## Equipment Type

This item defines the equipment classification for the HVAC system being analyzed. The choice of an equipment type determines the system types offered in the next input item, the components and controls which can be included in the system, choices for cooling and heating sources and whether a system can be linked to certain types of plants. For example, a Chilled Water Air Handling Unit can be connected to a chiller plant for plant sizing calculations, but a Packaged Rooftop Unit cannot.

Users may choose from six equipment classifications:

1. **Undefined:** This option allows you to avoid making an equipment type choice. It is often used for preliminary block load estimates in which equipment type is not yet relevant. It is also used in detailed system design studies in which the equipment type is not yet known.

   When Undefined is selected, cooling and heating sources for coils will default to "any". It will not be possible to choose specific sources such as "chilled water" or "hot water". Systems using the "undefined" equipment type are, however, allowed to be connected to chiller and boiler plants for plant sizing calculations.

2. **Packaged Rooftop Units:** Packaged rooftop DX cooling units. The equipment can be cooling only, or can also provide electric, combustion, hot water, steam or heat pump heating.

3. **Packaged Vertical Units:** Packaged indoor DX cooling units. The equipment can be cooling only, or can also provide electric, combustion, hot water, or steam heating.

4. **Split Air Handling Units:** Packaged or built-up air handling units using a DX cooling coil and a separate condensing unit. Equipment can be cooling only, or can also provide electric, combustion, hot water, steam or heat pump heating.

5. **Chilled Water Air Handling Units:** Packaged or built-up air handling units using a chilled water cooling coil. Equipment can be cooling only or can also provide electric, combustion, hot water or steam heating.

6. **Terminal Units:** This class of equipment involves separate cooling/heating units located in each zone. Examples include packaged DX fan coil units such as PTACs, PTHPs and window air conditioners, split DX fan coil units, hydronic fan coil units, water source heat pumps, induction beams and active chilled beams.

   The program offers special features for modeling these systems. In HAP, a terminal unit system can contain multiple zones, each containing a separate terminal unit. Thus, large quantities of units can be modeled quickly as part of one "system". HAP permits modeling of systems in which outdoor ventilation air is introduced directly to terminal units, and also systems in which a common ventilation unit is used to temper outdoor air and then deliver it to terminal units.

8:13-14 °C.

Pre cool : setpt - off-coil °C of Pre-cool

VAV: Central cooling → cycled/staged capacity, Fan on

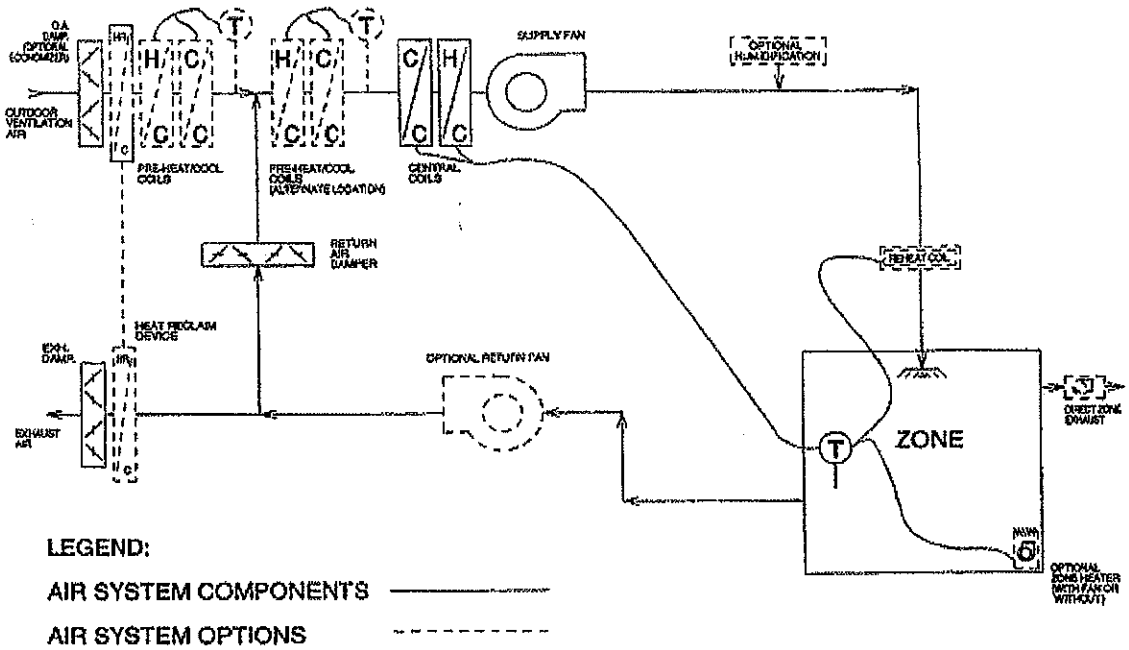
Select FCU : Terminal units (Chilled water) (CAV Tempering ventilation sys) 2 pipe Fan Coil : direct ventilation - No pre cool - common ventilated.

PAU.

off coil usu minus 10 °C from Room °C.

## CAV Single Zone System

This help topic describes the operating assumptions for a CAV single zone air system. This single-zone system uses a central air handler to provide a constant volume of conditioned air to the zone terminal. Depending on the user's description of the system, operation for cooling and heating in the occupied and unoccupied periods varies, as described in the following sections.




**CAV Single Zone System Schematic**

### A. Occupied Period Operation

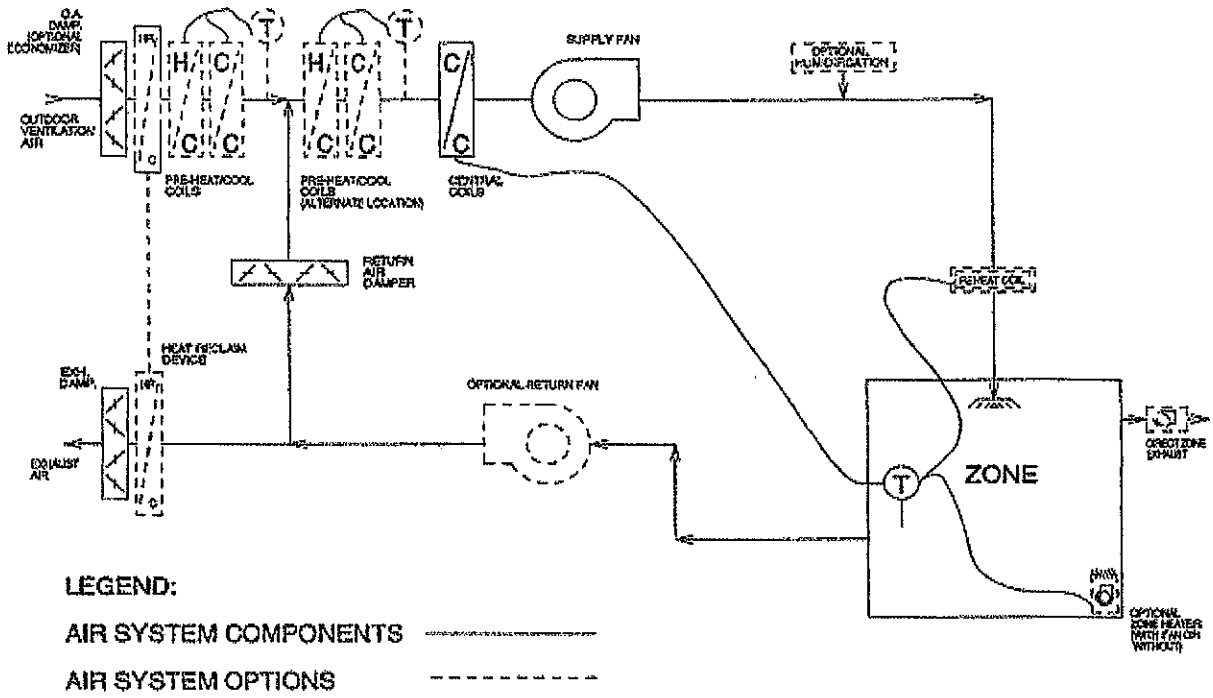
1. Zone Thermostat Calls for Cooling
   a. If fan cycling has been specified, the supply fan and cooling coil cycle on only when a cooling demand exists. Air is supplied to the zone at the design cooling supply temperature.
   b. Otherwise, the supply fan runs continuously. The cooling coil and the supply temperature are controlled according to user specifications.
2. Zone Thermostat Calls for Heating
   a. If cycled fan operation has been specified, the supply fan and heating coil cycle on only when a heating demand exists. Air is supplied to the zone at the design heating supply temperature.
   b. Otherwise, the supply fan runs continuously. The heating coil and the supply temperature are controlled according to user specifications.
   c. If a zone heating unit using room thermostat control exists, it acts as a second stage of heat for the zone and is only used if central heat is insufficient to meet the heating demand.
3. Zone Thermostat Does Not Call for Cooling or Heating
   a. If fan operation is cycled, the supply fan is off when no calls for cooling or heating exist.
   b. Otherwise, the supply fan runs continuously and provides unconditioned air to the zone. The cooling and heating coils are off.

### B. Unoccupied Period Operation

1. Zone Thermostat Calls for Cooling
   a. The supply fan and cooling coil cycle on to meet the cooling demand. Air at the design cooling supply temperature is provided.
2. Zone Thermostat Calls for Heating
   a. If a zone heating unit using room thermostat control exists, the supply fan is off. The zone heating unit provides the heat needed to maintain zone comfort conditions.
   b. Otherwise, the supply fan and heating coil cycle on to meet the heating demand. Air at the design heating supply temperature is provided.
3. Zone Thermostat Does Not Call for Cooling or Heating
   a. The supply fan is off.

## CAV Terminal Reheat System

This help topic describes operating assumptions for a CAV Terminal Reheat air system. This multiple-zone system uses a central fan to provide a constant volume of conditioned air to zone terminals. Zone thermostats control the output of terminal heating coils in order to regulate the air temperature delivered to the zone and maintain comfort conditions. Depending on the user's description of the system, cooling and heating operation varies in the occupied and unoccupied periods as described in the following sections.




**CAV Terminal Reheat System Schematic**

### A. Occupied Period Operation

1. The supply fan runs continuously for all hours to supply a constant volume of air to zone terminals.
2. Supply air temperature is controlled according to user specifications.
3. Zone Thermostat Calls For Cooling:
   a. The zone receives a constant volume of air at the supply temperature. The terminal heating coil is off.
4. Zone Thermostat Calls For Heating:
   a. The zone terminal receives a constant volume of air at the supply temperature. The terminal heating coil is energized to reheat the air in order to maintain zone comfort conditions.
   b. If zone heating units using room thermostat control are used, they act as a second stage of heat only when heat output from the terminal reheat coil is not sufficient to maintain conditions in the zone.
5. Zone Thermostat Does Not Call For Cooling or Heating:
   a. The zone receives a constant volume of air at the supply temperature. The terminal heating coil is off.

