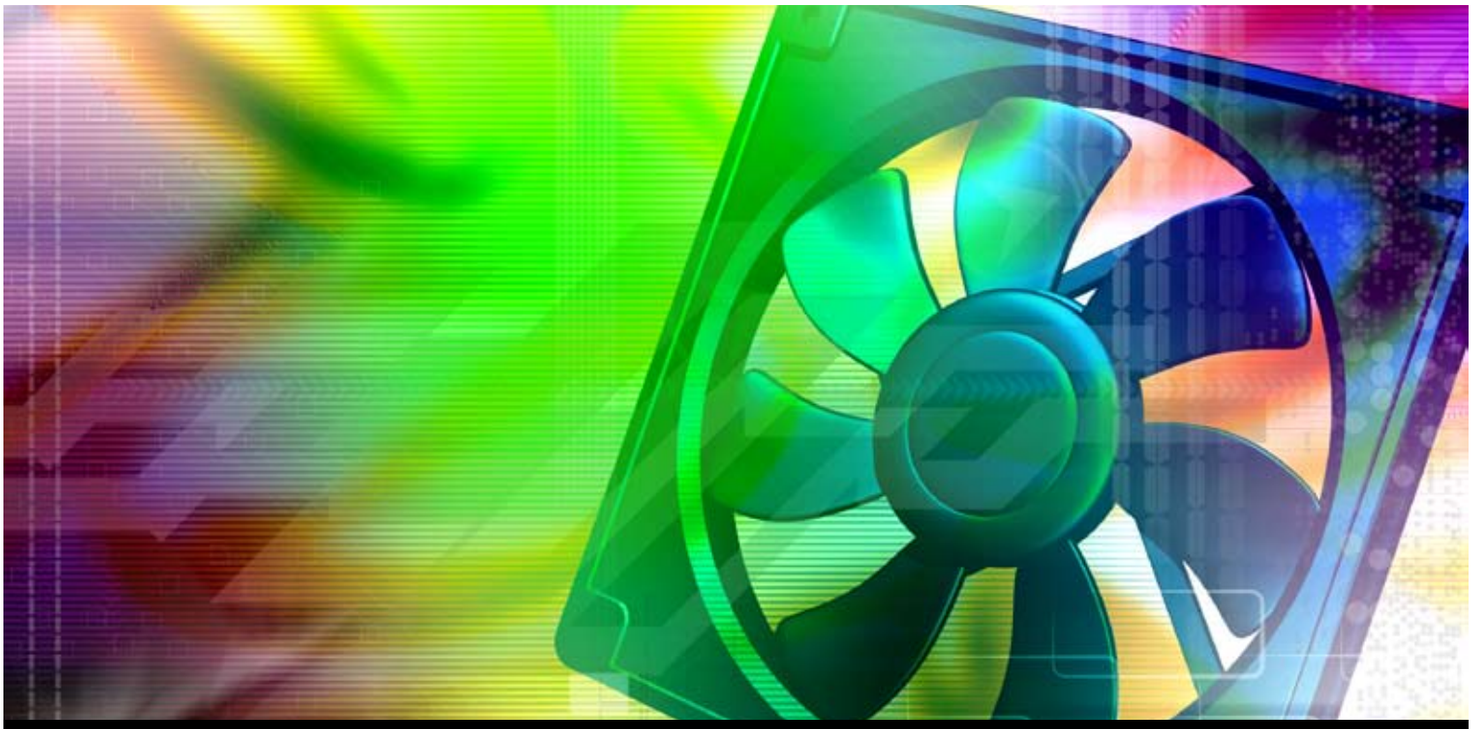


IMPROVING THE THERMAL EFFICIENCIES OF A DATA CENTRE, PART 1

Tony Khoury, National Sales and Technical Director, Page Data

In the first of a two-part series on data centre thermal management strategies, Tony Khoury helps to explain the role that a new generation cabinet has in segregating hot and cold air.

There is an old adage; if you can't measure it you can't manage it. This has become very true for our data centres and so someone had to come up with a way to measure data centre efficiencies in relation to power consumption. The most popular method is called Power Usage Effectiveness which is typically referred to as PUE. It is determined by the total amount of power being consumed by a data centre divided by the server power.

