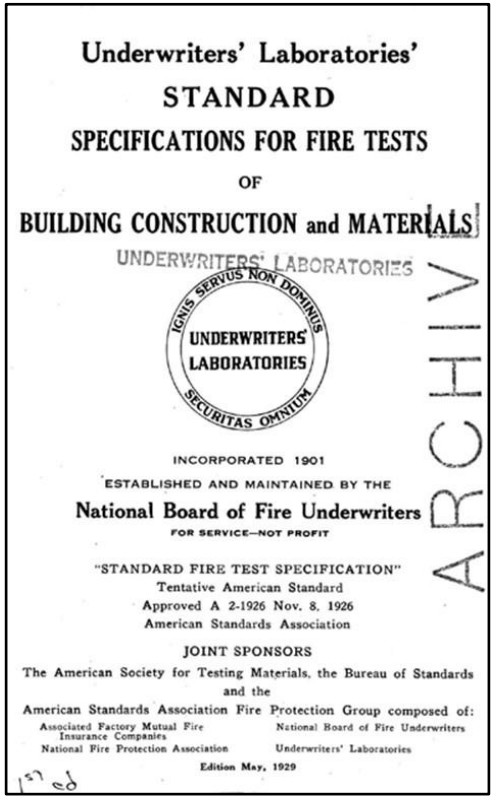
National Fireproofing Contractors Association

The History of Fire-Resistance Testing


Underwriters' Laboratories'
STANDARD
SPECIFICATIONS FOR FIRE TESTS
OF
BUILDING CONSTRUCTION and MATERIALS
UNDERWRITERS' LABORATORIES
IGNIS SERVUS NON DOMINUS
UNDERWRITERS LABORATORIES
SECURITAS OMNIUM
ARCHIV
INCORPORATED 1901
ESTABLISHED AND MAINTAINED BY THE
National Board of Fire Underwriters
FOR SERVICE—NOT PROFIT
"STANDARD FIRE TEST SPECIFICATION"
Tentative American Standard
Approved A 2-1926 Nov. 8, 1926
American Standards Association
JOINT SPONSORS
The American Society for Testing Materials, the Bureau of Standards and the
American Standards Association Fire Protection Group composed of:
Associated Factory Mutual Fire Insurance Companies
National Board of Fire Underwriters
National Fire Protection Association
Underwriters' Laboratories
Edition May, 1929

Rich Walke, Consultant to the NFCA

NFCA FREE Webinar Series

Learn – Network – Grow

July 16, 2024

Today's Presentation

National Fireproofing Contractors Association

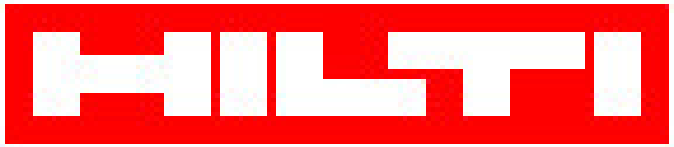
"The History of Fire-Resistance Testing"

Rich Walke, Consultant to the NFCA

Thanks Members…

NFCA GOLD Sponsors

NFCA SILVER Sponsors



Thanks Members…

- NFCA Contractors
- NFCA Associates
- NFCA Manufacturers

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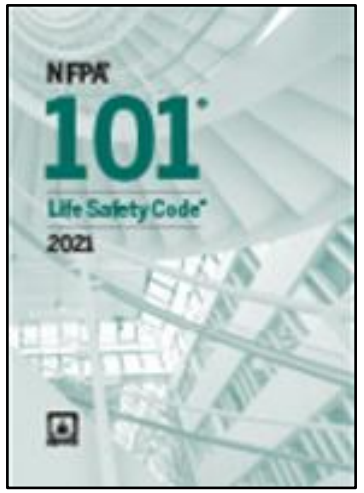
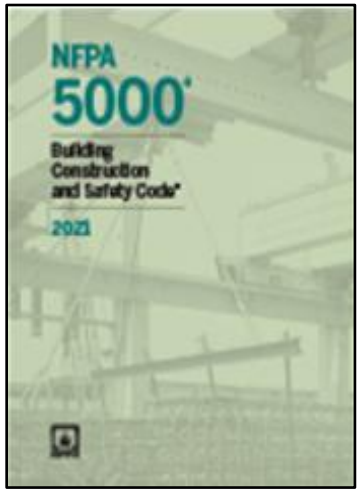
What Does NFCA Provide?

National Fireproofing Contractors Association

- **Fireproofing Education & Exams**
  - World-Class SFRM & IFRM Fireproofing Instruction
- **NFCA Contractor Accreditation Program for IFRM & SFRM**
  - Educated fireproofing Companies
  - **UL Qualified SFRM Contractor Program**
- **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
- **Technical expertise, Standards and Code development**
- **Fireproofing Handbook of Fireproofing Knowledge**
- **NFCA Website** to find Fireproofing Leaders – www.NFCA-online.org

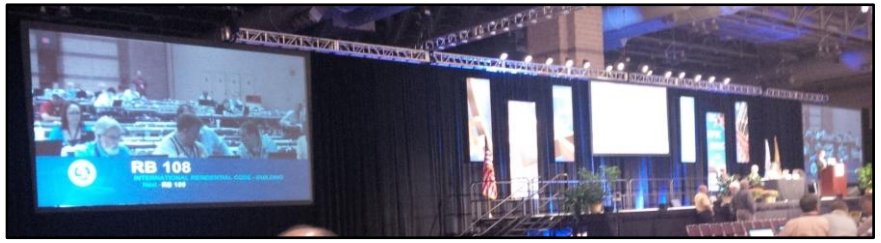
NFCA @ ICC, NFPA, Canada CDP





What does NFCA Do?

