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INTERNATIONAL STANDARD

Test procedures for determining physical properties of brush materials

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

Test procedures for determining physical properties of brush materials

FOREWORD

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IEC 60413 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This second edition cancels and replaces the first edition published in 1972. This edition constitutes a technical revision.

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

- a) Title modified.
- b) Addition of definitions in Clause 3.
- c) Clause 5 on test specimen: Nomenclature and addition of the different types of test specimen, specification on their dimensions, tolerances and preparation.
- d) Improvement of test procedures of the properties already disclosed in the previous edition (Clause 6 to Clause 11).

- e) Separation of apparent density and apparent porosity (respectively Clause 6 and Clause 10).
- f) Resistivity (Clause 7): Addition of the eddy current method.
- g) Rebound hardness (Clause 9): Addition of a new model of scleroscope and addition of Leeb method, as a possible alternative to the traditional scleroscope method.
- h) Common elements of the test report in a dedicated Clause 12.
- i) Addition of Annex A (normative): introduction of tests categories (serial/type tests), list of properties to be tested for each test category of test according to their purpose.
- j) Addition of Annex B: test procedures for other mechanical properties than flexural strength and hardness: tensile, compressive and impact strength.
- k) Addition of Annex C: test procedures for thermal properties (coefficient of linear expansion, specific heat capacity and thermal conductivity).
- l) Addition of Annex D: supplement to density and porosity.
- m) Addition of Annex E: recommendations on methods for elements analysis.
- n) Addition of Annex F: supplement of information concerning scleroscope hardness.

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

Draft	Report on voting
2/2286/FDIS	2/2298/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

- reconfirmed,
- withdrawn, or
- revised.

1 Scope

This document concerns graphite-based grades that are used for sliding electrical contacts, such as carbon brushes or pantograph strips.

By extension, it is possible to apply the test procedures of this document to all electrical sliding contacts for electrical transmission appliances and to other appliances of graphite-based materials (heat exchangers, bearings, etc.).

This document specifies uniformized procedures for determining their following properties:

- density and porosity;
- resistivity;
- flexural strength;
- hardness;
- ash content.

In addition, it provides recommendations on test procedures for other properties:

- Mechanical properties: Charpy impact test, compressive strength, tensile strength (Annex B).
- Thermal properties: coefficient of thermal expansion, specific heat capacity, thermal conductivity (Annex C).

The properties determined by these tests are inherent to the graphite-based materials and it is therefore important to distinguish them from performance characteristics in operation on electrical equipment (carbon brush in an electrical rotating machine, contact strips on a pantograph, etc.).

Since these materials are generally brittle, porous materials, it is reasonable that their properties vary much more than the same properties in metals.

Some test methods are suitable for use in production quality control (routine tests), others only for more thorough investigations, using precise laboratory techniques (see Annex A).

WARNING — The use of this document can involve hazardous substances, operations and equipment. It does not purport to address all of the safety or environmental problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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 60276, *Carbon brushes, brush holders, commutators and slip-rings - Definitions and nomenclature*

ISO 148-1, *Metallic materials - Charpy pendulum impact test - Part 1: Test method*

ISO 179-1:2023, *Plastics - Determination of Charpy impact properties - Part 1: Non-instrumented impact test*

ISO 6508-2, *Metallic materials - Rockwell hardness test - Part 2: Verification and calibration of testing machines and indenters*

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IEC 60050-826:2022, *International Electrotechnical Vocabulary (IEV) - Part 826: Electrical installations*

IEC 60773, *Rotating electrical machines - Test methods and apparatus for the measurement of the operational characteristics of brushes*

ISO 868, *Plastics and ebonite - Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 2739:2012, *Sintered metal bushings - Determination of radial crushing strength*

ISO 2859-1, *Sampling procedures for inspection by attributes - Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3448:1992, *Industrial liquid lubricants - ISO viscosity classification*

ISO 3611:2010, *Geometrical product specifications (GPS) - Dimensional measuring equipment: Micrometers for external measurements - Design and metrological characteristics*

ISO 4287:1997/Cor 2:2002, *Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters*

ISO 5022:1979, *Shaped refractory products - Sampling and acceptance testing*

ISO 6508-1:2023, *Metallic materials - Rockwell hardness test - Part 1: Test method*

