IEC 60034-19

Edition 2.0 2014-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Rotating electrical machines –
Part 19: Specific test methods for d.c. machines on conventional and rectifier-fed supplies

Machines électriques tournantes –
Partie 19: Méthodes spécifiques d'essai pour machines à courant continu à alimentation conventionnelle ou redressée

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ROTATING ELECTRICAL MACHINES –

Part 19: Specific test methods for d.c. machines on conventional and rectifier-fed supplies

FOREWORD

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International Standard IEC 60034-19 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition published in 1995. It constitutes a technical revision. The main technical changes with regard to the previous edition are as follows:

a) The description of the procedure for black band testing has been detailed and clarified.

b) Procedures for measurement of the magnetization curves under no-load and load conditions have been added.

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

FDIS	Report on voting
2/1756/FDIS	2/1764/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

NOTE A table of cross-references of all IEC TC 2 publications can be found on the IEC TC 2 dashboard on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

ROTATING ELECTRICAL MACHINES –

Part 19: Specific test methods for d.c. machines on conventional and rectifier-fed supplies

1 Scope

This part of IEC 60034 applies to d.c. machines rated 1 kW and above operating on rectifier-fed power supplies, d.c. buses or other d.c. sources.

Standardized methods are provided for determining characteristic quantities for conventional and rectifier-fed d.c. machines.

Excluded are d.c machines for specific applications.

These methods supplement the requirements in IEC 60034-1 and IEC 60034-2-1.

NOTE It is not intended that this standard should be interpreted as requiring the carrying out of any or all of the tests described therein on any given machine.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-2-1, *Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

3 Terms, definitions, symbols and subscripts

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
current ripple
peak-to-peak amplitude of the armature current of rectifier-fed d.c. machines

3.1.2
voltage ripple
peak-to-peak amplitude of the terminal voltage of rectifier-fed d.c. machines

3.1.3
time constant
time to achieve 63,2 % of steady-state value after applying a d.c. step input, assuming a first order system

3.1.4
black band zone
interval between the current limits of the commutating poles, between which sparkless commutation is attainable for load currents up to and including rated current

3.1.5
sparkless
absence of any type of sparking

3.2 Symbols

C is the capacitance, [F]

f is the frequency, [Hz]

I, i is the current, [A]

L is the inductance, [H]

n is the speed, [min^{-1}]

P is the power, [W]

R is the winding resistance, [Ω]

t is the time, [s]

U is the voltage, [V]

Δ_n is the black band width, [%]

δ_n is the black band shift, [%]

τ is the time constant, [s]

θ is the phase angle

3.3 Subscripts

1 input

2 output

a armature

b boost

e exciter

f field

LL additional loss

n test point

N rated condition

s subtract

0 no-load

∞ ultimate

4 Determination of current and voltage specific quantities (rectifier-fed)

4.1 General

This test serves to determine the variation of the terminal voltage and armature current for rectifier-fed d.c. machines at rated conditions.

4.2 Current ripple

The armature current ripple is best measured with an oscilloscope incorporating capability for reading both d.c. and a.c. values. An alternative method is to use a peak-to-peak reading voltmeter, reading the voltage drop across a non-inductive resistor in series with the armature circuit.

4.3 Voltage ripple

The voltage ripple may be measured using an oscilloscope, a suitable oscillograph or an electronic peak-to-peak indicating voltmeter in series with an appropriate blocking capacitor of sufficient size not to affect the a.c. readings.

It should be noted that in measuring the peak-to-peak value, deviations from the main waveform due to high frequency spikes should be ignored.

4.4 Measurement of average values

In the case of rectifier supply, the average d.c. values of armature voltage and current can be measured using permanent-magnet moving-coil type instruments, or other instruments including digital instrumentation known to provide true average readings.

4.5 Measurement of root-mean-square values

Root-mean-square values can be measured using electrodynamometer type, moving-iron type, or other instruments including digital instrumentation known to provide true r.m.s. readings. AC instrumentation of the type using rectifiers to sense only a portion of the voltage or current signal and instruments whose calibration is based on the assumption of a sinusoidal waveform shall not be used. Oscilloscope readings of the voltage and current signals are recommended.

4.6 Calculation of current and voltage ripple factors and form factor

The current ripple factors and the form factor shall be calculated using the formulas of IEC 60034-1, with maximum, minimum, average and r.m.s. waveform values measured according to 4.2 to 4.5 of this part. The voltage ripple factor shall be calculated similar to the current ripple factor.

5 Determination of the armature circuit inductance

5.1 Procedure performed before starting the tests

It is recommended to measure the armature circuit inductance by applying a single phase 50 Hz or 60 Hz alternating current to the armature circuit terminals of the machine. The rotor shall be locked to prevent rotation. Normal carbon brushes can be used if the alternating current is limited to approximately 20 % of the current rating of the machine to avoid overheating of the brushes or of the commutator during the short tests. The brushes shall be completely in contact with the commutator surface and inspected before the test is started and after the test is finished.