- NFCA @ ICC Codes…
  - 2021/2024 SFRM/IFRM Proposals…
- NFCA @ ASTM Task Groups - Fireproofing
- NFCA @ NFPA Fire Protection Features
- NFCA @ AISC, AISI
- NFCA @ National Codes, Canada – NBCC, NFCC
- NFCA @ American Institute of Steel Construction & American Iron and Steel Institute
- Industry Articles
  - Thermal Barriers, Patching, more…
- NFCA @ SFPE/ASCE Meetings
- NFCA requests IAS add NFCA Fireproofing Exam
- NFCA Committee ACTIONS



ASTM INTERNATIONAL

ICC INTERNATIONAL CODE COUNCIL
People Helping People Build a Safer World™

NFPA

NFCA @ 2027 IBC CDP

- International Fire Code
  - Maintain Protection & Repairs
- Fire-Resistive vs Fire-Resistant
- Occupiable Roofs – Fire-Resistance-Rated
- Attachments
- Table 601 - 20’ Rule; Clarifications
- Fireproofing Special Inspection
  - ASTM Standards – SFRM, IFRM, Boards/Wraps
  - Manufacturers Instructions
- Parking Garage Fire-Resistance

NFCA Contractor Accreditation Program

- **NFCA LIVE & VIRTUAL EDUCATION/EXAMS**
  - **Contractor Designated Responsible Individual**
  - **Focus on Fire-Resistance & Fireproofing**
  - **2024 Early Fall VIRTUAL**
  - **2025 Week of Learning –**
    - **Omni Interlocken**
    - **March 31-April 4, 2025**

Contractor Qualifications

- UL Qualified SFRM Fireproofing Contractors
  - NFCA Education
    - NFCA HAFK
    - UL Program Guide
  - NFCA SFRM Fireproofing Exam
  - Audits –
    - Office
    - Field

Underwriters Laboratories

Qualified SFRM Contractor Program

NFCA Contractor Accreditation Program (CAP)

- NFCA Accreditation “seal” - Registered NFCA mark.
- Contract - NFCA & CAP Contractor.

NFCA Handbook of Accepted Fireproofing Knowledge (HAFK)

National Fireproofing Contractors Association

- Study Resource for NFCA Fireproofing Exams
- Fireproofing in ‘One Place’
- NFCA Members = $500 Discount
- **FREE HAFK PDF for AHJ’s & Specifiers with Design Firms, Independent Specifiers**
- **SAFETY HANDBOOK INCLUDED**
- More New Chapters coming…
  www.nfca-online.org

UL Qualified SFRM Contactor Program

The UL Qualified SFRM Contractor Program is an independent, 3rd party credential.

Program requirements

Pass the NFCA Fireproofing Exam – (DRI)	Understanding NFCA Handbook of Fireproofing knowledge	Knowledge of the UL Product iq of UL Fire resistance designs	Management system requirement • Establish and effectively maintain a **management system** that meets the UL Program Requirements

UL Qualified Fireproofing Contractor Program

- **NFCA DRI**
- **Management System (MS)**
  - **Audits**
  - **Contractor's Office**
  - **A Jobsite**
- **Consider….**

UL Qualified Spray-Applied Fire Resistive Material (SFRM) Contractor Program requirements

Mark Integrity Program

Introduction:
This document outlines the contractor company requirements for participation in the UL Qualified Spray-Applied Fire Resistive Material (SFRM) Contractor Program.

The SFRM installation industry serves residential, institutional, commercial and industrial structures. The industry addresses the need to limit the damaging effects of fire by insulating structural building elements from fire. SFRMs help horizontal assemblies including floor/ceiling, roof/ceiling and building elements such as beams and columns obtain fire endurance ratings. SFRM contractors install certified SFRMs to establish a protective system for a structure to protect fire and life safety and comply with specification and customer requirements.

In order for a SFRM installation contractor organization to qualify for UL's SFRM Contractor Program, the contractor organization shall employ a knowledgeable individual who successfully demonstrates their competency to UL through successful completion of the Designated Responsible Individual (DRI) program at a contractor company that has been recognized in the NFCA Contractor Accreditation Program (CAP).

The company that enrolls in the UL Qualified SFRM Contractor program also has to establish, implement and maintain a management system focused on the application of SFRMs. A management system is used to describe the contractor's SFRM operations.

The Management System approach requires the Contractor

may be determined by the construction documents that have had final approval by code authorities. Where special inspection is implemented, the AHJ ultimately determines the acceptability of the installation.

Because the SFRM contractor firm's selection and installation of SFRMs to requirements relies on staff knowledge, the UL Qualified SFRM Contractor Program requires at least one individual employed by the Contractor organization to be designated as a Designated Responsible Individual (DRI) who has demonstrated his/her knowledge via examination and meets other related requirements defined in this document.

