Data Center Containment Best Practices: Key Considerations to Maximize ROI

Lars Strong, Senior Engineer and Company Science Officer, Upsite Technologies

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OPTIMIZING DATA CENTER COOLING

Airflow Management Awareness Month

- **June 7th – Data Center Containment Best Practices: Key Considerations to Maximize ROI**
  Lars Strong, Senior Engineer and Company Science Officer, Upsite Technologies

- **June 14th – How Artificial Intelligence and Machine Learning Can Optimize Data Center Performance**
  Lars Strong, Senior Engineer and Company Science Officer, Upsite Technologies
  Tracy Collins, Vice President of Sales, Americas, EkkoSense

- **June 21st – Data Center Risk Management: The Importance of Mitigating Risk to Maximize Resiliency**
  Mark Acton, Independent Consultant, Non Executive Director, EkkoSense

- **June 28th – How Modernization and New Digital Demands Have Impacted (and Changed) The Data Center**
  Bill Kleyman, Executive Vice President of Digital Solutions, Switch

Speaker Background

- Thought leader and recognized expert on data center optimization with over 20 years of experience
- Certified US Department of Energy Data Center Energy Practitioner (DCEP) HVAC and IT Specialist
- Presented on various topics around the world:
  - How IT Decisions Impact Facilities: The Benefit of Mutual Understanding
  - Designing, Deploying and Managing Efficient Data Centers
  - Myths of Data Center Containment
  - Understanding the Science Behind Data Center Airflow Management
  - Data Center Cooling Efficiency: Understanding the Science of the 4 Delta T's

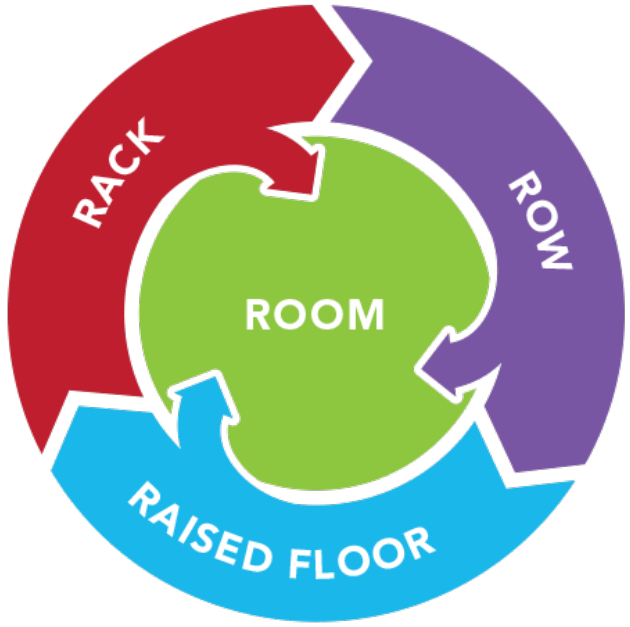
Lars Strong, P.E.
Senior Engineer and Company Science Officer, Upsite Technologies

Agenda

- The 4 R's of Airflow Management™
- Lesser Known Row Airflow Management Best Practices
- Data Center Containment Best Practices
- The Science of Data Center Containment
  - Modular Containment vs. Rigid Containment
  - Containment Installation Considerations
- Matching Cooling Capacity with IT Load
  - Cooling Optimization
  - Fan Laws
  - The Four Delta T's (ΔT)
- Questions

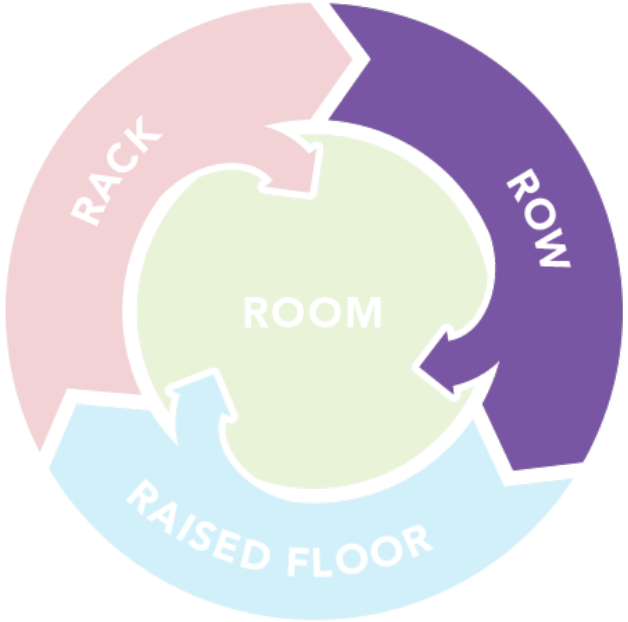
The 4 R's of Airflow Management

- With so many variables affecting airflow within a data center, it can be daunting to know where to start and how to get the most out of airflow management improvements
- The 4 R's of Airflow Management™ is a holistic methodology for identifying and implementing changes to optimize the data center's cooling infrastructure and realize energy savings
- The 4 R's are: the Raised Floor, the Rack, the Row, and the Room



Row Airflow Management

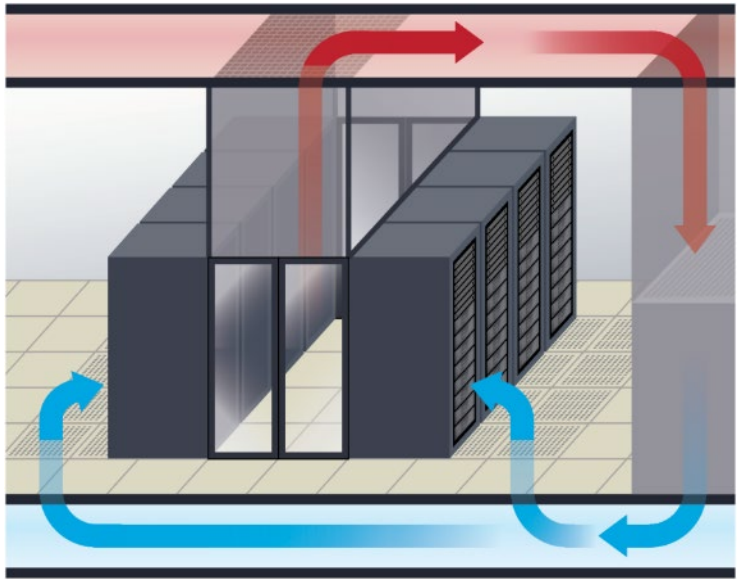
- Improving cold aisle and hot aisle separation at the row level is “Row Airflow Management”
  - Gaps underneath cabinets
  - Gaps between cabinets
  - Open aisle-ends
  - Open space above hot or cold aisles

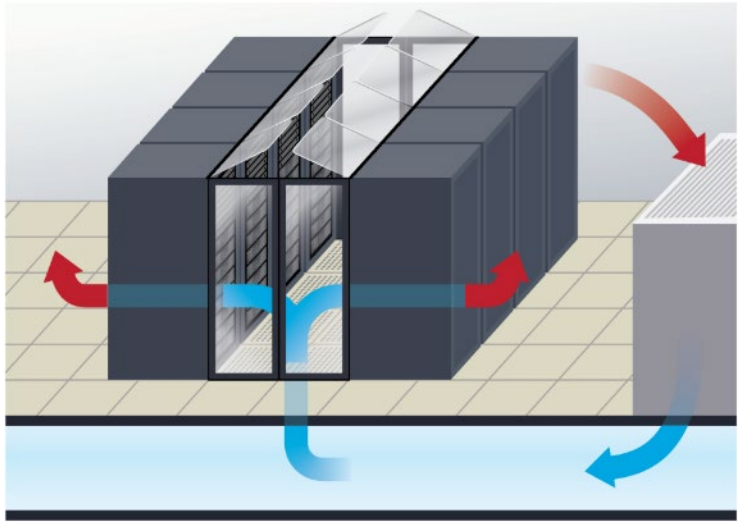


Row Airflow Management Configurations

- For hot aisle containment this generally involves utilizing the ceiling plenum as an exhaust air return path, ducting cooling units to the ceiling plenum, installing doors on the ends of hot aisles and baffles or a full chimney to the ceiling

- For cold aisles this involves installing doors on the ends of cold aisles and baffles or a full roof over the cold aisle

