Precision vs Comfort Cooling & The Beneficial Use of Intelligent Free Cooling

A Technical Paper prepared for SCTE•ISBE
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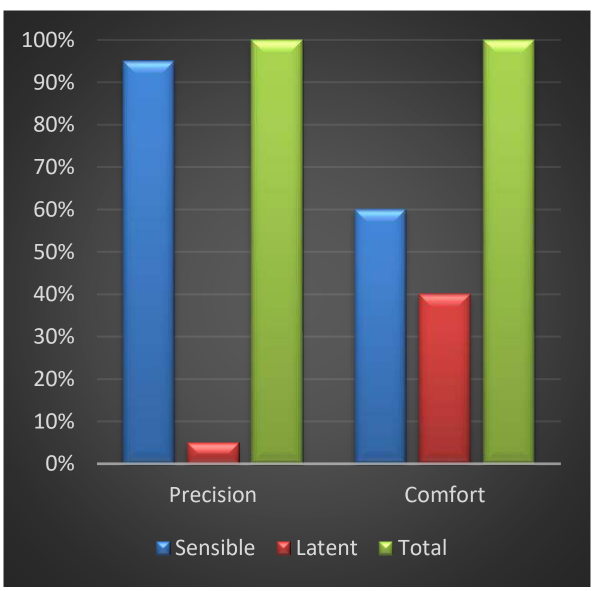
1. Introduction

Precision air conditioners are air conditioners designed for special rooms that require constant temperature, humidity, and cleanliness. Understanding the difference between comfort cooling and precision cooling can be a major factor in reducing energy consumption in data centers and other precision enviornments.

Typical applicable locations are the following:

- Data Centers
- Computer Rooms
- Telecom Equipment Rooms and Shelters
- Centralized Monitoring Rooms
- Healthcare Equipment Rooms
- Manufacturing Facilities - Precision Enviornments
- Test Labs

Table 1 - Precision vs. Comfort Cooling



Precision Cooling Equipment

- High sensible heat ratio
- 95% of work = cooling air temperature
- 5% of work = removing humidity

Comfort Cooling Equipment

- Lower sensible heat ratio
- 60% of work = cooling air temperature
- 40% of work = removing humidity

2. Why Do I need a Precision Air Conditioner?

Data centers (also referred to as server rooms or IT rooms) are the backbone of any business' organization, providing capabilities of centralized storage, backups, management, networking and the dissemination of data.

Most contemporary data centers contain equipment racks that secure servers, storage devices, network cabling and other IT equipment. Data center design is primarily comprised of the utility infrastructure like power supplies, fire suppression and other security devices.

Data center equipment generates a considerable amount of heat in a relatively small area. This is because every watt of power used by a system is dissipated into the air as heat. Unless the heat is removed, the ambient temperature will rise, eventually beyond design specifications resulting in electronic equipment failure.

Traditional comfort air conditioners are not designed to handle the heat load concentration and heat load composition of the data room, nor to provide the precise temperature and humidity conditions for the electrical equipment of data center. Precision air conditioners are designed for precise temperature and humidity control, with high reliability to ensure the continuous operation of data centers throughout the year.

Precision air conditioners in data centers can control the temperature and relative humidity in ± 34ºF, ± 5%, greatly improving the service life and reliability of the equipment.

2.1. Temperature and Humidity Requirements of Data Centers

Maintaining temperature and humidity design conditions is critical to the smooth operation of data rooms. The design conditions should be between 72 °F to 75 °F and a relative humidity (R.H.) of 35% to 50%. Just as environmental conditions may cause damage, rapid temperature fluctuations may also have a negative impact on hardware operation, which is one reason to keep the hardware running even when the hardware is not processing data.

In contrast, the comfort air-conditioning system is designed to keep the indoor temperature and humidity at 80 °F and 50% R.H when the outdoor temperature and humidity at 95 °F and 48% R.H in the summer. Comfort air conditioners on the other hand do not have dedicated humidification and control systems. A simple controller cannot maintain the set point 23 ± 68 °F required for the temperature. Therefore, high temperature and humidity may cause high ambient temperature and humidity range fluctuations.

