Firestopping & Effective Compartmentation

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Session Objectives

Firestopping overview
- Common terminology
- Compartmentation and containment

National Building Code of Canada (NBC)
- Notable sections: continuity, firestopping
- Important standards

Through-penetrations
- Technologies
- Selecting appropriate systems
- Engineering Judgments (EJ)
Firestopping Overview

Terminology and Theory
Every year, building fires kill more people than natural disasters, damage vital equipment and destroy billions of dollars in property.

Smoke travels 120-420 feet per minute under fire conditions.

Source: Estimate based upon ceiling jet velocity calculations for typical ceiling heights and heat release rates.

3/4 of all fire deaths are caused by smoke inhalation.

Source: Hall, Jr. John R. NFPA Fire Analysis & Research, Quincy, MA. “Burns, Toxic Gases, and other Hazards”.

So what can we do to help limit the destructive power of a fire in commercial building?

FIRESTOP!
Firestopping Responsibility

Collaborative Effort

- Owner
- Architect
- General Contractor
- Sub-contractor
- Code Official
- Manufacturer
A balanced approach to fire protection uses all available tools to improve fire safety. Passive protection allows occupants to leave prior to gas, smoke and flame spread.
Areas that Allow Flame / Smoke Spread

- Construction Joints
- Through-pens
- Doors / Windows
Purpose of Firestop

Fire travels through the path of least resistance, such as an unprotected opening in a floor or wall.


Maintain continuity of fire separation via installation of a firestop system. Seal penetrants, gaps or openings.

Restricts movement of fire / smoke into adjacent areas by restoring fire-resistance rating of assembly.
Compartmentation

- Confine fire to the zone of origin for a specified time
- Divide building into separate compartments via Fire Separations
- Prevents spread of fire, smoke and toxic gases
- Increases evacuation time for occupants
- Considered during building design
Definitions: Ratings

**Fire-Resistance Rating**
- Time in minutes / hours that assembly of materials withstands passage of flame and transmission of heat
- Continues to perform given structural function
- Conformance with CAN/ULC-S101

**Fire Protection Rating**
- Time in minutes / hours that a closure will withstand passage of flame
- Exposed to fire under specified conditions of test and performance criteria

**F Rating**
- Time in minutes / hours that firestop system withstands passage of flame
- Firestop system remains in opening during fire test
- Conformance with CAN/ULC-S115
Definitions: Assemblies

Fire Compartment
- Enclosed space in a building
- Separated from all other parts of building
- Achieved via enclosing construction, providing a fire separation having a required fire-resistance rating

Firewall
- Separation of non-combustible construction
- Subdivides building or separates adjoining buildings
- Resist spread of fire, fire-resistance rating, structural independence, continuous (from foundation to roof)

Fire Separation
- Combustible or non-combustible construction assembly
- Acts as a continuous barrier to spread for fire and / or smoke
- Remain in place, create compartments
- May or may not have a fire-resistance rating
Definitions: Restoring Continuity

**Firestop**
- Material used to fill gaps between fire separations
- The term includes both a through-penetration or membrane-penetration firestop
- Restores fire resistance rating and separation continuity

**Fireblock**
- Material, component or system that restricts spread of fire within a concealed space
- Or from a concealed space to adjacent space

**Closures**
- Device or assembly for closing opening in a fire separation
- Door, shutter, window, etc.
- Includes all components: hardware, closing devices, frames and anchors
Containment (Firestopping)

- **Firestop** required when an assembly is penetrated by various building services
- Sealed by a firestop system to close off openings between fire separations; maintains compartment continuity and fire-resistance rating
- Also needed for construction joints, formed between walls and floors
Containment: Through-penetration

Through-penetrations are created where pipes, tubing, ducts, chimneys, optical fibre cables, electrical wires, raceways, etc. pass completely through a rated floor / wall assembly.
Containment: Through-penetration

Install an assemblage of specific products that are designed, tested and rated to resist the spread of fire for a prescribed period of time.
Containment: Membrane Penetration

- Opening made **through one side** (wall, floor or ceiling membrane) of an assembly
- To firestop, install material to resist passage of flame and heat for a prescribed time period
- Common items are plumbing pipes and outlet boxes
Containment: Construction Joints

- Linear openings between adjacent fire-rated assemblies
- Typically designed to allow independent movement (dynamic joints)
- Includes perimeter joints
Containment: Flexible Wrap Systems

