

Rotating electrical machines

Part 1. Rating and performance

The European Standard EN 60034-1 : 1995 has the status of a
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Electricity Association
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ERA Technology Ltd.
Health and Safety Executive
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Page	Issue	Page	Issue
Front cover	2	20	2
Inside front cover	2	20a	1
a	1	20b	blank
b	blank	21	original
i	original	22	2
ii	2	23	2
EN title page	2	24 to 45	original
2	2	46	2
3 to 16	original	47 to 56	original
17	2	57	2
18	2	58 to 74	original
19	2	Inside back cover	original
		Back cover	original

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Foreword	2
Text of EN 60034-1	3
National annex NA (informative) Original IEC text amended by CENELEC common modifications	75

National foreword

This British Standard has been prepared by Technical Committee PEL/2 and is the English language version of EN 60034-1 : 1995 *Rotating electrical machines Part 1: Rating and performance* including its Corrigendum : April 1995 and its amendment A1 : 1996, published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived by CENELEC from IEC 34-1 : 1994, including amendment 1 : 1996, published by the International Electrotechnical Commission (IEC).

The foreword of the EN makes reference to the 'date of withdrawal', dow, of the relevant national standard. In this case the relevant national standard is BS 4999 : Part 101 : 1987 which will be withdrawn on 1995-12-31. Certificates and Marks will not be awarded after this date with respect to the withdrawn British Standard. However such Certificates and Marks, already awarded, may continue to apply to production until 2002-12-31.

The foreword of amendment A1 to the EN makes reference to the 'date of withdrawal (dow) of conflicting national standards' as 1997-04-01. In this case, the relevant national standard is BS EN 60034-1 : 1995, but the date of withdrawal relates only to those parts of the British Standard subject to Amendment No. 1. Certificates and marks will not be awarded after this date with respect to the British Standard not incorporating Amendment No. 1. They will be awarded only to the amended British Standard. However, such certificates and marks already awarded with respect to the British Standard not incorporating Amendment No. 1 may continue to apply for production until 2002-04-01.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by a side line in the margin. Parts of the original IEC text that have been modified by CENELEC have been quoted in national annex NA.

Cross-references

Publication referred to	Corresponding British Standard
EN 60034	BS EN 60034 <i>Rotating electrical machines</i>
EN 60034-6 : 1993	Part 6 : 1993 <i>Methods of cooling (IC Code)</i>
EN 60034-18	Part 18 <i>Functional evaluation of insulation systems</i>
EN 60445 : 1990	BS 5559 : 1991 <i>Specification for identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system</i>
HD 53.3 S1 : 1991 (IEC 34-3 : 1988)	BS 5000 <i>Rotating electrical machines of particular types or for particular appliances</i> Part 2 : 1992 <i>Specific requirements for turbine-type synchronous machines</i>
HD 53.12 S1 : 1986	BS 4999 <i>General requirements for rotating electrical machines</i> Part 112 : 1987 <i>Specification for starting performance of single-speed three-phase cage induction motors</i>
HD 345 : 1976	BS 4999 <i>General requirements for rotating electrical machines</i> Part 144 : 1987 <i>Specification for the insulation of bars and coils of high voltage machines, including test methods</i>
HD 472 S1	BS 7697 : 1993 <i>Nominal voltages for low voltage public electricity supply systems</i>
IEC 34 Series	BS 4999 <i>General requirements for rotating electrical machines</i>
IEC 34-2 : 1972	Part 102 : 1987 <i>Methods for determining losses and efficiency from tests (excluding machines for traction vehicles)</i>
IEC 85 : 1984	BS 2757 : 1986 <i>Method for determining the thermal classification of electrical insulation</i>

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

Descriptors: Rotating electrical machines, rating and performance

English version

Rotating electrical machines Part 1: Rating and performance

(includes amendment A1 : 1996)

(IEC 34-1 : 1994, modified + A1 : 1996)

Machines électriques tournantes
Partie 1: caractéristiques assignées et
caractéristiques de fonctionnement
(inclut l'amendement A1 : 1996)
(CEI 34-1 : 1994, modifiée + corrigendum 1994
+ A1 : 1996)

Drehende elektrische Maschinen
Teil 1: Bemessung und Betriebsverhalten
(enthält Änderung A1 : 1996)
(IEC 34-1 : 1994, modifiziert + A1 : 1996)

This European Standard was approved by CENELEC on 1994-10-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

This European Standard has been prepared by Technical Committee CENELEC TC 2, electrical rotating machinery.