Definitions

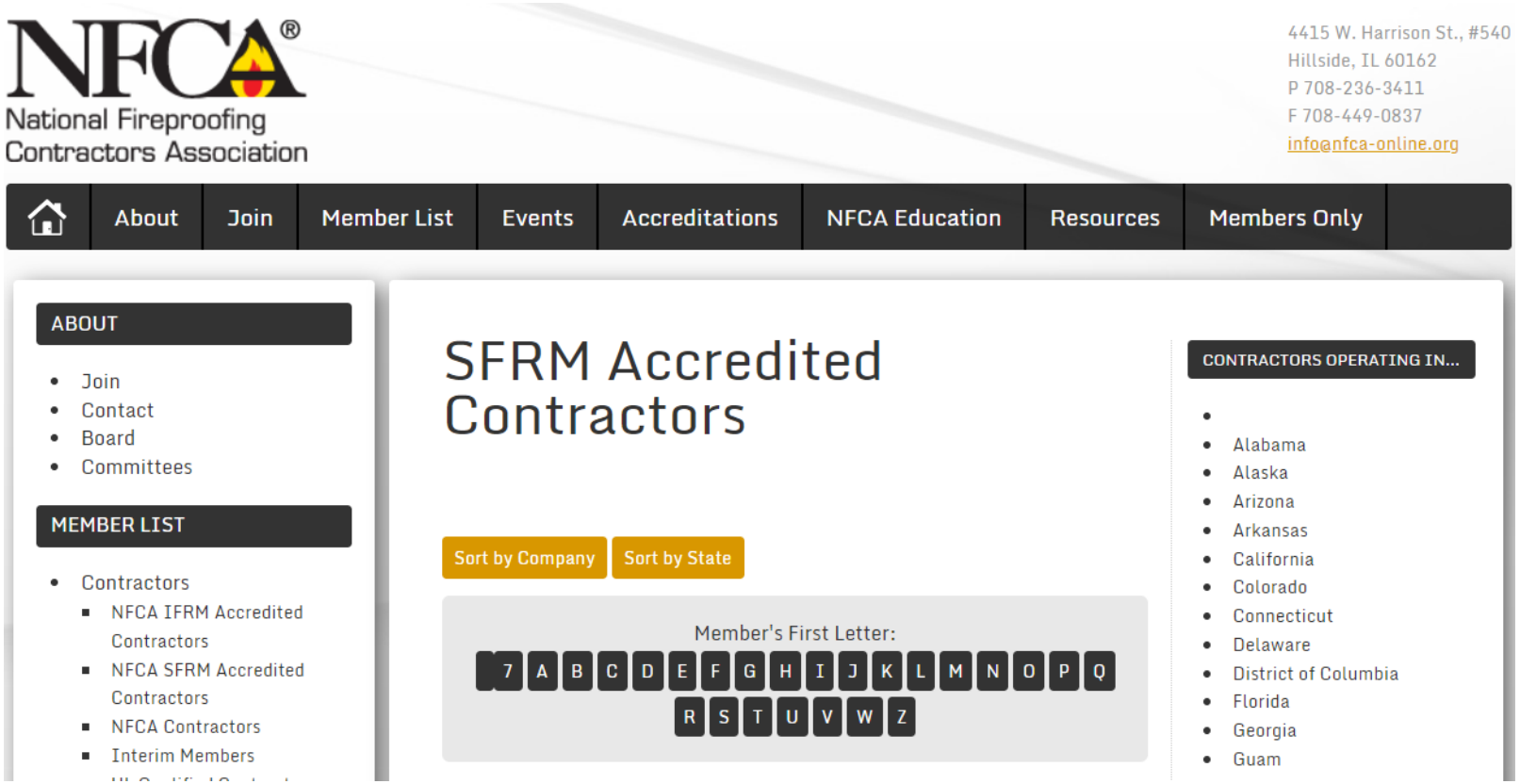
Authority Having Jurisdiction (AHJ) — The organization, office or individual responsible for implementing the adopted code. This is typically the building official or fire marshal, or another governmental agency who may also be the final authority signing the "Certificate of Occupancy Permit".

Certificate — The SFRM Contractor Certificate. This is a document issued after an audit has been completed, and conformance to all UL Qualified SFRM Contractor Program Requirements has been determined. The Certificate is valid until Dec. 31 of the following year from which the certificate was issued.

Continuing Education Unit (CEU) — For purposes of awarding CEU credit, the International Association of Continuing Education and Training (IACET) definition will be used for those individuals involved in the UL Qualified SFRM Contractor Program as follows: One (1) CEU is equal to 10

NFCA CAP Contractors

- Successful Contractor **meeting requirements**
- Listed @ NFCA-Online.org



What Makes Fire Resistance?
UL 263 & ASTM E119 – The Details….

NFCA Membership

National Fireproofing Contractors Association

- Thank you NFCA Members – You make NFCA programs possible!
- **Not a Member? Join Now!**
- Annual Contractor Membership $1495
- **NFCA CAP SFRM / IFRM Program**
- **UL Qualified Fireproofing Contractor Program**
- Contact info@NFCA-online.org for an application
- **NFCA Membership is an investment in your company and your industry**

NFCA Fireproofing Class

Today's Presentation

National Fireproofing Contractors Association

"The History of Fire-Resistance Testing"

Rich Walke, Consultant to the NFCA

Fire-Resistance in Commercial Construction

Past

Grenfell Tower Fire – June 14, 2027

Past – The Early Years – Global Efforts

- Earliest fire-resistance testing known was in London in the 1790s, done by The Associated Architects
  - Evaluated floor assemblies fireproofed using steel plates vs stucco
- Next record of floor fire testing, also from London, was in 1877
  - Evaluated the performance of non-bearing and bearing reinforced concrete floors.