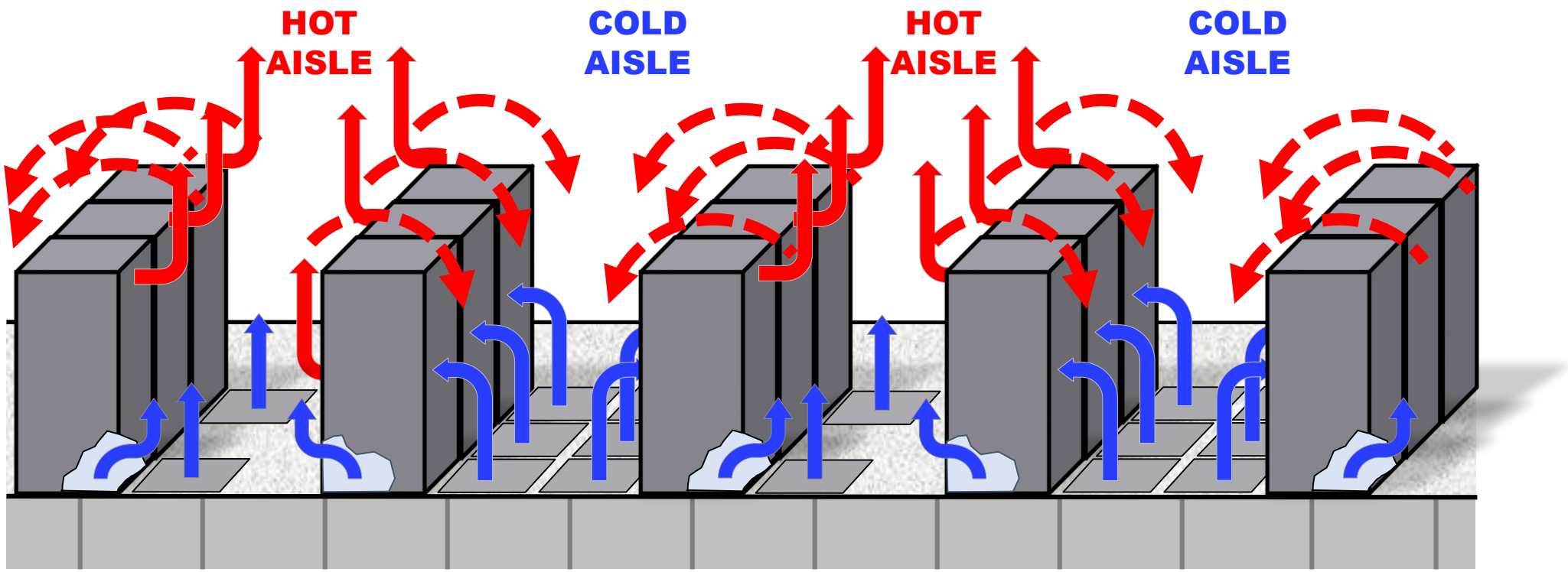




Typical Hot and Cold Aisle Configuration

With Poor Airflow Management

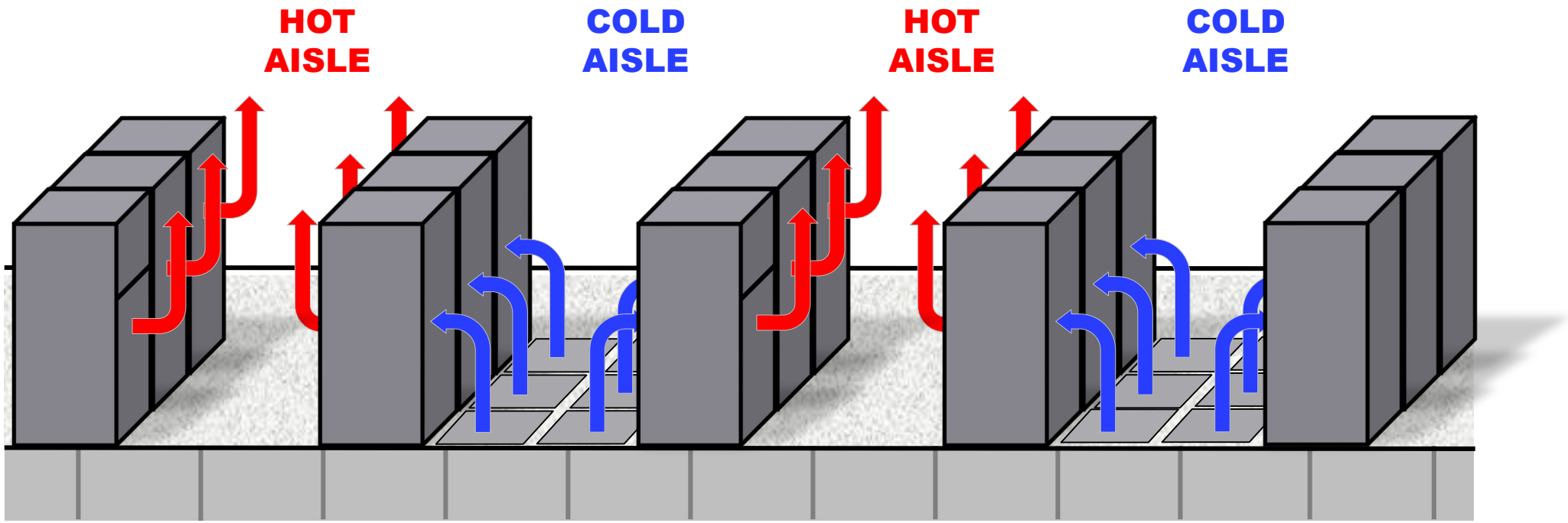
- We want to go from this:



Ideal Hot and Cold Aisle Configuration

With Good Airflow Management

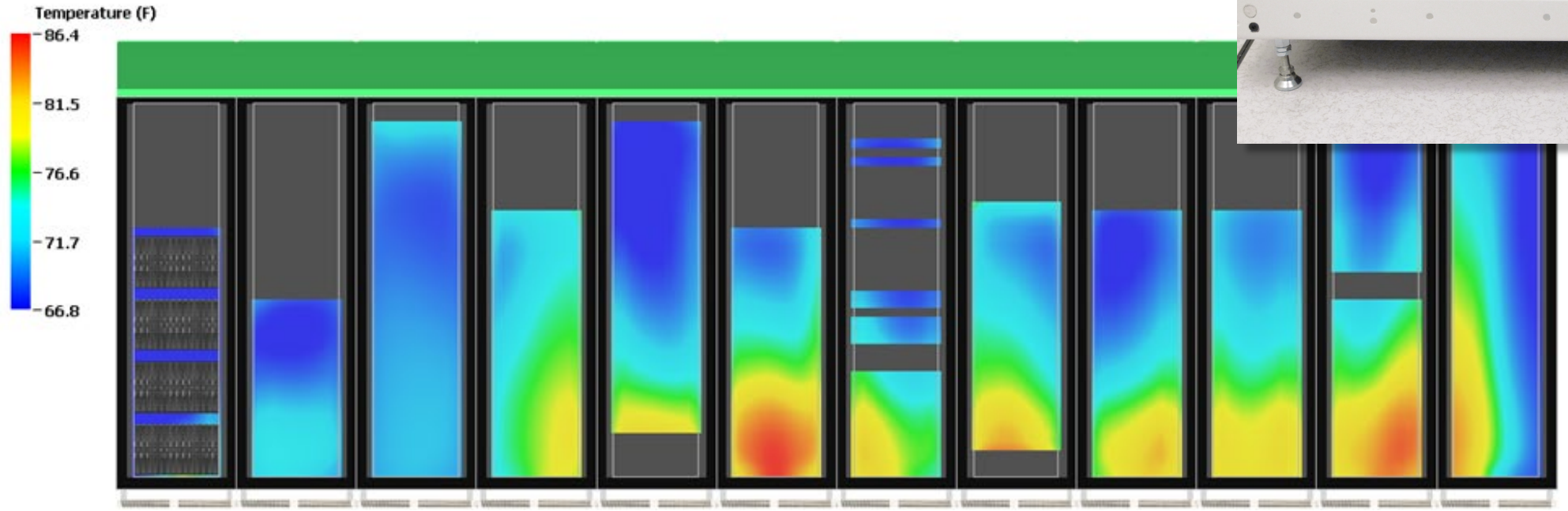
- To this:



Lesser Known Row Airflow Management Best Practices

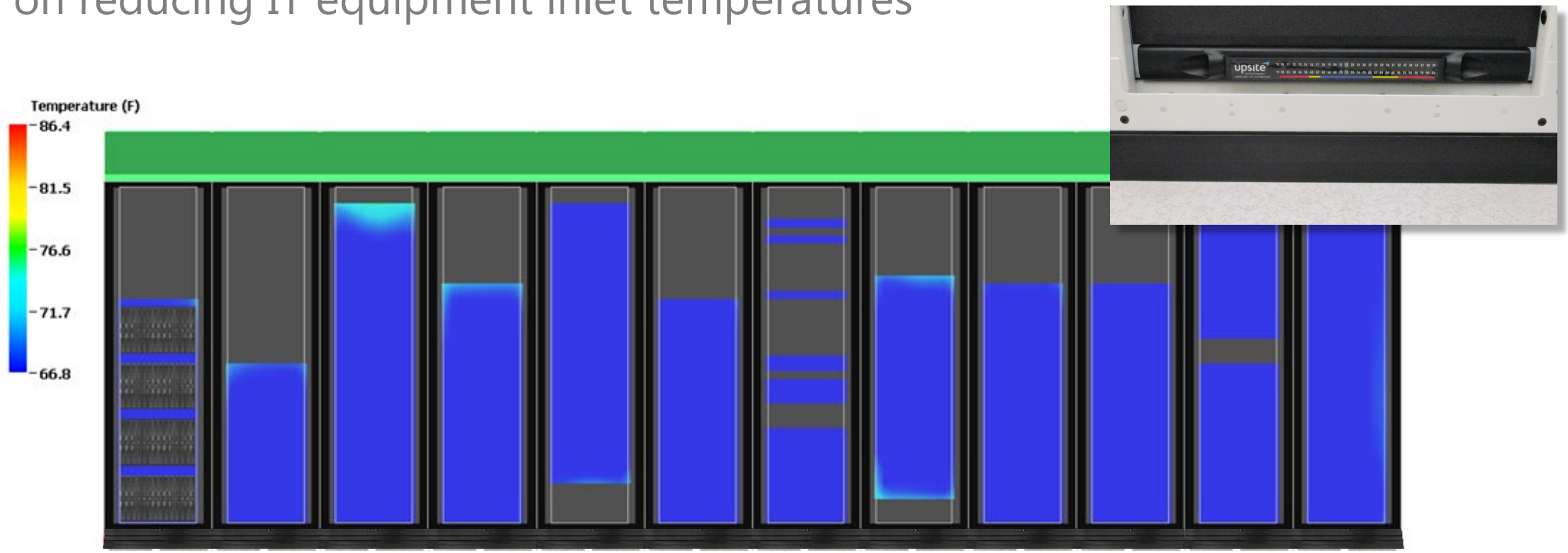
Block Open Spaces Underneath Racks

- Usually ranging in size from half an inch to two inches, this space allows IT equipment exhaust air to travel underneath the rack and ultimately back into the IT equipment air inlets



