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White Paper

DELPHI
Driving Tomorrow's Technology

Meeting The Increased Demand For Efficient Computer Room Cooling

Server Cooling Problems: An Overview

As microprocessors and other electronic components in servers grow more powerful, they consume more electrical power. Consequently, they emit more heat. While many computer rooms have sufficient cooling capacity, inefficiencies in the airflow within electronic enclosures have led to overheating, resulting in server shutdowns. Some operators have compensated by lowering the overall computer room temperature, but this solution leads to overly cool computer rooms, and is at best a short-term fix. The projected continued growth in microprocessor capacity will require more efficient use of cooling resources, especially for rack-mounted servers in electronic enclosures.

Why Server Cooling Is Critical

The primary cause reported of electronic device failures is overheating. All microprocessors have a maximum allowable temperature above which the processor will fail. Servers also contain many other electronic and electromechanical components that are susceptible to heat-induced failure. In general, electronic components that operate at lower temperatures will experience fewer failures, operate faster and last longer.

While outright system failures dramatize the need for better cooling, heat buildup in electronic enclosures can also lead to reduced system performance. The latest microprocessors have built-in speed regulating devices that reduce the clock speed when temperatures exceed a pre-set maximum. Obviously, slower CPU clock speeds caused by overheating will reduce overall system performance.

In addition to temporary shutdowns and degraded performance, higher operating temperatures can dramatically reduce the service life of electronic components, severely impacting ROI in electronic equipment.

As the speed (MHz) of a microprocessor increases, the heat removal requirements increase proportionally (all other parameters remaining equal). Because Moore's Law predicts that semiconductor performance will double every eighteen months, computer room operators can anticipate that heat removal requirements will also continue to increase.

How Server Cooling Systems Work

Servers in electronic enclosures typically employ two cooling systems.

- **Server Cooling Systems** — The vast majority of rack-mounted servers use two or more internal fans to pull cool air through the front of the server and exhaust it from the rear. Heat sources in the server include the microprocessor, power supplies, cards, and drives. Typically, temperatures are 10-15F hotter at the rear of the server as hot air is exhausted.
- **Raised Floor Computer Room Cooling** — Most computer rooms employ a raised floor system to deliver air-conditioned air to the electronic enclosures. Air-conditioned, filtered air at approximately 60-65F flows through under-floor channels (which also serve to route cable feeds) and is delivered to the enclosures through perforated tiles or grates. The cool air flows up through the enclosures and is exhausted at the top. The exhaust air from above the enclosures is then cooled, dehumidified/humidified and filtered before it is returned to the enclosures through the under-floor channels.

While these two cooling methods should be complementary, field studies show that typical computer room configurations do not make efficient use of the cooling air delivered to the enclosures.

Limiting Factors For Cooling Efficiency

Because neither the enclosures nor the server mounting devices are air-tight, three sources of air mix as cooling air is circulated through an electronic enclosure: (1)ambient computer room air, (2) raised floor cooling air, and (3) air that is recirculated inside the enclosure.

Based on thermal management audits conducted at a variety of computer rooms, the temperatures of each of these air sources are typically:

1) ambient computer room air	65-75F
2) raised floor cooling air	60-65F
3) air recirculating inside the enclosure	75-90F

Why do these air sources mix? Many enclosures have perforated front and rear doors. The internal server fans create an air flow from the front of the enclosure through the servers to the rear of the enclosure, thus drawing more of the warmer ambient room air into the enclosure rather than efficiently using the cooler air flowing up into the enclosure from the under-floor channels. Both computer modeling and field audits show that while some raised floor air and recirculated enclosure air are used for cooling, ambient computer room air is the majority air source.

Many enclosures also use fans on top of the cabinets to help pull air from the under-floor channels into the enclosure, but in many cases as the cooler air is drawn up through the enclosure it bypasses the server fronts, providing little additional cooling for internal server electronic devices.

Obviously, the optimal air mixture would use the raised floor air more efficiently to provide the coolest air to the front of the servers, maintaining server electronics at the lowest temperature.

Computational Fluid Dynamics Modeling Of Enclosure Air Flows

Computational Fluid Dynamics (CFD) modeling shows how enclosure configuration and equipment affect cooling efficiency. Input data for the following models was obtained from field audits of computer rooms.

The model is based on an 84” high, 27” wide, and 36” deep enclosure. Thermal conductivity of the enclosure walls is 0.17 W/m-K. The enclosure contains 11 servers, each generating 100W of heat and having 30 cfm of internal fan capacity. Computer room ambient air temperature is 75F, and the raised floor discharge air temperature at the enclosure is 65F with a static pressure of 0.1” H_2O. The resulting temperature distributions are shown in Figures 1 and 2.