The reason PUE is a commonly used term is because it was adopted by the Green Grid and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) as a way of measuring data centre efficiency. It also appeared in a report on Data Centre energy use to the US Congress.

PUE's typically range from 1.8 to 3.0 (sometimes higher) and according to some surveys, the average PUE for the existing Tier 3 data centres is somewhere around 2.6. This means that 1.6kW of power is being consumed, on average, to support a 1kW server load. In a newly designed data centre we can be safe in assuming that 0.1 to 0.15 of our PUE number comes from things other than cooling; UPS losses, lighting, etc. That leaves a whopping big amount being consumed by our cooling and air movement system and so the need to create greater efficiencies in both the supply of air and how it is managed is an important thing that every data centre manager is or should be working on.

Those building new data centres that understand this issue will tell you that they are working on achieving PUE's of 1.8 and in some cases are working towards 1.6. I have had discussions with people that tell me that they have a PUE of 1.3 and are using traditional cooling with hot and cold aisles. Those people either know something that no one else on the planet knows or they are missing something in their calculation. It is accepted that achieving PUE's of less than 1.6 takes some different thinking. That will be discussed in the next article in this series.

While a PUE of 1.0 is impossible to get, the closer it is to 1.0 the better and there are several ways to bring it down. Currently, most people aren't thinking enough about how a cabinet and the room it's in need to work together. The cabinet has always been a box

that houses the equipment and the IT guys bought it without any thought about its true role. The data centre space, on the other hand, is managed by the facilities guys whose role it is to bring power and air to each cabinet. Ultimately there needs to be a paradigm shift about the role of the cabinet which will put it into the mechanical space of the data centre.

Up until very recently, the role of the cabinet has been to simply manage cabling and equipment. We need to start thinking of the cabinet as being an architectural feature of the data centre space designed to manage the layout of equipment and cabling while securing the isolation between supply and return air. It fundamentally defines the barriers between the hot and cold air in a data centre.

I also see a lot of people believing they need more air conditioners because their equipment is running hot or they can't get enough air to service a new load they are installing. It needs to be said that normally there is more than enough cooling capacity to handle higher heat loads – there is just too much air being wasted through bad practice.

Bypass Air Must Be Managed

Bypass air is the conditioned air that bypasses the equipment intake area it was intended for. Think of the cable cut-outs in the raised floor at the rear of a cabinet that remain open. Many, many sites have more cold air exiting the floor at the rear of the cabinet, literally cooling the hot aisle, than they do coming out of the vents at the front of the cabinet.

Blocking bypass air can no longer be considered best practice - it needs to be considered as basic practice. All we're doing at the moment is taking air and blowing it where we don't want it and basically blowing our efficiencies out the back door. In most data centres we can reclaim 40% to 50% (or more) of our installed cooling capacity by simply reclaiming wasted bypass air. We have simple methods and a range of products available to resolve this problem and more and more people are buying them.

