



## Standard Guide for Fire Hazard Assessment of the Effect of Upholstered Seating Furniture Within Patient Rooms of Health Care Facilities<sup>1</sup>

This standard is issued under the fixed designation E2280; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### INTRODUCTION

The traditional approach to codes and standards is the specification of individual fire-test-response requirements for each material, component or product placed in a certain environment and deemed important to ensure fire safety. This practice has been in place for so long that it gives a significant level of comfort: a manufacturer knows what is required to comply with the specifications and specifiers apply the requirements. Implicit assumptions, not stated, are that the use of the prescribed requirements ensures an adequate level of safety. There is no need to impose any change on those manufacturers who supply safe systems meeting existing prescriptive requirements. However, as new materials and products are developed, manufacturers, designers, and specifiers often desire the flexibility to choose how the overall safety requirements are to be met. Thus, it is the responsibility of the developer of an alternative approach to state explicitly the assumptions being made to produce the output. The way to generate explicit and valid assumptions is to provide a performance-based approach, based on test methods providing data in engineering units, suitable for use in fire safety engineering calculations, as this guide provides. The resulting fire hazard assessment focuses on upholstered seating furniture items within patient rooms in health care occupancies. This requires developing the fire scenarios to be considered and the effect of all contents and design considerations within the patient room which are potentially able to affect the resulting fire hazard. This offers opportunities for innovation, and ingenuity, without compromising safety.

<https://www.astm.org/standards/E2280>

### 1. Scope ~~Scope~~\*

1.1 This is a guide to developing fire hazard assessments for upholstered seating furniture, within patient rooms of health care occupancies. As such, it provides methods and contemporary fire safety engineering techniques to develop a fire hazard assessment for use in specifications for upholstered seating furniture in such occupancies.

1.2 Hazard assessment is an estimation of the potential severity of the fires that can develop with certain products in defined scenarios, once the incidents have occurred. Hazard assessment does not address the likelihood of a fire occurring, but is based on the premise that an ignition has occurred.

1.3 Because it is a guide, this document cannot be used for regulation, nor does it give definitive instructions on how to conduct a fire hazard assessment.

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.15 on Furnishings and Contents. Current edition approved Dec. 15, 2017/Dec. 15, 2021. Published January 2018/January 2022. Originally approved in 2003. Last previous edition approved in 2013/2017 as E2280-13-17. DOI: 10.1520/E2280-17.10.1520/E2280-21.

\*A Summary of Changes section appears at the end of this standard

1.4 This guide is intended to provide assistance to those interested in mitigating the potential damage from fires associated with upholstered furniture in patient rooms in health care occupancies.

1.5 Thus, this guide can be used to help assess the fire hazard of materials, assemblies, or systems intended for use in upholstered furniture, by providing a standard basis for studying the level of fire safety associated with certain design choices. It can also aid those interested in designing features appropriate to health care occupancies. Finally, it may be useful to safety personnel in health care occupancies.

1.6 This guide is a focused application of Guide **E1546**, which offers help in reference to fire scenarios that are specific to upholstered furniture in health care occupancies, and includes an extensive bibliography. It differs from Guide **E1546** in that it offers guidance that is specific to the issue of upholstered furniture in patient rooms of health care facilities, rather than general guidance. **Appendix X11** includes some statistics on the magnitude of the potential problem in the U.S.

1.7 A fire hazard assessment conducted in accordance with this guide is strongly dependent on the limitations in the factors described in **1.7.1 – 1.7.4**.

1.7.1 Input data (including their precision or accuracy).

1.7.2 Appropriate test procedures.

1.7.3 Fire models or calculation procedures that are simultaneously relevant, accurate and appropriate.

1.7.4 Advancement of scientific knowledge.

1.8 This guide addresses specific fire scenarios which begin inside or outside of the patient room. However, the upholstered furniture under consideration is inside the patient room.

1.9 The fire scenarios used for this hazard assessment guide are described in **9.2**. They involve the upholstered furniture item within the patient room as the first or second item ignited, in terms of the room of fire origin. Additionally, consideration should be given to the effect of the patient room upholstered furniture item on the tenability of occupants of rooms other than the room of fire origin, and on that of potential rescuers.

<https://standards.iteh.ai/catalog/standards/sist/3da4712c-b164-4dc1-9088-cba1f7dafaf1/astm-e2280-21>

1.10 This guide does not claim to address all fires that can occur in patient rooms in health care occupancies. In particular, fires with more severe initiating conditions than those assumed in the analysis may pose more severe fire hazard than that calculated using this guide (see also **9.5**).

