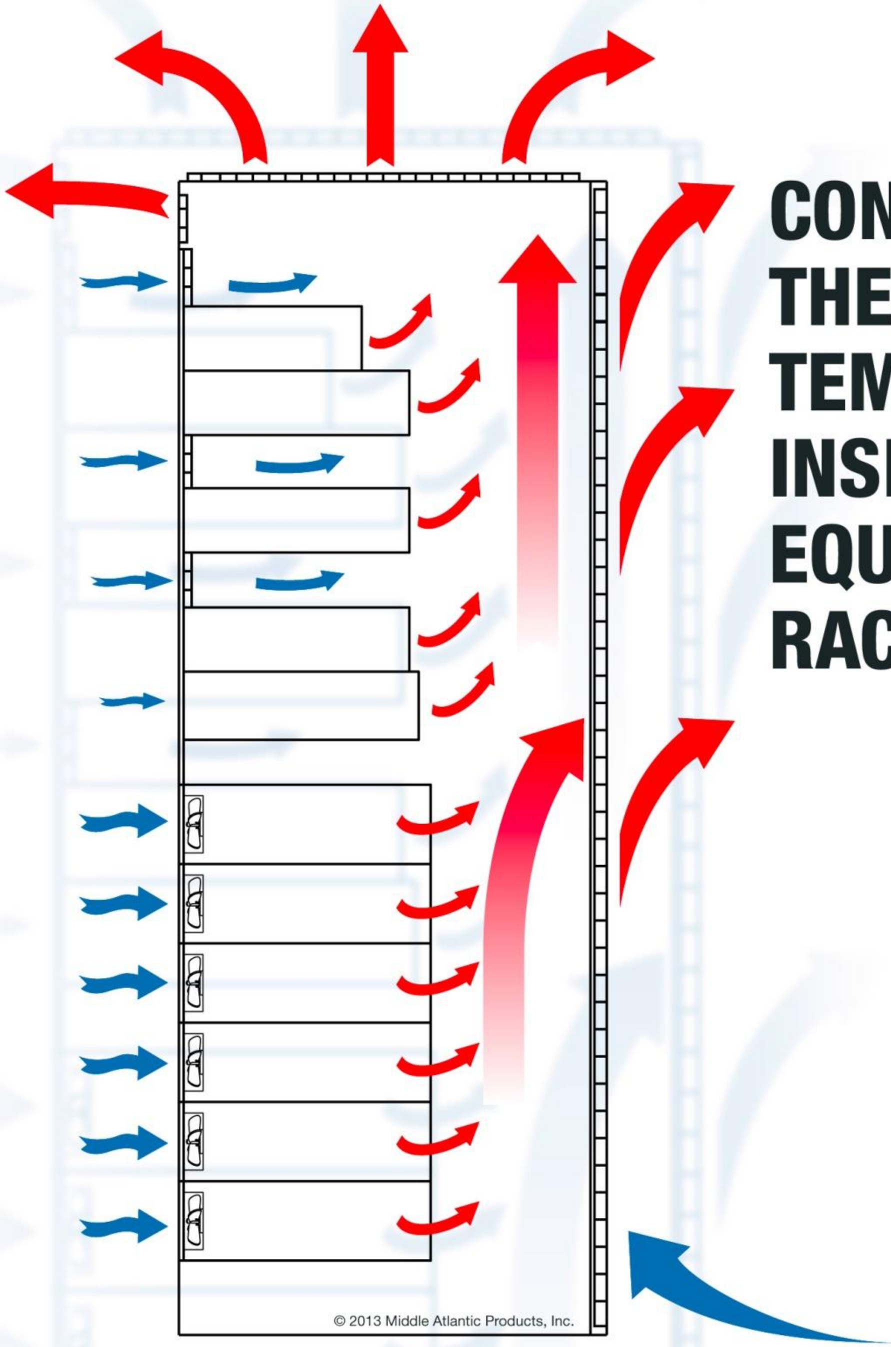

CONTROLLING THE TEMPERATURE INSIDE EQUIPMENT RACKS

what great systems are built on.™

Middle Atlantic Products

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Controlling the Temperature Inside Equipment Racks

Maintaining the temperature inside racks is **critical** to the proper functioning and survival of the circuits operating within them. The best way to control this temperature is to take a systems (integrated) approach to thermal management.

Thermal design of equipment racks and enclosures is essential to ensuring the functionality of the equipment and system when subjected to the surrounding environment. The most robust designs for thermal management, for instance, occur in the telecom industry, where equipment reliability can literally be a matter of life and death. People expect an immediate dial tone when they lift the receiver, even during a power failure.

Heat has been proven to substantially reduce the service life of most equipment, which makes it vital to engineer the removal of this heat.

85ºF is the maximum recommended constant operating temperature for most equipment; it will help provide a long service life for the equipment inside an enclosure.

Why 85ºF? **Most studies have shown that for every 10ºF rise over 85ºF, digital equipment life is reduced by approximately 40%!** However, the Uptime Institute states, “For every 18°F increase above 70°F, long-term reliability is reduced by 50%”. Clearly there is a need to control the temperature inside electronic enclosures.

Both the performance reliability and life expectancy of electrical equipment are inversely related to the component temperature of the equipment.

Amplifiers on the other hand, can operate at far hotter temperatures; many operate well (with reduced thermal headroom) at 110ºF! At elevated temperatures, computers and networking equipment fail more frequently than A/V equipment. With the continued integration of computer equipment and A/V equipment, more care needs to be taken when approaching thermal planning. Where conditioned space is at a premium, amplifier racks should be separated from digital audio/video racks.

Preface

HVAC systems should be engineered to meet the needs of the room. The HVAC system must be properly sized to accommodate the heat load generated by AV and IT equipment. In some cases, the HVAC system must maintain a low background noise level when operating. The objective there is to maintain the room's environment for safe equipment operating temperatures and noise-free acoustics, where low ambient sound levels are important. Heat loads, background noise specifications and ventilation requirements must be addressed very early with the HVAC designer/installer to ensure they are included with the design.

The objective of this guide is to calculate and understand when to vent a rack using natural convection, and when it's time to force the air (using fans).

When fans are the choice, you will be able to calculate the required amount of airflow (CFM), and where to place the vents.

Fan choices, filtering and environmental variables are discussed, along with a range of real-world application diagrams and helpful charts on how proper thermal management can be achieved.

Definitions

CFM - Cubic feet per minute, of airflow

Ton - One "Ton" of air conditioning = 400 CFM (on most units)

BTU/Hr. - British thermal units per hour, of heat
12,000 BTU/Hr. = 1 "Ton" of air conditioning

Watt - One Watt of current draw (Volts X Amps) = 3.413 BTU/Hr.

Rack - Enclosure, cabinet, for housing electronic equipment

Room Load Capacity – The point at which the equipment heat load in the room no longer allows the equipment to operate within the specified temperature requirements

HVAC - Heating, ventilation, air-conditioning

Measured Power – Actual current draw measured by an amp meter to determine waste heat, for all equipment other than amplifiers

Nameplate Rating – A power, voltage and frequency rating used for regulatory approval [**should not be exclusively used for waste heat calculations**]

Thermal System

There are three airflows involved in this thermal system; one is how the heat travels through the rack, another is how the air moves throughout the room and the last is how room heat is removed. The interactions between these airflows are important, and must be considered when taking a systems approach.

All heat (BTU/Hr.) generated by equipment must first be removed from the rack, and then the room itself must have the ability to remove the total heat from all racks. Many installations do not have the luxury of an air-conditioned environment, so consideration must be given to how the room itself will vent.

If the equipment room does not have the ability to remove the heat generated by the rack(s), then all of the following calculations will have little meaning. It is important to ensure that whatever heat is removed from the rack will not raise the room temperature significantly.

For digital equipment, the room itself should be no hotter than 75ºF. This gives a 10ºF temperature difference between the room and the recommended 85ºF internal rack temperature for optimum equipment life.

The cooler the room (as long as the room temperature is above the dew point so condensation does not occur), the fewer vents or fan CFM will be needed.

All necessary information is included within to calculate the total BTU/Hr. that will need to be removed.

Rack Placement

Heat flows from hot to cold and you cannot make the heat come out of a cabinet unless the outside air is cooler. Convection is the process of air passing over a hot object and carrying the heat away.

It is always better to focus on removing heat from above, rather than adding cold air.

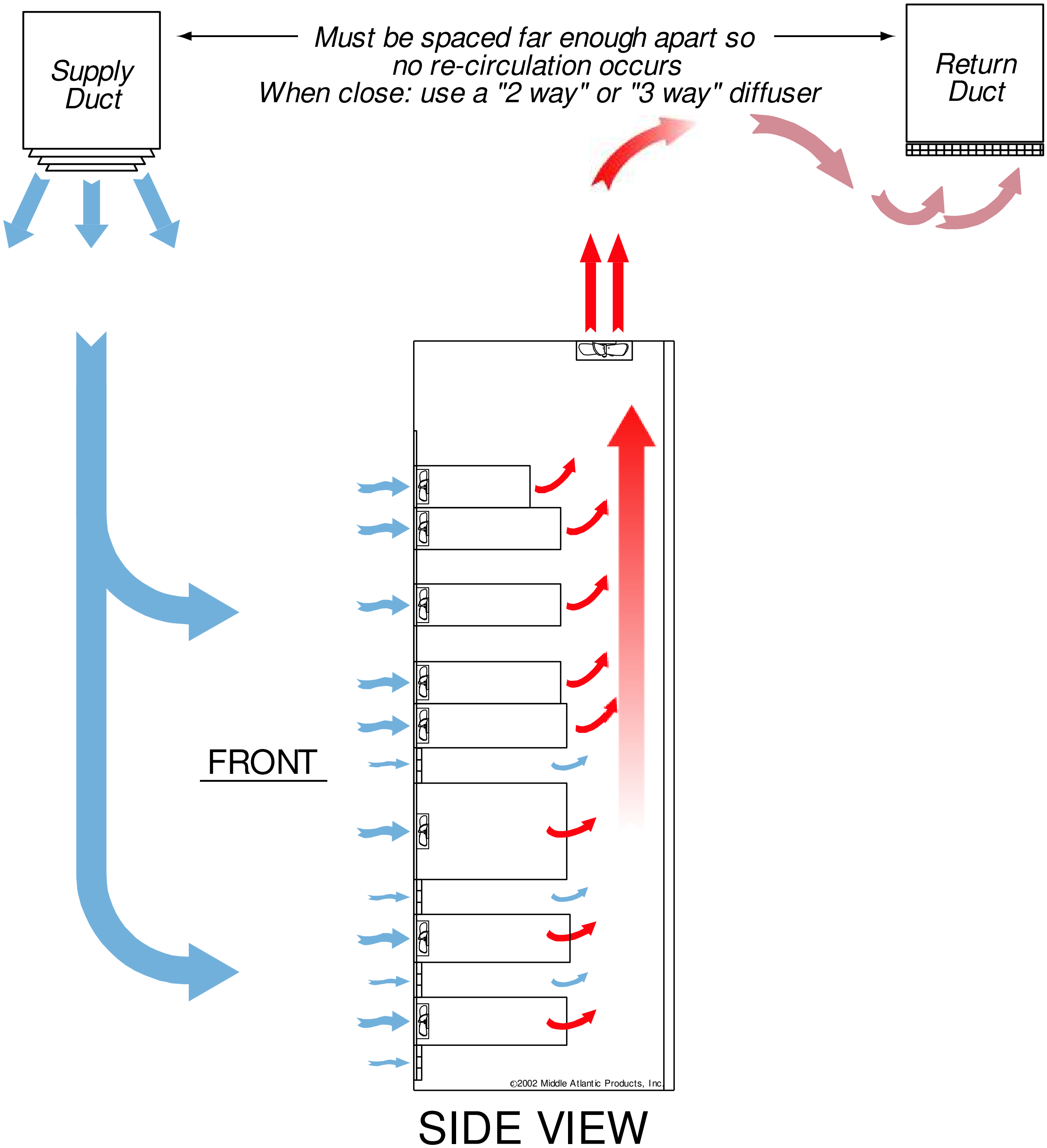
In quiet office environments where equipment is housed in racks in closets, fan noise is often not welcome. Ambient temperature can be higher in closets, and heat should be exhausted out if the ambient air inside the closet exceeds 75°F. In the case of a single rack in a closet, it is important to use a fully louvered closet door and monitor the temperature when there is no active ventilation in the closet. If natural convection is not adequate to maintain 75°F a thermostatic exhaust fan needs to be installed.

