



kaleidescape

A/V Installation Cooling

A Description of the Effects of Thermal Dynamics in Cooling Rack Enclosures

Summary

This paper is a practical guide to thermal and fluid dynamics of audiovisual equipment installations in rack enclosures. A discussion of the cooling mechanisms used in various A/V components and resultant airflow is followed by configuration examples of passive convection and forced air rack enclosures.

Best practices are illustrated along with common pitfalls when designing rack configurations.

Background

High-end entertainment components rarely travel alone. Modern movie and music systems now require network connections via switches and routers, and typically contain some amount of digital storage. These components connect to high quality receivers and amplifiers for immersive listening and viewing experiences. Satellite receivers provide live content, and gaming systems have interactive entertainment. A power conditioner is usually added to ensure optimal signal quality from all the components.

Stacking equipment in a rack enclosure set into a wall or stored in a closet is a popular installation method. Proper thermal management of an A/V rack is important to avoid performance degradation and prevent premature component failure. Components must be climate controlled to ensure longevity and optimal performance.

High-end A/V installations must balance function with aesthetics. Installations must maintain acceptable operating temperatures around the clock and under maximum loads but should not interfere with the owner's comfort by generating noise or by modifying the local environment. To ensure consistent installation success, the following thermal management topics must be understood.

- How each A/V component has been designed to cool itself
- How to use the natural flow of hot air within an installation
- When additional fans should be used
- How to select fans for a particular installation
- How to verify the installation, and monitor for system failures

Individual Component Requirements

High-end electronic audio and video components are typically tuned for optimal output quality in one environment — the one most comfortable for the test engineer. Deviation from a comfortable room temperature environment alters the signal integrity of the audio and video streams and can reduce component lifetime.

To create optimal environments for electronic components it is necessary to understand how common chassis designs cool themselves. This knowledge helps determine the best placement and spacing for each component in a rack installation. The following examples apply to most product types.

Satellite and Cable Tuners

Most video tuners have large vent arrays on the top of the chassis with very few bottom vents. This vent design allows cold air to drop into the chassis from the top and rise out above hot electronics. See Figure 1. This is especially true for standard definition devices but might not apply to high definition devices.

It is good practice to keep at least one rack unit of clearance above these components to allow fresh air to enter this airspace and give hot air an easy exit path.



Figure 1 Satellite and cable receivers typically exhaust hot air through vents located on top of the chassis

DVR and Blu-ray Players

Video recorder and high definition playback devices tend to use one or two fans located at the rear of the chassis to clear hot air from the inner cavity. Air enters the chassis from the bottom or sides and exhausts straight out the rear. The exhaust fan is usually visible on the back panel. See Figure 2.

Before installing these players, the location of intake vents must be noted and kept free from obstructions.



Figure 2 DVR and Blu-ray players typically intake cool air from the bottom and sides and exhaust hot air through vents located on the back of the chassis

Audio Amplifiers and Receivers

Audio amplifiers and receivers have a variety of cooling designs. Most use passive convection and contain a large vertical heatsink to cool hot amplifying electronics. Large vents are located beneath and above this heatsink. Leaving one rack unit of space above and below a receiver provides a clear path for air to enter bottom vents and easily exit the area above the top vents. See Figure 3.

If adequate clearance cannot be provided for these components, small fan units are available to help exhaust amplifiers. These fans usually sit on the top vents to pull air out of the amplifier and redirect the air to an unblocked space.

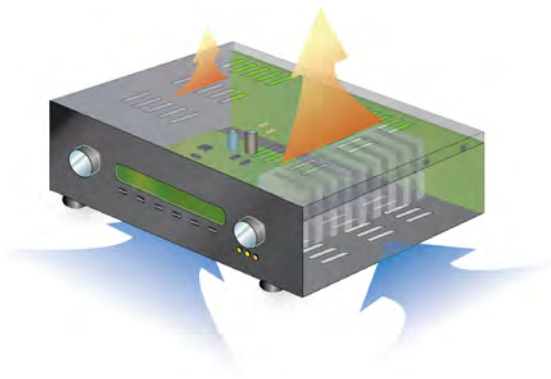


Figure 3 Common audio amplifiers use passive convection to intake air from the bottom and exhaust out the top of the chassis

Some amplifiers use the sides of the chassis as a heatsink (see Figure 4) while others have fans that pull air in from the rear and exhaust out the front. Be sure to verify the airflow of amplifiers equipped with fans and prevent rear intake amplifiers from exhausting into the front intakes of other equipment. See Figure 5.

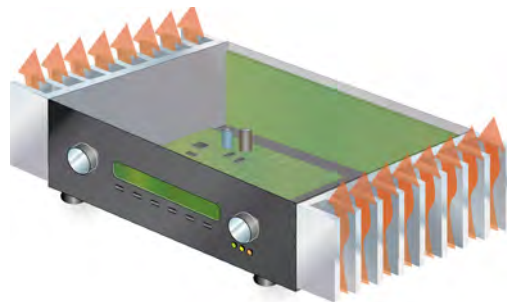


Figure 4 Amplifiers with chassis as a heat sink must have adequate clearance in the side areas of the rack

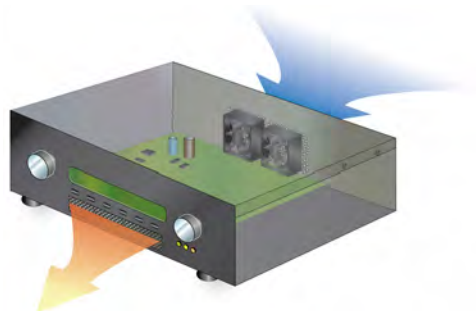


Figure 5 Amplifiers with rear intakes must be placed so there is no conflict with the rack's bulk airflow and should not be placed below components with front intakes

Gaming Consoles

Gaming consoles have strong internal fans for cooling. Most gaming consoles pull air from the front, sides and sometimes from the bottom. Air is almost always exhausted out the rear of the chassis. Air surrounding the chassis must be cool and all vents must have adequate clearance. See Figure 6.



