A White Paper from the Experts in Business-Critical Continuity™

Precision versus Comfort Cooling

Choosing a Cooling System to Support Business-Critical IT Environments

EMERSON™ Network Power

Executive Summary

Ensuring efficient operation without compromising reliability is essential to the success of companies that depend on achieving business-critical continuity. Unfortunately, whether due to rapid, unanticipated growth or a general lack of awareness with regard to the cooling requirements of sensitive electronic equipment, some data center professionals — particularly managers of small and/or remote facilities — are not able to provide adequate attention to their data centers' infrastucture system design.

Many data center managers end up trying to use comfort cooling solutions to satisfy their environmental control needs, as these systems can mean simplified and economical deployment up front. However, because they are not designed to meet the unique needs of critical IT equipment, reliance on comfort cooling systems can result in an increased risk for premature system failures as well as grossly inflated operating costs. In contrast, precision cooling systems are designed specifically to meet the needs of dense electrical heat loads.

The decision to accept the increased risk of comfort cooling systems is usually based on the lower initial costs. However, precision cooling systems actually represent the most cost-effective solutions when total cost of ownership is evaluated. Finally, data centers that incorporate high density cooling design into their expansion or renovation plans will benefit from scalable IT capacity and reduce the risk of IT downtime.

Consider the following:

- On average, Total Cost of Ownership (TCO) for comfort cooling systems is significantly higher — **up to 60 percent** — than that of precision cooling systems over the life of the equipment.
- The cost of downtime also is rapidly increasing as businesses rely more heavily on business critical IT systems. The failure of critical data center systems means a loss of service and customer goodwill that can translate to losses of **up to $50,000 per hour on average.**

While precision cooling systems enable IT managers to achieve the highest levels of equipment reliability and performance efficiency, it is important to remember that the reliability and cost effectiveness of any cooling system is largely dependent upon proper service and maintenance. Therefore, leveraging a team of factory-trained technicians who have an extensive knowledge of how to maintain mission-critical cooling systems is key to achieving high reliability and the lowest possible TCO.

Precision vs. Comfort Cooling

In small or remote facilities, the careful consideration of equipment essential to reliable operation is a step frequently overlooked in favor of other aspects of the planning process. As a result, areas such as environmental control, power continuity and monitoring of critical computer support systems often receive far less attention than decisions about servers, operating systems and other network-level components that make up a critical IT infrastructure. However, achieving business-critical continuity is as dependent on power and environmental support systems as on advanced networking equipment.

The high sensitivity of electronic components in data center and networking environments means that temperature, humidity, air movement and air cleanliness must be kept consistent and within specific limits to prevent premature equipment failures and costly downtime. Comfort cooling systems — including room air conditioners, residential central air conditioners and air conditioning systems for office and commercial buildings — are occasionally used in these applications. This is usually because the differences between comfort and precision cooling systems can be ambiguous.

Comfort cooling systems are engineered primarily for the intermittent use required to maintain a comfortable environment for people in facilities with a moderate amount of in-and-out traffic. However, while these systems are capable of effectively maintaining acceptable conditions for human occupants, they are not designed to regulate humidity and temperature within precise margins.

Precision cooling systems, on the other hand, are engineered primarily for facilities that require year-round constant cooling, precise humidity control and a higher cooling capacity per square foot. This type of environmental conditioning can utilize a wide range of cooling mediums, including air, chilled water and pumped refrigerants.

To further elaborate, a number of factors should be taken into consideration when comparing precision and comfort cooling systems.

Cooling Optimized to Electronic System Requirements

In recent years, there have been many changes in data center cooling requirements and capabilities that affect operation. Primary among these is an increase in the density of new IT equipment and the resulting increase in heat loads. Higher heat densities created by increased equipment loads generate sensible heat — a drier heat than that found in traditional facility environments — significantly changing the demands faced by the cooling system. To better understand these demands, it is important to remember that there are two types of cooling: latent and sensible.

Latent cooling, in short, is the ability to remove moisture from the surrounding environment. This is an important component in typical comfort-cooling applications — such as office buildings, retail stores and other facilities with high human occupancy and use — which are designed to maintain a comfortable balance of temperature and humidity.

Sensible cooling, on the other hand, is the ability to remove heat that can strictly be measured by a thermometer.

Comfort cooling systems have a sensible heat ratio of 0.60 to 0.70. This means that they are 60 to 70 percent dedicated to lowering temperature, and 30 to 40 percent dedicated to lowering humidity. These systems are typically found in facilities with considerable occupant traffic and doors leading directly to the outside.

Conversely, precision cooling systems are designed to achieve a sensible heat ratio of 0.80 to 1.0, with 80 to 100 percent of their effort is devoted to lowering temperature and only zero to 20 percent to lowering humidity.

