

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

STANDARD PREVIEW
(standards.iteh.ai)

Technique des essais à haute tension –
Partie 1: Définitions et exigences générales

IEC 60060-1:2010
<https://standards.iteh.ai/catalog/standards/sist/90da8dea-b3dd-47ed-ac00-50ce9ad41415/iec-60060-1-2010>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2010 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.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: 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 corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

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 It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

[IEC 60060-1:2010](#)

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00



IEC 60060-1

Edition 3.0 2010-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage test techniques –
Part 1: General definitions and test requirements
(standards.iteh.ai)

Technique des essais à haute tension –
Partie 1: Définitions et exigences générales
(standards.iteh.ai)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 17.220.20

ISBN 978-2-88912-185-4

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
3.1 Definitions related to characteristics of discharges	8
3.2 Definitions relating to characteristics of the test voltage	8
3.3 Definitions relating to tolerance and uncertainty	9
3.4 Definitions relating to statistical characteristics of disruptive-discharge voltage values	9
3.5 Definitions relating to classification of insulation in test objects	10
4 General requirements	11
4.1 General requirements for test procedures.....	11
4.2 Arrangement of the test object in dry tests	11
4.3 Atmospheric corrections in dry tests	12
4.3.1 Standard reference atmosphere.....	12
4.3.2 Atmospheric correction factors for air gaps	12
4.3.3 Application of correction factors.....	13
4.3.4 Correction factor components.....	13
4.3.5 Measurement of atmospheric parameters	16
4.3.6 Conflicting requirements for testing internal and external insulation.....	17
4.4 Wet tests	18
4.4.1 Wet test procedure	18
4.4.2 Atmospheric corrections for wet tests	19
4.5 Artificial pollution tests	19
5 Tests with direct voltage	19
5.1 Definitions for direct voltage tests.....	19
5.2 Test voltage	20
5.2.1 Requirements for the test voltage	20
5.2.2 Generation of the test voltage.....	20
5.2.3 Measurement of the test voltage.....	20
5.2.4 Measurement of the test current	21
5.3 Test procedures	21
5.3.1 Withstand voltage tests	21
5.3.2 Disruptive-discharge voltage tests	22
5.3.3 Assured disruptive-discharge voltage tests	22
6 Tests with alternating voltage	22
6.1 Definitions for alternating voltage tests.....	22
6.2 Test Voltage.....	22
6.2.1 Requirements for the test voltage	22
6.2.2 Generation of the test voltage.....	23
6.2.3 Measurement of the test voltage.....	24
6.2.4 Measurement of the test current	25
6.3 Test procedures	25
6.3.1 Withstand voltage tests	25
6.3.2 Disruptive-discharge voltage tests	25
6.3.3 Assured disruptive-discharge voltage tests	25

7	Tests with lightning-impulse voltage	26
7.1	Definitions for lightning-impulse voltage tests	26
7.2	Test Voltage	33
7.2.1	Standard lightning-impulse voltage	33
7.2.2	Tolerances	34
7.2.3	Standard chopped lightning-impulse voltage	34
7.2.4	Special lightning-impulse voltages	34
7.2.5	Generation of the test voltage	34
7.2.6	Measurement of the test voltage and determination of impulse shape	34
7.2.7	Measurement of current during tests with impulse voltages	35
7.3	Test Procedures	35
7.3.1	Withstand voltage tests	35
7.3.2	Procedures for assured disruptive-discharge voltage tests	36
8	Tests with switching-impulse voltage	36
8.1	Definitions for switching-impulse voltage tests	36
8.2	Test voltage	38
8.2.1	Standard switching-impulse voltage	38
8.2.2	Tolerances	38
8.2.3	Time-to-peak evaluation	38
8.2.4	Special switching-impulse voltages	38
8.2.5	Generation of the test voltage	38
8.2.6	Measurement of test voltage and determination of impulse shape	39
8.2.7	Measurement of current during tests with impulse voltages	39
8.3	Test procedures	39
9	Tests with combined and composite voltages	39
9.1	Definitions for combined- and composite-voltage tests	39
9.2.4	Tolerances	42
9.2.5	Generation	42
9.2.6	Measurement	42
9.3	Composite test voltages	43
9.3.1	Parameters	43
9.3.2	Tolerances	43
9.3.3	Generation	43
9.3.4	Measurement	43
9.4	Test procedures	43
	Annex A (informative) Statistical treatment of test results	45
	Annex B (normative) Procedures for calculation of parameters of standard lightning-impulse voltages with superimposed overshoot or oscillations	54
	Annex C (informative) Guidance for implementing software for evaluation of lightning-impulse voltage parameters	59
	Annex D (informative) Background to the introduction of the test voltage factor for evaluation of impulses with overshoot	62
	Annex E (informative) The iterative calculation method in the converse procedure for the determination of atmospheric correction factor	68
	Bibliography	73

