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Interested committees:

Title: Draft BS EN IEC 60060-1 High-voltage test techniques. Part 1: General definitions and test requirements.

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



42/391/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: IEC 60060-1 ED4	
DATE OF CIRCULATION: 2021-04-02	CLOSING DATE FOR COMMENTS: 2021-05-28
SUPERSEDES DOCUMENTS: 42/363/RR	

IEC TC 42 : HIGH-VOLTAGE AND HIGH-CURRENT TEST TECHNIQUES	
SECRETARIAT: Canada	SECRETARY: Mr Howard G. Sedding
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 14,TC 17,SC 17A,SC 17C,SC 18A,TC 23,TC 32,TC 36,TC 37,TC 122	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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TITLE:

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

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE TEST TECHNIQUES –

Part 1: General definitions and test requirements

FOREWORD

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- International Standard IEC 60060-1 has been prepared by IEC technical committee 42: High-voltage test techniques.
- This fourth edition of IEC 60060-1 cancels and replaces the third edition, published in 2010, 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) The positive tolerance of the front time of lightning impulse was extended for $U_m > 800$ kV to 100 % (= 2,4 μ s)
 - c) For switching impulse voltage a front time was introduced, similar to lightning impulse voltage.
 - d) With the new front time the standard switching impulse is defined as 170/2500 μ s.
 - e) The requirements for precipitations were adjusted depending on U_m .
 - f) Annex C "Procedure for manual calculation from graphical waveforms" was incorporated.

- f) No examples for software were given in Annex D “Guidance for implementing software for evaluation of lightning impulse voltage parameters”
- g) Annex about “Background to the introduction of the test voltage factor for evaluation of impulses with overshoot” was deleted.
- h) A new informative Annex F “New definition of the front time of switching impulse voltage” was incorporated.

FDIS	Report on voting
42/xx/FDIS	42/xx/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.

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 AC and 1,5 kV DC.

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 some specified procedures, tolerances and uncertainties may not be achievable.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

IEC 60507, 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

phenomenon associated with the failure of insulation under electrical stress which includes a collapse of voltage and the passage of current

Note 1 to entry: The term applies to electric breakdown in solid, liquid and gaseous dielectrics and combination of these.

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

[IEV 614-03-16]

3.1.2

sparkover

disruptive discharge in a gaseous or liquid insulating material

[IEV 212-11-48]

3.1.3

flashover

electric breakdown between conductors in a gas or a liquid or in vacuum, at least partly along the surface of solid insulation

[IEV 212-11-47]

3.1.4

puncture

disruptive discharge occurring through a solid insulation material, producing a path of permanent damage

Note 1 to entry: The term puncture is also used as a synonym for electric breakdown in solids.

[IEV 212-11-49]

3.1.5

disruptive discharge voltage value

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

Note 2 to entry: 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

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**

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**

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

Note 1 to entry: Unless otherwise specified, withstand voltages are referred to standard reference atmospheric conditions (see Clause 4.3.1)

Note 2 to entry: This applies to external insulation only.

3.2.5**assured disruptive discharge voltage**

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

3.2.6**voltage dip**

a sudden reduction of the voltage at a point in an electrical system followed by voltage recovery after a short period of time from a few cycles to a few seconds

[IEV 161-08-10 modified]

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 to entry: This difference should be distinguished from the uncertainty of a measurement.

Note 2 to entry: 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 with modified notes]

Note 1 to entry: In this standard, all uncertainty values are specified at a level of confidence of 95 %.

Note 2 to entry: Uncertainty is positive and given without sign.

Note 3 to entry: 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

p

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

Note 1 to entry: The parameter p may be expressed as a percentage or a proper fraction.

3.4.2 withstand probability

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

3.4.3 p % disruptive discharge voltage

U_p

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

Note 1 to entry: Mathematically the p % disruptive discharge voltage is the quantile of the order p (or p quantile) of the breakdown voltage.

Note 2 to entry: 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

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

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 1 to entry: For symmetric distributions U_a is identical to U_{50}

3.4.6 standard deviation of the disruptive voltage

s

a measure of the dispersion of the disruptive discharge 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 discharge voltage and

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

n is the number of observations (discharges).