It consists of the text of IEC 34-1 : 1994 and a number of common modifications remaining from HD 53.1 S2 : 1985 and its amendment A3. It is recalled that the contents of draft amendment prA4 : 1994 to HD 53.1 S2, based on 2(CO)565, 571, 572, 573, 580 and 585 is included in IEC 34-1 : 1994.

The text of the draft was approved by CENELEC as EN 60034-1 on 1994-10-04.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1995-12-31
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1995-12-31

For products which have complied with HD 53.1 S2 : 1985 and its amendment A3 : 1992 before 1995-12-31 as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2002-12-31.

Annexes designated 'normative' are part of the body of the text.

Annexes designated 'informative' are given only for information.

In this standard, annex ZA is normative and annex A is informative.

Annex ZA has been added by CENELEC.

Foreword to amendment A1

The text of document 2/923/FDIS, future amendment 1 to IEC 34-1 : 1994, prepared by IEC TC 2, Rotating machinery, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60034-1 : 1995 on 1996-07-02.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-04-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1997-04-01

For products which have complied with EN 60034-1 : 1995 before 1997-04-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2002-04-01.

CONTENTS

Page

SECTION 1: GENERAL

Clause

1	General	6
---	---------------	---

SECTION 2: DEFINITIONS

2	Definitions	8
---	-------------------	---

SECTION 3: DUTY AND RATING

3	Rules for declaration of duty and for selection of a class of rating	11
4	Duty types	12
5	Classes of rating	14
6	Designation	15
7	Assignment of ratings	16
8	Rated output	17
9	Rated voltage	17
10	Machines with more than one rating	18

SECTION 4: OPERATING CONDITIONS

11	Altitude, ambient temperature and coolant temperature	18
12	Electrical conditions	19

SECTION 5: TEMPERATURE RISE

13	Thermal classification of machines	23
14	Conditions during temperature-rise test	24
15	Determination of temperature rise	24
16	Limits of temperature rise and total temperature	31

SECTION 6: DIELECTRIC TESTS

17	Dielectric tests	41
----	------------------------	----

SECTION 7: MISCELLANEOUS CHARACTERISTICS

18	Occasional excess current for rotating machines	44
19	Momentary excess torque for motors	45
20	Pull-up torque	46

Clause	Page
21 Overspeed	47
22 Unbalanced currents of synchronous machines	48
23 Short-circuit current.....	49
24 Short-circuit withstand test for synchronous machines	50

SECTION 8: COMMUTATION TEST

25 Commutation test for direct or alternating current commutator machines	50
---	----

SECTION 9: TOLERANCES

26 Schedule of tolerances on quantities involved in the rating of electrical machines	50
---	----

SECTION 10: MARKING AND TECHNICAL DATA

27 Marking and technical data	52
-------------------------------------	----

SECTION 11: IRREGULARITIES OF WAVEFORM

28 Requirements and tests	55
---------------------------------	----

SECTION 12: CO-ORDINATION OF VOLTAGES AND OUTPUTS

29 Co-ordination of voltages and outputs	57
--	----

SECTION 13: CONSTRUCTIONAL REQUIREMENTS

30 Earth terminals	57
31 Shaft extension key	58

Figures

1 Continuous running duty. Duty type S1	59
2 Short-time duty. Duty type S2	59
3 Intermittent periodic duty. Duty type S3	60
4 Intermittent periodic duty with starting. Duty type S4	61
5 Intermittent periodic duty with electric braking. Duty type S5	62
6 Continuous operation periodic type. Duty type S6	63
7 Continuous operation periodic duty with electric braking. Duty type S7	64
8 Continuous operation periodic duty with related load speed changes. Duty type S8	65
9 Duty with non-periodic load and speed variations. Duty type S9	66
10 Duty with discrete constant loads. Duty type S10	67
11 Weighting curve for computing THF	68

Figures	Page
12 Adjustments for maximum ambient or primary coolant temperature	69
13 Voltage and frequency limits for generators.	70
14 Voltage and frequency limits for motors	70
Annex A — (informative) Guidance for the application of duty type S10 and for establishing the value of relative thermal life expectancy TL.....	71
Annex ZA — (normative) Other international publications quoted in this standard with the references of the relevant European publications.....	72

ROTATING ELECTRICAL MACHINES –

Part 1: Rating and performance

Section 1: General

1 General

1.1 Scope

This part of International Standard IEC 34 is applicable to all rotating machines except those covered by other IEC standards – for example, IEC 349.

