

Rotating electrical machines —

Part 1: Rating and performance

The European Standard EN 60034-1:2004 has the status of a
British Standard

ICS 29.160

National foreword

This British Standard is the official English language version of EN 60034-1:2004. It is identical with IEC 60034-1:2004. It supersedes BS EN 60034-1:1998 which will be withdrawn on 1 June 2007. It also supersedes BS 4999-143:1987, which is withdrawn. Recommended schedules for the basic tests that were originally given in BS 4999-143:1987 are given in National Annex NA.

The UK participation in its preparation was entrusted to Technical Committee PEL/2, Rotating electrical machines, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

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English version

Rotating electrical machines
Part 1: Rating and performance
(IEC 60034-1:2004)

Machines électriques tournantes
Partie 1: Caractéristiques assignées
et caractéristiques de fonctionnement
(CEI 60034-1:2004)

Drehende elektrische Maschinen
Teil 1: Bemessung und Betriebsverhalten
(IEC 60034-1:2004)

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CENELEC

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

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Foreword

The text of document 2/1278/FDIS, future edition 11 of IEC 60034-1, prepared by IEC TC 2, Rotating machinery, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60034-1 on 2004-06-01.

This European Standard supersedes EN 60034-1:1998 + corrigendum February 2000 + A1:1998 + A2:1999 + A11:2002.

The major changes introduced in this edition are:

Clause or Subclause	Change
7.2.2	New requirements for a.c. generators to supply non-linear circuits
8	Major changes to Tables 4, 7 and 9
9.1	New requirements for routine tests
9.2	Table 16 Test voltages of auxiliaries
9.11	Total harmonic distortion for synchronous machines
11.1	Protective earthing for machines
12.1	Table 20 Tolerance on efficiency
13	Electromagnetic compatibility

The following dates were fixed:

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- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2007-06-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60034-1:2004 was approved by CENELEC as a European Standard without any modification.

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ROTATING ELECTRICAL MACHINES –

Part 1: Rating and performance

1 Scope

This part of IEC 60034 is applicable to all rotating electrical machines except those covered by other IEC standards, for example, IEC 60349.

Machines within the scope of this standard may also be subject to superseding, modifying or additional requirements in other publications, for example, IEC 60079, and IEC 60092.

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 insofar as they are compatible.

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 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60027-4, *Letter symbols to be used in electrical technology – Part 4: Symbols for quantities to be used for rotating electrical machines*

IEC 60034-2, *Rotating electrical machines – Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)*

IEC 60034-3, *Rotating electrical machines – Part 3: Specific requirements for turbine-type synchronous machines*

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code)- Classification*

IEC 60034-6, *Rotating electrical machines – Part 6: Methods of cooling (IC code)*

IEC 60034-8, *Rotating electrical machines – Part 8: Terminal markings and direction of rotation*

IEC 60034-12, *Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors*

IEC 60034-15, *Rotating electrical machines – Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils*

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

IEC 60034-18 (all parts), *Rotating electrical machines – Functional evaluation of insulating systems*

IEC 60038, *IEC standard voltages*

IEC 60050(411):1996, *International Electrotechnical Vocabulary (IEV) – Chapter 411: Rotating machines*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60072 (all parts), *Dimensions and output series for rotating electrical machines*

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60204-11, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60279, *Measurement of the winding resistance of an a.c. machine during operation at alternating voltage*

IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

IEC 60971, *Semiconductor convertors. Identification code for convertor connections*

IEC 61293, *Marking of electrical equipment with ratings related to electrical supply – Safety requirements*

IEC 61986, *Rotating electrical machines – Equivalent loading and super-position techniques – Indirect testing to determine temperature rise*

IEC 62114, *Electrical insulation systems – Thermal classification*

CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

CISPR 14, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus*

CISPR 16, *Specification for radio disturbance and immunity measuring apparatus and methods*

3 Terms and definitions

For the purposes of this document, the definitions in IEC 60050(411) and the following definitions apply.

For definitions concerning cooling and coolants, other than those in 3.17 to 3.22, reference should be made to IEC 60034-6.

For the purposes of this standard, the term ‘agreement’ means ‘agreement between the manufacturer and purchaser’.

3.1

rated value

a quantity value assigned, generally by a manufacturer, for a specified operating condition of a machine

[IEV 411-51-23]

NOTE The rated voltage or voltage range is the rated voltage or voltage range between lines at the terminals.

3.2

rating

the set of rated values and operating conditions

[IEV 411-51-24]

3.3

rated output

the value of the output included in the rating

3.4

load

all the values of the electrical and mechanical quantities that signify the demand made on a rotating machine by an electrical circuit or a mechanism at a given instant

[IEV 411-51-01]

3.5

no-load (operation)

the state of a machine rotating with zero output power (but under otherwise normal operating conditions)

[IEV 411-51-02, modified]

3.6

full load

the load which causes a machine to operate at its rating

[IEV 411-51-10]

3.7

full load value

a quantity value for a machine operating at full load

[IEV 411-51-11]

NOTE This concept applies to power, torque, current, speed, etc.