Figure 1 – Recommended minimum clearance D of extraneous live or earthed objects to the energized electrode of a test object, during an a.c. or positive switching impulse test at the maximum voltage U applied during test

Figure 2 – k as a function of the ratio of the absolute humidity h to the relative air density ρ (see 4.3.4.2 for limits of applicability)	14
Figure 3 – Values of exponents m and w	16
Figure 4 – Absolute humidity of air as a function of dry- and wet-bulb thermometer readings	17
Figure 5 – Full lightning-impulse voltage	26
Figure 6 – Test voltage function	28
Figure 7 – Full impulse voltage time parameters	29
Figure 8 – Voltage time interval	30
Figure 9 – Voltage integral	30
Figure 10 – Lightning-impulse voltage chopped on the front	31
Figure 11 – Lightning-impulse voltage chopped on the tail	32
Figure 12 – Linearly rising front chopped impulse	32
Figure 13 – Voltage/time curve for impulses of constant prospective shape	33
Figure 14 – Switching-impulse voltage	37
Figure 15 – Circuit for a combined voltage test	40
Figure 16 – Schematic example for combined and composite voltage	41
Figure 17 – Circuit for a composite voltage test	42
Figure 18 – Definition of time delay Δt	43
Figure A.1 – Example of a multiple-level (Class 1) test	48
Figure A.2 – Examples of decreasing and increasing up-and-down (Class 2) tests for determination of 10 % and 90 % disruptive-discharge probabilities respectively	49
Figure A.3 – Examples of progressive stress (Class 3) tests	50
Figure B.1 – Recorded and base curve showing overshoot and residual curve	55
Figure B.2 – Test voltage curve (addition of base curve and filtered residual curve)	55
Figure B.3 – Recorded and test voltage curves	56
Figure D.1 – “Effective” test voltage function in IEC 60060-1:1989	63
Figure D.2 – Representative experimental points from European experiments and test voltage function	65
Figure E.1 – Atmospheric pressure as a function of altitude	69
Table 1 – Values of exponents, m for air density correction and w for humidity correction, as a function of the parameter g	15
Table 2 – Precipitation conditions for standard procedure	19
Table A.1– Discharge probabilities in up-and-down testing	52
Table E.1 – Altitudes and air pressure of some locations	69
Table E.2 – Initial K_t and its sensitivity coefficients with respect to U_{50} for the example of the standard phase-to-earth a.c. test voltage of 395 kV	70
Table E.3 – Initial and converged K_t values for the example of the standard phase-to-earth a.c. test voltage of 395 kV	72

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE TEST TECHNIQUES –

Part 1: General definitions and test requirements

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.

International Standard IEC 60060-1 has been prepared by IEC technical committee 42: High-voltage test techniques.

This third edition of IEC 60060-1 cancels and replaces the second edition, published in 1989, and constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

- a) The general layout and text was updated and improved to make the standard easier to use.
- b) Artificial pollution test procedures were removed as they are now described in IEC 60507.
- c) Measurement of impulse current has been transferred to a new standard on current measurement (IEC 62475).
- d) The atmospheric correction factors are now presented as formulas.

