HOT AISLE CONFIGURATION & CONTAINMENT

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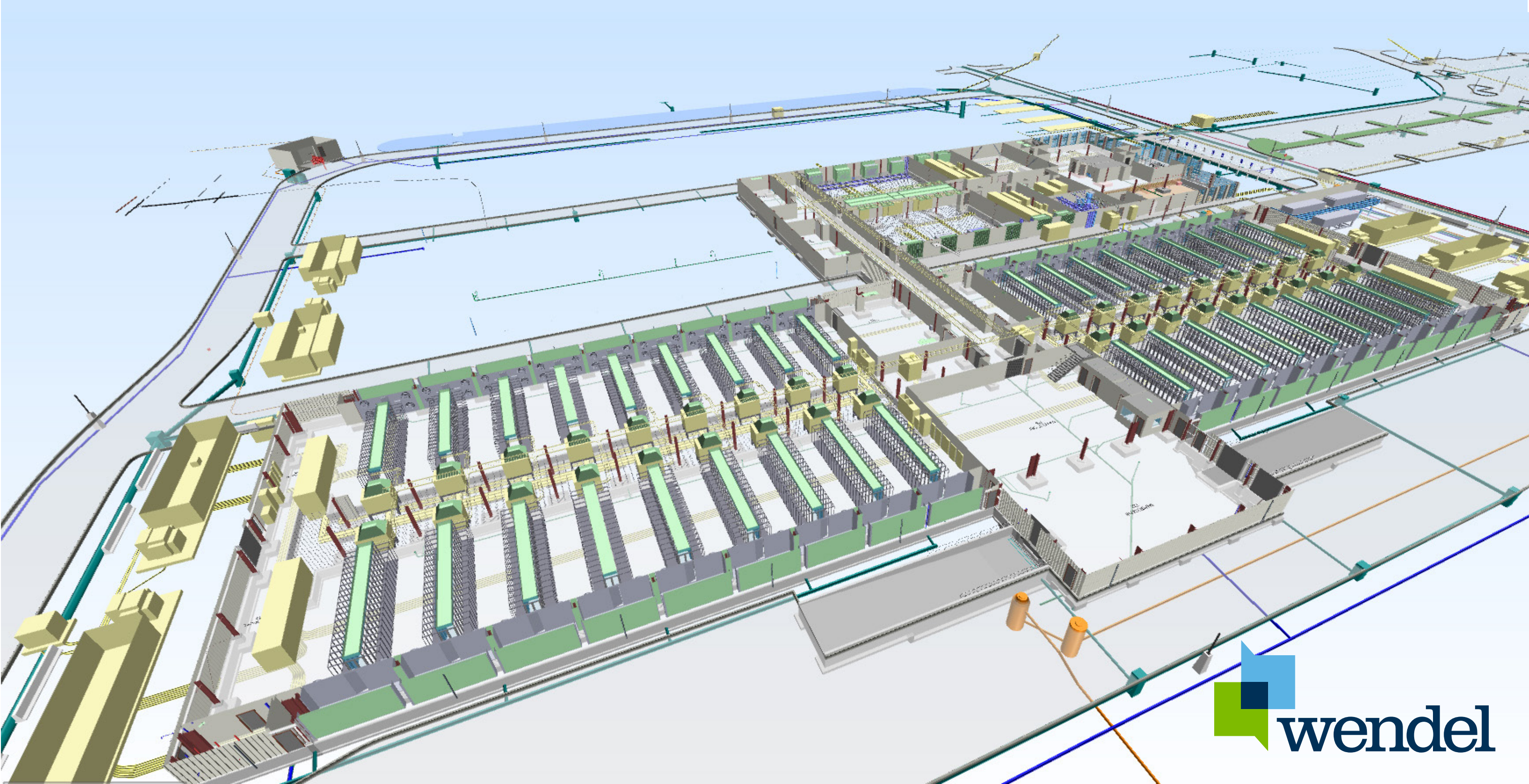
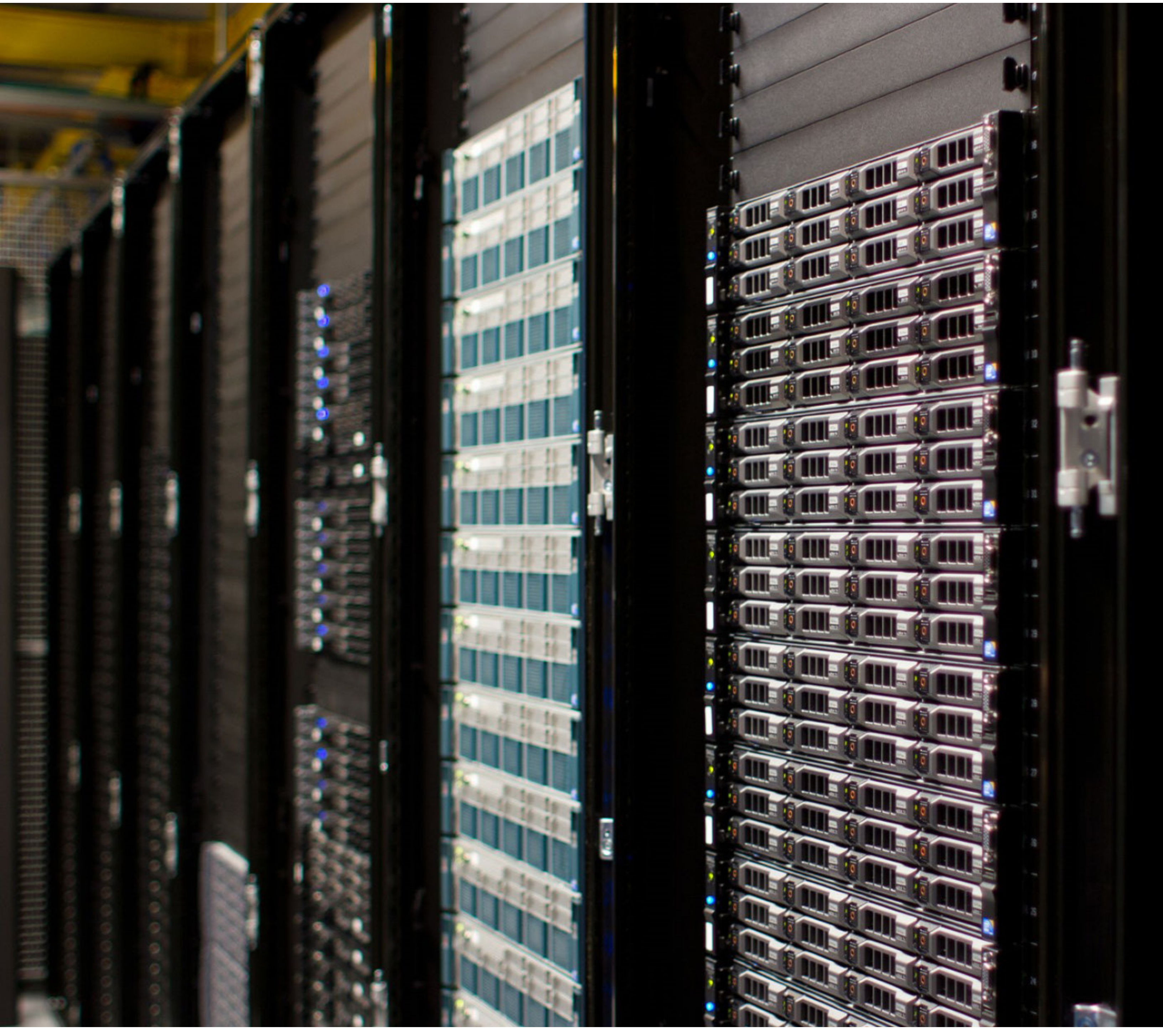