3.8

de-energized and rest

the complete absence of all movement and of all electrical supply or mechanical drive

[IEV 411-51-03]

3.9

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

[IEV 411-51-06]

3.10

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

[IEV 411-51-13]

3.11

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

[IEV 411-51-09]

3.12

locked-rotor torque

the smallest measured torque the motor develops at its shaft and with the rotor locked, over all its angular positions at rated voltage and frequency

[IEV 411-48-06]

3.13

locked rotor current

the greatest steady-state r.m.s. current taken from the line with the motor held at rest, over all angular positions of its rotor, at rated voltage and frequency

[IEV 411-48-16]

3.14

pull-up torque (of an a.c. motor)

the smallest 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 this definition.

3.15**breakdown torque (of an a.c. motor)**

the maximum 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 motors with torques that continually decrease with increase in speed.

3.16**pull-out torque (of a synchronous motor)**

the maximum torque which the synchronous motor develops at synchronous speed with rated voltage, frequency and field current

3.17**cooling**

a procedure by means of which heat resulting from losses occurring in a machine is given up to a primary coolant, which may be continuously replaced or may itself be cooled by a secondary coolant in a heat exchanger

[IEV 411-44-01]

3.18**coolant**

a medium, liquid or gas, by means of which heat is transferred

[IEV 411-44-02]

3.19**primary coolant**

a medium, liquid or gas, which, being at a lower temperature than a part of a machine and in contact with it, removes heat from that part

[IEV 411-44-03]

3.20**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 or through the external surface of the machine

[IEV 411-44-04]

3.21**direct cooled (inner cooled) winding¹**

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 inside the main insulation

[IEV 411-44-08]

3.22**indirect cooled winding¹**

any winding other than a direct cooled winding

[IEV 411-44-09]

¹⁾ In all cases when 'indirect' or 'direct' is not stated, an indirect cooled winding is implied.

3.23

supplementary insulation

an independent insulation applied in addition to the main insulation in order to ensure protection against electric shock in the event of failure of the main insulation

3.24

moment of inertia

the sum (integral) of the products of the mass elements of a body and the squares of their distances (radii) from a given axis

3.25

thermal equilibrium

the state reached when the temperature rises of the several parts of the machine do not vary by more than a gradient of 2 K per hour

[IEV 411-51-08]

NOTE Thermal equilibrium may be determined from the time-temperature rise plot when the straight lines between points at the beginning and end of two successive reasonable intervals each have a gradient of less than 2 K per hour.

3.26

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

3.27

encapsulated winding

a winding which is completely enclosed or sealed by moulded insulation

[IEV 411-39-06]

3.28

rated form factor of direct current supplied to a d.c. motor armature from a static power converter

the ratio of the r.m.s. maximum permissible value of the current $I_{\text{rms,maxN}}$ to its average value I_{avN} (mean value integrated over one period):

$$k_{\text{fN}} = \frac{I_{\text{rms,maxN}}}{I_{\text{avN}}}$$

3.29

current ripple factor

the ratio 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):

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

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.

3.30**tolerance**

the permitted deviation between the declared value of a quantity and the measured value

3.31**type test**

a test of one or more machines made to a certain design to show that the design meets certain specifications

[IEV 411-53-01]

NOTE The type test may also be considered valid if it is made on a machine which has minor deviations of rating or other characteristics. These deviations should be subject to agreement.

3.32**routine test**

a test to which each individual machine is subjected during or after manufacture to ascertain whether it complies with certain criteria

[IEV 411-53-02]

4 Duty**4.1 Declaration of duty**

It is the responsibility of the purchaser to declare the duty. The purchaser may describe the duty by one of the following:

- a) numerically, where the load does not vary or where it varies in a known manner;
- b) as a time sequence graph of the variable quantities;
- c) by selecting one of the duty types S1 to S10 that is no less onerous than the expected duty.

The duty type shall be designated by the appropriate abbreviation, specified in 4.2, written after the value of the load.

An expression for the cyclic duration factor is given in the relevant duty type figure.

The purchaser normally cannot provide values for the moment of inertia of the motor (J_M) or the relative thermal life expectancy (TL), see Annex A. These values are provided by the manufacturer.

