TECHNICAL REPORT

# Sealing Gaps Under IT Racks: CFD Analysis Reveals Significant Savings Potential

**By**
Lars Strong, P.E., Upsite Technologies, Inc.
Bruce Long, Upsite Technologies, Inc.

upsite technologies®
+1.888.982.7800
upsite.com

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### Executive Summary

Often overlooked, the small space between the bottom of an IT rack or cabinet and the raised floor or slab can have a significant impact on IT inlet temperatures. Such spaces are common, as casters and leveling feet under IT cabinets creates gaps from half an inch up to two or more inches between the floor and the bottom of the cabinet. However, this space allows the hot air from the IT equipment exhaust at the rear of the rack to flow under the rack and back into the IT equipment air inlets at the front of the rack. This recirculation of exhaust air increases the IT inlet temperatures, contributes to hot spots, and can ultimately lead to increased failure rates of IT equipment. This study examined the impact of sealing these small gaps.*

The Computational Fluid Dynamics (CFD) analysis revealed the impact of sealing these small gaps, which reduced temperatures as a result of eliminating the exhaust air recirculation under the rack. Sealing the gaps under the rack created opportunities to improve the overall airflow management in the data center. This, in return, improved the efficiency of the cooling system by allowing an increase in the cooling unit temperature set points and a reduction in cooling unit fan speeds. A more subtle, but important benefit, of optimizing the cooling unit operational conditions was releasing stranded capacity in the overall cooling system. The released capacity can be used to support increased IT loads and defer or eliminate capital expenses for new or upgraded cooling units.

** Model used the AisleLok® Under Rack Panel, designed by Upsite Technologies.*

All effective remediation was completed without causing any IT equipment intake air temperatures to exceed the ASHRAE®-recommended maximum of 80.6° F (27° C).

The analysis showed that sealing the gaps under IT racks had significant impacts:

- The average inlet temperature for servers in the bottom of the rack was reduced by 10.5° F (with a maximum reduction of 18.9° F).
- At the holistic room level, cooling unit fan speeds were reduced by 10%.
- Fan speed reduction resulted in energy savings of $5,318 annually for the small 2,260 sq. ft. computer room (@$0.10/kWhr); $47,059 annual energy savings for a 20,000 sq. ft. computer room.

The results of the model underscore the importance of blocking exhaust airflow from underneath the racks. While the gaps may be small, the impact of this exhaust air recirculation can be significant and undermine other airflow management initiatives that have been implemented (e.g. containment, blanking panels, grommets, etc.).

## Background

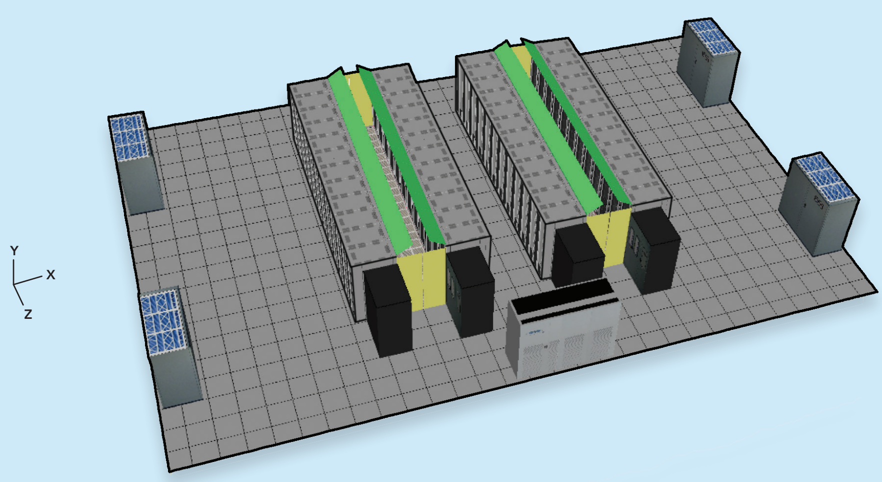
CFD modeling was used to study the impact that gaps under IT equipment racks have on IT equipment intake air temperatures. Two models were compared: a model with 1.5 inch gaps under each cabinet, and a model with the AisleLok® Under Rack Panels sealing the small gaps between the bottom of the rack and the floor. The models were identical in every other way and were designed to represent conditions commonly found in operating data centers. The models have the following parameters:

