



**SLOVENSKI STANDARD**  
**oSIST prEN IEC 60060-1:2023**  
**01-maj-2023**

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**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**

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19.080	Električno in elektronsko preskušanje	Electrical and electronic testing

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

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# 42/414/CDV

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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 38,TC 122	PROPOSED HORIZONTAL STANDARD: <input checked="" type="checkbox"/> Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: <input type="checkbox"/> EMC <input type="checkbox"/> ENVIRONMENT <input type="checkbox"/> QUALITY ASSURANCE <input type="checkbox"/> SAFETY	
<input checked="" type="checkbox"/> SUBMITTED FOR CENELEC PARALLEL VOTING <input type="checkbox"/> NOT SUBMITTED FOR CENELEC PARALLEL VOTING	
<p><b>Attention IEC-CENELEC parallel voting</b></p> <p>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.</p> <p>The CENELEC members are invited to vote through the CENELEC online voting system.</p>	

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- 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

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**INTERNATIONAL ELECTROTECHNICAL COMMISSION****HIGH-VOLTAGE TEST TECHNIQUES –****Part 1: General definitions and test requirements****FOREWORD**

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- 179 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising  
180 all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international  
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- 211 International Standard IEC 60060-1 has been prepared by IEC Technical Committee 42: High-  
212 voltage and high-current test techniques.
- 213 This fourth edition of IEC 60060-1 cancels and replaces the third edition, published in 2010,  
214 and constitutes a technical revision.
- 215 The significant technical changes with respect to the previous edition are as follows:
- 216 a) The general layout and text were updated and improved to make the standard easier to use,  
217 particularly the chapters for combined and composite test voltages.
- 218 b) The positive tolerance of the front time of lightning impulse was extended for  $U_m > 800$  kV to  
219 100 % (= 2,4  $\mu$ s)
- 220 c) For switching impulse voltage, a front time was introduced, similar to lightning impulse  
221 voltage and with the new front time the standard switching impulse is defined as 170/2500  
222  $\mu$ s.
- 223 d) The requirements for precipitations were adjusted depending on  $U_m$ .
- 224 e) Annex C "Procedure for manual calculation from graphical waveforms" was incorporated.



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

231

FDIS	Report on voting
42/xx/FDIS	42/xx/RVD

232

233 Full information on the voting for the approval of this document can be found in the report on  
234 voting indicated in the above table.

235 This publication has been drafted in accordance with the ISO/IEC Directives, Part 2

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

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

- 241 • reconfirmed;
- 242 • withdrawn;
- 243 • replaced by a revised edition or
- 244 • amended.

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## HIGH-VOLTAGE TEST TECHNIQUES –

### Part 1: General definitions and test requirements

#### 253 1 Scope

254 This part of IEC 60060 is applicable to:

- 255 – dielectric tests with direct voltage;
- 256 – dielectric tests with alternating voltage;
- 257 – dielectric tests with impulse voltage;
- 258 – dielectric tests with combinations of the above.

259 This part is applicable to tests on equipment having its highest voltage for equipment  $U_m$  above  
260 1 kV AC and 1,5 kV DC.

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

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

#### 265 2 Normative references

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

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

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

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

272 IEC 61083-1, Instruments and software used for measurements in high-voltage and high-  
273 current tests - Part 1: Requirements for instruments for impulse tests

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

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

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

#### 280 3 Terms and definitions

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

## 282 3.1 Definitions related to characteristics of discharges

### 283 3.1.1

#### 284 **disruptive discharge**

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

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

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

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

### 292 3.1.2

#### 293 **sparkover**

294 disruptive discharge in a gaseous or liquid insulating material

295 [IEV 212-11-48]

### 296 3.1.3

#### 297 **flashover**

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

300 [IEV 212-11-47]

### 301 3.1.4

#### 302 **puncture**

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

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

306 [IEV 212-11-49]

### 307 3.1.5

#### 308 **disruptive discharge voltage value**

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

### 311 3.1.6

#### 312 **non-disruptive discharge**

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

315 Note 1 to entry: Such an event is not considered as a disruptive discharge unless so specified by the relevant  
316 Technical Committee.