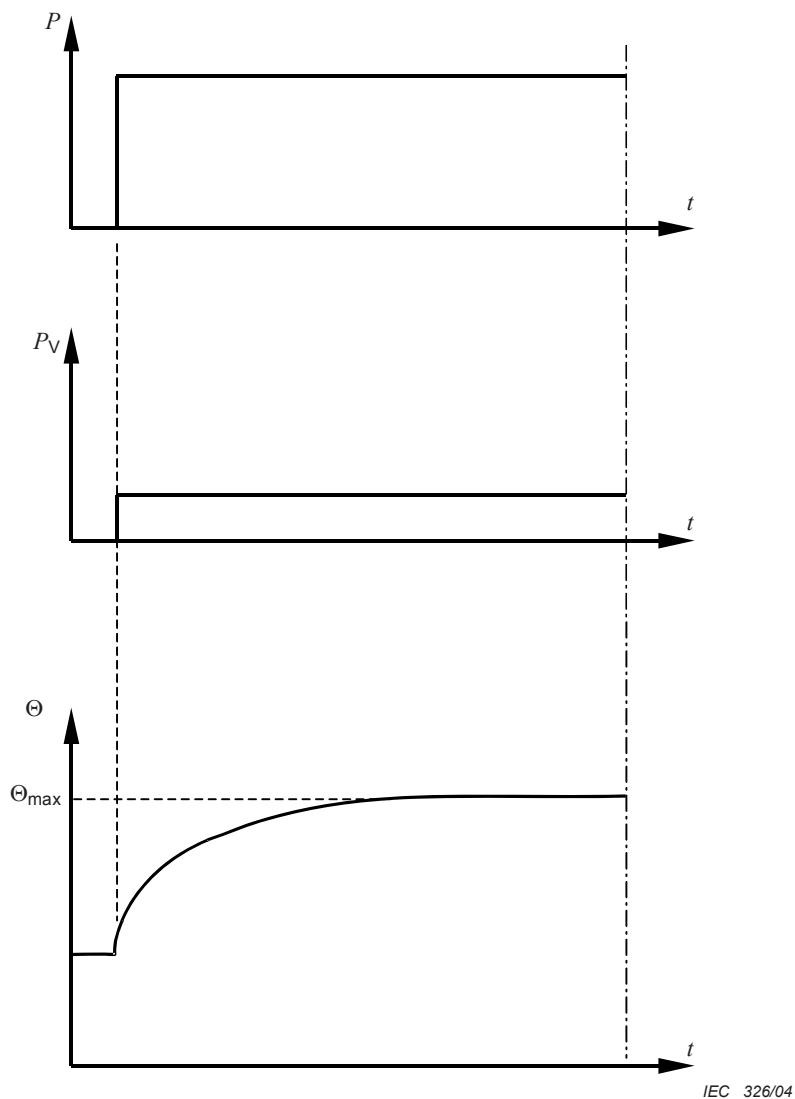
Where the purchaser does not declare a duty, the manufacturer shall assume that duty type S1 (continuous running duty) applies.

4.2 Duty types

4.2.1 Duty type S1 – Continuous running duty

Operation at a constant load maintained for sufficient time to allow the machine to reach thermal equilibrium, see Figure 1.

The appropriate abbreviation is S1.



Key

P	load
P_v	electrical losses
Θ	temperature
$\Theta_{\max}$	maximum temperature attained
t	time

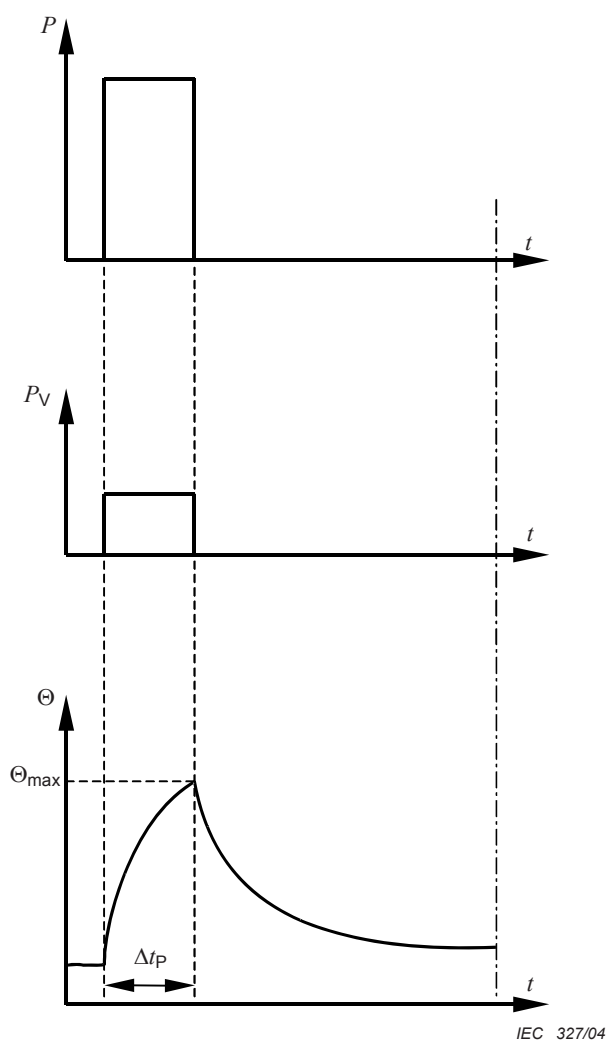
Figure 1 – Continuous running duty – Duty type S1

4.2.2 Duty type S2 – Short-time duty

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

The appropriate abbreviation is S2, followed by an indication of the duration of the duty,

Example: S2 60 min.



