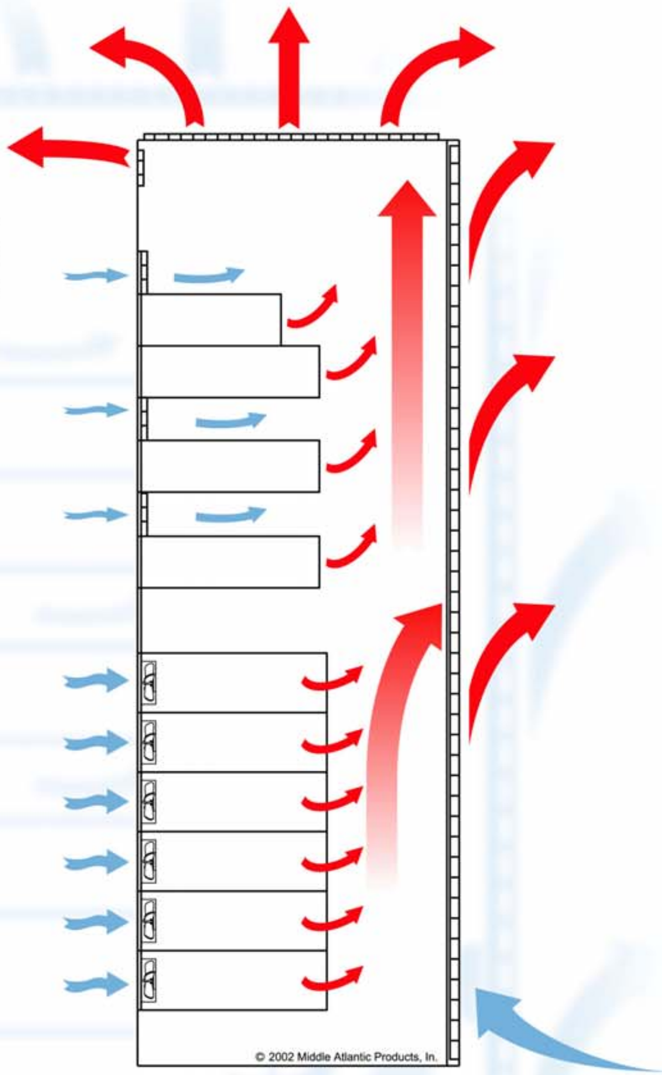
CONTROLLING THE TEMPERATURE INSIDE EQUIPMENT RACKS



WRITTEN BY:
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Middle Atlantic Products, Inc.

Controlling the Temperature Inside Equipment Racks

Maintaining the temperature inside racks is **critical** to the proper functioning and survival of the circuits operating within it. The best way to control this temperature is to take a system (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.

Objective

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's), 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's - 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

HVAC - Heating, ventilation, air-conditioning

Thermal System

There are two airflows involved in this thermal system; one is how the heat travels through the rack, and the other is how the air moves throughout the room. The interactions between these two 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. We want to be sure 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's 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.

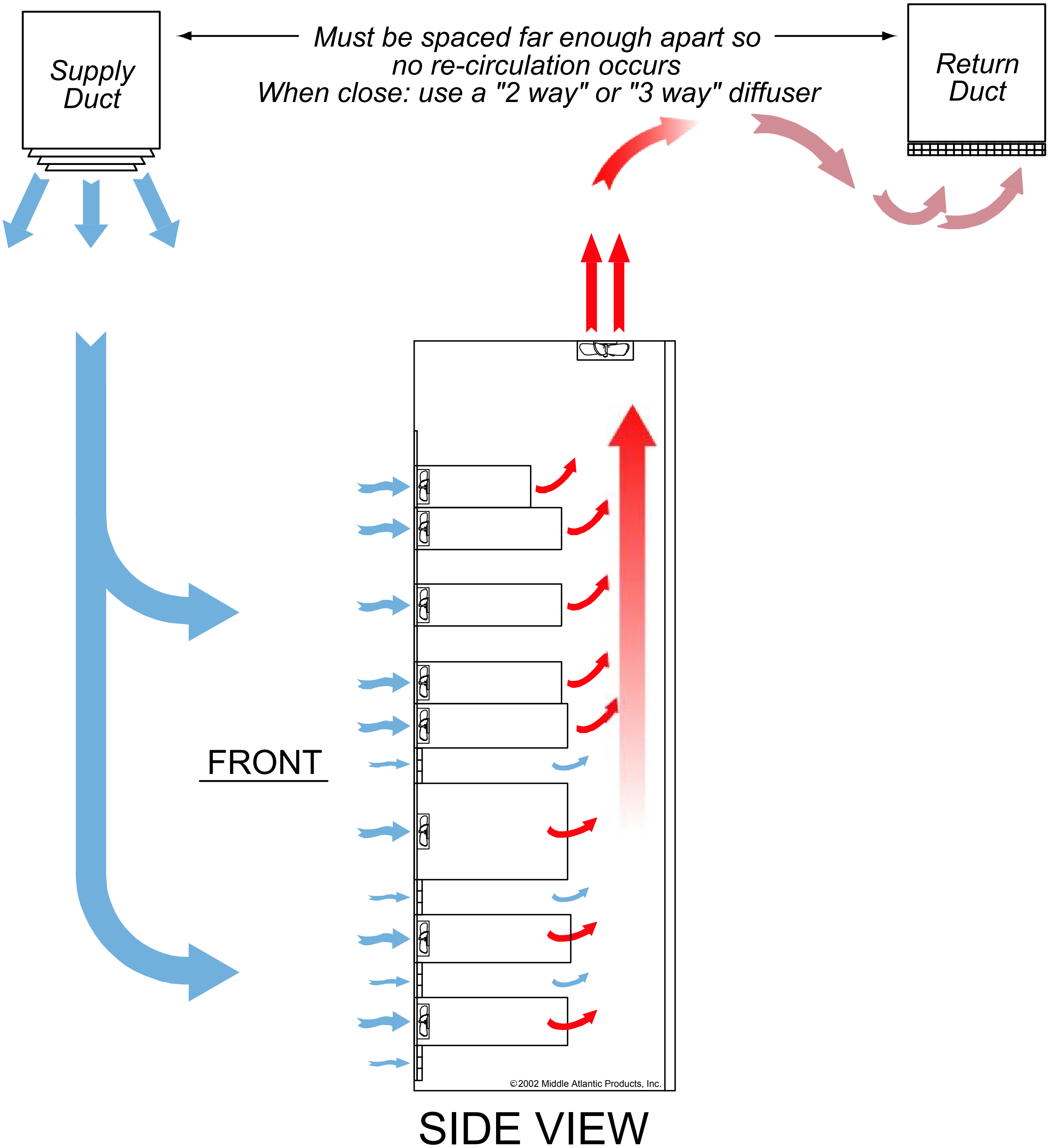
In environments where companies have equipment in racks housed in closets, fan noise is often not welcome. Ambient temperature can be higher in closets, and heat should be exhausted out if the ambient air inside the closet exceeds 75°F. In the case of a single rack in a closet, it is important to use a fully louvered closet door and monitor the temperature when there is no air conditioning feeding the closet.

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" made possible by the spacious sides of mounted equipment draws heat upward effectively.

Middle Atlantic Products offers a solution to achieving a chimney effect in its DRK Series cable management enclosure. These enclosures feature a 30" wide footprint, leaving ample room on either side of 19", 23" or 24" panel width front air-intake equipment. In addition, the Middle Atlantic Products WRK Series rack enclosure's wide design makes it ideally suited for achieving a chimney effect, and may be ganged together for multi-bay installations, or used stand alone (WRK-SA rack enclosures).

In forced-air applications, a narrower cabinet such as an MRK gangable rack enclosure can be selected to save space. The narrow 22" width of the MRK is especially important in larger multi-bay installations where space is at a premium. There are no exposed sides on racks in the middle of a multi-bay installation; therefore the only way to introduce air is through the face or rear. 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.

Many enclosure manufacturers do not take proper thermal engineering into consideration, so care should be given to the selection process.

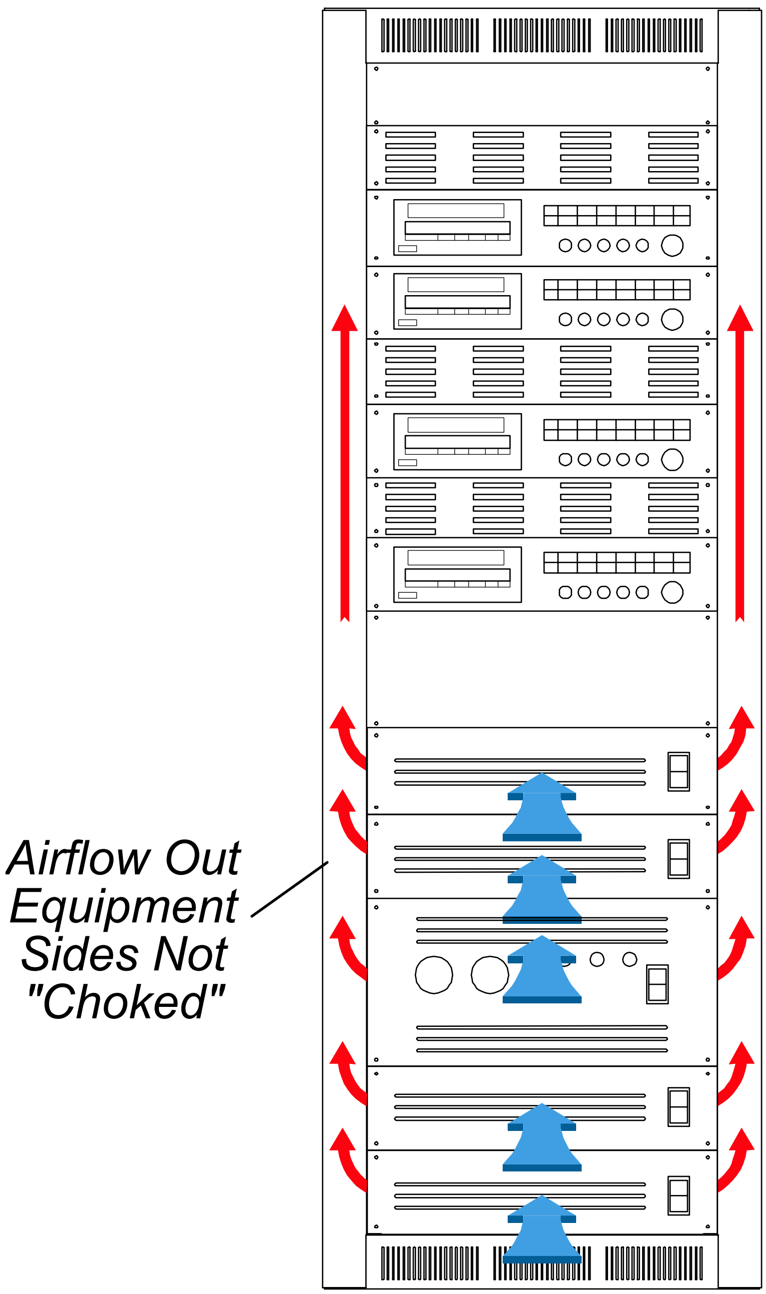
Its wide footprint makes a DRK Series enclosure ideal for achieving a chimney effect

The wide design of WRK Series enclosures additionally facilitate a chimney effect

Proper

"WIDER IS BETTER"

For The Side Chimney Effect On Front-Intake Equipment



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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 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 these clocks increases, the heat continues to rise. Couple that with the continuing miniaturization of electronics, and you can quickly see that the trend is for more and more heat to be generated per rackspace of equipment. This is also known as increased heat density.

Many data centers now have 1-space servers filling the racks, which generate a considerable amount of heat.

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.

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

100% of the power consumed by communications equipment and computer products is converted to heat.

Calculating BTU/Hr. output for equipment **other than amplifiers** 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.

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. This paper includes a chart to quickly obtain average BTU/Hr. values common for most amplifiers.

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 will be derived with that information.

This chart represents a typical amplifier thermal waste heat 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 following is typical of an amplifier manufacturer's information sheet:

"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.

The most common airflow found in higher current draw 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).

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

There are still a considerable number of 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.

