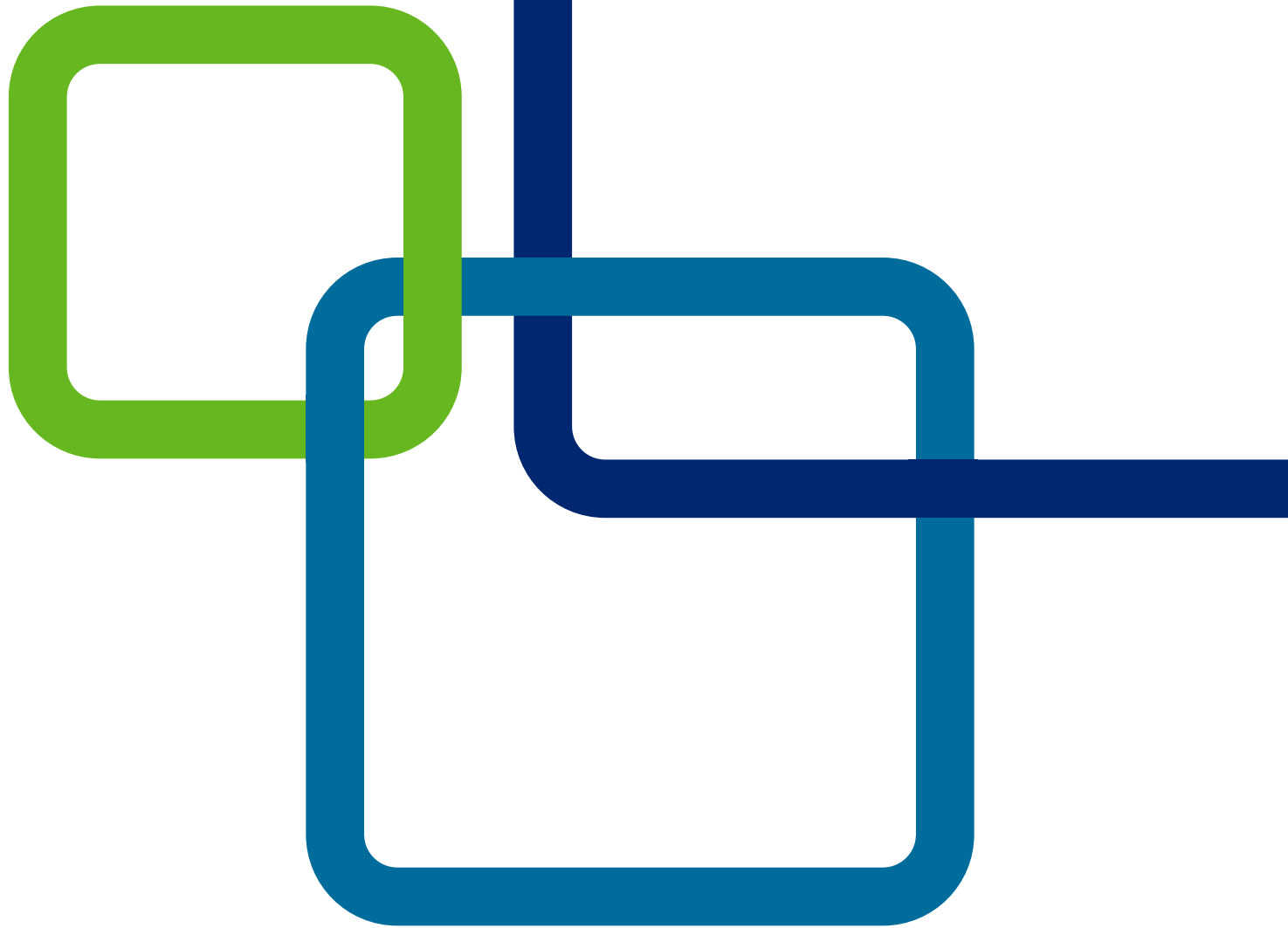




Workspace
Technology Limited



Technology Paper 005

Data Centre Airflow Containment Strategies

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Introduction

In many data centres as much as 60% of available supply cold air is short cycling back to the cooling units. Called “bypass airflow” this means that only 40% of the cold air supply is directly cooling computer equipment. The remaining 60% of cold air is mixed with the exhaust air.

The problem of bypass airflow is compounded with the deployment of higher power and heat densities which in turn leads to traditional perimeter air handling units failing to provide sufficient cooling for these increasing loads. Despite the fact that very often the cooling capacity is increased to levels considerably over that of the critical load combined with reduced set point temperatures, hot spots and unpredictable inlet temperatures still occur.

