

CHAPTER 3

IN-ROOM TERMINAL SYSTEMS

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IN-ROOM terminal systems condition spaces by distributing air and water sources to terminal units installed in habitable spaces throughout a building. In some systems, air is distributed to the space directly, not through the terminal unit. In-room terminals usually condition a single space, but some (e.g., a large fan-coil unit) may serve several spaces. The air and water are cooled or heated in central equipment rooms. The air supplied is called primary or ventilation air; the chilled water supplied is called primary or secondary water. Steam may also be used. Sometimes a separate electric heating coil is included in lieu of a hot-water coil. This chapter describes induction units and fan-coil units used in in-room terminal unit systems.

These systems are used primarily in perimeter spaces of buildings with high sensible loads and where close control of humidity is not required, but are sometimes used in interior zones. They work well in office buildings, hospitals, hotels, schools, apartment buildings, and research laboratories. In most climates, these systems are installed in perimeter building spaces and are designed to provide (1) all required space heating and cooling, (2) outside air for ventilation, and (3) simultaneous heating and cooling in different parts of the building during intermediate seasons.

Advantages

- Individual room temperature control allows each thermostat to be adjusted for a different temperature at relatively low cost.
- Separate heating and cooling sources in the primary air and secondary water give occupants a choice of heating or cooling.
- Less space is required for the distribution system when the air supply is reduced by using secondary water for cooling and high-velocity primary-air supply. The return air duct is smaller and can sometimes be eliminated or combined with the return air system for other areas, such as the interior spaces.
- The central air-handling apparatus is smaller than that of an all-air system because less air must be conditioned at that location.
- Dehumidification, filtration, and humidification are performed in a central location remote from conditioned spaces.
- Ventilation air is positively supplied and can accommodate constant recommended outside air quantities.
- Space can be heated without operating the air system, via the secondary-water system. Nighttime fan operation is avoided in an unoccupied building. Emergency power for heating, if required, is much lower than for most all-air systems.

Disadvantages

- For many buildings, in-room terminals are limited to perimeter space; separate systems are required for other areas.
- More controls are needed than for many all-air systems.

- Primary-air supply usually is constant with no provision for shut-off. This is a disadvantage in residential applications, where tenants or hotel room guests may prefer to turn off the air conditioning, or where management may desire to do so to reduce operating expense.
- Low primary chilled-water temperature and/or deep chilled-water coils are needed to control space humidity adequately.
- The system is not appropriate for spaces with high exhaust requirements (e.g., research laboratories) unless supplementary ventilation air is provided.
- Central dehumidification eliminates condensation on the secondary-water heat transfer surface under maximum design latent load, but abnormal moisture sources (e.g., open windows, cooking, or people congregating) can cause annoying or damaging condensation. Therefore, a condensate pan should be provided as for other systems.
- Low primary-air temperatures require heavily insulated ducts.
- Energy consumption for induction systems is higher than for most other systems because of the increased power needed to deliver primary air against the pressure drop in the terminal units.
- Initial cost for a four-pipe induction system is greater than for most all-air systems.

PERIMETER ZONE AIR-CONDITIONING LOADS

Variation in air-conditioning load for perimeter building spaces causes significant variations in space cooling and heating requirements, even in rooms that have the same exposure. Accordingly, accurate environmental control in perimeter spaces requires individual control. The following basic loads must be considered.

Internal Loads. Heat gain from lights is always a cooling load, and in most nonresidential buildings it is relatively constant during the day. Lights may be turned off manually or automatically when not required, which makes lighting loads more variable. Heat gain from occupants is also a cooling load and is commonly the only room load with a latent component. Heat gain from computers and other heat-generating equipment can vary greatly and is an important factor in building design.

External Loads. Solar heat gain is always a cooling load. It is often the major cooling load and is highly variable. For a given space, solar gain always varies during the day. The magnitude and rate of change of this load depend on building orientation, glass area, capacity to store heat, and cloud cover. Constantly changing shade patterns from adjacent buildings, trees, or exterior columns and nonuniform overhangs can cause significant variations in solar load between adjacent offices on the same solar exposure.

Transmission load can be either a heat loss or a heat gain, depending on outside temperature.

Moderate, uniformly positive pressurization of the building with ventilation air is normally sufficient to offset summer infiltration. In winter, however, infiltration can cause significant heat

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loss, particularly on the lower floors of high-rise buildings. The magnitude of this component varies with wind and stack effect, as well as with the temperature difference across the outside wall.

