Public Comment No. 12-NFPA 285-2020 [Section No. 5.7.2]

5.7.2 Joints and Seams.

5.7.2.1 Horizontal Joints and Seams.

5.7.2.1.1

At least one horizontal joint or seam in the exterior veneer extending the full width of the test specimen shall be installed in accordance with 5.7.2.1.2, 5.7.2.1.3, and 5.7.2.1.4.

5.7.2.1.2

The horizontal joint or seam shall be located between 1 ft (305 mm) and 3 ft (914 mm) above the top of the window opening unless otherwise permitted by 5.7.2.1.3 or 5.7.2.1.4.

5.7.2.1.3

The horizontal joint or seam shall not be required where one of the following criteria is met:

(1) Where the exterior veneer is exterior insulation finish systems (EIFS)

(2) Where the exterior veneer is ¾ in. (19 mm) thick or greater standard stucco veneer

(3) Where the actual design of the wall assembly to be used in the field will not have any horizontal joints

5.7.2.1.4

Where the wall assembly being tested is a replication of the design to be used in the field and that design will not have a horizontal joint at the location specified in 5.7.2.1, the joint shall be located as per the design.

5.7.2.2 Vertical Joints and Seams.

5.7.2.2.1

At least one vertical joint or seam in the exterior veneer shall be installed in accordance with 5.7.2.2.2, 5.7.2.2.3, and 5.7.2.2.4.

5.7.2.2.2

The vertical joint or seam shall extend upward the full height of the exterior veneer from the top of the window opening and be located within ±12 in. (152 mm) of the window opening's center line unless otherwise permitted by 5.7.2.2.3 or 5.7.2.2.4.

5.7.2.2.3

The vertical joint or seam shall not be required where one of the following criteria is met:

(1) Where the exterior veneer is exterior insulation finish systems (EIFS)

(2) Where the exterior veneer is ¾ in. (19 mm) thick or greater standard stucco veneer

(3) Where the actual design of the wall assembly to be used in the field will not have any vertical joints

(4)* Where the actual design of the wall assembly to be used in the field will not have any continuous vertical joints

5.7.2.2.4

Where the wall assembly being tested is a replication of the design to be used in the field and that design will not have a vertical joint at the location specified in 5.7.2.2, the joint shall be located as per the design.

5.7.2.3*

Where joints or seams are required by 5.7.2, the installation of the joints and seams shall be representative of actual field installations and shall be in accordance with the manufacturer's instructions.

Additional Proposed Changes

File Name	Description	Approved
285_J_Nicholas_Proposed_Text_For_Committee_Consideration_11192020.pdf	pdf of the proposed changes	✓

Statement of Problem and Substantiation for Public Comment

See attached pdf

Related Item

- First Draft Report

Submitter Information Verification

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Submittal Date: Fri Nov 20 12:14:50 EST 2020
Committee: FIZ-AAA

<u>NFPA 285 Section 5.7.2 & Other Issues</u>

Delete Sections 5.7.2.1.3, 5.7.2.1.4, 5.7.2.2.3 and 5.7.2.2.4 and reorganize Section 5.7.2 as stated in “New Proposed Text for Committee Consideration” found after the drawings.

PROBLEM WITH TEXT –
The problem with Sections 5.7.2.1.3, 5.7.2.2.3, 5.7.2.1.4, and 5.7.2.2.4 are as follows:
[1] Sections 5.7.2.1.3 and Section 5.7.2.2.3 create a conflict with Section 5.2.
[2] Sections 5.7.2.1.3, 5.7.2.2.3, 5.7.2.1.4, and 5.7.2.2.4 create non-standardized test conditions.
[3] Sections 5.7.2.1.3 and Section 5.7.2.1.4 do not address actual field conditions.
[4] Sections 5.7.2.1.3 and Section 5.7.2.1.4 benefit some specific exterior wall constructions.

SUBSTANTIATION FOR CHANGING TEXT – General: The application of NFPA 285 test assemblies is cited in the building codes (NFPA 5000 and the International Building Codes) are used a regulatory control. The intent of NFPA 285 is to create a “standard fire test method” that contributes to life safety. NFPA 285 allows architects, engineers and code officials a means to assess similar and dissimilar test specimens to the same standard test conditions.

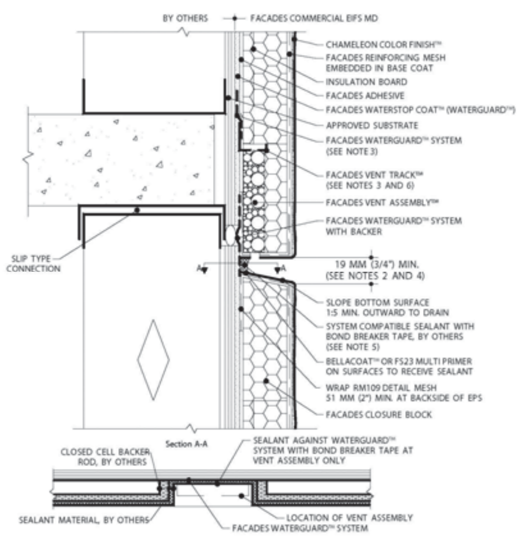
RATIONALE FOR CHANGING TEXT –
Sections 5.7.2.1.3 and Section 5.7.2.2.3 are in conflict with Section 5.7.1.2 that states, “Details of the construction of the test specimen <u>shall be representative of actual field installations</u> in accordance with the manufacturer's instructions.” It is true the majority of EIFS and 3/4-inch stucco veneer facades do not require horizontal and vertical joints because these applications have the vast majority of their construction are <u>*below four stories*</u>. Exterior walls used in the field and requiring testing to NFPA 285 typically has either vertical or horizontal joints, or both. Excluding a whole category of exterior walls, EIFS and 3/4-inch stucco veneer, from testing horizontal and vertical joints is in conflict with actual field installation used in buildings four stories and above.

