Improving Rack Cooling Performance Using Airflow Management™ Blanking Panels

White Paper 44

Revision 4

by Neil Rasmussen

> Executive summary

Unused vertical space in open frame racks and rack enclosures creates an unrestricted recycling of hot air that causes equipment to heat up unnecessarily. The use of airflow management blanking panels can reduce this problem. This paper explains and quantifies the effects of airflow management blanking panels on cooling system performance.

Contents

Click on a section to jump to it

APC white papers are now part of the Schneider Electric white paper library produced by Schneider Electric's **Data Center Science Center**
DCSC@Schneider-Electric.com

Introduction

Information technology equipment mounted in racks cools itself by drawing ambient air from the data center or network room. If the heated exhaust air is allowed to return to the air inlet of the equipment, an undesirable overheating condition may occur. Data centers and network rooms should be designed to prevent equipment from drawing heated air, and this can be accomplished by widely used installation practices, or by using systems that are pre-engineered.

Within the rack itself the possibility exists for hot exhaust air to be recycled into the equipment air intake. This mainly is caused when hot exhaust air returns above or below the equipment and back to the air intake. This phenomenon is not widely appreciated by users and is a primary cause of equipment overheating in actual data centers.

This paper explains how this problem occurs, provides actual examples of the effect, and shows that this problem significantly compromises the cooling of equipment when it occurs. The benefit of using airflow management blanking panels to reduce the problem is explained and quantified.

Exhaust air recirculation

Overheating due to exhaust air recirculation and the benefits of using airflow management blanking panels are well recognized by IT equipment manufacturers. In fact, IT equipment manufacturers advise users of the need to use airflow management blanking panels. The following excerpt is taken from a Compaq server installation guide:

Blanking Panels
CAUTION: Always use blanking panels to fill empty vertical spaces in the rack to maintain proper airflow. Using a rack without blanking panels results in improper cooling that can lead to thermal damage. If any of the vertical space in the rack is not filled by components, the gaps between components cause a change in airflow through the rack and across the components. Cover these gaps with blanking panels to maintain proper airflow.

An example of how the air flows in a typical rack is provided in **Figure 1**. In **Figure 1A**, the airflow without airflow management blanking panels installed is diagrammed. In **Figure 1B**, the installation of airflow management blanking panels changes the airflow.

Figures 1A and 1B

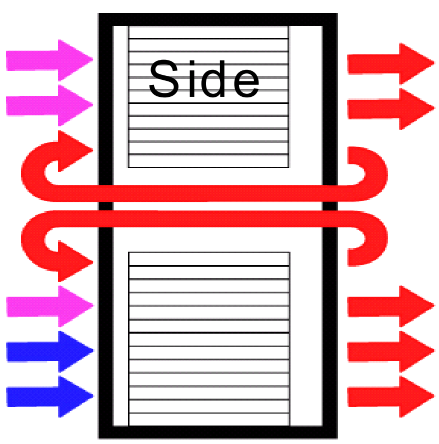
Diagrams of rack airflow showing effect of airflow management blanking panels

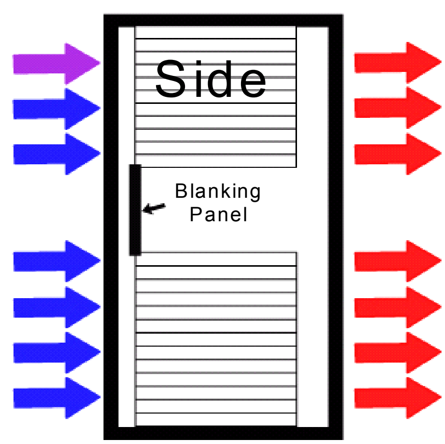
1A (left)

Without airflow management blanking panels

1B (right)

With airflow management blanking panels





Note that when recirculation creates an overheating condition, and this recirculation is not eliminated, then the only practical solution to the problem is to decrease the bulk air temperature supplied to the room to attempt to balance the effect. This reduces the efficiency of the air conditioning system, creates additional condensate (water) generation by the main air conditioning system, and creates a need for supplemental humidification. These consequences can result in significantly increased electricity costs, and they can make it uncomfortable for personnel in the data center.

Why aren't airflow management blanking panels commonly deployed

Airflow management blanking panels are not commonly deployed because of two main factors. The first factor is a lack of knowledge. Many misunderstand the role an airflow management panel plays within the rack itself. Some believe that blanking panels exist for aesthetic purposes only. This paper should serve to illustrate and clarify this issue.