2.2. Problems Caused by the Wrong Enviornment

High & Low Temperature

A high or low ambient temperature, or rapid temperature swings, can corrupt data processing and shut down an entire system. Temperature variations can alter the electrical and physical characteristics of electronic chips and other board components, causing faulty operation or failure. These problems may be transient or may last for days. Even transient problems can be very difficult to diagnose and repair.

High Humidity

High humidity can result in tape and surface deterioration, head crashes, condensation, corrosion, paper handling problems, and gold and silver migration leading to component and board failures.

Low Humidity

Low humidity greatly increases the possibility of static electric discharges. Such static discharges can corrupt data and damage hardware.

2.3. The Difference Between Precision and Comfort Cooling

In order to provide a stable and reliable working environment for IT devices, the temperature and humidity of the room must be strictly controlled within a range. Therefore, the design of precision air conditioners is very different from traditional comfort air conditioners in the following aspects:

High Sensible Heat Ratio and Small Enthalpy Difference

A heat load has two separate components: sensible heat and latent heat. Sensible heat is the increase or decrease in air-dry bulb temperature. Latent heat is the increase or decrease in the moisture content of the air. The total cooling capacity of an air conditioner is the sum of the sensible heat removed and the latent heat removed.

Total Cooling Capacity = Sensible Cooling + Latent Cooling

The Sensible Heat Ratio is the percentage of the total cooling that is sensible.

Sensible Heat Ratio (SHR) = Sensible Cooling

In a datacenter, the cooling load is made up almost entirely of sensible heat coming from IT hardware, lights, support equipment, and motors. There are very little latent loads since there are fewer people, limited outside air, and usually a vapor barrier to add further moisture protection. The required SHR of an air conditioner to match this heat load profile is very high, 0.95-0.99. Precision air conditioning is designed to meet these very high sensible heat ratios.

In contrast, a comfort air conditioner typically has a SHR of 0.65-0.70, and provides too little sensible cooling and too much latent cooling. The excess latent cooling means that too much moisture is continually being removed from the air and a high energy use humidifier is required to replace moisture.

Traditional comfort air conditioners are mainly designed for human comfort, with smaller amounts of supply air cfm per square foot than sensible cooling found in most precision enviornments. The sensible heat in equipment rooms accounts for more than 90% of the total heat. Heat loads from lighting, heat conduction through walls, ceilings, windows, floors, and solar radiation heat, seepage wind and fresh air heat through gaps, etc. The amount of moisture generated by the heat gain is very small, so the use of comfort air conditioners will inevitably cause the relative humidity in the equipment room to be too low. The surface of the internal circuit components of the device will accumulate static electricity, which will cause damage to the device and interfere with data transmission and storage. At the same time, as the cooling capacity (40% to 60%) is consumed in dehumidification, the actual cooling capacity of the cooling equipment is reduced, which greatly increases the energy consumption.

A precision air conditioner is designed to strictly control the evaporation pressure in the evaporator and increase the amount of supply air. The goal is to have the surface temperature of the evaporator higher than the dew point temperature of the air without the need for dehumidification. Thus, the cooling capacity is used to cool by reducing cooling loss during dehumidification (large air volume, small air enthalpy difference).

Large Air Volume

In order to dissipate the high heat loads of data centers, the cooling systems must circulate enormous velocities of air. Comfort air conditioners operate at very low CFM velocities and at slower rates of speed than precision air conditioners. They can only partially circulate airflow in short distances in the supply air direction, instead of generating an overall airflow circulation in the data center. This may result in localized temperature differences, low temperatures near the supply air direction, and high temperatures in other areas. All of these factors can result in local heat buildup, which can damage the IT device due to overheating.

Precision air conditioners produce high CFM levels, high air changes per hour rates that can potentially reaching 30~60 times per hour. This high amount of CFM moves more air through the space improving air distribution and reducing the chance of localized hot spots.

