IEC 60773

Edition 2.0 2021-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Rotating electrical machines – Test methods and apparatus for the measurement of the operational characteristics of brushes

Machines électriques tournantes – Méthodes d'essai et appareils pour le mesurage des caractéristiques opérationnelles des balais

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ROTATING ELECTRICAL MACHINES – TEST METHODS AND APPARATUS FOR THE MEASUREMENT OF THE OPERATIONAL CHARACTERISTICS OF BRUSHES

FOREWORD

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International standard IEC 60773 has been prepared by IEC technical committee 2: Rotating machinery.

This second edition cancels and replaces the first edition published in 1983. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– The clause structure has been modified on the view point of a laboratory testing procedure. The new sequence is as follows: test rig specification (Clause 4), general testing procedure (Clause 5), and specific procedure for each operational characteristic (Clauses 6 to 8).
– A new Clause 9 has been added to introduce the black-band test for the characterisation of the brush grades for DC machines.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
2/2045/FDIS	2/2050/RVD

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

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

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

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- withdrawn,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

ROTATING ELECTRICAL MACHINES – TEST METHODS AND APPARATUS FOR THE MEASUREMENT OF THE OPERATIONAL CHARACTERISTICS OF BRUSHES

1 Scope

This document applies to test methods for the measurement of the operational characteristics of brushes designed to operate on commutating and slip ring machines under specified test conditions.

By extension some tests may be relevant for other kinds of sliding electrical contacts for electrical appliances.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-19:2014, *Rotating electrical machines – Part 19: Specific test methods for d.c. machines on conventional and rectifier-fed supplies*

IEC 60136, *Dimensions of brushes and brush-holders for electrical machinery*

IEC 60276:2018, *Carbon brushes, brush holders, commutators and slip-rings – Definitions and nomenclature*

IEC 60356, *Dimensions for commutators and slip-rings*

IEC 60584-1:2013, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 60751:2008, *Industrial platinum resistance thermometers and platinum temperature sensors*

IEC TR 61015, *Brush-holders for electrical machines. Guide to the measurement of the static thrust applied to brushes*

ISO 1190-1:1982, *Copper and copper alloys – code of designation – Part 1: Designation of materials*

ISO 3274:1996, *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Nominal characteristics of contact (stylus) instruments*

ISO 15510:2014, *Stainless steels – Chemical composition*

3 Terms, definitions, symbols and abbreviated terms

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

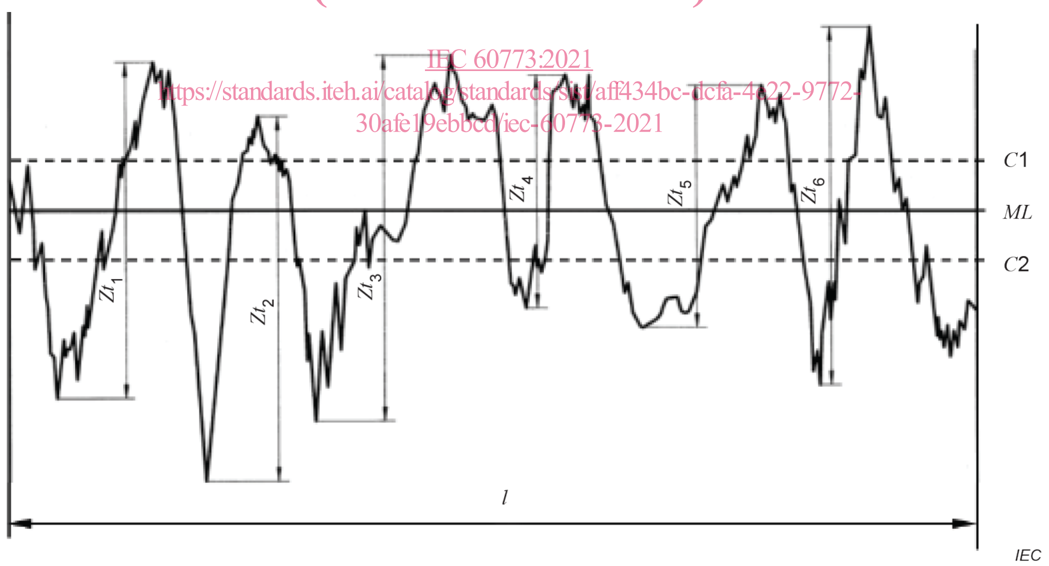
3.1.1
run-out
runout
inaccuracy of the rotating system, measured on the surface of the ring while turning

Note 1 to entry: This includes out-of-round (that is, lacking sufficient roundness); eccentricity (that is, lacking sufficient concentricity); or axial bending (regardless of whether the surfaces are perfectly round and concentric at every cross-sectional point).

