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colour inside

Electrical insulating materials and systems – Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses

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Electrical insulating materials and systems – Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses

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ELECTRICAL INSULATING MATERIALS AND SYSTEMS – ELECTRICAL MEASUREMENT OF PARTIAL DISCHARGES (PD) UNDER SHORT RISE TIME AND REPETITIVE VOLTAGE IMPULSES

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 61934, which is a technical specification, has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems.

This second edition cancels and replaces the first edition, published in 2006, and constitutes a technical revision.

The principal changes with regard to the previous edition concern the addition of

- an Introduction that provides some background information on the progress being made in the field of power electronics;
- impulse generators;
- PD detection methods;
- a new informative Annex C covering practical experience obtained from round-robin testing (RRT);
- example of noise levels, as shown in new informative Annex D.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
112/163/DTS	112/175/RVC

Full information on the voting for the approval of this technical specification 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.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Power electronics has developed along with both control theory and semiconductor technology. Switching is one of the essential features of power electronics control. For higher efficiency and smoother operation, switching times of the latest devices such as insulated-gate bipolar transistor (IGBT) tend to be shorter than microseconds. Such a short rise time may cause transient overvoltage impulses or surges in the systems. When the voltage impulses reach the breakdown strength of an air gap, partial discharge (PD) may occur. In addition, the impulses are repetitive from power electronics modulation such as pulse width modulation (PWM). Since PD may cause degradation of electrical insulation parts in the system, it is one of the most important parameters to be measured.

The first edition of IEC/TS 61934 was issued in April 2006. Because of rapid development in this field, the revision activity for the latest information was approved in TC112 at the Berlin meeting in September 2006. In addition to technical and editorial changes, practical experience obtained through round-robin test (RRT) is also presented in Annex C.

ELECTRICAL INSULATING MATERIALS AND SYSTEMS – ELECTRICAL MEASUREMENT OF PARTIAL DISCHARGES (PD) UNDER SHORT RISE TIME AND REPETITIVE VOLTAGE IMPULSES

1 Scope

IEC/TS 61934, which is a technical specification, is applicable to the off-line electrical measurement of partial discharges (PD) that occur in electrical insulation systems (EIS) when stressed by repetitive voltage impulses generated from electronic power devices.

Typical applications are EIS belonging to apparatus driven by power electronics, such as motors, inductive reactors and windmill generators.

NOTE 1 Use of this technical specification with specific products may require the application of additional procedures.

NOTE 2 The procedures described in this technical specification are emerging technologies. Experience and caution, as well as certain preconditions, are needed to apply it.

Excluded from the scope of this technical specification are

– methods based on optical or ultrasonic PD detection,
– fields of application for PD measurements when stressed by non-repetitive impulse voltages such as lightning impulse or switching impulses from switchgear.

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 60034 (all parts), *Rotating electrical machines*

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

3 Terms and definitions

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

3.1
repetitive voltage impulses
voltage impulses which are used as test voltage for the evaluation of switching surges from power electronic devices with a carrier or driven frequency

3.2
partial discharge
PD
electric discharge that only partially bridges the insulation between conductors

[IEC 60270:2000, 3.1, modified]

3.3
partial discharge pulse
current pulse in an object under test that results from a partial discharge occurring within the object under test

NOTE 1 The pulse is measured using suitable detector circuits, which have been introduced into the test circuit for the purpose of the test.

NOTE 2 A detector in accordance with the provisions of this technical specification produces a current or a voltage signal at its output related to the PD pulse at its input.

[IEC 60270:2000, 3.2, modified]

3.4
repetitive partial discharge inception voltage
RPDIV
minimum peak-to-peak impulse voltage at which more than five PD pulses occur on ten voltage impulses of the same polarity

NOTE This is a mean value for the specified test time and a test arrangement where the voltage applied to the test object is gradually increased from a value at which no partial discharges can be detected.

3.5
repetitive partial discharge extinction voltage
RPDEV
maximum peak-to-peak impulse voltage at which less than five PD pulses occur on ten voltage impulses of the same polarity

NOTE This is a mean value for a specified test time and a test arrangement where the voltage applied to the test object gradually decreases from a voltage at which PD have been detected.

3.6
impulse voltage polarity
polarity of the applied impulse voltage with respect to earth

[IEC 62068-1:2003, 3.10]

3.7
unipolar impulse
repetitive voltage impulse, the polarity of which is either positive or negative

[IEC 62068-1:2003, 3.8, modified]

NOTE The magnitude of the oscillation of the opposite polarity has to be less than 20 %.