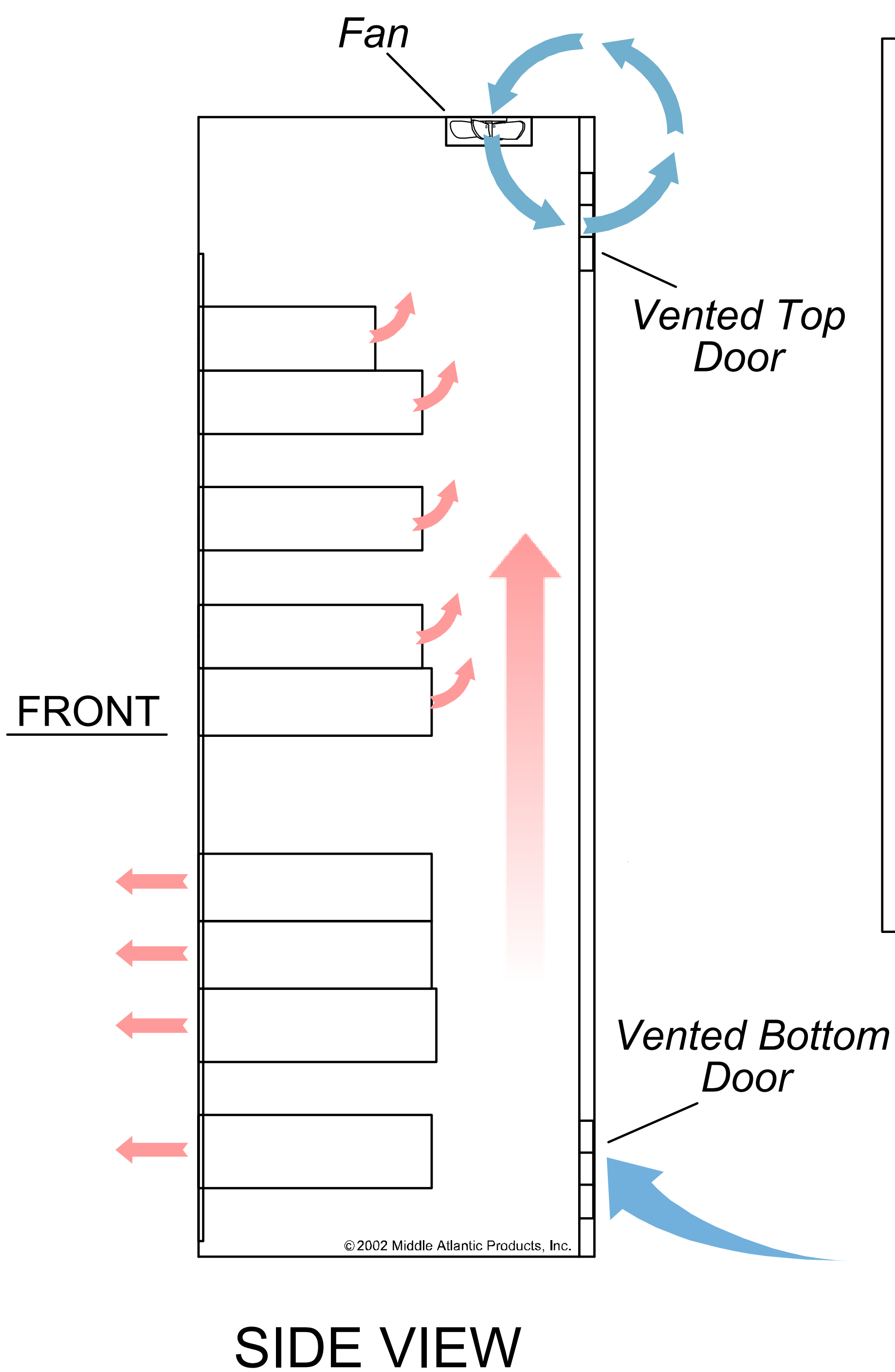
Downward airflows are a bad idea, creating “mixed convection” (mixture of forced air and convection) during operation and in the event of fan failure.

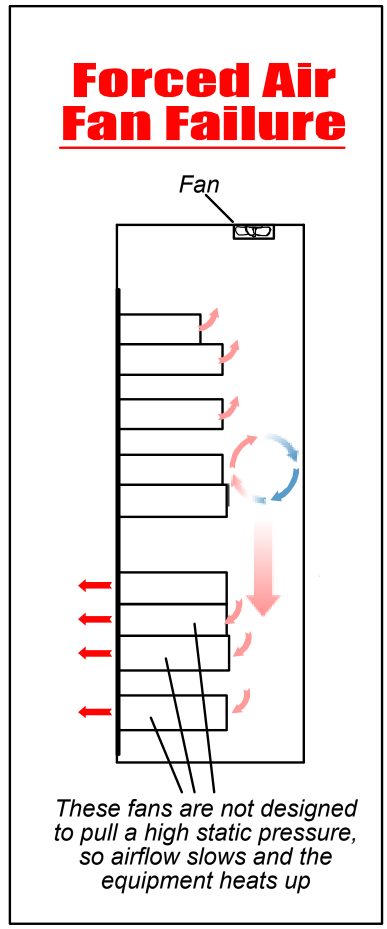
Most other non-amplifier equipment that has internal fans will draw air in through the rear (or sides), and exhaust out the sides (or rear). This re-circulates the cabinet air and care should be taken as to its placement so the natural convective rise of heat is not disturbed.

WRONG!

Forced Air

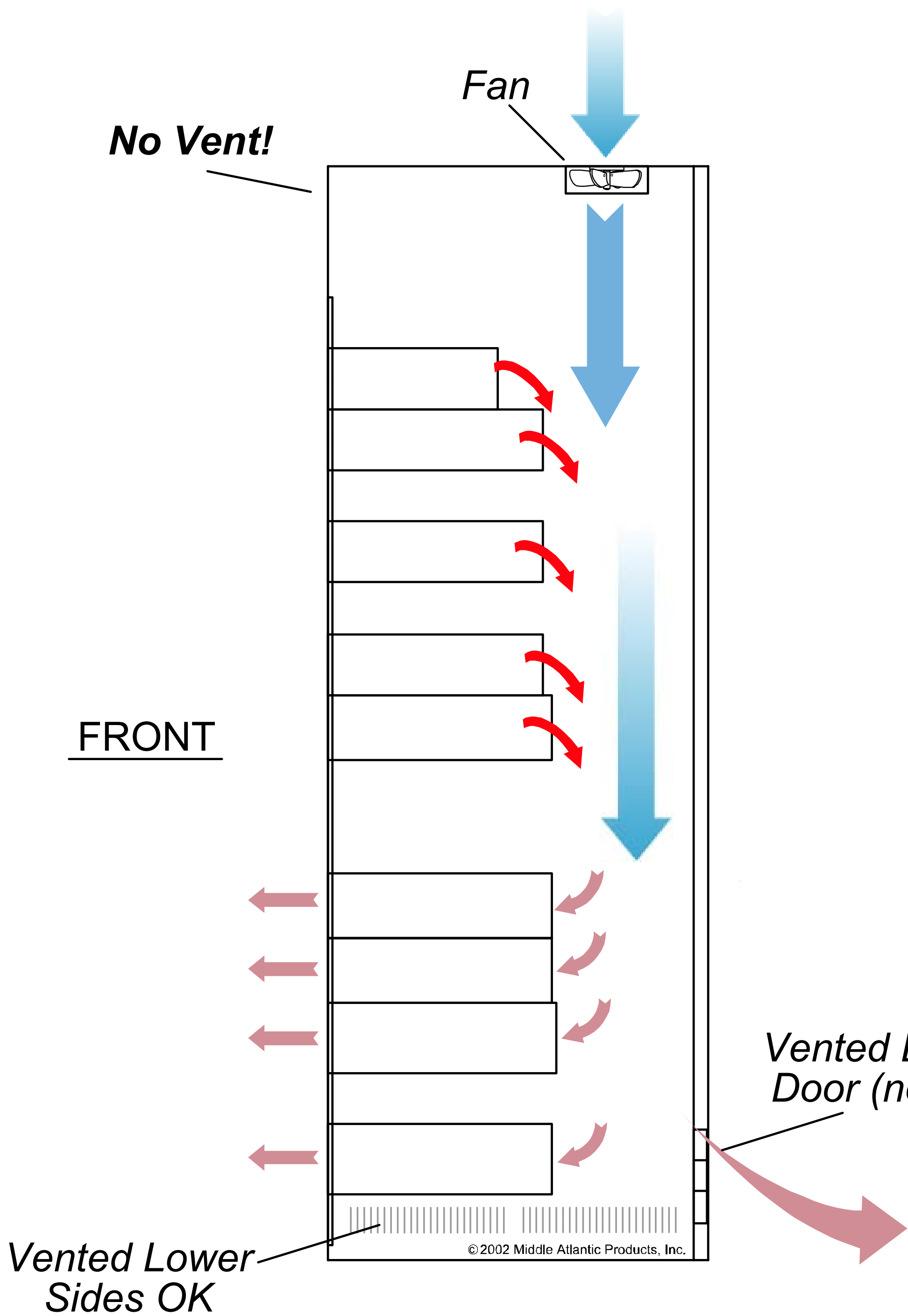
With Rear Equipment Fan Intake





Proper Forced Air

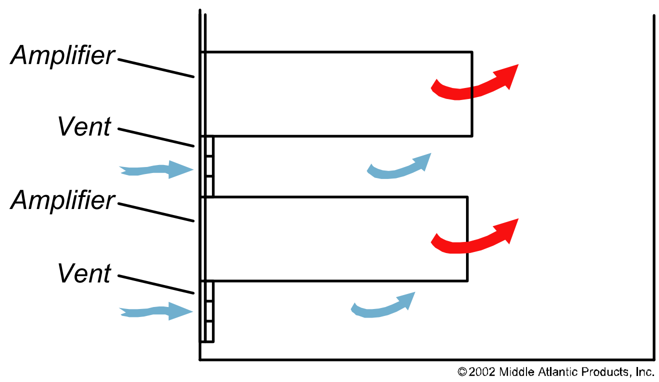
With Rear Equipment Fan Intake



SIDE VIEW

Hot air rises. 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.

Proper
Placement Of Vents
When Amplifiers Are Not Fan Cooled



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

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 unit (none in the middle for effective "chimney" flow), and an unimpeded airflow inside the rack.

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, 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, the better. Choose racks that have vents built into the top face for optimum performance, and ensure that a fully vented top has been installed

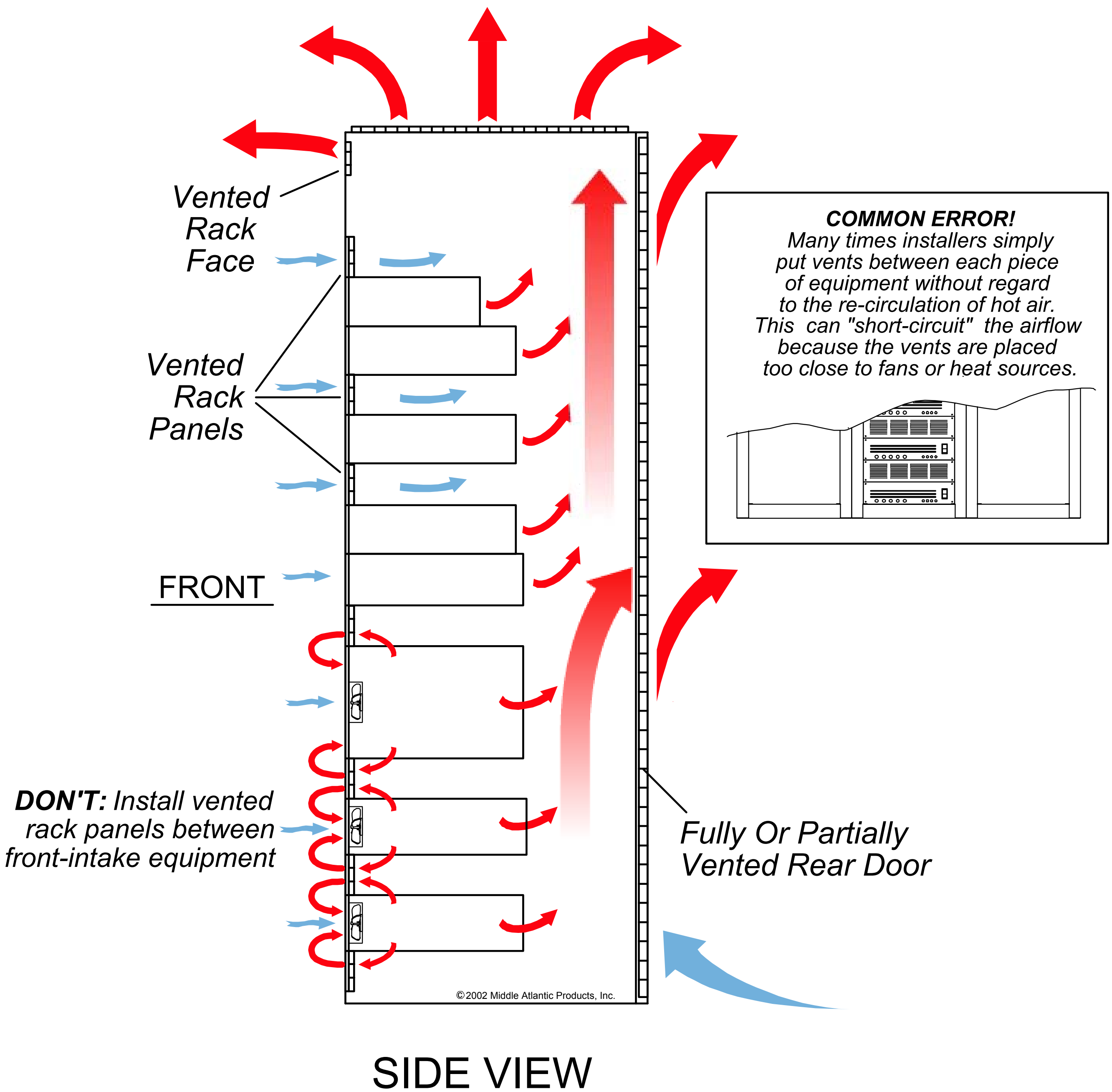
Installing a vented rear door in a passive cooling scenario is not necessarily required; this is dependant on the total BTU/Hr. produced within the rack. For clarification, consult the nomograph at the end of this paper.