- 2,260 sq. ft.
- Total IT load of 217 kW
- Total rated cooling capacity of 335 kW
- 48 racks with loads ranging from 1 kW to 12 kW, an average of 4.5 kW / rack
- Total conditioned airflow to the raised floor of 50,006 CFM, total IT equipment airflow 30,747 CFM, resulting in a ratio of conditioned airflow to IT required airflow of 1.6:1
- Cooling units with supply side control delivering 62° F conditioned air
- Raised floor cable openings sealed with KoldLok® Grommets
- Each of the racks were fitted with:
    - HotLok® Blanking Panels in unused U-spaces
    - Top, side and bottom rails sealed with the HotLok® Rack Airflow Management (RAM) Kit.
- Each of the rows were fitted with:
    - AisleLok® Modular Containment Rack Top Baffles
    - AisleLok® Modular Containment Bi-Directional Doors

Airflow management (AFM) fundamentals were implemented at the raised floor, rack and row levels to isolate the influence of open gaps under racks and the effect of sealing them.

**Figure 1**

*Isometric view of the layout for both models*

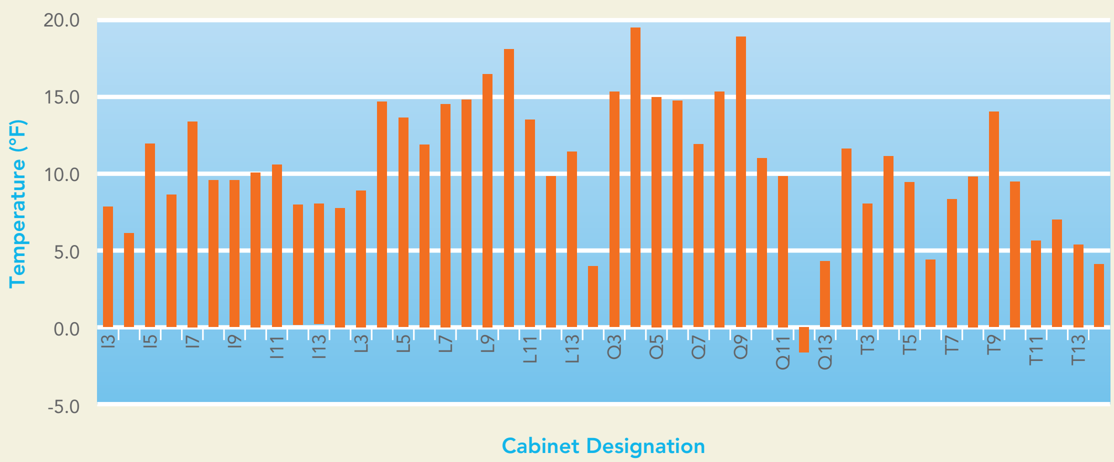


## IT Equipment Maximum Inflow Temperature Reduction by Rack

The average IT intake air temperature reduction for all racks in the model is 10.5° F. The chart below shows the drop in maximum IT inlet temperature for each rack in the model. The greatest reduction in IT intake air temperature of 18.9° F occurs in rack Q4.

