# SLOVENSKI STANDARD
# oSIST prEN IEC 60060-1:2023

**01-maj-2023**

---

**Visokonapetostne preskusne tehnike - 1. del: Splošne definicije in preskusne zahteve**

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

Hochspannungs-Prüftechnik - Teil 1: Allgemeine Begriffe und Prüfbedingungen

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



**Ta slovenski standard je istoveten z: prEN IEC 60060-1:2023**

---

**ICS:**

| | | |
|---|---|---|
| 17.220.20 | Merjenje električnih in magnetnih veličin | Measurement of electrical and magnetic quantities |
| 19.080 | Električno in elektronsko preskušanje | Electrical and electronic testing |

**oSIST prEN IEC 60060-1:2023 en**

IEC®

# 42/414/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

| | |
|---|---|
| PROJECT NUMBER:<br>**IEC 60060-1 ED4** | |
| DATE OF CIRCULATION:<br>**2023-03-24** | CLOSING DATE FOR VOTING:<br>**2023-06-16** |
| SUPERSEDES DOCUMENTS:<br>**42/403/CD, 42/409/CC** | |

| | |
|---|---|
| IEC TC 42 : HIGH-VOLTAGE AND HIGH-CURRENT TEST TECHNIQUES | |
| SECRETARIAT:<br>Canada | SECRETARY:<br>Mr Howard G. Sedding |
| OF INTEREST TO THE FOLLOWING COMMITTEES:<br>TC 14,TC 17,SC 17A,SC 17C,SC 18A,TC 23,TC 32,TC 36,TC 37,TC 38,TC 122 | PROPOSED HORIZONTAL STANDARD:<br>☒<br>Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary. |
| FUNCTIONS CONCERNED:<br>☐ EMC ☐ ENVIRONMENT | ☐ QUALITY ASSURANCE ☐ SAFETY |
| ☒ SUBMITTED FOR CENELEC PARALLEL VOTING<br>**Attention IEC-CENELEC parallel voting**<br>The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.<br>The CENELEC members are invited to vote through the CENELEC online voting system. | ☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING |



This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of

- any relevant patent rights of which they are aware and to provide supporting documentation,
- any relevant “in some countries” clauses to be included should this proposal proceed. Recipients are reminded that the enquiry stage is the final stage for submitting "in some countries" clauses. See AC/22/2007.

TITLE:

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

PROPOSED STABILITY DATE: 2027

NOTE FROM TC/SC OFFICERS:

# 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 and high-current 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 were updated and improved to make the standard easier to use, particularly the chapters for combined and composite test voltages.

b) The positive tolerance of the front time of lightning impulse was extended for $U_m$ > 800 kV to 100 % (= 2,4 µs)

c) For switching impulse voltage, a front time was introduced, similar to lightning impulse voltage and with the new front time the standard switching impulse is defined as 170/2500 µs.

d) The requirements for precipitations were adjusted depending on $U_m$.

e) 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 document 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 and high-current 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 is considered 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 measurements in high-voltage and high-current tests - Part 1: Requirements for instruments for impulse tests

IEC 61083-2, Instruments and software used for measurement in high-voltage and high-current tests - Part 2: Requirements for software for tests with impulse voltages and currents

IEC 61083-3, Instruments and software used for measurement in high-voltage and high-current tests - Part 3: Requirements for software for tests with impulse voltages and currents

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 of dielectric strength can be temporary.

[IEV 614-03-16, modified in Note 2 to entry]

**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 document

**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 is not considered 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 related to characteristics of the test voltage

**3.2.1**
**prospective characteristics**
characteristics which would have been obtained if no disruptive discharge had occurred and when a prospective characteristic is used and 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 document

**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) which 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]

### 3.3 Definitions related 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 has to 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 document, 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 is not be confused with the tolerance of a test-specified value or parameter.

### 3.4 Definitions related 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 $p$ is usually expressed as a percentage or a 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**
$U_a$



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

where

$U_i$ is the measured disruptive discharge voltage and

$n$ is the number of 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

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

where

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

$U_a$ is the arithmetic mean of the disruptive discharge voltages

$n$ 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 related 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 environmental conditions

Note 1 to entry: Examples of environmental conditions are pollution and humidity.

**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 and humidity

**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 test objects, 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 is 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 test objects.

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 an electric field calculation, taking into account voltage dependent maximum field strength as described in the literature, is recommended.

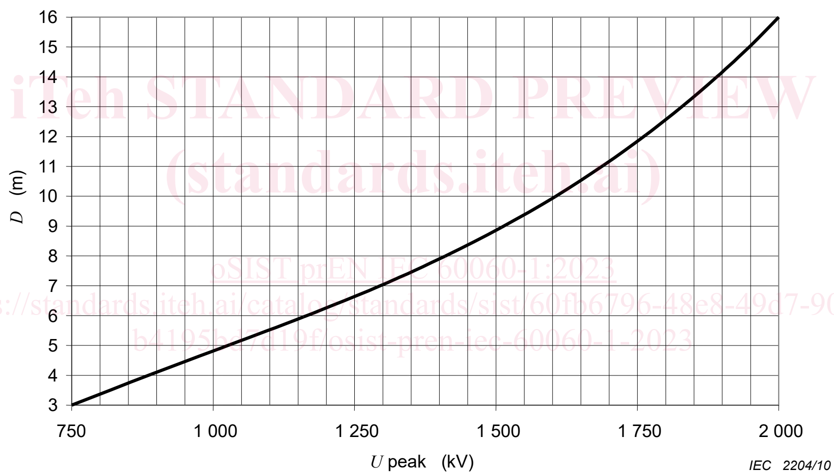




**Figure 1 – Recommended minimum clearance *D* of extraneous live or earthed objects to the energized electrode of a test object, during an AC or positive switching impulse test at the maximum voltage *U* applied during test**

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 °C;
- absolute pressure $p_0$ = 1 013 hPa (1 013 mbar);
- absolute humidity $h_0$ = 11 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