Machines within the scope of this standard may also be subjected to superseding, modifying or additional requirements in other publications – for example, IEC 79 and IEC 92.

NOTE – If particular clauses of this standard are modified to meet special applications, for example machines subject to radioactivity or machines for aerospace, all other clauses apply in so far as they are compatible.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 34. At the time of publication, the editions indicated were valid. All normative documents 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 normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 27, *Letter symbols to be used in electrical technology*

IEC 27-1: 1992, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 27-4: 1985, *Part 4: Symbols for quantities to be used for rotating electrical machines*

IEC 34, *Rotating electrical machines*

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 34-3: 1988, *Rotating electrical machines – Part 3: Specific requirements for turbine-type synchronous machines*

IEC 34-5: 1991, *Rotating electrical machines – Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*

IEC 34-6: 1991, *Rotating electrical machines – Part 6: Methods of cooling (IC code)*

IEC 34-12: 1980, *Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors for voltages up to and including 660 V*

IEC 34-18, *Rotating electrical machines – Part 18: Functional evaluation of insulating systems*

IEC 38: 1983, *IEC standard voltages*

IEC 50, *International Electrotechnical Vocabulary (IEV)*

IEC 50(411): 1973, *International Electrotechnical Vocabulary (IEV) – Chapter 411: Rotating machines*

IEC 72, *Dimensions and output series for rotating electrical machines*

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

IEC 279: 1969, *Measurement of the winding resistance of an a.c. machine during operation at alternating voltage*

IEC 364, *Electrical installations of buildings*

IEC 364-4, *Electrical installations of buildings – Part 4: Protection for safety*

IEC 364-4-41: 1991, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electric shock*

IEC 445: 1988, *Identification of equipment terminals and of terminations of certain designated conductors including general rules of an alphanumeric system*

IEC 449: 1973, *Voltage bands for electrical installations of buildings*

IEC 971: 1989, *Semiconductor converters – Identification code for converter connections*

ISO 497: 1973, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers.*

Section 2: Definitions

2 Definitions

For the definitions of general terms used in this standard, reference should be made to IEC 50(411).

For the purpose of this standard, the following definitions apply:

2.1 rated value: A quantity value assigned, generally by a manufacturer, for a specified operating condition of a machine.

2.2 rating: The set of rated values and operating conditions.

2.3 rated output: The numerical value of the output included in the rating.

2.4 load: All the numerical values of the electrical and mechanical quantities that signify the demand to be made on a rotating machine by an electrical circuit or a mechanism at a given instant.

2.5 no-load (operation): The state of a machine rotating with zero output power (but under otherwise normal operating conditions).

2.6 full load: The highest value of load specified for a machine operating at rated output.

2.7 full load power: The highest value of power specified for a machine operating at rated output.

NOTE – This concept also applies to torque, current, speed, etc.

2.8 rest and de-energized: The complete absence of all movement and of all electrical supply or mechanical drive.

2.9 duty: The statement of the load(s) to which the machine is subjected, including, if applicable, starting, electric braking, no-load and rest and de-energized periods, and including their durations and sequence in time.

2.10 duty type: A continuous, short time or periodic duty, comprising one or more loads remaining constant for the duration specified, or a non-periodic duty in which generally load and speed vary within the permissible operating range.

2.11 thermal equilibrium: The state reached when the temperature rises of the several parts of the machine do not vary by more than 2 K over a period of 1 h.

2.12 cyclic duration factor: The ratio between the period of loading, including starting and electric braking, and the duration of the duty cycle, expressed as a percentage.

2.13 locked rotor torque: The minimum measured torque which the motor develops with the rotor locked and rated voltage applied at rated frequency.

2.14 locked rotor current: The measured steady-state root-mean-square current taken from the line with the rotor locked with rated voltage and frequency applied.

2.15 pull-up torque (of an a.c. motor): The smallest value of the steady-state asynchronous torque which the motor develops between zero speed and the speed which corresponds to the breakdown torque, when the motor is supplied at the rated voltage and frequency.

This definition does not apply to those asynchronous motors of which the torque continually decreases with increase in speed.

NOTE – In addition to the steady-state asynchronous torques, harmonic synchronous torques, which are a function of rotor load angle, will be present at specific speeds.

At such speeds the accelerating torque may be negative for some rotor load angles.

Experience and calculation show this to be an unstable operating condition and therefore harmonic synchronous torques do not prevent motor acceleration and are excluded from the definition.

