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Standard Guide for Fire-Resistance Experiments[1]

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INTRODUCTION

This guide provides a means for ensuring comparability of findings among different researchers conducting fire-resistance experiments employing innovative and creative variations to standard test methods. This guide is intended to bring uniformity and consistency to tests and reports covering fire-resistance research that is generally conducted as a variation of Test Methods E119. Its provisions are voluntary and users are free to pick and choose from the provisions herein provided. The overriding goal is to make it possible to begin to provide data that ultimately can be used in fire safety engineering and fire-resistance modeling as those fields evolve. When the purpose of the research is to study the effect of changing specific individual variables on the outcome of Test Methods E119 fire-resistance tests, sound research practices dictate that only one variable should be changed at a time.

1. Scope

1.1 This guide covers the conduct of fire-resistance tests using conditions different than those addressed in Test Methods E119. This guide also addresses the reporting of data derived from those tests.

1.2 This guide does not provide or generate fire-resistance ratings suitable for determining compliance with code or regulatory requirements comparable to those resulting from tests conducted in accordance with Test Methods E119.

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

1.4 *This guide 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.*

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E119 Test Methods for Fire Tests of Building Construction and Materials

E176 Terminology of Fire Standards

E603 Guide for Room Fire Experiments

E1529 Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies

2.2 *Other Standards:*

ISO 834-1 Fire Resistance Tests – Elements of Building Construction – Part 1: General Requirements[3]

NFPA 251 Standard Methods of Tests of Fire Resistance of Building Construction and Materials[4]

3. Terminology

3.1 For definitions of terms used in this guide, refer to Terminology E176.

[1] This guide is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.11 on Fire Resistance.

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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 International Organization for Standardization, P.O. Box 56, CH-1211, Geneva 20, Switzerland.

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

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4. Significance and Use

4.1 The methods and procedures set forth in this guide relate to the conduct and reporting of fire-resistance tests obtained from particular fire-resistance tested specimens tested using conditions different than those addressed by Test Methods E119.

4.2 Data derived from fire tests conducted and reported under this guide are useful for general fire research and as potential input data for use in fire models.

4.3 It is necessary that users of this guide have knowledge and understanding of the provisions of Test Methods E119, including those pertaining to conditions of acceptance in order to understand how the alternative test conditions relate to those specified in Test Methods E119.

4.4 Users of this guide should be aware that tests conducted using exposure conditions different than those specified in Test Methods E119 do not provide or generate fire resistance ratings suitable for determining compliance with code or regulatory requirements.

4.4.1 In Test Methods E119, standard test specimens are subjected to specific exposure conditions. Substitution of different exposure conditions can change the measured fire-test-response characteristics of a test specimen. Therefore, the data are valid for only the alternative exposure conditions used.

5. General Principles

5.1 Except as specifically modified herein, fire-resistance tests should be conducted using the test furnaces, exposure conditions, test specimens, instrumentation, and acceptance criteria set forth in Test Methods E119.

5.2 Although it is possible to vary many variables at one time, and it may be desirable to do so when evaluating the response of a specimen to specific design fire conditions, it is usually desirable to vary only one parameter at a time when comparing results from two or more tests or when evaluating the effect on fire resistance of changing a specific variable.

5.3 *Limitations*—The test data is valid for only the specimen and parameters used in the test.

6. Alternative Time-Temperature Curves

6.1 The provisions in this section are applicable to the use of alternative time-temperature curves that are different from the time-temperature curve specified in Test Methods E119.

6.1.1 When the time-temperature curve specified in Test Methods E119 is used, it should be so stated in the report.

NOTE 1—There are a number of recognized time-temperature curves in use in fire-resistance test standards around the world.

6.2 When a recognized or published time-temperature curve is used, the reference in which the curve is described should be cited and the time-temperature curve should be reported.

6.3 Fire safety engineering and computer modeling are methods whereby non-standard time-temperature curves can be derived to represent specific design conditions.

