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An American National Standard

Standard Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or Composites Using a Bench Scale Oxygen Consumption Calorimeter[1]

This standard is issued under the fixed designation E1474; 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.

INTRODUCTION

This test method provides a means for measuring the ignition time and heat release of the composite upholstered components of upholstered furniture and mattresses using an oxygen consumption calorimeter.

1. Scope

1.1 This fire-test-response test method can be used to determine the ignitability and heat release from the composites of contract, institutional, or high-risk occupancy upholstered furniture or mattresses using a bench scale oxygen consumption calorimeter.

1.2 This test method provides for measurement of the time to sustained flaming, heat release rate, peak and total heat release, and effective heat of combustion at a constant initial test heat flux of 35 kW/m^2. This test method is also suitable to obtain heat release data at different heating fluxes. The specimen is oriented horizontally, and a spark ignition source is used.

1.3 The times to sustained flaming, heat release, and effective heat of combustion are determined using the apparatus and procedures described in Test Method E1354.

1.4 The tests are performed on bench-scale specimens combining the furniture or mattress outer layer components. Frame elements are not included.

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

1.6 *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.*

1.7 *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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 6.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D5865 Test Method for Gross Calorific Value of Coal and Coke

E176 Terminology of Fire Standards

E603 Guide for Room Fire Experiments

E906 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

2.2 *Other Documents:*

CA TB 133, Flammability Test Procedure for Seating Furniture for Use in Public Occupancies[3]

[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.

[3] Available from State of California, Dept. of Home Furnishings and Thermal Insulation, North Highlands, CA 95660-5595.

ISO 5725 Part 2, Accuracy (Trueness and Precision) of Measurement Methods and Results—Basic Method for the Determination of Repeatability and Reproducibility of a Standard Measurement Method[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms relating to this test method refer to Terminology D123 and E176.

3.1.2 *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. (see *gross heat of combustion*.)

3.1.2.1 *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.

3.1.3 *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 only under conditions of high pressure and in pure oxygen (contrast *effective heat of combustion*).

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

3.1.4.1 *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 incident 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, $kJ/(s\ m^2)$, W/cm^2, or $BTU/(s\ ft^2)$.

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.

3.2 *Definitions of Terms Specific to This Standard:*

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

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

3.2.3 *mattress, n*—a mattress is a ticking (outermost layer of fabric or related material) filled with a resilient material, used alone or in combination with other products, intended or promoted for sleeping upon.

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

3.2.4.1 *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.

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

3.2.6 *sustained flaming, n*—the existence of flame on or over the surface of the specimen for a period of 4 s or more.

3.2.7 *upholstered, adj*—covered with material (as fabric or padding) to provide a soft surface.

3.2.8 *upholstery material, n*—the padding, stuffing, or filling material used in a furniture item, which may be either loose or attached, enclosed by an upholstery cover material and support system, if present.

3.2.8.1 *Discussion*—This includes, but is not limited to, material such as foams, cotton batting, polyester fiberfill, bonded cellulose, or down.

4. Summary of Test Method

4.1 This test method is based on the observation that the net heat of combustion is generally directly related to the amount of oxygen required for combustion (**1**).[5] Approximately 13.1×10^3 kJ of heat is released per 1 kg of oxygen consumed. Specimens in the test are burned in ambient air conditions while being subjected to a prescribed initial test heat flux of 35 kW/m^2.

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

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

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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

5. Significance and Use

5.1 This test method is used to determine the time to sustained flaming and heat release of materials and composites exposed to a prescribed initial test heat flux in the cone calorimeter apparatus.

5.2 Quantitative heat release measurements provide information that can be used for upholstery and mattress product designs and product development.

5.3 Heat release measurements provide useful information for product development by yielding 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 does not spread flame over its surface under the fire exposure conditions of interest.

5.4 *Test Limitations*—The test data are invalid if either of the following conditions occur: (*1*) explosive spalling; or (*2*) the specimen swells sufficiently prior to ignition to touch the spark plug, or the specimen swells up to the plane of the heater base during combustion.

6. Safety Precautions

6.1 The test procedures involve high temperatures and combustion processes. Therefore, the potential for hazards such as burns, ignition of extraneous objects or clothing, and inhalation of combustion products exists. The operator must use protective gloves for insertion and removal of the test specimens. Do not touch either the cone heater or the associated fixtures while hot, except with the use of protective gloves.

