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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.

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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.	



42/461/CD

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SECRETARIAT:

Canada

SECRETARY:

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OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 2,TC 14,TC 17,SC 17A,SC 17C,SC 18A,TC 20,TC 23,TC 32,TC 36,TC 37,TC 112,TC 122

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

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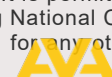
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TITLE:

High-voltage test techniques - Dielectric loss measurements "PROPOSED HORIZONTAL STANDARD"

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**HIGH VOLTAGE TEST TECHNIQUES – CAPACITANCE AND DIELECTRIC
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IEC 63405 has been prepared by subcommittee WG24: High-voltage test techniques - Dielectric loss measurements, of IEC technical committee 42: High-voltage and high-current test techniques. It is an International Standard.

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

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, [and the ISO/IEC Directives, JTC 1 Supplement] available at www.iec.ch/members_experts/refdocs. The

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180 specific document. At this date, the document will be

- 181 • reconfirmed,
- 182 • withdrawn,
- 183 • replaced by a revised edition, or
- 184 • amended.

185

INTRODUCTION

186

187 The electric power industry requires standardized tools to provide confidence in the
188 measurement of capacitance and dielectric loss, and to prove equivalence between tests
189 performed in different test facilities.

190 The measurement of capacitance and dielectric loss are effective methods to determine the
191 insulation status of electrical equipment. Capacitance and dielectric loss measurement are
192 widely used in electrical equipment manufacturers, power grid companies, colleges and
193 universities, testing and inspection institutions and other units. IEC 63405 specifies the general
194 principles and requirements for the measurement of capacitance and dielectric loss.

195

HIGH-VOLTAGE TEST TECHNIQUES — CAPACITANCE AND DIELECTRIC LOSS MEASUREMENTS

1 Scope

This document of IEC 63405 is applicable to the measurement of capacitance and dielectric loss at power frequency for electrical apparatus, components, or systems, with the highest voltage for equipment U_m above 1 kV.

This document

- defines the terms used
- suggests methods of test
- suggests test object connections
- provides possible test procedures
- provides guidance on requirements of calibration

This document is primarily concerned with capacitance and dielectric loss measurements for electrical equipment, such as capacitors, cables, power transformers, bushings, switches, circuit breakers, and instrument transformers. The tests of insulation materials (solid, liquid, gas, etc.) or power electronics components are NOT included in this standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of Uncertainty in measurements (GUM: 1995)*

3 Terms and definitions

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

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

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

3.1 Definitions for dielectric measuring systems

3.1.1

dielectric measuring system

complete set of devices suitable for performing a dielectric measurement

Note 1 to entry: A dielectric measuring system usually comprises the following components:

- a converting device with the leads required for connecting this device to the test object or into the circuit and the connections to earth;

– a transmission system connecting the output terminals of the converting device to the measuring instruments with its attenuating, terminating and adapting impedances or networks;

– a measuring instrument together with any connection to the power supply;

– software, used to obtain or calculate measuring results.

3.1.2

record of performance

detailed record, established and maintained by the user, describing the dielectric measuring system and containing evidence that the requirements given in this standard have been met

Note 1 to entry: This evidence includes the results of the initial performance test and the schedule and results of each subsequent performance test and performance check.

[SOURCE: IEC 60060-2:2025, term 3.1.2]

3.1.3

approved dielectric measuring system

dielectric measuring system that is shown to comply with one or more of the sets of requirements set out in this document

3.1.4

reference dielectric measuring system

dielectric measuring system with its calibration traceable to relevant national or international standards of measurement, and having sufficient accuracy and stability for use in the approval of other systems by making simultaneous comparative measurements with specific types of waveform and ranges of voltage

Note 1 to entry: A reference dielectric measuring system (maintained according to the requirements of this standard) can be used as an approved dielectric measuring system but the converse is not true.

3.1.5

scale factor

<of a dielectric measuring system> factor by which the value of the measuring-instrument reading is multiplied to obtain the value of the input quantity of the complete dielectric measuring system

Note 1 to entry: A dielectric measuring system can have multiple scale factors for different assigned measurement ranges, frequency ranges or waveforms.