6.3.1 When these design fires are used as the basis of a time-temperature curve, a table or equation representing the curve should be reported.

7. Alternative Pressure Differentials

7.1 The provisions in this section are applicable to the use of specific furnace pressure differentials.

NOTE 2—There are a number of recognized or published furnace pressure differentials in use in fire test standards around the world.

7.2 When a recognized or published furnace pressure differential is used, the reference in which the pressure differential is described should be cited and the pressures should be reported.

7.3 When other pressure differentials are used for exploratory research or to replicate actual fire conditions, or for any other reason, they should be described and should be reported.

7.4 Furnace pressure differentials should be measured as described in NFPA 251.

8. Alternative Test Specimens

8.1 The provisions in this section are applicable to the use of alternative test specimens that are different from the test specimens specified in Test Methods E119.

8.2 Test specimen dimensions, that is, height and width for walls, length and width for horizontal specimens, or lengths for columns or beams, should be reported and the method used to modify the furnace opening to accommodate the specimen size should be reported.

8.3 When test specimens having exposed and unexposed surfaces that are not parallel to each other or that are not flat (planar) are tested, their maximum and minimum thicknesses, and radii, if curved, should be reported.

8.4 When test specimens having one or more designed protrusions or indentations (pilasters, alcoves, etc.) either on the fire side, the unexposed side, or both, are tested, the size, shape, location, and dimensions of each protrusion or indentation should be described and reported.

8.5 When test specimens exceeding the depth of the specimen mounting frame are tested, the method(s) of protecting the portion of the test specimen extending beyond the frame should be described and reported.

9. Alternative Instrumentation – Furnace Environment

9.1 When alternative instrumentation is used in addition to the standard instrumentation specified in Test Methods E119, the alternative instrumentation should be spaced and mounted so as to not interfere with the standard instrumentation.

9.2 *Furnace Temperature Measurement:*

9.2.1 When the furnace control temperature measurement method (that is, shielded thermocouples) specified in Test Methods E119 is used it should be so stated in the report.

9.2.2 When Directional Flame Thermometers or plate thermometers are used they should be spaced as described in 9.2.2.1 through 9.2.2.2.

NOTE 3—Directional Flame Thermometers are described in Test Methods E1529. Specifications for plate thermometers are provided in ISO 834-1.

9.2.2.1 There should be nine plate thermometers equally distributed across the test specimen surface.

9.2.2.2 Directional Flame Thermometers and Plate thermometers should be located 4 ± 0.2 in. (100 ± 5 mm) from the exposed surface of the test specimen at the beginning of the test.

9.2.3 Other methods, sensors, or measurement devices for monitoring the furnace temperature should be described and reported.

9.2.4 Any special mounting methods used for plate thermometers or other temperature measuring devices should be described and reported.

9.2.5 The locations of furnace temperature measuring devices should be reported.

9.3 *Heat Flux Measurement:*

9.3.1 When heat flux measurements are taken in addition to furnace temperature control measurements, the methods, instrumentation, and heat flux profile should be described and reported.

9.3.1.1 Any special mounting methods should be described and reported.

9.3.2 The locations of heat flux measurement devices should be reported.

9.4 *Pressure Measurement:*

9.4.1 When furnace pressures are measured or controlled, the methods, instrumentation, and pressure differentials should be reported.

9.4.2 Furnace pressure should be measured using the tube sensor described in ISO 834-1 and NFPA 251.

9.4.2.1 In a vertical furnace, pressure should be measured at a minimum of two locations. The measuring locations should be separated by a minimum of ⅓ the test specimen height.

9.4.2.2 In a horizontal furnace, pressure should be measured at a single location a nominal 4 ± 0.2 in. (100 ± 5 mm) below the exposed surface of the test specimen at the beginning of the test.

