

The Different Types of Air Conditioning Equipment for IT Environments

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White Paper #59

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Executive Summary

Cooling equipment for an IT environment can be implemented in 10 basic configurations. The selection of the appropriate configuration for a particular installation is affected by the existing facility infrastructure, the total power level of the installation, the geographical location, and the physical constraints of the building. This document describes the 5 fundamental cooling transport methods that combine with 2 fundamental physical arrangements to give rise to the 10 basic configurations. A method for selection of the appropriate configuration for a particular installation is described. The information in this paper allows IT professionals to be more involved in the specification of precision cooling solutions that better align with IT objectives.

Introduction

Data Center and IT room heat removal is one of the most essential yet least understood of all critical IT environment processes. As the latest computing equipment becomes smaller and uses the same or even more electricity than the equipment it replaced, more heat is being generated in data centers. Precision cooling and heat rejection equipment is used to collect and transport this unwanted heat energy to the outside atmosphere.

This paper describes equipment that produces cool air (removes heat). It explains the different components and cooling methodologies designed to transport heat energy from the IT environment to the outside atmosphere. It provides information describing the best configurations for different IT environments and common practices and equipment options that may increase cooling system availability and decrease costs. The information presented here is a foundation allowing IT professionals to successfully manage the specification, installation, and operation of IT environment cooling systems.

Suggested complementary reading

How air conditioners work

APC White Paper #57, “Fundamental Principles of Air Conditioners for Information Technology” provides information regarding the nature of heat in the IT environment, operation of the refrigeration cycle and the basic functionality of precision cooling devices and outdoor heat rejection equipment.

Air distribution

APC White Paper #55, “Air Distribution Architecture Options for Mission Critical Facilities” provides information regarding the nine basic ways to use air to cool IT equipment in data centers and network rooms. This is a very important part of the cooling system as air distribution to IT equipment greatly affects its overall performance.

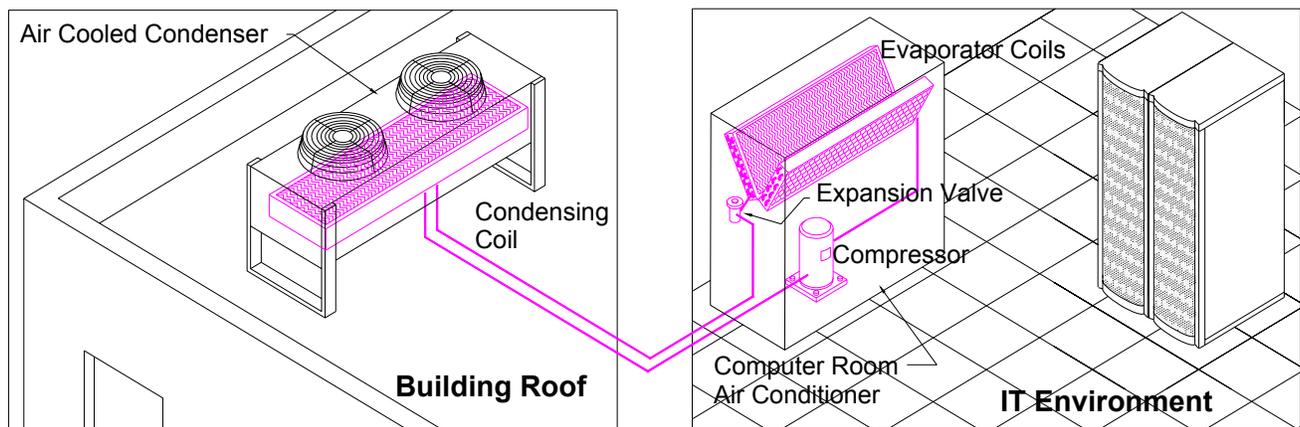
The 5 basic IT environment heat removal methods

There are 5 basic ways to collect and transport unwanted heat from the IT environment to the outdoor environment. One or more of these methods are used to cool virtually all mission critical computer rooms and data centers. Each method uses the refrigeration cycle to transport or *pump* heat from the data center or computer room to the outside environment. Some methods relocate the components of the refrigeration cycle away from the IT environment and some add additional *loops* (self-contained pipelines) of water and other liquids to aid in the process. The following sections provide a detailed look at the systems that incorporate these methods.

Air cooled systems (2-piece)

Air cooled computer room air conditioners are widely used in IT environments of all sizes and have established themselves as the “staple” for small and medium rooms. This type of system is often referred to as a *DX* system or *split system*. The “DX” designation stands for direct expansion and although this term often refers to an air cooled system, in fact any system that uses refrigerant and an evaporator coil can be called a DX system. In an air cooled system half the components of the refrigeration cycle are in the *computer room air conditioner* (also known as a *CRAC* unit) and the rest are outdoors in the air cooled condenser as shown in **Figure 1**. Refrigerant circulates between the indoor and outdoor components in pipes called refrigerant lines. Heat from the IT environment is “pumped” to the outdoor environment using this circulating flow of refrigerant.

Figure 1 – Air cooled DX system (2-Piece)



Advantages:

- Lowest overall cost
- Easiest to maintain

Disadvantages:

- Refrigerant piping must be installed in the field. Only properly engineered piping systems that carefully consider the distance and change in height between the IT and outdoor environments will deliver reliable performance.
- Refrigerant piping cannot be run long distances reliably and economically.
- Multiple computer room air conditioners cannot be attached to a single air cooled condenser.

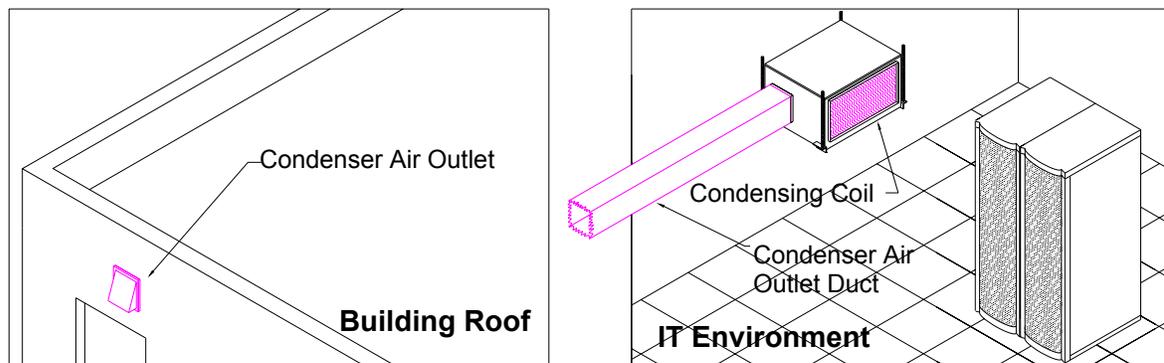
Usually Used:

- In wiring closets, computer rooms and small-to-medium data centers with moderate availability requirements.