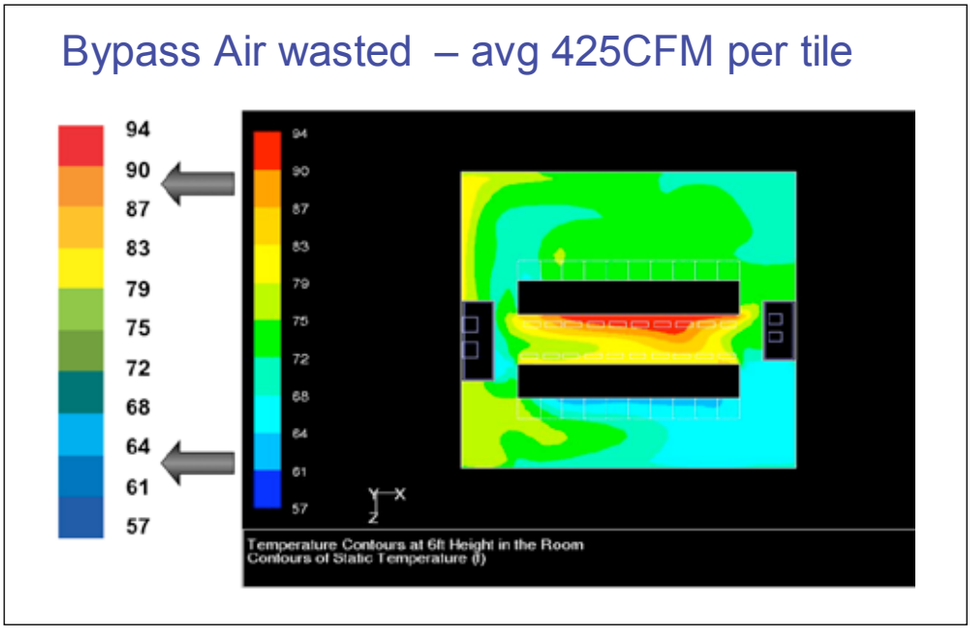
We did an evaluation on one data centre and calculated a 65% bypass air rate. Out of the 10 CRAC units that were running 3 could have been switched off. This would have saved about $20,000 in running costs per CRAC unit per year. If the bypass air problem was fixed in that room, which may have cost about $10,000, the ongoing cost efficiencies and the benefits of the CRAC units becoming redundant (not to mention the reduced maintenance costs and extended life of the systems) would have meant the work would have paid for itself very quickly.

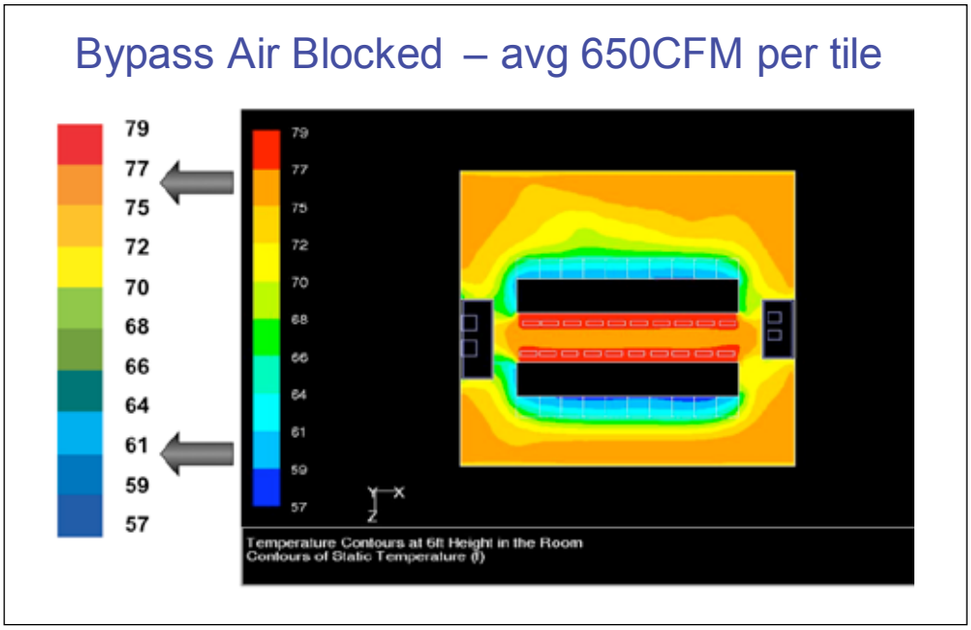
If you do nothing else after reading this article, make sure you deal with bypass air.