### B. Unoccupied Period Operation

1. Supply Fan:
   a. Cycles on when one or more zones call for cooling. The fan also cycles on when one or more zones call for heating, unless all zones calling for heating have zone heating units with room thermostat control available.
   b. If zone heating units are used and zones call only for heating, the supply fan is off. The zone heating units operate to meet zone heating loads.
   c. If no zones call for cooling or heating, the supply fan is off.
2. Supply Air Temperature
   a. If one or more zones call for cooling, supply air temperature is controlled according to user specifications.
   b. When zones only call for heating and the supply fan is operating, unconditioned air is provided to zone terminals.
3. Zone Thermostat Calls For Cooling

a. Operation is the same as in the occupied period.

4. Zone Thermostat Calls For Heating

   a. If zone heating units with room thermostat control are not used, operation is the same as described for the occupied period.

   b. If zone heating units with room thermostat control are used, these units provide heat sufficient to maintain zone conditions.

5. Zone Thermostats Do Not Call For Cooling or Heating

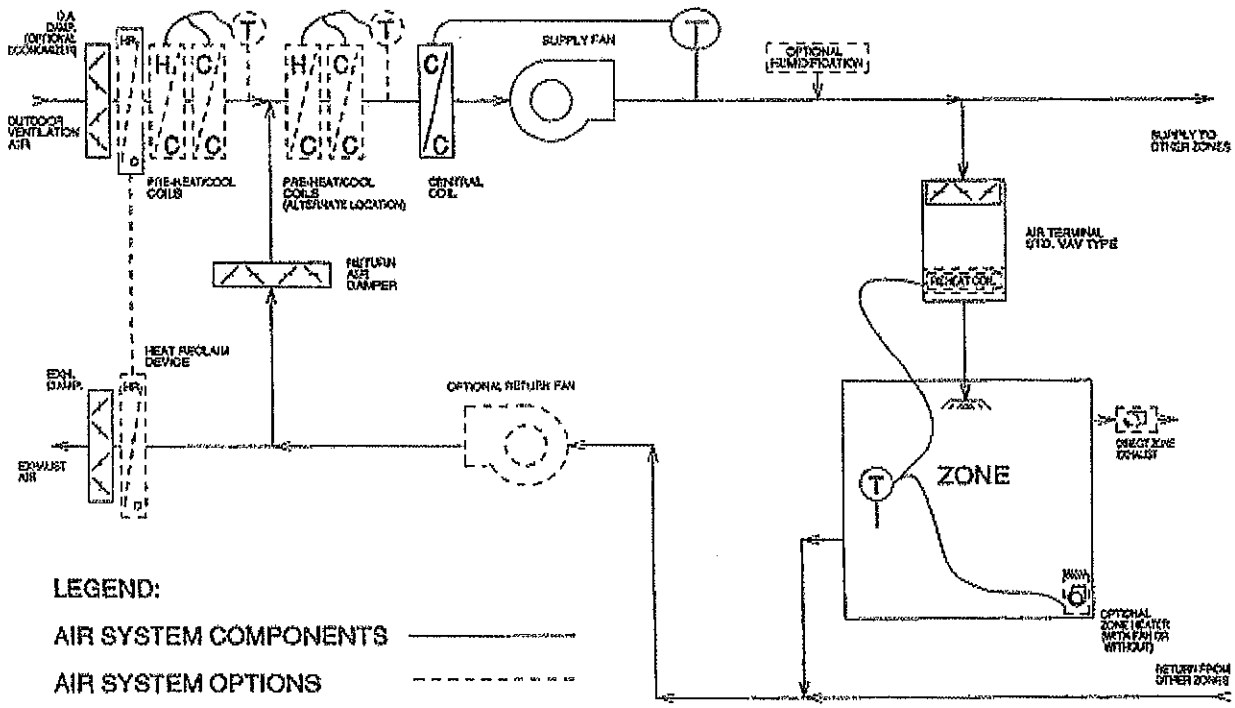
   a. The system is off.

## VAV System

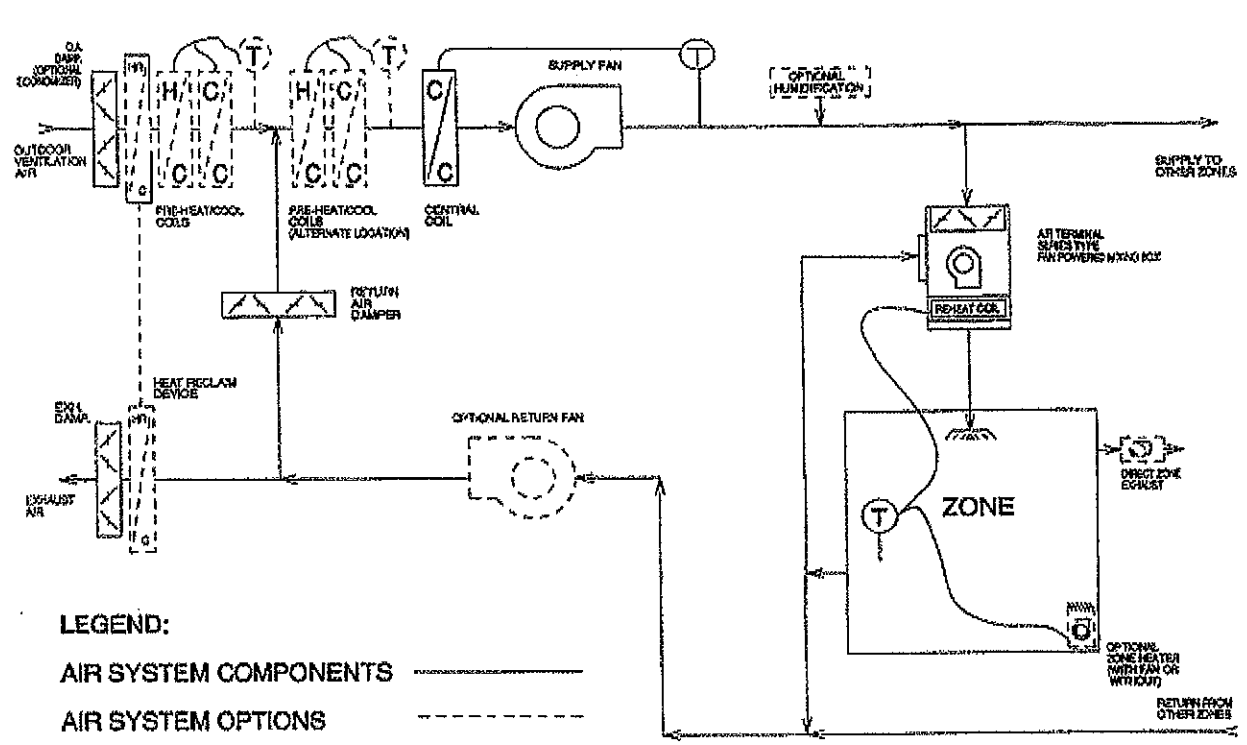
This help topic describes the operating assumptions for single-duct VAV systems. This multiple-zone system uses a central supply fan to provide a variable volume of conditioned air to zone terminals. Zone thermostats control the supply terminal equipment to regulate the flow of air into each zone and maintain zone comfort conditions. In a VAV system, any of the following supply terminal devices can be used, either one type exclusively for all zones, or a mixture of types among the various zones served by the system.

1. VAV boxes.
2. VAV boxes with terminal reheat.
3. Series fan powered mixing boxes with terminal reheat.
4. Parallel fan powered mixing boxes with terminal reheat.

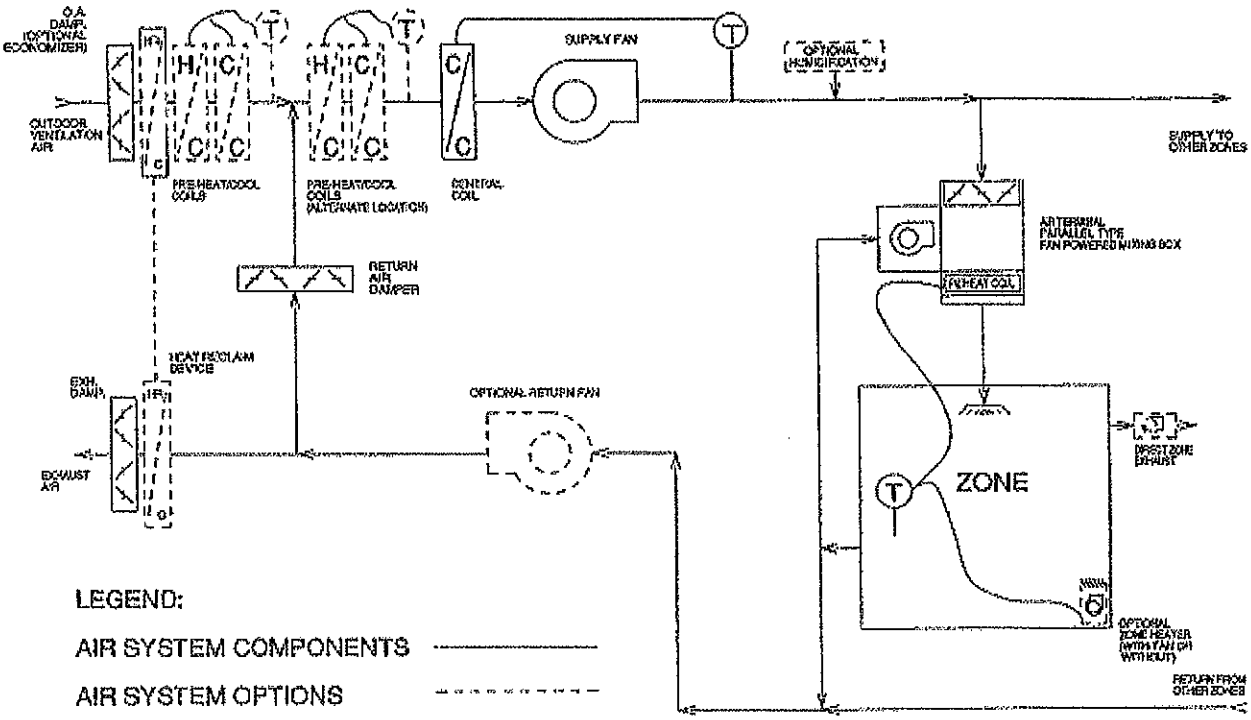
Cooling and heating operation of the system varies in the occupied and unoccupied periods as described in the following sections.




