

Electric traction (rail and road vehicles) —

Part 1: Specification for rotating electrical machines

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Policy Committee (PEL/-) to Technical Committee PEL/44, upon which the following bodies were represented:

- Association of Consulting Engineers
- British Cable Makers' Confederation
- British Railways Board
- Bus and Coach Council
- Department of Transport (Railways Inspectorate)
- London Regional Transport
- Power Supply Manufacturers' Association [PSMA (BEAMA Ltd.)]
- Railway Industry Association of Great Britain

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 1 April 1992

© BSI 10-1999

The following BSI references relate to the work on this standard:
Committee reference PEL/44
Special announcement in *BSI News* March 1992

ISBN 0 580 20829 X

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
National foreword	iii
Section 1. General	
1.1 Scope and object	1
1.2 Normative references	1
1.3 Service conditions	2
Section 2. Definitions	
2.1 General	3
2.2 Rating of a machine	3
2.3 Rated voltage	4
2.4 Rated speed of a machine	5
2.5 Maximum (or minimum) voltage of a machine	5
2.6 Maximum current	5
2.7 Maximum working speed	5
2.8 Output and input power of electrical machines and heat engines	6
2.9 Main generator characteristics	6
2.10 Effective field ratio of a series motor	6
2.11 Effective resistance of a series motor	6
2.12 Ripple factor	7
2.13 Pulsating frequency	7
2.14 Pulse control	7
Section 3. Characteristics	
3.1 General	8
3.2 Reference temperature	8
3.3 Efficiency characteristics	8
3.4 Commutator type traction motor characteristics	8
3.5 Polyphase a.c. traction motor characteristics	8
3.6 Main generator characteristics	9
3.7 Auxiliary motor characteristics	9
3.8 Auxiliary generator characteristics	9
3.9 Auxiliary motor-generator set and rotary convertor characteristics	9
Section 4. Marking	
4.1 Nameplate	10
4.2 Terminal and lead markings	10
Section 5. Test categories	
5.1 Test categories	11
5.2 Summary of tests	12
Section 6. Type tests	
6.1 Temperature-rise tests	13
6.2 Characteristic tests and tolerances	17
6.3 Commutation tests	19
6.4 Transient tests	20
6.5 Short-circuit tests on main and auxiliary alternators	22
6.6 Starting tests	22
6.7 Overspeed tests	23

	Page
Section 7. Routine tests	
7.1 Short-time soundness test	24
7.2 Characteristic tests and tolerances	24
7.3 Commutation routine tests	26
7.4 Overspeed tests	27
7.5 Dielectric tests	27
7.6 Vibration tests	28
7.7 Commutator radial run-out measurement	28
Annex A (informative) Methods of determining losses and efficiency	33
Annex B (normative) Noise	43
Annex C (normative) Supply voltages of traction systems	45
Annex D (informative) Agreement between user and manufacturer	45
Figure 1 — Typical a.c. motor characteristics	30
Figure 2 — Commutator type traction motor test points	31
Figure 3 — Main generator test points	32
Figure A.1 — Circuit for determining loss and efficiency by the regenerative method with the machines connected in parallel	35
Figure A.2 — Circuit for determining loss and efficiency by the regenerative method with the machines connected in series	36
Figure A.3 — Circuit for determining loss and efficiency by the regenerative method with the machines connected in series and with mechanical drive	36
Figure A.4 — Circuit for determining loss and efficiency of single-phase a.c. commutator motors by the regenerative method with the machines connected in series	37
Figure A.5 — Circuit for determining loss and efficiency of pulsating current motors by the regenerative method with the machines connected in series	38
Figure A.6 — Circuit for determining loss and efficiency of pulsating current motors by the regenerative method with the machines connected in parallel	39
Figure A.7 — Circuit for the measurement of the a.c. losses of pulsating current motors	40
Figure A.8 — Correction factor for additional load loss of uncompensated d.c. machines	41
Figure A.9 — Correction factor for pulsating current I^2R loss	42
Figure A.10 — Conventional values of traction motor transmission losses	43
Figure B.1 — Limiting mean sound power level for airborne noise emitted by traction motors	44
Table 1 — Summary of tests	12
Table 2 — Limits of temperature rise for continuous or other ratings	16
Table 3 — Temperature rise for short-time overload rating	16
Table 4 — Tolerances on the speed of commutator type traction motors	17
Table 5 — Dielectric test voltages	28
Table 6 — Limits of commutator radial run-out	29
Table B.1 — Limiting mean sound power level for airborne noise emitted by rotating electrical machines for rail and road vehicles other than traction motors	45
Publication(s) referred to	Inside back cover

National foreword

This Part of BS 173 has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee.