In the case of equipment racks in an air-conditioned room (without a raised computer floor), it is better to have the supply ducts and diffusers in front of the racks, and the return ductwork and registers in the rear of the room.

Avoid locating the racks directly under supply ductwork. Cold air falls, and the flow of the hot air that rises from the top of the rack should have no impediments on its way back to the return air (intake) duct.

Proper

Air Conditioning Airflow And Rack Placement



Enclosure Designs

For passive convection (no fan) applications, wider racks are beneficial; a good "chimney effect" is made possible by the space between the sides of mounted equipment and the enclosure's sides. The presence of this space facilitates the drawing of heat upward.

In forced-air applications, a narrower cabinet can be selected to save space. Additionally, the best way to exhaust the air is to incorporate a fan top.

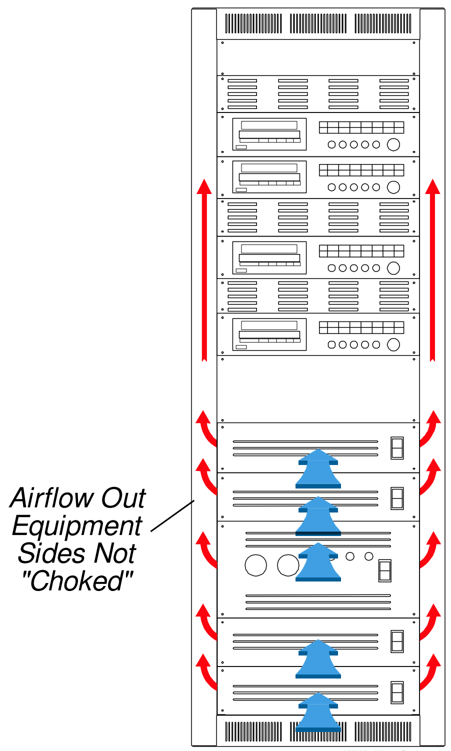
An enclosure **without** venting built-in to the top face should be selected when top-mount fans are required. Some enclosure manufacturers do not take proper thermal engineering into consideration, so care should be given to the rack selection process.

Proper

"WIDER IS BETTER"

For The Side Chimney Effect On Front-Intake Equipment

Enclosures with a wide footprint are ideal for achieving a chimney effect



Equipment

In most integrated audio/video installations, the largest heat load will come from power amplifiers **while they are driven**. However, there are an increasing amount of digital devices that produce a considerable amount of heat. Microprocessors, which are often embedded to do signal processing, emit greater heat from equipment than ever before.

Additionally, as the speed of microprocessors increases, the heat continues to rise. Coupled with the continuing miniaturization of electronics, the trend is for more and more heat to be generated per rackspace of equipment. This is also known as increased heat density.

Radiated Dissipation

Non-vented solid areas of all racks dissipate internal heat to the outside by radiation. As the internal temperature rises, so does the temperature of the sheet metal enclosure. This heat is then radiated to the ambient environment.

This is an important calculation for extremely dirty environments or outside installations where the cabinet must be sealed airtight.

This paper covers only passive convective venting and forced-air cooling, where the dissipated heat by radiation is negligible in the calculations of these scenarios.

BTU/Hr. Calculations

When designing electronics systems, it is critical to ensure that not only can heat be removed adequately, but also that any thermal management system, whether passive or active, can handle the heat generated by the specific components being installed. Waste heat output will vary greatly between different types of equipment, therefore consideration must be given to the individual components as well as how they act as part of the whole system in each rack or enclosure.

Most equipment converts almost all of the power drawn into waste heat. Calculating BTU/Hr. output for most equipment is simple: the more current it draws, the more BTU/Hr. will be produced. At 117 volts, each ampere of current drawn produces exactly 400 BTU/Hr. of heat output.
Note: estimating BTU/Hr. for amplifiers requires different considerations; see Amplifier Calculations section.

Nameplate ratings should never be used as a sole measure of equipment heat release. The purpose of a nameplate rating is solely to indicate the maximum power draw for safety regulatory approval. In real-world tests, equipment nameplate ratings far exceeded actual current draw. The drawback of thermal management planning based solely on the nameplate ratings is that in many cases, the specified AC equipment will be oversized for the actual amount of heat released, resulting in wasted money and decreased operating efficiency. The following example illustrates just how different a typical system's actual measured amperage is, compared to the nameplate ratings of its equipment:

Typical Financial Institution Video Teleconferencing Rack

Equipment	Nameplate Rating*	Actual Measured
CATV Tuner	0.16	
DVD Player	0.13	
Presentation Switcher	1.2	
Video Scaler	0.3	
Audio Mixer	1.69	
VTC Codec	2.3	
Transmitter/Volume Controller	0.12	
Control Processor	2.4	
4 Channel Amplifier	6.3	
75 W Power Supply	2.3	
Total System Amps:	16.9	2.54
Resulting in BTU Output:	6760	1016
CFM Required** for obtaining 85°F equipment temperature	418	63

*** Units with nameplate rating in watts have been converted to amps. Total system power factor averaged .78**
****In 70°F Room, actual (after frictional losses) airflow CFM, not fan manufacturers spec**

Amplifier Calculations

Amplifiers are not as straightforward, due to the different nature of circuit designs and other variables. Taking into consideration which output design is found in the amplifier, the type of power supply, what type of program material is played, how many Ohms the speaker load is, and at what level the amplifier is to be driven on average, the real-world BTU/Hr. output can be estimated. Amplifiers are available in many design classes, which have varying degrees of efficiency. Class A, B, AB, and D are several examples.

At the low end of the thermal efficiency spectrum, Class A amplifiers average no more than 20% efficiency, which means 80% of the line current draw will be converted to waste heat. It is extremely rare to find this class of amplifier installed in banks of equipment racks. At the other end of the thermal efficiency spectrum (high thermal efficiency), Class D amplifiers have up to 90% of the power cord draw watts converted to useable output watts, which means they will only generate 10% waste heat. Class D amplifiers, however, work more efficiently under loads, and actually generate more heat at idle than when driven! As with class A, it is rare to see class D amplifiers used in larger jobs.

Class AB amplifiers are the most common; therefore this paper's associated charts and graphs are based on that class of circuitry. Although most amplifier manufacturers publish their class AB amps at 60% to 70% efficiency with sine waves, real-world program material measurements show that a more conservative realistic efficiency is 50%, and is the basis for all calculations found in this paper.

Several amplifier manufacturers recognize the importance of thermal planning, and publish excellent data on how much waste heat in BTU/Hr. are generated for varying loads and input material. It is highly recommended to obtain this heat loss (waste heat) information from the amplifier manufacturers. The proper calculations then can be derived with that information.

The following is typical of an amplifier manufacturer's information sheet:

Model "X": 8 Ohm Stereo Mode, 16 Ohm Bridged Mono, or 4 Ohm Parallel Mono			
Program Material	**Program Duty Cycle**	**Waste Heat BTU/Hr.**	**Current Draw 120VAC**
Individual Speech	10%	390	1.6A
Acoustic/Chamber Music	20%	460	2.2A
Full Range Rock Music	30%	540	2.9A
Compressed Rock Music	40%	620	3.5A
Pink Noise	50%	700	4.2A

Model "X": 4 Ohm Stereo Mode, 8 Ohm Bridged Mono, or 2 Ohm Parallel Mono			
Program Material	**Program Duty Cycle**	**Waste Heat BTU/Hr.**	**Current Draw 120VAC**
Individual Speech	10%	390	1.6A
Acoustic/Chamber Music	20%	480	2.4A
Full Range Rock Music	30%	560	3.1A
Compressed Rock Music	40%	650	3.8A
Pink Noise	50%	730	4.5A

Model "X": 70V Mode, Any Configuration			
Program Material	**Program Duty Cycle**	**Waste Heat BTU/Hr.**	**Current Draw 120VAC**
Individual Speech	10%	390	1.6A
Acoustic/Chamber Music	20%	480	2.3A
Full Range Rock Music	30%	560	3.0A
Compressed Rock Music	40%	640	3.7A
Pink Noise	50%	720	4.4A

The information provided on this page is calculated data based on driving both channels to rated output. Other parameters used in calculation include a conservative idle current estimate of 90 Watts and a conservative estimation of efficiency at 65%. Information is provided for the purpose of getting an idea of current draw and heat produced. Actual performance will vary depending on environment, program material, load, signal, and AC mains voltage and frequency. Values of calculated current draw are intended to represent average draw corresponding to the thermal breaker requirements that should be met to handle the amplifier as a load on the AC mains. Peak current draw with dynamic program material may be significantly higher. Thermal information is provided to assist with calculating air conditioning needs. The above data should not be construed as specifications.

Planning Airflow Inside the Rack

Proper planning of the cooling air path inside a rack ensures that no “hot-spots” occur, and that the waste heat is effectively removed.

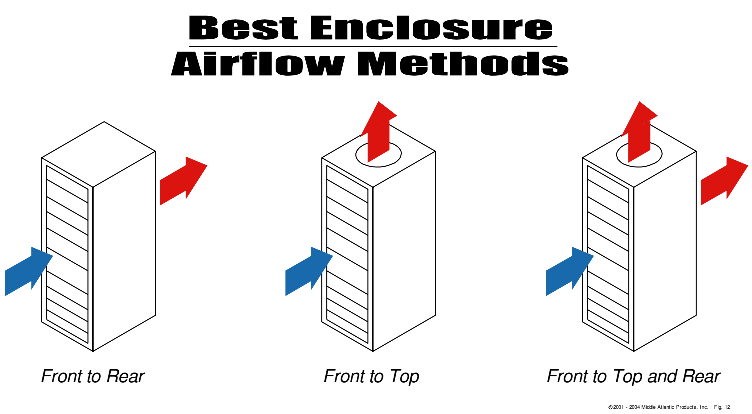
Good thermal designs require an understanding of the rack-mounted equipment airflow. There is some equipment that has internal fans that draw air in through the rear (or sides), and exhaust out the sides (or rear). This re-circulates the cabinet air and care should be taken as to its placement so the natural convective rise of heat is not disturbed. In forced-air racks (using fans to exhaust the heat) this is moot.

