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Test Code
for
CARBON BRUSHES

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Prepared by
Joint Subcommittee on Carbon Brushes
of the
AIEE Rotating Machinery Committee
AIEE Air Transportation Committee
NEMA Technical Committee of Carbon Section

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INTRODUCTION

The joint committee was formed "to prepare standard codes for testing carbon brush materials and brushes; to encourage research and development which may lead to improved brush performance; to encourage the preparation of technical papers relating to the manufacture, application, and operation of carbon brushes, and to promote conferences and technical meetings at which such papers shall be presented." The present test code is the result of several years of work on the preparation of a standard code for testing carbon brush materials and brushes.

The subcommittee has adhered to the principle that an AIEE Test Code on Carbon Brushes should define standard procedures and equipment for making tests and not be concerned with specifications concerning acceptable test results. An original Test Code is something of a pioneering venture and undoubtedly this Code will be improved considerably when revised from time to time in accordance with the results of practical use of it. The subcommittee believes that publication of this Code will provide for better understanding between persons engaged in testing brush materials and brushes and will aid and encourage research and development work which will lead to better brush performance.

Section 2 of the Code covering "Properties of Brush Materials" has been prepared by the Carbon Section of NEMA and published as NEMA Standard CBI-1956.

ACKNOWLEDGMENT

This Test Code for Carbon Brushes has been prepared by a joint subcommittee appointed by NEMA and AIEE. AIEE members were appointed by the Rotating Machinery and Air Transportation Committees. NEMA members were appointed by the Carbon Section of NEMA.

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The subcommittee wishes to acknowledge its indebtedness to those who have so freely given of their time and knowledge and have conducted experimental work. The members of the subcommittee have worked in task forces headed by Messrs. W. H. Austry, L. A. Heath, M. S. May, E. H. Myers, H. Partridge, O. C. Rutledge, S. D. Summers, F. R. Terrant, and W. W. Walker. Dr. H. M. Elsey gave technical advice. Mr. H. Partridge and Mr. W. W. Walker served successively as co-chairman. Dr. V. P. Hessler served a term as chairman. Mr. W. E. Clancy, chairman of NEMA Carbon Section Technical Committee gave assistance and encouragement. Mr. R. J. Blais of NEMA Section Service Department helped with arrangements and guidance.

AIEE TEST CODE FOR CARBON BRUSHES

1. PURPOSE AND SCOPE

1.1 It is the purpose of this Code to provide a uniform (standard) procedure for measuring the properties of materials, properties of shunt connections, and operating characteristics, for carbon, carbon-graphite, electrographitic, graphite, and metal-graphite brushes.

1.2 This Code covers electric brushes for all types of rotating alternating-current and direct-current motors and generators and similar apparatus.

2. TEST PROCEDURES FOR PROPERTIES OF BRUSH MATERIALS

2.1 Scope

2.1.1 The properties determined by these tests are inherent in the brush materials themselves as distinguished from performance characteristics in operation on electric equipment.

2.1.2 The purpose of these standards is to provide a uniform procedure for determining the following properties of carbon, carbon-graphite, electrographitic, graphite, and metal-graphite brushes:

Scleroscope hardness	Density
Specific resistance	Porosity
Transverse strength	Ash content

2.1.3 Some test methods are suitable for use in production quality control, others only for detail determination using precise laboratory techniques. The type of test is indicated for each method.

2.2 General

2.2.1 Sampling Procedure. Samples must be representative of the lot of material involved.

2.2.2 Test Specimen. The standard test specimen shall be:

(1) For carbon, electrographitic and graphite—1.625 inch long by 0.200 inch square (plus 0.000 inch, minus 0.002 inch).

(2) For metal graphites (low resistivity)—1.625 inch long by 0.125 inch square (plus 0.000 inch, minus 0.002 inch).

NOTE—Test specimens of the standard size can be cut readily from brushes or plate stock. The dimensions of the standard sizes were chosen as representing a convenient sample for the majority of tests.

For certain tests, a larger sample 2.5 inches by 0.5 inch by 0.5 inch may be required.

All adjacent surfaces must be at right angles. The length must be at right angles to the direction of compression for molded material and along the axis of extrusion for extruded material. On grades of a laminated structure, the length of the sample is parallel to the lamination.

Specimens should be marked on ends to indicate direction of pressing or extrusion so that the width may be distinguished from the thickness, particularly for transverse strength and hardness tests.

2.3 Scleroscope Hardness

2.3.1 General. This test method is suitable for production quality control.

2.3.2 Equipment and Test Specimen

2.3.2.1 Shore Model C2 scleroscope (or the equivalent) equipped with a hammer for testing the carbon.

NOTE—The manufacturer of the instrument will advise the type of hammer to be used for testing carbon. When specifications can be written covering the hammer, they will be incorporated in these standards.

2.3.2.2 Test specimen of the size indicated in paragraph 2.2.2 or any other convenient size.

The piece to be tested should have the skin removed and the surface should be machined, smooth and free from defects, dirt, or grit.