Air cooled self-contained systems (1-piece)

Self-contained systems locate all the components of the refrigeration cycle in one enclosure that is usually found in the IT environment. Heat exits the self-contained system as a stream of hot (about 120°F [49°C]) air called *exhaust air*. This stream of hot air must be routed away from the IT room to the outdoors or into an unconditioned space to ensure proper cooling of computer equipment as illustrated in **Figure 2**. If mounted above a drop ceiling and not using condenser air inlet or outlet ducts, the hot exhaust air from the condensing coil can be rejected directly into the drop ceiling area. The building's air conditioning system must have available capacity to handle this additional heat load. Air that is drawn through the condensing coil (becoming exhaust air) should also be supplied from outside the computer room. This will avoid creating a vacuum in the room that would allow warmer, unconditioned air to enter. Self-contained indoor systems are usually limited in capacity (up to 15kW) because of the additional space required to house all the refrigeration cycle components and the large air ducts required to manage exhaust air. Self-contained systems that mount outdoors on a building roof can be much larger in capacity but are not commonly used for precision cooling applications.

Figure 2 – Air cooled self-contained system (1-piece)



Advantages:

- Indoor self-contained systems have the lowest installation cost. There is nothing to install on the roof or outside the building.
- All refrigeration cycle components are contained inside one unit as a factory-sealed and tested system for highest reliability.

Disadvantages:

- Less heat removal capacity per unit compared to other configurations.
- Air routed into and out of the IT environment for the condensing coil usually requires ductwork and/or dropped ceiling.

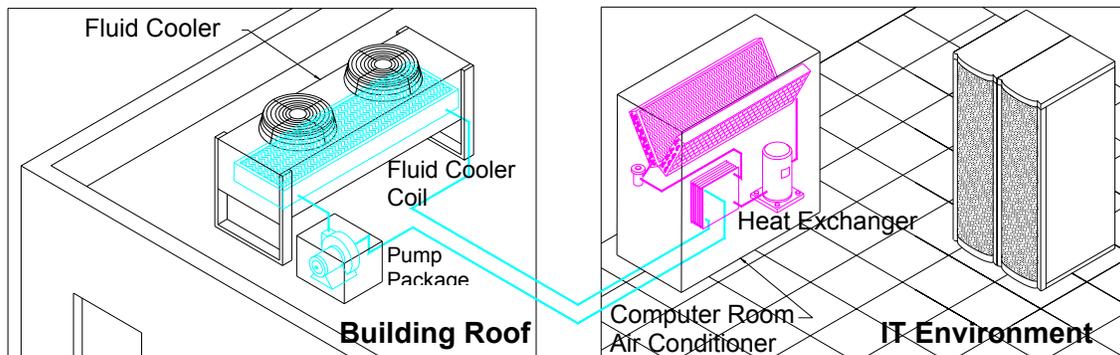
Usually Used:

- In wiring closets, laboratory environments and computer rooms with moderate availability requirements. Sometimes used to fix hot spots in data centers.

Glycol cooled systems

This type of system locates all refrigeration cycle components in one enclosure (like a self-contained system) but replaces the bulky condensing coil with a much smaller *heat exchanger* shown in **Figure 3**. The heat exchanger uses flowing glycol (a mixture of water and ethylene glycol, similar to automobile anti-freeze) to collect heat from the refrigerant and transport it away from the IT environment. Heat exchangers and glycol pipes are always smaller than condensing coils (2-piece air cooled systems) and condenser air ducts (self-contained air cooled systems) because the glycol mixture has the capability to collect and transport much more heat than air does. The glycol flows via pipes to an outdoor-mounted device called a *fluid cooler*. Heat is rejected to the outside atmosphere as fans force outdoor air through the warm glycol-filled coil in the fluid cooler. A pump package (pump, motor and protective enclosure) is used to circulate the glycol in its loop to and from the computer room air conditioner and fluid cooler.

Figure 3 – Glycol cooled system



Advantages:

- The entire refrigeration cycle is contained inside the computer room air conditioning unit as a factory-sealed and tested system for highest reliability with the same floor space requirement as a two piece air cooled system.
- Glycol pipes can run much longer distances than refrigerant lines (air cooled system) and can service several computer room air conditioning units from one fluid cooler and pump package.
- In cold locations, the glycol within the fluid cooler can be cooled so much (below 50°F [10°C]) that it can bypass the heat exchanger in the CRAC unit and flow directly to a specially installed *economizer coil*. Under these conditions, the refrigeration cycle is turned off and the air that flows through the economizer coil, now filled with cold flowing glycol, cools the IT environment. This process is known as “*free cooling*” and provides excellent operating cost reductions when used.

Disadvantages:

- Additional required components (pump package, valves) raise capital and installation costs when compared with air cooled DX systems.
- Maintenance of glycol volume and quality within the system is required.
- Introduces an additional source of liquid into the IT environment.

Usually Used:

- In computer rooms and small-to-medium data centers with moderate availability requirements.

