Today's technology rooms require precise, stable environments in order for sensitive electronics to operate optimally. Standard comfort air conditioning is poorly suited for technology rooms, leading to system shut-downs and component failures. Because precision air conditioning maintains temperature and humidity within a very narrow range, it provides the environmental stability required by sensitive electronic equipment, allowing your business to avoid expensive downtime.

**PRECISION AIR CONDITIONING APPLICATIONS**

Precision environmental control requirements reach far beyond the confines of the traditional data center or computer room to encompass a larger suite of applications.

Typical applications that benefit from precision air conditioning include:
1. Medical equipment suites (MRI, CAT scan)
2. Hospital facilities (operating, isolation rooms)
3. Clean rooms
4. Laboratories
5. Data centers
6. Server and computer rooms
7. Telecommunications (wiring closets, switch gear rooms, cell sites)
8. Printer/copier/CAD centers

**WHY DO I NEED PRECISION AIR CONDITIONING?**

Information processing and uptime is critical to the functioning of today's businesses. Therefore your company's health is dependent on the precision air conditioning's reliability. Technology rooms produce an unusual, concentrated heat load, and at the same time, are very sensitive to changes in temperature and humidity. A temperature and/or humidity swing can produce many problems including a complete system shutdown. This can create huge costs for the company, depending on the length of the interruption and the value of time and data lost.

In addition, technology rooms may reduce computing capacity as a protective measure, if environmental conditions are not properly controlled. This protective response results in reduced computational capacity for the owner. Standard comfort air conditioning is not designed to handle the heat load profile of critical purpose areas, nor is it designed to provide the precise temperature and humidity set point required for these applications. Precision air conditioning systems are designed for close temperature and humidity control. They provide high reliability for year-round operation, with the ease of service, system flexibility and redundancy necessary to keep critical applications running 24 hours a day.

**TEMPERATURE AND HUMIDITY DESIGN CONDITIONS**

Maintaining temperature and humidity design conditions is critical to the smooth operation of a data center or other technology room. Design conditions should be 68-77°F (20-25°C) and 40-55% relative humidity. As damaging as the wrong ambient conditions can be, rapid temperature swings can also have a negative effect on hardware operation. This is one of the reasons hardware is left powered up, even when not processing data. AAON precision air conditioning systems are designed to maintain temperature at ±1°F (0.56°C) and humidity at ±3-5% relative humidity, 24 hours a day, 8760 hours a year over a broad range of ambient conditions.

In contrast, most comfort systems are designed to maintain 80°F (27°C) and 50% relative humidity only during summer conditions of 95°F (35°C) and 40% relative humidity outdoor conditions. Usually there is no dedicated humidity control and the simple controllers cannot maintain the set point tolerance required for temperature or humidity, allowing potentially harmful temperature and humidity swings to occur.

**VARIABLE LOADS**

The technology rooms of the past represented relatively constant power (heat) loads with constant airflow through the server. Today's technology room loads are dynamic. The power of a server can depend on the computational demand being applied to the server. As the server...
power increases or decreases with computational loading, the required airflow through the server can also vary. Additionally, in an effort to improve server resource utilization, server virtualization is being commonly deployed, which can result in varying power demands. Precision air conditioning systems need to provide variable cooling capacity and variable airflow to properly match the variable power and variable airflows of today’s technology rooms.

**ENERGY UTILIZATION**

Energy efficiency is a key data center issue. The more energy efficient the data center, the lower the on-going operating costs for the facilities’ users. With the rise of computing demands and high density computational environments, efficient energy usage is extremely important. Power usage effectiveness (PUE) is a metric used to determine the energy efficiency of a data center. PUE is determined by dividing the amount of power entering a data center by the power used to run the computer infrastructure within it.