Figure 6 Gaming consoles typically intake cool air from many surfaces and exhaust hot air through vents located on the back of the chassis

Network Switches

Network switches have a variety of cooling designs. Small switches typically have side vents for passive convection while large switches have fans that pull air in one side of the chassis and exhaust out the other side. Other switches pull air in from the rear and exhaust out the front, or vice versa. Be sure to power on the switch to verify the airflow before installation. See Figure 7.

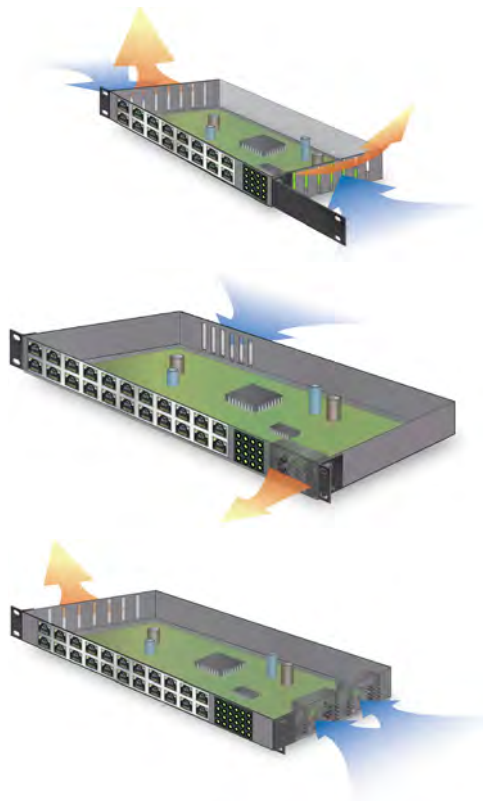


Figure 7 Network switches have various cooling designs that must be determined before installation

Kaleidescape Servers

Kaleidescape servers contain internal fan arrays that pull large volumes of air from the front and exhaust air out the rear of the chassis. This design supplies the hard drives with a reliable stream of cool air. It is essential that the front intake vents on servers be clear of obstructions. Servers require at least 1 inch of clearance between the front panel on the server and the rack door, with a rear clearance of 2 inches. Rear vents must also be clear of obstructions. See Figure 8.

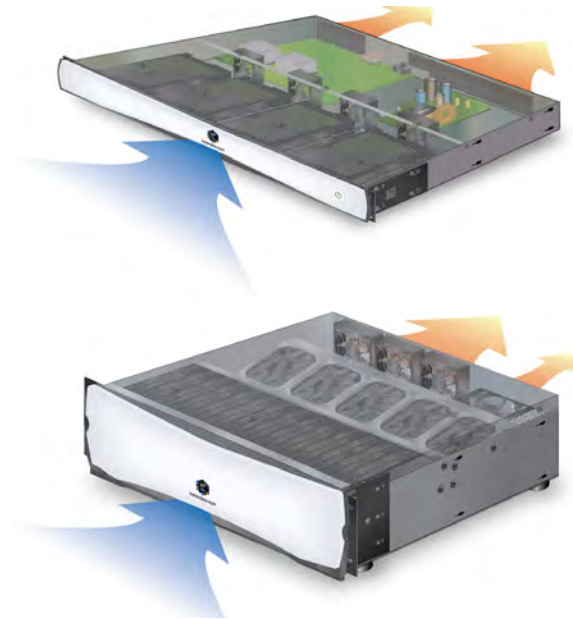


Figure 8 Kaleidescape servers intake cool air from the front and exhaust hot air through vents located on the back of the chassis

Kaleidescape servers are shipped with slot fillers known as blank disk cartridges when fewer hard drives than the maximum are ordered. If there are blanks, stagger hard drives between blanks to distribute heat dissipation between adjacent hard drives and increase drive lifespan. See Figure 9.



Figure 9 Staggering disk cartridges with blank cartridges reduces disk temperatures and can increase the lifespan of the drives

Kaleidescape servers have high airflow. In dusty environments or environments with pets, the front intake vents can become clogged. It is important to examine the front vents every 4 months for blockages. Blockages can result in high hard drive temperatures and premature failures.

Kaleidescape Players

Kaleidescape players contain quiet temperature-controlled fans to cool the electronics. Air enters players from the front and is exhausted out the rear. Players move much less air than servers but also require 1 inch of clearance in the front and 2 inches at the rear. Blockages to airflow or high temperature air entering the intake vents can cause the internal fans to work harder and make more noise. See Figure 10.



Figure 10 Kaleidescape players intake cool air from the front and exhaust hot air through vents located on the back of the chassis

Kaleidescape mini players are designed for flexible installations. Mini players can be rack mounted, wall mounted, or mounted behind the back of the display itself. Cool air is drawn through the front panel and frontmost bottom vents. Several exhaust vents are located on the rear panel, both sides, and at the back of the bottom surface. See Figure 11.

When installing mini players on walls or behind display panels, orienting the front panel to face down provides the best cooling since natural convection is assisting the internal fans in this orientation.



Figure 11 Kaleidescape mini players intake cool air from the front face and exhaust hot air through vents located on the back and sides of the chassis

Kaleidescape Mini Systems

The Kaleidescape Mini System contains hard drives and high power electronics. The Mini System has a quiet, temperature-controlled fan array to cool the hard drives and electronics. Intake vents are located at the front and bottom of the chassis. Exhaust vents are located at the rear and right side of the chassis. See Figure 12.



Figure 12 Kaleidescape Mini Systems intake cool air from the front and bottom, and exhaust hot air through vents located on the back and right side of the chassis

The Mini System ships with a rack mount kit that provides air ducts to pull cool air in the front. See Figure 13.



Figure 13 Kaleidescape Mini Systems rack mount kit provides air ducts to pull air in

Successful Rack-Mounting Configurations

There are two common, successful A/V rack cooling methods.

- Passive convection
- Forced air

Both designs remove heat from the rack by moving air through the rack. The more air that moves through the rack, the closer the internal rack temperature is to the temperature of the air pulled into the rack. This section describes how to cool the rack using each method and how to avoid mistakes that can cause racks to become too hot.

Passive convection designs are usually preferred when possible because this cooling method does not require fans. Passive convection designs are less expensive, silent, and do not rely on components that can degrade and fail over time.