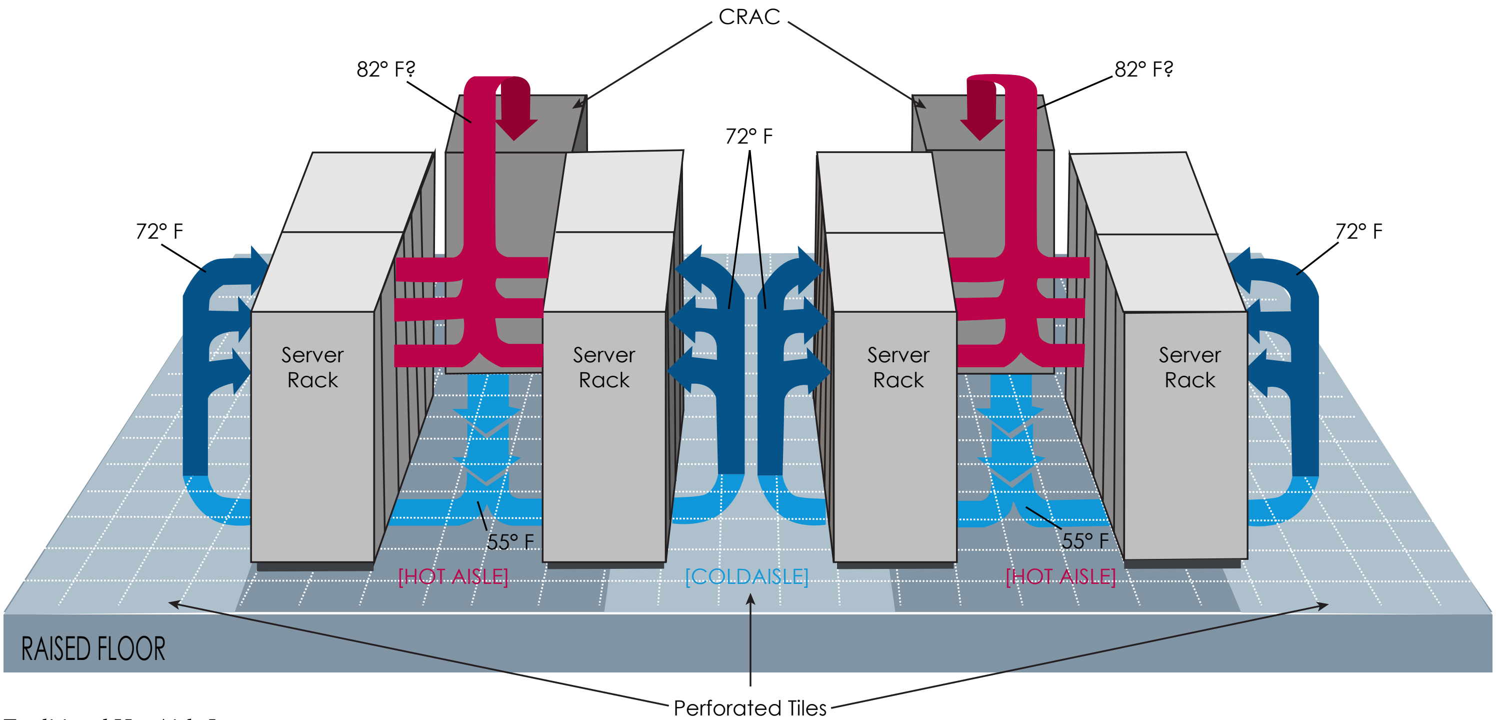
HOT AISLE CONFIGURATION & CONTAINMENT

HOW DOES HOT AISLE CONFIGURATION AND CONTAINMENT SAVE ENERGY?

This is the second article in a series that I hope will help data center operators in their understanding of what can be done to create a high performance data center. The articles will attempt to move from the simplest to implement to the more complex. This article will focus on hot and cold aisle configuration and containment.

Early data center rack arrangements were often task-based, where racks performing similar functions were located in close proximity to each other. There was little attention paid to where the rack inlets and discharges were placed; that is, there were no defined hot and cold aisles. When racks are arranged such that there is no defined hot and cold aisle, the hot air being discharged from the racks mixes with the air entering nearby racks, thus raising the temperature. This condition has two negative impacts.