To perform successfully, an air-conditioning system must satisfy these load variations on a room-by-room basis and fulfill all other performance criteria, such as humidity control, filtration, air movement, ventilation, and noise.

SYSTEM DESCRIPTION

An in-room terminal unit system may consist of only fan-coil room terminal units and a water distribution system, or it may include room terminal units with central air-conditioning equipment, and both a duct and water distribution system. Other in-terminal system designs introduce ventilation air into the fan-coil unit through an opening in the building skin. In these cases, care must be taken in freezing climates to minimize the risk of frozen coils.

Some in-room terminals serve individual rooms; larger spaces may be served by several units. Generally, the supply air volume from the central apparatus is constant and is called primary or ventilation air to distinguish it from recirculated room air or secondary air. The quantity of primary air supplied to each space is determined by (1) the amount of outside air required for ventilation and (2) the required sensible cooling capacity at maximum room cooling load (if used for sensible cooling). In this approach, during the cooling season, the air is dehumidified sufficiently in the central conditioning unit to maintain comfortable humidity conditions and to prevent condensation on the room cooling coil from the normal room latent load. In winter, moisture can be added centrally to limit dryness. As the primary air is dehumidified, it is also cooled to offset part of the room sensible loads. The air may be from outdoors, or may be mixed outside and return air. A heating coil may be required in the central air handler, as well as a preheater in areas with freezing weather.

In the ideal in-room terminal unit design, the secondary cooling coil is always dry; this greatly extends terminal unit life and eliminates odors and the possibility of bacterial growth in the unit in the occupied space. In this case, in-room terminals may be replaced by radiant panels (see Chapter 6, Panel Heating and Cooling, for more information). The primary air normally controls the space humidity. Therefore, the moisture content of the supply air must be low enough to offset the room latent heat gain and to maintain a room dew point low enough to preclude condensation on the secondary cooling surface. Even though some systems operate successfully with little or no condensate, a condensate drain is recommended. In systems that shut down during off hours, start-up load may include considerable dehumidification, producing moisture to be drained away.

The water side, in its basic form, consists of a pump and piping to convey water to the heat transfer surface in the unit in each conditioned space. In-room terminals are categorized as two-, three-, or four-pipe, and the water may provide heating, cooling, or both, depending on the type of in-room terminal system. They are similar in function and include both cooling and heating capabilities for year-round air conditioning. These piping arrangements are discussed in greater detail in the section on Fan-Coil Units and in Chapter 12.

INDUCTION UNITS

Figure 1 shows a basic arrangement for an induction unit terminal. Centrally conditioned primary air is supplied to the unit plenum. The acoustically treated plenum attenuates part of the noise generated in the unit and duct. The high-velocity induction unit nozzles typically generate significant high-frequency noise. A balancing damper adjusts the primary-air quantity within limits.

Medium- to high-velocity airflows through the induction nozzles and induces secondary air from the room through the secondary coil. Thus, the primary air provides the energy required to circulate

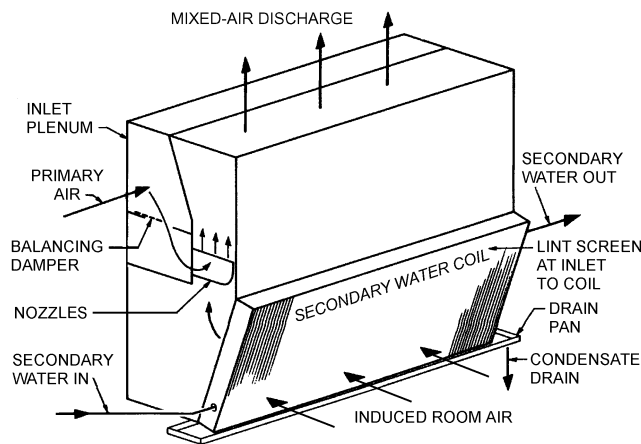


Fig. 1 Induction Unit

the secondary air over the coil in the terminal unit. This secondary air is either heated or cooled at the coil, depending on the season, the room requirement, or both. Ordinarily, the room coil does no latent cooling, but a drain pan without a piped drain collects condensed moisture from temporary latent loads such as at start-up. This condensed moisture then re-evaporates when the temporary latent loads are no longer present. Primary and secondary (induced) air is mixed and discharged to the room.