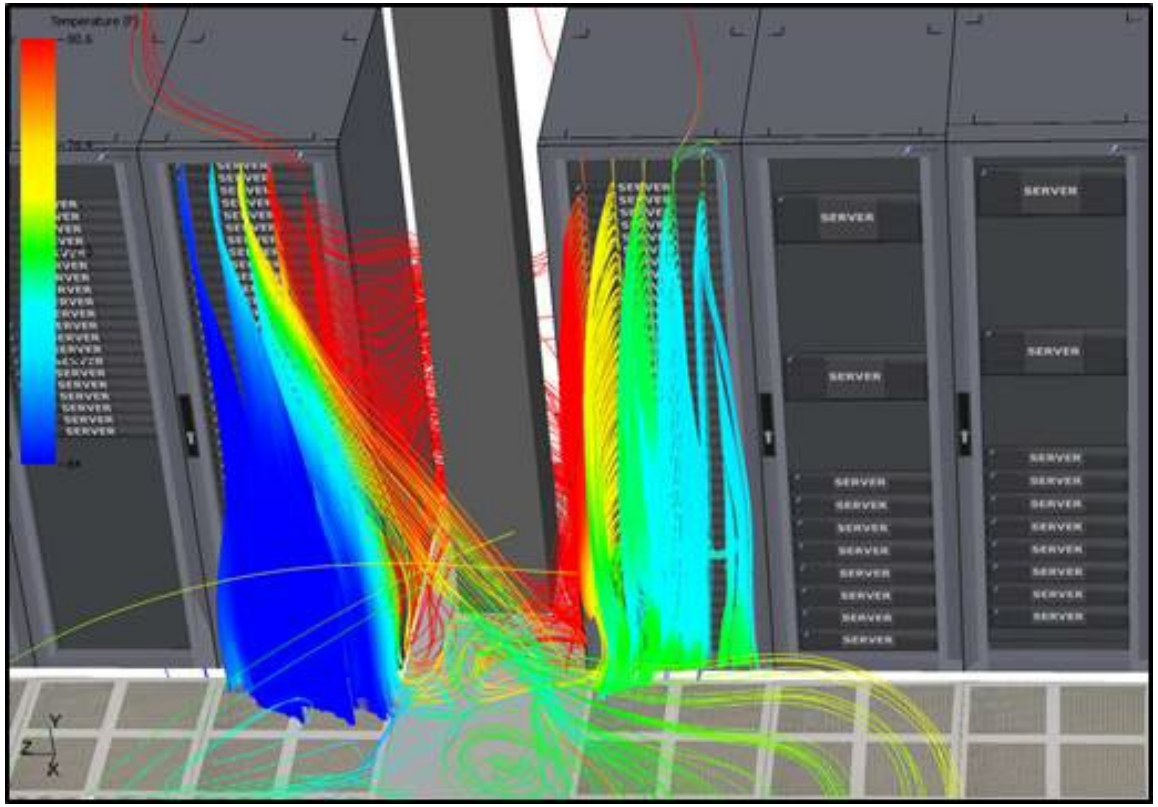
Block Open Spaces Underneath Racks

- To address this, blocking these open spaces with Under Rack Panels is an easy and cost-effective solution that can have a profound impact on reducing IT equipment inlet temperatures



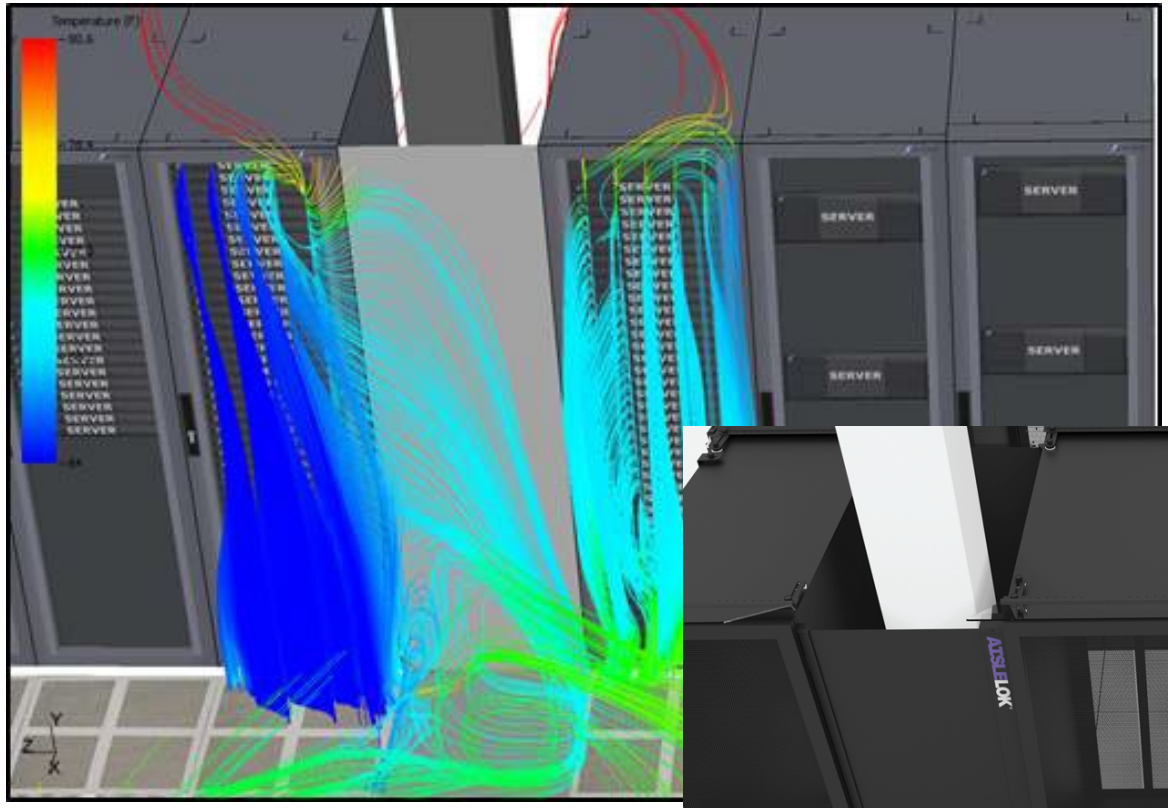
Seal Spaces in Cabinet Rows

- There are many cases where large gaps in between cabinets are present and have not been sealed off
- These gaps are usually due to a building column or a cabinet that has been removed



Seal Spaces in Cabinet Rows

- To address this issue, blocking off any open space in between cabinets, whether it's just a couple inches or a few feet, with Rack Gap Panels or sealing foam will dramatically impact IT equipment intake temperatures at a reasonable cost



Rack Gap Panel

Seal Spaces at the Ends of Cabinet Rows

- In cases where there is a missing cabinet at the end of an aisle, causing uneven aisle lengths, an Adjustable Mounting Post or a custom-sized rigid panel to make up the offset/difference is necessary to be able to install aisle-end doors

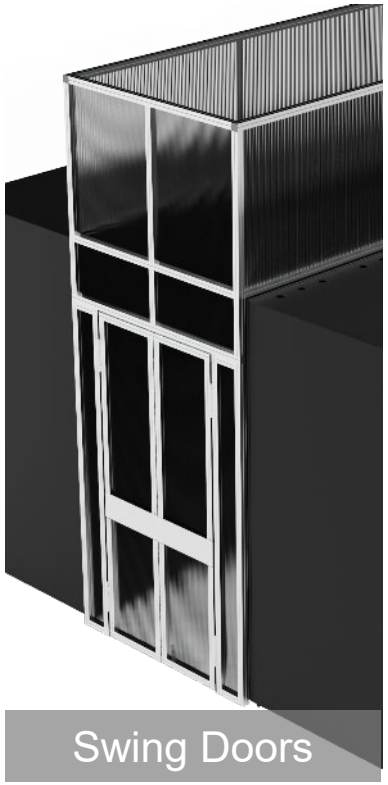
Adjustable Mounting Post w/ Rack Gap Panel

Data Center Containment Best Practices

Install Aisle-End Containment Doors

- Cabinets at the ends of rows are the most vulnerable to increased IT equipment intake temperatures because of the large potential for hot exhaust air to wrap around the ends of rows
- Whether applied to hot or cold aisles, aisle-end doors yield huge benefits by eliminating exhaust air recirculation or the premature loss of conditioned air
- Aisle-end doors are an effective solution that can be applied in singularity and still be extremely effective in reducing IT equipment intake temperatures and creating the opportunity for optimization

