INTERNATIONAL STANDARD

IEC 60270

Third edition
2000-12

High-voltage test techniques –
Partial discharge measurements

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE TEST TECHNIQUES –

PARTIAL DISCHARGE MEASUREMENTS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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International Standard IEC 60270 has been prepared by IEC technical committee 42: High-voltage test techniques.

This third edition cancels and replaces the second edition published in 1981 of which it constitutes a technical revision.

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

FDIS	Report on voting
42/162/FDIS	42/165/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 3.

Annex A forms an integral part of this standard.

Annexes B, C, D, E, F and G are for information only.

Terms used throughout this standard which have been defined in clause 3: **bold roman type**.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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- withdrawn;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

The contents of the corrigendum of October 2001 have been included in this copy.

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HIGH-VOLTAGE TEST TECHNIQUES –

PARTIAL DISCHARGE MEASUREMENTS

1 Scope

This International Standard is applicable to the measurement of **partial discharges** which occur in electrical apparatus, components or systems when tested with alternating voltages up to 400 Hz or with direct voltage.

This standard

– defines the terms used;

– defines the quantities to be measured;

– describes test and measuring circuits which may be used;

– defines analogue and digital measuring methods required for common applications;

– specifies methods for calibration and requirements of instruments used for calibration;

– gives guidance on test procedures;

– gives some assistance concerning the discrimination of **partial discharges** from external interference.

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The provisions of this standard should be used in the drafting of specifications relating to **partial discharge** measurements for specific power apparatus. It deals with electrical measurements of impulsive (short-duration) **partial discharges**, but reference is also made to non-electrical methods primarily used for **partial discharge** location (see annex F).

Diagnosis of the behaviour of specific power apparatus can be aided by digital processing of **partial discharge** data (see annex E) and also by non-electrical methods that are primarily used for **partial discharge** location (see annex F).

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This standard is primarily concerned with electrical measurements of **partial discharges** made during tests with alternating voltage, but specific problems which arise when tests are made with direct voltage are considered in clause 11.

The terminology, definitions, basic test circuits and procedures often also apply to tests with other frequencies, but special test procedures and measuring system characteristics, which are not considered in this standard, may be required.

Annex A provides normative requirements for performance tests on calibrators.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

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*

CISPR 16-1:1993, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

3 Definitions

For the purpose of this International Standard, the following definitions apply.

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3.1
partial discharge (PD)
localized electrical discharge that only partially bridges the insulation between conductors and which can or can not occur adjacent to a conductor

NOTE 1 **Partial discharges** are in general a consequence of local electrical stress concentrations in the insulation or on the surface of the insulation. Generally, such discharges appear as pulses having a duration of much less than 1 µs. More continuous forms can, however, occur, such as the so-called pulse-less discharges in gaseous dielectrics. This kind of discharge will normally not be detected by the measurement methods described in this standard.

NOTE 2 "Corona" is a form of **partial discharge** that occurs in gaseous media around conductors which are remote from solid or liquid insulation. "Corona" should not be used as a general term for all forms of PD.

NOTE 3 **Partial discharges** are often accompanied by emission of sound, light, heat, and chemical reactions. For further information, see annex F.

3.2
partial discharge pulse (PD pulse)
current or voltage pulse that results from a **partial discharge** occurring within the object under test. The pulse is measured using suitable detector circuits, which have been introduced into the test circuit for the purpose of the test

NOTE A **partial discharge** which occurs in the test object produces a current pulse. A detector in accordance with the provisions of this standard produces a current or a voltage signal at its output, proportional to the charge of the current pulse at its input.

3.3
quantities related to partial discharge pulses

3.3.1
apparent charge *q*
of a **PD pulse** is that charge which, if injected within a very short time between the terminals of the test object in a specified test circuit, would give the same reading on the measuring instrument as the **PD current pulse** itself. The **apparent charge** is usually expressed in picocoulombs (pC)

NOTE The **apparent charge** is not equal to the amount of charge locally involved at the site of the discharge, which cannot be measured directly.

3.3.2
pulse repetition rate *n*
ratio between the total number of **PD pulses** recorded in a selected time interval and the duration of this time interval

NOTE In practice, only pulses above a specified magnitude or within a specified range of magnitudes are considered.

3.3.3
pulse repetition frequency *N*
number of **partial discharge** pulses per second, in the case of equidistant pulses

NOTE **Pulse repetition frequency *N*** is associated with the situation in calibration.

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3.3.4
phase angle ϕ_i and time t_i of occurrence of a PD pulse
is

$$\phi_i = 360\ (t_i / T)$$

where t_i is the time measured between the preceding positive going transition of the test voltage through zero and the **partial discharge pulse** and T is the period of the test voltage

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The phase angle is expressed in degrees (°).

3.3.5
average discharge current *I*
derived quantity and the sum of the absolute values of individual **apparent charge** magnitudes q_i during a chosen reference time interval T_{ref} divided by this time interval:

$$I = \frac{1}{T_{ref}} \left(|q_1| + |q_2| + \ldots + |q_i| \right)$$

The **average discharge current** is generally expressed in coulombs per second (C/s) or in amperes (A).

3.3.6
discharge power *P*
derived quantity that is the average pulse power fed into the terminals of the test object due to **apparent charge** magnitudes q_i during a chosen reference time interval T_{ref}:

$$P = \frac{1}{T_{ref}} \left(q_1 u_1 + q_2 u_2 + ... + q_i u_i \right)$$

where u_1, u_2... u_i are instantaneous values of the test voltage at the instants of occurrence t_i of the individual **apparent charge** magnitudes q_i. The sign of the individual values must be observed

The **discharge power** is generally expressed in watts (W).