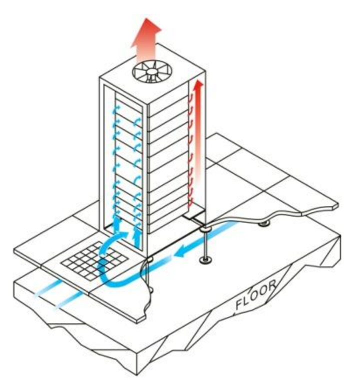
The most common airflow found in almost all equipment is that which pulls cooler air in from the front, and exhausts the heated air towards the rear or sides (known in this paper as “front-intake” equipment).

There are a few amplifier manufacturers who take the cabinet air through the rear and exhaust it out the front (known as “rear-intake” equipment). This presents some special thermal design challenges, as it does not allow hot air to exit the top of the rack. The fans in the rack top must push the air down when using this type of amplifier.

Downward airflows can be less than ideal, creating “mixed convection” (mixture of forced air and convection) during operation and in the event of fan failure. However, with proper installation there should be no issues.

Simulations and real-world testing show that moving air through a cabinet from bottom to top results in the lowest internal cabinet temperatures.



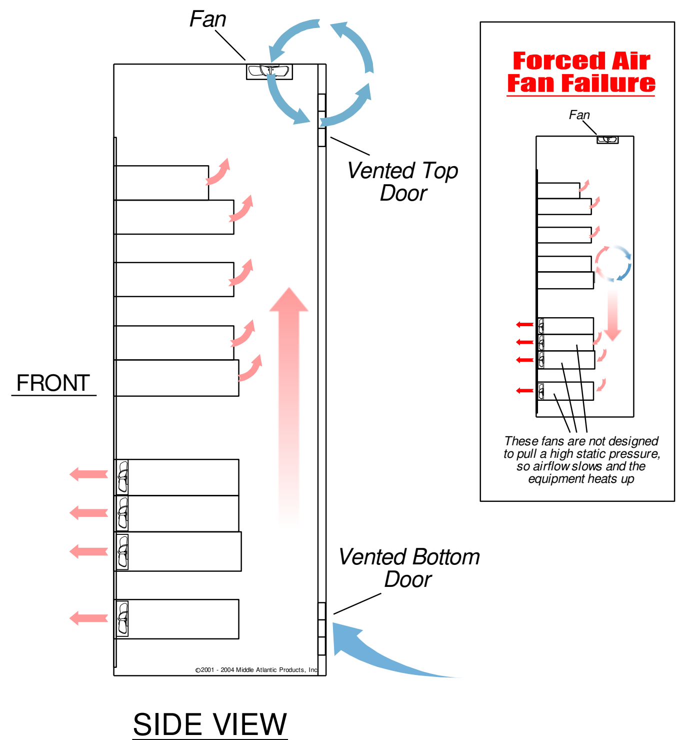


Bottom to Top, on Raised Floor

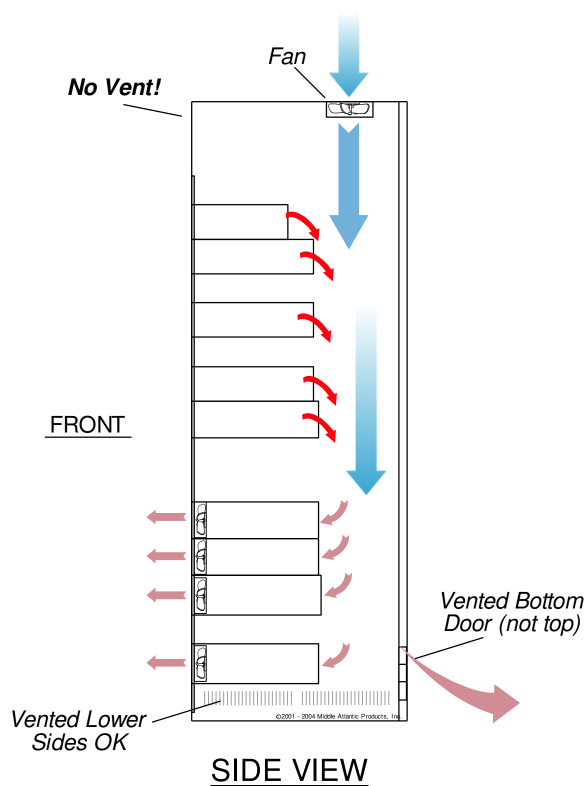
Rack-mounted equipment should follow this protocol for best operation, and cabinet systems can follow any of the methods shown. The recommended airflow protocols for equipment follow closely those recommended in Telcordia GR-3028-CORE.

Rear Equipment Fan Intake Common Mistake vs. Simple Solution

WRONG!
Forced Air
With Rear Equipment Fan Intake



Proper
Forced Air
With Rear Equipment Fan Intake



Planning Airflow: Passive Convection

In an environment at normal room temperature, a rack is able to dissipate 300 to 500 watts of heat (not “audio” watts) through natural convection. This requires adequate vent openings at the bottom and top of the rack (none in the middle for effective “chimney” flow), and unimpeded airflow inside.

The main advantage of natural convection is its intrinsic reliability. Air movement in a properly configured cabinet is generated by thermal gradients. Proper configuration most importantly includes optimization of component placement. Hotter equipment located lower in the rack will provide a greater natural airflow.

When using passive convection in high ambient temperatures (approximately 90°F and higher), the components that generate the most heat should be placed near the top of the cabinet, except when loaded racks are transported to job sites, or in a seismic installation.

Calculating airflows in a passive convection enclosure is complicated. The slow speed of airflow makes it nearly impossible to measure, and smoke tests show air can enter and exit from the same vent.

Equipment that passively vents (without fans) sometimes has intake vents on the bottom, or vents on the top, so care must be taken not to block these with equipment stacked directly on top of each other. Otherwise, it is acceptable to stack equipment directly on top of each other.

Many times installers simply put vents between each piece of equipment without regard to the re-circulation of hot air. This can “short-circuit” the airflow because the vents are placed too close to fans or heat sources.

Good airflow strategies break the temperature stratification areas, which cause “hot-spots”. In some cases the re-arrangement of vents and equipment is required.

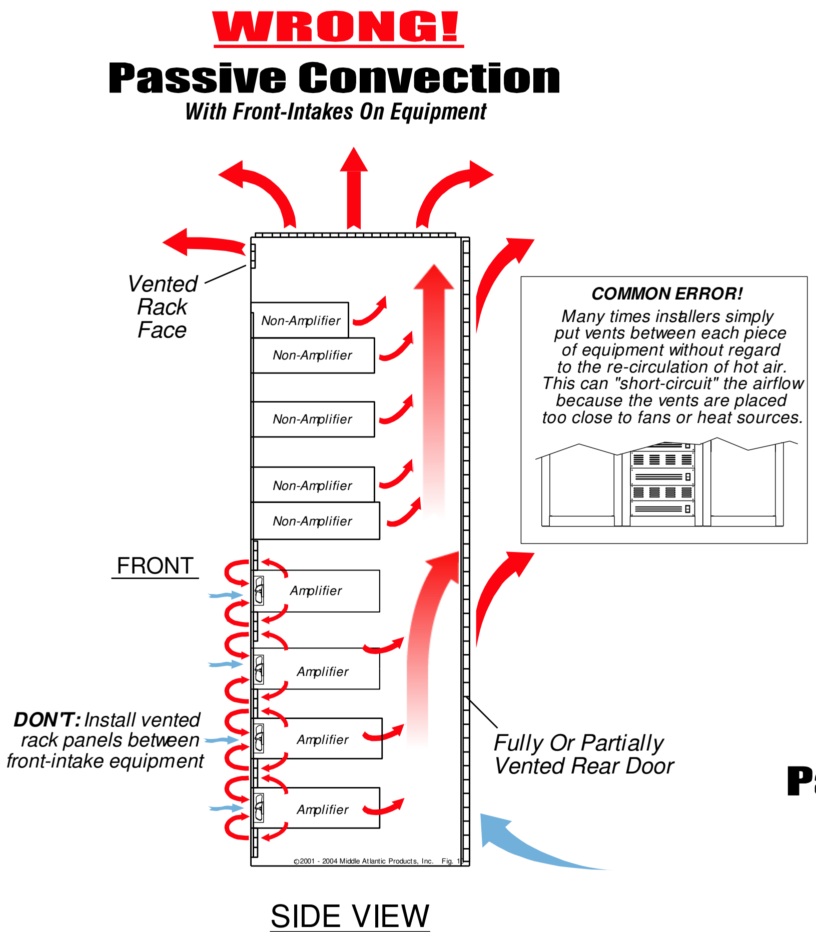
For equipment with front-intake, it is perfectly acceptable to save rackspace by stacking equipment directly on top of each other as long as this equipment has no vents on the top or bottom of its chassis.

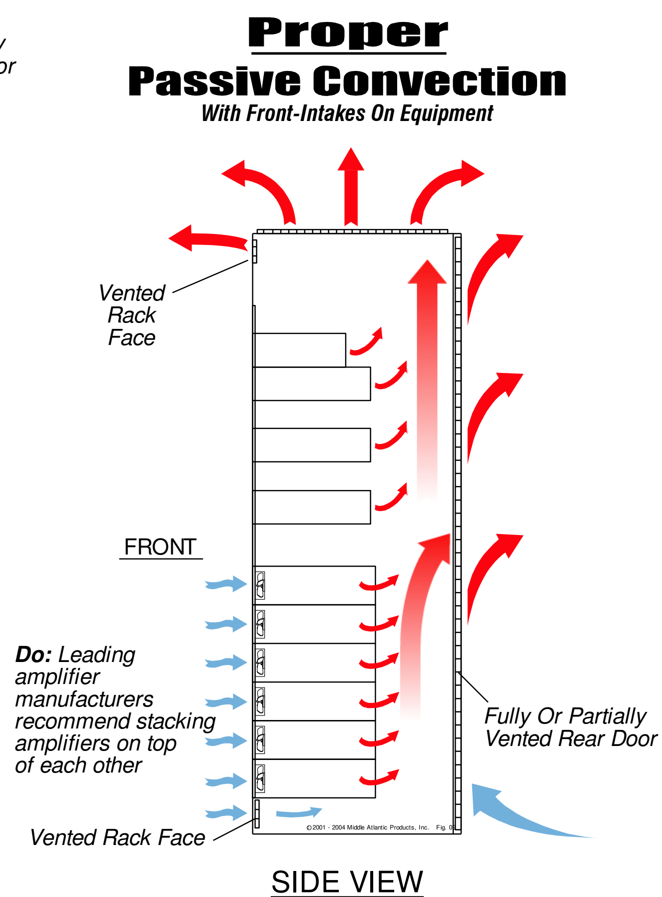
The following diagrams show this arrangement with passive convection. As with any passive convection scheme, the more venting up top and on the bottom, the better. Choose racks that have vents built into the top and bottom face for optimum performance, and ensure that a fully vented top option has been installed.

