Structural Fire-Resistance, Part II

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Info@NFCA-Online.org

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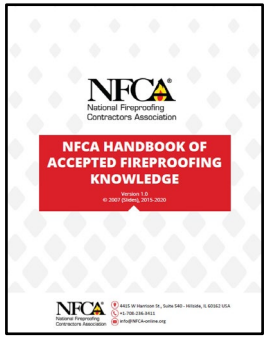
National Fireproofing Contractors Association

- **Fireproofing Education & Exams**
  - World-Class SFRM & IFRM Fireproofing Instruction
- **NFCA Contractor Accreditation Program for IFRM & SFRM**
  - Educated fireproofing Companies – UL QFCP
- **Week of Learning - Educational Conference**
  - Network with top Fireproofing Contractors, Manufacturers, Associates
  - A forum for suppliers and contractors to learn from one another
- **NFCA 100-400 Standards** for quality and life safety
- **NFCA Handbook of Fireproofing Knowledge**
- **NFCA Website** to find Fireproofing Leaders – www.NFCA-online.org
- **Technical expertise, Standards and Code development….**



What does NFCA Do?

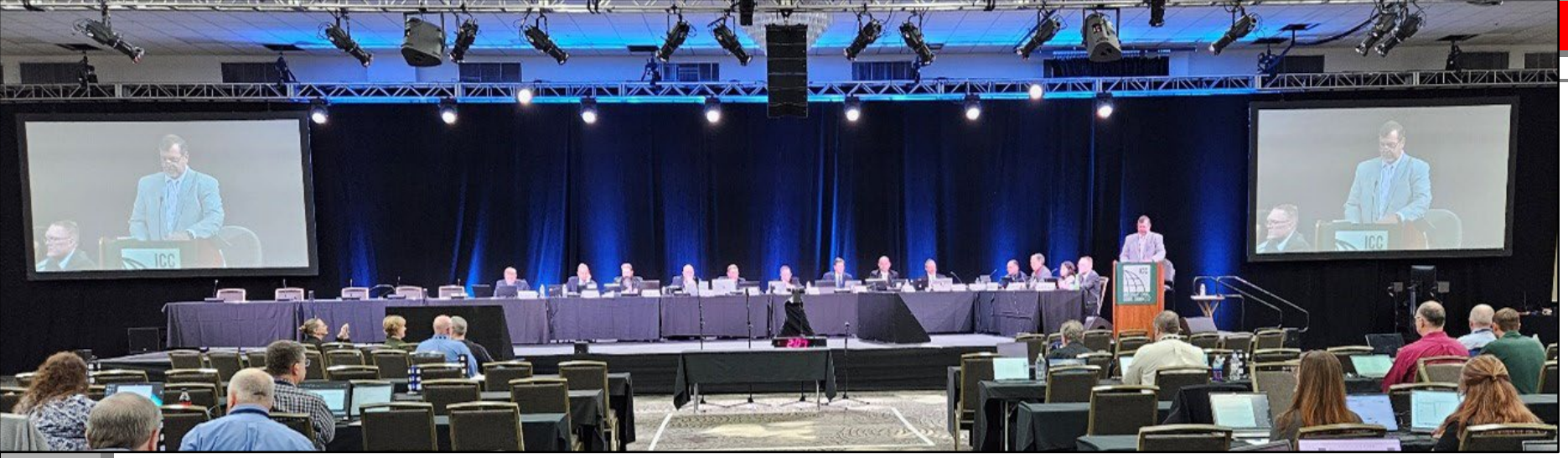
- NFCA @ ASTM Task Groups - Fireproofing
- NFCA @ NFPA Fire Protection Features
- NFCA @ AISC, AISI, CSI/CSC
- NFCA @ National Codes, Canada – NBCC, NFCC
- NFCA @ American Institute of Steel Construction (AISC)
- Industry Articles
- NFCA @ SFPE/ASCE Meetings
- NFCA Committee ACTIONS
- NFCA International Efforts
  - Middle East
  - Mexico
  - India
  - More…

CSI NATIONAL CONFERENCE 2024

ASTM INTERNATIONAL

NFPA

AISC AMERICAN INSTITUTE OF STEEL CONSTRUCTION FOUNDED 1921



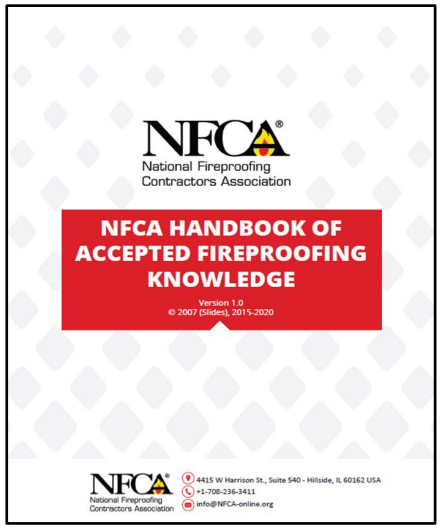
National Fireproofing Contractors Association

2027 Code Development Process (CDP) IBC, NFPA
2025/2030 CDP – NBCC, NFCC

Bill McHugh, Technical Director, NFCA
Rich Walke, Consultant to the NFCA

Contractor Qualifications – NFCA Contractor Accreditation Program (CAP)

- Contractor DRI's
- Inspection Agency Personnel
- Commitment to Fireproofing Installation
- NFCA Accreditation Seal - Registered mark



SFRM Accredited Contractor

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IFRM Accredited Contractor

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Contractor Qualifications – UL QFCP

- UL Qualified SFRM Fireproofing Contractors
  - NFCA Education
    - NFCA HAFK, DRI
    - UL Program Guide, Product iQ
  - NFCA SFRM Fireproofing Exam
  - Management System
  - UL Audits –
    - Office
    - Field

CERTIFIED
MANAGEMENT SYSTEM
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NFCA Educational Events

- NFCA/FCIA PasFiPro Canada Symposium
  - Members, Code Officials
- NFCA/FCIA PasFiPro Dubai, Doha
- NFCA @ Mexico LATAM/PCI
- NFCA's Week of Learning

NFCA – "Associate – Advocate" Fire & Life Safety

- Webinars, FSBI - Fire Safe Build India
- CSI – Construction Specifications Institute
- CSC – Construction Specifications Canada
- NFPA Expo & Committees
- ICC Expo & Hearings
- Dubai, UAE & Doha, Qatar
  & Riyadh, Saudi Arabia,
  Australia, New Zealand…
- ***Accreditation, Education, More…***

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(708) 236-3411 – Info@NFCA-online.org
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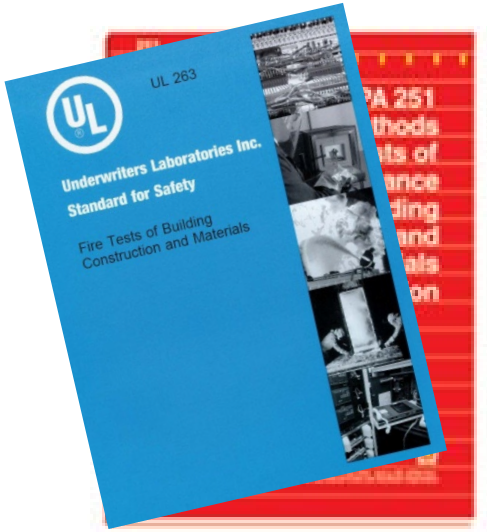
Fire-Resistance Basis – Rich & Tony

- How is Fire-Resistance Determined? Fire Test Standards
  - ASTM E119
  - UL 263
  - ULC-S101
  - ISO Standards
- Standard Time Temperature Curves, Worldwide
- Restrained/Unrestrained
- Loading – Fully? Partial? When and Where?

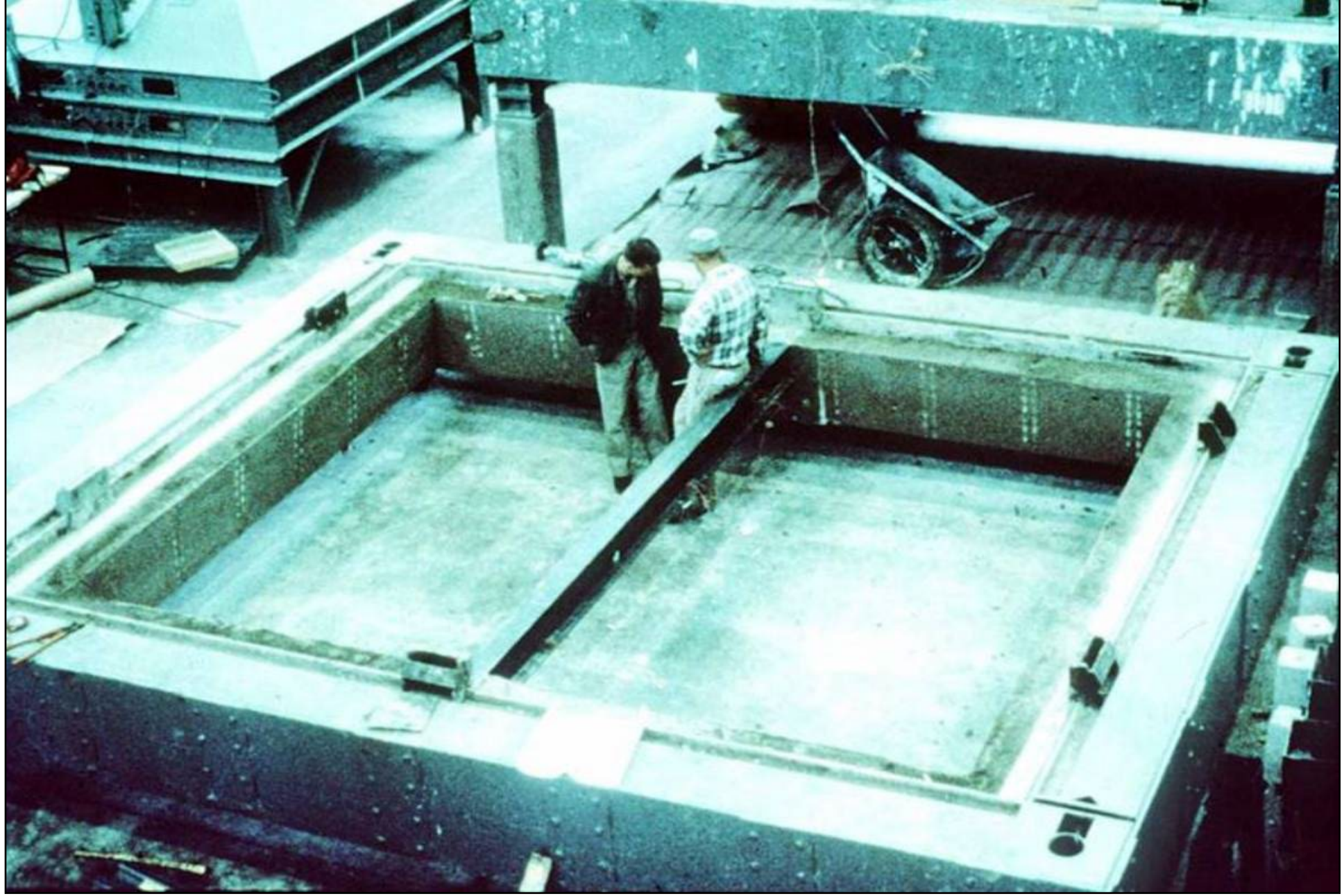
How is Fire Resistance Determined Standards