3.1.2
roughness
Ra
arithmetic mean of the absolute ordinate value *Z(x)* of a profile within a sampling length *l*

$$Ra = \frac{1}{l} \times \int_0^l |Z(x)| .dx$$

Example: Figure 1 shows an example of profile.



Key

Zt_i	height of profile element *i*
l	sampling length
ML	mean line
C1 and *C2*	upper and lower intersection lines (respectively)

Figure 1 – Profile and determination of height of profile elements

[SOURCE: ISO 4287:1997, Figure 9]

3.1.3
peak count
RPc
number of profile elements per centimeter of sampling length which exceed the upper intersection line *C1* and fall short of the lower intersection line *C2*

Note 1 to entry: Both intersection lines are parallel to the diagram mean line (see Figure 1).

[SOURCE: ISO 4287/A1:2009, 4.3.2]

3.1.4
abrasive stone
material used to grind a surface

Note 1 to entry: The quality of the material and the method of appliance depend on its use. Therefore, for the purpose of this document, definitions 3.1.5, 3.1.7 and 3.1.8 are used.

3.1.5
grinding stone
abrasive stone used to grind the test ring

Note 1 to entry: It is generally made of hard abrasive grains.

3.1.6
brush fitting
operation at the end of which the brush contact surface is matching the ring profile

3.1.7
fitting stone
abrasive stone used for fitting the brush to the commutator/ring

3.1.8
roughness stone
abrasive stone used to obtain the proper range of roughness to the test ring, generally made of soft abrasive grain

3.1.9
brush contact area
S
area of the brush in contact with the ring surface

Note 1 to entry: When radial brush is used the brush contact surface area S_r is the cross-section of the brush:

$$S = t \times a \tag{1}$$

where t and a are respectively the tangential and axial dimensions of the brush.

When inclined brush is used the bottom angle is part of the formula giving the brush contact surface area S_α:

$$S_\alpha = \frac{t \times a}{\cos \alpha} \tag{2}$$

where α is the contact angle (or bottom angle).

3.1.10
brush specific pressure
p
force per contact area of the brush, given by formula (3):

$$p = \frac{F_p}{S} \tag{3}$$

where F_p is the force applied by the pressure system;

and S is the brush contact surface area

Note 1 to entry: When F_p is expressed in grams force (gf) and brush contact surface in cm^2 the calculated specific pressure is in gf/cm^2. To convert into SI units: the result in gf/cm^2 multiplied by 98,07 gives p in N/m^2 (98,07 is the gravitational acceleration in m/s^2 multiplied by 10).

3.1.11
current ripple factor
q_i
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 $\bar{I}$ (mean value integrated over one period):

$$q_i = \frac{I_{max} - I_{min}}{2 \times \bar{I}}$$

Note 1 to entry: For small values of current ripple, the ripple factor may be approximated by the following expression:

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

Note 2 to entry: 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.

[SOURCE: IEC 60034-1:2017, 3.29]

3.1.12
stable state
state of a physical system in which the relevant characteristics are considered to be sensibly constant with time

[SOURCE: IEC 60050-103:2009, 103-05-01]

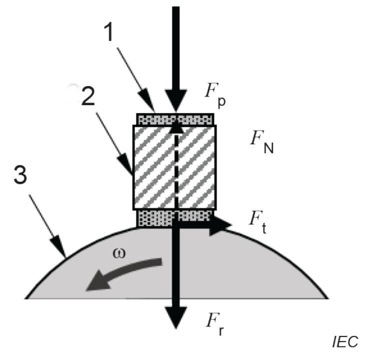
3.1.13
sensibly constant
a measurement result is considered as sensibly constant when deviation from mean value of a minimum of 3 consecutive measurements is less than 2,5 % (except otherwise specified)

Note 1 to entry: Stability state may be determined from the time-measurement rise plot when the straight lines between points at the beginning and end of two successive intervals of half hour each have a deviation of less than the criteria of 2,5 %.