The components of the PUE calculation look at the relationship between “Total Facility Power” (TFP) and “IT Equipment Power” (IEP). TFP is measured at the utility meter for the data center space and includes all of the components required to support the IT load including:

- Power components such as uninterruptible power supply (UPS) systems and power distribution units (PDUs)
- Cooling elements such as air conditioners, chillers and air handlers
- Other infrastructure components such as lighting

IEP, or more simply IT Load, is the sum total of the power used by the facility’s computing components including servers, storage devices and networking equipment. PUE is expressed as a ratio, with overall data center energy efficiency increasing the closer the number comes to one which indicates that a greater portion of the power required by the facility is used to drive the IT equipment. Efficient centers will often have PUE values of two or less, as shown in Figure 1.

**AAON PRECISION AIR CONDITIONING FEATURES**

AAON units are available with a variety of energy saving options.

- **Economizers**
  - A water side economizer, as shown in Figure 2, uses the outside air in conjunction with a refrigeration system. Instead of compressors, the outside air cools the water, which is then used to cool the air in the data center.
  - An air side economizer, as shown in Figure 3, uses the outside climate to cool the data center. This outside air is distributed to the cabinets via the existing air delivery system, except no mechanical activity is needed for heat rejection.
• **Dehumidification**
  o Return air bypass dampers, as shown in Figure 4, can be tied to a humidity sensor and when more dehumidification is needed more return air is bypassed.
  o By bypassing some air around the cooling coil, the air that passes through the evaporator coil is dehumidified by a greater amount. By increasing the dehumidification of the airstream and using the bypassed return air to reheat it, return air bypass offers a very efficient and cost effective humidity control option.

![Figure 3: Air Side Economizer](image)

• **Energy recovery**
  o The AAONAIRE energy recovery system can boost the savings of both the economizer and dehumidification systems.
  o By preheating and/or precooling the outside supply air with energy from exhaust air the economizer function can be used for more hours during the year recycling valuable heating and cooling dollars.
  o When outside humidity is high, the AAONAIRE energy recovery system dehumidifies the outside air. This greatly reduces the latent load on the air conditioning equipment. Air conditioners use much energy to dehumidify moist airstreams. Excessive moisture in a data center can result in hardware failure and critical downtime. Additionally during the winter, when outside air is dry, the AAONAIRE energy recovery system humidifies the incoming dry outside air. This result is increased uptime, reduced humidification and dehumidification requirements and year-round energy dollars saved.

![Figure 4: Return Air Bypass & Modulating Hot Gas Reheat](image)

The psychrometric chart of Figure 5 shows the temperature and humidity moderating affect of the AAONAIRE energy recovery system. This Figure assumes a 75% effective total energy wheel.

![Figure 5: Psychrometric Chart](image)
The center point of the chart represents the return air conditions entering the AAONAIRE energy recovery system. The differing outside air conditions, represented by circles, are shown at various points on the psychrometric chart. The resultant air properties entering the HVAC equipment are represented by diamonds. In all cases, heating and cooling requirements are significantly reduced with the addition of the AAONAIRE energy recovery system.

**REASONS FOR AAON PRECISION AIR CONDITIONING**

1 - Sensible Heat Ratio
A heat load has two separate components: sensible heat and latent heat. Sensible heat removal or addition causes corresponding changes in air-dry bulb temperature. Latent heat is associated with 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.

\[
\text{Total Cooling Capacity} = \text{Sensible Cooling} + \text{Latent Cooling}
\]

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

\[
\text{Sensible Heat Ratio (SHR)} = \frac{\text{Sensible Cooling}}{\text{Total Cooling}}
\]

![Figure 6: Precision vs. Comfort Sensible Heat Ratio](image)

In a technology room, the cooling load is made up almost entirely of sensible heat, as shown in Figure 6, coming from IT hardware, lights, support equipment, and motors. There is very little latent load since there are few people and limited outside air. The required SHR of an air conditioner to match this heat load profile is very high, 0.95-0.99. AAON precision air conditioning is designed to meet these very high sensible heat ratios.

In contrast, a standard air conditioner typically has been designed for a SHR of 0.65-0.70, thereby providing 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. In order to maintain the desirable 40-55% relative humidity band, continuous humidification would be necessary, which would consume large quantities of energy.