- US Based
  - ASTM E119
  - NFPA 251 (Withdrawn)
  - UL 263
- Canadian Based
  - ULC-S101



Floor/Ceiling or Roof/Ceilings

- Sample size – 180 sq ft / 12 ft
- Load applied – Per design



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Conditions of Acceptance
Floor/Ceilings or Roof/Ceilings

- Flame passage
- 250ºF / 325ºF
- Temperatures of supporting construction – Relates to Unrestrained Rating
- Support load – Relates to Restrained Rating

Time-Temperature Curves in World Wide Fire Test Standards

- Cellulosic
  - ASTM E119
  - UL 263
  - NFPA 251(withdrawn)
  - CAN/ULC-S101
  - BS 476 Cellulosic (ISO 834)
- Hydrocarbon
  - UL 1709
  - ASTM E1529

North American Based Cellulosic Fire Test Standards

- ASTM E119 / UL 263 / ULC-S101 represents a cellulosic fire
- Simulates a cellulosic fire in office buildings, hospitals, schools, etc.
- Furnace temperature reaches 2000°F over the course of 4 hours

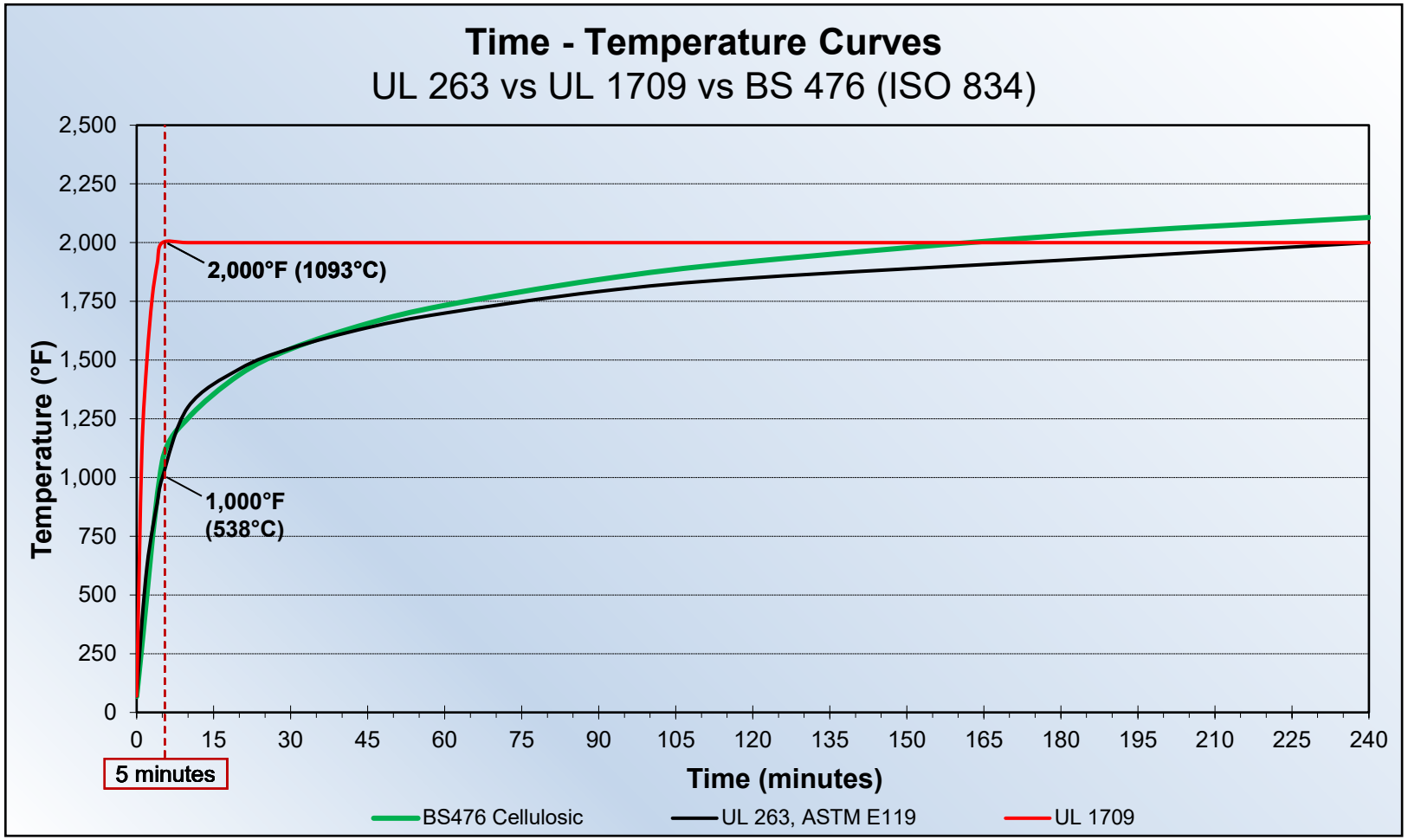
Non-North American Based Cellulosic Fire Test Standards

- BS 476 Cellulosic / ISO 834 represent a cellulosic fire
- Simulates a cellulosic fire in office buildings, hospitals, schools, etc.
- Furnace temperature reaches 1153°C (2106°F) over the course of 4 hours

North American Based Hydrocarbon Fire Test Standards

- UL 1709 (ASTM E1529) represents a rapid temperature rise hydrocarbon fire
- Simulates a hydrocarbon fire in refineries, petrochemical plants, etc.
- Furnace temperature reaches 2000°F in first 5 minutes and maintains this temperature throughout the duration of test

Global Time – Temperature Curves



UL 263 / ASTM E119
Cellulosic
- Office buildings
- Hospitals
- Schools

UL 1709 / ASTM E1529
Hydrocarbon
- Oil refineries
- Petrochemical plants

BS 476 / ISO 834
Cellulosic
- Office buildings
- Hospitals
- Schools

Restrained vs Unrestrained Ratings What's the Difference??

- Debate began in the 60's when it was observed that test assemblies maintained their structural integrity long after temperatures of the structural elements suggested the assemblies should have collapsed.
- Research ultimately suggested the restrained test condition was the reason.

Restrained vs Unrestrained Ratings What's the Difference??

- Standards writing organizations (ASTM, NFPA and UL) updated the fire resistance standards to differentiate restrained vs unrestrained ratings in the early 1970s.
  - ASTM E119 revised in 1971
  - UL 263 revised on January 15, 1971
- UL updated their designs to differentiate Restrained vs Unrestrained Ratings with the 1972 Fire Resistance Index (early name of Fire Resistance Directory).

Fire Test Methods

- ASTM E119, UL 263 & ULC-S101 – “Fire Tests of Building Construction and Materials”
  - Fire tests can be conducted either with the assembly restrained or unrestrained
  - Most tests are conducted with assembly restrained
  - Restrained test will generate a restrained assembly rating, an unrestrained assembly rating and an unrestrained beam rating. The unrestrained ratings are generally governed by the 1100°F / 1300°F average steel temperature limitations.

Fire Test Methods

- From restrained fire tests…
  - Conditions of acceptance for restrained rating
    - No flaming on unexposed side sufficient to ignite cotton waste
    - Max ave unexposed temp rise of 250°F and max individual unexposed temp rise of 325°F
    - Support applied load
    - Max ave beam temperature of 1100°F and max individual beam temperature of 1300°F for greater of 1 hr or 1/2 of rating period

Fire Test Methods

- From restrained fire tests…
  - Conditions of acceptance for unrestrained ratings
    - Essentially the same as for a restrained rating, except the beam limiting temperature criteria applies for the full rating period

