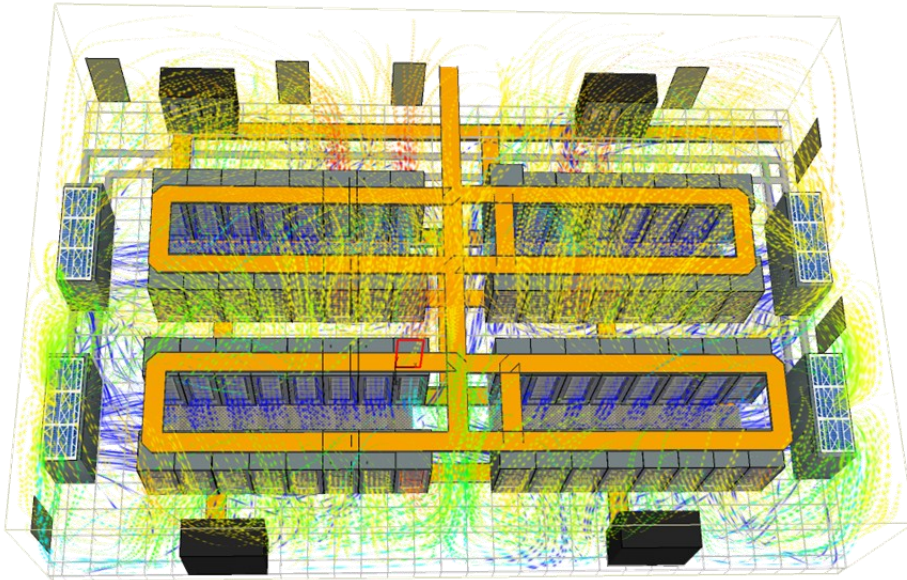
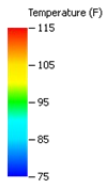
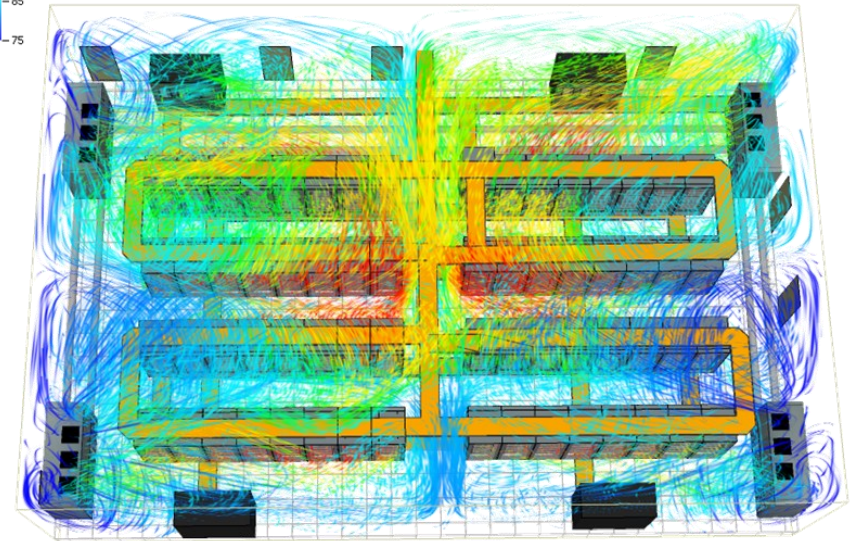
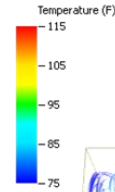


Comparison of up-flow cooling units in data center design.