3.3.7
quadratic rate *D*
derived quantity that is the sum of the squares of the individual **apparent charge** magnitudes q_i during a chosen reference time interval T_{ref} divided by this time interval:

$$D = \frac{1}{T_{ref}} \left(q_1^2 + q_2^2 + ... + q_m^2 \right)$$

The **quadratic rate** is generally expressed in (coulombs)^2 per second (C^2/s).

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3.3.8
radio disturbance meter
quasi-peak measuring receiver for frequency band B in accordance with the provisions of CISPR 16-1:1993

NOTE This type of instrument was earlier called a radio interference (or influence) meter.

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3.3.9
radio disturbance voltage U_{RDV}
derived quantity that is the reading of a **radio disturbance meter** when used for indicating the **apparent charge** *q* of partial discharges. For further information, see 4.5.6 and annex D

The **radio disturbance voltage** U_{RDV} is generally expressed in µV.

3.4
largest repeatedly occurring PD magnitude
largest magnitude recorded by a measuring system which has the pulse train response as specified in 4.3.3

The concept of the **largest repeatedly occurring PD magnitude** is not applicable to tests with direct voltage.

3.5
specified partial discharge magnitude
largest magnitude of any quantity related to **PD pulses** permitted in a test object at a specified voltage following a specified conditioning and test procedure. For alternating voltage tests, the specified magnitude of the **apparent charge** *q* is the **largest repeatedly occurring PD magnitude**

NOTE The magnitude of any **PD pulse** quantity can vary stochastically in successive cycles and also show a general increase or decrease with time of voltage application. The **specified PD magnitude**, the test procedure and also the test circuit and instrumentation should therefore be appropriately defined by the relevant technical committees.

3.6
background noise
signals detected during PD tests, which do not originate in the test object

NOTE **Background noise** can be composed of either white noise in the measurement system, broadcast radio or other continuous or impulsive signals. For further information, see annex G.

3.7
applied test voltages related to partial discharge pulse quantities
as defined in IEC 60060-1. The following voltage levels are of particular interest

3.7.1
partial discharge inception voltage U_i
applied voltage at which repetitive **partial discharges** are first observed in the test object, when the voltage applied to the object is gradually increased from a lower value at which no **partial discharges** are observed

In practice, the inception voltage U_i is the lowest applied voltage at which the magnitude of a **PD pulse** quantity becomes equal to or exceeds a specified low value.

NOTE For tests with direct voltage, the determination of U_i needs special considerations. See clause 11.

3.7.2
partial discharge extinction voltage U_e
applied voltage at which repetitive **partial discharges** cease to occur in the test object, when the voltage applied to the object is gradually decreased from a higher value at which **PD pulse** quantities are observed

In practice, the extinction voltage U_e is the lowest applied voltage at which the magnitude of a chosen **PD pulse** quantity becomes equal to, or less than, a specified low value.

NOTE For tests with direct voltage, the determination of U_e needs special considerations. See clause 11.

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3.7.3
partial discharge test voltage
specified voltage, applied in a specified **partial discharge** test procedure, during which the test object should not exhibit PD exceeding a **specified partial discharge magnitude**

3.8
partial discharge measuring system
system consisting of a coupling device, a transmission system and a measuring instrument

3.9
measuring system characteristics
The following definitions refer to measuring systems as specified in 4.3

3.9.1
transfer impedance $Z(f)$
ratio of the output voltage amplitude to a constant input current amplitude, as a function of frequency f, when the input is sinusoidal

3.9.2
lower and upper limit frequencies f_1 and f_2
frequencies at which the **transfer impedance $Z(f)$** has fallen by 6 dB from the peak pass-band value

3.9.3
midband frequency f_m and bandwidth Δf
for all kinds of measuring systems, the **midband frequency** is defined by:

$$f_m = \frac{f_1 + f_2}{2}$$

and the **bandwidth** is defined by:

$$\Delta f = f_2 - f_1$$

3.9.4
superposition error
caused by the overlapping of transient output pulse responses when the time interval between input current pulses is less than the duration of a single output response pulse. **Superposition errors** can be additive or subtractive depending on the **pulse repetition rate** of the input pulses. In practical circuits, both types will occur due to the random nature of the **pulse repetition rate**. However, since measurements are based on the **largest repeatedly occurring PD magnitude**, usually only the additive **superposition errors** will be measured

NOTE **Superposition errors** can attain levels of 100 % or more depending on the **pulse repetition rate** and the characteristics of the measuring system.

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3.9.5
pulse resolution time T_r
shortest time interval between two consecutive input pulses of very short duration, of same shape, polarity and charge magnitude for which the peak value of the resulting response will change by not more than 10 % of that for a single pulse

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The **pulse resolution time** is in general inversely proportional to the **bandwidth** Δf of the measuring system. It is an indication of the measuring system's ability to resolve successive PD events.

NOTE It is recommended that the **pulse resolution time** be measured for the whole test circuit, as well as for the measuring system, as **superposition errors** can be caused by the test object, for example reflections from cable ends. The relevant technical committees should specify the procedure for handling **superposition errors** and particularly, the allowable tolerances including their signs.

3.9.6
integration error
error in **apparent charge** measurement which occurs when the upper frequency limit of the PD current pulse amplitude-spectrum is lower than

- the upper cut-off frequency of a wideband measuring system; or
- the mid-band frequency of a narrow-band measuring system.

See figure 5.

NOTE If required for a special type of apparatus, the relevant technical committees are urged to specify more restrictive values for f_1 and f_2 to minimize the **integration error**.