SLOVENSKI STANDARD
oSIST prEN IEC 60034-27-2:2022

01-julij-2022

Električni rotacijski stroji - 27-2 del: Spletne meritve delne izpraznitve na izolaciji statorskih navitij neaktivnih električnih rotacijskih strojev

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

Ta slovenski standard je istoveten z: **prEN IEC 60034-27-2:2022**

ICS:

29.160.01	Rotacijski stroji na splošno	Rotating machinery in general

oSIST prEN IEC 60034-27-2:2022 **en,fr,de**

2/2099/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 60034-27-2 ED1**	
DATE OF CIRCULATION: **2022-06-03**	CLOSING DATE FOR VOTING: **2022-08-26**
SUPERSEDES DOCUMENTS: **2/2070/CC, 2/2072/DTS**	

IEC TC 2 : ROTATING MACHINERY	
SECRETARIAT: United Kingdom	SECRETARY: Mr Charles Whitlock
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY

☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** 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. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

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

PROPOSED STABILITY DATE: 2025

NOTE FROM TC/SC OFFICERS:

This project was changed from TS into an IS, IEC 60034-27-2 ED1, as per documents 2/2086/Q and 2/2093/RQ.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- 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/IS 60034-27-2, which is an international standard, has been prepared by IEC technical committee 2: Rotating machinery.

The text of this international standard 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 international 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 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

Partial Discharge (PD) on-line measurement of rotating electrical machines has gained widespread acceptance as it could reveal the presence of localized weak points of the stator insulation system and also various arcing and sparking phenomena. Nevertheless, 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 have an International Standard (IS) to give defined guidelines to the users of on-line PD measurements to assess the condition of their insulation systems.

On-line PD measurements are recorded with the rotating electrical machine experiencing all of the operating stresses; thermal, electrical, environmental and mechanical. Due to the realistic stress impact on the winding during measurement and due to the fact that the measurement is performed during all kinds of normal operation like base load and peak load, PD on-line testing could identify changes of the winding insulation system at a premature stage and enables real-time condition assessment as part of predictive maintenance strategies.

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. The trending information provides a good measure for early indication of a change in insulation condition. This gives time for planning further standstill examination in terms of visual inspection and off-line testing during next inspection outage.

This IS does not deal with on-line 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.

Limitations

PD on-line tests on stator windings produce comparative, rather than absolute measurements. This creates a fundamental limitation for the interpretation of PD data. Therefore, acceptance criteria with simple limits for new or rewound stator windings cannot be established as the following reasons demonstrate:

- There are many types of PD sensors as well as recording and analysing instruments. Generally, they are incompatible and will produce different results for the same PD activity.
- Even with the same measuring system, the high frequency partial discharge pulses will interact with the winding capacitance and inductance on their way from point of origin to the measuring point, e.g. at the winding terminals. Thus, PD measurements taken at machines with different winding design and rating produce different PD results, even though the actual type of PD source is the same.
- Different types of winding defects produce different PD magnitudes and have different impact on insulation destruction. There is no strong correlation between high PD and high risk of insulation failure.
- PD activity may occur close or far from the PD sensor. In general, if the PD source is inside the winding coils far away from the PD sensor, it will produce a smaller response at the PD sensor at the terminals compared to a PD source at the phase connections nearby due to pulse 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, alone or even in combination. In order to more comprehensively describe the condition of the stator insulation, PD measurements are required to be supplemented by other electrical tests. Also, determining the root cause of an insulation deterioration process using PD pattern recognition, especially if more than one process is occurring, is still somewhat subjective, although the digital analysing technology is evolving rapidly.

Noise and disturbance from electrical environment have a great impact to on-line PD measurement. Cross-coupling of PD and noise between different phases can make objective interpretation of the test results difficult. Therefore, different analogue and digital noise suppression techniques are used to improve PD measuring sensitivity and PD analysing tools.