Note 2 to entry: For dielectric measuring systems that display the value of the input quantity directly, the nominal scale factor of the dielectric measuring system is unity.

[SOURCE: IEC 60060-2:2025, term 3.3.1]

3.2 Definitions for dielectric properties

3.2.1

electric constant

permittivity of vacuum

ε_0

scalar constant linking the electric quantities and the mechanical quantities, obtained from the relation

$$\varepsilon_0 = \frac{1}{4\pi F} \cdot \frac{|Q_1 Q_2|}{r^2} \quad (1)$$

based on Coulomb's law in a vacuum, where F is the magnitude of the force between two particles with electric charges Q_1 and Q_2 respectively, placed at a distance r apart.

Note 1 to entry: In a vacuum, the product of the electric constant ε_0 and the electric field strength E is equal to the electric flux density D : $D = \varepsilon_0 E$.

Note 2 to entry: The electric constant ε_0 is related to the magnetic constant μ_0 and to the speed of light in vacuum c_0 by the relation $\varepsilon_0 \mu_0 c_0^2 = 1$.

284 Note 3 to entry: The value of the electric constant ε_0 is equal to $8,8541878128(13) \cdot 10^{-12} \frac{\text{A} \cdot \text{s}}{\text{V} \cdot \text{m}}$.

285 [SOURCE: IEC 60050-121:2021, 121-11-03]

286 3.2.2

287 absolute permittivity

288 permittivity

289 DEPRECATED: absolute dielectric constant

290 DEPRECATED: dielectric constant

291 ε

292 scalar quantity or tensor quantity, the product of which by the electric field strength E in a
293 medium is equal to the electric flux density D :

$$D = \varepsilon E \quad (2)$$

294 Note 1 to entry: For an isotropic medium, the absolute permittivity is a scalar quantity; for an anisotropic medium,
295 it is a tensor quantity.

296 [SOURCE: IEC 60050-121:2021, 121-12-12]

297 3.2.3

298 relative permittivity

299 DEPRECATED: relative dielectric constant

300 DEPRECATED: dielectric constant

301 DEPRECATED: permittivity

302 ε_r

303 scalar quantity or tensor quantity equal to the absolute permittivity divided by the electric
304 constant

305 Note 1 to entry: For an isotropic medium, the relative permittivity is a scalar quantity; for an anisotropic medium, it
306 is a tensor quantity.

307 Note 2 to entry: In the case of constant fields and alternating fields of sufficiently low frequency, the relative
308 permittivity of an isotropic or quasi-isotropic dielectric is equal to the ratio of the capacitance of a capacitor, in which
309 the space between and around the electrodes is entirely and exclusively filled with the dielectric medium, to the
310 capacitance of the same configuration of electrodes in vacuum. However, this use is not recommended.

311 Note 3 to entry: In practical engineering, it is usual to employ the term "permittivity" when referring to relative
312 permittivity, but this use is deprecated since "permittivity" is a synonym for "absolute permittivity".

313 [SOURCE: IEC 60050-121:2021, 121-12-13]

314 3.2.4

315 complex relative permittivity

316 DEPRECATED: relative complex dielectric constant

317 $\underline{\varepsilon}_r$

318 under sinusoidal conditions in a medium where the phasors $\underline{D}$ and $\underline{E}$ representing respectively
319 the electric flux density and the electric field strength are linearly related, complex quantity $\underline{\varepsilon}_r$
320 defined by the relation

$$\underline{D} = \varepsilon_0 \underline{\varepsilon}_r \underline{E} \quad (3)$$

321 where

322 ε_0 is the electric constant

323 Note 1 to entry: The complex relative permittivity is generally frequency dependent. For an isotropic medium, the
324 complex relative permittivity is a scalar quantity; for an anisotropic medium, it is a tensor quantity.

325 Note 2 to entry: Generally, ε_r is expressed as $\underline{\varepsilon}_r = \varepsilon_r' - j\varepsilon_r''$ where ε_r' is the real relative permittivity and ε_r'' is the
326 dielectric loss index, which represents dielectric losses.