Past – The Early Years – Global Efforts

- Column testing began in Germany in 1884
- Next recorded column testing was done in Austria in 1887
- Wall testing began in Germany in 1891
  - Compared wood walls with proprietary wallboard walls
- Floor testing began in Germany in 1893

Past – The Early Years – US

- In the 19th century, differentiation between fire resistance and non combustible was often confused.
- Early “codes” required non combustible construction, thinking that meant the building would withstand a fully evolved fire.
- Non combustible may not equal fire resistive due to:
  - Spalling and fracturing of some non combustible materials
  - Methods of construction

Past – The Early Years – US

- In the 1870s, larger height and areas made load-bearing masonry too costly
- By the 1880s, steel frame construction became more common
- Non combustible equals fire resistive??? Wrong!!!
- Early attempts at fireproofing steel used intuitive methods, such as terra-cotta tile on steel
- “Codes” were prescriptive but vague

Past – The Early Years – US

- As fire incident reports became available, these intuitive methods proved inadequate
- 1906 SF earthquake / fire generated many lessons of how not to fireproof buildings
  - Protection materials delaminated
  - Tiles cracked when hit with water from fire fighting efforts

Past – The Early Years – US

- First fire tests in US began in the 1890s
- 1890 Denver Tests – Fire and Hose Stream Test on floors
- 1891 St Louis Tests – Fire Tests on concrete arched floors protected with hung clay tiles
- 1896 New York Tests – Fire and Hose Stream Tests on loaded floor assemblies

Past – The Early Years – US

- 1896 New York Tests – Fire and Hose Stream Tests on unprotected steel and cast iron columns
- All of above test were ad hoc tests conducted using method developed by group conducting tests. No standardized test method existed.

Past – The Early Years – US

- 1899 NYC Building Code updated to include a requirement for fire testing in accordance with standardized fire test. Presumably “standard” was based on “Lessons Learned” during the NYC fire tests.
- First permanent test furnaces were constructed in 1902 in NY to conduct standardized tests for NYC
  - 18 by 21 ft floor furnace
  - 10 by 15 ft wall furnace
  - Few details available on furnaces or test results

Past – The Early Years – US

- UL developed permanent wall furnace in Chicago in 1903
  - Intended for testing fire doors and fire windows, but later used for testing walls. First wall tests focused on non-combustible materials
  - Gas-fired
  - 9 by 12 ft in size
  - Considered the first “modern” furnace

Past – The Early Years – US

- UL developed permanent floor furnace in Chicago in 1912
  - Few details available on furnaces or test results

Past – The Early Years – US

- UL conducted first standardized column tests between 1917 and 1920.
  - Conducted more than 100 tests on steel, cast iron, reinforced concrete and timber columns
  - Gas-fired furnace
  - Specimen loaded during fire test
  - Rating established based on temperature

Past – The Early Years
Development of ASTM Test Standard

- First standard for fire-resistance-rated floor assemblies promulgated as part of the NYC Building Code in 1899. Presumably standard was based on early testing done in NY.
- ASTM began work on standard in 1904
  - New standard initially cover “Fire-Proof Floor Construction”
  - Based on NYC Building Code Standard
  - Hose stream applied after fire exposure
  - Conceptually parameters of test similar to those today

Past – The Early Years
Development of ASTM Test Standard

- Conditions of Acceptance
  - No flame through or passage of smoke
  - No collapse
  - Permanent deflection no more than1/96 of length

Past – The Early Years
Development of ASTM Test Standard

- ASTM began work on a separate standard in covering non-load bearing walls in 1909
  - Conditions of Acceptance
    - No flame through or passage of smoke
    - Sustain the hose stream test
    - No “warp or bulge, or disintegration to an extent as to be unsafe”

Past – The Early Years
Development of ASTM Test Standard

- ASTM published ASTM C19 in 1918
  - Covered floor assemblies and non-load bearing partitions
  - Marked the end of the ad hoc fire testing era
  - Used Standard Time-Temperature curve developed by UL in 1916
    - Curve recognizes it takes time to heat up furnace.
    - Curve is an idealization of curves used by the various tests conducted prior to 1916
    - Curve remains unchanged today
  - Test conducted 25% longer than desired rating

Past – The Early Years
Development of ASTM Test Standard

- Partition specific criteria
  - Minimum specimen size of 9 by 14 ft
  - Hose stream applied after fire exposure
- Conditions of Acceptance for partitions
  - No flame through
  - Unexposed surface temperature shall not exceed 300°F (149°C)
  - Sustain the hose stream test
  - No “warp or bulge, or disintegration to an extent as to be unsafe”

Past – The Early Years
Development of ASTM Test Standard

- Floor specific criteria
  - Floor loaded to maximum working stress during fire test
  - Hose stream applied after fire exposure
  - After cooling, floor loaded to 2-1/2 times maximum working stress
- Conditions of Acceptance for floor assemblies
  - No flame through
  - No collapse

Past – The Early Years
Development of ASTM Test Standard

- Questions persisted after publication of ASTM C19 on Efficacy of Time-Temperature curve
  - Did curve accurately represent both wood and metallic furniture?
  - Multiple burn-out studies conducted. Concluded that assembly achieving a 4 hr rating by this curve would survive a burn-out.
  - Determined that area under curve, not specific curve, defined fire. This may not be true for intumescent products.
  - Concluded multiple curves for different occupancies was impractical
  - Curve remains today as originally published

Past – Development of ASTM Test Standard 1926 Evolutionary Changes

Floors and Roofs

- Unexposed surface temperature limits added
  - Maximum average temperature rise limitation of 250°F (139°C) and maximum individual point limitation of 325°F (181°C)
- Cotton waste test added

Past – Development of ASTM Test Standard 1926 Evolutionary Changes

Columns

- Criteria for testing columns added
  - Column loaded to maximum working stress during fire test
- Conditions of Acceptance for columns
  - Must maintain structural integrity