2 - Variable Capacity, Precision Temperature and Humidity Control

![Figure 7: Pulse Width Capacity Modulation of Variable Capacity Compressor](image)

AAON precision air conditioning systems have the fast-acting controls necessary to react quickly to changing conditions and maintain the tight tolerances required for a stable environment. AAON precision air conditioning systems usually include variable capacity scroll compressors capable of modulating cooling capacity between 10 and 100% as shown in Figure 7. AAON precision air conditioning systems are also available with multiple stages or modulating heating, a humidifier, and a dedicated dehumidification cycle, allowing the unit to satisfy any and all temperature and humidity control.
requirements. Standard air conditioners generally have basic, limited components unable to react quickly enough to maintain the required tolerance. Standard systems do not usually include precise dehumidification cycles necessary for a stable technological environment. The standard unit components, if available, are frequently “add-ons” and not part of an integrated system.

Technology spaces of today require infrastructure power to be minimized, allowing maximum power availability for computational needs. A major source of energy consumption with precision air conditioning systems is the supply fan. Constant air volume systems require much more energy than variable air volume systems.

To properly match the variable technology heat load, the precision air conditioner should provide variable cooling and airflow. For this reason, AAON precision air conditioning systems are available as variable air volume systems, minimizing fan energy and allowing maximized technology power availability. Figure 9 shows example energy savings of the Variable Air Volume (VAV) system (blue) to the Constant Air Volume (CV) system (red).

Figure 8: Variable capacity compressor without hot gas bypass compared to fixed capacity compressor with hot gas bypass

The AAON precision air conditioner’s ability to modulate capacity yields a high efficiency system and year round energy savings, as shown in Figure 8.

3- Variable Capacity Air Movement Efficiency
AAON precision air conditioning systems operate at a high air flow rate per unit heat removed, generally, 120-160 cfm per kW (410-550 cfm per ton) or greater. This high volumetric rate moves more air through the space improving air distribution and reducing the chance of localized hot spots. The high cfm/kW of precision cooling equipment also allows more air to move through filters, ensuring a cleaner environment. AAON precision air conditioners can be equipped with moderate to high-efficiency, deep-pleated filter bank, to minimize airborne particles.

AAON precision air conditioners utilize direct drive fan assemblies – removing the need for belt driven fans. Belt efficiencies are similar in size and scale to motor efficiencies; belts on smaller motors have efficiencies around 75-85% while belts used with larger motors generally have efficiencies around 90-95% when first installed. However, efficiency deteriorates by as much as 5% (to a nominal efficiency of 85-90%) over time due to run in and tension loss as a result of stretching.
Stretching produces belt slippage. In addition to slippage, efficiency losses are due to wrapping losses as the belt is stretched and drawn around pulleys thus generating heat; smaller pulleys exacerbate these losses, and are less efficient.

When considering the efficiency of the fan system (Power Out ÷ Power In) there are multiple locations where power is lost in the conversion from electrical power in to fan power out. Figure 10 shows a belt-driven, housed centrifugal fan system. It can be seen that losses stem from the motor, belt and impeller. Figure 11 shows an AAON precision direct drive system, it can be seen that belt losses are completely eliminated in this configuration. When selecting fans for a particular application, the application efficiency is best used when comparing fan types.

4- Heat Density
Heat densities in technology rooms can be hundreds of times higher than in a typical office setting and densities continue to increase. To illustrate, one ton of comfort air conditioning capacity (12,000 Btu/hour or 3413 Watts) is generally required per 300-400 square feet of office space. This translates to approximately 10 watts per square foot.

In contrast, one ton of precision air conditioning capacity can be required per 3-4 square feet of data center space. At four square feet per ton, this translates into a much larger 880 watts per square foot. This number continues to increase yearly as technology room loads continue to increase.

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5- Adaptability/Scalability

Industry projections of power density requirements show great uncertainty, however, data centers must meet requirements for future years. AAON has precision control air conditioning systems ranging from 2 to 365 tons (7 Kw to 1.3 mw), allowing you to adapt and scale your cooling capacity as your needs change. In addition, AAON precision control units can be located on the building roof, or other space outside of the critical white space, allowing for optimized white space utilization.