Forced air designs provide cooler rack temperatures and can handle more heat. These designs are typically used for dense or hidden installations.

Passive Convection Rack Design

Passive convection rack designs are reliable, cost effective and silent but they have limited heat capacity and require lots of open space both inside and outside the rack. This cooling design relies on the difference in density between cool air and warm air to create airflow through the rack. Hot air is less dense and rises above colder air. Components typically run hotter in a passive convection rack compared to a forced air rack because the air in the rack must be sufficiently hot before it will rise out of the rack.

A passive convection rack operates like a chimney. The intake vents are located at the bottom and the exhaust vents at the top. The hottest components, for example, the amplifiers, are like the fire at the base of the chimney and are placed in the bottom rack shelves to create a strong upward draft. Bottom placement also provides the hot components with the coolest air. If possible, wide, deep racks are recommended for passive convection designs to reduce drag on the upwardly rising air.

Well-designed Passive Convection Installation

Components in the top shelves are heated by hot air from the lower components. It is important to measure the air temperatures surrounding components in the upper portion of the rack. Components with small internal fans and front intakes, such as Kaleidescape players, can be placed in the upper shelves as long as the disc trays are accessible. These players are less affected by higher temperatures inside a rack because these players pull in cool air from the front of the rack instead of from inside the rack.

Vent plates are perforated panels screwed onto the front of a rack that allow air to move in or out of the rack. Vent plates can provide power hungry or hot components

with a fresh supply of cool air but too many vent plates can degrade the chimney effect and placing vent plates near components with internal fans can cause air recirculation (see Figure 15). Vent plates between components in the upper shelves can provide cool air to those components if necessary but should not be placed in the middle of the rack or the chimney action will be degraded.

When placing vent plates, use the following guidelines:

- Place vent plates at the top and bottom areas of the rack.
- Avoid placing vent plates directly above or below equipment with front intakes.
- Be sure components without internal fans have adequate vent clearances. Use blanking plates (not vent plates) in the middle of the rack to provide space above and below the components.

A well-designed passive convection rack puts ample spacing between components that do not contain internal fans, and vent plates are kept to the lower region of the rack. See Figure 14.

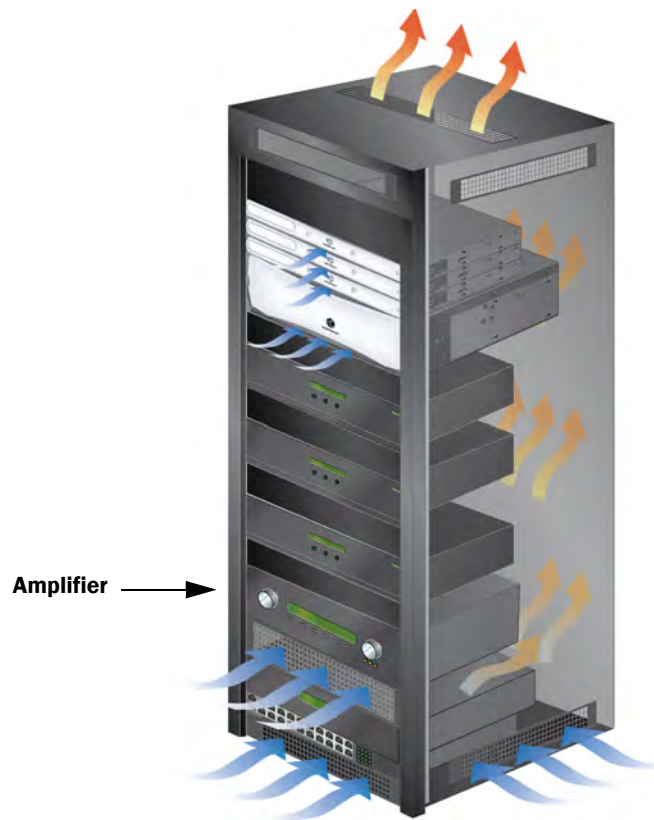


Figure 14 Example of a well-designed rack with passive convection cooling provides ample space above and below components

In the example, the amplifier has a vent directly below it and plenty of space above to allow cool air to rise through the chassis. The ample spacing between components gives the slow moving hot air streams exiting each component a chance to mix with colder air pulled in from the bottom, therefore preventing trapped hot air and the creation of hot spots. The Kaleidescape 3U Server and players are located in the top

shelves where the internal rack air is hottest. These components can be stacked and are less affected by the hotter internal air because they draw reliably cool air in from the front of the rack through internal fans. The rack is wide with plenty of open vent area at the top and bottom of the rack, and placed in a shaded area of an adequately temperature controlled room.

Common Mistakes for Passive Convection

1. Obstructions Choking the Airflow

For the passive convection chimney to work effectively, there must be a large unobstructed pathway from the bottom of the rack to the top, both in the rear and at the sides of the rack.

Common examples of obstructions include rear-mounted components like network switches or rack shelves that extend all the way to the back of the rack.

2. Placing Vent Panels in the Wrong Position

Placing vent plates near a component with internal fans can create air recirculation. This component will breathe in its own exhaust as well as degrade the chimney. This is especially true for Kaleidescape servers because of the powerful internal fans. See Figure 15.

