of the system divided by $\sqrt{3}$;
– between phase conductors having a peak value exceeding the amplitude of the highest voltage of the system

Note 1 to entry: Unless otherwise clearly indicated, such as for surge arresters, overvoltage values expressed in p.u. refer to $U_s \times \sqrt{2}/\sqrt{3}$

[SOURCE: IEC 60050-614: 2016, 614-03-10]

3.17.1
temporary overvoltage
TOV
power-frequency overvoltage of relatively long duration

Note 1 to entry: The overvoltage may be undamped or weakly damped. In some cases, its frequency may be several times smaller or higher than power frequency.

[SOURCE: IEC 60050-614:2016, 614-03-13]

3.17.2
transient overvoltage
short-duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

Note 1 to entry: Transient overvoltages may be immediately followed by temporary overvoltages. In such cases the two overvoltages are considered as separate events.

[SOURCE: IEC 60050-614:2016, 614-03-14]

3.17.2.1
slow-front overvoltage
SFO
transient overvoltage, usually unidirectional, with time to peak 20 µs < $T_p \leq$ 5 000 µs, and tail duration $T_2 \leq$ 20 ms

3.17.2.2
fast-front overvoltage
FFO
transient overvoltage, usually unidirectional, with time to peak 0,1 µs < $T_1 \leq$ 20 µs, and tail duration T_2 < 300 µs

3.17.2.3
very-fast-front overvoltage
VFFO
transient overvoltage, usually unidirectional with time to peak $T_f \leq$ 0,1 µs, and with or without superimposed oscillations at frequency 30 kHz < f < 100 MHz

3.17.3
combined overvoltage
overvoltage consisting of two voltage components simultaneously applied between each of the two phase terminals of a phase-to-phase (or longitudinal) insulation and earth

Note 1 to entry: It is classified by the component of higher peak value (temporary, slow-front, fast-front or very-fast-front).

3.18
standard voltage shapes for test
voltage and the overvoltage shapes for test that are determined in amplitude, wave front, wave tail and duration

Note 1 to entry: More details on the following three first standard voltage shapes are given in IEC 60060-1 and also in Table 1.

3.18.1
standard short-duration power-frequency voltage
sinusoidal voltage with frequency between 48 Hz and 62 Hz, and duration of 60 s

3.18.2
standard switching impulse
impulse voltage having a time to peak of 250 µs and a time to half-value of 2 500 µs

3.18.3
standard lightning impulse
impulse voltage having a front time of 1,2 µs and a time to half-value of 50 µs

3.18.4
standard combined switching impulse
for phase-to-phase insulation, combined impulse voltage having two components of equal peak value and opposite polarity

Note 1 to entry: The positive component is a standard switching impulse and the negative one is a switching impulse whose times to peak and half-value should not be less than those of the positive impulse. Both impulses should reach their peak value at the same instant. The peak value of the combined voltage is, therefore, the sum of the peak values of the components.

3.18.5
standard combined voltage
for longitudinal insulation, combined voltage having a standard impulse on one terminal and a power-frequency voltage on the other terminal

Note 1 to entry: The impulse component is applied at the peak of the power-frequency voltage of opposite polarity.

3.19
representative overvoltage
U_{rp}
overvoltage assumed to produce the same dielectric effect on the insulation as the overvoltage of a given class occurring in service due to various origins

Note 1 to entry: Representative overvoltages consist of voltages with the standard shape of the class, and may be defined by one value or a set of values or a frequency distribution of values that characterize the service conditions.

Note 2 to entry: This definition also applies to the continuous power-frequency voltage representing the effect of the service voltage on the insulation.

3.20
overvoltage limiting device
device which limits the peak values of the overvoltages or their durations or both

Note 1 to entry: They are classified as preventing devices (e.g. a preinsertion resistor) or as protective devices (e.g. a surge arrester).