Note 1 to entry: 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 to entry: 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

distances in atmospheric air, and along the surfaces in contact with atmospheric air of solid insulation of the equipment which are subject to dielectric stresses and to the effects of atmospheric and other environmental conditions from the site

Note 1 to entry: Examples of environmental conditions are pollution, humidity, vermin, etc.

[IEV 614-03-02]

3.5.2

internal insulation

internal distances of the solid, liquid or gaseous insulation of equipment which are protected from the effects of atmospheric and other external conditions

[IEV 614-03-03]

3.5.3

self-restoring insulation

insulation which completely recovers its insulating properties within a short time interval after a disruptive discharge

[IEV 614-03-04]

3.5.4

non-self-restoring insulation

insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge

[IEV 614-03-05]

Note 1 to entry: 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 measurement uncertainty;
- the random nature of the observed phenomena;
- any polarity dependence of the measured characteristics;
- 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 AC 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, is recommended.

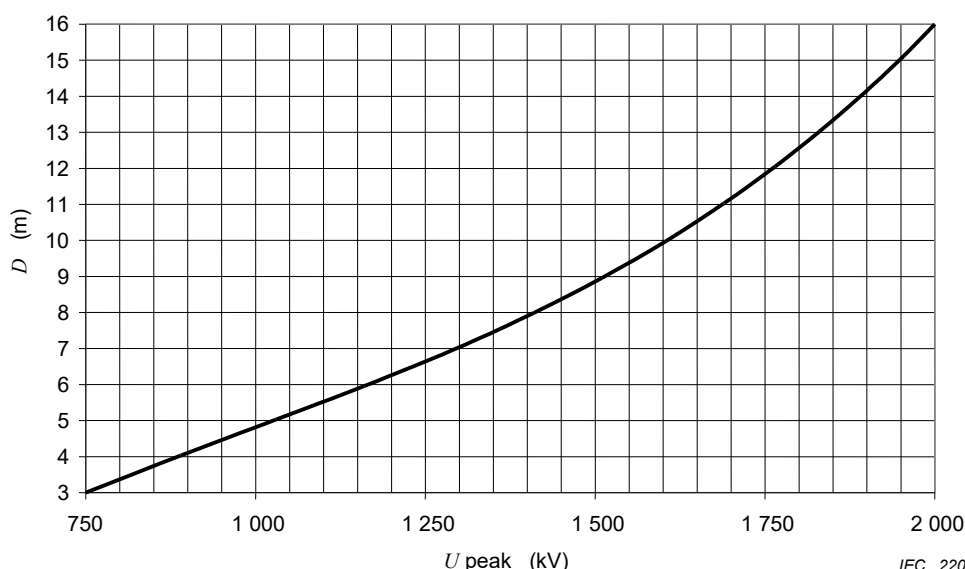


Figure 1 – Recommended minimum clearance D of extraneous live or earthed objects to the energized electrode of a test object, during an AC or positive switching impulse test at the maximum voltage U applied during test

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 document.

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

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

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.

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:

$$k_1 = \delta^m$$

where m is an exponent given in 4.3.4.3.

When the temperatures t and t_0 are expressed in degrees Celsius and the atmospheric pressures p and p_0 are expressed in the same units, the relative air density is:

$$\delta = \frac{p}{p_0} \times \frac{273 + t_0}{273 + t}$$

The correction is considered reliable for $0,8 < k_1 < 1,05$.

4.3.4.2 Humidity correction factor, k_2

The humidity correction factor may be expressed as:

$$k_2 = k^w$$

where w is an exponent given in 4.3.4.3 and k is a parameter that depends on the type of test voltage and may be obtained as a function of the ratio of absolute humidity h , to the relative air density δ , using the following equations (Figure 2):

$$\text{DC} \quad k = 1 + 0,014 (h/\delta - 11) - 0,00022 (h(\delta - 11)) \quad \text{for } 1 \text{ g/m}^3 < h/\delta < 15 \text{ g/m}^3$$

$$\text{AC} \quad k = 1 + 0,012 (h/\delta - 11) \quad \text{for } 1 \text{ g/m}^3 < h/\delta < 15 \text{ g/m}^3$$

$$\text{Impulse} \quad k = 1 + 0,010 (h/\delta - 11) \quad \text{for } 1 \text{ g/m}^3 < h/\delta < 20 \text{ g/m}^3$$

NOTE The impulse equation is based on experimental results for positive lightning impulse waveforms. This equation also applies to negative lightning impulse voltages and switching impulse voltages.