Exhaust Fans In Cabinets Is Nearly Always Bad News

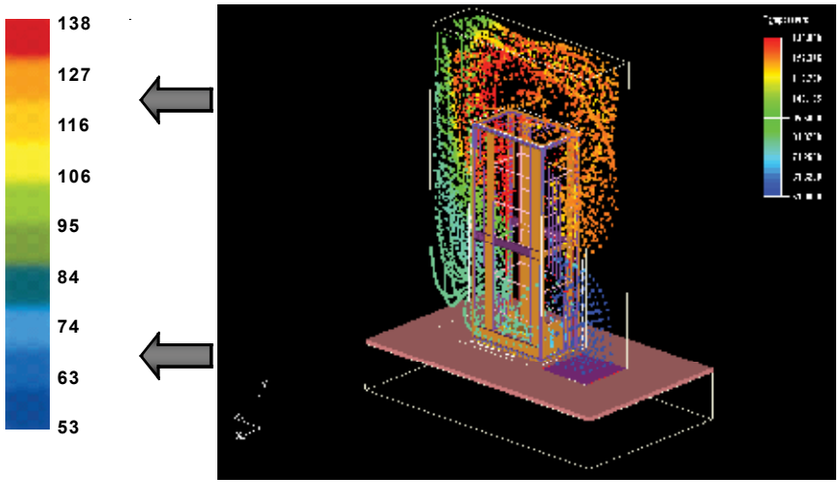
Firstly, fans are a single point of failure and this is never good news in a data centre filled with expensive equipment that needs to be running 24/7. Fans more often than not impede air flow and reduce the cooling efficiency of the room. In many cases roof top fans on a cabinet create hot spots because

> "if you can't measure it you can't manage it."

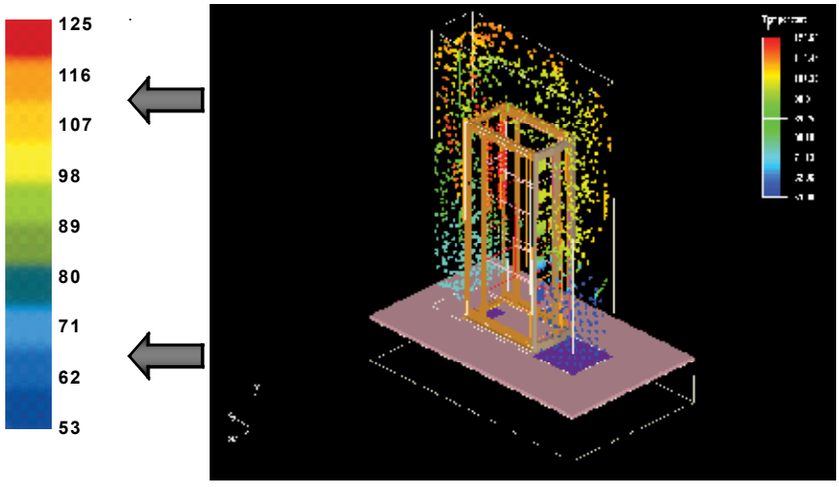




Top Mounted Fans Cause Hot Spots



Same cabinet with fans removed



> Blocking bypass air can no longer be considered best practice - it needs to be considered as basic practice.

they bring the hot air closer to the front of the cabinet. You don't need to suck the hot air out of the cabinet you just need to let it leave through the rear perforated door and then let it find its way back to the installed cooling system.

In some rare cases roof top fans are necessary but it is rare. Exhaust fans on rear doors make no sense to me at all. They are only necessary if the rear door is sealed and the air has no other way to get out. When you use perforated doors which allow a high level of airflow through them I can't see why a rear door fan would be needed in a new site.

Create An Air Dam

Once bypass air has been managed, we need to create an air dam between the front and rear of the cabinet. The 1st part of this is achieved by installing blank filler panels in the unused RU spaces within the cabinet. Unfortunately, the current generation of filler panels were never really designed for the sort of air containment that we're working towards today; they were only designed to be mounted easily and to look good. As a result many of the filler panels available today leave a space for air to re-circulate through. We now have new generation filler panels that have been designed to dam the air properly between filler panels.

The 2nd part of this discussion is the need to dam the air that re-circulates through the gap between the 19 inch vertical rails and the sides of the cabinets. There are 2 ways I am aware of to achieve this on new cabinets. One is by using a sold barrier (made for the cabinet in question) between the 19 inch vertical rails and either the sides or front of the cabinet and the other is by using brushes which cover the same area. Remember, the idea is to stop the air and I have seen some manufacturers using cheap scarcely dense brushes that really only keep about 50% to 70% of the air dammed. Just think truck tyre brushes – these don't work too well in damming the air to the levels we are looking for and after a while the bristles stay bent and further reduce their effectiveness.

For already installed cabinets, you can simply buy some strips of foam that, when fitted correctly, will do the same job.