Key

P	load
P_v	electrical losses
Θ	temperature
$\Theta_{\max}$	maximum temperature attained
t	time
Δt_p	operation time at constant load

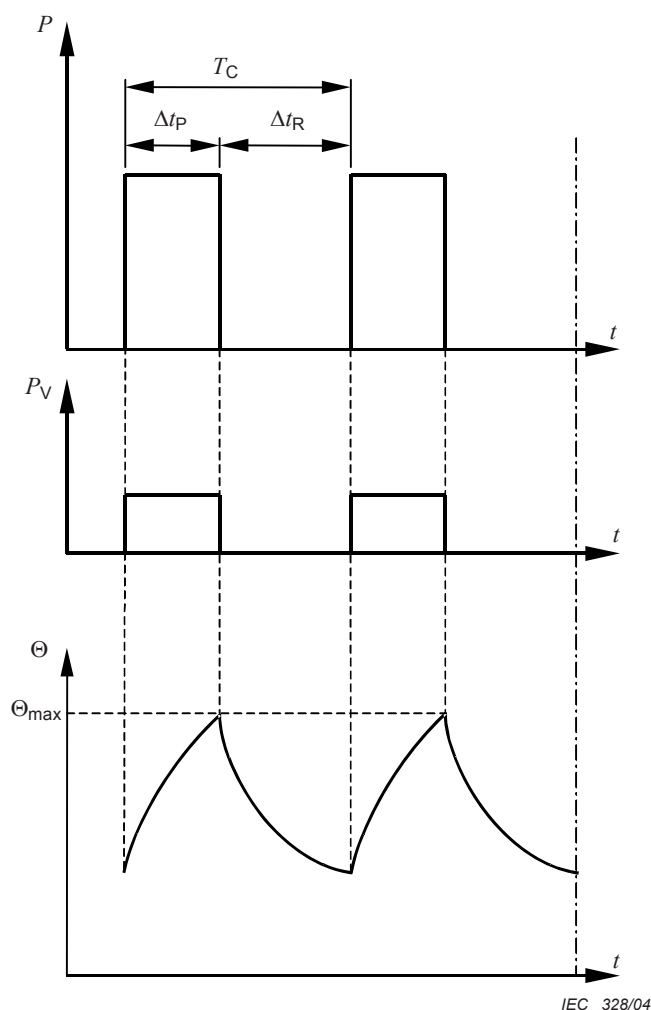
Figure 2 – Short-time duty – Duty type S2

4.2.3 Duty type S3 – Intermittent periodic duty ²

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

The appropriate abbreviation is S3, followed by the cyclic duration factor.

Example: S3 25 %



Key

P	load
P_V	electrical losses
Θ	temperature
$\Theta_{\max}$	maximum temperature attained
t	time
T_C	time of one load cycle
Δt_P	operation time at constant load
Δt_R	time de-energized and at rest
Cyclic duration factor = $\Delta t_P / T_C$	

Figure 3 – Intermittent periodic duty – Duty type S3

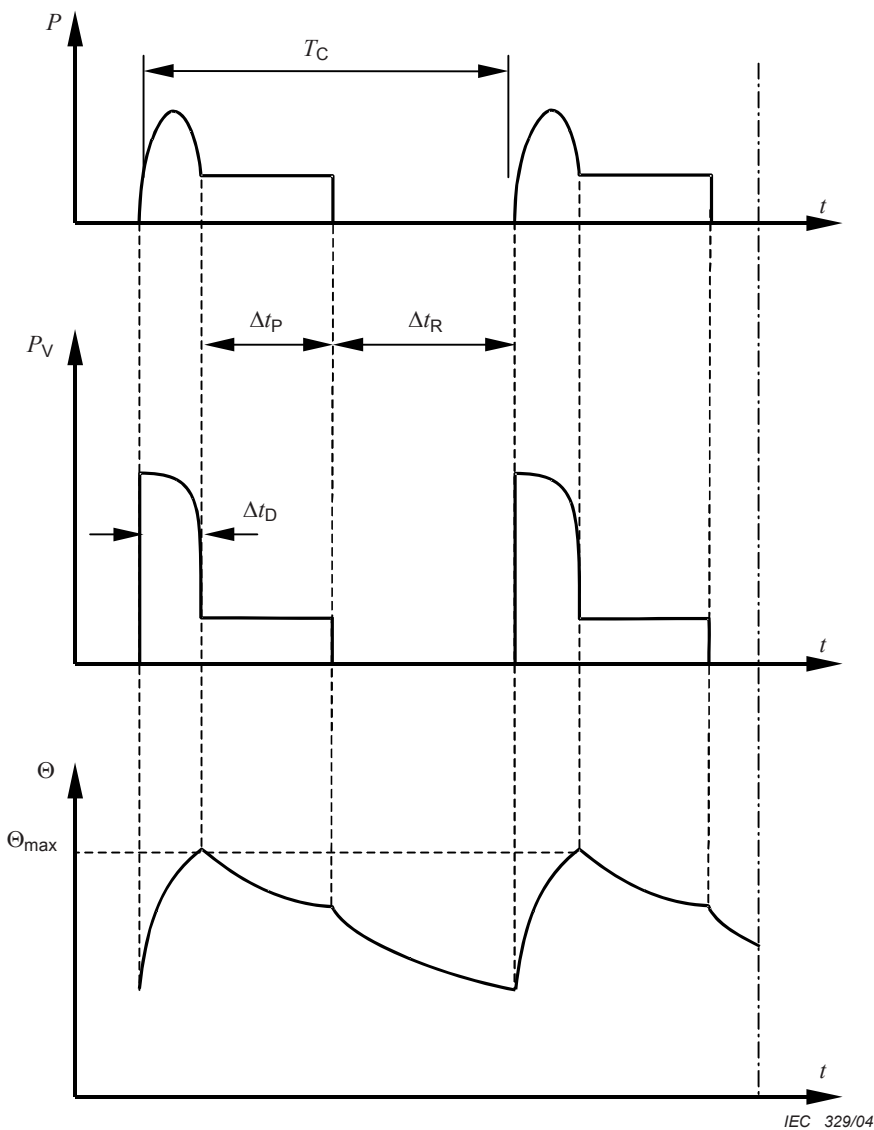
²⁾ Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.2.4 Duty type S4 – Intermittent periodic duty with starting ²