317 Note 2 to entry: Some non-disruptive discharges are termed “partial discharges” and are dealt with in IEC 60270.

## 318 3.2 Definitions related to characteristics of the test voltage

### 319 3.2.1

#### 320 **prospective characteristics**

321 characteristics which would have been obtained if no disruptive discharge had occurred and  
322 when a prospective characteristic is used and this shall always be stated

- 323 **3.2.2**  
324 **actual characteristics**  
325 those characteristics which occur during the test at the terminals of the test object
- 326 **3.2.3**  
327 **value of the test voltage**  
328 as defined in the relevant clauses of this document
- 329 **3.2.4**  
330 **withstand voltage**  
331 specified prospective voltage value which characterizes the insulation of the object with regard  
332 to a withstand test
- 333 Note 1 to entry: Unless otherwise specified, withstand voltages are referred to standard reference atmospheric  
334 conditions (see Clause 4.3.1) which applies to external insulation only.
- 335 **3.2.5**  
336 **assured disruptive discharge voltage**  
337 specified prospective voltage value which characterizes its performance with regard to a  
338 disruptive discharge test
- 339 **3.2.6**  
340 **voltage dip**  
341 a sudden reduction of the voltage at a point in an electrical system followed by voltage recovery  
342 after a short period of time from a few cycles to a few seconds
- 343 [IEV 161-08-10]
- 344 **3.3 Definitions related to tolerance and uncertainty**
- 345 **3.3.1** [https://standards.iteh.ai/catalog/standards/sist/60fb6796-48e8-49d7-9088-](https://standards.iteh.ai/catalog/standards/sist/60fb6796-48e8-49d7-9088-b4195bd7d19f/osist-pren-iec-60060-1-2023)  
346 **tolerance** [b4195bd7d19f/osist-pren-iec-60060-1-2023](https://standards.iteh.ai/catalog/standards/sist/60fb6796-48e8-49d7-9088-b4195bd7d19f/osist-pren-iec-60060-1-2023)  
347 constitutes the permitted difference between the measured value and the specified value
- 348 Note 1 to entry: This difference has to be distinguished from the uncertainty of a measurement.
- 349 Note 2 to entry: A pass/fail decision is based on the measured value, without consideration of the measurement  
350 uncertainty.
- 351 **3.3.2**  
352 **uncertainty (of measurement)**  
353 parameter, associated with the result of a measurement, that characterizes the dispersion of  
354 the values that could be reasonably attributed to the measurand
- 355 [IEV 311-01-02 with modified notes]
- 356 Note 1 to entry: In this document, all uncertainty values are specified at a level of confidence of 95 %.
- 357 Note 2 to entry: Uncertainty is positive and given without sign.
- 358 Note 3 to entry: It is not be confused with the tolerance of a test-specified value or parameter.
- 359 **3.4 Definitions related to statistical characteristics of disruptive discharge voltage**  
360 **values**
- 361 **3.4.1**  
362 **disruptive discharge probability**  
363 ***p***  
364 probability that an application of a certain prospective voltage value of a given shape will cause  
365 disruptive discharge on the test object

366 Note 1 to entry: The parameter  $p$  is usually expressed as a percentage or a fraction.

### 367 3.4.2

#### 368 withstand probability

369  $q$

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

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

### 373 3.4.3

#### 374 $p$ % disruptive discharge voltage

375  $U_p$

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

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

380 Note 2 to entry:  $U_{10}$  is called the “statistical withstand voltage” and  $U_{90}$  is called the “statistical assured disruptive  
381 discharge voltage”.

