Air-Handling Systems

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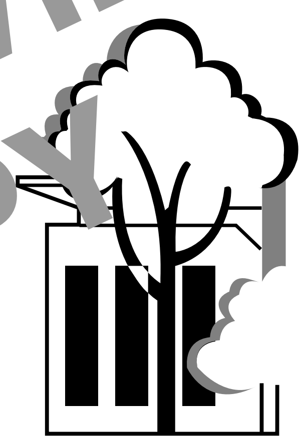
AIR-HANDLING SYSTEMS

Lesson One

Air Movement and Distribution



TPC Training Systems

43801

Lesson 1 Air Movement and Distribution

TOPICS

The Air-Handling System
Comfort Air Conditioning
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Heat and Moisture Transport
How Air Moves
Types of Airflow
Pressure Relationships
Controlling Ventilation and Pressurization
Dual-Duct Systems
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OBJECTIVES

After studying this Lesson, you should be able to…

- List the variables controlled by an air-handling system.
- Define comfort and explain how to predict whether or not people in a space will be comfortable.
- Define the following terms: laminar flow, turbulent flow, streamlining, and eddy currents.
- Differentiate between static pressure, velocity pressure, and total pressure in an air-distribution system.
- Compare a dual-duct system to a single-duct system in both structure and operation.

KEY TECHNICAL TERMS

Air-handling system 1.01 air handler plus distribution network
Air handler 1.01 equipment in which air is heated, cooled, humidified, dehumidified, and filtered
Comfort 1.04 the condition achieved when people within a space are unaware of the air around them
Natural convection 1.19 air movement caused by natural variations in pressure and air density
Forced convection 1.20 air movement caused by pressure differences created by a fan
Fluid friction 1.21 force that opposes flow
Laminar flow 1.22 smooth, layered flow
Turbulent flow 1.25 rough, irregular flow
Static pressure 1.35 acts in all directions at once
Velocity pressure 1.36 acts in the direction of flow
Ventilation 1.39 process of adding outdoor air to an enclosed space
Return air 1.43 air not exhausted but returned to the system

In this age of rising energy costs, facilities managers are inspecting their HVAC equipment to find ways to make it perform more efficiently. You are about to begin the study of a very important part of this equipment—the air-handling system. Because the energy used by air-handling systems can represent a significant part of your plant's overall energy consumption, the need for good maintenance cannot be overstated. The best air-conditioning equipment is of little use if it is not meeting the air quality and quantity requirements of the conditioned space.

Not all centrally air-conditioned buildings have centralized air-handling systems. For example, some air-conditioning systems distribute chilled water to the various spaces, using small fans to circulate room air through individual water coils in each space. The Unit you are about to study concentrates on the "all-air" system, with its central air handler and network of air-distribution conduits, called ducts. In this Lesson, you will learn the basic principles of airflow and air distribution. In the remainder of the Unit, you will learn the practical applications of these principles.

The Air-Handling System

1.01 An all-air, all-season air-conditioning system consists of three main subsystems—the refrigeration system, the heating system, and the air-handling system. The refrigeration system supplies a cold medium, and the heating system supplies a hot medium to coils located in the air handler. The *air-handling system* conditions and distributes the air. It consists of the air handler itself and the ductwork with its terminal devices. The *air handler* is the main piece of equipment in the air-handling system. In it air is filtered, humidified or dehumidified, and heated or cooled. A typical air handler is shown in Fig. 1-1. From the air handler, the air moves through the ductwork to all parts of the building.

1.02 Depending on their application, air handlers vary in size from small- to medium-sized packaged units like the one shown in Fig. 1-2 on the next page, to large walk-in models like the one shown in Fig. 1-3 on page 7. Many air handlers have steam or hot-water coils included with the cooling coils for all-season use. But regardless of size, make, or model, they all deliver conditioned air to a conditioned space.

