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An American National Standard

Standard Test Methods for Measurement of Material Flammability Using a Fire Propagation Apparatus (FPA)[1]

This standard is issued under the fixed designation E2058; 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 fire-test-response standard determines and quantifies material flammability characteristics, related to the propensity of materials to support fire propagation, by means of a fire propagation apparatus (FPA). Material flammability characteristics that are quantified include time to ignition (t_{ign}), chemical ($\dot{Q}_{chem}$), and convective ($\dot{Q}_c$) heat release rates, mass loss rate ($\dot{m}$) and effective heat of combustion (EHC).

1.2 The following test methods, capable of being performed separately and independently, are included herein:

1.2.1 *Ignition Test,* to determine t_{ign} for a horizontal specimen;

1.2.2 *Combustion Test,* to determine $\dot{Q}_{chem}$, $\dot{Q}_c$, $\dot{m}$, and EHC from burning of a horizontal specimen; and,

1.2.3 *Fire Propagation Test,* to determine $\dot{Q}_{chem}$ from burning of a vertical specimen.

1.3 Distinguishing features of the FPA include tungsten-quartz external, isolated heaters to provide a radiant flux of up to 110 kW/m^2 to the test specimen, which remains constant whether the surface regresses or expands; provision for combustion or upward fire propagation in prescribed flows of normal air, air enriched with up to 40 % oxygen, air oxygen vitiated, pure nitrogen or mixtures of gaseous suppression agents with the preceding air mixtures; and, the capability of measuring heat release rates and exhaust product flows generated during upward fire propagation on a vertical test specimen 0.305 m high.

1.4 The FPA is used to evaluate the flammability of materials and products. It is also designed to obtain the transient response of such materials and products to prescribed heat fluxes in specified inert or oxidizing environments and to obtain laboratory measurements of generation rates of fire products (CO_2, CO, and, if desired, gaseous hydrocarbons) for use in fire safety engineering.

1.5 Ignition of the specimen is by means of a pilot flame at a prescribed location with respect to the specimen surface.

1.6 The Fire Propagation test of vertical specimens is not suitable for materials that, on heating, melt sufficiently to form a liquid pool.

1.7 Values stated are in SI units. Values in parentheses are for information only.

1.8 This standard is used to measure and describe 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 *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 hazard statements, see Section 7.

1.10 *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]

E176 Terminology of Fire Standards

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

E1321 Test Method for Determining Material Ignition and Flame Spread Properties

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

[1] These test methods are under the jurisdiction of ASTM Committee E05 on Fire Standards and are the direct responsibility of Subcommittee E05.22 on Surface Burning.

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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.

E1623 Test Method for Determination of Fire and Thermal Parameters of Materials, Products, and Systems Using an Intermediate Scale Calorimeter (ICAL)

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, refer to Terminology E176.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fire propagation, n*—increase in the exposed surface area of the specimen that is actively involved in flaming combustion.

3.3 *Symbols:*

A_d = cross sectional area of test section duct (m^2)
c_p = specific heat of air at constant pressure (kJ/kg K)
$\dot{G}_{co}$ = mass flow rate of CO in test section duct (kg/s)
$\dot{G}_{co_2}$ = mass flow rate of CO_2 in test section duct (kg/s)
ΔH_{eff} = effective heat of combustion (kJ/kg)
K = flow coefficient of averaging Pitot tube [duct gas velocity/$(2\Delta p_m/\rho)^{1/2}$] (-)
M_{loss} = ultimate change in specimen mass resulting from combustion (kg)
$\dot{m}$ = mass loss rate of test specimen (kg/s)
$\dot{m}_d$ = mass flow rate of gaseous mixture in test section duct (kg/s)
P_{atm} = atmospheric pressure (Pa)
Δp_m = pressure differential across averaging Pitot tube in test section duct (Pa)
Q = cumulative heat released during Combustion Test (kJ)
$\dot{Q}_{chem}$ = chemical heat release rate (kW)
$\dot{Q}_c$ = convective heat release rate (kW)
T_a = gas temperature in test section duct before ignition (*K*)
T_d = gas temperature in test section duct (*K*)
t = time (s)
t_{ign} = ignition time (s)
Δt = time between data scans (s)
X_{CO_2} = measured carbon dioxide analyzer reading or mole fraction of carbon dioxide (-)
X_{CO} = measured carbon monoxide analyzer reading or mole fraction of CO (-)

3.4 *Superscripts:*

$\cdot$ = per unit time (s^{-1})
0 = before ignition of the specimen

3.5 *Subscripts:*

d = test section duct
j = fire product

4. Summary of Test Method

4.1 Three separate test methods are composed herein, and are used independently in conjunction with a Fire Propagation Apparatus. The Ignition and Combustion test methods involve the use of horizontal specimens subjected to a controlled, external radiant heat flux, which can be set from 0 up to 110 kW/m^2. The Fire Propagation test method involves the use of vertical specimens subjected to ignition near the base of the specimen from an external radiant heat flux and a pilot flame. Both the Combustion and Fire Propagation test methods can be performed using an inlet air supply that is either normal air or other gaseous mixtures, such as air with added nitrogen or air enriched with up to 40 % oxygen.

4.2 The Ignition test method is used to determine the time required for ignition, t_{ign}, of horizontal specimens by a pilot flame as a function of the magnitude of a constant, externally applied radiant heat flux. Measurements also are made of time required until initial fuel vaporization. The surface of these specimens is coated with a thin layer of black paint to ensure complete absorption of the radiant heat flux from the infrared heating system (note that the coating does not itself undergo sustained flaming).

4.3 The Combustion test method is used to determine the chemical and convective heat release rates when the horizontal test specimen is exposed to an external radiant heat flux.

4.4 The Fire Propagation test method is used to determine the chemical heat release rate of a burning, vertical specimen during upward fire propagation and burning initiated by a heat flux near the base of the specimen. Chemical heat release rate is derived from the release rates of carbon dioxide and carbon monoxide. Observations also are made of the flame height on the vertical specimen during fire propagation.

5. Significance and Use

5.1 These test methods are an integral part of existing test standards for cable fire propagation and clean room material flammability, as well as, in an approval standard for conveyor belting (**1-3**).[3] Refs (**1-3**) use these test methods because fire-test-response results obtained from the test methods correlate with fire behavior during real-scale fire propagation tests, as discussed in X1.4.

5.2 The Ignition, Combustion, or Fire Propagation test method, or a combination thereof, have been performed with materials and products containing a wide range of polymer compositions and structures, as described in X1.7.

5.3 The Fire Propagation test method is different from the test methods in the ASTM standards listed in 2.1 by virtue of producing laboratory measurements of the chemical heat release rate during upward fire propagation and burning on a vertical test specimen in normal air, oxygen-enriched air, or in oxygen-vitiated air. Test methods from other standards, for example, Test Method E1321, which yields measurements during lateral/horizontal or downward flame spread on materials and Test Methods E906, E1354, and E1623, which yield measurements of the rate of heat release from materials fully involved in flaming combustion, generally use an external radiant flux, rather than the flames from the burning material itself, to characterize fire behavior.

5.4 These test methods are not intended to be routine quality control tests. They are intended for evaluation of specific flammability characteristics of materials. Materials to be analyzed consist of specimens from an end-use product or the

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.