JENSEN HUGHES

Advancing the Science of Safety

NFPA 285 and Engineering Judgments

Presented at: XXIII Annual Westford Symposium on Building Science

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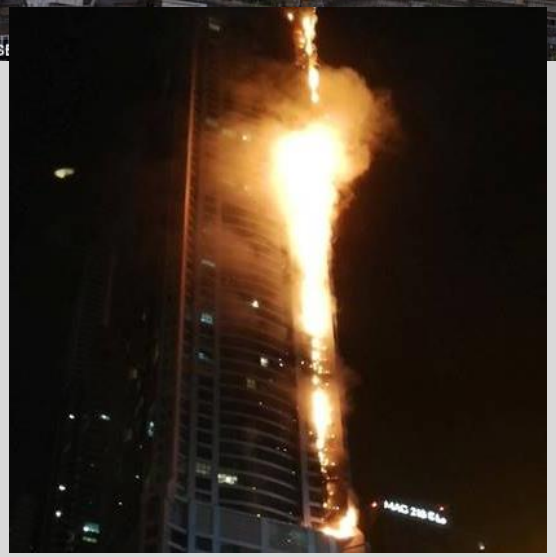
Learning Objectives

- NFPA 285
- Update on NFPA 285
- Use of NFPA 285 Test Results
- What Have we Learned
- Examination of Exterior Walls of Existing Buildings

What is the Commonality In These Fires?

- Marina Torch, Dubai August 2017
- Grenfell Tower, June 2017
- Azerbaijan May 2015
- Marina Torch, Dubai Feb 2015
- Grozny Towers, Chechnya April 2013
- Tamweel Tower, Dubai November 2012
- Polat Tower, Istanbul, Turkey July 2012
- Al Tayer Tower, April 2012
- Shanghai, November 2010
- Qatar, November 2010
- Mandarin Oriental Hotel Beijing China Feb 2009
- Monte Carlo, Las Vegas NV Jan 2008



Commonality is

- The exterior wall **assembly** was not tested via a full-scale fire propagation test of any kind
- Lack of Code requirements for fire performance of exterior walls
- Lack of enforcement of Codes

NFPA 285 More Important Now Then Before

- Changes in exterior wall construction:
  - Energy Conservation/Usage – Use of combustible insulations
  - Architectural appearance and costs – Use of combustible veneers
  - New building technologies – air/vapor/moisture management – Use of combustible WRB
- Exterior wall fires throughout the world
- Need to regulate and determine fire performance via standard test

NFPA 285

In the beginning….

In mid 1970's – use of foam plastic on or in noncombustible exterior walls was proposed.

- EIFS & Steel/Foam/Steel Panels

Problems with use:

- **Exterior walls of Type I, II, III or IV Construction must be noncombustible construction.**
- Foam plastic is combustible & past history
- Issues raised over potential for vertical and horizontal fire spread due to the combustible foam plastic insulation

History of NFPA 285

Energy Crisis:
Leads to increased exterior insulation applications

1988:
Uniform Building Code adopts UBC 17-6

1997:
Uniform Building Code adopts UBC 26-9

2000:
IBC begins requiring NFPA 285 testing

2009:
Requires testing ACMs / HPLs / FRPs

1970's → 1980's → 1990's → 2000's → 2010's

Late 70's:
SPI develops full-scale test

Full-scale Fire Test
UBC 17-6 / UBC 26-4

1998:
NFPA adopts UBC 26-9 as NFPA 285

Reduced-scale Fire Test
UBC 26-9 / NFPA 285

2012:
IBC expands NFPA 285 testing to WRB

2015 & 2018
IBC has approved WRB exceptions based on material properties and fuel load potential

Source: "NFPA 285: What you Need to Know" by Jesse J. Beitel – JBED Summer 2012 issue

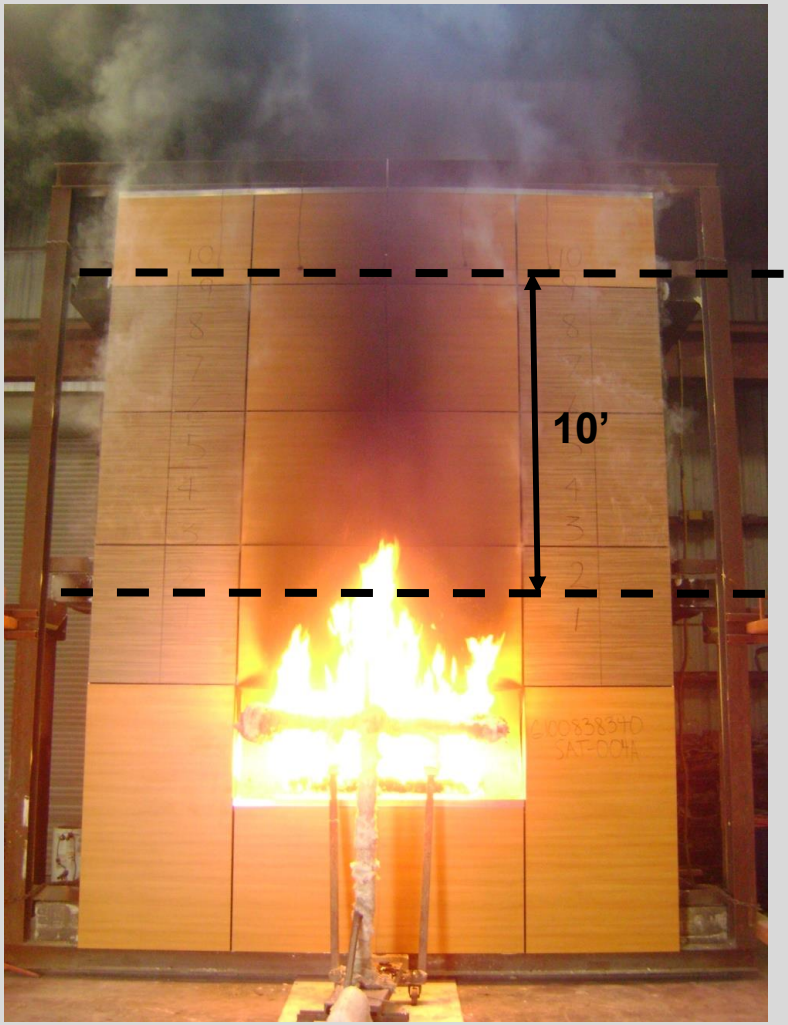
MULTI-STORY FIRE TEST STANDARD – 2ND Generation