This Technology Paper provides an overview of Data Centre “passive” airflow containment and management strategies which are available to help eliminate short cycling, correct cooling over capacity, improve inlet predictability and support higher density loads, whilst improving the Data Centre Infrastructure Efficiency (DCiE) of the facility.



Data Centre Environmental Conditions

Environmental conditions are determined at the air intake of the equipment. The discharge temperature of the hardware exhaust air is of little concern providing there is a clear return path to the air handling unit.

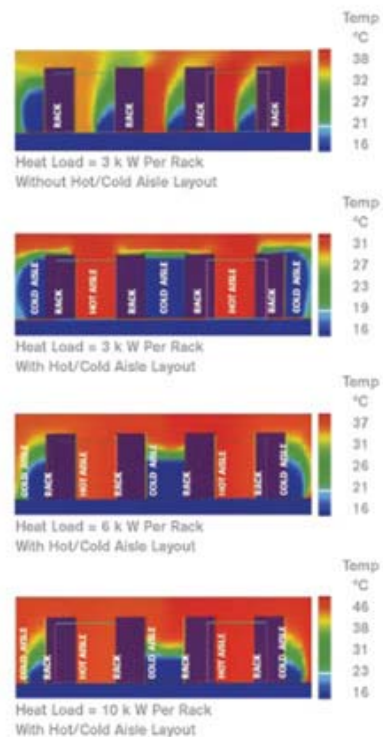
What counts in terms of reliability, performance and warranty, are the conditions at the equipment air intake.

While the equipment may operate at air intake temperatures of up to 32.2°C or a Relative Humidity within 35% to 80%, it may not run reliably. For maximum performance and reliability of equipment, ASHREA* set thermal guidelines for inlet temperatures for active equipment. e.g. temperatures of less than 25 °C with a rate of change not to exceed 5 °C per hour, Relative Humidity must exceed 40% with a rate of change not to exceed 5% per hour.

* ASHREA - American Society for Heating, Refrigeration and air-conditioning

In a traditional configuration air recirculation occurs. This leads to the difficulty of maintaining constant inlet temperatures, combined with the substantial decline of the efficiency of the system.

The effective maximum capacity of a traditional hot aisle/ cold aisle configuration is limited to 3/4Kw per cabinet due to this recirculation effect.



Benefits of Airflow Containment

The provision of airflow containment technology provides an effective passive method for eliminating the mixing of hot and cold airflows within a Data Centre or Server Room environment.

The goal of a well designed airflow containment and management system is to maximise the performance, uptime and life expectancy whilst reducing operating costs of the Data Centre.

The benefits of introducing Airflow Containment and Management systems are becoming widely accepted by Data Centre professionals. Key benefits of these systems are detailed below :-

Predictable Inlet Temperature / Humidity levels.

Closer environmental control is gained by reducing short cycling of air.

Reductions in Energy consumption and associated CO² Emissions. Savings will vary from site to site, typically many sites are "over cooled" due to waste and mixing of hot and cold airflows. Savings can be significant when un-required AC systems can be reconfigured to standby mode.

Improved DCiE / PUE * Room Energy Performance Ratings.

Cooling is one of the biggest Infrastructure overheads required to support the critical load. Reductions on the cooling electrical consumption will make immediate improvements in ratings.

Energy savings can be made by setting cooling systems to higher temperatures. Typically every increase of 1°C will equate to a reduction of running costs by 4%.

Losses due to leaks and re-circulating airflows are eliminated ensuring AC systems deliver 100% of their cooling capacity to the critical load.

Improved Net Sensible Cooling capacity of air-conditioning systems are achieved due to the increased resulting flow and return temperatures (Delta T), when containment is deployed.

Reduction of humidification / dehumidification costs.

The containment systems enable 100% of the exhaust air to be captured and returned back to the Air Handling Unit with no humidity returned.

* Data Centre Infrastructure Efficiency / Power Usage Efficiency are industry recognised standards for data centre room efficiency measurement introduced by the Green Grid. Please see Workspace Technology's Paper 004 Metrics for Data Centre Efficiency for further details on this subject.

Airflow Containment Technology

To maximise the benefits gained by the deployment of airflow containment technology a range of systems should be considered.

