

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electric traction – Rotating electrical machines for rail and road vehicles –
Part 2: Electronic converter-fed alternating current motors
(standards.iteh.ai)

Traction électrique – Machines électriques tournantes des véhicules ferroviaires
et routiers –
Partie 2: Moteurs à courant alternatif alimentés par convertisseurs électroniques



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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Tél.: +41 22 919 02 11
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRIC TRACTION –
ROTATING ELECTRICAL MACHINES
FOR RAIL AND ROAD VEHICLES –**

Part 2: Electronic converter-fed alternating current motors

FOREWORD

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International Standard IEC 60349-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This third edition cancels and replaces the second edition published in 2002. It constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

- As the limits of vibration velocities have been changed in IEC 60034-14, the limits valid for traction motors are now directly stated in this standard.
- In addition to the existing method for measuring and calculating the sound power level, the methods described in ISO 3741, ISO 3743, ISO 3744, ISO 3745, ISO 9614 are also allowed. However the maximum sound power levels and the correction for pure tones remain unchanged in Clauses C.7 and C.8.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/1416/FDIS	9/1466/RVD

Full information on the voting for the approval of this 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.

The list of all parts of IEC 60349 series, published under the general title, *Electric traction – Rotating electrical machines for rail and road vehicles*, can be found 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

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- withdrawn,
- replaced by a revised edition, or
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ELECTRIC TRACTION – ROTATING ELECTRICAL MACHINES FOR RAIL AND ROAD VEHICLES –

Part 2: Electronic converter-fed alternating current motors

1 Scope and object

This part of IEC 60349 applies to converter-fed alternating current motors forming part of the equipment of electrically propelled rail and road vehicles.

The object of this part is to enable the performance of a motor to be confirmed by tests and to provide a basis for assessment of its suitability for a specified duty and for comparison with other motors.

Where further testing is to be undertaken in accordance with IEC 61377-1 and IEC 61377-3, it may be preferable, to avoid duplication, that some type and investigation tests be carried out on the combined test bed.

Particular attention is drawn to the need for collaboration between the designers of the motor and its associated converter as detailed in 5.1.

NOTE 1 This part also applies to motors installed on trailers hauled by powered vehicles.

NOTE 2 The basic requirements of this part may be applied to motors for special purpose vehicles such as mine locomotives but this part does not cover flameproof or other special features that may be required.

NOTE 3 It is not intended that this part should apply to motors on small road vehicles, such as battery-fed delivery vehicles, factory trucks, etc. This part also does not apply to minor machines such as windscreen wiper motors, etc. that may be used on all types of vehicles.

NOTE 4 Industrial type motors complying with IEC 60034 may be suitable for some auxiliary drives, providing that it is demonstrated that operation on a converter supply will meet the requirements of the particular application.

The rating of traction motors fed in parallel by a common converter has to take into account the effect on load-sharing of differences of wheel diameter and of motor characteristics as well as weight transfer when operating at high coefficients of adhesion. The user is to be informed of the maximum permissible difference in wheel diameter for the particular application.

The electrical input to motors covered by this part comes from an electronic converter.

NOTE 5 At the time of drafting, only the following combinations of motors and converters had been used for traction applications, but it may also apply to other combinations which may be used in the future:

- asynchronous motors fed by voltage source converters;
- asynchronous motors fed by current source converters;
- synchronous motors fed by current source converters.

The motors covered by this part are classified as follows:

- a) Traction motors – Motors for propelling rail or road vehicles.
- b) Auxiliary motors not covered by IEC 60034 – Motors for driving compressors, fans, auxiliary generators or other auxiliary machines.

2 Normative references

The following referenced documents are indispensable for the application 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 60034-8, *Rotating electrical machines – Part 8: Terminal markings and direction of rotation*

IEC 60034-9, *Rotating electrical machines – Part 9 – Noise limits*

IEC 60034-17, *Rotating electrical machines – Part 17: Cage induction motors when fed from convertors – Application guide*

IEC 60050-131, *International Electrotechnical Vocabulary – Part 131: Circuit theory*

IEC 60050-151, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*

IEC 60050-411, *International Electrotechnical Vocabulary – Part 411: Rotating machinery*

IEC 60050-811, *International Electrotechnical Vocabulary – Part 811: Electric traction*

IEC 60085, *Thermal evaluation and designation*

IEC 61672, *Electroacoustics – Sound level meters*

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IEC 62498-1, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-131, IEC 60050-151, IEC 60050-411 and IEC 60050-811, as well as the following, apply.