1.11 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.12 *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.*

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

1.14 *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:*<sup>2</sup>

**D123 Terminology Relating to Textiles**

**E162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source**

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[E176 Terminology of Fire Standards](#)  
[E603 Guide for Room Fire Experiments](#)  
[E648 Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source](#)  
[E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials](#)  
[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](#)  
[E1352 Test Method for Cigarette Ignition Resistance of Mock-Up Upholstered Furniture Assemblies](#)  
[E1353 Test Methods for Cigarette Ignition Resistance of Components of Upholstered Furniture](#)  
[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](#)  
[E1472 Guide for Documenting Computer Software for Fire Models \(Withdrawn 2011\)<sup>3</sup>](#)  
[E1474 Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or Composites Using a Bench Scale Oxygen Consumption Calorimeter](#)  
[E1537 Test Method for Fire Testing of Upholstered Furniture](#)  
[E1546 Guide for Development of Fire-Hazard-Assessment Standards](#)  
[E1590 Test Method for Fire Testing of Mattresses](#)  
[E1591 Guide for Obtaining Data for Fire Growth Models](#)  
[E1740 Test Method for Determining the Heat Release Rate and Other Fire-Test-Response Characteristics of Wall Covering or Ceiling Covering Composites Using a Cone Calorimeter](#)  
[E2061 Guide for Fire Hazard Assessment of Rail Transportation Vehicles](#)  
[E2067 Practice for Full-Scale Oxygen Consumption Calorimetry Fire Tests](#)  
[E2257 Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies](#)  
[F1534 Test Method for Determining Changes in Fire-Test-Response Characteristics of Cushioning Materials After Water Leaching](#)

## 2.2 CA Standards:<sup>4</sup>

[CA Technical Bulletin 116, “Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Upholstered Furniture,” January 1980](#)  
[CA Technical Bulletin 117, “Requirements, Test Procedures, and Apparatus for Testing the Flame Retardance of Resilient Filling Materials Used in Upholstery Furniture,” January 1980](#)

## 2.3 NFPA Codes and Standards:<sup>5</sup>

[NFPA 101 Code to Safety to Life from Fire in Buildings and Structures](#)  
[NFPA 265 Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings](#)  
[NFPA 286 Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Wall and Ceiling Interior Finish](#)  
[NFPA 289 Standard Method of Fire Test for Individual Fuel Packages](#)  
[NFPA 555 Guide on Methods for Decreasing the Probability of Flashover](#)  
[NFPA 901 Uniform Coding for Fire Protection](#)

## 2.4 International Organization for Standardization (ISO) Standards:<sup>6</sup>

[ISO 4880 Burning Behaviour of Textiles and Textile Products—Vocabulary](#)  
[ISO 9705 Full Scale Room Fire Test for Surface Products](#)  
[ISO 13943 Fire Safety—Vocabulary](#)

## 2.5 Federal Standards:<sup>7</sup>

[Americans with Disabilities Act](#)  
[FED STD 191A Textile Test Method 5830](#)

## 2.6 Underwriters Laboratories Standard:<sup>8</sup>

[UL 1975 Standard Fire Tests for Foamed Plastics Used for Decorative Purposes](#)

## 2.7 International Code Council Codes:<sup>9</sup>

[IBC International Building Code, 2001 Supplement to 2000 Edition](#)  
[IFC International Fire Code, 2001 Supplement to 2000 Edition](#)

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from California Bureau of Home Furnishings and Thermal Insulation, Household Goods and Services (BHGS), State of California, Department of Consumer Affairs, 3485 Orange Grove Avenue, North Highlands, CA, 95660-5595. <https://bhgs.dca.ca.gov>.

<sup>5</sup> Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-9101.

<sup>6</sup> Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland or from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

<sup>7</sup> Available from General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, DC, 20407.

<sup>8</sup> Available from Underwriters Laboratories (UL), Corporate Progress, 333 Pfingsten Rd., Northbrook, IL 60062.

<sup>9</sup> Available from International Code Council (ICC), 5203 Leesburg Pike, Suite 600, Falls Church, VA 22041.

2.8 AATCC Standards:<sup>10</sup>

AATCC Test Method 86 - 2005 Drycleaning: Durability of Applied Designs and Finishes

AATCC Test Method 124 - 2006 Appearance of Fabrics after Repeated Home Laundering

### 3. Terminology

3.1 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 definitions given in Terminology **E176** shall prevail. For definitions of terms used in this guide and associated with textile issues refer to the terminology contained in Terminology **D123** and ISO 4880. In case of conflict, the definitions given in Terminology **D123** shall prevail.

3.2 *Definitions:* Definitions contained in Terminology **E176** deemed essential for use with this guide:

3.2.1 *fire hazard, n*—the potential for harm associated with fire.

3.2.1.1 *Discussion*—

A fire may pose one or more types of hazard to people, animals, or property. These hazards are associated with the environment and with a number of fire-test-response characteristics of materials, products, or assemblies including but not limited to ease of ignition, flame spread, rate of heat release, smoke generation and obscuration, toxicity of combustion products and ease of extinguishment.

3.2.2 *fire performance, n*—response of a material, product, or assembly in a specific fire, other than in a fire test involving controlled conditions (different from *fire-test-response characteristic, q.v.*).

3.2.2.1 *Discussion*—

The ASTM Policy on Fire Standards distinguishes between the response of materials, products or assemblies to heat and flame “under controlled conditions,” which is fire-test-response characteristic, and “under actual fire conditions,” which is fire performance. Fire performance depends on the occasion or environment and may not be measurable. In view of the limited availability of fire-performance data, the response to one or more fire tests, appropriately recognized as representing end-use conditions, is generally used as a predictor of the fire performance of a material, product, or assembly.