3.8
bipolar impulse
repetitive voltage impulse, the polarity of which changes

[IEC 62068-1:2003, 3.9, modified]

3.9
impulse voltage repetition rate
inverse of the average time between successive impulses of the same polarity, whether unipolar or bipolar

[IEC 62068-1:2003, 3.11, modified]

3.10
impulse rise time
time for the voltage impulse to go from 0 % to 100 %

NOTE Unless otherwise stated, this is estimated as 1,25 times the time for the voltage to rise from 10 % to 90 %.

[IEC 62068-1:2003, 3.12, modified]

3.11
impulse decay time
time interval between the instants at which the instantaneous value of an impulse decreases from a specified upper value to a specified lower value

NOTE Unless otherwise specified, the upper and lower values are fixed at 90 % and 10 % of the impulse magnitude.

3.12
impulse width
interval of time between the first and last instants at which the instantaneous value of an impulse reaches a specified fraction of impulse magnitude or a specified threshold

3.13
impulse duty cycle
ratio, for a given time interval, of the impulse width to the total time

3.14
peak partial discharge magnitude
largest magnitude of any quantity related to PD pulses observed in a test object at a specified voltage following a specified conditioning and test

[IEC 60270:2000, 3.4 modified]

NOTE For impulse voltage tests, the peak magnitude of the PD pulse is the largest repeatedly occurring PD magnitude.

4 Measurement of partial discharge pulses during repetitive, short rise-time voltage impulses and comparison with power frequency

4.1 Measurement frequency

IEC 60270 describes the methods employed to measure the electrical pulses associated with PD in test objects excited by DC and alternating voltages up to 400 Hz. The methods used to measure PD pulses when the test object is subjected to supply voltage impulses have to be modified from the standard narrow-band and wide-band frequency methods described in IEC 60270.

To measure the PD during repetitive short rise time voltage impulses, it is necessary to avoid the induced current of the excited impulse voltage. One technique is current or electromagnetic wave measurement at ultra-high frequency, that is, higher than that of the impulse. Ultra-wide band (UWB) detection is often used with a high-pass filter for the suppression of relatively lower frequency components of impulse voltage. In principle, narrow-band measurement in the ultra-high frequency (UHF: 300 MHz to 3 GHz) region is also effective for the suppression of the impulse voltage. The other method is the integration of PD current at a very low frequency compared to that of the impulse voltage.

4.2 Measurement quantities

Measured quantities concern the RPDIV, the RPDEV, the peak partial discharge magnitude and partial discharge pulse repetition rate.

RPDIV and RPDEV may depend on PD measurement sensitivity and measurement circuit noise, so that normalization, as indicated in Clause 7, is needed. Moreover, they depend on the test object and the pulse deformation from the discharge to the measurement point.

In this technical specification, PD readings are reported in units of mV. In all cases, a sensitivity evaluation of the measuring system is necessary and shall be carried out according to Clause 7.

4.3 Test objects

4.3.1 General

Test objects behave predominantly as inductive, capacitive or distributed equivalent impedances according to the voltage supply frequency content. For some test objects, whether they are predominantly inductive, capacitive or distributed impedances may depend on the PD detection frequency range (not only on the voltage supply frequency). Test objects with distributed behaviour have transmission line characteristics which may cause attenuation and distortion of the PD pulses as the pulses propagate through the test object. The following classification is effective only for low-frequency, narrow-band measurements.

4.3.2 Inductive test objects

Types of inductive test objects may include:

– stator and rotor windings;
– inductive reactors;
– transformer windings;
– motorettes and formettes (see the IEC 60034 series).

4.3.3 Capacitive test objects

Types of capacitive test objects may include:

– twisted pairs of winding wire;
– capacitors;
– packaging of switching devices;
– power electronic modules and substrates;
– isolated heat sinks;
– mainwall insulation models in stator coils and bars;
– printed circuit boards;
– optocouplers.

4.3.4 Distributed impedance test objects

The following test objects may have distributed equivalent impedance properties:

– cables;
– busbars;
– stator and rotor windings;
– transformer windings;
– turn insulation of stator and rotor windings.
– bushings with capacitive voltage stress control;

4.4 Impulse generators

4.4.1 General

Impulse generators used in this technical specification shall generate short rise time and repetitive voltage impulses with a low noise level. For a short rise time of impulses,