



Designation: D495 – 14

Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation¹

This standard is issued under the fixed designation D495; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers, in a preliminary fashion, the differentiation of similar materials' resistance to the action of a high-voltage, low-current arc close to the surface of insulation, when a conducting path is formed causing the material to become conducting due to the localized thermal and chemical decomposition and erosion.

1.2 The usefulness of this test method is very severely limited by many restrictions and qualifications, some of which are described in the following paragraphs and in Section 5. Generally, this test method shall *not* be used in material specifications. Whenever possible, alternative test methods shall be used, and their development is encouraged.

1.3 This test method will not, in general, permit conclusions to be drawn concerning the relative arc resistance rankings of materials that are potentially subjected to other types of arcs: for example, high voltage at high currents, and low voltage at low or high currents (promoted by surges or by conducting contaminants).

1.4 The test method is intended, because of its convenience and the short time required for testing, for preliminary screening of material, for detecting the effects of changes in formulation, and for quality control testing after correlation has been established with other types of simulated service arc tests and field experience. Because this test method is usually conducted under clean and dry laboratory conditions rarely encountered in practice, it is possible that the prediction of a material's relative performance in typical applications and in varying "clean to dirty" environments will be substantially altered (Note 1). Caution is urged against drawing strong conclusions without corroborating support of simulated service tests and field testing. Rather, this test method is useful for preliminary evaluation of changes in structure and composition

without the complicating influence of environmental conditions, especially dirt and moisture.

NOTE 1—By changing some of the circuit conditions described herein it has been found possible to rearrange markedly the order of arc resistance of a group of organic insulating materials consisting of vulcanized fiber and of molded phenolic and amino plastics, some containing organic, and some inorganic, filler.

1.5 While this test method uses dry, uncontaminated specimen surfaces, Test Method D2132, Test Methods D2303, and Test Method D3638 employ wet, contaminated specimen surfaces. Their use is recommended for engineering purposes and to assist in establishing some degree of significance to this test method for quality control purposes.²

1.6 This test method is not applicable to materials that do not produce conductive paths under the action of an electric arc, or that melt or form fluid residues that float conductive residues out of the active test area thereby preventing formation of a conductive path.

1.7 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.8 *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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 6.1.14, 6.1.19, Section 7, and 10.1.1.

2. Referenced Documents

2.1 *ASTM Standards:*³

D1711 Terminology Relating to Electrical Insulation

¹ This test method is under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.12 on Electrical Tests.

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² Also helpful is Test Method D2302 for Wet Tracking Resistance of Electrical Insulating Materials with Controlled Water-to-Metal Discharges. This test method was withdrawn and last appeared in the 1982 *Annual Book of ASTM Standards*, Part 39.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D2132 Test Method for Dust-and-Fog Tracking and Erosion Resistance of Electrical Insulating Materials

D2303 Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials

D3638 Test Method for Comparative Tracking Index of Electrical Insulating Materials

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)⁴

2.2 IEC Standard:

IEC 61621 Dry Solid Insulating Materials—Resistance Test To High-Voltage, Low-Current Arc Discharges⁵

NOTE 2—IEC 61621 is technically equivalent to D495, and is directly based upon Test Method D495. IEC 61621 describes only the tungsten electrodes, and does not include the stainless steel electrodes.

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this test method, refer to Terminology **D1711**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *arc resistance, n*—the total elapsed time in seconds from the start of this test procedure until failure occurs (see Section 14).

3.2.2 *failure, n*—the end-point of the test procedure employed in this test method (see Section 14).

3.2.3 *normal orientation, n*—a test condition in which the electrodes are located on the upper surface of the specimen.

3.2.4 *inverted orientation, n*—a test condition in which the electrodes are located on the under surface of the specimen.

3.2.4.1 *Discussion*—Tests made with inverted orientation are more severe than tests made with normal orientation. Reduced data dispersion has been encountered when testing certain materials using inverted orientation. With other materials, increased data dispersion may be encountered, especially with materials that evolve considerable gas during test.

3.3 Abbreviations:

3.3.1 The stainless steel strip electrodes are referred to as s.s.s. electrodes.

4. Significance and Use

4.1 The high-voltage, low-current type of arc resistance test is intended to simulate only approximately such service conditions as exist in alternating current circuits operating at high voltage, but at currents limited to units and tens of milliamperes.

4.2 In order to distinguish more easily among materials that have low arc resistance, the early stages of this test method are mild, and the later stages are successively more severe. The arc occurs intermittently between two electrodes resting on the surface of the specimen, in normal or inverted orientation. The severity is increased in the early stages by successively

decreasing to zero the interval between flashes of uniform duration, and in later stages by increasing the current.