3.2.3 *fire scenario, n*—a detailed description of conditions, including environmental, of one or more of the steps from before ignition to the completion of combustion in an actual fire, or in a full-scale simulation.

3.2.3.1 *Discussion*—

The conditions describing a fire scenario, or a group of fire scenarios, are those required for the testing, analysis, or assessment that is of interest. Typically they are those conditions that can create significant variation in the results. The degree of detail necessary will depend upon the intended use of the fire scenario. Environmental conditions may be included in a scenario definition but are not required in all cases. Fire scenarios often define conditions in the early steps of a fire while allowing analysis to calculate conditions in later steps.

3.2.4 *flashover, n*—the rapid transition to a state of total surface involvement in a fire of combustible materials within an enclosure.

3.2.4.1 *Discussion*—

Flashover occurs when the surface temperatures of an enclosure and its contents rise, producing combustible gases and vapors, and the enclosure heat flux becomes sufficient to heat these gases and vapors to their ignition temperatures. This commonly occurs when the upper layer temperature reaches  $600^{\circ}\text{C}$  or when the radiant heat flux at the floor reaches  $20\text{ kW/m}^2$ .

3.2.5 *heat release rate, n*—the heat evolved from the specimen, per unit of time.

3.2.6 *smoke, n*—the airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion.

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

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *tenability (of humans to fire-generated conditions), n*—the capability of humans to occupy a room without becoming incapacitated or being killed as a result of a fire.

<sup>10</sup> Available from American Association of Textile Chemists and Colorists (AATCC), One Davis Dr., P.O. Box 12215, Research Triangle Park, NC 27709-2215.

3.3.2 *tenability limit (of humans to fire-generated conditions)*, *n*—limit at which a human being is rendered physically incapacitated or dies as a consequence of exposure to one or more factors (such as toxic gases, temperature, heat flux, or smoke obscuration) generated by a fire.

3.3.3 *upholstered seating furniture, n*—a unit of interior furnishing that (1) contains any surface that is covered, in whole or in part, with a fabric or related upholstery cover material, (2) contains upholstery material, and (3) is intended or promoted for sitting upon.

3.3.3.1 *Discussion*—

For the purpose of this guide, mattresses, bedding and other sleep products are excluded from the definition of upholstered seating furniture.

3.3.4 *upholstery cover material, n*—the outermost layer of fabric or related material used to enclose the main support system or upholstery materials, or both, used in the furniture item.

3.3.5 *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, or located between the upholstery cover material and support system, if present.

3.3.5.1 *Discussion*—

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

## 4. Significance and Use

4.1 This guide is intended for use by those undertaking the development of fire hazard assessments for upholstered seating furniture in health care occupancies.

4.2 As a guide this document provides information on an approach to development of a fire hazard assessment, but fixed procedures are not established. Section 1.7 describes some cautions to be taken into account.

4.3 A fire hazard assessment developed following this guide should specify all steps required to determine fire hazard measures for which safety thresholds or pass/fail criteria can be meaningfully set by responsible officials using the standard.

4.4 A fire hazard assessment developed as a result of using this guide should be able to assess a new item of upholstered seating furniture being considered for use in a certain health care facility, and reach one of the conclusions in 4.4.1 – 4.4.4.

4.4.1 The new upholstered seating furniture item is safer, in terms of predicted fire performance, than the one in established use. Then, the new product would be desirable, from the point of view of fire safety.

4.4.2 There is no difference between the predicted fire safety of the new item and the one in established use. Then, there would be neither advantage nor disadvantage in using the new product, from the point of view of fire safety.

4.4.3 The new upholstered seating furniture item is predicted to be less safe, in terms of fire performance, than the one in established use. Then, the new item would be less desirable, from the point of view of fire safety than the one in established use.

4.4.3.1 If the new upholstered furniture item is predicted to be less safe, in terms of fire performance, than the one in established use, a direct substitution of the products would provide a lower level of safety and the new product should not be used, without other compensatory changes being made. A new upholstered furniture product can, however, be made acceptable if, and only if, it is part of a complete, comprehensive, fire safety design for the patient room. Such a patient room redesign should include one or more of the following features: use of an alternative layout (albeit one that cannot be altered by the patient room users) or increased use of automatic fire protection systems or changes in other furnishings or contents. In such cases, a more in-depth fire hazard assessment should be conducted to ensure that all of the changes together have demonstrated a predicted level of fire safety for the new design which is at least equal to that for the design in established use, in order to permit the use of the new upholstered seating furniture item.

4.4.3.2 Alternatively, the new design may still be acceptable if the predicted level of fire safety is commensurate with new stated fire safety objectives developed in advance.

4.4.4 The new upholstered seating furniture item offers some safety advantages and some safety disadvantages over the item in

established use. An example of this outcome could be increased smoke obscuration with decreased heat release. Then, a more in depth fire hazard assessment would have to be conducted to balance the advantages and disadvantages.

4.5 If the patient room does not contain an upholstered seating furniture item, then the fire hazard assessment implications of the introduction of an upholstered seating furniture item should be analyzed in the same way as in 4.4. The fire safety should then be compared with that achieved in the room in established use (which has no upholstered seating furniture). The same analysis would also apply if an additional upholstered furniture item is being considered for introduction in a patient room: the fire hazard assessment should compare the fire safety implications of the addition.