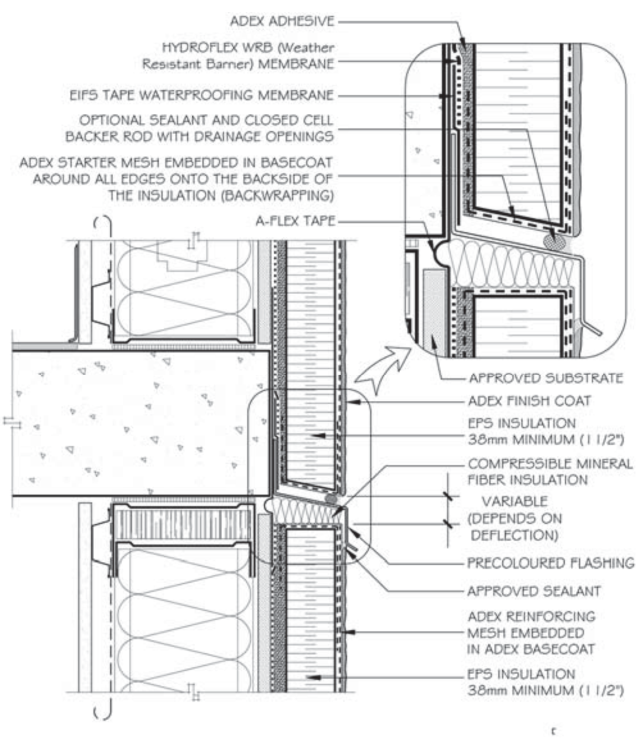
The Sections 5.7.2.1.3 and 5.7.2.2.3 Exceptions do not create a standardized fire test method. There is no technical justification for excluding exterior insulation finish systems (EIFS) and 3/4-inch stucco veneer from a horizontal or vertical joint requirement. Horizontal joints in EIFS and 3/4-inch stucco veneer exist in tall buildings. Also, horizontal joints are used where there is differential movement at floor elevations. Refer to the horizontal joint details following the rationale. Also, refer to the website course from Cornell that documents use of horizontal joints in EIFS construction https://courses.cit.cornell.edu/arch262/notes/12a.html. Vertical joints are used where there is differential movement between large sections of EIFS, or aligned with the building’s vertical expansion joint locations. Vertical joints in EIFS and 3/4-inch stucco veneer are extremely common on commercial buildings and like constructions.

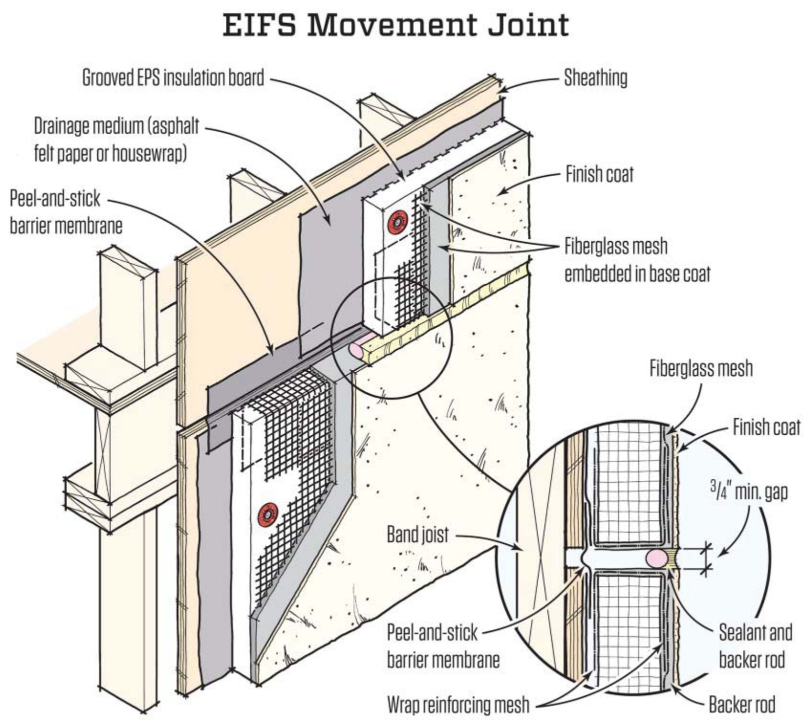
Sections 5.7.2.1.3 (3) and 5.7.2.2.3 (3 and 4) Exceptions do not address lateral and vertical flame spread, respectively, of the joint sealant or backing material. NFPA 285 is standardized to evaluate exterior walls with combustibles. Joint sealant and backing material are combustible materials and must be assessed regardless of the joint's juxtaposed construction. Also, degradation of the joint materials often exposes a flaw in the exterior wall design even when the exterior (exposed) veneer's surface is noncombustible concealing other combustible materials.

Sections 5.7.2.1.3 and 5.7.2.2.3 should not be used as part of the standardized fire test method as presented in Draft 2 because of potential misapplication of the restrictive test data to other actual field installations that have a horizontal or vertical joint. Like many other test standards, testing a unique field condition is allowed but the _deviations_ and _rationale for these deviations_ from the standard test method are noted in the test report and the test report cover page usually states "modified" before the test method designation to alert the user of some unique test conditions, which is in keeping with the life safety philosophy. The "New Proposed Text for Committee Consideration" provides a method to address test specimens with non-standardized or no joints and seams.

Sections 5.7.2.1.4 and 5.7.2.2.4 address a wall assembly being tested that is a replication of the design without joints to be used in the field. While Sections 5.7.2.1.4 and 5.7.2.2.4 are not in conflict with Section 5.7.1.2, these field designs are not typical. Therefore, these designs are not standard and they should also be noted as a deviation from the standardized test conditions for joints and seams. The "New Proposed Text for Committee Consideration" provides a method to address unique test specimens replicating specific design considerations with non-standardized or no joints and seams.







New Proposed Text for Committee Consideration –

5.7.2 Joints and Seams.

5.7.2.1 The installation of the joints and seams shall be in accordance with the manufacturer's instructions that are used in actual field installations.

5.7.2.2 At least one horizontal joint or seam in the exterior veneer extending the full width of the test specimen shall be installed and located between 1 ft (305 mm) and 3 ft (914 mm) above the top of the window opening.

5.7.2.3 At least one vertical joint or seam in the exterior veneer extending the full height of the test specimen shall be installed and located within ±12 in. (152mm) of the window opening's vertical center line.

5.7.2.4 This fire test method is not intended to preclude testing conditions other than those specified in 5.7.2. The deviation from the standardized joint conditions and rationale for the deviation shall be noted in the test report and the word "Modified" shall be placed before the standard's designation and title on the test report's cover page when one or more of the following alternate joint or seam conditions have been tested.

(1) Where the test specimen had no joints because the actual design of the wall assembly to be used in the field will not have any joints.