- Endothermic Mats: fire-proofing structural steel: columns, beams
- Electrical circuit protection (ECP): cable trays, conduits
- Insulative blankets: ventilation, grease, chemical fume and boiler exhaust ducts
- Steel / iron standpipe
- Plenum applications
National Building Code of Canada

Relevant Firestop Sections
3.1.8: Fire Separations, Closures and Compartmentation

3.1.8.1 General Requirements

1) Any wall, partition or floor assembly required to be a fire separation shall
   a) be constructed as a continuous element
   b) have a fire-resistance rating as specified (see A-3.1.8.1(1)(b))

2) Openings in a fire separation shall be protected with closures, shafts or other means in
   conformance with Articles 3.1.8.4 to 3.1.8.19, and 3.1.9 and 3.2.8. Means of egress
   should be free of smoke and doors in fire separations should be closed (A-3.1.8.1.(2)
   Installation of Closures).

A-3.1.8.1.(1)(b) Barrier to Control Smoke Spread. A fire separation may not need a fire-
resistance rating, but it should still act as a barrier to flame and smoke spread (i.e. waived
because of automatic sprinklers).
3.1.8.3 Continuity of Fire Separations

4) Continuity of *fire separation* maintained where it abuts another *fire separation*, floor or exterior wall assembly.

A-3.1.8.3.(4) Fire Separation Continuity. Maintain continuity by filling all openings at the juncture of assemblies with a material that will ensure integrity of the fire separation (at that location).
3.1.9.1 Fire Stops

1) Penetrations of a fire separation or membrane forming part of an assembly required to have a fire-resistance rating shall be:

a) sealed by a fire stop (tested to CAN/ULC-S115) with an F rating not less than the fire-protection rating required for closures in the fire separation (Table 3.1.8.4), or

b) Cast in place (no gaps b/t penetrant and assembly penetrated)
3.1.9: Penetrations in Fire Separations and Fire-rated Assemblies

3.1.9.1 Fire Stops

2) Penetrations of a firewall or 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 tested to CAN/ULC-S115, has an FT rating not less than the fire-resistance rating for the fire separation.

3.2.1.2 Storage Garage Considered Separate Building

- Floor & roof assemblies above the basement and exterior walls of basement above adjoining ground level are constructed as noncombustible fire separations
- Fire-resistance rating of at least 2 hours
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 3.6.4.2(2) shall be sealed by a fire stop that, when tested to CAN/ULC-S115, has an FT rating not less than the fire-resistance rating for the fire separation of the assembly.

3.6.4.2 Fire Separations for Horizontal Service Spaces

2) If located above a vertical fire separation, space need not be divided at fire separation as required by Article 3.1.8.3, provided the construction b/t service space and space below is a fire separation with a fire-resistance rating equivalent to that required for the vertical fire separation.

3.1.8.3 Continuity of Fire Separation

1) A horizontal service space above a vertical fire separation shall be divided at fire separation by an equivalent fire separation within the service space.
3.1.9: Penetrations in Fire Separations and Fire-rated Assemblies

3.1.9.1 Fire Stops

4) Sprinklers may penetrate fire separations required to have a fire-resistance rating without meeting requirements of Sentences (1) to (3) (no need for CAN/ULC-S115). Annular space must be covered by metal escutcheon plate as per NFPA 13 Installation of Sprinkler Systems.
3.1.9: Penetrations in Fire Separations and Fire-rated Assemblies

3.1.9.1 Fire Stops

5) Fire Dampers can penetrate a fire separation required to have a fire-resistance rating without meeting requirements of Sentences (1) to (3) (no need for CAN/ULC-S115). Fire damper must be installed in conformance with NFPA 80 Fire Doors and Other Opening Protectives.
Combustible drain, waste and vent piping can also penetrate a fire separation (or a membrane) required to have a fire-resistance rating, provided

a) The piping is sealed at the penetration by a fire stop that has an F rating not less than the fire-resistance rating required for the fire separation when subjected to CAN/ULC-S115 with a pressure differential of 50 Pa b/t exposed and unexposed sides (higher pressure on exposed side)

b) piping cannot be located in a vertical service space.
Evaluation Standards

CAN/ULC-S101: Fire Endurance Tests of Building Construction and Materials
CAN/ULC-S115: Fire Tests of Firestop Systems
CAN/ULC-S101