Past – Development of ASTM Test Standard 1947 Evolutionary Changes

General

ASTM C19 renumbered as ASTM E119

Columns

- Alternate criteria for testing columns unloaded added
- Conditions of Acceptance for columns
  - Average steel temperature limitation of 1000°F (538°C) and maximum individual point limitation of 1200°F (649°C)

Past – Development of ASTM Test Standard 1953 Evolutionary Changes

Beams

- Criteria for testing unloaded beams added
- Conditions of Acceptance for beams
  - Average steel temperature limitation of 1000°F (538°C) and maximum individual point limitation of 1200°F (649°C)

Past – Development of ASTM Test Standard 1953 Evolutionary Changes

Floors and Roofs

- Hose stream criteria removed
- Requirement to reload floors and roofs after hose steam removed

Past – Development of ASTM Test Standard 1973 Evolutionary Changes

Floors and Roofs, and Beams

- Concept of restrained vs unrestrained assemblies and beam introduced
- Conditions of Acceptance
  - Unrestrained Rating
    - Structural integrity
    - Average structural steel temperature limitation of 1100°F (593°C) and maximum individual point limitation of 1300°F (704°C) where steel is spaced more than 4 ft OC

Past – Development of ASTM Test Standard 1973 Evolutionary Changes

- Structural steel temperature limitation of 1100°F (593°C) where steel is spaced 4 ft or less OC
- For concrete structural members employing tensioning steel intended for use in spams greater than those tested, a steel temperature limitation of 800°F (427°C) for cold-drawn prestressing steel or 1100°F (593°C) for reinforcing steel applies

Past – Development of ASTM Test Standard 1973 Evolutionary Changes

- Conditions of Acceptance
  - Restrained Rating
    - Structural integrity
    - Average structural steel temperature limitation of 1100°F (593°C) and maximum individual point limitation of 1300°F (704°C) where steel is spaced more than 4 ft OC, applied for one half the rating period or 1 hr, whichever is greater
    - Structural steel temperature limitation of 1100°F (593°C) where steel is spaced 4 ft or less OC, applied for one half the rating period or 1 hr, whichever is greater

Past – Development of ASTM Test Standard 1973 Evolutionary Changes

- For concrete structural members spaced more than 4 ft OC, employing tensioning steel, steel temperature limitation of 800°F (427°C) for cold-drawn prestressing steel or 1100°F (593°C) for reinforcing steel, applied for one half the rating period or 1 hr, whichever is greater

Past – Development of ASTM Test Standard 1976 Evolutionary Changes

Floors and Roofs

- “Restricted Load Condition” in report title, if assembly loaded less than 100%
- Steel deck temperature requirements for unrestrained assemblies

Past – Development of ASTM Test Standard 2011 Evolutionary Changes

Beams

- New test for Loaded Unrestrained Beams

Past – Development of UL 263 Test Standard

- UL 263 first approved in 1926
- First standard was identified as UL A-2
- Over the years the UL standards development committee, now referred to as a Standards Technical Panel, and the ASTM E5 committee have attempted to align the requirements of UL 263 and ASTM E119
- For the most part, the committees have been successful

Past – UL Certification Activities – 1972

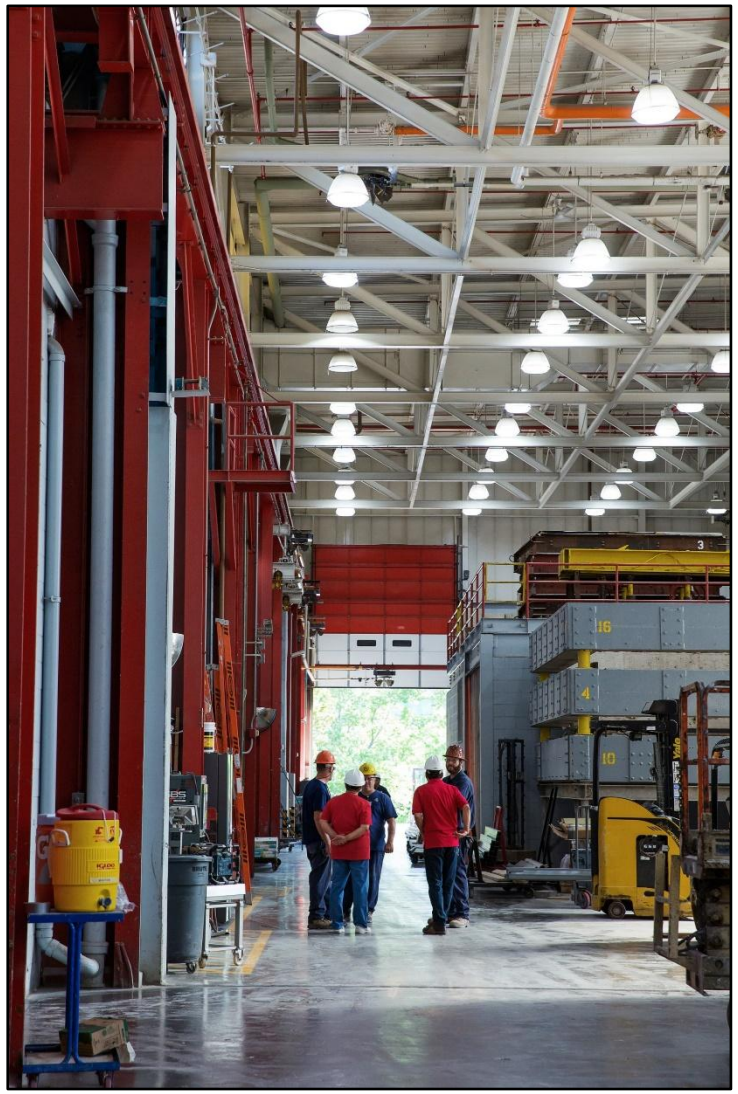
- Designs of horizontal assemblies rewritten to reflect restrained and unrestrained ratings
- Designs renumbered from previous numeric system to current alpha-numeric system
  - Design No. 99 – 3 Hr = N803