- Test submitted to NFPA Fire Test Committee and adopted as NFPA 285 in 1998.
- NFPA 285, "*Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-load-bearing Wall Assemblies Containing Combustible Components*"
- NFPA 285 referenced in all editions of IBC
  - 2000 to 2018 Editions of IBC
- NFPA 5000

WHAT IS NFPA 285?

- “Multi-story” fire test standard
- Assess ability of exterior wall to resist:
  - Flame propagation over exterior wall surface
  - Vertical flame propagation within the combustible core or components
  - Vertical flame propagation over the interior surface from one floor to the next
  - Lateral flame propagation to adjacent compartments
- Fire source reproduces ASTM E119 fire exposure conditions (room interior)
- Does not address floor-line perimeter fire barrier systems *per se*.
  - ASTM E2307

NFPA 285 Test Standard



2nd Floor Observation Room

1st Floor Burn Room – ASTM E119 temperature conditions

NFPA 285 Test Apparatus

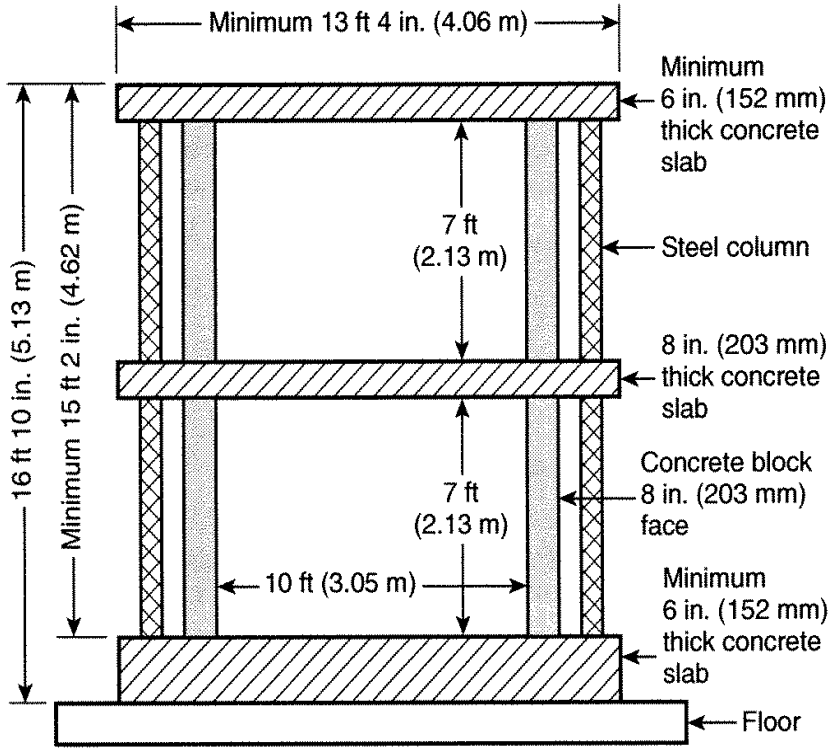


FIGURE 4.2.3 Front View of Test Apparatus Structure (not to scale).