Hot Aisle / Cold Aisle
(downflow)



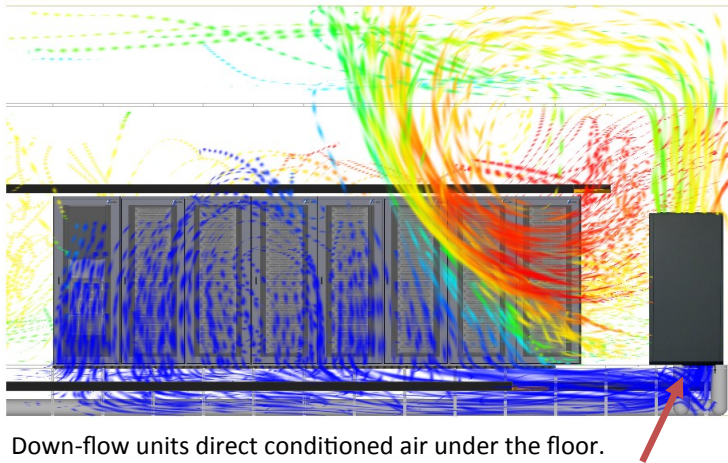
Hot Aisle / Cold Aisle
(up-flow)



Comparison of traditional and up-flow cooling units

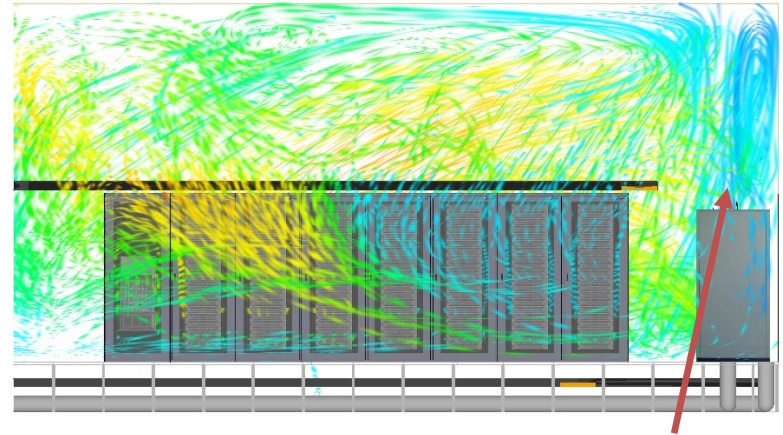
Below is a graphical illustration of the operation of the two types of cooling units discussed in this document. Both units are designed with specific installation designs and are described beneath each graphic.

down-flow Cooling units (cold aisle view)



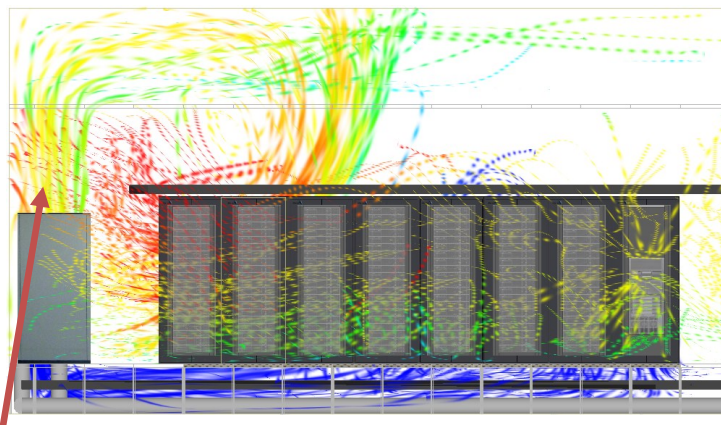
Down-flow units direct conditioned air under the floor.

up-flow Cooling units (cold aisle view)



