IEC 60349-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electric traction – Rotating electrical machines for rail and road vehicles – Part 1: Machines other than electronic converter-fed alternating current motors

Traction électrique – Machines électriques tournantes des véhicules ferroviaires et routiers – Partie 1: Machines autres que les moteurs à courant alternatif alimentés par convertisseur électronique

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 1: Machines other than electronic converter-fed alternating current motors

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International Standard IEC 60349-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition, published in 1999, and its amendment 1 (2002) of which 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 and 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
9/1415/FDIS	9/1465/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

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- withdrawn,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

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

Part 1: Machines other than electronic converter-fed alternating current motors

1 Scope and object

This part of IEC 60349 is applicable to rotating electrical machines, other than electronic converter-fed alternating current motors, forming part of the equipment of electrically propelled rail and road vehicles. The vehicles may obtain power either from an external supply or from an internal source.

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

Where further testing is to be undertaken in accordance with IEC 61377-2, it may be preferable, to avoid duplication, that some type and investigation tests be carried out on the combined test bed.

NOTE 1 This standard also applies to machines installed on trailers hauled by electrically propelled vehicles.

NOTE 2 The basic requirements of this standard may be applied to rotating electrical machines for special purpose vehicles such as mine locomotives, but it does not cover flameproof or other special features that may be required.

NOTE 3 It is not intended that this standard should apply to machines on small road vehicles such as battery-fed delivery vehicles, works trucks, etc. Neither does it apply to minor machines such as windscreen wiper motors, etc. that may be used on all types of vehicles.

NOTE 4 Industrial type machines complying with the IEC 60034 series may be suitable for certain auxiliary applications.

Electrical inputs or outputs of machines covered by this standard may be as follows:

a) direct current (including rectified polyphase alternating current);

b) pulsating current (rectified single-phase alternating current);

c) unidirectional chopper-controlled current;

d) single-phase alternating current;

e) polyphase alternating current (in general three-phase).

In this standard, the electrical machines concerned are classified as follows.

1) Traction motors – Motors for propelling rail or road vehicles.

2) Engine-driven main generators – Generators for supplying power to traction motors on the same vehicle or train.

3) Main motor-generator sets – Machines obtaining power from a line or battery, and supplying power to traction motors on the same vehicle or train.

4) Auxiliary motors – Motors for driving compressors, fans, auxiliary generators or other auxiliary machines.

5) Auxiliary generators – Generators for supplying power for auxiliary services such as air conditioning, heating, lighting, battery charging, etc.

6) Auxiliary motor-generator sets and auxiliary rotary converters – Machines which obtain their power from the line or other source to provide an electrical supply for auxiliary services.

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 60085, *Thermal evaluation and designation*

IEC 60638, *Criteria for assessing and coding of the commutation of rotating electrical machines for traction*

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

3.1.1
rated value
numerical value of any quantity included in a rating

NOTE For traction machines, certain special quantities are often included such as current ripple factor for a pulsating current motor, excitation condition for a variable field motor, etc.

3.1.2
continuous rating
electrical load the machine can withstand on the test bed for an unlimited period under the conditions specified in 8.1 without exceeding the limits of temperature rise given in Table 2, all other appropriate requirements in this standard also being satisfied

3.1.2.1
continuous ratings of an engine-driven main generator
an engine-driven main generator normally has two continuous ratings which are defined below:

a) continuous rating "at lower voltage"

   continuous rating determined by the temperature rise of the windings through which the load current flows (higher value of load current and lower voltage)

b) continuous rating "at higher voltage"

continuous rating determined by the temperature rise of the field windings (lower value of load current and higher voltage)

NOTE 1 These two continuous ratings correspond to points on the full power regulated characteristic as defined in 3.8.2 or on the inherent characteristic as defined in 3.8.3.

NOTE 2 Ratings similar to those specified above may, where appropriate, be applied to a main motor-generator set.

3.1.3
short-time (for example, 1 h) rating
electrical load that a machine can withstand 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 machine cold (see Clause A.1), all other appropriate requirements in this standard also being satisfied

3.1.4
short-time overload rating
electrical load that a machine can withstand 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 Annex A)

NOTE Short-time overload ratings are of value in determining the suitability of machines 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.