It is identical with IEC 349:1991 “*Electric traction. Rotating electrical machines for rail and road vehicles*” published by the International Electrotechnical Commission (IEC) and replaces BS 173:1980 which is withdrawn.

There is a high probability that BS 173-2 “*Specification for electronic convertor-fed alternating current motors*” when published will be identical with IEC 349-2. Simultaneously, the title of this Part of BS 173 will be amended to “*Part 1. Specification for rotating electrical machines other than convertor-fed alternating current motors*” and the text will be amended to delete tests which are applicable to convertor-fed motors.

Appendix B of BS 173:1980 which was identical to IEC 850 is now published as BS 7571.

BS 173:1980 implemented CENELEC HD 225, but there is a high probability that at a future date EN 60349 when published will be identical with IEC 349. At that time, this standard will be renumbered as BS EN 60349.

Cross-references

International Standard	Corresponding British Standard
IEC 34-2:1972	BS 4999 <i>General requirements for rotating electrical machines</i> Part 102:1987 <i>Methods for determining losses and efficiency from tests (excluding machines for traction vehicles)</i> (Identical) BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i> Part 1 <i>Terms common to power, telecommunications and electronics</i>
IEC 50 (131):1978	Group 01:1983 <i>Fundamental terminology</i> (Technically equivalent)
IEC 50 (151):1978	Group 02:1980 <i>Electrical and magnetic devices terminology</i> (Technically equivalent) Part 2 <i>Terms particular to power engineering</i>
IEC 50 (411)	Group 03:1971 <i>Rotating machinery terminology</i> (Technically equivalent)
IEC 85:1984	BS 2757:1986 <i>Method for determining the thermal classification of electrical insulation</i> (Identical)

The Technical Committee has reviewed the provisions of IEC 34-5:1991, IEC 34-8:1991, IEC 34-14:1988, IEC 50 (811):1991, IEC 411, IEC 638:1979, IEC 850:1988 and ISO/R 1680:1970, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 46, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1.1 Scope and object

1.1.1 This International Standard is applicable to rotating electrical machines 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.

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. It does not apply either 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 IEC 34 may be suitable for certain auxiliary applications.

1.1.2 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).

All the above may be synthesized and/or varied by phase or pulse control.

1.1.3 For the purpose of this standard, the electrical machines concerned are classified as follows:

1.1.3.1 *Traction motors*

Motors for propelling rail or road vehicles.

1.1.3.2 *Engine-driven main generators*

Generators for supplying power to traction motors on the same vehicle or train.

1.1.3.3 *Main motor-generator sets*

Machines obtaining power from a line or battery, and supplying power to traction motors on the same vehicle or train.

1.1.3.4 *Auxiliary motors*

Motors for driving compressors, fans, auxiliary generators or other auxiliary machines.

1.1.3.5 *Auxiliary generators*

Generators for supplying power for auxiliary services such as air conditioning, heating, lighting, battery charging, etc.

1.1.3.6 *Auxiliary motor-generator sets and auxiliary rotary convertors*

Machines which obtain their power from the line or other source to provide an electrical supply for auxiliary services.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 34-2:1972, *Rotating electrical machines — Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)*.

IEC 34-5:1991, *Rotating electrical machines — Part 5: Classification of degrees of protection provided by enclosures for rotating machines*.

IEC 34-8:1972, *Rotating electrical machines — Part 8: Terminal markings and direction of rotation of rotating machines*.

