



IEC 60071-2

Edition 5.0 2023-05
REDLINE VERSION

INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

**Insulation co-ordination –
Part 2: Application guidelines**

STANDARD PREVIEW
(standards.iteh.ai)

IEC 60071-2:2023

<https://standards.iteh.ai/catalog/standards/sist/75ad010d-ae75-41a8-89a4-764ebfa1c205/iec-60071-2-2023>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

[IEC 60071-2:2023](#)

<https://standards.iteh.ai/catalog/standards/sist/75ad010d-ac75-41a8-89a4-764eb1a1c205/iec-60071-2-2023>



IEC 60071-2

Edition 5.0 2023-05
REDLINE VERSION

INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

**Insulation co-ordination –
Part 2: Application guidelines**

STANDARD PREVIEW
(standards.iteh.ai)

[IEC 60071-2:2023](https://standards.iteh.ai/catalog/standards/sist/75ad010d-ae75-41a8-89a4-764ebfa1c205/iec-60071-2-2023)

<https://standards.iteh.ai/catalog/standards/sist/75ad010d-ae75-41a8-89a4-764ebfa1c205/iec-60071-2-2023>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.080.30

ISBN 978-2-8322-7074-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	9
1 Scope.....	11
2 Normative references	11
3 Terms, definitions, abbreviated terms and symbols.....	12
3.1 Terms and definitions.....	12
3.2 Abbreviated terms.....	12
3.3 Symbols.....	12
4 Concepts governing the insulation co-ordination.....	18
5 Representative voltage stresses in service	19
5.1 Origin and classification of voltage stresses.....	19
5.2 Characteristics of overvoltage protection devices.....	20
5.2.1 General remarks.....	20
5.2.2 Metal-oxide surge arresters without gaps (MOSA)	20
5.2.3 Line surge arresters (LSA) for overhead transmission and distribution lines	22
5.3 General approach for the determination of representative voltages and overvoltages	23
5.3.1 Continuous (power-frequency) voltage.....	23
5.3.2 Temporary overvoltages.....	23
5.3.3 Slow-front overvoltages	26
5.3.4 Fast-front overvoltages	32
5.3.5 Very-fast-front overvoltages.....	36
5.4 Determination of representative overvoltages by detailed simulations	37
5.4.1 General overview.....	37
5.4.2 Temporary overvoltages	37
5.4.3 Slow-front overvoltages	38
5.4.4 Fast-front overvoltages.....	39
5.4.5 Very-fast-front overvoltages.....	43
6 Co-ordination withstand voltage.....	44
6.1 Insulation strength characteristics.....	44
6.1.1 General	44
6.1.2 Influence of polarity and overvoltage shapes	46
6.1.3 Phase-to-phase and longitudinal insulation.....	47
6.1.4 Influence of weather conditions on external insulation	47
6.1.5 Probability of disruptive discharge of insulation	47
6.2 Performance criterion.....	49
6.3 Insulation co-ordination procedures	49
6.3.1 General	49
6.3.2 Insulation co-ordination procedures for continuous (power-frequency) voltage and temporary overvoltage	50
6.3.3 Insulation co-ordination procedures for slow-front overvoltages	51
6.3.4 Insulation co-ordination procedures for fast-front overvoltages	56
6.3.5 Insulation co-ordination procedures for very-fast-front overvoltages	57
7 Required withstand voltage.....	57
7.1 General remarks	57
7.2 Atmospheric correction	57
7.2.1 General remarks.....	57