4.5.1 An additional upholstered furniture item adds to the fuel load of a room. Thus, an analysis such as that in 4.4 would offer options 4.4.2 through 4.4.4 only.

4.6 Following the analysis described in 4.4, a fire hazard assessment developed following the procedures in this guide would reach a conclusion regarding the desirability of the furniture product studied.

4.7 An alternative to the analysis based on the anticipated fire performance of the materials or products contained in the patient room is the use of active fire protection measures, such as fire suppression sprinklers. Active fire protection involves measures such as automatic sprinklers and alarm systems, while passive fire protection involves using materials that are difficult to burn and give off low heat and smoke if they do burn. Traditional prescriptive requirements are based exclusively on passive fire protection, with the common approach being to describe the fire tests to be met for every property. The opposite extreme is based entirely on active fire protection, which assumes that active fire protection measures (mostly sprinklers) ensure fire safety. The fire safety record of sprinklers is excellent, but not flawless. Moreover, neither approach gives the type of flexibility that is the inherent advantage of fire hazard and fire risk assessments.

4.7.1 Note that the activation of automatic fire suppression sprinklers does not ensure a safe level of smoke obscuration.

4.8 This guide provides information on a different type of fire hazard assessment than Guide E2061. While Guide E2061 considers an entire occupancy, namely a rail transportation vehicle, this guide addresses a specific product, namely upholstered furniture.

## 5. Procedure

5.1 The procedure for conducting a fire hazard assessment on upholstered seating furniture in patient rooms of health care occupancies is given in Section 7, for the fire safety objectives in Section 6. This requires applying the design considerations in Section 8, for the scenarios considered in Section 9, and under the assumptions on patient rooms and patient room occupancy given in Section 10. The test methods to be used should be chosen from among those listed in Appendix X1 and some calculation methods are listed in Appendix X5.

## 6. Fire Safety Objectives

6.1 The primary fire safety objective is to ensure the safe (unharmful) evacuation or removal of all patients threatened by fire to an area of refuge in the event of a fire.

6.1.1 This is achieved if the time required, in the event of a fire, to evacuate the threatened area is less than the time for the fire to create untenable conditions (preferably for the fire not to create conditions that cause harm to people, whenever possible) in the patient room or along the evacuation path. The evacuation time includes the time required for the occupants to reach, or be transported to, a safe location and notification time.

6.1.1.1 As noted in 6.5, this fire safety objective does not address individuals intimate with the ignition.

6.1.2 The time to untenability is the shortest time until untenable conditions are created for any occupant starting at any location within the threatened area or along the evacuation path.

6.1.3 As this guide addresses the consequences of the fire-related properties of the upholstered furniture used, the upholstered furniture used should not decrease tenability.

6.1.4 The time required for evacuation or removal of patients to an area of refuge will be a function of the time required for safety personnel to arrive at the scene of the fire, which will depend, in turn, on the fire detection and fire suppression devices present

in the patient room or its vicinity and on the proximity of the safety personnel, including whether they are present in the health care facility or whether they are fire fighters coming from outside the facility.

6.1.5 In some health care facilities, the approach to patient fire safety involves protection in place. In such cases, the time for safe evacuation should be considered to be zero. The effect of this approach is that untenable conditions cannot be allowed to develop in the patient room.

6.2 A potential secondary fire safety objective, considered supportive of the primary objective (but less comprehensive) and more readily measurable, is to prevent flashover inside the fire room. This may require drastic reductions in the total room fuel load (see also NFPA Guide 555).

NOTE 1—Flashover is a crucial phenomenon **(1)**.<sup>11</sup> In this guide the onset of flashover is considered to occur when the upper layer temperature reaches  $600^{\circ}\text{C}$  or when the radiant heat flux at the floor reaches  $20\text{ kW/m}^2$  (see 3.2.4).

6.2.1 Analyses of fire statistics show that the vast majority of fire fatalities in the United States occur in fires that have gone to flashover **(2)**. In fact, fire statistics are tabulated in the United States, by NFPA, according to a concept roughly equivalent to flashover, namely according to whether there has been “flame damage beyond the room,” which does not occur if the fire does not progress beyond the pre-flashover stage, but does if flashover is reached and burning continues **(2)**. Thus, in this analysis, if a fire spreads beyond of the room of origin it is considered to have reached flashover.

6.2.1.1 If analysis shows that the flame damage outside of the room of origin has been caused by a factor, such as a flying brand, without flashover having occurred, the hazard assessment should take this into account.

6.3 In the primary fire safety objective, tenability (see 3.3.1 and 3.3.2) is assessed on the basis of fire effects on the occupants, including both direct effects, such as heat, toxic gases or oxygen deprivation, and indirect effects, such as reduced visibility due to smoke obscuration. A tenable environment will therefore prevent loss of life and reduce the likelihood of harm, including non-fatal injury to individuals.

6.3.1 Levels of tenability need to be set to develop a fire hazard assessment.

6.3.2 The default tenability criteria should be the values specified in Table X10.1. Appendix X10 also contains additional discussion on tenability criteria, and should be consulted. If the developer of the fire hazard assessment or the specifier require it, one or more of the default tenability criteria from Table X10.1 can be amended to satisfy the corresponding needs. In such case, an explanation should be given as to why the default criteria have been modified.