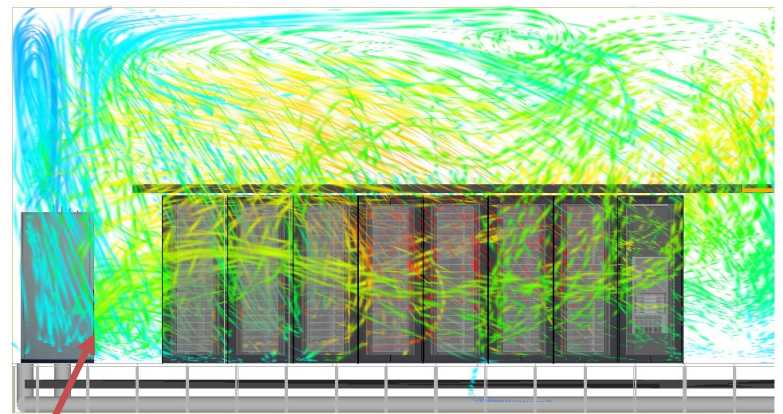
Up-flow units directs conditioned air into the room through the top of the cooling unit or via a duct running into the cold aisle.

down-flow Cooling units (hot aisle view)



Down-flow units intake hot exhaust air from the room via direct to the intake or plenum.

up-flow Cooling units (hot aisle view)



Up-flow units intake hot exhaust air from the bottom of the floor. The units are designed to be installed in the hot aisle.

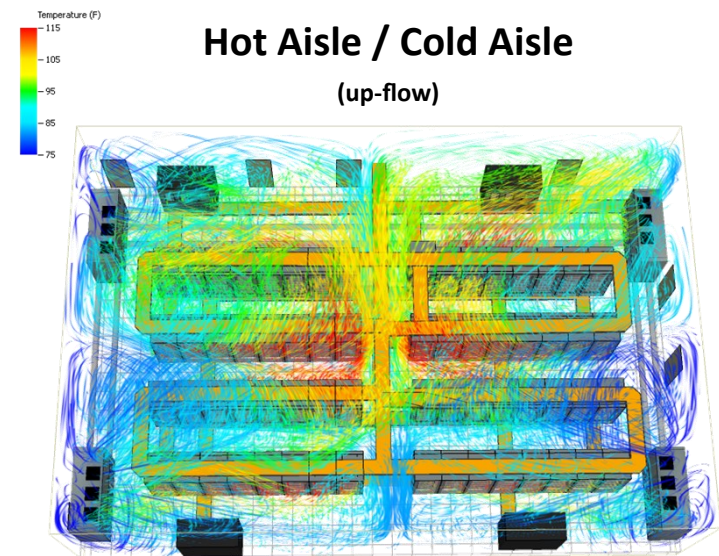
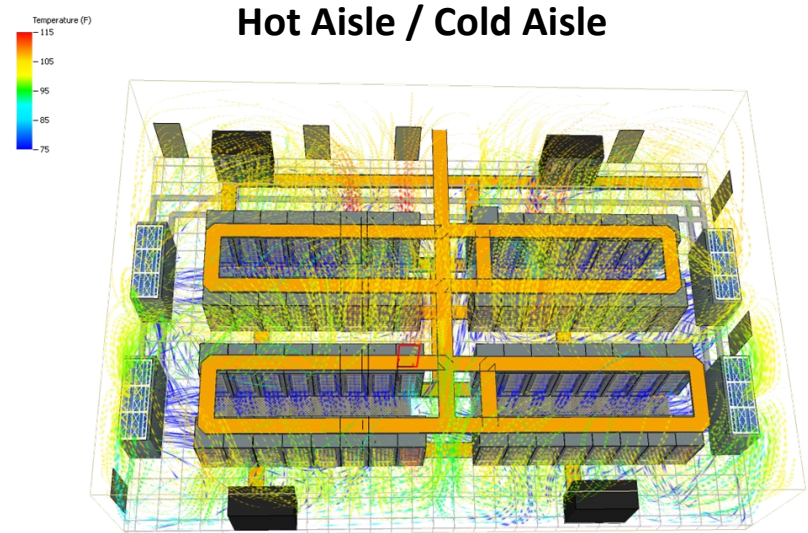
Room Specifications