- e) A new method has been introduced for the calculation of the time parameters of lightning impulse waveforms. This improves the measurement of the time parameters of lightning impulses with oscillations or overshoot.

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

FDIS	Report on voting
42/277/FDIS	42/282/RVD

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

A list of all the parts in the IEC 60060 series, under the general title *High-voltage test techniques*, can be found on the IEC website.

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

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

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[IEC 60060-1:2010](https://standards.iteh.ai/catalog/standards/sist/90da8dea-b3dd-47ed-ac00-50ce9ad41415/iec-60060-1-2010)

<https://standards.iteh.ai/catalog/standards/sist/90da8dea-b3dd-47ed-ac00-50ce9ad41415/iec-60060-1-2010>

HIGH-VOLTAGE TEST TECHNIQUES –

Part 1: General definitions and test requirements

1 Scope

This part of IEC 60060 is applicable to:

- dielectric tests with direct voltage;
- dielectric tests with alternating voltage;
- dielectric tests with impulse voltage;
- dielectric tests with combinations of the above.

This part is applicable to tests on equipment having its highest voltage for equipment U_m above 1 kV.

NOTE 1 Alternative test procedures may be required to obtain reproducible and significant results. The choice of a suitable test procedure should be made by the relevant Technical Committee.

NOTE 2 For voltages U_m above 800 kV meeting some specified procedures, tolerances and uncertainties may not be achievable.

2 Normative references (standards.iteh.ai)

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 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60507:1991, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*

IEC 61083-1, *Instruments and software used for measurement in high-voltage impulse tests – Part 1: Requirements for instruments*

IEC 61083-2, *Digital recorders for measurements in high-voltage impulse tests – Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms*

IEC 62475, *High-current test techniques: Definitions and requirements for test currents and measuring systems*

3 Terms and definitions

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

3.1 Definitions related to characteristics of discharges

3.1.1

disruptive discharge

failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between electrodes to practically zero

NOTE 1 Non-sustained disruptive discharge in which the test object is momentarily bridged by a spark or arc may occur. During these events the voltage across the test object is momentarily reduced to zero or to a very small value. Depending on the characteristics of the test circuit and the test object, a recovery of dielectric strength may occur and may even allow the test voltage to reach a higher value. Such an event should be interpreted as a disruptive discharge unless otherwise specified by the relevant Technical Committee.

NOTE 2 A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength; in a liquid or gaseous dielectric the loss may be only temporary.

3.1.2

sparkover

disruptive discharge that occurs in a gaseous or liquid dielectric

3.1.3

flashover

disruptive discharge that occurs over the surface of a dielectric in a gaseous or liquid dielectric

3.1.4

puncture

disruptive discharge that occurs through a solid dielectric

3.1.5

disruptive-discharge voltage value of a test object

value of the test voltage causing disruptive discharge, as specified, for the various tests, in the relevant clauses of the present standard

3.1.6

non-disruptive discharge

discharge between intermediate electrodes or conductors where the test voltage does not collapse to zero

NOTE 1 Such an event should not be interpreted as a disruptive discharge unless so specified by the relevant Technical Committee.

NOTE 2 Some non-disruptive discharges are termed “partial discharges” and are dealt with in IEC 60270.

3.2 Definitions relating to characteristics of the test voltage

3.2.1

prospective characteristics of a test voltage

characteristics which would have been obtained if no disruptive discharge had occurred. When a prospective characteristic is used, this shall always be stated.

3.2.2

actual characteristics of a test voltage

those characteristics which occur during the test at the terminals of the test object

3.2.3

value of the test voltage

as defined in the relevant clauses of this standard

3.2.4

withstand voltage of a test object

specified prospective voltage value which characterizes the insulation of the object with regard to a withstand test

NOTE 1 Unless otherwise specified, withstand voltages are referred to standard reference atmospheric conditions (see 4.3.1).

NOTE 2 This applies to external insulation only.