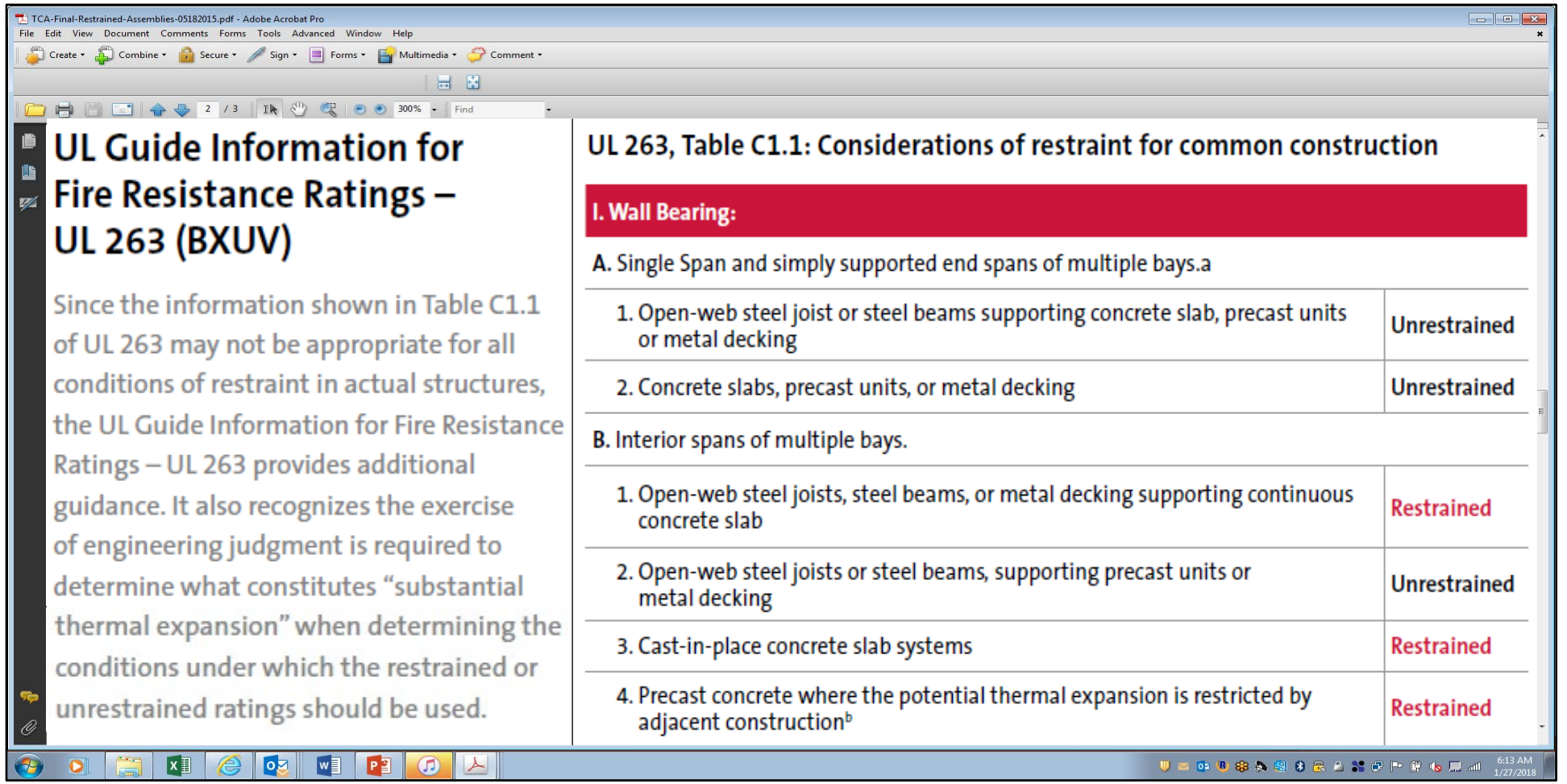
The Code Perspective

- **703.2.1.3 in the 2024 IBC – "Restrained classification.** Fire-resistance-rated assemblies tested under ASTM E119 or UL 263 shall not be considered to be restrained unless evidence satisfactory to the *building official* is furnished by the *registered design professional* showing that the construction qualifies for a restrained classification in accordance with ASTM E119 or UL 263. Restrained construction shall be identified on the *construction documents*."

Determining the Condition of Restraint in Buildings

- Two Methods of determining Restraint
  1. Appendices of ASTM E119 and UL 263 provide guidance for determining the condition of thermal restraint in buildings
     - CAN/ULC-S101 does not provides similar guidance
  2. Structural engineers can calculate the relative stiffness of the surrounding structure and compare it to the stiffness of the UL test frames
     - UL publishes the stiffness of the test frames as a point of comparison
       - GREATER STIFFNESS THAN THE UL TEST FRAME = RESTRAINED
       - LESS STIFFNESS = UNRESTRAINED

Appendices to the Standards



Stiffness of Test Frame

- Stiffness of UL test frames is 850,000 kip-in and 700,000 kip-in along the 14 ft and the 17 ft sides, respectively
- If the estimate stiffness exceeds these values then a case can be made that the assembly be considered thermally restrained

Partially Loaded Test Assemblies

- Both ASTM E119 and UL 263 allow assemblies to be loaded to something less than the full design capacity
- Section 10.3.1 of UL 263 permits an applied load less than the maximum. Such tests shall be identified in the test report as having been conducted under restricted-load conditions. The applied load, and the applied load expressed as a percentage of the maximum allowable design load, is to be included in the report.

Partially Loaded Test Assemblies

- Example of Listing

Unrestrained Beam

ASTM E119/UL 263
CAN/ULC-S101
Restricted Load: Maximum 75% of Design Load
Assembly Rating: Unrestrained, See Table

Good idea, bad idea???

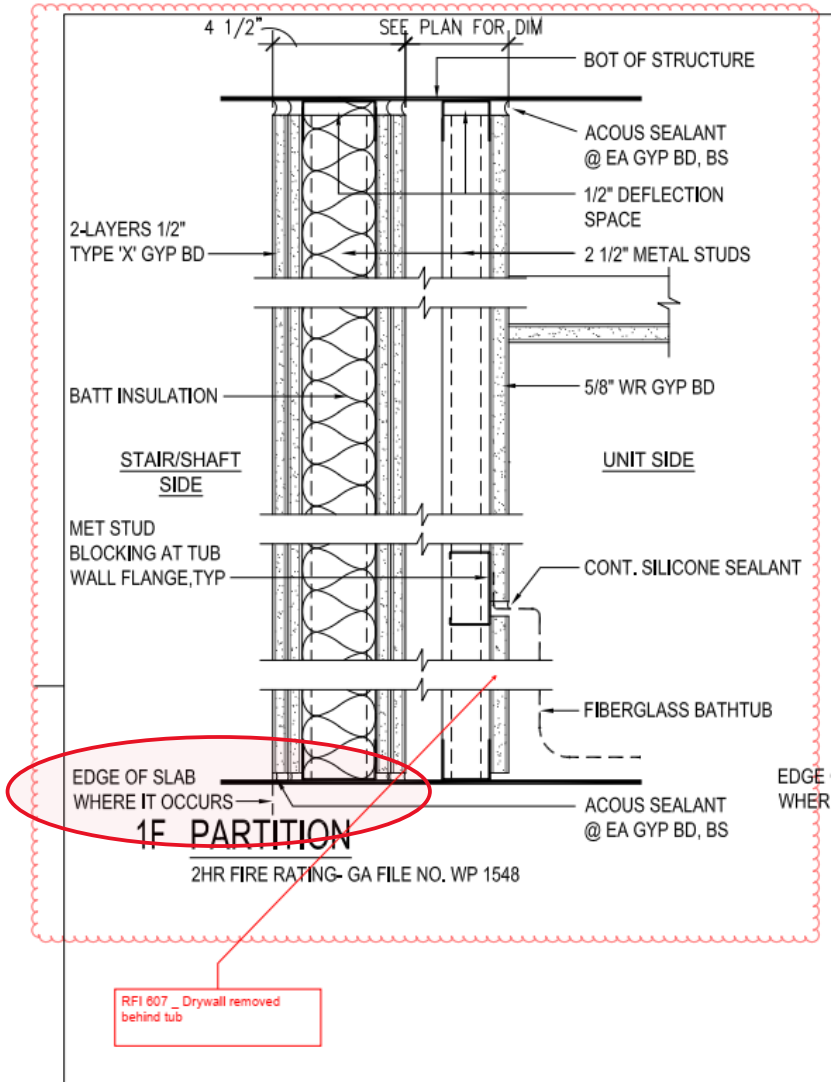
Fire-Resistance Continuity – Bill Koffel

- Fire-Resistance Continuity
  - Fundamental Requirement – In most cases, fire resistance-rated construction must be supported by construction having an equivalent or greater fire resistance rating

704.1.1 Supporting construction.
The *fire-resistance ratings* of supporting structural members and assemblies shall be not less than the ratings required for the fire-resistance-rated assemblies supported by the structural members.
Exception: Structural members and assemblies that support fire barriers, fire partitions, *smoke barriers* and horizontal assemblies as provided in Sections 707.5, 708.4, 709.4 and 711.2, respectively. (IBC 2024)

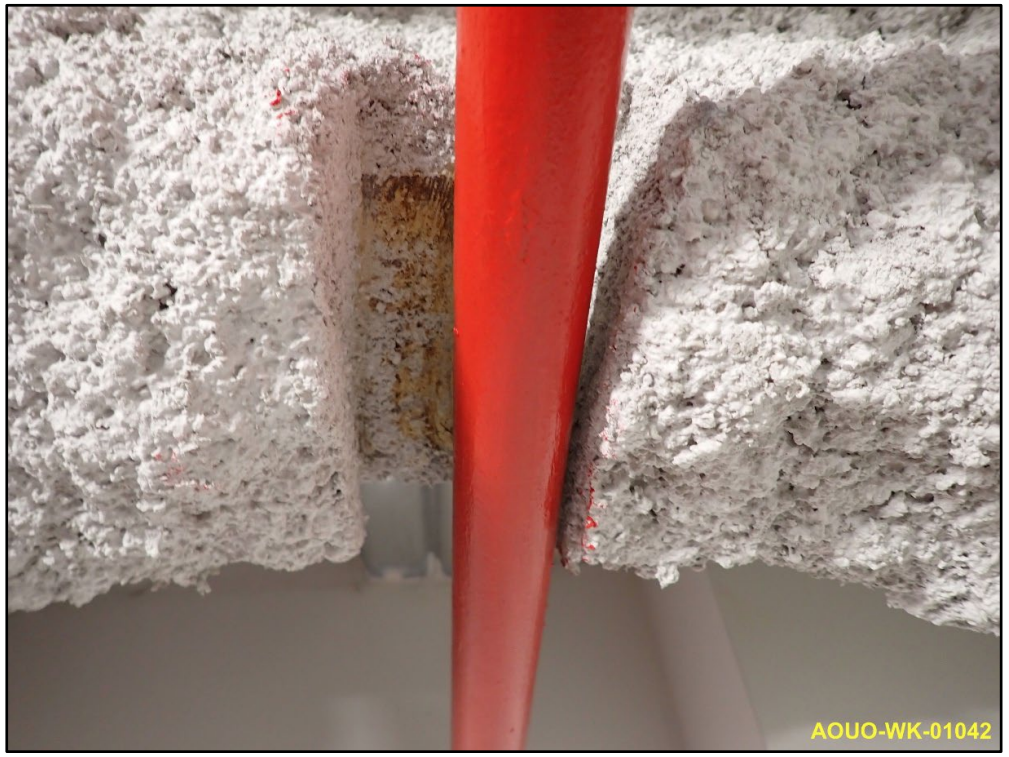
NFPA approach is different but similar in many respects

Fire-Resistance Continuity Issues



Fire-Resistance Continuity Issues – Bill Koffel

- How far is far enough?
  - Entire horizontal assembly
  - One bay plus
  - One bay
  - It depends
    - Horizontal exit
    - Occupancy separation fire barrier
    - Structural analysis



