FI RE STOPPIN G
- Codes, Tests and Applications

Donald F. Falconer, P.Eng.
Falconer Engineering and Testing
September 21, 2017
Executive Summary:

- Introduction – Project Study
- OBC 2012
  - Defined Terms
  - Fire Separations
  - Closures
  - Continuity of Fire Separations = Joint Firestops
  - Integrity of Fire Separations = Penetration Firestops
- Engineering Judgments
- Application Issues & Design Considerations
- Questions
Introduction

PROJECT STUDY:
Harmony Public School, Corbyville, ON

- 5,100 sq m (55,000 sq ft.)
- Rural
- Unsprinklered
- 5,100 sq m (55,000 sq ft.)
- Rural
- Unsprinklered
Fire Separations / Compartmentation

- historic means of limiting spread of fire
- Nero decreed after great fire of Rome 64 AD
- London, UK regulations date back to 1189
- London, after Great Fire of 1666 - new building regulations required stone and brick houses to have fire-resisting party walls
- All modern codes require fire compartments formed of fire-resistive floors, walls and roofs to mitigate the risk of fire to life and property.
Definitions (2012 OBC)

- **Fire Compartment** means a space in a *building* that is enclosed by exterior walls or separated from all other parts of the *building* by enclosing construction providing a fire separation having a *fire-resistance rating*.

- **Fire Resistance Rating** means the time in minutes or hours that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria, or as determined by extension or interpretation of information derived therefrom as prescribed in this Code.
Definitions (2012 OBC)

- **Fire Separation** means a construction assembly that acts as a barrier against the spread of fire. (See Note A-1.4.1.2.(1).)

- **Fire Stop** means a system consisting of a material, component and means of support used to fill gaps between *fire separations* or between *fire separations* and other assemblies [joints], or used around items that wholly or partially penetrate a *fire separation* [penetrations].
Definitions (2012 OBC)

- **Noncombustible** means that a material meets the acceptance criteria of CAN/ULC-S114, “Test for Determination of Non-Combustibility of Building Materials.”

- **Firewall** means a type of fire separation of noncombustible construction that subdivides a building or separates adjoining buildings to resist the spread of fire and that has a fire-resistance rating as prescribed in this Code and has structural stability to remain intact under fire conditions for the required fire-rated time.
### Table 3.1.2.1.
#### Major Occupancy Classification

Forming Part of Sentences 3.1.2.1.(1) and 3.1.2.2.(1) and 3.11.2.1.(3)

<table>
<thead>
<tr>
<th>Group</th>
<th>Division</th>
<th>Description of Major Occupancies</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Assembly occupancies intended for the production and viewing of the performing arts</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>Assembly occupancies not elsewhere classified in Group A</td>
</tr>
<tr>
<td>A</td>
<td>3</td>
<td>Assembly occupancies of the arena type</td>
</tr>
<tr>
<td>A</td>
<td>4</td>
<td>Assembly occupancies in which occupants are gathered in the open air</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>Detention occupancies</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>Treatment occupancies</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>Care occupancies</td>
</tr>
<tr>
<td>C</td>
<td>—</td>
<td>Residential occupancies</td>
</tr>
<tr>
<td>D</td>
<td>—</td>
<td>Business and personal services occupancies</td>
</tr>
<tr>
<td>E</td>
<td>—</td>
<td>Mercantile occupancies</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>High-hazard industrial occupancies</td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>Medium-hazard industrial occupancies</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
<td>Low-hazard industrial occupancies</td>
</tr>
</tbody>
</table>
# FIRESTOPPING
- Codes, Tests and Applications

## Table 3.1.3.1.
Major Occupancy Fire Separations(1)
Forming Part of Sentence 3.1.3.1.(1)

<table>
<thead>
<tr>
<th>Major Occupancy</th>
<th>A-1</th>
<th>A-2</th>
<th>A-3</th>
<th>A-4</th>
<th>B-1</th>
<th>B-2</th>
<th>B-3</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F-1</th>
<th>F-2</th>
<th>F-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-2</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1 (3)</td>
<td>1 (4)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-3</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>1 (3)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2 (5)</td>
<td></td>
<td>2 (6)</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>1 (4)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>F-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1) A building classified as Group A, Division 2 is permitted to conform to Sentence (2) provided
   a) it is not more than 2 storeys in building height, and
   b) it has a building area not more than the value in Table 3.2.2.25.

