



HVAC Cooling Systems for Data Centers

An Online Continuing Education Course for Engineers

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Abstract

Air-conditioning systems for data centers are designed for year-round cooling with very high cooling intensity per square foot of floor area. The high sensitivity of electronic components in such facilities requires that temperature, humidity, air movement and air cleanliness must be kept consistent and within specific limits to prevent premature equipment failures and costly downtime.

Because data centers are high-density, enclosed spaces that generate a significant amount of heat, traditional comfort cooling systems can't remove enough heat to protect the critical equipment. Instead, these unique areas require dedicated units with precision cooling capabilities. In a typical data center environment for example; the heat densities can be up to five times higher than in a typical office setting. To illustrate, one ton of comfort cooling capacity (12,000 BTU/hour, or 3,517 W) is required per 250-300 square feet of office space. This translates into 12 to 14 watts per square foot. In contrast, one ton of precision cooling capacity is required per 50-100 square feet of data center space, which translates to 35 to 70 watts per square foot on average. New data centers today are having load densities as high as 200 to 300 watts per square foot. From an airflow standpoint, precision cooling equipment typically supplies between 500 and 900 cubic feet per minute (CFM) per cooling ton. This contrasts with the much smaller range of 350 to 400 CFM per cooling ton typically delivered by comfort cooling equipment.

This 4- hour course presents some of the basic fundamental concepts governing design of air conditioning systems in today's data centers. The course is divided into 5 sections:

- Section - 1: Overview of a Data Center
- Section - 2: HVAC Cooling System Design
- Section - 3: Data Center HVAC Equipment
- Section - 4: Data Center Air Distribution
- Section - 5: Cooling Performance and Efficiency

SECTION 1: OVERVIEW OF A DATA CENTER

Data centers (also referred to as a server rooms or IT rooms) are the building blocks of any business organization providing capabilities of centralized storage, backups, management, networking and dissemination of data. Data centers fall into two major categories: corporate data centers (CDCs) and Internet data centers (IDCs).

Corporate data centers are owned and operated by private organizations, institutions or government agencies that are critically dependent upon information and communication technology systems. Their prime purpose is to support data processing and web-oriented services for their self-use.

Internet data centers are primarily owned and operated by third party service providers or by commercial operators. Their primary objective is to provide IT services to their clients and the customers on rent with or without IT hardware while sharing common power, cooling and facilities infrastructure. The services may include but are not limited to wide-area communications, fast and reliable internet access, web or application hosting, server rent out, back-up storage facilities, content distribution and load sharing with new variations appearing almost daily. This kind of facility benefits large companies like banking, stock exchanges, travel, insurance and other service providers who need back-up servers for business operations and to cover business risks. Small and medium scale companies also benefit both monetary and ensuring goodwill.

Data centers can easily be recognized by equipment racks that contain servers, storage devices, network cabling and equipment. The most critical of these elements are the rack structures housing IT equipment. Another critical part of data center architecture is the utility infrastructure like power supplies, air conditioning, fire suppression and other security devices. There are three functional requirements of a data center:

1. Data center space planning for locating servers, storage and network devices
2. Electric supplies and network connectivity provided to other devices both inside and out.
3. HVAC – Temperature/Humidity control environment within the parameters need.

DATA CENTER SPACE PLANNING AND DESIGN

When determining the location and design of the data center, consider the following issues:

1. Moisture and air leakage - Ensure that the data center is not located below any room that could cause water or moisture to leak into the data center. Exclude plumbing from the room, except plumbing that supports the fire suppression and heating, ventilation, and air conditioning (HVAC) systems. To prevent air and moisture leakage, do not install windows that open to the outside of the facility.

2. Contaminants - Isolate the data center from activities that could contaminate the environment. Ensure that the air intake for the data center is clean. Maintain airborne dusts, gasses, and vapors within defined limits for data center environments to minimize their impact on the systems. Ideally it is preferred that a data center is made as a room in the room, meaning that none of the walls are part of the outer facade of the building.
3. Access - Ensure that there is adequate access to the data center from the loading dock, freight elevator, or other equipment entrances.
4. Security - Provide secure points of entry to the data center so that only the proper personnel have access to the equipment. Equip data center doors with secure locking mechanisms that can remain operational during a power failure.
5. Room temperature and humidity - Ensure that the data center has the required air conditioning equipment to adequately cool the systems. Install an automatic alarm system to notify personnel if temperature or humidity exceeds the specified thresholds.
6. Airflow - Consider the intake and exhaust airflow of the systems and ensure that the airflow in the room facilitates cooling of equipment.
7. Raised flooring - Design the raised flooring to maximize access and to support equipment and cables.
8. Ceiling height – Ensure adequate ceiling height to accommodate a 7-foot equipment rack.
9. Aisle space - Provide adequate room at the front and back of cabinets and racks to allow unobstructed servicing of the systems and clear passage for personnel. Keep minimum 48” in the front and 36” on the rear.
10. Expansion room - Design the data center in a way that can accommodate future equipment expansion. Include resources that can provide additional power, environmental support, and floor usage.