6.3.3 In health care occupancies, the health care staff should be aware of specific requirements for certain patients, which must be taken into account for the appropriate areas.

6.3.4 Temperature and heat: Investigations of the tenability in a fire scenario have shown the maximum temperatures which human beings can withstand **(3-5)**, the maximum convected heat humans can tolerate **(6)**, and the heat flux required to blister or burn skin **(7-9)**.

6.3.5 Smoke toxicity: Investigations conducted of the toxicity of smoke of individual gases and of materials have resulted in knowledge about the effects of the primary toxic gases **(10-15)**, and the overall effects of smoke toxicity **(16-19)**. Such work has shown that results of standard toxicity tests on materials are less helpful for fire hazard assessment than either analyses of emissions of individual gases over time or calculations based on the overall amount of smoke emitted **(6,17,18)**. Furthermore, 2001 bioassay work on rodents over various exposure periods has indicated that the effects of smoke on incapacitation and lethality from smoke toxicity can be assigned to smoke concentration levels of  $17\text{ g/m}^3$  to  $27\text{ g/m}^3$  and  $21\text{ g/m}^3$  to  $37\text{ g/m}^3$  respectively **(20)**, which is consistent with the results of the survey conducted on all previous bioassay work:  $15\text{ g/m}^3$  and  $30\text{ g/m}^3$  respectively **(21)**. Various ways have been presented on how to combine one or more of these tenability effects, in documentation for the NIST program HAZARD I and in a review by Purser, **(6,22,23)**.

6.3.6 Smoke obscuration: Smoke obscuration (also known as smoke opacity) does not cause harm in and of itself. However, it seriously hinders ease of escape and ease of rescue of trapped fire victims. Investigations have been able to quantify the restrictions

<sup>11</sup> The boldface numbers in parentheses refer to the list of references at the end of this standard.

to escape imposed by smoke obscuration (24-26) and to propose reasonable visibility limits. A value of Total Smoke Released of 1,000 m<sup>2</sup> in a “standard room” is a criterion used in codes based on this concept (27,28). (See Appendix X7).

6.4 When conducting this fire hazard assessment the welfare and evacuation of individuals with disabilities (Americans with Disabilities Act) must be considered with particular care.

6.5 A fire safety objective of this guide is to protect the occupants not intimate with the initial fire development from loss of life and to improve the survivability of those who are intimate with the fire development (see NFPA 101). The fire safety of those individuals intimate with the fire development cannot be guaranteed through decisions based on the design of the upholstered furniture product.

6.5.1 An individual is deemed to be intimate with the fire development if that individual is located in the immediate vicinity of the ignition source, typically in contact with it.

6.5.2 The concept of an individual being intimate with the fire development is much more restrictive than being in the room of fire origin. If a compartment has more than one occupant, each occupying their own bed, for example, if one of them is intimate with the fire development, the other one would probably not be considered to be.

6.6 The user needs to consider the inclusion of a final fire safety objective, which is to prevent fire fatalities or serious injuries due to fire effects to the fire fighters responding to an incident.

6.7 The user also needs to consider that evacuation efforts may be affected by ongoing health care emergencies, unrelated to the fire, which may affect the availability of rescue personnel.

6.8 The user also needs to consider the potential effect of the fire (and the smoke) on the life-sustaining and health-care equipment used in the health care facility, to assess whether particular measures need to be taken to prevent the hazard to patients from increasing due to specific damage to certain equipment.

## **7. Steps in Conducting a Fire Hazard Assessment**

7.1 Fire hazard assessment begins by choosing fire safety objective(s) to be achieved. This step is described in Section 6.

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7.2 Fire hazard assessment requires specification of the design to be assessed, in a form that permits the fire safety performance of the design to be tested and modeled. This step is described in Section 8.

7.3 Fire hazard assessment requires specification of the fire scenarios for which the design will be required to meet the objectives. This step is described in Section 9.

7.4 Fire hazard assessment requires specification of any additional assumptions, such as conditions of the environment and characteristics of the anticipated occupants, in the assessment. This step is described in Section 10.

7.5 Fire hazard assessment requires the use of testing and calculation methods to determine whether the objectives are expected to be met by a specified design for a specified fire scenario, under the specified assumptions. The calculations to be performed are described in Section 11, and the selection and qualifying of calculation methods for the assessment are described in Section 12.

7.6 For the fire hazard assessment procedure to be valid, it is necessary that the calculation methods and the fire-test-response characteristics used produce valid estimates of success or failure in achievement of the fire safety objectives, given the specified fire scenario(s).

7.7 Fire hazard assessment finds a specified design to be acceptable if, under the specified assumptions, each of the objectives will be met when a health care facility patient room is involved in a fire, for each of the specified fire scenarios.

7.7.1 It is advisable for the validity of the fire hazard assessment procedure to be confirmed by peer review.



## 8. Use of Design Specifications in Calculations for Estimates of Fire Hazard

8.1 The issue of design of products, or of health care patient rooms as a whole, can have significant impact on fire safety. Design specifications can be used as input into the calculation methods of a fire hazard assessment. However, for design specifications to be useful, they cannot be expressed in vague terms but must be expressed as either numerical values or as other instructions, for example equations, compatible with the fire hazard assessment calculation method used.