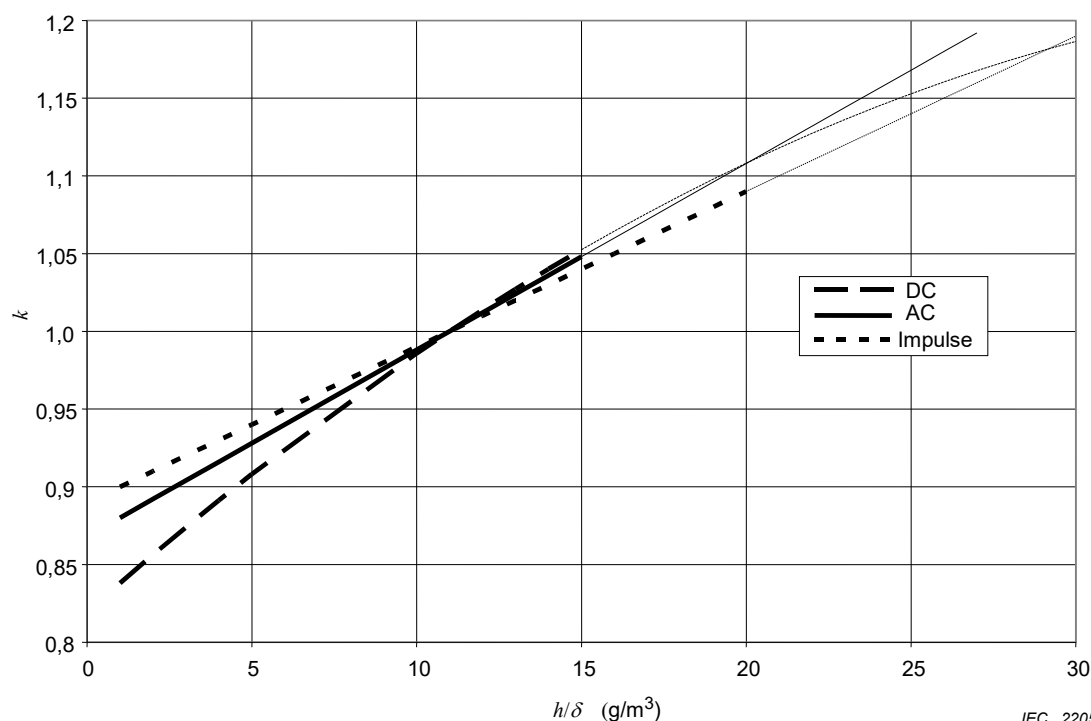


Figure 2 – k as a function of the ratio of the absolute humidity h to the relative air density δ (see 4.3.4.2 for limits of applicability)

For insulation of power equipment of $U_m \leq 72,5$ kV (or approximately gap lengths $l < 0,5$ m) no humidity correction can at present be specified.

NOTE For specific apparatus, the relevant Technical Committee has specified other procedures (e.g. IEC 62271-1).

4.3.4.3 Exponents m and w

As the correction factors depend on the type of pre-discharges, this fact can be taken into account by considering the parameter:

$$g = \frac{U_{50}}{500 L \delta k}$$

where U_{50} is the 50 % disruptive-discharge voltage (measured or estimated) at the actual atmospheric conditions, in kilovolt peak, L the minimum discharge path in m, δ the relative air density and k the dimension less parameter defined in 4.3.4.2.

In the case of a withstand test where an estimate of the 50 % disruptive discharge voltage is not available, U_{50} can be assumed to be 1,1 times the test voltage, U_0 .

The exponents, m and w , are obtained from Table 1 for the specified ranges of g (Figure 3).