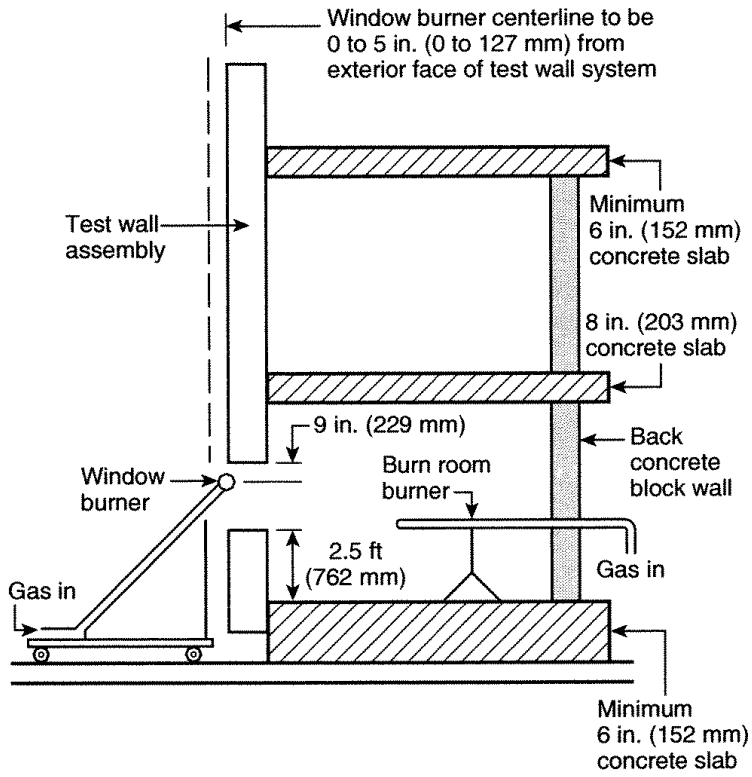
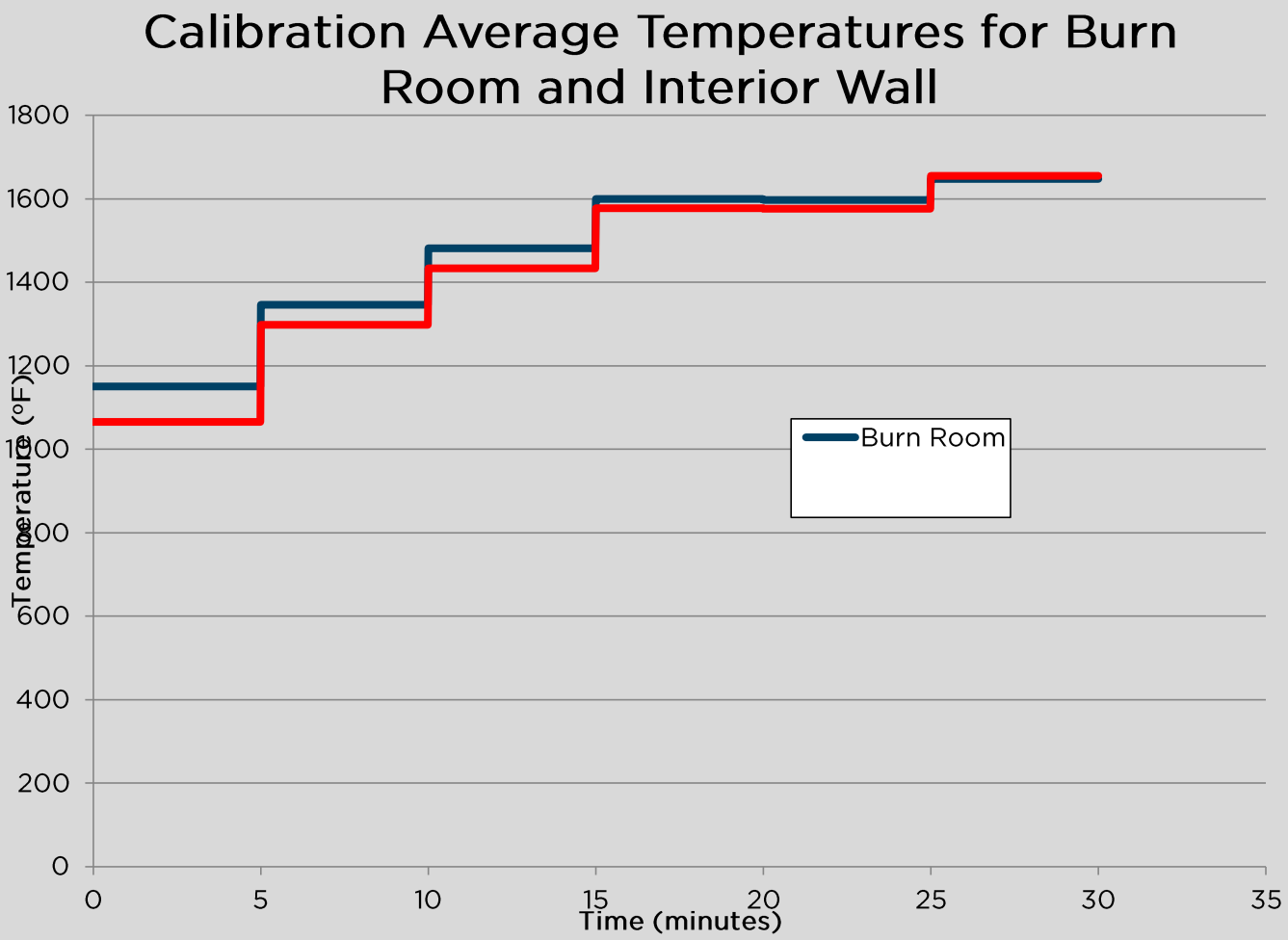
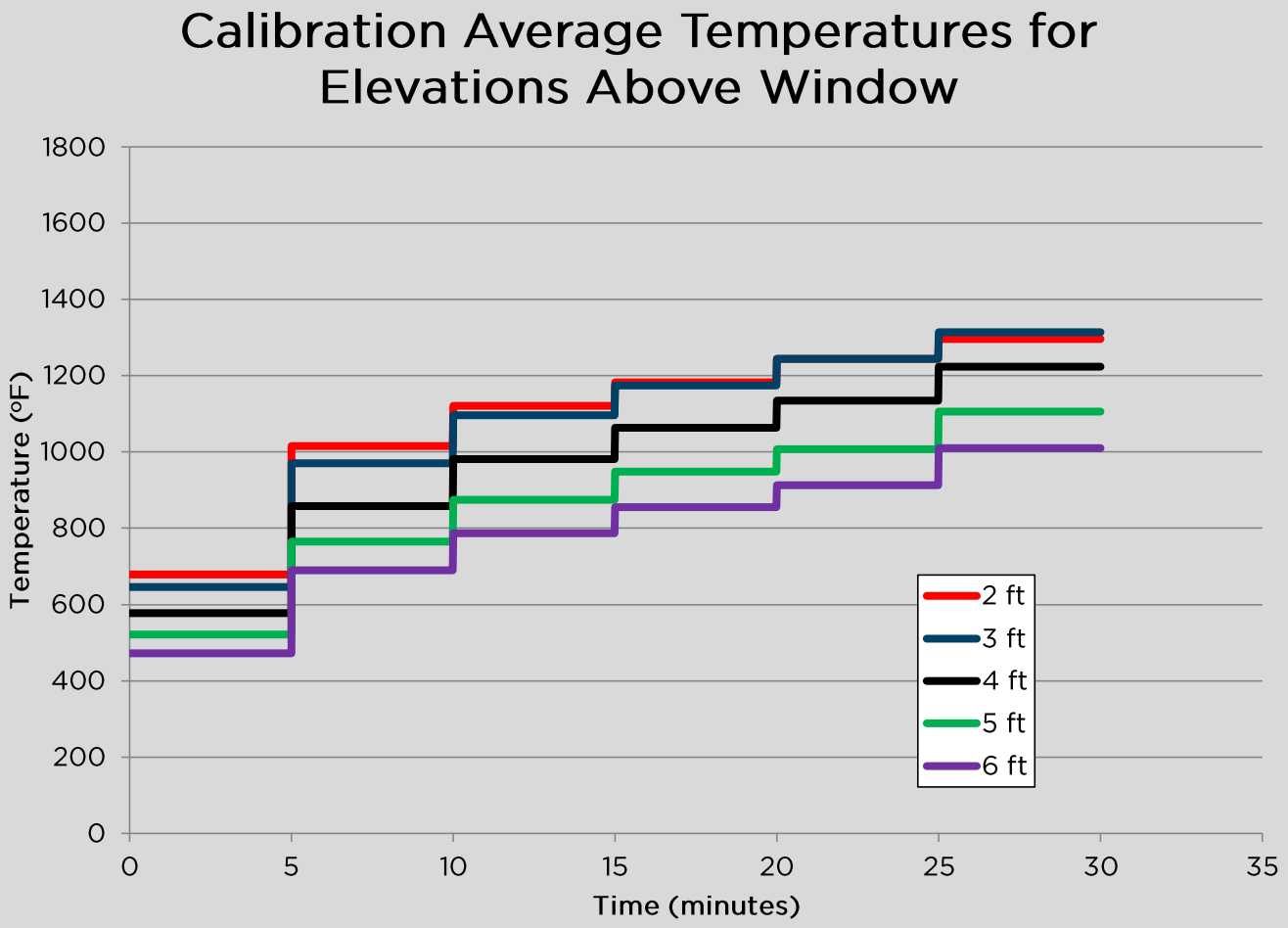


