

State of the Art of NFPA 285

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ABSTRACT

The increasing demand for high-performance, energy-efficient buildings over the last 20 yrs has led to the evolution of building-enclosure designs that incorporate multiple layers of materials, sized and sequenced to control condensation, water leakage and heat loss. While higher performing, this evolution of building-enclosure design has also introduced more combustible components into the exterior wall of the building. For many noncombustible building types, the International Building Code (IBC) requires testing to NFPA 285 – *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components* – to justify the inclusion of such combustible materials.

INTRODUCTION

This paper is one component of a four-part panel entitled, “Smoldering Issues of Fire Performance Evaluation.” The papers include:

- State of the Art of the NFPA 285 Fire Test, Brian Kuhn
- The NFPA 285 Fire Test’s Impact on Architectural Design & Energy Performance, Richard Keleher
- NFPA 285 in the Field: An Update on Local Adoption, Keith P. Nelson
- Exterior Combustible Wall Project of the Fire Protection Research Foundation, Amanda Kimball

This paper serves as an introduction to the building code provisions that require NFPA 285 fire testing, their history, and the nature of the NFPA 285 fire test itself.

DEVELOPMENT OF THE BUILDING CODES

Building codes have been developed over time as an accumulation of good practices and in response to various fire events and hazards. History is littered with events where whole villages and significant parts of large cities built mostly of wooden structures burned to the ground. These conflagrations were due to the number of open flame/ignition sources, proximity of the structures, the combustible nature of the building materials (including exterior walls and roofs), and the lack of fire-fighting brigades. Eventually, as a society we implemented measures to prevent such catastrophic losses: we bettered our fire departments and we regulated the proximity and construction materials of buildings. Building codes were first developed to save cities from burning down, then refined such as to save a city block, then to save neighboring properties, then the building itself, and now the codes are written such that we hope to contain a fire event to the room of origin.

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Modern building codes regulate the types of building materials allowed and degree of fire-resistance of building elements. Mostly, these building characteristics are dependent on the use and size of the building as well as its proximity to neighboring properties. This approach is known as equivalent risk theory² and is one of the fundamental concepts on which the building code is based.

As part of this concept, the code categorizes building methods and materials into several construction types. In the most current version of the International Building Code, there are five construction types:

- Types I and II construction are those types of construction in which the building elements are of noncombustible materials. This construction was originally known as fireproof construction.
- Type III construction is that type of construction in which the exterior walls are of noncombustible construction and the interior elements (floors and roof) can be of any type of materials permitted by code (including combustible materials such as wood). This construction is typical of many old-style mill and factory buildings and is commonly referred to as ordinary construction.
- Type IV construction is that type of construction in which the exterior walls are of noncombustible construction and the remainder of the building elements are of heavy timber.
- Type V construction is that type of construction in which the building elements can be of any type of materials permitted by code (including combustible materials such as wood). This construction is known as stick-built or frame construction.

The code allows certain combustible materials, such as plastics and wood, to be used in otherwise noncombustible construction, but only under specific circumstances. It should also be noted that the building code addresses materials used in the building structure and enclosure; building contents are loosely regulated and such requirements are difficult to enforce. Building contents are typically the jurisdiction of the fire code.

The commonality between Types I – IV construction is that each type is defined as having noncombustible exterior walls. As discussed above, regulating the combustibility of exterior walls reduces the hazard of fire spread from building to building.

INTRODUCTION OF FOAM PLASTIC AND DEVELOPMENT OF EXTERIOR WALL FIRE TESTING

In the 1970s, after the oil embargo and ensuing energy crisis, foam plastic insulation became popular as a means of increasing building insulation and increasing energy efficiency within structures. Exterior insulation and finish (EIFS) systems, which utilize expanded polystyrene (EPS) boards, were introduced and became popular for installation on the building façade. Eventually, other types of foam plastic insulation became common in exterior walls, especially as energy codes began to require continuous insulation to reduce thermal bridging and increase energy efficiency. Extruded polystyrene (XPS) rigid insulation, polyisocyanurate (polyiso, ISO)

² Chapter 6, Code and Commentary, 2009 International Building Code Code and Commentary, International Code Council (ICC), 2010.

insulation, and spray polyurethane foam (SPF, SPUF) are all used in various capacities in exterior walls in today's industry.