Table 1 – Values of exponents, m for air density correction and w for humidity correction, as a function of the parameter g

g	m	w
$<0,2$	0	0
0,2 to 1,0	$g(g-0,2)/0,8$	$g(g-0,2)/0,8$
1,0 to 1,2	1,0	1,0
1,2 to 2,0	1,0	$(2,2-g)(2,0-g)/0,8$
$>2,0$	1,0	0

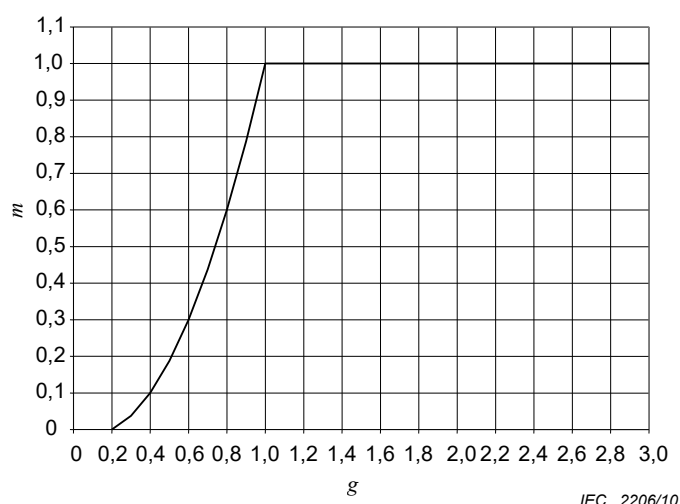


Figure 3a – Values of exponent m for air density correction as a function of parameter g

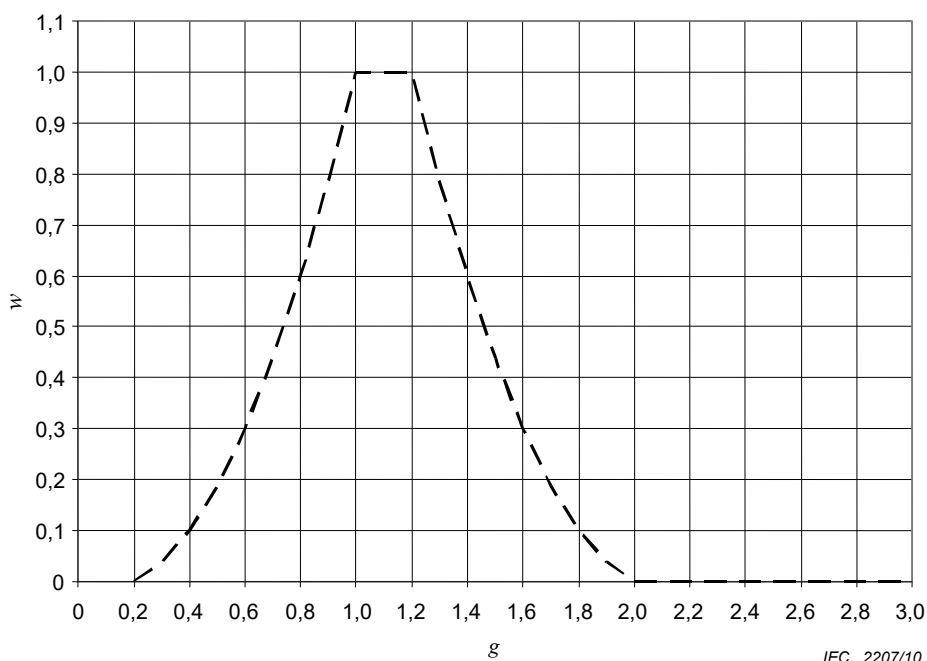


Figure 3b – Values of exponent w for humidity correction as a function of parameter g