Physical Space

- Dimensions: 40' Wide by 60' Long
- Concrete slab floor
- Ceiling height from raised floor: 14'
- 2403 sq. ft traditional raised floor data center

IT Specifications

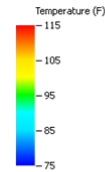
- 7.2 kW per enclosure
- Total IT Load = 459kW
- 64 Racks at 44 RMU (1408 servers @ 2U) 2240 Ports (servers * 2 ports)



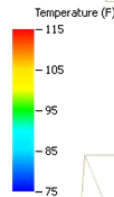
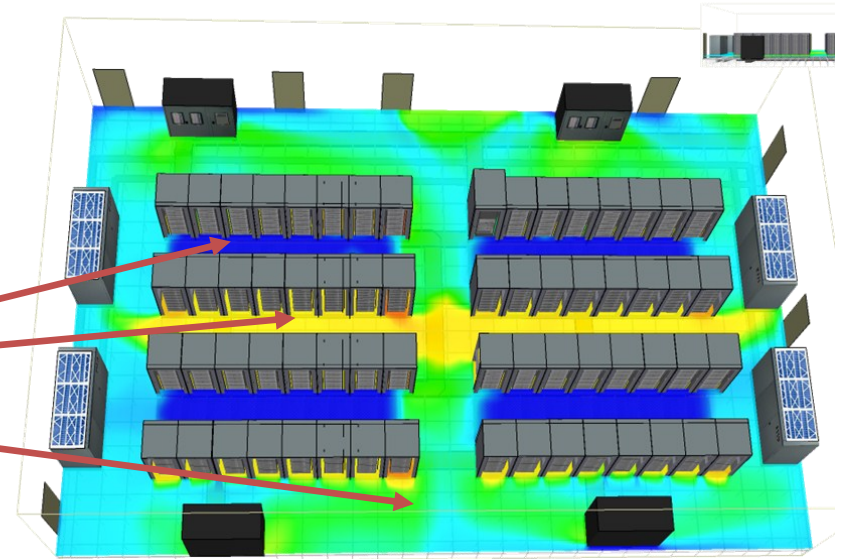
Up-flow CRAC units are designed to be placed in parallel to the hot

Shown are two images from the CFD model with a thermal plane 3" above the base of the enclosures. The thermal plane is a heat map used to indicate inconsistent temperatures, hot air recirculation and by-pass air conditions

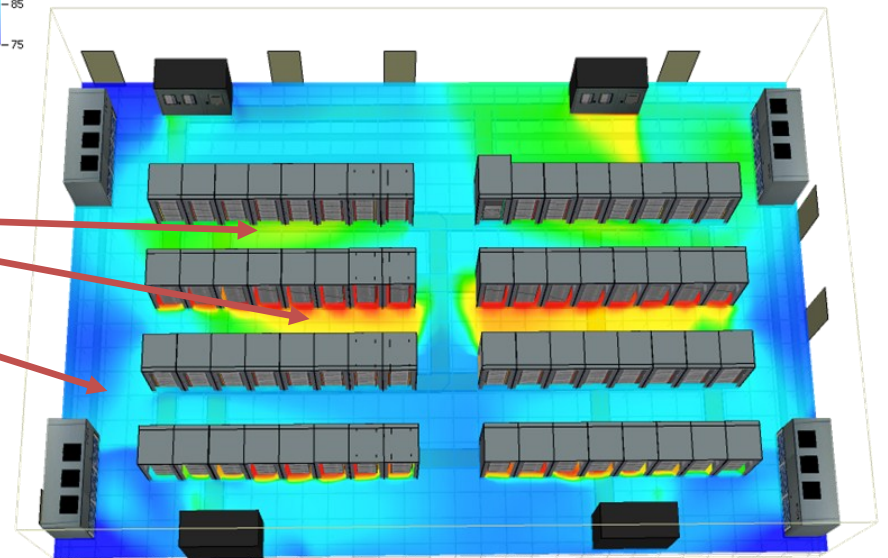
Hot Aisle / Cold Aisle configuration shows low intake temps in the cold aisle and lower exhaust temps in the hot aisle. The overall room environment is very inconsistent.