FIGURE A.4.4.8 Side View of Burner Placement in First-Story Test Room (not to scale).

NFPA 285 Test

2 Story Test with Interior & Exterior Burners


Calibration Average Temperatures for Burn Room and Interior Wall
1800
1600
1400
1200
1000
800
600
400
200
0
Temperature (°F)
0
5
10
15
20
25
30
35
Time (minutes)
Burn Room


Calibration Average Temperatures for Elevations Above Window
Temperature (°F)
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
35
Time (minutes)
2 ft
3 ft
4 ft
5 ft
6 ft

NFPA 285 – Pass Criteria

Test Requirements	Test Observations	Pass/Fail
Flames did not reach 10 ft. above the window opening.	Flames did NOT reach 10 ft. above the window opening.	PASS
Flames did not reach a lateral distance of 5 ft. from the vertical centerline.	Flames did NOT reach a lateral distance of 5 ft. from the vertical centerline.	PASS
Flames did not propagate beyond the limits of the first story test room.	Flames did NOT propagate beyond the limits of the first story test room.	PASS
No Visible flaming in the second story test room	NO Visible flaming in the second story test room.	PASS
TC's 11 and 14-17 (1000°F limit)	TC's 11 and 14-17 did not exceed their 1000°F limit.	PASS
TC's 18-19 and 31-40 (750 °F above ambient)	TC's 18-19 and 31-40 did not exceed 750 °F above their ambient temperature.	PASS
TC's 49-54 (500°F above ambient)	TC's 49-54 did not exceed 500°F above their ambient temperature.	PASS

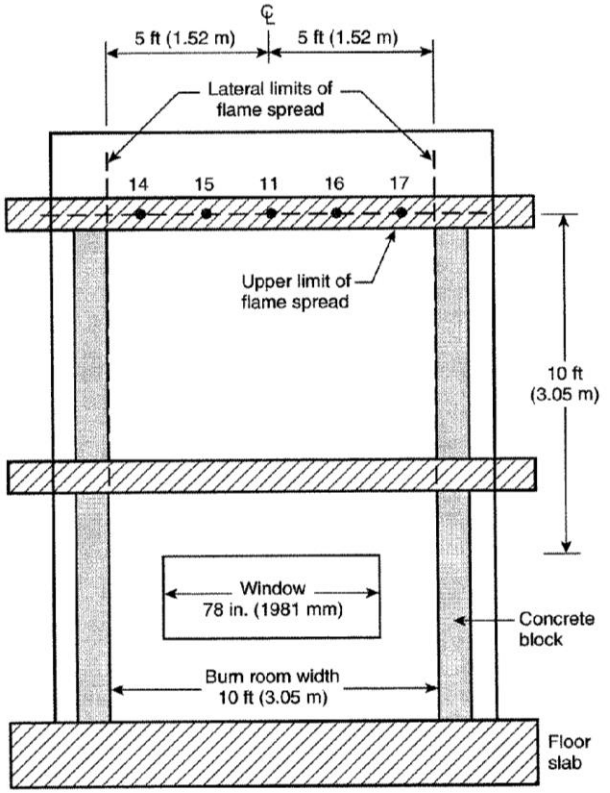


FIGURE 10.2.1.2 Limits of Flame Propagation (not to scale).

This is Not the Performance You Want!!

Applicability of NFPA 285 in IBC

- Foam plastics in buildings of any height – Section 2603.5.5 (approx. 1988)
- Combustible veneers – use on buildings over 40 ft in height
  - MCM's & ACM's – Section 1407.10 (2000)
  - HPL's – Section 1409.10 (2009)
  - EIFS – Section 1408.2 (2009)
  - FRP's (Section 2612.5 (2009)
- Water resistive barrier (WRB's) materials - Section 1403.5 (2012)
- ✓ **We continue to add combustibles to or in exterior walls – new veneers, other products or wall designs**

CHANGES TO NFPA 285

NFPA 285 Has Changed

- NFPA 285, "*Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-load-bearing Wall Assemblies Containing Combustible Components*"
- NFPA 285 (Currently 2012 edition) referenced in all editions (2000 – 2018) of IBC
- In 2021 edition of the IBC a new 2019 edition of will be referenced.
- NFPA 285, "*Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components*"
- Technical changes have occurred in the 2019 edition

Changes to NFPA 285 – 2019 – Part 1

- The title and the scope have been changed to remove the word “Non-Load-Bearing”
  - Test assembly does not have an applied live load but is built as if load-bearing
- Scope has been changed so as to allow NFPA 285 to be used for any Type of Construction – Types I through V
- Removes the word “noncombustible from type of walls to be tested.
- Test wall construction allows wood studs now.