7.2.2	Altitude correction.....	58
7.3	Safety factors.....	59
7.3.1	General	59
7.3.2	Ageing	60
7.3.3	Production and assembly dispersion	60
7.3.4	Inaccuracy of the withstand voltage	60
7.3.5	Recommended safety factors (K_s).....	60
8	Standard withstand voltage and testing procedures	61
8.1	General remarks	61
8.1.1	Overview	61
8.1.2	Standard switching impulse withstand voltage	61
8.1.3	Standard lightning impulse withstand voltage.....	61
8.2	Test conversion factors	62
8.2.1	Range I.....	62
8.2.2	Range II	62
8.3	Determination of insulation withstand by type tests	63
8.3.1	Test procedure dependency upon insulation type	63
8.3.2	Non-self-restoring insulation	63
8.3.3	Self-restoring insulation	63
8.3.4	Mixed insulation.....	64
8.3.5	Limitations of the test procedures	65
8.3.6	Selection of the type test procedures.....	65
8.3.7	Selection of the type test voltages	65
9	Special considerations for overhead lines apparatus and transmission line.....	66
9.1	Overhead line	66
9.1.1	General remarks	66
9.1.2	Insulation co-ordination for operating voltages and temporary overvoltages.....	67
9.1.3	Insulation co-ordination for slow-front overvoltages	67
9.1.4	Insulation co-ordination for lightning fast-front overvoltages	68
9.2	Cable line	69
9.2.1	General	69
9.2.2	Insulation co-ordination for operating voltages and temporary overvoltages.....	69
9.2.3	Insulation co-ordination for slow-front overvoltages	69
9.2.4	Insulation co-ordination for fast-front overvoltages.....	70
9.2.5	Overvoltage protection of cable lines	70
9.3	GIL (gas insulated transmission line) / GIB (Gas-insulated busduct)	71
9.3.1	General	71
9.3.2	Insulation co-ordination for operating voltages and temporary overvoltages	71
9.3.3	Insulation co-ordination for slow-front overvoltages	71
9.3.4	Insulation co-ordination for fast-front overvoltages.....	72
9.3.5	Overvoltage protection of GIL/GIB lines	72
9.4	Special considerations for substations Substation.....	68
9.4.1	General remarks	72
9.4.2	Insulation co-ordination for overvoltages.....	73
Annex A (informative)	Determination of temporary overvoltages due to earth faults	76
Annex B (informative)	Weibull probability distributions	80

B.1	General remarks	80
B.2	Disruptive discharge probability of external insulation	81
B.3	Cumulative frequency distribution of overvoltages	84
Annex C (informative) Determination of the representative slow-front overvoltage due to line energization and re-energization		86
C.1	General remarks	86
C.2	Probability distribution of the representative amplitude of the prospective overvoltage phase-to-earth	86
C.3	Probability distribution of the representative amplitude of the prospective overvoltage phase-to-phase	89
C.4	Insulation characteristic	91
C.5	Numerical example	93
Annex D (informative) Transferred overvoltages in transformers		100
D.1	General remarks	100
D.2	Transferred temporary overvoltages	101
D.3	Capacitively transferred surges	101
D.4	Inductively transferred surges	103
Annex E (informative) Determination of lightning overvoltages by simplified method		107
E.1	General remarks	107
E.2	Determination of the limit distance (X_p)	107
E.2.1	Protection with arresters in the substation	107
E.2.2	Self-protection of substation	108
E.3	Estimation of the representative lightning overvoltage amplitude	109
E.3.1	General	109
E.3.2	Shielding penetration	109
E.3.3	Back flashovers	110
E.4	Simplified method approach	112
E.5	Assumed maximum value of the representative lightning overvoltage	114
Annex F (informative) Calculation of air gap breakdown strength from experimental data		116
F.1	General	116
F.2	Insulation response to power-frequency voltages	116
F.3	Insulation response to slow-front overvoltages	117
F.4	Insulation response to fast-front overvoltages	118
Annex G (informative) Examples of insulation co-ordination procedure		122
G.1	Overview	122
G.2	Numerical example for a system in range I (with nominal voltage of 230 kV)	122
G.2.1	General	122
G.2.2	Part 1: no special operating conditions	123
G.2.3	Part 2: influence of capacitor switching at station 2	130
G.2.4	Part 3: flow charts related to the example of Clause G.2	132
G.3	Numerical example for a system in range II (with nominal voltage of 735 kV)	137
G.3.1	General	137
G.3.2	Step 1: determination of the representative overvoltages – values of U_{rp}	137
G.3.3	Step 2: determination of the co-ordination withstand voltages – values of U_{CW}	138
G.3.4	Step 3: determination of the required withstand voltages – values of U_{rw}	139