Hot Aisle / Cold Aisle



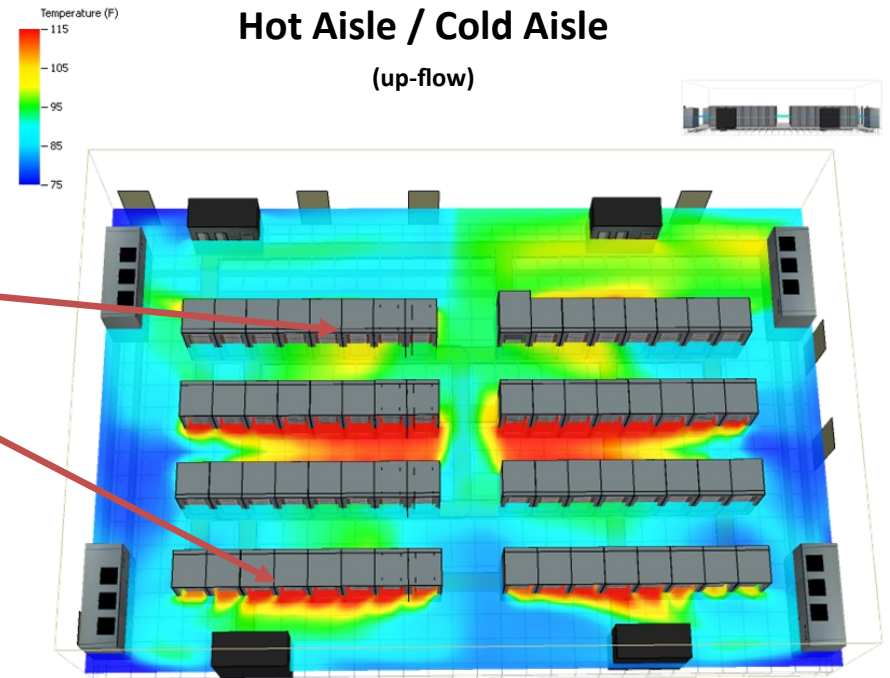
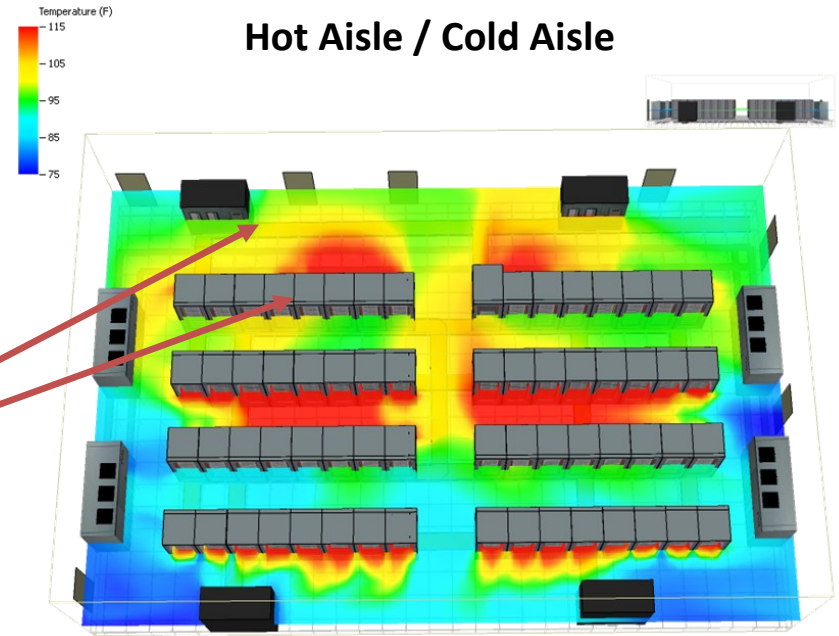
Hot Aisle / Cold Aisle (up-flow)



Hot Aisle / Cold Aisle with up-flow units show cold aisle temperatures considerably higher and more varied than traditional CRAC units. The outer perimeter of the room is more consistent however.