- **All of these changes allow testing of wood construction – i.e., tall wood buildings, podium construction, etc.**

Changes to NFPA 285 – 2019 – Part 2

- Construction of test wall assembly now requires specific locations for two joints in the exterior veneer when panels are used.
  - Vertical joint – one continuous vertical joint from top of window opening to top of wall. Must be within ± 12-inches of window centerline
  - Horizontal joint – one continuous horizontal joint between 1-ft and 3-ft. above the top of the window
  - Exceptions for Brick, EIFS, Stucco
- Window header, jamb & sill construction now specified for broadest coverage. Can still use specific construction if desired but limited to that tested.

Changes to NFPA 285 – 2019 – Part 3

- Calibration temperature ranges slightly changed from ±10% to -10% to +20%
- 10-minute observation period after the 30-minute test has been eliminated. Can be done is wanted but not required.

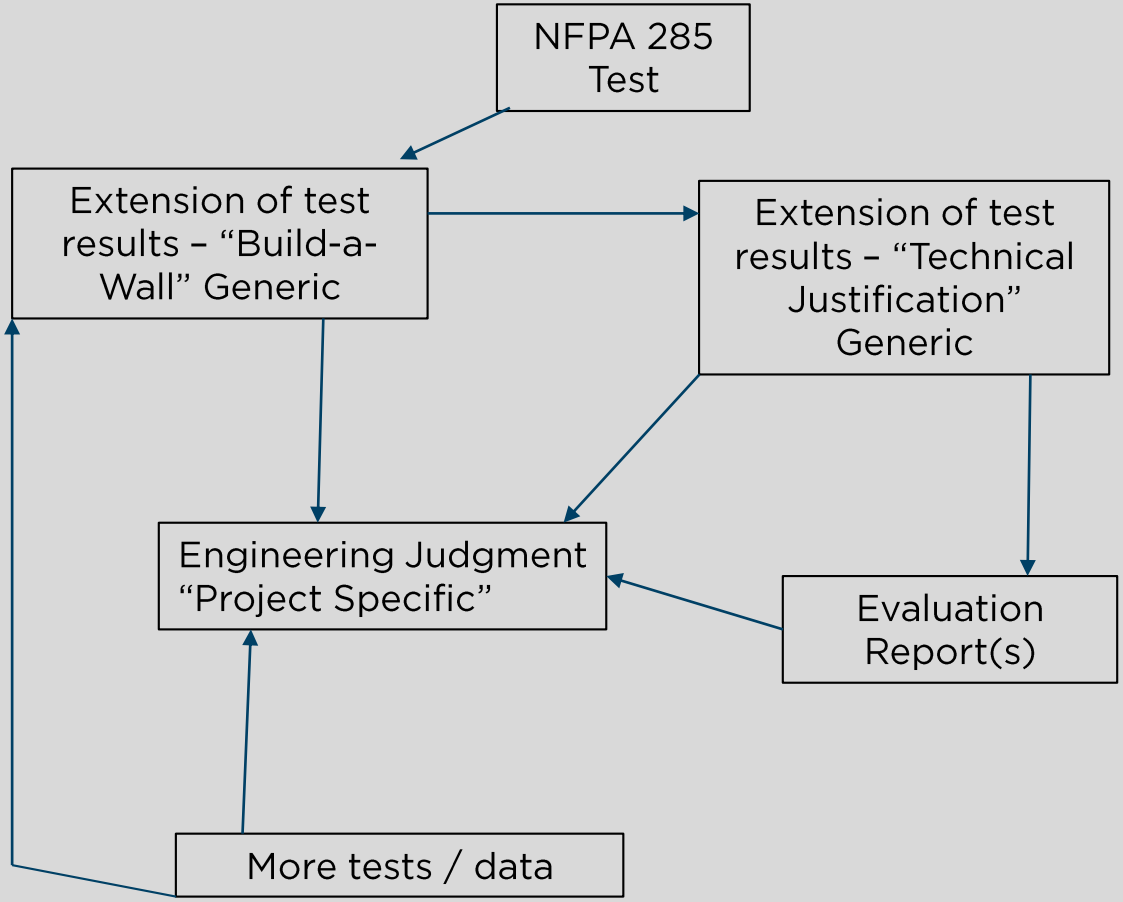
- Previous NFPA 285 tests may not meet the 2019 edition of NFPA 285
- Applies primarily to exterior veneers of panel systems (MCM, HPL, others)