See page 47 for recommended products from Middle Atlantic Products to achieve Passive Convection.

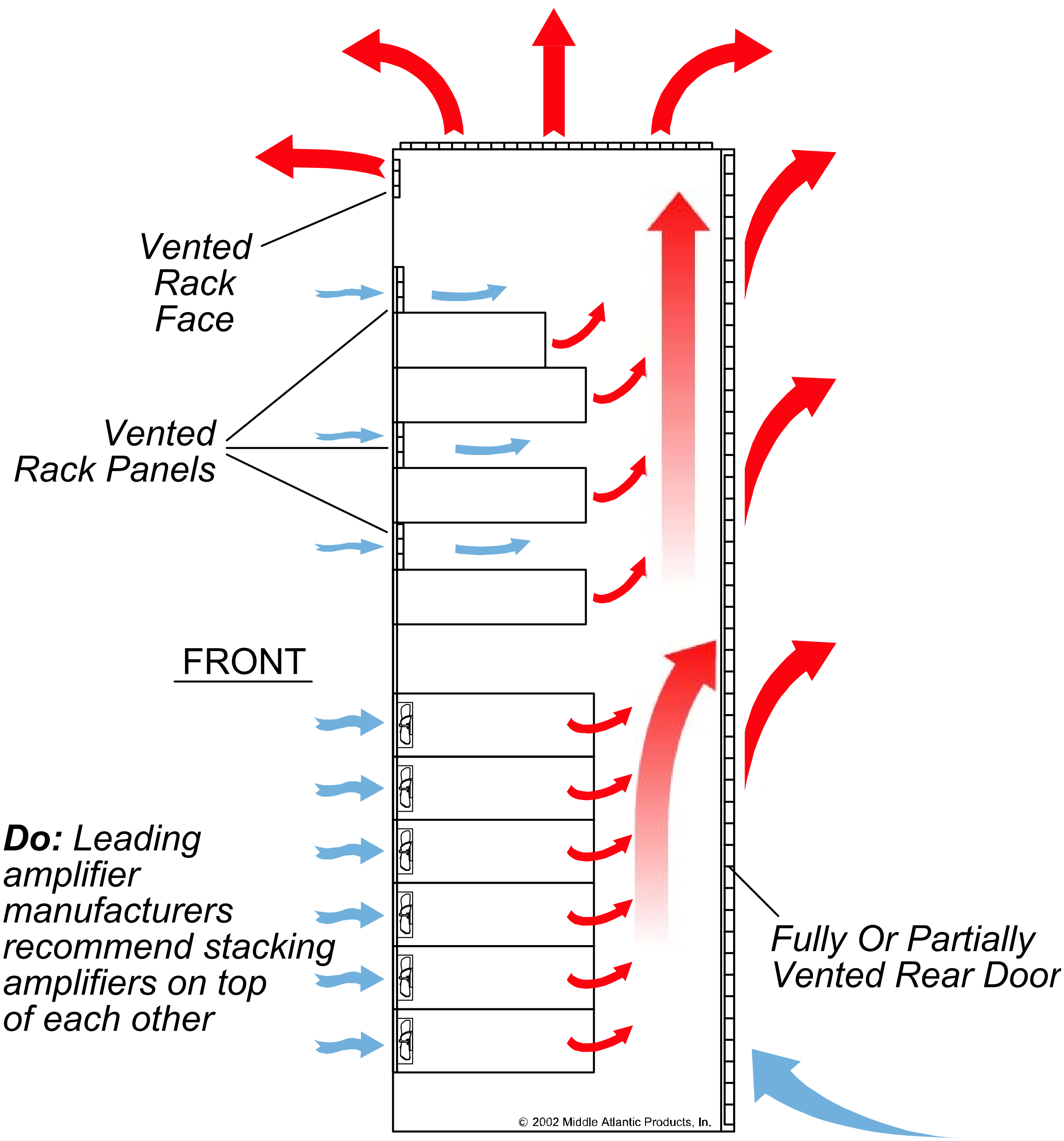
WRONG!

Passive Convection

With Front-Intake On Equipment



Proper
Passive Convection
With Front-Intakes On Equipment



SIDE VIEW

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Planning Airflow: Forced Air (Active Thermal Management)

In certain cases when there are too many BTU/Hr. for natural convection to properly perform this task, 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 (fans) 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. 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.

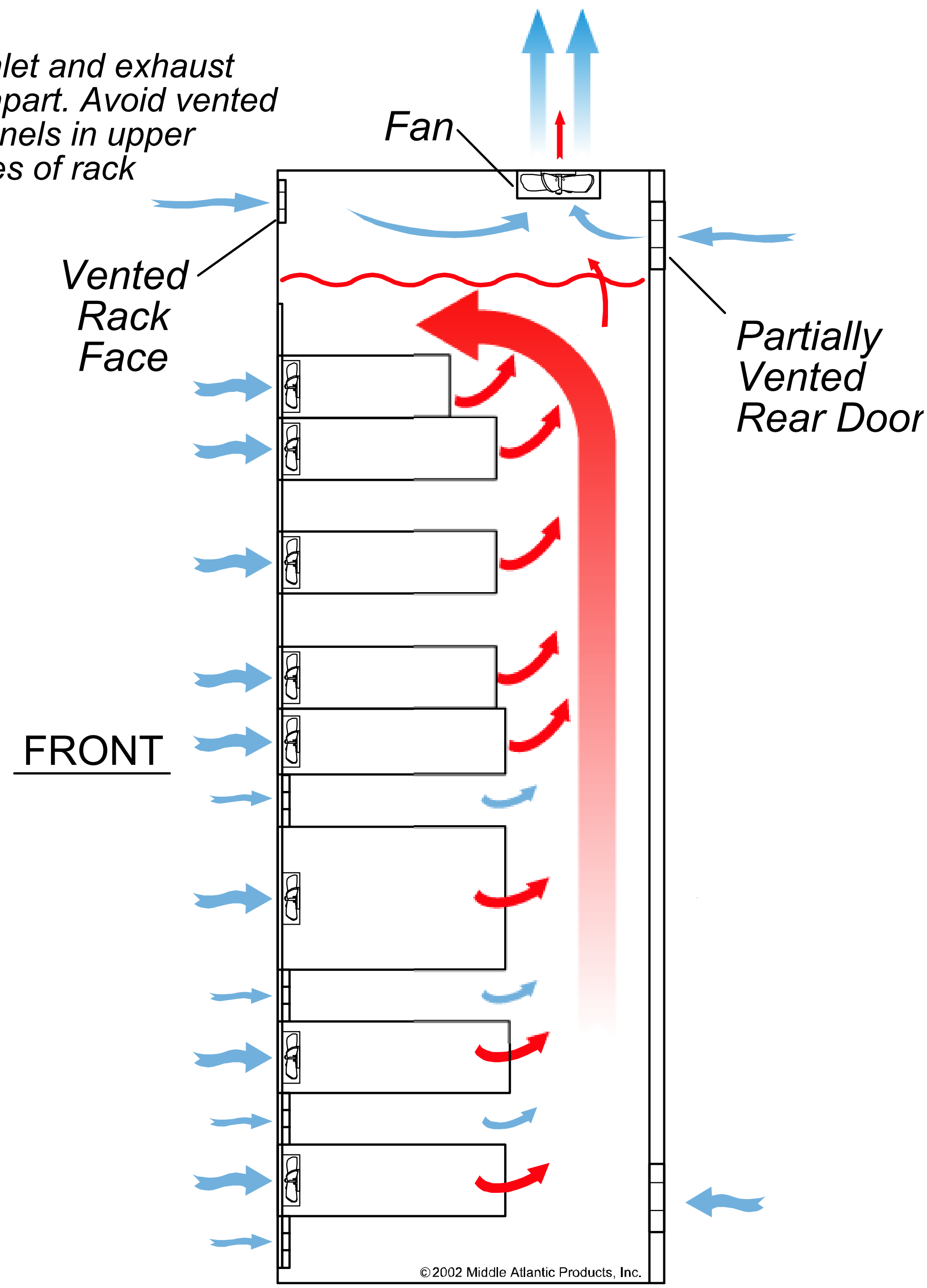
See page 47 for recommended products from Middle Atlantic Products to achieve Active Thermal Management.

WRONG!

Forced Air

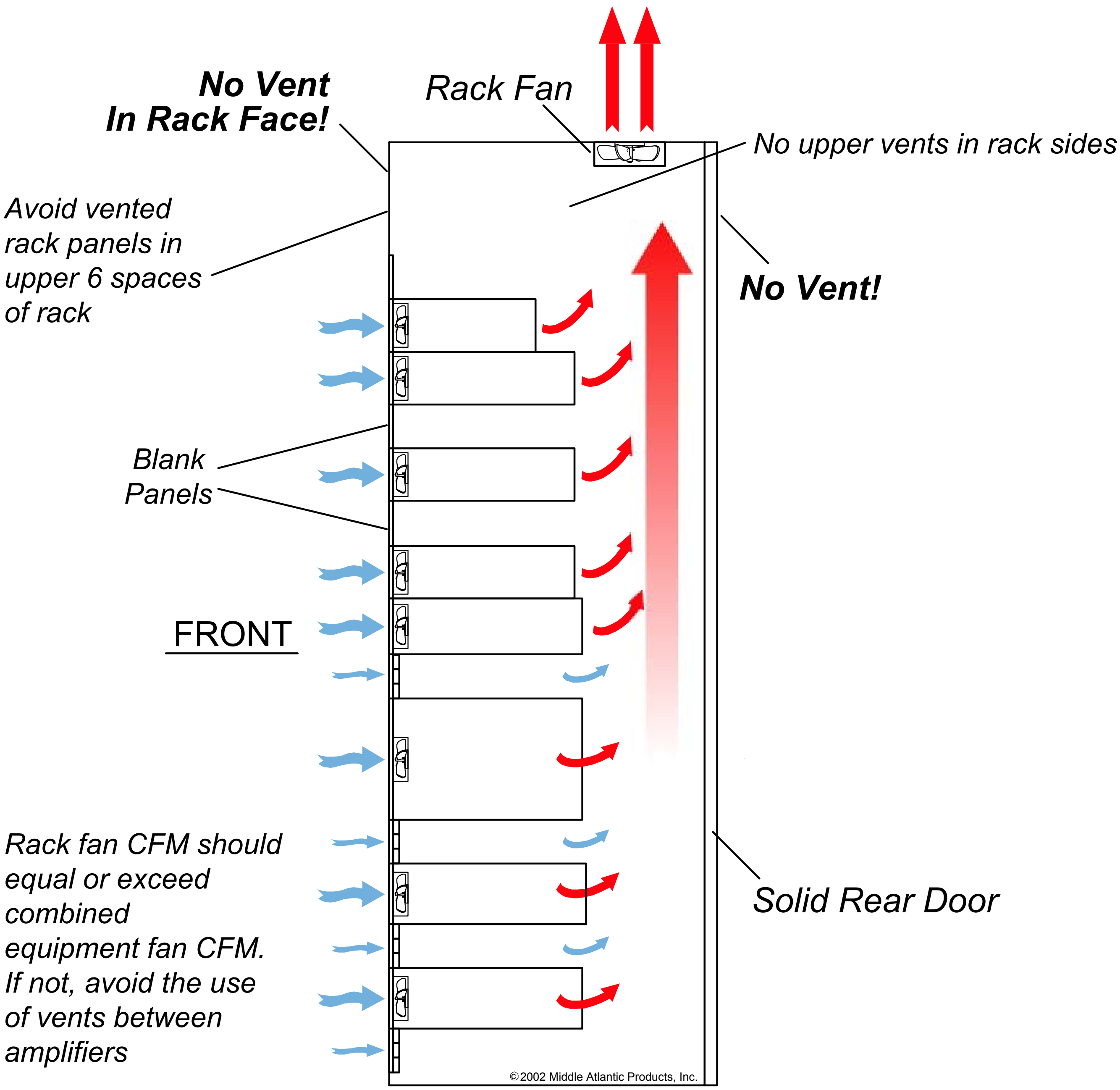
With Front-Intakes On Equipment

THE FIX:
Keep inlet and exhaust air far apart. Avoid vented rack panels in upper 6 spaces of rack