While managing bypass air and correctly separating hot and cold air does a lot to achieve higher efficiencies it doesn't take you as far you need to go, certainly not for a new data centre anyway. Following the above guidelines will help to segregate hot and cold air at a cabinet level. If you want to start to talk about heavy loads and lower PUE's you'll need to read the next edition of Strategic Facilities where we will look at how to segregate the hot and cold air at a room level and really start to achieve the ability to handle high and varied loads per cabinet, using passive cooling. ■

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Improving Thermal Efficiencies – Part 2

Tony Koury, National Sales & Technical Director, Page Data

> Problems can be resolved for far less money by making the cabinet and the room work more efficiently.

In this second article on data centre thermal management strategies, Tony Khoury explains the strategies for dealing with higher densities by segregating hot and cold air within the room.

In the last article regarding thermal management of data centres we discussed how we are starting to analyse and define data centre efficiencies by measuring PUE. We looked at the cabinet and its changing role within the data centre as well as how we could start to think about segregating hot and cold air within the cabinet. In this article we are going to look at some of the things that are being done to further improve these efficiencies and allow us to handle higher heat loads both within each cabinet as well as the whole room.

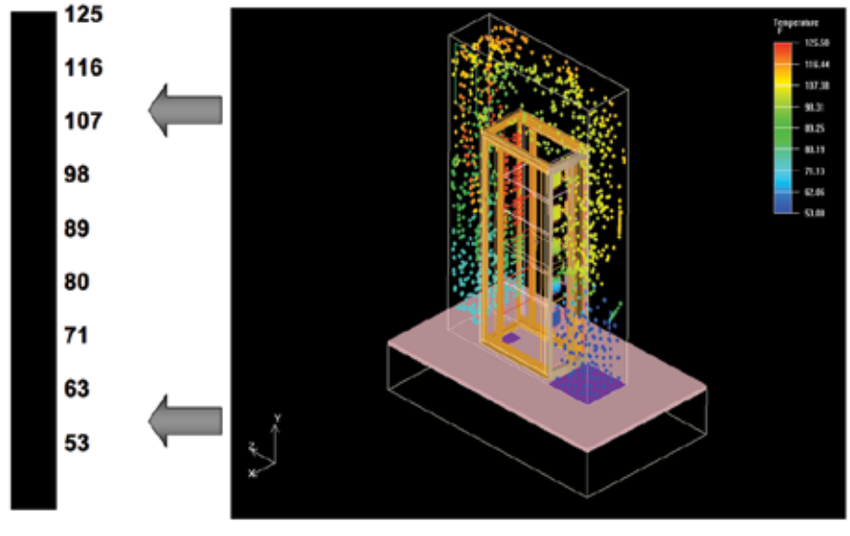
I sometimes shudder when I think about how much money is being spent on extra air conditioning either at a room or cabinet level when in fact, in most cases, the problem could have been resolved for far less money by making the cabinet and the room work more efficiently. Not only is it the initial cost of installation of extra or localised cooling units but it is also about the running costs and therefore the overall efficiency of the room that suffers as a result of the lack of understanding that is out there about this subject.

Let's look at some of the strategies available to people to overcome the extra density and lack of efficiencies at a room level.

The first thing to think about for an existing room is whether you have enough supply air to handle the extra heat loads. You also need to consider how to get cool air to both the bottom and top of each cabinet.

One way to do this is to add more air to the cabinet by creating a cold air chimney at the front of the cabinet inside the front door. Some people do this and then add a solid door to direct the air up the cabinet face. That is well and good until you don't have enough supply air and then things start to go wrong. My recommendation is to use both the air chimney and the front vent in the floor tile, together with a perforated front door, to deliver more air to the cabinet. In our business we go one step further and recommend peo-

What happens when the equipment needs more air than is available from the floor tile?



ple use a specific brand of cabinet that has the patented ability to deliver cold air to the top of the cabinet using side air ducts installed within the cabinets. This is a relatively new and inexpensive way of getting cold air to the top of the cabinet and it does not add any extra moving parts that can break down or use any more electricity.