Standard Methods of Fire Endurance Tests of Building Construction and Materials

• Overarching fire protection standard (*NBC 3.1.7 Fire-Resistance Ratings*)

Floor, Roof, Walls or Partitions
Require at least 9 thermocouples

Columns
8 (4 pairs), located 1/3 & 2/3 height

Beams
16, 4 per equally-spaced section
CAN/ULC-S115

Standard Methods of Fire Tests of Firestop Systems

CAN/ULC-S101 Time-Temperature Curve

• 5 minutes: from RT to 550°C (1000°F)
• 1 hour: 925°C (1700°F)
• 2 hours: 1010°C (1850°F)
• 3 hours: 1060°C (1940°F)
• 4 hours: 1110°C (2030°F)
Acceptance Criteria: F Rating

- Firestop system must remain within opening to meet F rating requirements
- Firestop system does not permit passage of flame though openings, or flaming of any element on unexposed side
- Flames can travel through metallic penetrants to non fireside (not a failure)
Acceptance Criteria: T Rating

Transmission of heat during test cannot raise temperature on non-fire side more than 181°C beyond ambient (initial temperature).

- 4 inches away from opening on unexposed surface
- On penetrant, 1 inch from unexposed surface
- 1 inch away from penetrant
Optional Criteria: L rating

- Volume of air flowing – per unit of time – through openings around test specimens
  - Under specified pressure difference
- Air leakage test chamber: sealed chamber with opening & removable mounting panel
  - 24 ± 11°C and 75 ± 1.25 Pa
  - For elevated conditions, 204 ± °5C
- Reported based on leakage rate, q
  - Firestop systems \( \frac{L}{s \cdot m^2} \)
  - Joint systems \( \frac{L}{s \cdot m} \)
Optional Criteria: W rating

- Based on UL 1479 criteria
- Measures water resistance
- Reservoir installed around desired assembly / firestop system
- 305 mm water pressure head
  - Safety factor of 3
  - Items sealed at bottom of floor
  - Sub-grade buildings (may have substantial water accumulation)
- Water is dyed, remains in reservoir for 72 hours
Firestop Technologies: Intumescent

As fire intensifies, product expands and chars
As fire intensifies, chemically-bound water molecules are released.
Firestop Technologies: Ablative

As fire intensifies, a hard char with thermal insulation is formed.
System Selection

Third Party Listings
Primary Considerations

- Floor / wall construction type and thickness
- Hourly rating requirements
- Penetrating item type and dimensions
- Annular spacing, Sleeve optional or required
- Cable fill percentage
- Packing materials
- Fire severity
- Ease of installation
- STC, W-rating, L-rating
Assembly Construction: Type

- Gypsum wallboard
- Concrete
  - Poured in-place concrete
  - Pre-cast concrete
  - Hollow-core concrete
  - Post-tension concrete
  - CMU concrete block wall
- Fluted metal deck
- Wood-framed assemblies
Assembly Construction: Hourly Rating

• Each construction type is designed for a specific hourly rating (fire-resistance rating).

• Choosing a firestop system: hourly rating must be equal to the hourly rating of the construction type.

System No. C-AJ-1044

March 15, 2007
F Ratings — 2, 3, and 4 hr. (See Items 2A and 4)
T Rating — 0 hr.
L Rating at Ambient — 2 CFM/sq. ft.
L Rating at 400°F — less than 1 CFM/sq. ft.
W Rating — Class I (See Item 4)

Products are part of a firestop system. It is the complete system that receives an hourly rating.
Assembly Construction: Substrate

Thicker concrete substrates absorb more heat.

Composite slabs (fluted metal deck) and hollow core concrete: hone-in on critical dimensions.

Critical Dimension

2-1/2" to 3-1/2" Typical

Critical Dimension: ≤ 1-1/4 inch
### Penetrant: Type

#### Plumbing
- Drains, waste, vents
- Chiller lines
- Water supply
- Acid drains
- Sprinkler systems
- Steam lines

#### Electrical
- Power
- Control
- Service
- Telephone
- Fibre-optic
- Coaxial

#### Mechanical
- Heating
- Ventilation
- Air conditioning
Penetrant: Annular Space

- Annular space: distance between penetrant and periphery of opening
- Distance between multiple penetrations
- Be aware of minimums and maximums!
Penetrant: Sleeve Requirements

In some systems, a steel or non-metallic sleeve is required. The system detail also indicates when a sleeve is optional.