4.3 Four general types of failure have been observed:

4.3.1 Many inorganic dielectrics become incandescent, whereupon they are capable of conducting the current. Upon cooling, however, they return to their earlier insulating condition.

4.3.2 Some organic compounds burst into flame without the formation of a visible conducting path in the substance.

4.3.3 Others are seen to fail by “tracking,” that is, a thin wiry line is formed between the electrodes.

4.3.4 The fourth type occurs by carbonization of the surface until sufficient carbon is present to carry the current.

4.4 Materials often fail within the first few seconds after a change in the severity stage. When comparing the arc resistance of materials, much more weight shall be given to a few seconds that overlap two stages than to the same elapsed time within a stage. Thus, there is a much greater difference in arc resistance between 178 and 182 s than between 174 and 178 s.

NOTE 3—Some investigators have reported attempts to characterize the remaining insulating value of the damaged area after failure by allowing the specimen to cool to room temperature, without disturbance of the original position of the electrodes, and then either (1) measuring the insulation resistance between the electrodes or (2) determining the percentage of breakdown voltage remaining relative to that obtained on an undamaged area of the specimen. A recommended circuit arrangement and test procedure for carrying out the second of these two means of characterizing the remaining insulating value of the damaged area is described in **Appendix X1**. Still another, and obvious, method of reevaluating the damaged area after failure is to repeat the arc resistance test after the specimen has cooled, with the electrodes undisturbed from their original positions. However, keep in mind that none of these methods will be universally applicable because of the severe physical damage to the test area in many instances.

5. Interferences

5.1 Changes in both the timing of the intermittent arc and the current, as well as other changes affecting the nature of the discharge, can affect the duration of a test of most specimens taken from a group of dissimilar materials. Any of these changes can drastically alter a material’s position in order of rank. Regardless of the conditions of anticipated use, do not use data obtained by this test method to infer that the materials examined occupy an unchanging quality relationship to each other.

5.2 This test method describes two electrode systems: stainless steel strip and tungsten rod. When testing materials with poor to moderate arc resistance (up to 180 s), use the stainless steel strip electrodes as the preferred technique. This technique decreases the variability often associated with the use of rod electrodes on materials having poor or moderate arc resistance. All of the factors that affect the disparate behavior of rod electrodes on such materials have not yet been fully reported. It is permissible to make additional tests with rod electrodes, so as to provide a basis for comparison with other data obtained with such electrodes. For values of arc resistance greater than 180 s, the use of the tungsten rod electrodes is recommended because the corners of the stainless steel strip electrodes erode appreciably under such conditions. It is possible that results obtained with the use of the tungsten rod electrode system will

⁴ The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from American National Standards Institute, 11 W 42nd St., New York, NY 10036.

be different from those obtained with the use of the stainless steel strip electrode system.

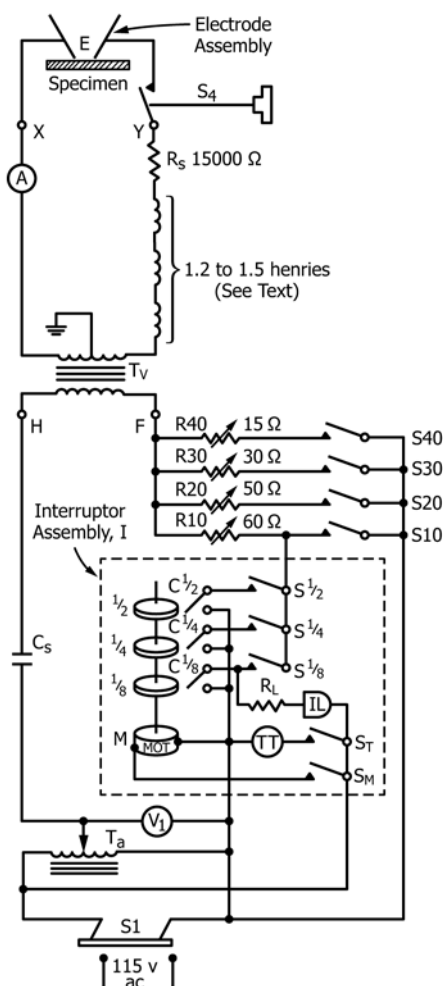
6. Apparatus

6.1 The apparatus (see Fig. 1 for electrical circuit) is specified to maximize data reproducibility among different test sets. The arc obtained will be relatively quiet, rather than the crackly blue spark characteristic of a condenser discharge. Primary voltage control is made by a variable transformer rather than by a variable inductance because of its proved deleterious effect on the performance of the arc.

