



Designation: **E1776–16** **E1776 – 22**

An American National Standard

Standard Guide for Development of Fire-Risk-Assessment Standards¹

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1. Scope

1.1 This guide covers the development of fire-risk-assessment standards.

1.2 This guide is directed toward development of standards that will provide procedures for assessing fire risks harmful to people, property, or the environment.

1.3 *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~~ safety, health, and ~~health~~ environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This standard is used to establish a means of combining the potential for harm in fire scenarios with the probabilities of occurrence of those scenarios. Assessment of fire risk using this standard depends upon many factors, including the manner in which the user selects scenarios and uses them to represent all scenarios relevant to the application. This standard cannot be used to assess fire risk if any specifications are different from those contained in the standard.*

1.5 This fire standard cannot be used to provide quantitative measures.

1.6 *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](#)

[E1546 Guide for Development of Fire-Hazard-Assessment Standards](#)

2.2 Other Documents:

[NFPA 557 Standard for Determination of Fire Loads for Use in Structural Fire Protection Design](#)³

[ISO 13943 Fire Safety – Vocabulary](#)⁴

[SFPE Engineering Guide to Performance-Based Fire Protection, Society of Fire Protection Engineers and NFPA, Quincy, MA, 2000](#)⁵

[ISO 13943 Fire Safety – Vocabulary](#)⁴

¹ This guide is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.33 on Fire Safety Engineering. Current edition approved June 1, 2016/February 1, 2022. Published July 2016/March 2022. Originally published in 1996. Last previous edition approved in 2007/2016 as E1776–13/E1776 – 16. DOI: 10.1520/E1776-16.10.1520/E1776-22.

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 NFPA, National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169–7471, <http://www.nfpa.org>.

⁴ Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

⁵ Available from NFPA, 1 Batterymarch Park, Quincy, MA 02169–7471.

3. Terminology

3.1 *Definitions*—See E176, Terminology of Fire Standards and ISO 13943, Fire Safety – Vocabulary. In case of conflict, the definitions in Terminology E176 shall prevail E176.

4. Significance and Use

4.1 This guide is intended for use by those undertaking the development of fire-risk-assessment standards. Such standards are expected to be useful to manufacturers, architects, specification writers, and authorities having jurisdiction.

4.2 As a guide, this document provides information on an approach to the development of a fire-risk-assessment standard; fixed procedures are not established. Limitations of data, available tests and models, and scientific knowledge can constitute significant constraints on the fire-risk-assessment procedure and associated standard.

4.3 While the focus of this guide is on developing fire-risk-assessment standards for products, the general concepts presented also can be applied to processes, activities, occupancies, and buildings.

5. Key Elements

5.1 This guide uses as its key elements the following:

5.1.1 The purpose of a fire-risk-assessment standard is to provide a standardized procedure for assembling a compilation of information relevant to the fire risk of a product under specific conditions of use.

5.1.2 The information assembled shall be relevant to the purpose of assessing the fire risk of the specific designated product within the range of all relevant fire scenarios.

5.1.3 The information assembled shall be explicit and quantitative. It shall provide a sufficiently thorough examination of the product's fire risk under the conditions defined by the scope of the specific standard so as to permit valid choices and decisions with respect to the fire risk of that product.

5.1.4 A persuasive scientific case must be made in the documentation of a specific fire-risk-assessment standard that the procedures, data, and risk measures specified by the standard will address questions about a product's fire risk with sufficient accuracy and validity that a more thorough assessment procedure would not materially alter any decisions that are to be made based on the standard. If such a case cannot be made for all products to be addressed, then the risk assessment shall specify those conditions under which a more thorough fire-risk-assessment procedure is to be used.

5.1.5 The absence of a data source, test method, or calculation procedure of sufficient scope and proven validity to support the needs of a particular fire-risk-assessment procedure does not, by itself, provide a sufficient justification for the use of a data source, test method, or calculation procedure of lesser scope or unproven validity. It is recognized that fire-risk assessments of such products may need to be performed in any event, using relevant nonstandardized procedures. When such nonstandardized or unvalidated procedures are used, the details shall be included to such an extent that the procedures become standardized only for use within the specified fire-risk-assessment procedure through final publication of the fire-risk-assessment standard document.

5.1.6 Among the possible significant outcomes of a fire-risk assessment are a revelation that a product produces either an increase, no increase, or a decrease in fire risk on some or all risk measures and for all or some of the scenarios specified by the standard relative to another product or relative to baseline risk values for those measures and scenarios. These baseline values may or may not be derived from fire-risk assessment of products already in use. However, when the product is proposed for an existing use, the appropriate baseline for comparison is existing products having the same use. For example, if a product's risk is uniformly rated greater than the reference values on all comparisons specified by the standard, then the overall fire-risk assessment of the product will be greater than the fire risk of the baseline (or product in use).