ELECTRIC SUPPLIES AND NETWORK CONNECTIVITY

The design of electrical power system must ensure that adequate, high-quality power is provided to each server, air conditioning and all peripherals at all times. The need to minimize feeder lengths is a primary consideration when developing the space plan for the data center power system.

The power infrastructure must be designed to provide sufficient redundancy, eliminate all single points of failure, and allow the isolation of a single system for testing or maintenance without affecting the power supplied to other systems. It is important to secure multiple sources of power when possible. It is prudent to attach to each primary power supply a common power cord from one power grid that can supply power to all systems, and to attach another power cord from a

different power grid to the redundant supplies. If a primary power grid goes offline, a backup power grid will provide power to the redundant supplies to keep the systems operating.

Estimated Power Requirements

A convenient measure of data center power density is watts per square feet (WPSF) of floor area. Current industry practices estimate power requirements at an average of 50 -150 WPSF but as the servers and storage systems become ever more powerful and compact, they place a greater strain on the facility to deliver more power, reject more heat and maintain adequate backup power reserves (both battery backup and onsite power generation). In addition add power requirements for HVAC system. A standard practice is to add 70% to the total IT equipment power needs.

Quality of Power

The electronic equipment is extremely sensitive to power interruptions or fluctuations. These electrical impurities can disrupt and even ruin sensitive electronic equipment. Surge arresters and line interactive systems often provide enough power conditioning for servers and should be included as part of the electrical system.

Emergency Power

Using an online uninterruptible power supply (UPS) and a backup power generator provide a good strategy for obtaining an uninterruptible source of power. The online UPS filters, conditions, and regulates the power. It protects the systems from fluctuating voltages, surges and spikes, and noise that may be on the power line. The battery backup for the UPS should be capable of maintaining the critical load of the data center for a minimum of 15 minutes during a power failure. This is typically sufficient time to transfer power to an alternate feed or to the power generator.

The backup power generator should be able to carry the power requirements of the IT equipment, HVAC and essential auxiliaries. The generator should include dual power distribution switch gear with automatic transfer switching. To offset the possibility of a generator failure, power system designers often include a temporary generator for secondary backup.

Grounding

Grounding design must address both the electrical service and the installed equipment. A properly designed grounding system should have as low an impedance as is practically achievable for proper operation of electronic devices as well as for safety. It is important to use a continuous, dedicated ground for the entire power system to avoid a ground differential between various grounds. Grounding design in the United States should comply with Article 250 of the U.S. National Electrical Code unless superseded by local codes. Use an antistatic wrist strap when working inside the chassis.

Physical security and fire protection

According to National Fire Protection Association, NFPA 75, “Standard for the Protection of Electronic Computer/Data Processing Equipment”, an emergency power off switch must be placed at every point of entry to the data center, which shall isolate power to every computer system, UPS and HVAC. It must be clearly labeled and unobstructed. An inert gas like FM 100 or argon should be used as fire suppression agent. Always have a smoke detector along with an alarm.

Emergency Power Control

A primary power disconnect switch is specified by NFPA 75 at each point of entry to computer systems and equipment. Multiple disconnects are required in some cases, the switches must

be in the data center is (in accordance with NFPA 75 association specifications) at each point of entry to disconnect power to all equipment, UPS, and batteries. This is not always acceptable, but in both

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HVAC – TEMPERATURE

The data center equipment generates a lot of heat. This is because every piece of equipment generates heat. If the heat is not removed, the equipment will overheat, resulting in electronic equipment failure.

The heat generated by the equipment is a relatively small area. The heat is removed by the air conditioning system. The air conditioning system removes the heat from the air as heat. Unless the air conditioning system is designed to meet the design specifications

The HVAC system for a data center is influenced by 5 main factors:

1. The type of IT equipment

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2. The IT equipment configuration
3. The “service levels”
4. The budget and
5. The ‘Green Policy’

Let’s look at each of the factors:

The IT Equipment

The type of IT equipment has a huge bearing on the choice of cooling infrastructure. Two types of servers are common: 1) rack-mount servers and 2) blade servers.

1. **Rack-mounted:** Rack-mounted servers are contained in a horizontal case “1U to 5U” in height. ‘U’ is a measurement of rack height that equals 1.75” (44.45mm). The benefits of rack servers are that they offer an efficient use of floor space, and easier management of