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BSI Standards Publication

Rotating electrical machines

Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/2, Rotating electrical machinery.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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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 60034-2-3, 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
2/1696/DTS	2/1719/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.

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.

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- withdrawn,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

The objective of this technical specification is to define test methods for determining the additional harmonic motor losses of converter-fed induction motors. These losses appear in addition to the losses on nominally sinusoidal power supply as determined by the methods of IEC 60034-2-1. Results determined according to this specification are intended to allow for comparison of the harmonic losses of different AC induction motors when fed by converters.

In power-drive systems (PDS), the motor and the frequency converter are often manufactured by different suppliers. While motors of the same design are produced in large quantities, they may be operated from the grid or from frequency converters of many different types, supplied by many different manufacturers. The individual converter properties (switching frequency, DC link voltage level, etc.) may influence the system efficiency as well. It is impractical to determine the additional harmonic motor losses for every combination of motor, frequency converter, connection cable, output filter and parameter settings. Accepting that it is extremely difficult to specify motor efficiency for converter operation, this specification describes a limited number of approaches, depending on the voltage level and the rating of the machine under test.

The procedures described in this specification result in a single number, the harmonic loss ratio r_{HL}, which is the ratio of the additional harmonic motor losses and the motor losses measured using a nominally sinusoidal voltage power supply.

The losses determined according to this specification are not intended to represent the losses in the final application. They provide, however, an objective basis for comparing different motor designs with respect to suitability for converter operation.

The methods in this technical specification apply to induction motors used with variable frequency drives. However, the application to other AC motors or DC motors and converters, is not excluded. The methods are mainly intended for motors fed by voltage source converters.

In general, when fed from a converter, the motor losses are higher than during operation on a nominally sinusoidal system. The additional harmonic losses depend on the spectrum of the impressed converter output quantity (either current or voltage) which is influenced by its circuitry and control method. For further information see IEC/TS 60034-25.

This technical specification is aimed at evaluating the additional harmonic motor losses resulting from non-sinusoidal power supply and consequently the efficiency of the converter-fed motor. It is not the purpose of this technical specification to define test procedures either for power drive systems or for frequency converters alone.

This technical specification is applicable to motors rated for 50 Hz or 60 Hz fundamental frequency. However, for other rated motor frequencies the test procedure may be applied provided a suitable power source is available, e.g. a 4-pole motor used at 3 000 rpm can be tested with 100 Hz and actual voltage rating.

Low-voltage motors

Experience has shown that the additional harmonic motor losses generally increase with load. The methods in this technical specification are based on supplies from converters with pulse width modulation (PWM) and constant pulse pattern. This is generally the case for voltage source converters except for over-modulation. Such voltage source converters have by far the largest market share in the low-voltage industrial drive market.

With respect to these types of converters and the growing need for verification of compliance with national energy efficiency regulations, this technical specification introduces a so-called test converter for testing low voltage motors.

In principle, the test converter is a voltage source with a clearly defined and reproducible harmonic content to supply the machine under test. The motor efficiency is to be determined at rated load for 50 Hz or 60 Hz. Defining 50 Hz or 60 Hz as test conditions has the advantage of providing a direct comparison of motor efficiency for grid and converter operation.

The above outlined test converter concept is a new approach to weigh the converter impact on an electrical machine without being forced having the final converter for testing. By releasing this technical specification, test facilities are invited to gain practical experience with this approach and to provide feedback for further refinement of the test procedure.

Limitations for low-voltage motors and high-voltage motors with multi-level converters

It has to be noted that the test method described herein is only a standardized method intended to give comparable efficiency figures for standardized test conditions. A motor ranking with respect to suitability for converter operation may be derived, but it is not possible to determine the actual motor losses for operation with a specific converter which would require a test of the whole power drive system (PDS).

Deviations are also expected for motors driven by multi-level voltage source or current source converters where the additional harmonic motor losses differ much more depending on speed and load than for two-level voltage source converters. Hence the determination of losses and efficiency should preferably use procedures where the motor is operated together with the same converter with which it is driven in service.

Another option is the determination of the additional harmonic motor losses by calculation. If this is requested by the customer, the converter manufacturer has to provide the pulse pattern for the motor manufacturer.

ROTATING ELECTRICAL MACHINES –

Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors

1 Scope

This technical specification specifies test methods for determining losses and efficiencies of converter-fed AC induction motors within the scope of IEC 60034-1. The AC induction motor is then part of a variable frequency power drive system (PDS) as defined in IEC 61800-2, IEC 61800-4 or IEC/TS 61800-8.

The additional harmonic losses determined by use of this technical specification are for comparison of different motor designs, but they are not appropriate to be used for efficiency determination of a PDS in a driven application with its wide range of torque versus speed operating points.

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

IEC 60034-2-1:2007, *Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60034-2-2, *Rotating electrical machines – Part 2-2: Specific methods for determining separate losses of large machines from test – Supplement to IEC 60034-2-1*

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC/TS 61800-8, *Adjustable speed electrical power drive systems – Part 8: Specification of voltage on the power interface*

3 Terms and definitions

For the purposes of this document the terms and definitions given in IEC 60034-1, IEC 60034-2-1 as well as the following apply.

3.1
motor losses with converter supply
when powered by a converter, motor losses are a combination of losses caused by fundamental frequency (usually 50 Hz or 60 Hz) and losses caused by the converter harmonics