### 382 3.4.4

#### 383 50 % disruptive discharge voltage

384  $U_{50}$

385 prospective voltage value which has a 50 % probability of producing a disruptive discharge on  
386 the test object

### 387 3.4.5

#### 388 arithmetic mean value of the disruptive discharge voltage

389  $U_a$

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

390

391 where

392  $U_i$  is the measured disruptive discharge voltage and

393  $n$  is the number of discharges.

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

### 395 3.4.6

#### 396 standard deviation of the disruptive voltage

397  $s$

398 a measure of the dispersion of the disruptive discharge voltage estimated by

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

399

400 where

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

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

403  $n$  is the number of observations (discharges).

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

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

### 410 **3.5 Definitions related to classification of insulation in test objects**

#### 411 **3.5.1**

##### 412 **external insulation**

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

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

#### 417 **3.5.2**

##### 418 **internal insulation**

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

#### 421 **3.5.3**

##### 422 **self-restoring insulation**

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

425 [IEV 614-03-04]

#### 426 **3.5.4**

##### 427 **non-self-restoring insulation**

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

430 [IEV 614-03-05]

431 Note 1 to entry: In test objects, parts of both self-restoring and non-self-restoring insulation are always operating in  
432 combination and some parts may be degraded by repeated or continued voltage applications. The behaviour of the  
433 insulation in this respect should be taken into account by the relevant Technical Committee when specifying the test  
434 procedures to be applied.

## 435 **4 General requirements**

### 436 **4.1 General requirements for test procedures**

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

- 441 – the required measurement uncertainty;
- 442 – the random nature of the observed phenomena;
- 443 – any polarity dependence of the measured characteristics;
- 444 – the possibility of progressive deterioration with repeated voltage applications.

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

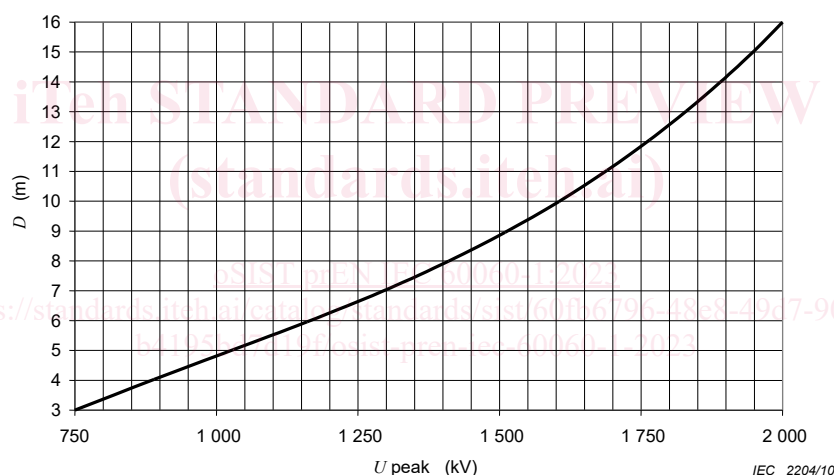
447 At the time of a test, the test object should have become acclimatised as much as practicable  
 448 to the ambient atmospheric conditions of the test area. The period allocated to reach equilibrium  
 449 should be recorded.

## 450 4.2 Arrangement of the test object in dry tests

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

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

460 NOTE 2 In the case of AC or positive switching impulse voltage tests above 750 kV (peak) the influence of an  
 461 extraneous structure may be considered as negligible if its distance from the energized electrode is also not less  
 462 than the height of this electrode above the ground plane. A guide for recommended minimum clearance is given in  
 463 Figure 1, as a function of the highest test voltage. Significant shorter clearances may be suitable in individual cases.  
 464 However, an experimental adaptation or an electric field calculation, taking into account voltage dependent maximum  
 465 field strength as described in the literature, is recommended.



466

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

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

## 474 4.3 Atmospheric corrections in dry tests

### 475 4.3.1 Standard reference atmosphere

476 The standard reference atmosphere is:

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

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