3.1.5
intermittent duty rating
electrical loads and conditions at which a machine may be operated on a duty cycle without the temperature rises at any point in the cycle exceeding the limits given in Table 2

3.1.6
equivalent rating
continuous rating with constant values of voltage, current and speed that, as far as temperature rise is concerned, is equivalent to a long series of the intermittent duty cycles which the machine has to withstand in service

NOTE This rating should be agreed between user and manufacturer.

3.1.7
guaranteed rating
rating guaranteed by the manufacturer

3.1.7.1
guaranteed rating of a traction motor
the guaranteed rating is normally a continuous rating, but in special cases the manufacturer and user may agree that it is a short-time or intermittent rating

3.1.7.2
guaranteed ratings of an engine-driven main generator
the guaranteed ratings are normally the two continuous ratings defined in 3.1.2, but in special cases, the manufacturer and user may agree that they are short-time or intermittent ratings

3.1.7.3
guaranteed ratings of a main motor-generator set
the guaranteed ratings are normally the continuous rating, but in special cases, the manufacturer and user may agree that they are short-time or intermittent ratings

3.1.7.4
guaranteed rating of an auxiliary machine
unless otherwise specified, the guaranteed rating is the continuous rating

3.2
rated voltage
specified value of the voltage at the terminals of the machine when operating at a rating. If unidirectional, the voltage is the arithmetic mean of the recurring waveform and if alternating it is the root mean square value of the fundamental frequency component of the recurring waveform

NOTE In the case of a machine with a protective resistor permanently in series, the resistor is considered as an integral part of the machine.

3.2.1
rated voltage of a motor fed directly or indirectly from a contact system (including motors of motor-generator sets)
highest value of voltage (excluding transients) which can appear at the motor terminals when it is drawing its rated current with the contact system at its nominal voltage as defined in Annex D

NOTE 1 In some cases, it may be necessary to assign ratings at other than the above voltage in order to fully define the performance of a machine, an example being a motor-generator set giving constant power output over a range of input voltages

NOTE 2 If, in the case of an indirectly fed motor, the regulation characteristic of the transformer or other device is not specified, the rated voltage is taken as 90 % of the open-circuit value

3.2.2
rated voltage of a motor fed from a generator or battery located on the vehicle

3.2.2.1
traction motors
rated voltage corresponding to the maximum voltage of the source when supplying the motor at its rated current

3.2.2.2
auxiliary motors
rated voltage corresponding to the nominal voltage of the auxiliary supply (see note to 3.2.4)

3.2.3
rated voltages of a main generator
two rated voltages corresponding to the two continuous ratings defined in 3.1.2

3.2.4
rated voltage of an auxiliary generator (including generators of auxiliary motor-generator sets or rotary converters)
voltage corresponding to the nominal voltage of the auxiliary supply

NOTE The nominal voltage of the auxiliary supply should normally be agreed between the manufacturer and the user, taking into account factors (such as standardization with other vehicles), which may influence the choice.

3.3
rated speed of a machine
speed at a guaranteed rating of the machine

3.3.1
rated speed of an engine-driven main or auxiliary generator
speed of the generator corresponding to the rated speed of the engine

3.3.2
rated speed of an axle-driven generator
speed agreed between the manufacturer and the user

3.4
maximum (or minimum) voltage

3.4.1
maximum (or minimum) voltage of a machine
highest (or lowest) voltage which the machine will be called upon to withstand in service, transient voltages being excluded. Also excluded is any reduction in the minimum voltage by control means during starting or acceleration

NOTE Unless otherwise agreed the maximum voltage of an auxiliary machine connected in series with other machines without mechanical coupling is taken as 1,2 times the highest voltage of the supply to the machines divided by the number in series.