ISO 6892-1:2009, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature*

ISO 7500-1, *Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension/compression testing machines - Verification and calibration of the force-measuring system*

ISO 11357-1:2023, *Plastics - Differential scanning calorimetry (DSC) - Part 1: General principles*

ISO 11357-4, *Plastics - Differential scanning calorimetry (DSC) - Part 4: Determination of specific heat capacity*

ISO 11713:2000, *Carbonaceous materials used in the production of aluminium - Cathode blocks and baked anodes - Determination of electrical resistivity at ambient temperature*

ISO 12985-1:2018, *Carbonaceous materials used in the production of aluminium - Baked anodes and cathode blocks - Part 1: Determination of apparent density using a dimensions method*

ISO 12985-2:2018, *Carbonaceous materials used in the production of aluminium - Baked anodes and cathode blocks - Part 2: Determination of apparent density and porosity using hydrostatic method*

ISO 13102:2012, *Geometrical product specifications (GPS) - Dimensional measuring equipment: Electronic digital-indicator gauge - Design and metrological characteristics*

ISO 13385-1:2019, *Geometrical product specifications (GPS) - Dimensional measuring equipment - Part 1: Design and metrological characteristics of callipers*

ISO 14420:2020, *Carbonaceous products for the production of aluminium - Baked anodes and shaped carbon products - Determination of the coefficient of linear thermal expansion*

ISO 15901-1:2016, *Evaluation of pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption - Part 1: Mercury porosimetry*

ISO 16859-1:2015, *Metallic materials - Leeb hardness test - Part 1: Test method*

ISO 16859-3, *Metallic materials - Leeb hardness test - Part 3: Calibration of reference test blocks*

ISO 18142:2014, *Carbonaceous materials for the production of primary aluminium - Baked carbon bodies - Determination of the dynamic elasticity modulus by the resonance method*

ISO 18265:2013, *Metallic materials - Conversion of hardness values*

ISO 18515:2014, *Carbonaceous materials for the production of aluminium - Cathode blocks and baked anodes - Determination of compressive strength*

ISO 18755:2022, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Determination of thermal diffusivity of monolithic ceramics by laser flash method*

ISO 19628:2024, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Thermophysical properties of ceramic composites - Determination of specific heat capacity*

ISO 21920-2:2021, *Geometrical product specifications (GPS) - Surface texture: Profile - Part 2: Terms, definitions and surface texture parameters*

ISO 22007-4:2024, *Plastics - Determination of thermal conductivity and thermal diffusivity – Part 4: Light flash method*

ASTM A956:2012, *Standard Test Method for Leeb Hardness Testing of Steel Products*

ASTM C559:2016(reapproved 2020), *Standard Test Method for Bulk Density by Physical Measurements of Manufactured Carbon and Graphite*

ASTM C561:2016, *Standard Test Methods for Ash in a Graphite Sample*

ASTM C611:1998, *Standard Test Method for Electrical Resistivity of Manufactured Carbon and Graphite Articles at Room Temperature*

ASTM C714:2000, *Standard test method for thermal diffusivity of carbon and graphite by a thermal pulse method*

ASTM C749:2015, *Standard test method for tensile stress-strain of carbon and graphite*

ASTM C769:2015, *Standard test method for sonic velocity in manufactured carbon and graphite materials for use in obtaining an approximate Young's modulus*

ASTM C886, *Standard Test Method for Scleroscope Hardness Testing of Carbon and Graphite Materials*

ASTM C1259:2001, *Standard test method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio for Advanced Ceramics by Impulse Excitation of Vibration*

ASTM E18:2015, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E289, *Standard Test Method for Linear Thermal Expansion of Rigid Solids with Interferometry*

ASTM E448-82:2008¹⁰, *Standard Practice for Scleroscope Hardness Testing of Metallic Materials (Withdrawn)*

ASTM E831, *Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis*

DIN 51200, *Design and application of test piece holding devices in hardness testing machines*

JIS B 7727, *Shore hardness test - Verification of testing machines*

SAE J300, *Engine Oil Viscosity Classification* (published by Society of Automotive Engineers International)

¹⁰ This document has been withdrawn.