A rectangular piece must have at least two parallel surfaces. A circular piece must have a uniform character diameter. Otherwise, the hammer will strike the piece a glancing blow, and false readings will result.

Test pieces should be placed so that the hammer impact is applied in the direction of molding compression in the case of brush plate materials and perpendicular to the axis of extrusion for extruded materials.

2.3.3 Test Procedure—Setting Up the Instrument.

- (1) Level the instrument.
- (2) Place the instrument on a firm support.
- (3) The "plumb bob" on the front of the instrument should swing freely in the ring.
- (4) Check calibration.
- (5) Prepare the anvil for the test piece. If the test piece is circular in cross-section, use the vee block anvil. If the test piece is rectangular in cross-section, use the basic flat anvil (which is part of the instrument proper.)

Keep the anvils clean. Wipe dust and dirt particles off the anvils with a soft lintless cloth. When a vee block anvil is used, wipe the flat anvil and the mating surface of the vee block anvil clean before placing them together. Dirt particles between the two anvils will cause false readings.

2.3.4 Test Procedure—Making the Hardness Test. Place the piece on the proper anvil. Lower the tube against the test piece and hold it firmly while the test is being made. Release the hammer, and read the height of the rebound.

Take at least six readings at various spots on each side of a rectangular block. The average of the readings is the scleroscope hardness. Take at least six readings on the diameter of round pieces. The average of the readings is scleroscope hardness.

2.4 Resistivity (Specific Resistance)—Voltmeter-Ammeter Method (Standard Method)

2.4.1 Equipment and Test Specimen

2.4.1.1 Source of direct current providing a range of 0 to 6 volts and 15 amperes (storage battery and variable resistance).

2.4.1.2 Voltmeter. For the range of 5 to 200 millivolts, use direct-current millivoltmeter having three scales of 0 to 20, 0 to 50, and 0 to 200 millivolts (or the equivalent). For the range of 0.4 to 20 millivolts, use direct-current millivoltmeter having four scales of 0 to 2, 0 to 5, 0 to 10, and 0 to 20 millivolts (or the equivalent). When the specified millivoltmeters or any other low-resistance millivoltmeters are used, they should be connected to a variable potential direct-current source to preset the millivoltmeter to the approximate value that is to be read.

2.4.1.3 Ammeter. Use direct-current ammeter having three scales of 0 to 1.5, 0 to 3.0, and 0 to 15 amperes (or the equivalent).

2.4.1.4 Resilient contact surfaces (silver-plated copper gauze with a backing of resilient insulating material at least 0.25 inch thick).

2.4.1.5 Sharp potential pointer having a spacing not less than either the width or the thickness of the test specimen and not greater than 50 percent of the length of the specimen.

2.4.1.6 Test specimen (see paragraph 2.2.2.).

2.4.2 Test Procedure

2.4.2.1 Direct current shall be passed through the specimen from end to end, through the resilient contact surfaces. The value of the current shall be such that it will give a good millivolt reading. A current value can be chosen which will bear relationship to the width, thickness, and pointer spacing such that the millivoltmeter or voltmeter will read the resistivity directly with a multiplier of 10^{-n} .

2.4.2.2. Examples:

Resistivity Range, Ohm Inches	Millivolt Range	Test Current, Amperes	Multiplication Factor for Milli- volt Readings
Specimen Size—0.200 inch by 0.200 inch cross-section, 1.5 inch minimum length, 0.75 inch potential pointer spacing.			
0.00004 to 0.020	0.4 to 200	0.533	10^{-4}
0.000004 to 0.0020	0.4 to 200	5.33	10^{-5}
Specimen Size—0.125 inch by 0.125 inch cross-section, 0.875 inch minimum length, 0.4375 inch potential pointer spacing.			
0.00004 to 0.020	0.4 to 200	0.356	10^{-4}
0.000004 to 0.0020	0.4 to 200	3.56	10^{-5}

2.4.2.3 The specimen should be tested at a temperature of 30C plus or minus 5 degrees C.

2.4.3 Calculations. The resistivity for one inch cube shall be calculated in accordance with the following formula:

$$\rho = \frac{E w t}{I l}$$

where:

ρ —Resistivity for one inch cube (ohm inches).

E —Voltage drop between potential pointers in volts.

w —Width of specimen in inches.

t —Thickness of specimen in inches.

I —Current in specimen in amperes.

l —Length between potential pointers in inches.

2.5 Resistivity (Specific Resistance) Kelvin Bridge Method (Alternate Method).

2.5.1 Equipment and Test Specimen

2.5.1.1 Source of direct current, contact surfaces, ammeter and potential pointer in accordance with paragraph 2.4.1.

2.5.1.2 Kelvin Bridge having a range of 0.00001 to 1.0000 ohm.

2.5.1.3 Galvanometer sensitive to 1 microampere.

2.5.1.4 Key.

2.5.2 Test Procedure. Set the potential pointers, approximately centered, on the length of the specimen. Pass the current between the contact surfaces lengthwise through the specimen. The current should be passed intermittently by means of a key so as not to overheat the specimen. With the current on, adjust the bridge resistance until the galvanometer has zero deflection. Read the specimen resistance (R).