Installing a vented rear door in a passive cooling scenario is not necessarily required; this is dependent on the total BTU/Hr. produced within the rack. For clarification, consult the nomograph at the end of this paper.

It is important to note how the passive convection scheme changes, with front-intakes on equipment (fans inside the amplifier, for example) and without fans built in.

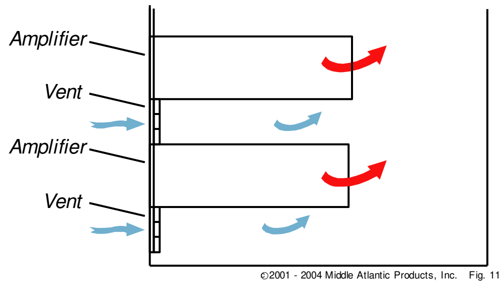
Passive Thermal Management Common Mistake vs. Simple Solution





Proper Placement Of Vents

When Amplifiers Are Not Fan Cooled



***Do:** If the amplifier is not fan cooled put vents underneath*

Hot air rises while cold air falls. The hotter it gets, the more CFM flow occurs by natural convection. The friction of all vents gets in the way of the flow; more open area, in the form of slots or perforations, is always better.

For multiple convection-cooled amplifiers, put vents in between, unless the amplifier manufacturer states otherwise.

Planning Airflow: Forced Air (Active Thermal Management)

In certain cases when there are too many BTU/Hr. for natural convection to adequately remove heat, it is essential to force the heated air from the rack. Active thermal management involves the use of fans to effectively remove heat from an equipment rack.

In these cases where forced air is required, it is acceptable (but not essential) to put vents between equipment with front-intakes.

Most front-intake equipment fans are between 25 and 50 CFM each. If a fan is required for the top of the rack, ensure that this fan's CFM rating is at least the sum of the CFM ratings of all the equipment fans. Hot air will not "short-circuit" and re-circulate between equipment, as the fan will draw air from all openings. A solid rear door is recommended in this situation to control airflow from front to rear.

It is important to note that Fan CFM is a **maximum** rating, as if you mounted it in free air. As soon as you connect it to an enclosure, the flow rate decreases because of air friction.

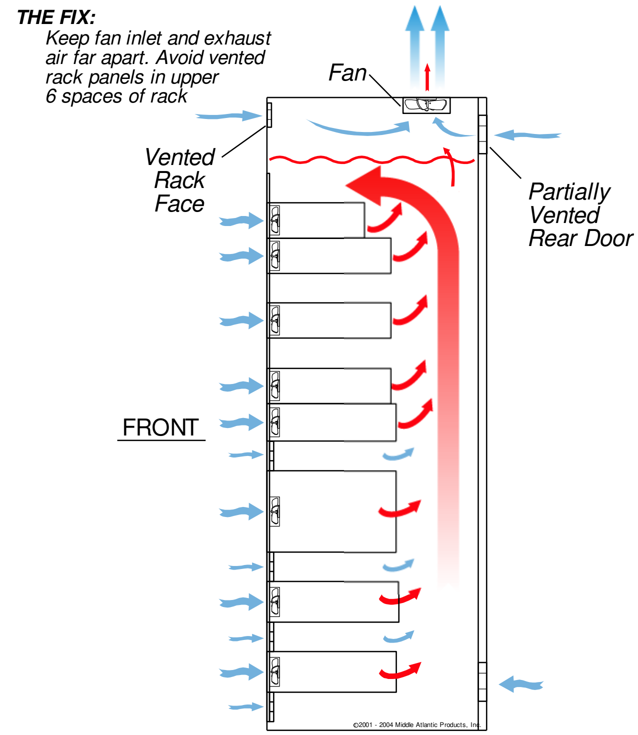
Note that the "Proper Forced Air With Front-Intakes on Equipment" diagram shows no vents in the upper rack face, no vents in the upper rear door, and no vents in the upper 6 spaces of the rack. This will prevent the "short-circuiting" of air at the top of the rack.

Active Thermal Management Common Mistake vs. Simple Solution

WRONG!

Forced Air

With Front-Intakes On Equipment



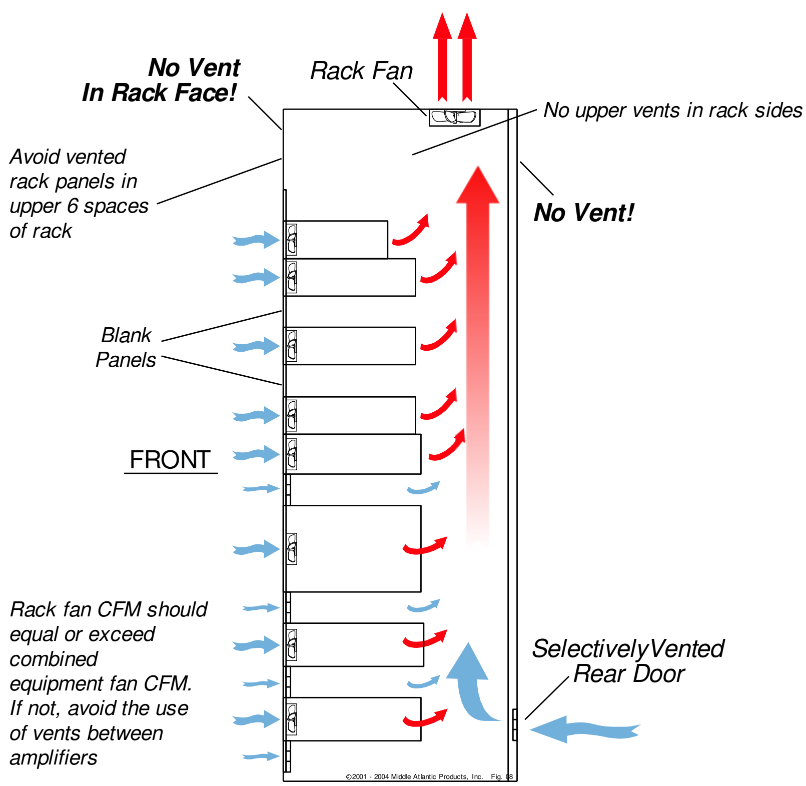
SIDE VIEW

PROBLEM:
Fans draw cooler room air from the top rack openings instead of drawing heated air from the rack itself.

Proper

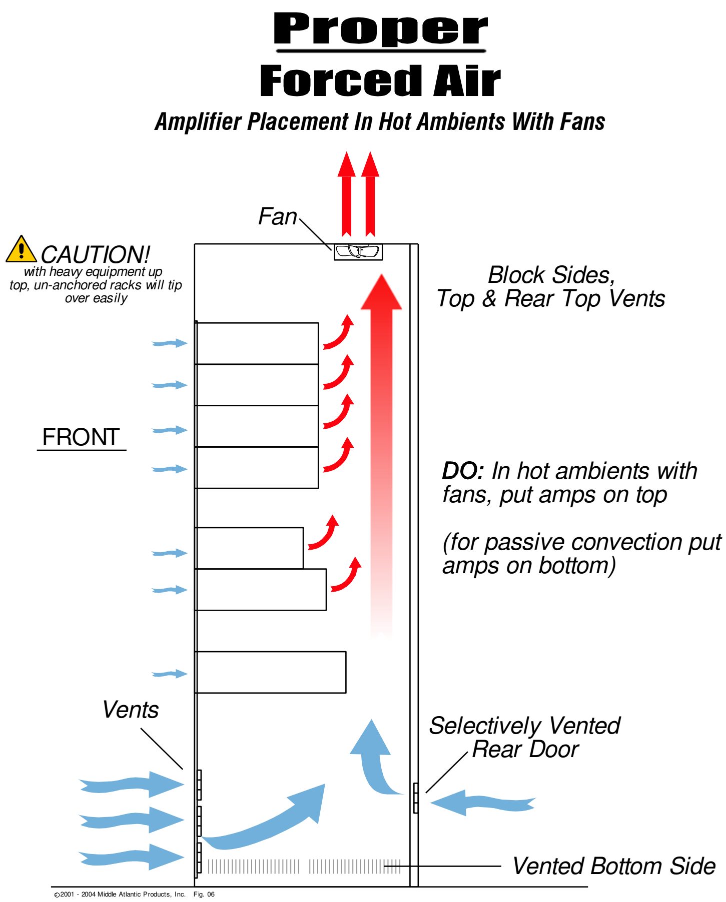
Forced Air

With Front-Intakes On Equipment

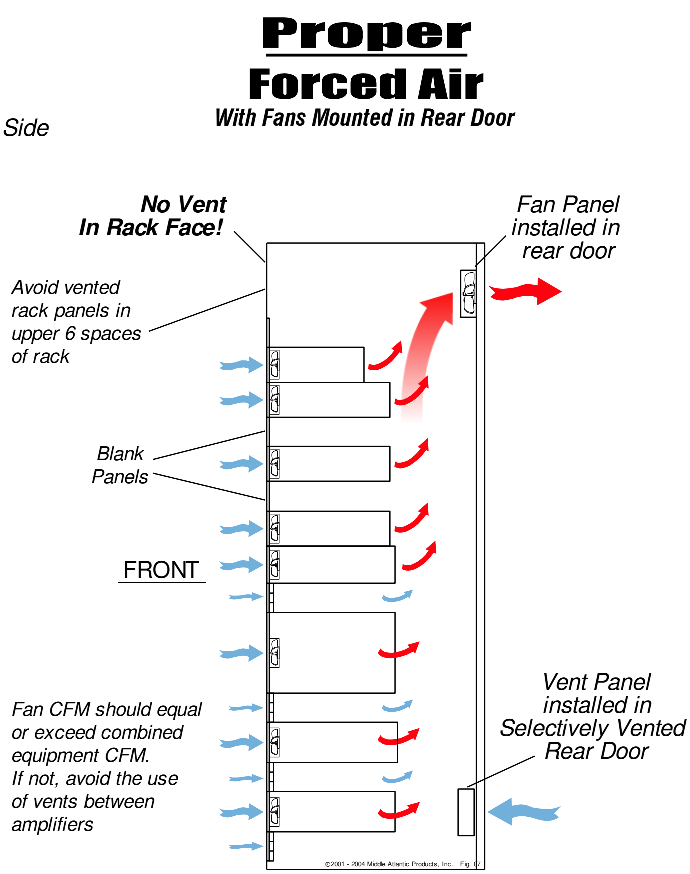


SIDE VIEW

Active Thermal Management Additional Simple Solutions



SIDE VIEW



SIDE VIEW

Vent Sizing for Forced Air (Fans)

To avoid "starving" the forced airflow, consideration must be given to provide adequate intake venting area. The following are minimum recommendations on the number of rackspaces of venting - more venting is better, *if properly placed.* See the diagrams elsewhere in this paper for where to put them, and where NOT to put them.