2.16 breakdown torque (of an a.c. motor): The maximum value of the steady-state asynchronous torque which the motor develops without an abrupt drop in speed, when the motor is supplied at the rated voltage and frequency.

This definition does not apply to those asynchronous motors of which the torque continually decreases with increase in speed.

2.17 pull-out torque (of a synchronous motor): The maximum torque which the synchronous motor develops at operating temperature and at synchronous speed with rated voltage, frequency and field current.

2.18 cooling: A procedure by means of which heat resulting from losses occurring in a machine is given up first to a primary coolant, by increasing its temperature. The heated primary coolant may be replaced by new coolant at a lower temperature or may be cooled by a secondary coolant in some form of heat exchanger.

2.19 coolant: A medium (liquid or gas) by means of which heat is transferred.

2.20 primary coolant: A medium (liquid or gas) which, by being at a lower temperature than a part of a machine and in contact with it, removes heat from that part.

2.21 secondary coolant: A medium (liquid or gas) which, being at a lower temperature than the primary coolant, removes the heat given up by this primary coolant by means of a heat exchanger.

2.22 direct cooled (inner cooled) winding: A winding mainly cooled by coolant flowing in direct contact with the cooled part through hollow conductors, tubes, ducts or channels which, regardless of their orientation, form an integral part of the winding and the main insulation.

2.23 Indirect cooled winding: A winding cooled by any method other than that of 2.22.

NOTES

- 1 In all cases when "indirect" or "direct" is not stated, an indirect cooled winding is implied.
- 2 For other definitions, other than those in 2.18 to 2.23, concerning cooling and coolants, reference should be made to IEC 34-6.

2.24 supplementary insulation: An independent insulation applied in addition to the basic insulation in order to ensure protection against electric shock in the event of failure of the basic insulation.

2.25 moment of inertia: The (dynamic) moment of inertia of a body about an axis is the sum (integral) of the products of its mass elements and the squares of their distances (radii) from the axis.

NOTE – This quantity is designated by the letter symbol J and is expressed in $\text{kg}\cdot\text{m}^2$.

2.26 thermal equivalent time constant: The time constant, replacing several individual time constants, which determines approximately the temperature course in a winding after a step-wise current change.

2.27 encapsulated winding: A winding which is completely enclosed or sealed by moulded insulation.

2.28 rated form factor (λ) of direct current supplied to a d.c. motor armature from a static power converter: The ratio, k_{IN} of the r.m.s. maximum permissible value of the current $I_{\text{r.m.s. maxN}}$ to its mean (average) value I_{avN} at rated conditions, i.e.

$$k_{\text{IN}} = \frac{I_{\text{r.m.s. maxN}}}{I_{\text{avN}}}$$

2.29 current ripple factor: The ratio, q_i of the difference between the maximum value I_{max} and the minimum value I_{min} of an undulating current to two times the average value I_{av} (mean value integrated over one period), i.e.:

$$q_i = \frac{I_{\text{max}} - I_{\text{min}}}{2 I_{\text{av}}}$$

NOTE – For small values of current ripple, the ripple factor may be approximated by the following expression:

$$q_i = \frac{I_{\text{max}} - I_{\text{min}}}{I_{\text{max}} + I_{\text{min}}}$$

The above expression may be used as an approximation if the resulting calculated value of q_i is equal to or less than 0,4.

Section 3: Duty and rating

3 Rules for declaration of duty and for selection of a class of rating

3.1 *Duty*

The duty, as defined in 2.9, may be described by one of the duty types defined in clause 4, or by the specification of another duty by the purchaser.

3.2 *Declaration of duty*

It is the responsibility of the purchaser to declare the duty as accurately as possible.

In certain cases where the load does not vary or where it varies in a known manner, the duty may be declared numerically or with the aid of a time sequence graph of the variable quantities.

If the time sequence is indeterminate, a fictitious time sequence (duty types S2 to S8) not less onerous than the true one, shall be selected, or the duty type S9 shall be applied.

If the duty is not stated, duty type S1 (continuous running duty) applies.

3.3 *Rating*

The rating, as defined in 2.1, is assigned by the manufacturer by selection of one of the classes of rating defined in clause 5. The class of rating selected shall normally be maximum continuous rating based on duty type S1 (continuous running duty), rating with discrete constant loads rating based on duty type S10 (duty with discrete constant loads) or short-time rating based on duty type S2 (short-time duty).

If this is not possible, a periodic duty type rating based on one of the duty types S3 to S8 (periodic duty) or the non-periodic duty type rating based on the duty type S9 (non-periodic duty) shall be selected.

