NFPA 285 Engineering Judgments: A Practical Compliance Option

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Photos courtesy Kingspan Insulation LLC

STRUCTURE FIRES HAVE DROPPED SIGNIFICANTLY OVER THE PAST 40 YEARS, AND ONE MAJOR CONTRIBUTOR TO THIS DECLINE IN FIRES AND FIRE DEATHS HAS BEEN THE DEVELOPMENT OF COMPREHENSIVE FIRE SAFETY MEASURES. THESE INCLUDE PERFORMANCE TESTING REQUIREMENTS OF MODEL BUILDING CODES.

Building codes in the United States regulate the use of plastics, foam plastic insulation, and other combustible materials used in the building envelope through a robust combination of reference standards, material fire tests and complete assembly fire performance requirements. Combined with other building and fire code requirements—such as compartmentation, active fire suppression sprinklers, egress provisions, and height and area limitations based on building type and occupancy—these provisions for the building assembly produce cooperative layers of fire safety. It is these multiple layers of fire safety, not a single requirement, which result in safe construction.

Modern wall assemblies have become increasingly complex as critical elements of the building enclosure. Advancements in our understanding of building science, coupled with the need to improve energy efficiency and resilience of buildings, have led to innovative solutions in both building products and construction methods. Many of the innovative products available today are subject to compliance with prescriptive fire testing and performance requirements as regulated under the *International Building Code* (*IBC*). One of the critical prescribed fire tests within the *IBC* for exterior wall assemblies is the National Fire Protection Association (NFPA) 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components*. This article discusses code aspects regarding fire safe construction and engineering judgments, and their use as a practical tool that can assist designers and building officials with assessing the compliance of exterior wall assemblies with the acceptance criteria of NFPA 285 (Figure 1).

The International Building Code

The *IBC* is recognized as the model building code for commercial construction, which is then adopted by state and local jurisdictions. Increasing use of energy efficient continuous insulation (ci) and innovative wall assemblies places a greater emphasis on fire performance of exterior walls; this is regulated under the *IBC* through NFPA 285.

Generally, NFPA 285 testing is required for combustible exterior wall assemblies containing combustible cladding, foam plastic insulation, or combustible water resistive barriers (WRB) installed on Types I, II, III, IV buildings of certain heights. Type V construction does not require NFPA 285 testing. The 2021 *IBC* regulates the fire safety of exterior walls containing combustible claddings, WRBs and foam plastic insulation in Chapter 14, "Exterior Walls" and Chapter 26, "Plastic."

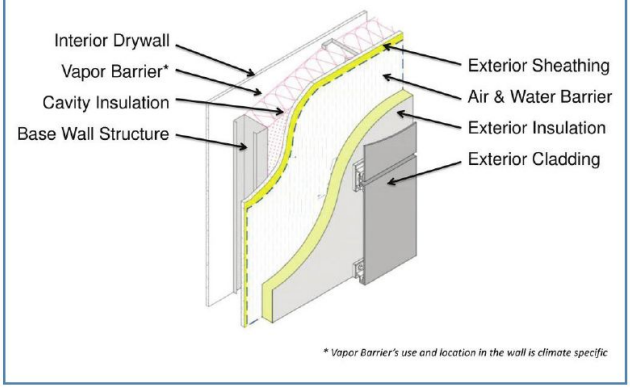
Chapter 14 of the *IBC* regulates the minimum requirements for exterior walls; exterior wall coverings; openings in the exterior wall; exterior windows and doors; and architectural trim. The provisions of Chapter 14 detail performance requirements regarding weather protection, structural performance, moisture control, reaction to fire, and flood resistance. *IBC* Chapter 26 contains provisions for the use of foam plastic insulation in exterior walls.

The *IBC* also establishes minimum requirements for building systems using prescriptive and performance-related provisions. Section 104.11, "Alternative materials, design and methods of construction and equipment," allows the use of alternate methods, etc. with strict guidance. Approval is granted on the basis of the building official's finding that the alternative, "…is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety."

The model codes recognize principles of fire science and fire protection engineering allow for the reasonable extension of test results to modifications of tested assemblies using comparative analysis of pertinent fire test data. For example, *IBC* Chapter 7, "Fire and Smoke Protection Features" contains provisions in *IBC* Section 703.2 and 716.1.1 that permit the use of engineering analysis to determine fire resistance.

