CHALLENGES TO AIR FLOW CONTAINMENT IN MISSION CRITICAL FACILITIES

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INTRODUCTION AND TOPICS TO ADDRESS

Firestopping is critical to building design, construction, and operation...

However, beyond Firestopping, what impact does airflow have on...
  - data center cooling costs and energy efficiency?
  - data hall pressurization for proper operation of suppression systems?
  - control of dust & whiskers that could damage server equipment?

Can the firestopping method affect a building’s performance?

What do owners, designers & contractors need to understand when addressing cable pathways in critical facilities?
Agenda

1. What is firestop and why is it necessary

2. Elements of compartmentation

3. Designing for real life applications

4. Critical needs in data centers

5. Best practices to help improve a building’s performance
LET’S START WITH THE BASICS

What is firestop?

• **Firestop systems** (if installed correctly), help restore the rating of a floor or wall as it is penetrated by an object such as a cable bundle and resist the spread of smoke and fire.

• **Firestop** is part of the life safety plan in building structures.

• **Life safety** also includes air ducts with dampers, smoke and fire alarms, wired glass, fire rated doors, sprinkler systems etc.

Why is it necessary?

• How do people react during a fire?

• To give people more time to safely exit a structure, even if they don’t react right away.

• Mandated by the Codes: NBCC, NFPA, IBC
WHAT IS THE LEADING KILLER IN FIRES?

Smoke and Toxic Gases
NFPA FIRE STATISTICS

2015 facts:
• **1,3 million** fires
• **501,500** structure (building) fires
• **$10.3B** in property damage

A fire department responds to a fire every **23 seconds**

More than **8 out of 10** civilian deaths caused by fire were due to structure (building) fires

Source: NFPA Fire Loss Statistics 2015
WHY CONTAIN SMOKE, TOXIC GASES, & FIRE?

Viscosity: **47%** of survivors caught in a fire could not see more than 12 feet.

Source: NFPA Fire Protection Handbook, 18th Ed. Table 1-1P. Pg.1-15.

Approximately **57%** of people killed in fires are not in the room of the fire’s origin.

Source: NFPA Fire Protection Handbook, 18th Ed. Table 8-1P. Pg. 8-17.

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”. 
WE CAN’T RELY ON ANY SINGLE SAFEGUARD TO PROTECT PEOPLE & PROPERTY

The Balanced Approach to Fire Protection
Agenda

1. What is firestop and why is it necessary

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THE ELEMENTS OF COMPARTMENTATION

The spread of fire can be restricted by dividing a building into separate compartments with fire-resistive walls and floors increasing the availability of escape routes for occupants.

Compartmentation protects escape routes such as corridors or stairs.

**Fire walls**

**Fire floors**
TYPES OF FIRE / SMOKE ASSEMBLIES

- Fire Walls
- Fire Barrier Walls
- Shaft Wall
- Fire Partitions

- Smoke Barriers
- Smoke Partitions
COMMON TERM ON PROJECT PLANS: “SMOKE WALL”

Reality ... Codes recognize:
“Smoke Barrier” or “Smoke Partition”
What’s the difference?
WHAT IS A SMOKE BARRIER

Definition: Vertical or horizontal continuous membrane that will restrict movement of smoke

• L-rating (air leakage) must be less than 5 CFM/SQ.FT. for penetrations or 50 cfm leakage per 100 sq. ft. of wall area
• F-rating: 1-hour (U.S. code)

Lower L-ratings means less air leakage
EXAMPLE OF SMOKE PROPAGATION

Real case: fire in a hospital and smoke propagation:
in less than 2 minutes the hallways in this hospital were full of toxic smoke ...

Incorrectly sealed penetrations
WHAT IS A SMOKE PARTITION?

• No fire resistance
• Span floor to floor or Floor to ceiling, if ceiling will limit the transfer of smoke
• Sealed windows
• No louvers in doors
• Doors not required to be self-closing
• Joints and penetrations “shall be filled with an approved material to limit the free passage of smoke”
• Most common use: Corridor walls in sprinklered hospitals
CRITICAL: CLARIFY THE ASSEMBLY TYPE!

**Key Points:**
- The term “Smoke Wall” is not referenced by codes. Clarify the assembly type!
- “Smoke Barriers” are 1 hour fire-rated assemblies! They require firestop systems and products
- “Smoke Partitions” are non fire-rated and must only resist the passage of smoke.
SUCCESSFUL COMPARTMENTATION

People with complete trust in a building’s compartmentation
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HOW TO ADDRESS THIS APPLICATION?

Cable trays through 2 hour fire-rated concrete wall assembly
MULTIPLE CODES REQUIRING FIRESTOPPING
GLOBAL CODES & TEST STANDARDS

- Codes in most countries require firestopping to be designed and installed per a testing standard.