3.4 *Selection of a class of rating*

Where a machine is manufactured for general purposes, it shall have maximum continuous rating and be capable of performing duty type S1.

If the duty has not been specified by the purchaser, duty type S1 applies and the class of rating assigned shall be maximum continuous rating.

When a machine is intended to have a short-time rating, the rating shall be based on duty type S2 as defined in 4.2 and as designated in clause 6.

When a machine is intended to supply varying loads or loads including a period of no-load or periods where the machine will be in a state of rest and de-energized, the class of rating shall be a periodic duty type rating based on a duty type selected from duty types S3 to S8 as defined in 4.3 to 4.8 and as designated in clause 6.

When a machine is intended non-periodically to supply variable loads at variable speeds, including overloads, the non-periodic duty type rating shall be based on duty type S9 as defined in 4.9 and as designated in clause 6.

When a machine is intended to supply discrete constant loads including periods of overload or periods of no-load, or periods where the machine will be in a state of rest and de-energized, the class of rating shall be a rating with discrete constant loads based on duty type S10 as defined in 4.10 and as designated in clause 6.

A class of rating having been assigned to a machine on the basis of a duty type selected from duty types S3 to S9, where a test is specified it is normally sufficient to test the machine at an equivalent continuous rating as defined in 5.3. A class of rating having been assigned to a machine on the basis of duty type S10, where a test is specified it is normally sufficient to test the machine at maximum continuous rating based on duty type S1.

In some cases, a test at the actual or estimated duty may be arranged by agreement between manufacturer and purchaser but such a procedure is not generally practical.

In the determination of the rating:

- for duty types S1 to S8, the specified value(s) of the constant load(s) is taken to be the rated output and is expressed in watts for motors and volt-amperes for generators – see 4.1 to 4.8 and period(s) "N" in figures 1 to 8;
- for duty type S9, a suitable full load value(s) is taken as the rated output – see 4.9 and "P" in figure 9;
- for duty type S10 the maximum value of the load based on duty type S1 is taken as rated output.

4 Duty types*

The duty types are as follows:

4.1 Continuous running duty – Duty type S1

Operation at constant load of sufficient duration for thermal equilibrium to be reached (see figure 1).

* Whilst the ten duty types are intended to apply primarily to motors, certain of them may also be used to define generator duties (e.g. the duty types S1, S2 and S10).

4.2 Short-time duty – Duty type S2

Operation at constant load during a given time, less than that required to reach thermal equilibrium, followed by a rest and de-energized period of sufficient duration to re-establish machine temperatures within 2 K of the coolant (see figure 2).

4.3 Intermittent periodic duty – Duty type S3

A sequence of identical duty cycles, each including a period of operation at constant load and a rest and de-energized period (see figure 3). In this duty, the cycle is such that the starting current does not significantly affect the temperature rise.

NOTE – Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.4 Intermittent periodic duty with starting – Duty type S4

A sequence of identical duty cycles, each cycle including a significant period of starting, a period of operation at constant load and a rest and de-energized period (see figure 4).

NOTE – Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.5 Intermittent periodic duty with electric braking – Duty type S5

A sequence of identical duty cycles, each cycle consisting of a period of starting, a period of operation at constant load, a period of rapid electric braking and a rest and de-energized period (see figure 5).

NOTE – Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.6 Continuous-operation periodic duty – Duty type S6

A sequence of identical duty cycles, each cycle consisting of a period of operation at constant load and a period of operation at no-load. There is no rest and de-energized period (see figure 6).

NOTE – Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.7 Continuous-operation periodic duty with electric braking – Duty type S7

A sequence of identical duty cycles, each cycle consisting of a period of starting, a period of operation at constant load and a period of electric braking. There is no rest and de-energized period (see figure 7).

NOTE – Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.8 Continuous-operation periodic duty with related load/speed variations – Duty type S8

A sequence of identical duty cycles, each cycle consisting of a period of operation at constant load corresponding to a predetermined speed of rotation, followed by one or more periods of operation at other constant loads corresponding to different speeds of rotation (carried out for example by means of a change of the number of poles in the case of induction motors). There is no rest and de-energized period (see figure 8).

NOTE – Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.9 Duty with non-periodic load and speed variations – Duty type S9

A duty in which generally load and speed are varying non-periodically within the permissible operating range. This duty includes frequently applied overloads that may greatly exceed the full loads (see figure 9).