On a macro scale, more cooling air must be delivered to the space to maintain space temperature. The air discharging from the rack mixes with the cooling air, which raises the inlet to the racks. To limit the impact of the mixing, additional air must be delivered to the space to maintain space temperature set point. This also results in the air returning to the computer room air conditioner (CRAC) at a relatively cool



Traditional Hot Aisle Layout

condition when compared to the CRAC discharge air temperature. The smaller the difference in temperature between the CRAC return and discharge air, the lower the CRAC efficiency and higher the volume of air required to meet cooling requirements.

On a micro scale, today's servers have cooling fans that can modulate speed based on their internal cooling requirements. If the inlet temperature to the rack is elevated due to a nearby rack discharging toward it, the server fan must spin faster to provide cooling. To recap, when racks are arranged such that there are no defined hot and cold aisles, the result is inefficient cooling. This is a result of hot server discharge elevating the cooling air temperature due to mixing. This will elevate the amount of cooling air required to maintain space temperature.

Very early in the push to increase data center energy efficiency, the idea of arranging data racks such that there are dedicated hot and cold aisles was conceived. The reason for this type of arrangement is to ensure that cold air is delivered to the front of the data racks and hot and hot air is exhausted to a common hot aisle at the back of the rack. Typically the cool supply air was delivered to the front of the racks through floor diffusers that are tied to a below floor supply air plenum. Air from the hot aisle would be returned to the CRAC units through return air grilles tied to a ceiling return air plenum. This reduces the amount of hot and cold air mixing, thus providing more controllable air temperatures at the inlet of the rack. This arrangement also allowed a lower air volume to be supplied by the CRAC by raising the temperature difference between return and supply air.

The equation in **Figure 1** calculates the cooling load across the CRAC's cooling coil (for simplicity the moisture cooling component has been left out). By rearranging the equation we can determine the air volume required to provide the appropriate cooling load. The typical CRAC discharge temperature is around 55°F., and it is common in many data centers to want to have the space temperature around 72°F, which results in an approximate 17°F temperature difference across the

Figure 1

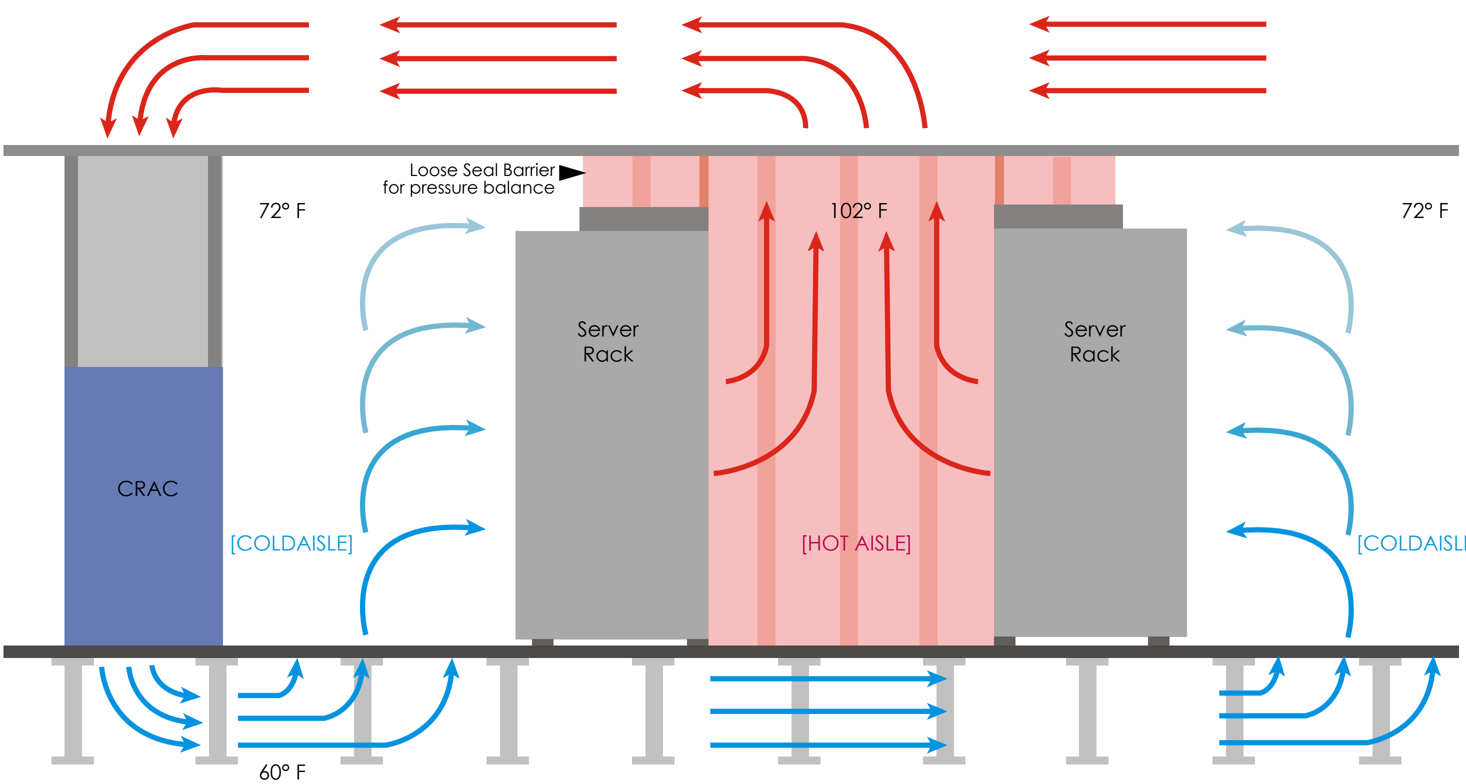
$$q = 1.085 \times CFM \times \Delta T$$
$$CFM = q / (1.085 \times \Delta T), \quad \Delta T = T_{\text{space return}} - T_{\text{space supply}}$$