Aisle-End Containment Examples



Swing Doors

Bi-Directional Doors and Sliding Doors

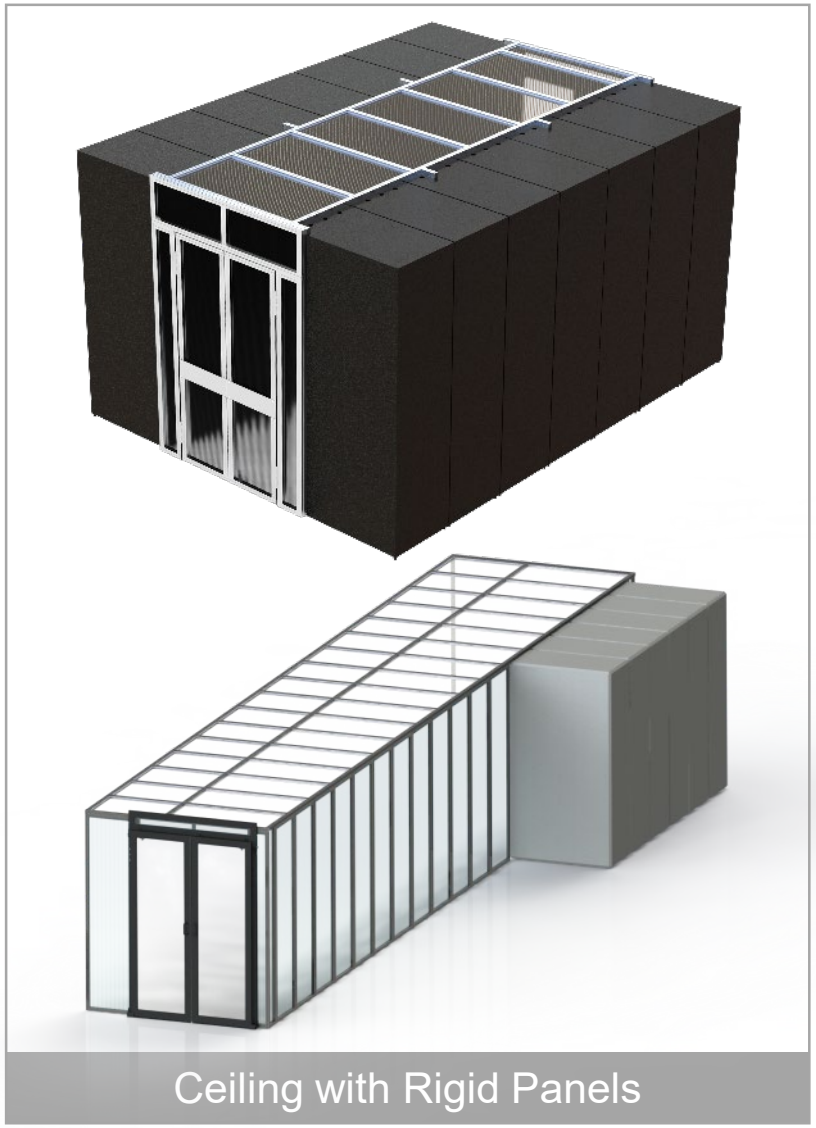
Single Hinge Doors

Curtains

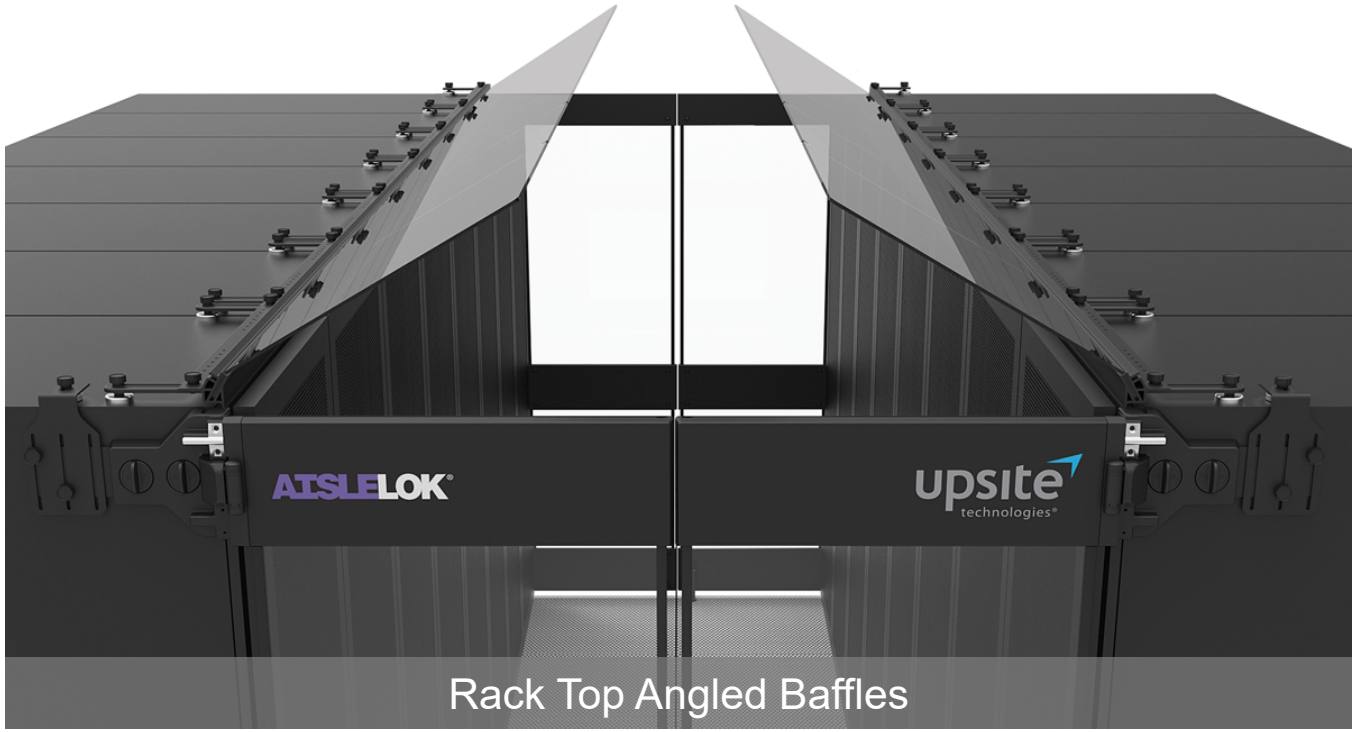
Install Top-of-Rack Containment

- Typically deployed in situations of high cabinet densities or when the highest possible efficiency is desired
- In cold aisles, this involves some form of partitions, baffles, or roofing over the aisle to contain conditioned supply air
- In hot aisles, a configuration of baffles or duct work runs from the hot aisle to the returns of the cooling units