Assumptions:

1. Rackmounted vents have 64% minimum open area
2. No equipment has front-intake (Less venting is required if "series" conditions are present from the front-intake fans in equipment)
3. 4" fans deliver 95 CFM
4. 6" fans deliver 220 CFM
5. 10" fans deliver 550 CFM
6. H10" (High-output) fans deliver 825 CFM

Fan Qty	Fan size	Minimum # of vented rackspaces
1	4"	2 spaces
2	4"	3 spaces
3	4"	4 spaces
4	4"	5 spaces
1	6"	4 spaces
2	6"	5 spaces
3	6"	6 spaces
1	10"	6 spaces
1	H10"	8 spaces

If the rack has a vented rear door (Bottom-only is ideal for top mounted fans), less rackmount venting is required. Visual interpolation is adequate for approximating how many vented rackspaces are required in this situation. Please note that the overall vented area should not be less than specified in the above chart.

Airflow Obstructions

Shelves can be an important component of the enclosure's internal airflow planning process. Shelf surfaces that overhang the internal natural rise of heat should be vented.

Any obstruction to airflow will raise the temperature in the lower portion of the rack, possibly creating a stratification zone, and should be avoided if possible.

Large horizontal cable bundles, when not properly dressed, can also obstruct airflow.

Fans (Forced Air)

Fans will substantially reduce interior operating temperatures if intake vent placement, size, and airflow are done correctly.

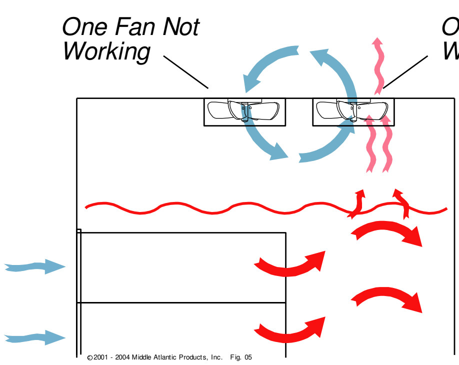
Fans however, add little value over good convection designs if air "short-circuiting" occurs from having air intake points close to the fan.

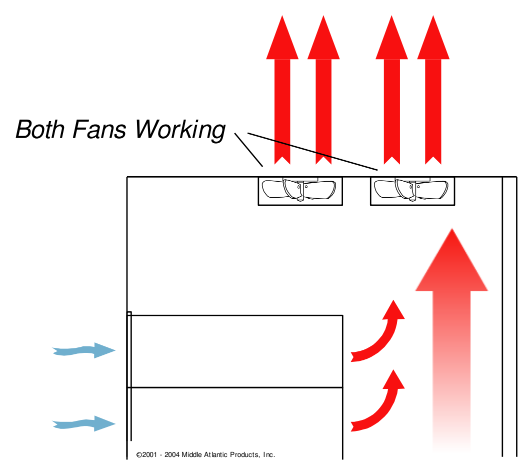
Venting in the wrong locations can also cause "hot spots", where air does not flow. Proper fan/vent placement will force more air "disturbance" inside of a rack, breaking up these hot spots. The use of a fan tray can also remove hot spots. Additionally, fans help reduce condensation in colder ambients. Condensation increases equipment downtime.

The ideal spot for fan placement (unless it is a dirty environment) is in the top, where the hotter air needs to be removed. This also aids the natural force of the hot air rising. Rack mounting fans is recommended where there is a likelihood of contaminants falling into the rack from above.

Baffles can be installed in difficult situations as a solution to maintain a proper airflow. A baffle will channel air across a problem location, as in an excessive heat spot, or an isolated area.

Using multiple fans mounted next to each other requires that they be checked regularly for proper operation. Once one fan stops functioning, it provides a short-circuit path for the airflow. Don't be fooled by thinking two fans will help; when one fails, it acts as a vent near a fan and **will not** remove heat from the enclosure effectively. Care should be taken to ensure fans are operating properly to avoid this re-circulation of heated enclosure air.





Fan Life

All fans fail over time. Of the many types of fans available, ball-bearing fans outlast sleeve-bearing fans by about 50%. At 90ºF a ball-bearing fan will last approximately 55,000 hours, while a sleeve-bearing fan will quickly become inoperable at this temperature.

Because of the necessary bearings inside fan assemblies, fans are more susceptible to failure than any other component. The most practical way to extend fan life is to use a proportional speed thermostatic fan control. These fan controls extend equipment life and reduce service calls by varying fan speed based upon temperature. A temperature probe triggers fans when an enclosure's internal temperature reaches a pre-set level.

The faster a fan runs, the faster it wears out. Variable speed fans are also "self-adaptive" - they take into account changes in ambient temperature and the varying power dissipated by equipment. Even if filters are employed, the more unnecessary air that is forced through the rack will deposit dust inside the electronics, reducing its thermal transfer. Slowing the airflow down to the required amount will reduce the deposited dust.

Static Pressure

Two terms are used to describe fan performance: Airflow Rate and Static Pressure. Airflow rate is the volume of air moved per unit of time, commonly expressed as cubic feet of air per minute (CFM). Static pressure (S.P.) is the pressure or suction the fan is capable of developing. In a rack, it is the measurement of resistance to airflow.

There is system impedance involved with forced-air cooling. As air travels through intake vents and filters, the air pressure drops. The system impedance is the sum of all pressure drops. The fan selected must be capable of operating at this static pressure, or the CFM will drop.

All fans have performance curves, which show how much CFM will be delivered at various static pressures. All diagrams and fans referred to in this paper operate within the proper range.

In situations where there are inlet restrictions, a blower should be selected rather than a fan. Blowers typically are capable of a higher static pressure.

By definition, a fan is an axial device in which the air moves straight through. A blower's air intake is 90 degrees to the discharge outlet, and is not frequently used in an audio/video rack. Blowers also produce a more concentrated airflow than fans, and can lead to more audible noise.

Vents, Fans, And Equipment Layout

The optimum configurations presented in this paper have been derived using both thermal modeling and actual temperature measurements.

The installation of front doors in most cases has an effect on airflow. A fully perforated front door (64% minimum open area) does not impede any fan's performance; the paths of air inside the rack and temperatures are not changed. A vented plexiglass front door's performance varies based on the design of the door, from inadequate to adequate.

As a general rule, if a vented front door with less than 64% open area is chosen, fans are recommended. The exception to this rule is when the equipment has high static pressure front-intake fans built in (which is rare).

In all other cases, the use of a fan in the top of the rack "in series" with the equipment's built-in fans will increase the static pressure (decrease the air system's impedance), so air can be "pulled" through the vented door more effectively. In this series arrangement, both the rack fan and equipment fans work together as a team, increasing the cooling effectiveness.

It is a common misconception that the equipment fan working in conjunction with a rack fan will increase the airflow. As you can see from the "Parallel vs. Series Fans" chart on the next page, all this provides is a greater static pressure. It does NOT increase the airflow. The only way to increase airflow is to add a fan in parallel, or obtain a fan with a greater CFM rating.