(2) Where the test specimen had either a horizontal or vertical joint omitted because the actual design of the wall assembly to be used in the field will not have a horizontal or vertical joint.
(3) Where the test specimen had noncontinuous joints because the actual design of the wall assembly to be used in the field will not have continuous joints.

Additional Issues for Committee Consideration –

There are many technical issues with NFPA 285 that PSL has made clear to test laboratories and other consultants as well as manufacturers. They are cited below. If the NFPA 285 Technical Committee wishes to ignore these life safety issues so be it.

Laboratories are bound by strict compliance with the provisions cited in NFPA 285. NFPA 285 has no allowable tolerance or correction factor to normalize and standardize test results that are affected by the numerous variables contained in NFPA 285.

NFPA 285 is used to determine the *fire-test-response characteristics* of *combustible material*s used as parts of *exterior wall*s or *exterior wall covering*s. The fire exposure created by NFPA 285 is intended to represent post-flashover fires of interior origin.

NFPA 285 states, "The purpose of this *standard* is to provide a standardized fire test procedure for evaluating the suitability of *exterior wall* assemblies and panels used as components of curtain wall assemblies that are constructed using *combustible material*s or that incorporate combustible components for installation on buildings."

It is extremely important to understand the development and purpose of NFPA 285 in order to appreciate PSL's observations, comments, and conclusions. This *standard* has an Annex A *Explanatory Material* that provides this information.

NFPA 285 was published in 1998, at which time there were two ISMA apparatus already constructed and in use in the United States to conduct UBC[1] Test Standard 26-9, the predecessor to this *standard*: [1] SwRI in San Antonio, TX completed their ISMA apparatus in 1991 and [2] Omega Point Laboratories (OPL) in Elmendorf, TX, which is now Intertek, completed their ISMA apparatus in 1994.

NFPA 285 Annex A *Explanatory Material* states, "When the ICC Uniform Building Code (UBC) was modified to recognize this application, the full-scale fire test was also codified and was published in the 1988 edition of the UBC as Test Standard 17-6. When the 1994 edition of the UBC was reorganized, the test became UBC Test Standard 26-4.

In the early 1990s, SPI sponsored a test program that developed a reduced-scale version of the UBC 26-4 test. This test used an indoor, intermediate-scale, multistory test apparatus, a single wall with a window opening, and two gas-fired burners to produce the same exposure conditions as the UBC 26-4 test. A combination of temperature measurements and visual observations

[1] Uniform Building Code

were used to determine the extent of vertical and horizontal flame propagation over the face of the wall systems or through the combustible core material. After development of the test apparatus, a series of tests were conducted that showed correlation between the new intermediate-scale test and the full-scale UBC 26-4 test. Testing was done with wall systems that both passed and failed in the UBC 26-4 test, with similar results being attained in the intermediate-scale test method (Beitel and Griffith[2]).

This test was recognized by the UBC as an alternative to the UBC 26-4 test and was published as UBC Test Standard 26-9 in the 1997 edition of the UBC.

In 1998, NFPA adopted NFPA 285, which used as its basis the UBC 26-9 test. The NFPA 285 test is technically the same as the UBC 26-9 test, with the only differences between the test methods being formatting and editorial issues. The International Building Code and NFPA 5000 reference NFPA 285 for assessment of fire performance of exterior walls."

Standardized Fire Test

Controlling a fire under laboratory conditions is still very difficult due to a number of variables outside the control of those performing the fire test. Typically, a standardized fire test indicates that the method of testing, fire exposure, and test results are equivalent when assessing materials, products and assemblies. Fire testing usually establishes confidence when another fire test is conducted on identical materials, products and assemblies that the test results will still be applicable or comparable. Unlike many other fire test methods, NFPA 285 does not have accuracy (a.k.a. precision) or bias statements. To that end many fire tests have tolerances or use a correction factor to confirm the test results are still applicable or comparable.

NFPA 285 is used to determine acceptability of materials, products or assemblies for use in building construction. Therefore, a means to determine that the *standard* was used correctly and followed by competent laboratory personnel is important when assessing the *fire-test-response characteristics* of materials, products or assemblies subjected to NFPA 285 testing. Further, the calculation or interpretation of test results depends on the accuracy of the test procedure described in the *standard*.

The accuracy of a *standard* provides information concerning the nature of the test results. Typically, the accuracy of a *standard* is usually determined by intra-laboratory testing during a *standard*'s conception and subsequently determined by inter-laboratory (a.k.a. round-robin-testing) testing. NFPA 285's accuracy is then established when the calibration wall assembly described in Chapter 7 *Calibration* is used to compare the spread of the resulting test data between laboratories, which has not been performed. The accuracy of the *standard* is determined by comparing how close the test results are using the procedures cited in NFPA 285 under the allowable conditions: fuel sources, environmental, temperature, etc. When the accuracy of the *standard* is published then the usefulness of the test data can be established for

[2] Beitel, J. J., and Griffith, J. R., Jr., "Development of an Intermediate-Scale Fire Test for the Evaluation of Flammability Characteristics of Exterior, Non-Loadbearing Wall Panel Assemblies Using Foam Plastic Insulation, Phase," Phase II, Revised Final Report, 1 Society of the Plastics Industry, New York, NY, May 1994

various applications. Accuracy established the variability of test results between laboratories and between calibrations of the NFPA 285 apparatus. Since one of NFPA 285's *Conditions of Acceptance* is based on a set of temperature limits rather than a change in temperature, it is important to the *standard*'s user to understand the accuracy of the test data when the test is performed at the two (2) prescribed ambient temperature limits: 50F and 90F. The user *should* be able to understand the repeatability of results at a specific laboratory as well as the reproducibility of test results between laboratories.

Bias is the tendency of a statistic to overestimate or underestimate a parameter that affects a conclusion. Bias is seen when there is a great difference between the accepted reference value and the mean of a large number of test results. Most bias is unintentional. For example, this can occur when a calibration wall assembly is constructed using materials that have unseen damage or variables as well as when test procedure is conducted mechanically while fatigued rather than reading and following each step in the *standard*. Based on the number of published *Listing*s based on NFPA 285 testing, information concerning bias could be published. Corrective measures (e.g. tolerance or correction factors) can be added to NFPA 285 by understanding the accuracy and bias of the NFPA 285 test data

Standardized Requirements

Like most fire tests NFPA 285 establishes a set of standardized requirements. However, the term standardized fire exposure does not mean that the NFPA 285 fire exposure is identical at every test facility or the same year to year when testing an identical test specimen. These variations are a result of many factors, such as revisions to the *standard*, fuel used (natural gas versus propane), the ambient temperature at time of testing, and the calibration results.