Fire-Resistance Issues – Bill Koffel

Secondary Attachments

704.6.1 Secondary attachments to structural members.

Where primary and secondary structural steel members require fire protection, **secondary steel attachments to those structural members** shall be protected with the same fire-resistive material and thickness as required for the structural member. The protection shall extend away from the structural member a distance of not less than 12 inches (305 mm), or shall be applied to the entire length where the attachment is less than 12 inches (305 mm) long. Where an attachment is hollow and the ends are open, the fire-resistive material and thickness shall be applied to both exterior and interior of the hollow steel attachment. **(IBC 2021)**

704.5.1 Secondary attachments to structural members.

Where primary and secondary structural steel members require fire protection, **any additional structural steel members** having direct connection to the primary structural frame or secondary structural members shall be protected with the same fire-resistive material and thickness as required for the structural member. The protection shall extend away from the structural member a distance of not less than 12 inches (305 mm), or shall be applied to the entire length where the attachment is less than 12 inches (305 mm) long. Where an attachment is hollow and the ends are open, the fire-resistive material and thickness shall be applied to both exterior and interior of the hollow steel attachment. **(IBC 2024)**

Fire-Resistance Issues – Rich Walke

- Fire Resistance Continuity
  - Multiple materials, same structural building element? Mixing boards / SFRM / IFRM??
  - Can a wall be used on one side of column for fireproofing?
  - Bond Strength based on heights – Just those floors or whole building?
    - Occupiable floor or occupiable roof 0-75’ higher than lowest fire department access
    - 75’-420’
    - 420’ ++

Multiple Materials on Same Structural Building Element?

- Mixing Boards / SFRM / IFRM
  - Examples
    - Boards on beam, IFRM on columns, SFRM on deck, all on same structure, or
    - High-density SFRM on lower 8 ft column and low-density at higher elevations
  - UL's BXUV Guide Info, including the limitations on the use of the beam substitution equation, is silent on this concept
  - Manufacturers freely promote the concept
  - Good idea, bad idea?

Use of Wall on One Side of Column as Fireproofing?

- Hypothetical Scenario
  - Column is either in contact with a rated CMU wall, or located in close proximity to the wall obstructing the ability to protect the fourth side of the column. Can the wall be considered as part of the fire protection of the column?
  - Should testing of this type of construction be factored into ASTM E119 / UL 263

Bond Strength Based on Building Heights

- IBC Section 1705.6 (Special Inspections) states the bond strength of cured SFRM shall not be less than 150 psf
- IBC Table 403.2.3 (High-Rise Buildings) states the bond strength shall be min 430 psf for buildings up to 420 ft in height and min 1000 psf for buildings greater than 420 ft
- This sets up three tier approach

Height of Building	SFRM Minimum Bond Strength
Buildings up to 75 ft in height	150 psf
Buildings greater than 75 ft and up to 420 ft	430 psf
Buildings greater than 420 ft in height	1000 psf

Bond Strength Based on Building Heights

- Question:
  - For a “Super High-Rise” building greater than 420 ft in height must the entire building be protected with a material having a min bond strength of min 430 psf, or can the lowest 75 ft be be protected with a material having a min bond of 150 ft, the intermediate levels with a material having a min bond strength of 430 psf and the upper levels with a material having a min bond strength of 1000 psf?

Fire-Resistance Issues – Bill/Tony

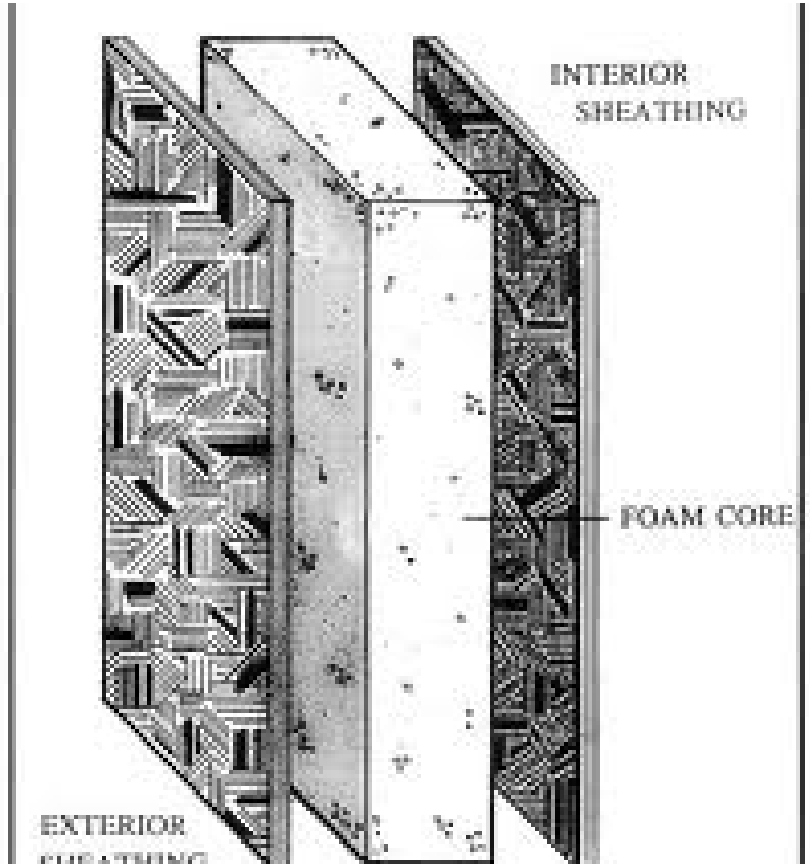
- Fire-Resistance & Thermal Barriers
  - Fireproofing installed over Insulation for hourly ratings??
  - Insulation Installed over Fireproofing??
  - What's the proof?
  - ASTM E119/UL 263 Fire-Resistance testing? Not yet!

- Fireproofing used as Thermal Barriers?
  - SFRM/IFRM?
  - Canada

What is a Thermal Barrier?

Thermal Barriers – Protection of Foamed Plastics

- A thermal barrier is a material, applied between a foamed plastic, e.g. spray polyurethane foam (SPF), EPS, XPS, etc. and interior spaces designed to slow the temperature rise of the foam plastic during a fire situation, and to delay its ignition and fire, heat, and smoke contribution to a fire.
  - Although FRR type testing is traditionally used, it relates strictly to “Fire Growth” hazard
  - Some minor exclusions permitted by IBC and IRC
  - Almost ALWAYS required where foamed plastics are used on Interiors



IBC/IRC Testing Required

NFPA 275 requires two (2) tests:

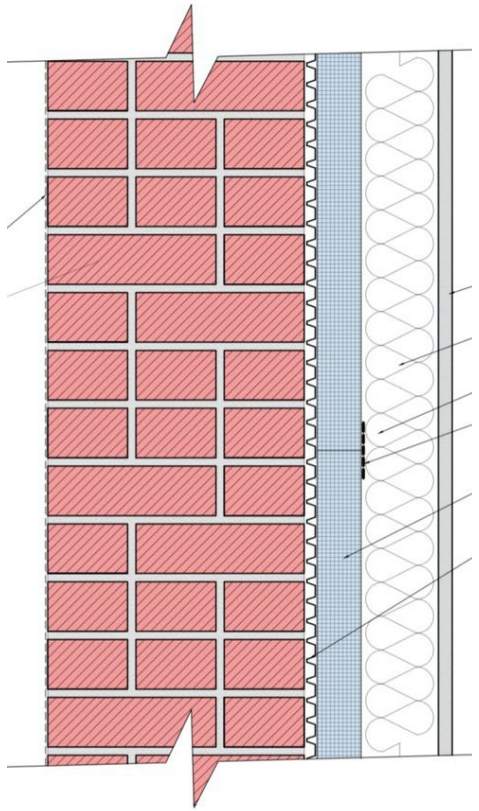
1. ASTM E119 Temperature Transmission Fire Test (Part I) wherein the temperature rise of the unexposed surface of the barrier material is limited within the test standard; and

2. Integrity Fire Test (Part II) to establish that the barrier material will sufficiently remain in place during a fire scenario by complying with one of the following 15-minute fire test standards: NFPA 286, UL 1715, FM 4880 or UL 1040.

IBC/IRC – Generic Thermal Barriers

The IBC (International Building Code®) and the IRC (International Residential Code®) define approved thermal barriers (“15-minute thermal barriers”) as:

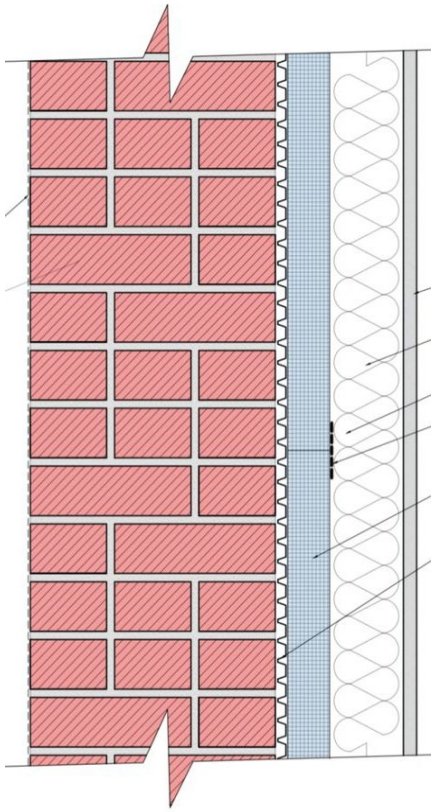
- ½ inch (12.7 mm) gypsum wallboard;
- 23/32-inch (18.2 mm) wood structural panel (IRC only);
- nominal ½” plywood for floors , or;
- a material that is tested in accordance with and meets the acceptance criteria of both the temperature transmission fire test and the integrity fire test of NFPA 275
- IRC and IBC also permit alternative **thermal barrier assemblies** tested to NFPA 286, UL 1715, UL 1040 or FM 4880.
- NFPA 275 thermal barriers also required in exterior walls using ACM, MCM, HPL and IMP panels .



IRC – Ignition Barriers

WHAT IS AN IGNITION BARRIER?