Future Issues With NFPA 285

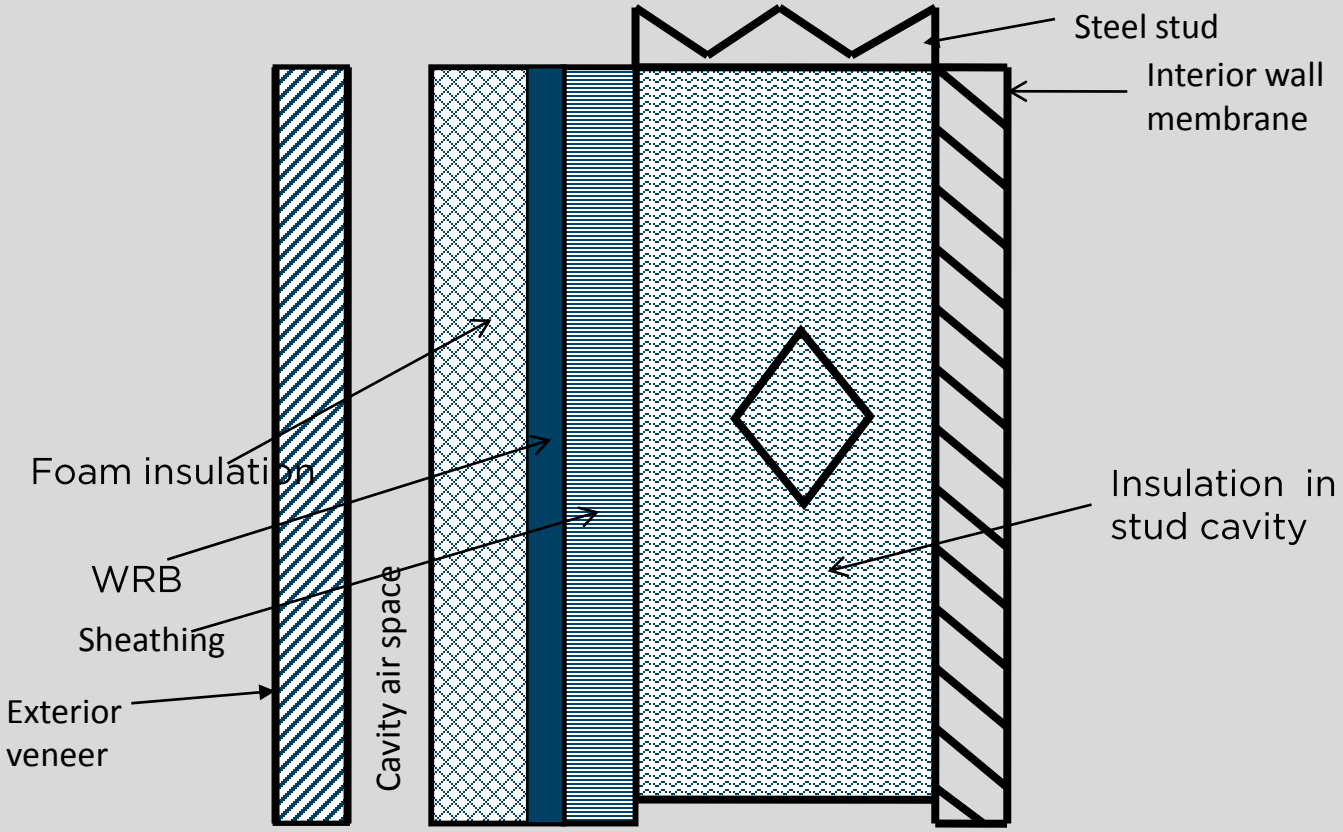
- Work progressing by ULI and Intertek Testing to develop searchable NFPA 285 tested wall assemblies.
- Work progressing in NFPA on a document regarding a guide for the extension of NFPA 285 test results
- Potential testing of decorative features/pop-outs.
- Other issues may brought up such as wind, fire size, corners, wing walls, etc.

USE OF NFPA 285 TESTS

Use of an NFPA 285 Test



Various Wall Systems



Potential Variations of Wall Systems

Extension of Test Results

- NFPA 285 tests are full-scale fire tests of an assembly with various components some of which are combustible
- The use of various components in a test assembly is similar to the test wall assemblies in ASTM E119 – Fire-resistance test.
- In listings for fire-resistance, many of the components have alternatives. These alternatives have probably not been tested in the full-scale E119 but have been “extended/engineered” into the listing via other tests, similarity of materials, etc.
- The results of a single NFPA 285 test can be “extended/engineered” in a similar manner to other alternative materials

Extensions

- Extensions are a listing of various materials or alternative materials that can be combined in an appropriate manner and result in a wall assembly that will exhibit complying NFPA 2854 fire performance.
- The “Build-A-Wall” tables are an extension of one or more NFPA 285 tests and other testing based on the material and its use may justify inclusion.
- Extensions must always based on test data and engineering judgment
- Extensions do not usually provide the explicit rationale for the inclusion of materials or products.
- Extensions are living documents – may increase or may decrease

Example of an Extension of Results Analysis

Table I. Walls Containing XPS Insulation and ??? Water-resistive Barriers

Wall Component	Materials
Base wall system – Use either 1, 2 or 3	1 – Concrete wall 2 – Concrete Masonry wall 3 – 1 layer – ⅝-inch thick, Type X, Gypsum wallboard on interior, installed over steel studs: minimum 3⅝-inch depth, minimum 20-gauge at a maximum of 24-inch OC with lateral bracing every 4 ft. vertically
Floorline Firestopping	4 lb/cu ft. mineral wool (e.g. Thermafiber or Roxul) in each stud cavity at each floorline – attached with Z-clips or equivalent
Cavity Insulation – Use either 1 or 2	1 – None 2 – Any noncombustible insulation (faced or unfaced)
Exterior sheathing – Use either 1 or 2	1 – ½-inch thick, exterior type gypsum sheathing 2 – ⅝-inch thick, Type X, exterior type gypsum sheathing
Water-resistive barrier applied to gypsum sheathing – Use either 1, 2 or 3	1 – ???? applied at a maximum 40 mils WFT 2 – ???? applied at a maximum 20 mils WFT 3 – ???? applied at a maximum 32 mils WFT
Exterior insulation	Extruded Polystyrene Foam Insulation (XPS) - Type IV per ASTM C578 – Maximum of 3-inch thickness Note: As an option, insulation joints may be covered with an asphalt or Butyl-based flashing tape – max. 4-inch width can be used.
Water-resistive barrier applied to exterior insulation – Use either 1 or 2	1 – None 2 – Any shown in Table II
Exterior Veneer – Use either 1, 2, 3, 4 or 5	1 – Brick - Standard nominal 4-inch thick, clay brick. Brick installed with standard type veneer anchors at maximum 24 inches OC vertically on each stud. Maximum 2-inch air gap between exterior insulation and brick 2 – Concrete – 2 inches thick or greater. Maximum 2-inch air gap between exterior insulation and concrete. 3 – Concrete masonry units – 4 inches thick or greater. Maximum 2-inch air gap between exterior insulation and CMU. 4 – Stone veneer – Minimum 2-inch thick, Limestone or natural stone veneer or minimum 1-1/2 inch thick cast artificial stone veneer. Any standard non-open-joint installation technique such as ship-lap, etc. can be used. 5 – Terracotta cladding – Use any terracotta cladding system in which terracotta is minimum 1-1/4 inch thick. Any non-open-joint installation technique such as ship-lap, etc. can be used.
Special Conditions	Use header treatment shown in Figure 1 for all window and door openings in wall.
Flashing of window, door and other exterior wall penetrations.	As an option, flash window, door and other exterior penetrations with limited amounts of asphalt, acrylic or butyl-based flashing tape – max. 12-inch width.