Airflow containment and management product options include :-

- Cold Aisle Corridors / Containment
- Hot Aisle Containment
- Hot Aisle Return Plenum
- Airflow Baffles
- Floor Sealing Systems
- Blanking Plates and Cabinet Recirculation Seals

The intelligent deployment of containment technology will have an immediate impact on any Server Room or Data Centre facility.



Aisle Containment Systems

Aisle containment systems use a combination of end of aisle doors and overhead panels which are built around the equipment cabinets to separate and enclose hot or cold air paths. It is recognised by many leading industry experts that the separation of hot and cold air is one of the most important energy efficient measures available to new and legacy data centres.

Typical Aisle Containment Configuration options include :-

Cold Aisle Corridor

This is the most popular classic configuration for data centres with raised access floors and perimeter down flow cooling. This solution fits in well with existing Data Centre configurations and has been widely accepted as a de facto standard.

Hot Aisle Containment

This system does not need a raised access floor and is designed to support aisle based In-Row cooling technology.

A third and more flexible option is provided by :-

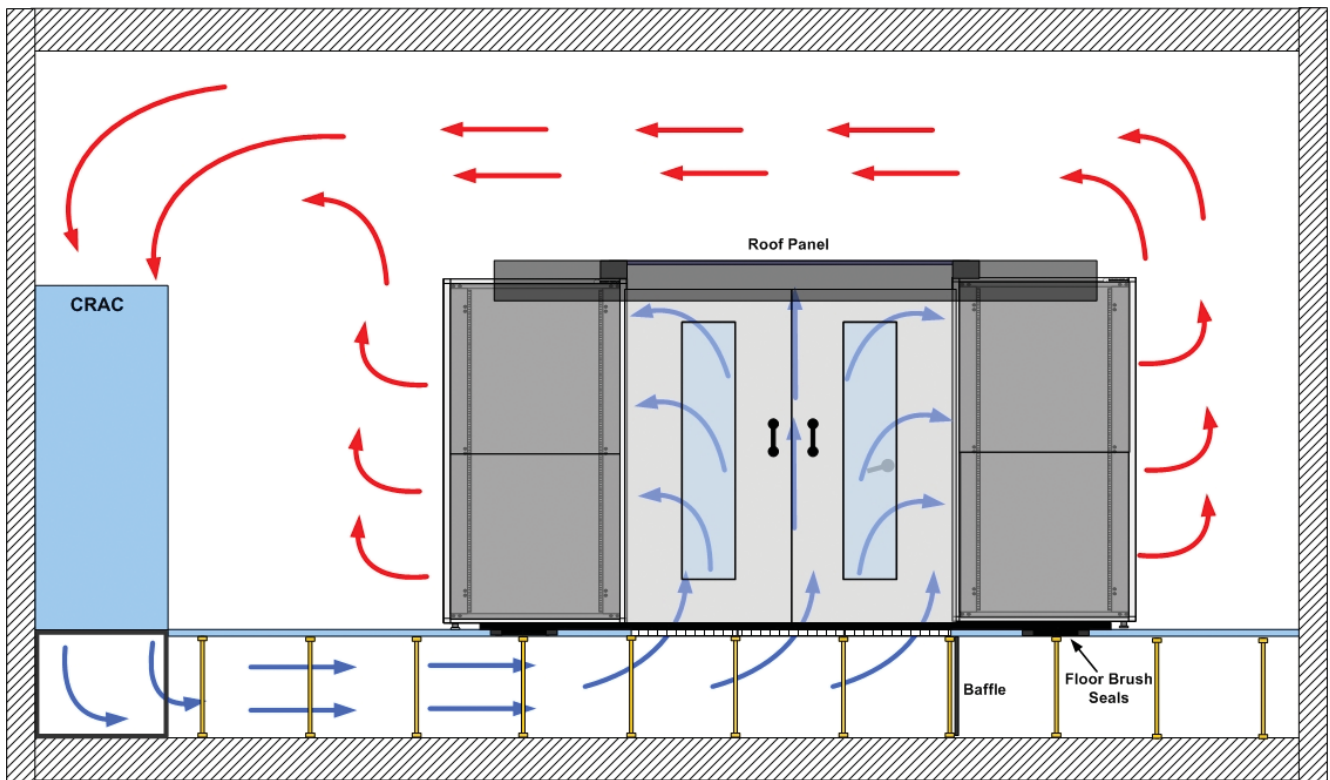
Hot Aisle Return Plenum

This option delivers maximum flexibility supporting a range of multi-cooling technology options.