G.3.5	Step 4: conversion to switching impulse withstand voltages (SIWV).....	140
G.3.6	Step 5: selection of standard insulation levels	141
G.3.7	Considerations relative to phase-to-phase insulation co-ordination	141
G.3.8	Phase-to-earth clearances.....	142
G.3.9	Phase-to-phase clearances	143
G.4	Numerical example for substations in distribution systems with U_m up to 36 kV in range I	143
G.4.1	General	143
G.4.2	Step 1: determination of the representative overvoltages – values of U_{rp}	144
G.4.3	Step 2: determination of the co-ordination withstand voltages – values of U_{cw}	144
G.4.4	Step 3: determination of required withstand voltages – values of U_{rw}	145
G.4.5	Step 4: conversion to standard short-duration power-frequency and lightning impulse withstand voltages	146
G.4.6	Step 5: selection of standard withstand voltages.....	147
G.4.7	Summary of insulation co-ordination procedure for the example of Clause G.4	147
Annex H (informative)	Atmospheric correction – Altitude correction application example	149
H.1	General principles.....	149
H.1.1	Atmospheric correction in standard tests	149
H.1.2	Task of atmospheric correction in insulation co-ordination	150
H.2	Atmospheric correction in insulation co-ordination	152
H.2.1	Factors for atmospheric correction.....	152
H.2.2	General characteristics for moderate climates	152
H.2.3	Special atmospheric conditions.....	153
H.2.4	Altitude dependency of air pressure.....	154
H.3	Altitude correction.....	155
H.3.1	Definition of the altitude correction factor.....	155
H.3.2	Principle of altitude correction	156
H.3.3	Altitude correction for standard equipment operating at altitudes up to 1 000 m	157
H.3.4	Altitude correction for standard equipment operating at altitudes above 1 000 m	157
H.4	Selection of the exponent m	158
H.4.1	General	158
H.4.2	Derivation of exponent m for switching impulse voltage	158
H.4.3	Derivation of exponent m for critical switching impulse voltage	161
Annex I (informative)	Evaluation method of non-standard lightning overvoltage shape for representative voltages and overvoltages	164
I.1	General remarks	164
I.2	Lightning overvoltage shape	164
I.3	Evaluation method for GIS	164
I.3.1	Experiments	164
I.3.2	Evaluation of overvoltage shape	165
I.4	Evaluation method for transformer	165
I.4.1	Experiments	165
I.4.2	Evaluation of overvoltage shape	166

Annex J (informative) Insulation co-ordination for very-fast-front overvoltages in UHV substations	171
J.1 General.....	171
J.2 Influence of disconnector design.....	171
J.3 Insulation co-ordination for VFFO	172
Annex K (informative) Application of shunt reactors to limit TOV and SFO of high voltage overhead transmission line	174
K.1 General remarks	174
K.2 Limitation of TOV and SFO	174
K.3 Application of the neutral grounding reactor to limit resonance overvoltage and secondary arc current	174
K.4 SFO and Beat frequency overvoltage limited by neutral arrester	175
K.5 SFO and FFO due to SR de-energization	176
K.6 Limitation of TOV by Controllable SR	176
K.7 Insulation coordination of the SR and neutral grounding reactor.....	176
K.8 Self-excitation TOV of synchronous generator	176
Annex L (informative) Calculation of lightning stroke rate and lightning outage rate	177
L.1 General.....	177
L.2 Description in CIGRE [37]	177
L.3 Flash program in IEEE [49]	178
L.4 [Case Study] Calculation of Lightning Stroke Rate and Lightning Outage Rate (Appendix D in CIGRE TB 839 [37]).....	178
L.4.1 Basic flow of calculation method.....	178
L.4.2 Comparison of Calculation Results with Observations.....	181
Bibliography.....	183
Figure 1 – Range of 2 % slow-front overvoltages at the receiving end due to line energization and re-energization [27].....	28
Figure 2 – Ratio between the 2 % values of slow-front overvoltages phase-to-phase and phase-to-earth [28], [29].....	29
Figure 3 – Diagram for surge arrester connection to the protected object.....	36
Figure 4 – Modelling of transmission lines and substations/power stations.....	42
Figure 5 – Distributive discharge probability of self-restoring insulation described on a linear scale	52
Figure 6 – Disruptive discharge probability of self-restoring insulation described on a Gaussian scale	52
Figure 7 – Evaluation of deterministic co-ordination factor K_{Cd}	53
Figure 8 – Evaluation of the risk of failure	54
Figure 9 – Risk of failure of external insulation for slow-front overvoltages as a function of the statistical co-ordination factor K_{CS}	56
Figure 10 – Dependence of exponent m on the co-ordination switching impulse withstand voltage.....	59
Figure 11 – Probability P of an equipment to pass the test dependent on the difference K between the actual and the rated impulse withstand voltage.....	65
Figure 12 – Example of a schematic substation layout used for the overvoltage stress location.....	72
Figure A.1 – Earth fault factor k on a base of X_0/X_1 for $R_1/X_1 = R_f = 0$	77