- Firestop systems are tested according to international standards such as:
  USA: ASTM E 814 / UL 1479
  Canada: CAN/ULC S-115
  Europe: BS 476, EN 1363, DIN 4102

- A successful test yields an approval or firestop listing.
All “nationally recognized test agencies” are of equal status (code acceptance)

Each agency publishes its own listing directory
# COMMON TESTING PARAMETERS

<table>
<thead>
<tr>
<th>Rating</th>
<th>Reference Standards</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>F rating</td>
<td>ASTM E814, UL 1479, CAN/ULC S115</td>
<td>Time period (expressed in hours) that assembly resists the passage of flames</td>
</tr>
<tr>
<td>T rating</td>
<td>ASTM E814, UL 1479</td>
<td>Time by which unexposed (non-fireside) of assembly reaches 325°F (163°C) over ambient temperature</td>
</tr>
<tr>
<td>L rating</td>
<td>UL 1479</td>
<td>Air leakage test run at ambient and 400°F (204°C)</td>
</tr>
<tr>
<td>W rating</td>
<td>UL 1479</td>
<td>Water leakage testing</td>
</tr>
</tbody>
</table>

➢ To achieve successful testing in the U.S. the firestop system must also pass the hose stream test
FIRE TEST PROCEDURE

1. Assembly is placed on furnace.
2. Assembly is exposed to fire test.
3. Assembly is subjected to hose stream test (if required)
4. Assembly results after hose stream.
HOSE STREAM VERIFIES MECHANICAL INTEGRITY OF SYSTEM AFTER FIRE

Stream delivered through 2½ inch hose with a straight-bore nozzle at:

- 30 psi - 1, 2 & 3-hour tests
- 45 psi - 4-hour test

Time duration calculated based on the area of test assembly and the fire resistance rating.

Hose stream test not required in Canada.

A firestop system can be listed if no gaps are detected after hose stream test.
AIR LEAKAGE TESTING

L-rating (UL)

• Measures the amount of air leakage through the firestop system in CFM
• Tested at ambient (cold smoke) and at 400°F (hot smoke) temperature.
• Leakage testing is desired in datacenters to protect equipment against smoke damage (fire), zinc whiskers, and for improved energy efficiency
AIR LEAKAGE TESTING

Air Permeability (EN)

- Measures the amount of air leakage through the firestop system in CFM
- Measures air leakage at multiple pressures levels and cable % fill

Diagram: Joint length-related air permeability pressures

Diagram: Overall area-related air permeability pressures
WHAT IS THE HOURLY RATING OF A TYPICAL FIRESTOP PRODUCT?

ZERO

Only Firestop systems have ratings!
MULTIPLE PARAMETERS OF A FIRESTOP SYSTEM

Firestop system performance can change completely if altering any parameter.
A FIRESTOP SYSTEM IS ISSUED IF ALL ELEMENTS OF THE TEST ARE PASSED
WHAT IS PERCENT FILL?

Definition: The cross-sectional area of an opening that is occupied by penetrating items, typically cables. Percent fill is specific to each firestop system.

What is the actual percent fill?

Visually, the opening appears to be 2/3 full
4” circular opening
85 cables, ¼” diameter

Let’s calculate actual percent fill...
WHAT IS PERCENT FILL?

**Definition:** The cross-sectional area of an opening that is occupied by penetrating items, typically cables. Percent fill is specific to each firestop system.

**What is the actual percent fill?**

**Answer:**

\[
(A_o) = 3.14 \times (2^2) = 12.56 \text{ in}^2
\]

\[
(A_c) = [3.14 \times (0.125^2)] \times 85 = 4.17 \text{ in}^2
\]

\[
(\%f) = (4.17/12.56) \times 100 = 33.2\%
\]

**Warning:** Actual % fill rates are typically half of what they visually appear.
PERCENT FILL HAS AN IMPACT ON FUTURE CAPACITY

Consider
Many firestop solutions limits cable fill to ~ 25% of opening

Challenge
How do you ensure this is not exceeded during actual use?

Solution
When designing networks, consider a firestop system’s percent fill and plan for future MAC work

Design tip: Specify sleeve solutions allowing up to 100% visual fill
HOW TO ADDRESS THIS APPLICATION?

Cable trays through 2 hour fire-rated concrete wall assembly
• System Number, Test Standard
• F-Rating: up to 3 hours
• Concrete Floor or Wall
• Allowable cable type, size
• Allowable opening size
• Allowable percent fill
• Preformed, reusable Firestop product
We learned about firestop system selection. Let’s put our knowledge to the test.

How would you address the following application?
HOW WOULD YOU ADDRESS THIS APPLICATION?

Not all firestop applications are tested
ENGINEERING JUDGMENTS

For conditions where a tested system does not exist, an Engineering Judgment may be needed

Typical Engineering Judgment Conditions:

• Annular space larger/smaller than tested
• Irregular hole shape
• Hole shape different than tested
• More penetrating items or cable % fill in opening than system allows
• Access to one side only
• Structural member penetrations
• Intersections of rated assembly with non-rated assembly

Engineering Judgments should only be designed by qualified firestop manufacturer’s personnel
LET’S REVIEW …

- Test standards & requirements for fire barrier management
  - F-rating, T-rating, etc.
- Elements of a firestop test
- Parameters included in a tested system
- Engineering Judgments
IS THERE A RELATIONSHIP BETWEEN FIRESTOP AND BUILDING PERFORMANCE?