The table below details the cooling technology that can be supported by each of the three primary aisle containment configurations.

Aisle Configuration	Perimeter Downflow Cooling	In-Row Cooling	Rear Rack Cooling	Self Contained Cooling	Room Airflow Exchange
Cold Aisle Corridor (CAC)	Yes	No*	No	Yes	Yes
Hot Aisle Containment (HAC)	No*	Yes	Yes	Yes	Yes
Hot Aisle Return Plenum (HARP)	Yes	Yes	Yes	Yes	Yes

* If cold aisle/ hot aisle corridor is employed there will be a clash of air temperatures due to the inverse nature of each containment system. This can be overcome with additional room segregation.



Airflow Schematic Cold Aisle Corridor

Cold Aisle Corridor

This system is based on the principle of complete separation of hot and cold air flows which leads to significant improvements in efficiency.

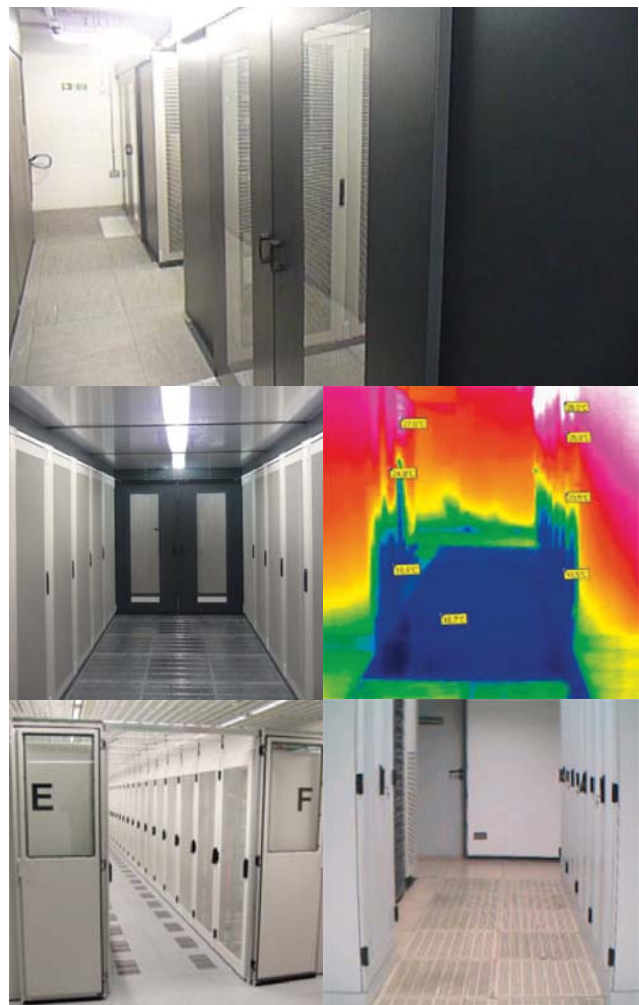
This is achieved by enclosing the cold aisle with roof panels. These roof panels are generally transparent allowing light into the corridor.

