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Insulation co-ordination - Part 11：Definitions, principles and rules for HVDC system

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IEC TC 99 : INSULATION CO-ORDINATION AND SYSTEM ENGINEERING OF HIGH VOLTAGE ELECTRICAL POWER INSTALLATIONS ABOVE 1,0 kV AC AND 1,5 kV DC

SECRETARIAT:	SECRETARY:
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OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD:
TC 8,SC 22F,TC 115	☒ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☒ SAFETY

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TITLE:

Insulation co-ordination - Part 11: Definitions, principles and rules for HVDC system

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NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INSULATION CO-ORDINATION –

Part 11: Definitions, principles and rules for HVDC system

FOREWORD

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IEC 60071-11 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. It is an International Standard.

This International Standard and IEC 60071-12 'Application guidelines for LCC HVDC converter stations' jointly replace IEC 60071-5 published in 2014.

The sections arrangement of this standard and corresponding sections of IEC 60071-5:2014 are as follows:

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

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

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

The language used for the development of this International Standard is English.

This document was 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 http://www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INSULATION CO-ORDINATION–

Part 11: Definitions, principles and rules for HVDC system

1 Scope

1.1 General

This standard applies to High-voltage direct current (HVDC) systems. It specifies the principles on the procedures for the determination of the specified withstand voltages, creepage distance and air clearances for the equipment and the installations of these systems.

This standard gives the insulation co-ordination principles related to line commutated converter (LCC) and voltage sourced converters (VSC) HVDC systems. The main principles of this standard also apply to other special converter configurations of LCC, such as the capacitor commutated converter (CCC) as well as the controlled series compensated converter (CSCC) etc.

This standard applies to insulation co-ordination of equipment connected between the converter AC bus (including the AC harmonic filters, the converter transformer, the circuit breakers) and the DC line side. The line and cable terminations in so far as they influence the insulation co-ordination of converter station equipment are also covered.

This standard applies only for HVDC applications in power systems and not for industrial conversion equipment. Principles and guidance given are for insulation co-ordination purposes only. The requirements for human safety are not covered by this standard.

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.

1.2 Additional background

The use of power semi-conductor device in a series and/or parallel arrangement, along with the unique control and protection strategies employed in the conversion process, has ramifications requiring particular consideration of overvoltage protection of equipment in converter stations compared with substations in AC systems.

The basic principles and design objectives of insulation co-ordination of converter stations, in so far as they differ from normal AC system practice, are described.

NOTE In IEC 60071-12, Application guidelines, all rules for insulation co-ordination given in this standard are justified in detail, in particular the association of the specified withstand voltages with the rated voltage for equipment, and arrester configuration.

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

IEC 60071-1:2019, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-2:2018, *Insulation co-ordination – Part 2: Application guidelines*

IEC 60099-4:2014, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

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

IEC 60700-1:2015, *Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1 Electrical testing*

IEC TS 60815-1:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

IEC TS 60815-4:2016, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 4: Insulators for d.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

NOTE Many of the following definitions refer to insulation co-ordination concepts (IEC 60071-1), or to arrester parameters (IEC 60099-4).

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

[SOURCE: IEC 60071-1: 2019, 3.1]

3.2

nominal DC voltage

mean value of the DC voltage required to transmit nominal power at nominal current

3.3

highest DC voltage

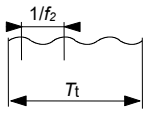
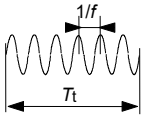
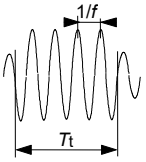
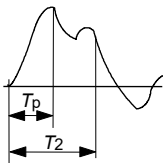
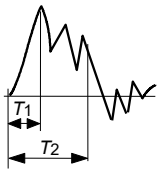
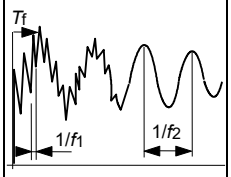
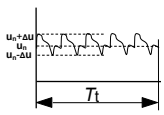
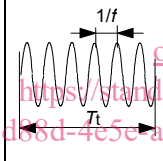
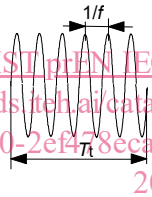
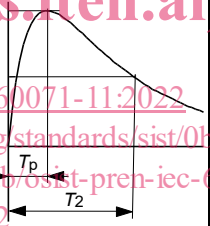
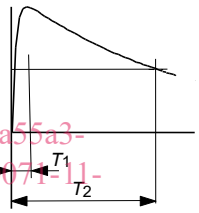
highest value of DC voltage for which the equipment is designed to operate continuously, in respect of its insulation as well as other characteristics

3.4
overvoltage

voltage having a value exceeding the corresponding highest steady state voltage of the system

Note 1 to entry: Table 1 presents (as per IEC 60071-1) the classification of these voltages which are defined in 3.4.1 to 3.4.2.3.