AAON offers small precision air conditioning systems range from 2 to 5 tons (7 to 17 kW) with variable cooling capacities, variable supply airflow and variable chiller capacity. Typical applications include wiring closets, telecom rooms and small computer and server rooms.

AAON medium precision air conditioning systems extend up to 70 tons (250 kW) with variable cooling capacities, variable supply airflow and variable chiller capacity. Typical applications include computer rooms and small data centers.

AAON large precision air conditioning systems extend up to 365 tons (1.2 MW) with variable cooling capacity and variable supply airflow, as well as, factory installed chiller pumping packages. Typical applications include medium to large data centers.

6- Reliability/Availability

Built in redundancies are a must in critical applications because precision cooling must be continuously available. Typically N+1 or 2N redundancy may be deployed depending on the criticality of the application.

AAON offers many redundancy features

- Multiple Independent Refrigeration Circuits
- Dual Input Power Options
- Dual End Chillers
- Dual Arm Pumps
• Multiple Fans with Back Draft Dampers for N+1 or 2N redundancy

• And many more features to keep your system operating year round, 7 days a week, 24 hours a day.

7 - Security
The security of the air conditioning system is as important as that of the data center/server hardware since the hardware cannot operate without environmental control. AAON precision control units can be placed on a roof or some other secure area within the facility. Proper equipment security measures should be taken to ensure no operational interruptions. AAON precision heating and cooling equipment can be provided with lockable handles on all service doors, coil guards and factory installed burglar bars to prevent building entrance through the air conditioning unit.

SYSTEM SELECTION
1. Air Cooled
• Refrigeration system can “split” between indoor air conditioner and outdoor air-cooled heat rejection unit or packaged with both evaporator and condenser outside.
• Compressors can be located in the indoor or outdoor equipment.
• Field installed refrigerant pipelines (two per compressor or circuit) may interconnect indoor and outdoor units. Packaged units are provided with all refrigerant pipelines installed and tested.
• For split systems, refrigerant piping design is critical. The design must address pressure losses, refrigerant velocities, oil return, and traps.
• Excellent for multiple units and expanding installations. Packaged systems are self-contained, stand-alone modules.

2. Water Cooled
• Indoor air conditioner is a complete, self-contained refrigeration system.

Figure 14: Lockables Handles
• Heat is rejected to a coolant water supply via a heat exchanger in the indoor unit. The coolant water is then usually pumped to a cooling tower and re-circulated. Other water sources such as wells can also be used.
• Cooling tower should be winterized in cold and temperate climates.
• Tower should be designed with redundancy, or an emergency back-up water supply should be available.
• Water treatment is required when a cooling tower is used.
• The refrigeration system arrives factory charged and tested.

3. Chilled Water

• Chilled water is supplied from a chiller to air handling units in the technology room. The refrigeration system is contained in the packaged chiller.
• Indoor air conditioners contain controls, chilled water coil, chilled water control valve, blowers, filters, humidifiers and reheat.
• Chilled water temperature should be as high as possible to keep a high sensible heat ratio (47°F/8.3°C or higher).
• Redundancy should be extended to chiller plant and pump packages.
• Chiller plant should be winterized for year-round operation.
• Do not combine with comfort cooling chillers since chilled water supply temperatures should differ (42°F/5.6°C for comfort vs. 47°F+/8.3°C+ for technology room).

4. Supplementary Chilled water Coil

• A supplementary chilled water coil can be included in a direct expansion refrigerant system to provide complete redundancy in a single unit.
• Unit may operate as a chilled water system with 100% modular DX back up in the event of an emergency.
• Unit may act as a direct expansion refrigerant system with emergency central plant chilled water back up if required.

CONCLUSION
Technology rooms 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.

AAON precision air conditioning systems provide the efficiency, reliability and flexibility to meet the increasing demands for heat rejection, humidity control, filtration, and other requirements of technology rooms and other high availability computer facilities.

Contact your local AAON representative to learn more about the many heating and cooling solutions AAON can provide.
References/Industry Links:
www.thegreengrid.org
www.blade.org
www.7x24exchange.org
www.uptimeinstitute.org
www.ashrae.org
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