**Figure 2**

*IT equipment maximum inflow temperature reduction per rack*

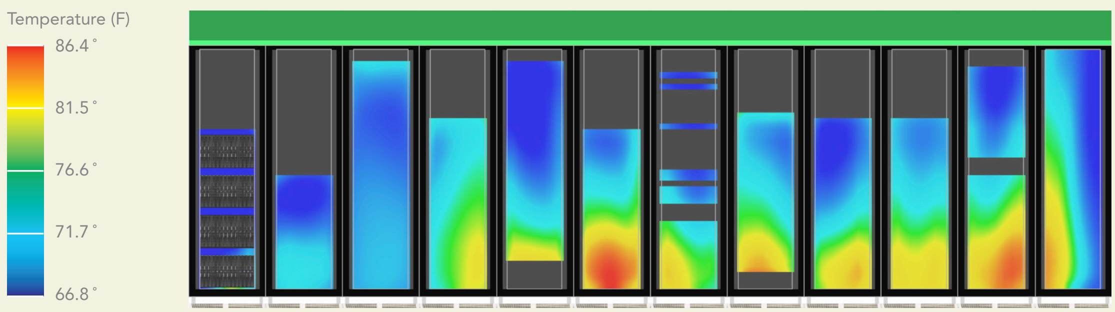


## Comparison of IT Equipment Inflow Temperatures for a Representative Cabinet Row

This image shows the variation in IT equipment intake air temperatures across a row in the CFD model. The dark gray areas are where blanking panels fill locations without IT equipment. The maximum IT inlet temperature is 86.4° F.

**Figure 3**

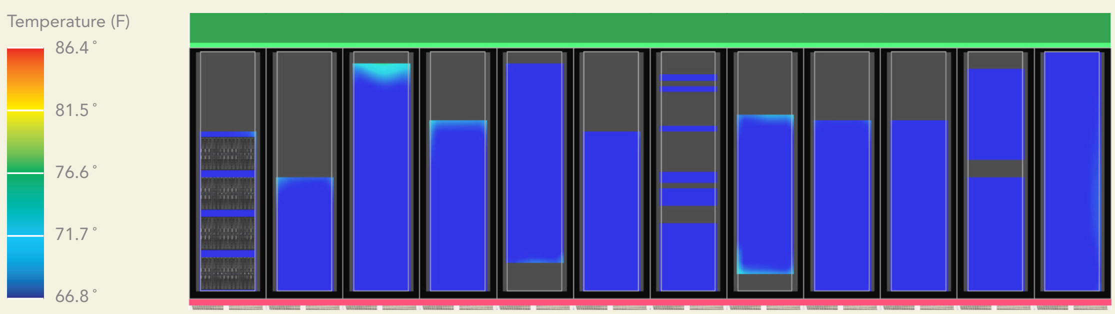
*IT equipment inflow temperature without Under Rack Panels*




This image now shows the dramatic improvement in IT equipment intake air temperatures across the same row after installation of Under Rack Panels. With Under Rack Panels, the maximum IT inlet temperature is 75.0° F, a reduction of 11.4° F.

**Figure 4**

*IT equipment inflow temperature with Under Rack Panels*

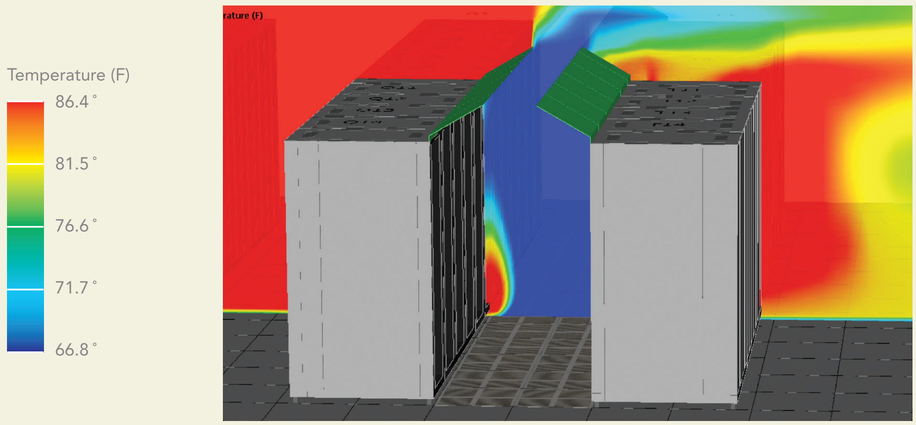


### Isometric View of Air Temperature Cross Section

The image below clearly shows why intake air temperatures are much higher with gaps under the racks: hot exhaust air is flowing from the hot aisle under the racks and into the cold aisle. The hot exhaust air coming from under the racks prevents the conditioned air supplied by the tiles in the cold aisle from reaching the equipment in the bottoms of the racks.

