# Building Fire Safety:

## There Is No Singular Solution. It Takes a Village.

By Eric Banks and Justin Koscher

**MODERN BUILDINGS REPRESENT** the culmination of everything society has learned about the built environment. By most metrics, buildings today are the best they have ever been, with record-setting examples enclosing over 18 million sq ft (1.7 million m$^2$)[1] of floor area and rising over 2,700 ft (820 m)[2] in height. Even so, everyone involved in construction has a role to play in ensuring building fire safety—from the people who develop the codes that regulate buildings, to the product manufacturers, designers, specifiers, contractors, plan reviewers, and code officials, and ultimately to the occupants living and working in our buildings every day.

As construction practices and building materials have evolved, so has knowledge of fire science, fire dynamics, and fire safety throughout a building's life cycle—from materials, design, and construction to ongoing use and maintenance (including repairs, updates, and renovations). Fire behavior and its governing principles do not change based on jurisdictional boundaries, so understandably over time building codes in many jurisdictions have evolved to show some commonality among systematic approaches to fire safety. In 2020, the International Fire Safety Standards Coalition (IFSSC), a global group of expert organizations, published a set of five Common Principles[3] for fire safety that are universally applicable, performance based, and interrelated:

1. **Prevention:** Safeguarding against the outbreak of fire and/or limiting its effects.
2. **Detection and Communication:** Investigating and discovering of fire followed by informing occupants and the fire service.
3. **Occupant Protection:** Facilitating occupant avoidance of and escape from the effects of fire.
4. **Containment:** Limiting of fire and all of its consequences to as small an area as possible.
5. **Extinguishment:** Suppressing of fire and protecting of the surrounding environment.

Failure to address fire safety during building design and construction through to the ongoing use and management of completed buildings increases the risk of small fires becoming significant fire events. Notable fire events throughout history provide valuable lessons that have helped shape the fire safety principles and strategies used in modern construction. In recent decades, the importance of fire safety systems and devices, regulatory compliance and enforcement (i.e., compliance with building and fire codes), and regular maintenance have proven no less important at ensuring fire safety in buildings than the building's basic design and the materials of construction.

Within the International Code Council's International Codes (I-codes) family are two highly correlated codes—the *International Building Code*[4] (IBC) and the *International Fire Code*[5] (IFC)—that provide a practical example of how the application of fire safety principles is achieved through multiple reinforcing layers of prescriptive and performance requirements. This article will provide a high-level examination of how the IBC requirements support the Common Principles, followed by a more specific examination in context of requirements for exterior walls, including NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components*.[6]

### *INTERNATIONAL BUILDING CODE* REQUIREMENTS

The IBC requirements are structured in a manner that begins with the general classification of the building based on its occupancy and use and construction type. Occupancy and use classifications group together similar uses while construction type establishes a minimum set of criteria for the primary building elements (structural frame, interior and exterior walls, floors, and roofs). Virtually all other requirements and limitations, from materials to building height and area, are influenced by these two classifications. **Table 1** provides examples of topics and IBC chapters where provisions related to fire safety principles are located.

### EXTERIOR WALLS

Exterior wall provisions demonstrate how multiple layers of requirements combine to provide fire safety. In context of fire performance and fire safety, the IBC subjects exterior wall assemblies and their materials of construction to an array of fire performance testing described in **Table 2**.[7-21] Most of the specific requirements are located in IBC chapters 6, 7, 8, 14, and 26.[4]

The IBC provides several reinforcing layers of fire safety. The first layer of fire safety is provided by construction type and its prescriptive requirements for materials of construction (i.e., noncombustible or other) and fire resistance ratings for a list of specific primary building elements that includes exterior walls. The second layer applies fire separation distance (FSD), occupancy classifications, and other items to clarify or modify prescribed requirements for fire resistance. Under certain conditions FSD also triggers requirements for ignition resistance and testing. A third layer is the IBC's recognition of uses of combustible materials in noncombustible construction but subject to prescribed limitations and/or qualification through full-scale fire performance testing. One example, supporting multiple fire safety principles—prevention, occupant protection, and containment—is