Typical Performance Curves: Fans and Blowers

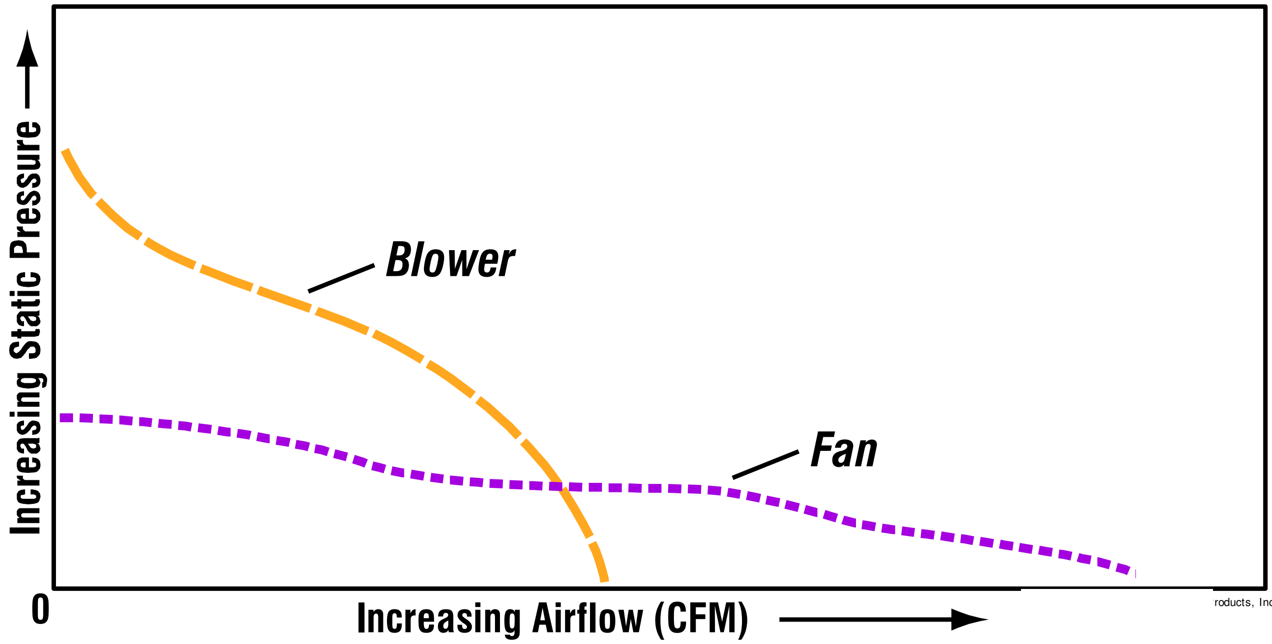


chart #1

Parallel vs. Series Fans

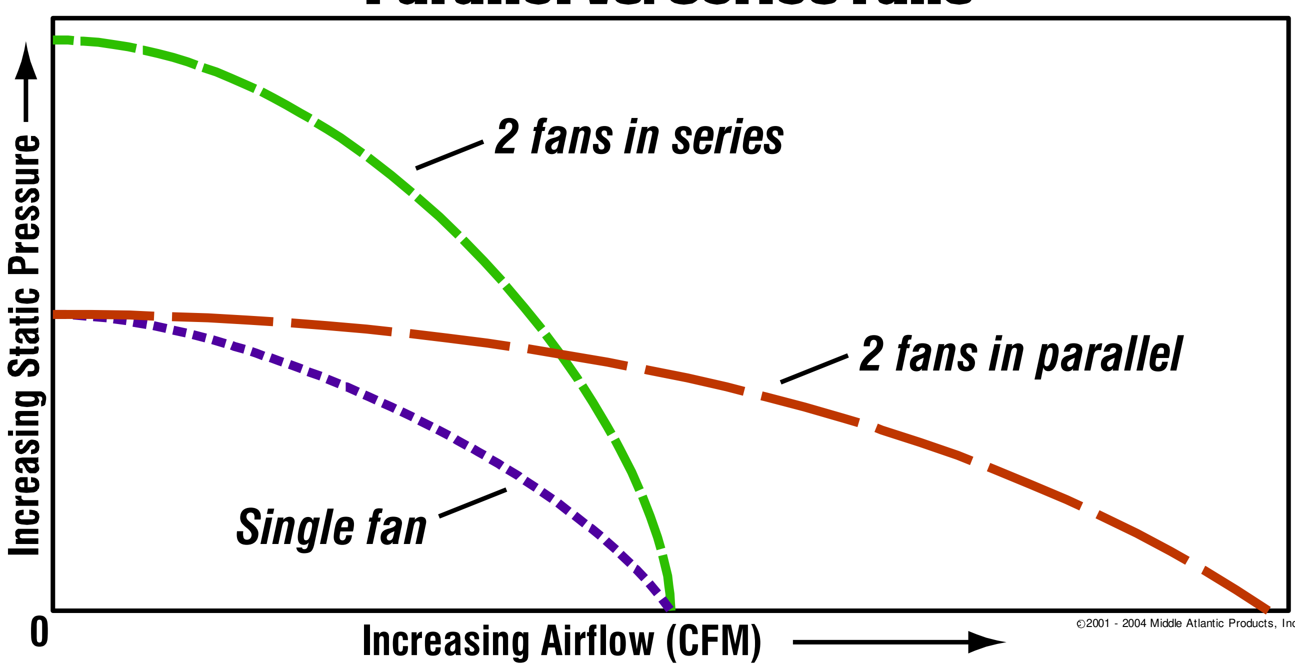


chart #2

Filters

Filtering helps protect digital and other sensitive equipment from "hygroscopic dust failure", which occurs in humid environments (generally 65% relative humidity or higher).

Dust absorbs moisture and deposits itself on circuit boards. Computers and other digital equipment utilizing rapid microprocessor clock rates will be most affected by this hygroscopic dust failure.

Many manufacturers sell washable filter kits that can be mounted over fans or used as a filtered vent panel to protect equipment from the hazards of hygroscopic dust failure.

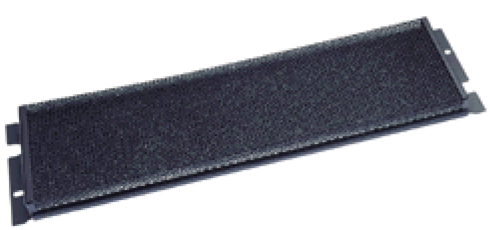
Inlet air filters are highly recommended to extend the service life of digital equipment, as most switchers, routers, hubs, and other processing equipment have their power supply fans in the rear, without any filtered front air intake.

Filters are especially important in environments where airborne particles or dust can be found.

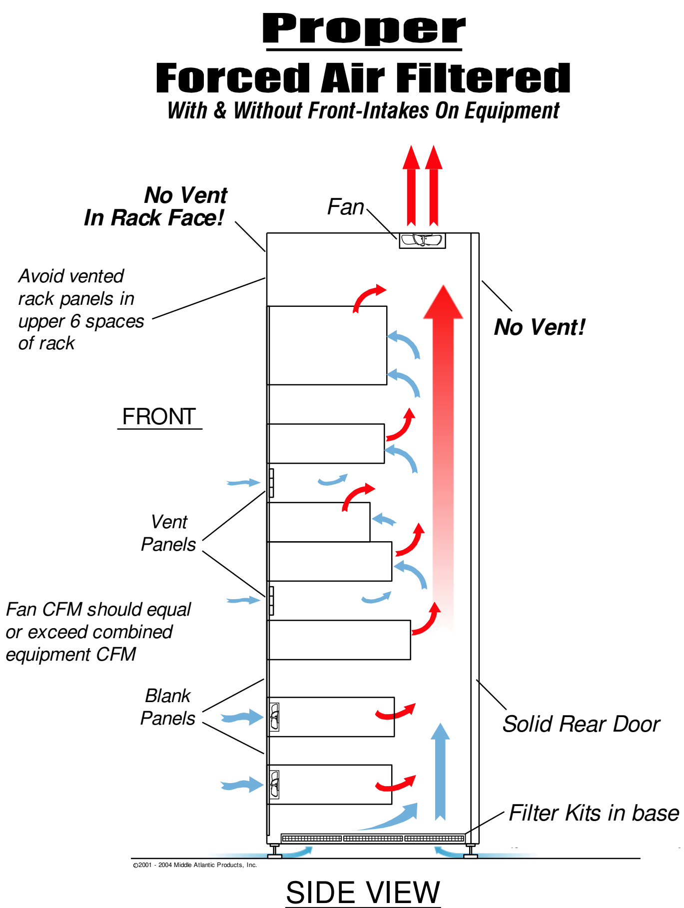
Filter loading and subsequent maintenance requirements can be greatly reduced with the use of a proportional speed thermostatic fan control circuit, since the overall volume of air is lower when not required.

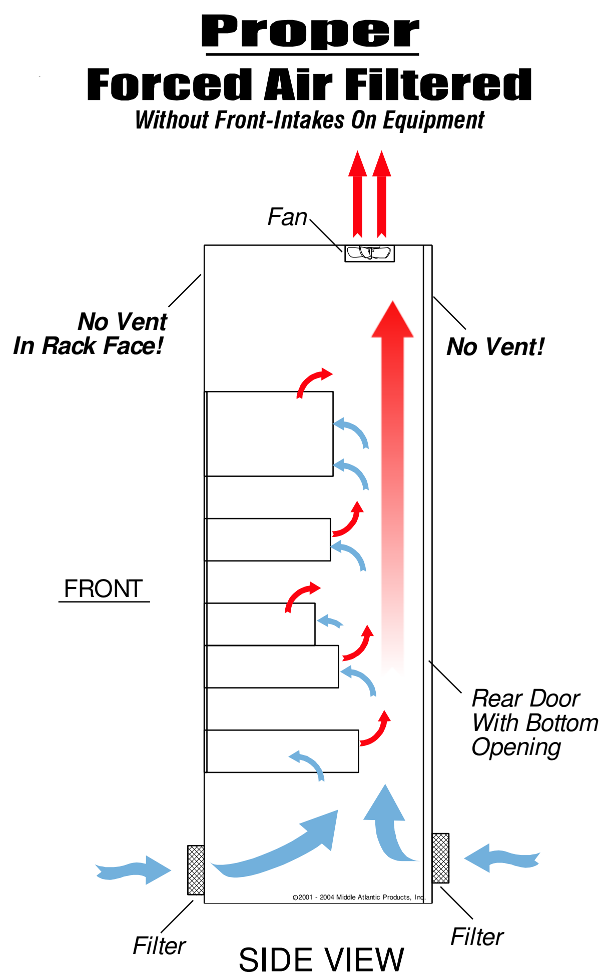
Good filters should have a long service life, low static pressure drop and should be washable. **Filters require maintenance or they will clog!** Filters that are extremely dirty act like blank panels, and will dangerously elevate rack temperatures. Do not use filters unless an effective maintenance process is in place.

A heat exchanger is a better solution for keeping contaminants out of the enclosure in very dusty environments or when maintenance is questionable.



Forced Air Filtered Simple Solutions

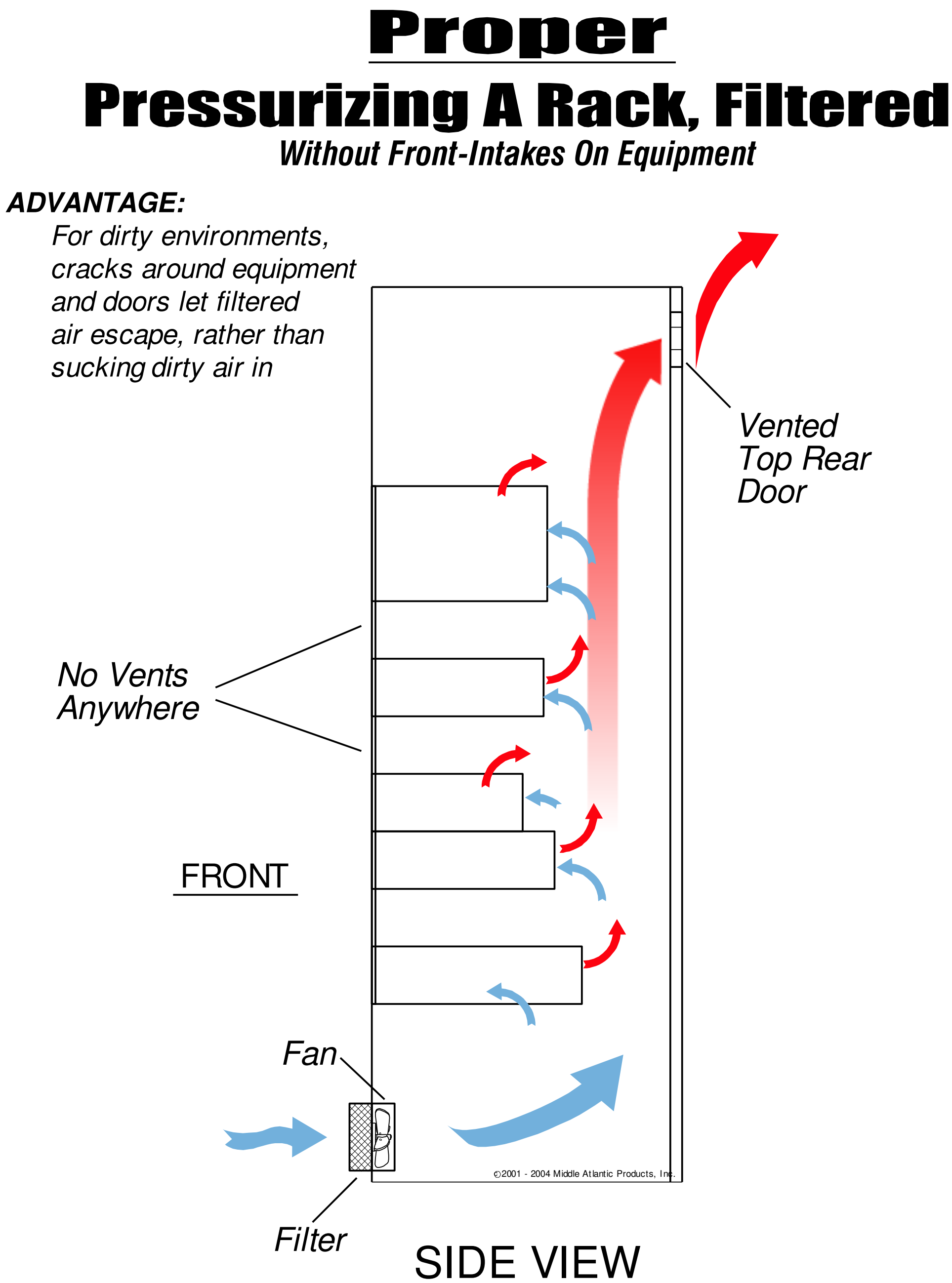




Pressurizing Racks

The best solution for dusty or dirty environments where filters will need to be changed regularly is to pressurize the rack, rather than sucking the air out of the top.