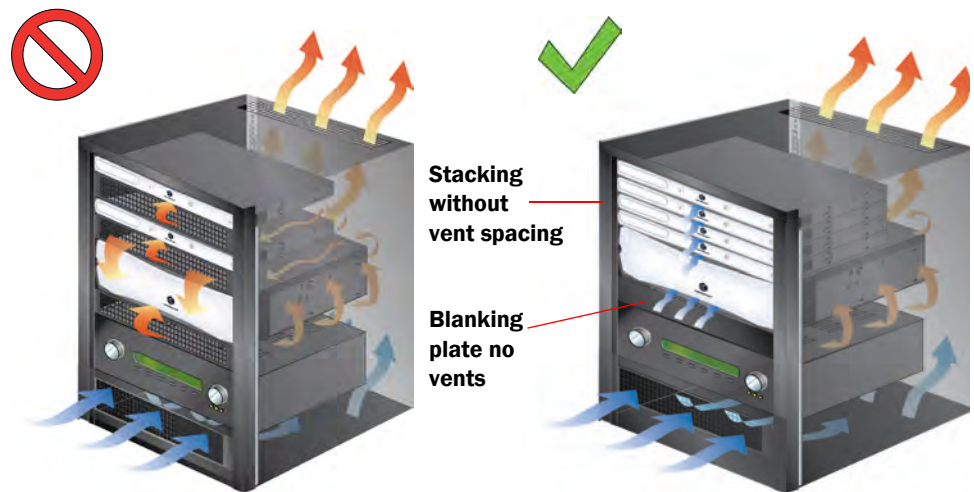


Figure 15 Intake vents near components with internal fans in a passive convection rack design can cause air recirculation

3. Insufficient Component Clearance

Insufficient clearance for top/bottom vented units does not allow cool air in and hot air out. This situation occurs when there is insufficient clearance above exhaust or below intake vents for components without internal fans. Components with top vents should have at least one rack unit of space above them.

4. Compound Heating

This problem occurs when hot exhaust air from a lower component flows directly into the intake vents of the component above, for example, when two amplifiers are stacked on top of each other. The bottom amplifier exhausts hot air out the top directly into the bottom intake vents of the upper amplifier. The upper amplifier then operates much hotter than the lower amplifier.

Place the upper amplifier on a rack shelf with full bottom plate (no vents) to prevent compound heating. See Figure 16.

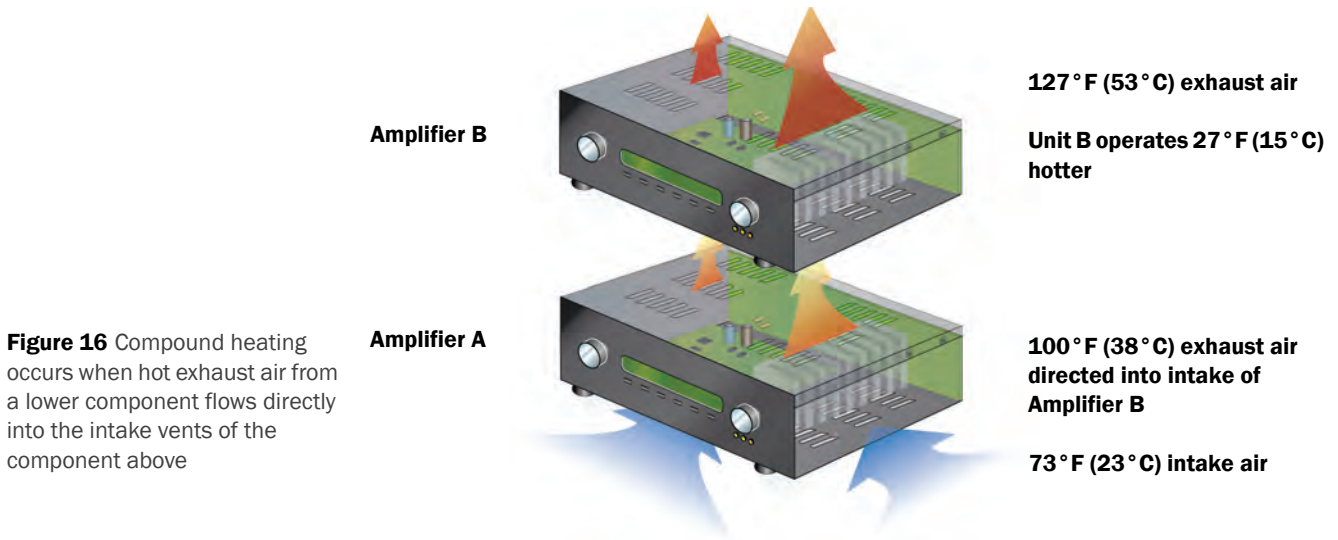


Figure 16 Compound heating occurs when hot exhaust air from a lower component flows directly into the intake vents of the component above

5. Improper Room or Closet Cooling

With a passively-cooled rack, the room or closet temperature must be much cooler than the internal rack temperature to keep air moving inside the rack. If the room is not properly cooled, temperatures both in the rack and in the room will continue to rise, potentially over the course of hours or days after the installation is complete.

Windows and sun exposure also affect rack temperature. Be sure to factor heating from the sun when calculating whether the cooling system for the room is sufficient. Sunlight can also heat the rack enclosure significantly, especially if shining on a large portion of the rack, through a transparent front door, or on the back of the rack.

6. Too Much Heat

If the heat output from the housed electronics exceeds 1,700 BTU/hr (500 W), a passive convection design is not sufficient. Rack manufacturers specify the best ways to set up their racks for passive convection and how much heat their racks can handle. If the passive rack air temperature is measuring above 95° F (35° C) at the top vents, fans must be added to implement a forced air rack design.

Note: Multiply the inefficiency (100% - efficiency in %) of an amplifier by the total rated power to determine the amplifier's heat output.

Forced Air Rack Design

A forced air rack design uses fans or blowers to remove heat by creating pressure differences that ensure a steady flow of air through the rack enclosure. This design is typically used for dense rack installations where considerable heat is generated inside the rack or where space constraints cannot support passive convection.

Forced air can maintain cooler temperatures for electronic components because of the increased amount of air flowing through the rack.

The installation designer has greater aesthetic control when using forced convection because the vertical placement of specific components has little effect on the overall cooling performance unless a component is blocking the main airflow path of an intake vent or the rack's exhaust fans.

When designing a forced air rack, the most important design features are 1) the placement of vent plates, and 2) the type and size of exhaust fans. Vent plates are perforated metal plates attached to the front of the rack. Vent plates allow air to flow into the rack from the environment. They come in various "open area" designs, the more open area, the easier for the air to travel in. Vent plates with the most open area are typically added at the bottom of the rack. Those with lesser open area are usually placed in the middle to prevent the bulk of the airflow from entering the middle of the rack and skipping the lower electronics.

When placing vent plates, use the following guidelines.