4.10 Duty with discrete constant loads – Duty type S10

A duty consisting of not more than four discrete values of load (or equivalent loading), each value being maintained for sufficient time to allow the machine to reach thermal equilibrium (see figure 10). The minimum load within a duty cycle may have the value zero (no-load or rest and de-energized).

NOTES

1 The discrete values of load will usually be equivalent loading based on integration over a period of time. It is not necessary that each load cycle be exactly the same, only that each load within a cycle be maintained for sufficient time for thermal equilibrium to be reached, and that each load cycle be capable of being integrated to give the same thermal life expectancy.

2 For this duty type, a constant load appropriately selected and based on duty type S1 should be taken as the reference value for the discrete loads (equivalent loading).

5 Classes of rating

In assigning the rating, the manufacturer shall select one of the classes of rating defined in 5.1 to 5.6.

5.1 Maximum continuous rating

A rating at which the machine may be operated for an unlimited period, while complying with the requirements of this standard.

5.2 Short-time rating

A rating at which the machine may be operated for a limited period, starting at the ambient temperature, while complying with the requirements of this standard.

5.3 Equivalent continuous rating

A rating for test purposes at which the machine may be operated until thermal equilibrium is reached and which is considered to be equivalent to one of the periodic duty types defined in 4.3 to 4.8 or to the duty type S9, as defined in 4.9, while complying with the requirements of this standard.

5.4 Periodic duty type rating

A rating at which the machine may be operated on duty cycles while complying with the requirements of this standard.

This class of rating, if applied, shall correspond to one of the periodic duty types defined in 4.3 to 4.8.

The time for a duty cycle shall be 10 min and the cyclic duration factor shall be one of the following values:

15 %, 25 %, 40 %, 60 %.

5.5 *Non-periodic duty type rating*

A rating at which the machine may be operated non-periodically while complying with the requirements of this standard.

This class of rating, if applied, shall correspond to the non-periodic duty with non-periodic load and speed variations, as defined in 4.9.

5.6 *Discrete constant loads rating*

A rating at which the machine may be operated with the associated loads of duty type S10 as defined in 4.10 for an unlimited period of time while complying with the requirements of this standard. The maximum permissible load within one cycle shall take into consideration all parts of the machine, e.g. the insulation system regarding the validity of the exponential law for the thermal life expectancy, bearings with respect to temperature, other parts with respect to thermal expansion. Unless specified in other relevant IEC standards, the maximum load shall not exceed 1,2 times the maximum value of the load based on duty type S1. The minimum load may have the value zero, the machine operating at no-load or being at rest and de-energized. Considerations for the application of this class of rating are given in annex A.

6 Designation

6.1 *Duty types*

A duty type may be designated by an abbreviation of the terms given in clause 4, for example duty types S1 and S9 by S1 and S9.

For the duty type S2, the abbreviation S2 is followed by an indication of the duration of the duty. For duty types S3 and S6, the abbreviations S3 and S6 are followed by the cyclic duration factor.

Examples: S2 60 min
 S3 25 %
 S6 40 %

For the duty types S4 and S5, the abbreviations S4 and S5 are followed by the indication of the cyclic duration factor and the moment of inertia of the motor, J_M , and the moment of inertia of the load, J_{ext} , both referred to the motor shaft.

Example: S4 25 % $J_M = 0,15 \text{ kg m}^2$ $J_{ext} = 0,7 \text{ kg m}^2$

For the duty type S7, the abbreviation S7 is followed by the moment of inertia of the motor (J_M) and the moment of inertia of the load (J_{ext}), both referred to the motor shaft.

Example: S7 $J_M = 0,4 \text{ kg m}^2$ $J_{ext} = 7,5 \text{ kg m}^2$

For the duty type S8, the abbreviation S8 is followed by the moment of inertia of the motor, J_M , and the moment of inertia of the load J_{ext} , both referred to the motor shaft, together with the load, speed and cyclic duration factor for each speed condition.

Example: S8	$J_M = 0,5 \text{ kg m}^2$	$J_{ext} = 6 \text{ kg m}^2$	16 kW	740 r/min	30 %
			40 kW	1 460 r/min	30 %
			25 kW	980 r/min	40 %

For the duty type S10, the abbreviation S10 is followed by the p.u. quantities $p/\Delta t$ for the respective load and its duration and the p.u. quantity TL for the thermal life expectancy of the insulation system. The reference value for the thermal life expectancy is the thermal life expectancy at maximum continuous rating and permissible limits of temperature rise based on duty type S1. For rest and de-energized periods the load shall be indicated by letter r .

