# Implementing Hot and Cold Air Containment in Existing Data Centers

## White Paper 153

Revision 0

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## Executive summary

Containment solutions can eliminate hot spots and provide energy savings over traditional uncontained data center designs. The best containment solution for an existing facility will depend on the constraints of the facility. While ducted hot aisle containment is preferred for highest efficiency, cold aisle containment tends to be easier and more cost effective for facilities with existing raised floor air distribution. This paper investigates the constraints, reviews all available containment methods, and provides recommendations for determining the best containment approach.

## Introduction

Data center containment strategies can greatly improve the predictability and efficiency of traditional data center cooling systems. In fact, The Green Grid views an air management strategy as "the starting point when implementing a data center energy savings program"[1]. However, most existing data centers are constrained to certain types of containment strategies. Note that this paper is for existing data centers. For information on containment for new data centers, see White Paper 135, *Impact of Hot and Cold Aisle Containment on Data Center Temperature and Efficiency.*

Containment, in general, provides some important benefits for an existing data center:

- **Reliability will be increased** by preventing hot spots. Containment can prevent the mixing between hot air and cold air, which can provide a lower uniform IT inlet air temperature for IT equipment to reduce hot spots.
- **Rack power density can be increased** by eliminating hot air recirculation. For a traditional, uncontained raised-floor data center, rack power densities are typically kept below 6kW/rack average to help prevent hot IT exhaust air from re-circulating back into the front of the IT equipment. After containing and sealing the holes to eliminate hot air recirculation paths, rack power densities can increase without the threat of hotspots.
- **Cooling capacity will be increased** by increasing the "deltaT" (i.e. the difference in temperature between the cold supply air and the hot return air) across cooling units. For a traditional, uncontained raised-floor data center, more than 50% of the cold air supplied from the cooling units will bypass back to these units directly as a result of any leakage paths that exist. After contained, supply air will instead go through IT equipment where it will absorb heat energy and transport it back to the cooling units. The higher exhaust air temperatures will lead to a bigger deltaT across cooling units, which can increase the cooling capacity about 20% or more.
- **Cooling system energy savings will be increased** by being able to shut down cooling units that become redundant as the result of effectively separating hot and cold air streams through the use of an air containment system. Additionally, economizer mode hours are increased. When the outdoor temperature is lower than the indoor temperature, the cooling system compressors don't need to work to reject heat to the outdoors.

**This paper describes containment** methods available today, investigates constraints and user's preferences, provides guidelines for determining the appropriate containment approach, and emphasizes the importance of ongoing air management maintenance.

## Two methods for deploying containment

Hot air and cold air containment are the two high-level methods for an air management strategy, and both of them provide significant energy savings over traditional, uncontained configurations. Why do we need to decide between hot air and cold air containment? Why not just contain both and run the rest of the room on building air? Containing both air streams provides no significant benefit except in cases where IT cabinets are located in a harsh environment (i.e. manufacturing floor). Containing a single air stream is enough to prevent hot and cold air mixing. For more information about this topic, please see White Paper 55, *The Different Types of Air Distribution for IT Environments*.

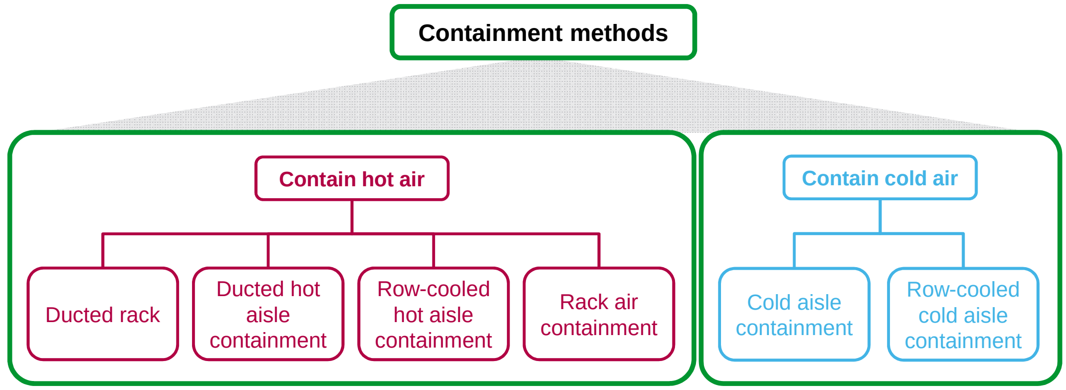
**Figure 1** shows the types of hot and cold air containment. Which type of air containment is a better choice for existing data centers? This question has raised a lot of discussions among manufacturers, consultants, and end users. In reality, the best containment type will largely depend on the constraints of the facility. Some IT managers will have a choice between two

[1] *http://www.thegreengrid.org/~/media/WhitePapers/White_Paper_11_-Seven_Strategies_to_Cooling_21_October_2008.ashx?lang=en* (accessed 5/23/2012)

or more types, while others may be restricted to a single type of hot or cold air containment due to physical constraints.