Water cooled systems

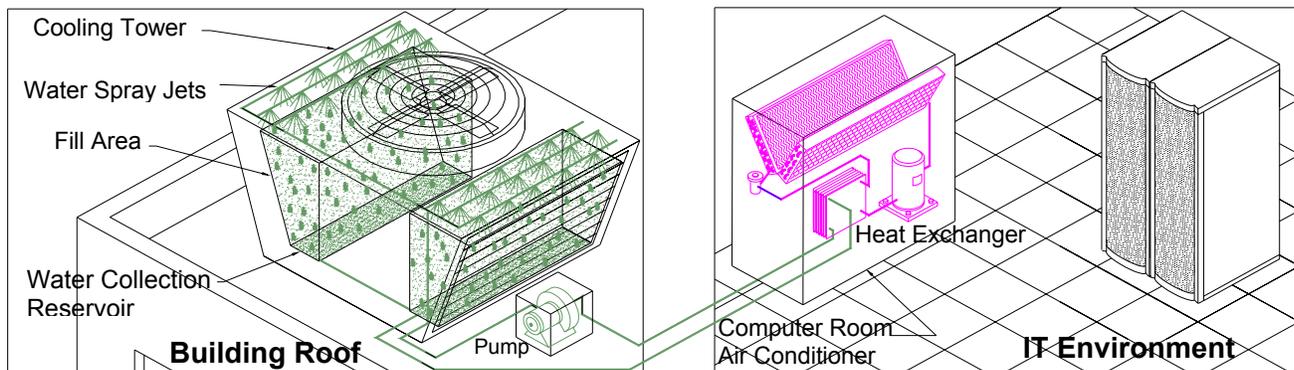
Water cooled systems are similar to glycol cooled systems in that all refrigeration cycle components are located inside the computer room air conditioner. However, there are two important differences between a glycol cooled system and a water cooled system:

- A water (also called *condenser water*) loop is used instead of glycol to collect and transport heat away from the IT environment
- Heat is rejected to the outside atmosphere via a *cooling tower* instead of a fluid cooler.

As seen in **Figure 4**, a cooling tower rejects heat from the IT room to the outdoor environment by spraying warm condenser water onto sponge-like material (called *fill*) at the top of the tower. The water spreads out and some of it evaporates away as it drips and flows to the bottom of the cooling tower (a fan is used to help speed up the evaporation by drawing air through the fill material). In the same manner as the human body is cooled by the evaporation of sweat, the small amount of water that evaporates from the cooling tower serves to lower the temperature of the remaining water. The cooler water at the bottom of the tower is collected and sent back into the condenser water loop via a pump package.

Condenser water loops and cooling towers are usually not installed solely for the use of water cooled computer room air conditioning systems. They are usually part of a larger system and may also be used to reject heat from the building's comfort air conditioning system (for cooling people) and water chillers (water chillers are explained in the next section).

Figure 4 – Water cooled system



Advantages:

- All refrigeration cycle components are contained inside the computer room air conditioning unit as a factory-sealed and tested system for highest reliability.
- Condenser water piping loops are easily run long distances and almost always service many computer room air conditioning units and other devices from one cooling tower.
- In leased IT environments, usage of the building's condenser water is generally less expensive than chilled water (chilled water is explained in the next section).

Disadvantages:

- High initial cost for cooling tower, pump, and piping systems.
- Very high maintenance costs due to frequent cleaning and water treatment requirements.

- Introduces an additional source of liquid into the IT environment.
- A non-dedicated cooling tower (one used to cool the entire building) may be less reliable than a cooling tower dedicated to the Computer Room Air Conditioner.

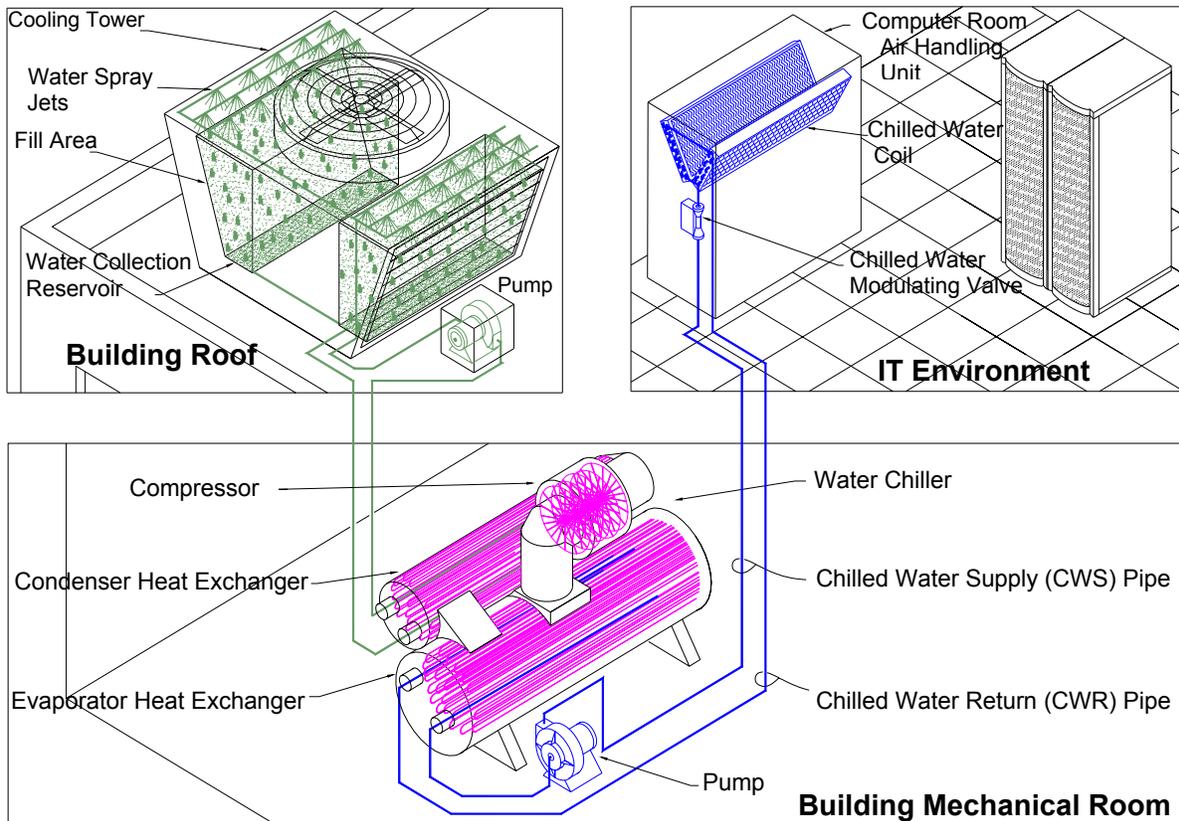
Usually Used:

- In conjunction with other building systems in small, medium and large data centers with moderate-to-high availability requirements.