Example: S10 $p/\Delta t = 1,1/0,4$ $1/0,3$ $0,9/0,2,$ $r/0,1,$ $TL = 0,6$

The value of TL shall be rounded off to the nearest multiple of 0,05. Advice concerning the significance of this parameter and derivation of its value is given in annex A.

6.2 *Classes of rating*

The designations of the classes of rating are as follows:

- maximum continuous rating – "cont" or "S1";
- discrete constant loads rating – S10 together with the declared value of TL;
- short-time rating – duration of the operating period, e.g. "60 min" or "S2 60 min";
- equivalent continuous rating – "equ";
- periodic and non-periodic duty type ratings – as for the duty types (see above, for example "S3 25 %").

The designations specified in 6.1 and 6.2 follow the value of the rated output. If no designation follows the rated output, maximum continuous rating applies.

7 Assignment of ratings

The ratings shall be assigned in accordance with the requirements of this section and be marked on the rating plate in accordance with section 10.

For machines with more than one rating, the machine shall comply with this standard in all respects at each rating.

Where reactors are connected between machine terminals and the supply and are regarded as an integral part of the machine, the rated values shall refer to the terminals of the reactor on the supply side.

NOTE – This does not apply to power transformers connected between the machine and the supply

For all machines the preferred rated output values expressed in watts, shall be taken from the R40 series of preferred numbers, rounded-off in accordance with ISO 497.

When a specific IEC publication exists for machines of a particular type, the rated output values shall be in accordance with any series specified in that publication.

Special consideration is required when assigning ratings to machines fed from or supplying static converters. IEC 34-17 gives guidance for the case of cage induction motors covered by IEC 34-12.

8 Rated output

8.1 D.C. generators

The rated output is the output at the terminals and shall be expressed in watts (W).

8.2 A.C. generators

The rated output is the apparent electric power at the terminals and shall be expressed in volt-amperes (VA) together with the power factor.

The rated power factor for synchronous generators shall be 0,8 lagging (over-excited) unless otherwise specified.

8.3 Motors

The rated output is the mechanical power available at the shaft and shall be expressed in watt (W).

NOTE – It is the practice in many countries for the mechanical power available at the shafts of motors to be expressed also in horsepower (1 h.p. is equivalent to 745,7 W, 1 ch (cheval or metric horsepower) is equivalent to 736 W).

8.4 Synchronous condensers

The rated output is the reactive power at the terminals and shall be expressed in volt-amperes reactive (var) in both the leading (under-excited) and the lagging (over-excited) conditions.

9 Rated voltage

9.1 Rated voltage at the terminals

The rated voltage is the voltage between lines at the terminals of the machine at rated output.

9.2 Generators intended for operation over a relatively small range of voltages

D.C. generators

For d.c. generators intended to operate over a relatively small range of voltage, the rated output and current shall relate to the highest voltage of the range, unless otherwise specified (see also 12.3).

A.C. generators.

For a.c. generators intended to operate over a relatively small range of voltage, the rated output and power factor shall relate to any voltage within the range, unless otherwise specified (see also 12.3).

10 Machines with more than one rating

10.1 Ratings for multi-speed motors

For multi-speed motors, a definite rating shall be assigned for each speed.

10.2 Ratings for machines with varying quantities

When a rated quantity (output, voltage, speed, etc.) may assume several values or vary continuously within two limits, the rating shall be stated at these values or limits. This provision does not apply to voltage variations of $\pm 5\%$ or to star-delta connections intended for starting.

Section 4: Operating conditions

11 Altitude, ambient temperature and coolant temperature

Machines shall be designed for the following operating site conditions unless other conditions are specified by the purchaser. For machines intended for operation at site conditions other than the following, the requirements of 16.3 apply.

11.1 Altitude

The height above sea level does not exceed 1 000 m.

11.2 Ambient temperature

The temperature of the air at the operating site does not exceed 40 °C.

11.3 Temperature of the water at inlet to water-cooled heat exchangers

The temperature of the water at inlet to the heat exchanger does not exceed 25 °C.

11.4 Minimum ambient and coolant temperature

The minimum temperature of the air at the operating site is -15 °C.

The above applies to all machines except the following:

a) A.C. machines with rated outputs exceeding 3 300 kW (or kVA) per 1 000 r/min, machines with rated output less than 600 W (or VA) and all machines having a commutator or sleeve bearings. For these machines, the minimum ambient temperature is 0 °C

b) Machines having water as a primary or secondary coolant. The minimum temperature of the water and the ambient air is +5 °C.