**Schematic for VAV System with VAV Reheat Terminals**




**Schematic for VAV System with Series Fan Powered Mixing Box Terminals**




**Schematic for VAV System with Parallel Fan Powered Mixing Box Terminals**

**A. Occupied Period Operation**

1. The supply fan runs continuously to supply a variable volume of supply air to each zone.
2. Supply air temperature is controlled according to user specifications.
3. Zone Thermostat Calls for Cooling
   a. For zones using VAV and VAV/RH terminals, the terminal damper regulates the flow of air into the zone to maintain comfort conditions.

b. For zones using Series Fan Powered Mixing Box terminals, the terminal fan operates so that a constant volume of air equal to the design zone airflow rate is provided at all times. This airflow is a mixture of cold primary air and plenum return air. The primary air damper is positioned so the mixture of primary air and plenum return air will provide air at a temperature sufficient to maintain comfort conditions in the zone.

c. For zones using Parallel Fan Powered Mixing Box terminals, the primary damper is positioned to provide sufficient cold primary air to the zone to maintain comfort conditions. The terminal fan is off

4. Zone Thermostat Calls for Heating

a. For zones using VAV terminals, the terminal damper closes to the minimum airflow position. If zone heating units with room thermostat control are used, the zone heating units operate to maintain comfort conditions in the zone. Otherwise, there is no heating capability and the zone temperature floats.

b. For zones using VAV/RH terminals, the terminal damper closes to the minimum airflow position. The terminal reheat coil operates to maintain comfort conditions in the zone. If a zone heating unit with room thermostat control is used, it serves as a second stage of heat and is only used if the terminal reheat coil cannot maintain zone conditions.

c. For zones using Series Fan Powered Mixing Box terminals, the primary air damper closes to its minimum position. The terminal fan continues to provide a constant volume of air to the zone which is a mixture of cold primary air and plenum return air. Plenum return air serves as the first stage of heat. If this is not sufficient to maintain zone conditions, the terminal reheat coil turns on and serves as a second stage of heat. If a zone heating unit with room thermostat control is used, it serves as a third stage of heat and is only used if the terminal reheat coil cannot maintain zone conditions.

d. For zones using Parallel Fan Powered Mixing Box terminals, the primary air damper closes to its minimum position. The terminal fan turns on and mixes warm plenum return air with cold primary air. This serves as the first stage of heat. If first stage heat is not sufficient to maintain zone conditions, the terminal reheat coil turns on and serves as the second stage of heat. If a zone heating unit with room thermostat control is used it serves as the third stage of heat and is only used if the terminal reheat coil cannot maintain zone conditions.

5. Zone Thermostat Does Not Call for Cooling or Heating

a. For zones using VAV and VAV/RH terminals, the terminal damper closes to its minimum flow position. The zone temperature floats.

b. For zones using Series Fan Powered Mixing Box terminals, the primary air damper closes to its minimum flow position. The terminal fan runs to provide a constant volume of air to the zone. This air is the mixture of cold primary air and warm plenum air. The zone temperature floats.

c. For zones using Parallel Fan Powered Mixing Box terminals, the primary air damper closes to its minimum flow position. The zone temperature floats. The terminal fan is off.

**B. Unoccupied Period Operation.**

1. Supply Fan

a. Cycles on when one or more zones call for cooling.

b. Cycles on when one or more zones call for heating and these zones cannot meet the heating demand independently. See discussion in items 4 below.

c. If no zones call for cooling or heating, the supply fan is off.

2. Supply Air Temperature

a. When the supply fan is operating, supply air temperature is controlled according to user specifications.

3. Zone Thermostat Calls for Cooling

a. Operation is the same as in the occupied period.

4. Zone Thermostat Calls for Heating

a. For zones using VAV or VAV/RH terminals which contain a zone heating unit with room thermostat control, the zone heating unit operates to maintain zone conditions.

b. If zones using VAV terminals exist which do not contain a zone heating unit with room thermostat control, the central supply fan remains off. The zone temperature floats and the heating demand cannot be met.

c. If zones using VAV/RH terminals exist which do not contain a zone heating unit with room thermostat control, the central supply fan must run to allow the terminal reheat coil to operate. Operation in this mode is the same as in the occupied period.

d. For zones using Series or Parallel Fan Powered Mixing Box terminals, the terminal fan turns on and supplies plenum return air to the zone. This serves as the first stage of heating. If first stage heat is not sufficient to maintain zone conditions, the terminal reheat coil turns on and serves as the second stage of heat. If a zone heating unit with room thermostat control exists, it serves as the third stage of heat and only operates if 1st and 2nd stage heating are not sufficient to maintain zone conditions.

5. Zone Thermostats Do Not Call for Cooling or Heating

a. The system and all terminal equipment are off.

## Variable Volume / Temperature (VVT) System

This help topic describes the operating assumptions for a VVT air system. VVT stands for "Variable Volume/Variable Temperature". VVT is essentially a time-sharing system in which the same set of equipment and controls alternately provides cooling and heating as required by the zones it serves. During operation, for example, the system may provide cooling to one group of zones for part of an hour, heating to another group of zones for another part of the hour, and ventilation air to all zones for the remainder of the hour. VVT system operation is similar in both the occupied and unoccupied periods. Operation in both periods is described below.

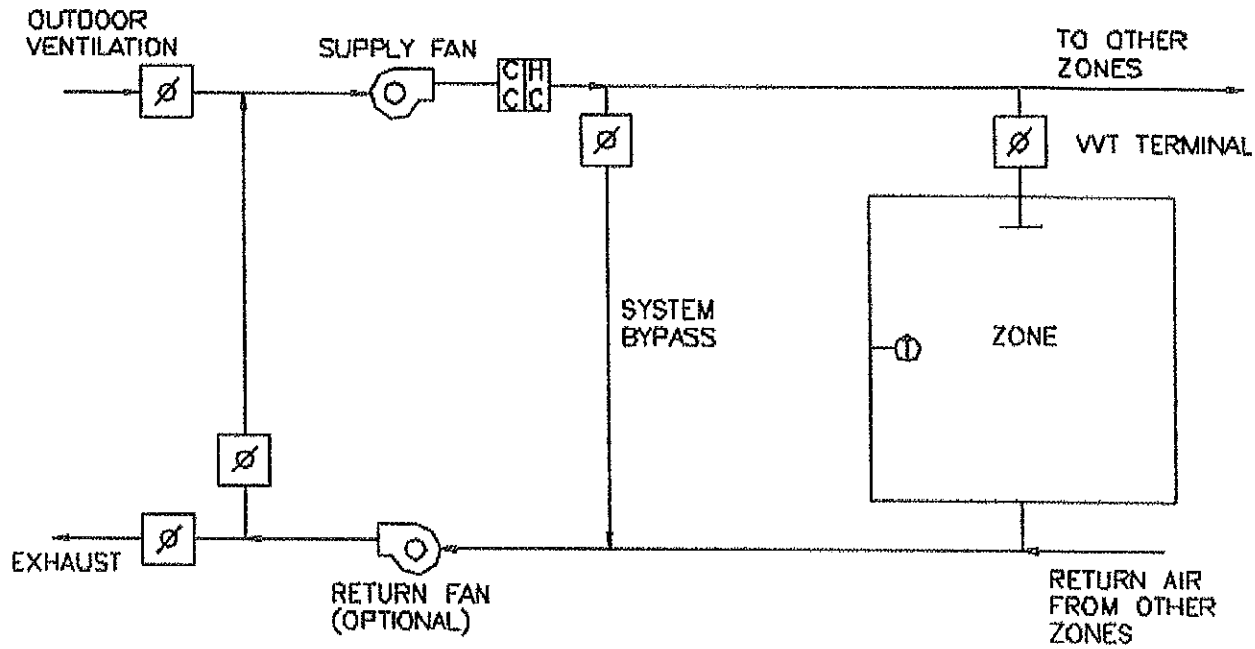



**Figure 13.16 VVT System**

A. Occupied Period Operation

1. **Summary Of Operation.** During the occupied period, the supply fan runs continuously for all hours. Depending on the zone load conditions, the system may operate in cooling, changeover, heating, and/or ventilation modes during the hour. The length of time spent in any mode depends on the magnitude of the zone cooling and heating loads. If the zone cooling and heating loads are small, the system will spend only short periods of time in the cooling or heating modes, and much longer periods of time will be spent in ventilation mode. Descriptions of each operating mode follow.
2. **Cooling Mode Operation.** If one or more zone thermostats call for cooling, the system will enter the cooling mode. The central cooling coil is energized, and supplies a variable volume of air at the cooling supply temperature. Terminal dampers control the amount of cold air entering the zone to maintain comfort conditions. As each zone thermostat falls below the cooling setpoint, its terminal damper is closed. When all terminal dampers are closed, the system leaves the cooling mode.
3. **Changeover Mode Operation.** When the system switches operation from cooling mode to heating mode (or from heating mode to cooling mode), the system first goes into changeover mode to purge conditioned air from the supply ducts before entering the next mode. For example, when switching from cooling mode to heating mode, the system purges the supply ducts of cold air so that zones requiring heating do not receive cold air.

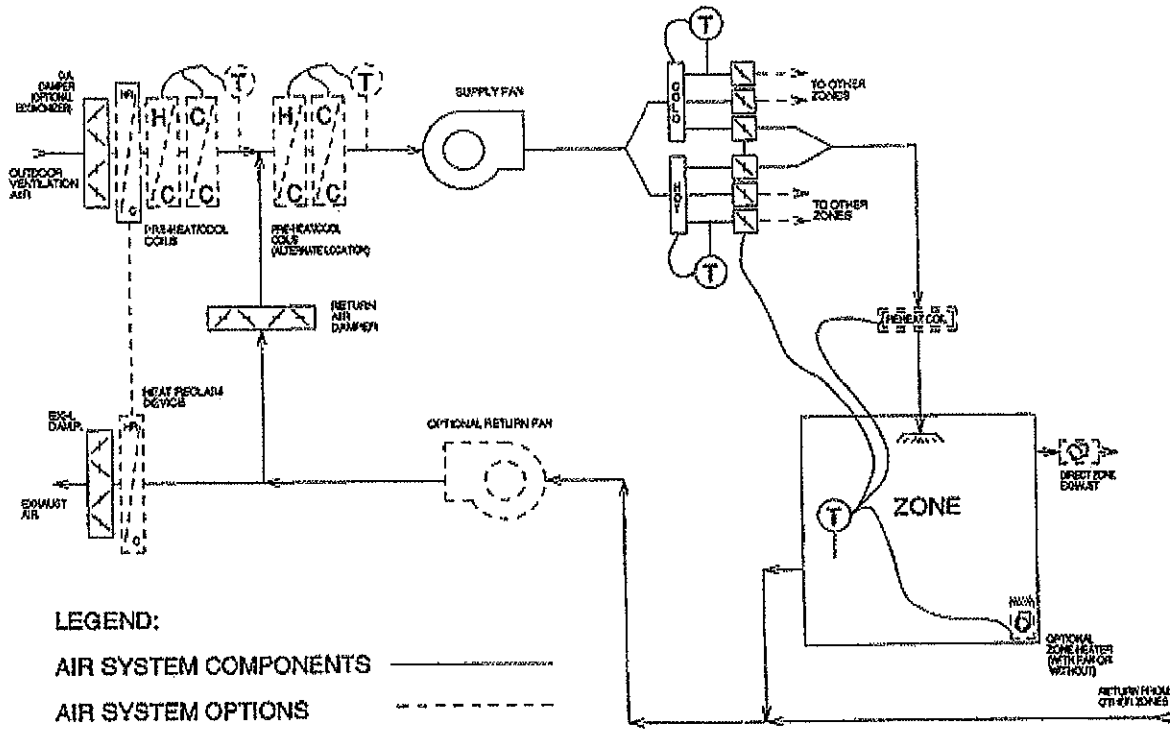
   During changeover mode, all terminal dampers are closed. The supply fan blows air directly through the bypass duct into the return duct. The supply airflow rate is equal to the bypass flow rate. The length of time spent in changeover mode is specified by the user.
4. **Heating Mode Operation.** If one or more zone thermostats call for heating, the system will enter the heating mode. The central heating coil is energized, and supplies a variable volume of air at the heating supply temperature. Terminal dampers control the amount of warm air entering the zone to maintain comfort conditions. As each zone thermostat rises above the heating setpoint, its terminal damper is closed. When all terminal dampers are closed, the system leaves the heating mode.
5. **Ventilation Mode Operation.** When all zone cooling and heating demands have been satisfied, the system operates in ventilation mode. During the ventilation period, all zone terminal dampers are open to the minimum ventilation position. The supply fan provides neutral air. Zone temperatures float.