Top-of-Rack Containment – Cold Aisle Examples

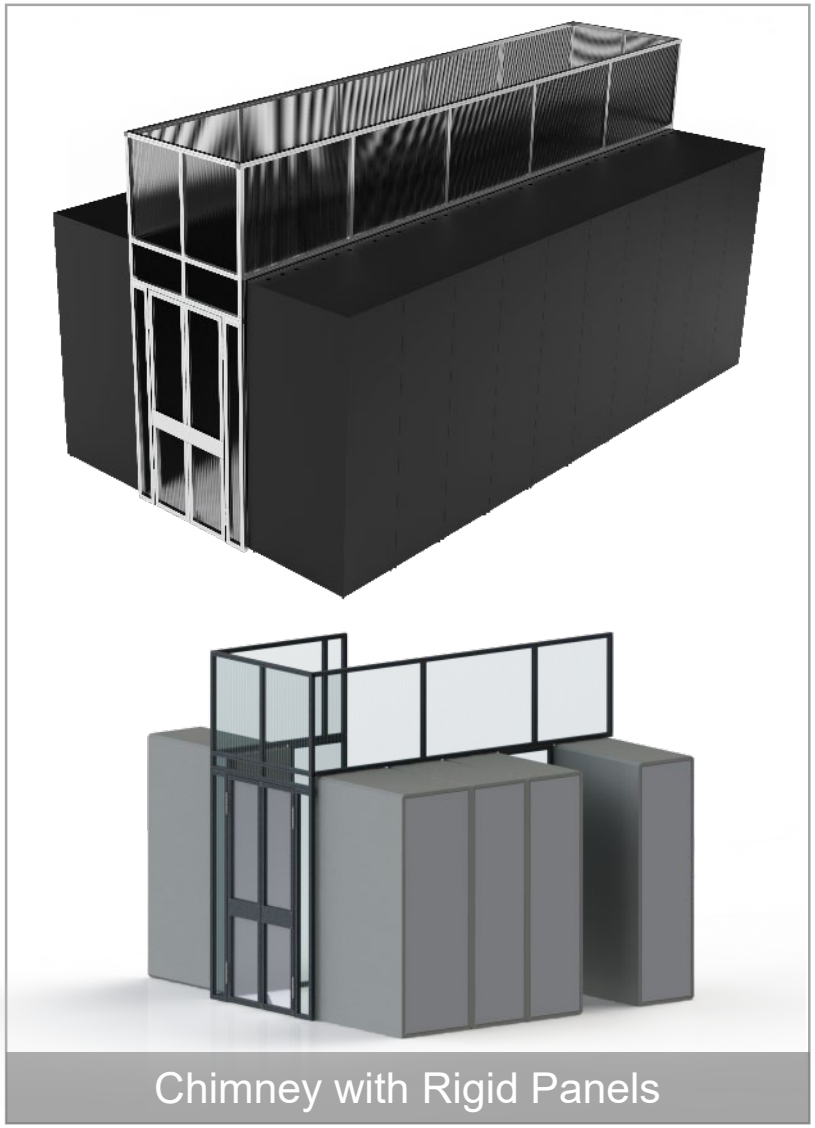


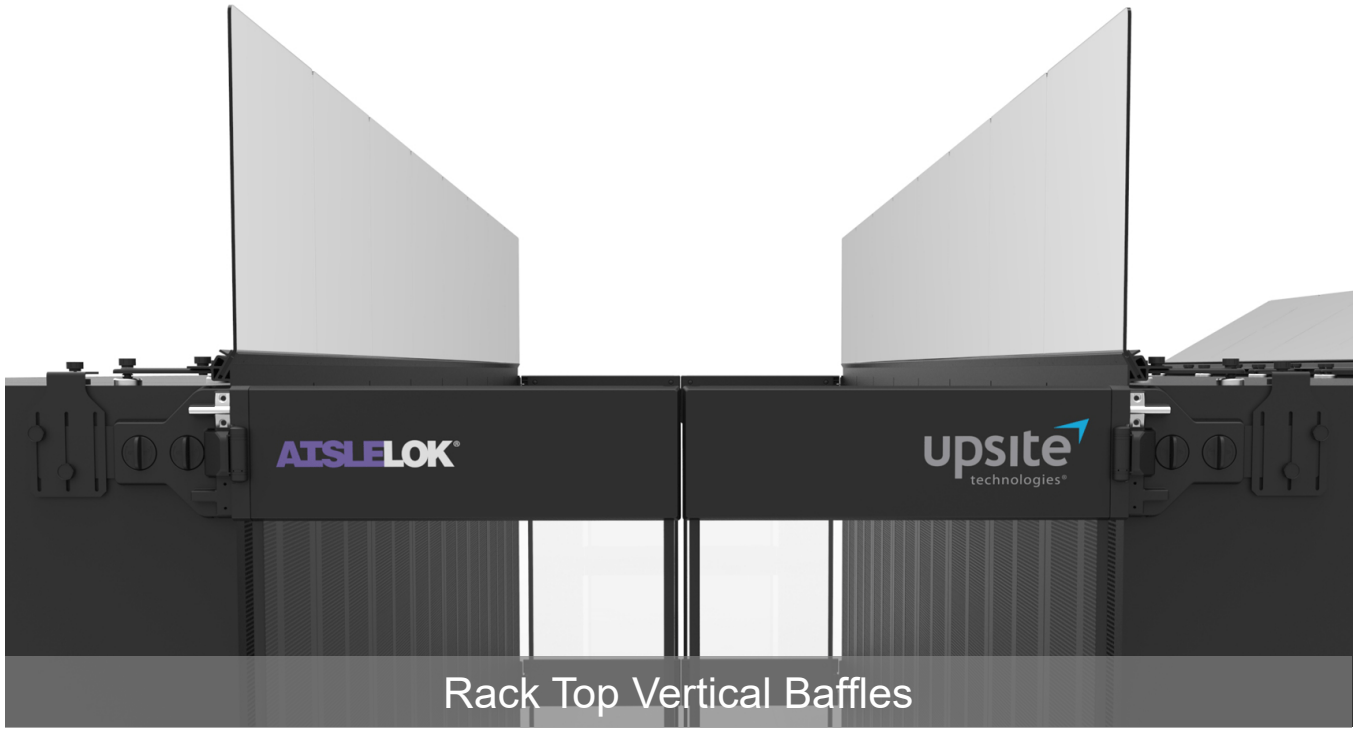
Ceiling with Rigid Panels



Rack Top Angled Baffles

Top-of-Rack Containment – Hot Aisle Examples





Top-of-Rack Containment – Cooling Unit Examples

Cooling Unit Extension

Cooling Unit Extension

The Science of Data Center Containment

Hot Aisle vs. Cold Aisle Containment – **Benefits**

Hot Aisle Containment

- Open area of room is the “cold” environment
- Leakage from raised floor openings in the larger area of the room goes into the cold space
- Generally more effective, more likely to be implemented fully
- Hot aisle containment will be more forgiving for network racks and stand-alone equipment
- Hot aisle containment can perform well in a slab environment
- With a well-designed space, a standard grid fire suppression system could be installed around a hot aisle containment array of barriers and meet code
- Enables more surface area / building mass for “cold storage” in cold area

Hot Aisle vs. Cold Aisle Containment – **Benefits**

Cold Aisle Containment

- Generally easier to implement
- Only requires doors at aisle ends and cap on top
- Generally less expensive to implement
- Cold aisle containment is typically going to be easier to retrofit in an existing data center
- Cold aisle containment doesn't absolutely need to be on a raised floor, but it typically is because of challenges associated with delivering supply air to the contained space(s)

Hot Aisle vs. Cold Aisle Containment – **Challenges**

Hot Aisle Containment

- Requires a contained path for air to flow from the hot aisle back to the cooling units
- Generally more expensive
- May require modifications to fire suppression system, more gas required
- High temperatures in the hot aisle create uncomfortable conditions for technicians working on IT gear

Hot Aisle vs. Cold Aisle Containment – **Challenges**

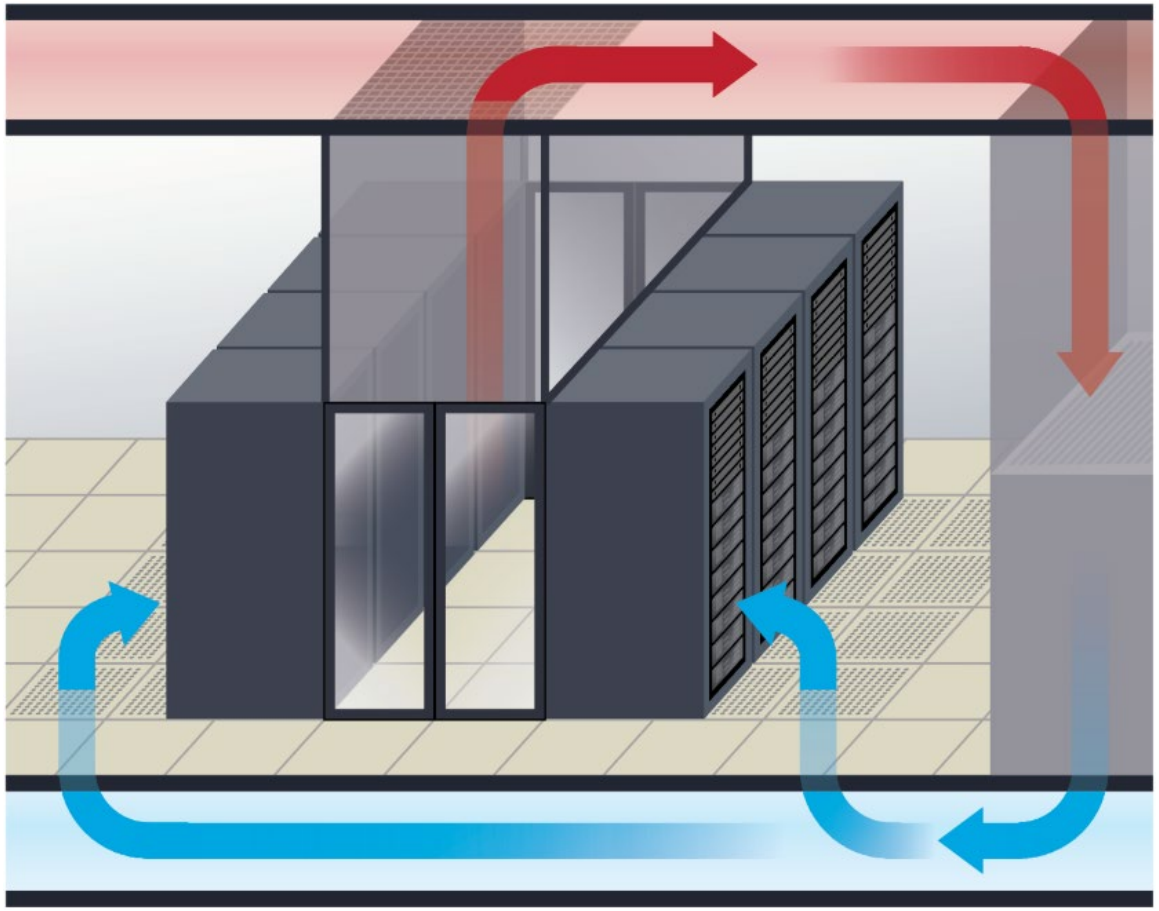
Cold Aisle Containment

- Remainder of data center becomes the hot aisle and that space should be dramatically hot
- There may not be any space with a suitable temperature profile for equipment that for whatever reason is not compatible with living in the containment arrangement
- Conditioned air leaking from the raised floor enters the exhaust air paths returning to cooling units
- Requires consideration of fire suppression system (drop away panels, mechanical system opens ceiling upon smoke detection)

Rigid Hot Aisle Containment

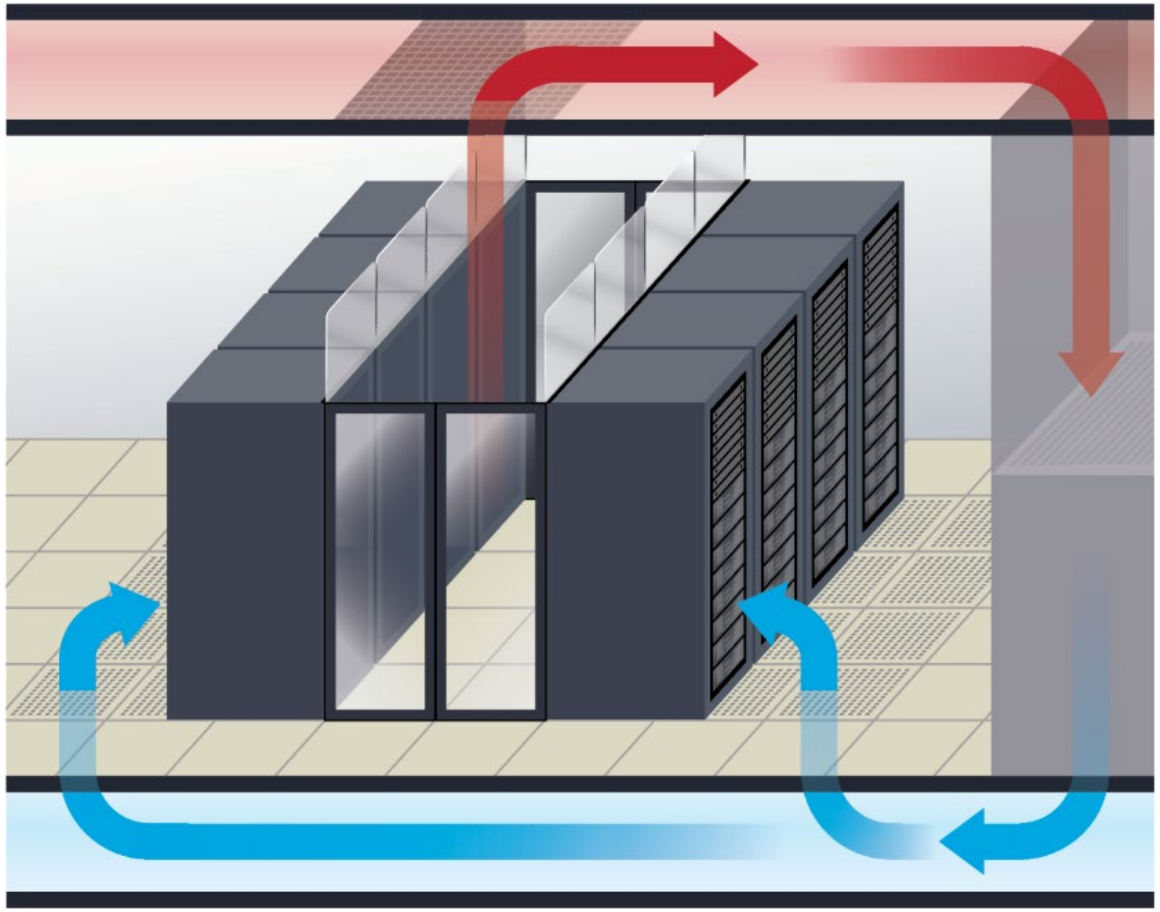
- Requires full ducting of racks to the ceiling plenum as well as ducting the returns of CRAC/CRAH units to the same overhead plenum

- Requires installation crew for construction – either internal crew with required skill set or experienced 3rd party or vendor