Air Cleanliness

Air quality is equally important for electronic circuitry. Dust is certainly one of the worst enemies and can adversely affect the operation and reliability of data processing equipment due to stray currents.

For traditional comfort air conditioners, due to the small air volume and the low ventilation rate, the air in data centers cannot guarantee a sufficiently high speed to bring the dust back to the filter. Thus, the dust is deposited inside of the electrical equipment, which has detrimental effects on the electrical equipment. At the same time, the air filter is not intended for clean applications.

Precision air conditioners produce large volumes of supply air and high ventilation rates. They require high efficiency air filtration to filter out dust to preserve the overall cleanliness of data centers.

Reliability

The 24-Hour operation of precision air conditioners are designed and built to run non-stop 8760 hours a year. These systems are designed with components selected and redundancy incorporated to ensure zero downtime. System controls maintain room conditions for the full range of outside ambient conditions, summer or winter. Comfort air conditioners are designed to run during summer days, up to an expected maximum of 1200 hours per year. These systems are not designed or expected to operate non-stop, or 8760 hours a year. Neither the controls nor the refrigeration systems are designed for zero downtime or winter operation.

Humidity Control

Precision air conditioners are generally equipped with a humidity control system, which consists of a high-efficiency humidification system, dehumidification and electric heating compensation systems. Through the microprocessor, precision air conditioners can accurately control the temperatures and humidity in data centers based on the data from each sensor. The comfort air conditioner is generally not equipped with a humidification system. Comfort air conditioner systems tend to control the temperature inaccurately and cannot control the humidity, so these systems cannot meet the heating and cooling load needs of most data centers.

Control Accuracy

Precision air conditioning systems usually consist of a cooling system, an electrical heating compensation system, a humidification system and a de-humification system. These are all critical, so that the unit can quickly respond to environmental changes through the microprocessor-based controller, and ensure the environment can be accurately maintained with a very small temperature set point range.

Comfort air conditioning systems usually do not produce heat, humidification and dehumidification systems, but these are essential for a stable indoor environment. Comfort air conditioner systems have limited controls that are unable to react quickly or provide rapid control.

Air Distribution Method

The air supply schemes of air-conditioned rooms depend on the heat source and distribution in the room. In view of equipment arrangement and the wiring method in data centers, two design configurations are common: 1) a raised floor system, and 2) overhead air distribution.

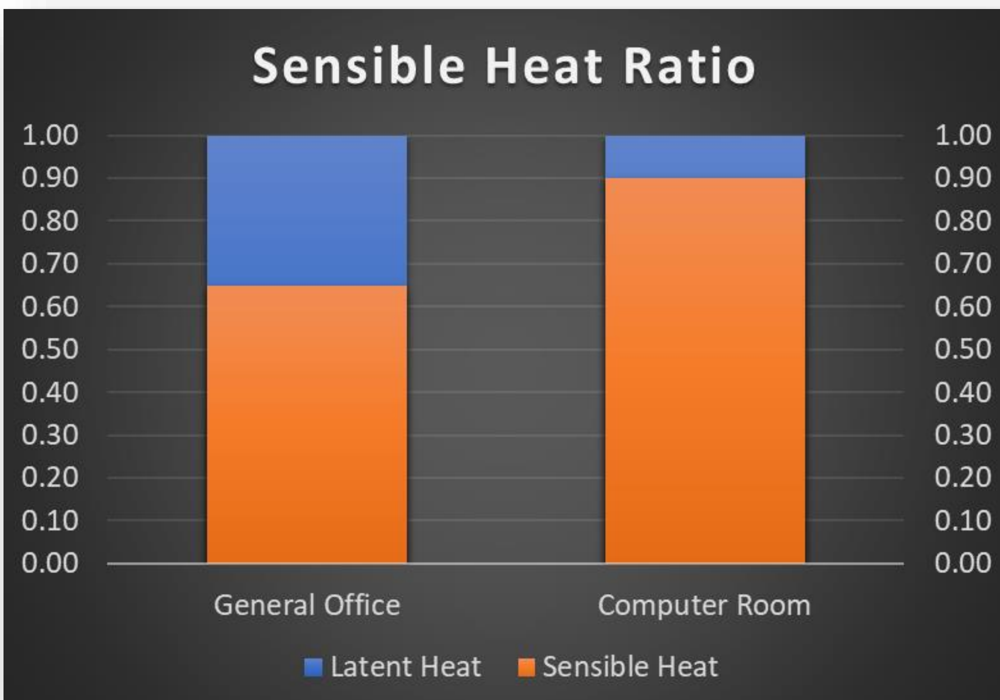
Precision air conditioners usually do not use air ducts for supply air and return air, but use the space under the raised floor or upper the ceiling as the static pressure box. This space acts as a plenum chamber for supply air and return, so that the static pressure is uniform throughout the entire data center.