Chilled water systems

In a chilled water system the components of the refrigeration cycle are relocated from the computer room air conditioning systems to a device called a *water chiller* shown in **Figure 5**. The function of a chiller is to produce *chilled water* (water refrigerated to about 46°F [8°C]). Chilled water is pumped in pipes from the chiller to *computer room air handlers* (also known as *CRAH* units) located in the IT environment. Computer room air handlers are similar to computer room air conditioners in appearance but work differently. They cool the air (remove heat) by drawing warm air from the computer room through *chilled water coils* filled with circulating chilled water. Heat removed from the IT environment flows out with the (now warmer) chilled water exiting the CRAH and returning to the chiller. At the chiller, heat removed from the returning chilled water is usually rejected to a condenser water loop (the same condenser water that water cooled computer room air conditioners use) for transport to the outside atmosphere. Chilled water systems are usually shared among many computer room air handlers and are often used to cool entire buildings.

Figure 5 – Chilled water system



Advantages:

- Computer room air handlers generally cost less, contain fewer parts, and have greater heat removal capacity than computer room air conditioners with the same footprint.
- Chilled water piping loops are easily run very long distances and can service many IT environments (or the whole building) from one chiller plant.
- Chilled water systems can be engineered to be extremely reliable.
- Chilled water systems have the lowest cost per kW for large installations.

Disadvantages:

- Chilled water systems generally have the highest capital costs for installations below 100kW of electrical IT loads.
- CRAHs generally remove more moisture from data center air than their CRAC counterparts, requiring more money be spent on humidifying the room in many climates.
- Introduces an additional source of liquid into the IT environment.

Usually Used:

- In conjunction with other systems in medium and large data centers with moderate-to-high availability requirements or as a high availability dedicated solution in large data centers.

The 2 fundamental physical arrangements of precision cooling equipment

There are 2 basic arrangements of precision cooling equipment. There are systems that attach to the ceiling and systems that stay on the floor. Variants, such as wall-mounted or mini-split systems are similar to ceiling mounted systems and are employed similarly when adequate wall space is available.

Ceiling mounted systems

These are small (300-500 pound) (136-227 kg) precision cooling devices suspended from the IT room's structural ceiling. They cool 3-17kW of computer equipment and utilize any of the 5 IT environment heat removal methodologies. Ceiling mounted systems (**Figure 6**) do not require floor space in the IT environment however installation and maintenance activities are more complicated due to their overhead placement. Specification, installation and maintenance of ceiling mounted precision cooling systems should be accomplished among IT professionals, facilities personnel and manufacturer's representatives or mechanical contractors.

Figure 6 – Typical ceiling mounted computer room air conditioner



It is important to make a distinction between ceiling mounted systems and rooftop systems. A self-contained rooftop DX system is usually associated with the cooling of office space and humans (comfort cooling). A brief description is provided because sometimes specially configured or custom units are used to cool IT environments. Most rooftop DX systems are completely self-contained and range in capacity from 40 to 150 kW. All refrigeration system components including the air cooled condenser are contained in one large enclosure. For operation, only an electrical supply and two roof openings are required to let air in and out. Inside the IT environment a rooftop system usually needs air ducts installed to distribute cooling air to equipment loads. Using a system of this type that is not optimized for the IT environment can cause low humidity conditions that are potentially destructive to IT equipment.

Floor mounted systems

Floor mounted precision cooling systems usually offer the greatest range of features and capabilities. They are increasingly being used to cool or to assist in the cooling of smaller IT environments as power consumption of computer equipment continues to increase.

Portable systems (also known as spot coolers) are considered part of the floor mounted category, however they almost always have wheels and can be easily located anywhere precision cooling is required (**Figure 7**). Portable systems cool 2-6kW of computer equipment and often a normal wall outlet can be used to supply electrical power (2-4kW models). Portable systems are almost always self-contained systems. Specification, installation and maintenance of most portable cooling systems can be accomplished by IT professionals without the assistance of facilities personnel or mechanical contractors.

Figure 7 – Typical floor mounted portable computer room air conditioner



Large floor mounted precision cooling systems have been extensively used to cool mission critical computing environments since their inception. These are usually the highest capacity cooling devices found in the IT environment with the ability to cool 20kW to over 200kW of IT equipment per chassis. Floor mounted systems utilize IT environment floor space and must be strategically located in the room for maximum effectiveness. Specification, installation and maintenance of large floor mounted precision cooling systems is highly dependent on the existing electrical, mechanical and structural capabilities of the building

they are to be operated in. *For this reason it is important for IT professionals to work closely with facilities management and manufacturer's representatives during the specification process. Often the services of a State-Registered Professional Engineer are required to design and certify the solution.* Most mechanical contracting firms familiar with the IT environment can install and if desired, maintain the solution. Recent developments in large floor mounted systems have reduced their energy consumption and the overall space they require in the computer room or data center. Their outer dimensions and appearance have changed so they fit in spaces sized for IT rack enclosures as seen in **Figure 8**. This allows for operational cost savings and more flexibility in IT environment planning.

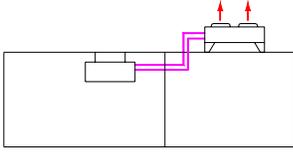
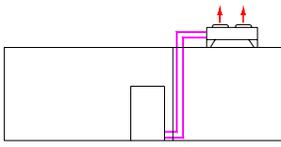
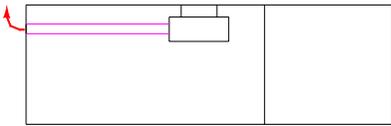
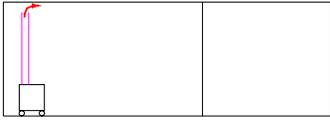
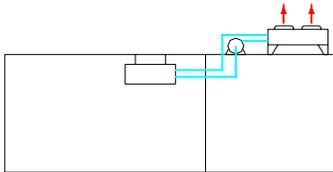
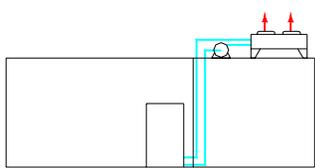
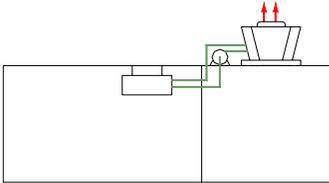
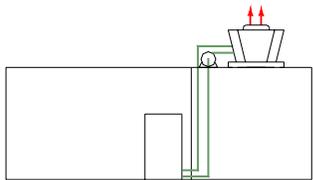
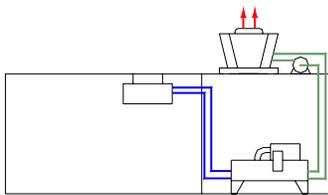
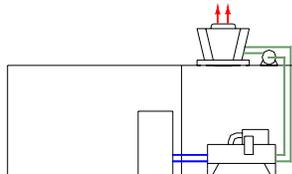
Figure 8 – Typical floor mounted computer room air conditioner



The 10 combinations of heat removal methods and equipment arrangements

The various equipment arrangements combined with their applicable heat removal methods are shown in **Table 1**. Any time the use of condenser water or chilled water is considered, consultation with facilities personnel or a cooling professional is recommended to ensure adequate capacity remains in the system for the proposed solution.