In declaring values of inductance it shall be stated whether the value refers to the saturated or unsaturated condition.

Measure and record the r.m.s. value of voltage U, current I, frequency f and the phase angle θ between voltage and current. The phase angle may be determined using suitable means such as an oscilloscope or a phasemeter, or by an indirect method, e.g. using a wattmeter.

5.2 Measurement of armature circuit inductance of shunt and compound-wound machines

The armature circuit inductance of shunt and compound-wound machines is to be measured for both unsaturated and saturated conditions.

For the unsaturated test the shunt-field winding shall be short-circuited to avoid high voltages being induced in the winding. For the saturated test the shunt field is excited as for rated operation from a d.c. power supply, having a current ripple not exceeding 6 %.

5.3 Measurement of armature circuit inductance of series-excited machine

The test on a series-excited machine is to be done for the saturated condition only. This test shall be carried out with the series-field winding separately excited at rated current using a d.c. power supply having a current ripple factor not exceeding 6 %.

The saturated inductance, so determined, does not include the inductance contributed by the series-field which shall be determined as described in 6.3 for the saturated shunt-field test.

5.4 Calculation of armature circuit inductance L_a on the basis of direct measurement

The armature inductance L_a is given by:

$$L_a = \frac{U \cdot \sin\theta}{2\pi \cdot f \cdot I}$$

where U, I, f and θ are determined according to 5.1.

5.5 Saturated armature circuit inductance at a loaded condition

To determine the saturated armature circuit inductance under load, the machine to be tested shall be operated as a generator at about the specified load current, and an a.c. current of about 20 % of the rated current shall be superposed on the d.c. load current by using an a.c. generator, a capacitor C and an inductor L, as shown in Figure 1.

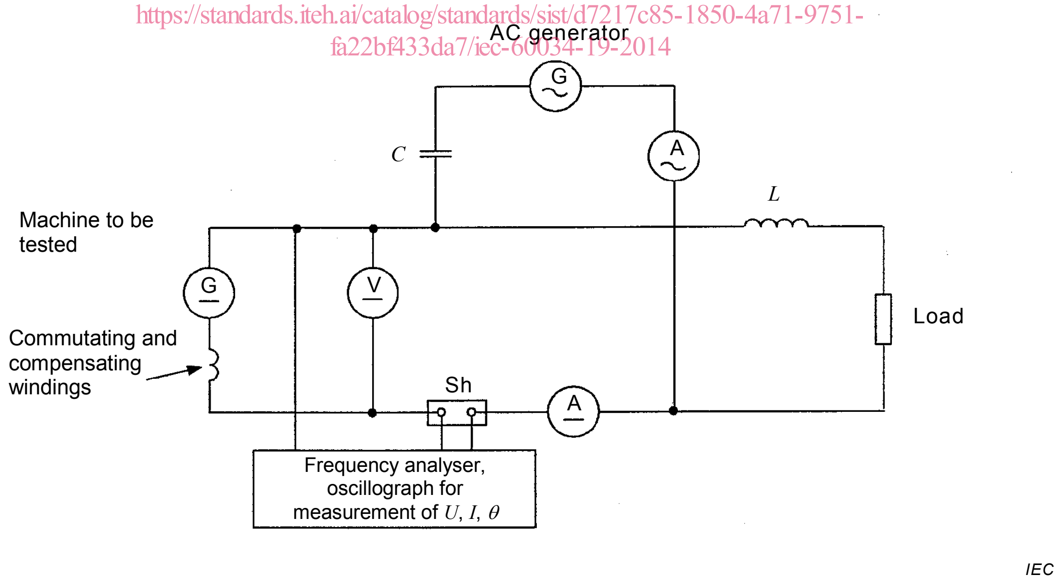

Figure 1 – Determination of saturated armature circuit inductance

The armature circuit inductance is calculated by the same formula as that in 5.4, using the r.m.s. values of a.c. voltage U and a.c. current I.

6 Determination of shunt-field inductance

6.1 General

The shunt-field inductance is to be determined from the rate of rise of shunt-field current upon abrupt application of voltage to the shunt-field terminals. The effective shunt-field inductance is calculated from the rate of rise of direct-axis flux as indicated by the armature voltage appearing at the brushes. During the test the machine is driven at rated full-field speed with the armature open-circuited. The test is to be done for both unsaturated and saturated conditions.

In declaring values of inductance it shall be stated whether the value refers to the saturated or unsaturated condition.

6.2 Unsaturated shunt-field inductance

To find the unsaturated inductance, the shunt-field shall be excited from a voltage source having a regulation at rated full-field excitation of the test machine of less than 2 %. The shunt-field voltage is slowly cycled twice between the value yielding rated armature voltage and zero, and then the armature voltage is reduced to approximately 50 % of rated value.