IEC 34-14:1988, *Rotating electrical machines — Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher — Measurement, evaluation and limits of the vibration severity.*

IEC 50(131):1978, *International Electrotechnical Vocabulary — Chapter 131: Electric and magnetic circuits.*

IEC 50(151):1978, *International Electrotechnical Vocabulary — Chapter 151: Electrical and magnetic devices.*

IEC 50(411):1973, *International Electrotechnical Vocabulary — Chapter 411: Rotating machines.*

IEC 50(811):1991, *International Electrotechnical Vocabulary — Chapter 811: Electric traction.*

IEC 85:1984, *Thermal evaluation and classification of electrical insulation.*

IEC 411, *Power convertors for electric traction.*

IEC 638:1979, *Criteria for assessing and coding of the commutation of rotating electrical machines for traction.*

IEC 850:1988, *Supply voltage of traction systems.*

ISO/R 1680:1970, *Test code for the measurement of airborne noise emitted by rotating electrical machinery.*

1.3 Service conditions

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

a) Altitude

Height above sea level not exceeding 1 200 m.

b) Temperature

Temperature in the shade not exceeding 40 °C.

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.

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.

Section 2. Definitions

For the purpose of this International Standard the following definitions apply.

2.1 General

For the definitions of general terms used in this International Standard, reference should be made to IEC 50(131), IEC 50(151), IEC 50(411) and IEC 50(811).

2.2 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.

2.2.1

rated value

numerical value of any quantity included in a rating. 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

2.2.2 continuous rating

Electrical load the machine can withstand on the test bed for an unlimited period under the conditions specified in 6.1 without exceeding the limits of temperature rise given in Table 2, all other appropriate requirements in this standard also being satisfied.

2.2.2.1

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 2.9.2 or on the inherent characteristic as defined in 2.9.3.

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

2.2.3

short-time (for example, one hour) 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 6.1 starting with the machine cold (see 6.1.3.1), all other appropriate requirements in this standard also being satisfied

2.2.4

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 6.1.9)

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.

2.2.5

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

2.2.6

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. This rating should be agreed between user and manufacturer

2.2.7 guaranteed rating

Rating guaranteed by the manufacturer.

2.2.7.1**guaranteed rating of a traction motor**

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

2.2.7.2**guaranteed ratings of an engine-driven main generator**

the guaranteed ratings are normally the two continuous ratings defined in **2.2.2.1**, but in special cases, the manufacturer and user may agree that they are short-time or intermittent ratings

2.2.7.3**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

2.2.7.4**guaranteed rating of an auxiliary machine**

unless otherwise specified, the guaranteed rating is the continuous rating

2.3 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.

2.3.1**rated voltage of a motor fed directly or indirectly from a contact system (including motors of motor-generator sets)**

the 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 C

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

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

2.3.2 rated voltage of a motor fed from a generator or battery located on the vehicle:**2.3.2.1****traction motors**

the rated voltage is that corresponding to the maximum voltage of the source when supplying the motor at its rated current

2.3.2.2**auxiliary motors**

the rated voltage is that corresponding to the nominal voltage of the auxiliary supply (see note to **2.3.4**)

2.3.3**rated voltages of a main generator**

the two rated voltages corresponding to the two continuous ratings defined in **2.2.2.1**

2.3.4**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.

2.4 rated speed of a machine

Speed at the guaranteed rating of the machine.

2.4.1

rated speed of an engine-driven main or auxiliary generator

the speed of the generator corresponding to the rated speed of the engine

2.4.2

rated speed of an axle driven generator

the speed agreed between the manufacturer and the user

2.5 maximum (or minimum) voltage of a machine

2.5.1

general

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

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

2.5.2

machines supplied directly or indirectly from a contact system

the maximum and minimum voltages normally correspond to the highest and lowest voltages of the traction system (see Annex C), account being taken of the regulation of any transformer or control equipment interposed between the line and the machine

2.6

maximum current

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

2.7 maximum working speed

2.7.1

maximum working speed of a traction motor

the 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

2.7.2

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.

2.7.3

maximum working speed of a generator with a rotational speed proportional to the speed of the vehicle

the highest rotational speed assigned to the generator by the manufacturer

See note to 2.7.1.

2.7.4

maximum working speed of a main or auxiliary motor-generator set, an auxiliary convertor or an auxiliary motor

the 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.