However, most buildings larger than stick-built residential were and are required to be of noncombustible construction. Foamed plastic insulations, which are essentially solid petroleum, are highly combustible. As a response to the increase in use of foam plastic insulations, the industry identified a need to develop a fire testing methodology to quantify the fire propagation characteristics of such combustible materials and thus provide a means to evaluate their appropriateness for installation on noncombustible exterior walls.

A full-scale test program was sponsored in 1980 by the Society of Plastics Industry.³ The program consisted of a series of outdoor, full-scale tests designed to evaluate the extent of vertical and lateral flame spread within the test walls. The results showed that flame spread was limited for the systems tested, and so foam plastic insulation was allowed as an exterior wall material. The Uniform Building Code (UBC) first codified this fire testing program in the 1988 edition of the UBC (UBC Test Standard 26-4).

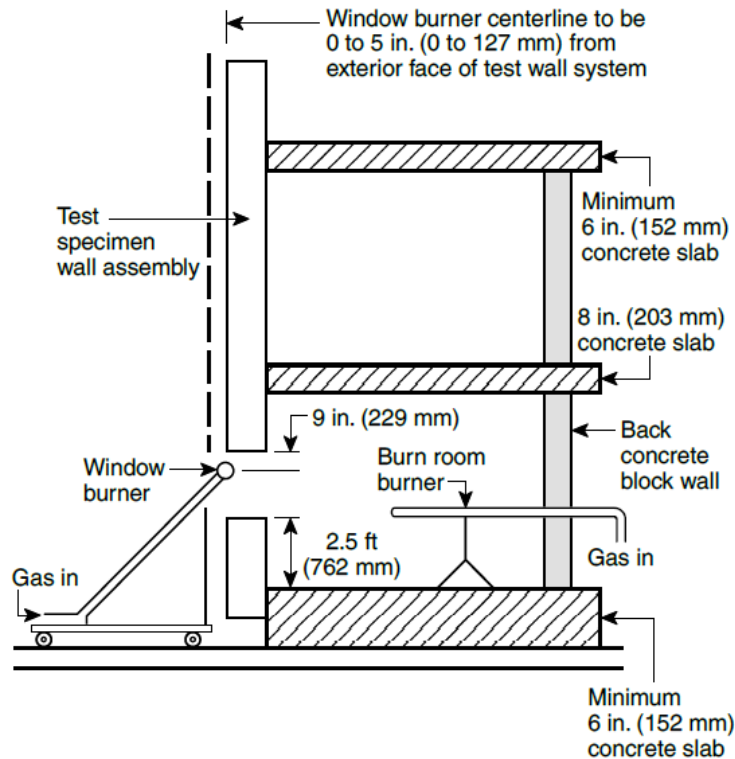
SPI sponsored another test program in the early 1990s that led to the development of a reduced, intermediate-scale version of the UBC 26-4 test. Instead of an outdoor test, the modified version utilized an indoor, two-story test apparatus with two gas burners to replicate the fire exposure conditions of UBC 26-4. After enough tests were completed to justify a correlation between the two test methods, the new test was adopted in the UBC as Test Standard 26-9 in the 1997 edition of the UBC. In 1998, NFPA adopted the standard that is referenced by the IBC today: NFPA 285, *Standard Fire Test Method of for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components*. NFPA 285 is based on and is technically the same as the UBC 26-9 test standard.