Table 1 – The 10 basic cooling system configurations

	Ceiling Mounted	Floor Mounted
Air Cooled System (2Piece)	 <p>Requires roof access and a 10' (3m) floor to structural ceiling height. Roof should be within 2 stories of IT environment. Air cooled condenser and refrigerant piping required.</p>	 <p>Requires roof access. Roof should be within two stories of IT environment. Requires air cooled condenser and refrigerant piping. Portable systems usually don't use outdoor components.</p>
Air Cooled Self Contained System (1Piece)	 <p>IT environment must have dropped ceiling or ducts should be installed for condenser air. Ensure 10' (3m) floor to structural ceiling height.</p>	 <p>IT environment must have dropped ceiling for condenser air tubes. Large floor mounted systems require outdoor heat rejection components</p>
Glycol Cooled Systems	 <p>Building must have roof access and a 10' (3m) floor to structural ceiling height. Fluid cooler, pump package and glycol piping required.</p>	 <p>Requires roof access. Fluid cooler, pump package and glycol piping required. Portable systems usually don't use outdoor components.</p>
Water Cooled Systems	 <p>Building must have 10' (3m) floor to structural ceiling height. Hookup to building condenser water required</p>	 <p>Building must have condenser water system with adequate capacity. Hookup required. Portable systems don't use condenser water.</p>
Chilled Water Systems	 <p>Building has 10' (3m) floor to structural ceiling height and reliable chilled water system. Chilled water hookup required.</p>	 <p>Building must have reliable chilled water system with adequate capacity. Chilled water hookup required. Portable systems usually don't use chilled water.</p>

Which cooling solutions are appropriate for use in different size IT environments?

A practical guide describing appropriate cooling configurations for different sized IT environments is shown below in table format. Use the tables as a reference when working with facilities personnel and cooling professionals in the specification, installation and operation of precision cooling solutions. Five sizes are considered:

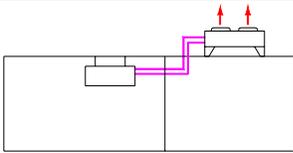
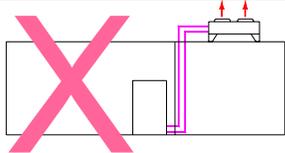
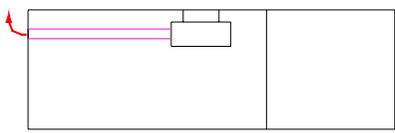
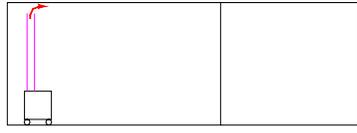
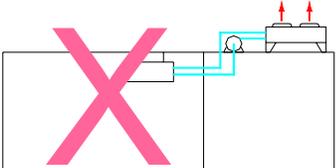
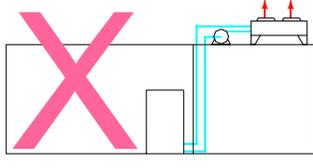
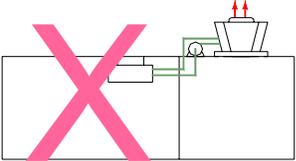
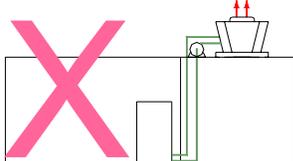
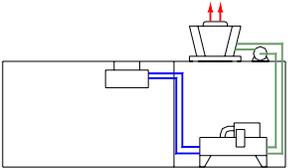
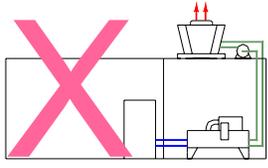
Wiring closets	(1-3 rack enclosures or equivalent using 1-18 kW of electricity)
Computer rooms	(1-5 rack enclosures or equivalent using 3-30 kW of electricity)
Small data centers	(5-20 rack enclosures or equivalent using 7-100 kW of electricity)
Medium data centers	(20-100 rack enclosures or equivalent using 28-500 kW of electricity)
Large data centers	(> 100 rack enclosures or equivalent using >200 kW electricity)

Cooling solutions marked with an “X” in a configuration diagram are generally not used with the associated heat removal method in that size space, although exceptions apply. A good example of this is a small computer room in a building that has nearby chilled water piping (very common in hi-rise buildings). Although the most common solution for the small computer room is an air cooled DX unit, installing a chilled water computer room air handler and feeding it with the nearby chilled water can save time and money. Any time a condenser water or chilled water system is considered consultation with facilities personnel or a cooling professional is recommended to ensure adequate capacity remains in the system to support the proposed solution.

Wiring closets

Wiring closets (1-3 rack enclosures or equivalent using 1-18 kW of total electricity) often present unique cooling challenges due to their small size and ventilation restrictions. If closet temperatures are high, first try to increase ventilation to IT and communications equipment. If temperatures remain high and a precision cooling solution is required, ensure equipment ventilation and clearance requirements can be met for the proposed solution.