2.5.3 Calculations. The resistivity for one inch cube shall be calculated in accordance with the following formula:

$$\rho = \frac{R A}{l}$$

where:

ρ —Resistivity for one inch cube (ohm inches).

R —Resistance of specimen between potential pointers in ohms.

A —Cross-sectional area of specimen in square inches.

l —Distance between potential pointers in inches.

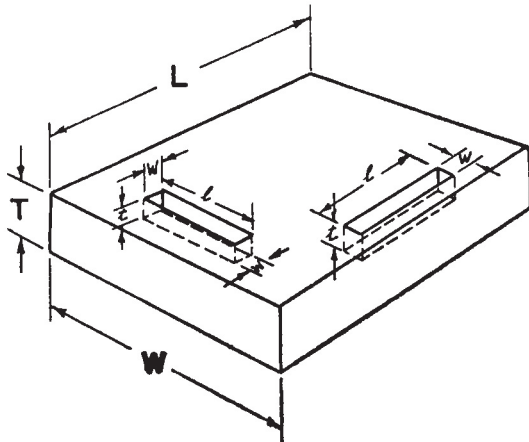
2.6 Transverse Strength

2.6.1 Equipment and Test Specimen

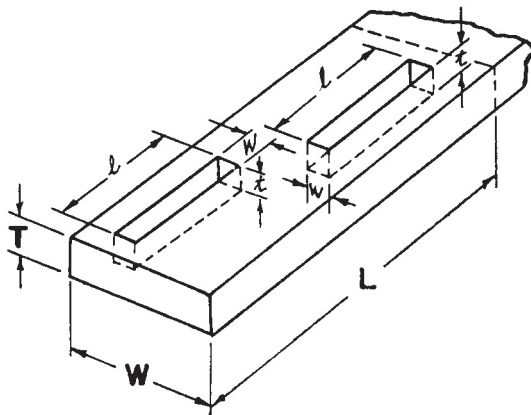
2.6.1.1 Pressure device with a suitable pressure gauge or scale (for example, any hydraulic or mechanical press).

2.6.1.2 Three knife edges, rounded on a radius of 0.062 inch.

2.6.1.3 Test specimen in accordance with paragraph 2.2.2. The specimen shall be very carefully ma-



MOLDED BLOCK



EXTRUDED BLOCK

Figure 1

chined and identified so that the breaking force may be applied in the direction of the molding pressure in the case of molded stock and at right angles to the axis of extrusion in the case of extruded stock. See Figure 1.

2.6.2 Test Procedure. Test specimens having a cross-section of 0.200 inch by 0.200 inch shall be supported on two knife edges 1.2 inch apart. Test specimens having a cross-section of 0.125 inch by 0.125 inch shall be supported on two knife edges 0.6 inch apart.

The stress shall be applied at the center of the specimen midway between the supporting knife edges by a third knife edge.

Force shall be applied at a steady rate not exceeding 0.5 pound per second for specimens having a cross-section of 0.125 inch by 0.125 inch and not ex-

ceeding 2 pounds per second for specimens having a cross-section of 0.200 inch by 0.200 inch.

The total net force in pounds at which the specimen ruptures shall be noted.

2.6.3 Calculations

Transverse strength shall be calculated in accordance with the following formula:

$$\text{Transverse strength} = \frac{3 l F}{2 w t^2}$$

where:

F —Total force in pounds at the instant of rupture.

w —Width of the specimen in inches.

t —Thickness of specimen in inches.

l —Distance between supporting knife edges.

2.7 Density—General. Manufactured carbon is an inherently porous material and, therefore, both real and apparent densities are useful to the manufacturer of carbon products as aids in controls.

The following methods are considered accurate to three significant figures. This is sufficiently accurate for the properties of the type discussed, and it should be remembered that carbon products vary much more than do metals.

The four standard methods of determining real and/or apparent density are:

- (1) Measurement-and-weight method (for apparent density only).
- (2) Immersion method (for apparent density only).
- (3) Oil-absorption method (for both real and apparent density).
- (4) Pycnometer method (for real density only).

The measurement-and-weight method is suitable for production quality control testing. The other methods are more suitable for laboratory investigation.

2.8 Apparent Density—Measurement-and-Weight Method

2.8.1 Equipment and Test Specimen

2.8.1.1 Micrometers suitable for measuring the test samples in inches to three decimal places.

2.8.1.2 Scale or balance suitable for weighing the test samples in grams and having a sensitivity of 0.5 percent or better. (For samples of the common small sizes, a balance having a capacity of 100 grams and a sensitivity of 0.01 gram is very suitable).

2.8.1.3 Saw or other device for cutting the sample to a suitable size, grinding wheel or other device for "squaring up" the sample.

2.8.1.4 Test specimen in accordance with paragraph 2.2.2 or any rectangular or cylindrical sample of a suitable size with square ends. The specimen shall be machined to an accuracy of plus or minus 0.001 inch.