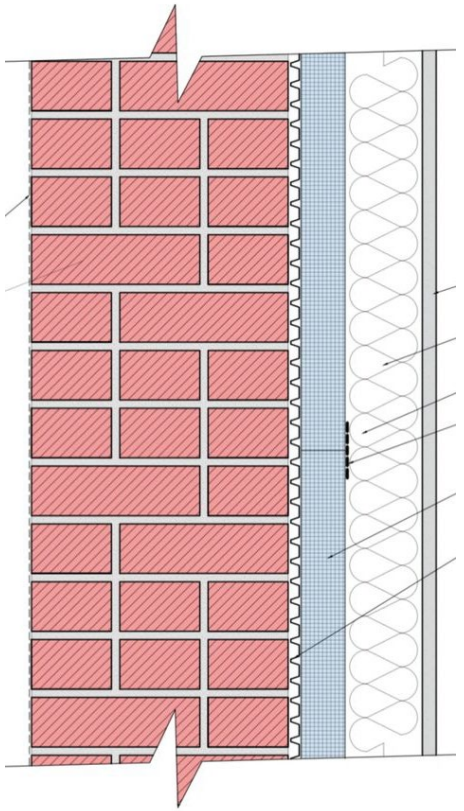
- Model building codes include a specific exception to the thermal barrier requirement in attics and crawlspaces where entry is made only for repairs or maintenance (IRC) or for the service of utilities (IBC).
- Foam plastic insulation must be separated from the attic or crawlspace using an ignition barrier.
- Ignition barriers do not provide as much fire protection as thermal barriers but are considered acceptable for attic and crawlspaces where entry is limited.



NBCC - Interior Finishes

Thermal Barriers – Protection of Foamed Plastics

- A thermal barrier is a material, applied between a foamed plastic, e.g. spray polyurethane foam (SPF), EPS, XPS, etc. and interior spaces designed to slow the temperature rise of the foam plastic during a fire situation, and to delay its ignition and fire, heat, and smoke contribution to a fire.
    - Although ULC-S101 time-temperature exposure testing is used, it relates strictly to “Fire Growth” hazard
    - Virtually ALWAYS required where foamed plastics are used on Interiors

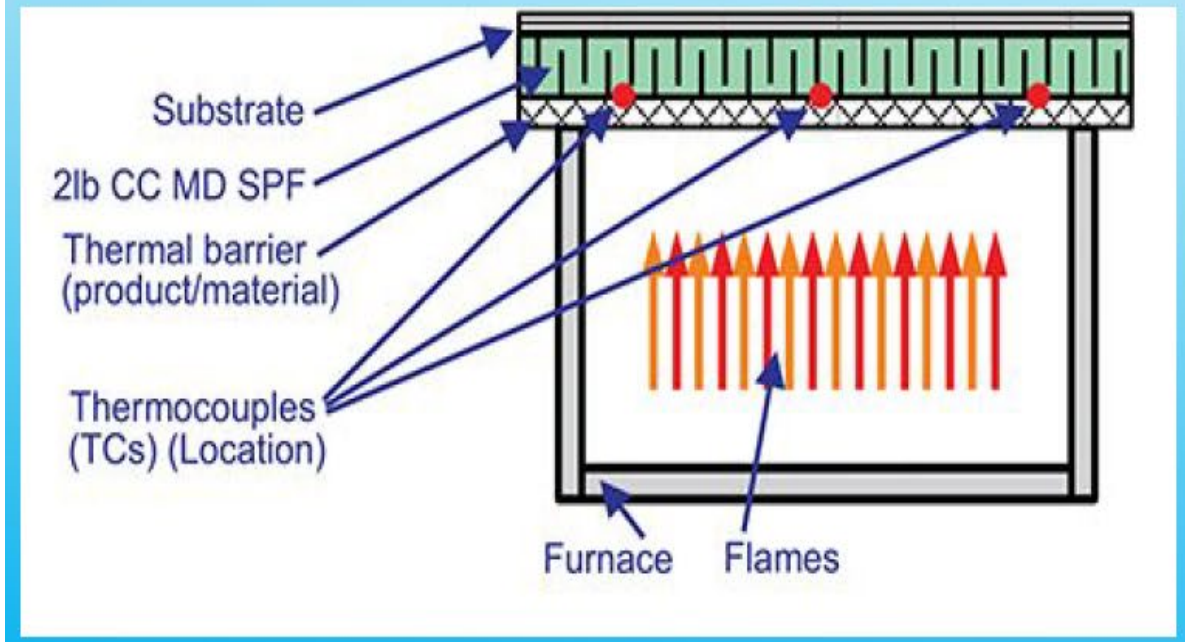


NBCC Testing Required

The NBCC provides multiple options depending on the application:

1. Generic (prescriptive) options using gypsum board, concrete or masonry
2. CAN/ULC-S124 testing using CAN/ULC-S101 time/temperature curve in a horizontal orientation, wherein the temperature rise **at the interface** of the barrier material and the foam plastic is limited within the test standard
3. CAN/ULC-S101 testing in a vertical orientation wherein the temperature rise **at the interface** of the barrier material and the foam plastic is limited within the test standard; and
4. CAN/ULC-S145 room fire testing of thermal barrier assemblies – **measures flashover**

CAN/ULC-S124 Test



- Small Scale 700 mm X 700 mm exposed area
- Measures temperature at interface of foam plastic and thermal barrier
- developed to respond to the need for a small-scale cost-effective test to assist in the evaluation of the materials used as thermal barriers.
- No provision for flame spread or smoke development (needs ULC S-102 assembly test)
- **It needs to be noted that some performance characteristics, such as the stability of the protective covering is not evaluated in this test method.**

CAN/ULC S-145 FULL SCALE ROOM TEST PROTECTIVE COVERINGS

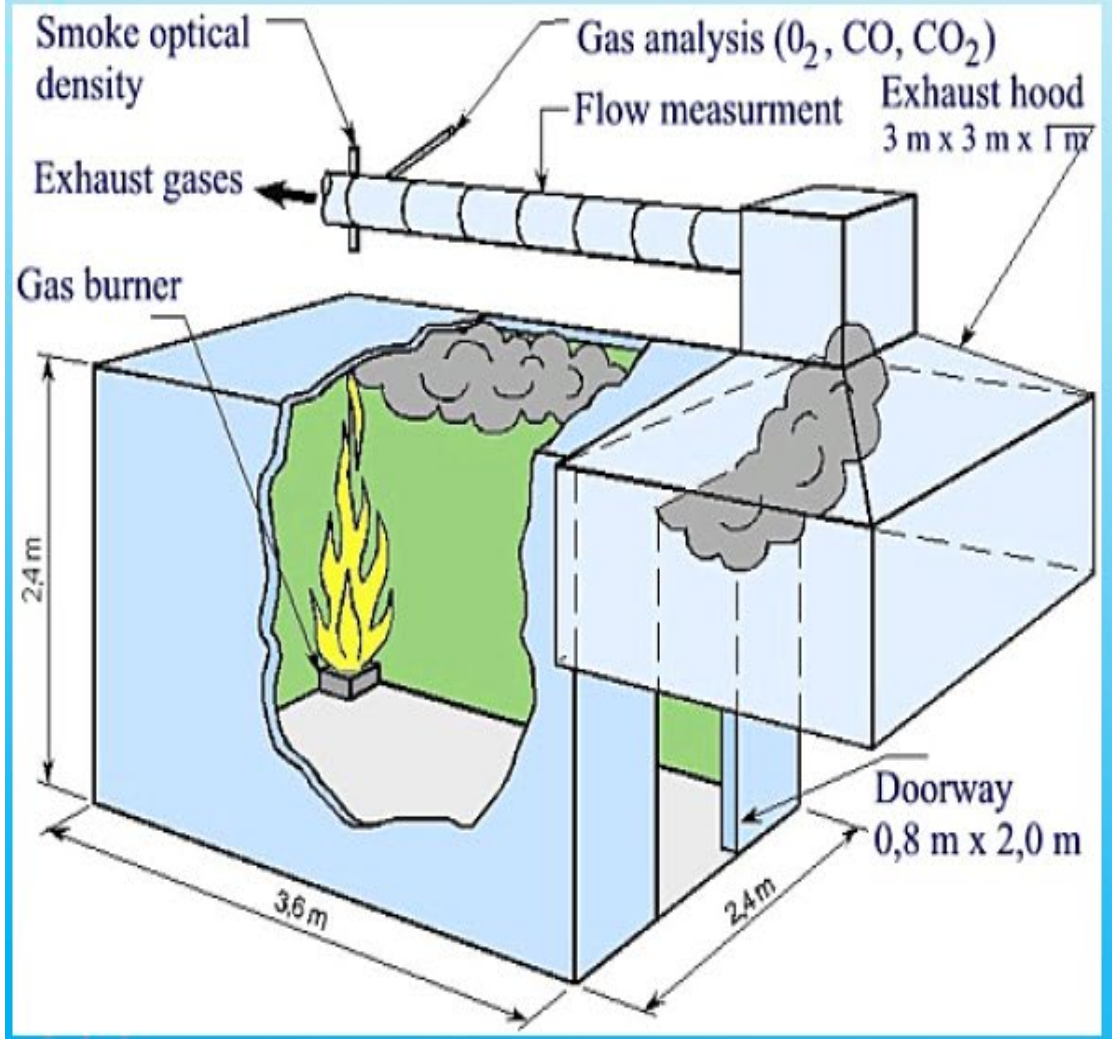
IGNITION SOURCE

- The ignition source shall be a propane gas burner having a square top surface layer of a porous, inert material. e.g. sand.
- The burner shall be placed on the floor in a corner opposite to the doorway wall. The burner walls shall be in contact with the specimen

BURNER OUTPUT

- The net heat output shall be 100 kW during the first 10 min after ignition and
- then shall be increased to 300 kW for an additional 10 min.

CAN/ULC S-145 FULL SCALE ROOM TEST PROTECTIVE COVERINGS



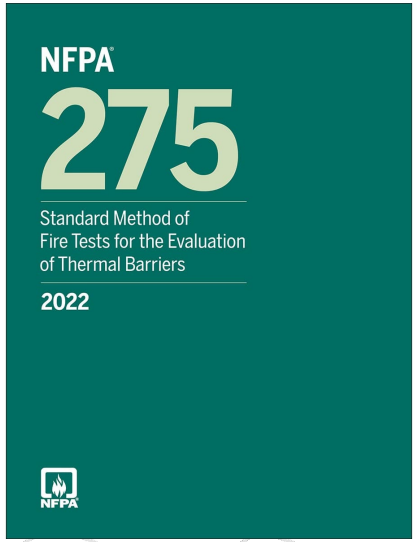
- Large Scale test specimen 3.6M X 2.4M X 2.4M Room
- Fully evaluates the fire protection performance as well as the ability for the protection to remain in place for the specified duration.
- Determines the contribution to fire growth of protective coverings over **specific types** of foamed plastic insulation.
- This test method measures the time to flashover under specified test conditions.