**Figure 1**

*Types of air containment*




The following sections will describe the logical steps for deciding which solutions to implement starting with assessing the facility, reviewing all potential solutions, and selecting the right containment solution.

## Assess the facility

An assessment of the existing conditions of the facility is essential to choosing the right containment solution for a given data center and should be done in advance. During an assessment, constraints are noted. Constraints are obstacles that cannot be overcome, or can only be changed at great expense or with unacceptable consequences. For example, raising the existing data center ceiling height is not realistic and is considered as a constraint. The containment may lead to the failure of existing fire detection / suppression system, which is an unacceptable consequence and is also considered as a constraint. Each constraint must be examined to determine its effect on the containment deployment, and whether it is worth the financial cost or other negative consequence of removing it.

For complex projects, expert review is essential in order to check the cost or other consequences of constraints, which end users may not be aware of. Once the consequences of certain constraints are clear, it is important to review them and determine if they can be refined or adjusted to achieve a better overall result. Existing facilities have various constraints that are dictated by circumstances and which are not under the control of the customer. Constraints include facility limitations, regulatory limitations, or unchangeable business requirements. Some examples of these constraints include:

### IT equipment arrangement

Data centers that lack a uniform and consistent hot / cold aisle arrangement severely limit the choice of containment solutions. A hot / cold aisle layout along with proper aisle widths is essential conditions for aisle containment deployment. In the long term, it is recommended that users eventually migrate to a hot / cold aisle arrangement for their IT equipment in order to broaden the choice of containment solutions.

### Ceiling height

The constraint here can be that there is not enough ceiling height to install a drop ceiling for use as an air return plenum. This is normally an essential condition for ducted hot aisle containment or ducted rack solutions.

## Raised floor plenum depth

This constraint is present when the raised floor plenum depth is too small to provide sufficient cooling air volume to any higher density racks.  This can be due to a poorly-designed raised floor and or due to the resistance caused by cabling, conduit, and piping located under the raised floor.  This will limit the ability to adopt a cold aisle containment solution.

## Column location

A support column normally has two main locations (within a row of racks or aligning with a rack aisle) in a data center, which may cause interference between the columns and aisle containment panels.

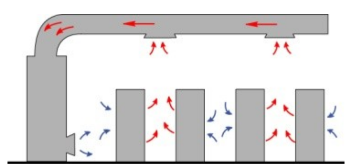
## Cabling

Overhead cabling can possibly interfere with ducted containment panels.  This constraint may eliminate ducted hot aisle containment or ducted racks as possible options.  If cabling is routed across the aisle in a single location, the ducted solutions may still be possible.

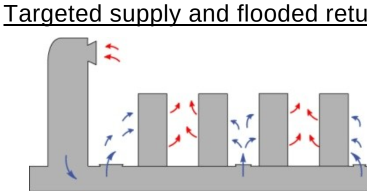
## Air distribution type[2]

It's normally difficult to change the air distribution type in an existing data center, and yet the air distribution type will be also critical in determining the level of investment and complexity involved in deploying a particular containment method.  For example, it will be easy and cost effective to deploy hot air containment for data centers with targeted return and flooded supply, while it's easy and cost effective to deploy cold air containment for data centers with targeted supply and flooded return.

Targeted return and flooded supply



Targeted supply and flooded return



## Considerations for lighting

Creating a containment space in an existing data center can lead to poor lighting inside of the space.  Although some containment solutions have used transparent or translucent ceiling panels to let existing light in, it will reduce the amount of light, especially if the panels get dirty.

## Considerations for fire detection and suppression system

After containment is implemented, high volumes of air will be directed at IT equipment and back to the cooling units.  This high airflow pattern can dilute smoke and will, therefore, pose significant challenges for having adequate fire detection and suppression.  Detector actuation is affected by local airflow patterns and by smoke dilution, and suppression agent dispersion is affected by the volume of airflow and by obstructions associated with the equipment used to create the containment solutions.

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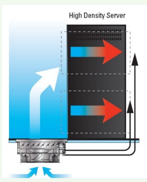
[2] See White Paper 55, *The Different Types of Air Distribution for IT Environments*, for more information.