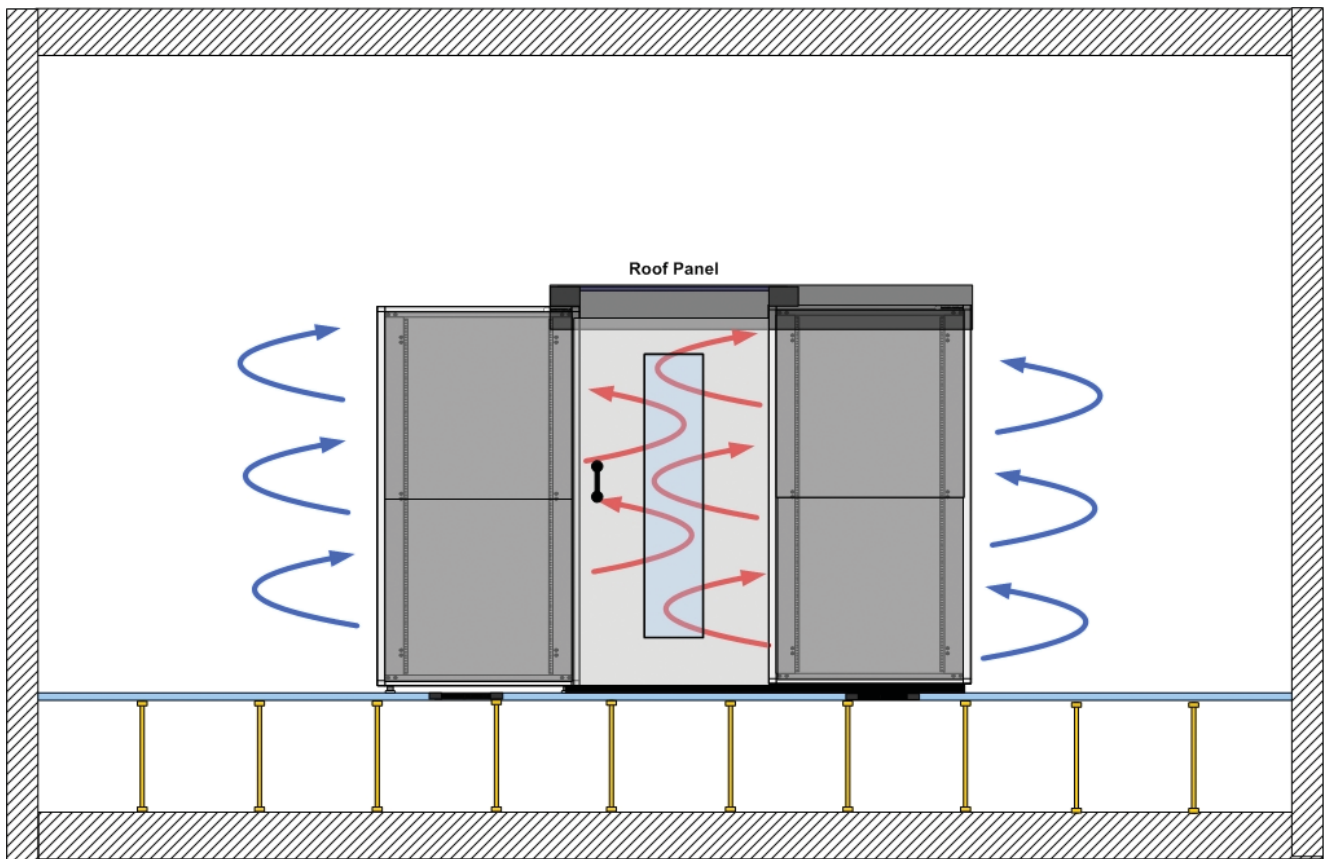
Both ends of the cold aisle are normally sealed using doors or transparent flexible panels to create a "Cold Aisle Corridor".

The temperature between the bottom and top of the rack will become constant. This enables the deployment of servers at any position in the rack.

AC supply air temperature can be increased. Temperatures of between 22° to 24° are considered acceptable within the cold aisle corridor.

With the associated increase in the return air temperatures to air handling units, the effective Net Sensible cooling capacities are increased.





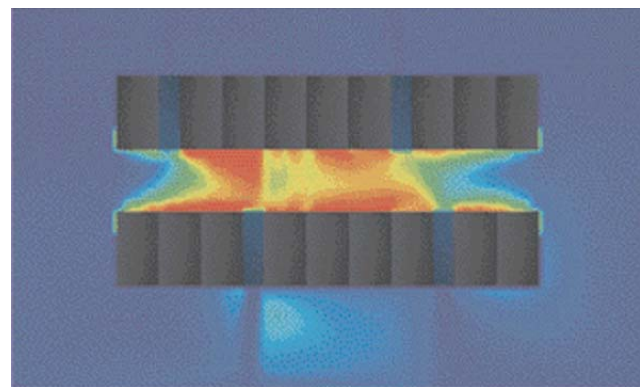
Airflow Schematic Hot Aisle Containment with In Row Cooling

