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

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

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Insulation co-ordination

Part 1:
Definitions, principles and rules

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INSULATION CO-ORDINATION

Part 1: Definitions, principles and rules

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

International Standard IEC 71-1 has been prepared by IEC technical committee 28: Insulation co-ordination.

This seventh edition cancels and replaces the sixth edition published in 1976 which dealt only with insulation co-ordination between phase and earth, and the first part of the first edition – published in 1982 – of IEC Publication 71-3 which dealt with insulation co-ordination between phases.

This standard constitutes a technical revision and forms Part 1 of IEC Publication 71.

IEC Publication 71-2 (in preparation) will constitute the Application Guide for the insulation co-ordination of electrical equipment.

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

DIS	Report on voting
28(CO)58	28(CO)60

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

Annex A is for information only.

INSULATION CO-ORDINATION

Part 1: Definitions, principles and rules

1 Scope

This part of International Standard IEC 71 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 standard 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 standardized values from which the standard withstand voltages shall be selected.

This part 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 part also apply to transmission line insulation, the values of the withstand voltages may be different from the standard withstand voltages.

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

NOTE – In IEC 71-2 Application Guide, (under revision), all rules for insulation co-ordination given in this Standard are justified in detail, in particular the association of the standard withstand voltages with the highest voltage for equipment. When more than one set of standard 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 normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 71-1. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 71-1 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 38: 1983, *IEC standard voltages*

IEC 60-1: 1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 **insulation co-ordination:** The selection of the dielectric strength of equipment in relation to the voltages 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 protective devices. [IEV 604-03-08, modified]

NOTE – By "dielectric strength" of the equipment, is meant here its rated or its standard insulation level as defined in 3.32 and 3.33 respectively.

3.2 **external insulation:** The 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 external conditions, such as pollution, humidity, vermin, etc. [IEV 604-03-02, 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:** The internal solid, liquid, or gaseous parts of the insulation of equipment which are protected from the effects of atmospheric and other external conditions. [IEV 604-03-03]

3.4 **self-restoring insulation:** Insulation which completely recovers its insulating properties after a disruptive discharge. [IEV 604-03-04]

3.5 **non-self-restoring insulation:** Insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge. [IEV 604-03-05]

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 electrodes 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:** The 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:

– **three-phase:** having three phase terminals, one neutral terminal and one earth terminal.

– **phase-to-earth:** a three-phase insulation configuration where two phase terminals are disregarded and, except in particular cases, the neutral terminal is earthed.

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

– **longitudinal**, 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 (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:** A suitable approximate value of voltage used to designate or identify a system. [IEV 601-01-21]

3.9 **highest voltage of a system:** The highest value of operating voltage which occurs under normal operating conditions at any time and at any point in the system. [IEV 601-01-23]

3.10 **highest voltage for equipment (U_m):** The highest r.m.s. value of phase-to-phase voltage 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. [IEV 604-03-01]

3.11 **isolated neutral system:** A system where the neutral point is not intentionally connected to earth, except for high impedance connections for protection or measurement purposes. [IEV 601-02-24]

3.12 **solidly earthed neutral system:** A system whose neutral point(s) is(are) earthed directly. [IEV 601-02-25]

3.13 **impedance earthed (neutral) system:** A system whose neutral point(s) is(are) earthed through impedances to limit earth fault currents. [IEV 601-02-26]

3.14 **resonant earthed (neutral) system:** A 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. [IEV 601-02-27]

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:** 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. [IEV 604-03-06]

3.16 **overvoltage:** Any voltage between one phase conductor and earth or between phase conductors having a peak value exceeding the corresponding peak of the highest voltage for equipment. [IEV 604-03-09, modified]

NOTES

1 Unless otherwise clearly indicated, such as for surge arresters, overvoltage values expressed in p.u. shall be referred to $U_m \times \sqrt{2}/\sqrt{3}$.

2 For any insulation configuration, an overvoltage is any voltage across its terminals higher than the peak of the power-frequency voltage existing between them when all phase terminals of the equipment are energized with the highest voltage for equipment.

3.17 *Classification of voltages and overvoltages*

According to their shape and duration, voltages and overvoltages are divided in the following classes (see also table 1):

a) **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.

b) **temporary overvoltage:** Power frequency overvoltage of relatively long duration. [IEV 604-03-12, 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.

c) **transient overvoltage:** Short-duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped. [IEV 604-03-13]

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:

– **slow-front overvoltage:** Transient overvoltage, usually unidirectional, with time to peak 20 μs $< T_p \leq$ 5 000 μs, and tail duration $T_2 \leq$ 20 ms.

– **fast-front overvoltage:** Transient overvoltage, usually unidirectional, with time to peak 0,1 μs $< T_1 \leq$ 20 μs, and tail duration $T_2 <$ 300 μs.

– **very-fast-front overvoltage:** Transient overvoltage, usually unidirectional with time to peak $T_f \leq$ 0,1 μs, total duration < 3 ms, and with superimposed oscillations at frequency 30 kHz < f < 100 MHz.

d) **combined (temporary, slow-front, fast-front, very-fast-front) 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.

3.18 *Standard voltage shapes*

The following voltage shapes are standardized:

a) The **standard short-duration power-frequency voltage:** a sinusoidal voltage with frequency between 48 Hz and 62 Hz, and duration of 60 s.

b) The **standard switching impulse:** an impulse voltage having a time to peak of 250 μs and a time to half-value of 2 500 μs.

c) The **standard lightning impulse:** an impulse voltage having a front time of 1,2 μs and a time to half-value of 50 μs.

NOTE – More detailed definitions of these standard voltage shapes are given in IEC 60-1 (see also table 1).

d) The **standard combined switching impulse:** 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.

3.19 **representative overvoltages (U_{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:** The maximum permissible peak voltage value on the terminals of a protective device subjected to lightning (or switching) impulses under specific conditions. [IEV 604-03-56 and 604-03-57]

3.22 **performance criterion:** The 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:** The value of the test voltage to be applied under specified conditions in a withstand 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.