Standardized Fire Exposure

2012 Edition of NFPA 285 Section 7.1.13 that states, "The allowable tolerances for the comparison of determined average values to the specified average values *shall* be 10 percent for temperatures and as shown in Table 7.1.11". This section is critical as it limits the maximum calibration wall assembly surface temperatures and by default the heat energy.

However, the 2019 Edition of NFPA 285 introduced a very significant change to the NFPA 285 calibration wall assembly surface temperatures cited in Table 7.1.11. However, the change is not evident in the Table 7.1.11. Rather this revision was made to Section 7.1.13 in the 2019 Edition of NFPA 285 that now states, "The allowable values for the comparison to the specified average values in Table 7.1.11 *shall* be no lower than 10 percent below the degree F value and no higher than 20 percent above the degree F value shown in Table 7.1.11".

The maximum calibration wall assembly surface temperatures are now allowed to be 10% greater than in the 2012 Edition of NFPA 285. This increase is in direct conflict with NFPA 285's to be technically equivalent to UBC Standard Test 26-9 as stated in this standard's Annex A *Explanatory Material* states, "The NFPA 285 test is technically the same as the UBC 26-9 test, with the only differences between the test methods being formatting and editorial issues." The publication by Beitel and Griffith previously referenced confirms that the ISMA as operated in

1998 met the intent for a reduced scale test. These calibration wall assembly surface temperatures are a significant increase. For example, in the 1998, 2006 and 2012 Editions of NFPA 285 the calibration thermocouple (TC#7) located 6 feet above the window opening was allowed to register a maximum of 1111°F. Now that same calibration thermocouple (TC#7) located 6 feet above the window opening was allowed to register a maximum of 1212°F. However, the NFPA 285 temperature limitations for critical thermocouples (TC#11 and TC#14 through TC#17) remain unchanged at 1000°F. At least two (2) ISMAs were constructed and in use for testing in compliance with UBC Test Standard 26-9 prior to the publication of NFPA 285. Further, prior to 2019 at least four (4) ISMAs were in use testing in compliance with NFPA 285 calibration wall assembly surface temperatures. The ISMA apparatus has not undergone any changes. Based on this fact, there does not appear to be a technical justification for this change to Section 7.1.13.

Most MCM and HPL as well as polyiso insulation test specimens will be adversely affected by this allowable temperature increase. In contrast, exterior insulation finish systems (EIFS) and standard stucco veneer will probably not be adversely affected by this increase. Maintaining the existing NFPA 285 temperature limitations without a tolerance of correction factor, means that an identical test specimen (MCM or HPL) that complied with the in the 1998, 2006 and 2012 Editions of NFPA 285 with a maximum 1000°F reading at TC#11, probably will not pass the 2019 Edition of NFPA 285 with the new 10% increase in the calibration test. The change to Section 7.1.13 appears to have created an unstandardized test condition when comparing all *exterior walls* under NFPA 285 protocols.

NFPA 285 Standardized Gas

NFPA 285 does not specifically cite, by text in a section of the *standard*, the gas that is to be used to fuel the burners generating the fire. However, natural gas and propane have been used for this purpose. The reason that both gases have been used is based on their use as acceptable fuels for testing in compliance with UBC Test Standard 26-9. NFPA 285 was based on UBC Test Standard 26-9 and is its precursor in the building codes.

Natural gas is a combination of multiple gases, including propane, but is substantially pressurized methane (i.e. liquid). A cubic foot of natural gas has an energy content of approximately 1,031 Btu, but the range of values, depending upon the composition of the gas. “Thus, the energy content of natural gas is variable because natural gas has variations in the amount and types of energy gases (methane, ethane, propane, butane) it contains: the more non-combustible gases in the natural gas, the lower the energy (Btu). In addition, the volume mass of energy gases which are present in a natural gas accumulation also influences the Btu value of natural gas. The more carbon atoms in a hydrocarbon gas, the higher its Btu value. It is necessary to conduct the Btu analysis of natural gas at each stage of the supply chain. Gas chromatographic process analyzers are used in order to conduct fractional analysis of the natural gas streams, separating natural gas into identifiable components. The components and their concentrations are converted into a gross heating value in Btu-cubic foot.”[3]

[3] Handbook of Industrial Hydrocarbon Processes 2011, Pages 1-41
https://www.sciencedirect.com/book/9780750686327/handbook-of-industrial-hydrocarbon-processes

Propane gas is compressed and transported as a liquid. Propane is typically refined from petroleum and natural gas processing. Propane gas can emulate the combustion properties (e.g. heat energy) of natural gas.

Gas	Gross Heating Value		Net Heating Value	
	Btu/ft^3	Btu/lb	Btu/ft^3	Btu/lb
Natural Gas (typical)	950 – 1150	19500 – 22500	850 – 1050	17500 – 22000
Propane - C_3H_8	2572	21564	2371	19834

Table 1 – Btu Comparison of Natural Gas to Propane[4]

NFPA 285 Gas Variables and Effects

Chapter 7 Calibration Procedure in NFPA 285 is quite detailed. However, this part of the *standard* does not address at least one (1) very important issue. The calorific value (BTU/ft^3) is defined as the amount of heat produced on combusting a unit volume of gas. The fact that natural gas's caloric value can range from 850 BTU/ft^3 to 1050 BTU/ft^3 presents a variable not addressed in NFPA 285.

The accuracy of the test results obtained from NFPA 285 testing is a result of the calibration of the test equipment, i.e. room burner and window burner.

NFPA 285 Section 7.2 states, "*Frequency of Calibration* – Calibration *shall* be performed in the following circumstances:

(1) Initially, prior to the first wall assembly test

(2) When significant changes to the gas flow systems are made (e.g., flowmeters are new)

(3) Within 1 year prior to the test of an actual product wall assembly

(4) When the ceramic blankets covering more than 50 percent of the wall or ceiling surface in the burn room are replaced."

As previously stated, energy content of natural gas is variable. However, there is no NFPA 285 requirement to perform calibration when the caloric value of the natural gas changes due to a change in its composition. Refer to Table 2 – *Composition Comparison of Natural Gas to Propane*.