Airflow control in fire barrier management is becoming increasingly important in data centers as it can impact:

- Cooling costs
- Room pressurization
- Dust control
- Damage to expensive equipment
- Noise transmission
- Seismic issues

How does firestop system selection impact these design needs?
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DATA CENTER STAKEHOLDERS

What keeps you up at night?

Owner

Facility Manager

Designer

Auditor

Contractor
DATA CENTER PERFORMANCE CONCERNS

Design & installation considerations should factor firestop airflow control solutions.
AIRBORNE PARTICULATES POSE RISK IN DATA CENTERS

Conductive particles:
- A main cause of conductive dust is zinc whiskers which «grow» on ferrous (steel) surfaces, especially those that have been coated with tin, zinc or cadmium to help protect them from corrosion

Risk:
- Whiskers may physically detach from their surfaces and enter a data center’s airflow causing electronic system failures and short circuits

Non-conductive particulates
- Contamination from construction activities such as cement and drywall dust, or paper and cardboard fibers can cause problems such as optical interference or obstruct cooling airflow, resulting in:

Risk:
- lower thermal efficiency and increased cooling costs
- overheating and equipment failure
- shortened equipment life span
- server failures causing enterprise disruption

“Particulate contamination can increase a data center’s power demand by 2% or more”

Source: “The Threat of Data Center Contamination” - datacenterknowledge
HEALTH, SAFETY, ENVIRONMENTAL (HSE) COMPLIANCE

Leadership in Energy & Environmental Design (LEED V4)

Cradle to Cradle

Living Building Challenge (LBC) Red List

Environmental Protection Agency (EPA) 40CFR Part 59
National Volatile Organic Compound Emission Standards

South Coast Air Quality Mgmt District (SCAQMD)

HSE regulations are increasing and influencing firestop product selection
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### SOLUTIONS: TRADITIONAL FIRESTOP METHODS

<table>
<thead>
<tr>
<th>Sprays, Caulks, Sealants</th>
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</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td>• Economical</td>
</tr>
<tr>
<td>• Versatile, covers multiple applications</td>
</tr>
<tr>
<td>• Multiple listings available</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>• Non re-penetrable</td>
</tr>
<tr>
<td>• Correct installation challenges</td>
</tr>
<tr>
<td>• Mineral wool use … particulates</td>
</tr>
<tr>
<td>• Messy installation</td>
</tr>
<tr>
<td>• Wash-off, shrinkage issues</td>
</tr>
<tr>
<td>• Inspection concerns</td>
</tr>
</tbody>
</table>
SOLUTIONS: “PRE-FORMED” FIRESTOP METHODS

Pre-formed Devices

Advantages
- Re-penetrable
- Reliable, fast installation
- Superior air flow performance vs. traditional methods*
- Pre-cured, always the right amount of product
- Easier to design - BIM
- Inspection advantages – no destructive testing per IBC 2012 (U.S.)

Disadvantages
- Higher material cost (~neutral TIC)

* Always refer to listed system
INITIAL DESIGN CONSIDERATIONS

Performance Requirements

✓ Minimum Code compliance for firestop system rating
✓ Room pressurization
✓ Reduce cooling and heating costs
✓ Prevent airborne disease transmission
✓ Correct installation
✓ Better ensure life safety and property loss prevention
✓ Ease of inspection
✓ Re-penetrability (MAC work)
✓ Labor cost savings

Solution

Traditional Firestop System
(no air leakage performance required)

Pre-formed firestop system
(with superior airflow control testing)
COMPARE AIRFLOW SOLUTIONS

Firestop pre-formed device pathways: air tightness at 40% cable fill

- Device A
- Device B

Testing compared 4" Firestop cable devices with 40% cable fill (57x CAT 6 cables); both devices installed acc. to manufacturer IFU.
Leakage measured @ 21 °C, 50 - 57% RH and tested according to EN 1026.
Airflow in [m³/h] measured for over- and under-pressure, chart displays average values.
CLEARLY CONVEY YOUR DESIGN INTENT

- Detail firestop / airflow cable pathways on Datacom or Telecom plans
- Include in Division 26 or 27 specs
- BIM/Revit design
PROCEDURE / PERMIT PROGRAMS

Implementing a firestop cable pathway procedure or “permit program” for ongoing operation of each data center facility is critical.
SUMMARY OF KEY LEARNINGS

• Elements of firestop and compartmentation
• Code and test standard requirements for fire barrier management
• Tested systems and engineering judgments
• Impact of firestop systems in building performance
• Key owner design considerations
• Best design practices
THANK YOU

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