Secondary airflow can cause induction-unit coils to become dirty enough to affect performance. Lint screens used to protect these terminals require frequent in-room maintenance and reduce unit thermal performance.

Induction units are installed in custom enclosures, or in standard cabinets provided by the manufacturer. These enclosures must permit proper flow of secondary air and discharge of mixed air without imposing excessive pressure loss. They must also allow easy servicing.

Although induction units are usually installed under a window at a perimeter wall, units designed for overhead installation are available. During the heating season, the floor-mounted induction unit can function as a convector during off hours, with hot water to the coil and without a primary-air supply. A number of induction unit configurations are available, including units with low overall height or with larger secondary-coil face areas to suit particular space or load needs.

Induction units may be noisier than fan-coil units, especially in frequencies that interfere with speech. On the other hand, white noise from the induction unit enhances acoustical privacy by masking speech from adjacent spaces.

In-room terminals operate dry, with an anticipated life of 15 to 25 years. The piping and ductwork longevity should equal that of the building. Individual induction units do not contain fans, motors, or compressors. Routine service is generally limited to temperature controls, cleaning lint screens, and infrequently cleaning the induction nozzles.

In existing induction systems, conserving energy by raising the chilled-water temperature on central air-handling cooling coils can damage the terminal cooling coil, causing it to be used constantly as a dehumidifier. Unlike fan-coil units, the induction unit is not designed or constructed to handle condensation. Therefore, it is critical that an induction terminal operates dry.

FAN-COIL UNITS

Fan-coil unit systems can include cooling as well as heating, normally move air by forced convection through the conditioned space, filter circulating air, and may introduce outside ventilation air. Units with chilled-water coils, heating coils, blowers, replaceable air filters, drain pans for condensate, etc., are designed for these purposes. These units

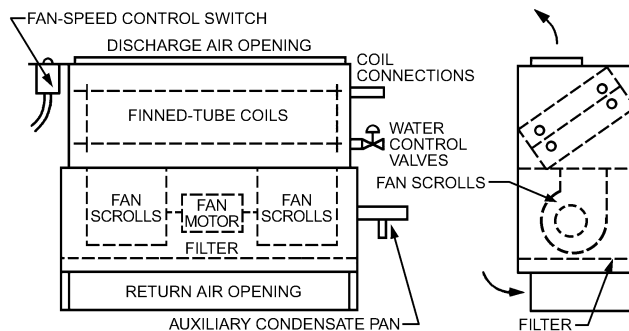


Fig. 2 Typical Fan-Coil Unit

are available in various configurations to fit under window sills, above furred ceilings, in vertical pilasters built into walls, etc. These units must be properly controlled by thermostats for heating and cooling temperature control, by blower control or other means for regulating air quantity. If they do not have a method to add ventilation air into the building, a separate means of outside air ventilation must be provided.

Basic elements of fan-coil units are a finned-tube coil, filter, and fan section (Figure 2). The fan recirculates air continuously from the space through the coil, which contains either hot or chilled water. The unit may contain an additional electric resistance, steam, or hot-water heating coil. The electric heater is often sized for fall and spring to avoid changeover problems in two-pipe systems. It may also be used to provide reheat for humidity control.

A cleanable or replaceable moderate-efficiency filter, located upstream of the fan, prevents clogging of the coil with dirt or lint entrained in the recirculated air. It also protects the motor and fan, and reduces the level of airborne contaminants in the conditioned space. The fan-coil unit is equipped with an insulated drain pan. The fan and motor assembly is arranged for quick removal for servicing.

Most manufacturers furnish units with cooling performance certified as meeting Air-Conditioning and Refrigeration Institute (ARI) standards. The unit prototypes have been tested and labeled by Underwriters Laboratories (UL), or Engineering Testing Laboratories (ETL), as required by some codes. Requirements for testing and standard rating of room fan-coils having air-delivery capacities of 1500 cfm or below are described in ARI *Standard* 440-1998 and ANSI/ASHRAE *Standard* 79-2002.

Fan-coil units with a dampered opening for connection to apertures in the outside wall are available. These units are not suitable for commercial buildings because wind pressure allows no control over the amount of outside air that is admitted. Also, freeze protection may be required in cold climates. They are, however, often used in residential construction because of simple operation and low first cost, and because operable windows can cause imbalance in a ducted ventilation air system. Fan-coil units for the domestic market are generally available in nominal sizes of 200, 300, 400, 600, 800, and 1200 cfm, often with multispeed, high-efficiency fan motors. Where units do not have individual outside air intakes, means must be provided to introduce retreated outside air through a duct system to each room or space.