Consider the following: a calibration test is performed using natural gas with a commonly accepted energy content of approximately 1,031 Btu. During the course of the next year between calibration limitations, several shipments of natural gas are used that have less caloric value than the natural gas used during calibration. The *fire-test-response characteristics* of

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4 https://www.engineeringtoolbox.com/heating-values-fuel-gases-d_823.html

*Combustible material*s may be greatly enhanced. Conversely, a calibration test is performed using natural gas with a low energy content of approximately 950 Btu. During the course of the next year between calibration limitations, several shipments of natural gas are used that have greater caloric value than the natural gas used during calibration. The *fire-test-response characteristics* of *combustible material*s may be greatly diminished.

Without a set requirement and tolerance on the caloric value of natural gas, NFPA 285 does not provide a standardized fire exposure. In addition, without requiring verification of the caloric value of the natural gas used during each NFPA 285 test, verification of compliance with the established requirement and tolerance stated in NFPA Table 4.6.13 *Calibration Gas Flow Rates (Based on Natural Gas)* is not possible. Lastly, NFPA 285 Section 7.2 *Frequency of Calibration* needs to be revised to address and include this caloric variable of natural gas.

Composition (%)									
Fuel	**Carbon Dioxide (CO_2)**	**Carbon Monoxide (CO)**	**Methane (CH_4)**	**Butane (C_4H_{10})**	**Ethane (C_2H_6)**	**Propane ($C_3.H_8$)**	**Hydrogen (H_2)**	**Hydrogen Sulfide (H_2S)**	**Oxygen (O_2)**
Natural Gas	0 - 0.8	0 - 0.45	82 - 93		0 - 15.8		0-1.8	0 - 0.18	0 - 0.35
Propane				0.5 - 0.8	2.0 - 2.2	73 - 97			

Table 2 – Composition Comparison of Natural Gas to Propane[5]

Propane has a set calorific value (BTU/ft^3) of 2371. Using propane instead of natural gas would decrease the variability between NFPA 285 tests conducted at various laboratories and remove the variability of the caloric variability of natural gas: 850 – 1050 BTU/ft^3. NFPA 285 only contains Table 4.6.13 *Calibration Gas Flow Rates (Based on Natural Gas)*. NFPA 285 could create a table for propane gas flow rates based on natural gas's accepted energy content of approximately 1,031 Btu using the same references for both the room and window burners for each time interval: *standard* cubic feet per minute (SCFM); m^3/min; kW; and Btu/min. Conducting the fire test using propane instead of natural gas may be more accurate because there is no variation in the caloric value of propane like there potentially is in natural gas from the time of calibration to fire testing.

NFPA 285 Text & Meaning

The meaning of text within a *standard* has effects and consequences. Therefore, participants of all SDO's must be cognizant of numerous factors that can affect the conduct of a test as well as the test results.

This section of the Evaluation discusses variables in NFPA 285 or laboratory testing that can affect the *fire-test-response characteristics* of an identical test specimen tested at different

[5] https://www.engineeringtoolbox.com/chemical-composition-gaseous-fuels-d_1142.html

laboratories, environmental conditions, and ambient laboratory temperatures. NFPA 285 states, "NOTICE: *An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A*."

The 2012 Edition of NFPA 285 Section 4.6.3.5 states, "The burner *shall* be positioned with its centerline 2.5 ft ± 1 **in.** (0.8m±25mm) above the floor surface of the test facility." In 2019, a very significant but subtle text change (i.e. inch to feet) was made to the location of this burner. The 2019 Edition of NFPA 285 Section 4.6.3.5 states, "The burner *shall* be positioned with its centerline 2.5 ft ± 1 **ft** (0.8 m ± 0.3 m) above the floor surface of the test facility." This change of 1 inch to 1 foot may affect the configuration of the exterior flame plume. What technical justification was presented to document that this 1200% change will not affect the configuration of the exterior flame plume. For example, lowering the burner may broaden the base of the flume plume. While rising burner may narrow the flame plume. Where both conditions will still meet the calibration requirements but alter the mass of combustible material affected by the flame plume. Therefore, two (2) identical test specimens can have very different results.

This change can alter the performance of a test specimen, especially those test specimens tested to the 1998, 2006 and 2012 Editions of NFPA 285. At least two (2) ISMAs were constructed and in use for testing in compliance with UBC Test Standard 26-9 prior to the publication of NFPA 285. Further, prior to 2019 at least four (4) ISMAs were in use testing in compliance with NFPA 285 calibration wall assembly surface temperatures. The ISMA apparatus has not undergone any changes. Based on this fact, there does not appear to be a technical justification for this change to Section 4.6.3.5.

NFPA 285 Section 7.1.7 states, "Prior to the conduct of the calibration test, the paper facing of the gypsum wallboard on the exterior face of the calibration wall assembly *shall* be burned away by igniting both the room burner and the window burner and immediately adjusting the burners to their maximum flow rates as prescribed in Table 4.6.13 for not less than 5 minutes at these gas flow rates." Refer to Section 5.5 *Calcination Process*. NFPA 285 Section 7.1.8 states, "The calibration test *shall* be conducted with the gas burners supplied during the test according to the calibration gas flow rates prescribed in Table 4.6.13."NFPA 285 Section 8.1.7 states, "The gas flow rates established in accordance with 4.6.13 through 4.6.14 and 7.1.17 *shall* be followed for test room burners and the window burner except as required in 8.1.8."

NFPA 285 Section 4.6.13* states, "The burners ***shall*** be fired during the fire test according to the calibration gas flow rates shown in Table 4.6.13." The title of Table 4.6.13 is "*Calibration Gas Flow Rates (Based on Natural Gas)*". "Annex A *Explanatory Material – Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs*… A.4.6.13 The calibration flow rates shown in Table 4.6.13 are designed to achieve the temperatures shown in Table 7.1.11." Only natural gas can meet the specified requirements of Table 4.6.13 because the NFPA 285 definition of shall does not allow for alternatives or variances.

