



Designation: **C611–98 (Reapproved 2016) C611 – 21**

Standard Test Method for Electrical Resistivity of Manufactured Carbon and Graphite Articles at Room Temperature¹

This standard is issued under the fixed designation C611; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope ~~Scope~~*

1.1 This test method covers the determination of the electrical resistivity of manufactured carbon and graphite articles at room temperature.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~ environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 Definitions:

2.1.1 ~~resistivity~~ *resistivity, n* —the property of a material that determines its resistance to the flow of an electrical current. It is defined as the value of ρ , in milliohm metres, as follows:

$$\rho = (R \cdot A) / L$$

where:

R = resistance of a specimen of the material of uniform cross section, ohms,

A = uniform cross section, mm², and

L = distance between potential contacts, mm.

3. Significance and Use

3.1 This test method provides a means of determining the electrical resistivity of carbon or graphite specimens. The use of specimens that do not conform to the specimen size limitations described in the test method may result in an alteration of test method accuracy.

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.F0 on Manufactured Carbon and Graphite Products.

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*A Summary of Changes section appears at the end of this standard

4. Apparatus

4.1 The means for applying current and potential terminals to the specimen is specified in 5.2.3.1. A typical specimen holder is shown in Fig. 1.

4.2 Bridge, Potentiometer, or Suitable Digital Voltmeter, with necessary accessories for making resistance measurements with a limit of error of less than 0.5 %. Fig. 2 schematically depicts two wiring diagrams that have been found satisfactory for this purpose.

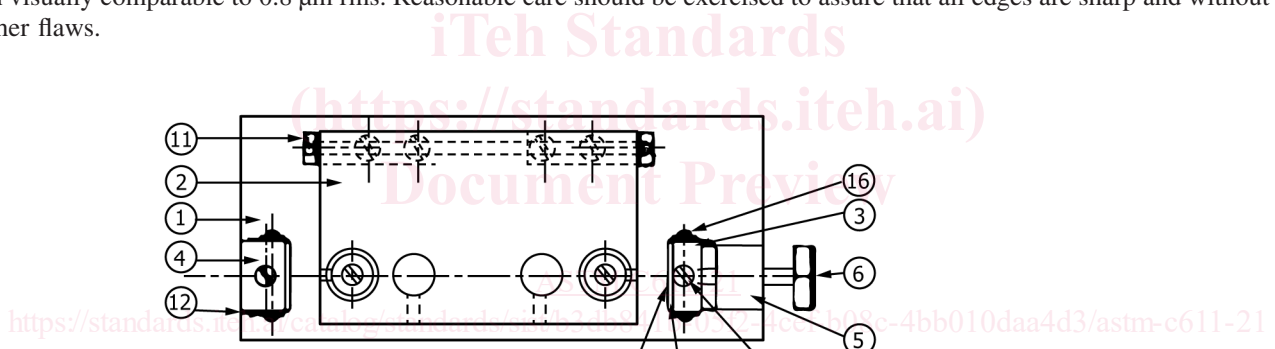
4.3 The means for measuring the dimensions of the specimen should be adequate to determine its gage length and its mean area of cross section, each within 0.5 %.

5. Test Specimen

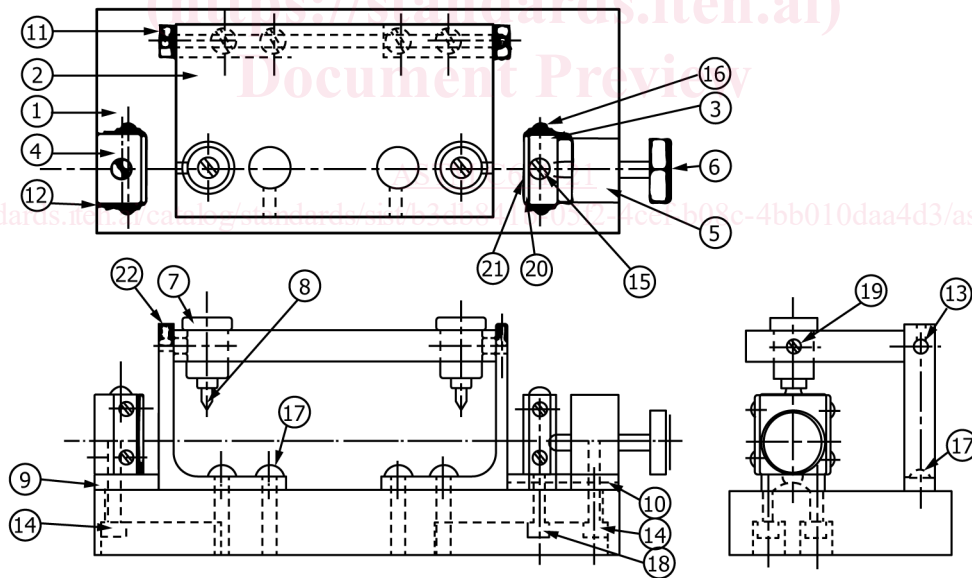
5.1 The test specimen may be in the form of a strip, rod, bar, or tube.