B. Unoccupied Period Operation

1. **Summary Of Operation.** During the unoccupied period, the system operates only when one or more zones call for cooling or heating. When all cooling and heating requests have been satisfied, the system is shut off. The system will not operate in ventilation mode. Descriptions of each operating mode follow.
2. **Cooling Mode Operation.** Operation is the same as in the occupied period.
3. **Changeover Mode Operation.** Operation is the same as in the occupied period.
4. **Heating Mode Operation.** Operation is the same as in the occupied period.
5. **System Off Mode Operation.** When all zone cooling and heating demands have been satisfied, the supply fan is turned off. No conditioning is provided to the zones. Zone temperatures float.

## CAV 2-Deck Multizone System

This help topic describes operating assumptions for a 2-Deck Multizone air system. This multiple-zone system uses a central two-deck blow-thru air handler to provide a constant volume of conditioned air to zone terminals. Each zone has its own supply air duct to carry conditioned air from the central air handling unit. The zone thermostat controls the blending of air from the hot and cold decks into its supply air duct to provide air at a temperature sufficient to maintain the zone temperature within comfort conditions. Depending on the user's description of the system, cooling and heating operation varies in the occupied and unoccupied periods as described in the following sections.




**CAV 2-Deck Multizone System Schematic**

### A. Occupied Period Operation

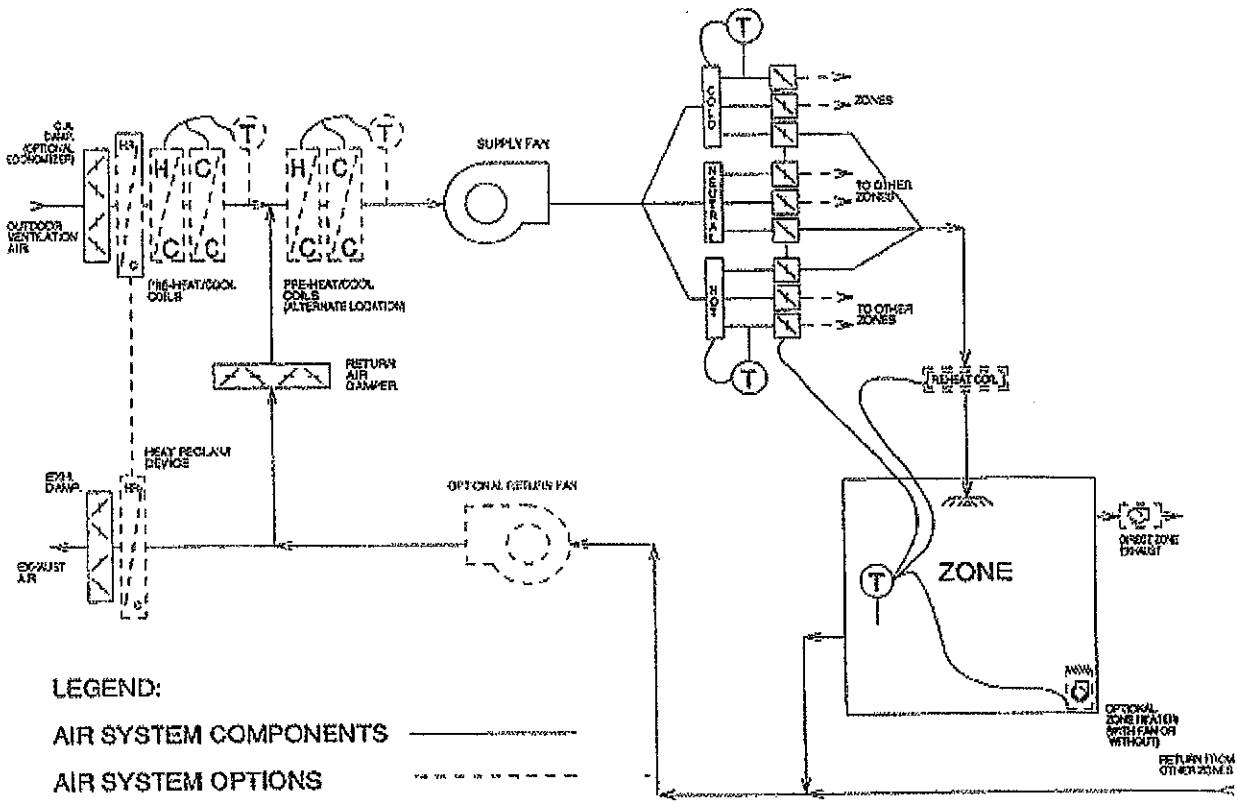
1. Supply Fan runs continuously for all hours to supply a constant volume of air to zone terminals.
2. Hot deck and cold deck supply air temperatures are controlled according to user specifications.
3. Each zone controls the amount of air it receives from the hot and cold decks, to provide air at a temperature sufficient to maintain the zone temperature within comfort conditions.

### B. Unoccupied Period Operation

1. Supply Fan
   a. Cycles on when one or more zones call for cooling. The fan also cycles on when one or more zones call for heating, unless all zones calling for heating have zone heating units with room thermostat control available.
   b. If zone heating units with room thermostat control are used and zones call only for heating, the supply fan is off. The zone heating units operate to meet zone heating loads.
   c. If no zones call for cooling or heating, the supply fan is off.
2. Supply Air Temperature
   a. If the supply fan is on, supply temperature is controlled in the same way as in the occupied period.
3. Zone Thermostat Calls For Cooling
   a. Operation is the same as in the occupied period.
4. Zone Thermostat Calls For Heating
   a. If zone heating units with room thermostat control are not used, operation is the same as described for the occupied period.
   b. If zone heating units with room thermostat control are used, these units operate to meet the heating demand.
5. Zone Thermostats Do Not Call For Cooling or Heating
   a. The system is off.

## CAV 3-Deck Multizone System

This help topic describes the operating assumptions for a CAV 3-Deck Multizone air system. This multiple-zone system uses a central three-deck blow-thru air handler to provide a constant volume of conditioned air to zone terminals. Each zone has its own supply air duct to carry conditioned air from the central air handling unit. The zone thermostat controls the blending of air from the neutral deck with air from the hot or cold deck, to provide air at a temperature sufficient to maintain zone comfort conditions. Depending on the user's description of the system, cooling and heating operation varies in the occupied and unoccupied periods as described in the following sections.




**CAV 3-Deck Multizone System Schematic**

### A. Occupied Period Operation

1. Supply Fan runs continuously for all hours to supply a constant volume of air to zone terminals.
2. Hot deck and cold deck supply air temperatures are controlled according to user specifications.
3. Zone Thermostat Operation
   a. When a zone thermostat calls for cooling, air from the cold and neutral decks are mixed to supply sufficient cooling to maintain zone comfort conditions.
   b. When a zone thermostat calls for heating, air from the hot and neutral decks are mixed to supply sufficient heating to maintain zone comfort conditions.
   c. When a zone thermostat does not call for cooling or heating, air from the neutral deck is supplied to the zone. The zone temperature floats.

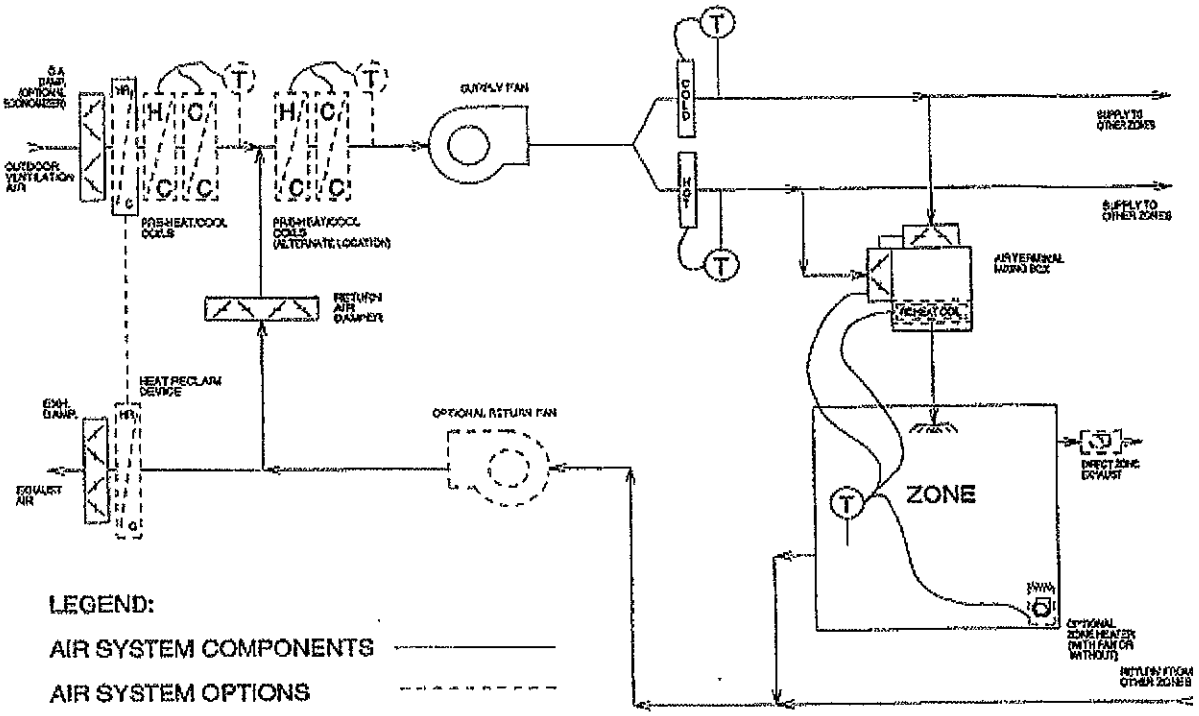
### B. Unoccupied Period Operation

1. Supply Fan
   a. Cycles on when one or more zones call for cooling. The fan also cycles on when one or more zones call for heating, unless all zones calling for heating have zone heating units with room thermostat control available.
   b. If zone heating units with room thermostat control are used and zones call only for heating, the supply fan is off. Zone heating units operate to meet zone heating loads.
   c. If no zones call for cooling or heating, the supply fan is off.
2. Supply Air Temperature
   a. If the supply fan is on, supply temperature is controlled in the same way as in the occupied period.
3. Zone Thermostat Calls For Cooling
   a. Operation is the same as in the occupied period.

4. Zone Thermostat Calls For Heating
   a. If zone heating units with room thermostat control are not used, operation is the same as described for the occupied period.
   b. If zone heating units with room thermostat control are used, these units provide heat sufficient to maintain the zone temperature in the heating setpoint throttling range.
5. Zone Thermostats Do Not Call For Cooling or Heating
   a. The system is off.

## CAV Dual Duct System

This help topic describes the operating assumptions for a CAV Dual Duct air system. This multiple-zone system uses a central two-deck blow-thru air handler to provide a constant volume of conditioned air to zone terminals. Air is distributed to the terminals through two parallel main ducts. The hot deck supply duct carries warm air to the zones; the cold deck supply duct carries cold air to the zones. The zone thermostat controls the mixing of air from the hot and cold supply ducts to provide air at a temperature sufficient to maintain zone comfort conditions. Depending on the user's description of the system, cooling and heating operation varies in the occupied and unoccupied periods as described in the following sections.




