Emerging Fire Protection Challenges with Hot Aisle/Cold Aisle Containment in Data Centers

Steve Carter (ORR Protection Systems)
Jeffery Kidd (Hiller New England Fire Protection)
John Spalding (Healey Fire Protection)
Paul Rivers (3M Company)
Things are changing...

- **Significantly higher rack power densities**
  - Saves on facility space
  - Supports blade server technology
  - Contributes to reduced energy costs

- **New cooling technologies**
  - Supports high density computing
  - Improves cooling efficiencies

- **Challenging the performance of Fire Protection Systems**

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**Survey Results**
In 2 years 25% of all data centers will have an avg. rack density greater than 12kW.

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**Average Rack Density**

<table>
<thead>
<tr>
<th>Rack Density</th>
<th>% of Data Centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 12kW</td>
<td></td>
</tr>
<tr>
<td>12 - 24kW</td>
<td></td>
</tr>
<tr>
<td>&gt; 24kW</td>
<td></td>
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</tbody>
</table>
Cooling the Data Center

- **Traditional Cooling Systems**
  - Hot and cold air mix
  - Requires lots of energy to cool large volume of air

- **Hot Aisle/Cold Aisle Containment Systems**
  - “Contain” the air
  - Separate cool supply air from warm exhaust air
  - Optimize energy efficiency
Cooling the Data Center

**Cold Aisle Containment Systems**
- Position rows with “fronts” facing each other
- Draw cold air from shared aisle

**Hot Aisle Containment Systems**
- Position rows with “rears” facing each other
- Exhaust hot air into shared aisle
Many different approaches...

- **Fixed infrastructure systems**
  - Attach ceiling panels & end-doors to racks
  - Commonly referred to as “Pods”

- **Plastic Curtains**
  - Attach to ceiling
  - Extends to top of racks or floor

- **Additional measures...**
  - Blanking panels
  - Cabling grommets
Many different approaches...

- **Aisle containment may be...**
  - Included in *initial design*
  - *Retrofitted* to existing data center
  - *Modified* over life of data center
Fire Protection in the Data Center

- Pre-Action Sprinkler
- Smoke Detection
- Clean Agent Suppression
5 Fire Protection Challenges

Challenge # 1: Obstructions

*Impacts...*

- Sprinkler spray patterns
- Smoke detection coverage and spacing
- Clean Agent nozzle clearance and coverage
Challenge # 1: Obstructions

Sprinkler spray patterns...

- NFPA 13 Requirements
  - Figure A.8.5.5.1
  - Fixed obstructions > 4 ft.

NFPA 13(2010 Edition)

8.5.5 Obstructions to Sprinkler Discharge.

8.5.5.1* Performance Objective. Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.5.5.2 and 8.5.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard. (See Figure A.8.5.5.1.)
Challenge # 1: Obstructions

Clean Agent nozzles...

- Coverage Area
  - System Mfr. requirements
  - Typical 40 ft. x 40 ft.
Challenge # 1: Obstructions

Clean Agent nozzles...

- Clearance
  - System Mfr. requirements
  - 4 to 6 ft. clearance

Example Manufacturer Design Manual:

Walls and Obstructions:

<Agent> discharged from the nozzle requires a certain length from the nozzle to atomize into a gas. If the <Agent> comes into contact with a surface before the agent is fully atomized, frosting can occur. As a result, the concentration throughout the enclosure will be less than required to appropriately protect the space. Therefore, nozzles must be located with at least four to six feet of clearance from walls and/or significant obstructions (ex. high rise racking and columns). If this requirement cannot be met, additional agent may be discharged to compensate for this agent "loss".
5 Fire Protection Challenges

**Challenge # 2: Inadequate automatic obstruction removal**

*Impacts...*

- Sprinkler spray patterns
- Clean Agent nozzle clearance and coverage
- Clean Agent concentration development
Challenge # 2: Inadequate automatic obstruction removal

What does the product literature say about Fire Protection?

“Hardware is designed so that curtains fall away in the case of a fire, allowing sprinklers full operating range.”

“Should an event occur that would set off a water sprinkler system, the UL listed fusible links will melt... will fall harmlessly away from the ceiling down to the floor.”
5 Fire Protection Challenges

**Challenge # 2:** Inadequate automatic obstruction removal

*Will there be reliable and adequate removal prior to sprinkler operation?*
5 Fire Protection Challenges

Challenge # 2: Inadequate automatic obstruction removal

- Doesn’t address Clean Agent Extinguishing Systems
  - Typically smoke *not* heat detection
  - Operates long before elevated ceiling temperatures
Challenge # 3: Multiple areas of containment (separate volumes)

Impacts...

- Clean Agent concentration development
- Smoke Detection coverage and spacing
- Smoke Detection cross-zoning sequences
**Challenge # 3: Multiple areas of containment (separate volumes)**

*Will the Clean Agent concentration develop within each area of containment?*

- New NFPA 2001 requirement
  - “Each volume...”
  - Provide detectors, piping and nozzles

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5.3.5.2 Each volume, room, and raised or sunken floor to be protected shall be provided with detectors, piping network, and nozzles.
Challenge # 3: Multiple areas of containment (separate volumes)

Cross-Zone Smoke Detection...