If an ambient temperature lower than that given above is to be expected, the purchaser shall specify the minimum ambient temperature and whether it applies only during transport and storage or also after installation.

11.5 *Characteristics of the gas used as a coolant in hydrogen-cooled machines*

Hydrogen-cooled machines shall be capable of operating at a rated output under rated conditions with a coolant containing not less than 95 % hydrogen by volume.

NOTE – For safety reasons, the hydrogen content should at all times be maintained at 90 % or more, it being assumed that the other gas in the mixture is air.

For calculating efficiency in accordance with IEC 34-2, the standard composition of the gaseous mixture shall be 98 % hydrogen and 2 % air by volume, at the specified values of pressure and temperature of the recooled gas, unless otherwise agreed between the manufacturer and the purchaser. Windage losses shall be calculated at the corresponding density.

12 Electrical conditions

12.1 *Electrical supply*

A.C. machines within the scope of this standard shall be suitable for three-phase, 50 Hz or 60 Hz, with voltages derived from the nominal voltages given in IEC 38.

For a.c. motors supplied from static converters, these restrictions on voltage, frequency and waveform do not apply. In this case the rated voltages shall be selected by agreement between manufacturer and purchaser.

In deriving rated voltages for machines, it is necessary to take into consideration the differences between distribution and utilization system voltages.

For large high-voltage a.c. generators, the voltages may be selected for optimum performance.

12.2 *Form and symmetry of voltages and currents*

AC motors rated for use on a power supply of fixed frequency, supplied from an a.c. generator (whether local or via a supply network) shall be so designed as to be capable of operating under the conditions detailed in 12.2.1, 12.2.2 (see also clause 22) or 12.2.3 as appropriate.

NOTE – When the supply voltage is significantly non-sinusoidal e.g. from static converters, the r.m.s. value of the total waveform and of the fundamental waveform are both relevant in determining the performance of an a.c. motor.

AC motors supplied from static converters have to tolerate higher harmonic contents of the supply voltage (see IEC 34-17 for the case of cage motors within the scope of IEC 34-12).

12.2.1 A.C. motors shall be suitable for operation on a supply voltage having a harmonic content as limited by the requirements of a) below, and, for a polyphase motor, from a supply system where the voltage unbalance is defined by the requirements of b) below.

Should the limits in a) and b) occur simultaneously in service at the rated load, this shall not lead to any deleterious temperature in the motor and it is recommended that the excess resulting temperature rise or temperature related to the limits specified in tables 1, 2 and 3 should be not more than approximately 10 K.

a) Three-phase a.c. motors (including synchronous motors, but not design N motors) and a.c. single-phase motors shall be suitable for operation on a supply voltage having a harmonic voltage factor (HVF) not exceeding 0,02 unless the manufacturer declares otherwise.

Design N motors (see IEC 34-12) shall be suitable for operation on a supply voltage having an HVF not exceeding 0,03.

The HVF shall be computed by using the following formula:

$$\text{HVF} = \sqrt{\sum \frac{u_n^2}{n}}$$

where

u_n is the per unit value of the harmonic voltage (referred to rated voltage U_N)

n is the order of harmonic (not divisible by three in the case of three-phase a.c. motors)

Usually it is sufficient to consider harmonic orders $n \leq 13$.

In temperature-rise testing as specified in section 5, the HVF shall not exceed 0,015.

b) A polyphase voltage system is deemed to form a virtually balanced system of voltages if its negative-sequence component does not exceed 1 % of its positive-sequence component over a long period, or 1,5 % for a short period not exceeding a few minutes, and if the voltage of its zero-sequence component does not exceed 1 % of its positive-sequence component.

NOTE — Motors shall be able to operate with a negative sequence component of voltage of 2 %; but this may involve very severe conditions which could affect the life of motors.

In temperature-rise testing as specified in section 5, the negative-sequence component of the system of voltages shall be less than 0,5 % of the positive-sequence component, the influence of the zero-sequence system being eliminated. By agreement between manufacturer and purchaser, the negative-sequence component of the system of currents may be measured instead of the negative-sequence component of the voltages, and shall not exceed 2,5 % of the positive-sequence component of the system of currents.

NOTE — In the vicinity of large single-phase loads (e.g. induction furnaces), and in rural areas particularly on mixed industrial and domestic systems, supplies may be distorted beyond the limits set out above. Special arrangements will then be necessary between manufacturer and purchaser.