Table 3.2.2.25.

Maximum Building Area, Group A, Division 2, up to 2 Storeys
Forming Part of Sentence 3.2.2.25.(1)

<table>
<thead>
<tr>
<th>No. of Storeys</th>
<th>Maximum Area, m²</th>
<th>Facing 1 Street</th>
<th>Facing 2 Streets</th>
<th>Facing 3 Streets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1 600</td>
<td>2 000</td>
<td>2 400</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>800</td>
<td>1 000</td>
<td>1 200</td>
</tr>
</tbody>
</table>

2) The building referred to in Sentence (1) is permitted to be of combustible construction or noncombustible construction used singly or in combination, and
   a) floor assemblies shall be fire separations and, if of combustible construction, shall have a fire-resistance rating not less than 45 min,
   b) mezzanines shall have, if of combustible construction, a fire-resistance rating not less than 45 min,
   c) roof assemblies shall have, if of combustible construction, a fire-resistance rating not less than 45 min, except that in a building not more than 1 storey in building height, the fire-resistance rating is permitted to be waived provided the roof assembly is constructed as a fire-retardant-treated wood roof system conforming to Article 3.1.14.1., and the building area is not more than
      i) 800 m² if facing one street,
      ii) 1 000 m² if facing 2 streets, or
      iii) 1 200 m² if facing 3 streets, and
   d) loadbearing walls, columns and arches supporting an assembly required to have a fire-resistance rating shall
      i) have a fire-resistance rating not less than 45 min, or
      ii) be of noncombustible construction.
Suite Fire Separations Also Regulated By:
3.3 Safety Within Floor Areas
3.3.1.1. Separation of Suites (3/4/h)
3.3.1.3. Means of Egress
3.3.1.4. Public Corridor Separations (3/4 h)
3.3.1.5. Egress Doorways (max 15 m distance to egress)
3.3.1.6. Travel Distance
3.1.7. Fire-Resistance Ratings

3.1.7.1. Determination of Ratings

(1) Except as permitted by Sentence (2) and Article 3.1.7.2., the rating of a material, assembly of materials or a structural member that is required to have a fire-resistance rating, shall be determined on the basis of the results of tests conducted in conformance with CAN/ULC-S101, “Fire Endurance Tests of Building Construction and Materials”.
3.1.7. Fire-Resistance Ratings

3.1.7.1. Determination of Ratings

(2) A material, assembly of materials or a structural member is permitted to be assigned a fire-resistance rating on the basis of MMAH Supplementary Standard SB-2, “Fire Performance ratings”.

[SB-2 Same as NBCC Appendix D]
STANDARD METHODS OF FIRE ENDURANCE TESTS OF BUILDING CONSTRUCTION AND MATERIALS
FIGURES

FIGURE 1
STANDARD TIME-TEMPERATURE CURVE
(Reference: Clauses 5.1.1, 5.2.5)
FIRESTOPPING
- Codes, Tests and Applications

Code References

CAN/ULC-S101 – Rating Criteria

- Sustain the applied load (loadbearing assemblies)
- No passage of flame or gases hot enough to ignite cotton pads
- Limiting unexposed surface temperature-rise: 140°C average or 180°C at any point
- No passage of hose stream (wall & partitions)
- Limiting structural steel temperatures
FIGURE 1  Test Furnace for Floors and Roofs

