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Standard Test Method for Heat Release, Flame Spread, Smoke Obscuration, and Mass Loss Testing of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration[1]

This standard is issued under the fixed designation D5537; 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 is a fire-test-response standard.

1.2 This test method provides a means to measure the heat released and smoke obscuration by burning the electrical insulating materials contained in electrical or optical fiber cables when the cable specimens, excluding accessories, are subjected to a specified flaming ignition source and burn freely under well ventilated conditions. Flame propagation cable damage, by char length, and mass loss are also measured.

1.3 This test method provides two different protocols for exposing the materials, when made into cable specimens, to an ignition source (approximately 20 kW), for a 20 min test duration. Use it to determine the heat release, smoke release, flame propagation and mass loss characteristics of the materials contained in single and multiconductor electrical or optical fiber cables.

1.4 This test method does not provide information on the fire performance of materials insulating electrical or optical fiber cables in fire conditions other than the ones specifically used in this test method nor does it measure the contribution of the materials in those cables to a developing fire condition.

1.5 Data describing the burning behavior from ignition to the end of the test are obtained.

1.6 This test equipment is suitable for measuring the concentrations of certain toxic gas species in the combustion gases (see Appendix X4).

1.7 The values stated in SI units are to be regarded as standard (see IEEE/ASTM SI-10). The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.8 *This standard measures and describes the response 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*

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

1.10 *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.*

1.11 *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:*[2]

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 D09.17 on Fire and Thermal Properties.

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[2] 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**

D5424 Test Method for Smoke Obscuration of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration
E84 Test Method for Surface Burning Characteristics of Building Materials
E176 Terminology of Fire Standards
E603 Guide for Room Fire Experiments
E800 Guide for Measurement of Gases Present or Generated During Fires
E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
E1537 Test Method for Fire Testing of Upholstered Furniture
E2067 Practice for Full-Scale Oxygen Consumption Calorimetry Fire Tests
E3020 Practice for Ignition Sources
IEEE/ASTM SI-10 International System of Units (SI), The Modernized Metric System

2.2 *NFPA Standards:*[3]
NFPA 70 National Electrical Code
NFPA 265 Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings
NFPA 286 Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth
NFPA 289 Standard Method of Fire Test for Individual Fuel Packages

2.3 *Underwriters Laboratories Standards:*[4]
UL 1581 Reference Standard for Electrical Wires, Cables, and Flexible Cords, ANSI/UL 1581
UL 1685 Standard Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables

2.4 *Canadian Standards Association Standard:*[5]
CSA FT4, Vertical Flame Tests: Cables in Cable Trays, Section 4.11.4 in Standard C 22.2 No. 0.3, Test Methods for Electrical Wires and Cables

2.5 *IEEE Standard:*[6]
IEEE 1202 Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies

2.6 *ISO Standard:*[7]
ISO 9705 Fire Tests—Full Scale Room Test for Surface Products
ISO 13943 Fire Safety—Vocabulary

3. Terminology

3.1 For definitions of terms used in this test method and associated with fire issues refer to Terminology E176 and ISO 13943. In case of conflict, the terminology in Terminology E176 shall prevail. For definitions of terms used in this test method and associated with electrical insulation refer to Terminology D1711.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *heat release rate, n*—the heat evolved from the specimen, per unit of time.

3.2.2 *sample, n*—an amount of the cable type and construction to be tested, which is representative of the product for test.

3.2.3 *smoke obscuration, n*—reduction of light transmission by smoke, as measured by light attenuation.

3.2.4 *specimen, n*—the individual length of cable, or cable bundle, to be placed in the cable tray, which is representative of the product to be tested.

4. Summary of Test Method

4.1 This fire-test-response standard determines a number of fire-test-response characteristics associated with burning the materials insulating electrical or optical fiber cables, made into cable specimens, and located in a vertical cable tray and ignited with a propane gas burner. The main fire properties measured are the rate of heat release and its amount. Associated with these measurements, the test procedure also determines flame propagation cable damage (by char length), smoke obscuration, and mass loss of specimen. The apparatus described in this test method is also suitable for measuring rates and concentrations of gaseous combustion products released.

4.2 The vertical cable tray that holds the specimen is located in an enclosure of specified dimensions.

4.3 A hood, connected to a duct is located above the fire enclosure. Heat and gas release analysis instrumentation is placed in the duct. Smoke release instrumentation (optional) is also placed in the duct.

[3] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.
[4] Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062-2096, http://www.ul.com..
[5] Available from Canadian Standards Association (CSA), 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, http://www.csa.ca.
[6] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331, http://www.ieee.org.
[7] 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.