327 [SOURCE: IEC 60050-121:2021, 121-12-14]

3.2.5**dielectric loss**

power absorbed from a time-varying electric field by a polarised substance, excluding absorbed power due to conductivity of the substance

Note 1 to entry: The dielectric loss is usually dissipated as heat.

Note 2 to entry: In 60050-121 dielectric loss is defined as power absorbed from a time-varying electric field by a polarized substance, excluding absorbed power due to the conductivity of the substance. In practice the loss due to the conduction current in the dielectric is usually included in the dielectric loss.

[SOURCE: IEC 60050-212:2010, 212-11-27]

3.2.6**dielectric dissipation factor**

$\tan \delta$

loss tangent

absolute value of the ratio of the imaginary to the real parts of the complex relative permittivity

$$\tan \delta = \frac{\varepsilon_r''}{\varepsilon_r'} \quad (4)$$

Note 1 to entry: The dielectric dissipation factor is equal to the tangent of the dielectric loss angle.

Note 2 to entry: In English the abbreviation DDF is sometimes used to characterize the dielectric loss in insulating materials.

[SOURCE: IEC 60050-212:2010, 212-11-29]

3.2.7**capacitance**

C

for a capacitive two-terminal element with terminals A and B, quotient of the electric charge at A by the voltage u_{AB} between the terminals

$$C = \frac{q}{u_{AB}} \quad (5)$$

where the sign of the electric charge is determined by taking the electric current in the time integral defining this charge as positive if its direction is from A to B and negative if its direction is from B to A

Note 1 to entry: A capacitance cannot be negative.

Note 2 to entry: The coherent SI unit of capacitance is farad, F

[SOURCE: IEC 60050-131:2013, 131-12-13]

3.3 Definitions related to tests on dielectric measuring systems**3.3.1****calibration**

set of operations that establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

Note 1 to entry: The determination of the scale factor is included in the calibration.

[SOURCE: IEC 60050-311:2001, 311-01-09, modified – Notes 1 and 2 replaced by Note 1.]

3.3.2**type test**

conformity test made on one or more items representative of the production

Note 1 to entry: For a dielectric measuring system, this is understood as a test performed on a component or on a complete dielectric measuring system of the same design to characterise it under operating conditions.

[SOURCE: IEC 60050-151:2001, 151-16-16, modified – Note 1 has been added]

3.3.3**routine test**

conformity test made on each individual item during or after manufacture

Note 1 to entry: This is understood as a test performed on each component or on each complete dielectric measuring system to characterise it under operating conditions.

[SOURCE: IEC 60050-151:2001, 151-16-17, modified – Note 1 has been added]

3.3.4**performance test**

test performed on a complete dielectric measuring system to characterise it under operating conditions

[SOURCE: IEC 60060-2:2010, term 3.7.4]

3.3.5**performance check**

simple procedure to ensure that the result of the most recent performance test is still valid

Note 1 to entry: The determination of the scale factor is included in the calibration.

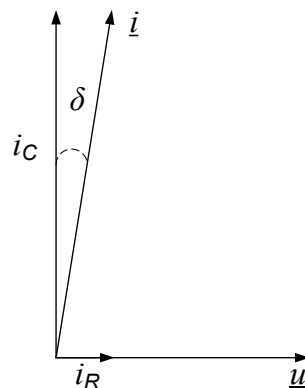
[SOURCE: IEC 60060-2:2010, term 3.7.5]

4 Measuring system of capacitance and dielectric loss**4.1 General theory of capacitance and dielectric loss measurement**

The dielectric dissipation factor is an important indicator reflecting the insulation status of high-voltage electrical apparatus, components, or systems.

As shown in Figure 1, the test voltage $\underline{u}$ is applied across the test object, and the total current $\underline{i}$ flowing through the test object can be decomposed into a current component i_C (orthogonal to the phase of the test voltage $\underline{u}$) and a current component i_R (in the same direction as the test voltage $\underline{u}$). Then, the dielectric dissipation factor (DDF) can be expressed as

$$\tan \delta = \frac{i_R}{i_C} \quad (6)$$

**Key**

u Test voltage

i Test current

i_R Active component of test current

i_C Reactive component of test current

Figure 1 – Phasor diagram for the test object showing the voltage and current vectors