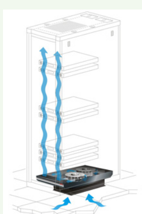
### Active tiles

Active tiles are a means to enhancing the effectiveness of a raised floor. This device can control the airflow rate based on the exhaust air temperature by controlling the RPM (revolutions per minute) of the fans. It can be used to support up to 12 kW per rack without containment by increasing the airflow rate. The following picture shows an example of the application.




### Air distribution units

Air distribution units (ADU) fit into the rack's bottom U spaces and direct the airflow vertically to create a cold air "curtain" between the front door and the servers. They can support up to 4kW per rack.



## Considerations during a cooling outage

Containment solutions have some influence on ride through time in the event of a cooling system outage. For more information about this topic, please see White Paper 179, *Data Center Temperature Rise During a Cooling System Outage*.

## Considerations for working conditions around IT equipment

After containing the cold air, the rest of the room will, in effect, become a large hot-air return plenum, with the same temperature as the hot aisle. This can be problematic for IT personnel who are permanently stationed at a desk in the data center. In addition to human comfort, the reliability for any IT equipment located on the data center perimeter (e.g. storage gear) may also be negatively affected. This uncontained area may also violate OSHA regulations or ISO 7243 guidelines for exceeding wet-bulb globe temperature.

## Likely assessments and solutions

The following bullets provide a summary of some of the likely assessments and proposed solutions.

- The data center is set up in a hot aisle / cold aisle arrangement. The raised floor is used as a supply air plenum. The height between the top of the rack and ceiling is less than 508 mm (20 inches). If this represents the assessed data center, see the solution named "*Cold aisle containment system*" below. Note that active tiles or air distribution units may be required if high density racks cannot draw or pull enough cool air from the raised floor. Active tiles allow airflow rate adjustment for particular racks (see side bar).
- The data center is set up in a hot aisle / cold aisle arrangement. There is no raised floor. The drop ceiling is used as a return air plenum, and the height between the top of rack and ceiling is greater than 508 mm (20 inches). If this represents the assessed data center, see the solution named "*Ducted hot aisle containment system*" below.
- The data center is not set up in a hot aisle / cold aisle arrangement. The drop ceiling is used as a return air plenum, and the height between the top of rack and ceiling is greater than 508 mm (20 inches). There are scattered high density racks. If this represents the assessed data center, see the solution named "*Ducted rack*" below.
- The data center is not set up in a hot aisle / cold aisle arrangement. The height between the top of rack and ceiling is less than 508mm (20 inches). There are scattered high density racks. If this represents the assessed data center, see the solution named "*Rack air containment system*" below.

# Review all potential solutions

This section describes each of the containment solutions and explains when it is recommended to deploy, when is it less than optimal to deploy, and describes important considerations for deploying it including payback period. The most common solutions are presented first. It is important to note that the payback periods are based on an equivalent non-contained data center which will inevitably have hot spots that increase in severity with the increase in average rack density. All of these containment solutions will allow for higher rack power densities, allow for increased cooling system energy savings, eliminate hot spots, and increase cooling unit capacity, which in addition to payback period, should all factor into justifying the cost of a solution.

While it is acceptable to implement both types of cold air containment or multiple types of hot air containment, **hot and cold air containment types should never be mixed. Mixing hot and cold air containment solutions will likely lead to lower cooling system efficiency than can be achieved through either hot OR cold air containment**.

## Cold aisle containment system (CACS)

This containment method applies to a raised floor (room-cooled downflow units) cooling distribution system. CACS encloses the cold aisle, allowing the rest of the room to become a large hot-air return plenum. By containing the cold aisle, the hot and cold air streams are separated (**Figure 2**). For more information about this topic, please see White Paper 135, *Impact of Hot and Cold Aisle Containment on Data Center Temperature and Efficiency*.

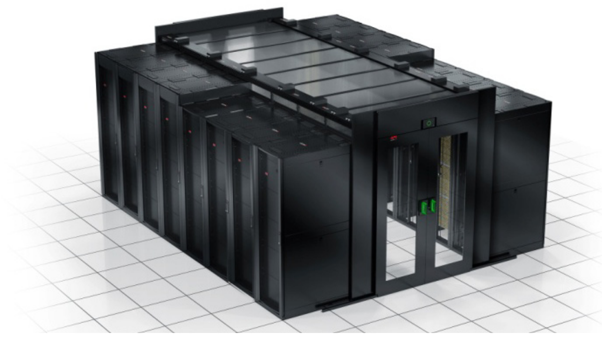


**Figure 2**

*Example of a cold aisle containment system with a room-based cooling approach*
*(Schneider Electric EcoAisle shown)*