Hot Aisle Containment

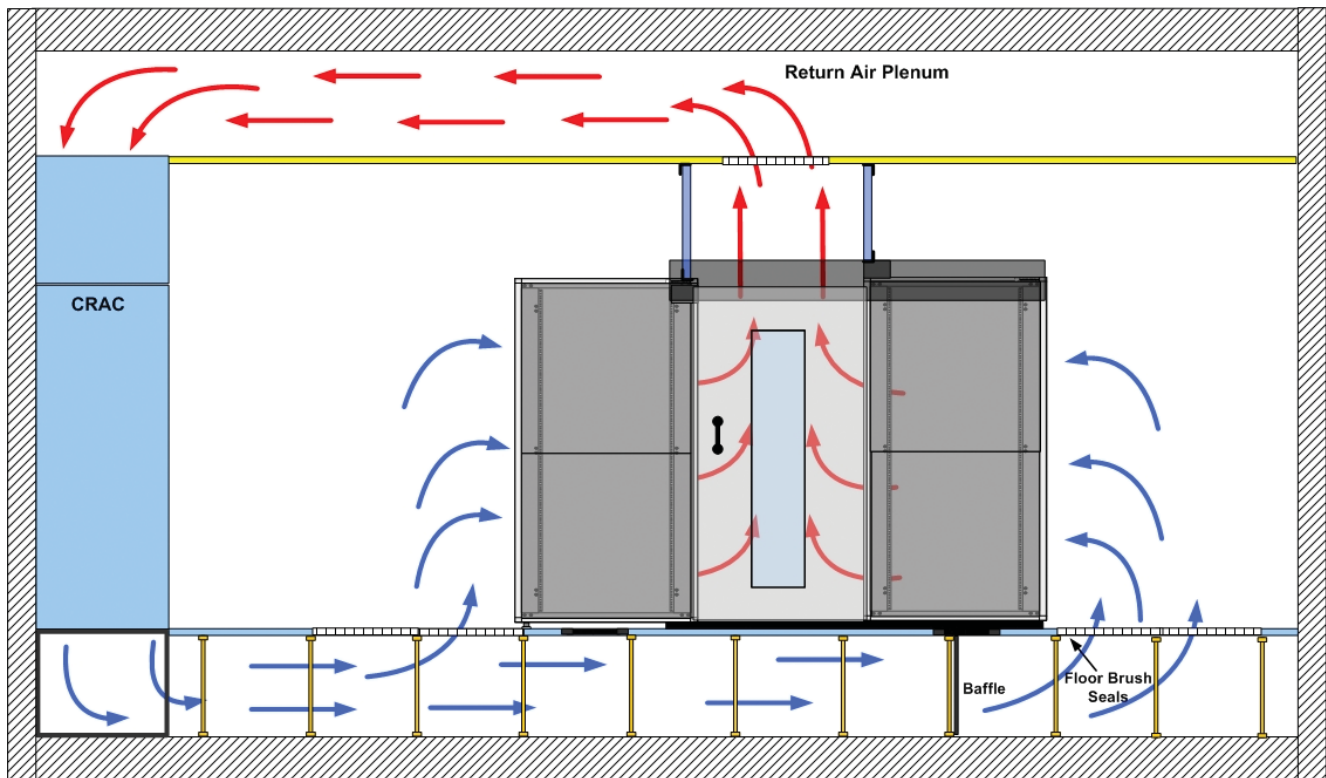
As a reverse to “Cold Aisle Corridor” (CAC) the “Hot Aisle Containment” (HAC) configuration increases cooling predictability in extreme high density environments within rack level solutions that neutralise the hot exhaust air at the rack or row level.

Hot Aisle Containment configuration is characterised by high density technology clustered together in two rows of cabinets within the general data centre floor space. These systems are usually deployed with aisle based “In Row” cooling units which provide cold air to the front of the equipment cabinets. A containment system is used to enclose and prevent the escape of hot cabinet exhaust air into the general data centre environment. Aisle based “In Row” cooling units will then draw the hot air back and re-circulate it as cold air to the front of the cabinets.

This approach effectively eliminates mixing of cold and hot air, to maximise system efficiency. There is a neutral impact on the overall server room environment.



CFD Thermal Image Example



Airflow Schematic Hot Aisle Return Plenum

Hot Aisle Return Plenum (HARP)

Hot Aisle Return Plenum (HARP) configuration provides Data Centre Managers with maximum flexibility.

Unlike the Cold Aisle Corridor CAC and Hot Aisle Containment HAC configurations the HARP will support a comprehensive mix and match of cooling technology including Perimeter/Downflow, Aisle/In-Row, Rear Rack and Self Contained cooling solutions without compromising the segregation of hot and cold airflow paths.

Hot Aisle Return Plenum - HARP configuration utilises the ceiling plenum return air path which is a standard feature in many traditional and newly built data centre facilities.

The HARP configuration delivers the improved efficiency benefits of Hot Aisle Containment with the advantage of the support for traditional downflow cooling which is still predominant in both existing and new data centre builds.

All three containment configurations will help eliminate mixing of hot and cold air, provide even inlet temperature distribution and improve the Delta T flow and return temperatures.

Hot Aisle Vs Cold Aisle

There are a number of arguments for and against each of the two traditional approaches to aisle containment systems.