SIDE VIEW

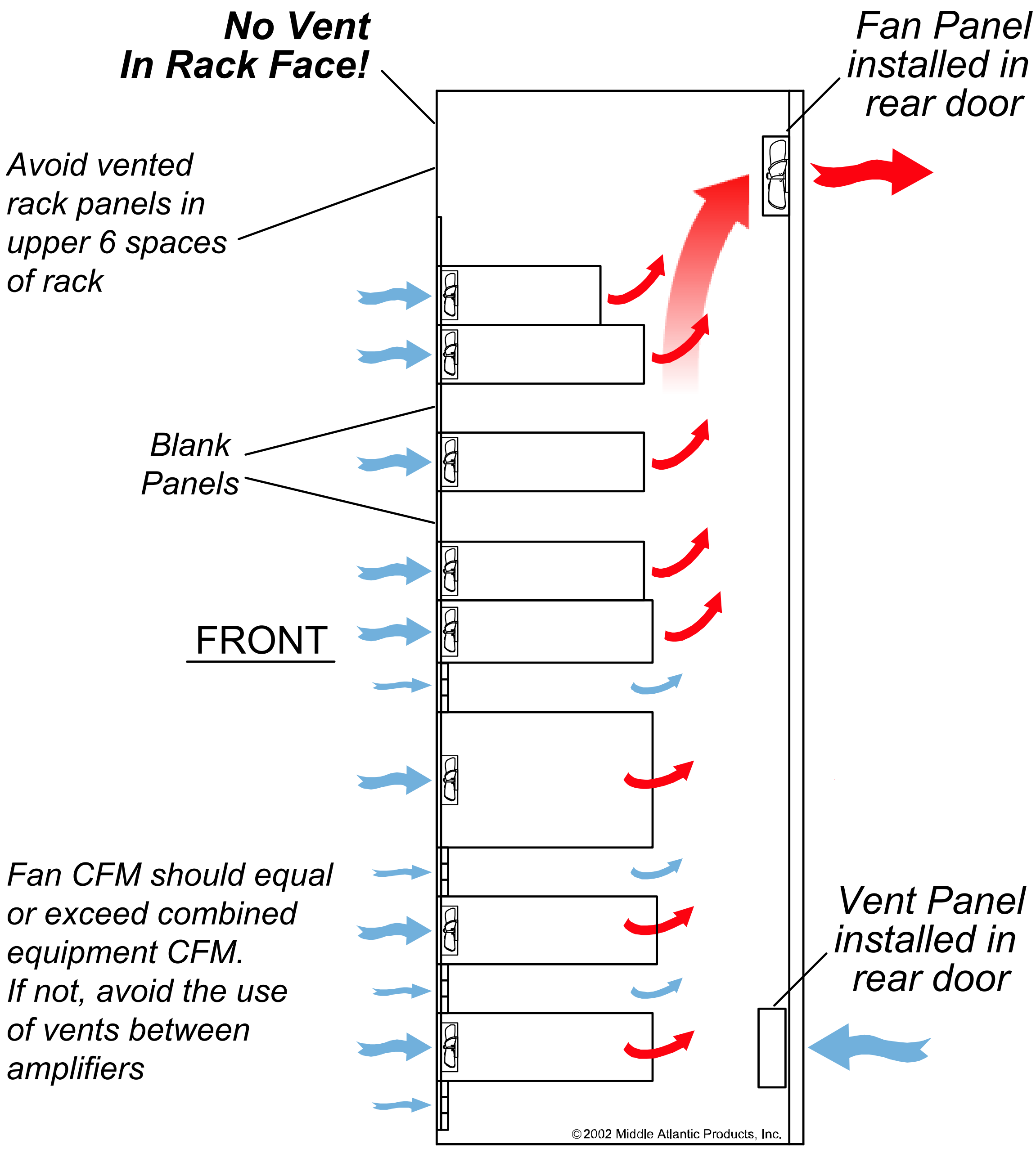
Proper
Forced Air
With Front-Intakes On Equipment



SIDE VIEW

Proper Forced Air

With Fans Mounted in Rear Door

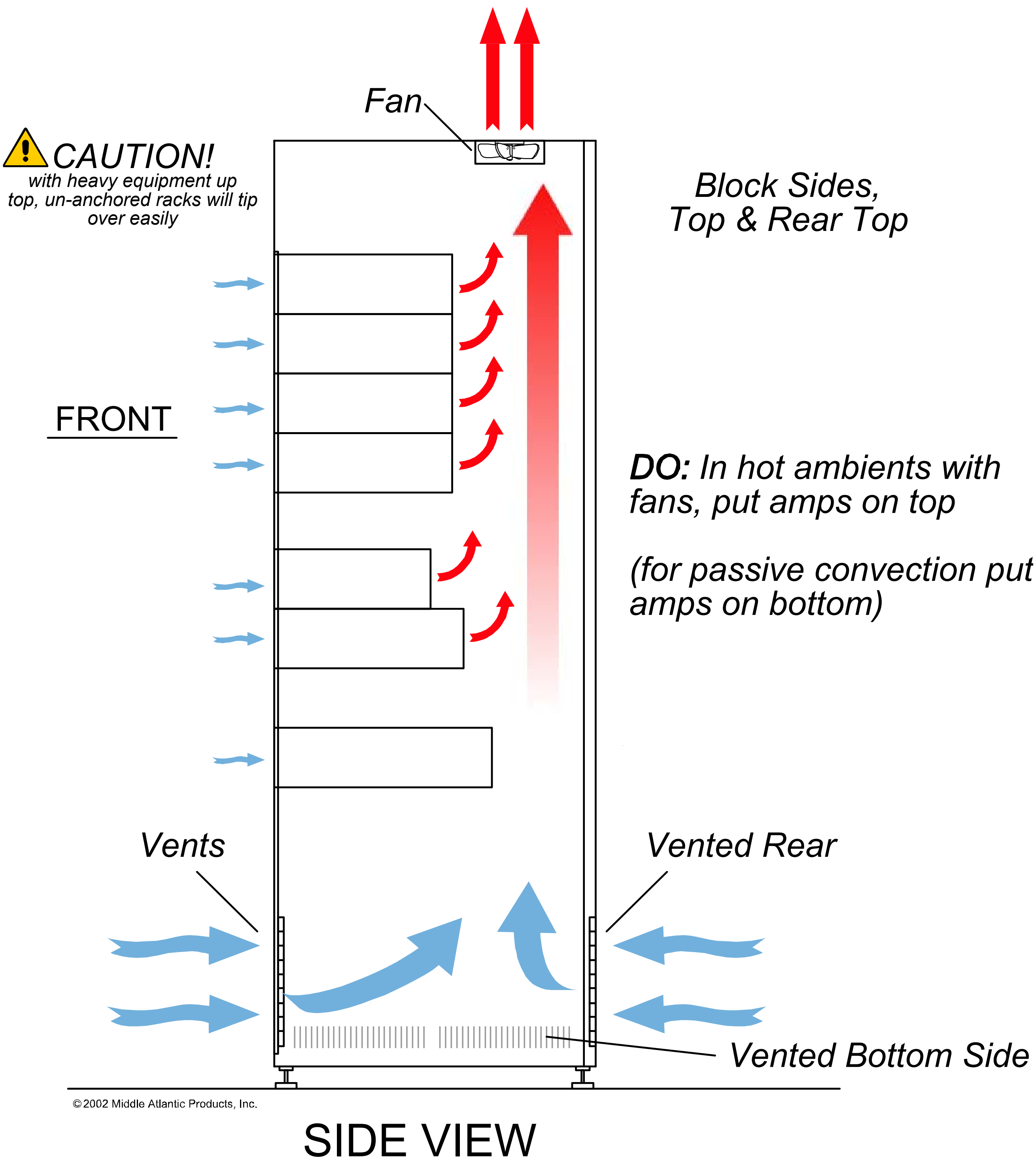


SIDE VIEW

Proper

Forced Air

Amplifier Placement In Hot Ambients With Fans



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 68% 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 (Middle Atlantic Products model FAN)
4. 10" fans deliver 550 CFM (Middle Atlantic Products model FAN10)
5. H10" (High-output) fans deliver 825 CFM (Middle Atlantic Products model BMF-FAN10)

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	10"	6 spaces
1	H10"	8 spaces

If the rack has a vented rear door (Bottom-only is proper 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 must not be less than specified in the above chart.

Middle Atlantic Products FAN10

Middle Atlantic Products FAN

Vented Shelves

Shelves are an important component of the 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.

Middle Atlantic Products U317 Vented rackshelf

Forced Air (Fans)

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

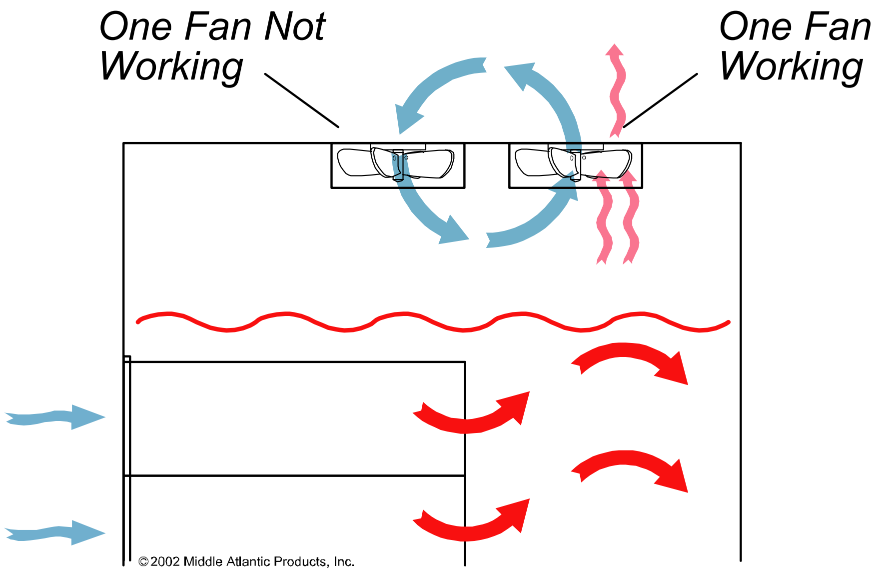
Fans however, add little value over good convection designs if air "short-circuiting" occurs from having intake points close to the fan (See diagram on next page).

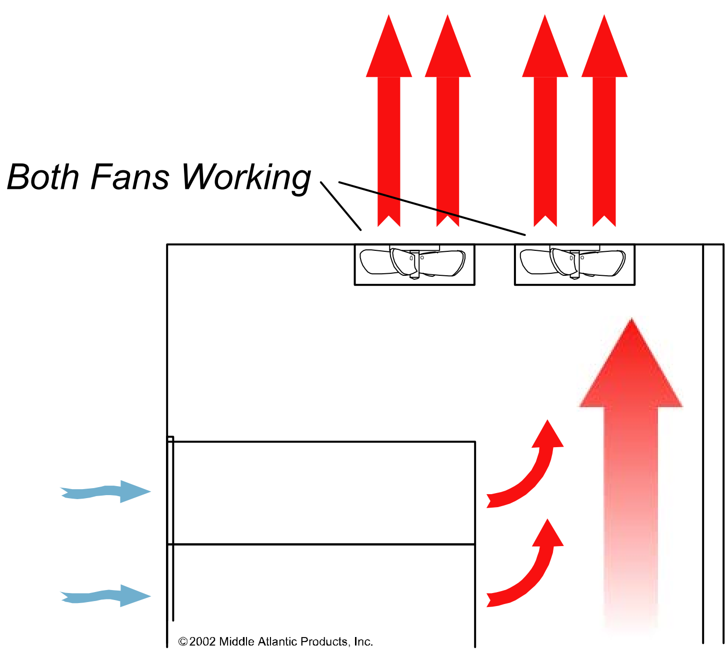
Venting in the wrong locations can also cause "hot spots", where air does not flow. Proper fan/vent placement will force more air "disturbance" inside of a rack, breaking up these hot spots. Additionally, fans help reduce condensation in colder ambients. Condensation increases equipment downtime.

The ideal spot for fan placement (in clean environments) 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 are installed in difficult situations as the only 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 circuit.**

The Middle Atlantic Products FC Series Progressive Thermostatic Fan Control extends equipment life and reduces 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 FC Series' innovative design allows control of up to four 120-volt fans and is available to mount in Middle Atlantic Products' MPR modular power raceway system or as a stand-alone module.