2.4. Sensible Cooling vs. Latent Cooling

Sensible cooling is used to remove heat, while latent cooling is used to remove moisture. Spaces with high density heat loads and little need for dehumidification require high sensible cooling capability and low latent cooling capability. This would generally be a 0.8 to 1.0 sensible heat ratio (SHR) where the ratio is represented as sensible cooling over total cooling. Spaces like these require precision cooling.

In data room applications where there are rapid temperature swings, high or low humidity can have negative effects on the room's electronics. High, low, or fluctuating temperatures are capable of corrupting and even shutting down entire data systems. For precision air systems with lower than 1 SHR, a humidifier is often included to put moisture back into the room.

Table 2 - Sensible Heat Ratio



2.5. Beneficial Use of Intelligent Free Cooling

Intelligent Free Cooling

Intelligent Free cooling is an energy efficient process incorporated within contemporary HVAC systems that uses low external air temperatures to assist in lowering the internal air temperature in a building, or data center, by using naturally cool air or water instead of a mechanical cooling process.

While intelligent free cooling with direct outside air is extremely efficient for cooling remote cell sites and small equipment rooms, care must be taken in locations where air contamination is an issue.

Air Filter Protection Device (AFPD)

The patented AIRSYS AFPD (Air Filter Protection Device) is field proven and engineered to protect air filters from dust and debris. In many locations, the AFPD will optimize free cooling during periods when the air is clean, thereby extending the life of the primary air filter.

2.6. Why Do I Need Intelligent Free Cooling and an Air Filter Protection Device?

Due to the risk of clogged filters causing diminished cooling capacity and high temperature alarms, free cooling is often manually disabled for these locations by technicians to reduce costly service calls. On an average telecom shelter site or small data center with a 10kW load, approximately $2,000/yr. on an average is lost when relying solely on compressors for cooling. Not to mention the wear and tear that occurs by the overuse of compressors causing more service calls.

This issue can be resolved by setting up Intelligent Free Cooling (IFC), a 2-layer approach to maximize energy saving while protecting the building from air contaminates.

Figure 1 - Intelligent Free Cooling and AFPD, a Two-Layer Approach:

Air Filter Protection Device (AFPD)

This AIRSYS patented AFPD device is field installed and communicates airborne contaminate density to the AIRSYS Lead/Lag controller. The controller immediately shuts the outdoor air damper when the contaminate density exceeds the predefined threshold.

Air Pressure Switch

An air pressure switch comes standard on all AIRSYS units and allows the user to set maximum primary air filter dirtiness. If this threshold is exceeded, Free Cooling (FC) is disabled until the filters are replaced. Even in worst-case scenarios, mechanical cooling capacity will be maintained.

Note: Software upgrades to AIRSYS Lead/lag Controller may be required for compatibility. Have your maintenance contractor contact us for more information.

Benefits of Intelligent Free Cooling

Unlocking Energy Savings

Compared to relying solely on compressors for cooling, enabling IFC can easily save $1,000-$2,000/yr. for each medium sized (10kW) site. The ROI is less than 6 months from utility cost savings alone.