Figure 3 – Values of exponents m and w

4.3.5 Measurement of atmospheric parameters

4.3.5.1 Humidity

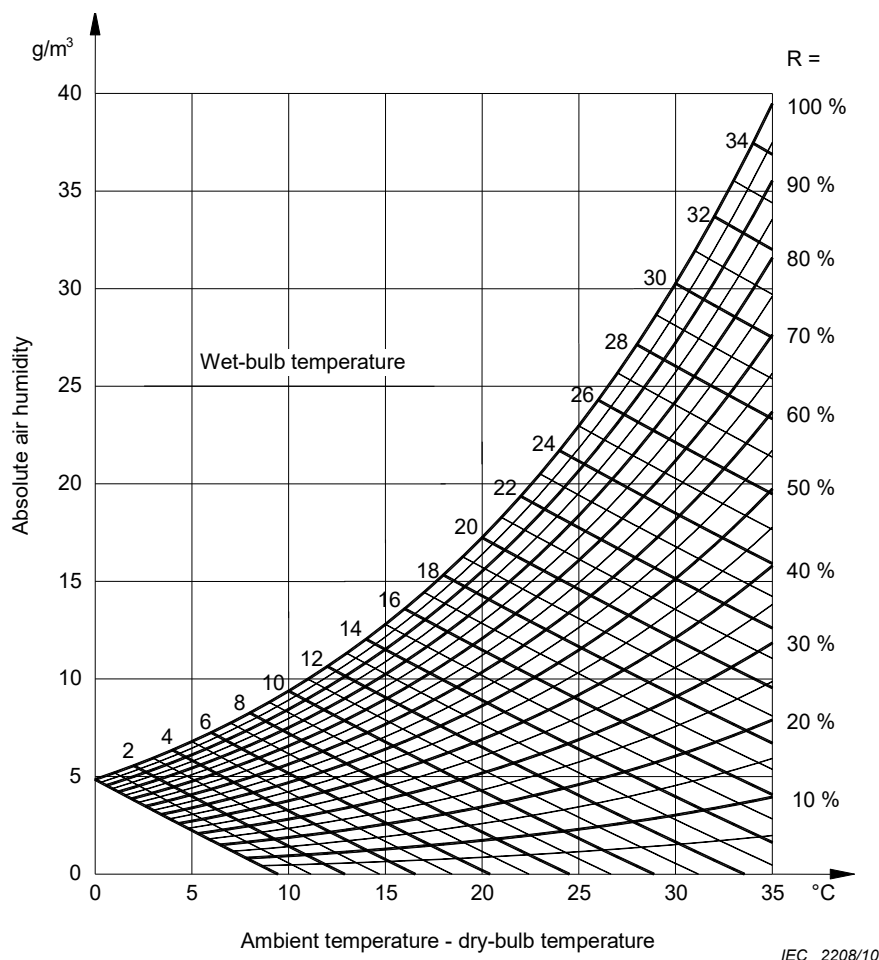
The humidity should preferably be determined with an instrument measuring directly the absolute humidity with an expanded uncertainty not larger than 1 g/m³.

Measurement of relative humidity and the ambient temperature can also be used for the determination of the absolute humidity, using the formula below, provided that the uncertainty of the absolute humidity determination in this case is the same as required above.

$$h = \frac{6,11 \cdot R \cdot e^{\frac{17,6t}{273+t}}}{0,4615 \cdot (273+t)}$$

where h is the absolute humidity in g/m³, R the relative humidity in percent and t the ambient temperature in °C.

NOTE This measurement may also be made by means of a ventilated wet and dry bulb hygrometer. The absolute humidity as a function of the thermometer readings is determined from Figure 4, which also permits determination of the relative humidity. It is important to provide adequate airflow so as to reach a steady state and to read the thermometers carefully in order to avoid excessive errors in the determination of the humidity.



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Figure 4 – Absolute humidity of air as a function of dry- and wet-bulb thermometer readings

4.3.5.2 Temperature

The ambient temperature should be measured with an expanded uncertainty of not larger than 1 °C.

4.3.5.3 Absolute pressure

The ambient absolute pressure should be measured with an expanded uncertainty of not larger than 5 hPa.

4.3.6 Conflicting requirements for testing internal and external insulation

While withstand levels are specified under standard reference atmospheric conditions, cases will arise where the application of atmospheric corrections (due to atmospheric conditions differing from the standard reference ones) results in the withstand level for internal insulation appreciably in excess of that for the associated external insulation. In such cases measures to enhance the withstand level of the external insulation shall be adopted to permit application of the correct test voltage to the internal insulation. These measures should be specified by the relevant Technical Committee with reference to the requirements of particular classes of apparatus and could include immersion of the external insulation in liquids or compressed gases.

For those cases where the test voltage of the external insulation is higher than that of the internal insulation, the external insulation can only be correctly tested when the internal insulation is especially designed with increased strength. If not, the internal insulation should be tested with the rated value and the external insulation be tested by means of test fixtures unless the relevant Technical Committee states otherwise, in which case it shall specify the test procedure to be used.

4.4 Wet tests

4.4.1 Wet test procedure

This wet test procedure is intended to simulate the effect of natural rain on external insulation. It is recommended for tests with all types of test voltages and on all types of apparatus.