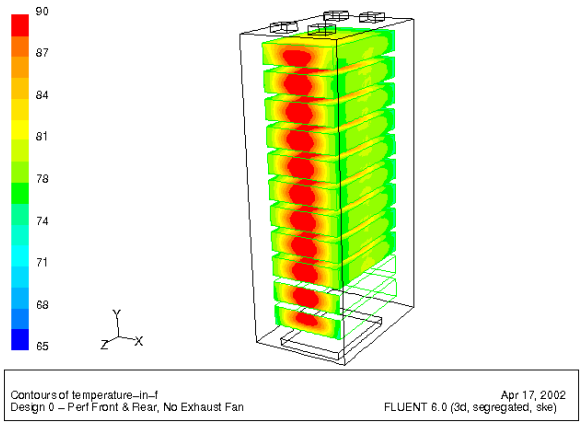

Figure 1 shows air flow for an enclosure with top vents and perforated front and rear doors. Air exhausted from individual servers is 90F+.

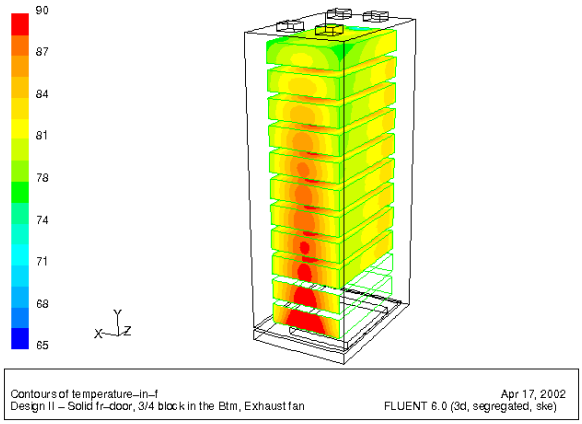

Figure 2 shows an improvement in cooling efficiency using a non-perforated front on the enclosure. The solid front door reduces the amount of computer room ambient air pulled into the enclosure, increasing the amount of air drawn up from the raised floor cooling system.

Delphi ECS Enclosure Blower: A System Solution For Greater Cooling Efficiency

As noted above, the internal server cooling fans create an air flow pattern within electronic enclosures from front to back. While the models in Figures 1 and 2 show a way to make more efficient use of cooling air, it is possible to achieve even greater cooling efficiency by directing cooler air from the raised floor cooling system to the front of the enclosure.

Based on these CFD models, Delphi Thermal Systems developed the Electronics Cooling Systems Enclosure Blower. The ECS Enclosure Blower is installed on sliding rails in the two lowest RMU's of rack space, with space remaining for cable routing from the under-floor channels to the enclosure. The blower directs cool air from the raised floor system to the front of the enclosure. Because air entering the front of the servers is now up to 10F cooler, much greater cooling efficiency is achieved.

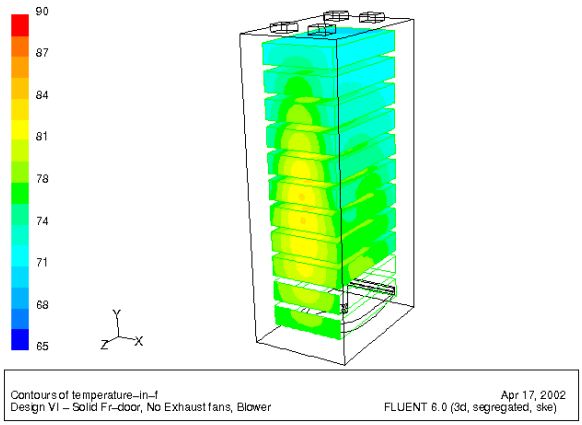

Figure 3 shows a dramatic reduction in server exhaust air temperatures using the Delphi ECS Enclosure Blower, indicating much greater cooling efficiency from the redirected air flow in the enclosure.

Conclusion

While relatively minor changes to electronic enclosure configurations can increase cooling efficiency, increasing heat output from advanced microprocessors and other electronic components will require great cooling efficiency in the near future. By redirecting cool air to the front of the enclosure, the Delphi ECS Enclosure Blower delivers air to rack-mounted servers up to 10F cooler than standard enclosure systems, allowing computer room operators to meet current and future cooling needs without a significant investment in new cooling equipment.

Delphi ECS Enclosure Blower Specifications

The Delphi ECS Enclosure Blower fits standard 19" rack openings, mounting in a maximum of the lowest 2 RMU's of existing or new enclosures. Installation is simple, requiring only one person and a screwdriver. Sliding rails (included) allow adjustment within the rack for cable routing from the under-floor channel to the enclosure. A backward-inclined centrifugal fan in a durable, lightweight polymer housing provides maximum efficiency with minimum noise. Designed for a 50,000 hour service life, the Delphi ECS Enclosure Blower is UL listed and comes with a 2-year warranty.

Figure 4 Delphi ECS Enclosure Blower with attachment rails (included)