Figure A.2 – Relationship between R_0/X_1 and X_0/X_1 for constant values of earth fault factor k where $R_1 = 0$	78
Figure A.3 – Relationship between R_0/X_1 and X_0/X_1 for constant values of earth fault factor k where $R_1 = 0,5 X_1$	78
Figure A.4 – Relationship between R_0/X_1 and X_0/X_1 for constant values of earth fault factor k where $R_1 = X_1$	79
Figure A.5 – Relationship between R_0/X_1 and X_0/X_1 for constant values of earth fault factor k where $R_1 = 2X_1$	79
Figure B.1 – Conversion chart for the reduction of the withstand voltage due to placing insulation configurations in parallel	85
Figure C.1 – Probability density and cumulative distribution for derivation of the representative overvoltage phase-to-earth	87
Figure C.2 – Example for bivariate phase-to-phase overvoltage curves with constant probability density and tangents giving the relevant 2 % values	95
Figure C.3 – Principle of the determination of the representative phase-to-phase overvoltage U_{pre}	97
Figure C.4 – Schematic phase-phase-earth insulation configuration.....	98
Figure C.5 – Description of the 50 % switching impulse flashover voltage of a phase-phase-earth insulation	98
Figure C.6 – Inclination angle of the phase-to-phase insulation characteristic in range "b" dependent on the ratio of the phase-phase clearance D to the height H_t above earth	99
Figure D.1 – Distributed capacitances of the windings of a transformer and the equivalent circuit describing the windings	105
Figure D.2 – Values of factor J describing the effect of the winding connections on the inductive surge transference	106
Figure H.1 – Principle of the atmospheric correction during test of a specified insulation level according to the procedure of IEC 60060-1	150
Figure H.2 – Principal task of the atmospheric correction in insulation co-ordination according to IEC 60071-1	151
Figure H.3 – Comparison of atmospheric correction $\delta \times k_h$ with relative air pressure p/p_0 for various weather stations around the world.....	154
Figure H.4 – Deviation of simplified pressure calculation by exponential function in this document from the temperature dependent pressure calculation of ISO 2533	155
Figure H.5 – Principle of altitude correction: decreasing withstand voltage U_{10} of equipment with increasing altitude	156
Figure H.6 – Sets of m -curves for standard switching impulse voltage including the variations in altitude for each gap factor	161
Figure H.7 – Exponent m for standard switching impulse voltage for selected gap factors covering altitudes up to 4 000 m.....	161
Figure H.8 – Sets of m -curves for critical switching impulse voltage including the variations in altitude for each gap factor	162
Figure H.9 – Exponent m for critical switching impulse voltage for selected gap factors covering altitudes up to 4 000 m	162
Figure H.10 – Accordance of m -curves from Figure 10 with determination of exponent m by means of critical switching impulse voltage for selected gap factors and altitudes.....	163
Figure I.1 – Examples of lightning overvoltage shapes.....	166

