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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

IEC 60071-1:2006

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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 28: Insulation co-ordination.

This eighth edition cancels and replaces the seventh edition published in 1993 and constitutes a technical revision.

The main changes from the previous edition are as follows:

– in the definitions (3.26, 3.28 and 3.29) and in the environmental conditions (5.9) taken into account clarification of the atmospheric and altitude corrections involved in the insulation co-ordination process;

– in the list of standard rated short-duration power frequency withstand voltages reported in 5.6 addition of 115 kV;

– in the list of standard rated impulse withstand voltages reported in 5.7, addition of 200 kV and 380 kV;
– in the standard insulation levels for range I (1kV < $U_m \leq$ 245 kV) (Table 2) addition of the highest voltage for equipment U_m = 100 kV;
– in the standard insulation levels for range II (U_m > 245 kV) (Table 3) replacement of 525 kV by 550 kV and of 765 kV by 800 kV;
– in order to remove that part in the next revision of IEC 60071-2, addition of Annex A dealing with clearances in air to assure a specified impulse withstand voltage in installation;
– in Annex B, limitation at two U_m values for the values of rated insulation levels for 1kV < $U_m \leq$ 245 kV for highest voltages for equipment U_m not standardized by IEC based on current practice in some countries.

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

FDIS	Report on voting
28/176/FDIS	28/177/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.

The IEC 60071 comprises the following parts under the general title *Insulation co-ordination:*

Part 1: Definitions, principles and rules

Part 2: Application guide

Part 4: Computational guide to insulation co-ordination and modelling of electrical networks

Part 5: Procedures for high-voltage direct current (HVDC) converter stations

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.

INSULATION CO-ORDINATION –

Part 1: Definitions, principles and rules

1 Scope

This part of IEC 60071 applies to three-phase a.c. 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 should be selected.

This standard recommends that the selected withstand voltages should be 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 standard.

Although the principles of this standard also apply to transmission line insulation, the values of their withstand voltages may 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 standard.

NOTE In IEC 60071-2, Application Guide, all rules for insulation co-ordination given in this standard 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.

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.

IEC 60038:2002, *IEC standard voltages*

IEC 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

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

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

IEC 60507, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*

IEC 60633, *Terminology for high-voltage direct current (HVDC) transmission*

3 Terms and definitions

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

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

[IEC 604-03-08:1987, modified]

NOTE By "dielectric strength" of the equipment, is meant here its rated or its standard insulation level as defined in 3.35 and 3.36 respectively.

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.

[IEC 604-03-02:1987, modified]

NOTE External insulation is either weather protected or non-weather protected, designed to operate inside or outside closed shelters respectively.

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

[IEC 604-03-03:1987]

3.4
self-restoring insulation
insulation which, after a short time, completely recovers its insulating properties after a disruptive discharge during test

[IEC 604-03-04:1987, modified]

NOTE Insulation of this kind is generally, but not necessary, external insulation

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

[IEC 604-03-05:1987, modified]

NOTE The definitions of 3.4 and 3.5 apply 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.

3.6
insulation configuration terminal
any of the terminals between any two of which a voltage that stresses the insulation can be applied. 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. It includes all elements (insulating and conducting) which influence its dielectric behaviour. The following insulation configurations are identified:

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

3.7.2
phase-to-earth (p-e) 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(p-p) 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(t-t) insulation configuration
insulation configuration having two phase terminals and one earth terminal. The phase terminals belong to the same phase of a three-phase system temporarily separated into two independently energized parts (e.g. open switching devices). 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

[IEC 601-01-21:1985]

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

[IEC 601-01-23:1985, modified]

3.10
highest voltage for equipment
U_m
highest value of phase-to-phase voltage (r.m.s. 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. Under normal service conditions specified by the relevant apparatus committee this voltage can be applied continuously to the equipment

[IEC 604-03-01:1987, modified]

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

[IEC 601-02-24:1985]

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

[IEC 601-02-25:1985]

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

[IEC 601-02-26:1985]

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

[IEC 601-02-27:1985]

NOTE 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.

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 r.m.s. 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 r.m.s. phase-to-earth power frequency voltage which would be obtained at the given location in the absence of any such fault

[IEC 604-03-06:1987]

3.16
overvoltage
any 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 $\sqrt{3}$;

  [IEC 604-03-09, modified] or

– between phase conductors having a peak value exceeding the amplitude of the highest voltage of the system

  [IEC 604-03-09:1987, modified]

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

3.17
classification of voltages and overvoltages
according to their shape and duration, voltages and overvoltages are divided in the following classes

NOTE More details on the following six first voltages and overvoltages are also given in Table 1.

3.17.1
continuous (power frequency) voltage
power-frequency voltage, considered having constant r.m.s. value, continuously applied to any pair of terminals of an insulation configuration

3.17.2
temporary overvoltage
TOV
power frequency overvoltage of relatively long duration

[IEC 604-03-12:1987, modified]

NOTE The overvoltage may be undamped or weakly damped. In some cases its frequency may be several times smaller or higher than power frequency.

3.17.3
transient overvoltage
short-duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[IEC 604-03-13:1987]

NOTE Transient overvoltages may be immediately followed by temporary overvoltages. In such cases the two overvoltages are considered as separate events.

Transient overvoltages are divided into:

3.17.3.1
slow-front overvoltage
SFO

transient overvoltage, usually unidirectional, with time to peak 20 μs < T_p ≤ 5 000 μs, and tail duration T_2 ≤ 20 ms

3.17.3.2
fast-front overvoltage
FFO
transient overvoltage, usually unidirectional, with time to peak 0,1 μs < T_1 ≤ 20 μs, and tail duration T_2 < 300 μs

3.17.3.3
very-fast-front overvoltage
VFFO
transient overvoltage, usually unidirectional with time to peak T_f ≤ 0,1 μs, and with or without superimposed oscillations at frequency 30 kHz < f < 100 MHz

3.17.4
combined 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. 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
the following voltage shapes are standardized:

NOTE 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, a combined impulse voltage having two components of equal peak value and opposite polarity.

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, a combined voltage having a standard impulse on one terminal and a power frequency voltage on the other terminal. The impulse component is applied at the peak of the power frequency voltage of opposite polarity

3.19
representative overvoltages
$\boldsymbol{U}_{\mathbf{rp}}$
overvoltages assumed to produce the same dielectric effect on the insulation as overvoltages of a given class occurring in service due to various origins.

They 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 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. They are classified as preventing devices (e.g., a preinsertion resistor), or as protective devices (e.g., a surge arrester)

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

[IEC 604-03-56:1987 and IEC 604-03-57:1987]

3.22
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. This 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

3.23
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. 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 standard, the specified probability is P_w = 90 %.

NOTE In this standard, for non-self-restoring insulation are specified conventional assumed withstand voltages, and for self-restoring insulation are specified statistical withstand voltages.

3.24
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

3.25
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

3.26
standard reference atmospheric conditions
atmospheric conditions to which the standardized withstand voltages apply (see 5.9)

3.27
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. 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