Even in situations where the total volume of air might be a little bit lacking, getting cold air to the top of the cabinet as well as the bottom of the cabinet will definitely be better than having all of the cold air being consumed by the bottom of the cabinet and having the top of the cabinet being fed completely by heated air from the hot aisle. This in itself will deal with most hot spots within an existing room.

ADDING FANS TO A CABINET IS GENERALLY NOT A GOOD IDEA

Where possible don't add fans anywhere in the room that are not part of the room cooling system. I have seen many rooms where people have added fan units at the bottom of the cabinet trying to drag more cold air into the cabinet in question. It needs to be noted that these fan units don't create more cold air but simply re-distribute it.

In my experience, it is rare that using these fan units actually has any meaningful effect. They add noise and they use more electricity which is exactly what we are trying to stop. These fans can sometimes starve the vented floor tile in front of the cabinet of air and so the total amount of available air to the cabinet is not cumulative. There are very few situations where using these fans is a good move. I have also seen rooms where every cabinet has a fan unit drawing air from the floor and I really don't see how this is a good idea, not to mention what it costs to do this.

Last, but not least, when we use these fan units we create a situation where we have no redundancy and so this goes against so many of the ideas built into the data centre space in the first place.

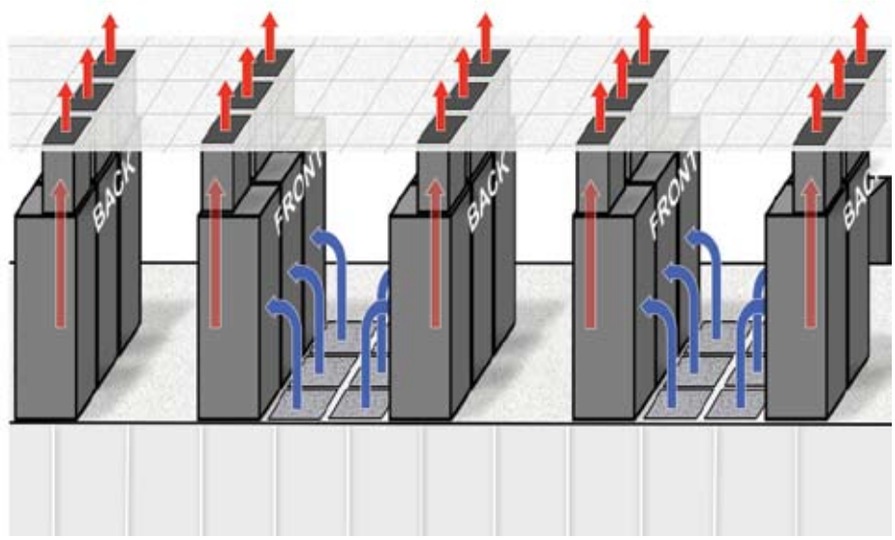
SEGREGATING AIR AT A ROOM LEVEL

In one way or another, many of you have heard about this strategy but I want to take this opportunity to explain the real issues and benefits of it, while considering ways to make the segregation truly effective. There have been various commentaries in the market regarding either hot aisle or cold aisle containment. What they are talking about is the containment of the hot and cold aisles by putting barriers between them. This is normally achieved by putting a roof between cabinets and doors at the end of aisles and this can be done to either the hot or cold aisle.

If asked to choose between the two methods, it is clear to me that containing the hot aisle offers the best solution. This segregates the hot and cold air while allowing the majority of the room to be filled with cool air. The problem is that the hot aisle gets hot and people won't want to work there. Even if this strategy seems fine today, just think about what is going to happen when our heat loads increase and the hot aisles get even hotter.

> “It is rare that using cabinet fan units actually has any meaningful effect.”