3.1.14
friction coefficient
μ
ratio of tangential force acting at the interface F_t to the radial force acting at the interface F_r:

$$\mu = \frac{F_t}{F_r} \quad (4)$$

Note 1 to entry: Figure 2 illustrates the forces acting on the brush when a radial brush-holder is applied. The numerical value of radial force F_r is equal to the numerica value of the normal reaction force F_N (of the brush contact surface on the ring) and to the numerical value of the pressure system force F_p on the brush top.



Key

1 Brush

2 Brush-holder

3 Test ring

ω Angular velocity (giving the rotation direction)

Figure 2 – Forces acting on a brush

3.1.15
brush voltage drop
U_B
total voltage drop between the brush terminal and the slip ring or commutator

Note 1 to entry: U_B is a complex parameter which is made up from the sum of the voltage drops U_s, U_f, U_i, and U_c as illustrated in Figure 2 (which concerns a brush with a tamped flexible).

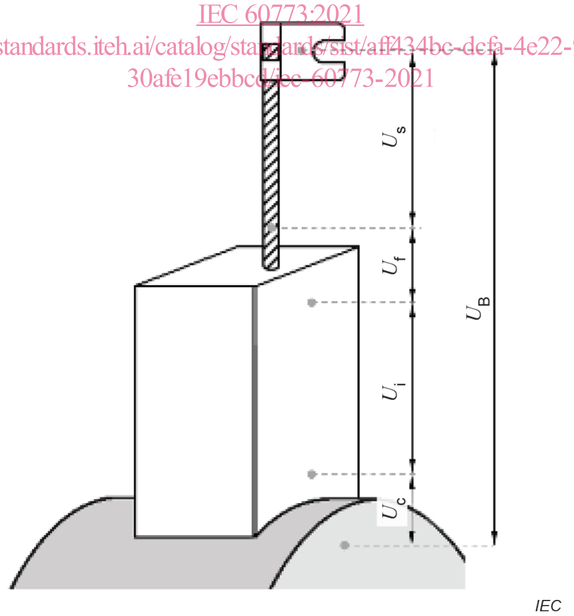


Figure 3 – Voltage drops in a brush when in operation

3.1.16
shunt voltage drop
U_s
voltage drop in the shunt (flexible) and in the shunt connection to the brush terminal

3.1.17
connection drop
U_f
voltage drop between the shunt (flexible) and the brush grade

Note 1 to entry: The connection drop U_f measurement is described in IEC 60136.

3.1.18
brush internal drop
U_i
internal voltage drop of the brush (due to the brush grade resistance)

3.1.19
brush contact drop
U_c
voltage contact drop between the brush grade and the ring

Note 1 to entry: The brush contact drop U_c is an operating characteristic of a brush. See Clause 7.

3.1.20
slot pitch
τ_Q
distance between two consecutive slots of the ring, defined by the periphery of the ring $\pi \times D$ divided by the number of slots Q:

$$\tau_Q = \frac{\pi \times D}{Q} \quad (5)$$

where D is the diameter of the ring

[SOURCE: IEC 60027-4:2006,612]

3.1.21
covering ratio
coverage ratio
τ_B
number of segments spanned by the brush along t dimension, calculated from formula (6)

$$\tau_B = \frac{t}{\tau_Q} \quad (6)$$

3.1.22
peripheral speed
v_p
speed of movement of a point on the surface of a body rotating about its axis expressed as a distance per unit of time

It is calculated from formula (7)

$$v_p = \frac{n \times \pi \times D}{60} \quad (7)$$

where

D is the ring diameter, in metres, and n is the speed of rotation, in number of revolutions per minute (r/min).

[SOURCE: IEC 60050-811:2017, 811-13-29, modified – formula is added]