Fire-Resistance in Commercial Construction

Present

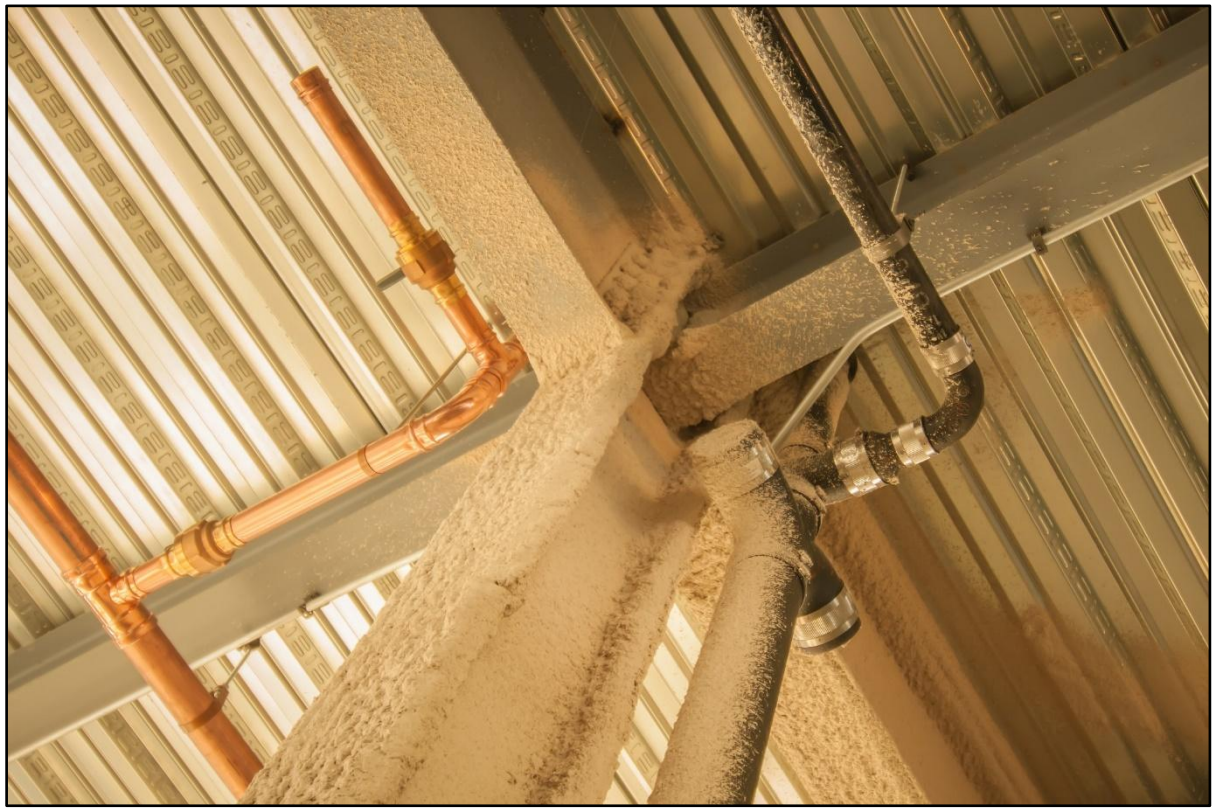
UL 263 14th edition

- Revisions published August 5, 2021
- Overhaul of sample conditioning requirements
- Measurement recording intervals (chart recorder to electronic)
- Intended to represent current practice…
- SFRM: “air condition the test lab”



UL 263 14th edition

- Revisions published March 14, 2022
- Fixed SFRM conditioning requirement
- Latest revision



