

Complying With NFPA's Aisle Containment Requirements

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Aisle containment is one of the most common energy-efficiency strategies deployed in data centers, both new and existing. Through the segregation of airstreams, containment systems offer potential advances to energy-efficiency and PUE scores. However, they are also introducing hazards as it relates to fire protection when not properly implemented.

The National Fire Protection Association (NFPA) updated the requirements for aisle containment fire protection for data centers in the 2012 edition of NFPA Standard 76, *Standard for the Fire Protection of Telecommunications Facilities*, and the 2013 edition of NFPA Standard 75, *Standard for Fire Protection of Information Technology Equipment*.

Today, although these requirements can have a profound impact on both retrofits and new construction of aisle containment in data centers, they are still not broadly understood by the industry.

The necessary fire protection retrofits can also have an impact on the potential return on investment (ROI) of aisle containment retrofits, making the evaluations and options to consider more challenging.

Mechanical, electrical, and plumbing (MEP) consultants, owners, and manufacturers alike are continuing to implement aisle containment, unaware that their energy savings activities are creating significant hazards and risks to the data center operations.

This column outlines some historical context and explains the new requirements for aisle containment fire protection.

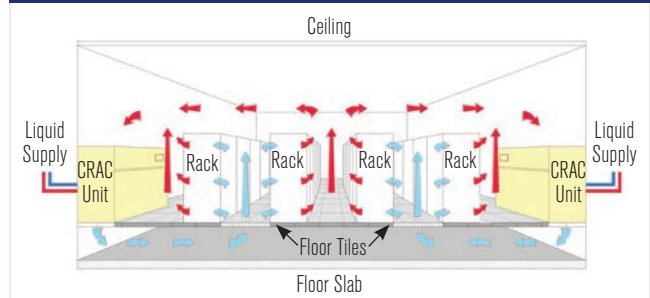
Background

Legacy data centers operated without aisle containment (Figure 1). This resulted in the mixing of the hot and cold airstreams in the space, diluting (decreasing) the return air temperatures to the HVAC equipment.

The lower return air temperatures have a direct effect on the HVAC equipment energy efficiency.

Hot aisle containment systems (HACS) and cold aisle containment systems (CACS) were introduced to

FIGURE 1 Typical data center with no aisle containment (graphic from ASHRAE TC 9.9's *Datacom Equipment Power Trends and Cooling Applications*).



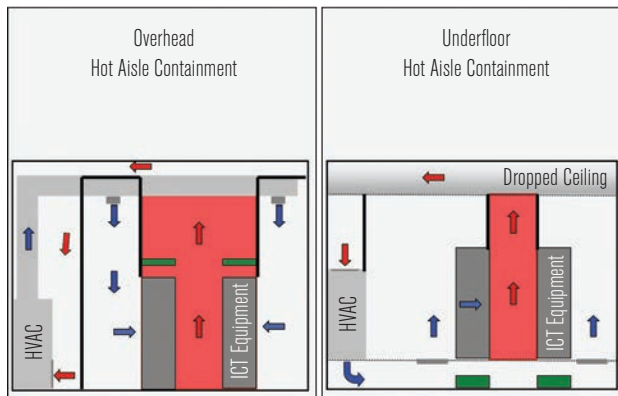
“contain” the airflows and prevent the mixing (Figures 2 and 3). A third version of containment colloquially known as “chimneys” (also called “hot collars” in the NFPA standards to avoid confusion over fireplace chimneys) was also introduced by the industry (Figure 4).

By separating the hot and cold air, the higher temperatures at the top end of the ASHRAE TC 9.9's *Thermal Guidelines for Data Processing Environments* recommended envelope (80.6°F [27°C]) could be more confidently delivered to the inlet of the IT equipment (i.e., lower risk of dilution meant that source supply air temperatures from the HVAC equipment could be increased and did not have to compensate for heat gain through mixed air conditions prior to entering the IT equipment inlet).

This higher supply air inlet temperature, in turn, would allow the temperature of the return air discharging the IT equipment to also be higher. And, the segregation of the airstreams means that this warmer

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FIGURE 2 Hot aisle containment systems (HACS).



return air could get to the HVAC equipment without further dilution. This warmer air enables optimization of the energy efficiency by enabling:

- Lower HVAC and IT fan energy in select cases;
- Increased compressor efficiency and capacity; and
- More economizer hours of operation.