Figure I.2 – Example of insulation characteristics with respect to lightning overvoltages of the SF ₆ gas gap (Shape E).....	167
Figure I.3 – Calculation of duration time T_d	167
Figure I.4 – Shape evaluation flow for GIS and transformer	168
Figure I.5 – Application to GIS lightning overvoltage	169
Figure I.6 – Example of insulation characteristics with respect to lightning overvoltage of the turn-to-turn insulation (Shape C).....	169
Figure I.7 – Application to transformer lightning overvoltage	170
Figure J.1 – Insulation co-ordination for very-fast-front overvoltages.....	173
Figure L.1 – Outline of the CIGRE method for lightning performance of an overhead line	178
Figure L.2 – Flowchart to calculate lightning outage rate of transmission lines	180
Figure L.3 – Typical conductor arrangements of large-scale transmission lines.....	181
Figure L.4 – Lightning stroke rate to power lines -calculations and observations-.....	181
Figure L.5 – Lightning outage rate -calculations and observations-	182
Table 1 – Test conversion factors for range I, to convert required SIWV to SDWV and LIWV	62
Table 2 – Test conversion factors for range II to convert required SDWV to SIWV	63
Table 3 – Selectivity of test procedures B and C of IEC 60060-1.....	64
Table B.1 – Breakdown voltage versus cumulative flashover probability – Single insulation and 100 parallel insulations.....	83
Table E.1 – Corona damping constant K_{CO}	108
Table E.2 – Factor A for various overhead lines	114
Table F.1 – Typical gap factors K for switching impulse breakdown phase-to-earth (according to [1] and [4]).....	120
Table F.2 – Gap factors for typical phase-to-phase geometries	121
Table G.1 – Summary of minimum required withstand voltages obtained for the example shown in G.2.2.....	129
Table G.2 – Summary of required withstand voltages obtained for the example shown in G.2.3.....	131
Table G.3 – Values related to the insulation co-ordination procedure for the example in G.4.....	148
Table H.1 – Comparison of functional expressions of Figure 10 with the selected parameters from the derivation of m -curves with critical switching impulse	163
Table I.1 – Evaluation of the lightning overvoltage in the GIS of UHV system	167
Table I.2 – Evaluation of lightning overvoltage in the transformer of 500 kV system	170

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSULATION CO-ORDINATION –

Part 2: Application guidelines

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). 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. 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 IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60071-2:2018. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60071-2 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 fifth edition cancels and replaces the fourth edition published in 2018. This edition constitutes a technical revision.

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

- a) Clause 4 Concepts governing the insulation co-ordination has been added.
- b) Subclause 5.3 has been revised, and Subclause 5.4 Detailed simulation has been added because it is widely applied in the recent practices of insulation coordination.
- c) Special considerations for cable line and GIL/GIB have been added in Clause 9.
- d) Annex K (informative) Application of line shunt reactor to limitation of TOV and SFO in high voltage overhead transmission lines has been added.
- e) Annex L (informative) Calculation of lightning stroke rate and lightning outage rate has been added.

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

Draft	Report on voting
99/356/CDV	99/392/RVC

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 www.iec.ch/publications.

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 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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INSULATION CO-ORDINATION –

Part 2: Application guidelines

1 Scope

This part of IEC 60071 constitutes application guidelines and deals with the selection of insulation levels of equipment or installations for three-phase ~~electrical~~ AC systems. Its aim is to give guidance for the determination of the rated withstand voltages for ranges I and II of IEC 60071-1 and to justify the association of these rated values with the standardized highest voltages for equipment.

This association is for insulation co-ordination purposes only. The requirements for human safety are not covered by this document.

This document covers three-phase AC systems with nominal voltages above 1 kV. The values derived or proposed herein are generally applicable only to such systems. However, the concepts presented are also valid for two-phase or single-phase systems.

This document covers phase-to-earth, phase-to-phase and longitudinal insulation.