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

The appropriate abbreviation is S4, followed by the cyclic duration factor, 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 % $J_M = 0,15 \text{ kg} \times \text{m}^2$ $J_{ext} = 0,7 \text{ kg} \times \text{m}^2$



Key

P	load	t	time
P_V	electrical losses	T_C	time of one load cycle
Θ	temperature	Δt_D	starting/accelerating time
Θ_{max}	maximum temperature attained	Δt_P	operation time at constant load
		Δt_R	time de-energized and at rest

Cyclic duration factor = $(\Delta t_D + \Delta t_P)/T_C$

Figure 4 – Intermittent periodic duty with starting – Duty type S4

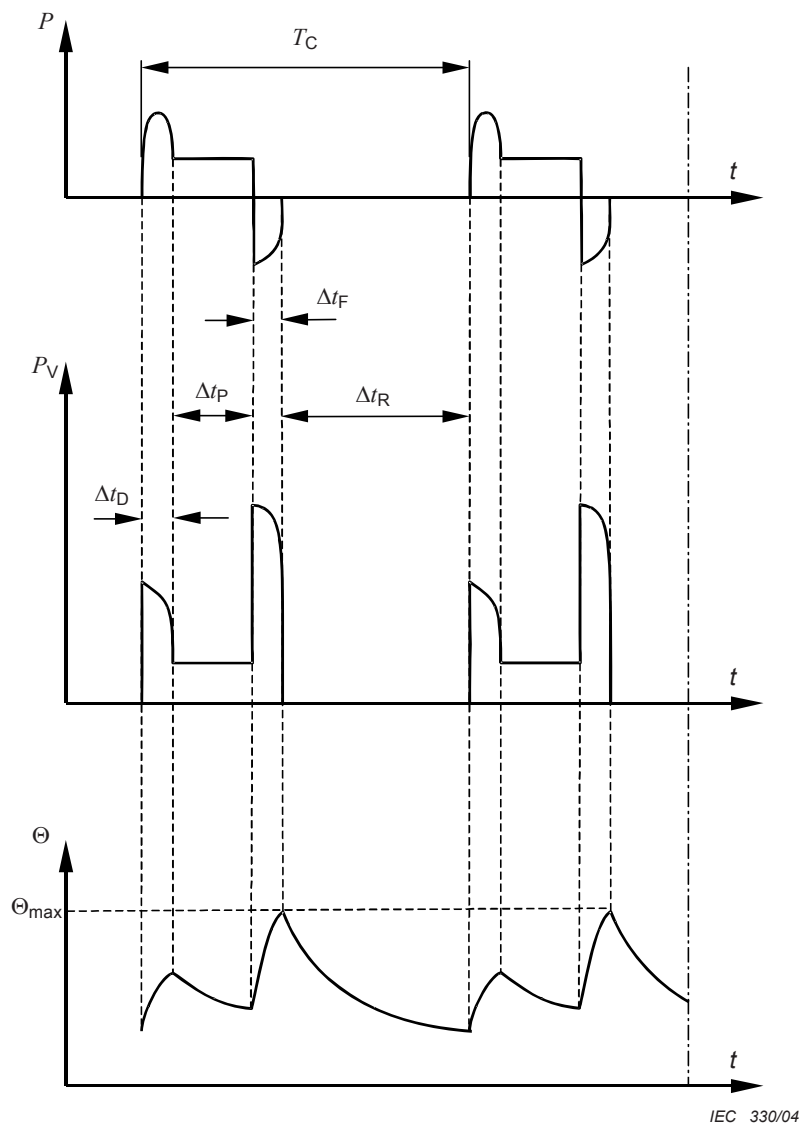
² Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.2.5 Duty type S5 – Intermittent periodic duty with electric braking ²

A sequence of identical duty cycles, each cycle consisting of a starting time, a time of operation at constant load, a time of electric braking and a time de-energized and at rest, see Figure 5.