1. Furnace (loading device not shown)  
2. Flue  
3. Gas Burners  
4. Observation Ports  
5. Restraining Frame  
6. Thermocouple Tubes  
7. Specimen

Source: Underwriters' Laboratories of Canada
FIRESTOPPING
- Codes, Tests and Applications

2012 Ontario Building Code

MMAH Supplementary Standard SB-2, Fire-Performance Ratings (NBCC Appendix D)

- Generic materials i.e. concrete assemblies, Type X gypsum wallboard membranes, etc.
  i.e. gypsum board partition
  15.9 mm Type X gypsum on the fire side = 40 minutes
  + steel studs @ 400 mm OC = 10 minutes
  Rating = 50 minutes

- No proprietary materials like firestopping, SFRM or proprietary gypsum board
3.1.7. Fire-Resistance Ratings

3.1.7.3. Exposure Conditions for Rating

(1) Floor, roof and ceiling assemblies shall be rated for exposure to fire on the underside.

(2) Firewalls and interior vertical fire separations shall be rated for exposure to fire on each side.

(3) Exterior walls shall be rated for exposure to fire from inside the building.
3.1.8. Fire Separations and Closures

3.1.8.1. General Requirements

(1) Any wall, partition or floor assembly required to be a fire separation shall,

(a) Except as permitted by Sentence (2), be constructed as a continuous element, and

(b) as required in this Part, have a fire-resistance rating as specified.

(2) Openings in a fire separation shall be protected with closures, shafts or other means in conformance with Articles 3.1.8.4. to 3.1.8.18. and Subsections 3.1.9. and 3.2.8.
Definitions (2012 Ontario Building Code)

- **Closure** means a device or assembly for closing an opening through a *fire separation* or an exterior wall, such as a door, a shutter, wired glass and glass block, and includes all components such as hardware, closing devices, frames and anchors.
3.1.8.3. Continuity of Fire Separations

(4) The continuity of a fire separation shall be maintained where it abuts another fire separation, a floor, a ceiling, or an exterior wall assembly.

[explained as …]

A-3.1.8.3.(4) Fire Separation Continuity. The continuity of a fire separation where it abuts against another fire separation, a floor, a ceiling or an exterior wall assembly is maintained by filling all gaps at the juncture of the assemblies with a material that will ensure the integrity of the fire separation at that location.
While the NBCC does not make specific mention of fire stops for construction joints, their need is clearly implied through the requirements for continuity of fire separations...
STANDARD METHOD OF FIRE TESTS OF FIRESTOP SYSTEMS
FI RESTOPPING
- Codes, Tests and Applications

**CAN/ ULC-S115 IN A NUTSHELL**

- Same fire exposure conditions (Time-temperature curve) as CAN/ULC-S101
- Covers tests of:
  - through-penetration fire stops
  - outlet boxes in wall assemblies
  - joint firestop systems
FIRESTOPPING
- Codes, Tests and Applications

CAN/ ULC-S115 IN A NUTSHELL

- Ratings:
  - **F**: remains in opening with no passage of flame or occurrence of flaming on the unexposed side
  - **FT**: F + no unexposed surface temperature rise more than 181 C above initial temperature
  - **FH**: F + no openings that permit projection of water from hose stream beyond unexposed side
  - **FTH**: F + H + T
  - **L**: leakage rate from air leakage tests
3.1.9. Penetrations in Fire Separations and Fire-Rated Assemblies

3.1.9.1. Fire Stops

(1) Except as required by Sentences (2) and (3), penetrations of a fire separation or a membrane forming part of an assembly required to have a fire-resistance rating shall be

(a) sealed by a fire stop that, when subjected to the fire test method in CAN/ULC-S115, “Fire Tests of Firestop Systems”, has an F rating not less than the fire-protection rating required for closures in the fire separation in conformance with Table 3.1.8.4., or
2012 Ontario Building Code