The second factor is the difficulty in installation. Legacy screw-in airflow management blanking panels require up to four screws, four bushings, and four cage nuts to install. This takes time and adds difficulty to the process of deploying a rack. Human error is a serious issue when installing screw-in airflow management blanking panels because small cage nuts, screws and panels are oftentimes dropped near production equipment leading to potential downtime. In addition, legacy screw-in airflow management blanking panels typically ship in kits of various U heights. For example, a kit might include 1, 2, 4, and 8U panels. This presents a challenge because, not only does the correct amount of total U height need to be available, but also the right combination of panel sizes to fill the required spaces. These factors can slow down what is often a time sensitive process when deploying or refreshing a data center.

Having airflow management blanking panels that snap-in to any square-holed rack enclosure and install without tools significantly reduces the time and labor cost associated with installing panels. In addition, by standardizing on a panel size of 1U, racks can be populated easily, rather than dividing out empty spaces into various-sized panels of 1, 2, 4, and 8U. For instance, if there was a 3U space that needed to be filled in a rack, and only two 2U panels remained, the space could not be filled with material on hand. One would have to wait for an order of 1U panels to arrive before the installation could be completed.

An example of a solution that meets these requirements is the Schneider Electric AR8136BLK airflow management panel, as seen in **Figure 2a** and **2b**.

Figure 2A

Example of modular snap-in airflow management panel

Figure 2B

Snap-in feature of airflow management panel

Consider the material and labor cost of installing airflow management blanking panels in a 100-rack data center, assuming an average of 10U of empty space in each rack (a total of 1000U of airflow management blanking panels). **Table 1** compares the cost of installing 1U snap-in panels with the cost of installing legacy screw-in panels of various sizes. The material cost savings are on the order of 41%, labor cost saving are 97% for a total cost savings of 48% when snap-in airflow management blanking panels are used.

Table 1

Airflow management panel cost analysis for 100 rack data center

	1U snap-in blanking panels	Legacy screw-in blanking panels				
		Variety pack	1U blanking panels	2U blanking panels	4U blanking panels	8U blanking panels
Typical blanking panel cost per U	$4.00	$4.67	$12.00	$7.25	$6.13	$4.00
Blanking panel cost for 1000U	$4,000.00	$4,667.00	$12,000.00	$7,250.00	$6,125.00	$4,000.00
Average install time per blanking panel (seconds)	4.3	300	300	300	300	300
Time to install 1000U of blanking panels (hours)	1.2	22.2	83.3	41.7	20.8	10.4
Install cost for 1000U based on a labor rate of $25 / hour	$29.76	$555.56	$2,083.33	$1,0141.67	$520.83	$260.42
Material cost						
Total material cost for 1U snap-in blanking panels	$4,000.00					
Total average material cost for screw-in blanking panels	$6,808.33					
Labor cost						
Total labor cost using 1U snap-in blanking panels	$29.76					
Total average labor cost using screw-in blanking panels	$892.36					
Savings						
% material cost savings using 1U snap-in blanking panels	41.2%					
% labor cost savings using 1U snap-in blanking panels	96.7%					
On average, 1U snap-in blanking panels install 30 times faster than legacy screw-in panels						

Analysis assumptions

- 100 rack data center with an average of 10U space to fill per rack or 1000U of blanking panels required
- 3 minute install time for (42) 1U snap-in blanking panels
- 5 minute install time per legacy screw-in blanking panel
- Legacy blanking panels have 4 holes per panel
- Variety pack consists of 1U, 2U, 4U, and 8U blanking panels (1 of each) – 67 kits are used for 1000U

Other contributing factors to improper airflow

The absence of airflow management blanking panels in unused rack space is only one path that permits exhaust air recirculation. There are also types of equipment that are mounted in a rack that permit hot exhaust air to return to the front of the rack. In addition, some rack designs do not inherently separate intake and exhaust air. The key contributing factors to air leakage and how to control them are summarized in **Table 2**. This list can serve as a checklist for audit of existing data centers, or for evaluating proposed data center and network room designs. **Table 2** suggests that the selection of equipment such as racks and monitors should not be done without considering the rack airflow. Implementation of the control principles summarized in **Table 2** is essential to assuring an optimal and reliable rack cooling system.

Table 2

Factors contributing to overheating caused by air recirculation in the rack along with methods to control them

Contributing factor	Consequence	Control / checklist
Unused vertical rack space	Open area permits hot exhaust air to return to equipment air intake resulting in overheating	Use airflow management blanking panels in all unused rack locations
Rack rails inset from side of enclosure	Open side area permits hot exhaust air to return to equipment air intake resulting in overheating	Do not use 23 in (584 mm) racks with rails set to 19 in (483 mm) Use racks which do not have open space between rail and side of enclosure
Monitors on shelves	Open space around monitor permits hot exhaust air to return to equipment air intake resulting in overheating	Use thin flip-top LCD monitors Obtain rack mount bezels for CRT monitors
Tower servers on shelves	Open space around servers permits hot exhaust air to return to equipment air intake resulting in overheating	Use rack mount servers Note: the power density of tower servers in the rack is very low which reduces the magnitude of this problem
Vertical rack space used to pass cables from front to back of rack	Open space around cables permits hot exhaust air to return to equipment air intake resulting in overheating	Use airflow management blanking panels equipped with a flexible brush or shield that allow the cables to pass through and reduce air leakage
Front or rear doors on the rack with restricted ventilation	Airflow resistance of the doors creates a pressure gradient which amplifies all of the above effects	Use fully perforated front and rear doors Do not use doors with glass, or doors with limited perforation
Space between racks	Open area permits hot exhaust air to return to equipment air intake resulting in overheating	Bay racks together wherever possible