Simply put, 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.

FC Series Proportional speed thermostatic fan control units extend fan life and are available to mount within an MPR Modular Power Raceway System or can be used as a stand-alone unit.

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 (68% 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 68% 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, 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.

Static Pressure

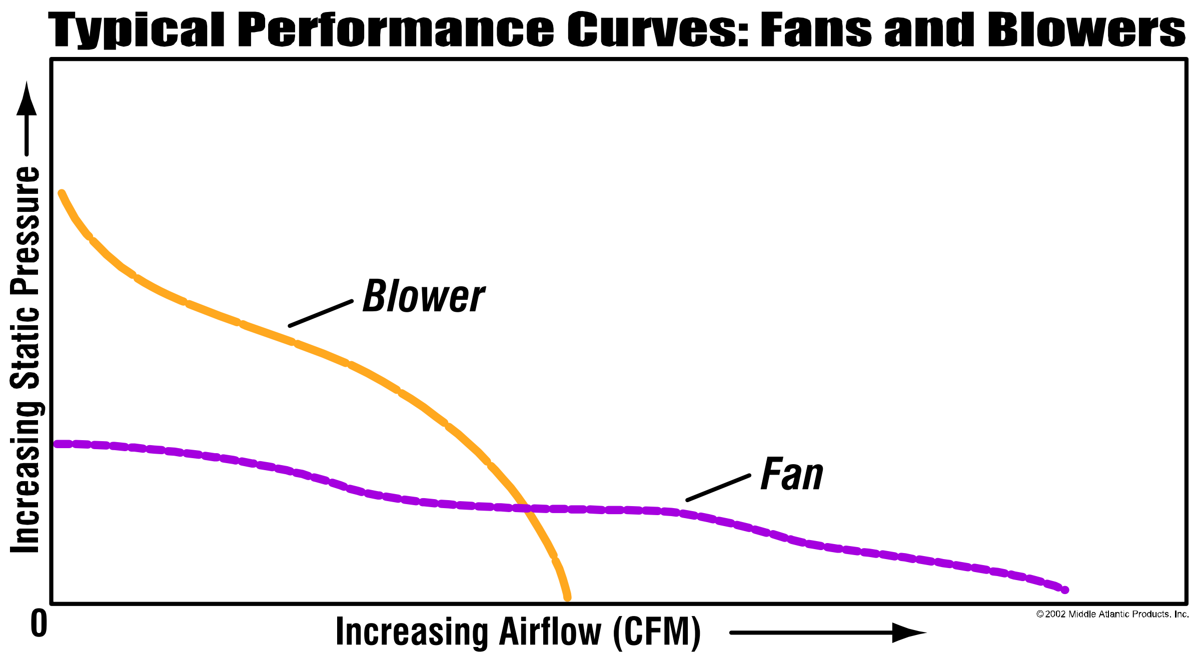
Two terms are used to describe fan performance: Airflow Rate and Static Pressure. Airflow rate is the volume of air moved per unit of time, commonly expressed as cubic feet of air per minute (CFM). Static pressure (S.P.) is the pressure or suction the fan is capable of developing. In a rack, it is the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

All fans have performance curves, which show how many CFM's 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.


Typical Performance Curves: Fans and Blowers
Increasing Static Pressure
Blower
Fan
0
Increasing Airflow (CFM)
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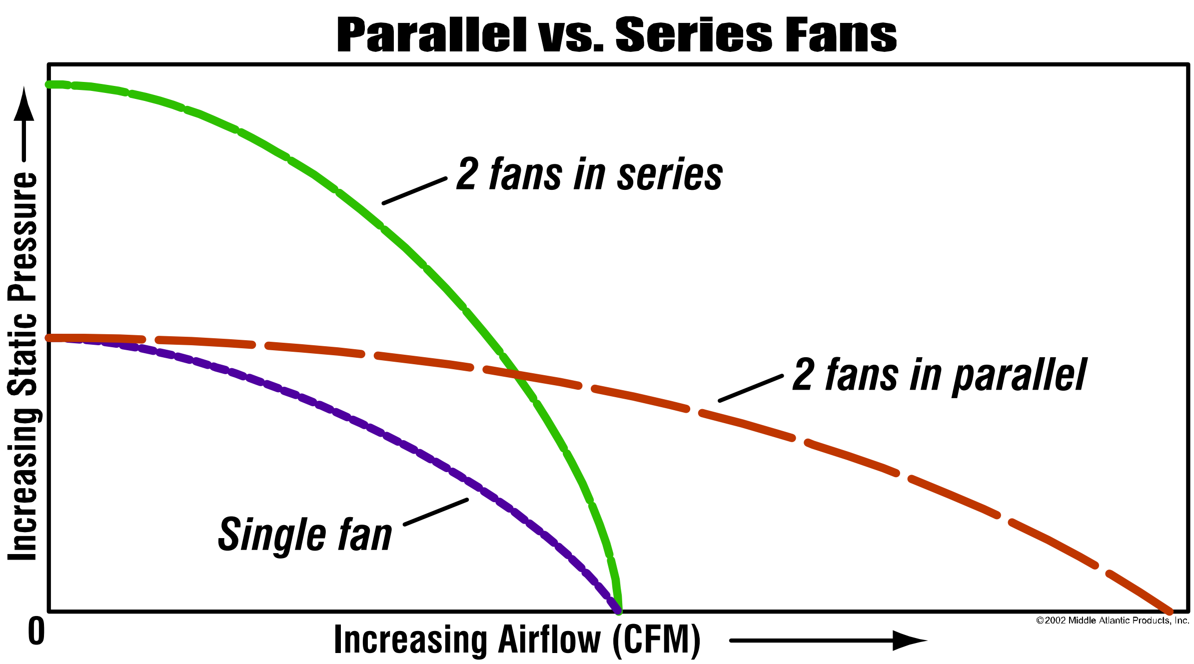
Parallel vs. Series Fans
Increasing Static Pressure
2 fans in series
2 fans in parallel
Single fan
0
Increasing Airflow (CFM)
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Filters

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 clock rates will be most affected by this hygroscopic dust failure.

Middle Atlantic Products’ part FILTER washable filter kit is 1” thick and can be mounted over fans or used as a filtered vent panel to protect equipment from the hazards of hygroscopic dust failure.

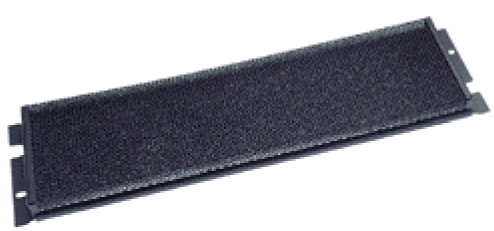
Inlet air filters are highly recommended to extend the service life of digital equipment, as most switchers, routers, hubs, and other processing equipment have their power supply fans in the rear, without any filtered front air intake.

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 thermostatic fan speed control circuit, since the overall volume of air is lower when not required.

Good filters will have a long service life, and low static pressure drop. **Filters require maintenance or they will clog!**