**CACS is recommended under the following conditions:**

- When racks and the IT equipment are in a hot aisle / cold aisle arrangement
- When the data center uses a raised floor and flooded return air distribution method
- When there are no stand-alone IT devices (i.e. storage) on the data center perimeter
- When high density racks can't draw or pull enough cool air from the raised floor.
- When the containment project must be completed quickly

**CACS is less than optimal under the following conditions:**

- No hot aisle / cold aisle arrangement and its impractical to migrate to it
- Downflow cooling units are used with hard floor (i.e. flooded supply and flooded return)
- Stand-alone IT devices (i.e. storage) on the data center perimeter
- When inadequate air supplied by perforated tiles due to obstructions under the floor (i.e. wiring and piping)
- When the data center is frequently occupied by personnel (hot work environment)

**Considerations when deploying CACS:**

- Lower number of free cooling hours are possible due to lower cooling unit supply air temperature (with the assumption that the cooling unit supply temperature is lowered to reduce the hot aisle temperature in the working environment where employees may be stationed)
- Isolation partitions should be installed in front of perimeter IT equipment (i.e. storage, tape libraries) exposed to high temperatures in the uncontained area
- Some customized containment solutions may be required due to building column constraints, IT racks used from a lot of different vendors, or odd rack/row number
- Active tiles may be required to add more air pressure to shallow raised floors
- Additional lighting fixtures may be required in the cold aisle
- Authority having jurisdiction (AHJ) may require fire detection and suppression in the cold aisle or other provisions discussed later in this paper
- Perforated tiles or other supplemental cooling should be placed near stand-alone IT devices (i.e. storage) on the data center perimeter to prevent overheating
- Payback period ranges from months to a few years depending on how many cooling units can be turned off and if active tiles are required

## Ducted hot aisle containment system (Ducted HACS)

This containment method can be used with either a raised floor or a hard floor-based (room-cooled) air distribution system. Ducted HACS encloses the hot aisle, allowing the rest of the data center to become a large cold-air plenum (**Figure 3**). For more information about this topic, please see White Paper 182, *The Use of Ducted Air Containment Systems in Data Centers*.

**Figure 3**

*Example of a ducted hot aisle containment system with a room-based cooling approach*
*(Schneider Electric EcoAisle shown)*

**Ducted HACS is recommended under the following conditions:**

- When racks and IT equipment are arranged in a hot/cold aisle arrangement
- When there is a drop ceiling hot air return plenum
- When there are stand-alone IT devices (e.g. storage systems) on the data center perimeter
- Data center is frequently occupied by personnel (will not create a hot working environment in the uncontained area)

**Ducted HACS is less than optimal under the following conditions:**

- There is no hot aisle / cold aisle arrangement and it is impractical to migrate to it
- There is no drop ceiling (so this would require special return ductwork), or there's not enough ceiling height (used to install a return air plenum)

**Considerations when deploying ducted HACS:**

- The duct may interfere with existing systems (i.e. cabling, lighting, fire suppression system)
- Longer deployment time for each rack (labor effort is greater)
- Some customized containment solutions may be required due to building column constraints, IT racks used from a lot of different vendors, or odd rack row number
- Additional lighting fixture may be required in hot aisle
- AHJ may require fire detection and suppression in hot aisle or other provisions discussed later in this paper
- Shorter payback period compared with CACS with active tiles but slightly longer payback period compared CACS without active tiles

## Ducted rack

This containment method best applies to environments with scattered high density racks with front-to-back airflow pattern. With this method, a duct is mounted to the back of the rack to contain the hot exhaust air, and then duct it into the drop ceiling. By containing the exhaust airflow path, the hot and cold air streams are separated (**Figure 4)**. For more information about this topic, please see White Paper 182, *The Use of Ducted Air Containment Systems in Data Centers*.

**Figure 4**

*Example of ducted rack air containment method*
*(Schneider Electric Vertical Exhaust Duct shown)*

**Ducted rack is recommended under the following situations:**

- When the data center has a drop ceiling, air return plenum
- When the data center has scattered high density racks (i.e. greater than 6kW)
- When the rack rows have unequal length
- When the rack uses a front-to-back airflow pattern
- No hot aisle / cold aisle arrangement and it is impractical to migrate to it
- The data center is frequently occupied by personnel (ducted rack will not create a hot working environment in either the aisle or in the uncontained area)
- When building columns interfere and prevent aisle containment solutions

**Ducted rack is less than optimal under the following conditions:**

- When the rack is designed for other airflow patterns (i.e. side-to-side)
- There is no drop ceiling (which would require special return ductwork), or the ceiling is too low (required to install a return air plenum)
- The IT racks in place are from a variety of different vendors and, therefore, have varied dimensions and connection interfaces for the ductwork