For those situations where the code does not provide prescriptive provisions, Section 104.11 provides building officials with duties and powers to consider supporting information such as test data and engineering analysis in their review and approval of alternative materials, designs, and methods of construction as meeting the intent of the code. Both Sections 703.2 and 716.1.1 include reference to Section 104.11 as a compliance method. Engineering analyses that extend NFPA 285 results to modifications of tested assemblies are within the scope and intent of *IBC* 104.11.

Figure 1



National wall assembly.

Image courtesy North American Modern Building Alliance

The test and the data

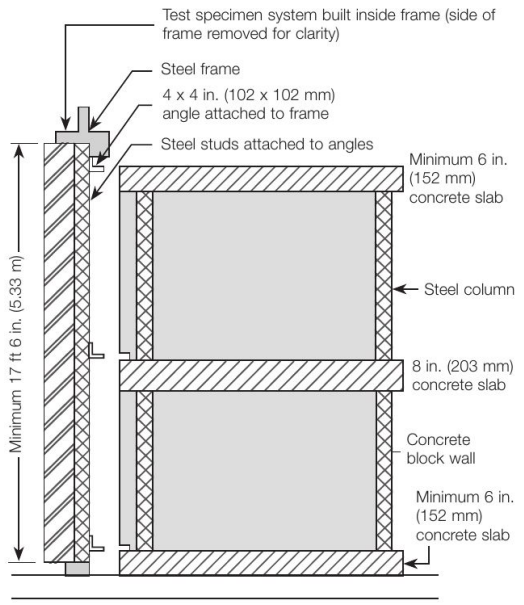
As shown in Figure 2 (page 28), the NFPA 285 test method is an assembly fire test that evaluates the fire propagation characteristics of exterior wall assemblies that contain combustible components such as, but not necessarily limited to, combustible claddings, insulation and many air and water-resistive barriers. The multi-story test assembly measures:

- flame propagation over exterior wall surface;
- vertical flame propagation within the wall assembly or its components;
- lateral flame propagation within the wall assembly or its components; and
- vertical flame propagation from one floor to the next.

NFPA 285 test method evaluates vertical and lateral flame propagation characteristics of full-scale exterior wall assembly designs. The fire exposure simulates a fire scenario where a post-flashover fire has breached the exterior window of the room of origin, exposing the exterior of the wall to a flame assault and heat plume. Test specimens are full-scale, minimum 5.3 m (17.5 ft) by minimum 4 m (13.3 ft), and fully configured wall assemblies, containing all assembly layers (*i.e.* exterior wall covering, water-resistive barrier, air barrier, vapor barrier/retarder, and insulation), accessories (*e.g.* sealants, brackets, shims, etc.), and a base wall (typically a light-gauge metal frame curtain wall).

Each test wall assembly is highly instrumented with each assembly layer—including air gaps—containing multiple thermocouples (TCs). Number of TCs, TC location, and any applicable acceptance criteria are specified by the NFPA 285 test method and determined by the materials of construction and the configuration of the wall assembly. Acceptance criteria determining the pass/fail result is a combination of temperature limitations, temperature-rise limitations, and visual observations of flaming at specified locations in the test specimen and the

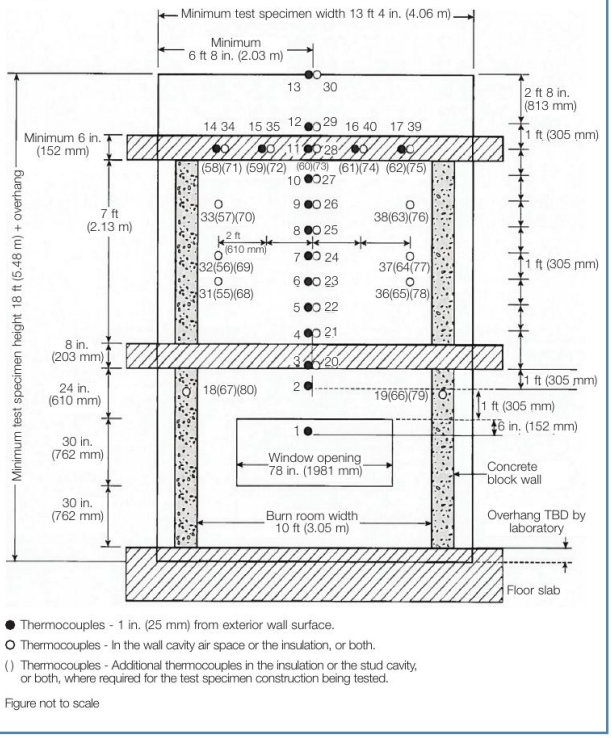
Figure 2



Side view of test apparatus with test specimen in movable test frame (not to scale).