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

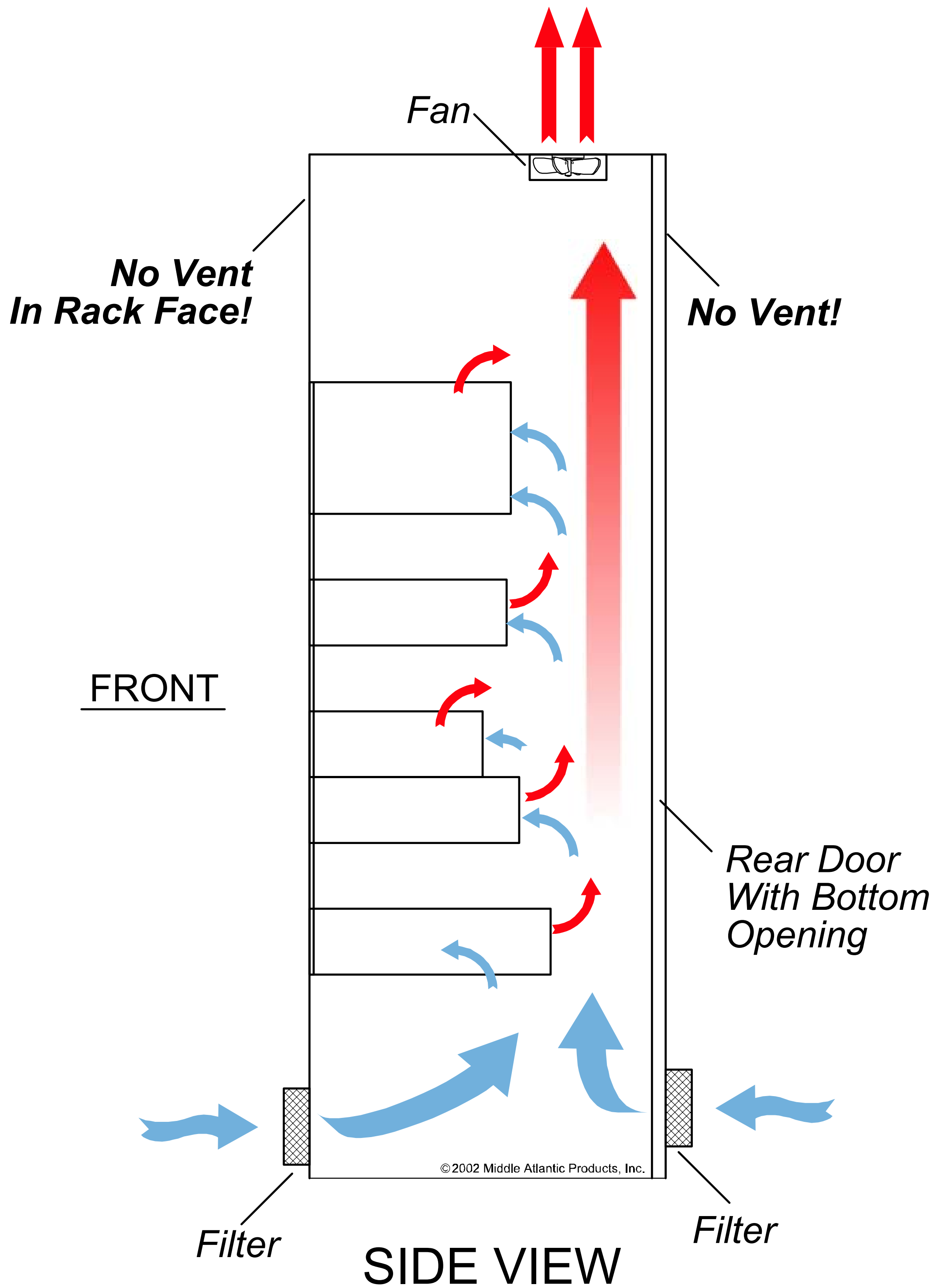


Middle Atlantic Products washable filter, part FILTER

Proper

Forced Air Filtered

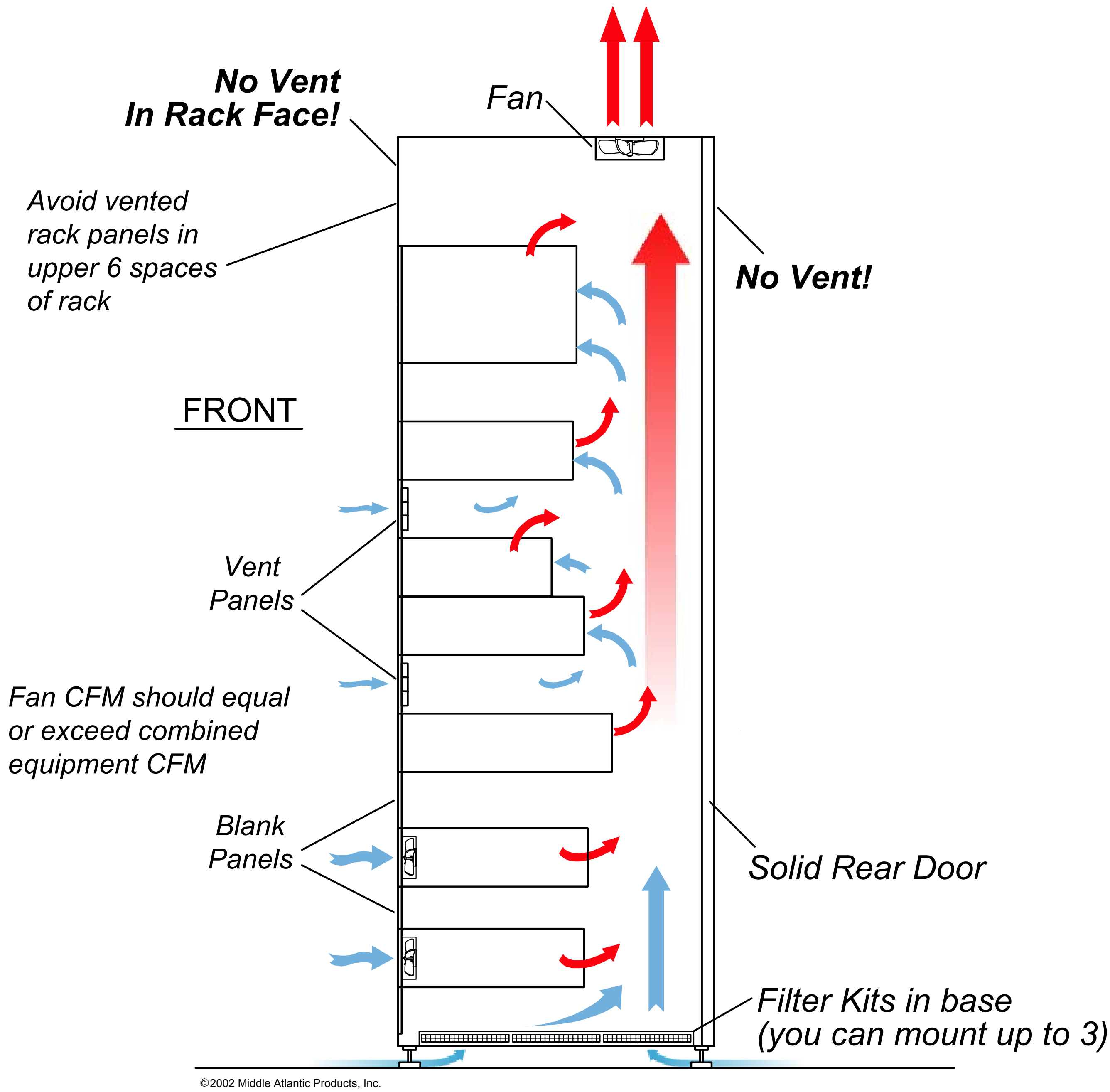
Without Front-Intakes On Equipment



Proper

Forced Air Filtered

With & Without Front-Intakes On Equipment



SIDE VIEW

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.

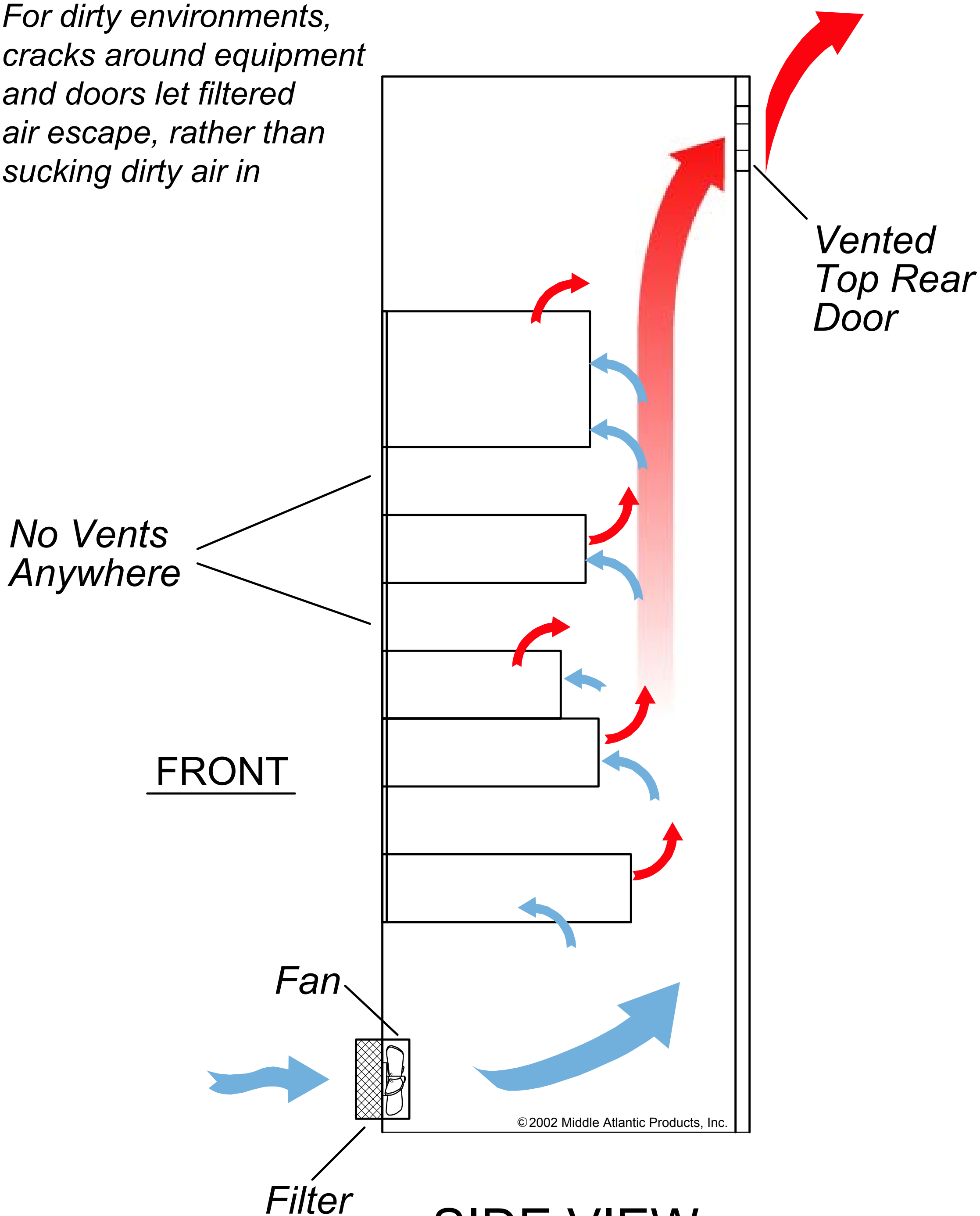
Proper

Pressurizing A Rack, Filtered

Without Front-Intakes On Equipment

ADVANTAGE:

For dirty environments, cracks around equipment and doors let filtered air escape, rather than sucking dirty air in



SIDE VIEW

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.

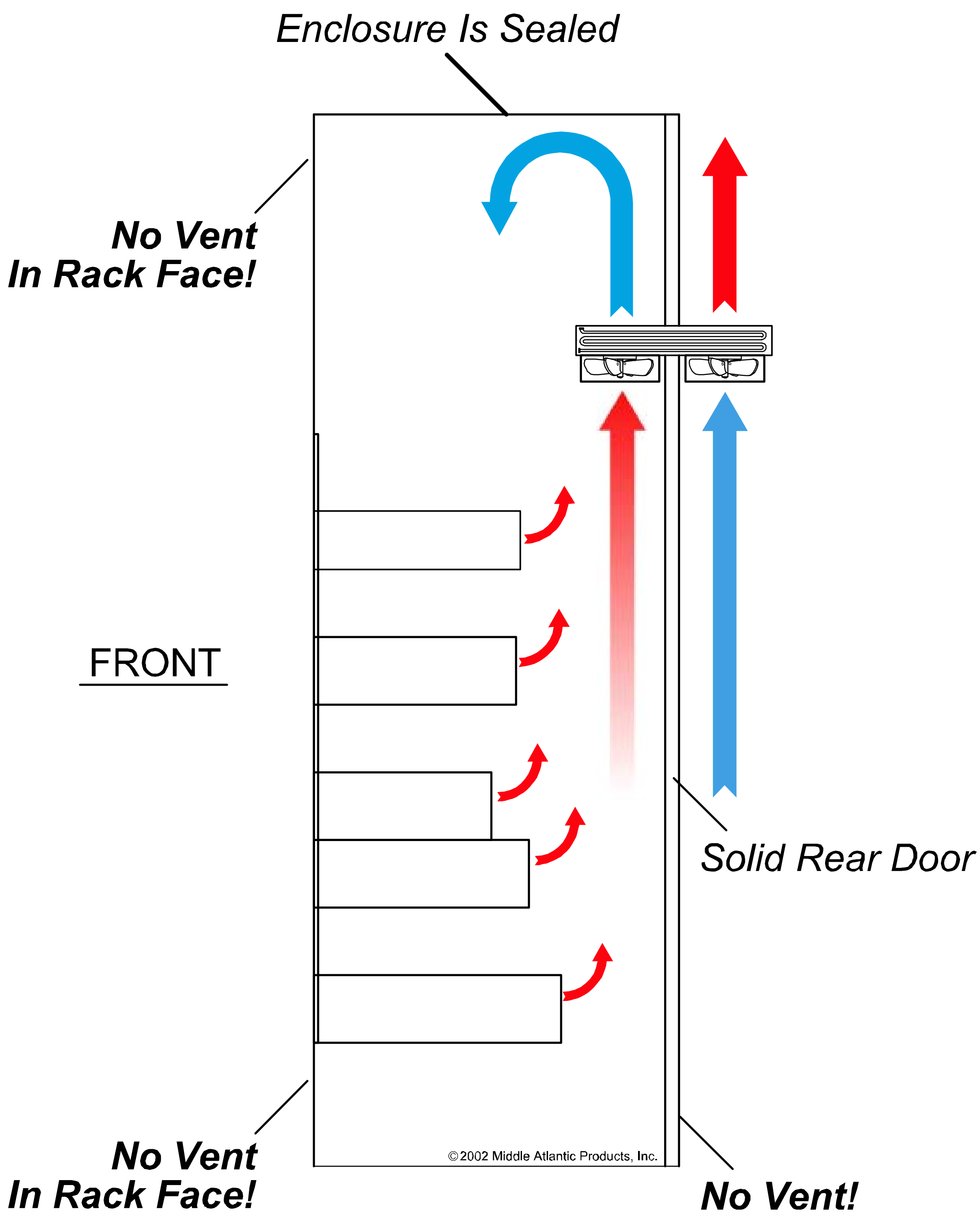
These devices (either water-coil or refrigerant-compressed) are also the only way to make the temperature inside the rack cooler than the ambient air. Care should be taken to avoid condensation when cooling the rack with an air conditioning unit.

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

Proper

Simplified Heat Exchangers And Air Conditioners



SIDE VIEW

Data Centers And Raised Computer Room Floors

Data center installations require careful airflow design by a professional engineer skilled in the HVAC trades.

A total system approach is essential and must take into account the thermal loads along with the minimum static pressure required inside the cabinet.

It is essential to provide selective openings in the raised floor instead of allowing air to leak out where not required. If excess air enters some enclosures, other enclosures will not get the required airflow and equipment may overheat.

Airflow under the computer floor must be directed and managed, which can only be accomplished by measuring the CFM and static pressures inside the enclosures. There are many ways to control the static pressure inside the cabinet: the amount of air let into the bottom, the design of the rear door, the careful placement of blank panels, etc.