Containment provided a solution to the energy problems in data centers, but it simultaneously introduced problems for fire protection.

Fire Protection in Data Centers

Fire protection in data centers involves more than just detection and suppression. Like any building, the selection and placement of suppression and detection is predicated upon the types of fuel loads, prevention measures that can be expected and even the response type and/or time from the fire departments or operations.

Aisle containment introduced a new set of fire protection challenges in data centers. Those challenges included the following:

Prevention

- Materials of construction
- Listings, combustibility, flammability, etc.
- Plenums issues

Detection

- Detector locations
- Response times
- Temperatures on detectors

Suppression

- Obstructions for sprinklers
- Gas concentrations
- Removable obstructions

FIGURE 3 Cold aisle containment systems (CACS).

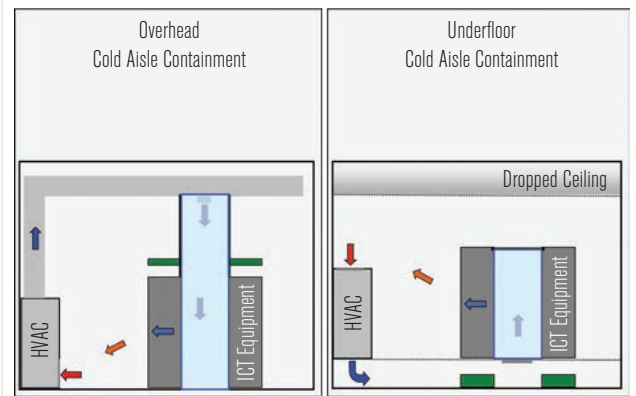
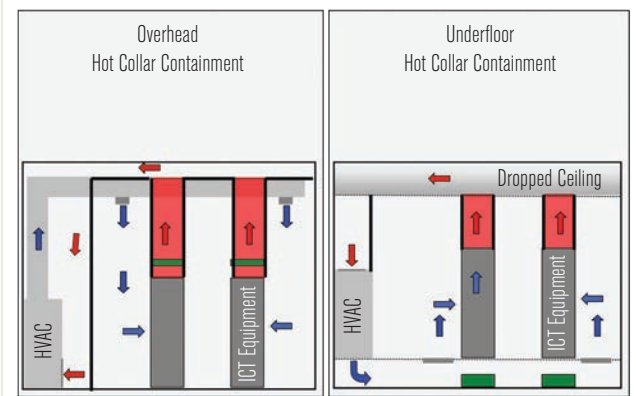


FIGURE 4 Hot collar (chimney)



Response

- Impact to detection response
- Impact on suppression response
- First responders ability to find fire

Photo 1 shows perhaps one of the most obvious problems introduced by the presence of aisle containment. The containment has created a new barrier between the detection and the suppression. If this were a double-interlocked pre-action system, where the suppression is activated by the detection, this could present a significant delay in the response to the system.

Like all fire protection, the suppression systems are designed to cover a small area, quickly, before the fire grows out of control. If the fire is permitted to burn too long before the suppression is activated, the suppression may quickly get overwhelmed before the fire department can respond to extinguish the fire, resulting in a complete fire loss.

Photo 2 shows a good representation of a scenario where a fire could be permitted to grow too large before the suppression can activate. Note the lack of

sprinkler heads within the aisle containment itself. If a fire occurs within the contained volume, it can grow much larger than had the curtain obstructions not been present.

Aisle Containment Challenges

Aisle containment has introduced a number of challenges to the fundamental NFPA requirements of fire protection in a data center. We'll cover each of the five main categories in this section as follows:

1. Obstructions;
2. Inadequate automatic obstruction removal;
3. Multiple volumes;
4. Higher temperatures; and
5. High airflow velocities and air changes per hour.

Obstructions

Beginning with obstructions, aisle containment introduced barriers or obstructions to both detection and suppression systems by design. NFPA standards, manufacturer's installation instructions, and UL listings dictate certain requirements for placement suppression and detection in and around obstructions. However, those instructions did not explicitly address aisle containment previously.