Table 1 – Classes and shapes of overvoltages, Standard voltage shapes and Standard withstand voltage tests

Class	Low frequency			Transient		
	Continuous		Temporary	Slow-front	Fast-front	Very-fast-front
Voltage or over-voltage shapes						
Range of voltage or over-voltage shapes	$T_t \geq 3\ 600s$ $1/T_t = f_1 = 0$ Hz $f_2 < 2\ 500$ Hz	f = 50 Hz or 60 Hz $T_t \geq 3\ 600$s	10 Hz $< f <$ 500 Hz 0,02 s $\leq T_t \leq$ 3 600 s	20 µs $< T_p \leq$ 5 000 µs $T_2 \leq$ 20 ms	0,1 µs $< T_1 \leq$ 20 µs $T_2 \leq$ 300 µs	$T_f \leq$ 100 ns 0,3 MHz $< f_1 <$ 100 MHz 30 kHz $< f_2 <$ 300 kHz
Standard voltage shapes						a
	$\frac{\Delta U}{U_n} \leq 3\%$ [b] T_t [a]	f = 50 Hz or 60 Hz T_t [a]	48 Hz $\leq f \leq$ 62 Hz T_t = 60 s	T_p = 250 µs T_2 = 2 500 µs	T_1 = 1,2 µs T_2 = 50 µs	
Standard withstand voltage test	DC voltage test [a]	a	Short-duration power frequency test	Switching impulse test	Lightning impulse test	a

[a] To be specified by the relevant apparatus committees.

[b] Unless otherwise specified by the relevant Technical Committees, standard voltage shapes should be in accordance with IEC 60060-1.

3.4.1
temporary overvoltage

overvoltages of relatively long duration (ranging from 0,02 to 3 600 s as per IEC 60071-1)

Note 1 to entry: The overvoltage may be undamped or weakly damped.

3.4.2
transient overvoltage

short-duration overvoltage of a few millisecond or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60071-1: 2019, 3.17.3]

3.4.2.1
slow-front overvoltage

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

Note 1 to entry: For the purpose of insulation co-ordination, slow-front overvoltages are classified according to their shape, regardless of their origin. Although considerable deviations from the standard shapes occur on actual systems, in this standard it is considered sufficient in most cases to describe such overvoltages by their classification and peak value.

3.4.2.2
fast-front overvoltage

overvoltage at a given location on a system, due to a lightning discharge or other cause, the shape of which can be regarded, for insulation co-ordination purposes, as similar to that of the standard impulse (IEC 60060-1) used for lightning impulse tests

Note 1 to entry: Fast-front overvoltage is defined as transient overvoltage, usually unidirectional, with time to peak 0,1 μs < T_1 ⩽ 20 μs, and tail duration T_2 ⩽ 300 μs in IEC 60071-1:2019, 3.17.3.2.

Note 2 to entry: For the purpose of insulation co-ordination, fast-front overvoltages are classified according to their shape, regardless of their origin. Although considerable deviations from the standard shapes occur on actual systems, in this standard it is considered sufficient in most cases to describe such overvoltages by their classification and peak value.

3.4.2.3
very-fast-front overvoltage

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

[SOURCE: IEC 60071-1:2019, 3.17.3.3]

3.4.2.4
steep-front overvoltage

transient overvoltage classified as a kind of fast-front overvoltage with time to peak3 ns < T_1 < 1,2 μs

Note 1 to entry: A steep-front impulse voltage for test purposes is defined in IEC 60700-1.

Note 2 to entry: The front time is decided by means of system studies.

3.4.2.5
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: Combined overvoltage can include temporary, slow-front, fast-front or very-fast front overvoltages.

Note 2 to entry: It is classified by the component of higher peak value.

3.5
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

Note 1 to entry: In this standard it is generally assumed that the representative overvoltages are characterized by their assumed or obtained maximum values.

[SOURCE: IEC 60071-1:2019, 3.19]