THE NFPA 285 FIRE TEST

The NFPA 285 fire test utilizes the intermediate-scale multi-story apparatus (ISMA). This is the same piece of equipment used to test slab edge firesafing for curtain wall systems. For the test, a mockup of the exterior wall assembly is constructed and then affixed to the ISMA as shown in Figure 1. The wall assembly should be representative of the design intended to be constructed in the field, including joints, seams, veneers, insulation, air/vapor/water barriers and attachments. The 2012 version of NFPA 285 acknowledges nine standard exterior wall system configurations in Figure 6.1(b) ranging from EIFS systems to cavity wall conditions.

³ History taken from Standard No. 285, National Fire Protection Association (NFPA), 2012 Edition.

Figure 1 - Section View of NFPA 285 Test Apparatus (permission from NFPA pending)



The test is intended to simulate a fire that starts in a compartment, grows to flashover, breaks out an exterior window, and exposes the exterior façade to fire. As such, the test begins when the burn room burner is ignited. The window burner is ignited five minutes into the test simulating the fire breaking out the window. Many critics of the test observe that, in today's commercial building stock, a majority of buildings are protected with automatic sprinkler systems that are intended to control or suppress a fire within the room of origin and prevent flashover. Neither the building code provisions nor the NFPA 285 test standard take this argument into account. Proponents for the test argue that even with a sprinklered building there are still modes of ignition at the building exterior (fireworks, fires starting at the base of the building, etc) such that testing of the exterior façade is necessary.

The burners are turned off at the 30 minute mark, and evaluation of the test assembly continues until the 40 minute mark, at which point the test is complete. The standard does not discuss the relevance of these time periods.

NFPA 285 is a pass/fail test. There are no hourly ratings or Class A/B/C associated with the results. There are three modes of failure for the test:

- Temperature at the thermocouples within the wall cavity air space or within the wall/stud cavity insulation exceeds 1000°F or 750°F, respectively.
- Flames spread 10 ft vertically or 5 ft laterally from the window opening.
- The second story is exposed to fire as determined either via temperature above 500°F within the room or by the presence of flames within the room.

If any of these conditions are reached before the 40-minute mark, then the test is considered a failure.

There are only a few laboratories in the US that offer NFPA 285 testing as a service. Generally, a single test costs about \$15,000 to execute. The test sponsor should also consider costs to construct test specimens, retain consultants if desired, and conduct multiple tests if necessary. The testing process can take upwards of 3 to 6 months to complete depending on lab schedules and time needed for construction and curing of test specimens.

HISTORY OF NFPA 285 TESTING IN THE BUILDING CODE

Building codes generally started in cities because that is where catastrophic fires occurred. As examples, New York, Chicago, Los Angeles, and San Francisco all developed their own building code, some of which are still in use today.

Eventually, there developed three regional model building code organizations in the US which each promulgated its own regional model code as shown below.

Table 1 - Legacy Codes

Organization	Code
Building Officials and Code Administrators International (BOCA)	BOCA National Building Code (NBC)
Standard Building Code Congress International (SBCCI)	Standard Building Code (SBC)
International Conference of Building Officials (ICBO)	Uniform Building Code (UBC)

The legacy codes introduced regulations regarding the use of foam plastic insulation as early as 1979. As discussed above, 1988 marked the first reference to an actual test standard for foam plastic insulation in or on exterior walls when UBC codified Test Standard 26-4. While the BOCA and SBC codes also introduced requirements for testing of foam plastic in exterior walls, those codes did not identify a specific test standard.

Discussions regarding appropriate code requirements continued during that timeframe, as evidenced by an article in the September 1990 issue of AWCI's Construction Dimensions⁴. The article discusses potential code changes for each code and plans for AWCI (Association of the Wall and Ceiling Industry) and EIMA (Exterior Insulation Manufacturers Association) to protect the status of EIFS systems. Proposed code changes at that time included provisions for property line setbacks, ignitability, and radiant heat transfer.