**CAV Dual Duct System Schematic**

**A. Occupied Period Operation**

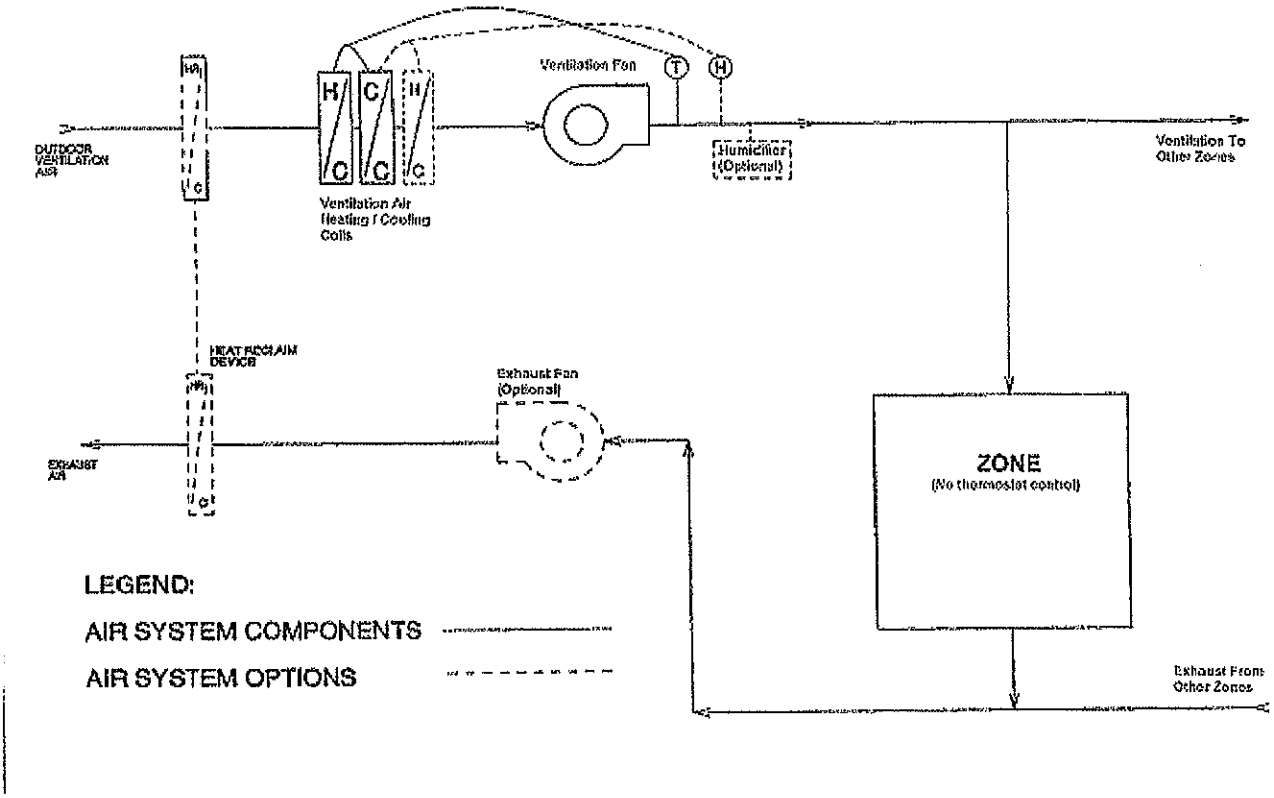
1. The supply fan runs continuously for all hours to supply a constant volume of air to zone terminals.
2. Hot deck and cold deck supply air temperatures are controlled according to user specifications.
3. Each zone controls the amount of air it receives from the hot and cold supply air ducts to provide air at a temperature sufficient to maintain the zone temperature within the thermostat throttling range.

**B. Unoccupied Period Operation**

1. Supply Fan
   a. Cycles on when one or more zones call for cooling. The fan also cycles on when one or more zones call for heating, unless all zones calling for heating have zone heating units with room thermostat control available.
   b. If zone heating units with room thermostat control are used and zones call only for heating, the supply fan is off. Zone heating units operate to meet the zone heating loads.
   c. If no zones call for cooling or heating, the supply fan is off.
2. Supply Air Temperature
   a. If the supply fan is on, supply temperature is controlled in the same way as in the occupied period.
3. Zone Thermostat Calls For Cooling
   a. Operation is the same as in the occupied period.
4. Zone Thermostat Calls For Heating
   a. If zone heating units with room thermostat control are not used, operation is the same as described for the occupied period.
   b. If zone heating units with room thermostat control are used, these units provide sufficient heat to maintain the zone temperature in the heating throttling range.
5. Zone Thermostats Do Not Call For Cooling or Heating
   a. The system is off.

## CAV Tempering Ventilation System

This help topic describes the operating assumptions for a CAV Tempering Ventilation air system. This system provides tempered ventilation air to a region of the building, but does not provide conditioning to control the space air temperature. That is, the zone served by the system does not have a thermostat. This system model should be used for applications such as factories, warehouses or gymnasiums which are supplied with tempered outdoor air but are not heated or air-conditioned to control the space temperature. Depending on the user's description of the system, system operation in the occupied and unoccupied periods varies as described below.




**CAV Tempering Ventilation System Schematic**

### A. Occupied Period Operation

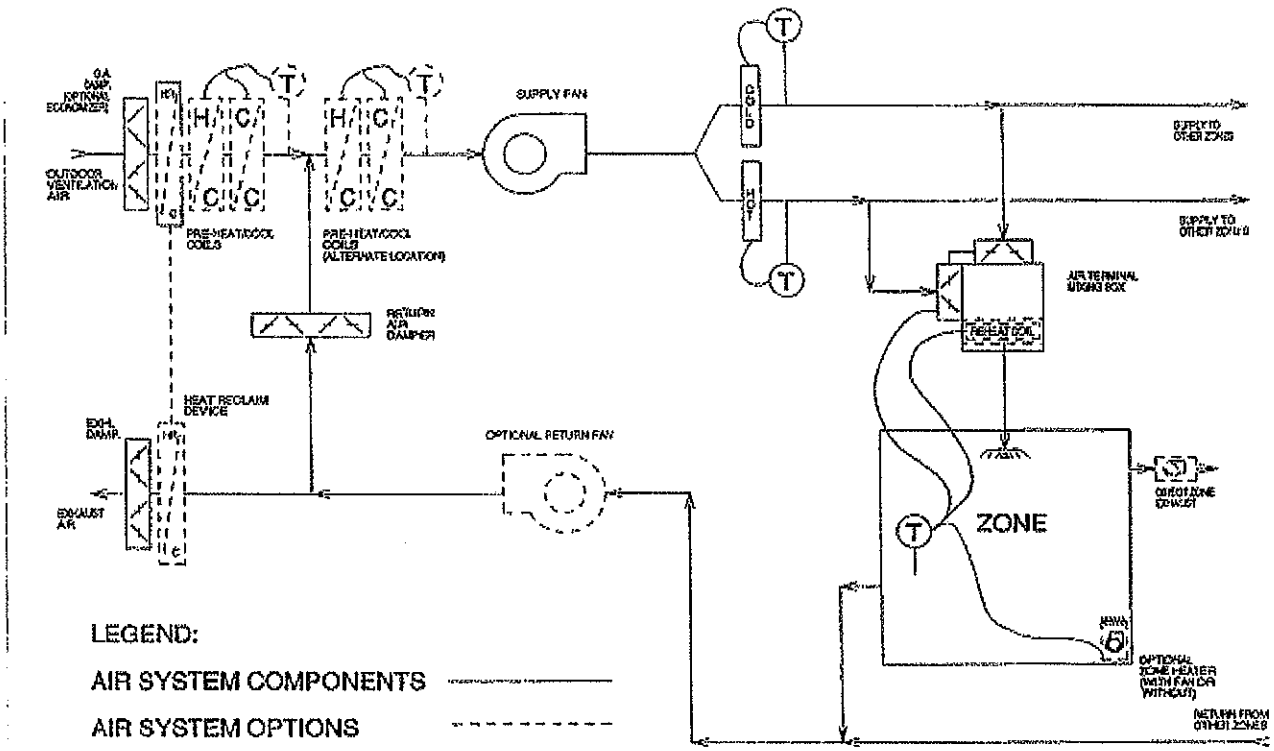
1. The supply fan runs continuously to supply 100% outside air.
2. If a cooling coil is available, the coil will operate whenever the duct temperature downstream of the unit is above the duct cooling setpoint. The air will be cooled so the duct temperature is held at the setpoint.
3. If a cooling coil is available and dehumidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit is above the duct cooling setpoint, the cooling coil will be energized to hold the duct air at the setpoint. If the duct humidity is above the RH setpoint, the cooling coil will provide additional cooling to lower the coil dewpoint, thus condensing more moisture, and holding the duct air at the dehumidification setpoint. A heating coil will provide reheat so the duct air temperature continues to be held at duct cooling setpoint.
4. If a heating coil is available, the coil will operate whenever the duct temperature downstream of the unit is below the duct heating setpoint. The air will be heated so the duct temperature is held at the setpoint.
5. If a heating coil is available and humidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit is below the duct heating setpoint, the heating coil will be energized to hold the duct air at the setpoint. If the duct humidity is below the RH setpoint, the humidifier will add moisture to the air stream to hold the duct humidity at the setpoint.

### B. Unoccupied Period Operation

1. The system is off during the unoccupied period.

## VAV 1-Fan Dual Duct System

This help topic describes the operating assumptions for a VAV 1-Fan Dual Duct air system. This multiple-zone system uses a central two-deck blow-thru air handler to provide a variable volume of conditioned air to zone terminals. Air is distributed to the terminals through two parallel main ducts. The hot deck supply duct carries warm air to the zones; the cold deck supply duct carries cold air to the zones. The zone terminals mix air from the hot and cold supply ducts providing air to the zones at a temperature sufficient to maintain comfort conditions. Depending on the user's description of the system, cooling and heating operation varies in the occupied and unoccupied periods as described in the following sections.




**VAV 1-Fan Dual Duct System Schematic**

**A. Occupied Period Operation**

1. The supply fan runs continuously to supply a variable volume of air to zone terminals.
2. The hot deck and cold deck supply air temperatures are controlled according to user specifications.
3. Zone Damper Control
   a. When a zone thermostat calls for cooling, the heating damper is fully closed and the cooling damper controls the amount of air received from the cold supply duct to maintain zone comfort conditions.
   b. When a zone thermostat calls for heating, the cooling damper closes to its minimum airflow position and the heating damper controls the amount of air received from the hot supply duct to maintain zone comfort conditions. If a zone heating unit with room thermostat control exists, it serves as a second stage of heat and is only used if central heating is not sufficient to maintain zone conditions.
   c. When a zone thermostat does not call for cooling or heating, the heating damper is fully closed and the cooling damper is at its minimum flow position. The zone temperature floats.