- The total open area of all vent plates should be equal, at minimum, to the combined intake area of all exhaust fans.
- Vent plates should not be placed in the upper region of the rack, otherwise the bulk of the airflow will skip the electronic components in lower shelves.
- Blanking plates can be used to provide clearance for electronics vented at the top.

Well-designed Forced Air Installation

Figure 17 shows correct placement of various electronic components in a forced air rack design.

Waste heat fluctuates from 2,000 BTU/hr (600 W) (idle) to 7,000 BTU/hr (2000 W) (full load)

Temperature controlled fans keep the rack quiet when the electronics are idle

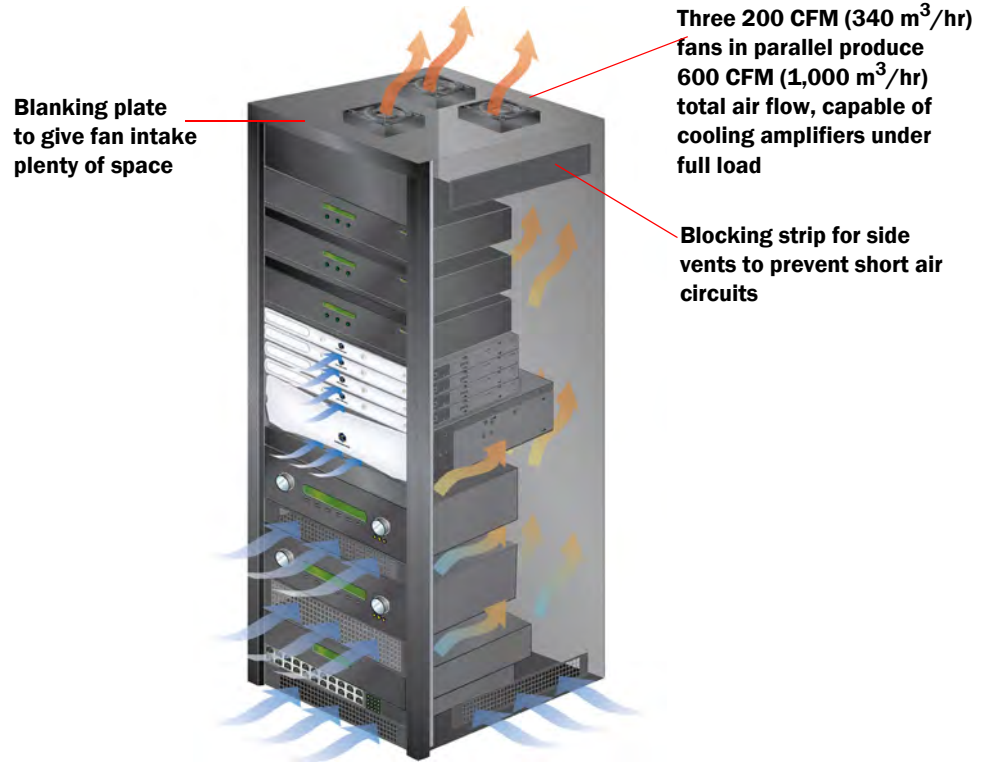


Figure 17 Example installation with proper vent placement and fan sizing in a forced air rack design

The example has more equipment than the passive convection design, producing approximately 2,000 watts (7,000 BTU/hr) of waste heat with two fully loaded multichannel amplifiers. Airflow calculations determine that 600 CFM (cubic feet per minute) or 1,000 m³/hr (cubic meters per hour) of airflow is required to keep the internal temperature of the rack below 85° F (30° C).

To prevent large fan losses caused by drag, the rack must maintain at least 2 inches between the rear door and the rear of any component. Cables must be organized to prevent any obstruction in the vertical flow of air in the sides of the rack. Blanking plates maintain clearance above components with top vents. Kaleidescape components are stacked to conserve space and there is nothing blocking their front intakes. Note that the top side vents have been blocked to prevent air recirculation and the top four shelves are vacant to provide the rack exhaust fans with adequate clearance at fan intakes.

Calculating Rack Airflow

The amount of airflow required for the system must be carefully calculated to ensure that the internal rack temperature remains below 85° F (30° C) under full load. Too little airflow can result in high internal rack temperatures, and too much airflow can be noisy and distracting.

When calculating airflow, the total heat output produced by all of the electronic components must be addressed. Each component has heat output information on a safety sticker or in the user manual. (Note that power dissipated through loudspeakers is not heat output into the rack. Amplifier heat output is found in the user manual by multiplying the inefficiency (100% - efficiency in %) of an amplifier by the total rated power of the amplifier.) The formula below can be used to determine the required airflow for a rack installation.

Imperial Airflow in CFM = $0.94 \times \frac{\text{Heat Output in BTU/hr}}{85^\circ\text{F} - \text{Room Temperature in } ^\circ\text{F}}$

Metric Airflow in m³/hr = $3.00 \times \frac{\text{Heat Output in W}}{30^\circ\text{C} - \text{Room Temperature in } ^\circ\text{C}}$

For example, if heat output is 7,000 BTU/hr and the room temperature is 73°F, the required airflow is $0.94 \times (7000/12) = 550$ CFM.

- **Heat Output:** The sum of all heat released by the electronic equipment into the internal airspace of the rack when at full load.
- **Room Temperature:** The air temperature of the air entering the rack system (measured directly in front of the intake vent plates).

Note: CFM = cubic feet per minute; m³/hr = cubic meters per hour;
BTU/hr = watts x 3.4

Higher altitudes require greater airflow because of the reduced air density. Heat is removed from the rack by air molecules. Less heat is removed from the rack when there are fewer air molecules (lower density air). See [Table 1](#) for airflow adjustment factors for given altitudes.

Find the installation altitude, then multiply the calculated airflow by the adjustment factor to determine the required airflow at higher altitudes.

Table 1 Airflow Adjust Factors for Altitude

Installation Altitude	Adjustment Factor
Sea Level	1.00
2,000 ft (600 m)	1.05
4,000 ft (1,200 m)	1.15
6,000 ft (1,800 m)	1.25
8,000 ft (2,400 m)	1.35
10,000 ft (3,000 m)	1.45

For example, at 8,000 ft, the adjusted airflow is $550 \text{ CFM} \times 1.35 = 740 \text{ CFM}$.