3.4.2
maximum and minimum voltage of a machine supplied directly or indirectly from a contact system
voltages normally corresponding to the highest and lowest voltages of the traction system (see Annex D), account being taken of the regulation of any transformer or control equipment interposed between the line and the machine

3.5
maximum current
maximum value of current shown on the characteristic curve supplied by the manufacturer

3.6
maximum working speed

3.6.1
maximum working speed of a traction motor
highest rotational speed assigned to the traction motor by the manufacturer

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

3.6.2
maximum working speed of an engine-driven main or auxiliary generator
generator speed corresponding to the maximum governed speed of the engine for the particular application

NOTE This will normally be the maximum governed speed on "no-load". Transient speed variations during load changes should be disregarded.

3.6.3
maximum working speed of a generator with a rotational speed proportional to the speed of the vehicle
highest rotational speed assigned to the generator by the manufacturer. See note in 3.6.1

3.6.4
maximum working speed of a main or auxiliary motor-generator set, an auxiliary converter or an auxiliary motor
highest rotational speed assigned to the machine by the manufacturer

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

3.7
output and input power of electrical machines and heat engines

3.7.1
output power of a motor
mechanical output power available at the motor shaft, expressed in kilowatts (kW)

3.7.2
maximum service output power of a heat engine
maximum output power assigned to a heat engine for a particular application

3.7.3
available input power to a main generator
input power converted to electricity to supply the traction motors and other loads, such as train heating, connected to it

NOTE 1 It is used to derive the ratings and characteristics of the generator.

NOTE 2 The maximum available input power to a main generator is the maximum service output power of the heat engine, less the power it provides to drive, either directly or indirectly, the engine cooling equipment and vehicle auxiliaries, assuming these are operating at their minimum input power for the given condition.

NOTE 3 The available input power is not necessarily absorbed by the main generator over its whole working current range.

3.8
main generator characteristics

3.8.1
regulated characteristic
characteristic obtained if the power demand of a main generator is regulated to absorb the available input power, the product of current and voltage remaining substantially constant between the limits of regulation

3.8.2
full power regulated characteristic
regulated characteristic corresponding to the maximum available input power

3.8.3
inherent characteristic
characteristic of a generator designed to operate without load regulating equipment to match its power demand to the available engine output power

3.9
effective field ratio of a series motor
ratio of the actual field ampere-turns to the maximum obtainable at the same armature current

NOTE 1 A series motor is said to be

– in full field when the field current is equal to the armature current;

– in maximum field when the effective field ratio is the maximum used in service;

– in weak field when the effective field ratio is below the maximum;

– in minimum field when the effective field ratio is the minimum used in service.

NOTE 2 For motors without permanent shunts across the field windings, full field and maximum field are the same.

3.10
effective resistance of a series motor
resistance value which, when multiplied by the load current, gives the total resistive voltage drop in the machine windings, i.e. it takes account of any shunt across the field windings

3.11
ripple factor
ripple factor of a continuous pulsating current is defined as:

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} \times 100$$

expressed as a percentage in which I_{max} and I_{min} are respectively the maximum and the minimum values of the current waveform

NOTE This is in accordance with IEC 61287-1.

3.12
pulsating frequency
frequency of the fundamental alternating component of a pulsating current or voltage

3.13
pulse control
control of the power supply to a machine by varying the starting and terminating points of repeated pulses of voltage or current

NOTE Pulse control devices include, but are not limited to, choppers, inverters and electronically controlled rectifiers.

4 Environmental conditions

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

a) Altitude

Height above sea level: Class A3 according IEC 62498-1.

b) Temperature

Temperature in the shade: Class T1 according IEC 62498-1.

Whenever the machines 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.

The manufacturer shall be informed by the user of any particularly arduous conditions such as dust, humidity, temperature, snow, dynamic effects, etc. under which the machines are intended to work.

5 Characteristics

5.1 General

Machine specifications shall, as a general rule, include characteristic curves in accordance with the following subclauses. These curves, defined as the "specified characteristics", shall be plotted up to the designed operating limits of each variable.

When the first few machines of a type have been tested, "declared characteristics" shall be produced from the results in accordance with 8.2.

Unless otherwise agreed, the declared characteristics of machines electromagnetically identical with any previously manufactured for the same user or application shall be those of the existing machines, in which case compliance with the characteristics shall be demonstrated by routine tests only.

5.2 Reference temperature

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