A major advantage of fan-coil unit systems is that the delivery system (piping versus duct systems) requires less building space: a smaller central fan room (or none) and little duct space. The system has all the benefits of a central water chilling and heating plant, but allows shutting off local terminals in unused areas. It gives individual room control with little cross-contamination of recirculated air. Extra capacity for quick pulldown response may be provided. Because this system can heat with low-temperature water, it is particularly suitable for solar or heat recovery refrigeration equipment. For existing building retrofit, it is often easier to install piping and wiring for a fan-coil unit system than the large ductwork required for an all-air system.

Fan-coil unit systems require much more maintenance than central all-air systems, and this work must be done in occupied areas. Units that operate at low dew points require condensate pans and a drain system that must be cleaned and flushed periodically. Condensate disposal can be difficult and costly. It is also difficult to clean the coil. Filters are small, low-efficiency, and require frequent changing to maintain air volume. In some instances, drain systems can be eliminated if dehumidification is positively controlled by a central ventilation air system.

Rooms are often ventilated by opening windows or by outside wall apertures, if not handled by a central system. Ventilation rates are affected by stack effect and wind direction and speed.

Summer room humidity levels tend to be relatively high, particularly if modulating chilled-water control valves are used for room temperature control. Alternatives are two-position control with variable-speed fans (chilled water is either on or off, and air-flow is varied to maintain room temperature) and the bypass unit variable chilled-water temperature control (chilled-water flow is constant and face and bypass dampers are modulated to control room temperature).

Fan-coil systems are best applied where individual space temperature control or cross-contamination prevention is needed. Suitable applications are hotels, motels, apartment buildings, and office buildings. Fan-coil systems are used in many hospitals, but they are less desirable because of the low-efficiency filtration and difficulty in maintaining adequate cleanliness in the unit and enclosure. In addition, the limits set by *Guidelines for Design and Construction of Hospital and Health Care Facilities* (AIA 2001) do not permit air recirculation in certain types of spaces.

Types and Location

Fan-coil units are available in many configurations. Figure 3 shows several **vertical configurations**. Low vertical units are available for use under windows with low sills; however, in some cases, the low silhouette is achieved by compromising features such as filter area, motor serviceability, and cabinet style.

Floor-to-ceiling, **chase-enclosed units** are available in which the water and condensate drain risers are part of the factory-furnished unit. Stacking units with integral prefabricated risers directly one above the other can substantially reduce field labor for installation, an important cost factor. These units are used extensively in hotels and other residential buildings. For units serving multiple rooms, the supply and return air paths must be isolated from each other to prevent air and sound interchange between rooms.

Vertical or chase-enclosed models at the perimeter give better results in climates or buildings with high heating requirements. Heating is enhanced by underwindow or exterior wall locations. Vertical units can operate as convectors with the fans turned off during night setback.

Horizontal overhead units may be fitted with ductwork on the discharge to supply several outlets. A single unit may serve several rooms (e.g., in an apartment house where individual room control is not essential and a common air return is feasible). Units must have larger fan motors designed to handle the higher static pressure resistance of the connected ductwork.

Horizontal models conserve floor space and usually cost less, but when located in furred ceilings, they can create problems such as condensate collection and disposal, mixing return air from other rooms, leaky pans damaging ceilings, and difficult access for filter and component removal. In addition, possible condensate leakage may present air quality concerns.

When outside air is introduced from a central ventilation system, it may be connected directly to the inlet plenums of horizontal units or introduced directly into the space. If introduced directly, provisions should be made to ensure that this air is pretreated and held at a temperature equal to the room temperature so as not to cause occupant discomfort when the space unit is off. One way to prevent

