Vertical Self-Contained Systems

System Description

Vertical self-contained systems are based on specially-designed air handling systems spread throughout the building with integral air conditioning. Each unit has multiple water-cooled DX refrigeration circuits.

Air distribution can be constant volume or variable air volume (VAV). VAV is the most common for office applications.

High-Rise Office Buildings

Vertical self-contained units are often used in high-rise office applications in the following manner. The units are sized to meet the cooling loads for a large area of the building (typically an entire floor). Air distribution is typically VAV or fan-powered VAV.

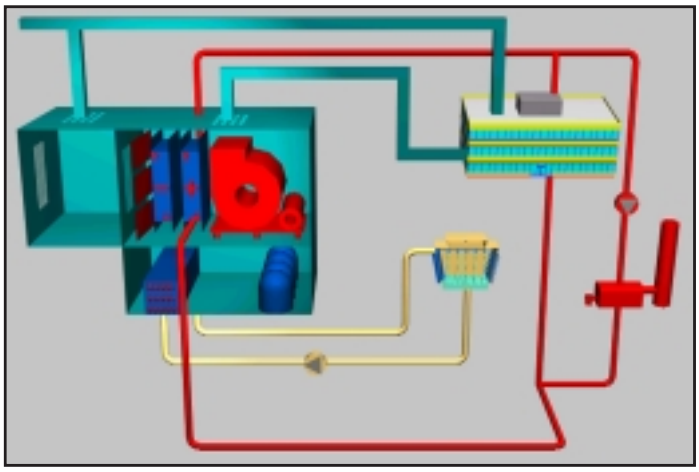
The mechanical rooms housing the units are usually right above each other throughout the building. The mechanical room itself is the return air plenum with openings to the ceiling plenum in the occupied space. Return fans are typically not used.

An acoustically-designed discharge plenum is installed on top of the unit and the supply ductwork is connected to the plenum. Additional acoustic treatments may be required to provide appropriate sound levels within the occupied space.

The units are cooled by a cooling tower loop brought down through the building's mechanical rooms.

Air-side economizers can be connected to the units if the mechanical rooms have an exterior wall. In most cases, the mechanical rooms are in the core of the building, making air-side economizing difficult.

To provide some form of free cooling, water-side economizers are used. A second cooling coil is included in the units. When weather permits, the cooling tower water temperature is lowered (typically in the range of 50°F). Valving within the unit diverts cooling tower water through the cooling coil to provide free cooling.



The tower water can then be used to cool the refrigeration system if supplemental mechanical cooling is required. By arranging the system so supplemental mechanical cooling can augment free cooling, the length of the free cooling season is greatly extended.

IAQ Considerations

ASHRAE Standard 62.1-1999 provides procedures for calculating ventilation rates to maintain minimum acceptable indoor air quality.

If the vertical self-contained units have air-side economizers, ventilation air can be introduced at the air handling unit. When water-side economizers are used, a dedicated ventilation unit is often required. The ventilation unit can be placed on the roof and deliver the correct amount of ventilation air through a shaft to each floor's mechanical room.

Energy recovery in the ventilation unit is possible and greatly improves the operating cost of the building. A preheat coil in the ventilation unit that utilizes the cooling tower water to warm the outdoor air in cooler climates can be very effective.

System Pros

- Can be used with VAV air systems.
- Cooling capacity is based on block load when used with VAV.
- Floor-by-floor units avoid large air shafts and significantly reduce fan horsepower. Multiple units provide redundancy.
- Air- or water-side economizers can be added easily to the design to avoid mechanical cooling during cooler weather.
- Part load mechanical cooling is very efficient.
- Can provide simultaneous water-side free cooling with mechanical cooling to extend the free cooling season.

System Cons

- Floor-by-floor mechanical rooms use rentable space.
- Compressors and large fan systems require careful application to avoid sound issues.
- Water-side economizers require a dedicated ventilation unit.

Energy Considerations

Vertical self-contained systems offer efficient use of supply fans since they are close (on the same floor) to the occupied space. VAV systems further improve fan savings. Using water-side economizers simultaneously with mechanical cooling significantly extends the season where water-side economizers can be used compared to traditional chilled-water systems. The following are some considerations outlined in ASHRAE Std 90.1-1999. The numbers in brackets refer to Std. 90.1-1999 sections.

- Energy efficiency tables for HVAC equipment (6.2.1).
- Equipment must be automatically scheduled off during unoccupied hours (6.2.3.1).
- Demand Controlled Ventilation is required for systems with at least 3,000 cfm of outdoor air and occupant density greater than 100 people per 1,000 ft^2 (6.2.3.9).
- Air- or water-side economizers are required. There are several exceptions to this rule, particularly when dealing with heat recovery (6.3.1).
- Where humidification is required to maintain humidity above 35°F dewpoint, water-side economizers must be used when economizers are required. Introducing large amounts of cool, dry air while meeting the sensible cooling load adds significantly to the humidifier load. Process loads, including hospitals, are exempt (6.3.2.4).
- For systems under 20,000 cfm, VAV is limited to 1.7 hp/1,000 cfm. For systems over 20,000 cfm, VAV systems are limited to 1.5 hp/1,000 cfm (6.3.3.1).
- 30 hp and larger fan motors must use no more than 30% of design power at 50% airflow (6.3.3.2).
- Energy recovery is required for systems with at least 5,000 cfm supply air and a minimum of 70% outdoor air. This is specifically aimed at schools and labs (6.3.6.1).
- Hydronic systems with a system pump power that exceeds 10 hp must employ variable flow and isolation valves at each terminal device. The system must be able to operate down to at least 50% of design flow. Individual pumps over 50 hp and 100 ft. head must have VFDs and consume no more than 30% design power at 50% design flow (6.3.4.1).
- Fan motors larger than 7½ hp on cooling towers must either have VFDs or be two speed. A control system is required to minimize power usage (6.3.5).
- For constant volume systems under 20,000 cfm, fans are limited to 1.2 hp/1,000 cfm. For systems over 20,000 cfm, fans are limited to 1.1. hp/1,000 cfm (6.3.3.1).

A thorough explanation of the Standard is beyond the scope of this document. The designer should have access to the Standard and a complete understanding of its contents. The ASHRAE 90.1-1999 Users Manual is also very helpful. ASHRAE considers Standard 90.1-1999 a high-profile standard and continuously updates it.

Typical Applications

Besides high-rise office buildings, vertical self-contained systems are used in cooling electronics equipment such as data communications centers or 'internet hotels'. Schools are another good application.

Common applications include:

- Multi-Story Office Buildings
- Data Communication Centers
- Schools