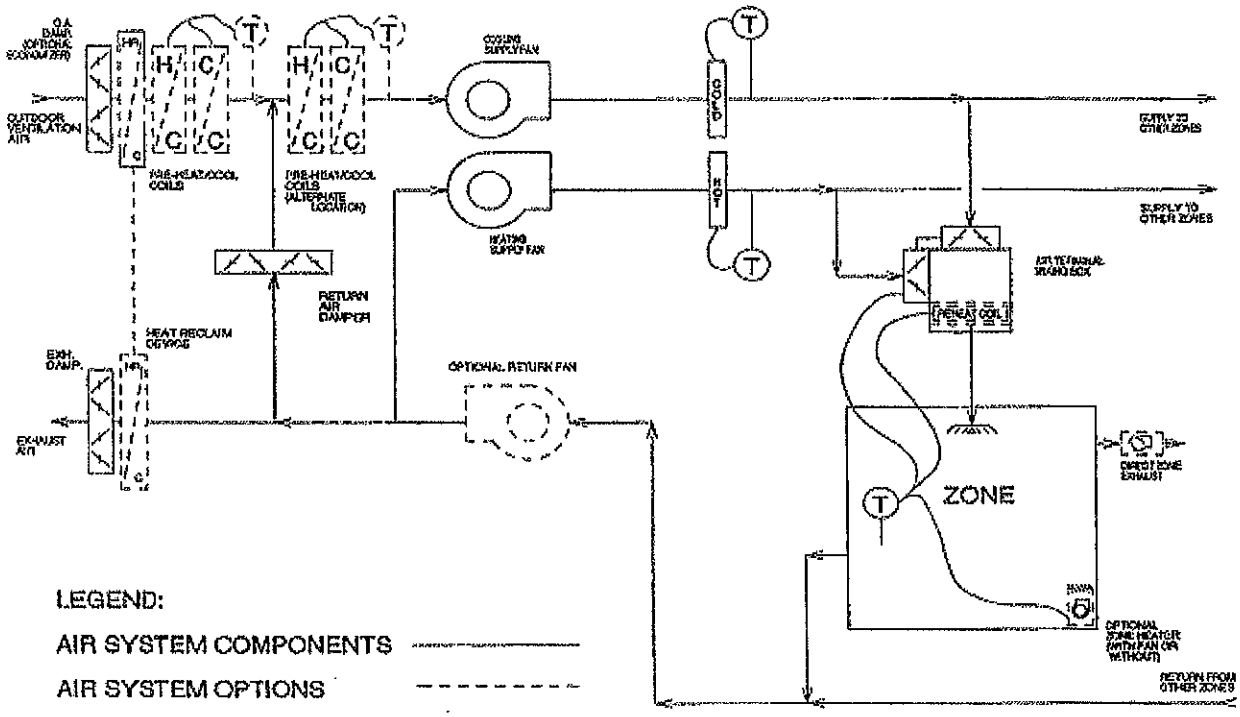
**B. Unoccupied Period Operation**

1. Supply Fan
   a. Cycles on when one or more zones call for cooling. The fan also cycles on when one or more zones call for heating, unless all zones calling for heating have zone heating units with room thermostat control units available.
   b. If zone heating units with room thermostat control are used and zones call only for heating, the supply fan is off.
   c. If no zones call for cooling or heating, the supply fan is off.
2. Supply Air Temperature
   a. If the supply fan is on, supply temperature is controlled in the same way as in the occupied period.
3. Zone Thermostat Calls For Cooling
   a. Operation is the same as in the occupied period.

4. Zone Thermostat Calls For Heating
   a. If zone heating units with room thermostat control are not used, operation is the same as described for the occupied period.
   b. If zone heating units with room thermostat control are used, these units provide sufficient heat to maintain zone comfort conditions.
5. Zone Thermostats Do Not Call For Cooling or Heating
   a. The system is off.

## VAV 2-Fan Dual Duct System

This help topic describes the operating assumptions for a VAV 2-Fan Dual Duct air system. This multiple-zone system uses a central two-deck, two-fan air handler which provides a variable volume of conditioned air to zone terminals. Air is distributed to the terminals through two parallel main ducts. The hot deck has its own VAV fan which supplies warm return air to the zones. A heating coil in the hot deck operates whenever the warm return air is insufficient to meet zone demand. The cold deck has its own VAV fan and cooling coil, and supplies cold air to the zones. The zone terminals mix air from the hot and cold supply ducts, providing air to the zones at a temperature sufficient to maintain comfort conditions. Depending on the user's description of the system, cooling and heating operation varies in the occupied and unoccupied periods as described in the following sections.




**VAV 2-Fan Dual Duct System Schematic**

### A. Occupied Period Operation

1. The cold deck supply fan runs continuously to supply a variable volume of cold air to zone terminals.
2. The hot deck supply fan runs continuously during the hour whenever one or more zones call for heating; otherwise, the hot deck fan is off.
3. Hot deck and cold deck supply air temperatures are controlled according to user specifications.
4. Zone Thermostat Control
   a. When a zone thermostat calls for cooling, the heating damper is fully closed while the cooling damper controls the amount of air received from the cold supply duct to maintain zone comfort conditions.
   b. When a zone thermostat calls for heating, the cooling damper is closed to its minimum flow position and the heating damper controls the amount of air received from the hot supply duct to maintain zone comfort conditions. If a zone heating unit with room thermostat control is used, it serves as a second stage of heat and only operates if central heating is not sufficient to maintain zone conditions.
   c. When a zone thermostat calls for neither cooling nor heating, the heating damper is fully closed and the cooling damper is closed to its minimum flow position. The zone temperature floats.

### B. Unoccupied Period Operation

1. Cold Deck Supply Fan
   a. Cycles on when one or more zones call for cooling. Also cycles on whenever the hot deck supply fan is operating.
2. Hot Deck Supply Fan
   a. Cycles on when one or more zones call for heating, unless all zones calling for heating have zone heating units with room thermostat control available.
   b. If zone heating units with room thermostat control are available, the hot deck fan is off.
3. Supply Air Temperature

a. If the supply fan is on, supply temperature is controlled in the same way as in the occupied period.

4. Zone Thermostat Control

a. When a zone thermostat calls for cooling, operation is the same as in the occupied period.

b. When a zone thermostat calls for heating and zone heating units with room thermostat control are not used, operation is the same as in the occupied period.

c. When a zone thermostat calls for heating and zone heating units with room thermostat control are used, the zone heating units provide the heat needed to maintain zone conditions.

d. When a zone thermostat does not call for cooling or heating, the system is off. The zone temperature floats.

## Terminal Unit Systems

This topic describes the operating assumptions for the following terminal HVAC systems:

- Packaged DX Fan Coils
- Split DX Fan Coils
- Variable Refrigerant Flow
- 2-Pipe Fan Coils
- 4-Pipe Fan Coils
- Water Source Heat Pumps
- Groundwater Source Heat Pumps
- Ground Source Heat Pumps

Air side operation of all eight types of equipment is the same. The terminal unit is a single-zone constant air volume unit providing conditioned air to the zone. Ventilation air may be provided to the terminal unit directly from outdoors as shown in Figure 1. As an alternative, unconditioned or pre-conditioned outdoor ventilation air can be provided by a centrally located ventilation air handler. When used, it is assumed air from the central ventilation unit is ducted to the inlet of each terminal unit in the system. This arrangement is shown in Figure 2.

Operating assumptions for the terminal units and the central ventilation unit are described separately below.