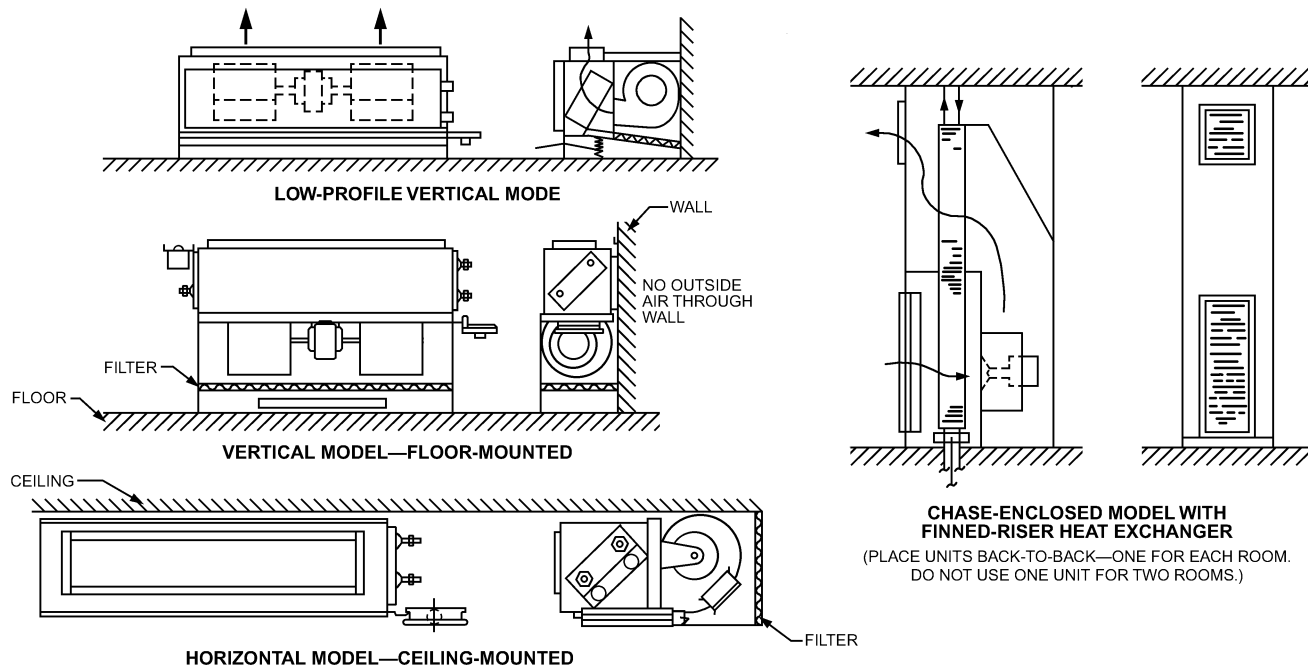


Fig. 3 Typical Fan-Coil Unit Arrangements

air leakage is to provide a spring-loaded motorized damper that closes off the ventilation air whenever the unit's fan is off. Coil selection must be based on the temperature of the entering mixture of primary and recirculated air, and air leaving the coil must satisfy the room sensible and latent cooling and heating requirements.

Selection

Some designers size fan-coil units for nominal cooling at medium speed when a three-speed control switch is provided. This method ensures quieter operation in the space and adds a safety factor (capacity can be increased by operating at high speed). Sound power ratings are available from many manufacturers.

Only the internal space heating and cooling loads need to be handled by terminal fan-coil units when outside air is pretreated by a central system to a neutral air temperature of about 70°F. This pretreatment should reduce the size and cost of the terminal units. All loads must be considered in unit selection when outside air is introduced directly through building apertures into the terminal unit.

Wiring

Fan-coil conditioner fans are driven by small motors, generally shaded pole or capacitor start with inherent overload protection. Operating wattage of even the largest sizes rarely exceeds 300 W at high speed. Running current rarely exceeds 2.5 A. Almost all motors on units in the United States are 120 V, single-phase, 60 Hz current, and they provide multiple (usually three) fan speeds and an off position. Other voltages and power characteristics may be encountered, depending on location, and should be investigated before determining the fan motor characteristics.

In planning the wiring circuit, required codes must be followed. The preferred wiring method generally provides separate electrical circuits for fan-coil units and does not connect them into the lighting circuit.

Separate electrical circuits connected to a central panel allow an energy management system or the building operator to turn off unit fans from a central point during unoccupied hours. Although this panel costs more initially, it can lower operating costs in buildings that do not have 24 h occupancy. In hot, humid climates, care must

be taken to avoid excess humidity when units are off to avoid mildew formation. Using separate electrical circuits allows a single remote thermostat to be mounted in a well-exposed perimeter space to operate unit fans. Another method is to operate the fan-coil continuously on low speed during unoccupied periods.

