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colour inside

Rotating electrical machines –
Part 32: Measurement of stator end-winding vibration at form-wound windings

INTERNATIONAL
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COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 32: Measurement of stator end-winding vibration at form-wound windings

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- 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 TS 60034-32, 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
2/1810/DTS	2/1849/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 website 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- withdrawn,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.

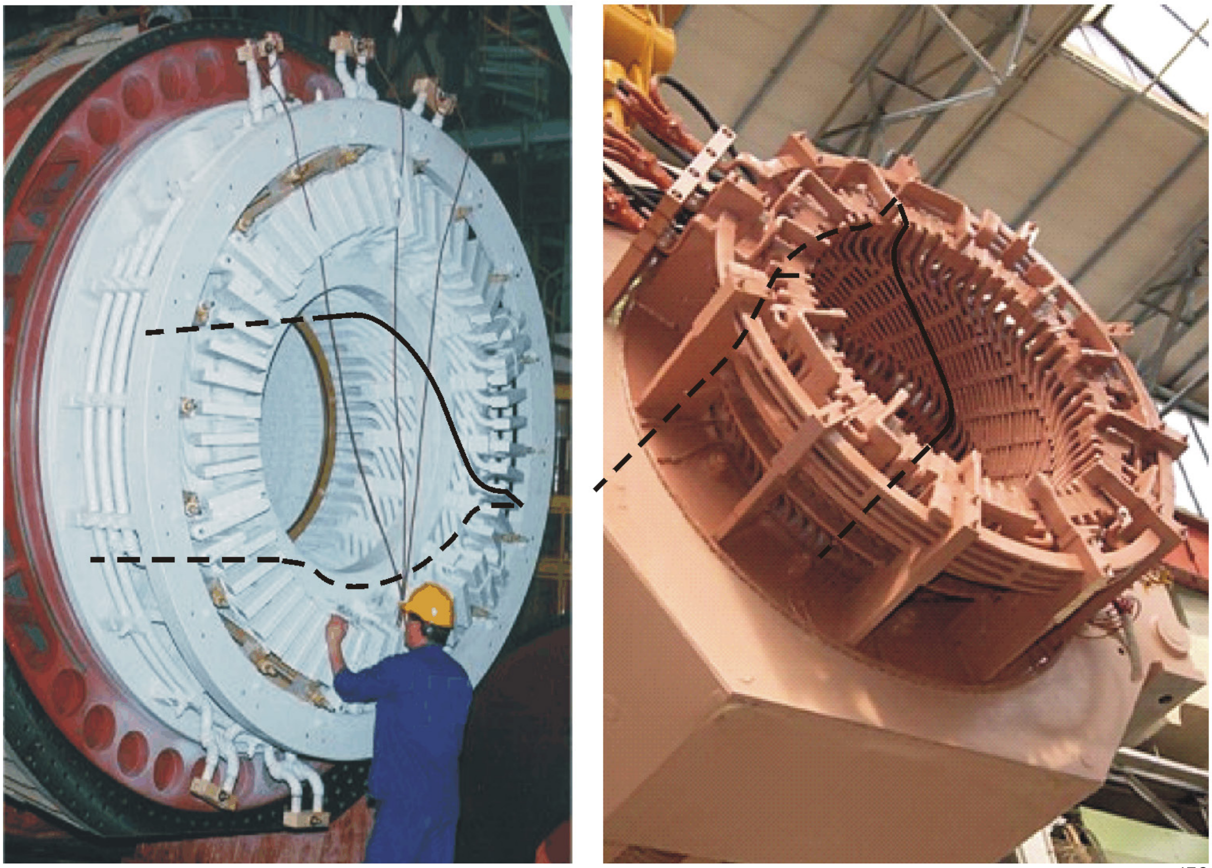
IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Large alternating current (AC) machines are equipped with multiphase stator windings. The information in this document is based on a dual-layer design. Such windings are connected to a multiphase voltage system (multiphase current system), which establishes a rotating magnetic field in the air gap between the rotor surface and stator bore. The voltage and current can vary during operation in order to adapt to varying mechanical load. Electrical machines are normally designed for motor or generator operating mode. The majority of AC machines are equipped with symmetrical three-phase windings, consisting of three, electrically isolated, spatially distributed winding parts that are intended for common operation.

Large AC rotating electrical machines are typically equipped with form-wound windings consisting of form wound coils (as defined in IEC 60034-15:2009, 2.3), single winding coils (single winding bars) which are given their shape before being assembled into the machine.

The winding overhang, or end-winding, is the portion of the stator winding that extends beyond the end of the magnetic core and is, in most cases, formed as a circular cone, see some examples in Figure 1 below.



NOTE Individual coil end marked with black line.

Figure 1 – Stator end-winding of a turbogenerator (left) and a large motor (right) at connection end with parallel rings

The majority of large AC machines with form-wound stator windings are equipped with a stator end-winding support structure. Among other functions it is expected to withstand the high electromagnetic force loading when the machine is exposed to an electrical fault in the electrical supply system. This includes a fault in the supply lines of an electrical grid or in an electronic supply device. In many cases the stator end-winding support structure is not only designed to increase the structural strength, but also provide appropriate structural stiffness and inertia to systematically influence structural dynamics and thus the vibration level during operation.