Selecting Fans

Once the required rack airflow has been calculated, the correct fans must be chosen. Fans always operate below the manufacturer's specified airflow numbers when installed. Published airflow numbers are "free air" flow, this means that the fan is floating in free space without any obstructing objects nearby. When placed in a rack system, the fan will have to fight the drag created when air moves through vents or small channels, or changes flow direction, or suddenly contracts or expands. It is good practice to add an additional 15% to the rack airflow calculation to account for performance losses attributed to drag and gradual degradation due to aging of fan bearings.

Common Mistakes of Forced Air

1. Fans in Series Do Not Add Up

When two fans are "in series" the first fan intakes air from the surroundings and blows air into the rack while the second exhausts air out of the rack. Fans in series do NOT produce double the airflow unless system drag is large.

A fan moving 50 CFM of air located at the intake area of a rack and a 50 CFM fan at the rack exhaust can only move a maximum of 50 CFM through the rack. When fans are placed in series, the sensitivity to obstructions is reduced but the total airflow is not increased. To achieve 100 CFM, two 50 CFM fans have to be placed side by side, or "in parallel" as far apart as possible. See Figure 18.

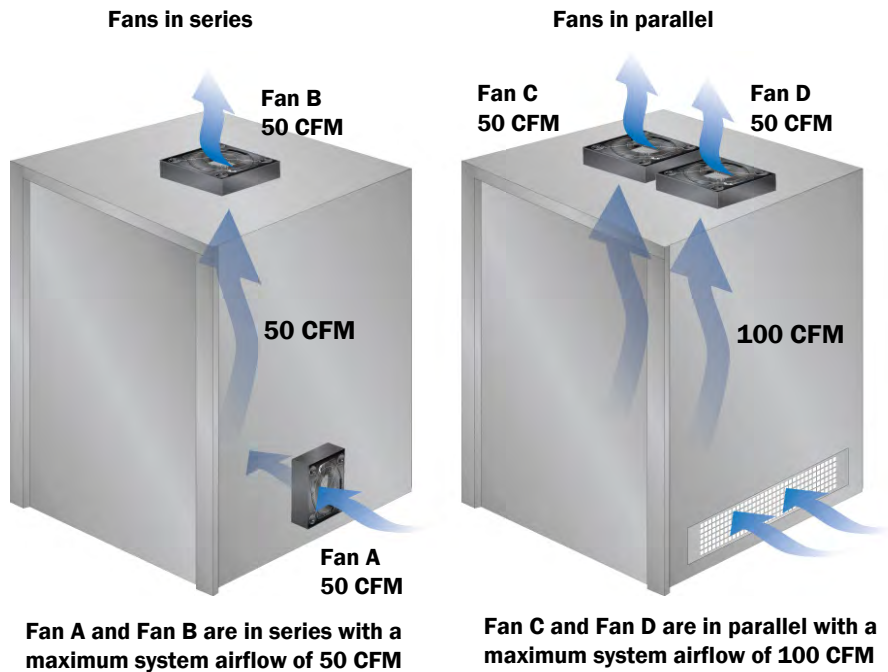


Figure 18 Fans in series do NOT produce double the airflow; fans in parallel combine airflow production

2. Improper Use of Fans in Parallel

Fans in parallel must be of equal power or airflow rating. A weak fan with low airflow located next to a strong fan with high airflow will result in air recirculation through the weak fan. The strong fan pulls air through the weak fan, reversing the airflow of the weak fan and undermining the intended airflow of the rack installation.

Fans in parallel must also be placed on the same temperature control circuit to prevent one fan from operating at higher speeds than the other.

Lastly, when fans are placed in parallel a fan failure drastically reduces the overall rack airflow because the failed fan acts as an inlet. Airflow enters the failed fan and skips the electronics in this situation. See Figure 19.

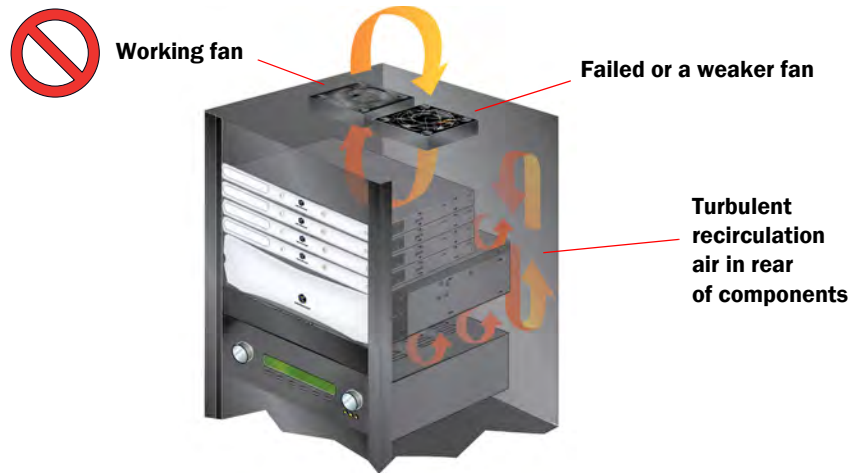


Figure 19 Air can be recirculated by using unequal fans in parallel with unequal ratings

3. Obstructing Fan Inlets

Fans operate far below published airflow if objects are placed near their intake areas. In addition, fan noise increases substantially when objects are placed in front of the intake because of the air turbulence created. See Figure 20. It is good practice to keep objects at least one fan diameter away from the fan intake area.