**Table 3.1.8.4.**

**Fire-Protection rating of Closure**

Forming Part of Sentence 3.1.8.4.(2) and Clause 3.1.9.1.(1)(a)

<table>
<thead>
<tr>
<th>Fire-Resistance rating of Fire Separation</th>
<th>Required Fire-Protection rating of Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 min</td>
<td>20 min</td>
</tr>
<tr>
<td>45 min</td>
<td>45 min</td>
</tr>
<tr>
<td>1 h</td>
<td>45 min</td>
</tr>
<tr>
<td>2 h</td>
<td>1.5 h</td>
</tr>
<tr>
<td>3 h</td>
<td>2 h</td>
</tr>
<tr>
<td>4 h</td>
<td>3 h</td>
</tr>
</tbody>
</table>
3.1.9. Penetrations in Fire Separations and Fire-Rated Assemblies

3.1.9.1. Fire Stops

or (b) tightly fitted (see Appendix A.)

A-3.1.9.1.(1)(b) Tightly Fitted. The intention behind the use of the term “tightly fitted” is to reinforce that there are to be no gaps between the building service or other penetrating item and the membrane or assembly it penetrates. A typical means of fire stopping for a service or other penetration through a concrete slab or wall is “cast in place” concrete.
3.1.9. Penetrations in Fire Separations and Fire-Rated Assemblies

3.1.9.1. Fire Stops

(2) Penetrations of a **firewall** or a horizontal **fire separation** that is required to have a **fire-resistance rating** in conformance with Article 3.2.1.2. shall be sealed at the penetration by a **fire stop** that, when subjected to the fire test method in CAN/ULC-S115, “Fire Tests of Firestop Systems”, has an FT rating not less than the **fire-resistance rating** required for the **fire separation**.
3.1.9. Penetrations in Fire Separations and Fire-Rated Assemblies

3.1.9.1. Fire Stops

(3) Penetrations of a fire separation in conformance with Sentence 3.6.4.2.(2) shall be sealed by a fire stop that, when subjected to the fire test method in CAN/ULC-S115, “Fire Tests of Firestop Systems”, has an FT rating not less than the fire-resistance rating for the fire separation of the assembly.

[3.6.4.2.(2) pertains to a horizontal service space above a vertical fire separation]
3.1.9. Penetrations in Fire Separations and Fire-Rated Assemblies

3.1.9.1. Fire Stops

Sprinklers are permitted to penetrate a fire separation or a membrane forming part of an assembly required to have a fire-resistance rating without having to meet the fire stop requirements of Sentence (1), (2) or (3), provided the annular space created by the penetration of a fire sprinkler is covered by a metal escutcheon plate in accordance with NFPA 13, “Installation of Sprinkler Systems”.
3.1.9. Penetrations in Fire Separations and Fire-Rated Assemblies

3.1.9.1. Fire Stops

(5) Unless specifically designed with a fire stop, fire dampers are permitted to penetrate a fire-separation or a membrane forming part of an assembly required to have a fire-resistance rating without having to meet the fire stop requirements of Sentences (1), (2) or (3), provided the fire damper is installed in conformance with NFPA 80, “Fire Doors and Other Opening Protectives.”
3.1.9.2. Combustibility of Service Penetrations

(1) Except as permitted by Articles 3.1.9.3. and 3.1.9.4., pipes, ducts, electrical outlet boxes, totally enclosed raceways or other similar service equipment that penetrate an assembly required to have a fire-resistance rating shall be noncombustible unless the assembly has been tested incorporating that service equipment.

