Designation: ~~D3874 – 18~~ D3874 – 20

Standard Test Method for Ignition of Materials by Hot Wire Sources[1]

This standard is issued under the fixed designation D3874; 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*

1.1 This test method is intended to differentiate, in a preliminary fashion, among materials with respect to their resistance to ignition because of their proximity to electrically-heated wires and other heat sources.[2]

1.2 This test method applies to molded or sheet materials available in thicknesses ~~ranging from 0.25 to 6.4 mm (0.010 to 0.25 in.).~~up to and including 13.0 mm (0.51 in.).

1.3 This test method applies to materials that are rigid or flexible at normal room temperatures. ~~That is, it applies to materials for which the specimen does not deform~~ It is important to minimize deformation during preparation, especially during the wire-wrapping step described in 10.1~~.~~, by following the method outlined under Clause 10, Sample Preparation. Examples of deformation ~~that render this test method inapplicable include:~~include bowing, in either a transverse or a longitudinal direction, twisting of the specimen, and indentation of the wire into the specimen during the wire-wrapping step, to a degree visible to the eye.

~~1.3.1 Bowing, in either a transverse or a longitudinal direction, or twisting of the specimen, during the wire-wrapping step, to a degree visible to the eye.~~

~~1.3.2 Visible indentation of the wrapped wire into the specimen.~~

1.4 The values stated in SI units are to be regarded as ~~the~~ standard. The ~~inch-pound units~~ values given in parentheses ~~are for information only.~~ after SI units are provided for information only and are not considered standard. (See SI10 for further details.)

1.5 This test method measures and describes the response ~~or~~of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

NOTE 1—Although this test method and IEC TS 60695-2-20 ~~(withdrawn),~~(withdrawn) differ in approach and in detail, data obtained using either are technically equivalent.

1.8 *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. Referenced Documents

2.1 *ASTM Standards:*[3]

D1711 Terminology Relating to Electrical Insulation

D6194 Test Method for Glow-Wire Ignition of Materials

E176 Terminology of Fire Standards

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[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 D09.17 on Fire and Thermal Properties.

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[2] ~~K. N. Mathes, Chapter 4,~~Mathes, K. N., "Surface Failure ~~Measurements",~~Measurements," *Engineering Dielectrics, ~~Vol. IIB,~~ Vol IIB, Electrical Properties of Solid Insulating ~~Materials,~~Materials: Measurement Techniques, ~~R. Bartnikas, Editor,~~ ASTM STP 926*, ~~ASTM, Philadelphia,~~ Chapter 4, ASTM International, 1987.

[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.

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

E3020 Practice for Ignition Sources
IEEE/ASTM SI-10 American National Standard for Metric Practice
2.2 *IEC Standards:*[4]
IEC TS ~~60695-2-20~~60695-2-20:2004 Fire Hazard Testing—Section 20: Glowing/Hot-wire Based Test Methods, Hot-wire Coil Ignitability Test on Materials (withdrawn)
IEC 60695-4 Fire Hazard Testing—Part 4: Terminology Concerning Fire Tests for Electrotechnical Products
2.3 *ISO ~~Standards~~Standard:*[5]
ISO 13943 Fire Safety—Vocabulary

3. Terminology

3.1 *Definitions:*

3.1.1 Use Terminology E176 ~~and~~ , ISO 13943, and IEC 60695-4 for definitions of terms used in this test method and associated with fire issues. Where differences exist in definitions, those contained in Terminology E176 shall be used. Use Terminology D1711 for definitions of terms used in this test method and associated with electrical insulation materials.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ignition, n*—the initiation of combustion. **E176**

3.2.1.1 *Discussion*—

The combustion may be evidenced by glow, flame, detonation, or explosion. The combustion may be sustained or ~~transient (see~~transient. (See Terminology E176~~).~~.)