1. Two heat sources affecting firestop
2. Compounded by thinner concrete
3. UL system must indicate sleeve as an option
Packing Material

1. Mineral wool (basalt)
2. Fibreglass
3. Backer rod (paper, cardboard)
4. Nothing

**Listed in order of thermal performance**
Percentage Cable Fill

System states calculated percentage cable fill, size and types of cables permissible to penetrate assembly.

Visual fill appears twice as full compared to actual / calculated
Membrane Penetration

• Cables, pipes, electrical boxes, tubes, combustion vents, wires
• Penetration: one side of wall, floor or floor / ceiling assembly
• Common membranes: ceiling tile, gypsum wallboard
• Firestop install: penetrated-side only

3.1.9.1 Firestops
1) Penetrations of a fire separation or a membrane forming part of an assembly required to have a fire-resistance rating shall be...
Membrane Penetration

Electrical Metallic Outlet Boxes

U300 or U400 Series gypsum wallboard assembly

4S electrical box

Does not require putty pads:

• Each box is 103 cm² (16 in²) or less
• Only six 4S boxes (< 645 cm² or 100 in²) in 9.29 m² (100 ft²) area
• Only one box per stud cavity
NBC / SCC-Recognized Testing Agency

Underwriters Laboratories LLC

Intertek Group PLC:
Omega Point Laboratories
Warnock Hersey

Factory Mutual Research
Responsibility of Test Agency

- To determine whether a firestop system will pass applicable test standard criteria
- To provide listings (designs, cut sheets) for each successfully-tested configuration
- To establish a nomenclature for each category of listed systems

UL: C-AJ – XXXX
Intertek: PHV 120-XX
UL Nomenclature

CAJ – 1552

The first alpha component identifies the type of assembly being penetrated:

C  combination floor or wall
F  floor
W  wall
UL Nomenclature

CAJ – 1552

The second alpha component further identifies the construction type:

A signifies a concrete with a minimum thickness less than or equal to 5”
B signifies a concrete with a minimum greater then to 5”
C signifies a framed floor
D signifies a steel deck in a marine vessel
E signifies a floor-ceiling assembly consisting of concrete with membrane protection
F-I currently not used
J signifies a concrete or masonry wall with a minimum thickness less than or equal to 8”
K signifies a concrete or masonry wall with a minimum thickness greater 8”
L signifies a framed wall
M signifies bulkheads in marine vessels
O-Z currently not used
UL Nomenclature

**CAJ – 1552**

The numeric component uses sequential numbers to identify the penetrating item:

<table>
<thead>
<tr>
<th>Number Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000–0999</td>
<td>No penetrating items</td>
</tr>
<tr>
<td>1000–1999</td>
<td>Metallic pipe, conduit, or tubing</td>
</tr>
<tr>
<td>2000–2999</td>
<td>Nonmetallic pipe, conduit, or tubing</td>
</tr>
<tr>
<td>3000–3999</td>
<td>Electrical cables</td>
</tr>
<tr>
<td>4000–4999</td>
<td>Cable trays with electrical cables</td>
</tr>
<tr>
<td>5000–5999</td>
<td>Insulated pipes</td>
</tr>
<tr>
<td>6000–6999</td>
<td>Miscellaneous electrical penetrants such as buss ducts</td>
</tr>
<tr>
<td>7000–7999</td>
<td>Miscellaneous mechanical penetrants such as air ducts</td>
</tr>
<tr>
<td>8000–8999</td>
<td>Groupings of penetrations including any combination of items listed above</td>
</tr>
<tr>
<td>9000–9999</td>
<td>Not used at present time</td>
</tr>
</tbody>
</table>
UL System Example

System No. C-AJ-1058
May 09, 2013

ANSI/UL1479 (ASTM E814)
F Rating – 3 Hr
T Rating – 0 Hr
L Rating At Ambient – Less Than 1 CFM/sq ft
L Rating At 400 F – Less Than 1 CFM/sq ft
W Rating – Class 1 (See Item 4)

CAN/ULC S115
F Rating – 3 Hr
FT Rating – 0 Hr
FH Rating – 3 Hr
FTH Rating – 0 Hr
L Rating At Ambient – Less Than 1 CFM/sq ft
L Rating At 400 F – Less Than 1 CFM/sq ft

UL System Example

1. Floor or Wall Assembly – Min 4-1/2 in. (114 mm) thick reinforced lightweight or normal weight (100-150pcf or 1600-2400 kg/m³) concrete. Wall may also be constructed of any UL Classified Concrete Blocks*. Max diameter of opening is 27-1/4 in. (692 mm).