Images courtesy NFPA 285, 2019 Edition

Figure 3



Thermocouple locations on exterior wall surface and cavity wall space.

second-story room of the test apparatus. Information required for test reports includes time versus temperature data for all TCs, visual observations, photographs of the assembly (pre-test exterior, pre-test interior, post-test exterior, post-test interior, and wall cavity insulation post-test), damage sketch(es), other burner-related and calibration-related information, and detailed drawings for the assembly and window opening area (Figure 3).

The data collected during an NFPA 285 test records the 'real time' dynamic behavior of each individual assembly layer. When combined, the data from all assembly layers describes how heat and fire moved throughout the assembly in all three dimensions—vertically, horizontally, and through. It is this quality of NFPA 285 test data that makes it possible for qualified individuals, using experience and sound principles of fire science and fire engineering, to evaluate performance effects of certain modifications to tested assemblies and to confirm, with confidence, the alternative assembly will continue to comply with the acceptance criteria of NFPA 285(Figure 4).

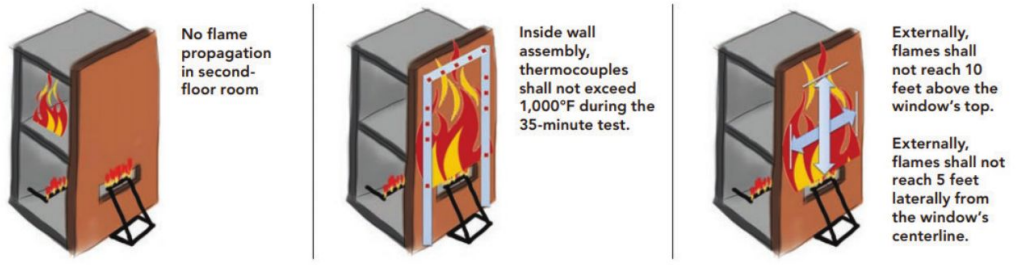
After a testing period of 30 minutes, a successful test will show no flame propagation to the second story room and none of the thermocouple locations having acceptance criteria may exceed the prescribed limit (*e.g.* 260, 398.9, 537.7 C [500, 750, 1000 F] or temperature rise less than 260 or 398.9 C [500 or 750 F]). Flame spread cannot exceed 3 m (10 ft) above the top of the window, nor more than 1.5 m (5 ft) laterally from the centerline of the window.

Engineering judgments

Engineering analyses extending full-scale NFPA 285 test results are a determination of equivalence, whether a modified assembly will perform at least equivalently to the tested assembly in terms of the acceptance criteria. As discussed above, NFPA 285 test data tells a detailed story of how an assembly performed throughout the test. This detailed data, when reviewed by qualified individuals, provides valuable information and insight into each assembly layer's behavior as well as its influence on, and reaction to, the behavior of adjacent assembly layers. Ongoing fire testing, consulting and certification continues to increase experience, understanding of comparative performance, and knowledge of performance trends for products and assemblies subjected to the NFPA 285 test. Put simply: every test result provides knowledge, educating every test that follows.

Under the IBC, there are three compliance pathways for an exterior wall requiring NFPA 285 testing. First, an individual exterior wall assembly is tested and meets the acceptance criteria. Second, an exterior wall assembly design is tested and listed or certified by an approved agency for compliance with NFPA 285.

Figure 4



NFPA 285 fire test parameters and pass criteria, equivalence guidelines for engineering judgments.

Image courtesy DuPont Building Innovations

Third, an engineering analysis or judgment based on the test data for a similar assembly showing compliance with the acceptance criteria.

Engineering judgments are reports issued by credible individuals or organizations to provide an assessment of component substitutions or installation/configuration deviations compared against an assembly tested to NFPA 285. They determine whether the variation, change, or substitution still results in a wall assembly that exhibits similar fire performance, meeting the acceptance criteria of the NFPA 285 test or tests that form the baseline.