9.4.3 Any special mounting methods should be described and reported.

9.4.4 The locations of pressure measurement devices should be reported.

9.5 *Furnace Oxygen Concentration:*

9.5.1 When furnace oxygen concentration is being monitored, it should be measured in the furnace stack.

9.5.1.1 Oxygen concentration should be measured using a paramagnetic-type oxygen analyzer.

9.5.1.2 The sampling probe should be similar to the sampling probe used in duct measurements of hood calorimeters described in Guide .

9.5.1.3 Gas samples should be continuously drawn out of the stack through a sampling line.

9.5.2 The oxygen concentration profile should be reported.

9.6 *Other Measurement Instrumentation:*

9.6.1 Additional instrumentation such as load cells, additional thermocouples, moisture content measurement devices, motion sensors, or other instrumentation not described or specified in Test Methods E119 should be fully described and reported.

10. Alternative Instrumentation – Specimen

10.1 When alternative instrumentation is used in addition to the standard instrumentation specified in Test Methods E119, the alternative instrumentation should be spaced and mounted so as to not interfere with the standard instrumentation.

10.2 *Unexposed Surface Temperature Measurement for Walls and Floor/Ceilings:*

10.2.1 When the unexposed surface temperature measurement methods specified in Test Methods E119 are used, it should be so stated in the report.

10.2.2 Other methods, sensors, or measurement devices used for monitoring the unexposed surface temperature should be described and reported.

10.2.2.1 Any special mounting methods should be described and reported.

10.2.3 The locations of temperature measuring devices should be reported.

10.3 *Heat Flux Off the Unexposed Surface of Walls and Floor/Ceilings:*

10.3.1 When total heat flux off the unexposed surface is measured, it should be measured as described in 10.3.1.1 through 10.3.1.3.

10.3.1.1 Total heat flux coming off the unexposed surface should be measured using a Schmidt-Boetler-type water-cooled total heat flux gauge.

10.3.1.2 The heat flux gauge should be placed near the center of the unexposed surface of the specimen and as close to the specimen surface as practical.

10.3.1.3 When the test specimen contains a transparent element, an additional heat flux gauge should be placed near the center of the transparent element and as close as practical to the surface of the transparent element.

10.4 *Temperature Profile Through Test Specimens:*

10.4.1 When the temperature profile of test specimens is monitored, it should be monitored as described in 10.4.1.1 through 10.4.1.4.

10.4.1.1 Temperatures should be measured through the thickness of the test specimen at not less than two locations representative of each major heat-transfer path within the specimen.

10.4.1.2 The surface temperature on the exposed side should be measured with a 24-gauge, Type K bare bead thermocouple placed in contact with the exposed surface of the test specimen.

10.4.1.3 The surface temperature on the unexposed side should be measured using an optical pyrometer suitable for measuring temperatures on the unexposed side.

10.4.1.4 Internal temperatures should be measured using Inconel-sheathed Type K thermocouples with a sheath diameter of 0.04 in. (1.0 mm).

10.5 *Gas Temperature Measurement:*

10.5.1 When gas temperatures are measured they should be measured as described in 10.5.1.1 through 10.5.1.3.

10.5.1.1 Gas temperatures should be measured using aspirated thermocouples.

NOTE 4—Aspirated thermocouples are described in Guide E603.

10.5.1.2 Gas temperatures should be measured on the exposed and unexposed surfaces at each location where a temperature profile is being monitored.

10.5.1.3 Aspirated thermocouples should be placed as close to the surface as possible.

10.6 *Temperature Measurement for Beams and Columns:*

10.6.1 When the beam and column temperature measurement methods specified in Test Methods E119 are used, it should be so stated in the report.

10.6.2 Other methods, sensors, or measurement devices for monitoring beam and/or column temperatures should be described and reported.

10.6.2.1 Any special mounting methods should be described and reported.

10.6.3 The locations of temperature measuring devices should be reported.

11. Loading

11.1 *Procedure for Establishing the Load:*

11.1.1 When the method of applying and calculating the load described in Test Methods E119 is used, it should be so stated in the report.