5.1.7 If the assessment shows that the product is not uniformly rated higher than, equivalent to, or less than the other product(s) or the baseline for all risk measures, and reflecting all scenarios specified by the standard, then the implications of the fire risk assessment for product evaluation will not be clear without the development of appropriate decision rules. Such rules would determine the overall risk, giving appropriate weighting to each risk measure.

6. Relationship Between Fire Hazard and Fire Risk

6.1 It is important to differentiate between *fire hazard* and *fire risk*. The relationship is as follows:

6.1.1 A fire-hazard measure addresses the expected performance of a product for a particular fire scenario, including designated conditions of use. A fire-risk measure incorporates fire-hazard measures but also incorporates the probability of occurrence of each fire scenario and addresses all relevant fire scenarios.

6.1.2 Because the number of distinguishable relevant fire scenarios in any fire-risk assessment is usually unmanageably large, it will normally be necessary for fire scenarios to be grouped into classes for purposes of analysis. This may make the fire-risk assessment less product-specific or less specific to conditions of use than would be true of a fire-hazard assessment.

6.1.3 Some existing fire-risk-assessment models and calculation procedures define fire risk as the sum over all fire scenario classes of the probability-weighted fire hazard for that fire scenario class. In such an approach:

6.1.3.1 The fire scenarios in each fire scenario class shall be very similar with respect to those characteristics that determine fire hazard.

6.1.3.2 Each fire scenario class will have a probability (P_i) that represents the likelihood of a fire corresponding to a scenario in that class.

6.1.3.3 For each fire scenario class, a specific fire scenario shall be chosen as representative of the class, so that the fire hazard for that specific fire scenario can be used as a valid estimate of H_i , the fire hazard of the fire scenario class. This is defined as the probability-weighted mean fire hazard for all the specific fire scenarios in the fire scenario class, a quantity that cannot be directly calculated.

6.1.3.4 If this structure is adopted, then the relationship between fire risk measure and fire hazard measure is given by the following formula:

$$Risk = \sum_i (P_i \times H_i) \quad (1)$$

where:

H_i = hazard for representative scenario of scenario class $i, i = 1, \dots, n$ and

P_i = probability of scenario class $i, i = 1, \dots, n$.

6.1.4 For a fire-risk-assessment standard, this formula shows that a fire-risk-assessment procedure may be constructed from a fire-hazard-assessment procedure, a valid structure of fire scenario class and representative fire scenarios by class, and valid sources for fire scenario class probability data.

7. Fire Risk-Assessment Standards

7.1 Fire-risk-assessment standards shall conform in style and content to the *ASTM Form and Style Manual*⁶.

7.2 Fire-risk-assessment standards shall include sections entitled: Scope, Significance and Use, Terminology, and Procedure. The sections shall be numbered and arranged in that order.

7.2.1 *Scope*—The statement in the Scope should clearly state:

7.2.1.1 The product or class of products of interest,

7.2.1.2 The fire scenario classes and representative fire scenarios included in the standard,

7.2.1.3 The assumptions used in the standard,

⁶ Available from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

7.2.1.4 The structure of the fire-risk-assessment procedure, including test methods, models, other calculation procedures, data sources, fire hazard measures, fire risk measures, and any other evaluation criteria or procedures used, and

7.2.1.5 Any limitations on the application of the standard, such as the manner, form, or orientation in which the product is incorporated within an assembly, geometric restrictions essential to use of the product, the quantity of product in use, the end use of the product, and the type of occupancy to which the standard is applicable.

7.2.2 *Significance and Use:*

7.2.2.1 The major uses and any limitations of the standard fire-risk-assessment procedure should be clearly described, including an explicit description of the extent to which the included fire scenario classes and representative fire scenarios, in 7.2.1.2, constitute all the relevant fire scenario classes and representative fire scenarios for the product (class) and occupancy type addressed by the standard.

7.2.2.2 The significance of the assessment to users shall be clearly stated.

7.2.3 *Terminology*—Terms unique to the fire-risk-assessment standard shall be clearly defined. Standard terms as defined in Terminology E176 shall be used.

7.2.4 *Procedure:*

7.2.4.1 This section shall include detailed descriptions of the fire-risk-assessment procedure and its component parts, including test methods, calculation procedures, scenario description, data sources, and evaluation criteria or procedures.

7.2.4.2 Where sources for data on fire experience or expert judgment are cited, the procedures for assembling the data and the accuracy, precision, and reliability of the data shall be documented. The data shall be accessible to personnel conducting or reviewing the fire-risk assessment.

7.2.4.3 If calculation procedures include models, the versions used shall be carefully identified and referenced, and major assumptions and limitations of the models shall be noted. Validation information, or lack thereof, shall also be noted.