4.4 Two different test procedures are specified, which differ in the burner used and in the electrical or optical fiber cable loading. These reflect details of four existing test methods: UL 1581 (vertical tray flammability test, protocol A) and CSA Standard C 22.2 No. 0.3 (FT4 vertical tray flammability test) or IEEE 1202 (protocol B) and UL 1685 and Test Method D5424 (both protocols, for smoke obscuration only).

4.5 Information specific to the individual protocols is found in 7.7, 7.9, and 11.1.

5. Significance and Use

5.1 This test method provides a means to measure a variety of fire-test-response characteristics associated with heat and smoke release and resulting from burning the materials insulating electrical or optical fiber cables, when made into cables and installed on a vertical cable tray. The specimens are allowed to burn freely under well ventilated conditions after ignition by means of a propane gas burner. The ignition source used in this test method is also described as a premixed flame flaming ignition source in Practice E3020, which contains an exhaustive compilation of ignition sources.

5.2 The rate of heat release often serves as an indication of the intensity of the fire generated. General considerations of the importance of heat release rate are discussed in Appendix X1 and considerations for heat release calculations are in Appendix X2.

5.3 Other fire-test-response characteristics that are measurable by this test method are useful to make decisions on fire safety. The test method is also used for measuring smoke obscuration. The apparatus described here is also useful to measure gaseous components of smoke; the most important gaseous components of smoke are the carbon oxides, present in all fires. The carbon oxides are major indicators of the completeness of combustion and are often used as part of fire hazard assessment calculations and to improve the accuracy of heat release measurements.

5.4 *Test Limitations:*

5.4.1 The fire-test-response characteristics measured in this test are a representation of the manner in which the specimens tested behave under certain specific conditions. Do not assume they are representative of a generic fire performance of the materials tested when made into cables of the construction under consideration.

5.4.2 In particular, it is unlikely that this test is an adequate representation of the fire behavior of cables in confined spaces, without abundant circulation of air.

5.4.3 This is an intermediate-scale test, and the predictability of its results to large scale fires has not been determined. Some information exists to suggest validation with regard to some large-scale scenarios.

6. Test Specimens

6.1 Use multiple lengths of electrical or optical fiber cable as test specimens.

6.2 The mounting of the specimen on the cable tray is specified in 7.9.

7. Apparatus

7.1 *Enclosure:*

7.1.1 The enclosure in which the specimen is tested is shown in Fig. 1.

7.1.2 The enclosure has floor dimensions of 2.44 m ± 25 mm by 2.44 m ± 25 mm, with a height of 3.35 m ± 25 mm (8 ft ± 1 in. by 8 ft ± 1 in. by 11 ft ± 1 in. high). On top of the walls there is a pyramidal collection hood with a collection box.

7.1.2.1 Other enclosure sizes, such as 2.4 by 2.4 by 2.4 m (8 by 8 by 8 ft) or the 3-m cube are permitted, provided that the internal volume of the enclosure, exclusive of the pyramidal hood, ranges between 14.5 m^3 (512 ft^3) and 36 m^3 (1272 ft^3), the floor area ranges between 6 m^2 (64 ft^2) and 9 m^2 (97 ft^2), and the maximum air movement within the enclosure complies with 7.1.12 (Note 1).

NOTE 1—There is, as yet, not enough information as to the equivalence on smoke release between the various facilities. Further work needs to be done to confirm this.

7.1.2.2 In case of disputes, the referee method is the tests conducted using the enclosure in 7.1.2.

7.1.3 *Walls*—The maximum conductive heat flux loss of the walls of the structure is 6.8 W/(m^2K) (30 Btu/h-ft^2), based upon an inside wall temperature of 38°C (100°F) and an outside air temperature of 24°C (75°F). Paint the interior surface of the walls flat black. Any materials of construction that meet the preceding requirements are acceptable. Two examples of acceptable construction materials are nominally 152 mm (6 in.) thick concrete masonry blocks (density: 1700 kg m^{-3} (106 lb ft^{-3}) and thermal conductivity nominally k = 1.75 ~~W/(mK),~~W/(mK), at 21°C; 12.13 Btu in./ft^2 h°F, at 70°F) or nominally 13 mm (0.5 in.) gypsum board, with 89 ± 6 mm (3.5 ± 0.25 in.) of standard fiberglass insulation, with an R value of 1.94 m^2 K/W (which corresponds in practical units to an R value of 11 hft^2 °F/Btu). Windows for observation of the fire test are allowed in the walls; ensure that the total area of the windows does not exceed 1.86 m^2 (20 ft^2).

7.1.3.1 Select materials of construction which can withstand the high temperatures and presence of open flame within the test enclosure and duct.