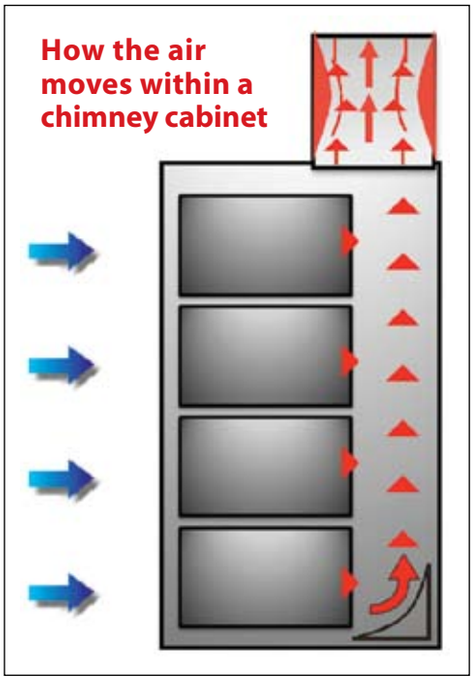
Higher densities per rack rely on the segregation of hot and cold air



Containing the cold aisle on the other hand is normally something I recommend against. At low to medium density loads this may be OK but there are some issues for the long term with this approach.

Firstly, most of the room is now hot and people simply don't like that. From an equipment perspective, all is fine if the cold air being supplied matches the equipment intake requirement. This is a difficult thing to manage because trying to change the volume of available air to match changing needs is very difficult to do in small, confined sections of the room. In the event of a cooling system failure this design has real issues and starving equipment of cold air is something you need to design against.

> By using a chimney cabinet it is possible to cool over 50kW's of load per cabinet without the addition of spot, water-based or localised cooling methods.



I recommend using a hot air return chimney on each cabinet that can be ducted straight back into a ceiling return plenum or can take the hot air away from the cabinet and direct it to the top of the room where it makes its way back to the CRAC units without mixing with the supply air. This means that each cabinet is its own segregated island with cold air being delivered to the front of the cabinet through a perforated door and hot air being sent out the top of the cabinet.

COMPLETE USE OF COLD AIR

If asked, most data centre managers would say that it is impossible to use 100% of the available cold air supply. While they are correct, let's consider the options.

In a traditional data centre, designed with hot and cold aisles (and lots of air mixing within the cabinets and the room), only 20% to 50% of our total supply air gets to the equipment it was intended for. In the chimney cabinet designs, when done properly, we can assume that 90% of the cold air gets to the spot it was intended for.

It is important to note that once we have segregated hot and cold air at cabinet and room levels the only real way for cold air to leave the room is by undergoing thermal transfer through a piece of equipment and back to the cooling system. This concept is as close to 100% utilisation of the cold air as we are likely to get without extra money being spent to seal everything in the room, both within the cabinet and the room itself.

WHAT DOES IT ALL MEAN?

Let's look at the advantages that this design brings to our data centres.

1. Hot and cold aisles are no longer critical, but still a good idea.

2. Supply air can be fed into the room from under the floor or through walls and ceilings.

3. The relationship that has historically been created between a vented floor tile, raised floor and a cabinet is no longer valid. The new relationship is between a full room equipment heat load and its complete air supply capabilities.

4. Having 10 cabinets with 1kW of equipment in each or one cabinet with 10kW of equipment produces the same outcome. This allows you to place high loads in a data centre wherever you like, as long as the full load is not greater than the full supply capacity of the cooling system.

5. Current testing tells us that by using a chimney cabinet it is possible to cool over 50kW's of load per cabinet without the addition of spot, water-based or localised cooling methods. There is no reason to have to allocate specific locations within the data centre to cater for high and low density because the high density spots can be anywhere in the room.

6. A raised floor is no longer necessary for supplying cold air to the room. The raised floor may still be useful for other services, but the height of it can be dramatically reduced.

7. Supply air temperatures can be increased adding further efficiencies to the supply cycle, increasing capacities and reducing overall running costs.

8. In many cases, harnessing the hot air and returning it to your cooling system as hot air means substantial benefits for cooling system efficiencies and overall capacity.

9. Substantial operating cost reductions.

10. Mother Nature should thank us for doing the right thing by her.

Much of what has been discussed here may be obvious to some of you, while others may be reading this unsure of whether to believe it or not. But these concepts have been used in many data centres around the world and the benefits are applicable to all data centres from rooms with one cabinet to data centre buildings with many hundreds of cabinets installed in them.

It is time for change and this is the simplest way I know to contribute to the sustainability discussion that everyone seems to be having. Not only that, but it will also save you and your company money. ■

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