**Considerations when deploying a ducted rack:**

- Some customized ductwork may be required to match the racks its being attached to
- There is a need to seal the rack rear doors and replace top panels to ensure air streams are contained
- Overhead cabling may interfere with the duct
- Longer deployment time is required for each rack (sealing the rack rear doors, replacing the top panels, etc.)
- If a rack or a row is deployed with ductwork attached to the rack, the lighting may be blocked between the different rack rows
- AHJ requires fire or smoke detectors in the duct
- Wide-spread use of the ducted rack may cause a pressure imbalance inside of the drop ceiling or between the nearby racks
- About the same payback period compared with ducted HACS (from a few months to three years)

### Row-cooled hot aisle containment system (Row-cooled HACS)

This containment solution applies to data centers with existing row-based cooling units but could also serve as a solution for data centers with perimeter cooling units. For data centers with existing in-row cooling units, containment is achieved by simply adding ceiling panels over the aisle. For data centers with existing perimeter cooling units, this containment solution adds cooling units in between racks (**Figure 5**) or over hot aisles. This method should be used when high density racks are added in a low density data center, and when all racks are in some form of hot aisle containment. For more information see White Paper 134, *Deploying High-Density Pods in a Low-Density Data Center*.

**Figure 5**

*Example of a prepackaged row-cooled hot aisle containment system*
*(Schneider Electric EcoAisle shown)*

**Row-cooled HACS is recommended under the following conditions:**

- When in-row cooling units are already deployed
- When racks and IT equipment is arranged in a hot aisle / cold aisle arrangement
- When both cold aisle containment and ducted hot aisle containment are less than optimal choices (i.e. overhead cabling interferes with ducted containment panels)
- When higher density racks are being added to an existing lower density data center
- In cases where floor space must be conserved (consume the same space as two rows of low density racks)
- Data center is frequently occupied by personnel (will not create a hot working environment in the uncontained area)
- When containment project needs to be completed quickly (i.e. prepackaged solution can reduce the deployment time)

**Row-cooled HACS is less than optimal under the following conditions:**

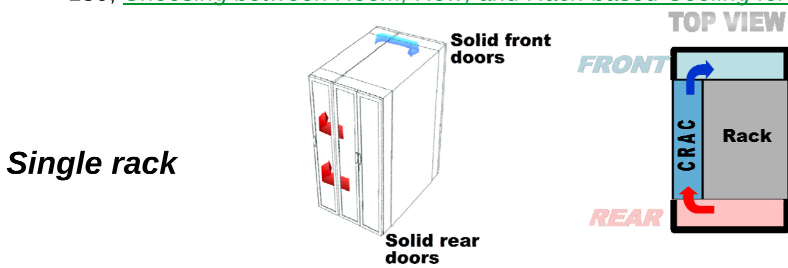
- No hot aisle / cold aisle arrangement and it is impractical to migrate to it
- Unable to move IT racks within rows in order to insert row-based cooling units
- Extra data center floor space is unavailable to deploy a new rack pod

**Considerations when deploying row-cooled HACS:**

- Adding row-based cooling units will raise costs
- Some customized containment solutions may be required due to building column constraints, IT racks used from a lot of different vendors, or odd rack row number
- Customized containment solutions may be required in cases where IT racks are used from a variety of different vendors, or when there is an odd number of racks or rows
- Additional lighting fixture may be required in hot aisle
- AHJ may require fire detection and suppression in hot aisle or other provisions discussed later in this paper
- Payback period about 6 months to 2 years when row-based cooling units pre-exist and several years if row-based cooling units must be purchased

## Rack air containment system (RACS)

This containment method is an ideal solution for use with very high density racks by integrating rack-based cooling units with the racks, forcing the air to circulate only inside of the containment (**Figure 6**). For more information about this topic, please see White Paper 130, *Choosing between Room, Row, and Rack-based Cooling for Data Centers*.