Shown are two images from the CFD model with a thermal plane 45" above the base of the enclosures. The thermal plane is a heat map used to indicate inconsistent temperatures, hot air recirculation and by-pass air conditions

Hot Aisle / Cold Aisle configuration shows an increase in cold aisle temperatures indicating the hot exhaust air is recirculating into the cold aisle. Additionally, the hot aisle temperatures are more varied due to by-pass conditioned air reducing hot aisle temperatures.

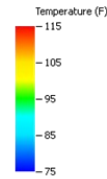


Up-flow configuration cold aisle temperatures remain similar to the lower plane. Hot aisle temperatures are more varied due to by-pass conditioned air reducing hot aisle temperatures.

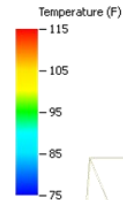
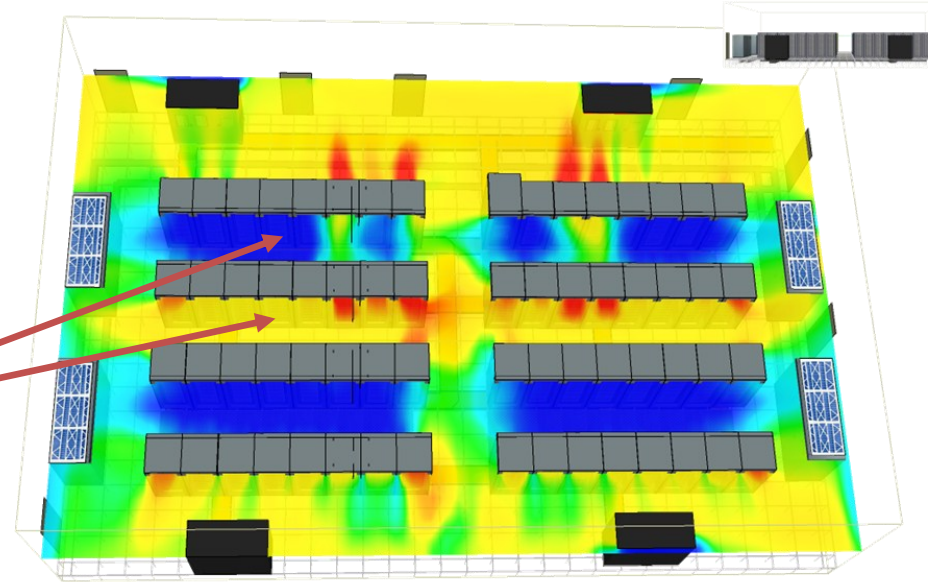
Shown are two images from the CFD model with a thermal plane 81" above the base of the enclosures. The thermal plane is a heat map used to indicate inconsistent temperatures, hot air recirculation and by-pass air conditions

Temperatures in the cold aisle are lower than the middle plane demonstrated. This is likely due to a high velocity of airflow in the cold aisle creating a vertical by-pass air situation. Hot aisle temperatures are further evidence that the conditioned air is mixing in the hot aisle reducing the overall temperatures.

Cold aisle temperature variances at the top of the enclosure are in excess of safe IT equipment operations. The recirculation of hot exhaust air is flowing to the equipment intakes at the top of the enclosures. This condition is known as "top-third" where the upper RMU of the enclosure are unusable for equipment.