4. Summary of Test Method

4.1 In this test method, a rectangular bar-shaped test specimen, with the center portion wrapped with a coil of heater wire, is supported horizontally at both ends. The circuit is then energized by applying a fixed power density to the heater wire, which rapidly heats up. The behavior of the test specimen is ~~observed.~~observed until one of the following happens: ~~(a)~~(*a*) the material under test ignites, ~~(b)~~(*b*) the material under test melts, ~~(c) 120~~or (*c* ~~s~~) 120 s of exposure have gone by without ignition or melting. The time to ignition and the time to melt through, as applicable, are recorded.

5. Significance and Use

5.1 During operation of electrical equipment, including wires, resistors, and other conductors, it is possible for overheating to occur, under certain conditions of ~~operation,~~operation or when malfunctions occur. When this happens, a possible result is ignition of the insulation material.

5.2 This test method assesses the relative resistance of electrical insulating materials to ignition by the effect of hot wire sources.

5.3 This test method determines the average time, in seconds, required for material specimens to ignite under the specified conditions of test.

5.4 This method is suitable to characterize materials, subject to the appropriate limitations of an expected precision of ±15 %, to categorize materials.

5.5 In this procedure the specimens are subjected to one or more specific sets of laboratory conditions. If different test conditions are substituted or the end-use conditions are changed, it is not always possible by or from this test to predict changes in the fire-test-response characteristics measured. Therefore, the results are valid only for the fire test exposure conditions described in this procedure.

6. Apparatus

6.1 *Heater Wire*—The heater wire shall be a No. 24 AWG, Nichrome (Nickel-Chrome) wire, that is iron free, with the following nominal properties: a wire composition of 20 % chromium-80 % nickel, a diameter of 0.5 mm (0.020 in.), a nominal cold resistance of 5.28 Ω/m (1.61Ω/ft), and a length-to-mass ratio of 580 m/kg (864 ft/lb).

6.2 Calibrate each spool of test wire for energized resistance, in accordance with the method outlined in Annex A1. Such calibration is necessary due to the typical variability of wire lots in composition, processing, sizing, and metallurgy.

6.3 *Supply Circuit*—The supply circuit, which is a means for electrically energizing the heater wire, shall comply with 6.3.1 – 6.3.4.

[4] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, ~~Case postale~~ 1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, ~~http://www.iec.ch.~~https://www.iec.ch.

[5] Available from International Organization for Standardization (ISO), ~~1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.~~ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

6.3.1 The supply circuit capacity shall be sufficient to maintain a continuous linear 50 to 60 Hz power density of at least 0.31 W/mm (8.0 W/in.) over the length of the heater wire at or near unity power factor. The power density of the supply circuit at 60 A and 1.5 V shall approximate 0.3 W/mm.

6.3.2 The supply circuit shall have a means of voltage adjustment to achieve the desired current as determined from Annex A1. Such means of voltage adjustment shall provide a smooth and continuous adjustment of the power level.

6.3.3 The supply circuit shall have a means of voltage adjustment of measuring the power to within ±2 %.

6.3.4 The test circuit shall be provided with an easily actuated on-off switch for the test power, and with timers to record the duration of the application of test power.

6.4 *Test Chamber*—Use as a test chamber a draft-free closed chamber having a volume of at least 0.3 m^3 (10.5 ft^3). The ratio between any two transverse dimensions of the chamber shall not exceed 2.5. The test chamber shall be positively vented to the outside of the test facility before and after the test, but it shall remain closed and unvented during the test. The chamber shall be equipped with an observation window.

6.5 *Test Fixture*—Two supporting posts shall be positioned 70 mm (2¾ in.) apart to support the specimen in a horizontal position, at a height of 60 mm (2⅜ in.) above the bottom of the test chamber, in the approximate center of the test chamber.

6.6 *Specimen-Winding Fixture*—A fixture shall be provided to uniformly position the wire, with a spacing of 6.35 ± 0.05 mm (0.250 ± 0.002 in.) between turns and with a winding tension of 5.4 ± 0.02 N (1.21 ± ~~0.0045 lbf).~~0.0045 lbf).