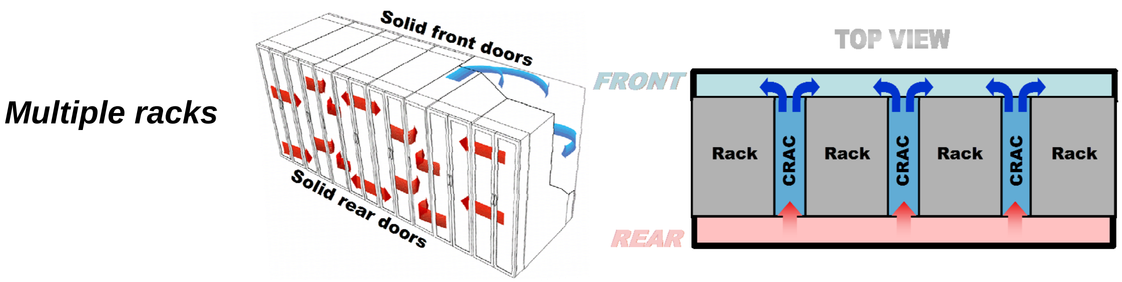




**Figure 6**

*Example of a rack air containment system for a single rack or multiple racks*

**RACS is recommended under the following conditions:**

- When there are scattered high density racks, or sound attenuation is required
- For complete isolation in cases such as stand-alone open data center environments, or mixed layouts, or to prevent exposure to hot aisles.
- In wiring closets that lack any form of cooling, exposing high density equipment to high temperatures

**RACS is less than optimal under the following conditions:**

- When there is a need to take racks in and out of an existing row frequently
- When multiple rows need to be contained
- When racks, cooling units, etc are with different dimensions
- Aisle width is too narrow to add containment (containment will add the depth of the rack)

**Considerations when deploying RACS:**

- Front RACS is not recommended for row cooling systems that contain humidifiers as it could lead to moisture being directed onto the servers if there is a humidity malfunction
- Has the highest first cost because more cooling units are needed
- More cooling units are required for redundancy, which will drive up first cost
- Rack air containment will add additional depth of the rack
- Some customized containment solutions may be required due to building column constraints, IT racks used from a lot of different vendors, or odd rack row number
- Longest deployment time if cooling unit and containment is being installed for each rack (integrate cooling unit with rack(s))
- Payback period about 6 months to 2 years when row-based cooling units pre-exist (If row-based units must be purchased, this solution has the longest payback period)

## Row-cooled, cold aisle containment system (Row-cooled CACS)

This containment solution should be used in data centers with perimeter cooling units and when all racks are in some form of cold aisle containment. This solution adds cooling units in between racks. The cold aisle is enclosed and the containment system is deployed as a pod (**Figure 7**). For more information about row-based cooling, please see White Paper 137, *Energy Efficient Cooling for Data Centers: A Close-Coupled Row Solution*.

**Figure 7**

*Example of a row-cooled cold aisle containment system*
*(Schneider Electric EcoAisle shown)*

**Row-cooled CACS is recommended under the following conditions:**

- When racks and IT equipment is arranged in a hot aisle / cold aisle arrangement
- All IT racks can be configured with some form of cold aisle containment to avoid exhaust hot air to the fronts of uncontained racks
- When raised floor cooling has reached its maximum airflow capacity due to height and or congestion
- When more perimeter cooling units cannot be added to increase cooling capacity
- When containment project wants to be completed quickly (i.e. prepackaged solution can reduce the deployment time)

**Row-cooled CACS is less than optimal under the following conditions:**

- No hot aisle / cold aisle arrangement and impractical to migrate to
- Limited budget (row-based cooling units have high capital cost)
- Unable to move IT racks within rows to insert row-based cooling units
- Data center is crowded with IT racks (difficult to do isolation)

**Considerations when deploying Row-cooled CACS:**

- Adding row-based cooling units will increase cost
- Movement of IT racks required to insert row-based cooling units within row
- Some customized containment solutions may be required due to building column constraints, IT racks used from a lot of different vendors, or odd rack row number
- Additional lighting fixture may be required in cold aisle
- AHJ may require fire detection and suppression in cold aisle or other provisions discussed later in this paper
- Payback period about 6 months to 2 years when row-based cooling units pre-exist and several years if not

An overall comparison of the six containment methods is shown in **Table 1**. Note that all four of the aisle containment methods may require additional lighting fixtures, fire detection and suppression (decided by AHJ) units in the aisle itself.