5.2 In order to determine the resistivity, each specimen shall conform to the following:

5.2.1 The cross-sectional area shall be uniform within 0.75 %. In general, the diameter of circular cross section, or the thickness and width of a strip specimen shall be determined by micrometer measurements, and a sufficient number of measurements shall be made to obtain a mean cross-sectional area to within 0.5 %. The test specimen shall be machined to yield planar and parallel end faces. These faces shall be perpendicular to the specimen length to within 0.001 mm/mm. All surfaces shall have a surface finish visually comparable to 0.8 μm rms. Reasonable care should be exercised to assure that all edges are sharp and without chips or other flaws.



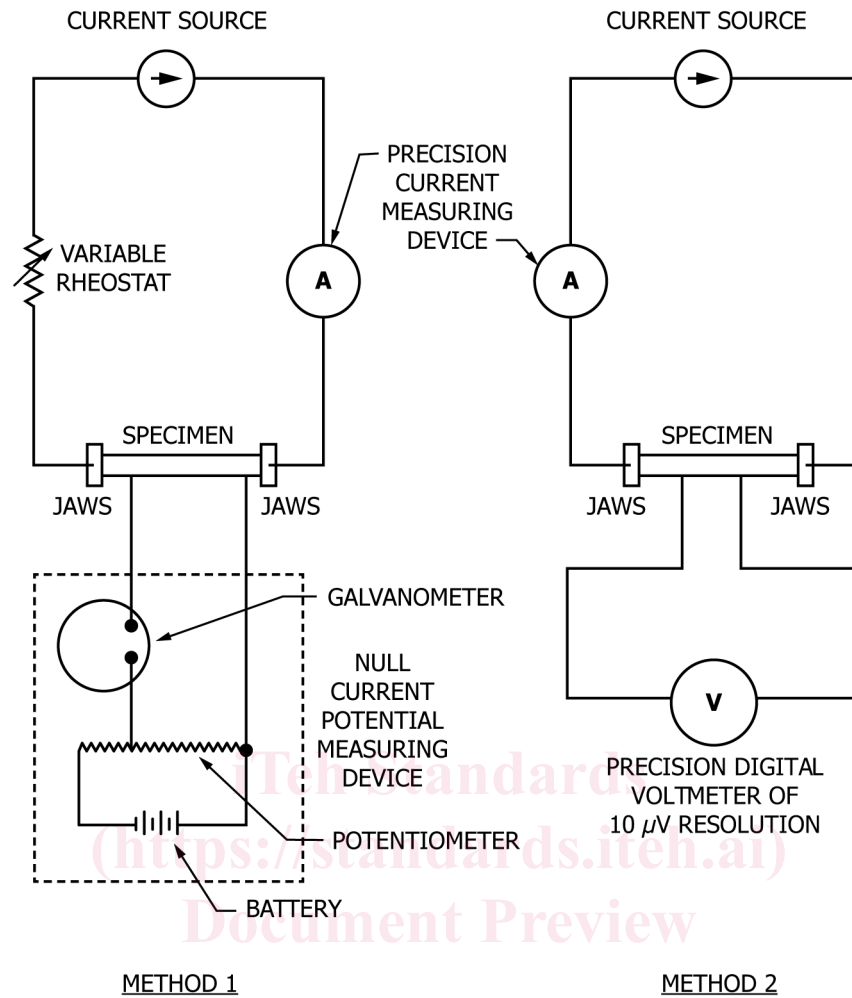
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|----------------------------|----------------------|
| 1—Base block | 12—Wire gauze holder |
| 2—Pivot block | 13—Pivot red |
| 3—Current block adjustable | 14—Screw: sockethead |
| 4—Current block stationary | 15—Roundhead screw |
| 5—Clamp block | 16—Roundhead screw |
| 6—Clamp screw | 17—Roundhead screw |
| 7—Brush holder | 18—Screw, sockethead |
| 8—Contacts | 19—Set screw |
| 9—Current block support | 20—Neoprene |
| 10—Current block guide | 21—Wire gauze |
| 11—Pivot bracket | 22—Set screw |