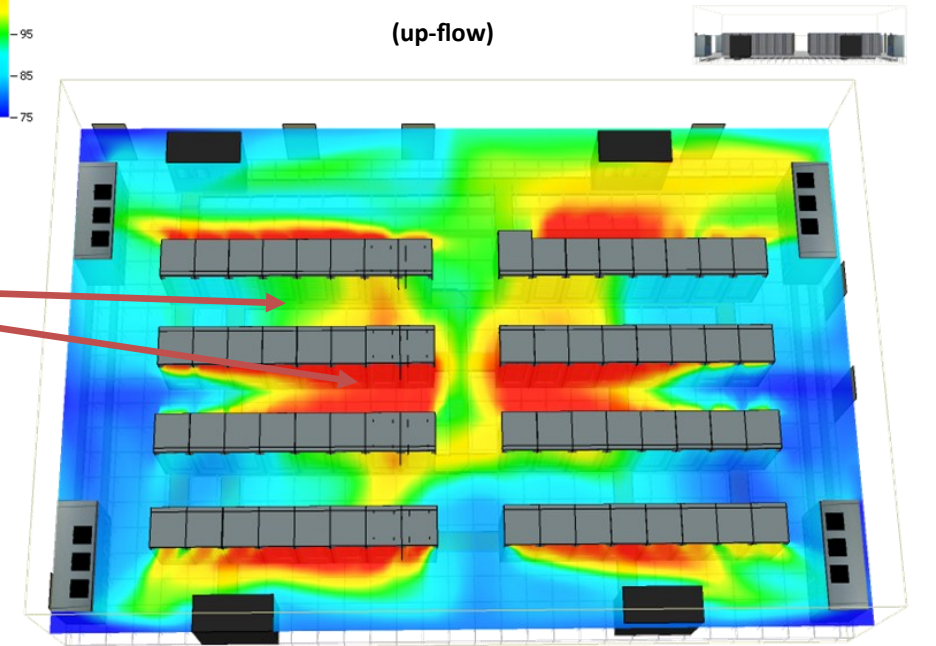


Hot Aisle / Cold Aisle



Hot Aisle / Cold Aisle

(up-flow)