6.7 *Support Bar*—Steel bar(s), 13 + 0.5/-0 mm (0.512 + 0.02/-0.00 in.) wide, 125 ± 5 mm (4.9 ± 0.2 in.) long, by 0.5 ± 0.1 mm (0.02 ± 0.04 in.) thick.

6.8 *Weight*—A weight of sufficient mass to flatten the heater wire against the specimen without indenting the specimen.

NOTE 2—50 N (11 lbf) has been found to be a sufficient for most specimens.

6.9 *Plate*—Flat metal plate, minimum 1.5 mm (0.06 in.) thick, large enough to accommodate weight.

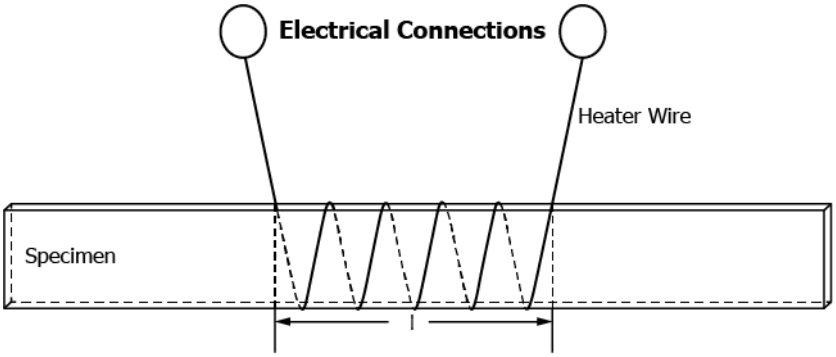
7. Safety Precautions

7.1 It is possible that fumes and products of incomplete combustion are liberated from the specimen when conducting this test. Avoid the inhalation of such fumes and products of combustion and exhaust them from the test chamber after each run.

7.2 Take precautions to safeguard the health of personnel against the risk of explosion or fire, the inhalation of smoke, or other products of combustion, or the exposure to the residues potentially remaining on the specimen after testing.

8. Test Specimens

8.1 The test specimen shall consist of a bar measuring ~~12.5~~13.0 ± ~~0.2~~0.5 by 125 ± 5 mm (½ by 5 in.) and of the thickness to be tested.



l_{min} = 5*6.3 mm = 31.5 mm
l_{max} = 5*6.4 mm = 32.0 mm

FIG. 1 Heater Wire Spacing

9. Conditioning

9.1 Condition the specimens and heater wire as follows:

9.1.1 *Sample Conditioning*—Prior to testing, maintain the samples in a dry condition. If this is not practical, dry the samples in an air-circulating oven at 70 ± ~~2°C~~2 °C (158 ± ~~3.5°F)~~3.5 °F) for seven days and cool over a desiccant, such as silica gel, for a minimum of 4 h. Prior to testing, condition the dry samples for at least 40 h at 23 ± ~~2°C~~2 °C (73 ± ~~3.5°F)~~3.5 °F) and 50 ± 5 % relative humidity. Maintain the test facilities at 50 ± 5 % relative humidity and ~~23°C.~~23 °C.

9.1.2 *Heater Wire Conditioning and Calibration*—For each test, use a length of previously calibrated wire ~~measuring approximately 250~~in accordance with Table 1~~mm (10 in.).~~ . Prior to testing, anneal each straight length by energizing the wire to dissipate ~~0.26~~0.26 W ~~W/mm~~ /mm of length ~~(6.5~~(6.5 W ~~W/in.~~ /in. of ~~length)~~lefngth) for 8 to 12 s to relieve the internal stresses within the wire. Calibrate the wire in accordance with Annex A1 to determine the correct current level.

