SLOVENSKI STANDARD
oSIST prEN IEC 60034-2-3:2023

01-januar-2023

Električni rotacijski stroji - 2-3. del: Posebne preskusne metode za ugotavljanje izgub in izkoristka motorja na izmenični tok, napajanega prek pretvornikov

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

Drehende elektrische Maschinen – Teil 2-3: Besondere Verfahren zur Bestimmung der Verluste und des Wirkungsgrades von umrichtergespeisten Wechselstrommaschinen

Machines électriques tournantes - Partie 2-3: Méthodes d'essai spécifiques pour la détermination des pertes et du rendement des moteurs à courant alternatif alimentés par convertisseur

Ta slovenski standard je istoveten z: **prEN IEC 60034-2-3:2022**

ICS:

29.160.01	Rotacijski stroji na splošno	Rotating machinery in general

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COMMITTEE DRAFT FOR VOTE (CDV)

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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
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TITLE:

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

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NOTE FROM TC/SC OFFICERS:

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ROTATING ELECTRICAL MACHINES –

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

FOREWORD

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International Standard IEC 60034-2-3 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition of IEC 60034-2-3, published in 2020.

The text of this International Standard is based on the following documents:

FDIS	Report on voting

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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

The objective of this document is to define test methods for determining total losses including additional high frequency motor losses and efficiency of converter-fed motors. Additional high frequency 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 document are intended to allow comparison of losses and efficiency of different motors if fed by converters.

Furthermore, the document gives seven standardized operating points to characterize the development of losses and efficiency across the whole torque/speed range. An interpolation procedure is provided to calculate losses and efficiency at any operating point (torque, speed).

In power-drive systems (PDS), the motor and the frequency converter are often manufactured by different suppliers. 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.) will also influence the system efficiency. As it is impractical to determine motor losses for every combination of motor, frequency converter, connection cable, output filter and parameter settings, this document describes a limited number of approaches, depending on the voltage level and the rating of the motor under test.

The losses determined with the comparable converter as defined in this document 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.

In general, if fed from a converter, motor losses are higher than during operation on a nominally sinusoidal system, even though the converter normally enables vast energy savings overall on system level, if the motor and the load application can be operated with variable speed. The additional high frequency losses depend on the harmonic 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.

It is not the purpose of this document to define test procedures either for power drive systems or for frequency converters alone.

Comparable converter

Latest experience and theoretical analysis have shown that the additional high frequency motor losses generally do not increase much with load. The methods in this document are mainly based on supplies from converters with pulse width modulation (PWM).

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

In principle, the comparable converter is a voltage source with a typical high frequency harmonic content supplying the motor under test. It is not applicable to medium voltage motors.

Limitations for the application of the comparable converter

It must be noted that the test method with the comparable converter described herein is 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 equivalent to determining of the actual motor losses for operation with a specific converter which requires a test of the whole power drive system (PDS) with the specific converter used in the final application.

Deviations are also expected for motors driven by multi-level voltage source or current source converters where the additional high frequency 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 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 high frequency motor losses by calculation. If this is requested, then the pulse pattern of the converter is required. Such procedures are not part of this standard.

The interpolation of losses and efficiency at any operating point (torque, speed) is applicable to the constant flux range and the field weakening and overload range.

ROTATING ELECTRICAL MACHINES –

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

1 Scope

This part of IEC 60034 specifies test methods and an interpolation procedure for determining losses and efficiencies of converter-fed motors. The motor is then part of a variable frequency power drive system (PDS) as defined in IEC 61800-9-2.

Applying the approach of the comparable converter, the motor efficiency determined by use of this document is applicable for comparison of different low voltage motor designs only. The comparable converter approach is not applicable to medium voltage motors.

The document also specifies procedures to determine motor losses at any load point (torque, speed) within the constant flux range (constant torque range, base speed range), the field weakening range and the overload range based on determination of losses at seven standardized load points. This procedure is applicable to any variable speed AC motor (induction and synchronous) rated according to IEC 60034-1 for operation on a variable frequency and variable voltage power supply.