NFPA275 vs CAN/ULC-S145

Both NFPA 275 (Part II) and ULC-S145 use large room fire tests to evaluate flashover, but:

- NFPA 275 (Part II) uses NFPA 286 room fire test which requires;
  - 40 kW/m^2 for 5 minutes, followed by
  - 160 kW/m^2 for 10 minutes
  - Flames cannot spread to the ceiling during the initial 40 kW/m^2 exposure. During the 160 kW/m^2 exposure, flames cannot spread to the outer extremity of the sample on any wall or ceiling.

- CAN/ULC-S145 employs CAN/ULC-9705 room fire test which requires;
  - 100 kW/m^2 for 10 minutes, followed by
  - 300 kW/m^2 for 10 minutes
  - Only criteria is room flashover at anytime during the test.



CAN/ULC-S145

7 CONDUCT OF TEST

7.1 The full-scale room test shall be conducted in accordance with CAN/ULC-9705, Fire Tests – Full-Scale Room Test for Surface Products, except as specified in this Standard.

7.2 Flashover is determined to have occurred at the point in time at which any two of four criteria listed below are reached:

(a) Floor level heat flux exceeds 20 kW/m^2;

(b) Average upper layer temperature exceeds 600 °C;

(c) Visible flames exit doorway;

(d) Heat release rate exceeds 1 MW.

7.3 The test ends if flashover occurs or after 20 min, whichever occurs first.

8 CLASSIFICATION AND RESULTS

8.1 CLASSIFICATION 20 min

8.1.1 When tested in accordance with this Standard, if flashover does not occur for the full 20 min duration of the test and the total smoke released throughout the test does not exceed 1350 m^2, the protective covering shall be permitted a classification of 20 min.

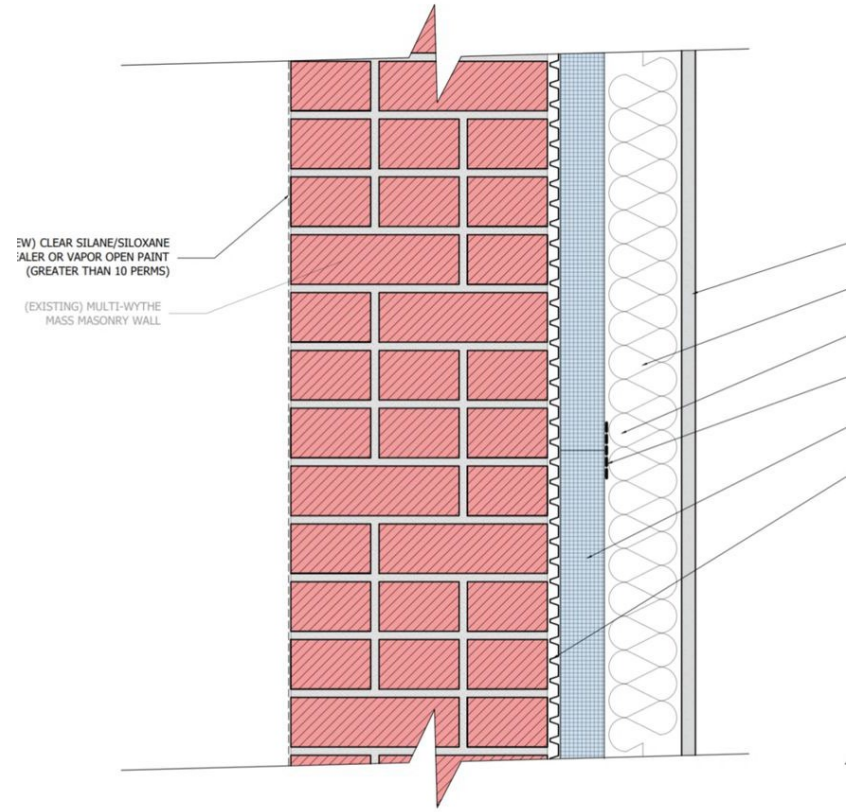
8.2 CLASSIFICATION 10 min

8.2.1 When tested in accordance with this Standard, if flashover does not occur during the first 10 min of test and the total smoke released throughout the test does not exceed 675 m^2, the protective covering shall be permitted a classification of 10 min.

NBCC - Interior Finishes

Thermal Barriers – Interior Side of Exterior Walls

- Article 3.1.5.12 (3) contains the specific provisions for the interior protection of foamed plastic insulation used in an exterior wall or an “exterior wall panel”. For unsprinklered buildings greater than 18 m in height, the insulation must be protected on the interior surface by a thermal barrier consisting of:
  - Minimum 12.7 mm gypsum board, mechanically fastened,
  - Lath and plaster, mechanically fastened,
  - Masonry or Concrete not less than 25 mm thick, or
  - Any thermal barrier that, when tested in accordance with CAN/ULC-S101, does not develop and average temperature rise more than 140°C or a maximum temperature rise of 180°C at any point on the unexposed face during a 20 minute test duration.
- In addition, the foamed plastic material must have a flame spread rating of between 25 and 500 when tested in accordance with CAN/ULC-S102 and, by reference, ULC-S127.

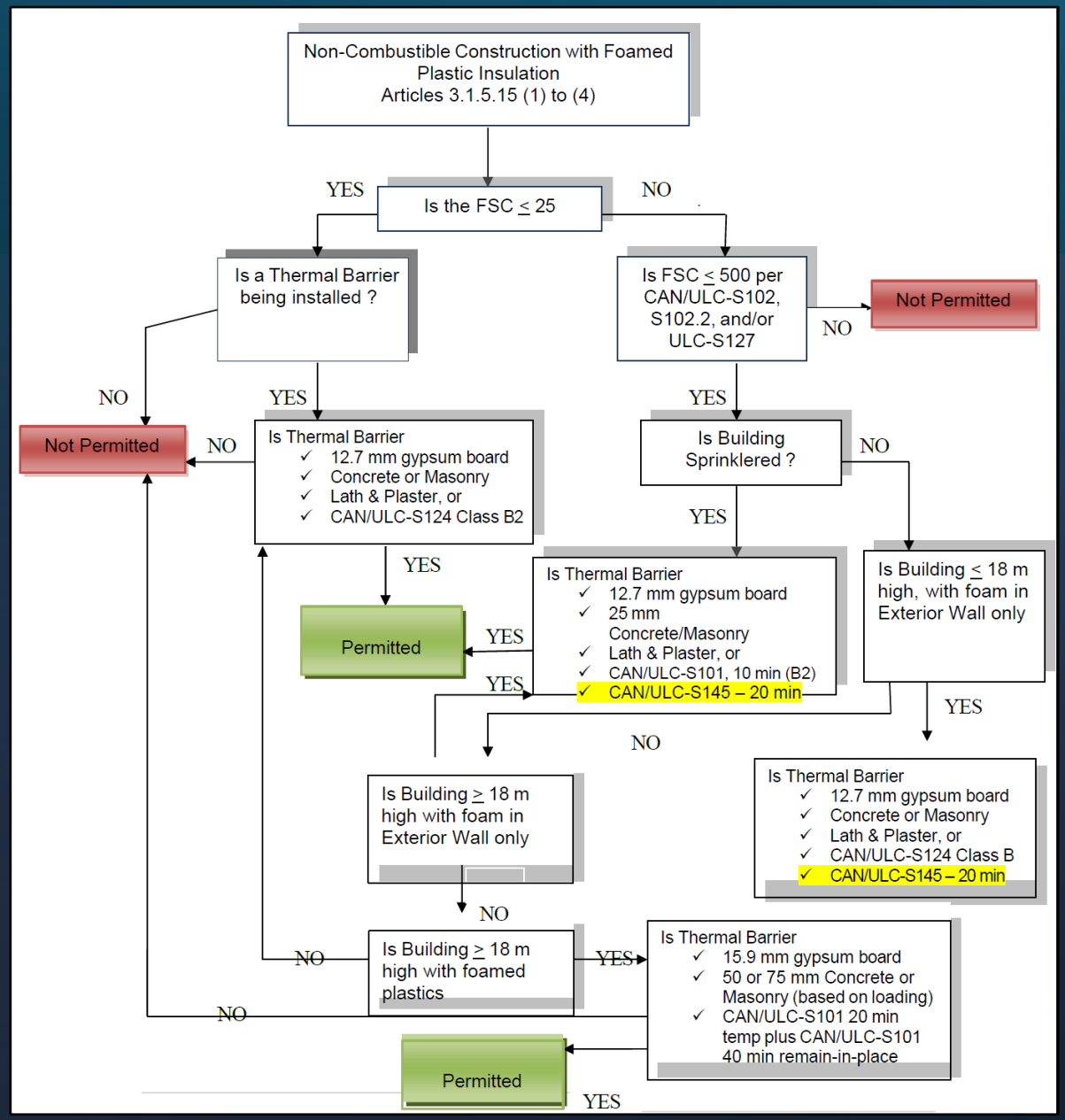


NBCC - Interior Finishes

Thermal Barriers – Protection of Foamed Plastics

- Depending on building height, FSC and location, the NBCC may require any of the following:
- Max flame spread less than 500 and:
  - Minimum 12.7 mm gypsum board (depending on the building and FSC of the foamed plastic material itself), or
  - Concrete or masonry, or
  - Mechanically attached lath and plaster, or
  - A thermal barrier tested to CAN/ULC-S124 for a period of 15 min (Class A) and 10 min (Class B)
  - CAN/ULC-S101 full scale exposure for 20 min temp criteria and 40 min ‘remain-in-place’
  - CAN?ULC-S145 – 20 min