2.8 output and input power of electrical machines and heat engines

2.8.1

output power of a motor

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

2.8.2

maximum service output power of a heat engine

the maximum output power assigned to a heat engine for a particular application

2.8.3

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

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

2.9 main generator characteristics

2.9.1

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

2.9.2

full power regulated characteristic

regulated characteristic corresponding to the maximum available input power

2.9.3

inherent characteristic

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

2.10

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.

2.11

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

2.12**ripple factor** (for the purpose of this standard)

the 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 411.

2.13**pulsating frequency**

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

2.14**pulse control** (for the purpose of this standard)

pulse control is defined as control of the power supply to a machine by varying the starting and terminating points of repeated pulses of voltage or current. Pulse control devices include, but are not limited to, choppers, inverters and electronically controlled rectifiers

Section 3. Characteristics

3.1 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 6.2.

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.

3.2 Reference temperature

All characteristics, irrespective of the class of insulation 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 characteristic.

NOTE The reference temperature will slightly affect the calculated efficiency, a higher temperature giving a lower efficiency.

3.3 Efficiency characteristics

Efficiency characteristics shall take account of losses in external resistances normally included in either the main or excitation circuits. Any power used in providing separate excitation shall be included in the losses unless otherwise accounted for (e.g. as an auxiliary load), in which case the omission shall be stated.

3.4 Commutator type traction motor characteristics

The characteristic curves shall normally show motor speed, torque and efficiency as a function of current. Alternatively the curves may show vehicle speed and tractive effort at the rail as a function of current, 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 A.10 of Annex A.

Curves shall be drawn for each excitation condition employed on the application except that where continuously variable field control is employed, only the maximum and minimum curves need be drawn. The effective machine resistance for each effective field ratio shall be stated.

The characteristic curves of traction motors supplied directly or indirectly from a contact system or from a battery located on the vehicle shall be drawn at the rated voltage except when the circuit includes equipment (such as a transformer or inductor) which introduces a current dependent voltage drop at the motor terminals. In these cases the curves shall be drawn for a motor voltage corresponding to the nominal supply voltage and a motor voltage current curve shall be included in the characteristics. If this information is not available the curves may be drawn for the rated voltage.

The characteristic curves of traction motors used on thermo-electric vehicles shall normally be drawn for a voltage corresponding to the lower voltage of the generator at its continuous rating, but they may, by agreement, be drawn for other voltages.

The characteristic curves of a.c. commutator motors shall be plotted for the rated frequency and shall show the power factor as a function of current.

In the case of motors used for rheostatic or regenerative braking, the characteristics shall show the performance in this mode. Unless otherwise agreed regenerative braking characteristics shall be drawn for a motor voltage corresponding to 1,1 times the nominal system voltage.

The declared braking characteristics may be derived either by calculation from the results of motoring tests or directly from tests in the braking mode.

3.5 Polyphase a.c. traction motor characteristics

NOTE In view of technical development, clauses 3.5, 6.2.3 and 7.2.3 relating to polyphase rotating machines are to be considered solely as a provisional guide and are at present under review.

Characteristics shall be drawn for both asynchronous and synchronous machines showing torque, current, voltage, frequency, efficiency and power factor as a function of speed over the whole range of application of the machine.

Characteristics of synchronous machines shall also include curves of excitation current and those of asynchronous machines shall include curves of slip.

Unless stated otherwise the voltage and current shall be the fundamental components of the respective waveforms and the other curves shall take account of the harmonics present in the supply.

These overall characteristics provide the basis for design of the control system and for calculation of train performance. They may, if preferred, show vehicle speed and tractive effort in place of motor speed and torque, in which case the requirements of clause 3.4 regarding transmission losses shall apply.

Additional characteristics are required to provide a basis for routine tests. These shall be drawn as follows for a sinusoidal supply at either power frequency or a frequency used in service.

- a) For asynchronous motors the curves shall show voltage, input power and power factor against no load current, and also current, input power and power factor against voltage with the rotor locked.
- b) For synchronous motors the curves shall show voltage, input power and current against excitation current at unity power factor on no-load and also current against excitation for the machine driven at synchronous speed on short circuit.

Typical general and additional characteristics are shown in Figure 1.