Unlike facilities that need to take occupant comfort into consideration, data center environments — particularly network closets and IDF/MDF rooms — are typically not occupied by people.

In most cases, they have limited access and no direct means of egress to the outside of the building except for seldom-used emergency exits. And because their environment is primarily composed of dry heat, data centers require minimal moisture removal.

In light of their unique environmental attributes, most data center environments require a 0.80 to 0.90 sensible heat ratio for effective and efficient cooling. This is because the need for latent heat removal decreases in tandem with the need for dehumidification. This means more nominal 20-ton comfort cooling units would be required to handle the same sensible load as nominal 20-ton precision units.

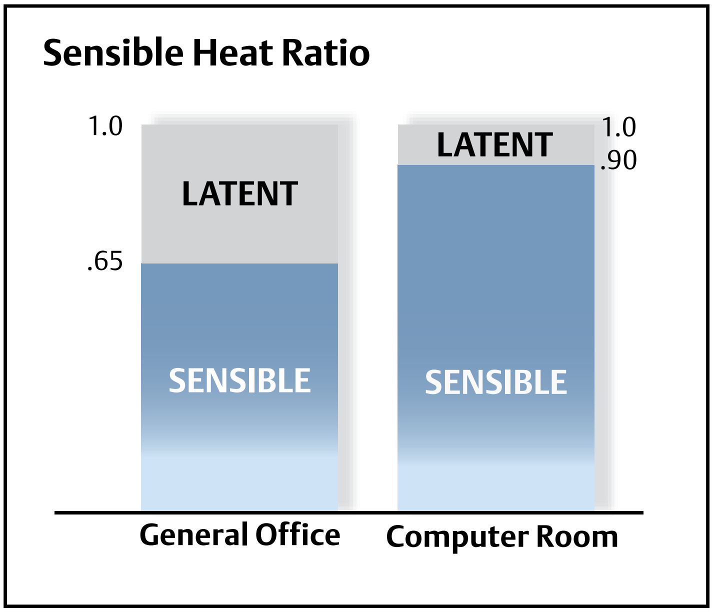

Figure 1. General office environments have loads that are 60-70 percent sensible (.6-.7 SHR), while computer rooms have 90-100 percent sensible loads (.85-1.0 SHR)

Systems Sized to the Higher Densities of Data Center Environments

In a typical data center environment, heat densities can be up to five times higher than in a typical office setting. And with high density rack configurations becoming more popular due to efficient virtualization, data center temperatures are increasing at a faster rate than ever before.

To illustrate, one ton of comfort cooling capacity (12,000 BTU/hour, or 3,517 W) is required per 250-300 square feet of office space. This translates into 12 to 14 watts per square foot. In contrast, one ton of precision cooling capacity is required per 50-100 square feet of data center space. That translates to a 35 to 70 watts per square foot on average, with performance of precision cooling continuing to increase annually as new, more efficient systems are developed. With this in mind, consider that some sites can have load densities as high as 200 to 300 watts per square foot.

From an airflow standpoint, precision cooling systems are designed to manage larger load densities than most comfort cooling systems. Precision cooling equipment typically supplies between 500 and 900 cubic feet per minute (CFM) per cooling ton.

This contrasts with the much smaller range of 350 to 400 CFM per cooling ton typically delivered by comfort cooling equipment.

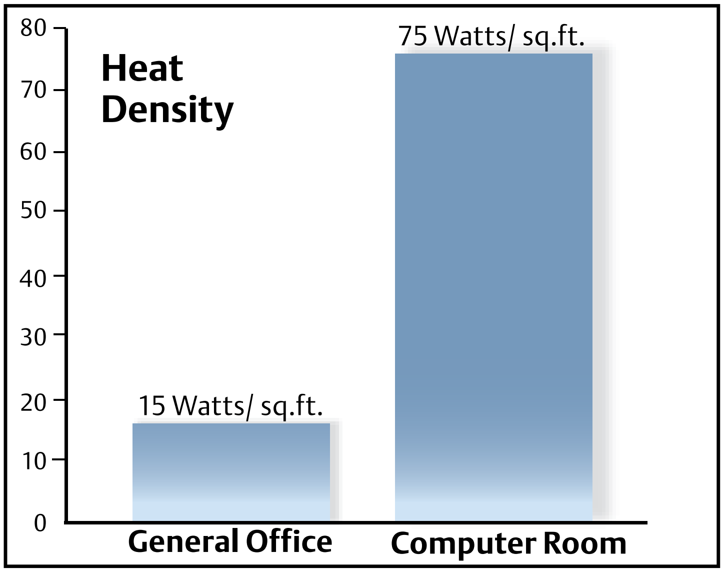

Figure 2. Heat densities are typically three to five times higher in computer room environments than in office environments.