8.1.1 Once expressed as numerical or other specific values, design specifications are a source for input variables for fire hazard assessment. For example, design specifications will include specification of the materials to be used in the room linings, including ceilings, walls, and floors. The calculations required to assess whether flashover will be prevented in the patient room (an objective specified in 6.2) will require heat absorption parameters for the room linings. These heat absorption parameters will not be identical to the design specifications for the room lining materials but will be derivable from these specifications by reference to data from established test methods. Because this guide does not specify the models or calculation methods to be used, it follows that it cannot list the input variables that will be required or the appropriate procedures to use in deriving those input variables from design specifications.

8.1.2 A fire hazard assessment is an evaluation of a complete design which addresses certain fire safety objectives. Therefore, the design specifications used must address and include all relevant products and design features used, including those specified by conventional prescriptive practices. Thus, a fire hazard assessment of a remodeling or redesign cannot be limited to the parts of the design being changed. Rather, a fire hazard assessment of a redesign carried out according to the practices presented in this guide must address the patient room, including contents, and its surroundings, in its entirety.

8.2 In connection with this guide, the term “design” refers both to the general arrangement of the patient room (for example, size, location of openings, number and configuration of furnishings, as well as to whether furnishings are fixed in place) and to the materials, products, and components used to build the patient room. The development of such designs often involves decisions which include tradeoffs and ad hoc benefit analyses, and is a traditional approach.

8.2.1 The design should also consider items which are brought into the patient room for occasional use. This includes medical equipment such as an oxygen tank or breathing apparatus. Other examples are mattress overlays (such as decubitus pads) or wheelchairs. In some cases, such temporary furnishings can provide a fire scenario of greater severity than is usually considered for this occupancy (see also 9.5).

8.3 Design specifications for products, components, and materials should include fire-test-response characteristics. The test methods from Appendix X1 should be used to develop these fire-test-response characteristics. Alternatively, other test methods may also be used, provided the tests chosen comply with the criteria of 8.3.1 and 8.3.2.

8.3.1 This guide does not provide a required test method to assess any fire-test-response characteristic. The developer of a fire hazard assessment will need to provide evidence of the validity of any test method chosen for use in testing of components or composites.

8.3.2 The test methods referenced in Appendix X1: (a) have been designed to yield results in fire safety engineering units, which are appropriate for fire hazard assessment and (b) measure heat release rate, which has been demonstrated to be an essential component of fire hazard assessment (25,26,29,30). The concept of restricting fuel load is described in Appendix X2.

8.3.2.1 The choice of any test method is non-mandatory and the developer of a fire hazard assessment will need to provide evidence of its validity for use in testing of materials or products for use patient rooms of health care occupancies (see also 7.7.1). Design and quality control of component materials critically affects the precision of composite fire test results. Therefore, emphasis should be placed on ensuring consistency in the actual fire performance of components which have been assessed as part of a composite system.

8.3.3 It is likely that design specifications of any finished product with different component materials will not normally be available (from the suppliers of the individual materials or components that go into them) in a form suitable for application of fire hazard assessment. Manufacturers of such products cannot normally be expected to have developed data on characteristics that are not part of existing sets of requirements or recommendations for their products. Similarly, suppliers of individual materials cannot be expected to identify or provide products, components, or materials, based exclusively on the kinds of design specifications required for fire hazard assessment. Therefore, suppliers of such products may require the translation of the performance specifications into conventional specifications for the individual materials.

8.3.3.1 Thus, an alternative approach should exist whereby fire safety objectives are permitted to be achieved by meeting certain sets of fire-test-response characteristics of individual materials or products, if fire loss experience has shown that such sets of requirements have led to suitable fire safety. However, selective use of parts of the methodology in this guide and of individual fire-test-response characteristics does not satisfy the fire safety objectives of this guide. This guide is not suitable for use in developing a fire hazard assessment except in its entirety.

8.3.4 Aesthetic design, as well as geometric and spatial configuration of the individual furnishing items, can have significant influence on the ignition and burning properties of all items used for room furnishings and contents.

8.4 A particular choice of material and material combinations (for fabric, padding, and interliner, if present) in upholstered furniture can have the effect of delaying fire development or even of preventing a fire from becoming self propagating. Furthermore, the concept used to increase fire safety (such as improved fire performance of the materials, incorporation of upholstery barriers, redesign of furniture construction features, or prevention of transport of furniture items as part of variations in room layout) can affect the resulting fire hazard. Several preliminary fire research projects have investigated the role of materials and product design characteristics on the fire properties of the room contents and furnishings (31-52).

8.5 The construction features which are a part of the furniture item design can be critical. Important factors for consideration include the presence or absence of armrests, gaps between various cushion areas, internal cavities, dust covers, crevice or entrapment areas, and skirts. Other factors include the shape and construction of the back, the size of the gap between back and seat, the type of threads used, and the relative dimensions of the various materials used at each location.