1.03 An air-handling system controls, at least in part, the following variables associated with air:

- temperature
- relative humidity

Fig. 1-1. Typical air handler

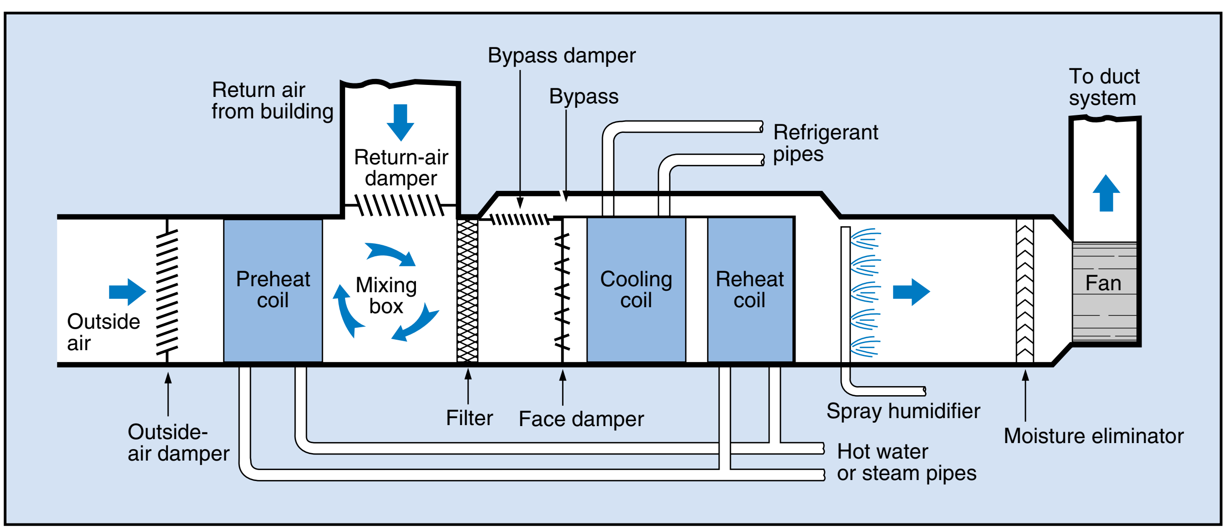
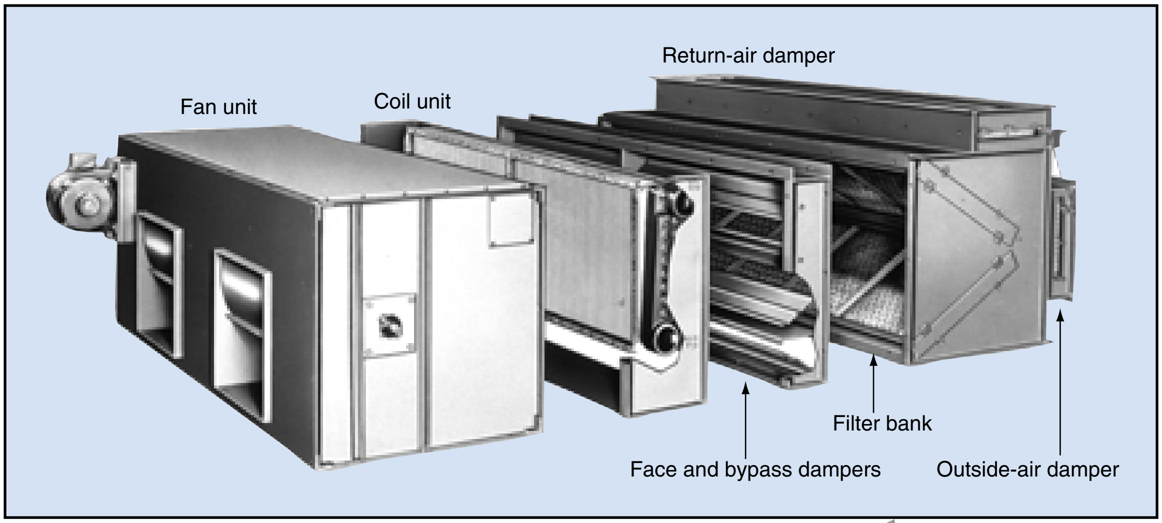


Fig. 1-2. Exploded view of a medium-sized air handler



- movement
- pressure
- purity.

The air-handling system controls these variables to fairly close tolerances, either to ensure human comfort or to maintain a required space condition for an industrial process or manufactured product. Both factors affect productivity and are, therefore, important to any company.

Comfort Air Conditioning

1.04 *Comfort* is defined in the air-conditioning industry as the condition achieved when people within a space can carry out their various activities without being aware of the air around them. They do not notice the temperature or the humidity. They are unaware of contaminants in the air. They feel no draft and notice no noise from the air-conditioning equipment or from the flow of air.