[3.1.9.3.(1) through (7) – are exceptions for wires, cables, raceways, metal sheathed cables and noncombustible outlet boxes of limited dimensions and spacing]
3.1.9.4. Combustible Piping Penetrations

(1) Except as permitted by Sentences (3) to (8), combustible piping shall not be used if any part of the piping system penetrates:

a) a fire separation required to have a fire-resistance rating, or

b) a membrane that forms part of an assembly required to have a fire-resistance rating.
3.1.9.4. Combustible Piping Penetrations  (3) Except as provided by Sentences (4) to (7), combustible piping is permitted to penetrate a fire separation required to have a fire-resistance rating or is permitted to penetrate a membrane that forms part of an assembly required to have a fire-resistance rating, provided the piping is sealed at the penetration by a firestop that has an F rating not less than the fire-resistance rating required for the fire separation when subjected to the fire test method in CAN/ULC-S115, “Fire tests of Firestop Systems”, with a pressure differential of 50 Pa between the exposed and unexposed sides, with the higher pressure on the exposed side.
3.1.9.5. Combustible Piping Penetrations (4) Except as required by Sentence (7), combustible drain piping is permitted to penetrate a horizontal fire separation, provided it leads directly from a noncombustible water closet through a concrete floor slab and the piping is sealed at the penetration by a fire stop in conformance with Clause 3.1.9.1.(1)(a).

[F rating not less than the fire-protection rating required for closures in the fire separation]
3.1.9.5. Combustible Piping Penetrations (5) Except as required by Sentence (7), combustible piping is permitted to penetrate a vertical or horizontal fire separation, provided the fire compartments on each side of the fire separation are sprinklered and the piping is sealed at the penetration by a fire stop in conformance with Clause 3.1.9.1.(1)(a).

[waives 50 Pa and reduces F rating to not less than the fire-protection rating required for closures in the fire separation if both compartments sprinklered]
3.1.9.5. Combustible Piping Penetrations (7) Where combustible piping penetrates a firewall or a horizontal fire separation described in Sentence 3.2.1.2.(1), the piping shall be sealed at the penetration by a fire stop that has an FT rating not less than the fire-resistance rating required for the firewall or horizontal fire separation when subjected to the fire test method in CAN/ULC-S115, “Fire Tests of Firestop Systems”, and,

(a) the fire stop shall have been tested with a pressure differential of 50 Pa between the exposed and unexposed sides, with the higher pressure on the exposed side, or

(b) the fire compartments on each side of the firewall or horizontal fire separation shall be sprinklered.
3.1.9.5. **Combustible Piping Penetrations (8)**

*Combustible* piping for central vacuum cleaning systems is permitted to penetrate a *fire separation*, provided the installation conforms to the requirements that apply to combustible piping specified in Sentence (3).

[F rating = *fire-resistance rating* required for the *fire separation* and tested with 50 Pa pressure differential]
### FIRESTOPPING
- Codes, Tests and Applications - 2012 OBC - Summary

<table>
<thead>
<tr>
<th>Penetration Type</th>
<th>‘12 OBC</th>
<th>Construction Condition</th>
<th>Fire Stop Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noncombustible</td>
<td>3.1.9.1.(1)(a)</td>
<td>all</td>
<td>F = Closure Rating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.9.1.(2)</td>
<td>Firewall or 3.2.1.2 Floor</td>
<td>FT = FRR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.9.1.(3)</td>
<td>Horizontal Service Space</td>
<td>FT = FRR</td>
</tr>
<tr>
<td>Combustible Pipe</td>
<td>3.1.9.5.(3)</td>
<td>all</td>
<td>F = FRR + 50 Pa</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.9.5.(5)</td>
<td>Both compartments sprinklered</td>
<td>F = Closure Rating*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.9.5.(7)</td>
<td>Firewall or 3.2.1.2 Floor</td>
<td>FT = FRR + 50 Pa or Both compartments must be sprinklered*</td>
</tr>
<tr>
<td>Combustible central vac pipe</td>
<td>3.1.9.5.(8)</td>
<td>all</td>
<td>F = FRR + 50 Pa</td>
</tr>
</tbody>
</table>

*Note: 2015 NBCC differences*
The Perimeter Joint Conundrum

- Most exterior walls are not fire-resistance rated, but OBC 3.1.8.1.(1)(a) and 3.1.8.3.(4) require continuity of fire separations to exterior walls = joint fire stop system

- CAN/ULC-S115 scope is limited to:
  1.7.D Materials and construction intended for use in linear openings between adjacent fire resistive structures.
  1.8 This test method is not applicable to a joint firestop system placed into a perimeter joint located between a fire resistance rated floor and a non fire resistance rated exterior wall.
The Perimeter Joints Conundrum

Solutions?