There are benefits of the hot aisle system i.e. improved performance and more comfortable working temperatures compared to a cold aisle system.

The reality is that each system is aligned to support a particular cooling technology.

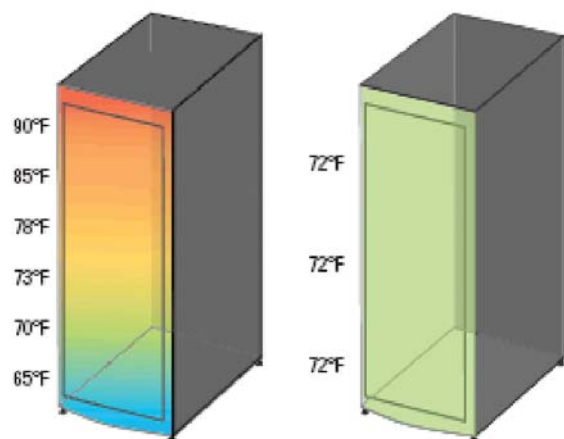
Hot Aisle Containment is specific to aisle based "In Row" cooling and the Cold Aisle Corridor configuration is ideal for perimeter cooling when combined with raised access floors.

Room Characteristic	Hot Aisle Return Plenum (HARP)	Cold Aisle Corridor (CAC)	Hot Aisle Containment (HAC)
Raised Access Floor	Required	Required	Will work with or without floor
General Room Temperature	Cold	Warm	Cold
Room Neutral	Yes	No	Yes
Ceiling Plenum	Required	This will work with or without a ceiling plenum	This will work with or without a ceiling plenum
Reduced Dehumidification	Yes	Yes	Yes
Even Inlet Temperatures	Yes	Yes	Yes
Improved Delta T	Yes	Yes	Yes
Will work with none racked equipment	Yes	No (unless separate screening)	Yes
Ability to Scale to High Density	Yes	Up to 7.5Kw without fan assisted airflow	Yes
Supports Multiple Cooling Technologies	Yes	No	No

Many medium and large Data Centres have downflow perimeter cooling which is ideally suited to cold aisle corridor configuration. However the implementation of Cold Aisle Corridor based systems can make it difficult to introduce high density cooling technologies such as APC's, HACS and rear rack cooling systems without complicated screening arrangements.

The use of Hot Aisle Return Plenum based systems, overcomes the flexibility issues of hot and cold aisle solutions by:-

- Support for multiple cooling technologies and airflow arrangements
- Allows the deployment of self contained HAC's systems to reside alongside traditional downflow perimeter cooling
- Simple to retrofit into existing DC's with return air ceiling plenums
- HARP provides a comfortable working temperature for general room access
- Increased system cooling capacity through increased delta temperature and inlet temperature control
- Flexibility to position additional floor grille tiles anywhere outside of the hot aisle



Traditional Inlet Temperature vs Aisle Contained Inlet Temperature

Airflow Control Systems

To maximise results from the deployment of aisle based containment systems, additional airflow control technology will be required to provide a complete solution.

Airflow Baffles

One of the challenges with a Data Centre environment is how to get the air that is beneath a raised floor through the perforated tiles and into the front intakes of rack mounted vertically integrated server housings that are producing the heat.

The installation of vertical under floor baffle partition systems, help direct airflow within the raised access floor space. Baffles direct the source of the cold air from the air handling units to where the air is, or is not needed.

Baffles help maintain the static pressure further away from an Air Handling Unit and provide a simple solution to effectively cool thermal hot spots in information technology equipment centres.

Floor Sealing Systems

When raised access floors are deployed in combination with down flow AC systems the leakage of cold air in the wrong places will reduce the effective cooling capacity of the system. Increasing cooling capacity to compensate is expensive and wasteful.

A better solution is to reclaim lost cooling capacity by sealing unmanaged openings that are wasting cold air. This will ensure air is circulated to where it is needed via correctly positioned grille floor tiles.

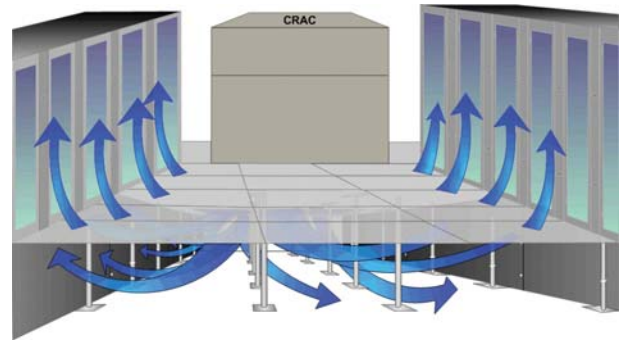
Typically these openings are found where cable access is required, below cabinets.