10. Sample Preparation

10.1 If the sample is rigid at room temperature, use Method A below. If the sample is soft or flexible at room temperature and prone to bowing, twisting, or indentation by the heater wire, use Method B below.

10.1.1 *Method A*—Wrap the center portion of the test specimen with the heater wire, conditioned in accordance with 9.1.2, using the winding fixture specified in 6.6 or other appropriate technique, and a winding force of 5.4 ± 0.02 N (1.21 ± 0.0045 lbf). Apply five turns spaced 6.35 ± 0.05 mm (¼ in.) apart. (See Fig. 1.)

10.1.2 *Method B*—If the material is flexible but will not be indented by the wire during the wrapping process, place a 13 + 0.5/-0 mm wide support bar on one side of the specimen to maintain the specimen rigid during winding. If the material is pliable and susceptible to indentation by the heater wire, place a support bar on each side of the specimen. It is recommended that a release liner be used if the material is tacky. Wrap the center portion of the test specimen with the heater wire, conditioned in accordance with 9.1.2, with a winding force of 5.4 ± 0.02 N (1.21 ± 0.0045 lbf). Apply five complete turns spaced 6.35 ±0.05 mm (¼ in.) apart, using the winding fixture specified in 6.6, or other appropriate technique. (See Fig. 1.) Ensure that the specimen is adequately supported to prevent distortion. Remove the support bar(s) and release liner (if used) carefully so as not to disturb the wire spacing. Place the wrapped specimen on a flat surface, and place a plate and a weight on top of specimen to create full contact between the specimen and the wire along the entire width of the specimen. Indentation of specimen by the wire needs to be avoided. Confirm that the correct spacing between turns was maintained.

11. Test Procedure

~~10.1 Wrap the center portion of the test specimen with a test wire, conditioned in accordance with 9.1.2, using the winding fixture as specified in 6.6 and a winding force of 5.4 ± 0.02 *N* (1.21 ± 0.0045 lbf). Apply five complete turns spaced 6.35 ± 0.05 mm (¼ in.) between turns.~~

11.1 Position the specimen on the test fixture such that the length and width are horizontal. Securely connect the free ends of the wire to the test circuit. The connection is to be capable of transmitting the test power without significant losses, and insofar as possible, not mechanically affect the specimen during the test.

11.2 Start the test by energizing the circuit to dissipate ~~0.26~~0.26 W ~~W/mm~~/mm (6.5 W ~~(6.5 W/in.)~~ /in.) through the nickel-chrome wire. The ~~0.26~~0.26 W ~~W/mm~~ /mm shall be maintained during the test.

11.3 Continue heating until the test specimen ~~ignites (see~~ignites. (See 3.2.1~~).~~.) When ignition occurs, shut off the power and record the time to ignition. Discontinue the test if ignition does not occur within 120 s. For specimens that melt through the wire without ignition, discontinue the test when the specimen is no longer in intimate contact with all five turns of the heater wire.

11.4 Note the following observations:

11.4.1 The time to ignition of each specimen, and

11.4.2 The time for each specimen to melt through the wire if appropriate.

11.5 See Annex A2 for retest criteria and evaluation based on PLC classes.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the material tested including type, source, and manufacturer's code number,

12.1.2 Testing room conditions,

12.1.3 Number of specimens tested,

12.1.4 Thickness of specimens tested,

12.1.5 Time to ignition for each specimen or the time at which the wire turns no longer contact the specimen,

12.1.6 Calculation and record of the average time for ignition,

12.1.7 Assigned PLC based on Annex A2,

12.1.8 Calibrated test current, ~~and~~

12.1.9 Geometry of test ~~chamber.~~chamber, and

TABLE 1 Heater Wire Conditioning and Calibration

Sample Thickness (mm)	Wire Length (mm)	Power (W)
0 < x ≤ 4	250 ± 2	65 ± 1
4 < x ≤ 8	280 ± 2	73 ± 1
8 < x ≤ 13	350 ± 2	91 ± 1