Although less thermally efficient, pressurizing guarantees that clean air escapes through cracks and openings, rather than allowing dirty air to enter.



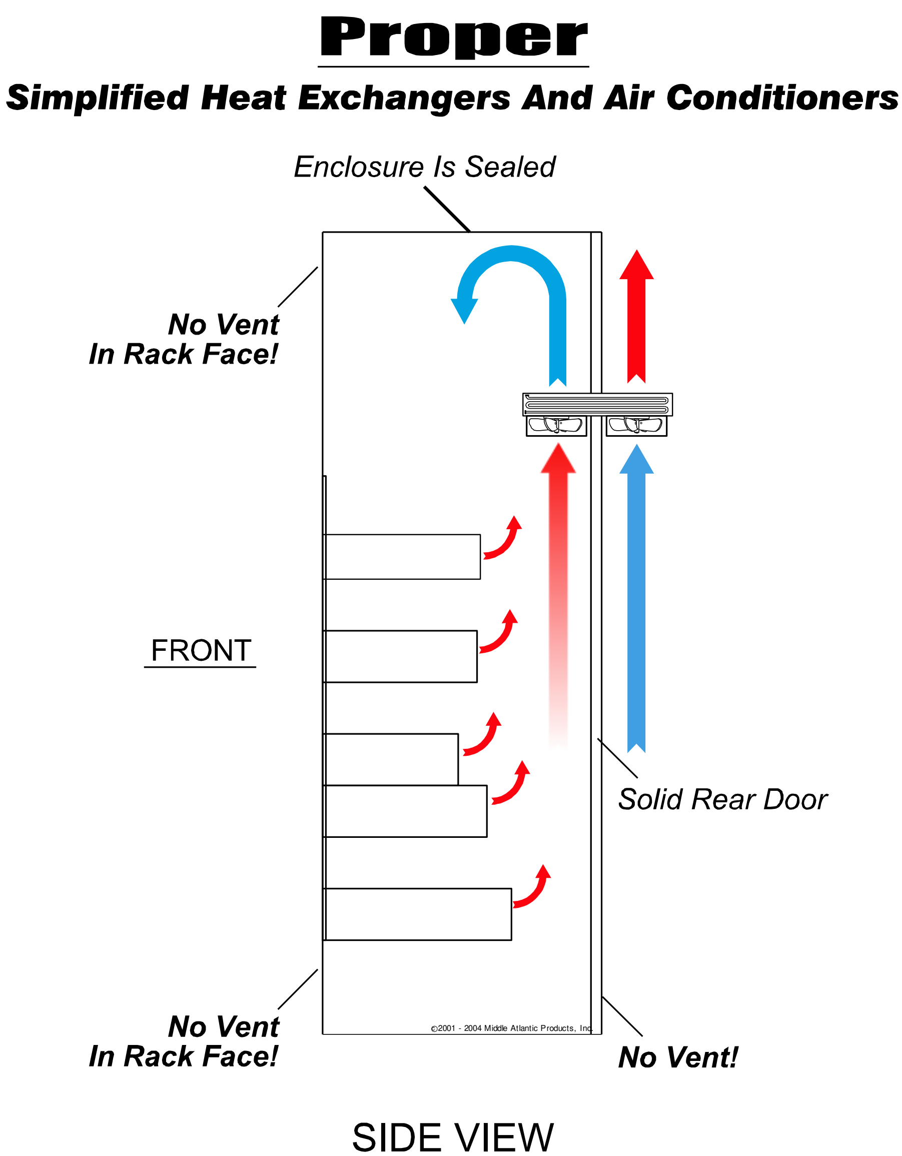
Heat Exchangers & Air Conditioning Units

In very harsh environments such as dirty factory floors, filters quickly become clogged and heat inside the rack builds rapidly. In these applications, NEMA (National Electrical Manufacturers Association) rated racks that are gasketed and sealed should be installed.

Heat exchangers and air conditioning units (mostly installed in NEMA rated racks) do not allow the ambient dirty air to mix with the enclosure interior air, which ensures that the interior rack air stays clean.

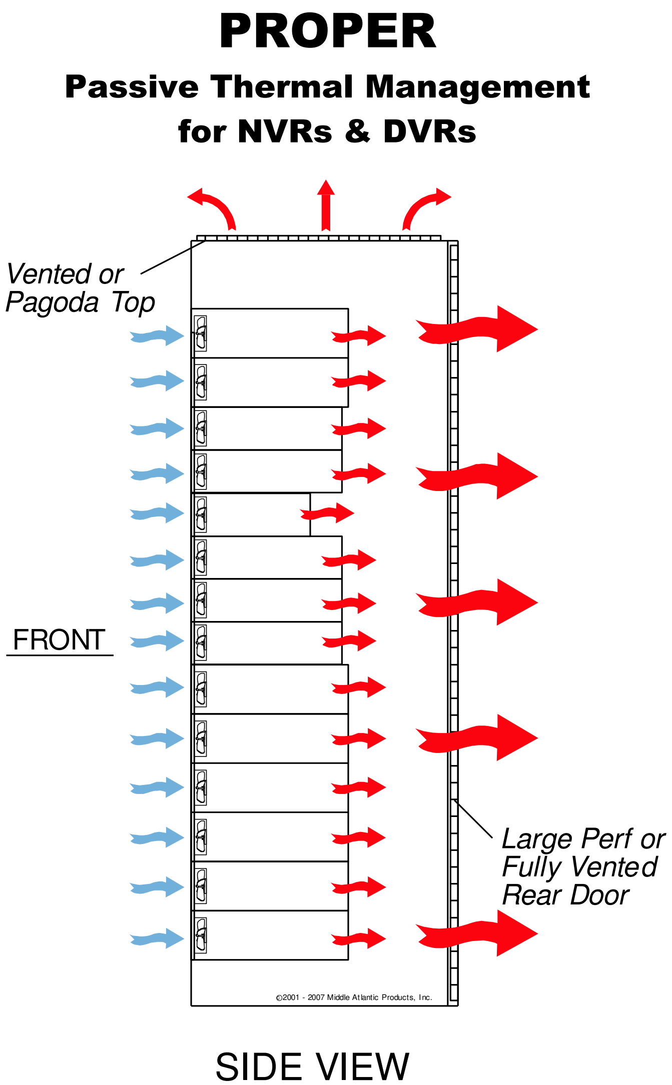
These devices (either water-coil or refrigerant-compressed) are also the only way to make the temperature inside the rack cooler than the ambient air. Care should be taken to avoid condensation when cooling the rack with an air conditioning unit. The dangers of condensation from cool air are overcome by ensuring the air temperature is above the dew point.

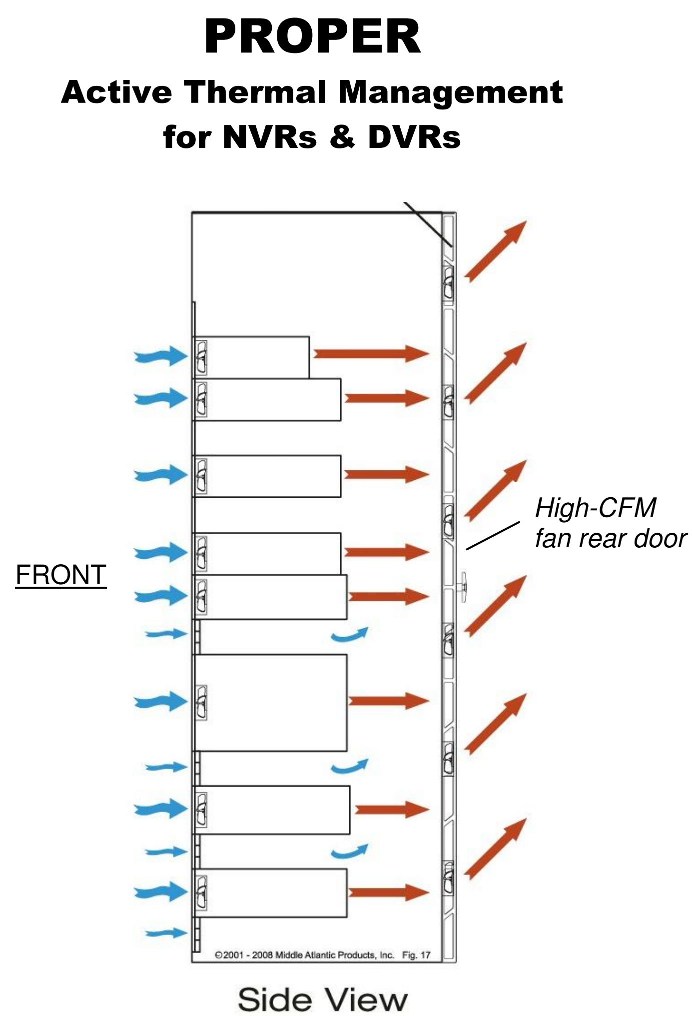
A good resource for heat exchangers can be found at: http://www.kooltronic.com



Planning for Thermal Management with NVRs & DVRs

The most common airflow found in most digital video recorders (DVRs), network video recorders (NVRs) and higher current draw equipment is that which pulls cooler air in from the front with the aid of front-intake fans, and exhausts the heated air towards the rear or sides (known in this paper as “front-intake” equipment). Effective thermal planning for NVR or DVR equipment cabinets involves the use of large perforated front & rear doors that ensure 64% minimum open area for adequate airflow into and out of the cabinet.