Fire-Resistance in Commercial Construction

Future

UL 263 – Future – Furnace / Method

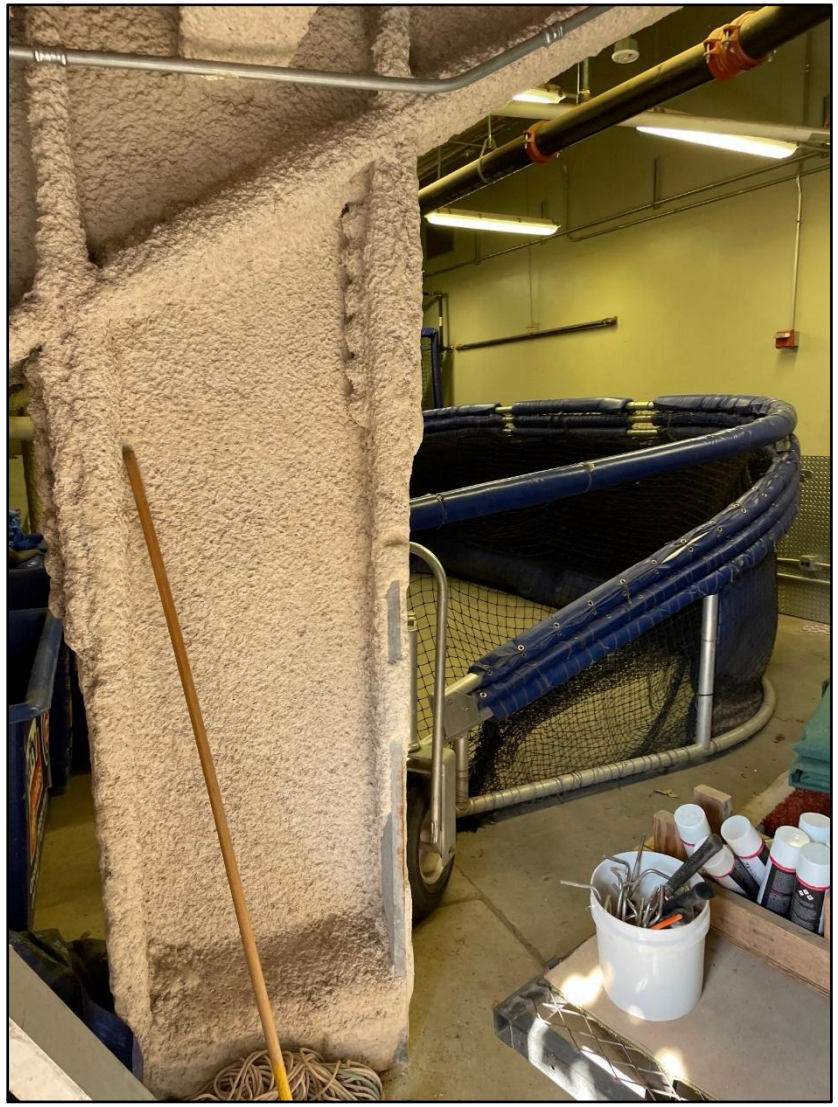
- Harmonize UL 263 with ULC S101?
- Harmonize time-temperature curve with EN curve?
- Harmonize furnace thermocouple with EN standard?
- Formalize small-scale testing procedures?
- Add furnace pressure requirements?
- Formalize furnace construction requirements?

UL 263 – Future – Acceptance Criteria

- Alternate acceptance criteria?
- Report additional results?

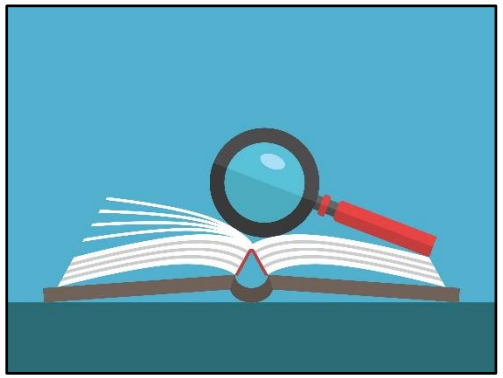
UL 263 – Future – Product Specific

- SFRM / IFRM patching test?



UL 263 – Past Criticisms

- Differing criteria for different building elements
- No furnace design criteria
- Measuring unexposed surface temperature under pad is unrealistic
- Restraint – “many heated discussions”
- Future
  - Determine contribution of each layer (component) in assembly
  - Replace time-temperature curve with “more realistic ones”
  - Computer design for fire endurance



T.Z. Harmathy and T.T. Lie (Fire Test Standard in the Light of Fire Research), 1970

UL 263 – Past Attempt to Change

K.J. Schwartz and T.T. Lie (Investigating the Unexposed Surface Temperature Criteria of Standard ASTM E119), 1985

- Research: self-ignition temperatures of combustibles in contact with unexposed surface in excess of 520°F
- Increase unexposed surface temperature rise criteria from 250°F / 325°F to 400°F / 450°F
- “fire spread by heat conduction is rare”

UL 263 proposal submitted March 1, 2013

- Transmission of heat through the specimen during the classification period shall not have raised the average temperature on its unexposed surface to more than ~~250°F (139°C) above its initial temperature~~ 400°C (752°F).

Yes	No	Abstain	Not Returned	Eligible Voters
1	17	1	8	27

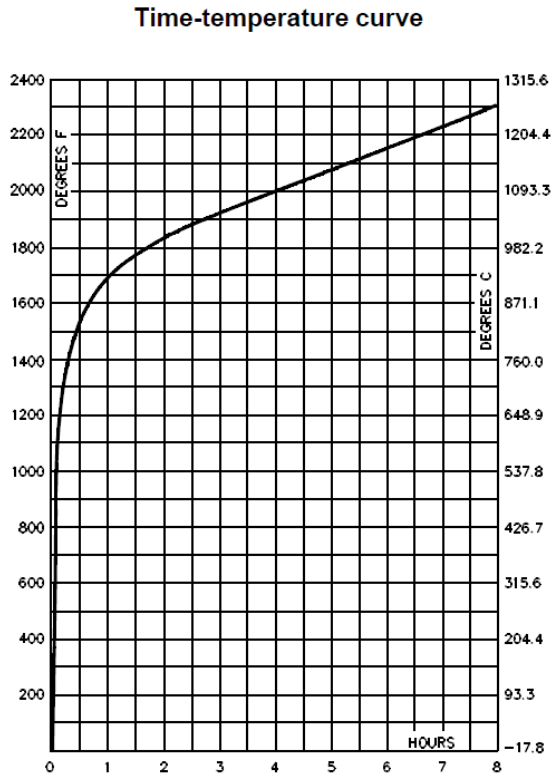
UL 263 – Recent Criticisms

Gales, J., Chorlton, B. & Jeanneret, C. The Historical Narrative of the Standard Temperature–Time Heating Curve for Structures. Fire Technology 57, 529–558 (2021)

- "No currently available historical literature can support the definition of the temperature points which describe the standard temperature–time heating curve."
- "This reinforces contemporary discussion that the heating curve lacks scientific basis in its representation of a real fire."