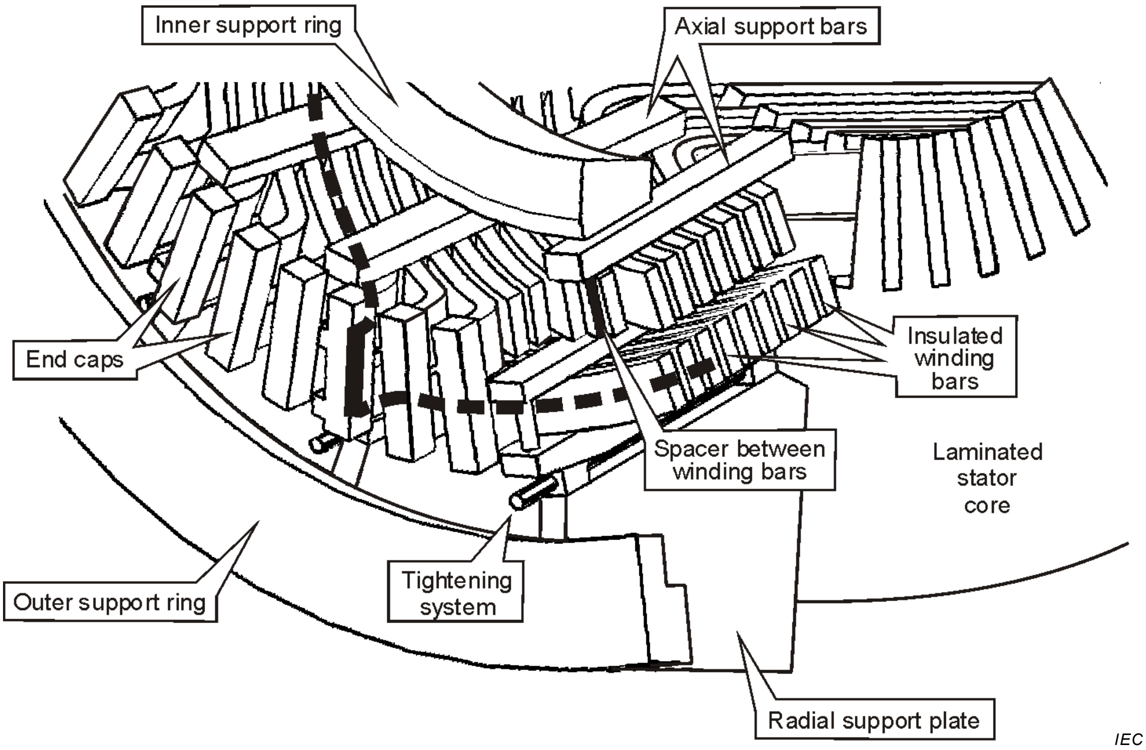


Figure 2 – Example for an end-winding structure of an indirect cooled machine

Typical support elements are plates and rings, which support the end-winding cone as a whole. Moreover, the distance between coils (or bars) of the end-winding are defined by spacing elements and their positions are fixed by fastening components. The typical materials used for support elements, spacers and fasteners are composites containing glass fibre materials as well as resin impregnated felts, cords and bandings (see Figure 2). Also, high electrical fields surrounding metal parts could produce electrical discharges compromising long term electrical strength.

Until now there existed no general Technical Specification to get reliable and comparable results for the identification of natural frequencies during stand-still and for vibration behaviour of stator end-windings during operation.

The experimental modal analysis of stator end-windings is a well-established tool which has also been used for the verification of natural frequencies and mode shapes of large electrical machines worldwide. The goal is to avoid operation of the machine with increased end-winding vibration levels under the influence of natural frequencies. Measurement of transfer functions and identification of structural dynamic properties (e.g. natural frequencies, mode shapes and other modal parameters) with an impact test is a common testing procedure. It is applied to new machines by the manufacturer and also used as a maintenance tool by the user or contractor during a major overhaul of large rotating machines.

Operational measurement of vibrational behaviour of stator end-windings can be performed by the installation of special vibration transducers at selected end-winding locations for periodic measurements or permanent on-line monitoring.

Although measurements of natural frequencies and vibration levels of stator end-windings are well established techniques, the interpretation of results is still a matter of further improvement and development. Therefore this first edition is a Technical Specification and not an International Standard.

ROTATING ELECTRICAL MACHINES –

Part 32: Measurement of stator end-winding vibration at form-wound windings

1 Scope

This part of IEC 60034 is intended to provide consistent guidelines for measuring and reporting end-winding vibration behaviour during operation and at standstill. It

– defines terms for measuring, analysis and evaluation of stator end-winding vibration and related structural dynamics,

– gives guidelines for measuring dynamic / structural characteristics offline and stator end-winding vibrations online,

– describes instrumentation and installation practices for end-winding vibration measurement equipment,

– establishes general principles for documentation of test results,

– describes the theoretical background of stator end-winding vibrations.

This part of IEC 60034 is applicable to:

– three-phase synchronous generators, having rated outputs of 150 MVA and above driven by steam turbines or combustion turbines;

– three-phase synchronous direct online (DOL) motors, having rated output of 30 MW and above.

This document is limited to the description of measurement procedures for 2-pole and 4-pole machines. For smaller ratings of machines than defined in this document, agreement can be made between the vendor and the purchaser for the selection of measurements in this document to be applied.

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 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-15, *Rotating electrical machines – Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines*

IEC 60079 (all parts), *Explosive atmospheres*

ISO 7626-5:1994, *Vibration and shock – Experimental determination of mechanical mobility – Part 5: Measurements using impact excitation with an exciter which is not attached to the structure*

ISO 18431-1, *Mechanical vibration and shock – Signal processing – Part 1: General introduction*

ISO 18431-2, *Mechanical vibration and shock – Signal processing – Part 2: Time domain windows for Fourier Transform analysis*