Real world example

The quantitative benefit of using airflow management blanking panels was evaluated by measuring the effect on an actual rack set up with servers in typical conditions. The conditions of this experiment are described in **Appendix A**. The reduction in temperature rise of the server inlet air resulting from the installation of an airflow management panel is shown in **Figure 3**.

Figure 3

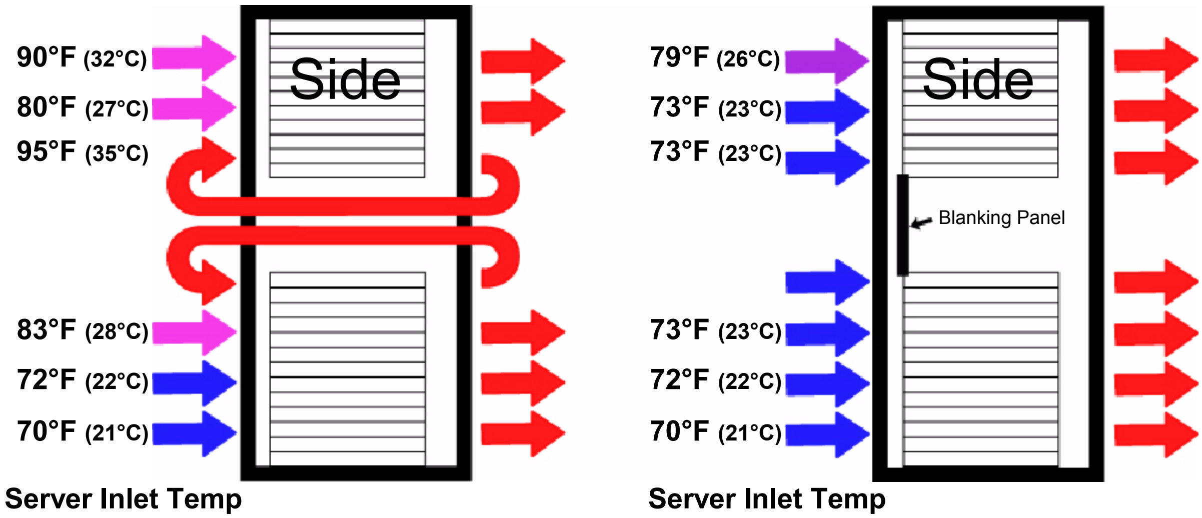
Effect of installation of airflow management panel on server air inlet temperature

3A (left)

Without airflow management blanking panels

3B (right)

With airflow management blanking panels



The summary of this data is presented in **Table 3**. The data shows that the coolest servers are located at the bottom of the rack and are unaffected by the use of the airflow management panel. The hottest server is located just above the unused and open vertical rack space and experiences an inlet temperature reduction of over 20°F (over 11°C) when the airflow management panel is installed.

Table 3

Experimental data showing effect of airflow management blanking panels on server air inlet temperature

Without airflow management blanking panels	95°F (35°C) – Hottest server	70°F (21°C) – Coolest server
With airflow management blanking panels (same server)	73°F (23°C)	70° F (21°C)
Temperature difference	22°F (12°C)	0°F (0°C)

The controlled test example represents a case where a number of high density racks are located side-by-side in long rows. In practice, high racks with high power density are often located near racks with low power density, and frequently used in short rows. The temperature reduction effect of airflow management blanking panels is expected to be attenuated in these cases. To confirm this effect, temperature measurements were made in actual network rooms with rows of mixed power density and short rows. Server inlet air temperature reductions resulting from the use of airflow management blanking panels to cover adjacent unused vertical rack space were observed in all cases. Actual measured temperature reductions varied from 5°F to 15°F (2.8°C to 8.3°C).

Understanding of the principle of air recirculation, when combined with the experimental results, suggest that the following general conclusions can be drawn:

- Under real-world conditions the use of airflow management blanking panels can reduce the operating temperature of IT equipment by 22°F (12°C).
- The benefit of using airflow management blanking panels is greatest for equipment located adjacent to and above the unused space covered by the airflow management panel.
- The use of airflow management blanking panels can reduce the incidents of overheating and "hot spot" problems experienced in data centers and network rooms.
- When airflow management blanking panels are added, the same server inlet air temperature can be obtained with a higher air conditioner discharge temperature; this leads to less dehumidification and higher air conditioner efficiency.
- The guidance provided by equipment manufacturers to utilize airflow management blanking panels is appropriate.