11.1.2 The method of applying the superimposed load should be described and reported and should include the following:

11.1.2.1 Rate of application of the load prior to conducting the test.

11.1.2.2 Equipment/hardware employed to apply the load.

11.1.2.3 Visual observations of the specimen's response to the load as it is being applied.

11.2 *Calculation of Loads:*

11.2.1 The methodology and assumptions used to calculate the superimposed test load should be reported.

11.2.2 All load calculations, both dead and live, should be reported in detail.

11.3 *Static Load Variation:*

11.3.1 The load versus time profile should be reported for test specimens tested under dynamic loading conditions.

12. Restraint and Structural Instrumentation

12.1 When structural components are tested in a restrained condition, the method of achieving restraint should be described and reported.

12.2 When assembly end restraint is measured, it should be measured as described in 12.2.1.

12.2.1 Load cells should be placed at the end boundaries of the test specimen.

NOTE 5—The use of multiple load cells will provide redundancy in the event of a load cell failure.

12.3 When transverse deflection is measured, it should be measured as described in 12.3.1 through 12.3.2.

12.3.1 Measure and report the time-history of transverse deflection measured at the mid-span of the primary structural member (beam, joist, column, or wall stud) nearest the center of the test specimen.

12.3.2 Measure and report the axial shortening or elongation of loaded columns and wall studs.

12.4 When strain in structural members is monitored, it should be measured as described in 12.4.1 through 12.4.3.

12.4.1 High-temperature strain gauges should be located at critical sections of structural members such as beams, joists, columns, or wall studs.

12.4.2 High temperature strain gauges should be located at all other important load transfer elements such as shear studs, metal deck, floor slabs and reinforcement, and connections.

12.4.3 Strain gauges should be positioned at the ends or mid-spans of the elements being monitored.

13. End-Point Criteria

NOTE 6—Specific end-point criteria may not be desirable for all tests; for example, tests conducted for research purposes or for maximum data acquisition.

13.1 When a test is conducted without specified end-point criteria it should be so stated in the report.

13.2 When a test is conducted with specific end-point criteria and those criteria differ from the conditions of acceptance specified in Test Methods E119, the criteria used should be described and recorded.

13.2.1 The time at which the controlling end-point criteria, or the times at which each of the end-point criterion, is met or achieved should be recorded.

14. Report of Results

14.1 Report the following information:

14.1.1 A full and complete description of each and every component of the test specimen including any membranes, structural members, concrete mixes and strengths, mixing water, joint compound, adhesives, fasteners, thermal insulation, and any other material(s) incorporated into the specimen, including the dimensions, volume, and weight of each component.

14.1.2 A description of how the components were assembled, mixed, installed, or applied to erect the test specimen.

14.1.3 The dimensions of the completed test specimen as reported in 8.2 through 8.5.

14.1.4 A description of the time-temperature curve used for the test and the basis or source of the curve.

14.1.5 A table of furnace temperature measurements and measurement intervals.

14.1.6 A table of the pressure or pressures measured, including measurement intervals, during the test and the basis or a reference citation for the source of the pressures used.

14.1.7 A complete description of any additional instrumentation and tables of data as recorded by the additional instrumentation as described in 9.2 through 9.6 and 10.2 through 10.6.

14.1.8 A complete description of loads, load calculations, and the methods of load application, as described in 11.1 through 11.3, for specimens tested with superimposed loads.

14.1.9 A description of any provisions taken to achieve restraint of the test specimen during the test.

14.1.10 Tables of end restraint measurements, transverse deflection, and strain measurements, including measurement intervals.

14.1.11 A description of the specific end-point criteria, if any, used for the test.

14.1.12 When specific end-point criteria are used, the time, expressed in hours, minutes, and seconds, elapsed from the beginning of the test to the time at which each end-point criteria was met.

14.1.13 Photographs as described in 14.1.13.1 through 14.1.13.4.

14.1.13.1 The thermocouple layout.

14.1.13.2 Pertinent construction details and features.

14.1.13.3 The unexposed surface taken before and after the test.

14.1.13.4 The exposed surface taken before and after the test.

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