Table 4.6.13 Calibration Gas Flow Rates (Based on Natural Gas)

Time Interval	Room Burner				Window Burner			
	SCFM	m^3/min	kW	Btu/min	SCFM	m^3/min	kW	Btu/min
0:00–5:00	38.0	1.08	687	39,064	0.0	0.00	0	0
5:00–10:00	38.0	1.08	687	39,064	9.0	0.25	163	9,252
10:00–15:00	43.0	1.22	777	44,204	12.0	0.34	217	12,336
15:00–20:00	46.0	1.30	831	47,288	16.0	0.45	289	16,448
20:00–25:00	46.0	1.30	831	47,288	19.0	0.54	343	19,532
25:00–30:00	50.0	1.42	904	51,400	22.0	0.62	398	22,616

Table 3 – NFPA 285 Calibration Requirements – Gas Low Rates

Table 7.1.11 Calibration Average Values for Time Periods Indicated

Thermocouple Location and Numbers	Temperature											
	0–5 min		5–10 min		10–15 min		15–20 min		20–25 min		25–30 min	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Test room ceiling: Nos. 18–22	1151	622	1346	730	1482	806	1600	871	1597	869	1648	898
Interior wall surface of test room: Nos. 15–17	1065	574	1298	703	1433	778	1578	859	1576	858	1655	902
1 ft (305 mm) above top of window opening: No. 2	602	317	870	466	952	511	992	533	1046	563	1078	581
2 ft (610 mm) above top of window opening: No. 3	679	359	1015	546	1121	605	1183	639	1245	674	1296	702
3 ft (914 mm) above top of window opening: No. 4	646	341	971	521	1096	591	1174	634	1245	674	1314	712
4 ft (1219 mm) above top of window opening: No. 5	577	302	858	459	982	528	1063	573	1135	613	1224	662
5 ft (1524 mm) above top of window opening: No. 6	521	272	765	407	875	469	949	509	1007	542	1106	597
6 ft (1829 mm) above top of window opening: No. 7	472	244	690	366	787	419	856	458	913	489	1010	543

Calorimeter Locations and Numbers	Heat Flux (W/cm^2)					
	0–5 min	5–10 min	10–15 min	15–20 min	20–25 min	25–30 min
2 ft (610 mm) above top of window opening: Letter C–2ft	0.9 ± 0.2	1.9 ± 0.4	2.5 ± 0.5	2.9 ± 0.6	3.4 ± 0.7	3.8 ± 0.8
3 ft (914 mm) above top of window opening: Letter C–3ft	1.0 ± 0.2	2.0 ± 0.4	2.6 ± 0.5	3.2 ± 0.6	3.7 ± 0.7	4.0 ± 0.8
4 ft (1219 mm) above top of window opening: Letter C–4ft	0.8 ± 0.2	1.5 ± 0.3	2.0 ± 0.4	2.5 ± 0.5	3.0 ± 0.6	3.4 ± 0.7

Table 4 – NFPA 285 Calibration Requirements – Temperature & Heat Flux

The exclusion of propane was clearly not intended since NFPA 285 was developed based on UBC Test Standard 26-9, which did not make this exclusion. Further, there were only two (2) apparatus in existence at that time: one propane and the other natural gas. NFPA 285 needs to address this issue. Litigation is based on the text of a standard.

Gas flow rates for propane are not specified or referenced directly or indirectly in NFPA 285. Further, the caloric value of propane is much greater than natural gas. Ergo, propane cannot comply with the gas flow rates required by NFPA 285 based on natural gas. Heat flux ranges for propane are not specified or referenced directly or indirectly in NFPA 285. Natural gas burns cleaner than propane. Therefore, propane may not comply with the feat flux ranges required by NFPA 285 for natural gas. This should be investigated.

PSL observed that simply removing the four (4) columns (i.e. Room Burner – SCFM and m^3/min columns and Window Burner – SCFM and m^3/min columns) referring to the gas flow rates specified in Table 4.6.13; deleting the reference to natural gas; that Table 4.6.13 could be used to calculate the gas flow rates for any gas used in the NFPA 285 test at the required time intervals provided that Section 7.1.8 was revised to read, "The calibration test ***shall*** be conducted with the gas burners supplied for use during the fire test procedure. The calibration caloric values prescribed in Table 4.6.13 ***shall*** be used to determine the gas flow rates for the specific gas used during the fire test procedure. The gas flow rates *shall* be documented and used during the fire test procedure. "

NFPA 285 Section 4.6.14 states, "Each burner ***shall*** attain its prescribed gas flow rate within 15 seconds of each specified change in the gas flow rate." This change occurred in the 2012 Edition of NFPA 285.

<u>The 2012 Edition of NFPA 285 introduced another very significant change to the window burner gas flow transition time.</u> NFPA 285 Section 4.6.14 states, "Each burner *shall* attain its prescribed gas flow rate within 15 seconds of each specified change in the gas flow rate." Further, at least two (2) ISMAs were constructed and in use for testing in compliance with UBC Test Standard 26-9 prior to the publication of NFPA 285. Further, prior to 2019 at least four (4) ISMAs were in use testing in compliance with NFPA 285 calibration wall assembly surface temperatures. A proportional–integral–derivative controller (PID controller) does not need 15 seconds to adjust the gas flow to the burners. <u>The ISMA apparatus has not undergone any changes. Based on this fact, there does not appear to be a technical justification for this change to Section 4.6.14, especially without an upper limitation (tolerance) on the gas flow rate.</u>

This transition time change does not limit a maximum gas flow rate during this time period. The test specimen reacts to heat. *Combustible material*s can be adversely affected by additional energy. The total allowable transition time is 75 seconds based on five (5) time intervals specified in NFPA 285. The additional cumulative heat energy now allowed by this change is not factored into the temperature limitations set forth in this *standard*. Because there is no limit on gas flow during the transition time, a tremendous amount of heat energy created by a significant gas flow increase could greatly alter the temperature readings and subsequent test results. The *standard*'s test limitations were not altered to address this variable that can affect the test results. What is the technical justification for increasing the severity of the test?

NFPA 285 Section 8.1.7 in the Test Procedure includes another increase in the severity of the test, through an exception. NFPA 285 Section N8.1.8 states, "When it has been demonstrated during the calibration procedure that the burners must follow different gas flow rates to attain the prescribed test room and exterior face temperatures and heat fluxes, then the gas flows determined from the calibration tests within a tolerance of ±10 percent *shall* be used." PSL thought that this NFPA 285 Section N8.1.8 should have been located in the calibration section as part of the explanation for the additional 10% increase from the 2012 Edition of NFPA 285. However, others said that this is an additional 10% tolerance allowed during the actual fire test.