- Alternative Solutions (EJs) based upon:
  - cUL CW Systems (ASTM E 2307)
  - ITS PHV designs (formerly OPL CEJ designs)
  - cUL FW, HW or WW Systems for similar construction
  - ULC JF or PJ Systems for similar constructions

Note: There are no firestop systems tested in accordance with CAN/ULC-S115 for joints between edge-of-slabs and non-rated walls or between rated walls and underside of non-rated roofs.
FIRESTOPPING
- Codes, Tests and Applications

Engineering Judgements

1.2.1.1. Compliance with this Code

(1) Compliance with this Code shall be achieved by,

(a) complying with the applicable acceptable solutions in Division B, or

(b) using alternative solutions that will achieve at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the applicable acceptable solutions.

[Canadian Codes are objective based]

[alternative solution = formal sealed EJ]
Engineering Judgements

- “...will achieve minimum level of performance”
  - technical rationalization
- level = quantitative in nature
- in the areas defined by the objectives and functional statements attributed to the applicable acceptable solutions.
  - objective and functional statements must be identified and satisfied
Engineering Judgements

Attributed Functional & Objective Statements

<table>
<thead>
<tr>
<th>3.1.7.1(1) &amp; 3.1.9.1.(1)</th>
<th>[F03-OS1.2]</th>
<th>[ F04-OS1.3]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[F03-OP1.2]</td>
<td>[ F04-OP1.3]</td>
</tr>
</tbody>
</table>

Functional Statements:

F03 - To retard the effects of fire on areas beyond its point of origin

F04 - To retard failure or collapse due to the effects of fire
Objective Statements

- **OS1.2** - An objective of this Code is to limit the probability that, as a result of the design or construction of a building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to fire caused by fire or explosion impacting areas beyond its point of origin.

- **OS1.3** - An objective of this Code is to limit the probability that, as a result of the design or construction of a building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to fire caused by the collapse of physical elements due to a fire or explosion.
FIRESTOPPING
- Codes, Tests and Applications

Engineering Judgements

Objective Statements

- **OP1.2** - An objective of this Code is to limit the probability that, as a result of its design or construction, a building will be exposed to an unacceptable risk of damage due to fire caused by fire or explosion impacting areas beyond its point of origin.

- **OP1.3** - An objective of this Code is to limit the probability that, as a result of its design or construction, a building will be exposed to an unacceptable risk of damage due to fire caused by collapse of physical elements due to a fire or explosion.
Tools for Proper EJs:

- Fire test experience
- ASTM E2750 – Standard Guide for Extension of Data from Penetration Firestop System Tests Conducted in Accordance with ASTM E814
- IFC – Recommended IFC Guidelines for Evaluating Firestop Systems in Engineering Judgments (EJs)
- Finite element modeling
- Additional fire tests
FI RESTOPPING
- Codes, Tests and Applications

Engineering Judgements

EJs by Falconer Engineering and Testing:

- Sealed by a Professional Engineer licensed in project jurisdiction
- Based on 39 years of fire testing experience
- Identify the variations from tested assemblies
- Provide technical quantitative rationalization
- Identify Code Objective and Functional Statements
- Clearly state Conditions and Limitations
- Are site specific
- May include construction observation & verification

Sept. 21, 2017
FI RESTOPPING
- Codes, Tests and Applications

Common Issues

➢ Head-of-Wall (HW) to underside of beams not detailed correctly

➢ Building movements not considered in Firestop system design, selection and installation