EXTENSION OF USE OF WRBS

WRB Code Requirement In 2012 IBC

1403.5 Vertical and lateral flame propagation. Exterior walls on buildings of Type I, II, III or IV construction that are greater than 40 feet (12 192 mm) in height above grade plane and contain combustible water-resistive barrier shall be tested in accordance with and comply with the acceptance criteria of NFPA 285.

WRB Code Requirement In 2015 IBC

3 Exceptions Added

Exception 1:

Walls in which the water-resistive barrier is the **only** combustible component and the exterior wall has a wall covering of brick, concrete, stone, terra cotta, stucco or steel with minimum thicknesses in accordance with Table 1405.2.

WRB Code Requirement In 2015 IBC

Exception 2 has 3 requirements to be met:

- WRB is the **only** combustible component in the wall
- WRB has the following performance in ASTM E1354:
  - Peak HRR <150 kW/m^2
  - Total HR <20 MJ/m^2
  - Effective Heat of Combustion <18 MJ/kg
- WRB has a Class A FSI/SDI

Sample Burning In Cone Calorimeter

Photo Courtesy of GBH Int'l

WRB Code Requirement In 2015 IBC

Exception 3:

Windows and doors and flashing for windows and doors shall not be considered to be part of a water resistive barrier for purposes of this section.

What Do the 2015 Changes mean?

- WRBs that meet exceptions can be used w/o 285 test
- If WRB is used with another combustible material in the wall such as foam plastic, combustible veneer, etc. then 285 probably required due to the requirements of the other combustible materials

How Can Other WRBs Meet NFPA 285?

- There is no one test or test assembly to qualify a WRB for use in all assemblies
- Perform NFPA 285 test – WRB is one of several materials in assembly
- Limited analysis based on NFPA 285 tests in conjunction w/ small-scale tests (ASTM E1354).

WRB Analysis

- Use WRB X in a successful NFPA 285 test
- Develop fire performance parameters for WRB X (ASTM E1354 Cone Calorimeter)
- Develop fire performance parameters for WRB Y
- Compare fire performance parameters – if same or better, then maybe substitute Y for X in tested assembly in same location

Technical Justification Analysis

- Technical Justifications provide the technical rationale/basis for including in the Extension any changes or additions to the tested assembly.
- Each change or item must be substantiated either by technical information, additional testing or experience.
- These analyses are typically provided to the Evaluation Services for their use.
- If required, the Client can provide these analyses to AHJs, etc.

Engineering Judgments

- EJs are typically “specific” to a building or condition that has changes to the wall assembly from the tested assembly
- Change to one or more of the tested wall components or their location in the wall, geometry, etc.
- EJ must provide the technical rationale for the allowance of the change
- EJs generally require a PE stamp.
- “Generic” EJs are Evaluation Reports, listed systems (ULI, Intertek)
- “Specific” EJs are typically for architects, general contractors, and Code Officials
- EJs are allowed by code (Section 104.11) when accepted by Code Official.

Components of an EJ

- Must be done by a qualified, experienced technical organization or engineer
- Must clearly describe the change being requested and how it varies from the tested assembly.
- Does the EJ provide technical justification for the change?
- How is a substitution / change determined to be OK, i.e., additional testing, test experience, technical rationale. etc.

Question That an EJ Must Answer

Does the variation, change or substitution still provide a wall assembly that exhibits the same or similar fire performance as the NFPA 285 test(s) that were used for the basis of the EJ?

WHAT HAVE WE LEARNED?

What Have We Learned - General

285 applies to any exterior wall assembly where required by Code

285 is a test of a complete wall assembly & applies only to the tested construction – similar to ASTM E119

Appropriate extension of tested configurations is possible but within limits

Substitutions of one material for another can (maybe) cause different test results

Addition of combustibles (insulation, WRBs, etc.) can cause different test results

What Have We Learned – General (Cont.)

- Changes in configurations (air gaps, attachment systems, etc.) can produce different results
- Wall systems constructed using a number of Class A (ASTM E84) materials does not ensure a successful NFPA 285 test
- Wall systems constructed using a number of previously NFPA 285 tested materials does not ensure a successful NFPA 285 test
- Noncombustible materials on or in wall assembly (e.g., stone wool) can protect combustible materials underneath

What Have We Learned - Specifics

- A fire-resistance rated assembly with wood studs and gyp on both sides can be substituted for a rated steel stud and gyp on both sides base wall assembly, i.e. rated assembly for a rated assembly
- WRBs are not the same and location is an issue
- All insulation materials are not the same and each has its limitations. XPS, EPS, Polyisos, Phenolics, SPFs and mineral wool
- Baseline veneers – Brick & ACM are generally used to allow other noncombustible veneers