7.2.4.4 If calculation procedures are used, it will be especially helpful if sample calculations are included.

7.2.4.5 Standard test methods shall be carefully identified and referenced. If a test method not yet adopted as a national standard is used, its descriptions shall provide all the information that would be included if it were being submitted separately for consideration as a standard test method. Data on reproducibility and validation of nonstandardized methods shall be included or its unavailability shall be explicitly noted. Engineering Guide to Performance-Based Fire Protection, Society of Fire Protection Engineers and NFPA, Quinc. If a standard test method has been modified for the standard, all details of the modification and evidence of the effects of the modification on results shall be included. These guidelines also apply to any large-scale test protocols.

8. Fire-Risk-Assessment Procedure

8.1 *Overview of Elements of Fire Risk:*

8.1.1 Possible sources of harm to people, directly or indirectly, include toxic (narcotic or irritant) substances produced by a fire, thermal insults (heat stress and burns) due to convected and radiant flux, obscuration of vision by smoke (which may interfere with the ability to escape), oxygen depletion, and structural damage leading to traumatic injury.

8.1.2 Possible sources of harm to property include direct damage to contents, furnishings, structure, or other installed or moveable combustibles, from heat, corrosive smoke, soot or firefighting, and indirect damage as a consequence of business interruption or other adverse effects on the ability of the property to be used for its designed purposes.

8.1.3 Harm to the environment includes direct harm to animals or plant life located outside the property of origin, and indirect harm to people, animals, plant life, or property as a result of contamination of air, water, or adjacent land.

8.1.4 The fire risk of a product depends on its properties, how it is used, and the context in which it is used, including the number

and characteristics of people potentially exposed and the value and fragility of property exposed to a fire involving the product. Therefore, a fire-risk-assessment procedure for a particular product should describe the product, how it is used, and its context of use.

8.2 *Development of a Fire-Risk-Assessment Standard*—The steps to follow in developing a fire-risk-assessment standard are as follows. Fig. 1 graphically displays the steps to be pursued, where the left side shows steps for fire-hazard assessment, in accordance with Guide E1546, and the right side shows steps for fire-risk assessment, in accordance with this standard.

8.2.1 Define the scope (for example, the product(s) or product class of interest, and where and how the products are used),

8.2.2 Identify the measure of fire effect to be used in defining fire hazard and fire risk (for example, deaths, injuries, business loss, property loss),

8.2.3 The measure of fire risk should be identified as a function of the measures of fire hazard (for example, if fire hazard is defined as fire effect for a specific scenario, then fire risk may be defined by the formula given in 6.1.3.4),

8.2.4 Identify the structure for the fire scenarios of concern, including, if needed by the selected measure of fire risk, scenario class definitions and representative scenarios (for example, geometry, ventilation, and other spacial characteristics of environment; initial heat source; initial fuel source if not the product; locations and burning properties of secondary fuel sources; occupant characteristics),

8.2.5 Using Guide E1546, identify the fire-hazard estimation procedure to be used to calculate the fire hazard for each representative fire scenario,

8.2.6 Identify the necessary data sources to support the procedures and measures identified in 8.2.2 – 8.2.5, including calculation of probabilities, and

8.2.7 Identify the necessary safety factors, sensitivity analyses, or other elements required to permit valid interpretation of the fire-risk estimates, in light of the uncertainties and biases of data or calculation methods, which shall have been previously documented in 8.2.2 – 8.2.6.

8.3 *Define the Scope*—The first step involves defining the products or class of products to which the fire-risk-assessment standard is to apply (that is, scope) and examining the points of variability and commonality in the product or product class and in product usage that define parameters of the fire-risk-assessment procedure.

8.4 *Identify the Measure of Fire Effect*—The candidate measures for calculation of fire risk each has its advantages and disadvantages.

8.4.1 *Measures of End Outcomes*, such as deaths, injuries, or property damage, are the most directly related to the ultimate concerns of fire impact on people, property, or the environment. However, these measures require more extensive and elaborate estimation procedures than do some other measures, which may not require so much information on the entire building or occupancy or on its occupants. As the analysis goes beyond the product's immediate environment, it becomes more difficult to isolate differences between products, but such differences are still real and potentially important.

8.4.2 *Measures of Physical Fire Effects*, such as extent of flame or smoke damage or whether flashover occurs, are less directly and reliably related to the ultimate concerns of fire impact on people, property, or the environment. However, most of these measures can be calculated with less elaborate estimation procedures, including procedures that do not characterize occupants or spaces beyond the first room or area involved in fire. This eliminates some sources of uncertainty and makes it easier to isolate effects of product differences, although the ultimate significance, to the end outcomes that are ultimately of concern, of the risk differences so identified may be less clear.

8.5 *Identify Measure of Fire Risk:*

8.5.1 *Mean Fire Hazard*—The formula given in 6.1.3.4 defines fire risk as the mean value of fire hazard and is the fire-risk measure to be used in most circumstances.

8.5.2 *Probability of Hazard*—An alternative measure defines fire risk as the probability that a specified level of fire hazard will