- **Conventional FACP**
  - 2 circuits (zones)
  - May require 2 detector types
- **Addressable FACP**
  - “Counting” Zone
  - May require 2 detector types
Challenge # 4: High temperatures

Impacts...

- Sprinkler temperature rating
- Smoke Detection operating temperature range
- Clean Agent concentration adjustments
5 Fire Protection Challenges

**Challenge # 5:** High airflow velocities

*Impacts...*

- Smoke Detection performance
- Clean Agent dispersion
NFPA 75

- Standard for the Protection of Information Technology Equipment
  - Next Edition 2012
  - NITMAM Deadline Oct. 21, 2011
- New Section 5.7 Aisle Containment and Hot Air Collar Systems for ITE
- Challenges addressed with 8 new requirements

3.3.10 Information Technology Equipment System. Any electronic digital or analog computer, along with all peripheral support, memory, programming, or other directly associated equipment, records, storage, and activities.
NFPA 75

1. Constructed with Fire Retardant Materials
   - Flame spread index < 50
   - Smoke development < 450

5.7.3 Elements of aisle containment and hot air collars shall be constructed of materials that have a maximum flame spread index of 50 and a maximum smoke development of 450 in accordance with one or more of the following:

(2) UL 723, Standard for Test for Surface Burning Characteristics of Building Materials.
Not classified as plenum

- Aisle containment or hot air collars
- Space above raised floor and below above ceiling
- “Plenum-rated” construction materials are unnecessary

5.7.4 Aisle containment systems and hot air collars shall not be considered to be plenums.
Rated for temperature max of hot aisles

- **Hot Aisles:**
  - Normal operation up to 120 °F
  - HVAC failure possible 150 °F
- **Smoke Detection:**
  - Typical max. operating temp. of 100 °F or 120 °F
- **Heat Detection / Sprinklers:**
  - Consider when selecting temp. rating
- **Suppression:**
  - Consider temperature adjustments for agent calculations

5.7.6* Detection and suppression components within aisle containment systems shall be rated for the intended temperatures of hot aisles when installed in those locations.
Retrofitted Aisle Containment: Consider Existing Fire Systems

- Maintain compliance with applicable NFPA codes and standards
- Evaluate design
- Modify installation
- Reacceptance test

5.7.7* Where aisle containment systems are installed, the existing suppression and detection systems shall be evaluated, modified and tested as necessary to maintain compliance with the applicable codes and standards.
NFPA 75

5 Sprinkler Systems: Address Obstructions

- Follow NFPA 13 requirements
- Modify sprinkler system as necessary

5.7.8 Where automatic sprinklers are present and the application of aisle containment systems or hot air collars creates obstructions to proper operation of sprinkler systems, the sprinkler system shall be modified as necessary to comply with NFPA 13.
Sprinkler Systems: Automatic Obstruction Removal only if...

a. Removed by Smoke Detection (Thermal Mechanical and Fusible Links not permitted)
b. Releasing devices are listed for the purpose
c. Remove all obstructions for entire suppression zone
d. Removal doesn’t impact egress (per NFPA 101)
e. Doesn’t lower intended level of protection

5.7.8.1* Sprinkler system modifications shall not be required where all of the following conditions are met:...
If the aisle containment prevents the gaseous suppression system, where present, from producing the required design concentrations throughout the entire volume served, the gaseous suppression system shall be modified to produce the required concentration throughout the volume served.
8 Gaseous Suppression Systems: Automatic Obstruction Removal only if...

- Removed by Smoke Detection
  (Thermal Mechanical and Fusible Links not permitted)
- Releasing devices are listed for the purpose
- Removed prior to agent discharge
- Remove all obstructions for entire suppression zone
- Removal doesn’t impact egress (per NFPA 101)
- Doesn’t lower intended level of protection

5.7.10.1* Gaseous suppression system modifications shall not be required where all of the following conditions are met:...
Smoke Detection Performance

- **Really High Airflow Rates**
  - Possible 500 to 1,000 ACH
  - Dilutes smoke
  - High velocity air movement

- **Need for better design guidance**
  - NFPA 72 tables stop at 60 ACH
  - Fire Protection Research Foundation Project

  ✓ *Develop modeling tools for reliable analysis of detection performance in high airflow conditions.*

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**NFPA 72 (2010) – Annex B**

**B4.5** There are currently no quantitative methods for estimating either smoke dilution or airflow effects on locating smoke detectors.
The mission of FSSA is to promote the use of, and be the leading recognized authority on, special hazard fire protection systems; employing existing and new technologies to safeguard people, high-value assets and the environment. FSSA members are dedicated to the highest level of safety, reliability and effectiveness of special hazards fire suppression.
Typical Designs

- **Cold Aisle Containment System (CACS)**

  - Delivers cold air through raised floor space supplied to cold aisle through perforated floor tiles.
  - Traditional CRAC units [2]
  - Remainder of room is large hot air return [1]
  - Optional Hot Air Collar for delivery directly to return air plenum [1]
  - Optional In-Row Cooling [2]
Typical Designs

- **Hot Aisle Containment System (HACS)**
  - Cold air supplied through perforated floor tiles
  - Collect exhaust air in hot aisle
  - Traditional CRAC units [2]
  - [2] Optional In-Row Cooling