3.1

rating of a motor

combination of simultaneous values of electrical and mechanical quantities, with their duration and sequence, assigned to the motor by the manufacturer

3.2

rated value

numerical value of any quantity included in a rating

3.3

continuous rating

mechanical output that the motor can deliver on the test bed for an unlimited time under the conditions specified in 8.1 without exceeding the limits of temperature rise given in Table 2, all other appropriate requirements in this part also being satisfied

NOTE Several continuous ratings may be specified.

3.4**short-time rating (for example, one hour)**

mechanical output that the motor can deliver on the test bed for the stated time without exceeding the limits of temperature rise given in Table 2, the test being carried out as specified in 8.1 starting with the motor cold, all other appropriate requirements in this part being also satisfied

3.5**short-time overload rating**

mechanical output that the motor can deliver on the test bed for the stated time without exceeding the limits of temperature rise given in Table 3, the test being started and carried out as specified in 8.1.6

NOTE Short-time overload ratings are of value in determining the suitability of motors for duties which involve relatively long periods of operation below the continuous rating followed by a period above it. These are most likely to occur in locomotive applications. They are not relevant to the repeated short load cycles of rapid transit and similar duties, and should not be specified for such applications.

3.6**intermittent duty rating**

duty cycle in which the motor may be operated without the temperature rises exceeding the limits given in Table 2 at any point

3.7**equivalent rating**

continuous rating with constant values of voltage, current and speed that, as far as temperature rise is concerned, is equivalent to the intermittent duty cycle which the motor has to withstand in service

NOTE This rating should be agreed between user and manufacturer.

3.8**guaranteed rating**

rating assigned by the manufacturer for test purposes

3.9**guaranteed rating of a traction motor**

normally the continuous rating but in special cases the user and manufacturer may agree that it be a short-time or intermittent rating

3.10**guaranteed rating of an auxiliary motor**

continuous rating unless otherwise specified

3.11**rated voltage**

root-mean-square value of the fundamental component of the line-to-line voltage applied to a motor when it is operating at a guaranteed rating.

NOTE For motors fed directly or indirectly from a contact system, it is normally the highest voltage (excluding transients) which can be applied to the motor when it is drawing the rated current, with the contact system at its nominal voltage as defined in Annex D.

3.12**rated speed**

speed at a guaranteed rating

3.13**maximum voltage**

highest root-mean-square value of the fundamental component of the line-to-line supply voltage which can be applied to the motor in service

3.14**repetitive peak voltage**

peak value of the waveform of the converter output voltage, any random transient peaks arising from line voltage transients or other causes being disregarded

3.15**maximum current**

maximum current shown on the specified characteristic as defined in 5.3

3.16**maximum working speed****3.16.1****maximum working speed of a traction motor**

highest rotational speed assigned to the motor by the manufacturer

NOTE When the characteristics of the vehicle for which a motor is intended are specified, this speed is not less than that corresponding to the maximum service speed of the vehicle assuming fully worn metallic wheels or the minimum rolling diameter of rubber tyres.

3.16.2**maximum working speed of an auxiliary motor**

highest rotational speed assigned to the motor by the manufacturer

NOTE For specific applications, when assigning this speed, the most unfavourable conditions of voltage, frequency, loading, etc., that can occur in service should be taken in account.

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4 Environmental conditions

Unless otherwise specified by the user, the following environmental conditions are assumed:

a) Altitude

Height above sea level not exceeding Class A3 according IEC 62498-1.

b) Temperature

Air temperature in the shade Class T1 according IEC 62498-1.

Whenever motors are intended to operate where one or both of these limits will be exceeded, special requirements may be agreed between user and manufacturer. For more information refer to IEC 60034-1.

Furthermore, the user shall inform the manufacturer of any particularly severe environmental condition such as dust, humidity, temperature, snow, dynamic effects, etc., to which the motors will be subjected.

5 Characteristics**5.1 Exchange of information**

The motor and converter designers shall collaborate to produce all the technical information necessary to ensure that the combined unit will meet the requirements of this part of IEC 60349.

To fulfil this requirement, the motor designer shall provide the converter designer with all the information necessary to fully evaluate the interaction between the motor and the converter.

The converter designer shall also provide the motor designer with the characteristics showing, for example, the converter line-to-line output voltage (including the repetitive voltage peaks), current, fundamental frequency, harmonics and power over the whole range of the application, including operation at the maximum and minimum values of the contact-system voltage.