The appropriate abbreviation is S5, followed by the cyclic duration factor, 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: S5 25 % $J_M = 0,15 \text{ kg} \times \text{m}^2$ $J_{ext} = 0,7 \text{ kg} \times \text{m}^2$



IEC 330/04

Key

P	load	T_C	time of one load cycle
P_V	electrical losses	Δt_D	starting/accelerating time
Θ	temperature	Δt_P	operation time at constant load
Θ_{max}	maximum temperature attained	Δt_F	time of electric braking
t	time	Δt_R	time de-energized and at rest

Cyclic duration factor = $(\Delta t_D + \Delta t_P + \Delta t_F)/T_C$

Figure 5 – Intermittent periodic duty with electric braking – Duty type S5

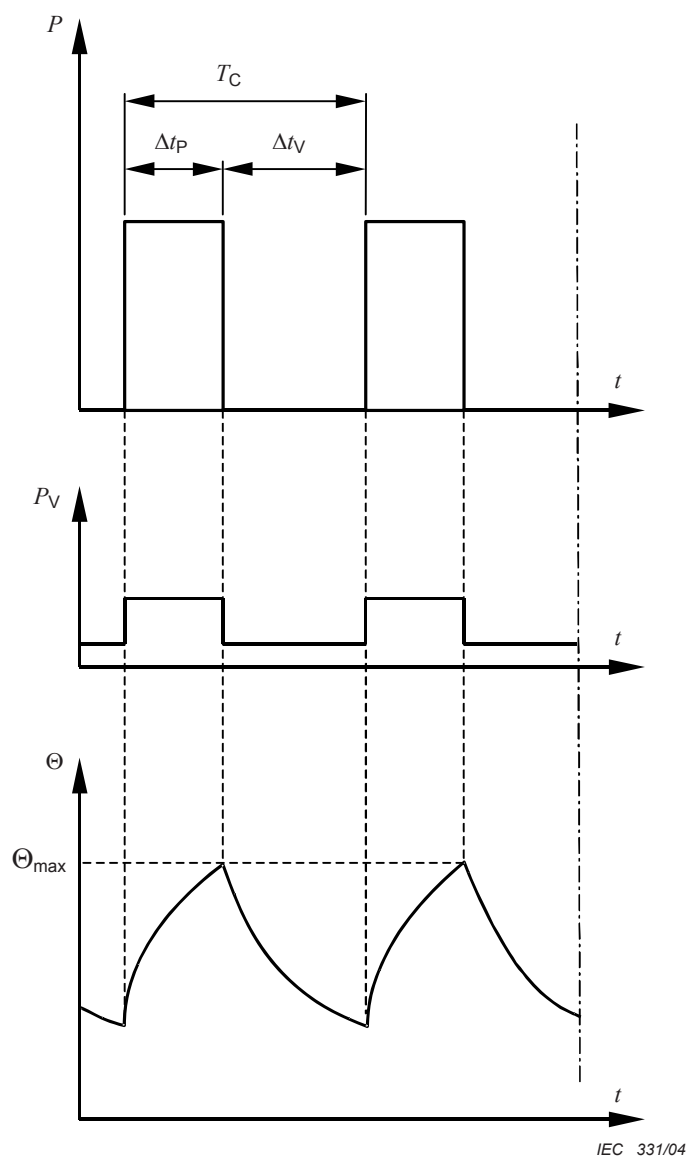
² Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.2.6 Duty type S6 – Continuous-operation periodic duty ²

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

The appropriate abbreviation is S6, followed by the cyclic duration factor.

Example: S6 40 %



Key

P	load	t	time
P_V	electrical losses	T_C	time of one load cycle
Θ	temperature	Δt_P	operation time at constant load
$\Theta_{\max}$	maximum temperature attained	Δt_V	operation time at no-load
Cyclic duration factor = $\Delta t_P / T_C$			

Figure 6 – Continuous operation periodic duty – Duty type S6

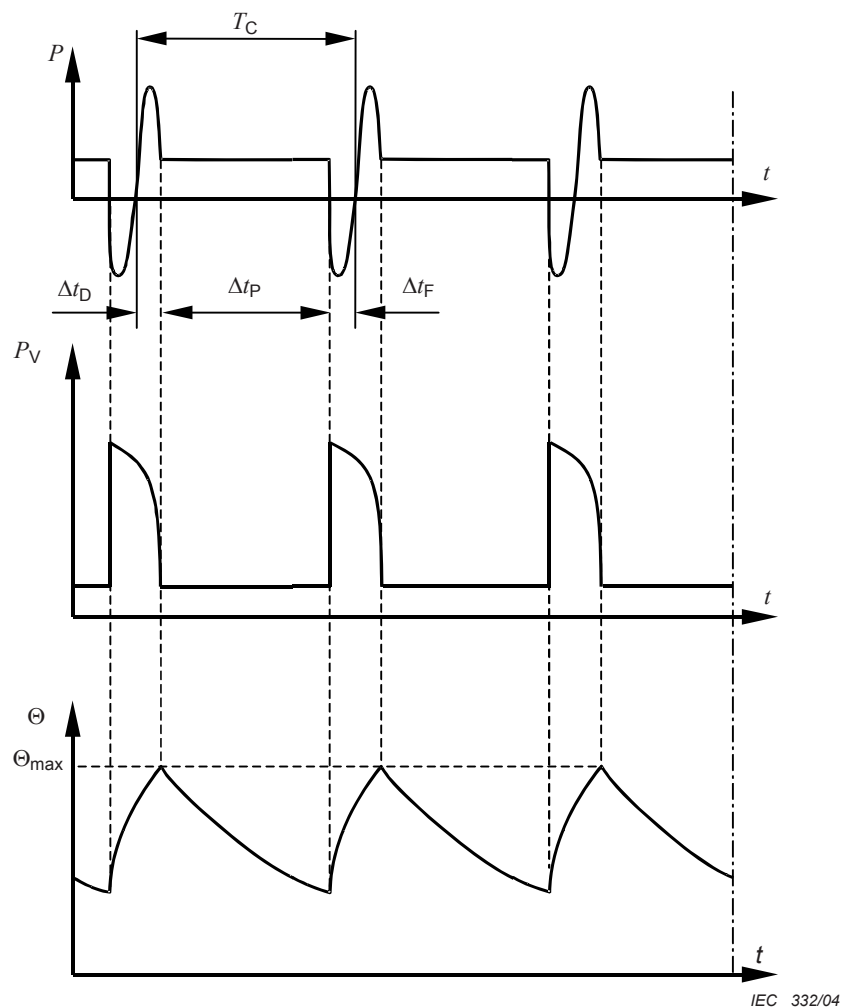
² Periodic duty implies that thermal equilibrium is not reached during the time on load.