**Table 1**. Examples of *International Building Code* (IBC)[4] provisions and associated fire safety principles

| Common Principle | IBC Topics | IBC Chapters |
|---|---|---|
| Prevention | Noncombustible/noncombustible materials<br>Construction type classification<br>Interior finish requirements<br>Thermal barriers and ignition barriers<br>Ignition resistance<br>Surface burning characteristics<br>Flame propagation<br>Construction fire safety<br>Inspection/special inspection | 6, 7, 8, 14, 15, 17, 26, 33 |
| Detection and Communication | Fire protection and life safety systems<br>Smoke detection | 9 |
| Occupant Protection | Occupancy classification<br>Construction type classification<br>Means of egress<br>Thermal barriers<br>Smoke barriers and smoke control | 3, 6, 7, 9, 10, 14, 26 |
| Containment | Fire-resistant assemblies<br>Fire walls, fire barriers, fire partitions<br>Fire doors<br>Thermal barriers<br>Fireblocking and firestopping<br>Surface burning characteristics<br>Flame propagation<br>Inspection/special inspection | 6, 7, 9, 14, 17, 26 |
| Extinguishment | Automatic sprinkler systems<br>Fire department connections<br>Portable fire extinguishers | 9 |

**Table 2**. Example fire performance attributes and required testing for exterior walls under the *International Building Code* (IBC)[4]

| Performance Attribute | Fire Performance Testing Requirements |
|---|---|
| Material properties of components:<br>A. Noncombustible/combustible<br>B. Surface burning<br>C. Interior finishes<br>D. Thermal barriers | <br>A. ASTM E136[7]<br>B. ASTM E84[8]/UL 723[9]<br>C. ASTM E84[8]/UL 723,[9] NFPA 286,[10] or NFPA 265[11]<br>D. Prescribed materials or NFPA 275[12] |
| Properties of exterior wall assemblies:<br>A. Fire resistance (may include internal exposure or exposure from both sides, loadbearing or non-loadbearing, protected and unprotected openings, special requirements for fire walls, and others)<br>B. Ignition resistance (from radiant heat)<br>C. Flame propagation | <br>A. ASTM E119[13]/UL 263[14] (Note: protected openings test to NFPA 252,[15] NFPA 257,[16] UL 9,[17] UL 10B,[18] or UL 10C[19])<br>B. NFPA 268[20]<br>C. NFPA 285[6] |
| Other associated:<br>A. Perimeter fire containment<br>B. Fireblocking in concealed spaces | <br>A. ASTM E2307[21]<br>B. Prescribed materials and locations |

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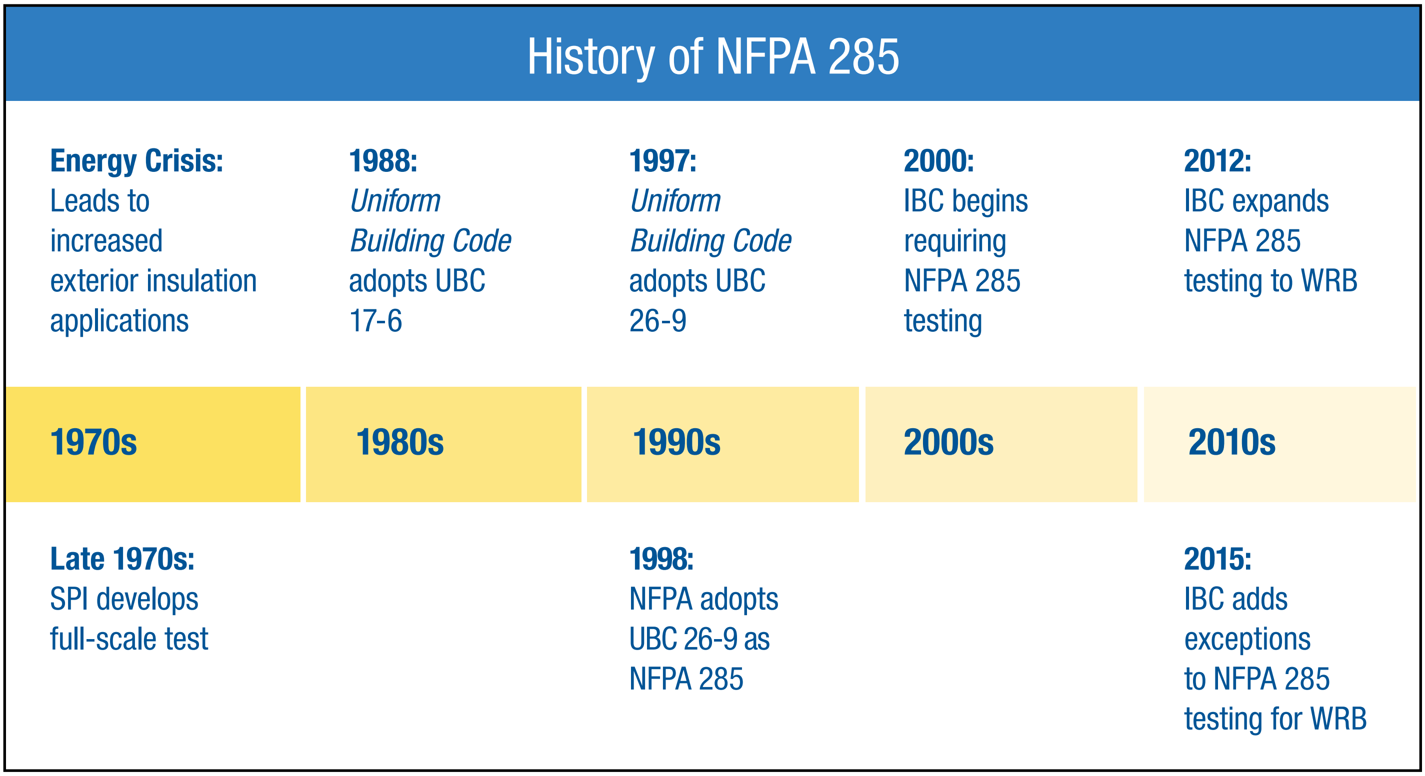