## 9. Fire Scenarios of Concern

9.1 The fire scenarios in 9.2 are designed to represent the spectrum of most likely fires involving upholstered seating furniture in the patient rooms of health care occupancies.

9.1.1 When prevention of flashover is one of the objectives (see 6.2), the performance of upholstered furniture that becomes involved in the fire only at the time of or after flashover, either in the room of fire origin or in a second room, need not be assessed in terms of the room of fire origin (see 9.2.6).

9.2 Specific fire scenarios considered in this guide. [ASTM E2280-21](https://standards.iteh.ai/catalog/standards/sist/3da4712c-b164-4dc1-9088-cba1f7dafaf1/astm-e2280-21)

<https://standards.iteh.ai/catalog/standards/sist/3da4712c-b164-4dc1-9088-cba1f7dafaf1/astm-e2280-21>

9.2.1 Upholstered furniture item is first ignited, as an eventual consequence of smoldering ignition by cigarettes.

9.2.2 Upholstered furniture item is first item ignited, by direct ignition from a small open flame source, such as a match, lighter or candle.

9.2.3 Upholstered furniture item is first item ignited, by direct ignition from a large source, such as a radiant heater.

9.2.4 Upholstered furniture item is first item ignited, by direct ignition (from either of the type of sources in 9.2.1 and 9.2.2), accentuated by an accelerant, such as a spilled flammable liquid (or some intentional action, such as vandalism) (see also Appendix X3).

9.2.5 The upholstered furniture item is the second item ignited, prior to flashover, as a result of heat released by the first item ignited. The source of heat is likely to be another furnishing or content item. This scenario is included since the concept of secondary ignition of products allows the treatment of such fires. Note that, for the purposes of this guide to fire hazard assessment, the upholstered furniture item is assumed to be either the first or the second item ignited only.

9.2.6 If the upholstered furniture item is not ignited until flashover, by other ignition sources within the room, the effect of the upholstered furniture item need not be assessed further in terms of the room of fire origin.

9.2.6.1 The rationale for 9.2.6 is that, if the product is not burning until flashover, or until flashover is inevitable, it can be assumed that the product is likely to have little effect on whether the room will get to flashover. Moreover, in practice, there is little, if any, statistical information available on fires where the item is neither (a) the first or second item ignited nor (b) burning before flashover occurs.

9.2.6.2 After flashover, the room of fire origin has ceased to be tenable. However, the fire may still impact the survival of occupants of other rooms. Thus, the impact of the fire on occupants of other rooms, after flashover in the room of origin, would still need to be addressed. Flashover in the room of origin can also impact the evacuation of patients from rooms other than the room of origin.

9.2.6.3 Thus, once flashover has occurred, consideration may need to be given to the effect of the patient room upholstered furniture, on an increased heat, smoke obscuration and toxic load on occupants of rooms other than the room of fire origin, and on potential rescuers.

9.2.6.4 If the fire starts in a room other than the patient room and spreads into the patient room, that fire will already be a flashover fire before the upholstered furniture item in the patient room is involved (see 6.2.1), and it will be an example of a fire scenario of the type addressed in 9.2.6.

9.2.7 A specialized fire scenario, other than those listed in 9.2.1 through 9.2.6, resulting from an unusual design, room occupancy or special circumstances, can also be addressed, but a detailed description of it must be provided before undertaking the fire hazard assessment.

9.3 NFPA develops statistics of fires in facilities that care for the sick, for example in (53).

9.4 The application of this guide to a fire hazard assessment of upholstered furniture items in rooms other than patient rooms, for example lounges or cafeterias, would require additional considerations and is beyond the scope of the present document. If the fire starts in a room outside of the patient room, and spreads into it, that fire must be considered to have already become fully developed before it involves the product to be assessed, namely the upholstered furniture within the patient room (see 6.2.1 and 9.2.6.4).

9.5 The enumeration of fire scenarios in 9.2 assumes that other fire scenarios either are less severe, and therefore will lead to achievement of the fire safety objectives, with respect to upholstered furniture, if the design achieves the objectives for the specified fire scenarios, or are less likely and therefore need not be considered as part of the fire hazard assessment (see also 8.2.1).

## 10. Assumptions Regarding Patient Room

### 10.1 Patient Room Design and Layout:

[ASTM E2280-21](https://standards.iteh.ai/catalog/standards/sist/3da4712c-b164-4dc1-9088-cba1f7dafaf1/astm-e2280-21)

<https://standards.iteh.ai/catalog/standards/sist/3da4712c-b164-4dc1-9088-cba1f7dafaf1/astm-e2280-21>