Table 2 – Basic cooling system configurations for wiring closets

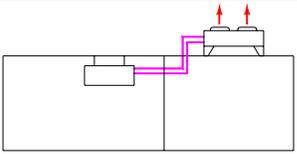
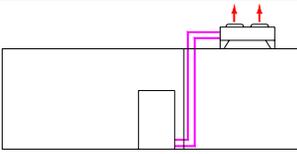
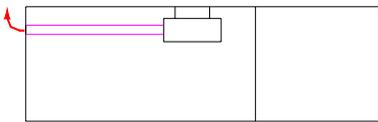
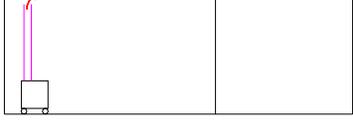
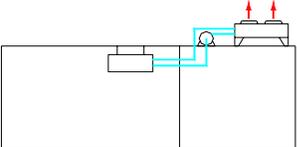
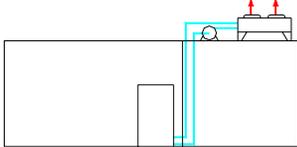
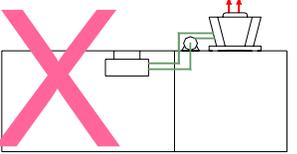
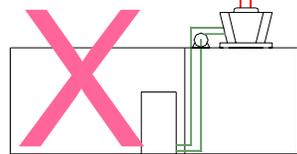
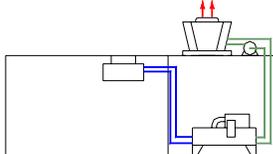
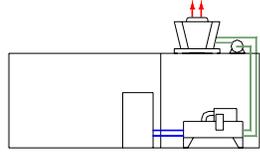
	Ceiling Mounted	Floor Mounted
Air Cooled DX System (2Piece)	 <p>Use if: Building has roof access and enough room for solution. Roof is within 2 stories of wiring closet. Use for 3-17kW of equipment.</p>	 <p>Take up significant floor space in a wiring closet. Typically sized system much larger than wiring closet requirements.</p>
Air Cooled Self Contained System (1Piece)	 <p>Use if: Ducts can be installed to supply and return condenser air. Use for 3-17kW of equipment.</p>	 <p>Use if: Ease of install and portability are advantages. Hot air exhaust ducts can be run outside the wiring closet. Use for 3-6 kW of equipment.</p>
Glycol Cooled Systems	 <p>Not commonly used in this power range</p>	 <p>Take up significant floor space in a wiring closet. Typically sized system much larger than wiring closet requirements.</p>
Water Cooled Systems	 <p>Not commonly used in this power range</p>	 <p>Take up significant floor space in a wiring closet. Typically sized system much larger than wiring closet requirements.</p>
Chilled Water Systems	 <p>Use if: The only cooling source is chilled water, no possible location for outdoor condensers. Some hi-rise buildings.</p>	 <p>Take up significant floor space in a wiring closet. Typically sized system much larger than wiring closet requirements.</p>

Computer rooms

Computer rooms (1-5 rack enclosures or equivalent using 3-30 kW of total electricity) are often reused office space with varying levels of available space and ventilation. For rooms with very small electrical loads the building air conditioning system may be sufficient provided adequate ventilation is provided to the room.

Most computer rooms require multiple portable or ceiling mounted systems and some heavily loaded rooms work well with a large floor mounted system if floor space is available.

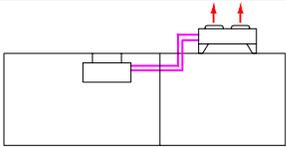
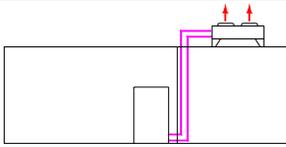
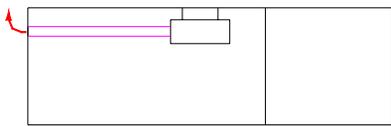
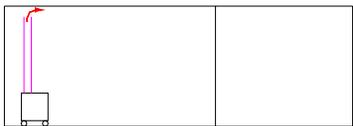
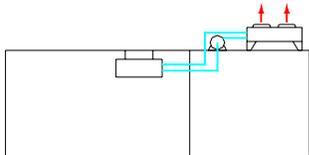
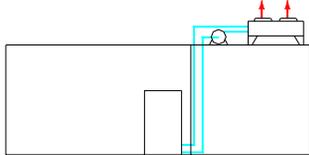
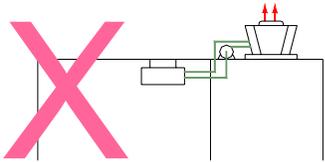
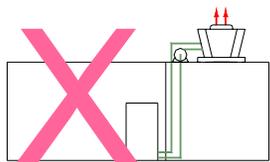
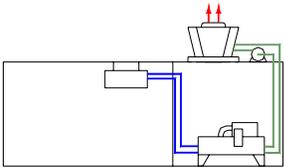
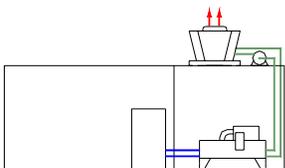
Table 3 – Basic cooling system configurations for computer rooms

	Ceiling Mounted	Floor Mounted
Air Cooled DX System (2Piece)	 <p>Use if: Building has roof access and a 10' (3m) floor to structural ceiling height. Roof is within 2 stories of IT environment. Single or multiple systems are a good choice for 6-30 kW loads</p>	 <p>Use if: Building has roof access and available space for solution. Roof is within two stories of IT environment. Single large system OK for loads greater than 25kW if it fits.</p>
Air Cooled Self Contained System	 <p>Use if: IT environment has dropped ceiling or ducts can be installed for condenser air. Ensure 10' floor to structural ceiling height. Single or multiple ceiling mounted systems are a good choice for 6-30 kW loads</p>	 <p>Use if: Dropped ceiling for condenser air ducts exists. Single or multiple portable systems are OK for less than 12 kW of equipment</p>
Glycol Cooled Systems	 <p>Use if: Building has roof access and a 10' (3m) floor to structural ceiling height. Computer room is a long distance to outdoors.</p>	 <p>Use if: Building has roof access and available space for solution. Single large system OK for loads greater than 25kW if it fits. Use if free cooling is desired in areas with cold winters.</p>
Water Cooled Systems	 <p>Condenser water is usually not routed far from mechanical room. Use is a possibility in some hi-rise buildings.</p>	 <p>Condenser water is usually not routed far from mechanical room. Use is a possibility in some hi-rise buildings.</p>
Chilled Water Systems	 <p>Use if: The only cooling source is chilled water, no possible location for outdoor condensers. Some hi-rise buildings.</p>	 <p>Use if: The only cooling source is chilled water, no possible location for outdoor condensers. Some hi-rise buildings.</p>

Small data centers

Small data centers (5-20 rack enclosures or equivalent using 7-100 kW of total electricity) are usually purpose-built rooms with sufficient space and ventilation for IT equipment. If the amount of electricity consumed by IT equipment is high (more than 3 kW per rack enclosure) then more space may have to be devoted to the room's cooling solution. Most small data centers use ceiling mounted and large floor mounted cooling systems. Portable systems are used as needed for hot spots and temporary cooling.