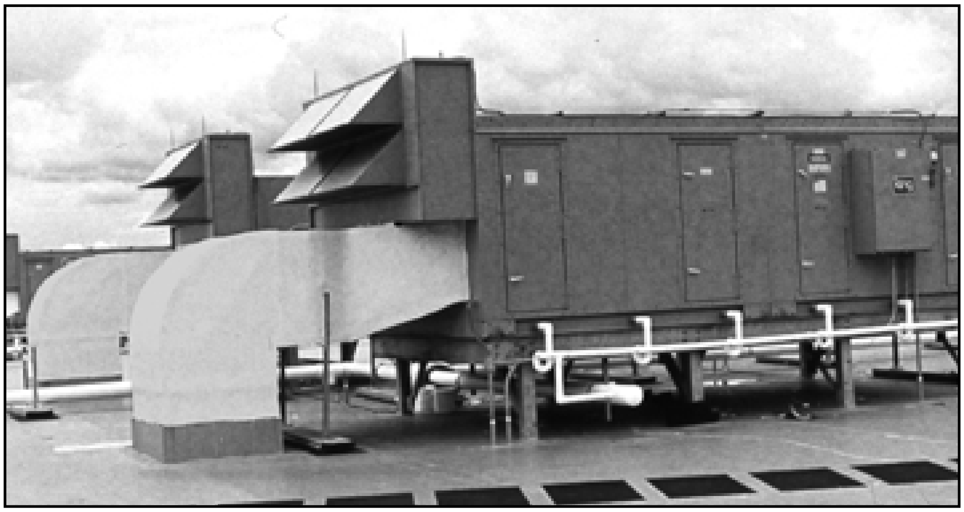
1.05 Achieving a condition of perfect comfort for l00% of the people in a conditioned space at any given moment is nearly impossible. Comfort depends, to a large extent, on the physical and mental condition of the occupants of an area at that specific time as well as their level of physical activity. However, by using the ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) comfort chart shown in Fig. 1-4, you can predict reasonably well whether or not the occupants of an area will be comfortable. The comfort chart is plotted on the coordinates of the ASHRAE psychrometric chart.

1.06 Most people are comfortable at a dry-bulb temperature of approximately 74 to 76°F (23 to 24°C) and a relative humidity of 30 to 60%. The ASHRAE comfort chart is divided into summer and winter comfort zones to take into account differences in clothing weight. As air conditions move away from the comfort zones on the chart, fewer and fewer people will be comfortable.

1.07 Physically, the human body is a heat- and moisture-producing machine that must maintain its temperature within a narrow range of temperatures to stay comfortable and healthy. The body regulates its temperature by controlling the rate of heat transfer from the skin surface to the environment. It does this by controlling blood flow to the skin, by shivering, and by sweating. For example, as the ambient temperature rises, blood flow to the skin increases. Thus, more heat transfers from the body surface to the surrounding air.

1.08 If increased blood flow cannot cool the body enough, the body uses its second line of defense against heat—sweating. Sweating coats the skin with moisture, which allows more body heat to be removed through evaporation. However, if the rela-

Fig. 1-3. Large-capacity air handler



tive humidity in a space is 100%, no moisture can evaporate. For people to be comfortable, therefore, the relative humidity within a space must be low enough to permit moisture on the skin to evaporate at a reasonable rate. Thus, to ensure human comfort, a good air-conditioning system must provide proper humidity control.

Process Air Conditioning

1.09 Process air conditioning is as important, if not more important, than comfort air conditioning. Many industrial processes require that air be conditioned to meet specific production needs. For example, the printing process and the manufacture of photographic