**Table 1**

*Pros and cons of the six air containment methods*

| Containment method | | Pros | Cons |
|---|---|---|---|
| Cold air containment | Cold aisle containment system | Easy and cost effective for raised floor applications; cooling capacity can be shared with other racks within two rows; fastest deployment time of all containment types | Lower number of free cooling hours; creates uncomfortable working environment in uncontained areas |
| | Row-cooled, cold aisle containment system | In-row cooling units increase cooling capacity of existing CACS environment with perimeter cooling units; prepackaged solution can save deployment time | Higher first capital cost; need to move IT racks to insert row-based cooling units within row |
| Hot air containment | Ducted rack | Easy to deploy for scattered HD racks; Don't require a hot aisle / cold aisle arrangement; can be deployed piece by piece to reduce upfront capital cost; offers higher number of free cooling hours | May cause pressure imbalance inside of drop ceiling or between nearby racks; increased labor time; longer deployment time for each rack |
| | Ducted, hot aisle containment system | Creates comfortable work environment in uncontained areas; cooling capacity can be shared with other racks within two rows; offers higher number of free cooling hours | High temperature in the hot aisle may create uncomfortable work environment in contained area, longer deployment time for each rack |
| | Row-cooled, hot aisle containment system | Low-cost option for data centers with existing row-based cooling. Thermally neutral to the existing room-based cooling system; cooling capacity can be shared with other racks within two rows; prepackaged solution can save deployment time | In data centers with existing perimeter cooling units: Higher upfront capital cost; need to move IT racks to insert row-based cooling units within row.<br>High temperature in hot aisle may create uncomfortable work environment in contained area |
| | Rack air containment system | Almost immune to the constraints of existing facility; easy to plan for any power density; isolated from the existing cooling system; attenuates noise | In data centers with existing perimeter cooling units, has the highest first cost because more cooling units are needed; cooling capacity can't be shared with other racks; containment will add the depth of rack which will consume more floor space |

## Select containment methods

Once the constraints of an existing facility are well understood and the containment solutions have been reviewed and compared, the selection between hot air and cold air containment will be easier. At this point in the process, most people have only one or two practical containment solutions to implement. The containment solution will be selected on the basis of physical constraints since these issues are the primary constraint on containment deployment. While it is acceptable to implement both types of cold air containment or multiple types of hot air containment, **hot and cold air containment types should never be mixed. Mixing hot and cold air containment solutions will likely lead to lower cooling system efficiency than can be achieved through either hot OR cold air containment.**

The air distribution method and cooling unit position are two major considerations on physical constraints. **Table 2** shows the containment recommendation for two common air distribution methods, while **Table 3** shows containment selection according to less common air distribution methods.

**Table 2**

*Select containment according to common air distribution methods (X means not recommended or impractical)*

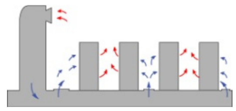
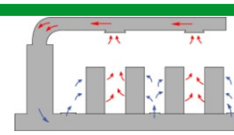
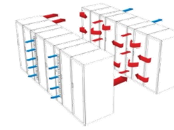
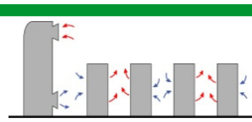
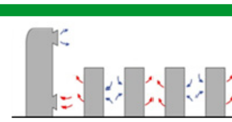
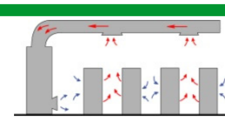
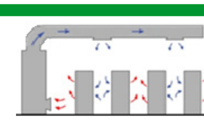
| Air distribution method | |  Type 1 |  Type 2 (perimeter cooling units) |  Type 2 (row-based cooling units) |
|---|---|---|---|---|
| Cold air containment | Cold aisle containment system | Preferred | Selected when fast deployment is required | X |
| | Row-cooled cold aisle containment system | Used when additional capacity is unattainable from existing perimeter cooling units or raised floor limitations | Used when additional capacity is unattainable from existing perimeter cooling units or raised floor limitations | X |
| Hot air containment | Ducted rack | X | Only recommended for scattered high density racks | X |
| | Ducted hot aisle containment system | X | Preferred | X |
| | Row-cooled hot aisle containment system | X | Used when additional capacity is unattainable from existing perimeter cooling units or raised floor limitations | Preferred |
| | Rack air containment system | Only recommended for scattered high density racks or to contain a single rack row | | |

**Table 3**

*Select containment according to less common air distribution methods (X means not recommended or impractical)*

| Air distribution method | |  Type 3 |  Type 4 |  Type 5 |  Type 6 |
|---|---|---|---|---|---|
| Cold air containment | Cold aisle containment system | X | X | X | Preferred |
| | Row-cooled cold aisle containment system | X | X | X | Used when additional capacity is unattainable from existing perimeter cooling units |
| Hot air containment | Ducted rack | X | X | Only recommended for scattered high density racks | X |
| | Ducted hot aisle containment system | X | X | Preferred | X |
| | Row-cooled hot aisle containment system | Selected when new high density racks need to be added in a traditional low density data center | Selected when new high density racks need to be added in a traditional low density data center | Used when additional capacity is unattainable from existing perimeter cooling units | X |
| | Rack air contain-ment system | Only recommended for scattered high density racks or to contain a single rack row | | | |

## Selecting containment hardware

After reviewing all the potential solutions, one can find most of the containment methods will have the following common considerations when deploying:

- Customized containment solutions may be required if different kinds of IT racks exist
- For aisle containment or ducted rack, additional lighting fixture may be required
- Fire suppression may be required by authority having jurisdiction (AHJ) inside of the aisle containment

Look for solutions with hardware capable of integrating with constraints which is critical to the success of containment deployment. Examples of such solutions include:

**Flexibility**
Containment solutions that adapt to varying aisle widths, rack heights, rack depths to support either hot aisle or cold aisle containment, or even single rows. Easy over aisle access will let users remove individual panels to allow access above the aisle for cabling and maintenance.

