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Rotating electrical machines –
Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines

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CONTENTS

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC/TS 60034-27-2, which is a technical specification, has been prepared by IEC technical committee 2: Rotating machinery.

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

Enquiry draft	Report on voting
2/1636/DTS	2/1649/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.

NOTE A table of cross-references of all IEC TC 2 publications can be found on the IEC TC 2 dashboard 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 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

For many years, the measurement of partial discharges (PD) has been employed as a sensitive means of assessing the quality of new insulation as well as a means of detecting localized sources of PD in used electrical winding insulation arising from operational stresses in service. Compared with other dielectric tests (i.e. the measurement of dissipation factor or insulation resistance) the differentiating character of partial discharge measurements allows localized weak points of the insulation system to be identified. Especially on-line PD measurements are not only sensitive to partial discharges but also to various arcing and sparking phenomena.

With regard to condition assessment of rotating machines, the measurement of partial discharges can provide information on:

– points of weakness in the insulation system;
– degradation processes;
– maintenance measures and intervals between overhauls.

Although the PD testing of rotating machines has gained widespread acceptance, it has emerged from several studies that not only are there many different methods of measurement in existence but also the criteria and methods of analysing and finally assessing the measured data are often very different and not really comparable. Consequently, there is a need to give some guidance to those users who are considering the use of PD measurements to assess the condition of their insulation systems.

Partial discharge testing of stator windings can be divided into two broad groups:

a) off-line measurements, in which the stator winding is isolated from the power system and a separate power supply is employed to energize the winding;
b) on-line measurements, in which the rotating machine is operating normally and connected to the power system.

Both of these approaches have advantages and disadvantages with respect to one another. A detailed discussion of PD off-line testing is provided in IEC/TS 60034-27, whereas this technical specification is confined to on-line techniques. The approach to deal with PD on- and off-line measurement techniques in two different technical specifications is considered necessary to render each specification sufficiently concise to be of use by non-specialists in the field of PD measurement.

PD on-line measurements are recorded with the rotating machine experiencing all of the operating stresses; thermal, electrical, environmental and mechanical. On-line PD testing has the following advantages:

– the voltage distribution across the winding is the same as during operation;
– the measurements are made at operating temperature;
– normal mechanical forces are present.

Due to the realistic stress impact on the winding during measurement and due to the fact that the measurement is performed during normal operation, on-line PD testing has become very popular. Since no service interruption is required, once the PD sensors are installed during a scheduled unit outage, and no external power source is needed, on-line testing is usually cost effective compared to off-line PD measurement. Condition changes of the stator winding insulation system can be identified and evaluated at an early stage based on a real-time condition assessment and thus condition-based and predictive maintenance strategies can be improved.

Empirical limits verified in practice can be used as a basis for evaluating test results. Furthermore, PD trend evaluation and comparisons with machines of similar design and similar insulation system measured under similar conditions, using the same measuring equipment, are recommended to ensure reliable assessment of the condition of the stator winding insulation.

This technical specification does not deal with online PD measurements on converter driven electrical machines because different measuring techniques are needed to distinguish between noise from the converter and PD from the winding. For this purpose IEC/TS 61934 may apply.

Limitations

On-line PD tests on stator windings produce comparative, rather than absolute measurements. This creates a fundamental limitation for the interpretation of PD data, and implies that simple limits for allowable PD cannot be established unless many precautions are taken. For the same reasons, PD acceptance criteria for new or rewound stator windings cannot be established unless many precautions are taken. The reasons for the difficulty to set absolute limits for PD include:

- There are many types of PD sensors as well as recording and analyzing instruments. Generally they are incompatible and will produce different results for the same PD activity.
- Even with the same measuring system, partial discharges will interact with the winding capacitance, inductance and/or surge impedance to produce different voltage and current pulses. Thus PD measurements from machines with different ratings and/or winding connections may produce different PD results, even though the actual amount of damage may be the same.
- Different types of defects can produce different PD magnitudes, even with the same amount of damage.
- PD may occur close or far from the PD sensor. In general if the PD is physically far from the PD sensor, it will produce a smaller response at the PD sensor due to attenuation.

Users should also be aware that there is no evidence that the time to failure of the stator winding insulation can be estimated using any PD quantity, even in combination with other electrical tests. Also, determining the root cause of an insulation deterioration process using pattern recognition, especially if more than one process is occurring, is still somewhat subjective, although the technology is evolving rapidly.

Noise and disturbance may have a great impact on the detected signals, especially for on-line PD measurements. Cross-coupling of PD and noise on one phase can obscure PD on another phase. With some measuring systems, this can make objective interpretation of the test results difficult.

Users of PD measurement should be aware that, due to the principles of the method, not all insulation-related problems in stator windings can be detected by measuring partial discharges, e.g. insulation failures involving continuous leakage currents due to conductive paths between different elements of the insulation or pulse-less discharge phenomena.

ROTATING ELECTRICAL MACHINES –

Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines

1 Scope

This part of IEC 60034, which is a technical specification, provides a common basis for

– measuring techniques and instruments;
– the arrangement of the installation;
– normalization and sensitivity assessment;
– measuring procedures;
– noise reduction;
– the documentation of results;
– the interpretation of results;

with respect to partial discharge on-line measurements on the stator winding insulation of non-converter driven rotating electrical machines with rated voltage of 3 kV and up. This technical specification covers PD measuring systems and methods detecting electrical PD signals. The same measuring devices and procedures can also be used to detect electrical sparking and arcing phenomena.

NOTE The main differences between on-line measurements and off-line measurements are due to a different voltage distribution along the winding and various thermal and mechanical effects related to the operation, like vibration, contact arcing or temperature gradients between stator copper and stator iron core. Furthermore, especially for hydrogen-cooled machines the gas and the gas pressure is different for off- and on-line PD measurements.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC/TS 60034-27, *Rotating electrical machines – Part 27: Off-line partial discharge measurements on the stator winding insulation of rotating electrical machines*