A credible engineering judgment should be issued by a qualified organization or individual, clearly describe the conditions with drawings if necessary, stipulate the engineering judgment is not a tested or listed assembly, reference the base tested assemblies upon which the judgment is issued, and identify deviation from the tested assembly along with the supporting argument and data. Acceptance of an engineering judgment for building code compliance affirms the proposed design and use will result in a level of safety and performance that meets the intent of the applicable codes and standards. Only the authority having jurisdiction (AHJ) may accept the engineering judgment for building code compliance.

Listings, certifications and code reports

Many manufacturers develop and maintain third-party certifications for assemblies tested in accordance with NFPA 285. These certifications are provided by duly accredited agencies and take the form of design listings and code evaluation/research reports that recognize specific assembly configurations and components. Designers and AHJs rely on third-party certifications to be accurate, current, and representative of the products, assemblies, and performance recognized in the listings and code reports.

Third-party certification has three basic phases: sampling and testing; assessment and certification; and ongoing maintenance. The first two phases are straightforward—test representative samples of products and assemblies to collect performance data which is then evaluated for compliance with the applicable requirements. If found compliant, certification (*i.e.* recognition) is granted.

Design listings for assemblies complying with NFPA 285 are available directly from certification agencies through online product directories. Code evaluation/research reports are also available directly from certification agencies through online directories such as those provided by the International Code Council-Evaluation Service (ICC-ES), Intertek, and Underwriter's Laboratories (UL).

After certification is granted, ongoing certification maintenance includes regular verification the manufactured product is consistent with what was tested. This is accomplished through verification testing or manufacturing surveillance inspections. In addition to monitoring the products, ongoing certification maintenance requires monitoring of test methods and performance standards for changes that may impact associated listings. When test methods or standards are updated, a certification agency must evaluate technical changes to determine if existing listings are impacted in terms of recognized performance or, in the case of assemblies, the recognized configuration. This can range from no impact up to existing testing no longer complying with the standard. When technical changes effect existing listings, it is usually possible to revise the listing. Revisions may range from limiting the scope of recognition (*e.g.* not recognizing NFPA 285, 2019 edition or the 2021 *IBC*) to listing cancellation. These evaluations are performed by the certification agency within their respective competencies and scopes of accreditation.

The 2019 edition of NFPA 285 contains several substantive technical changes regarding the test specimen construction. These changes will require certification agencies to review test data that was conducted in accordance with earlier editions of NFPA 285 and perform an engineering judgement regarding compliance with the 2019 edition of the standard. Depending on the certification agency, such engineering judgments may rest upon evaluations of existing data, review of engineering judgments submitted by the listing holder, or a combination of both.

Figure 5

NFPA 285 test specimen.
Photo courtesy Kingspan Insulation LLC

Review of relevant changes to NFPA 285-2019

The 2021 *IBC* references the 2019 edition of NFPA 285, whereas earlier editions reference the 2012 and earlier editions of NFPA 285. Between 2012 and 2019, substantive technical changes were made to the NFPA 285 test method. As jurisdictions begin to adopt and enforce the 2021 *IBC*, it becomes necessary for manufacturers, designers, and AHJs to address exterior wall assembly designs based on test data collected in accordance with previous editions of NFPA 285. These technical changes provide an opportunity to discuss a practical example of how data analysis and engineering judgments may provide a suitable compliance solution. For this simple example, the following discussion will focus on technical changes to NFPA 285 regarding requirements for the construction and configuration of test specimens. For the 2019 edition, the NFPA 285 test method contains new, more detailed, and specific content regarding framing systems, joints and seams, and window headers.

Framing system

Prior to the 2019 edition, NFPA 285 test specimen construction requirements limited framing materials of test specimens to steel studs. Increasing use of Type III "pedestal" construction and the option to use fire-retardant-treated wood (FRTW) framing in exterior walls of Type I-IV construction highlighted a disconnect between the *IBC* and the NFPA 285 test. To address this issue, and to allow manufacturers to validate performance of wood-framed exterior wall assemblies, changes were made in order to specifically permit test specimens consisting of wood framing.

Joints and seams

Editions before 2019 required test specimens contain typical horizontal and/or vertical seams (including backing, caulking, etc.) when joints and seams are used in actual construction, but no other guidance was provided. Experience gained from increasing tests of panelized systems began to show location joints and seams could influence test results as much or more than their presence or absence in the test specimen. Language specifying the placement of vertical and horizontal joints and seams was added to ensure joints and seams are exposed to the full assault of the exterior fire plume, providing a "worst case" test condition.