Reducing Long Term Operational Expenditures (OPEX)

Depending on the climate, IFC can offset compressor run times and turn-ons by 40-90% throughout the year. This eases the wear and tear on the compressor and related components such as switches, contactors, and condenser fan motors. This significantly extends the life expectancy of the system and reduces overall maintenance costs.

Added Cooling Redundancy

Having another form of cooling provides a safety layer in temperature control on remote sites. IFC can help offset the entire heat load during colder months and cooler nights while providing emergency ventilation during the hotter times of the year.

3. Conclusions

The added two-layer approach of both IFC and AFPD will provide added reliability for HVAC equipment in the harshest environmental conditions. Our AIRSYS UNICOOL system incorporates both technologies in unison to enhance energy efficiency as well even in the most challenging outdoor environments across the globe. Contact our team of trained field service technicians, sales engineers and customer service representatives to learn more about how we can assist you in deploying one of our AIRSYS systems in your next project!

4. Appendix

4.1. Figure 2 - Comparison – Precision Air Conditioners vs. Comfort Air Conditioners

No.	Items	Precision air conditioner (CRAC)	Comfort air conditioner
1	Design motivation	Designed to dissipate high heat loads. Ensure the temperature, humidity and cleanliness of the equipment room.	Designed for human comfort perceived as pleasant by people.
2	Application	Data Centers Computer rooms Telecom equipment room and shelters, Centralized monitoring rooms Healthcare Equipment Rooms Manufacturing facilities requiring precise environments Precision operating rooms	Offices, hotels, supermarkets, Movie theaters.
3	Operating time	Server rooms operate 24 hours a day, seven days a week, 365 days a year. CRAC units are designed to operate continuously, non-stop on an annual basis.	Intermittent and cyclic operation only when people are working or occupying the area. 10~12 hours per day at 100~150 days per year.

No.	Items	Precision air conditioner (CRAC)	Comfort air conditioner
4	Air volume	Operate at a high air flow rate, the high ventilation rate is necessary to remove hot spots, 30-50 times per hour.	Operate at a much lower airflow, ventilation rate is less than 5 times per hour, high enthalpy difference.
5	Proportion of capacity or sensible heat ratio (SHR)	Provide very high sensible heat ratio (SHR) - 0.85 to 0.95.	Typically has a SHR of 0.60 to 0.70, thereby providing little sensible cooling and too much latent cooling. This means that more capacity is needed to do the same job as a precision air conditioning system.
6	Supply air temperature	Higher than dew point temperature.	Lower than dew point temperature.
7	Air cleanliness	CRAC Units clean the air continuously through the high-efficiency air filters and the system design of the blower operating all of the time.	Use disposable or washable filters of undetermined efficiency. Not intended for clean applications.
8	Humidity regulation	Have the ability to control the humidity levels to the space. The units can add humidity with a humidifier that is built into the unit.	Achieve unregulated dehumidification suitable for comfort cooling.
9	Environment adaptability	Outdoor temperature -86°F~+113F.	Outdoor temperature -41°F~+104°F.
10	Control accuracy	Regulate temperatures and humidity within tight limits; ±1 °F and humidity at ±5 %.	Can't regulate humidity and temperature within precise margins.
11	Control system	Equipped with microprocessor-based controls, which are sensitive and respond quickly to environment conditions.	Generally, have basic, limited controls, unable to react or provide rapid control
12	Remote control	Easy integration to BMS using standard protocols, remotely monitor the units, collect and store data.	Unable to remotely control the unit.
13	Alarm	Automatically shows the fault and alarm on time on the interface.	Unable to show alarms.
14	Diversity of options	Very large due to individual production.	Lower, due to mass production.

No.	Items	Precision air conditioner (CRAC)	Comfort air conditioner
15	Air distribution method	Diversity of schemes, top throw, down throw, up-front throw, displacement, ducted, etc.	Up-front air supply in a short distance, resulting in localized hot spots.
16	Reliability	Be designed to accommodate continuous heat extraction and consider redundancy into the design to continue the facility's operation during a failure event.	Designed with standard components, inability to switch to another unit during failure event.