3.2.5

assured disruptive-discharge voltage of a test object

specified prospective voltage value which characterizes its performance with regard to a disruptive-discharge test

3.3 Definitions relating to tolerance and uncertainty

3.3.1

tolerance

constitutes the permitted difference between the measured value and the specified value

NOTE 1 This difference should be distinguished from the uncertainty of a measurement.

NOTE 2 A pass/fail decision is based on the measured value, without consideration of the measurement uncertainty.

3.3.2

uncertainty (of measurement)

parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could be reasonably attributed to the measurand

[IEV 311-01-02]

[IEC 60060-1:2010](https://standards.iteh.ai/catalog/standards/sist/90da8dea-b3dd-47ed-ac00-50ce9ad41415/iec-60060-1-2010)

[https://standards.iteh.ai/catalog/standards/sist/90da8dea-b3dd-47ed-ac00-](https://standards.iteh.ai/catalog/standards/sist/90da8dea-b3dd-47ed-ac00-50ce9ad41415/iec-60060-1-2010)

NOTE 1 In this standard, all uncertainty values are specified at a level of confidence of 95 %.

NOTE 2 Uncertainty is positive and given without sign.

NOTE 3 It should not be confused with the tolerance of a test-specified value or parameter.

3.4 Definitions relating to statistical characteristics of disruptive-discharge voltage values

3.4.1

disruptive-discharge probability of a test object

p

probability that one application of a certain prospective voltage value of a given shape will cause disruptive discharge in the test object

NOTE The parameter p may be expressed as a percentage or a proper fraction.

3.4.2

withstand probability of a test object

q

probability that an application of a certain prospective voltage value of a given shape does not cause a disruptive discharge on the test object

NOTE If the disruptive-discharge probability is p , the withstand probability q is $(1 - p)$.

3.4.3

p % disruptive-discharge voltage of a test object

U_p

prospective voltage value which has p % probability of producing a disruptive discharge on the test object

NOTE 1 Mathematically the p % disruptive-discharge voltage is the quantile of the order p (or p quantile) of the breakdown voltage.

NOTE 2 U_{10} is called the “statistical withstand voltage” and U_{90} is called the “statistical assured disruptive-discharge voltage”.

3.4.4
50 % disruptive-discharge voltage of a test object

U_{50}
prospective voltage value which has a 50 % probability of producing a disruptive discharge on the test object

3.4.5
arithmetic mean value of the disruptive-discharge voltage of a test object,

U_a

$$U_a = \frac{1}{n} \sum_{i=1}^n U_i$$

where

U_i is the measured disruptive-discharge voltage and

n is the number of observations (discharges).

NOTE For symmetric distributions U_a is identical to U_{50} .

3.4.6
standard deviation of the disruptive voltage of a test object

s

a measure of the dispersion of the disruptive voltage estimated by

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (U_i - U_a)^2}$$

where

U_i is the i^{th} measured disruptive voltage and

U_a is the arithmetic mean of the disruptive voltages (in most cases it is identical to U_{50}).

n is the number of observations (discharges).

NOTE 1 It can also be evaluated by the difference between the 50 % and 16 % disruptive-discharge voltages (or between the 84 % and 50 % disruptive-discharge voltages). It is often expressed in per unit or percentage value referred to the 50 % disruptive-discharge voltage.

NOTE 2 For successive disruptive-discharge tests the standard deviation s is defined by the formula. For multiple level and up-and-down tests it is defined by the difference of the quantiles. The methods are equivalent because, between $p = 16$ % and $p = 84$ % all distribution functions are nearly identical.