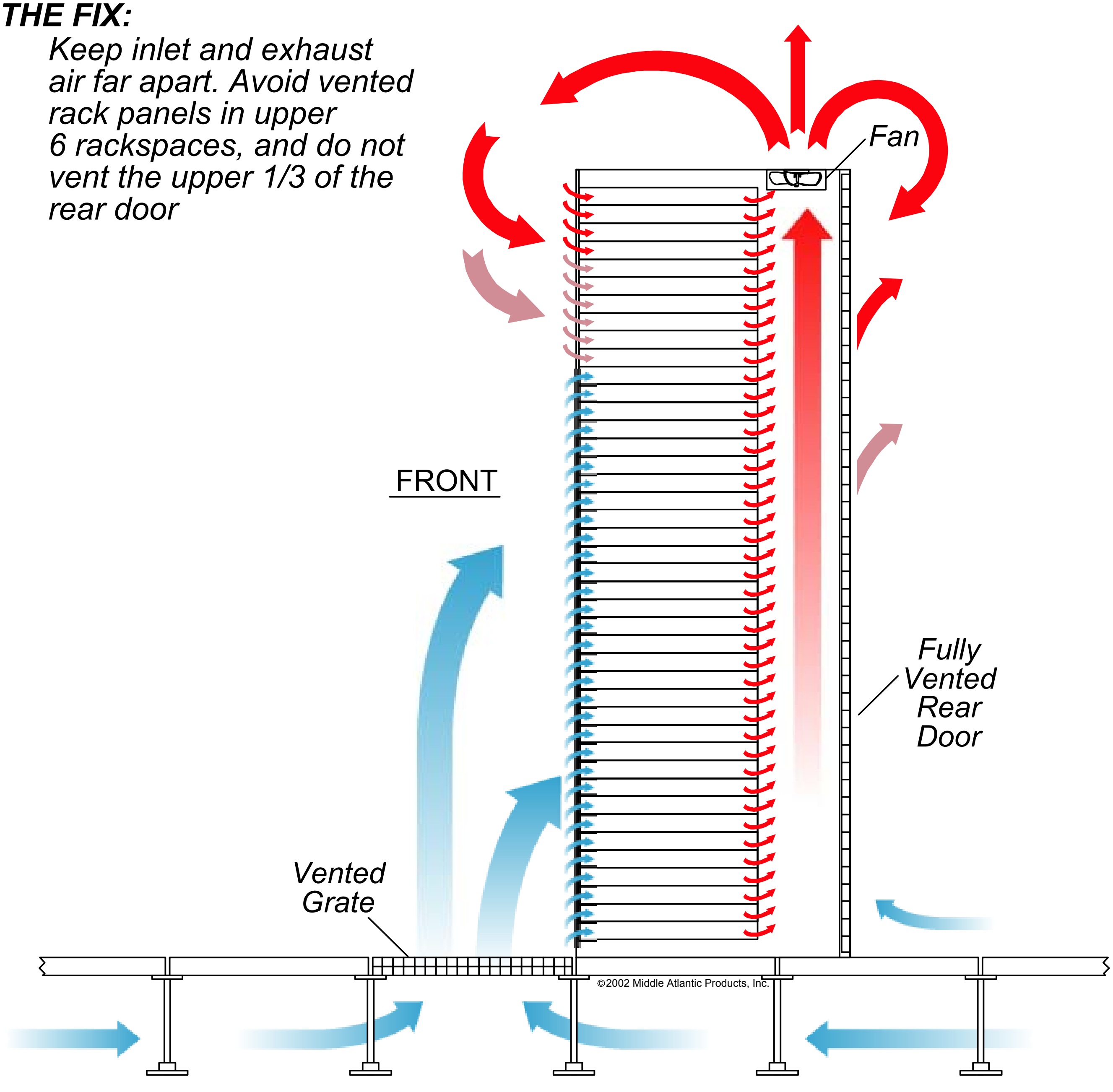
For extremely high heat densities, or large variances between heat densities in adjacent enclosures, additional spot cooling may be required. This can be accomplished by utilizing a variety of solutions, one of which is an enclosure mounted cooling system. Most popular for higher BTU/Hr. are the types that use flexible hose and a liquid-to-air heat exchanger.

WRONG!

Forced Air On Raised Floor, Vented Floor Grate With High-Density Servers

THE FIX:

Keep inlet and exhaust air far apart. Avoid vented rack panels in upper 6 rackspaces, and do not vent the upper 1/3 of the rear door



SIDE VIEW

Data Centers And Raised Computer Room Floors (Continued)

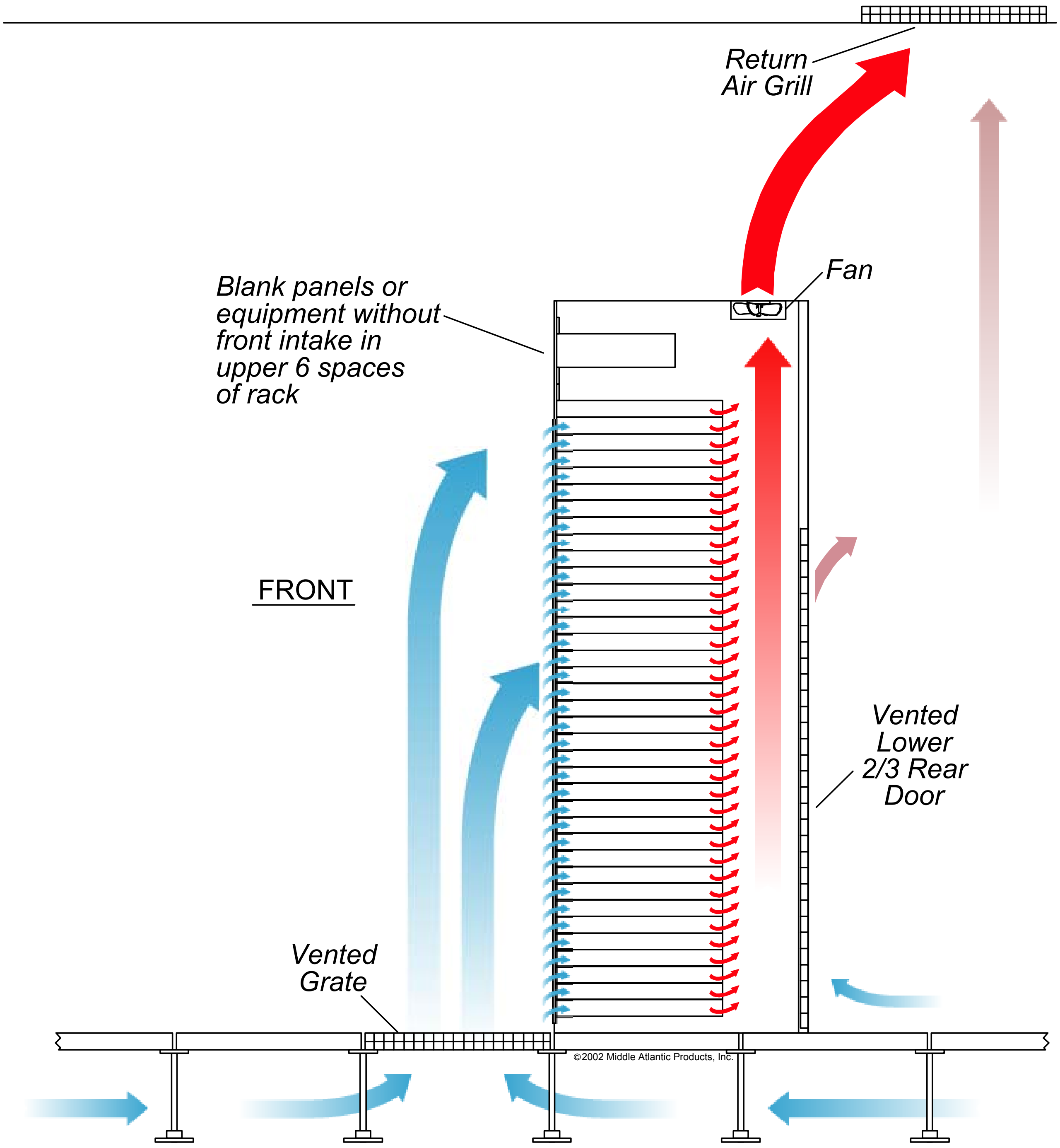
The idea of a balanced system is to use the cool air effectively, and not to waste it by allowing it to re-circulate back to the HVAC unit without first picking up heat.

We feel cold air coming out of a grill and assume air conditioners make cold air. Air conditioning units really remove heat rather than provide cool air, contrary to intuition. Therefore, we need to ensure that cool air is not wasted by it re-circulating back to the return grills without first picking up heat.

In a data center system designed for airflow, it is important that the total cabinet fan CFM's do not exceed the rooms HVAC unit CFM. If this situation occurs, the required static pressure drops and some cabinets will be starved for essential CFM's of airflow, possibly resulting in overheated equipment.

Proper

Forced Air On Raised Floor, Front Grill With 1-Space Servers



SIDE VIEW

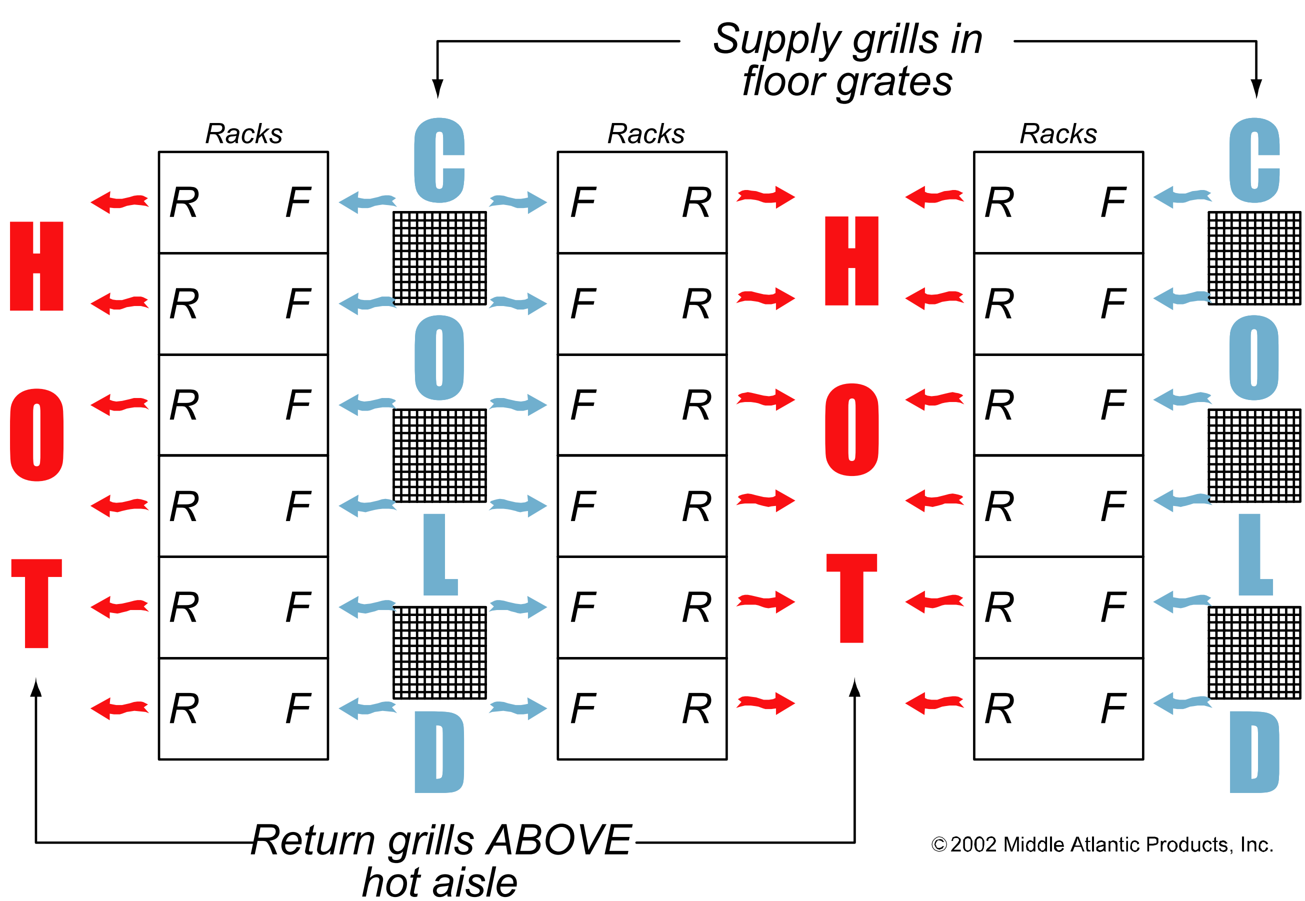
Data Centers And Raised Computer Room Floors (Continued)

There are two strategies for introducing cool air into enclosures while on a raised computer floor. The first is to provide an air outlet grate in front of the rack, and the second 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 data center 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.