Piping

Even when outside air is pretreated, a condensate removal system should be installed for fan-coil units. This precaution ensures that moisture condensed from air from an unexpected source, such as an open window, that bypasses the ventilation system is removed. Drain pans are integral for all units. Condensate drain lines should be oversized to avoid clogging with dirt and other materials, and condensate drains should be cleaned periodically. Condensation may occur on the outside of the drain piping, which requires that these pipes be insulated. Many building codes have outlawed systems without condensate drain piping because of the potential damage and possibility of mold growth in stagnant water accumulated in the drain pan.

Capacity Control

Fan-coil unit capacity is usually controlled by coil water flow, fan speed, or a combination of these. Water flow can be thermostatically controlled by return air temperature or a wall thermostat and two- or three-way valve. Unit controls may be self-contained direct digital microprocessor, line voltage or low-voltage electric, or pneumatic.

Fan speed control may be automatic or manual. Automatic control is usually on-off with manual speed selection. Units are available with variable-speed motors for modulated speed control. Room thermostats are preferred where automatic fan speed control is used. Return air thermostats do not give a reliable index of room temperature when the fan is off. Residential fan-coil units have manual three-speed fan control with water temperature, both heating and cooling, scheduled based on outside temperature. On-off speed control is poor because (1) alternating shifts in fan noise level are more obvious than the sound of a constantly running fan, and (2) air circulation patterns within the room are noticeably affected.

Maintenance

Room fan-coil units are equipped with filters that should be cleaned or replaced when dirty. Good filter maintenance improves sanitation and provides full airflow, ensuring full-capacity delivery. Cleaning frequency varies with the application. Units in apartments, hotels, and hospitals usually require more frequent filter service because of lint.

Fan-coil unit motors may require periodic lubrication. Motor failures are not common, but when they occur, the entire fan can be quickly replaced with minimal interruption in the conditioned space. The condensate drain pan and drain system should be cleaned or flushed periodically to prevent overflow and microbial build-up. Drain pans should be trapped to prevent any gaseous back-up.

WATER DISTRIBUTION

For terminal units requiring chilled and/or hot water, the piping arrangement determines the performance quality, ease of operation, and initial cost of the system.

Two-Pipe Distribution

Two-Pipe Changeover Without Central Ventilation. In this system either hot or cold water is supplied through the same piping. The terminal unit has a single coil. The simplest system with the lowest initial cost is the two-pipe changeover with (1) outside air introduced through building apertures, (2) manual three-speed fan control, and (3) hot- and cold-water temperatures scheduled by outside temperatures. This system is generally used in residential buildings or hotels with operable windows and relies on the occupant to control fan speed and open or close windows. The changeover temperature is set at some predetermined set point. If a thermostat is used to control water flow, it must reverse its action depending on whether hot or cold water is available.

The two-pipe system cannot simultaneously heat and cool, which is required for most projects during intermediate seasons when some rooms need cooling and others need heat. This problem can be especially troublesome if a single piping zone supplies the entire building. This deficiency may be partly overcome by dividing the piping into zones based on solar exposure. Then each zone may be operated to heat or cool, independent of the others. However, one room may still require cooling while another room on the same solar exposure requires heating, particularly if the building is partially shaded by an adjacent building or tree.

Another deficiency is the need for frequent changeover from heating to cooling, which complicates operation and increases energy consumption to the extent that it may become impractical. For example, two-pipe changeover system hydraulics must consider the water expansion (and relief) that occurs during cycling from cooling to heating.

Caution must be used with this system when outside air is directly introduced into spaces with widely varying internal loads. Continuous introduction of outside air with reduced load can introduce unconditioned outside air, which can cause very high space humidity levels that may not be able to be handled without reheat capability. The outside air damper in the unit must be motor-operated so it can be closed during unoccupied periods when minimal cooling is required.

For these reasons, the designer should consider the disadvantages of the two-pipe system carefully; many installations of this type waste energy, and have been unsatisfactory in climates where frequent changeover is required and where interior loads require cooling simultaneously as exterior spaces require heat.

Two-Pipe Changeover with Partial Electric Strip Heat. This arrangement provides simultaneous heating and cooling in intermediate seasons by using a small electric strip heater in the terminal unit. The unit can handle heating requirements in mild weather, typically down to 40°F, while continuing to circulate chilled water to handle any cooling requirements. When the outside temperature

drops sufficiently to require heating beyond the electric strip heater capacity, the water system must be changed over to hot water.

Two-Pipe Nonchangeover with Full Electric Strip Heat. This system may not be recommended for energy conservation, but it may be practical in areas with a small heating requirement.