Fig. 1-4. ASHRAE comfort chart

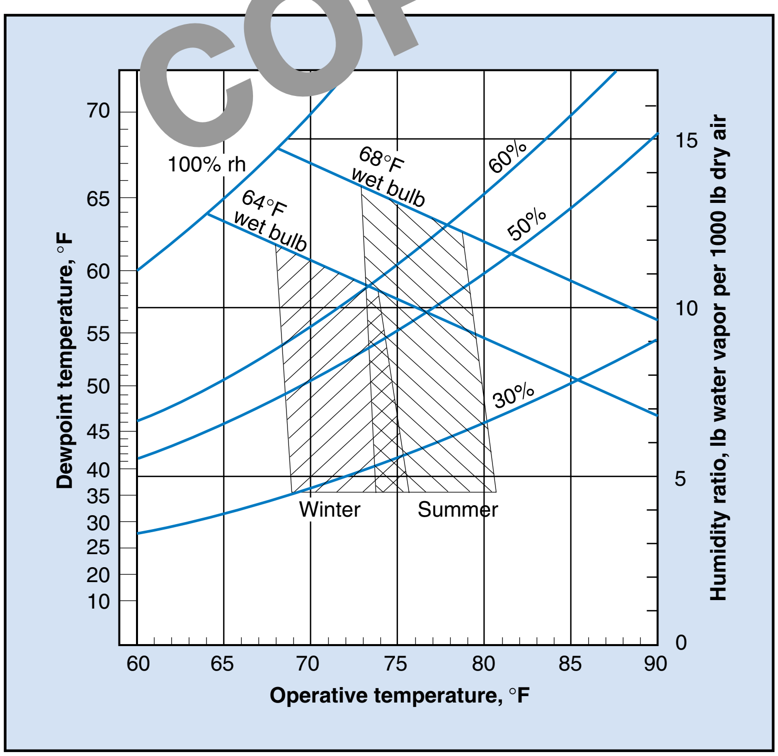
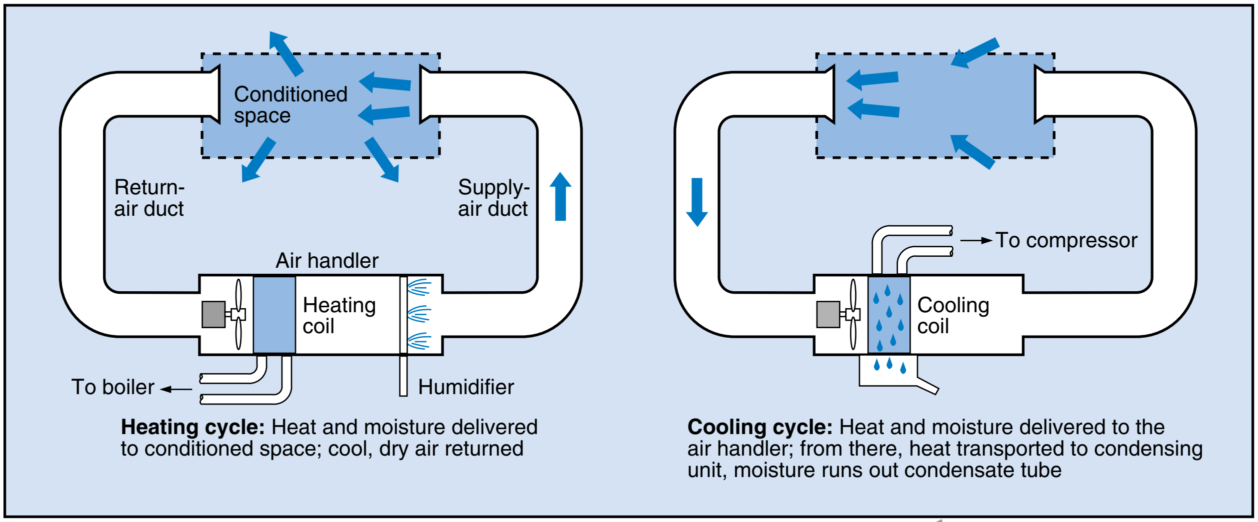


Fig. 1-5. The air-handling system transports heat and moisture



film, pharmaceuticals, and textiles all depend on proper temperature/humidity relationships and the removal of air contaminants for product quality. Certain environments have rigid cleanliness requirements in addition to temperature and humidity requirements. Computer rooms and hospital operating rooms are two examples.

1.10 Usually, process and product requirements fall within the range of the comfort zone. When they do not, however, process requirements come first. In humidity control, for example, process requirements can be as low as 5% or as high as 90% relative humidity. At either extreme, people are likely to feel uncomfortable. However, the system must meet the process needs first.

1.11 Before it delivers air to a defined space, the central air handler:

- removes contaminants from the air
- adds or removes moisture, as required
- cools or heats the air, as required.