NBCC 2025 Thermal Barrier Requirements



NBCC - Interior Finishes

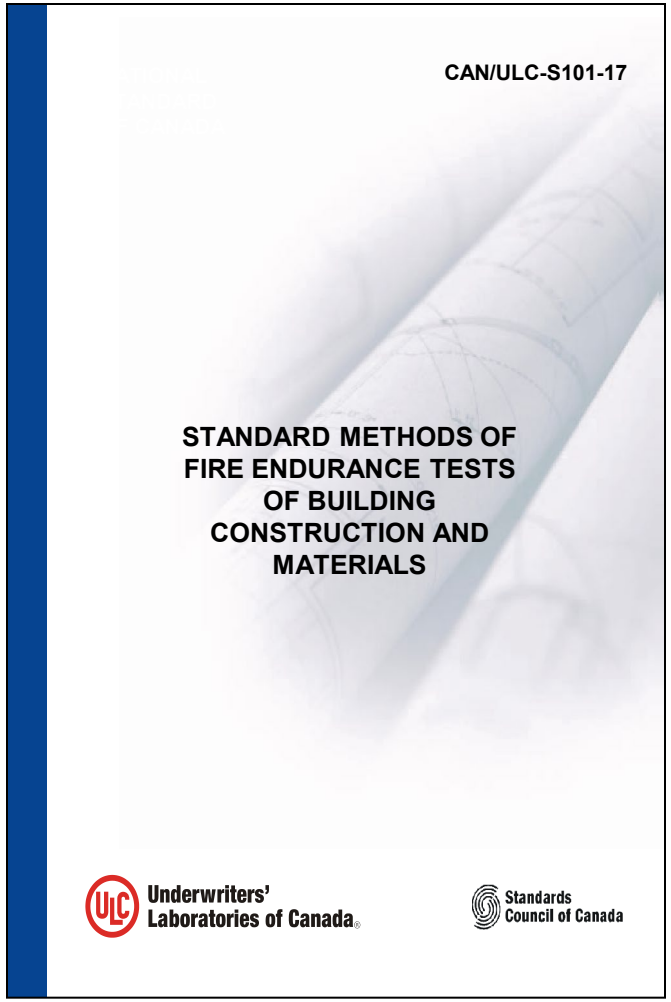
Thermal Barriers – Part 9 - Protection of Foamed Plastics

- Part 9 also has foamed plastics in Article 9.10.17.10 which requires that foamed plastics which form part of a wall or ceiling assembly in combustible construction **be protected from adjacent space in the** building**, other than adjacent concealed spaces within** attic or roof spaces**, crawl spaces, and wall assemblies, by:**
  - one of the interior finishes described in Subsections 9.29.4. to 9.29.9 (i.e. similar to thermal barriers, except specified generically),
  - sheet metal mechanically fastened to the supporting assembly independent of the insulation and having a thickness of not less than 0.38 mm and a melting point not below 650°C, provided the building does not contain a Group C major occupancy, or
  - any thermal barrier that meets the requirements of a Class B Thermal Barrier per CAN/ULC-S124, Test for the Evaluation of Protective Coverings Over Foamed Plastics.

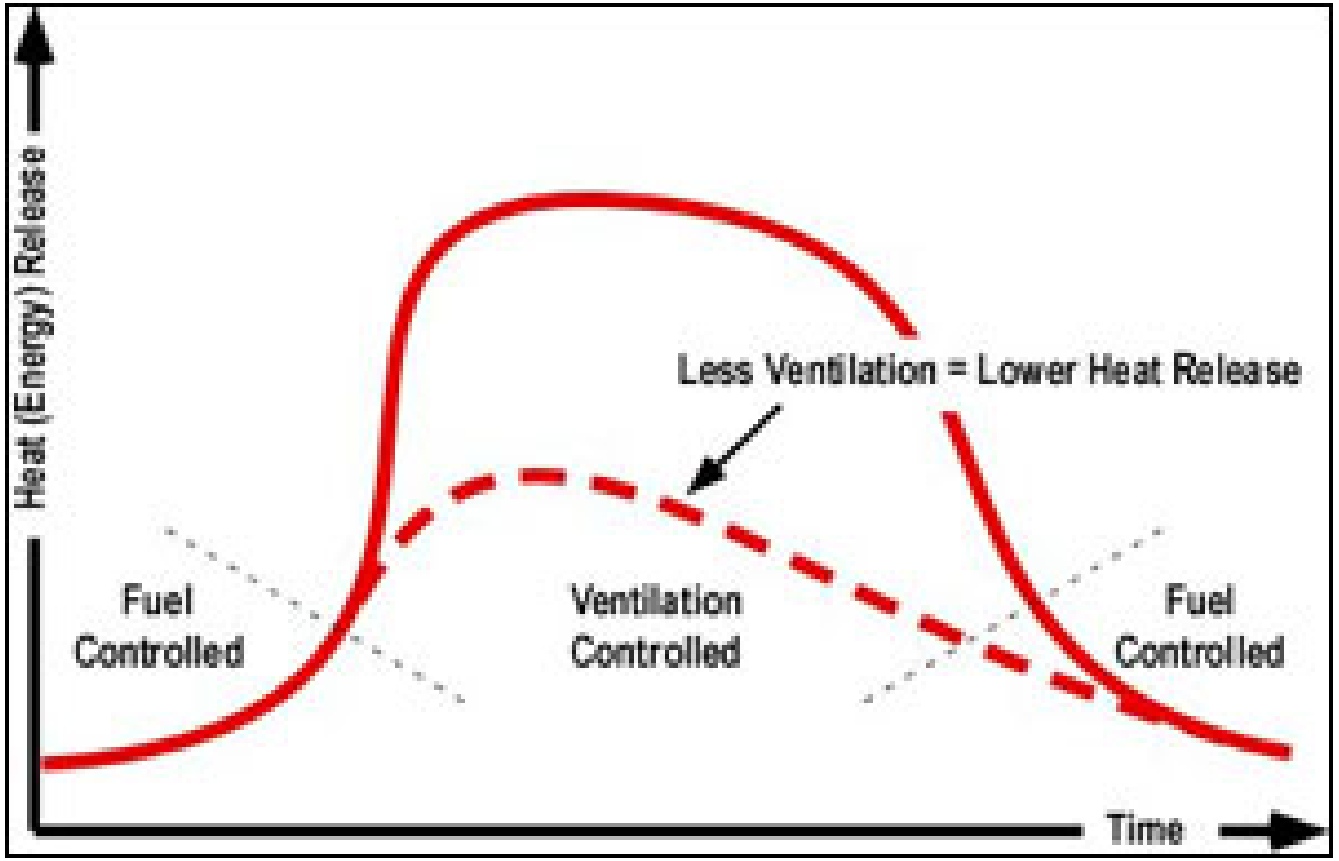
Fire Resistance Ratings

Fire Separations

Fire Resistance Rating – usually based on the assembly meeting the acceptance criteria in the standard CAN/ULC-S101-M, "Standard Method of Fire Endurance Tests of Building Construction and Materials".