➢ Mineral Wool - Incorrect compression, orientation and/or density
FI RESTOPPING
- Codes, Tests and Applications

HW to Beam Systems

1. Floor Assembly — The fire-rated fluted steel deck/concrete floor assembly shall be constructed of the materials and in the manner described in the individual D700, D800, or D900 Series Floor-Ceiling Design in
## FIRESTOPPING
- Codes, Tests and Applications

**HW to Beam Systems**

**System No. HW-D-0252**

April 08, 2015

<table>
<thead>
<tr>
<th><strong>ANSI/UL 2079</strong></th>
<th><strong>CAN/ULC S115</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly Ratings — 1 and 2 Hr (See Item 1)</td>
<td>F Ratings — 1 and 2 Hr (See Item 1)</td>
</tr>
<tr>
<td>Nominal Joint Width - 3/4 or 1-1/2 in. (See Item 3).</td>
<td>FT Ratings — 1 and 2 Hr (See Item 1)</td>
</tr>
<tr>
<td>Class II Movement Capabilities — 50% or 100 % Compression or Extension (See Item 3)</td>
<td>FH Ratings— 1 and 2 Hr (See Item 1)</td>
</tr>
<tr>
<td>L Rating At Ambient — Less Than 1 CFM/sq ft</td>
<td>FTH Ratings — 1 and 2 Hr (See Item 1)</td>
</tr>
<tr>
<td>L Rating At 400 F — Less Than 1 CFM/sq ft</td>
<td>Nominal Joint Width - 3/4 or 1-1/2 in. (See Item 3)</td>
</tr>
<tr>
<td></td>
<td>Class II Movement Capabilities — 50% or 100 % Compression or Extension (See Item 3)</td>
</tr>
<tr>
<td></td>
<td>L Rating At Ambient — Less Than 1 CFM/sq ft</td>
</tr>
<tr>
<td></td>
<td>L Rating At 400 F — Less Than 1 CFM/sq ft</td>
</tr>
</tbody>
</table>
D. Spray-Applied Fire Resistive Material* — After installation of the steel attachment clips (Item 2B), steel floor units and structural steel support to be sprayed with the min thickness of material specified in the individual D700, D800, or D900 Series Design. The flutes of the steel floor units are to be filled with material across the entire top flange of the steel beam. Additional material shall be applied to the web of the steel beam on each side of the wall. For a 1 hr Assembly Rating, the thickness of material applied to each side of the steel beam web shall be 13/16 in. (21 mm). For a 2 hr Assembly Rating, the thickness of material applied to each side of the steel beam web shall be 1-3/8 in. (35 mm).

SOUTHWEST FIREPROOFING PRODUCTS CO — Type 5, Type 5GP

W R GRACE & CO - CONN — Type MK-6/HY
Common Deficiencies

**Inadequate compression of mineral wool**

To calculate minimum thickness needed:

\[
T_{\text{uncomp}} = \frac{(W_{\text{nom}} \times 100)}{(100 - I_{\text{comp}})}
\]

Where:

- \(T_{\text{uncomp}}\) = Uncompressed Thickness Necessary, in.
- \(I_{\text{comp}}\) = Insulation Compression Percentage Specified in System, percent
- \(W_{\text{nom}}\) = Nominal (Installed) Joint Width, in.
Calculating thickness of mineral wool

Example:

4” HW joint, HW-D-1059, Item 3a specifies min. 37% compression of 8 pcf mineral wool

\[ T_{uncomp} = \frac{W_{nom} \times 100}{100 - l_{comp}} \]

\[ T_{uncomp} = \frac{4 \times 100}{100 - 37} \]

\[ = \frac{400}{63} = 6.4” \]

Need to compress minimum 6-1/2” of the 8 pcf MW into the nominal 4” joint to comply with HW-D-1059.
FI RESTOPPING - Codes, Tests and Applications