A 10% increase is a significant change in gas flow, which can greatly alter the heat energy being released by combustion of the gas. A proportional–integral–derivative controller (PID controller) is used to calibrate the burners based on gas flow. If the computer program that has the PID controller values set is used, why would an additional tolerance be allowed? This gas flow change can create a detrimental effect on the test specimen. However, once again this potential adverse effect on the temperature readings and test data is not addressed in the current NFPA 285 temperature limitations.

One purpose of the fire test is to determine the additional energy generated during combustion of the combustible materials used in the test specimen. The purpose of calibration is defeated by allowing additional energy generated by the test apparatus to be introduced during the fire test. Further, this additional energy is reported as being contributed by the test specimen through the test data recorded by the thermocouples on the face of the test assembly, when in fact this is erroneous and misleading because the total energy cannot be differentiated (properly subdivided) and attributed to either the test apparatus and test specimen.

Further, at least two (2) ISMAs were constructed and in use for testing in compliance with UBC Test Standard 26-9 prior to the publication of NFPA 285. Further, prior to 2019 at least four (4) ISMAs were in use testing in compliance with NFPA 285 calibration wall assembly surface temperatures. What is the technical rationale for this additional change? The ISMA apparatus has not undergone any changes. Based on this fact, there does not appear to be a technical justification for this change to Section N8.1.8.

This *standard* has existed since 1998. When the NFPA 285 Technical Committee focuses on changes regarding the conduct the NFPA 285 test, such as gas flow rates and maximum calibration wall assembly surface temperatures, by increasing them due consideration must also be given to the effect these changes will have on test results. Further, the repeatability and reproducibly of NFPA 285 tests are affected by these changes.

The combination of all the increases in temperature and gas flow in the 2019 Edition of NFPA 285 have created a far greater heat profile, well beyond that discussed in the Annex. What technical justification has been presented to the NFPA 285 Technical Committee to justify these changes? The ISMA apparatus has not undergone any changes. Based on this fact, there does not appear to be a technical justification for these substantial changes.

NFPA 285 Environmental Considerations

Typically a standardized fire test indicates that the test specimen, testing procedures, fire exposure, and temperature acquisition are equivalent when assessing materials, products and assemblies. Standardized fire testing usually establishes confidence when another fire test is conducted on identical materials, products and assemblies that the test results will still be applicable or comparable. To that end, most fire tests have tolerances or use a correction factor to confirm the test results are still applicable or comparable. Regarding temperature, NFPA 285 uses temperature limitations based on absolute temperature values (e.g. 1000°F @ TC#11) rather than a change in temperature (ΔT).

Thermal inertia ($I = \sqrt{k\rho c}$) affects the test specimen's response time to heat energy. However, there are variations between different sources for *k, ρ, and c*[6,7] values used to determine thermal inertia. The *k, ρ, and c* values used in this Evaluation are used as constants. Thermal inertia is a constant until an ignition temperature is reached which may alter a material's thermal properties. Those familiar with *fire-test-response characteristics* of materials, products and assemblies know that the thermal inertia is a constant value that does not change with ambient temperature and typical temperatures used in fire testing. Therefore, the energy required to increase the temperature by 1°F is the same whether the temperature is 50°F or 90°F. The NFPA 285 temperature limitations do not compensate for this fact.

NFPA 285 Initial Temperature Considerations

NFPA 285 Section 8.1.5 states, "Ambient conditions at the start of the fire test *shall* be as follows: (1) The temperature of the air in the test facility *shall* be between 50°F and 90°F (10°C and 32°C). " Environmental conditions may affect the results of NFPA 285 tests because these fire tests are based on temperature limits rather than temperature rise. The fire test can be conducted at temperatures of the air in the test facility between 50°F and 90°F. This means that a test conducted at 50°F and passes reaching the 1000°F temperature limit probably will not pass when tested at 90°F.

$$Q = m \times C_P \times \Delta T$$

Q = heat energy
m = mass (lb) = plain steel = 1 lb
C_P = specific heat = aluminum = 0.091[8] Btu/(lb$_m$ °F
ΔT = change in temperature ($T_{LMT} - T_{AMB}$)
    T_{LMT} = NFPA 285 Limit for TC#11 and TC#14 through TC#17 = 1000°F
    T_{AMB} = Allowable NFPA 285 Initial Temperature Range = 50°F to 90°F
ΔT_L = least change between temperatures (1000°F – 50°F) = 950°F
ΔT_G = greatest change between temperatures (1000°F – 90°F) = 910°F
Q_L = heat energy required at lowest temperature
Q_G = heat energy required at lowest temperature

Btu Energy Difference Based on One (1) Pound of Aluminum
$Q = m \times C_P \times \Delta T$

6 https://www.engineeringtoolbox.com/specific-heat-metals-d_152.html
7 https://ncfs.ucf.edu/burn_db/Thermal_Properties/material_thermal.html
8 https://www.engineeringtoolbox.com/specific-heat-metals-d_152.html

	m *lb*	C_P *Btu/(lb$_m$ °F)*	ΔT_L	ΔT_G	*Q* *Btu*
Q_L	*1*	*0.091*	*950*		*86.45*
Q_G	*1*	*0.091*		*910*	*82.81*

Table 8 – Aluminum Energy Differences Based on Initial Test Temperatures

Btu Energy Difference Based on One (1) Pound of Plain Steel $Q = m \times C_P \times \Delta T$					
	m *lb*	C_P *Btu/(lb$_m$ °F*	ΔT_L	ΔT_G	*Q* *Btu*
Q_L	*1*	*0.12*[9]	*950*		*114*
Q_G	*1*	*0.12*		*910*	*109.2*

Table 9 – Steel Energy Differences Based on Initial Test Temperatures

Since same amount of energy is required to initiate an increase in temperature of two (2) identical assemblies, then the NFPA 285 temperature limitations (e.g. 1000°F @ TC#11) will affect the *fire-test-response characteristics*, when one (1) of the identical assemblies is tested at 50°F and the other identical assembly is tested at 90°F. The effect of temperature at the time of test is demonstrated using the preceding equation: This maximum energy difference is 4.21% between 50°F and 90°F. This maximum difference is a constant for all materials.

Table 10 represents the energy differences based on 5°F intervals between 50°F and 90°F, which can be interpolated and could be used as a correction factor based on initial test temperature and the 1000°F limitation based on TC#11, which most often represents the worst-case temperature rise during the fire test.