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 on-line PD activity, e.g. insulation failures involving continuous leakage currents due to conductive paths between different electrical potential of the insulation system or fine main insulation cracks with too small PD activity compared to normal delamination PD 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 60034-27 series deals with on-line PD measurements and provides a common basis with standardized procedures if possible 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 international standard 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.

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 60034-27-1, *Rotating electrical machines – Part 27-1: Off-line partial discharge measurements on the stator winding insulation*

IEC TS 62478, *High voltage test techniques-Measurement of partial discharges by electromagnetic and acoustic methods, 2016-08*

3 Terms and definitions

For the purposes of this document the general terms and definitions for partial discharge measurements given in IEC 60270 apply, together with the following.

3.1
Partial discharge
PD
localized electrical discharge that only partially bridges the insulation between conductors and which can or cannot occur adjacent to a conductor

3.2

on-line measurement

measurement taken with the rotating electrical machine in operation

3.3

off-line measurement

measurement taken with the rotating electrical machine at standstill, the machine being disconnected from the power system

Note 1 to entry: The necessary test voltage is applied to the winding from a separate voltage source.

3.4 conductive slot coating

conductive paint or tape layer in intimate contact with the groundwall insulation in the slot portion of the coil side, often called ‘semiconductive’ coating

Note 1 to entry: This coating together with adequate slot design provides electrical contact to the stator core, without shorting the core laminations.

3.5

stress control coating

paint or tape on the surface of the groundwall insulation that extends beyond the conductive slot portion coating in high-voltage stator bars and coils

Note 1 to entry: The stress control coating reduces the electric field stress along the winding overhang to below a critical value that would initiate PD on the surface. The stress control coating overlaps the conductive slot portion coating to provide electrical contact between them.

3.6

corona discharge

visible partial discharge adjacent to the surface of a bare conductor or the surface of an insulation of a conductor

3.7

slot discharges

discharges that occur between the outer surface of the slot portion of a coil or bar and the earthed core laminations due to high electrical field strength

3.8

vibration sparking

interrupted surface currents between the outer surface of the slot portion of a bar and the earthed core laminations due to axially induced voltages on the conductive slot coating combined with bar vibrations

3.9

internal discharges

discharges that occur within the mainwall insulation

3.10

surface discharges

discharges that occur on the surface of the insulation or on the surface of winding components in the winding overhang or the active part of the machine winding

3.11

pulse magnitude distribution

number of pulses within a series of equally-spaced windows of pulse magnitude during a predefined measuring time

3.12

pulse phase distribution

number of pulses within a series of equally-spaced windows of phase during a predefined measuring time

3.13

phase resolved partial discharge pattern (PRPD)

PD distribution map of PD magnitude and number of PD pulses vs. a.c. cycle phase position, for visualization of the PD behaviour during a predefined measuring time

3.14
PD sensor
general type of transducer, which can be used to detect PD signals from the machine winding

Note 1 to entry: A PD sensor typically consists of a high voltage coupling capacitor of low inductance design and a low voltage coupling device in series.

3.15
coupling device
usually an active or passive four-terminal network that converts the input currents to output voltage signals

Note 1 to entry: These signals are transmitted to the measuring device by a transmission system. The frequency response of the coupling device is normally chosen at least so as to efficiently prevent the test voltage frequency and its harmonics from reaching the measuring device.

3.16
resistance temperature detector
RTD
temperature detector inserted into the stator winding, usually between the top and bottom bar or between embedded coil sides in a given slot

3.17
PD magnitude Q
magnitude associated with a PD pulse recorded by a measuring system

Note 1 to entry: In this document, the symbol Q will be used as a placeholder for both definitions of charge, Q_m and Q_{IEC} as given in IEC 60034-27-1. This magnitude is usually derived from a stream of individual PD pulses.

4 Cause and effects of on-line PD

Generally, partial discharges (PD) can develop at locations where the dielectric properties of insulating materials are inhomogeneous. At such locations, the local electrical field strength may be enhanced. Due to local electrical over-stressing this may lead to a local, partial breakdown. This breakdown only partially bridges the insulation material. PD in general requires a gas volume or void volume to develop, e.g. cavities embedded in the insulation adjacent to conductors or at insulation interfaces.

