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Standard Guide for Room Fire Experiments[1]

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INTRODUCTION

This guide has been written to assist those planning to conduct full-scale compartment fire experiments. There are many issues that should be resolved before such an experimental program is initiated, and this guide is written with the objective of identifying some of these issues and presenting considerations that will affect each choice of procedure.

This guide deals with any or all stages of fire growth in a compartment. Whether it is a single- or multi-room experiment, observations can be made from ignition to flashover or beyond full-room involvement.

One major reason for conducting research on room fires is to learn about the room fire buildup process so the results of standard fire test methods can be related to performance in full-scale room fires, allowing the further refinement of these test methods or development of new ones.

Another reason concerns computer fire modeling. Full-scale tests can generate data needed for modeling. Comparisons of modeling with full-scale test results can serve to validate the model.

The various results among room fire tests reflect different experimental conditions. The intent of this guide is to identify these conditions and discuss their effects so meaningful comparisons can be made among the room fire experiments conducted by various organizations.

1. Scope

1.1 This guide addresses means of conducting full-scale fire experiments that evaluate the fire-test-response characteristics of materials, products, or assemblies under actual fire conditions.

1.2 It is intended as a guide for the design of the experiment and for the use and interpretation of its results. The guide is also useful for establishing laboratory conditions that simulate a given set of fire conditions to the greatest extent possible.

1.3 This guide allows users to obtain fire-test-response characteristics of materials, products, or assemblies, which are useful data for describing or appraising their fire performance under actual fire conditions.

1.3.1 The results of experiments conducted in accordance with this guide are also useful elements for making regulatory decisions regarding fire safety requirements. The use for regulatory purposes of data obtained from experiments conducted using this guide requires that certain conditions and criteria be specified by the regulating authority.

1.4 The rationale for conducting room fire experiments in accordance with this guide is shown in 1.5 – 1.8.

1.5 Room fire experiments are a means of generating input data for computer fire models and for providing output data with which to compare modeling results.

1.6 One of the major reasons for conducting room fire experiments is as an experimental means of assessing the potential fire hazard associated with the use of a material or product in a particular application. This should be borne in mind when designing nonstandard experiments.

1.7 A rationale for conducting room fire experiments is the case when smaller-scale fire tests inadequately represent end-use applications.

1.8 A further rationale for conducting room fire experiments is to verify the results obtained with smaller scale tests, to understand the scaling parameters for such tests.

1.9 Room fire tests can be placed into four main categories: reconstruction, simulation, research, and standardization.

1.10 *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] This guide 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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1.11 *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.*

1.12 *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]

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials
D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters
D5424 Test Method for Smoke Obscuration of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration
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
E800 Guide for Measurement of Gases Present or Generated During Fires
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
E1355 Guide for Evaluating the Predictive Capability of Deterministic Fire Models
E1537 Test Method for Fire Testing of Upholstered Furniture
E1590 Test Method for Fire Testing of Mattresses
E1822 Test Method for Fire Testing of Stacked Chairs
E2067 Practice for Full-Scale Oxygen Consumption Calorimetry Fire Tests
E2257 Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies
E3057 Test Method for Measuring Heat Flux Using Directional Flame Thermometers with Advanced Data Analysis Techniques

2.2 *UL Standards:*[3]

UL 1040 Fire Test of Insulated Wall Construction
UL 1715 Fire Test of Interior Finish Material

2.3 *ICBO Standards:*[4]

Uniform Building Code Standard UBC 8-2 Standard Test Method for Evaluating Room Fire Growth Contribution of Textile Wallcoverings
Uniform Building Code Standard UBC 26-3 Room Fire Test Standard for Interior of Foam Plastic Systems

2.4 *FM Standard:*[5]

FM 4880 Large Scale Open Building Corner Test

2.5 *ISO Standards:*[6]

ISO 9705 Fire Tests—Full Scale Room Fire Tests for Surface Products
ISO 13943 Fire Safety—Vocabulary
ISO 17025 General Requirements for the Competence of Testing and Calibration Laboratories
GUM, Guide to the Expression of Uncertainty in Measurement

2.6 *NFPA Standards:*[7]

NFPA 265 Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings
NFPA 286 Standard Method of Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth
NFPA 555 Guide on Methods for Evaluating Potential for Room Flashover

2.7 *Other Standard:*[8]

DASMA 107 -98 (03) Room Fire Test Standard for Garage Doors Using Foam Plastic Insulation

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this guide and associated with fire issues, refer to the terminology contained in Terminology E176 and ISO 13943. In case of conflict, the terminology in Terminology E176 shall prevail.

3.1.2 *heat release rate, n*—the thermal energy released per unit time by an item during combustion under specified conditions.

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

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

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *full-scale test, n*—a test in which the product(s) to be tested is utilized in the same size as in its end use.

[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 Underwriters Laboratories, Inc., 333 Pfingsten Rd., Northbrook, IL 60062.

[4] Available from International Conference of Building Officials, 5360 Workman Mill Rd. Whittier, CA 90601.

[5] Available from Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, P.O. Box 9102, Norwood, MA 02662.