Beginning with the *Uniform Building Code®* in 1988, to the current edition of the *International Building Code®*, fire testing is required for exterior wall assemblies containing combustible components.

***Figure 1.*** *Timeline of NFPA 285,* **Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components,**[6] *development activities.*

NFPA 285.[6] Code enforcement and inspections provide another layer of fire safety intended to help ensure that design and installation are in compliance with the provisions of the IBC.

## ABOUT NFPA 285

### History

NFPA 285 is a large-scale fire test used to evaluate the vertical and lateral flame propagation of exterior wall assemblies. This section examines the test standard's history and how its development has continued over the decades.

Beginning in the late 1970s, a project led by the Society of the Plastics Industry (SPI) led to the development of a fire test to evaluate the use of foam plastic insulation products within exterior wall assemblies on buildings of noncombustible construction. Building code and fire officials, as well as fire science experts, collaborated to develop a large-scale fire test that would assess a fire scenario in a multifloor building. The original fire test evaluated a wall assembly's ability to resist multidimensional flame spread horizontally, vertically, and within the test assembly in order to limit the spread of fire from the room of origin.

The research also led to building code provisions that were incorporated into the 1988 edition of the *Uniform Building Code* (UBC).[22] The provisions recognized the large-scale fire test that was developed as UBC Test Standard 17-6 (later renamed as UBC Test Standard 26-4). The size (approximately 26 ft [7.9 m] high by 20 ft [6 m] wide) and scale of this test was such that testing typically occurred outdoors. Later, an industry research program was created to investigate development of an intermediate-scale test apparatus that would correlate to the existing method and permit testing to occur indoors in a more consistent and controlled test environment. The test method resulting from this work was adopted as UBC Test Standard 26-9. Finally, in the late 1990s UBC Test Standard 26-9 was evaluated by the National Fire Protection Association (NFPA) and adopted as NFPA 285. **Figure 1** illustrates the multi-decade history of NFPA 285.

### NFPA 285 Test Standard Details

Today, NFPA 285 reflects more than 40 years of collective knowledge and experience with evaluating flame propagation of exterior wall assemblies containing combustible components. The NFPA 285 test standard is designed to evaluate an exterior wall assembly's contribution to vertical and lateral flame spread in each of the following:

- Over the exterior face of the wall assembly
- Within the wall assembly cross section
- Over the interior surface of the wall assembly
- From the compartment of origin

NFPA 285 is an assembly test, not a component test, meaning that the entire exterior wall assembly is evaluated as it is configured. Inherent in fire performance testing of assemblies is the recognition that the presence or absence of a single material, configuration detail, or attribute does not render an exterior wall assembly safe or unsafe.

### NFPA 285's Fire Scenario

The fire test condition of NFPA 285 replicates the scenario where a post-flashover interior room fire has breached an exterior window, exposing the wall cross section and exterior face to flame and heat. In this scenario, the interior room and its contents are fully involved and a fire suppression system (e.g., automatic sprinklers) is either absent or has been overwhelmed. The test is 30 minutes in length.