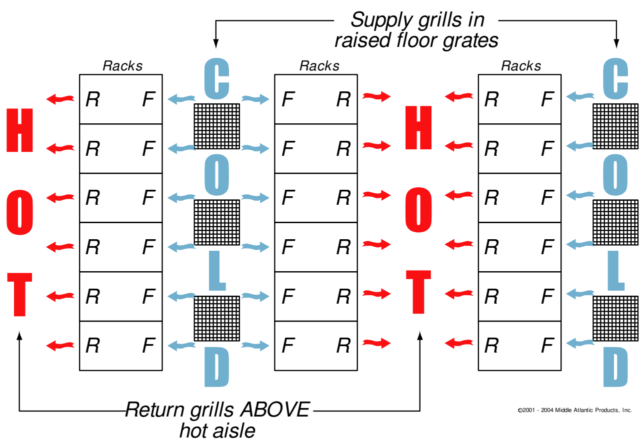


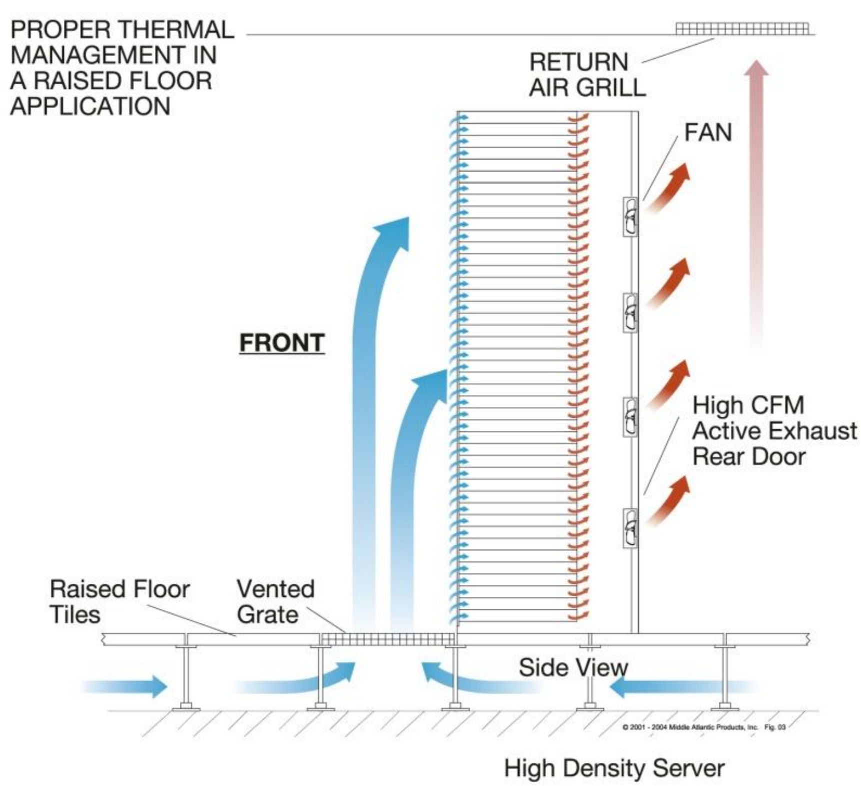
Raised Computer Room Floors

There are many strategies for introducing cool air into enclosures while on a raised computer floor. One provides an air outlet grate in front of the rack, and another is to have the air enter through the bottom of the rack. Both methods work well, as long as proper airflow is engineered into the system, ensuring adequate air is provided to the intakes of equipment. However, floor grates in front are recommended.

The downside to a totally perforated cabinet with cold air-cooling in a raised floor environment is uneven cooling and short-circuiting of airflow. If the air is too cold, condensation can occur, and energy costs for the facility will be high.

Most industry experts agree that the optimum layout for high heat density racks is an arrangement in rows of two, to produce hot and cold aisles. The fronts of the racks face each other in the cold aisle, with air grating down the center for cold air supply. The rear sides of the racks face each other in the hot aisles, with return grills overhead for optimum utilization of the air conditioning system.





How to Calculate Ventilation Required to Provide an Interior Rack Temperature of 85°F

This nomograph will show the minimum ventilation (active or passive) required, to provide an interior rack temperature of 85ºF.

Amplifiers vary greatly in waste heat output. This nomograph should be used ONLY when waste heat data is available from the amplifier manufacturer

To calculate total waste heat (column B):

1. Obtain total waste heat output by combining the published waste heat BTU/Hr. of all amplifiers in the rack.

2. Add up total measured amperage draw from all other equipment and multiply by 400 (total amperage x 400 = total BTU/Hr. @117v.)

Important Note: Nameplate ratings should at no time be used as a measure of equipment heat release. The purpose of a nameplate rating is solely to indicate the maximum power draw for safety regulatory approval.

3. Combine BTU/Hr. totals from steps 1 and 2 to obtain total for all equipment. Mark total in column B.

To obtain minimum ventilation requirements:

1. Mark ambient room temperature in column C, and connect points in B and C with a straight-edge.

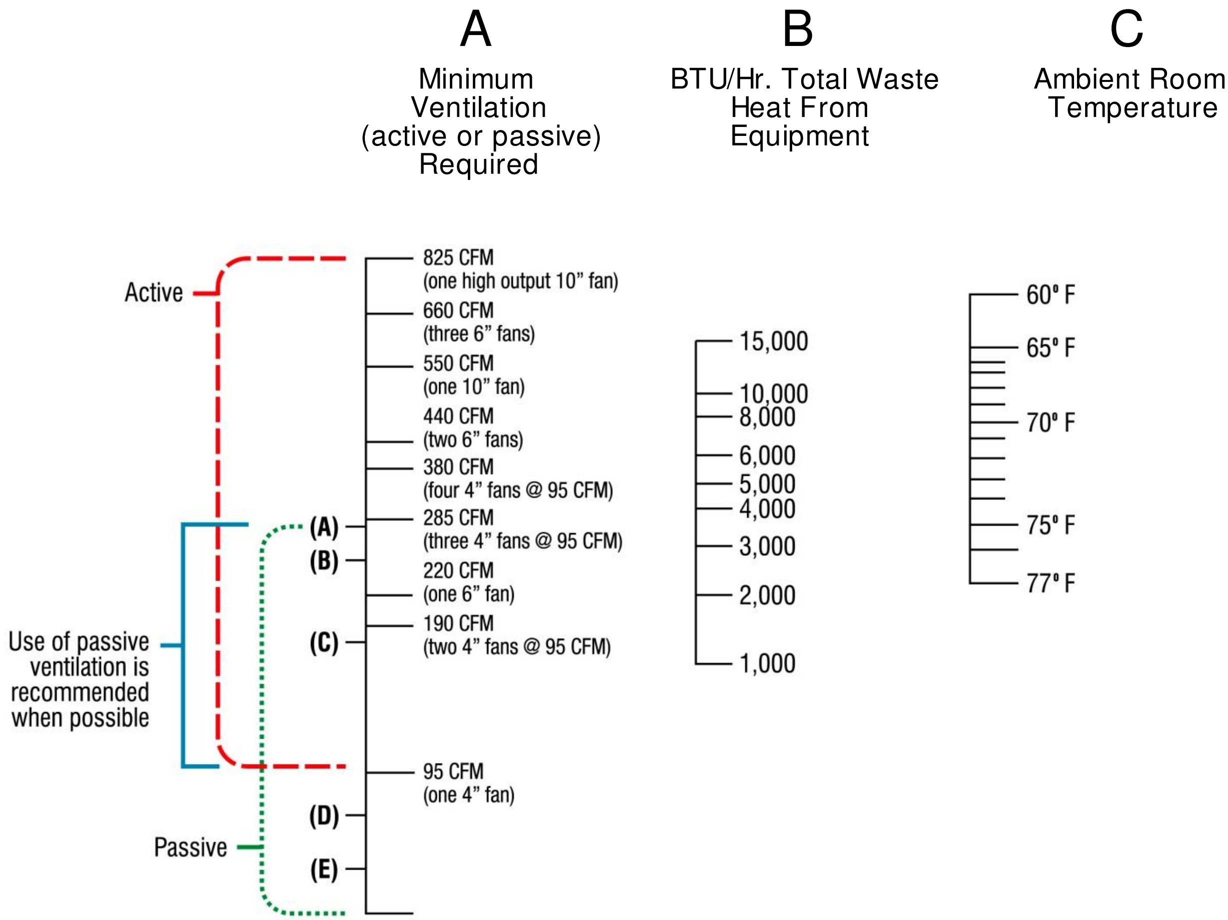
2. The minimum cooling required providing an interior rack temperature of 85ºF will be shown on column A, where the straightedge intersects the minimum cooling requirements column.

System Requirements:

1. For passive and active ventilation, ensure adequate intake vents are installed
2. Be certain no “short-circuiting” of air occurs (See earlier diagrams)

NOMOGRAPH

Calculate ventilation required to provide an interior rack temperature of 85° F



PASSIVE VENTILATION REQUIREMENTS

(A) - Fully vented rear door, vented rack top, in vented-face rack

(B) - Fully vented rear door, vented rack top, in solid-face rack

(C) - Solid rear door, vented rack top, in vented-face rack

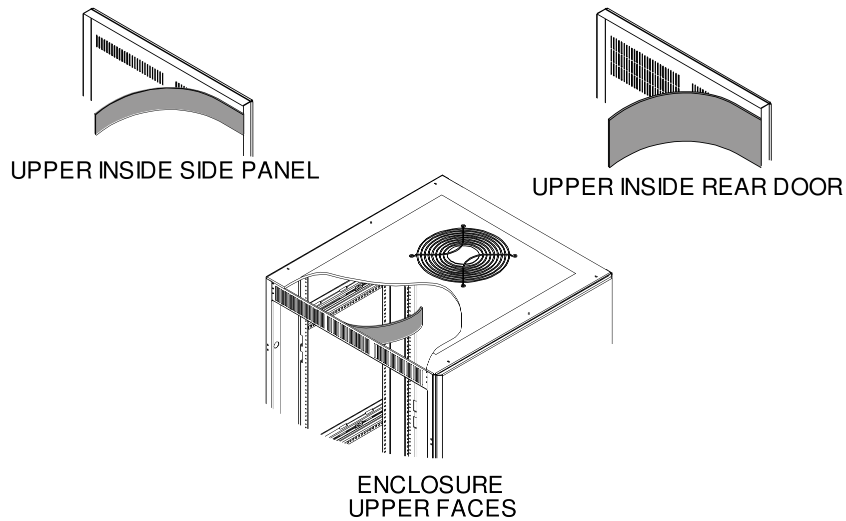
(D) - Solid rear door, 4 space vent in upper rackspace, solid top

(E) - Solid rear door, 2 space vent in upper rackspace, solid top

Thermal Solutions

Careful placement of vent blockers, as part of your proper thermal management planning, will prevent the short-circuiting of airflow in rack enclosures. Magnetized on one side only to eliminate stray magnetic fields, vent blockers will ensure that heated enclosure air will be forced out through top-mounted exhaust fans.

Vent Blockers



High CFM Rear Doors

High-CFM cupboard style split rear doors pull hot air from the rear of the cabinet and direct it up towards return air ducts.

Fan Tray Systems

Rackmount fan tray systems allow the placement of fans directly above vents on equipment to help remove hot air, or to promote vertical airflow in the rear of racks.

Future Planning

The design of racks and thermal loading should take into account future expansion & changes. As stated earlier, the room needs to exhaust all the heat produced by the equipment, so it is important that the facility be able to handle future expansion.

Blanking panels should be installed in all unused rack and cabinet spaces to maximize and improve the functionality of the controlled air system. Vented panels should be added to the front cabinet rails, if properly oriented (per diagrams contained within this document), thereby preventing the recirculation of hot air to the equipment inlet.

Many times when equipment is added to a rack, the effective thermal design is compromised. Care should be taken to identify and correct these if the interior rack temperature exceeds 85°F.

On some rack tops, laser knockouts are provided if additional fans are necessary once all equipment has been installed.

****Troubleshooting Tip****

In some cases where airflow is inadequate, equipment fails. A quick, short-term fix can sometimes be achieved by opening the rear door, placing a floor fan facing the rear and cooling out the rack. This should never be used as a long-term fix, but it may keep heat-sensitive equipment working while a replacement is obtained.

Standards

Some current standards relating to thermal management, heat release, and temperature requirements are found in the NEBS (Network Equipment Building Standards) series.

Telcordia GR-63-CORE had been found to be unclear in many respects, so a new standard was released, GR-3028-CORE (Thermal management in telecommunications central offices). This includes the results of advanced computer modeling techniques for thermal management. Currently, Telcordia is revising this document to meet current industry requirements.

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