The documents recording this exchange of information shall form an integral part of the specification of the motor and of the converter.

NOTE 1 For more information refer to IEC 61287-1, 5.3.1.1.

NOTE 2 The length of cable run between motor and converter and the effect on peak voltages seen at the motor terminals should be considered.

NOTE 3 For information about wave fronts and the impact to the motor see IEC 60034-17.

5.2 Reference temperature

All characteristics, irrespective of the thermal class of the insulation system used on the motor to which they apply, shall be drawn for a winding reference temperature of 150 °C which shall be stated in the characteristics.

5.3 Specified characteristics

Motor specifications shall, as a general rule, include characteristic curves in accordance with the relevant clauses of this part. These curves, defined as the "specified characteristics", shall be plotted to the designed operating limits of each variable. Unless otherwise agreed between user and manufacturer, the characteristics shall show the machine performance at the nominal voltage of the supply system as defined in Annex D, and shall be submitted to the user before the order for the motor is placed.

5.4 Declared characteristics

Declared characteristics are derived from the results of type tests carried out in accordance with 8.2.1 and shall meet the requirements of 8.2.2.

Unless previously agreed, the declared characteristics of motors electromagnetically identical with any previously manufactured for the same user or application shall be those of the existing motors. In such a case, compliance with the characteristics shall be demonstrated by routine tests only.

5.5 Efficiency characteristics

Efficiency characteristics shall take into account losses arising from the harmonics in the supply from the converter. Power used for excitation of synchronous motors shall also be included in the losses unless otherwise accounted for, (e.g. as an auxiliary load), in which case the omission shall be stated in the characteristics.

5.6 Traction motor characteristics

The specified and declared characteristics of a traction motor shall be the converter-fed variable frequency characteristics, which shall show motor line-to-line voltage, current, frequency, mean torque and efficiency as a function of speed over the whole range of application of the motor. Characteristics of asynchronous motors shall show slip and those of synchronous motors shall show the excitation current. Voltage curves shall show the root-mean-square value of the fundamental component. Current curves shall show the root-mean-square value of the fundamental component and the total root-mean-square value. For motors used in the braking mode, similar characteristics shall be produced showing the torque input and the electrical output as a function of motor speed.

NOTE 1 Subclause 5.1 refers to the need for the exchange of information between the designers of the motor and of the converter.

As an alternative to motor torque and speed, the characteristics may show tractive effort at the rail and vehicle speed, in which case the gear ratio, wheel diameter and transmission losses shall be stated. If conventional values are used for the latter, they shall be in accordance with Figure B.1.

NOTE 2 Clause 1 refers to the need to consider the effect on parallel-fed motors of differing wheel diameters and of weight transfer between axles.

5.7 Auxiliary motor characteristics

The specified and declared characteristics of auxiliary motors shall be the converter-fed characteristics, which shall show the motor line-to-line voltage, current, speed and mean torque as a function of motor output for each operating frequency over the whole range of application of the motor. The characteristics of motors which operate at continuously variable frequency shall be plotted for the maximum and minimum frequencies only.

Characteristics of asynchronous motors shall show slip and those of synchronous motors shall show the excitation current. Voltage curves shall show the root-mean-square value of the fundamental component. Current curves shall show the root-mean-square value of the fundamental component and the total root-mean-square value. The characteristics shall take account of the additional losses arising from the supply harmonics and the efficiency at the guaranteed rating shall be stated.

Alternatively, the characteristics may be plotted as a function of speed.

NOTE Subclause 5.1 refers to the need for the exchange of information between the designers of the motor and of the converter.

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6 Marking

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6.1 Nameplate

All motors covered by this part of IEC 60349 shall carry a nameplate including at least the following information:

- a) Manufacturer's name.
- b) Motor type designation.
- c) Motor serial number.
- d) Year of manufacture.

Furthermore, a serial number shall be punched on both the stator and rotor of every motor, and motors designed for unidirectional rotation shall carry an arrow indicating the direction of rotation.

NOTE The motor serial number and rotation arrow should be easily readable when the motor is installed in the vehicle.

6.2 Terminal and lead marking

Terminal and lead markings shall be in accordance with IEC 60034-8 unless otherwise agreed.

7 Test categories

7.1 Test categories

7.1.1 General

There are three categories of tests:

- type tests;
- routine tests;
- investigation tests.