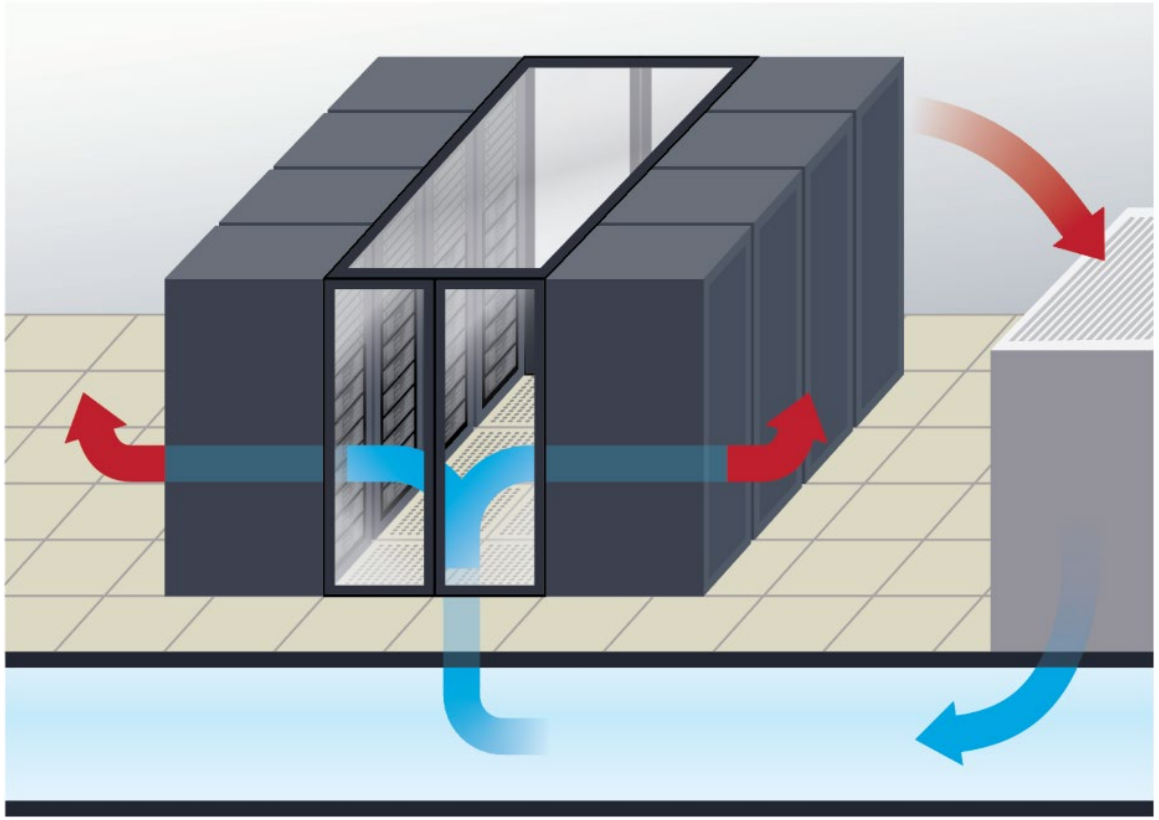
Modular Hot Aisle Containment

- Offers the core benefits of hot aisle containment with greater flexibility and at a lower cost
- Doors and baffles attach magnetically, eliminating the need for 3rd party installation
- Can be installed, removed, and re-installed by on-staff team members



Rigid Cold Aisle Containment

- Utilizes aisle-end doors and optional drop-away “roof” panels that cap the cold aisle for complete cold-aisle containment
- Requires installation crew for construction – either internal crew with required skill set or experienced 3rd party or vendor



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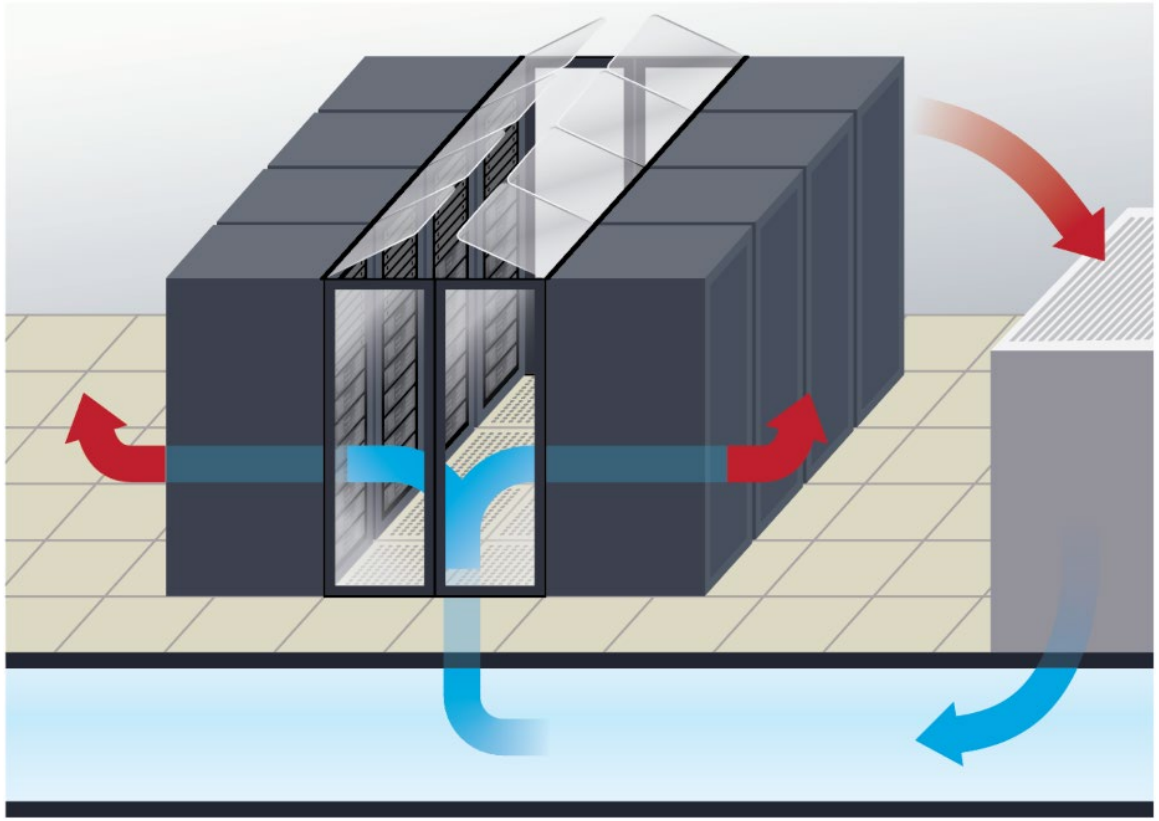


Matching Cooling Capacity with IT Load (Cooling Optimization)

What is Cooling Optimization?

- Cooling optimization is the process of making adjustments to the cooling system controls to improve energy efficiency resulting in reduced operating costs, improve cooling capacity, and deferred capital expenditure
- Provide appropriate IT equipment intake air conditions and redundant cooling capacity, with the lowest possible flow rate of conditioned air at the warmest possible temperature
- Cooling optimization is often an iterative process of making adjustments to controls, allowing the system to equalize, and then making additional adjustments, and so on
- Each time additional airflow management improvements are implemented, or significant IT equipment changes occur, there are opportunities for refining the cooling optimization

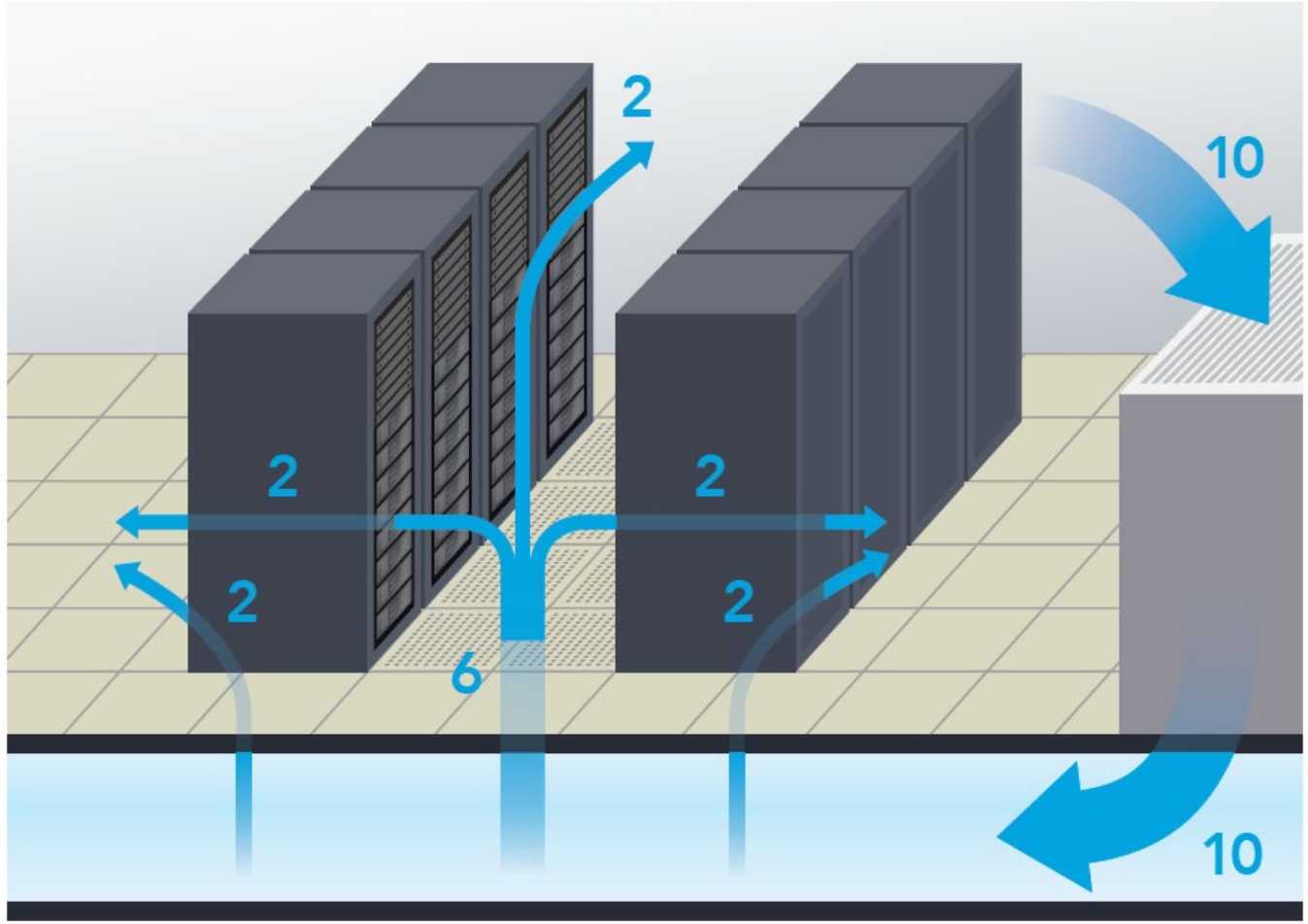
Why is Cooling Optimization Important?