[6] Available from International Organization for Standardization, P.O. Box 56, CH-1211, Geneva 20, Switzerland.

[7] Available from National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

[8] Available from Door and Access Systems Manufacturers Association International, 1300 Summer Avenue, Cleveland, OH 44115-2851.

3.2.1.1 *Discussion*—In practical applications, this term is usually applied to tests where the item to be tested is larger than would fit in a bench-scale test.

4. Summary of Guide

4.1 This guide does not define a standard room fire test. It does, however, set down many of the considerations for such a test, for example, room size and shape, ventilation, specimen description, ignition source, instrumentation, and safety considerations that must be decided on in the design of a room fire experiment. It discusses performance criteria for the particular array of finishing and furnishing products that comprise the room. The behavior of any particular product in the room depends on the other products and materials present and how they are arranged in relation to one another.

4.2 Whether a particular arrangement simulates the evaluation desired depends on the size and location of the ignition source. It is therefore important that the ignition source simulate, insofar as possible, an initiating fire for the desired scenario.

4.3 The time to flashover is often considered (for example in room-corner tests) the time from the start of test until any two of the following conditions have been attained:

(1) The heat release rate exceeds 1 MW in a standard ASTM/ISO room (sixed 2.4 by 3.7 by 2.4 m; 8 by 12 by 8 ft). This criterion is the first criterion used by room corner tests such as NFPA 286.

(2) The heat flux on the compartment floor exceeds 20 kW/m^2.

(3) The average upper air temperature exceeds 600°C.

(4) Flames exit the compartment door.

(5) Radiant heat ignition of a cellulosic (cotton or paper) indicator on the floor occurs.

4.3.1 Other possible performance criteria indicating flashover include the total amount or rate of smoke and heat released, the extent of the flame spread for a low-energy ignition source, and the size of the primary ignition source required.

4.3.2 Where multi-room experiments are being conducted, flashover may not be an appropriate performance criteria. In fact, the experiments may have to be conducted beyond flashover. Post-flashover is usually required in the test room in order to observe high levels of toxic gases and smoke in remote rooms or flame spread in adjoining surface areas. Other performance criteria could be the levels of combustion products that impair visibility and cause incapacitation or lethality in remote rooms.

4.4 Primary ignition sources include gas burners, wood cribs, waste containers, and pools of liquid fuel. Waste containers and wood cribs have the advantage of presenting a solid fuel fire with some feedback effects and a luminous flame that appears to simulate the burning of furniture. However, the gas burner is the best choice for most fire experiments because of its reproducibility. The placement of the ignition source depends on the desired effect on the target material.

4.5 The instrumentation for measuring burning rate, heat release rate, heat flux, temperature, upper layer depth, air velocity, flame spread, smoke, and gas concentration is discussed, along with suggested locations. A minimum level of instrumentation is also suggested.

4.6 A typical compartment size is 2.4 by 3.7 m [8 by 12 ft], with a 2.4-m [8-ft] high ceiling. A standard-size doorway (0.80 by 2.0-m high) should be located in one wall, probably in one of the shorter ones. The top of the doorway should be at least 0.4 m [16 in.] down from the ceiling to partially contain smoke and hot gases.

4.7 Insofar as possible, the construction details of the wall and ceiling, as well as any enclosed insulation, should duplicate the room being simulated. Boundary surfaces that do not form the specimen should also be constructed of materials consistent with the room being simulated (see 6.2.3).

4.8 The safety of observers and the crew extinguishing the fire is emphasized strongly in this guide.

4.9 The analysis of data should include a comparison of the critical times, heat fluxes, temperatures, heat release rate, and smoke generation in the room with ignition, flame spread, and smoke properties of the specimen materials. This would aid in the development or modification of small-scale tests and would provide useful information for assisting in the development of analytical room fire models.

5. Significance and Use

5.1 This guide provides assistance for planning room fire tests. The object of each experiment is to evaluate the role of a material, product, or system in the fire growth within one or more compartments.

5.2 The relationship between laboratory fire test methods and actual room fires can be investigated by the use of full-scale and reduced-scale experiments. This guide is aimed at establishing a basis for conducting full-scale experiments for the study of room fire growth.

5.3 Room fire tests can be placed into four main categories: reconstruction, simulation, research and standardization.

5.3.1 Reconstruction room fire tests are full scale replicates of a fire scene with the geometry, materials, contents, and ignition source intended to duplicate a particular scenario. The usual purpose of such a test is to evaluate what happened or what might happen in such a scenario.

5.3.2 Simulation room fire tests are comparable to reconstruction fire tests, except that not all of the parameters are duplicated. A simulated fire test is one in which one or more components of a fire scenario are altered, usually in order to facilitate conducting the test. The compartment design must carefully address geometry and materials of construction to ensure that they do not significantly alter the fire response. Reconstruction and simulation fire tests often have a distinctive objective, such as time to flashover, that is related to the nature of the original fire scene.

5.3.3 Research room fire tests are conducted in order to elucidate the effects of one or more of the following: geometry, materials, placement of items, ventilation, or other parameters. The measured effects (such as room temperature, heat flux,