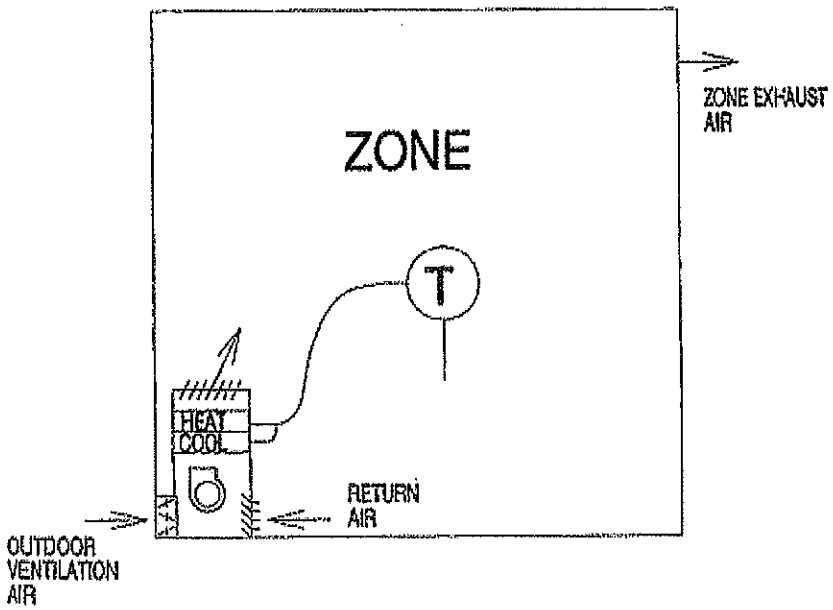



**Figure 1. Terminal Unit Schematic (Direct Ventilation Air Case)**

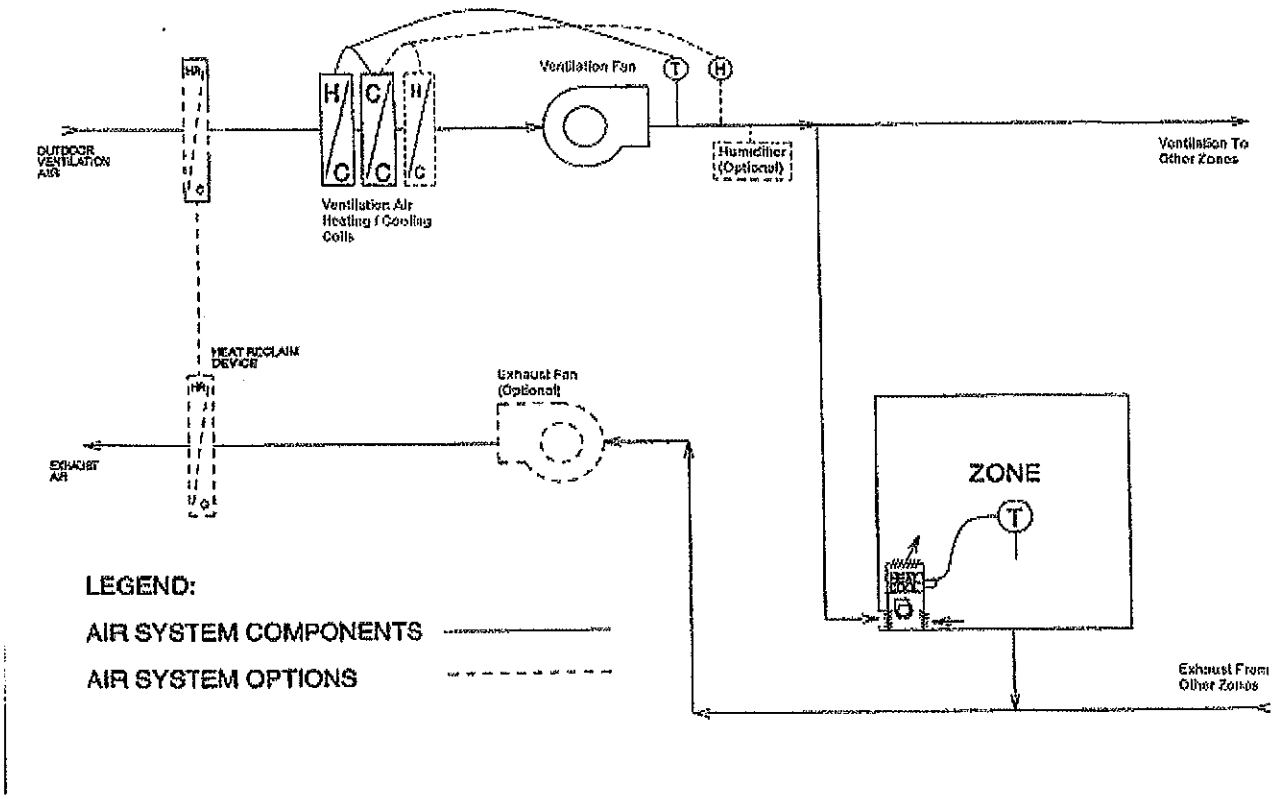



**Figure 2. Terminal Unit Schematic (Common Ventilation Unit Case)**

## A. Operation of Terminal Units

### A-1. Occupied Period Operation

1. Continuous Fan Operation
   a. The terminal supply fan runs continuously.
   b. If the zone thermostat calls for cooling, the cooling coil operates to maintain zone conditions.
   c. If the zone thermostat calls for heating, the heating coil operates to maintain zone conditions.
   d. If the zone thermostat does not call for cooling or heating, neither coil operates but the supply fan continues to run in order to ventilate the zone. The zone temperature floats in the deadband between cooling and heating setpoints.
2. Cycled Fan Operation
   a. If the zone thermostat calls for cooling, the terminal supply fan cycles to meet the cooling demand. Air is provided at the design cooling supply temperature. The supply fan is on only as long as necessary to meed the demand and then turns off.
   b. If the zone thermostat calls for heating, the supply fan cycles to meet the heating demand. Air is provided at the design heating supply temperature. The supply fan is on only as long as necessary to meed the demand and then turns off.
   c. If the zone does not call for cooling or heating, the fan is off.

### A-2. Unoccupied Period Operation

1. Continuous or Cycled Fan Operation
   a. If the zone thermostat calls for cooling, the terminal supply fan cycles to meet the cooling demand. Air is provided at the design cooling supply temperature. The supply fan is on only as long as necessary to meed the demand and then turns off.
   b. If the zone thermostat calls for heating, the terminal supply fan cycles to meet the heating demand. Air is provided at the design heating supply temperature. The supply fan is on only as long as necessary to meed the demand and then turns off.
   c. If the zone does not call for cooling or heating, the terminal supply fan is off.

## B. Operation of Common Ventilation Unit

When the terminal unit system is configured with a common ventilation unit, the ventilation unit operates as follows:

### B-1. Occupied Period Operation

1. The ventilation supply fan runs continuously to supply 100% outside air.
2. If a ventilation cooling coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit rises above the duct cooling setpoint. The air will be cooled so the duct temperature is held at the setpoint.
3. If a cooling coil is present and scheduled on, and dehumidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit is rises above the duct cooling setpoint, the cooling coil will be energized to hold the duct air at the setpoint. If the duct humidity is above the maximum RH setpoint, the cooling coil will provide additional cooling to lower the coil dew point, thus condensing more moisture, and holding the duct air at the maximum RH setpoint. A heating coil will provide dehumidification reheat so the duct air temperature continues to be held at duct cooling setpoint.
4. If a heating coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit falls below the duct heating setpoint. The air will be heated so the duct temperature is held at the setpoint.
5. If a heating coil is present and scheduled on, and humidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit falls below the duct heating setpoint, the heating coil will be energized to hold the duct air at the setpoint. If the duct humidity is below the minimum RH setpoint, the humidifier will add moisture to the air stream to hold the duct humidity at the minimum RH setpoint.

**B-2. Unoccupied Period Operation**

1. The ventilation system is off during all unoccupied period hours.

## Induction Beam System

This topic describes the air-side operating assumptions for Induction Beam systems

In this system a Dedicated Outside Air System (DOAS) provides pre-conditioned air to ceiling-mounted induction beam terminals serving each zone (Figure 1). This primary air flows through specially designed nozzles to produce high velocity jets of air. The air jets create a region of negative pressure relative to zone air pressure in a mixing chamber which induces air from the room into the terminal where it flows over a cooling or heating coil. This induced, conditioned air then mixes with primary air in the mixing chamber, and the mixed air is supplied through a supply louver to the zone to provide conditioning (Figure 2).

An induction beam terminal is a total cooling device, able to provide both sensible and latent cooling. Typically the DOAS unit is designed to meet the ventilation sensible and latent loads, and may meet a portion of the zone sensible and latent loads. The induction beam terminal is sized to meet the remainder of the zone sensible and latent loads.

Operating assumptions for the system are described below.

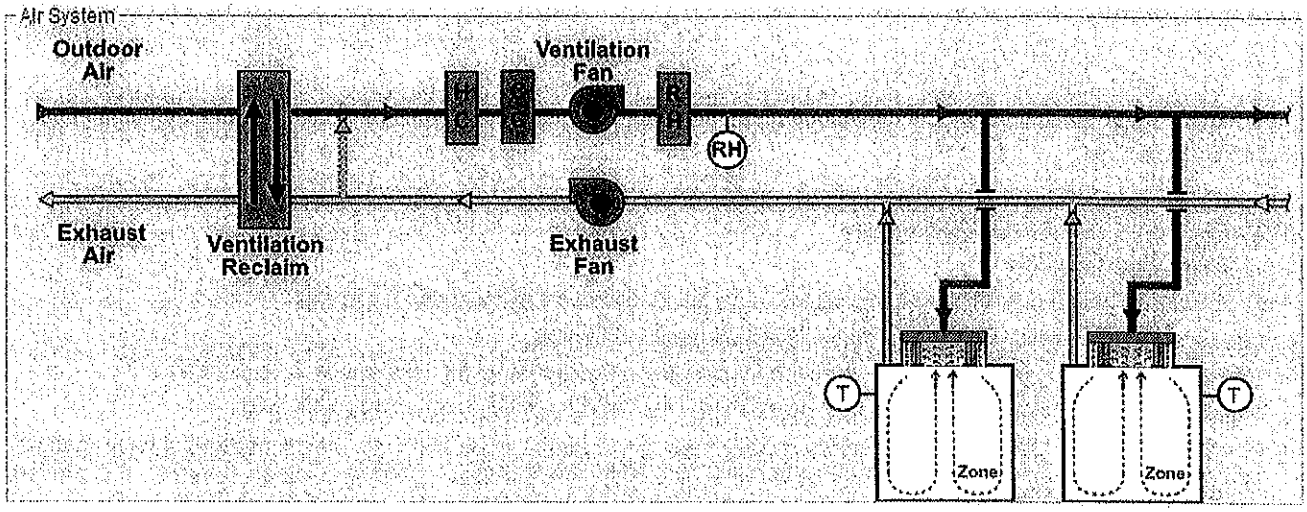



**Figure 1. Induction Beam System Diagram**

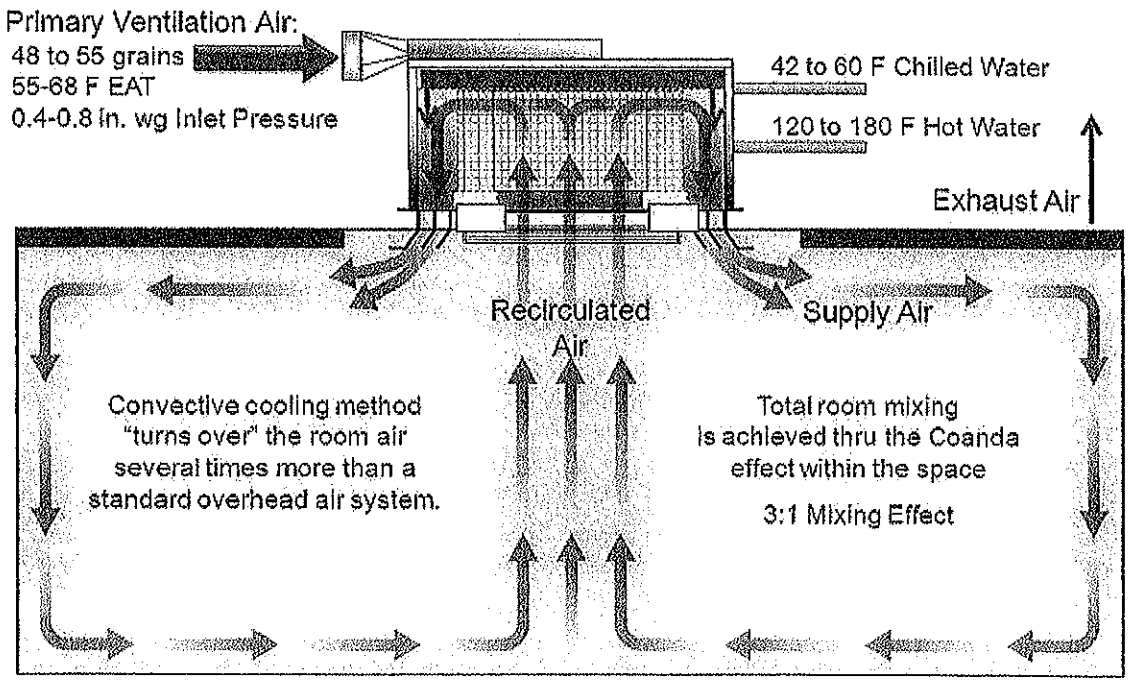



**Figure 2. Induction Beam Terminal Diagram**

A. Operation During Occupied Period Hours

A-1. Ventilation Unit Operation

1. The ventilation supply fan runs continuously at its design airflow to supply 100% outside air.
2. If a ventilation cooling coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit rises above the occupied period discharge cooling setpoint. The air will be cooled so the duct temperature is held at this setpoint.
3. If a cooling coil is present and scheduled on, and dehumidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit rises above the occupied discharge cooling setpoint, the cooling coil will be energized to hold the duct air at the setpoint. If the duct humidity is above the

maximum RH setpoint, the cooling coil will provide additional cooling to lower the coil dew point, thus condensing more moisture, and holding the duct air at the maximum RH setpoint. A heating coil will provide dehumidification reheat so the duct air temperature is held at occupied discharge heating setpoint (if a heating coil exists) or the occupied discharge cooling setpoint (if no heating coil exists).

4. If a heating coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit falls below the occupied discharge heating setpoint. The air will be heated so the duct temperature is held at this setpoint.

**A-2. Induction Beam Terminal Operation**

1. The zone thermostat operates with occupied period settings.
2. If the zone thermostat calls for cooling, the water valve for the cooling coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required sensible cooling to satisfy the thermostat. If the coil apparatus dew point is below the dew point of room air entering the coil, latent cooling will also occur. Condensed moisture is collected in a drain pan in the terminal which drains into the condensate removal system.
3. If the zone thermostat calls for heating, the water valve for the heating coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required heating to satisfy the thermostat.
4. If the zone thermostat does not call for cooling or heating, the water valves for the terminal cooling and heating coils remain closed. The terminal continues to induce room air into the terminal and supply air to the zone but no cooling or heating by the induction beam terminal occurs.