Obstructions impact suppression and detection in the following ways:

- Sprinkler spray patterns and fire growth;
- Smoke detection coverage and spacing; and
- Gaseous agent nozzle clearances, coverage, and dispersion.

Typical gaseous agent nozzles provide coverage for a 40 ft × 40 ft (12 m × 12 m) area. Those same nozzles require a 4 ft to 6 ft (1 m to 2 m)

PHOTO 1 Separation of detection and suppression from aisle containment.



clearance from any obstructions to avoid dispersion problems and allow proper mixing with the air.

Likewise, sprinklers typically have a 16 ft (5 m) diameter spray pattern and have a minimum 4 ft (1 m) clearance requirement from nearby obstructions per NFPA Standard 13-2013, *Standard for the Installation of Sprinkler Systems*, Section 8.5.5.

Inadequate Automatic Obstruction Removal

The second challenge was the inadequate automatic obstruction removal. Initially manufacturers designed containment systems with "fusible links," thinking this was the solution to the obstruction problem (Figure 5). If those fusible links did not have the expected response from a fire, the impacts were the same as the obstructions above.

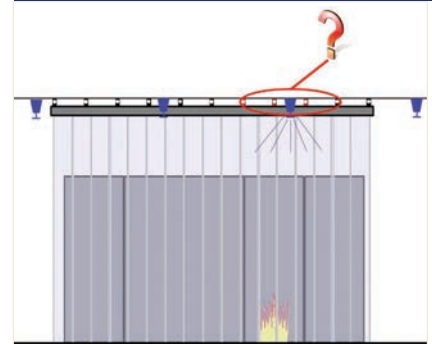
Fundamentally, fusible links are used on fire dampers and sprinkler heads where their response was predictable due to the single point necessary for initiating the system.

When used on curtains, multiple fusible links would have to operate to remove the obstruction. This resulted in an unpredictable response and time delays that could

PHOTO 2 Separation of suppression from aisles.



FIGURE 5 Fusible link curtains.



create larger fire hazards than the suppression or extinguishing design could handle.

Multiple Volumes

The third challenge reviewed by the NFPA committees was the issue of multiple volumes or enclosed spaces within a room. The impacts considered were:

- Gaseous agent concentration development;
- Smoke detection coverage and spacing; and
- Smoke detection cross-zoning sequences.

Gas suppression systems, for example, are required to achieve their design concentrations throughout the entire "volume"

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within a short specified time according to their UL listings. Aisle containment introduces some unknowns about the proper concentrations being achieved uniformly throughout the space.

In addition, those systems typically require cross-zoning or multiple detectors to initiate before the release sequence begins. If detectors cross the containment boundary, the delays introduced could be unacceptable for proper suppression performance.

Higher Temperatures

The fourth challenge consisted of higher temperatures created by aisle containment systems. By design, aisle containment is intended to increase the return temperatures to the HVAC systems. Concurrently, ASHRAE TC 9.9 had revised the recommended and allowable temperature ranges to a much wider envelope. The impacts of these higher temperatures include:

- Sprinkler temperature rating;

- Smoke detection operating temperature range; and
- Possible gaseous agent concentration adjustments.

The combination meant that hot aisle or “chimney” temperatures could be in excess of 100°F (38°C), which was the default temperature rating limit of most detection equipment. This temperature also coincides with the maximum ceiling temperatures for ordinary rated sprinkler heads (135°F [57°C] rating). As a result, some data centers would have to consider intermediate rated sprinkler heads.

High Airflow Velocities and Air Changes Per Hour

The fifth and final challenge is the introduction of higher air change rates and higher airflow velocities introduced by some forms of containment, particularly chimneys. This particular challenge was ultimately determined to be a problem in modern day data centers regardless of aisle containment.

The higher air change rates have an impact on:

- Smoke detection performance; and
- Gaseous agent dispersion and performance.

Already, some data center end users have noticed the change in smoke detector response brought about by aisle containment retrofits. Some have argued that NFPA 76 already has the answer to this problem through guidance that suggests the return air at the HVAC is the best location for smoke detection in high airflow environments.

NFPA Standards for Aisle Containment

Most of the above challenges have now been addressed in the updated versions of NFPA Standard 75 (2013) and Standard 76 (2012). In the following sections we recap some, but not all, of the important updates to these standards by highlighting one or more requirements from each of them. Readers are strongly encouraged to purchase copies of these standards and review the new requirements in their entirety.