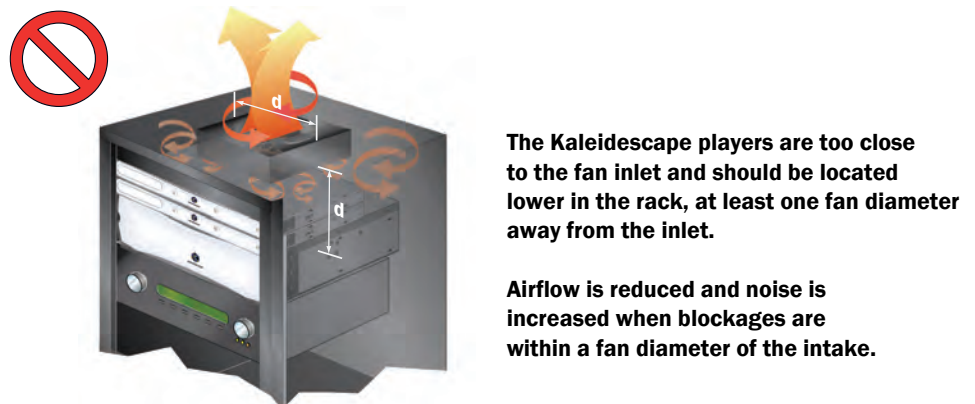


Figure 20 Obstructed fan inlets degrade fan output

4. Misguided Airflow

Rack enclosures might require modification by the installer for forced air designs because racks are often shipped in a passive convection configuration. All vents in the upper portion of the rack must be blocked for forced air designs when the exhaust fan is located at the top.

Upper vents are typically located on the side walls or rear door. A top mounted exhaust fan pulls most of the airflow through these vents and bypasses the electronics components. The same is true for oversized vent panels located in the top or middle of the rack. See Figure 21.

Good design practice is to seal the entire rack, and then add vent panels or remove seals where air intakes should be located. There must be a solid door at the rear of the rack.

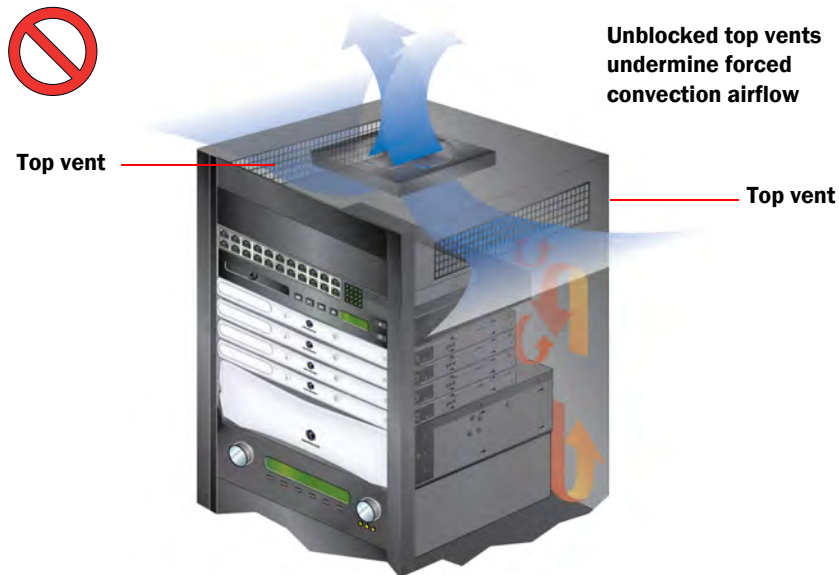


Figure 21 Top vent air is short-circuited if vents are not blocked

5. Weak Fans or Constricted Airflow

If an electronics cabinet is extremely dense, has obstacles that create many turns in the end-to-end airflow path, or the required rack airflow exceeds 500 CFM, the 15% compensation for performance losses caused by drag might not be high enough. A radial fan or blower might be a better option than typical axial fans designed for A/V rack systems. Radial fans are more powerful and better able to overcome drag but rarely appear attractive on paper with a free air flow of approximately half an axial fan. A radial fan can have half the free air flow of a similar sized axial fan but double the in-system flow if the system drag is significant.

If the system has been installed and the airflow is not sufficient, use the following points to troubleshoot the rack airflow.

- Verify that all fans are blowing in the right direction.
- Search for and remove any constrictions caused by oversized components, cable bundles, blocked vents or rack doors.
- Confirm that the rack top vents intended for passive convection designs have been blocked.
- Increase the size of the intake vents. The combined area of all intake vents should be at least the size of the combined fan intake areas.
- Replace fans with models that can handle higher pressures.
- Try using radial fans (blowers) with equivalent airflow or add fans in series with the original fans. See Figure 18.

6. Choked Airflow in the Front Airspace

Components that extend past the front of the rack can constrict airflow between the front of the rack and any front door. When front doors are installed, it is good practice to have vents at the top and bottom of the door, and in the middle if feasible. See Figure 22.

The total vent area for the front door should equal the total area of all vent plates installed on the front of the rack plus the total vent area of all front intake components. Recessing rack rails to provide a large space between component fronts and the inside surface of the front door is also recommended.

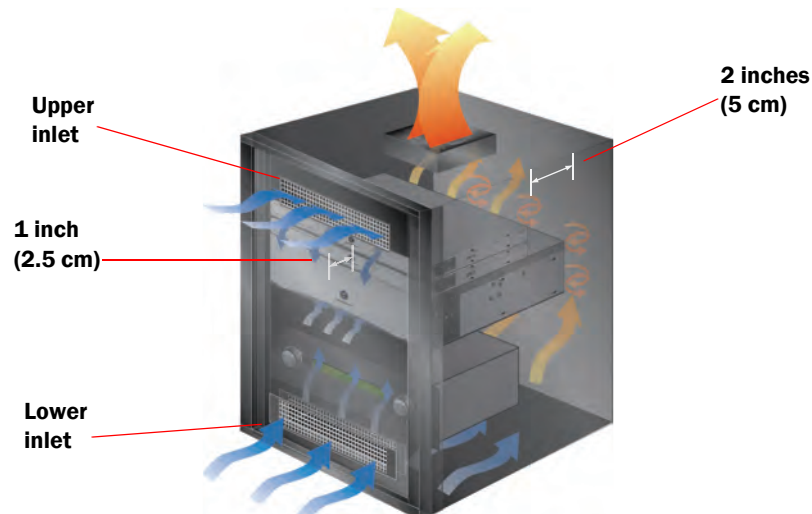


Figure 22 Proper clearances must be maintained to prevent choked airflow

7. Lack of Periodic Cleaning

If the rack is located in a dirty environment, the intake vents for the rack and components can become clogged with dust. The wire chases can also become dirty. Educating home owners on cleaning procedures helps ensure that the rack system consistently operates at peak efficiency.