Energy Differences Based on NFPA 285 Initial Temperature Limitations			
Initial Test Temperature °F	**Energy Difference %**	**Initial Test Temperature °F**	**Energy Difference %**
Minimum Initial Temperature 50	**0.00**	75	2.63
55	0.53	80	3.16
60	1.05	85	3.68
65	1.58	**Maximum Initial Temperature 90**	**4.21**
70	2.11		

[9] https://www.engineeringtoolbox.com/specific-heat-metals-d_152.html

Table 10 – Potential Tolerances Based on Initial Test Temperatures

NFPA 285 set a temperature limitation of 1000°F based on a maximum ambient laboratory temperature of 90°F. Therefore, if the maximum temperature limitation of 1000°F is maintained for repeatability within a laboratory and reproducibility between laboratories then a tolerance or correction factor is required. Otherwise, a test specimen with an NFPA 285 test result of 1000°F obtained at an initial 50°F, in accordance with NFPA 285 Section 8.1.5, will exceed 1000°F when that identical test specimen is tested at 90°F, which is noncompliant with Section 10.2.1.2 limitations. Therefore, when tests are conducted above 50°F a correction factor is needed to correlate results and establish standardization of the test data as is done in numerous fire test methods. Establishing a consistent methodology for interpretation of test results demonstrates technical competence.

Table 10 only addresses the variation in the energy differences based on NFPA 285 initial temperature limitations and not the numerous other factors creating unstandardized test data because of the variable cited in this document. Some of the variables may have a cumulative effect negatively impacting the *fire-test-response characteristics* of the test specimen.

Test Facility's NFPA 285 Ambient Conditions

NFPA 285 Section 8.1.5 states, "Ambient conditions at the start of the fire test *shall* be as follows: (1) The temperature of the air in the test facility *shall* be between 50°F and 90°F (10°C and 32°C)." In most fire tests that include tolerances or correction factors and are based on changes in temperature rather than temperature limits, the ambient laboratory temperature has little effect on the test results. However, NFPA 285 does not include tolerances or correction factors and is based on temperature limits rather than changes in temperature. Further the *standard*'s Section 5.3 states, "Size of Test Specimen. The test specimen *shall* be not less than 17.5 ft high × 13.3 ft wide (5.3 m high × 4.1 m wide)."

NFPA 285 has created a paradox within Section 8.1.5 because the test specimen is a minimum of 17.5 feet tall. During the colder months of the year, most laboratories must heat the test facility. In doing so, a temperature gradient is created in their building, which is not considered by most laboratory personnel.

For example, an NFPA 285 conducted in December. The ambient conditions were 61°F and 22% relative humidity measured at ground level. Yet the TC#11 indicated a temperature of 79°F at Time 00:00 (min:sec). This is documented evidence that a temperature gradient existed at the time of commencing the fire test. This 18°F differential is could be the difference in meeting or exceeding the 1000°F limitation.

Further, if the laboratory's test facility was shut down without continuing heating or cooling, then the test specimen may not have established equilibrium before being tested. The intermediate-scale multistory apparatus (ISMA) is a six-sided device. According to Merriam-Webster's Collegiate Dictionary, 11th Edition as prescribed by NFPA 285, ambient temperature is defined as "existing or present on all sides **:** encompassing the ambient air temperature". This fact makes it almost impossible to maintain the ambient conditions cited in NFPA 285 for all fire tests. This ambient condition is another consideration not addressed by NFPA 285 that can affect the *fire-test-response characteristics* generating the test data as well as NFPA 285's repeatability within a laboratory and reproducibility between laboratories.

The fire test can be conducted at relative humidity of the air in the test facility between 20% and 80%. Some materials that compose the test specimen may be hydroscopic. Therefore, the higher 80% humidity potentially allows these materials to absorb more moisture than at 20% humidity. The test results may be affected because "The presence of moisture, if it does not result in explosive spalling, increases the fire endurance."[10]

Critical NFPA 285 Thermocouples

NFPA 285 uses thermocouples to determine the temperatures registered on the face of the calibration wall assembly and the test specimen. However, the *standard* provides little detail about these critical measuring instruments other than their gage and type specified in Section 6.3 *Thermocouples* that states, "Temperature measurements *shall* be made using 20-gauge Type K thermocouples, except that those used to measure the temperatures shown in Figure 6.1(d) *shall* be 18-gauge Type K thermocouples". The thermocouple locations are illustrated in very basic drawings that are adequate for that purpose: refer to NFPA 285 Figure 6.1(a) and Figure 6.1(b). The reference to location is made as follows: "●THERMOCOUPLE – 1 in. (25 mm) from *exterior wall* surface".

However, the critical elements regarding temperature acquisition are left up to each laboratory. This can create great variations in the temperatures registered by these *exterior wall* thermocouples. For example, it is common practice for laboratories to bundle the thermocouple wires together and protrude each thermojunction 1 inch. The base of the bundle is often weighted to apply tension in the hope of avoiding movement of the thermojunction. However, sometimes the test specimen begins to degrade and the debris impacts the bundle causing the thermojunction to rotate inward towards the *exterior wall* or the debris causes the bundle to move outward away from the *exterior wall*. This is a critical issue for standardization of test data. There are methods used by other test methods that can assist in addressing this issue, such as a "thermocouple tree".

Laboratories

In science, a standardized[11] test is a method of assessment built on the principle of consistency. The test methodology used does not favor one group of test specimens over another and all test results are assessed equally by taking into account the variables within the test method that can affect the test results.

There is documentation (test reports) that testing identical test specimens at different laboratories creates variations in the test data. This may be due to the numerous variables

[10] Harmathy, T. Z., Ten Rules of Fire Endurance Ratings, Fire Technology, Vol. 35, May 1965
[11] standardized – brought into conformity with a standard **:** done or produced in a standard, consistent way https://www.merriam-webster.com/dictionary/standardized

discussed herein (ambient temperature, humidity, maximum gas flow rates, maximum calibration temperatures, temperature acquisition, etc.) or the technical competence of the laboratory personnel. Whatever the reason, it is critical to establish intra-laboratory and inter-laboratory accuracy and a statistical assessment of the test data obtained from calibration tests to determine a bias with and between laboratories. Without a tolerance or correction factor and accuracy and bias information, the current NFPA 285 2019 Edition is not considered a standardized test method because of the numerous variables and unjustified technical changes increasing the test severity to a 20 year old standard.

Some interest has been expressed by large MCM, HPL, and polyiso manufacturers in publishing an article asking for technical information that justifies the changes existing in the current NFPA 285 2019 Edition.