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Of importance are several new definitions, including a definition for aisle containment as follows:

*NFPA 75—3.4.2 Aisle Containment. An HVAC method deployed in the occupied area of an air-cooled ITE space utilizing physical separation of hot exhaust air from cooler intake air between equipment cabinets, rows of ITE, or associated power and cooling infrastructure; containment is typically above and at both ends of a hot aisle or a cold aisle, in whole or part.**

The committees added requirements for the materials of construction, consistent with the International Building Code (IBC), which dictated fire retardant materials as follows:

- Flame spread index <50; and
- Smoke development <450.

NFPA 76—8.2.3.3 Elements of aisle containment and hot air collars shall be constructed of noncombustible materials, limited combustible materials, or 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:

(1) ASTM E 84, Standard Test Method for Surface Burning Characteristics of Building Materials

(2) UL723, Standard for Test for Surface Burning Characteristics of Building Materials.

Of particular importance was how to deal with containment in terms of the plenum classification. After a lot of historical review, the committees determined that aisle containment was readily accessible by first responders and, therefore, not to be classified as plenums like the raised floor space or ceiling spaces.

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*NFPA 76—8.2.3.4 Aisle containment systems and hot air collars shall not be considered to be plenums.**

New requirements for temperature ratings were introduced as follows:

*NFPA 76—8.2.3.6 Smoke detectors within aisle containment systems shall be rated for the intended temperatures of hot aisles when installed in those locations.**

New requirements for retrofitted aisle containment systems have to consider existing fire systems impacts as follows:

*NFPA 76—8.2.3.7 Where aisle containment systems are installed, the existing suppression and detection systems shall be evaluated to determine if it is necessary to modify them in order to maintain compliance with the applicable codes and standards.**

Where sprinkler systems are existing, they must be modified to comply with the obstruction requirements listed in NFPA 13.

NFPA 76—8.2.3.8 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 to comply with NFPA 13.

Perhaps the most significant change involves new requirements for automatic obstruction removal to comply with several new sections (now prohibiting any fusible link means) as follows:

*NFPA 75—5.6.8.1 Sprinkler system modifications shall not be required where all of the following conditions are met.**

*(1) An automatic means of smoke detection initiates the removal of the obstruction prior to operation of the suppression system.**

(2) Removing the obstruction or a portion thereof does not compromise means of egress per NFPA 101, Life Safety Code.

(3) The design and installation of removable obstruction elements does not diminish the level of protection below that which existed prior to the installation of the aisle containment or hot air collar.

*(4) The releasing devices are listed for the application.**

(5) All removable obstructions are removed for the entire suppression zone.

Gaseous suppression systems must also be modified to ensure the required concentrations are achieved throughout the entire protected volume (per NFPA Standard 2001-2015, *Standard on Clean Agent Fire Extinguishing Systems*) as follows:

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NFPA 75—5.6.9 Where gaseous suppression systems are present, they shall be designed to develop the required concentration of agent for the entire volume they serve, in accordance with NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems.

5.6.10 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.

Still, these changes did not answer how to address the high airflow velocities and air changes per hour. Currently, there is ongoing research through the Fire Protection Research Foundation to address this and related unanswered questions brought about by the introduction of aisle containment and the higher densities in today's data centers.

Closing Comments

Aisle containment introduced a great solution to the energy-efficiency challenge. Hot aisle containment systems (HACS), cold aisle containment systems (CACS), and

chimneys reduce the mixing of cold and hot air in the data center, which enables energy savings at the HVAC equipment. Aisle containment has become a standard practice in the industry, both retrofits and new construction, as a result.

However, aisle containment has introduced challenges to fire protection requirements and fire safety in data centers. NFPA released updated standards in 2012 and 2013 aimed at solving these fire protection challenges introduced with aisle containment.

These new requirements have dispelled misconceptions over what is considered acceptable fire protection practice in data center when using aisle containment. Things like fusible link curtains are no longer considered an acceptable practice. Meanwhile, the committees have clarified that aisle containment is not considered a plenum.

Through a proactive review of these new standards, MEP consultants, owners, and manufacturers can ensure that their next aisle containment project meets both energy objectives and fire-safety requirements. ■

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