This document is not intended to deal with routine tests. These are to be specified by the relevant product committees.

The content of this document strictly follows the flow chart of the insulation co-ordination process presented in Figure 1 of IEC 60071-1:2006/2019. Clauses 5 to 8 correspond to the squares in this flow chart and give detailed information on the concepts governing the insulation co-ordination process which leads to the establishment of the required withstand levels.

This document emphasizes ~~the necessity of considering~~ to consider, at the very beginning, all origins, all classes and all types of voltage stresses in service irrespective of the range of highest voltage for equipment. Only at the end of the process, when the selection of the standard withstand voltages takes place, does the principle of covering a particular service voltage stress by a standard withstand voltage apply. Also, at this final step, this document refers to the correlation made in IEC 60071-1 between the standard insulation levels and the highest voltage for equipment.

The annexes contain examples and detailed information which explain or support the concepts described in the main text, and the basic analytical techniques used.

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

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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1:2006/2019, *Insulation co-ordination – Part 1: Definitions, principles and rules*
~~IEC 60071-1:2006/AMD1:2010~~

IEC 60505:2011, *Evaluation and qualification of electrical insulation systems*

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*

~~ISO 2533:1975, *Standard Atmosphere*~~

IEC TR 60071-4:2004, *Insulation co-ordination – Part 4: Computational guide to insulation co-ordination and modelling of electrical networks*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

~~No terms and definitions are listed in this document.~~

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

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

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

3.1.1

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 or its standard insulation level as defined in 3.36 and 3.37 of 60071-1:2019 respectively.

[IEC 60071-1:2019, 3.1]

3.1.2

earth fault factor

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 60071-1:2019, 3.15]

3.2 Abbreviated terms

AIS	air-insulated substation
EGLA	externally gapped line arrester
EHV	extra high voltage: the highest voltage for equipment above 245 kV and up to and including 800 kV
EMT	electro-magnetic transients
ESDD	equivalent salt deposit density

FFO	fast-front overvoltage
GIS	gas-insulated switchgear, gas-insulated substation
LIPL	lightning impulse protection level
LIWV	lightning impulse withstand voltage
LSA	line surge arrester
MOSA	metal-oxide surge arrester
MTBF	mean time between failure
NGLA	non-gapped line arrester
SDWV	short-duration power-frequency withstand voltage
SFO	slow-front overvoltage
SIPL	switching impulse protection level
SIWV	switching impulse withstand voltage
SVU	series varistor unit
TCV	trapped charge voltage
TOV	temporary power-frequency overvoltages
UHV	ultra high voltage: the highest voltage for equipment above 800 kV
VFFO	very-fast-front overvoltage

3.3 Symbols

For the purposes of this document, the following symbols and definitions apply. The symbol is followed by the unit to be normally considered, dimensionless quantities being indicated by (-).

Some quantities are expressed in p.u. A per unit quantity is the ratio of the actual value of an electrical parameter (voltage, current, frequency, power, impedance, etc.) to a given reference value of the same parameter.

A	(kV)	parameter characterizing the influence of the lightning severity for the equipment depending on the type of overhead line connected to it
a_1	(m)	length of the lead connecting the surge arrester to the line
a_2	(m)	length of the lead connecting the surge arrester to earth
a_3	(m)	length of the phase conductor between the surge arrester and the protected equipment
a_4	(m)	length of the active part of the surge arrester
B	(-)	factor used when describing the phase-to-phase discharge characteristic
C_e	(nF)	capacitance to earth of transformer primary windings
C_s	(nF)	series capacitance of transformer primary windings
C_2	(nF)	phase-to-earth capacitance of the transformer secondary winding
C_{12}	(nF)	capacitance between primary and secondary windings of transformers
C_{1in}	(nF)	equivalent input capacitance of the terminal 1 of three-phase transformers
C_{2in}	(nF)	equivalent input capacitance of the terminal 2 of three-phase transformers
C_{3in}	(nF)	equivalent input capacitance of the terminal 3 of three-phase transformers