**Figure 5**

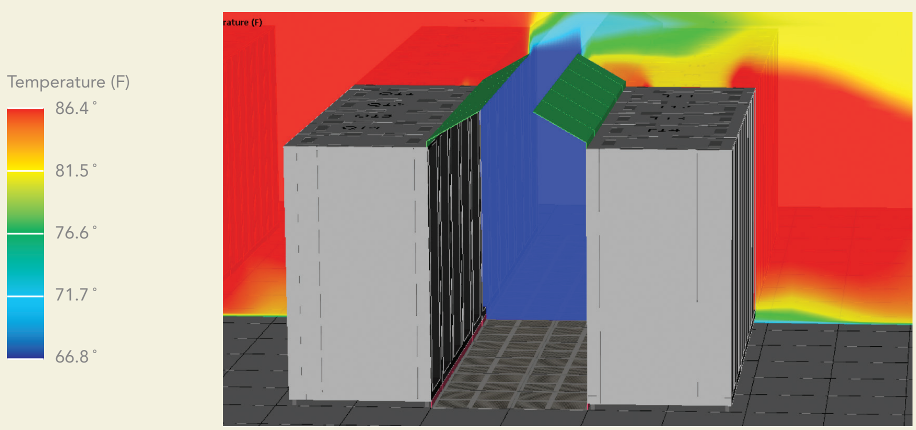
*Cross section of temperature without Under Rack Panel*




Sealing the space under racks with AisleLok® Under Rack Panels prevents hot exhaust air from flowing into the cold aisle. The conditioned air supplied by the tiles in the cold aisle can fill the space and support the IT equipment from the bottom to the top of the rack.

**Figure 6**

*Cross section of temperature with Under Rack Panel*

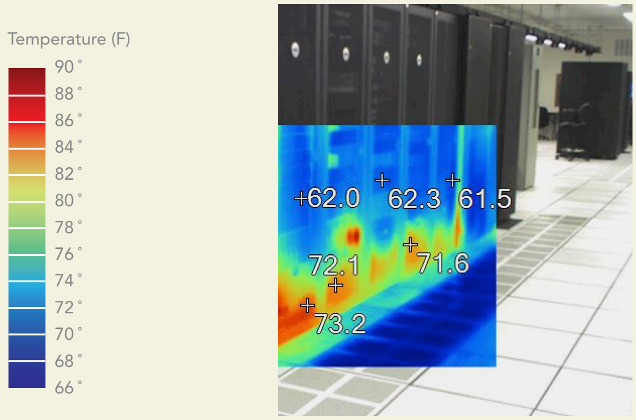


### Infrared Imaging of Operating Data Centers Highlights the Problem

Conditions were observed in operating data centers to further validate the CFD modeling results. The infrared images below show the impact of open spaces under the racks in a real-world (or actual) conditions. The IT equipment at the bottom of the racks are receiving approximately 10° F warmer intake air than the IT equipment just 2' above. This is due to the approximately 1.25" gaps occurring under each of the cabinets. If these spaces were sealed, the IT equipment intake air temperatures would drop by approximately 10° F to 12° F.