Window headers

Prior to 2019, NFPA 285 did not provide guidance or requirements regarding the window opening, other than its dimensions and location. However, experience from tests of different types of wall assemblies showed window head designs influence performance during the test. Language specifying certain details of how to close around the window opening and requirements to include window details and drawings in the test report ensure this critical information is included in the test record and clearly communicated to users of the test data when designing wall assemblies for actual construction on buildings.

An example scenario

If a designer is developing a wall assembly based on test data collected in accordance with the 2012 edition of NFPA 285, but the jurisdiction has adopted the 2021 *IBC* and, by reference, the 2019 edition of NFPA 285. One cannot assume the existing data complies with the 2021 *IBC* requirements because of the important technical differences between the two editions.

An engineering judgment based on analysis of the existing test data against the 2019 edition of NFPA 285 is a quick way to determine whether the test specimen construction complies with the new limitations and requirements. Also, this analysis and judgment must take place before it is possible to begin considering any other differences between the tested wall assembly and the designer's assembly intended for use as the basis of design.

In terms of wall framing, prior to the 2019 edition, testing with wood framing was deemed a "modified" test. Now that wood framing is specifically permitted, an evaluation may judge the previous data to be in full compliance with the newest edition of the test method. Guidance regarding extensions of data from steel stud to wood stud framing and vice-versa based on testing experience is still limited but developing.

Reviewing locations of vertical and horizontal joints and seams (*e.g.* if the assembly contains an MCM rainscreen system) will determine if they comply with the specific locations now required by the test. Figure 5 depicts an NFPA 285 test specimen with dashed lines added to highlight joints in the panel system and a red box outlining the area (not to scale) where a vertical and/or horizontal joint or seam is required: between 0.3 m (1 ft) and 0.9 m (3 ft) above the top of the window and within 0.3 m (1 ft) on either side of the window centerline. In Figure 5, the joint placements of the test specimen fall within the required area.

The review of a window closure will focus on the construction of the window head, jambs, and sill as well as the materials and manner used to close them. For this issue, there is more latitude. Although the newest edition of NFPA 285 includes requirements standardizing the construction and closure of the window opening, there is also the option to close the window opening per details provided by the testing client. The window details must include drawings and the details are included in the test report.

If any test specimen construction details are found to not comply with the requirements of the 2019 edition of NFPA 285, then additional analysis is required.

Such an analysis could entail review of the actual test data and how deviation in test specimen construction could influence results. For example, if the horizontal joint location is not within the required area, then more detailed review of the test specimen construction, thermocouple data and test record, including photographic records of the post-test damage, becomes necessary to determine how results will change if the joint is moved to the area now required by NFPA 285. With any comparative evaluation, it is not always possible to develop a conclusive finding. In that case, retesting in accordance with the current edition of the standard is the most appropriate conclusion.

The design practices and regulatory requirements for today's buildings are the result of continuous research, observation, and comparative analysis of performance followed by robust review and consensus. There will always be a place for comparative analysis and engineering judgment so long as materials knowledge, engineering, and building science continue to evolve. Talented professionals will continue to search for innovative solutions to current and future challenges and opportunities for the built environment such as climate change, reduced environmental impact, and occupant safety. **CS**

ADDITIONAL **INFORMATION**

Authors

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Key Takeaways

Many of the innovative products available today are subject to compliance with prescriptive fire testing and performance requirements as regulated under the *International Building Code* (*IBC*). One of the critical prescribed fire tests within the *IBC* for exterior wall assemblies is the National Fire Protection Association (NFPA) 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components*.

The three options for determining code compliance of exterior walls required to be tested in accordance with NFPA 285 are: to test the specific wall assembly to be constructed, a third-party certified design listings, or an engineering analysis and judgment of a wall assembly based on NFPA 285 test data for a similar assembly. This article discusses code aspects regarding fire safe construction and engineering judgments, and their use as a practical tool to assist designers and building officials.

MasterFormat No.

01 84 13–Interior Construction Performance Requirements
07 80 00–Fire and Smoke Protection

UniFormat No.

C1010–Interior Partitions

Key Words

Divisions 01, 07
Fire performance
Fire Safety
International Building Code
NFPA 285
Wall Assembly