- Without cooling optimization, airflow management improvements are primarily an expense
- Cooling optimization is the only way to achieve a return on investment from airflow management improvements

"You can't purchase efficiency… Efficiency has to be managed."

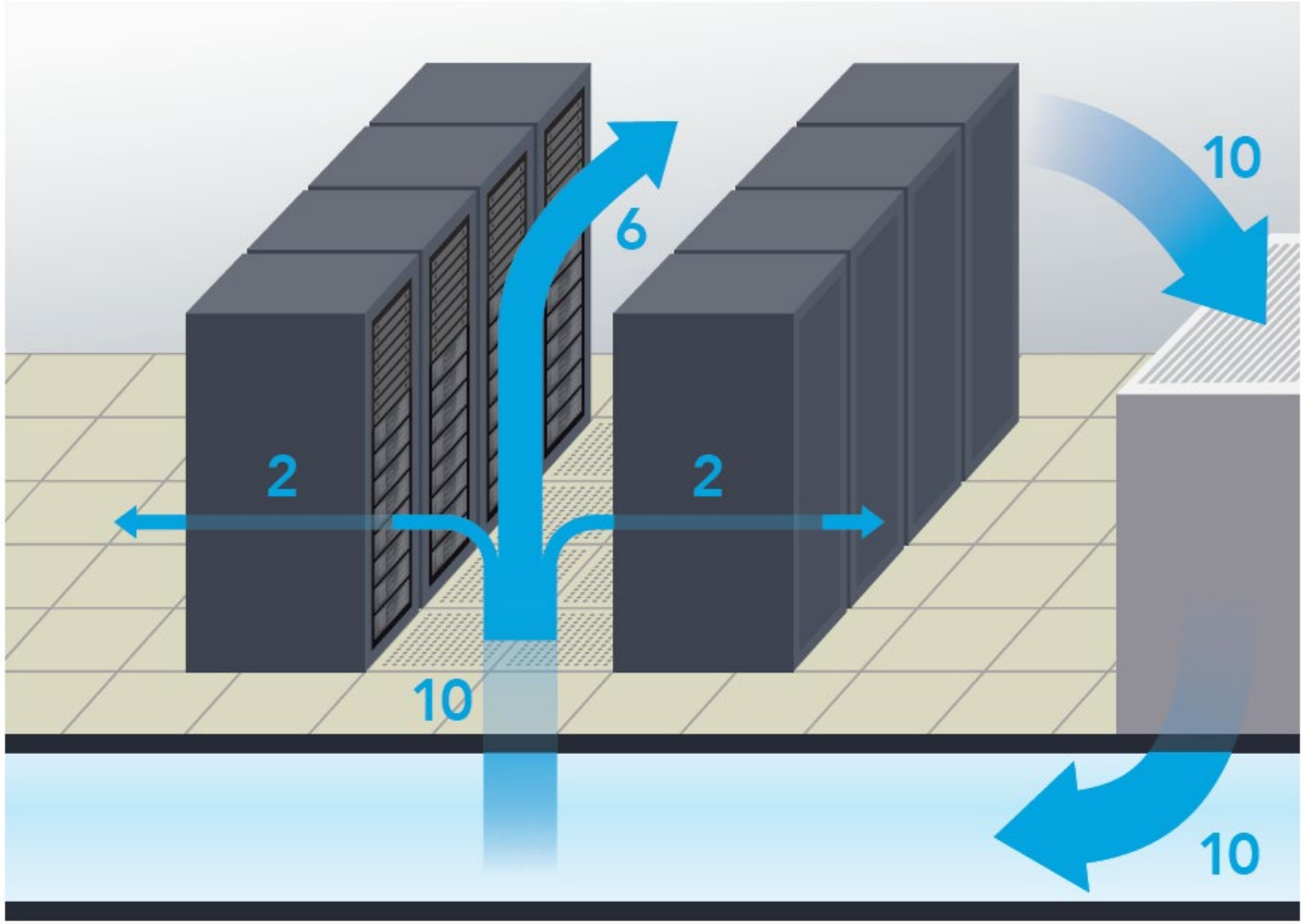
How Cooling Optimization Works

- This figure shows typical airflow patterns before airflow management and cooling optimization



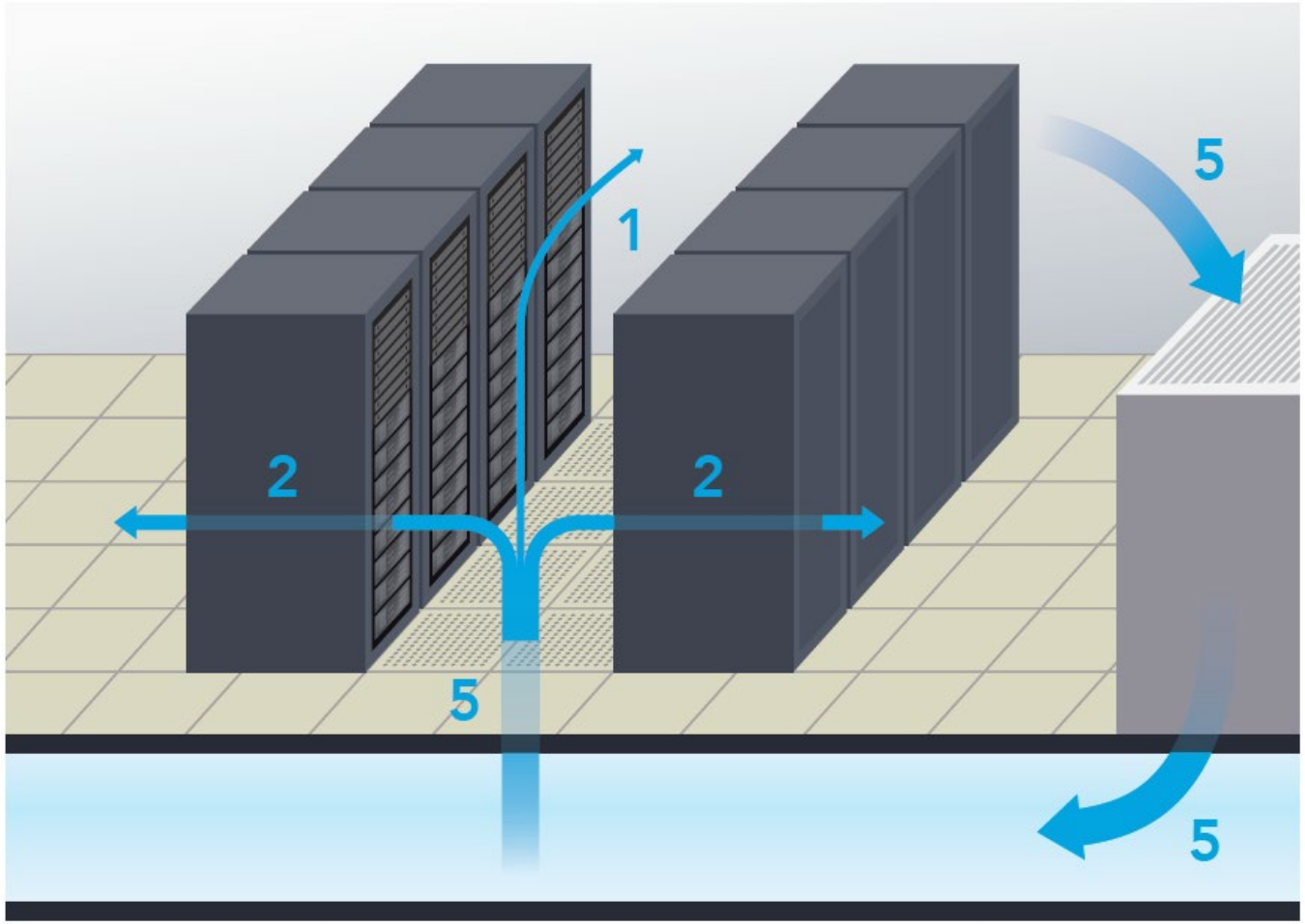
How Cooling Optimization Works

- This figure shows typical airflow patterns after airflow management, but before cooling optimization



