Designation: D6113 – 21

Standard Test Method for Using Cone Calorimeter to Determine Fire-Test-Response Characteristics of Insulating Materials Contained in Electrical or Optical Fiber Cables[1]

This standard is issued under the fixed designation D6113; 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 Several fire-test-response characteristics, including the time to sustained flaming, heat release rate, total heat released, effective heat of combustion, and specific extinction area; are measured or calculated by this test method at a constant radiant heat flux. For specific limitations see also 5.7 and Section 6.

1.3 The tests are conducted by burning the electrical insulating materials contained in electrical or optical fiber cables when the cable test specimens, excluding accessories, are subjected to radiant heat.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *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.* For specific precautionary statements, see Section 7.

1.6 *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.*

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

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:*[2]

D618 Practice for Conditioning Plastics for Testing

D1711 Terminology Relating to Electrical Insulation

D5424 Test Method for Smoke Obscuration of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration

D5485 Test Method for Determining the Corrosive Effect of Combustion Products Using the Cone Corrosimeter

D5537 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

E176 Terminology of Fire Standards

E603 Guide for Room Fire Experiments

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E906/E906M Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using a Thermopile Method

E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

E1474 Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or Composites Using a Bench Scale Oxygen Consumption Calorimeter

E2058 Test Methods for Measurement of Material Flammability Using a Fire Propagation Apparatus (FPA)

E2965 Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter

[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.

Current edition approved March 1, 2021. Published May 2021. Originally approved in 1997. Last previous edition approved in 2016 as D6113 – 16. DOI: 10.1520/D6113-21.

[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.

2.2 *CSA Standard:*[3]

CSA C22.2 No. 0.3, FT4, Vertical Flame Tests: Cables in Cable Trays, Section 4.11.4 in C22.2 No. 0.3, Test Methods for Electrical Wires and Cables

2.3 *IEC Standards:*[4]

IEC 60695-4 Fire Hazard Testing. Part 4: Terminology Concerning Fire Tests

IEC 60695-5-2 Fire Hazard Testing. Part 5: Assessment of Potential Corrosion Damage by Fire Effluent - Section 2: Guidance on the Selection and Use of Test Methods

2.4 *IEEE Standard:*[5]

IEEE 1202 Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, IEEE Standard 1202

2.5 *ISO Standards:*[6]

ISO 13943 Fire Safety: Vocabulary

ISO 11907-4 Plastics—Smoke Generation—Determination of the Corrosivity of Fire Effluents—Part 4: Dynamic Decomposition Method Using a Conical Radiant Heater

2.6 *NFPA Standards:*[7]

NFPA 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

NFPA 287 Standard Test Methods for Measurement of Flammability of Materials in Cleanrooms Using a Fire Propagation Apparatus (FPA)

2.7 *OSHA Standard:*[8]

OSHA 191.1450 Occupational Exposure to Hazardous Chemicals in Laboratories

2.8 *UL Standards:*[9]

ANSI/UL 1581 Reference Standard for Electrical Wires, Cables, and Flexible Cords

ANSI/UL 1666 Standard Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

ANSI/UL 1685 Standard Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method and associated with fire issues use Terminology E176, ISO 13943, and IEC 60695-4. 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 *cone calorimeter, n*—the apparatus which is used in Test Method E1354 to determine heat release rate, by the principle of oxygen consumption calorimetry, and other fire-test-response characteristics.

3.2.2 *effective heat of combustion, n*—the ratio of the measured heat release to the mass loss, under specified test conditions.

3.2.2.1 *Discussion*—The effective heat of combustion is a function of the test conditions, including heating flux, exposure time and test specimen geometry.

3.2.3 *heat flux, n*—heat transfer to a surface per unit area, per unit time (see also *initial test heat flux*).

3.2.3.1 *Discussion*—The heat flux from an energy source, such as a radiant heater, can be measured at the initiation of a test (such as Test Method E1354 or E906/E906M) and then reported as the initial test heat flux, with the understanding that the burning of the test specimen can generate additional heat flux to the specimen surface. The heat flux can also be measured at any time during a fire test, for example as described in Guide E603, on any surface, and with measurement devices responding to radiative and convective fluxes. Typical units are kW/m^2, W/cm^2, or BTU/(s ft^2).

3.2.4 *heat release rate, n*—the calorific energy released per unit time by the combustion of a material under specified test conditions.

3.2.5 *ignitability, n*—the measure of the ease with which a specimen can be ignited due to the influence of an external energy source, under specified test conditions.

3.2.6 *initial test heat flux, n*—the heat flux set on the test apparatus at the initiation of the test (see also *heat flux*).

3.2.6.1 *Discussion*—The initial test heat flux is the heat flux value commonly used when describing or setting test conditions.

3.2.7 *net heat of combustion, n*—the quantity of heat released by the complete combustion of a unit mass of the material, the water produced being in the vapor state.

3.2.8 *orientation, n*—the plane in which the exposed face of the test specimen is located during testing, which is horizontal facing up for this test.