In addition, the use of blade servers and other newer rack-mounted equipment has created unprecedented new data center cooling requirements. New servers and communications switches generate heat densities as much as ten times heat per square foot as systems manufactured just ten years ago. Comfort cooling systems are simply ill-equipped to deal effectively with this new challenge and the associated cooling required. Data center designers and engineers should consider the need for specialized cooling units to work in conjunction with raised floor precision cooling systems.

Furthermore, data centers using traditional precision cooling configurations with large computer room air conditioning (CRAC) units feeding air underneath the raised floor can run into problems — such a hot spots — as high-density rack configurations are implemented.

Even though there may be a high level of cooling capacity in the room, the way air is being distributed can lead to problems if a cooling unit fails. To mitigate these issues, critical cooling systems are integrating new techniques — such as row-based cooling, cold-aisle containment and other targeted cooling strategies. Further, emerging technologies in environmental control are allowing individual room-based CRAC units to be networked together and monitored by comprehensive management programs.

Precise Humidity Control

Since most data centers operate 24 x 7 x 365, precise humidity conditions must be maintained around the clock. Ignoring the impact of humidity can result in serious long-term problems, including damage to equipment and other resources, and to the facility's infrastructure.

The optimal dew point range for data centers is 41.9 to 59 degrees Fahrenheit as recommended by the 2008 ASHRAE *Environmental Guidelines for Datacom Equipment*.[1] For example, above-normal moisture can corrode switching circuitry, causing malfunctions and equipment failures.

At the other end of the spectrum, low humidity can cause static discharges that interfere with normal equipment operation. This is a more likely scenario in a data center, since it is typically cooled 24 x 7, creating lower levels of relative humidity.

Comfort cooling systems typically do not have built-in humidity controls, making it difficult to maintain stable dew point levels over extended periods of time. If the necessary controls and components are added, they must be specially configured to operate as a complete system.

Precision cooling systems feature multi-mode operation to provide a proper ratio of cooling, humidification and dehumidification. This makes them much more suitable for the low tolerance range of humidity levels in a data center.

Protection Against Airborne Contaminants

Even small amounts of dust or other particles can damage storage media and charged electronic components. Most comfort cooling systems use residential-type air filters that are 10 percent efficient, making them inadequate for a data center environment.

[1] It should be noted that the 2004 version of these guidelines targeted a RH range of 40 to 50 percent, rather than a specific dew point range.

Precision cooling system filters have higher quality internal filter chambers that meet minimum MERV 8 ASHRAE requirements.[2]

Furthermore, systems that employ chilled water and pumped refrigerant passively lower temperatures through contact with sealed coils, further reducing the chance of airborne particle contamination.

Efficient, Continuous Year-Round Cooling

Comfort cooling systems for most buildings are designed to operate an average of eight hours per day, five days per week. This translates into about 1,200 hours per year, assuming cooling is required only during the summer months. Conversely, most data centers require cooling 24 hours per day, 365 days per year regardless of outside weather conditions. Precision cooling systems and their components are specifically engineered to meet this high cooling demand. An air-based precision cooling unit's circulating fan is capable of operating continually, 8,760 hours per year, with other components turning on and off as needed. Furthermore, a precision system can operate effectively to minus 30 degrees Fahrenheit, and Glycol cooled models can cool effectively down to minus 60 degrees Fahrenheit. Comfort cooling systems with outdoor heat exchangers, on the other hand, are typically inoperable when outside ambient temperatures drop below 32 degrees Fahrenheit due to lack of head pressure control.

Unique energy-saving configurations — such as dual cooling systems — also are becoming more popular as a way to save energy. Utilizing this option, a conventional air cooled direct expansion unit is converted to a dual source cooling system by the addition of a second coil that utilizes a central building chiller supply. The unit can function either as a chilled water system, a compressor-based system, or a combination of both. During times when the chiller supply is available, compressor operation is eliminated, reducing energy costs.

For colder climates, an even more effective energy savings solution is to utilize an outdoor fluid cooler (drycooler and pump package) in conjunction with the chilled water coil conversion, which will provide "free cooling" when ambient temperatures permit.

Lower Operating Costs

Because of basic engineering, design and equipment differences, a purchase price comparison of comfort versus precision air conditioning systems does not tell the complete story. A more accurate comparison considers the difference in operating costs between the two systems.

To follow is a basic example of an operating cost comparison between the two approaches, using the assumptions outlined below:

- Each ton of cooling requires 1.0 horsepower (or 0.747 kW)
- The compressor motors and fans are 90 percent efficient
- Electricity costs $0.10 per kilowatt-hour
- Humidification is required November through March (3,650 hours)
- The precision cooling system has a SHR of 0.90; the comfort system has a SHR of 0.60.