A partial discharge can occur when the local field strength exceeds the dielectric strength of the material. This process may result in numerous PD pulses during one cycle of the applied voltage.

The amount of charge transferred in the discharge is closely related to the specific properties of the inhomogeneity such as the dimensions, the actual breakdown voltage and the specific dielectric properties of the materials involved, e.g. surface properties, kind of gas, gas pressure, etc.

Stator winding insulation systems for high voltage machines will normally have some PD activity but are inherently resistant to partial discharges due to their inorganic mica components. However, significant PD in these machines is usually more a symptom of insulation deficiencies, like manufacturing problems or in-service deterioration, rather than being a direct cause of failure. Nevertheless, depending on the individual processes, PD in machines may also directly attack the insulation and thus influence the ageing process. The time to failure or failure probability may not always correlate with PD levels, but depends significantly on other factors, for example operating temperature, wedging conditions, bar vibrations, degree of contamination, etc.

The measurement and the analysis of the specific PD behaviour can be efficiently used for quality control of new windings and winding components and for early detection of insulation deficiencies caused by thermal, electrical, ambient and mechanical ageing factors in service, which might result in an insulation fault.

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 may be different for off- and on-line PD measurements.

Further details on the nature of PD are given in Annex A.

5 Noise and disturbances

5.1 General

An important challenge with on-line PD measurement is separating stator-winding PD from electrical noise or disturbances as well as clustering the signal with respect to specific PD sources. In contrast to properly set-up off-line PD tests, in most on-line tests electrical disturbance pulses will often be present, and these disturbance pulses may be more frequent and of larger magnitude than the stator winding PD pulses, also the signals may be phase-locked to the AC power frequency voltage. If the disturbances are not adequately suppressed, or the test technician is not able to adequately identify what is a disturbance and what is PD from the stator, there is a great risk that the disturbance will be classified as stator PD. Consequently, the stator may be identified as having serious insulation problems, when in fact the insulation may be in good condition. If too many “false positive” indications occur, confidence is lost in the test, and future testing may not be routinely done, losing the benefit of on-line PD testing.

5.2 Noise and disturbance sources

Consistent with IEC 60034-27-1, noise is defined to be non-stator winding signals that clearly are not pulses. Noise may be due to electronic devices within the PD detection system itself, for example thermal noise from semiconductive devices. Noise can also be from radio stations, radio transmitters, mobile telephones, power line carrier signals, etc. This noise is easily separated from pulse-like signals either visually on an oscillographic display or with the use of filters. Thus, it is not considered further in this international standard.

Disturbances are electrical pulses of relatively short duration that may have many of the characteristics of stator winding PD pulses – but in fact are not stator winding PD. Disturbances can be differentiated into two groups: In lower frequency range they preferably spread as electrical signals via metal conductors and in the very high frequency range they mainly distribute wireless as electromagnetic waves. Some of these disturbances are synchronized to the AC cycle, and some are not. Sometimes synchronized disturbance pulses can be suppressed based on their position with respect to the AC phase angle.

Examples of synchronized disturbances are:

a) Partial discharges caused by e.g. electrostatic precipitators or bushing discharges

b) Power tool operation such as from arc welding and commutator sparking (may also be unsynchronized)

c) Transients caused by power electronics, for example converter fed motors or excitation systems. This disturbance may also be unsynchronized to the AC cycle

d) Poor electrical connections (leading to contact sparking) on the bus or cable connecting the rotating electrical machine to the power system

e) Poor electrical connections elsewhere in the plant that lead to contact sparking

f) PD in other apparatus connected to the motor or generator terminals, for example output bus, power cable, switchgear and/or transformers

g) Arcing or sparking sources within the motor or generator, such as stator core lamination sparking

Examples of non-synchronized disturbances are:

h) Power tool operation (arc welding and commutator sparking)

i) Transients caused by power electronics, for example converter fed motors or static excitation systems

j) Slip ring sparking on the machine rotor

k) Overhead crane power rail sparking