**B. Operation During Unoccupied Period Hours**

**B-1. Ventilation Unit Operation**

1. If "Continuous Operation" was chosen for unoccupied hours, the ventilation supply fan runs continuously.
   a. If the reduced airflow option is not used, the fan runs at its design airflow rate.
   b. If reduced airflow is specified, the fan runs to deliver the specified reduced airflow rate (50% to 95% of design flow).
   c. If ventilation dampers are open during the unoccupied period, the ventilation unit provides 100% outdoor air.
   d. If ventilation dampers are closed during the unoccupied period, the ventilation unit provides air that is the mixture of recirculated air and outdoor air leaked through the outdoor air dampers, if leakage was specified. If leakage was not specified, then the unit provides 100% recirculated air.
2. If "Cycled on Demand" was chosen for unoccupied hours, the ventilation supply fan operates as follows:
   a. If the air temperature in all zones is floating in the zone thermostat deadbands, there are no calls for cooling or heating and the ventilation unit remains off.
   b. If the air temperature in one or more zones rises above the cooling setpoint or falls below the heating setpoint, the thermostat issues a call for cooling and the ventilation unit turns on.
   c. If the reduced airflow option is not used, the fan runs at its design airflow rate.
   d. If reduced airflow is specified, the fan runs to deliver the specified reduced airflow rate (50% to 95% of design flow).
   e. If ventilation dampers are open during the unoccupied period, the ventilation unit provides 100% outdoor air.
   f. If ventilation dampers are closed during the unoccupied period, the ventilation unit provides air that is the mixture of recirculated air and outdoor air leaked through the outdoor air dampers, if leakage was specified. If leakage was not specified, then the unit provides 100% recirculated air. If leakage is not specified, the ventilation unit provides 100% recirculated air.
   g. The ventilation unit runs until all thermostats are satisified and then turns off. Therefore it cycles on when a cooling or heating demand exists in one or more zones, and cycles off as soon as all demands have been satisfied. If the demands can be satisified with run time less than 60 minutes, the ventilation unit will only run for the portion of the hour necessary.
2. Cooling coil operation is the same as for the occupied period except that the unoccupied period setpoint is used: If a ventilation cooling coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit rises above the unoccupied period discharge cooling setpoint. The air will be cooled so the duct temperature is held at this setpoint.
3. Dehumidification control is the same as for the occupied period: If a cooling coil is present and scheduled on, and dehumidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit rises above the unoccupied discharge cooling setpoint, the cooling coil will be energized to hold the duct air at the setpoint. If the duct humidity is above the maximum RH setpoint, the cooling coil will provide additional cooling to lower the coil dew point, thus condensing more moisture, and holding the duct air at the maximum RH setpoint. A heating coil will provide dehumidification reheat so the duct air temperature continues to be held at the unoccupied discharge heating setpoint (if a heating coil exists) or the unoccupied discharge cooling setpoint (if no heating coil exists).
4. Heating coil operation is the same as for the occupied period except that the unoccupied period setpoint is used: If a heating coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit falls below the unoccupied discharge heating setpoint. The air will be heated so the duct temperature is held at this setpoint.

**B-2. Induction Beam Terminal Operation**

1. The zone thermostat operates with unoccupied period settings.
2. If the zone thermostat calls for cooling, the water valve for the cooling coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required sensible cooling to satisfy the thermostat. If the coil apparatus dew point is below the dew point of room air entering the coil, latent cooling will also occur. Condensed moisture is collected in a drain pan in the terminal which drains into the condensate removal system.
3. If the zone thermostat calls for heating, the water valve for the heating coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required heating to satisfy the thermostat.
4. If the zone thermostat does not call for cooling or heating, the water valves for the terminal cooling and heating coils remain closed. The terminal continues to induce room air into the terminal and supply air to the zone but no cooling or heating is done by the

Induction beam terminal.

## Active Chilled Beam System

This topic describes the air-side operating assumptions for Active Chilled Beam systems

In this system a Dedicated Outside Air System (DOAS) provides pre-conditioned air to ceiling-mounted chilled beam terminals serving each zone (Figure 1). This primary air flows through nozzles to produce high velocity jets of air. The air jets create a region of negative pressure relative to zone air pressure in a mixing chamber which induces air from the room into the terminal where it flows over a cooling or heating coil. This induced, conditioned air then mixes with primary air in the mixing chamber, and the mixed air is supplied through a supply louver to the zone to provide conditioning (Figure 2).

An active chilled beam is a sensible-only cooling device. The DOAS unit is designed to meet the ventilation sensible and latent loads, and must also provide dry enough air to absorb the latent load in the zone. Special care in design is required to ensure moisture will not condense on active chilled beam terminals in the zone. The active chilled beam is designed to meet the portion of the zone sensible cooling load not met by the DOAS unit..

Operating assumptions for the system are described below.

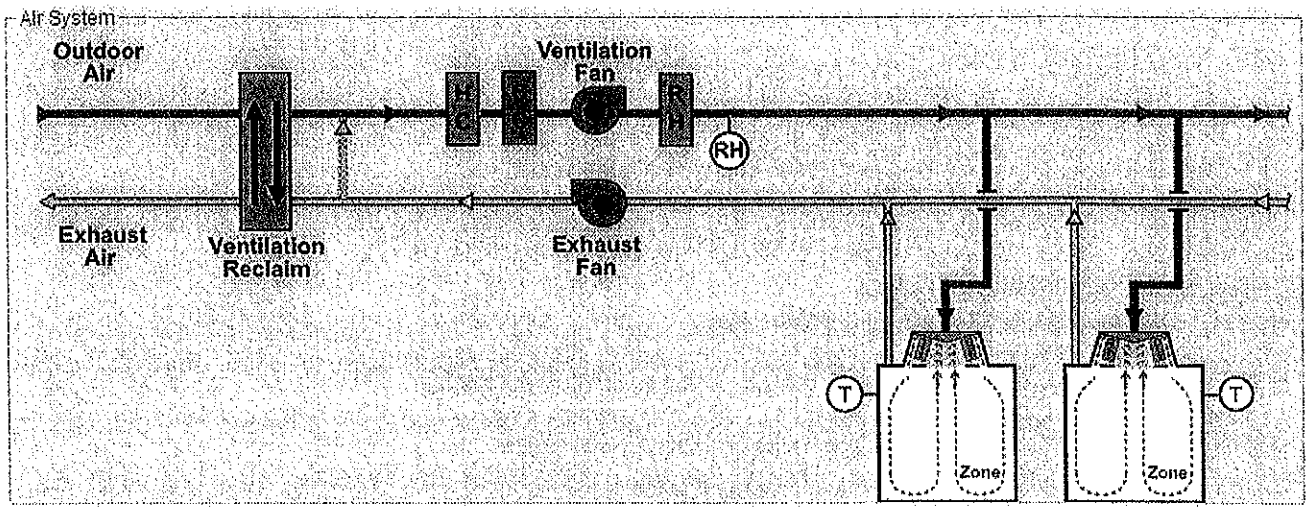



**Figure 1. Chilled Beam System Diagram**

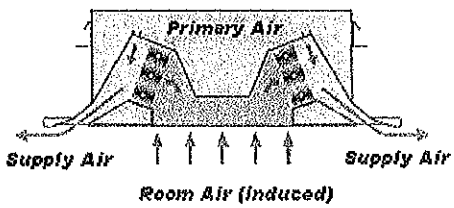



**Figure 2. Chilled Beam Terminal Diagram**

### A. Operation During Occupied Period Hours

#### A-1. Ventilation Unit Operation

1. The ventilation supply fan runs continuously at its design airflow to supply 100% outside air.
2. If a cooling coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit rises above the occupied period discharge cooling setpoint. The air will be cooled so the duct temperature is held at the setpoint.
3. If a cooling coil is present and scheduled on, and dehumidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of discharge air downstream of the unit rises above the occupied discharge cooling setpoint, the cooling coil will be energized to hold the duct air at the setpoint. If the duct humidity is above the maximum RH setpoint, the cooling coil will provide additional cooling to lower the coil dew point, thus condensing more moisture, and holding the duct air at the maximum RH setpoint. A heating coil will provide dehumidification reheat so the duct air temperature is held at the occupied period discharge heating setpoint (if a heating coil exists) or the discharge cooling setpoint (if no heating coil exists).
4. If a heating coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit falls below the occupied period discharge heating setpoint. The air will be heated so the duct temperature is held at the setpoint.

#### A-2. Active Chilled Beam Terminal Operation

1. The zone thermostat operates with occupied period settings.
2. If the zone thermostat calls for cooling, the water valve for the cooling coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required sensible cooling to satisfy the thermostat.
3. If the zone thermostat calls for heating, the water valve for the heating coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required heating to satisfy the thermostat.
4. If the zone thermostat does not call for cooling or heating, the water valves for the terminal cooling and heating coils remain closed. The terminal continues to induce room air into the terminal, and supply air to the zone but no cooling or heating is done by the chilled beam terminal.

**B. Operation During Unoccupied Period Hours**

**B-1. Ventilation Unit Operation**

1. The ventilation supply fan runs continuously at the design airflow rate.
   a. If ventilation dampers are open during the unoccupied period, the ventilation unit provides 100% outdoor air.
   b. If ventilation dampers are closed during the unoccupied period, the ventilation unit provides air that is the mixture of recirculated air and outdoor air leaked through the outdoor air dampers, if leakage was specified. If no leakage was specified, then the ventilation unit provides 100% recirculated air.
2. Cooling coil operation is the same as for the occupied period except that the unoccupied setpoint is used: If a ventilation cooling coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit rises above the unoccupied period discharge cooling setpoint. The air will be cooled so the duct temperature is held at this setpoint.
3. Dehumidification control is the same as for the occupied period: If a cooling coil is present and scheduled on, and dehumidification control is used, the unit will control both dry-bulb temperature and relative humidity (RH) downstream of the unit. If the temperature of duct air downstream of the unit rises above the unoccupied discharge cooling setpoint, the cooling coil will be energized to hold the duct air at the setpoint. If the duct humidity is above the maximum RH setpoint, the cooling coil will provide additional cooling to lower the coil dew point, thus condensing more moisture, and holding the duct air at the maximum RH setpoint. A heating coil will provide dehumidification reheat so the duct air temperature continues to be held at the unoccupied discharge heating setpoint (if a heating coil exists) or the unoccupied discharge cooling setpoint (if no heating coil exists).
4. Heating coil operation is the same as for the occupied period except that the unoccupied setpoint is used: If a heating coil is present and scheduled on, the coil will be energized when the duct temperature downstream of the unit falls below the unoccupied period discharge heating setpoint. The air will be heated so the duct temperature is held at this setpoint.

**B-2. Active Chilled Beam Terminal Operation**

1. The zone thermostat operates with unoccupied period settings.
2. If the zone thermostat calls for cooling, the water valve for the cooling coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required sensible cooling to satisfy the thermostat.
3. If the zone thermostat calls for heating, the water valve for the heating coil in the induction beam is opened. The valve regulates water flow through the coil to deliver the required heating to satisfy the thermostat.
4. If the zone thermostat does not call for cooling or heating, the water valves for the terminal cooling and heating coils remain closed. The terminal continues to induce room air into the terminal, and supply air to the zone but no cooling or heating is done by the chilled beam terminal.