In the early 1990s, the three legacy code bodies began to synchronize the model codes. In 1997, the three bodies combined to form the International Code Council (ICC), and the first edition of the International Building Code (IBC) was published in 2000. At that time, the only requirement for exterior wall testing was found in Chapter 26; exterior walls with foam plastic insulation were required to be tested to NFPA 285 or UBC 26-4. By the 2003 edition of IBC, NFPA 285 was the only test standard referenced.

Eventually, other combustible materials became popular for use within the exterior wall system. Metal composite, high-pressure laminate, and fiber-reinforced polymer (plastic) building panels have become popular for facades due to cost and flexibility in size, shape, appearance, and color. Also, the four barriers of building science – the air, vapor, thermal, and water barriers – were moved outboard of the exterior sheathing in many exterior wall designs to optimize

⁴ Association of the Wall and Ceiling Industry (AWCI). Construction Dimensions. September 1990, p 17.

building performance. Such barriers have varying levels of flammability but are almost always combustible in nature. And so, exterior walls which were once wholly noncombustible now contain multiple combustible components.

In turn, new provisions have been added to the building code to regulate these materials. Restrictions were put in place regarding flame spread indices, total panel area, self-ignition temperature thresholds, property line setback requirements, height limits, and NFPA 285 testing. A summary of the various building code provisions requiring NFPA 285 fire testing is shown below along with the edition of the code in which the requirement was first introduced:

Table 2 - NFPA 285 Testing Requirements in the IBC

Material	Code Section	First Appearance in the IBC
Water-resistive barrier (WRB)	1403.5	2012
Metal composite materials (MCM)	1407.10	2003
High-pressure laminates (HPL)	1409.10	2012
Foam plastic insulation	2603.5	2000
Fiber-reinforced polymers (FRP)	2612.6	2009

STATE OF COMPLIANCE IN THE INDUSTRY

While the requirements for fire testing exterior walls containing foam plastic insulation and other combustible materials have been in place since the late 1980s, there is a surprising lack of awareness of the existence and nature of these requirements in both the design and code enforcement communities. This may be because the provisions are located further back in the code than the traditional fire and life safety requirements contained in Chapters 3 through 10; it may be because industry talk died down after many EIFS systems were deemed acceptable in the 1990s; it may be because there have been ambiguous alternative approval code sections (such as IBC 2603.9).

Whatever the case, there are three main drivers that recently are increasing the amount of combustible material in the exterior wall assembly:

- Energy codes are continuing to increase the requirements for continuous insulation outboard of the exterior wall.
- Designers are specifying multiple layers of materials in the exterior wall system to control condensation (vapor barriers), water leakage (water-resistive barriers) and heat loss (air barriers).
- Designers are specifying combustible exterior paneling systems for aesthetic purposes and cost control.

Because of these drivers, the industry needs to increase its awareness of NFPA 285 fire testing regulations and understand the code requirements that are currently in place. Many combinations of materials in existing exterior wall design actually have not passed the NFPA 285 test. However, because of a lack of awareness or enforcement of the code provisions, these walls are being approved and constructed anyway. There have been several high-profile exterior wall fires around the world over the past 10 years. Even though the fatality count is low, the degree of structural and building envelope damage is high and many of these buildings were

torn down. These events should be a wakeup call to our industry to make sure that buildings in the US are not susceptible to the same fate.

At the same time, we need to push the boundaries of building science and enclosure technology to create buildings that will serve us well through the upcoming challenges of a changing climate and the unknown future of cheap energy. Wholly non-combustible mass masonry walls are a thing of the past. Building enclosure design is progressing rapidly. We need to reconcile what are currently competing parts of the IBC stated intent – “safeguard the public safety to life and property from fire hazards” and “safeguard the public health and welfare through energy conservation.” We need to continue to examine and potentially modify the building code and/or the NFPA 285 test standard. We need to do much more testing of various exterior wall assemblies to build a database from which designers and fire protection engineers can develop engineering judgments. Most of all, we need a unified vision of providing buildings that manage fire risk but are also high-performing and energy-efficient.