The installation of specially designed raised floor brush grommets will help seal the floor and prevent leakage of air where cables are routed into equipment cabinets.

Blanking Panels

IT equipment installed within cabinets cools itself by drawing air from the data centre. Most equipment will draw the cold air in from the front and expel the heated exhaust air from the rear of the equipment. If the hot exhaust air is allowed to re-circulate to the inlet air, this will cause mixing of hot and cold creating an overheating condition.

Many data centre managers decrease the bulk air temperature supplied to the room to attempt to balance the effect. This is an energy inefficient method generating additional condensate (water)



- Control and Balance Data Centre Airflow
- Separate Hot Aisles from Cold Aisles
- Fits any Raised Floor Pedestal
- Can be used in Ceiling Plenums
- Reduces Energy Consumption and Operating Costs
- An Energy Saving and Thermal Tuning Tool

The incorporation of floor sealing systems will help:

- Increase existing cooling unit capacity
- Reduce the need to purchase additional cooling units
- Improve equipment reliability and extend equipment life
- Increase static pressure under the raised floor and improve cool air delivery through perforated tiles and floor grates
- Facilitate cold aisle/hot aisle best practices.



Example Brush Seal Systems

by the main air conditioning system, resulting in a need for supplemental humidification. This can lead to increased electricity costs.

The simple and effective method to prevent air recirculation within cabinets is to install blanking panels. This strategy reduces hot spots and saves energy by increasing the CRAC return air temperature.

Blanking panels should be installed as part of an overall strategy to prevent mixing of hot and cold airflows within the data centre.

Conclusions

The prevention of hot and cold air mixing is essential to the overall reduction of Data Centre operating costs.

The installation of aisle based containment technology is a simple and cost effective way of eliminating the short cycling and hot and cold air mixing when combined with air leakage products.

Whilst there are some advantages of Hot Aisle Containment over that of Cold Aisle Corridor configurations the deployment of systems will be dictated by both the physical room characteristics and existing or proposed cooling technology.

The installation of Hot Aisle Return Plenum technology overcomes the restrictions with both cold and hot aisle solutions and provides a flexible configuration which will support a mix and match of cooling technology.

This paper recommends that Data Centre and Server Room Managers should consider the deployment of airflow management products as part of an overall strategy for decreasing energy consumption costs and improving the DCiE/PUE rating of the facility.

FlexAisle® is an aisle based vendor independent flexible Data Centre airflow containment solution by Workspace Technology Ltd.

FlexAisle® provides a simple and cost effective passive method for eliminating the mixing of hot and cold airflows within a Data Centre or Server Room environment. The goal of **FlexAisle®** is to maximise the performance, uptime and life expectancy whilst reducing operating costs.

FlexAisle® can be installed new, or retrofitted within existing Data Centre and Server Room environments. **FlexAisle®** is a non intrusive, easy fit solution which provides Data Centre Managers with the ability to re-organise and expand facilities inline with business requirements.

FlexAisle® uniquely provides the ability to support multiple cooling configurations and is independent of cabinet vendors enabling Data Centre Managers to support a mix and match of server and communications rack systems.



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About Workspace Technology

Workspace Technology provides a range of services for Network Critical Physical Infrastructure (NCPI) facilities which include communications, server and data centre facilities.

The design and implementation of **ecodesign*** energy efficient solutions forms part of Workspace Technology's overall strategy for providing clients with a complete turnkey approach to the design and build of server room and data centre solutions.

Workspace Technology's expertise and services incorporates consultancy, upgrades, expansion, re-locations, turnkey design & build, planned maintenance and support and remote monitoring services.

Further details of Workspace Technology's products can be found on the following websites.

www.workspace-technology.com

www.flexaisle.com

www.mobiledatacentre.com

Workspace Technology are approved Integration Partners for a number of leading manufacturers for UPS and critical cooling systems and are APC Premier Partners.

***ecodesign** represents Workspace Technology's commitment to help clients reduce their carbon footprint through the deployment of energy efficient technology and design. Airflow Containment and management systems are central to our energy efficiency strategy and forms part of our comprehensive Server Room Solutions and Services offering.



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