What Have We Learned – Specifics - 2

- Noncombustible materials can be used to protect combustible materials – mineral wool, gypsum wallboard
- Geometry of veneers, especially combustible veneers, can significantly affect performance. Includes issues such as air gaps, attachment systems

What NFPA 285 Provides

- NFPA 285 provides a determination of vertical fire performance of exterior wall assemblies.
- NFPA 285 performance verified by actual fire performance of exterior walls.
- NFPA 285 tested systems will reduce the potential for vertical flame spread by exterior walls.
- NFPA 285 data/results must be used in an appropriate manner.
- NFPA 285 tested systems/assemblies will increase and greater choices will be available

EXISTING BUILDINGS & NFPA 285

Existing Buildings

- Are our existing exterior walls built to meet Code at time of construction or current Code?
- Did the Code specify NFPA 285 for the materials used?
- If Yes, does the wall assembly meet NFPA 285?
- Some number of buildings were built with combustible materials before NFPA 285 as required for the various components
- These building are at risk for exterior fires

What About Existing Buildings?

Question:

Does the exterior wall meet NFPA 285?

Answer:

Maybe yes, maybe no

How to proceed:

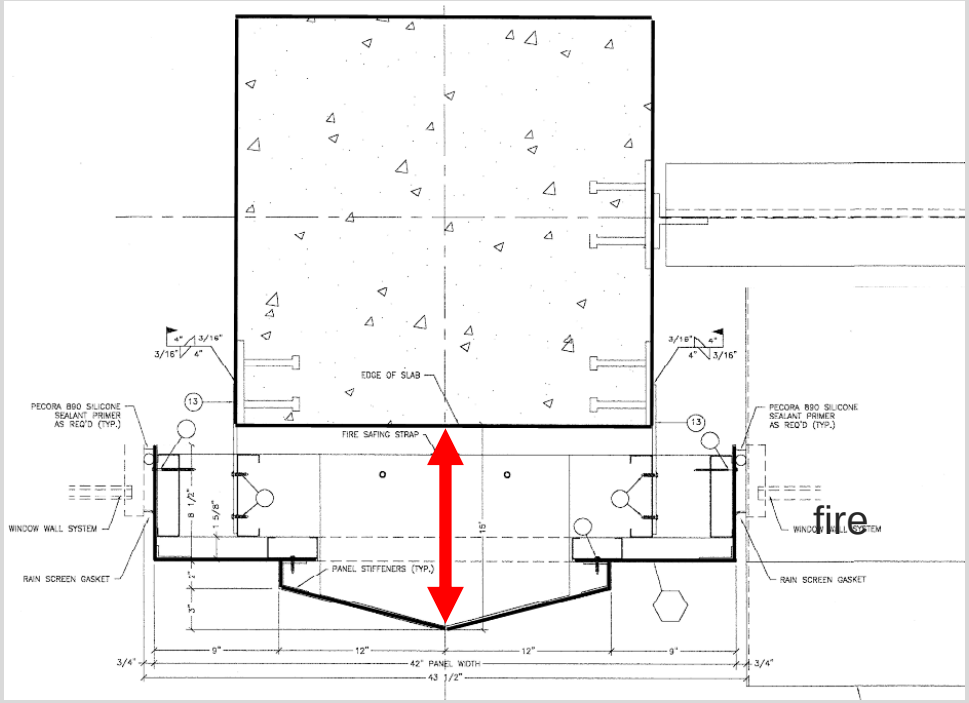
Need to make inspections of the exterior walls

Based on info, make a determination of the potential fire performance of the walls

BUILDING INSPECTIONS

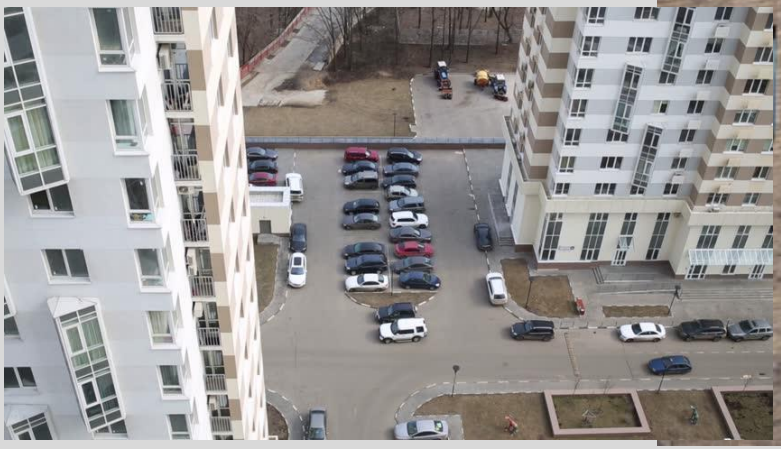
- Observe/document exterior cladding materials installations
- Determine cladding material (EIFS, MCM, HPL, solid metal, IMP)
- Document installation
  - Air gaps
  - Insulation materials
  - Attachment system
  - Substrate
- Remove samples
  - Forensic testing
- Find documentation

Document other building protection features



REMEDIATION OPTIONS

- Limited!
- Replace non-compliant cladding/insulation materials – 2021 EBC will require when a % of wall area is replace
- Modify wall construction
- Improve building fire protection features
- Remove exterior ignition risks
- Analysis based on test data



SUMMARY / WRAP-UP

- Unacceptable number of fires recently in high rise buildings with combustible claddings
- Majority of fires involved non-NFPA 285 (or similar) compliant exterior wall assemblies
- Exterior wall assembly must be complaint
  - Exterior façade/cladding
  - Insulation materials
  - Water-resistive barrier materials
- NFPA 285 is not perfect/solution
- Balanced design – appropriate exterior wall assemblies with fully sprinklered buildings
- Proper code compliance review during design
- Proper construction and enforcement during construction phase
- Regular building inspections.

Thank You and Questions?

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