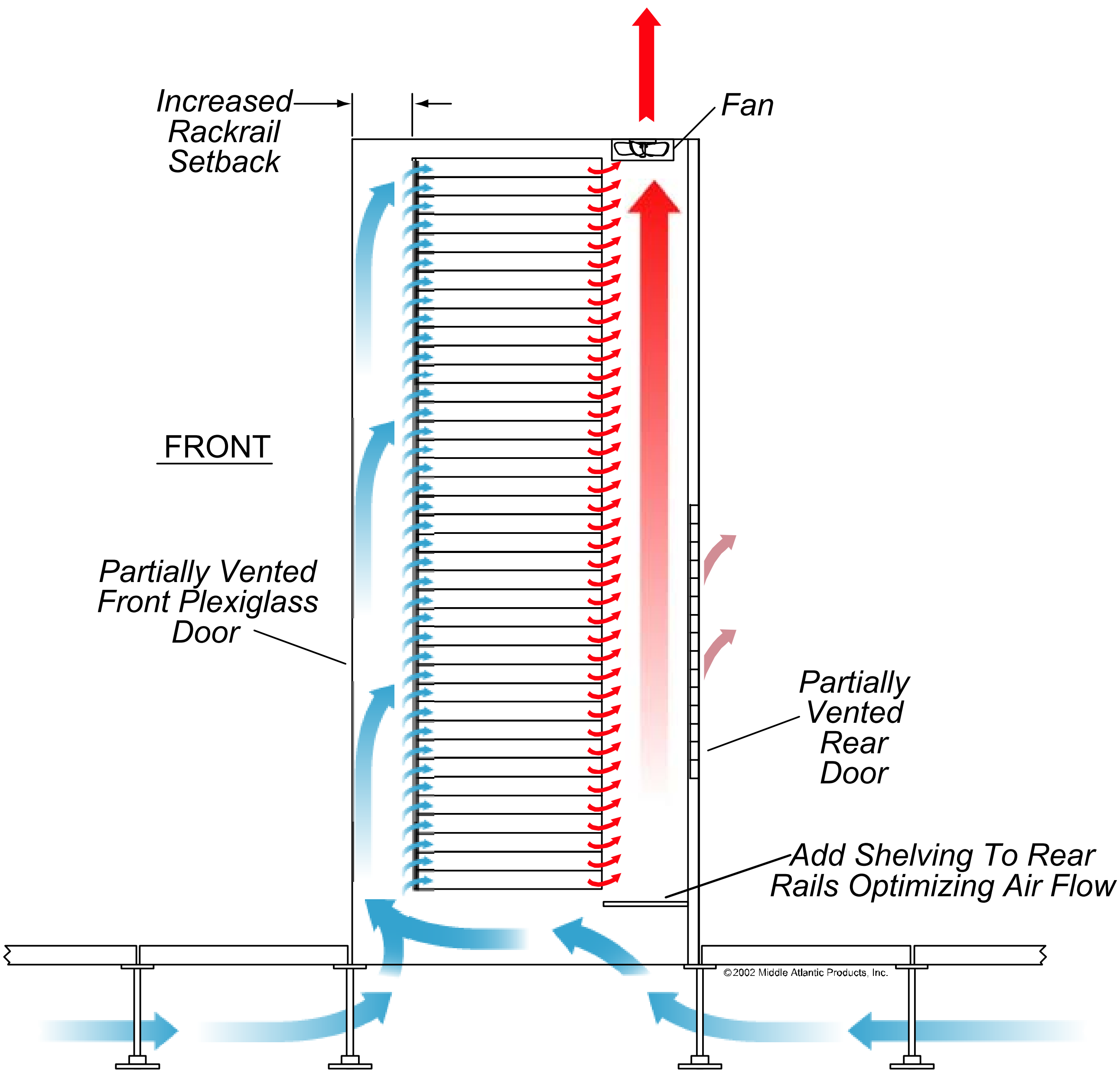
Older data centers were mostly designed for equipment racks with less heat output per rack footprint, so attention should be given to any equipment changes or additions.

Most 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 of the racks face each other in the hot aisles, with return grills overhead for optimum utilization of the air conditioning system.



Proper

Forced Air On Raised Floor, Open-Bottom Rack Intake With High-Density Servers



SIDE VIEW

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.)

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.

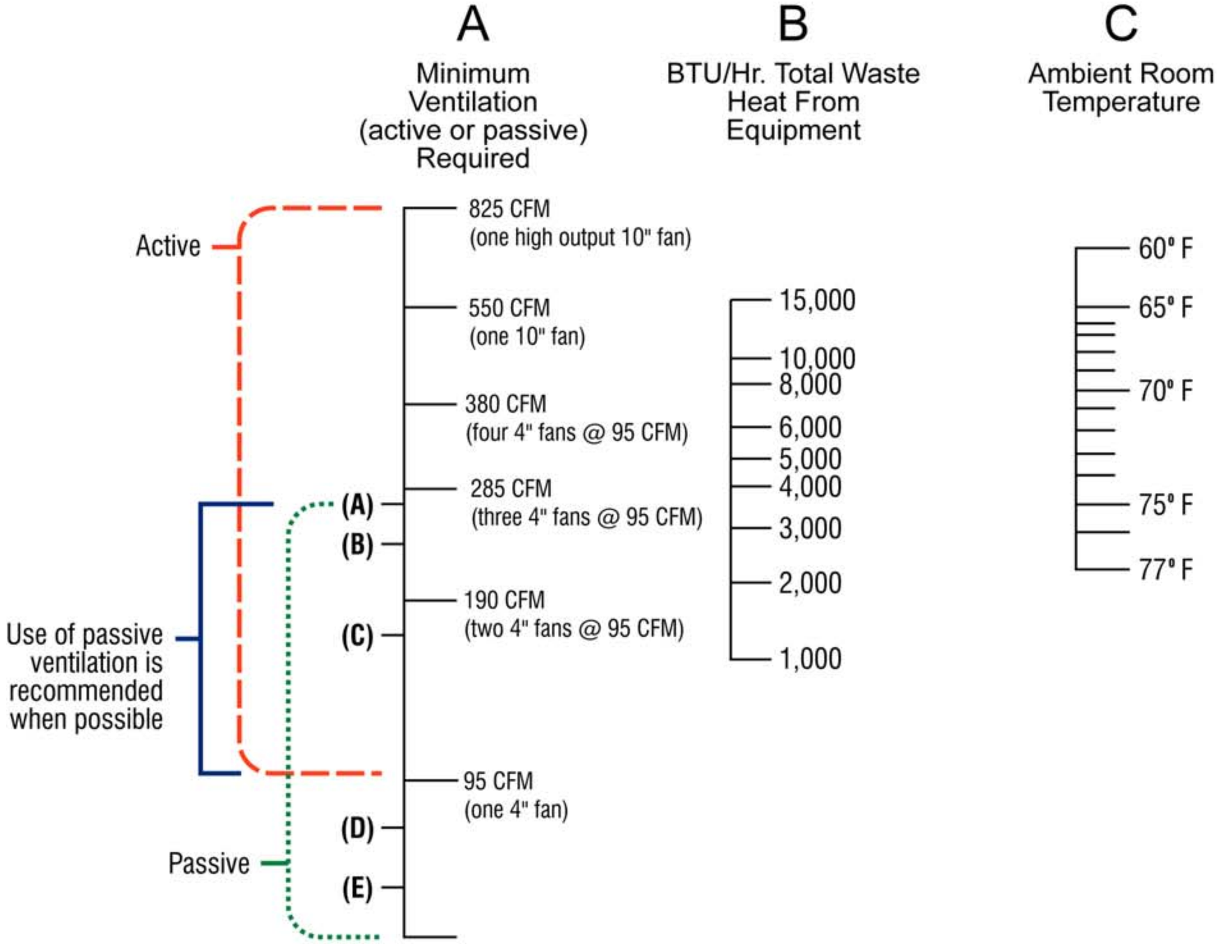
2. The minimum cooling required providing an interior rack temperature of 85ºF will be shown on column A, where the straightedge intersects the minimum cooling requirements column.

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

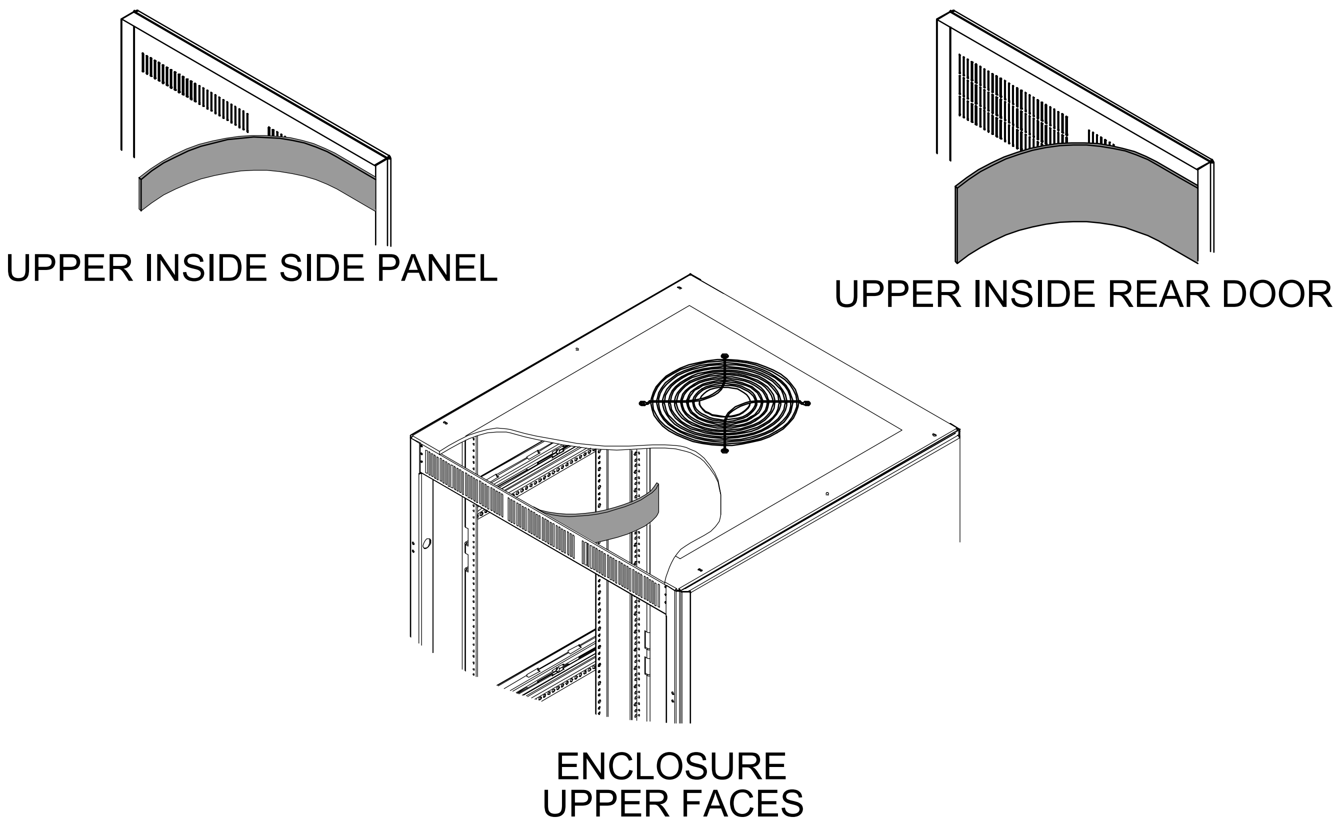
(D) - Solid rear door, 4 space vent in upper rackspace, solid top

(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, VBK Series vent blockers will ensure that heated enclosure air will be forced out through top-mounted exhaust fans. Middle Atlantic Products offers magnetic vent blocker kits for WRK, ERK, DWR, VRK and SR Series cabinets and enclosures.

Vent Blockers



Future Planning

The design of racks and thermal loading should take into account future expansion & changes.

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

On some enclosure manufacturers' tops, laser knockouts are provided for adding additional fans once all equipment has been installed.

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.

****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 has been found to be unclear in many respects, so a new standard was recently released, GR-3028-CORE (Thermal management in telecommunications central offices). This includes the results of advanced computer modeling techniques for thermal management.

Recommended Products from Middle Atlantic Products to Achieve Effective Active and Passive Thermal Management

ACTIVE						PASSIVE	
PART #	ENCLOSURE TOP	TOP FAN OPTIONS	VENT BLOCKERS	SIDE PANELS	REAR DOOR	ENCLOSURE TOP	REAR DOOR
DRK19-44-31	10" fan top standard	FAN10, BMF-FAN10	*	SPN-44-312	custom rear door	MW-VT	vented door included
WRK-44SA-27	MW-10FT, MW-4FT	FAN, QFAN, FAN10, BMF-FAN10	VBK-WSA27	*	solid door included	MW-VT	MW-VRD-44
WRK-44-27	MW-10FT, MW-4FT	FAN, QFAN, FAN10, BMF-FAN10	VBK-W27-W32	SPN-44-267	solid door included	MW-VT	MW-VRD-44
MRK-4426	MW-10FT, MW-4FT	FAN, QFAN, FAN10, BMF-FAN10	*	SPN-44-267	solid door included	MW-VT	MW-VRD-44
VRK-44-31H	MW-10FT, MW-4FT	FAN, QFAN, FAN10, BMF-FAN10	VBK-V	SPN-44-312	vented door included	MW-VT	vented door included
VMRK-54	MW-10FT, MW-4FT	FAN, QFAN, FAN10, BMF-FAN10	*	SPN-54-312	solid door included	MW-VT	custom rear door
ERK-4425	ERK-10FT, ERK-4FT	FAN, QFAN, FAN10, BMF-FAN10	VBK-E25	*	solid door included	ERK-VT	ERK-VRD-44

* These features are already optimized for active thermal management

Note: Top Fan Options should be chosen according to information presented in nomograph

If you have any questions about thermal management and which enclosures will satisfy your thermal needs, please call the Middle Atlantic Products customer support team at 800-266-7225

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Biography

Bob Schluter

A multiple patent holder, Bob Schluter has been active in the Professional Audio, Video, and Computer industries in various capacities since 1976. From his early involvement in electronic equipment design and recording studios throughout his 25 years as President and Chief Engineer of Middle Atlantic Products, Bob has been intimately involved in integrating and installing audio, video, and computer systems, and adapting rack enclosures to accommodate the rapidly changing technologies. Constantly in touch with evolving methods of signal distribution, Bob is currently designing next generation enclosure systems and thermal control products.