Four-Pipe Distribution

Four-pipe distribution of secondary water has chilled-water supply, chilled-water return, hot-water supply, and hot-water return pipes. The four-pipe system generally has a high initial cost compared to a two-pipe system, but it has the best fan-coil system performance. It provides (1) all-season availability of heating and cooling at each unit, (2) no summer/winter changeover requirement, (3) simpler operation, and (4) hot-water heating that uses any heating fuel, heat recovery, or solar heat. In addition, it can be controlled to maintain a dead band between heating and cooling so simultaneous heating and cooling cannot occur. For further discussion of design considerations for two-, three-, and four-pipe systems with central ventilation, see later sections of this chapter.

Three-Pipe Distribution

Three-pipe distribution uses separate hot- and cold-water supply pipes. A common return pipe carries both hot and cold water back to the central plant. The terminal unit control introduces hot or cold water to the common unit coil based on the need for heating or cooling. These systems are not recommended because of their energy inefficiency from constantly reheating and recooling water.

CENTRAL PLANT EQUIPMENT

Central equipment size is based on the block load of the entire building at the time of the building peak load, not on the sum of individual in-room terminal-unit peak loads. Cooling load should include appropriate diversity factors for lighting and occupant loads. Heating load is based on maintaining the unoccupied building at design temperature, plus an additional allowance for pickup capacity if the building temperature is set back at night. For additional information, see Chapter 4, Central Cooling and Heating.

If water supply temperatures or quantities are to be reset at times other than at peak load, the adjusted settings must be adequate for the most heavily loaded space in the building. Analysis of individual room load variations is required.

If the side of the building exposed to the sun or interior zone loads require chilled water in cold weather, using condenser water with a water-to-water heat exchanger should be considered. Varying refrigeration loads require the water chiller to operate satisfactorily under all conditions.

VENTILATION

Central fan equipment is primarily used for an in-room terminal unit system to provide the correct amount of ventilation or makeup air to the various spaces served by terminal units.

Ventilation air is generally the most difficult factor to control and represents a major load component. The designer must select the method that meets all applicable codes, performance requirements, cost constraints, and health requirements.

A central, outside air pretreatment system, which maintains neutral air at about 70°F, best controls ventilation air with the greatest freedom from problems related to the building's stack effect and infiltration. Ventilation air may then be introduced to the room through the terminal unit, or directly into the room as shown in Figure 4. Any type of terminal unit in any location may be used if the outside air ventilation system has separate air outlets.

Ventilation air contributes significantly to the room latent cooling load, so a dehumidifying coil should be installed in the central ventilation system to reduce room humidity during periods of high

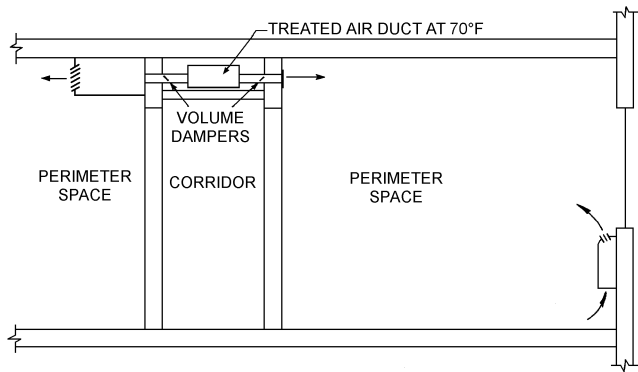


Fig. 4 Ventilation from Separate Duct System

outside moisture. Centrally supplied air can be supplied at a low enough dew point to absorb moisture generated in the space, but as a minimum should be supplied at a neutral condition so that the room terminal unit has to remove only the space-generated latent load.

An additional advantage of central ventilation is that, if its supply air dew point is selected to handle the internal latent load, the terminal cooling coil remains dry, extending the unit's life. However, a piped condensate drain is still recommended. This neutral temperature removes the outside air load from the terminal unit, so it can switch from heating to cooling and back without additional internal or external heat loads.

In buildings where terminal units only serve exterior zones and a separate all-air system serves interior zones, exterior zone ventilation air can be provided through the interior zone system. This arrangement can provide desirable room humidity control, as well as temperature control of the ventilation air. In addition, ventilation air held at the neutral condition of 70°F at 50% rh can be introduced into any terminal unit without affecting comfort conditions.