3.2.9 *oxygen consumption principle, n*—the expression of the relationship between the mass of oxygen consumed during combustion and the heat released.

3.2.10 *smoke obscuration, n*—the reduction in visibility due to the smoke.

3.2.11 *specific extinction area, n*—a measure of smoke obscuration potential per unit mass lost, determined as the product of the extinction coefficient and the volumetric mass flow rate, divided by the mass loss rate.

3.2.12 *sustained flaming, n*—existence of flame on or over the surface of the test specimen for periods of 4 s or more.

[3] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.

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

[5] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, http://www.ieee.org.

[6] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[7] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[8] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[9] Available from Underwriters Laboratories (UL), UL Headquarters, 333 Pfingsten Road, Northbrook, IL, 60062, http://www.ul.com.

3.2.12.1 *Discussion*—Flaming of less than 4 s duration is identified as flashing or transitory flaming.

3.2.13 *total heat released, n*—integrated value of the rate of heat release, for a specified time period.

4. Summary of Test Method

4.1 All fire-test-response characteristics in this test method are determined using the apparatus and procedures described in Test Method E1354. (See also 9 and 10.)

4.2 The oxygen consumption principle, used in this test method, is based on the observation that, generally, the net heat of combustion is directly related to the amount of oxygen required for combustion (**1**).[10] Approximately 13.1 MJ of heat are released per 1 kg of oxygen consumed. Test specimens in this test method are burned in ambient air conditions, while being subjected to a prescribed external initial test heat flux. (See also X5.1.)

4.3 The heat release is determined by the measurement of the oxygen consumption, as determined by the oxygen concentration and the flow rate in the combustion product stream, as described in Test Method E1354.

4.4 The primary measurements are oxygen concentration and exhaust gas flow rate. Additional measurements include the time to sustained flaming, the smoke obscuration generated, the mass loss rate, and the effective heat of combustion. Ignitability is determined by measuring the time from initial exposure to time of sustained flaming of the test specimen.

4.5 A cone calorimeter is used to measure the consumption of oxygen during this test; heat release is then calculated, based on the oxygen consumption principle. The test specimen is mounted horizontally and a spark ignition source is employed.

5. Significance and Use

5.1 This test method is used to determine the heat release rate and a number of other fire-test-response characteristics as a result of exposing insulating materials contained in electrical or optical cables to a prescribed initial test heat flux in the cone calorimeter apparatus.

5.2 Quantitative heat release measurements provide information that is potentially useful for design of electrical or optical cables, and product development.

5.3 Heat release measurements provide useful information for product development by giving a quantitative measure of specific changes in fire performance caused by component and composite modifications. Heat release data from this test method will not be predictive of product behavior if the product will not spread flame over its surface under the fire exposure conditions of interest.

5.4 The fire-test-response characteristics determined by this test method are affected by the thickness of the material used as test specimen, whether as a plaque or as coating on a wire or cable. The diameter of the wire or cable used will also affect the test results.

5.5 A radiant exposure is used as an energy source for this test method. This type of source has been used for comparison with heat release rate and flame spread studies of insulating materials constructed into cables when burning in a vertical cable tray configuration (Test Methods D5424 and D5537) (**2-9**). No definitive relationships have been established.

5.6 The value of heat release rate corresponding to the critical limit between propagating cable fires and non-propagating fires is not known.

5.7 This test method does not determine the net heat of combustion.

5.8 It has not been demonstrated that this test method is capable of predicting the response of electrical or optical fiber cables in a full scale fire. In particular, this test method does not address the self-extinguishing characteristics of the cables in a full scale fire.

6. Test Limitations

6.1 If during the test of one or more of the three replicate test specimens, any of the following unusual behavior occurs: molten material overflows the specimen holder trough; a test specimen is displaced from the zone of controlled irradiance (explosive spalling); or the test specimen swells sufficiently prior to ignition to touch the spark plug or swells up to the plane of the heater base during combustion; then test an additional specimen of the identical preconditioned test specimens in the test mode in which the unusual behavior occurred. Do not incorporate data obtained from the tests noted above, yielding inadequate results, in the averaged data but report the occurrence. This test method is not suitable if more than three out of six test specimens tested show any of the above characteristics.

6.2 The applicability of this test method to smoldering ignition of cables has not been demonstrated. This test method is not suitable for initial test heat fluxes below 10 kW/m^2.

6.3 The validity of the results of this test method for a particular scenario depends on the conditions under which the tests are conducted. In particular, it has been established that the use of a different initial test heat flux will change relative results.

7. Safety Precautions

7.1 The test procedures involve high temperatures and combustion processes. Hazards therefore exist for burns, ignition of extraneous objects or clothing, and inhalation of combustion products. The operator must take appropriate precautions during the insertion and removal of the test specimens, for example, by using protective gloves. Do not touch either the cone heater or the associated fixtures while hot, except with the use of appropriate protective gear.

7.2 Vent the combustion products flowing through the exposure chamber through a properly designed exhaust system. An adequate method of venting the combustion products

[10] The boldface numbers given in parentheses refer to a list of references at the end of this test method.