7. Test Specimen Preparation—Method A (2)

7.1 *Equipment and Supplies for Specimen Preparation:*

7.1.1 *Cutting Equipment*—Cut foams with a band saw; a foam-cutting blade shall be used. This blade has no teeth; instead, it has a wavy scallop to the edge. Ensure that the blade is well sharpened. Make certain that no silicones or other oils are applied to lubricate the blade; lubrication shall be solely with graphite or molybdenum compounds. The band saw blade must make a straight and true cut of the foam. Set the blade guide no higher than 12 mm above the stock to be cut.

7.1.2 *Forming Blocks*—The specimen preparation rests crucially upon the proper use of forming blocks. These blocks are made in dimensions of 98 by 98 by 50 mm. Each of these dimensions shall be controlled to ± 0.5 mm. Use, as the material for the forming blocks, a dense wood, such as maple, which is minimally subject to dimensional changes when the humidity is changed. Do not use pine. Use only fully kiln-dried timber for making the forming blocks. Ensure that all surfaces are cut straight and true and are smooth. The edges shall not be rounded, but the corners shall be slightly rounded. It is preferable to lacquer the blocks with an acrylic lacquer to ensure a hard, smooth, stable surface. Make up a minimum of 12 blocks to allow a reasonable number of specimens to be prepared at the same time.

7.1.3 *Adhesive*—Several adhesives have been found suitable for securing the fabrics. The adhesive shall be low in flammability and shall have suitable holding power to permit inserting the resilient padding, stay in place until the testing is performed (that is, through the required conditioning) and during the flammability test procedure. For the latter, the glued portions of the fabric shall neither flame excessively nor retard burning. Adhesives that are based on polychloroprene, acrylic, or water have been found suitable.

7.1.3.1 *Adhesive Selection*—Adhesives based on polychloroprene in methylene chloride solvent have been found suitable for all composites tested.[6] Adhesives based on acrylic in water solvent (white glue, readily available in hardware and craft stores)[7] have been proven adequate for many, but not all, fabrics and interliners tested by a United States testing laboratory. Other adhesives are also suitable, provided they meet the stated requirements.

7.1.3.2 *Adhesive Application*—The method of adhesive application depends on the particular adhesive selected. Water-soluble adhesives are applied directly from the bottle and therefore do not require a brush. Likewise, any spillage is readily cleanable with water. This type of adhesive does not set as quickly as the solvent-based adhesives, which permits shifting the fabric as necessary to create a neat, tight package. However, the glued specimen shall be left overnight to ensure a good seal. On the other hand, polychloroprene-based adhesives are applied with a brush made of hog bristles or other stiff, course material. The brush shall be flat and square cut, with a width of 7 to 8 mm. A solvent compatible with the adhesive shall be used for cleanup and storage of the brush. The solvent-based glues set up very quickly and do not permit any adjustment around the wood block.

7.1.3.3 *Adhesive Checking*—To test the efficiency of an adhesive, apply a small amount on two small pieces of the fabric or interliner to be used. Allow the adhesive to dry (at least overnight), and then attempt to tear the fabric pieces from one another. To be acceptable, the glued pieces shall not be able to be separated without tearing the fabric.

7.1.4 *Tape*—Masking tape or other tape with adhesive is used to assist in assembling the test composites. Any type of tape which will adequately adhere to all fabrics and be easy to remove after completion of assembly is suitable for this purpose. Some interliners or fabrics will be damaged by direct application of masking tape to their surface, since removal results in tearing or marring the surface. For items susceptible to such damage, prepare strips of paper slightly wider than the width of the masking tape and long enough to reach all the way around the forming block. Then secure the paper strips with tape.

7.1.5 *Aluminum Foil*—Use aluminum foil that is 0.03 to 0.04 mm thick.[8] No other foil thickness shall be used; it is especially important not to substitute a thicker foil.

7.2 *Basic Preparation of Specimens:*

7.2.1 The basic instructions here pertain to specimens which comprise only a single layer of fabric over a single layer of

[6] Parabond A-1535 obtained from Para-Chem Southern, Inc., Simpsonville, SC is an example of a suitable adhesive of this type.

[7] DAP Weldwood, Hobby'n Craft Glue is an example of a suitable adhesive of this type.

[8] Commercially available heavy duty foil has the appropriate thickness.