3.5 Definitions relating to classification of insulation in test objects

3.5.1
external insulation

air insulation and the exposed surfaces of solid insulation of the equipment, which are subject both to dielectric stresses and to the direct effects of atmospheric and other external conditions

3.5.2
internal insulation

internal solid, liquid or gaseous elements of the insulation of equipment protected from the direct effects of external conditions such as pollution, humidity and vermin

3.5.3

self-restoring insulation

insulation which completely recovers its insulating properties after a disruptive discharge caused by the application of a test voltage

[IEV 604-03-04, modified]

3.5.4

non-self-restoring insulation

insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge caused by the application of a test voltage

[IEV 604-03-05, modified]

NOTE In high-voltage apparatus, parts of both self-restoring and non-self-restoring insulation are always operating in combination and some parts may be degraded by repeated or continued voltage applications. The behaviour of the insulation in this respect should be taken into account by the relevant Technical Committee when specifying the test procedures to be applied.

4 General requirements

4.1 General requirements for test procedures

The test procedures applicable to particular types of test objects, for example, the test voltage, the polarity to be used, the preferred order if both polarities are to be used, the number of applications and the interval between applications shall be specified by the relevant Technical Committee, having regard to such factors as:

- the required accuracy of the test results;
- the random nature of the observed phenomena;
- any polarity dependence of the measured characteristics and
- the possibility of progressive deterioration with repeated voltage applications.

At the time of a test, the test object shall be complete in all essential details, and it should have been processed in the normal manner for similar equipment.

At the time of a test, the test object should have become acclimatised as much as practicable to the ambient atmospheric conditions of the test area. The period allocated to reach equilibrium should be recorded.

4.2 Arrangement of the test object in dry tests

The disruptive-discharge characteristics of a test object with external insulation may be affected by its general arrangement (for example, proximity effects such as distance in air from other live or earthed structures, height above ground level and the arrangement of its high-voltage lead). The general arrangement should be specified by the relevant Technical Committee.

NOTE 1 A clearance to extraneous structures not less than 1,5 times the length of the shortest possible discharge path on the test object usually makes such proximity effects negligible. In wet or pollution tests, or wherever the voltage distribution along the test object and the electric field around its energized electrode are sufficiently independent of external influences, smaller clearances may be acceptable, provided that discharges do not occur to extraneous structures.

NOTE 2 In the case of a.c. or positive switching-impulse voltage tests above 750 kV (peak) the influence of an extraneous structure may be considered as negligible if its distance from the energized electrode is also not less than the height of this electrode above the ground plane. A guide for recommended minimum clearance is given in Figure 1, as a function of the highest test voltage. Significant shorter clearances may be suitable in individual

cases. However, an experimental adaptation or a field calculation, taking into account a voltage dependent maximum field strength as described in the literature [1, 2]¹, is recommended.

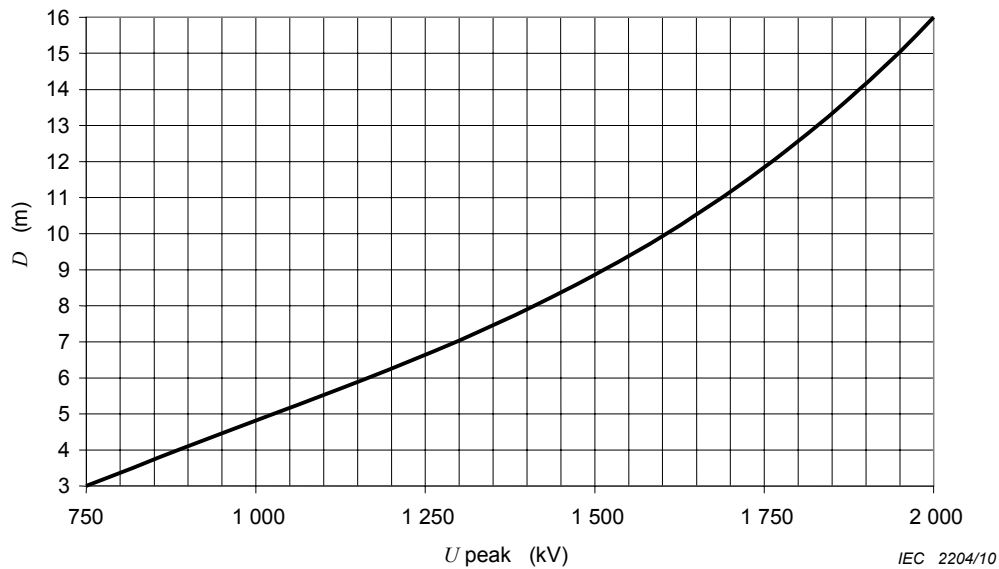


Figure 1 – Recommended minimum clearance *D* of extraneous live or earthed objects to the energized electrode of a test object, during an a.c. or positive switching impulse test at the maximum voltage *U* applied during test