10.1.1 The specific patient room layout must be defined to conduct this fire hazard assessment.

10.1.2 An example patient room involves a room ~~9 m long, 3.8 m 9 m long, 3.8 m wide and 2.4 m 2.4 m high~~, with a single door ~~2 m 2 m high and 1 m 1 m wide~~, which is assumed to be open. The walls are estimated to be covered by ca. ~~16 mm (nominal 0.63 in.) 16 mm (nominal 0.63 in.)~~ gypsum-board type X, itself covered by wallpaper (thermal conductivity: ~~0.140.14 W W/(m·K); (m·K)~~; density: ~~770 770 kg kg/m<sup>3</sup>~~; specific heat: ~~900900 J J/(kg·K); (kg·K)~~) and the ceiling by ca. ~~15 mm (0.59 in.) 15 mm (0.59 in.)~~ acoustic tile (thermal conductivity: ~~0.0580.058 W W/(m·K); (m·K)~~; density: ~~290 290 kg kg/m<sup>3</sup>~~; specific heat: ~~13401340 J J/(kg·K); (kg·K)~~), with concrete flooring (ca. ~~12 mm (0.47 in.) 12 mm (0.47 in.)~~, thermal conductivity: ~~1.61.6 W W/(m·K); (m·K)~~; density: ~~2400 2400 kg kg/m<sup>3</sup>~~; specific heat: ~~800800 J J/(kg·K); (kg·K)~~). The ceiling is assumed to be horizontal (not beamed or sloping), and to have a smoke detector, but no fire suppression sprinklers. This room contains two beds, two bedside tables, each one adjacent to one bed and two chairs, each located just past the bedside table from the bed, as well as some floor covering system (See [Appendix X4](#) for some tentative heat release data).

10.1.3 The closing (or the partial closing) of the patient room door would each constitute a different fire scenario. The use of either of these scenarios should be justified by the user.

10.1.4 A fire hazard assessment requires the definition of a patient room design and layout. If an analysis is conducted without specifying a different patient room, the default patient room to be used should be the one in 10.1.2.

### 10.2 Patient Room Occupancy:

10.2.1 The occupants of patient rooms can include both patients, visitors and staff. The maximum patient occupancy will be occupancy to room capacity. Furthermore, there is likely to be a mix of patient occupants with different abilities, including a

significant proportion who will have disabilities because of age, or physical or mental impairment and even some occupants who may be impaired for other reasons, for example as a result of the use of prescription drugs, or other substances.

10.2.2 Occupancy of the patient room (room of fire origin), and any occupiable spaces nearby to which the fire can spread, could be set for analysis purposes, for example, so as to pose the greatest challenge to the fire safety objectives. Typically, this would involve occupancy to capacity, with all occupants disabled, for whatever reason.

10.2.3 Assumptions regarding numbers and abilities of disabled persons need to incorporate any appropriate relevant provisions of the Americans with Disabilities Act.

10.2.4 Assumptions regarding age distributions of the occupants need to reflect data on age patterns among health care facility patients. Assumptions regarding the capabilities of older or younger occupants (including visitors and staff) need to reflect patterns in the general population and need to be documented as to sources of data.

10.2.5 Assumptions regarding impairment due to prescription drugs or other substances among occupants need to be documented as to source data. If data are unavailable, alternative methods of developing the assumptions need to be sought. One example is to use the patterns in the general population, weighted to reflect the age of health care facility patients. Another example is to conservatively assume that all patients are impaired by drugs. A third example is to choose an arbitrary fraction of patients who are impaired, for example 10 %.

10.2.6 In view of the type of facility under consideration, assume that fire occurs when the maximum number of people will be sleeping. If there are no data available to determine the maximum fraction of people sleeping, assume all patients are sleeping.

10.2.6.1 One example of patient room occupancy, which could be used for the default patient room scenario described in 10.1.2, involves two patients, one in each bed, asleep at the time of ignition. One patient is able to walk, at an average speed of 0.5 m/s, while the other one cannot walk unassisted. Time periods must be estimated for assistance to arrive and for the patient who cannot walk unassisted to be removed from the room. Minimum times for this to occur are likely to be 30 s and 4 min after the smoke detector alarm goes off (if one is present), but the times should be based on the actual facility investigated.

10.2.6.2 A fire hazard assessment requires the definition of a patient room occupancy. If an analysis is conducted without specifying a different patient room occupancy, the patient room occupancy to be used should be the one in 10.2.6.1.

## 11. Required Calculations

11.1 The fire hazard assessment conducted following the procedures in this guide involves using calculation procedures to determine whether the fire safety objectives in Section 7 will be met if the design specified in Section 8 experiences each of the fires of the scenarios specified in Section 9, and given the additional assumptions specified in Section 10.

11.1.1 Use Guide E1546 when developing the procedure.

11.1.2 Use NFPA 901 if needed for overall coding of materials or products.

11.2 Because the fire safety objectives are all stated in terms of specified fire effects by location and time, the fire hazard assessment calculation procedures must support the calculations in 11.2.1 through 11.2.5.

11.2.1 Translate the fire scenario specifications into a description of the fire in its initial stages, as a function of time in the initially involved space. Among the fire-test-response characteristics of the materials or products initially involved that may be required for such a description are rate of heat release, rate of mass loss, total heat release (if burned to completion, or cumulative heat release to end of burning otherwise), flame spread, cumulative full-scale smoke obscuration and toxic potency of the products of combustion released.

11.2.2 Translate the design specifications into characteristics of the fuel load environment near the initial fire. Use these and the time-based description of the initial fire as a function of time to calculate the spread of fire to secondary items and the ignition of those secondary items.

11.2.3 Calculate the timing of major fire events for each space, including the onset of flashover and fire spread from one space to an adjacent space. The calculation of fire spread from one space to another will require measurement of barrier fire resistance characteristics.