CRAC. If the racks are arranged in a hot and cold aisle configuration air can be delivered such that air entering the front of the cabinets is still at 72°F while the air in the hot aisle can be say 78°F, the temperature difference across the CRAC now becomes 23°F. This results in a 23% reduction in CFM (air volume). This may not seem like a lot until the fan energy reduction is factored in. The energy saved by reducing the fan volume is roughly the cube of the CFM reduction percentage or in this case a 54% reduction in fan energy. Based on this level of energy reduction, it's hard to believe but I still walk into data centers where there are no defined hot and cold isles.

Over the last few years the separation between hot and cold aisles has gone to the next logical step. In the typical open hot and cold aisle configuration there is a limit to the temperature difference that can be maintained. This is because there is no physical separation between the hot and cold aisle. The lack of separation allows mixing of the air, due to turbulence and buoyancy, to take place near the ends of the aisles and over the racks. This is known as thermal contamination. Thermal contamination is most pronounced at the end of the rows, where the hot and cold aisle can communicate. So what if we were able to separate the hot and cold aisle physically?

Recently many data center operators have moved to hot or cold aisle containment. Containment is a highly effective energy conservation measure that places a physical barrier between the aisles which prevents cold and hot air from mixing. Though many will espouse the virtues of one type

Hot or Cold Aisle Containment

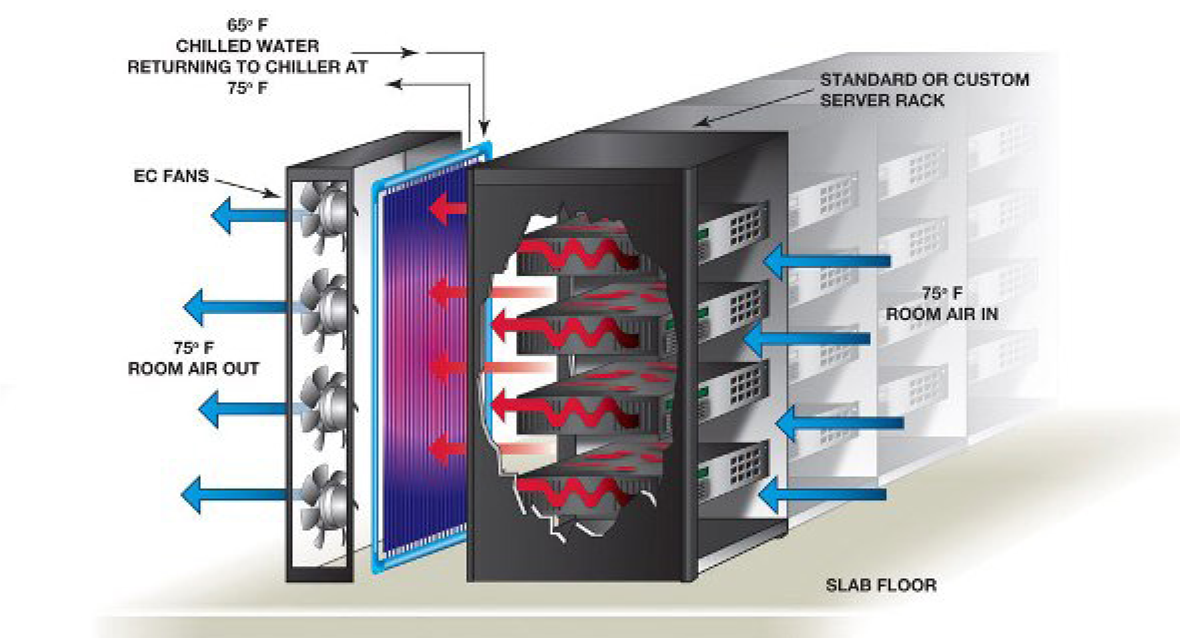


Two different
containment options:
1) Hard enclosure
2) Plastic curtains

of containment over the other, there really is no difference from a physics point of view. The idea behind any type of containment is to deliver air to the front of the rack at a fixed setpoint, while allowing a higher rack discharge temperature. I have experienced hot aisle temperatures as high as 105°F and have heard of some operators allowing even higher temperatures. The typical refrigeration based CRAC has an upper limit of 90-95°F on the return side, so for evaluation purposes we will utilize a 90°F return temperature. Utilizing the above equation the supply air volume required will be reduced by approximately 50%. This will represent an energy reduction of approximately 87% to deliver the air. Additionally, energy savings will result on the refrigeration side due to the higher return temperatures.