6.1.1 *Transformer, T_v* —A self-regulating transformer (non-power factor corrected) with a rated primary potential of 115 V at 60 Hz ac, a rated secondary potential (on open circuit) of 15 000 V, and a rated secondary current (on short circuit) of 0.060 A.

6.1.2 *Variable Autotransformer, T_a* —An autotransformer rated at 7 A or more, and nominally adjustable up to 135 V.

6.1.3 *Voltmeter, V_1* —An ac voltmeter, readable to 1 V in the range 90 to 130 V, is permanently connected across the output of the autotransformer to indicate the voltage supplied to the primary circuit.



NOTE 1—Switches S_M to S_{40} are aligned in the sequence of their closing, from bottom to top, during a test.

FIG. 1 Arc-Resistance Test Circuit

NOTE 4—A constant primary voltage supply is recommended. Commercially available line voltage stabilizers that do not distort the voltage wave form are suitable.

6.1.4 *Milliammeter, A* —An ac milliammeter capable of reading from 10 to 40 mA with an error of not over $\pm 5\%$. Before use, this meter shall be calibrated in a test circuit containing no arc gap. Since this milliammeter is used only when setting up or making changes in the circuit, it is to be shorted out by a by-pass switch when not in use.

NOTE 5—Although provision has been made for the suppression of radio-frequency components of current in the arc, it will often be desirable to check for their presence when the apparatus is first constructed. This is done by use of a suitable thermocouple-type r-f milliammeter temporarily inserted in series with the milliammeter.

6.1.5 *Current Control Resistors, R_{10} , R_{20} , R_{30} , R_{40}* —Four resistors are required in series with the primary of T_v but in parallel with each other. These resistors must be adjustable to permit exact settings of the currents during calibration. R_{10} is always in the circuit to provide a 10 mA current. Its value is approximately 60 Ω , with a current rating of at least $1\frac{1}{4}$ A. Closing switch S_{20} , to add R_{20} in parallel with R_{10} , will provide a 20 mA arc current. R_{20} is about 50 Ω with a current rating of at least $1\frac{3}{4}$ A. Similarly, R_{30} and R_{40} have values of about 30 Ω and 15 Ω respectively, with associated current ratings of 2 and 5 A. These resistors, when switched in, provide arc currents of 30 mA and 40 mA respectively.

6.1.6 *Suppressing Resistor, R_3* —Rated at 15 000 Ω and at least 24 W. This resistor, along with the inductors in 6.1.7, is used to suppress parasitic high frequency in the arc circuit.

6.1.7 *Air Core Inductors*—Inductance totaling from 1.2 to 1.5 H is obtained from about 8 coils of No. 30 cotton- or enamel-covered wire. A single coil of this inductance must not be used. Each coil consists of 3000 to 5000 turns of wire wound on insulating nonmetallic cores of about $\frac{1}{2}$ in. (12.7 mm) diameter and $\frac{5}{8}$ in. (15.9 mm) inside length.

6.1.8 *Interruptor, I* —This motor-driven device is used to give the required cycles for the three lower steps of the test by opening and closing the primary circuit according to the schedule in Table 1, with an accuracy of $\pm \frac{1}{120}$ s or better. The interruptor can be a synchronous motor driving three appropriate sets of cams which actuate the contactor switches.

6.1.9 *Timer, TT* —A stop watch or electric interval timer operating at 115 V ac, accurate to 1 s.

6.1.10 *Indicator Lamp, IL* —A6 W, 115 V lamp with a 2000 Ω resistor, R_1 , in series. This lamp indicates the interrupting

TABLE 1 Sequence of 1-min Current Steps

Step	Current, mA	Time Cycle ^A	Total Time, s
$\frac{1}{8}$ 10	10	$\frac{1}{4}$ s on, $\frac{1}{4}$ s off	60
$\frac{1}{4}$ 10	10	$\frac{1}{4}$ s on, $\frac{3}{4}$ s off	120
$\frac{1}{2}$ 10	10	$\frac{1}{4}$ s on, $\frac{1}{4}$ s off	180
10	10	continuous	240
20	20	continuous	300
30	30	continuous	360
40	40	continuous	420

^A In the earlier steps an interrupted arc is used to obtain a less severe condition than the continuous arc; a current of less than 10 mA produces an unsteady (flaring) arc.