> Sealing cable cutouts

Cable cutouts in a raised floor environment cause significant unwanted air leakage and should be sealed. This lost air, known as bypass airflow, contributes to IT equipment hotspots, cooling inefficiencies, and increases infrastructure costs.

Many sites ignore unsealed floor openings and believe that inadequate cooling capacity is the problem. As a result, additional cooling units are purchased to address the overheating. In fact, those supplementary units may not be needed.

One alternative to minimize the cost of additional cooling capacity is to seal cable cutouts. The installation of raised floor grommets both seals the air leaks and increases static pressure under a raised floor. This improves cool air delivery through the perforated floor tiles

Conclusion

IT equipment in the rack environment can overheat if the heated exhaust air flows back into the air intake. There are a number of situations that can occur in a rack which permit or even encourage air recirculation and the resultant overheating.

When a properly designed rack is used in conjunction with rack-mounted equipment, a primary cause of air recirculation is unoccupied rack space. The use of airflow management blanking panels to fill this unoccupied space eliminates the problem.

This paper provides a checklist of items that should be considered when designing a new data center or network room, and can be used to perform an audit of an existing data center or network room. When these guidelines are followed, overheating due to recirculation can be significantly reduced, and the efficiency of the air conditioning system is improved.

About the author

Neil Rasmussen is a Senior VP of Innovation for Schneider Electric. He establishes the technology direction for the world's largest R&D budget devoted to power, cooling, and rack infrastructure for critical networks.

Neil holds 19 patents related to high-efficiency and high-density data center power and cooling infrastructure, and has published over 50 white papers related to power and cooling systems, many published in more than 10 languages, most recently with a focus on the improvement of energy efficiency. He is an internationally recognized keynote speaker on the subject of high-efficiency data centers. Neil is currently working to advance the science of high-efficiency, high-density, scalable data center infrastructure solutions and is a principal architect of the APC InfraStruXure system.

Prior to founding APC in 1981, Neil received his bachelors and masters degrees from MIT in electrical engineering, where he did his thesis on the analysis of a 200MW power supply for a tokamak fusion reactor. From 1979 to 1981 he worked at MIT Lincoln Laboratories on flywheel energy storage systems and solar electric power systems.

Resources

Click on icon to link to resource

White Paper Library
whitepapers.apc.com

TradeOff Tools™
tools.apc.com

Contact us

For feedback and comments about the content of this white paper:

Data Center Science Center
DCSC@Schneider-Electric.com

If you are a customer and have questions specific to your data center project:

Contact your **Schneider Electric** representative

Appendix A: description of experimental conditions

The purpose of the experiment is to create an environment similar to an actual data center. The experiment was conducted in a single rack, using thirty 1U server simulators. Each 1U server simulator consists of an actual 1U server chassis with power supply and fans, but with the CPU motherboard replaced with a resistive load. Each simulated server load was set up to draw 150 Watts. Thirty server simulators were placed in a 42U APC NetShelter VX enclosure 42 inches (1067 mm) deep. The total load was 4.5kW. The server simulators were arranged such that a single 11 U space was left in approximately half way up the enclosure. Inlet temperatures were monitored at every 7^{th} U space starting at the 2^{nd} U and ending at the 41^{st} U.

To model the presence of the experimental rack in a row of racks, it was assumed that every rack in the row would be identical and that the experimental rack would be located near to the center of a long row. The air source is assumed to be a uniform line of raised floor ventilated tiles in front of the rack. In this case, all horizontal air pressure gradient vectors between adjacent racks approximately cancel, and the lateral air motion between racks would be approximately zero. Furthermore, racks are assumed to exist in rows with alternating hot and cold isles. Therefore, the air pressure gradients between adjacent rows approximately cancel, and the lateral air motion between rows is approximately zero across a line midway between the rows. To simulate the previously described data center condition in the laboratory with a single rack, partitions were placed as shown in **Figure A1**. The partitions balance the air pressure gradients without the need to actually install and operate a large number of racks.

The server inlet air temperatures were measured with an Agilent 34970A data logger using Type "T" thermocouples with a published accuracy of +/- 1.0°C. The thermocouples were mounted in the air 2 inches in front of the air intake grille. Bulk air temperature was measured at the partition inlet opening and at the partition exhaust opening shown in **Figure A1**.

Figure A1

Experimental setup

The free air temperature at the inlet was 70°F (21°C) during the experiment. The bulk exhaust temperature was 95°F (35°C) during the experiment.