In the case of motors used in the braking mode, similar characteristics shall show the performance when braking. They may be derived from tests in that mode or by calculation from the declared motoring characteristics.

3.6 Main generator characteristics

The characteristic curves shall show voltage as a function of load current. In the case of an a.c. generator intended to operate with a rectifier the characteristics shall also show the output of the rectifier. A brushless alternator and its exciter shall be regarded as a single machine.

If the engine has a number of pre-determined intermediate speed notches, additional curves shall be drawn for a sufficient number of these speeds to adequately show the performance of the generator.

Each curve shall be identified with its excitation condition, input power, generator speed and, if applicable, notch number. In addition, the efficiency on the full power characteristic shall be shown for at least the two continuous ratings.

NOTE See clause 3.3 concerning the inclusion of excitation power in the losses when determining the efficiency.

Similar characteristics shall be drawn for the generators of main motor-generator sets, due account being taken of the characteristics of the driving motor and regulating equipment.

3.7 Auxiliary motor characteristics

Characteristic curves of speed, torque (or output power), efficiency and, in the case of a.c. machines, power factor shall be plotted as a function of motor current at the rated voltage and frequency.

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

Curves shall be drawn for each excitation condition employed in the application.

3.8 Auxiliary generator characteristics

The characteristic curves of output voltage, power and efficiency shall be plotted as a function of output current at the rated speed and, for variable speed machines, at the minimum and maximum speeds for the application. The frequency of a.c. outputs shall be stated.

In the case of generator operating with a voltage regulator the characteristics shall be plotted at the nominal voltage and the range of excitation current stated.

A brushless alternator and its exciter shall be regarded as a single machine.

3.9 Auxiliary motor-generator set and rotary convertor characteristics

The characteristic curves of output voltage, output power, machine speed, and input current shall be plotted as a function of output current with the machine supplied at minimum, rated and maximum voltage. The overall efficiency at the continuous rating shall be stated. The characteristics of a.c. machines shall show the power factor.

In the case of machines operating with a voltage or frequency regulator, the characteristics shall be drawn with the voltage or frequency at its nominal value. The range of excitation current shall be stated.

If the machine drives an external load, such as a blower, the power absorbed by it shall be shown or stated and the statement of overall efficiency shall be replaced by one of the total input power to the machine at the continuous rating.

Section 4. Marking

4.1 Nameplate

All the machines covered by this standard shall carry a nameplate including at least the following information:

- 1) Manufacturer's name
- 2) Machine type designation
- 3) Machine serial number
- 4) Year of manufacture

Furthermore, a serial number shall be punched on both stator and rotor of each machine and machines designed for unidirectional rotation shall carry an arrow to indicate the direction of rotation.

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

4.2 Terminal and lead markings

Terminal and lead markings shall be in accordance with IEC 34-8 unless otherwise agreed.

Section 5. Test categories

5.1 Test categories

5.1.1 General

There are three categories of tests:

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

5.1.2 Type tests

Type tests are intended to establish the ratings, characteristics and performance of new types of machine. Unless otherwise agreed, full type tests shall be carried out on one machine of a new specification or method of manufacture. In addition, tests to establish the declared characteristics shall be carried out on further machines in accordance with clause 6.2.

The fully tested machine shall be one of the first ten manufactured.

A machine may be exempted from type tests if the manufacturer produces a record, acceptable to the user, of type tests already carried out on a machine of the same electromagnetic design for the same service conditions and at the same ratings.

By agreement between manufacturer and user more machines may be fully or partially type tested at intervals.

Type tested machines shall also be routine tested.

5.1.3 Routine tests

Routine tests are intended to demonstrate that each machine is sound both electrically and mechanically, and that it is essentially identical with the machine which has been type tested.

Routine tests as specified in section 7 shall normally be carried out on all machines but alternative tests may be agreed between user and manufacturer. It may also be agreed that only a proportion of machines chosen at random from those built on the order shall be fully routine tested, subject to overspeed and dielectric tests in accordance with clauses 7.4 and 7.5 being carried out on all machines.

5.1.4 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. The results of these tests shall not influence the acceptance of a machine unless agreement to the contrary has been similarly reached.