Babrauskas, V. Comments on "The Historical Narrative of the Standard Temperature–Time Heating Curve for Structures" by Gales, et al.. Fire Technology 58, 15–20 (2022)

- "Over the decades, there has been a great deal of scientific research confirming that the temperatures on the ASTM E119 time–temperature curve describe a well-justified, near-upper-bound to experimental data."



UL 263 / ASTM E119 – Final Thoughts

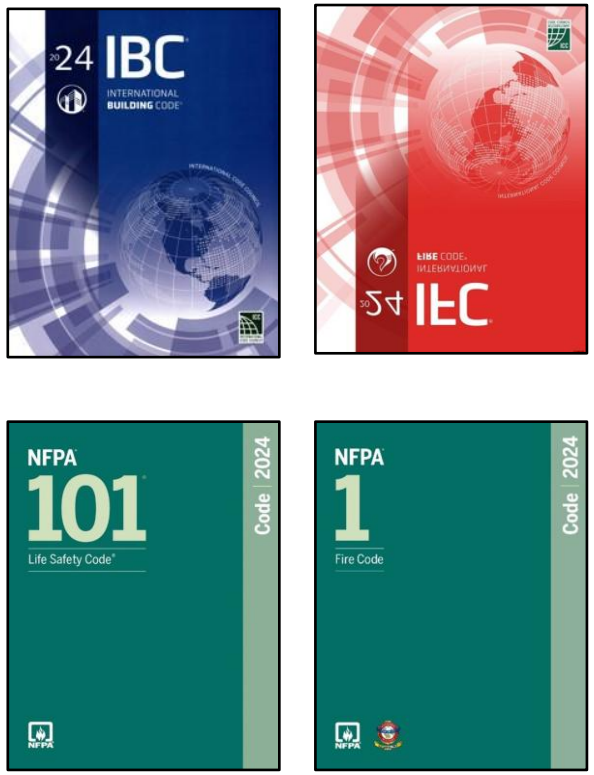
- Standard not product specific
- Gypsum, plywood, IFRM, SFRM
- Construction element specific (wall, floor, column, beam, etc.)
- Brilliant foresight in 1918 to establish test method to evaluate construction of any material
- 100 year lifespan

UL 263 / ASTM E119 – Final Thoughts

- Buildings are safer
- Occupants are safer
- First responders are safer
- Standard is doing its job

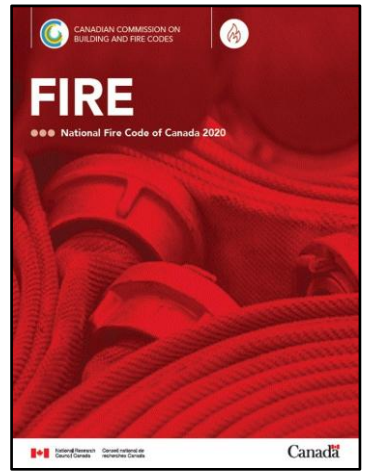
Fire-Resistance-Rated Construction

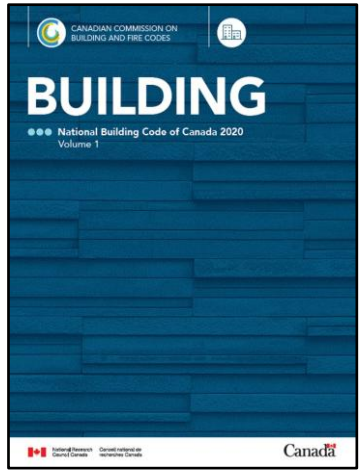
- Worldwide codes requiring fire-resistance based on ASTM E119 / UL 263:
  - International Building Code
  - International Fire Code
  - NFPA 101 Life Safety Code
  - NFPA 5000 Building Code
  - UAE Fire and Life Safety Code – Chapter 1, Section 21
  - Saudi Fire and Life Safety Code
  - Other Worldwide Codes



Fire-Resistance-Rated Construction

- Canadian Codes requiring fire-resistance based on a very similar standard, ULC-S101:
  - National Building Code of Canada
  - National Fire Code of Canada





IBC Requirements

- Chapter 7 – Fire and Smoke Protection Features
  - 703.2 – Fire-resistance ratings shall be determined in accordance with Section 703.2.1 or 703.2.2 without the use of automatic sprinklers or any other fire suppression system being incorporated, or in accordance with Section 703.2.3
    - 703.2.1 **Tested assemblies** – Fire-resistance ratings shall be determined in accordance with ASTM E119 or UL 263

IBC Requirements Cont.

- 703.2.2 **Analytical methods** – Methods for determining fire resistance shall be based on fire exposure and acceptance criteria of ASTM E119 or UL 263. Required fire resistance permitted to be established based on any of the following:
  - Designs documented from approved sources
  - Prescriptive requirements from Section 721
  - Calculations in accordance with Section 722
  - Engineering analysis based on ASTM E119 or UL 263
  - Fire-resistance designs certified by an approved agency

IBC Requirements Cont.

- 703.2.3 **Approved alternate methods** – Required fire resistance permitted to be established by alternate protection methods in accordance with Section 104.11

Suggested Reading

- Babrauskas, V. (1976) Fire Endurance in Buildings. Ph.D. Dissertation, University of California, Berkeley
- Fire Protection Through Modern Building Codes, 5th edition, AISI (1981)
- Bono, J.A., “New Criteria for Fire Endurance Tests,” Fire Test Performance, ASTM STP 464, 1970
- Babrauskas, V. Comments on “The Historical Narrative of the Standard Temperature–Time Heating Curve for Structures” by Gales, et al.. Fire Technology 58, 15–20 (2022)

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Thanks for Attending!!!

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