There are many versions of containment available on the market. They can range from hard enclosures to plastic curtains. Which containment version is best suited for your data center will depend on factors such as the physical configuration of the racks and your overhead infrastructure. I have heard some folks speak poorly about plastic curtains, but properly installed they can be a highly effective containment method and can often accommodate complex overhead infrastructure more easily than fixed enclosures.

One final thought about containment. Recently there has been an increasing use of rack mounted cooling doors. The reality is that rack cooling doors are, in part, another form of containment. In the case of the cooling door the hot aisle is the space between the back of the server and the face of the cooling coil. There are a couple of benefits to the cooling doors but their primary benefit is the rack density that they are able to cool. One manufacturer has cooling doors that are able to cool up to a 75 kW of rack load. Due to a number of physical/practical considerations a load that reaches that high a rack density would be difficult to accommodate with a traditional containment arrangement. (Use of rack based cooling will be covered in a future article.)



Exploded View of Active Rear Door Rack Cooling System

motivair COOLING SOLUTIONS

Image courtesy of The Power of MonMan Monitoring Management: Mission Critical Solutions; https://www.monman.com/motivair-chilled-door-rack-cooling-details

SUMMARY

There are significant energy savings available through the use of a hot and cold aisle configuration. Aisle configuration allows cool supply air to be delivered to the racks with a limited amount of mixing with the hot air. It also allows warmer return air temperatures to the CRAC's thus reducing the supply air volume, and subsequently reducing the energy need to move the air. Hot and cold aisle containment provide further supply air volume reduction and energy savings by placing a physical barrier between the hot and cold aisle. The physical separation of the hot and cold air allows even greater savings by allowing an even higher return air temperature to the CRAC, resulting in a lower air volume requirement and increase in energy efficiency.

The next in this series of articles will focus on other energy savings method that can be utilized in the white space.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