Temperature Monitoring and Design Verification

Design Verification

The final installation step is to perform a thermal design verification under the following conditions:

- The rack must be installed in its final location. (Testing in the shop before installation is error prone.)
- All electronics must be active and fully loaded and in the state that produces the highest heat output for at least 2 hours.
- All rack doors must be closed and fans must be running from the intended control circuit if present.

Air temperatures must be tested at rack intake and exhaust vents at a minimum. Temperatures of each component intake must also be measured if possible. Simple mercury thermometers or basic digital temperature sensors with 2 degree accuracy can be used. Air temperature probes should not touch any component surface. Figure 23 shows typical test points.

1) **Air exiting the enclosure** – The recommended temperature of air exiting the enclosure is 85°F (30°C) or lower.

2) **Air entering the enclosure** – Verify that the intake air is at the expected room temperature, around 73°F (23°C) or lower.

3) **Air at intake vents for each component** – Hot spots can form in areas where air is trapped inside the rack; so it is important to measure the air intake temperatures at each component. Be sure these air temperatures are below the maximum ratings for the components.

Test Points for Design Verification

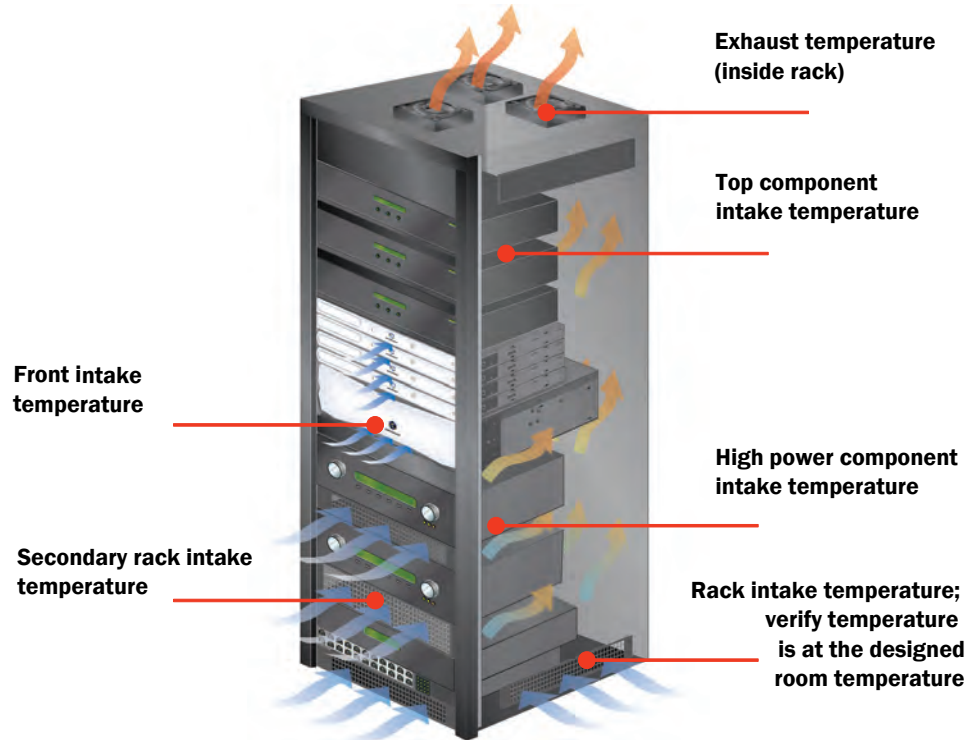


Figure 23 Temperature measurement locations include air intake and exhaust points as well as component intake vents

Temperature Monitoring

Because environmental and physical changes in a household affect electronic installations, in-system thermal monitoring and alerting is recommended. A monitoring system can alert the system administrator of rack and HVAC failures, as well as overheating caused by pet fur clogging air intake vents, a new thermostat setting, or some other circumstance. A monitoring system can substantially reduce the cost of such failures.

Two classes of monitoring systems are available, local and remote.

Local systems are typically integrated into a fan control circuit that can kill power to the rack electronics if the internal air temperature rises to a damaging level (113°F or 45°C is a typical trip point).

Remote systems can provide real time and historical temperature data to both owner and dealer via the Internet. These systems can also provide the following advantages.

- Generate email alerts if temperatures elevate to a warning condition.
- Enable proactive action because the dealer can perform periodic checks to verify that the rack is operating in a stable manner consistent with design goals.

- Reduce system downtime because the dealer is automatically alerted if a suspicious situation occurs. Diagnostic services such as component temperature history can speed debugging thermal problems.

Kaleidescape Alerts are an example of a remote monitoring system included with A/V equipment. This service provides current and historical temperatures of each component in the system via the Kaleidescape Extranet. The system administrator is alerted of elevated temperatures through email. Monitoring systems built into rack components are cost-effective and can be used to monitor the temperatures of surrounding environments indirectly which helps protect other equipment as well.

Conclusion

A successful rack installation requires knowledge of the equipment installed, some planning, and thorough verification. The cooling design of each component and proper vent clearances must be considered. Airflow calculations determine the necessary fan configuration, eliminating guesswork and time consuming experimentation. Design verification ensures the exhaust temperature is within acceptable range and that there are no unexpected hot spots inside the rack.

Two simple and successful rack cooling designs are passive convection and forced air. Passive convection is silent and does not rely on fan components that can fail over time. Forced air rack designs rely on air movers such as fans or blowers. Forced air rack designs are required for racks in tight spaces or with high heat output.

Regardless of the rack design, thermal monitoring equipment can help prevent cooling system failures resulting in damaged equipment. Local and remote monitoring systems are often complementary. Some A/V equipment offers built-in remote temperature monitoring that allows dealers to check the environment of the installation indirectly. These systems allow dealers to offer proactive assistance to the clients and additional thermal protection.

Rack installation is one of the last steps in the transaction between customer and dealer. The installation is the final impression. Successful thermal installations improve the relationship between customer and dealer by maintaining a pleasant living environment and improving the lifetime of the owner's equipment.

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