NOTE See Clause 1 on duplication of tests.

7.1.2 Type tests

7.1.2.1 General

Type tests are intended to prove the ratings, characteristics and performance of new types of motor. They shall be carried out on one motor of every new design. Unless otherwise agreed, the motor shall be one of the first ten manufactured. Where there is a change in place and/or method of manufacture, refer to 7.1.2.4.

Before testing commences, the manufacturer shall provide the user with a test specification outlining the tests to be undertaken to demonstrate compliance with this standard. Following completion of the type tests, the manufacturer shall supply the user with a full test report.

7.1.2.2 Type tests on converter supply

If each motor is fed by its own converter, the type test shall preferably be carried out using the converter to be employed in service, but, as an alternative, a supply which closely resembles the supply from the vehicle converter in waveform and harmonics may be employed.

If several motors are fed in parallel from a single converter, the type test shall be carried out on a single motor using a supply closely resembling the supply from the vehicle converter in waveform and harmonics.

If requested by the user, the manufacturer shall demonstrate the similarity of the test and service supplies, and shall state the likely effect on the performance of the motor of any difference between them.

Unless otherwise agreed, the type test shall be repeated if the electrical output characteristics of the converter are changed.

7.1.2.3 Type tests on sinusoidal supply

This test is to provide a reference for the characteristics of a machine.

The test shall include a temperature rise test at a rating agreed between the manufacturer and the system responsible.

Voltage, frequency, torque, ventilation and test duration can be at the manufacturers discretion, but the duration of the test must be at least 1 h and at values that do not over-stress the machine above those normally seen in service.

The test parameters shall be maintained for any subsequent test on that design of machine.

The temperature rise measurements shall be carried out as detailed in 8.1.

7.1.2.4 Repeat type test

Subject to agreement, and to the results of both the type test on sinusoidal supply (see 7.1.2.3), and the routine test being within the tolerances established on the previous motors, a full type test is not required if the manufacturer produces a full type test report, for a motor of the same electromagnetic design at the same or higher rating. This also applies to repeat orders, and where there is a change of place and/or method of manufacture.

7.1.3 Routine tests

Routine tests are intended to demonstrate that a motor has been assembled correctly, is able to withstand the appropriate dielectric tests, and is in sound working order both mechanically and electrically.

The routine tests specified in Clause 9 shall normally be carried out on all motors but, before placing an order, the user and manufacturer may agree to adopt an alternative test procedure (e.g. in the case of motors produced in large quantities under a strict quality assurance procedure). This may permit reduced routine testing of all motors or may require the full tests on a proportion of motors chosen at random from those produced on the order. Any such agreement shall require the dielectric tests specified in 9.5 to be carried out on all motors.

7.1.4 Investigation tests

Investigation tests are optional special tests performed to obtain additional information. They shall be carried out only if agreement between user and manufacturer has been reached before placing the order for manufacture of the motors. The results of these tests shall not influence acceptance of a motor unless similarly agreed.

7.2 Summary of tests

Table 1 lists the tests required for compliance with this part of IEC 60349.

Table 1 – Summary of tests
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Type of motor	Test category	Subclause						
		Temperature rise	Short-time thermal test/heat run	Characteristics	Over-speed	Dielectric	Vibration	Noise
Asynchronous	Type	8.1	7.1.2.2	8.2	8.3	–	8.4	Annex C ^a
	Routine	–	9.1 ^a	9.3.1	9.4 ^a	9.5	9.6 ^a	–
Synchronous	Type	8.1	–	8.2	8.3	–	8.4	Annex C ^a
	Routine	–	9.2/9.1 ^a	9.3.2	9.4	9.5	9.6 ^a	–

All motors, including those type tested, shall be routine tested.

^a Optional tests, subject to agreement between user and manufacturer.

8 Type tests

8.1 Temperature-rise tests

8.1.1 General

The tests shall be carried out at the guaranteed ratings of the motor.

The rated mechanical output may be measured directly or indirectly at the motor shaft, or be obtained without measurement by supplying the motor at the voltage, current and frequency shown on the declared characteristics as producing the rated mechanical output.

In the case of continuous rating tests, the time to reach a steady temperature may be shortened by commencing the test at an increased load or reduced ventilation provided that the rated conditions are subsequently maintained for at least 2 h or until it is demonstrated by appropriate means that steady temperatures have been reached.

NOTE Steady temperature is defined as a change in temperature of less than 2 K during the final hour of the test.