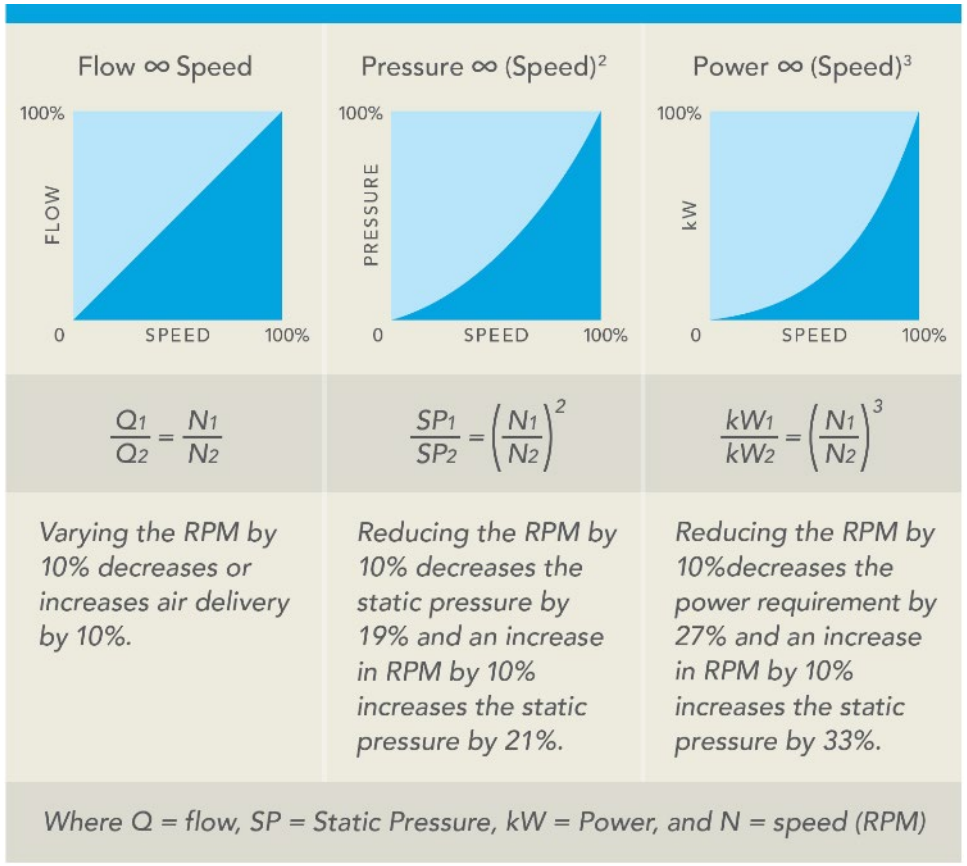
How Cooling Optimization Works

- This figure shows typical airflow patterns after both airflow management and cooling optimization
- Conditioned airflow supplied by the cooling unit has been reduced by 50% (from 10 units to 5 units)



Fan Laws

- Airflow is directly proportional to fan speed
  - If the fan speed is reduced by 10%, the flow rate will decrease by 10%
- Pressure is proportional to the fan speed squared
  - If the fans speed is reduced by 10%, pressure will decrease by 19%
- Fan energy consumption is proportional to the fan speed cubed
  - If the fan speed is reduced by 10%, the energy consumption will decrease by 27%



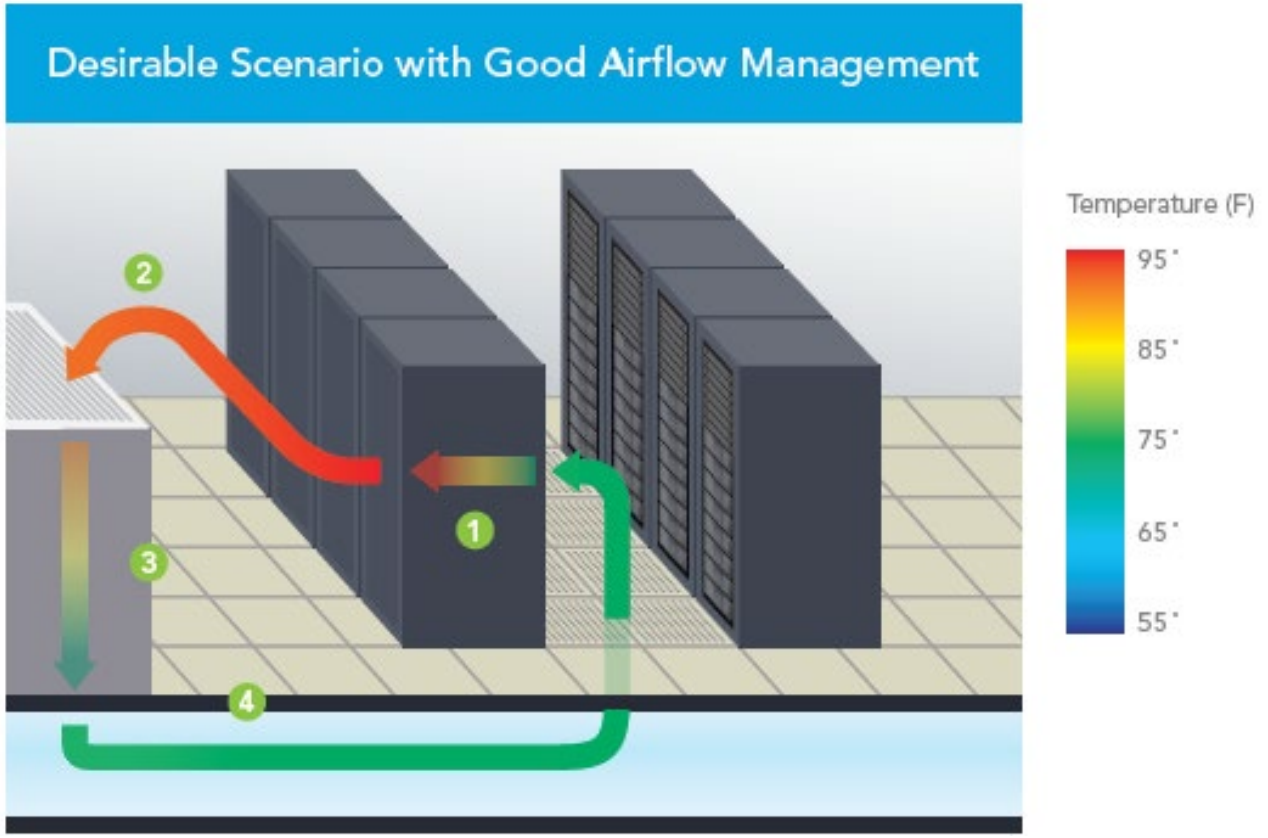
Fan Energy Savings

- 10-30 ton (105 kW) cooling units
- 10 hp (7.5 kW) fan motors
- $0.10/kWhr

Fan speed Reduction (%)	Energy Reduction (%)	Fan Motor Size (kW)	Energy Reduction/Unit (kW)	# of Cooling Units	Total Energy Reduction (kW)	Cost of Electricity ($/kWhr)	Savings ($/Year)
10%	27.1%	7.5	2.0	10	20.3	0.1	$ 17,805
25%	57.8%	7.5	4.3	10	43.4	0.1	$ 37,983
50%	87.5%	7.5	6.6	10	65.6	0.1	$ 57,488

The Four Delta T's (ΔT)

1. Though IT equipment
2. IT equipment exhaust to cooling unit
3. Through cooling unit
4. Cooling unit supply to IT equipment intake



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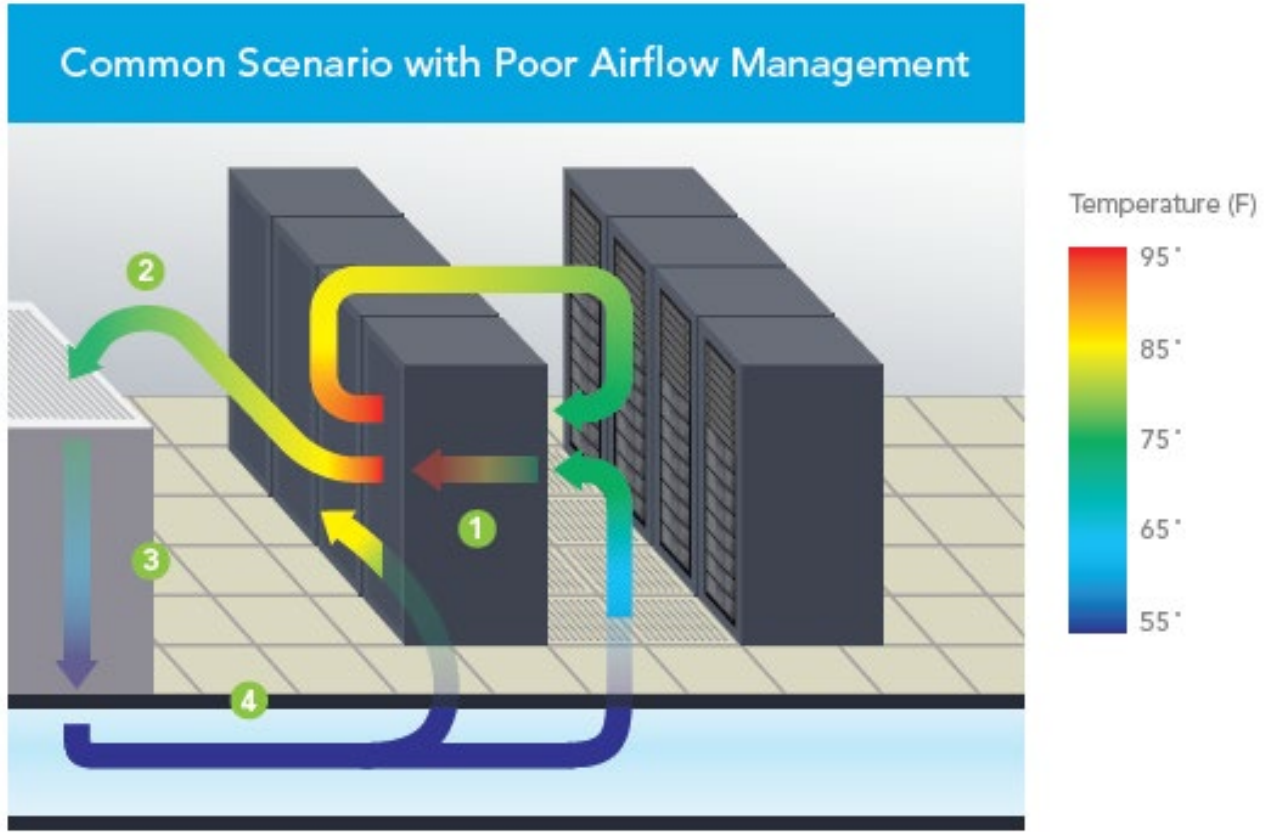

Key Takeaways

- Row level airflow management is not all about containment – there are other areas in the row such as underneath cabinets and in between adjacent cabinets that need to be sealed to manage airflow at the row level effectively
- Modular containment is extremely effective at reducing IT equipment intake temperatures
- In situations when cabinet densities are high enough, or a high level of efficiency is desired, full hot or cold aisle containment is necessary
- Optimization needs to be part of your airflow management improvement process – provide appropriate IT intake air temperatures with the lowest fan speeds and warmest set points possible

Questions?

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