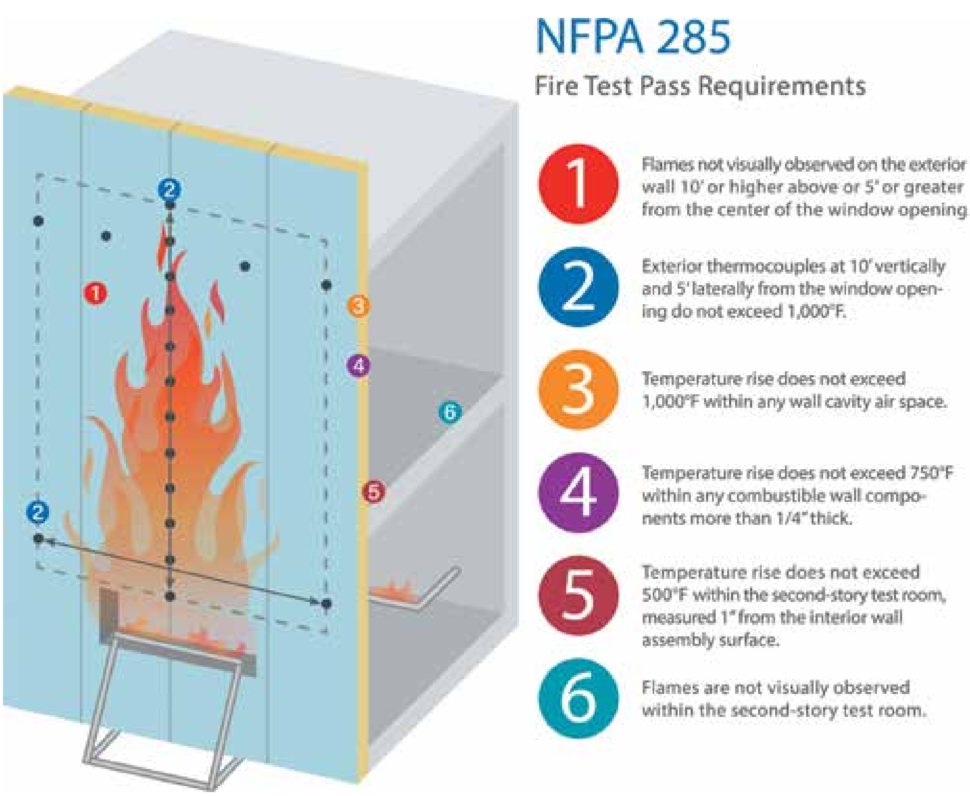


***Figure 2.*** *NFPA 285,* **Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components,**[6] *pass/fail criteria.*

Source: Polyisocyanurate Insulation Manufacturers Association.

### NFPA 285 Test Specimen Configuration

NFPA 285 is a multistory exterior wall assembly test (first and second floors) with a window opening into the first-floor room. The test specimen is approximately 18 ft (5.5 m) high by 14 ft (4.3 m) wide with the window opening measuring 30 in. (760 mm) high by 78 in. (2.0 m) wide. The fire sources are two gas burners; one located inside the first-floor room (following the ASTM E119[13] standard time versus temperature cure) and one located outside the first-floor room in close proximity to the window header. The test assembly is mounted on the face of the test apparatus (also known as the test facility). Thermocouples are fitted throughout the assembly in several layers, the exact locations of which depend on the specific materials and configuration of the assembly to be tested.

### Acceptance Criteria

The NFPA 285 test method contains a series of acceptance criteria determining whether an assembly passes the test. The criteria include limits for visual flame propagation, temperature limits, and temperature-rise limits at specific locations within the different layers of the assembly. These criteria are illustrated and explained in **Figure 2**.

## COMPLYING WITH NFPA 285

Since the inaugural 2000 edition, the IBC has used NFPA 285 to regulate flame propagation in, on, and through exterior walls containing combustible components for buildings of construction types I - IV. Initially found only in chapter 26 to regulate use of foam plastic insulation, NFPA 285 is now also found in chapter 14 as the IBC has evolved to include more and specific fire safety provisions for exterior wall coverings and assemblies. Upon its publication, the 2024 IBC will contain revisions that:

- Add new triggers and clarify existing triggers for NFPA 285 testing
- Prescriptive methods for compliance with NFPA 285

Among the changes in the 2024 IBC is a provision that clarifies three prescribed compliance methods for exterior wall assemblies required to meet NFPA 285. This provision added to chapter 14 provides building officials and other users with clear guidance when establishing compliance with the acceptance criteria of NFPA 285. The three compliance methods are:

1. NFPA 285 test data for the exterior wall assembly meeting the acceptance criteria.

Test what is planned for construction: Wall component manufacturer (or other interested party) engages an accredited laboratory to construct a test specimen of the wall assembly, perform the testing, and provide a test report specific to the assembly configuration.

2. Designs listed by an approved agency.

Construct what was tested: Manufacturers develop and maintain third-party certifications for assemblies tested and complying with NFPA 285. These certifications are provided by duly accredited agencies, are based on NFPA 285 test data, and take the form of design listings and code evaluation/research reports that recognize specific assembly configurations and components. Design listings for assemblies complying with NFPA 285 are available directly from certification agencies through online product directories.