PRIMARY-AIR SYSTEMS

Figure 5 illustrates a primary-air system for in-room terminal systems. The components are described in Chapter 2. Some primary-air systems operate with 100% outside air at all times. Systems using return air should have provision for operating with 100% outside air (economizer cycle) to reduce operating cost during certain seasons. In some systems, when the quantity of primary air supplied exceeds the ventilation or exhaust required, excess air is recirculated by a return system common with the interior system. A good-quality filter (55% efficiency or higher) is desirable in the central air treatment apparatus. If it is necessary to maintain a given humidity level in cold weather, a humidifier can usually be installed. Steam humidifiers have been used successfully. Water-spray humidifiers must be operated in conjunction with (1) the preheat coil elevating the temperature of the incoming air or (2) heaters in the spray water circuit. Water-spray humidifiers should be used with caution, however, because of the possible growth of undesirable organisms in untreated water.

The cooling coil is usually selected to provide primary air at a dew point low enough to dehumidify the total system. Supply air must leave the cooling coil at about 50°F or less, and be almost completely saturated.

The supply fan should be selected at a point near maximum efficiency to reduce power consumption, supply air heating, and noise. Sound absorbers may be required at the fan discharge to attenuate fan noise.

Reheat coils are required in a two-pipe system. Reheat is not required for primary-air supply of four-pipe systems. Formerly, many primary-air distribution systems for induction units were

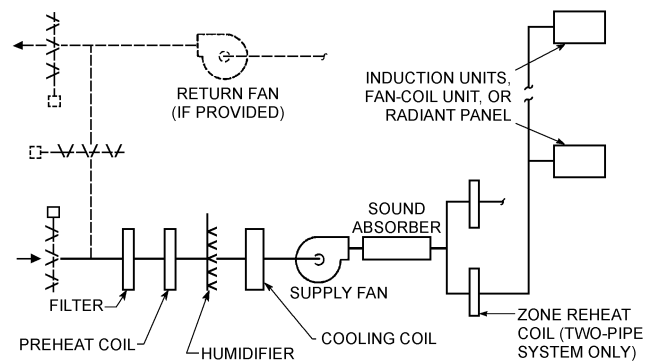


Fig. 5 Primary-Air System

designed with 8 to 10 in. of water gage static pressure. With energy use restrictions, this is no longer economical. Good duct design and elimination of unnecessary restrictions (e.g., sound traps) can result in primary systems that operate at 4.5 to 6.0 in. of water gage. Primary-air distribution systems serving fan-coil systems can operate at pressures 1.0 to 1.5 in. of water lower. Careful selection of the primary-air cooling coil and induction units for reasonably low air-pressure drops is necessary to achieve a medium-pressure primary-air system. Distribution for fan-coil systems may be low-velocity or a combination of low- and medium-velocity systems. See Chapter 34 in the 2001 *ASHRAE Handbook—Fundamentals* for a discussion of duct design. Variations in pressure between the first and last terminals should be minimized to limit the pressure drop required across balancing dampers.

Room sound characteristics vary depending on unit selection, air system design, and equipment manufacturer. Units should be selected by considering the unit manufacturer's sound power ratings, desired maximum room noise level, and the room's acoustical characteristics. Limits of sound power level can then be specified to obtain acceptable acoustical performance.

PERFORMANCE UNDER VARYING LOAD

Under peak load conditions, the psychometrics of induction-unit and fan-coil unit systems are essentially identical for two- and four-pipe systems. Primary air mixes with secondary air conditioned by the room coil in an induction unit before delivery to a room. Mixing also occurs in a fan-coil unit with a direct-connected primary-air supply. If primary air is supplied to the space separately, as in fan-coil systems with independent primary-air supplies, the same effect occurs in the space.

During cooling, the primary-air system provides part of the sensible capacity and all of the dehumidification. The rest of the sensible capacity is accomplished by the cooling effect of secondary water circulating through the unit cooling coils. In winter, primary air is provided at a low temperature, and if humidity control is provided, the air is humidified. All room heating is supplied by the secondary-water system. All factors that contribute to the cooling load of perimeter space in the summer, except transmission, add heat in the winter. The transmission factor becomes negative when the outside temperature falls below room temperature. Its magnitude is directly proportional to the difference between the room and outside temperatures.

For in-room terminal unit systems, it is important to note that in applications where primary air enters at the terminal unit, primary air is provided at summer design temperature during winter. If the economizer cycle is used, heating and cooling energy is not duplicated by reheating primary air that has already been mechanically cooled. For systems where primary air does not enter at the terminal unit, the primary air should be reset to room temperature in