



Engineering White Paper

**SEVEN WAYS PRECISION AIR
CONDITIONING OUTPERFORMS
COMFORT SYSTEMS IN
CONTROLLED ENVIRONMENTS**



SUMMARY

Efficient, reliable operation of business critical computer systems is essential to the success of companies in virtually every industry. The cost of downtime is high, with even a short interruption causing the potential loss of productivity, profits and customer goodwill. And, business critical computers are no longer clustered only in one centralized location. Many organizations today have multiple data centers, including smaller centers at remote locations.

Often small or remote data centers don't benefit from the same attention to support system design as large data centers, despite the fact that the costs associated with downtime from the systems they house can be remarkably high. One area, in particular, that may be receiving inadequate attention is environmental control: Whether through rapid growth -- results in the data center "outgrowing" its support systems -- or lack of understanding of the cooling requirements of sensitive electronics, some users end up trying to use comfort cooling for precision electronics.

The result is increased risk for premature failure of protected equipment and higher than necessary operating costs.

Precision cooling systems are designed specifically to meet the needs of dense electronic loads, which generate a dryer heat than typical comfort-cooling environments and require year-round, 24-hour cooling. Electronics are also more sensitive to variations in humidity and air quality than typical comfort-cooling environments.

When an decision is made to accept the increased risk of using comfort cooling systems for sensitive electronics, it is usually based on higher initial costs of the precision cooling system. But, because precision cooling systems are designed and sized for the high sensible cooling requirements and year-round operation of the data center, they are less expensive to operate over their life than comfort systems. Consequently, when initial costs and operating costs are both taken into account, precision cooling systems actually represent the most cost-effective solution to cooling sensitive electronics.

Precision vs. Comfort Cooling

Consideration given to the planning and design of equipment essential to reliable data center operation is often less than given to other aspects of the facility planning process, particularly in smaller or remote facilities. Areas such as environmental control, power reliability and effective monitoring of critical computer support systems receive far less attention than decisions about servers, operating systems and network configurations. Yet, the performance of these systems is as dependent on power and environmental support systems as on the network connection.

The combination of heat generation and sensitivity of electronic components in data center computer and network systems requires that temperature, humidity, air movement and air cleanliness be maintained within stringent limits.

Precision cooling systems have been designed specifically for this purpose. Available comfort cooling systems are occasionally used in these applications; however, that is usually because the differences between comfort and precision cooling systems are not well understood.

Comfort air systems include room air conditioners, residential central air conditioners and air conditioning systems for office and commercial buildings. They 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.

Precision air systems are engineered primarily for facilities that require year-round constant cooling, precise humidity control and a higher cooling capacity per square foot than comfort systems.

Specifically, seven major differences exist between precision air conditioning and comfort systems.

1. Cooling Optimized to Electronic System Requirements

Dense loads of electronics generate a dryer heat than typical comfort-cooling environments and this significantly changes the demands on the cooling system.

There are two types of cooling: latent and sensible.

Latent cooling is the ability of the air conditioning system to remove moisture. This is important in typical comfort-cooling applications, such as office buildings, retail stores and other facilities with high human occupancy and use. The focus of latent cooling is to maintain a comfortable balance of temperature and humidity for people working in and visiting such a facility. These facilities often have doors leading directly to the outside and a considerable amount of entrance and egress by occupants.

Sensible cooling is the ability of the air conditioning system to remove heat that can be measured by a thermometer. Data centers generate much higher heat per square foot than typical comfort-cooling building environments, and are typically not occu-

pied by large numbers of 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.