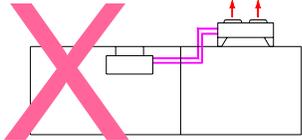
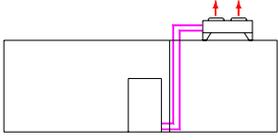
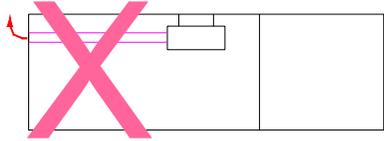
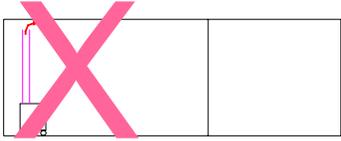
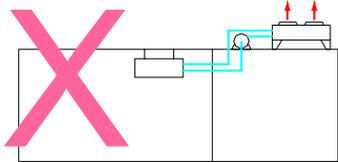
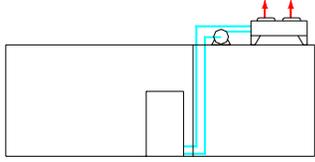
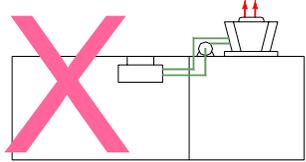
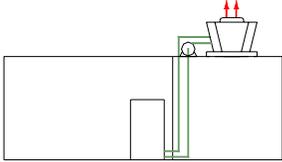
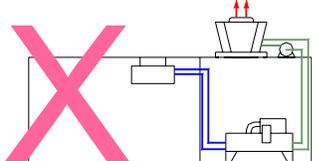
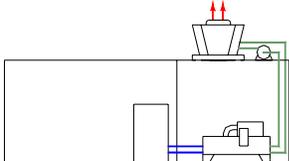
Table 4 – Basic cooling system configurations for small data centers

	Ceiling Mounted	Floor Mounted
Air Cooled DX System (2Piece)	 <p>Use if: Building has roof access and a 10' (3m) floor to structural ceiling height. Roof is within 2 stories of IT environment. Single or multiple systems are a good choice for 7-30 kW loads</p>	 <p>Use if: Building has roof access and roof is within two stories of IT environment. Large system(s) OK for loads greater than 25kW.</p>
Air Cooled Self Contained System	 <p>Use if: IT environment has dropped ceiling or ducts can be installed for condenser air. Ensure 10' floor to structural ceiling height. Single or multiple ceiling mounted systems are a good choice for 7-30 kW loads</p>	 <p>Use if: Dropped ceiling for condenser air ducts exists. Single or multiple portable systems are OK for hot spots or emergency use</p>
Glycol Cooled Systems	 <p>Use if: Building has roof access and a 10' (3m) floor to structural ceiling height. Long distance to outdoors.</p>	 <p>Use if: Building has roof access but data center is far away. Single large system OK for loads greater than 25kW. Use if free cooling is desired in areas with cold winters.</p>
Water Cooled Systems	 <p>Condenser water is usually not routed far from mechanical room. Use is a possibility in some hi-rise buildings.</p>	 <p>Condenser water is usually not routed far from mechanical room. Use is a possibility in some hi-rise buildings.</p>
Chilled Water Systems	 <p>Use if: The only cooling source is chilled water, no possible location for outdoor condensers. Some hi-rise buildings.</p>	 <p>Use if: The only cooling source is chilled water, no possible location for outdoor condensers. Some hi-rise buildings.</p>

Medium data centers

Medium data centers (20-100 rack enclosures or equivalent using 28-500 kW total electricity) are almost always purpose-built rooms with sufficient space and ventilation for IT equipment. If the amount of electricity consumed by IT equipment is high (averaging more than 3 kW per rack enclosure or equivalent) more space may have to be devoted to the room's cooling solution. Most medium data centers use multiple large floor mounted cooling systems.

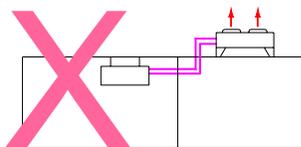
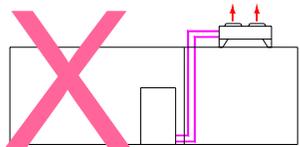
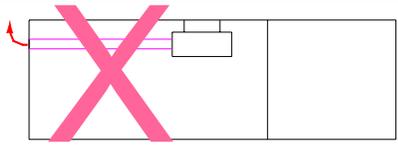
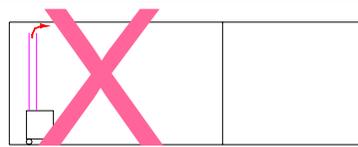
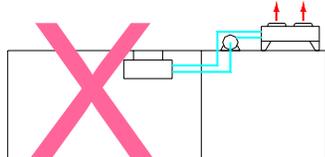
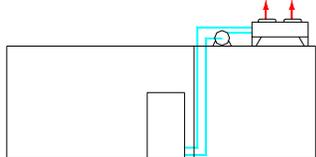
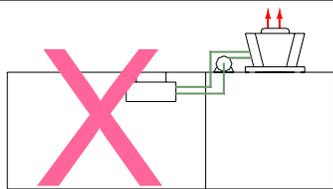
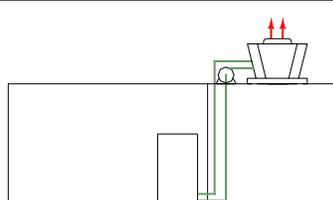
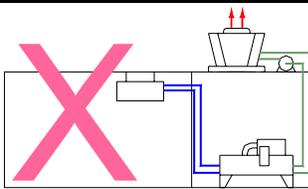
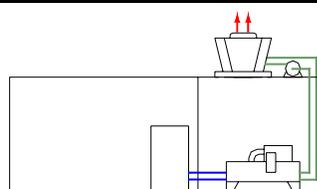
Table 5 – Basic cooling system configurations for medium data centers

	Ceiling Mounted	Floor Mounted
Air Cooled DX System (2Piece)	 <p>Insufficient capacity per unit</p>	 <p>Use if: Building has roof access and roof is adjacent the data center. For smaller and low-density data centers. Lowest cost solution.</p>
Air Cooled Self Contained System	 <p>Insufficient capacity per unit</p>	 <p>Insufficient capacity per unit</p>
Glycol Cooled Systems	 <p>Insufficient capacity per unit</p>	 <p>Use if: Building has roof access but data center is far away. No chilled water or condenser water already piped into data center. Use if free cooling is desired in areas with cold winters.</p>
Water Cooled Systems	 <p>Insufficient capacity per unit</p>	 <p>Use if: Building condenser water system has more available capacity or lower usage cost (high rise) than chilled water</p>
Chilled Water Systems	 <p>Insufficient capacity per unit</p>	 <p>Use if: Building has reliable chilled water supply without setbacks.</p>

Large data centers

Large data centers (> 100 rack enclosures or equivalent using >200 kW total electricity) are purpose-built rooms optimized for the availability of IT equipment. Rising power densities are forcing increased space allocation for cooling solutions. Large data centers use multiple large floor mounted cooling systems or very large custom rooftop central cooling systems (not shown in the diagrams below).