3.21
lightning impulse protective level
U_{pl}
maximum permissible peak voltage value on the terminals of a protective device subjected to lightning impulses under specific conditions

[SOURCE: IEC 60050-614:2016, 614-03-56]

3.22
switching impulse protective level
U_{ps}
maximum permissible peak voltage value on the terminals of a protective device subjected to switching impulses under specific conditions

[SOURCE: IEC 60050-614:2016, IEC 614-03-57]

3.23
performance criterion
basis on which the insulation is selected so as to reduce to an economically and operationally acceptable level the probability that the resulting voltage stresses imposed on the equipment will cause damage to equipment insulation or affect continuity of service

Note 1 to entry: The performance criterion is usually expressed in terms of an acceptable failure rate (number of failures per year, years between failures, risk of failure, etc.) of the insulation configuration.

3.24
withstand voltage
value of the test voltage to be applied under specified conditions in a withstand voltage test, during which a specified number of disruptive discharges is tolerated

Note 1 to entry: The withstand voltage is designated as:

a) conventional assumed withstand voltage, when the number of disruptive discharges tolerated is zero. It is deemed to correspond to a withstand probability P_w = 100 %;

b) statistical withstand voltage, when the number of disruptive discharges tolerated is related to a specified withstand probability. In this document, the specified probability is P_w = 90 %.

Note 2 to entry: In this document, the conventional assumed withstand voltages are specified for non-self-restoring insulation. The statistical withstand voltages are specified for self-restoring insulation.

3.25
co-ordination withstand voltage
U_{cw}
for each class of voltage, the value of the withstand voltage of the insulation configuration in actual service conditions, that meets the performance criterion

3.26
co-ordination factor
K_c
factor by which the value of the representative overvoltage must be multiplied in order to obtain the value of the co-ordination withstand voltage

3.27
standard reference atmospheric conditions
atmospheric conditions to which the standardized withstand voltages apply

Note 1 to entry: See 5.9.2.

3.28
required withstand voltage
U_{rw}
test voltage that the insulation must withstand in a standard withstand voltage test to ensure that the insulation will meet the performance criterion when subjected to a given class of overvoltages in actual service conditions and for the whole service duration

Note 1 to entry: The required withstand voltage has the shape of the co-ordination withstand voltage, and is specified with reference to all the conditions of the standard withstand voltage test selected to verify it.

3.29
atmospheric correction factor
K_t
factor to be applied to the co-ordination withstand voltage to account for the difference in dielectric strength between the average atmospheric conditions in service and the standard reference atmospheric conditions

Note 1 to entry: It applies to external insulation only, for all altitudes.

Note 2 to entry: For the atmospheric correction factor, the atmospheric conditions taken into account are air pressure, temperature and humidity. For insulation co-ordination purposes, usually only the air pressure correction needs to be taken into account.

3.30
altitude correction factor
K_a
factor to be applied to the co-ordination withstand voltage to account for the difference in dielectric strength between the average pressure corresponding to the altitude in service and the standard reference pressure

Note 1 to entry: The altitude correction factor is part of the atmospheric correction factor.

3.31
safety factor
K_s
overall factor to be applied to the co-ordination withstand voltage, after the application of the atmospheric correction factor (if required), to obtain the required withstand voltage, accounting for all other differences in dielectric strength between the conditions in service during life time and those in the standard withstand voltage test

3.32
actual withstand voltage of an equipment or insulation configuration
U_{aw}
highest possible value of the test voltage that can be applied to an equipment or insulation configuration in a standard withstand voltage test

3.33
test conversion factor
K_{tc}
for a given equipment or insulation configuration, the factor to be applied to the required withstand voltage of a given overvoltage class, in the case where the standard withstand shape of the selected withstand voltage test is that of a different overvoltage class

Note 1 to entry: For a given equipment or insulation configuration: the test conversion factor of the standard voltage shape (a) to the standard voltage shape (b) must be higher than or equal to the ratio between the actual withstand voltage for the standard voltage shape (a) and the actual withstand voltage of the standard voltage shape (b).

3.34
rated withstand voltage
value of the test voltage, applied in a standard withstand voltage test that proves that the insulation complies with one or more required withstand voltages