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[2] MERV 8 or higher rated filters are required in HVAC equipment for the building to be eligible for LEED Certification

A more detailed analysis can be done on specific equipment.

First, calculate the cost per ton of cooling for a year:

$$\frac{0.747 \text{ kW/ton x } 8760 \text{ hrs./yr. x } \$0.10\text{/kWh}}{0.90 \text{ efficiency}}$$

This results in a cost of $727 ton/yr.

Then, determine the cost per sensible ton of cooling by dividing the total cost by the SHR for each system. For the precision cooling system the cost per sensible ton is:

$$\frac{\$727}{0.90 \text{ SHR}} = \$808 \text{ ton/yr.}$$

For the comfort cooling system, the cost per sensible ton is:

$$\frac{\$727}{0.60 \text{ SHR}} = \$1{,}212 \text{ ton/yr.}$$

In this example, the operating cost to run a comfort cooling system for one year exceeds the cost to run a precision cooling system by $404 per ton of sensible load. This is consistent with the generally accepted principle that it takes three tons of comfort cooling capacity to equal two tons of precision capacity.

A second point of comparison is the cost of humidification, which is determined by calculating the latent cooling that occurs per ton of sensible cooling.

For a precision system:

$$\frac{12{,}000 \text{ BTU/ton}}{0.90 \text{ SHR} - 12{,}000 \text{ BTU/ton}} = 1{,}333 \text{ latent BTU/ton}$$

For a comfort system:

$$\frac{12{,}000 \text{ BTU/ton}}{0.60 \text{ SHR} - 12{,}000 \text{ BTU/ton}} = 8{,}000 \text{ latent BTU/ton}$$

The comfort system expends 6,667 BTU of energy per ton of sensible cooling to remove humidity that must be replaced to maintain required data center moisture content of 45-50 percent.

The added cost is:

$$\frac{6{,}667\text{BTU/ton x } 3{,}650\text{hrs./yr. x } \$0.10\text{/kWh}}{3{,}413 \text{ BTU/hr./kW}} = \$713 \text{ ton/yr.}$$

In this scenario, when all cooling and humidification costs are considered, the operating cost of a comfort-based system exceeds the operating cost of a precision cooling system by **$1,119 per ton of sensible cooling annually.**

Enhanced Service and Support

Today's critical data center environments require advanced environmental support systems to efficiently achieve business-critical continuity. Because precision cooling systems run continuously and are necessary for the proper operation of IT equipment, regular maintenance is of the utmost importance.

A precision cooling system cannot fully benefit the data center if it is not functioning at the highest level. Precision cooling systems must be properly maintained and serviced throughout their entire lifecycle to maximize the organization's return on investment.

The level of knowledge required to maintain standard building comfort cooling systems is very different from that required for precision cooling systems.

Because precision cooling systems are engineered and tuned very differently from comfort cooling systems, service providers without specific knowledge of how to maintain the equipment may not be prepared to handle the job.

Inexperienced service providers greatly increase the risk of equipment failure, whereas OEM factory-trained service providers can ensure that a precision cooling system is operating at its optimal point of performance and efficiency.

Understanding these systems' added complexity, most precision cooling system manufacturers employ factory-trained, locally-based installation, service and support partners that are accustomed to the needs and sensitivities of working with specific equipment in the data center environment.

While non-OEM service providers may have the knowledge required to install precision cooling equipment, they do not necessarily have the service expertise needed to assure optimum performance of these systems throughout their lifecycles. Manufacturer-backed service technicians are trained by the factory to handle all aspects of service and have the knowledge and experience necessary to pinpoint subtle areas of concern within the data center that may be causing issues with the cooling units.

Because even a short amount of downtime can impact an organization's bottom line, many precision air systems are designed for rapid serviceability and, in most cases, are backed by factory-trained service personnel who can arrive in nearly half the time required by other providers. Depending upon the manufacturer, 24-hour emergency service and preventive maintenance service may be available.

Conclusion

Business-critical data centers have unique environmental requirements and, as a result, necessitate cooling systems that match those requirements.

While comfort cooling systems are appropriate for “comfort” environments — facilities that are occupied by people or that house routine equipment and supplies — they are not well suited to environments that require precise regulation of temperature, humidity and air quality. Furthermore, though initial equipment costs may favor the installation of comfort cooling equipment, energy costs over the life of the equipment and overall cooling quality make precision cooling equipment the better long-term investment.

Precision cooling systems are specifically designed to address the unique demands of today’s complex IT environments. When maintained properly, these systems can meet the increasing demands for heat rejection, humidity control, filtration and other requirements in data centers and other high availability computer facilities while also providing additional efficiency, reliability and flexibility benefits.

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SL-24644-R09-10 Printed in USA