Common Deficiencies

- Proper orientation of mineral wool

Always Compress Against Grain
**FIRESTOPPING**
- Codes, Tests and Applications

**Joint Movement Capability**

- Floor deflections, thermal, wind, seismic

<table>
<thead>
<tr>
<th>Movement Class</th>
<th>Min Number of Cycles</th>
<th>Min Cycling Rate (cycles per minute)</th>
<th>CAN/ ULC-S115</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>Class I</td>
<td>500</td>
<td>1</td>
</tr>
<tr>
<td>Wind</td>
<td>Class II</td>
<td>500</td>
<td>10</td>
</tr>
<tr>
<td>Seismic</td>
<td>Class III</td>
<td>100</td>
<td>30</td>
</tr>
</tbody>
</table>
FIRESTOPPING
- Codes, Tests and Applications

Joint Movement Capability

- Most building elements are subject to movement – firestops must be designed and built accordingly
- If not specified, ask about design movements before you select and install firestop systems

Harmony PS Example:

- 38 mm (1-1/2”) max snow deflection for roof
  - +/- 50 % system requires a 1-1/2 / 0.5 = 3” joint
  - +/- 25 % system requires a 1-1/2 / 0.25 = 6” joint

Problem: limited number of systems for these combinations
PROJECT STUDY:
Harmony Public School, Corbyville, ON

Aggravating Factors:
- Large unsprinklered building
- Suite and corridor separations, and egress distances required ¾ h fire separations
- 1-1/2” max. roof deflection for snow load
- Suite fire separation walls aligned or partially aligned with roof trusses (next slide)!
- Services hung from roof above classroom ceilings run length of building penetrating the fire separations
- Installation began with materials and systems that did not accommodate 1-1/2” roof deflection
PROJECT STUDY: Harmony Public School, Corbyville, ON

- 5,100 sq m (55,000 sq ft)
- Rural
- Unsprinklered
PROJECT STUDY: Harmony Public School, Corbyville, ON

- 5,100 sq m (55,000 sq ft)
- Rural
- Unsprinklered
PROJECT STUDY:
Harmony Public School, Corbyville, ON

- 5,100 sq m (55,000 sq ft)
- Rural
- Unsprinklered

1-1/2” Max Snow Load Roof Deflection
PROJECT STUDY: Harmony Public School, Corbyville, ON

Professional Engineering Judgments and Verification were requested by the Architect and City.
Ej's: Re-designed HW and SP firestops for 1-1/2" vertical roof deflection based on systems with +/- 50% movement capability.
Ej's:
Re-designed HW and SP firestops for 1-1/2” vertical roof deflection based on systems with +/- 50% movement capability.
NOTES:

1. CFS-SP WB FIRESTOP JOINT SPRAY SEALANT SHALL BE APPLIED IN ACCORDANCE WITH HILTI'S WRITTEN INSTALLATION INSTRUCTIONS.
2. ALL MINERAL WOOL SHALL BE MINIMUM 64 kg/cu.m (4 pcf), AND SHALL BE COMpressed NOT LESS THAN 50 PERCENT AGAINST THE GRAIN OF THE WOOL.
3. PENETRATING ITEMS SHALL NOT BE SLEEVED. EXISTING SLEEVE SHALL BE REMOVED FROM THE WALL.
Design deficiencies and variations from tested systems are often discovered during the construction process.

The FCIA contractor is viewed as the firestop expert on the job, and is looked-to for solutions.

The FCIA contractor may be in position to work with the Fire Protection Engineer and provide Engineering Judgment(s) to solve site issues.

The Engineered solutions (EJs) will likely add value to the FCIA contractor's scope of the work.
Questions?

Donald F. Falconer, P.Eng.
Falconer Engineering and Testing
230 Bassett Blvd.,
Whitby, Ontario L1R 1G3
C: 905-767-7752
www.falconerengineering.com
E-mail: don@falconerengineering.com

Sept. 21, 2017
THE END