See Concrete Block (CAEZ) category in the Fire Resistance Directory for names of manufacturers.

2. Through-Penetrant – One metallic pipe, conduit or tubing to be installed either concentrically or eccentrically within the firestop system.

An annular space of min 0 in. (point contact) to max 3-1/4 in. (83 mm) is required within the firestop system. When optional steel sleeve is used, min annular space shall be 1/2 in. (13 mm). Pipe, conduit or tubing to be rigidly supported on both sides of floor or wall assembly.

The following types and sizes of metallic pipes, conduits or tubing may be used:

- Steel Pipe – Nom 24 in. (610 mm) diam (or smaller) Schedule 10 (or heavier) steel pipe. When Type FB-1000 NS or FB-1003 SL sealant (see Item 4) is used, pipe diam shall not exceed 8 in. (203 mm).
- Conduit – Nom 4 in. (102 mm) diam (or smaller) steel electrical metallic tubing or nom 6 in. (152 mm) diam (or smaller) steel conduit.
- Copper Tubing – Nom 6 in. (152 mm) diam (or smaller) Type L (or heavier) copper tubing. When Type FB-1000 NS or FB-1003 SL sealant (see Item 4) is used, tubing diam shall not exceed 4 in. (102 mm).
- Copper Pipe – Nom 6 in. (152 mm) diam (or smaller) regular (or heavier) copper pipe. When Type FB-1000 NS or FB-1003 SL sealant (see Item 4) is used, pipe diam shall not exceed nom 4 in. (102 mm).
- Iron Pipe – Nom 24 in. (610 mm) diam (or smaller) cast or ductile iron pipe. When Type FB-1000 NS or FB-1003 SL sealant (see Item 4) is used, pipe diam shall not exceed nom 8 in. (203 mm).

3. Packing Material – Min 3 in. (76 mm) thickness of min 4 pcf (64 kg/m³) mineral wool batt insulation firmly packed into opening as a permanent form. Packing material to be recessed from top surface of floor or from both surfaces of wall as required to accommodate the required thickness of fill material.

4. Fill, Void or Cavity Material* – Sealant – Min 1/2 in. (13 mm) thickness of fill material applied within annulus, flush with top surface of floor or both surfaces of wall assembly. At the point contact location between pipe and concrete, a min 1/2 in. (13 mm) diam bead of sealant shall be applied at the concrete/pipe interface on the top surface of floor and on both surfaces of wall assembly.

   (Note: W Rating applies only when FB-1000 NS, FB-1003 SL or FB-3000 WT is used.)
   floor or both surfaces of wall assembly. At the point contact location between pipe and concrete, a min 1/2 in. (13 mm) diam bead of sealant shall be applied at the concrete/pipe interface on the top surface of floor and on both surfaces of wall assembly.

   (Note: W Rating applies only when FB-1000 NS, FB-1003 SL or FB-3000 WT Sealant is used.)

*Bearing the UL Classification Mark:

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Intertek Nomenclature

Intertek uses a simplified naming convention. In general: **AAB/XX(X) YY(Y)-ZZ**

Where:

- **AA** is unique to every company
- **XX(X)** is a two or three letter designation for listing type
  - PV = penetrate vertical separation
  - PH = penetrate horizontal separation
- **YY(Y)** is a two or three number designation for the fire duration in minutes
- **ZZ** is the unique listing number for similar penetration types staring at 01
Non-compliant Systems
Compliant Systems
Engineering Judgments

System Unavailable
IFC EJ Guidelines

- If system available, do not use an EJ
- Issued by manufacturer’s qualified technical personnel or by a 3rd party agency
- Based on interpolation of similar, previously tested firestop systems
- Consider construction elements that require fire protection – probable behaviour
- Limited to specific configurations and performance expectations
- Accepted for one project location
Challenging EJ Submissions
Effective EJs

- Descriptively written
- EJ is required
- Installation steps indicated
- Date issued
- Reference listed design
- Job name and location
- Proper justification
- Critical firestop elements
Questions? Thank you!