After recording, the shunt-field voltage is reduced to zero and the field circuit is opened. Then the shunt-field voltage is reset to the recorded value. The shunt-field circuit is closed, and then the shunt-field voltage and current, and the armature voltage are observed and recorded against time.

6.3 Saturated shunt-field inductance

To find the saturated inductance, the shunt-field excitation shall be set (see Figure 2) so that an abrupt change in field voltage produces a change in open-circuit armature voltage from 90 % to 110 % rated value. With the switch closed, the shunt-field supply voltage U_f is adjusted to produce a field current yielding 110 % of rated armature voltage. With the switch opened, R_{ext} (see Figure 2) is cycled twice between the values yielding 90 % and 110 % of rated armature voltage, finishing at the 90 % value. The switch is then closed, and the shunt-field voltage and current and the armature voltage are recorded against time.

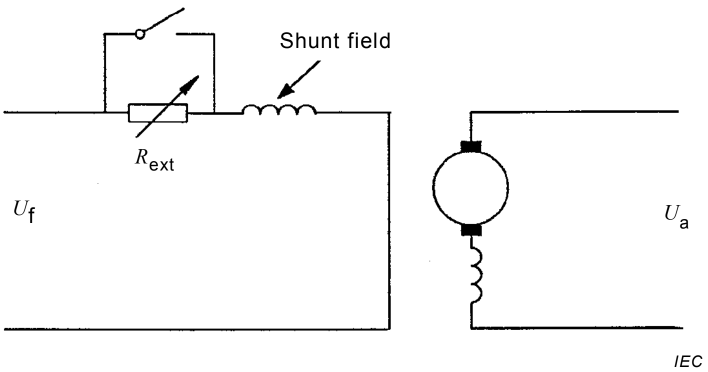

Figure 2 – Test circuit for saturated shunt-field inductance measurement

6.4 Shunt-field inductance with consideration of eddy current effect

The field inductance can be calculated taken the effect of eddy currents in the iron core of the machine on the transient field current into account.

The values of $(I_{f\infty} - I_f)/I_{f\infty}$ against time t are evaluated using a logarithmic scale for the former, where I_f is the magnitude of change in field current after the abrupt application of field voltage and $I_{f\infty}$ is the ultimate value of I_f. In Figure 3 two points p and q are arbitrarily chosen within the straight part of the plot. The value "a" is read on the logarithmic scale at the intersection with the ordinate of the extension of the straight line passing through the two points p and q.

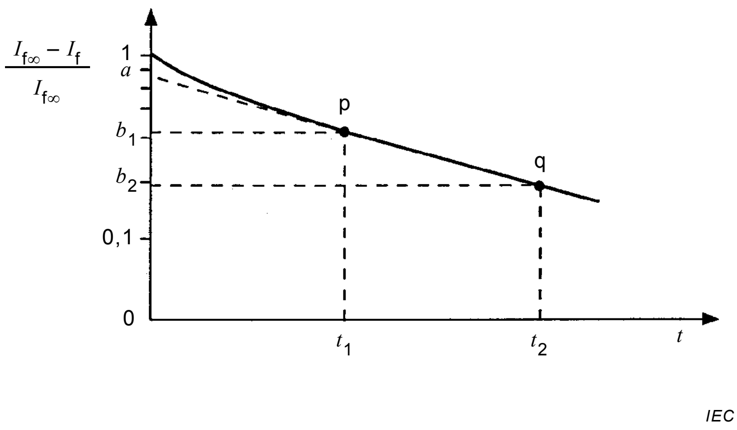

Figure 3 – Determination of the field inductance

The value "c" shall be calculated by:

$$c = \frac{\log_e b_1 - \log_e b_2}{t_2 - t_1}$$

where

b_1 and b_2 are the values of $(I_{f\infty} - I_f)/I_{f\infty}$ at the time t_1 and t_2 respectively. The value of the field inductance is as follows:

$$L_f = R_f \cdot \frac{a}{c}$$

where

R_f is the field resistance.

NOTE This formula is based on the following approximate formula:

$$I_f = I_{f\infty} \cdot \left(1 - \frac{\tau_f}{\tau_f + \tau_e} \cdot e^{-\frac{t}{\tau_f + \tau_e}}\right)$$

where

τ_f is the time constant of the field circuit and τ_e is the time constant of the equivalent eddy current circuit.

6.5 Shunt-field inductance without consideration of eddy current effect

When the effect of eddy current in the iron core may be neglected the experimental values of shunt-field inductance shall be evaluated from the following expressions:

$$L_f = R_f \times \tau_{fI}$$

$$L_{feff} = R_f \times \tau_{aU}$$

where

L_f is the shunt-field inductance;

L_{feff} is the shunt-field effective inductance;