NOTE 1—Contacts for the voltage and current probes may be made through channels drilled in the brush holders (7) and the current blocks (3 and 4), respectively.

FIG. 1 Typical Test Apparatus



NOTE 1—Adjustable, regulated dc power supply—line and load regulation to 0.1 % and ripple and noise ≤ 0.1 %.

FIG. 2 Typical Schematic for Resistivity Measurements

5.2.2 The test specimen shall show no defects observable with normal vision and shall be free of surface deposits.

5.2.3 The minimum ratio of specimen length to maximum cross-sectional dimension (width or diameter) shall be 6 : 1.

5.2.3.1 The gage length may be measured by any scale that will give an accuracy of ± 0.5 % in the length measured. In the direction of the length of the specimen, the dimension of each potential contact shall be not more than 0.5 % of the distance between the potential contacts. The minimum distance between each potential contact and the adjacent current contact shall be the maximum cross-sectional dimension (width or diameter) of the specimen. If knife edges are used, they shall be parallel to each other and perpendicular to the longitudinal direction of the sample. The minimum ratio of gage length to maximum cross-sectional dimension (width or diameter) shall be 4 : 1.

5.2.4 No dimension shall be smaller than five times the length of the largest visible particle.

5.2.5 No joints or splices are permissible, unless this is the variable under study.

6. Conditioning

6.1 The specimen shall be dried for a minimum of 2 h at 110 °C, cooled to room temperature in a desiccator, and stored in a desiccator until tested.

7. Procedure

7.1 *Resistance Measurement*—Measure resistance with instruments accurate to $\pm 0.5\%$ or less (see **Note 1**). To ensure a correct reading, the reference standard and the test specimen must be allowed to come to the same temperature as the surrounding medium.

NOTE 1—For resistance below $10\ \Omega$, a Kelvin bridge method may be used, and for higher resistance, a Wheatstone bridge method may be used.

7.1.1 Clean the surface of the specimen at current and potential contact points to obtain good electrical contact. Mount the sample in the test apparatus, apply current, and measure the voltage. Take four measurements, on each side of a rectangular specimen, or at 90° ($\pi/2$ radians) apart on a round specimen. Reverse the current direction and take four measurements again. Remove the specimen from the test apparatus, turn it end for end, replace it in the apparatus, and repeat the measurements. The total of 16 measurements is recommended to minimize errors due to contact potential and forward and reverse currents. Average all individual values of measured resistance and use this value to calculate the resistivity.

7.2 *Heating of the Specimen*—In all resistance measurements, the measuring current raises the temperature of the specimen above that of the surrounding medium. Therefore, take care to keep the magnitude of the current low, and the time short enough, so that changes in resistance cannot be detected. The measuring current shall be so small that the resistance of a specimen is not changed, thereby, as much as 0.1% – 0.5% . This condition may be determined experimentally, or calculated from the power expended and the surface area of the specimen. A specimen heating check should be run after each group of samples. If resistance changes designed to confirm that a prolonged measurement time (in excess of the normal measurement time) of a sample in a given position and under a fixed current (that is, with no sample rotation or reverse current) does not change the resistance by more than 0.5% . This sample heating check should be documented for a given material and sample dimensions in order to verify that the current used is appropriate for such sample and test conditions. If the absolute difference between measured values of prolonged resistance ($R_{prolonged}$) and initial resistance ($R_{initial}$) exceeds 0.1% – 0.5% , the sample should be cooled to ambient temperature and rerun at a lower measuring current.

7.3 A sample data collection work sheet that may be used for the testing is shown in **Fig. 3**.

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