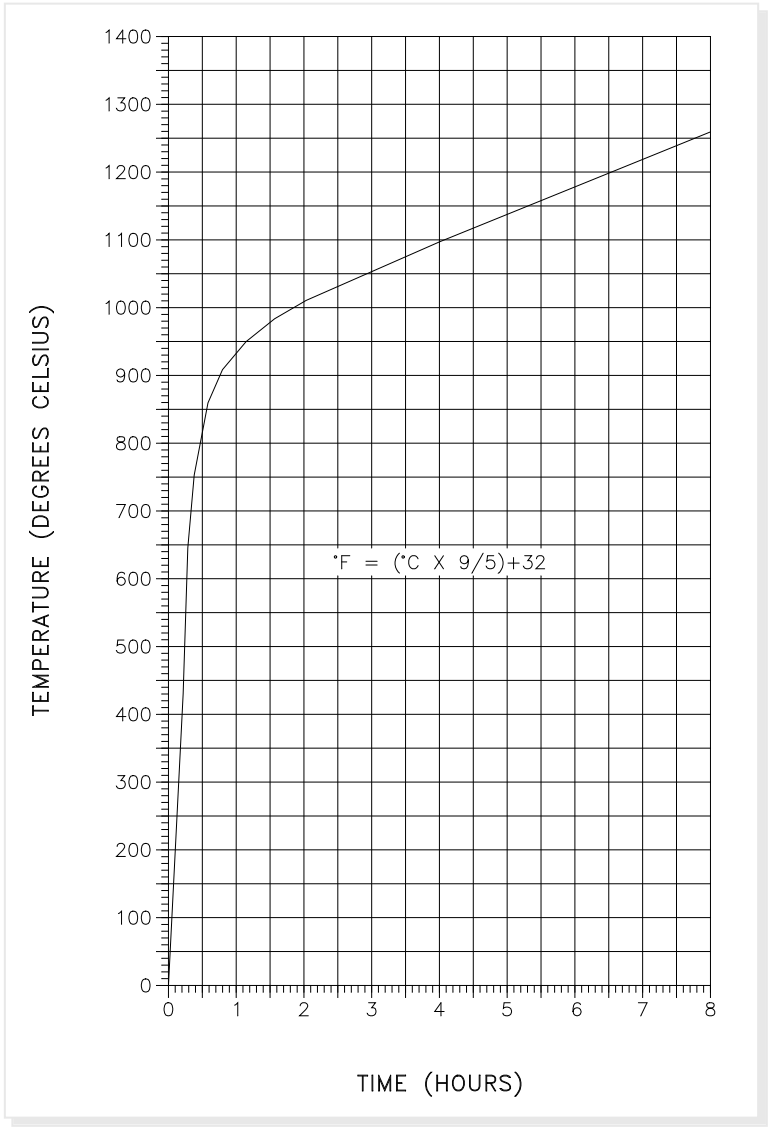


Fire Performance Testing



Typical “real world” Fire Exposure Curves

Fire Performance Testing

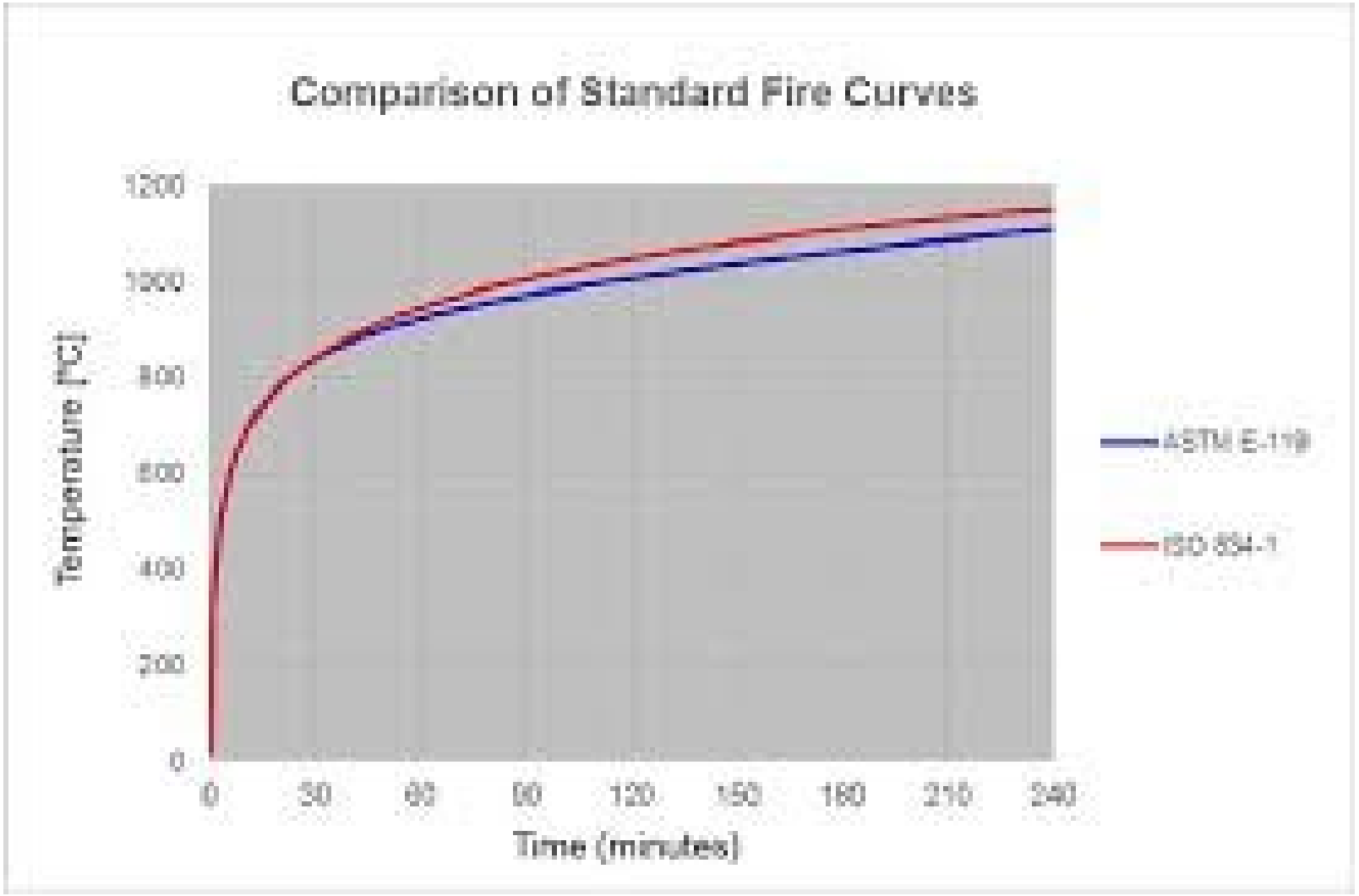


ASTM E119, UL 263 and CAN/ULC-S101 all employ the same Standard Fire Exposure Curve

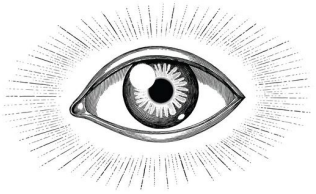
The curve serves as a means to conduct **comparative** testing between different construction assemblies

Fire resistance ratings are not **absolute numbers**, they are comparative ratings based on the fire exposure conditions and criteria of the tests

Care needs to be taken when using alternative time-temperature curves

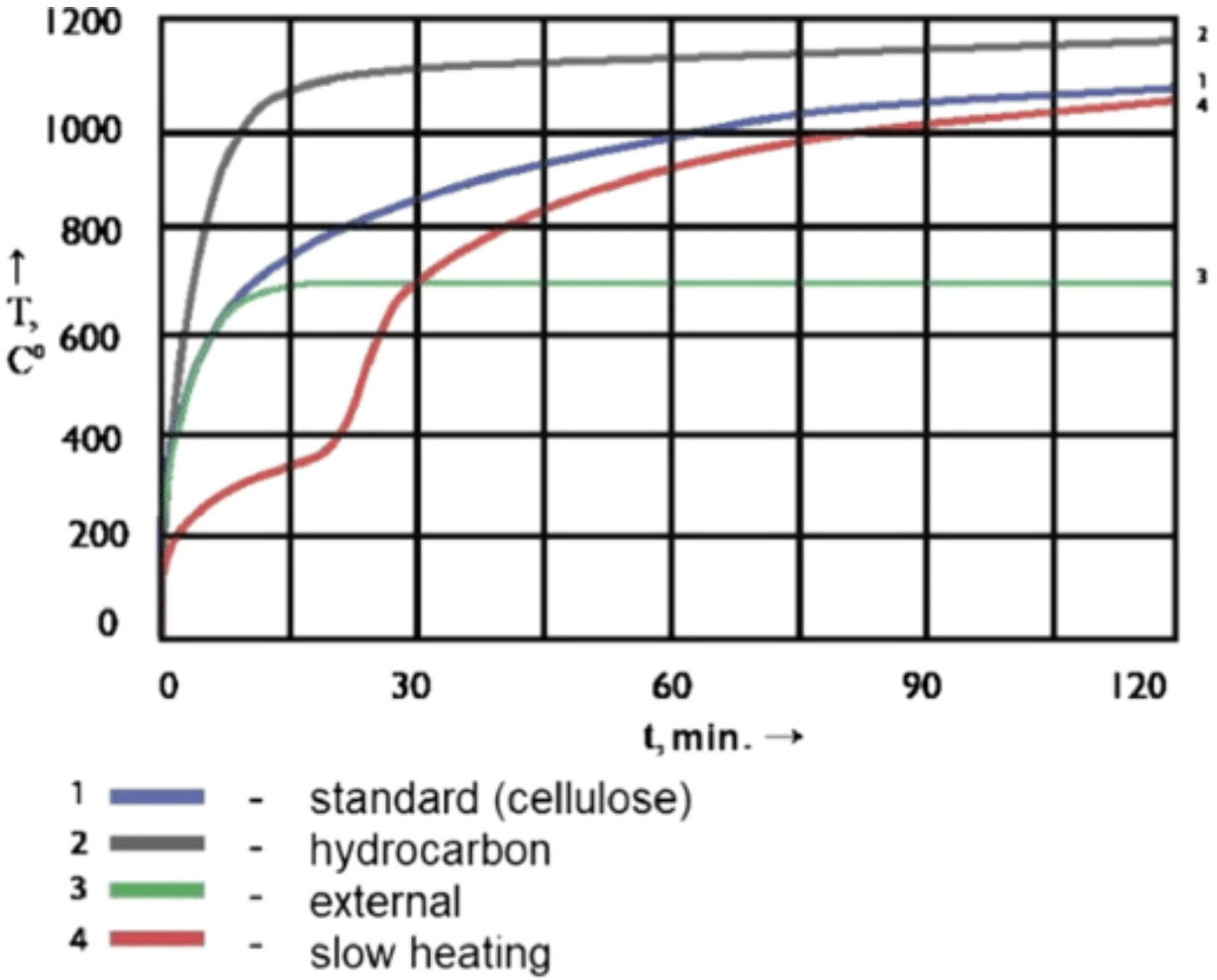


More than meets the



Temperature/time curves according to EN 1363-2:1999 Fire resistance tests.

Part 2: Alternative and additional procedures



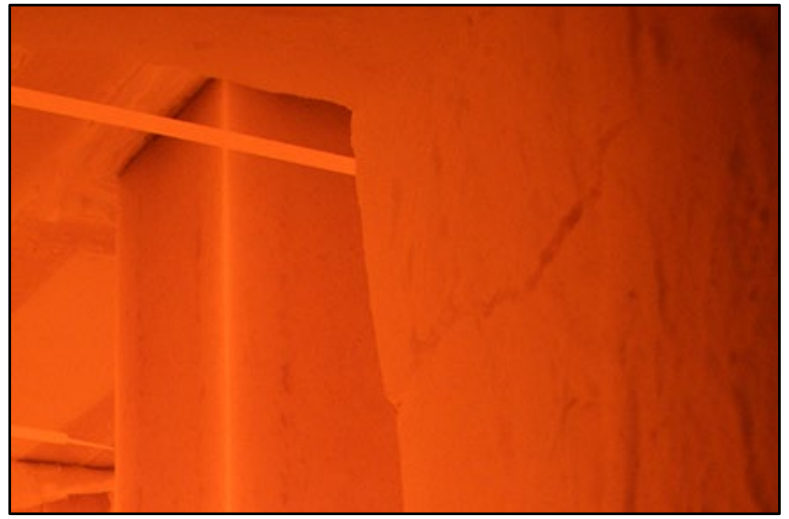
CAN/ULC-S101 vs ASTME119/ UL263

- Unlike ASTM E119 and UL 263, CAN/ULC-S101 requires:
  - Loads to be calculated using Limit States Design method (LSD)
  - Roving thermocouple required (similar to ISO 834-1)
  - Load factors based on National Building Code of Canada requirements
  - Furnace pressure and neutral plane location defined (similar to UL 263, but not ASTM E119)

Fire Resistance Criteria

Generalized Acceptance Criteria (CAN/ULC-S101)

- No passage of flames or hot gases
- Temperature rise on the unexposed side limited to - 140º C average or 180ºC individual – Includes “Roving TC” per ISO
- Assembly must remain in place & not collapse under design loads
- No through openings created during the fire or hose stream test (up to 45 psi water pressure)
- Maximum temperature of steel structural supporting elements (floors, ceilings, beams, columns) of 593ºC average, 704ºC individual



Fire-Resistance Issues – Bill McHugh

- Performance Based Structural Fire Design
  - Simple?
  - Easy?
  - ASCE 7-Appendix
  - IBC 104.2.3
  - Prove Equivalence to Ch. 7 via ASTM E119/UL 263
  - AHJ Approval

National Fireproofing Contractors Association

Structural Fire-Resistance, Part II

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Bill McHugh, NFCA Technical Director
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