An Introduction to Cold Aisle Containment Systems in the Data Centre

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Executive Summary

Data centres are one of the leading contributors to global carbon emissions and continually increasing energy consumption, aside from heavy industrial consumers. A huge amount of energy within the data centre is used purely in computation, yet this represents just a fraction of that required to power the whole data centre facility. In addition to computational energy, there are significant energy costs associated with providing resilient electrical infrastructure and controlled air conditions required within the data centre.

Currently, most data centre cooling techniques are air-based and provide sensitive servers and rack equipment with cool air temperatures of around 21° C. Air temperatures must be stringently monitored and controlled; Containing air delivery and avoiding or eliminating the mixing of cold conditioned air with warm unconditioned air often forms the basis of major energy reduction strategies. Simply rearranging a badly configured data centre can see dramatic reductions in energy consumption of up to 65%; even a well organised data centre can see reductions in the region of 30% when containment is implemented.

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Notes & Resource

The purpose of this paper is to provide end users, and those with an interest in data centre systems, a brief introduction to cold aisle containment and a discussion of the considerations and benefits of these systems and where they fit within the modern efficiency data centre.

Target Audience: End User

The Traditional Approach

Historically, data centres and server rooms were arranged in an incidental, space dictated manner. It was common for little attention to be given to airflow and circulation within the room, mostly employing a brute force method of cooling to maintain the required temperatures and humidity levels across the room. Frequently this resulted in overcooling some areas in order to avoid hot spots in others and, while the temperatures and power densities involved at the time allowed this practice to continue, this was never a sustainable practice.

The concept of the cold aisle and hot aisle rack arrangement together with a raised air delivery plenum was championed during the early 1990s by Dr. Bob Sullivan who developed the arrangement of the server rooms to account for increasing power densities and improve air management. This perspective on server rack cooling, although seemingly simple, was revolutionary within the data centre arena. It presented a resourceful method of arranging racks and equipment to pool hot and cold air separately and reduce the mixing of the two air streams, which has now served well for many years, allowing greater capacities of up to 1-2 kW per rack. However, the constant growth in computing demands and computational density has compounded to result in even small tech rooms requiring large amounts of IT power and subsequently increased cooling demands.

In order to counteract the recirculation issues which can occur between cold and hot aisles over the top of the racks, as illustrated in Figure 1, a common, inefficient but effective technique of over supplying the cold aisle can ensure that hot air remains outside of the server air intake, as illustrated in Figure 2.

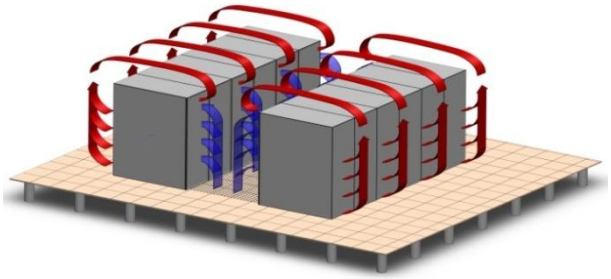

Figure 1 - Hot Air Recirculation in an Open Cold Aisle

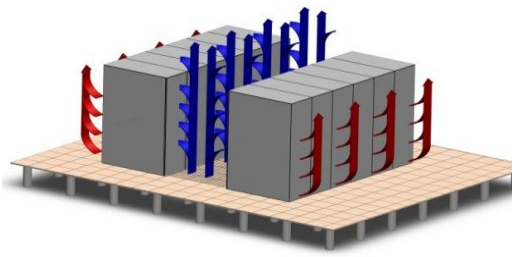

Figure 2 - Over Pressurisation of the Cold Aisle

In light of many driving factors, such as environmental impact, and the acknowledgement that the growing trends in power dependency and consumption are unsustainable a strong focus has naturally centred onto energy efficiency and how best to reduce our energy consumption without compromising substance, function or quality. The identification of data centres as a key area for energy efficiency savings on a national, and also corporate level, naturally questions the effectiveness of traditional cooling. The challenge becomes how best to manage running costs, energy costs and carbon footprint, whilst simultaneously accommodating the increasing power densities and thermal loads which the industry requires.

The Contained Cold Aisle

One of the most effective methods of increasing energy efficiency, while allowing for increased densities and thermal loads, is the implementation of a physically managed airflow system, building on under floor air delivery and extending it to include containment at the aisle.

There are two main trains of thought with respect to this; firstly, to contain the hot aisle and flood the room with cold air, and secondly, to contain the cold aisle and allow the heat to be rejected from the servers back into the room to then be cooled by in room CRAC units, as illustrated in Figure 3, below.