Table 6 – Basic cooling system configurations for large data centers

	Ceiling Mounted	Floor Mounted
Air Cooled DX System (2Piece)	 <p>Insufficient capacity per unit</p>	 <p>Large data centers usually have dedicated chilled water systems. Only use if no chilled water system exists or no capacity is available.</p>
Air Cooled Self Contained System (1Piece)	 <p>Insufficient capacity per unit</p>	 <p>Insufficient capacity per unit</p>
Glycol Cooled Systems	 <p>Insufficient capacity per unit</p>	 <p>Use if: Waterside free cooling is desired in areas with cold winters.</p>
Water Cooled Systems	 <p>Insufficient capacity per unit</p>	 <p>Use if: Building condenser water system has more available capacity or lower usage cost than chilled water</p>
Chilled Water Systems	 <p>Insufficient capacity per unit</p>	 <p>Use if: Data center has mission critical chilled water supply.</p>

Common cooling system equipment options

Numerous options are available to Facilities and IT professionals when specifying cooling solutions. Use the following guide in conjunction with the equipment manufacturer's technical literature. Note that options may vary based on the size and type of the solution considered.

Airflow direction. Large floor mounted systems flow air in a downward direction (downflow) or an upward direction (upflow) and some can even flow horizontally (horizontal flow). See APC White Paper #55, "Air Distribution Architecture Options for Mission Critical Facilities" for ways to distribute cooling air to computer equipment based on the direction of airflow.

- Use a downflow system in a raised floor environment or in a non-raised floor environment when system is mounted on a pedestal.
- Use an upflow system in an existing upflow environment
- Horizontal flow systems should be considered for IT consolidations and IT environment renovations using a hot/cold aisle configuration.

Fire, smoke, and water detection devices provide early warning and/or automatic shut off during catastrophic events.

- Use recommended in all units. Use mandatory if required by local building codes. Best used in conjunction with IT monitoring and building management systems for quickest notification.

Humidifiers are commonly located inside precision cooling devices to replace water vapor lost in the cooling process and are used to prevent IT equipment downtime due to static electrical discharge. See APC White Paper #58, "Humidification Strategies for Data Centers and Network Rooms" for more information on humidifiers and their functions.

- Use a humidifier in all computer room air conditioners and air handlers unless the room has a properly functioning vapor barrier and central humidification system. The room must have no current high or low humidity-related problems.

Reheat systems actually add heat to conditioned cold air exiting a precision cooling device to allow the system to provide increased dehumidification of IT environment air when it's required.

- Use a reheat system for rooms in warm, humid climates or in rooms with poor or non-existent vapor barriers.

Economizer coils use glycol to cool the IT environment in a manner similar to a chilled water system when the glycol stream is cold enough. Provides excellent operating cost reductions when used.

- Use in conjunction with glycol cooled units in cold climates.
- Use if required by local building codes (Pacific Northwest region of USA).

“**Multicool**” coils enable the use chilled water to be used in addition to the air cooled, glycol cooled or condenser water cooled DX system.

- Use if building chilled water is available but is unreliable or is frequently turned off.

Availability considerations and practices

The availability and reliability of a precision cooling system is most dependent upon the continued operation of the cooling and heat rejection devices (chillers, CRAC units, fluid coolers etc.), the proper engineering and installation of the piping that connects the devices, and the electricity and wiring that powers the system. A failure in any of these areas can lead to IT equipment downtime or damage.

One of the most important actions an IT professional can take is to work with facilities personnel or building management to ensure building chilled water and condenser water supplies are available every moment the dependent IT environment is operational. Many costly cooling system “failures” have occurred due to scheduled chiller or cooling tower downtime the IT professional was not aware of. There are also common design and maintenance practices to minimize single points of failure in cooling architectures. For example, on-time and properly performed preventative maintenance services always reduce the likelihood of equipment failure. A single cooling and heat rejection device added to a room’s cooling system can provide N+1 redundancy if a component fails. Always choose a reputable consulting engineer, mechanical contractor and electrical contractor to design and install critical piping systems and electrical feeds.

On-site power generation systems should be sized to handle IT environment cooling and power needs. Cooling systems are not commonly fed by uninterruptible power systems, however in high power density IT environments there is a growing trend towards providing uninterruptible power to CRAC and CRAH fan systems. This ensures continued air movement to minimize hot spots until electrical power returns or on-site generator systems start and restore full electrical power. Late model cooling equipment usually utilizes microprocessor control and reporting systems that seamlessly integrate with IT monitoring and building management systems to relay cooling system performance information and instantly notify responsible personnel when problems occur.

Conclusions

Cooling systems for data centers and network rooms are primarily differentiated in the way they physically reside in the IT environment and in the way they collect and transport heat to the outside atmosphere. There are 5 heat removal methods and 2 common physical equipment arrangements that can be combined to create 10 basic types of cooling systems.

Each of the 10 types of cooling systems possesses advantages and disadvantages that cause them to be preferred for various applications. The decision on which cooling system to choose should be based on the

uptime requirements, power density, geographic location and physical size of the IT environment to be protected, the availability and reliability of existing building systems, and the time and money available for system design and installation.

IT professionals versed in precision cooling components and heat removal methodologies can more effectively work with cooling professionals to ensure the specification of optimized cooling solutions that meet IT objectives.

About the Author:

Tony Evans is an engineer with APC in West Kingston, RI. He has 14 years of experience in power and cooling system design and is a member of ASHRAE Technical Committee 9.9 (Mission Critical Facilities, Technology Spaces, & Electronic Equipment).