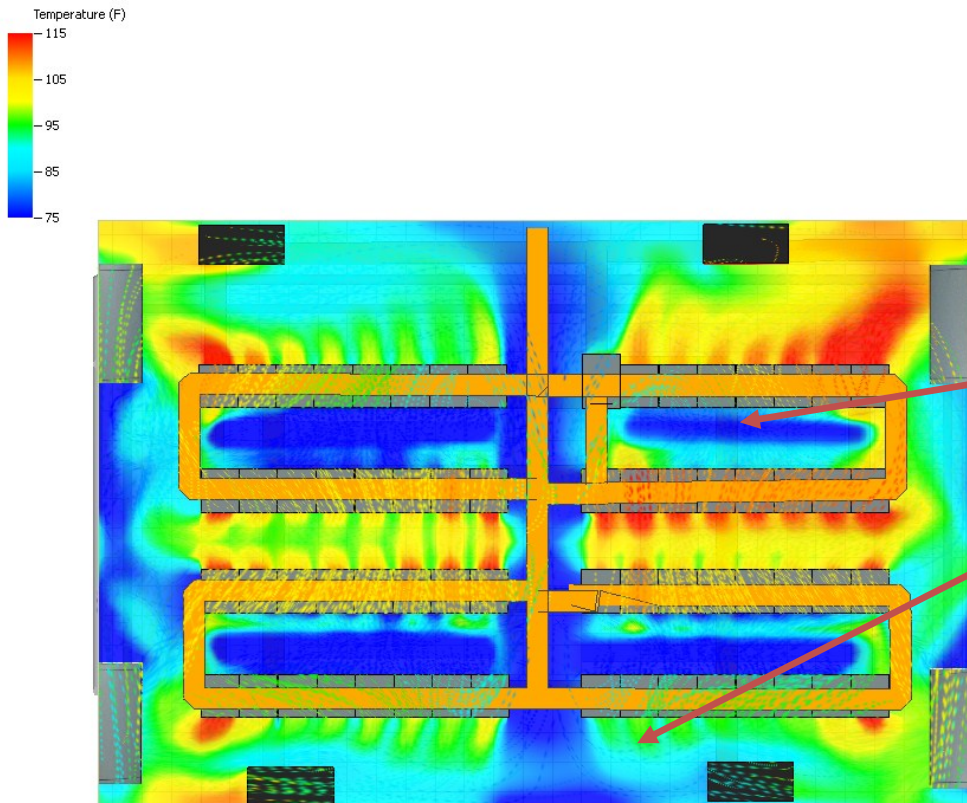


Conclusion

Upon review of the performance of an up-flow CRAC unit in the data center it is determined that up-flow units can perform similarly to a standard down-flow unit provided that proper design considerations are made.

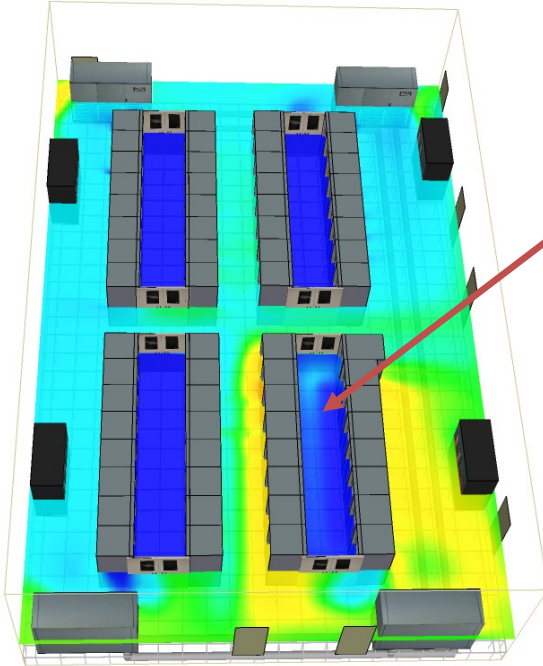
Design considerations for up-flow CRAC units

- Units must be placed parallel to the hot aisle
- Ducting the cold air return into the cold aisle to reduce mixing and by pass air



Up-flow CRAC units with cold air supply ducted over the cold aisle. This design greatly improves the overall performance of the data center. Conditioned air losses are reduced at the end of the aisles closest to the CRAC unit returns however, significant losses are seen at the opposing aisle ends. This can be reduced by adjusting the unit fan speed or through the use of adjustable baffles on the supply ducts.

Recommended Designs for Up-flow Units



Design One (Partial Cold Aisle Containment—End of Row Doors)

When up-flow units are used in conjunction with ducted cold air supply it is recommended that the end of the row in the cold aisle have containment doors installed to prevent cold air from travelling away from the IT equipment intakes into either the hot aisle or the back to the unit returns.

This design does not completely segregate the cold and hot exhaust air but does improve the cold aisle temperatures significantly.

Partial Cold Aisle Containment Infrastructure

Description	GL Part No.	Description
Enclosure		
GL840ES-2448MS	GL840ES-2448MS	44RMU enclosure 84" H x 24" W x 48" D (mesh front and rear doors)
Outside the enclosure		
End of Row Containment doors	ACD840ES	Aisle Containment Doors for 78"ES Enclosure; Supports 48-72" aisle width
Inside the enclosure		
Blanking "Filler Panels" installed in any unused RMU	3.50-FPTL19	3.50"H tool-less filler panel for 19" mounting on M6 rails, 2 RMU
Brush grommet installed in cable knockouts	BGT	Brush Grommet Kit for top cable pass through knockouts on ES Enclosure
Brush grommet kits installed along the rails	BGRK24	Brush Grommet Kit designed for 24"W x 78" and 84" ES enclosures