**Lighting**
Specify overhead panels that transmit as much as 90% of light. In addition, high efficiency LED lighting with on/off motion sensors are available that can be integrated with containment solutions (see picture to the right).

**Fire suppression**
The containment solution can alert personnel and drop ceiling panels automatically based on temperature or smoke detectors to allow the fire suppression system to extinguish the fire. **Figure 8** illustrates this fire suppression method. Some solutions offer emergency breaka-way sliding doors to quickly exit the aisle in the event of an emergency.


**Figure 8**

*Example of fire suppression system within a contained aisle*

## Ongoing air management maintenance

Once implementation of containment deployment has been completed, everything is not all right. In order to maintain and achieve good results upon the optimizing conditions imple-mented, data center operation managers must take charge of the process of monitoring the air flow patterns and temperatures to ensure the containment reliability.

For cold aisle containment, the air balance and control is a big challenge. The only air available to cool the IT equipment is the air delivered to the contained cold aisles. Cold aisle containment systems should control the air flow based on the pressure differential of the aisle, the non-rack IT equipment in the uncontained area must be monitored to insure adequate cool supply air.

For ducted hot aisle containment, if IT personnel must perform work there, the high tempera-ture in the hot aisle can be mitigated by temporarily opening the aisle doors to let in cooler air. Furthermore, even if the hot aisle remains closed, work environment regulations are still met because workers are not permanently stationed in the hot environment and most routine work takes place at the front of IT racks.

## Conclusion

Data center containment strategies can provide great benefits for data centers. Hot air and cold air containment are two approaches to do the containment deployment. The best approach for a specific deployment should be determined by assessing the facility constraints, reviewing all potential solutions, and selecting the right containment hardware.

Cold aisle containment and ducted hot aisle containment are two most common solutions for data centers with existing perimeter cooling units. Cold aisle containment is preferred for the facilities with raised floor as a supply air plenum, while ducted hot aisle containment is preferred for facilities with a drop ceiling as the hot air return plenum. For data centers with existing row-based cooling units, row-cooled hot aisle containment is preferred. Other containment solutions will be selected by unique requirements.

These conclusions are for existing data centers. For new data centers, please see WP135, *Impact of Hot and Cold Aisle Containment on Data Center Temperature and Efficiency*.

## About the author

**Paul Lin** is a Senior Research Analyst at Schneider Electric's Data Center Science Center. He holds a Bachelor's degree in Mechanical Engineering from Jilin University where he majored in Heating, Refrigeration and Air Conditioning. He also holds a Master's degree in Thermodynamic Engineering from Jilin University. Before joining Schneider Electric, Paul worked as the R&D Project Leader in LG Electronics for several years. He is now designated as a "Data Center Certified Associate", an internationally recognized validation of the knowledge and skills required of a data center professional.

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**John Niemann** is a global product director at Schneider Electric responsible for prefabricated modular data center cooling solutions. He has over 15 years HVAC experience. His career began in the commercial and industrial HVAC market where he was focused on custom air handling and refrigeration system, with expertise on energy recovery and filtration for critical environments. John began his career with Schneider Electric as Senior Product Manager responsible for the development of the InRow Cooling products, and later took over product line management responsibility for both InRow and small systems cooling. Throughout his career he has held roles in applications engineering, product management, marketing, and sales. John is a member of ASHRAE and The Green Grid, and holds a degree in mechanical engineering from Washington University in St. Louis, Missouri.

# Resources

*Impact of Hot and Cold Aisle Containment on Data Center Temperature and Efficiency*
White Paper 135

*The Different Types of Air Distribution for IT Environments*
White Paper 55

*Data Center Temperature Rise during a Cooling System Outage*
White Paper 179

*Energy Efficient Cooling for Data Centers: A Close-Coupled Row Solution*
White Paper 137

*The Use of Ducted Air Containment in Data Centers*
White Paper 182

*Deploying High-Density Pods in a Low-Density Data Center*
White Paper 134

*Choosing between Room, Row, and Rack-based Cooling for Data Centers*
White Paper 130

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