4.2.7 Duty type S7 – Continuous-operation periodic duty with electric braking ²

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

The appropriate abbreviation is S7, 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 $J_M = 0,4 \text{ kg} \times \text{m}^2$ $J_{ext} = 7,5 \text{ kg} \times \text{m}^2$



Key

P	load	t	time
P_V	electrical losses	T_C	time of one load cycle
Θ	temperature	Δt_D	starting/accelerating time
Θ_{max}	maximum temperature attained	Δt_P	operation time at constant load
Cyclic duration factor = 1		Δt_F	time of electric braking

Figure 7 – Continuous operation periodic duty with electric braking – Duty type S7

² Periodic duty implies that thermal equilibrium is not reached during the time on load.

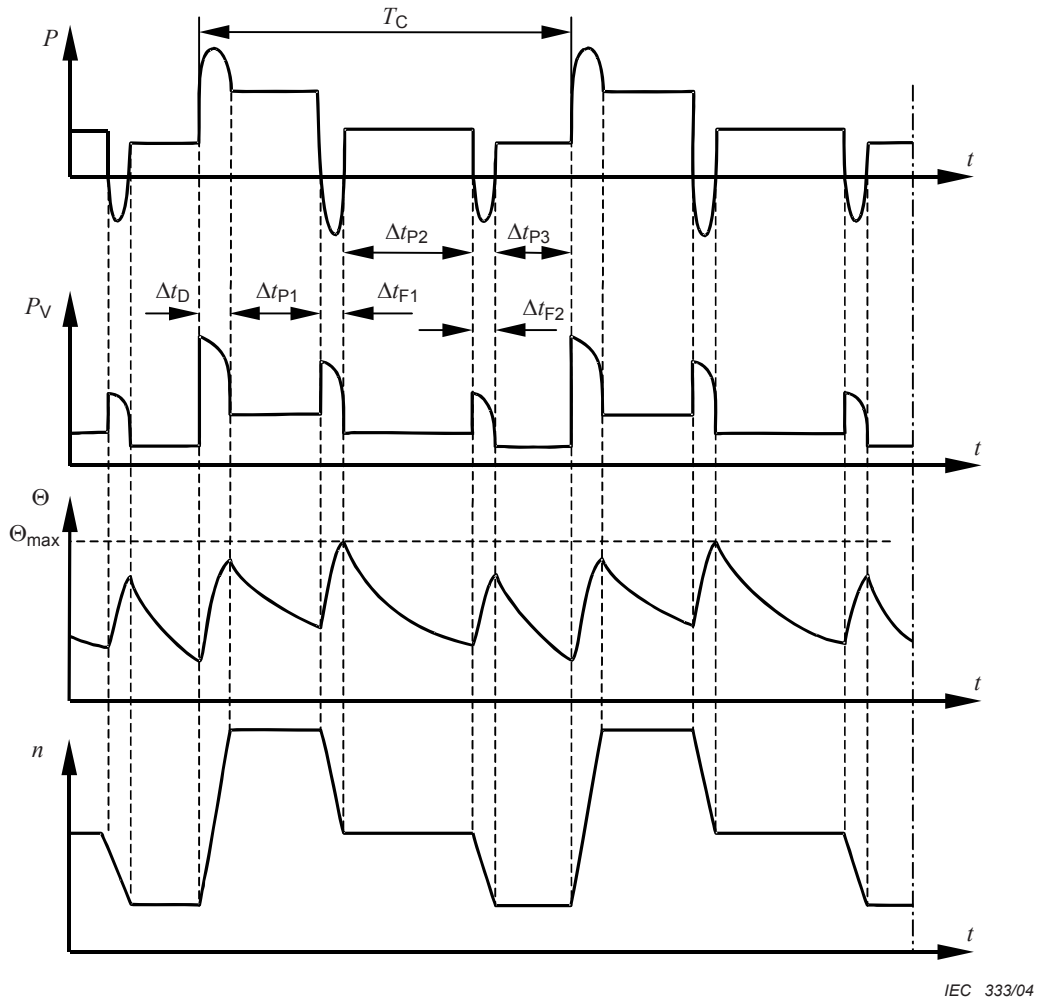
4.2.8 Duty type S8 – Continuous-operation periodic duty with related load/speed changes ²

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

The appropriate abbreviation is S8, 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 $J_M = 0,5 \text{ kg} \times \text{m}^2$	$J_{ext} = 6 \text{ kg} \times \text{m}^2$	16 kW	740 min ⁻¹	30 %
			40 kW	1 460 min ⁻¹	30 %
			25 kW	980 min ⁻¹	40 %

² Periodic duty implies that thermal equilibrium is not reached during the time on load.