Comfort air conditioning 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. Data center environments require a 0.80 to 0.90 sensible heat ratio for effective and efficient data center cooling. Precision air conditioning systems have been designed with a sensible heat ratio of 0.85 to 1.0. This means 80 to 100 percent of their effort is devoted to cooling and only 0 to 20 percent to removing humidity. So more “nominal” 20-ton comfort units will be required to handle the same sensible load as “nominal” 20-ton precision units

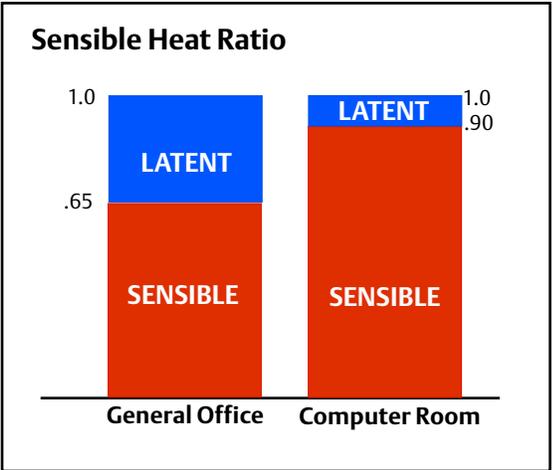


Figure 1. General office environments have loads that are 60-70 percent sensible (.6-.7 SHR), while computer rooms have 90-100 percent sensible loads (.85-1.0 SHR)

As the need for latent heat removal lessens, so too does the need for dehumidification. Data centers have a minimal need for latent cooling and require minimal moisture removal. Because precision cooling systems are engineered with a focus on heat removal rather than moisture removal and have a higher sensible heat ratio, they are the most useful and appropriate choice for the data center.

2. Systems Sized to the Higher Densities of Data Center Environments

Heat densities in electronics environments are three to five times higher than in a typical office setting, and increasing at a faster rate than ever before.

To illustrate, one ton of comfort air conditioning capacity (12,000 BTU/hour or 3413 watts) is required per 250-300 square feet of office space. This translates into 15 watts per square foot. In contrast, one ton of precision air conditioning capacity is required per 50-100 square feet of data center space. That translates into a much larger 75 watts per square foot. And this is an average number that is increasing yearly. Some sites can have load densities as high as 200 – 300 watts per square foot.

From an airflow standpoint, precision air systems are designed differently than comfort air systems to manage the larger load densities in data centers. A precision air system achieves a higher sensible heat ratio, helps maintain target temperature and

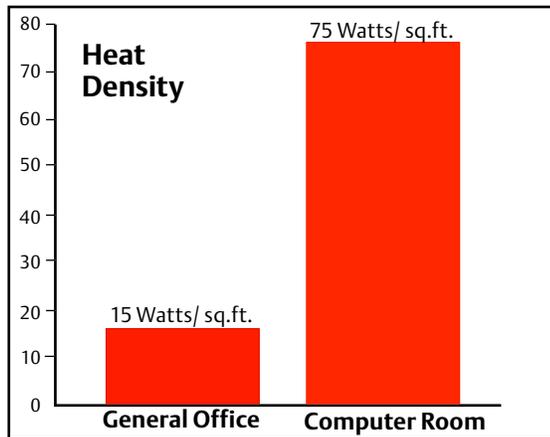


Figure 2. Heat densities are typically 3-5 times higher in computer room environments than in office environments.

humidity levels and contributes to better air filtration via the movement of significantly larger volumes of air. Precision air equipment typically supply 500 to 900 cubic feet per minute (cfm) per cooling ton. This contrasts with the much smaller range of 350 to 400 cfm typically delivered by comfort air equipment.

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

3. Precise Humidity Control

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 relative humidity range for a data center environment is 45-50 percent. An above-normal level of moisture can corrode switching circuitry, which can cause 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 24x7, creating lower levels of relative humidity.

Comfort air systems typically have no humidity control, which makes it difficult to maintain stable relative humidity levels. If the necessary controls and components are added, they have to be set-up to operate as a complete system. Precision air systems have 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.



Figure 3. Infrared humidifiers enable precision air conditioning systems to provide fast, precise humidity control.

4. Protection Against Airborne Contaminants

Even small amounts of dust or other particles can damage storage media and charged electronic components. Most comfort air systems use residential-type air filters that are 10 percent efficient, making them inadequate for a data center environment. Precision air system filters have higher quality internal filter chambers that are 20-30 percent efficient and ASHRAE compliant.

