Designation: E1354 – 23

An American National Standard

Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter[1]

This standard is issued under the fixed designation E1354; 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 provides for measuring the response of materials exposed to controlled levels of radiant heating with or without an external ignitor.

1.2 This test method is used to determine the ignitability, heat release rates, mass loss rates, effective heat of combustion, and visible smoke development of materials and products.

1.3 The rate of heat release is determined by measurement of the oxygen consumption as determined by the oxygen concentration and the flow rate in the exhaust product stream. The effective heat of combustion is determined from a concomitant measurement of specimen mass loss rate, in combination with the heat release rate. Smoke development is measured by obscuration of light by the combustion product stream.

1.4 Specimens shall be exposed to initial test heat fluxes in the range of 0 kW/m^2 to 100 kW/m^2. External ignition, when used, shall be by electric spark. The value of the initial test heat flux and the use of external ignition are to be as specified in the relevant material or performance standard (see X1.2). The normal specimen testing orientation is horizontal, independent of whether the end-use application involves a horizontal or a vertical orientation. The apparatus also contains provisions for vertical orientation testing; this is used for exploratory or diagnostic studies only.

1.5 Ignitability is determined as a measurement of time from initial exposure to time of sustained flaming.

1.6 This test method has been developed for use for material and product evaluations, mathematical modeling, design purposes, or development and research. Examples of material specimens include portions of an end-use product or the various components used in the end-use product.

1.7 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

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]

D5865 Test Method for Gross Calorific Value of Coal and Coke
E176 Terminology of Fire Standards
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E603 Guide for Room Fire Experiments
E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E906 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using a Thermopile Method

[1] This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.21 on Smoke and Combustion Products.

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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**

2.2 *ISO Standards:*[3]

ISO 5657-1986(E) Fire Tests—reaction to fire—ignitability of building materials

ISO 5660-1(2015) Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)

ISO 5725-2 (1994) Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method

ISO 9705-1 (2016) Reaction to fire tests – Room corner test for wall and ceiling lining products – Part 1: Test method for a small room configuration

3. Terminology

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

3.1.1 *effective heat of combustion, n*—the amount of heat generated per unit mass lost by a material, product or assembly, when exposed to specific fire test conditions (contrast *gross heat of combustion*).

3.1.1.1 *Discussion*—The effective heat of combustion depends on the test method and is determined by dividing the measured heat release by the mass loss during a specified period of time under the specified test conditions. Typically, the specified fire test conditions are provided by the specifications of the fire test standard that cites effective heat of combustion as a quantity to be measured. For certain fire test conditions, involving very high heat and high oxygen concentrations under high pressure, the effective heat of combustion will approximate the gross heat of combustion. More often, the fire test conditions will represent or approximate certain real fire exposure conditions, and the effective heat of combustion is the appropriate measure. Typical units are kJ/g or MJ/kg.

3.1.2 *gross heat of combustion, n*—the maximum amount of heat per unit mass that theoretically can be released by the combustion of a material, product, or assembly; it can be determined experimentally and only under conditions of high pressure and in pure oxygen (contrast *effective heat of combustion*).

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

3.1.3.1 *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 Test Method E906) 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).

3.1.4 *ignitability, n*—the propensity for ignition, as measured by the time to sustained flaming, in seconds, at a specified heating flux.

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

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

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

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *critical heat flux for ignition, n*—the midpoint within the range of heat fluxes between the maximum (highest) heat flux that produces no ignition and the minimum (lowest) heat flux that produces ignition, for a specified exposure time.

3.2.2 *heat release rate (in bench-scale heat release tests), n*—the heat evolved from the specimen, per unit of time and area.

3.2.2.1 *Discussion*—The heat release rate measured in this test method is expressed in units of kW/m^2 and not in units of kW.

3.2.3 *net heat of combustion, n*—the oxygen bomb (see Test Method D5865) value for the heat of combustion, corrected for gaseous state of product water.

3.2.3.1 *Discussion*—The net heat of combustion differs from the gross heat of combustion in that the former assesses the heat per unit mass generated from a combustion process that ends with water in the gaseous state while the latter ends with water in the liquid state.

3.2.4 *orientation, n*—the plane in which the exposed face of the specimen is located during testing, either vertical or horizontal facing up.

3.2.5 *sustained flaming, n*—existence of flame on or over most of the specimen surface for periods of at least 4 s.

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

3.3 *Symbols:*

A_s = nominal specimen exposed surface area, 0.01 m^2.
C = calibration constant for oxygen consumption analysis, m$^{1/2}$ – kg$^{1/2}$ – $K^{1/2}$.
Δh_c = net heat of combustion, kJ/kg.
$\Delta h_{c,eff}$ = effective heat of combustion, kJ/kg.
I = actual beam intensity.
I_o = beam intensity with no smoke.
k = smoke extinction coefficient, m^{-1}.
L = extinction beam path length, m.
m = specimen mass, kg.
m_f = final specimen mass, kg.
m_i = initial specimen mass, kg.
$\dot{m}$ = specimen mass loss rate, kg/s.
ΔP = orifice meter pressure differential, Pa.
q''_{tot} = total heat released, kJ/m^2 (Note that kJ ≡ kW·s).
$\dot{q}$ = heat release rate, kW.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.