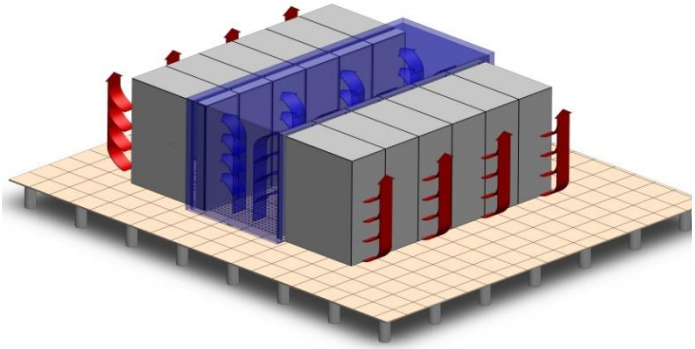

Figure 3 - Flow with Cold Aisle Containment

There is no universally acknowledged right or wrong approach, however, from our experience we have found cold aisle containment to be the most effective and practical solution; maintaining a suitable working environment for employees within the data centre at the same time as achieving effective, and importantly cost effective, results in energy efficiency.

Employing cold aisle containment allows efficiency to be improved over traditional methods in several ways. The reduction in air mixing results in the ability to increase air delivery and return temperatures, thus increasing the efficiency and capacity of the cooling hardware used. The increased operational air temperatures become even more advantageous when coupled with free cooling installations, where the ambient outdoor air temperature can be used for a greater proportion of the year due to the higher indoor set points.

Well managed airflow with minimal mixing reduces the need for over-supply and over-pressurisation of the cool supply air, reducing the work required by CRAC unit fans. This is particularly effective in reducing energy consumption due to the fact that the reduction in work performed by the fan is cubically related to the resulting decrease in the absorbed power of the fan. That is to say, reducing fan speed to 90% results in energy reductions of 90% x 90% x 90% = 72% - almost a 30% energy saving from only a 10% reduction in fan speed.

Cold Aisle Containment Systems

Cold aisle containment is simply a barrier between the cool supply air and the hot return air of the IT equipment. How this is achieved can vary depending on the level of containment desired and the budget available.

In limited situations, basic rooms with only a small number of racks can benefit from a retro fit of simple plastic curtains; however where the opportunity is available, data centres generally make use of purposefully constructed and contained zones such as those shown below.

Figure 4 – Some purpose built, cold aisle containment systems. The particular systems shown are manufactured by Knürr (Top) and Rittal (Bottom).

Fire Detection and Suppression

It is important to note that fire presents a great risk within a data centre to both operation and data protection hence early detection and suppression is a priority. Implementing a cold aisle may alter the effectiveness of your existing fire detection and suppression systems and as such strong consideration must be given to the cold aisle and under floor plenum with relation to fire detection and suppression.

There are variations in local fire code and what is both a recommended or legal requirement. In addition to this, there are differing opinions regarding the operation of air conditioning equipment during either a first alarm or during the release of gaseous fire suppression agent.

Some manufacturers of cold aisle containment systems have conducted tests which illustrate the effects on fire detection and suppression of contained closed aisles and also the impact of running air conditioning equipment during a possible fire situation These papers and studies can be useful to consult when deciding on the best possible fire strategy for your particular project and circumstances.

Due to the variations in legal requirements the only advice which can be given across the board with regard to fire suppression and detection is to discuss this with a certified fire professional and ensure that any system that is being proposed satisfies not only the legal requirements but also your own internal targets in terms of detection and response time and overall risk.

Enhancements and Additional Control

The containment of the cold aisle and overall management of the airflow within the data centre allows you to gain more control over meeting your overriding hardware requirements, whilst taking care not to over-cool or over-produce supply air. Emerson Network Power have drawn on their subsidiary companies of Knürr, who specialise in server racks, high density water cooled racks, and cold aisle containment, and the refrigeration arm of Leibert to create synergies in the control systems which can be implemented. Their recent development – SmartAisle – measures the temperature of air flowing through a small opening around the roof of the cold aisle; if the measured temperature is close to the return air temperature then this indicates warm air flowing into the cold aisle due to an under provision of cooling air. Conversely, if the temperature probe measures a cool temperature close to the supply air temperature then this indicates that cool air is being over provisioned. Both scenarios feed back to the CRAC units which then control the flow of the air into the under floor plenum, the CRAC units can then feedback to the chiller units to control the cooling demand enabling the chillers to reduce their cooling appropriately. This chain of control allows for an adaptive and efficient system but can only be considered in either a new build data centre or in a situation where fairly recent Emerson-Leibert CRAC and Chiller units are already being used.

References and Further Reading

A Comparison of Room-, Row-, and Rack-Based Data Centre Cooling Products - A Dell Technical White Paper By David L. Moss, Dell

CoolFlex - Cold Aisle Containment in Data Centres - An Application report – Knürr
Available from: http://www.knuerr.com/web/whitepapers/en/

Rittal White Paper 506: Cold Aisle Containment for Improved Data centre Cooling Efficiency
By: Daniel Kennedy, Rittal
Available from : http://www.rittal-corp.com/company/news/press_release.cfm?nid=139

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