5. Efficient Continuous Year-Round Cooling

Comfort air conditioning systems for most buildings are designed to operate an average of 8 hours per day, 5 days per week. This translates into about 1,200 hours per year, assuming cooling is required only during the summer months.

Most data centers require heat rejection 24 hours per day, 365 days per year regardless



Figure 4. Precision air conditioning systems are available in a range of configurations to provide room-level and rack-level protection.

of outside weather conditions. Precision air conditioning systems and their components are engineered to meet this high cooling demand. A precision air unit's circulating fan operates continually, 8,760 hours per year, with other components turning on and off as needed.

Moreover, comfort air systems with outdoor heat exchangers are typically inoperable due to lack of head pressure control when outside ambient temperatures drop below 32° F. A precision system can operate effectively to minus 30° F., and glycol-cooled models cool effectively down to minus 60 degrees F. outside ambient temperatures.

6. 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 will consider the difference in operating costs between the two systems.

To following is a basic example of an operating cost comparison between the two approaches, using the assumptions outlined below. A more detailed analysis can be done on specific equipment.

- Each ton of cooling requires 1.0 horsepower (or .747 kw)
- The compressor motors and fans are 90 percent efficient
- Electricity costs \$.06 per kilowatt-hour.

- Humidification is required November through March (3,650 hours)
- The precision air system has a SHR of 0.90; the comfort system has a SHR of 0.60.

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

$$\frac{0.746 \text{ kw/ton} \times 8760 \text{ hrs/yr} \times \$0.06/\text{kwh}}{0.90 \text{ efficiency}}$$

This results in a cost of \$436 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 air system the cost per sensible ton is

$$\frac{\$436}{0.90 \text{ SHR}} = \$484 \text{ ton/yr.}$$

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

$$\frac{\$436}{0.60 \text{ SHR}} = \$727 \text{ ton/yr.}$$

In this example, the operating cost to run a comfort air system for one year exceeds the cost to run a precision air system by **\$243** 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 rehumidification, which is determined by calculating the latent cooling that occurs per ton of sensible cooling.

For a precision system:

$$\frac{12000 \text{ Btu/ton}}{0.90 \text{ SHR}} - 12,000 \text{ Btu/ton} = \mathbf{1,333 \text{ latent Btu/ton}}$$

For a comfort system:

$$\frac{12000 \text{ Btu/ton}}{0.60 \text{ SHR}} - 12,000 \text{ Btu/ton} = \mathbf{8,000 \text{ latent Btu/ton}}$$

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:

$$\frac{6667 \text{ Btu/ton} \times 3650 \text{ hrs/yr} \times \$0.06/\text{kwh}}{3413 \text{ Btu/hr/kw}} = \mathbf{\$427 \text{ ton/yr.}}$$

In this scenario, when all cooling and rehumidification costs are considered, the operating cost of a comfort-based system exceeds the operating cost of a precision air system by **\$670** per ton of sensible cooling annually.

7. Enhanced Service and Support

Critical environments require high availability of critical support systems. Therefore, it is important that these systems operate reliably, and that their performance is tuned specifically to control the environment for the computer systems with which they are deployed.

Precision air systems often feature greater internal redundancy of components than comfort cooling systems, allowing them to continue operating in the event of some failures. In addition, they are supported by factory-trained, locally-based installation, service and support partners that are accustomed to the needs and sensitivities of working in the data center environment. Depending upon the manufacturer, 24-hour

emergency service and preventive maintenance service may be available on precision cooling systems.

Because even a short amount of downtime can impact the bottom line, leading precision air systems are designed for serviceability.

Conclusion

Computer systems have unique environmental requirements and necessitate cooling systems that match those requirements. Comfort cooling systems are appropriate for “comfort” environments – facilities that are occupied by people or that house routine equipment and supplies.

Precision cooling systems provide the efficiency, reliability and flexibility to meet the increasing demands for heat rejection, humidity control, filtration, and other requirements in data centers and other high availability computer facilities.



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