If not otherwise specified by the relevant Technical Committee, the test should be made at ambient atmospheric conditions in the test area without extraneous precipitation or pollution. The procedure for voltage application shall be as specified in the relevant clauses of this standard.

4.3 Atmospheric corrections in dry tests

4.3.1 Standard reference atmosphere

The standard reference atmosphere is:

- temperature $t_0 = 20 \text{ °C}$;
- absolute pressure $p_0 = 1\,013 \text{ hPa}$ (1 013 mbar) ;
- absolute humidity $h_0 = 11 \text{ g/m}^3$.

NOTE 1 An absolute pressure of 1 013 hPa corresponds to the height of 760 mm of the mercury column in a mercury barometer at 0 °C. If the barometer height is *H* mm of mercury, the atmospheric pressure in hectopascal is approximately:

$$p = 1,333 H \text{ hPa}$$

Correction for temperature with respect to the height of the mercury column is considered to be negligible.

NOTE 2 Instruments automatically correcting pressure to sea level are not suitable and should not be used.

4.3.2 Atmospheric correction factors for air gaps

The disruptive discharge of external insulation depends upon the atmospheric conditions. Usually, the disruptive-discharge voltage for a given path in air is increased by an increase in either air density or humidity. However, when the relative humidity exceeds about 80 %, the disruptive-discharge voltage becomes irregular, especially when the disruptive discharge occurs over an insulating surface.

¹ Numbers in square brackets refer to the Bibliography.

NOTE Atmospheric corrections do not apply to flashover, only to sparkover.

The disruptive-discharge voltage is proportional to the atmospheric correction factor K_t that results from the product of two correction factors:

- the air density correction factor k_1 (see 4.3.4.1);
- the humidity correction factor k_2 (see 4.3.4.2).

$$K_t = k_1 k_2$$

4.3.3 Application of correction factors

4.3.3.1 Standard procedure

By applying correction factors, a disruptive-discharge voltage measured in given test conditions (temperature t , pressure p , humidity h) may be converted to the value, which would have been obtained under the standard reference atmospheric conditions (t_0, p_0, h_0).

Disruptive-discharge voltages, U , measured at given test conditions are corrected to U_0 corresponding to standard reference atmosphere by dividing by K_t :

$$U_0 = U / K_t$$

The test report shall always contain the actual atmospheric conditions during the test and the correction factors applied.

4.3.3.2 Converse procedure

Conversely, where a test voltage is specified for standard reference conditions, it shall be converted into the equivalent value under the test conditions and this may require an iterative procedure.

If not otherwise specified by the relevant Technical Committee, the voltage U to be applied during a test on external insulation is determined by multiplying the specified test voltage U_0 by K_t ;

$$U = U_0 K_t$$

However, as U enters into the calculation of K_t , an iterative procedure might have to be used (see Annex E).

NOTE 1 The test for the correct choice of U for the calculation of K_t is to divide U by K_t . If the result is the specified test voltage, U_0 , then a correct choice of U has been made. If U_0 is too high, U has to be reduced but if it is too low, it has to be increased.

NOTE 2 When K_t is close to unity, iterative calculation is not necessary.

NOTE 3 In correcting power-frequency voltage the peak value has to be used, because the discharge behaviour is based on the peak value.

4.3.4 Correction factor components

4.3.4.1 Air density correction factor, k_1

The air density correction factor k_1 depends on the relative air density δ and can be generally expressed as:

$$k_1 = \delta^m$$