Key

P	load	t	time
P_V	electrical losses	T_C	time of one load cycle
Θ	temperature	Δt_D	starting/accelerating time
Θ_{max}	maximum temperature attained	Δt_P	operation time at constant load (P1, P2, P3)
n	speed	Δt_F	time of electric braking (F1, F2)
Cyclic duration factor = $(\Delta t_D + \Delta t_{P1})/T_C$; $(\Delta t_{F1} + \Delta t_{P2})/T_C$; $(\Delta t_{F2} + \Delta t_{P3})/T_C$			

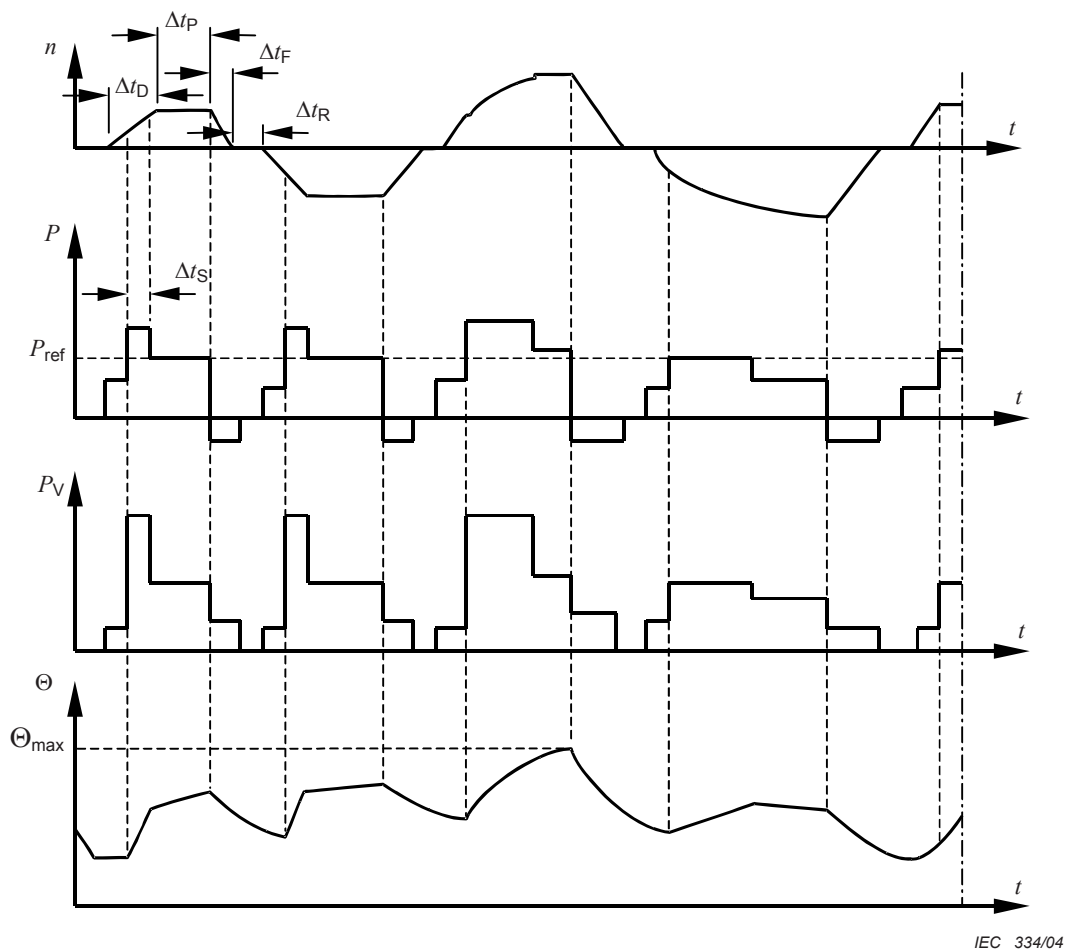
Figure 8 – Continuous operation periodic duty with related load/speed changes – Duty type S8

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

A duty in which generally load and speed vary non-periodically within the permissible operating range. This duty includes frequently applied overloads that may greatly exceed the reference load (see Figure 9).

The appropriate abbreviation is S9.

For this duty type, a constant load appropriately selected and based on duty type S1 is taken as the reference value (" P_{ref} " in Figure 9) for the overload concept.



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Key

P	load	t	time
P_{ref}	reference load	Δt_{D}	starting/accelerating time
P_{V}	electrical losses	Δt_{P}	operation time at constant load
Θ	temperature	Δt_{F}	time of electric braking
Θ_{max}	maximum temperature attained	Δt_{R}	time de-energized and at rest
n	speed	Δt_{S}	time under overload

Figure 9 – Duty with non-periodic load and speed variations – Duty type S9