**Figure 7**

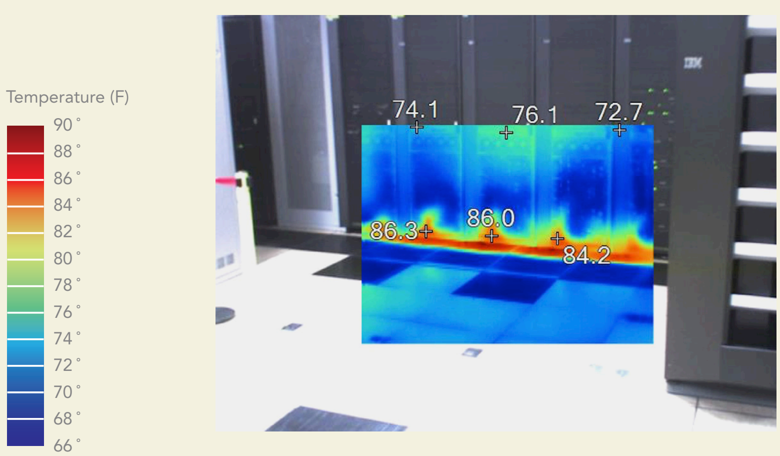
*Infrared image of IT intake air temperatures*




In the image below, although blanking panels have been installed in all open spaces within the racks and there is a full row of supply tiles immediately in front of the row, air from the hot aisle is still flowing under the cabinets causing IT intake air temperatures to exceed the ASHARE®-recommended maximum. It is unlikely that reducing the supply temperature or delivering more conditioned air will solve the problem. The solution is to seal the space between the raised floor and the bottoms of the racks. The most effective way to do this is by sealing the bottom front edge of the racks.

**Figure 8**

*Infrared image of IT intake air temperatures*



## Conclusion

Under rack panels, like the AisleLok® Under Rack Panel, can dramatically reduce the intake air temperature of IT equipment. While a common alternative strategy is to increase airflow to the equipment through high flow grates or higher fan speeds, adding AisleLok® Under Rack Panels provides a more cost-effective solution that not only improves IT intake air temperatures, but also creates the opportunity to reduce cooling costs and release stranded capacity. The maximum IT inlet temperature reduction in the modeling was 18.9° F. The average of the maximum IT inlet temperature reduction for all the servers in the modeling was 9.4° F.

Holistic airflow management, including sealing the gaps under the racks, is crucial to achieving optimal IT equipment intake air temperature distribution and allows for the greatest reductions in operating cost and increases in cooling capacity (by adjusting the cooling unit temperature and fan speed controls). Optimizing the cooling unit settings showed the ability to reduce fan speeds by 10%, resulting in energy savings of $5,318 annually for the small 2,260 sq. ft. computer room (@$0.10/kWhr). This equates to $47,059 of annual energy savings for a 20,000 sq. ft. computer room. Based on MSRP cost for the AisleLok® Under Rack Panel ($18 each), simple payback is achieved in less than 2 months.


## About the Authors

**Lars Strong, P.E., Senior Engineer**

Lars Strong, P.E., thought leader and recognized expert on data center cooling and airflow management, serves as the Company Science Officer of Upsite Technologies--the leader in data center cooling optimization. Lars is a certified U.S. Department of Energy Data Center Energy Practitioner (DCEP) HVAC Specialist. Lars has delivered and continues to deliver value-added services to domestic and international Fortune 100 companies through the identification and remediation of dilemmas associated with the fluid mechanics and thermodynamics of their data center cooling infrastructure. Lars brings his knowledge and ability to teach the fundamentals of cooling science to numerous U.S. and international private and public speaking events annually.

**Bruce Long, Engineer**

Bruce has over 15 years of experience in the design and development of new products—from concept to production—of uninterruptible power supply products for both the IT and commercial markets. He also spent seven years in the design, development and launch of data center assessment services and tools. These services were focused on improving data center efficiency, reducing energy consumption, optimizing cooling systems and improving operational excellence. He is a certified U.S. Department of Energy Data Center Energy Practitioner (DCEP). Bruce is also a past member of the Green Grid where he led the development of the EPA data center efficiency assessment service.