The relevant Technical Committee should specify the arrangement of the test object during the test.

The test object shall be sprayed with water of prescribed resistivity and temperature (see Table 2) falling on it as droplets (avoiding fog and mist) and directed so that the vertical and horizontal components of the spray intensity are approximately equal. These intensities are measured with a divided collecting vessel having openings of 100 cm² to 750 cm², one horizontal and one vertical with the vertical opening facing the spray.

The position of the test object relative to the vertical and horizontal rain components shall be specified by the relevant Technical Committee.

In general, the reproducibility of wet test results is less than that for other high-voltage discharge or withstands tests. To minimize the dispersion, the following precautions shall be taken:

- The collecting vessel shall be placed close to the test object, but avoiding the collection of drops or splashes from it. During the measuring period, it should be moved slowly over a sufficient area to average the effect of non-uniformities of the spray from individual nozzles. This measuring zone shall have a width equal to that of the test object and a maximum height of 1 m.

- 628 – For test objects between 1 m and 3 m in height, the individual measurements shall be
629 made at the top, centre and bottom of the test object. Each measuring zone shall cover
630 only one third of the height of the test object.
 - 631 – For test objects exceeding 3 m in height, the number of measuring zones shall be
632 increased to cover the full height of the test object without overlapping.
 - 633 – The above procedures shall be suitably adapted for test objects having large horizontal
634 dimensions.
 - 635 – The spread of results may be reduced if the test object is cleaned with a surface-active
636 detergent, which has to be removed before the beginning of wetting.
 - 637 – The spread of results may also be affected by local anomalous (high or low) precipitation
638 rates. It is recommended to detect these by localized measurements and to improve the
639 uniformity of the spray, if necessary.
- 640 The spray apparatus shall be adjusted to produce, within the specified tolerances, precipitation
641 conditions at the test object given in Table 2.
- 642 Any type and arrangement of nozzles meeting the requirements given in Table 2 may be used.
- 643

Table 2 – Precipitation conditions for standard procedure

Precipitation condition	Unit	$U_m \leq 550$ kV	$U_m > 550$ kV
Average precipitation rate of all measurements:			
– vertical component	[mm/min]	1,0 to 2,0	1,0 to 3,0
– horizontal component	[mm/min]	1,0 to 2,0	1,0 to 3,0
Limits for any individual measurement of vertical component	[mm/min]	$\pm 0,5$ from average of vertical	$\pm 1,5$ from average of vertical
Limits for any individual measurement of horizontal component	[mm/min]	$\pm 0,5$ from average of horizontal	$\pm 1,5$ from average of horizontal
Temperature of water	[°C]	Ambient temperature ± 15	Ambient temperature ± 15
Conductivity of water	[μ S/cm]	100 ± 15	100 ± 15

The water temperature and resistivity shall be measured on a sample collected immediately before the water reaches the test object. They may also be measured at other locations (e.g., in a storage reservoir) provided that a check ensures that no significant change occurs by the time the water reaches the test object.

The test object shall be pre-wetted initially for at least 15 min under the above-specified conditions and these conditions shall remain within the specified tolerances throughout the test, which should be performed without interrupting the wetting. The pre-wetting time shall not include the time needed for adjusting the spray. It is also possible to perform an initial pre-wetting by unconditioned mains water for 15 min, followed without interruption of the spray by a second pre-wetting for at least 2 min before the test begins, using water with all the correct precipitation conditions, which should be measured immediately before starting the test.

Unless otherwise specified by the relevant Technical Committee, the test procedure for wet tests shall be the same as that specified for the corresponding dry tests. The test duration for an AC test shall be 60 s, if not otherwise specified. In general, for alternating and direct voltage wet withstand tests, it is recommended that one flashover should be permitted provided that in a repeat test no further flashover occurs.

4.4.2 Atmospheric corrections for wet tests

A density correction factor shall be applied as specified in 4.3, but no humidity correction factor shall be applied for wet tests.

4.5 Artificial pollution tests

Artificial pollution tests are intended to provide information on the behaviour of external insulation under conditions representative of pollution in service, although they do not necessarily simulate any particular service conditions. They are described in IEC 60507.

5 Tests with direct voltage

5.1 Definitions for direct voltage tests

5.1.1

value of the test voltage

arithmetic mean value