3. Analysis of an assembly design based on a similar assembly tested to and meeting NFPA 285.

Construct with evaluated deviation(s): The data collected during an NFPA 285 test records the real-time dynamic behavior of each individual assembly layer. This data from all assembly layers makes it possible for qualified individuals and organizations, using experience and sound principles of fire science and fire engineering, to evaluate the performance effects of certain modifications to tested assemblies. These engineering analyses confirm that the alternative assembly will continue to comply with the acceptance criteria of NFPA 285.

### Guidance for Extending NFPA 285 Results

Another example of stakeholders doing their part to support fire safety is that the 2023 Edition of NFPA 285 includes a new Annex B, "Guide for Extensions of Results from Assemblies that Meet NFPA 285 Test Requirements."[6] The annex, developed under the NFPA Committee on Fire Tests, by a group consisting of fire experts, industry experts, and representatives from both testing and certification agencies, supports fire safety by providing the most current industry experience and limitations when performing an analysis to extend data from successfully tested assemblies. The annex provides users and stakeholders with important and transparent guidance on how specific variations should be evaluated in addition to recommended limitations. The scope of Annex B reads, "This annex covers the extension of compliant test results obtained from NFPA 285 tests to wall assemblies that differ from a tested wall assembly in materials, components, or configurations of materials. This annex is based on engineering principles and testing experience with regard to the extension of test data based on certain considerations." Topics covered in the annex include base walls, water-resistive barriers (WRBs), fireblocking and firestops, air cavities, exterior insulation, window treatments, and exterior wall coverings, veneers, and claddings.

Certification agencies providing listing and certification services for wall assemblies complying with NFPA 285 routinely perform engineering analyses during the development and maintenance of listings. Additionally, test programs developed for purposes of third-party certification will often include "worst-case" assembly designs to allow for subsequent analysis to produce a scope of recognition


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Recommendations by FPEs and consultants can be part of a submission to building officials in support of approval, and to certification agencies in support of test programs, recognition expansion, and ongoing certification.

based on the tested assembly. Independent fire-protection engineers (FPEs) and qualified consultants also prepare this type of analysis. Recommendations by FPEs and consultants can be part of a submission to building officials in support of approval, and to certification agencies in support of test programs, recognition expansion, and ongoing certification. Whether issued by a certification agency, an independent FPE, or a consultant, the final authority to accept engineering analyses in support of approval belongs to the authority having jurisdiction.

## SUMMARY: IT REALLY DOES TAKE A VILLAGE

Today's modern codes create a framework of overlapping requirements that manage risk and leverage both component and assembly fire testing to verify performance, all in support of fire safety. Requirements, and their enforcement, that govern the design and construction of exterior walls are examples that demonstrate the interrelated roles of the "village" of stakeholders—code officials, designers, manufacturers, installers, and occupants—in achieving fire safety that is provided under modern codes. Everyone has a role to play to ensure fire safety throughout the life cycle of our buildings—from design to construction and throughout use.

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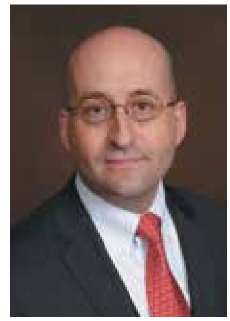
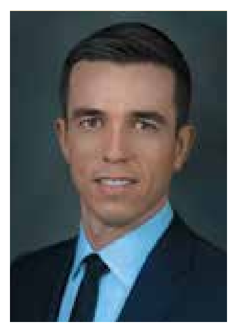
## ABOUT THE AUTHORS



ERIC BANKS

**Eric Banks** *is a technical consultant specializing in the development, physical and fire testing, codes and standards compliance, and certification of building products and their associated applications with an emphasis on foam plastics. He has over 20 years of experience in these areas, working with and for both product manufacturers and certification agencies. He is actively engaged in codes-and-standards development work.*



JUSTIN KOSCHER

**Justin Koscher** *is president of the Polyisocyanurate Insulation Manufacturers Association (PIMA), a trade association that serves as the voice of the rigid polyisocyanurate insulation industry and a proactive advocate for safe, cost-effective, sustainable, and energy-efficient construction. Before joining PIMA in January 2017, he served as a director at the American Chemistry Council's Center for the Polyurethanes Industry. Koscher obtained his BA from Illinois Wesleyan University and JD from DePaul University College of Law.*

Please address reader comments to chamaker@iibec.org, including "Letter to Editor" in the subject line, or IIBEC, *IIBEC Interface*, 434 Fayetteville St., Suite 2400, Raleigh, NC 27601.