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

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

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

IEC 61800-9-2, *Adjustable speed electrical power drive systems – Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters*

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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
additional high frequency losses
additional high frequency losses are produced in the motor by the non-sinusoidal voltage and current waveforms generated by the converter and are in addition to the losses of iron, friction and windage, rotor winding, stator winding and additional load loss (fundamental losses)

3.2
constant flux range
speed range from standstill up to the highest speed where the motor can be supplied with a voltage that changes in proportion to the speed so that the magnetic flux remains constant (constant ratio U/f) for induction motors and according to the MTPA (maximum torque per ampere) for synchronous motors. Within the constant flux range, the maximum motor torque is constant (constant torque range), if constant flux control is used.

3.3
fundamental losses
fundamental losses in the motor can be segregated into five different components: iron losses (varying with motor frequency and applied fundamental voltage), friction and windage losses (varying with motor speed), rotor winding losses, stator winding losses and additional load losses (all three varying with motor current). Fundamental losses are the losses of a motor running with application of rated voltage at fundamental frequency that does not contain any higher frequencies.

3.4
motor losses with converter supply
if powered by a converter, motor losses are a combination of losses caused by fundamental frequency and losses caused by the converter high frequencies

3.5
multi-level voltage source converter
a frequency converter topology, where the output voltage (phase-to-ground) is switched in three or more steps or levels up to the maximum possible output value of voltage in both plus and minus

3.6 switching event
an operation sequence of one semiconductor with switching once on and switching once off

3.7
switching frequency
number of switching events of one semiconductor within one second. It determines, together with the selected pulse pattern and the converter topology, the lowest frequency of non-controllable high frequencies or inter-harmonics at the IPC (in-plant point of coupling) or the motor

3.8
thermal equilibrium
steady state temperature level of a motor which is reached, if the rate of change of temperature is 1 K or less per half hour

3.9
two-level voltage source converter
a frequency converter topology, where the output voltage (phase-to-ground) is switched in one step or level up to the maximum possible output voltage

Note For a two-level converter, the pulse frequency measured phase to phase is two times the switching frequency defined in 3.5 in case of continuous modulation and about 1,33 times the switching frequency defined in 3.5 in case of discontinuous modulation.

4 Symbols and abbreviated terms

c_{BH}	Loss separation coefficient for friction and windage losses and hysteresis losses
c_{Con}	Winding connection coefficient
c_{fe}	Loss separation coefficient for hysteresis losses and eddy current losses
c_{LL}	Loss separation coefficient for additional load losses
c_{Volt}	Voltage coefficient
c_{WHf}	Loss separation coefficient for winding losses and high frequency losses
f	Frequency, Hz
f_{Mot}	Fundamental motor frequency, Hz
f_N	Rated motor frequency, Hz
f_{sw}	Switching frequency, Hz
I_0	No-load current, A
I_N	Rated current, A
MTPA	Maximum torque per ampere control applied to synchronous motors
n	Speed, s^{-1}
n_N	Rated speed, s^{-1}
n_{ref}	Reference speed, s^{-1}
n_{FW}	Relative speed at which field weakening range starts,
P	Power, W
P_{Ccon}	Constant losses if supplied by a converter, W
P_{Csin}	Constant losses at sinusoidal supply according to IEC 60034-2-1, W
PDS	Power drive system
P_{LHL}	Additional high frequency loss due to converter supply, W
P_N	Rated power, W
P_{ref}	Reference power, W
P_{1C}	Motor input power if supplied by a converter, W
$P_{1\_60034\text{-}2\text{-}1}$	Motor input power at sinusoidal supply according to IEC 60034-2-1, W
P_{2C}	Motor output power if supplied by a converter, W
$P_{2\_60034\text{-}2\text{-}1}$	Motor output power at sinusoidal supply according to IEC 60034-2-1, W
PWM	Pulse width modulation
T	Motor torque, Nm
T_C	Motor torque if supplied by a converter, Nm