1.12 These functions are performed by the filter bank, the spray humidifier, the cooling coil (which both cools the air and removes moisture from it) and the heating coils. Refer to these components in Fig. 1-1. The order shown might not be exactly the same as it is in your system's air handler. For example, you might have a blow-through fan located ahead of the coils rather than a draw-through type as shown. Note the position of the moisture eliminator, a shield that removes entrained water droplets from the airstream.

Heat and Moisture Transport

1.13 The air-handling system operates in a cycle. It delivers fresh conditioned air to a defined space and removes stale air. Part or all of this "used" air returns to the air handler where it is reconditioned and sent back to the space again.

1.14 As air moves through the cycle, it transports heat and water vapor. In a year-round system, the direction of travel depends on whether the system is heating or cooling. Figure 1-5 shows that heat and moisture (represented by the shaded arrows) travel to the conditioned space during the heating cycle. Heat and moisture leakage from the system occurs at the conditioned space (by conduction, by radiation, and by air loss through cracks and door/window openings). During the cooling cycle, heat and moisture are transported from the conditioned space back to the air handler, where they are removed by the cooling medium. Heat is released to the atmosphere at the condensing unit or cooling tower. Moisture, which drops from the cooling coil, is carried away by the condensate collection system.

1.15 You should now be able to see that air movement is critical to the air-conditioning process. So far, this Lesson has explained why the air must be made to flow in an air-conditioning system. The next question to consider is how is this done?

How Air Moves

1.16 Air is a mixture of various gases, water vapor, and contaminants. It behaves like any other gas, in that it

- can be compressed
- fills any container you put it in
- exerts equal pressure on all the walls of a closed container.

1.17 Because it is in a gaseous state, air is easily set in motion by a slight difference in pressure between two points within the container or defined space. No matter how small the pressure difference, the air will move toward the point of lower pressure.

1.18 The unit of pressure measurement used in air-handling systems is the *inch of water column*. Since we are talking about net pressures above or below atmospheric pressure, you might also hear it referred to as *inches of water gauge*. It is usually written as "H_2O or in. wg. Thus, a pressure of 0.35 in. wg can support a column of water 35/100 in. high. This unit of pressure measurement was selected because of its ease and accuracy in measuring small pressures. The pressure in a duct is usually too small to be easily measured in pounds per square inch (psi) or inches of mercury (in. Hg).

1.19 Drafts indoors and natural breezes outdoors are caused by differences in pressure. These pressure differences, in turn, are caused by variations in air density between warmer and cooler air. Air currents set up in this manner are called *natural convection* currents. Most of the distribution of heat and moisture within a conditioned space takes place by convection.

1.20 Natural convection is not sufficient to provide the circulation needed in modern air-handling systems, however. In these systems, large pressure differences are needed because air must be exchanged at a faster rate than natural convection can produce. These large pressure differences are created by *forced convection*. In air handling, forced convection is caused by a fan or blower. You will learn about the operation of fans in Lesson Two.

1.21 The moment the fan impeller begins to turn, it creates a pressure difference and sets air in motion. At the same moment, a counterforce occurs that opposes the airflow. This opposing force (called *fluid friction*) increases as the air velocity increases. Most of this force comes from friction between the airflow and the walls of the system, plus any obstructions in the airstream.

Types of Airflow

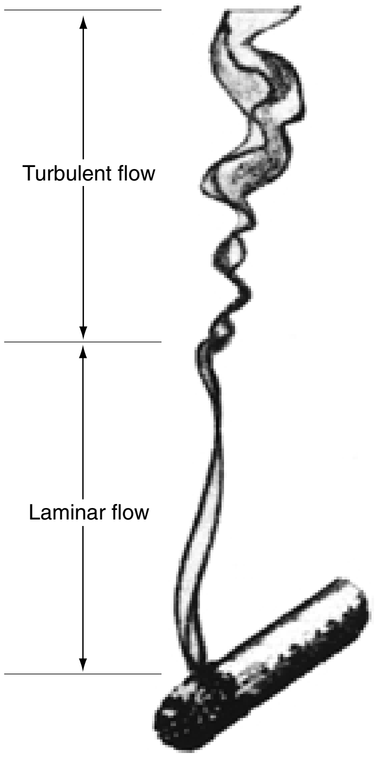
1.22 There are two types of airflow—laminar and turbulent. Laminar comes from the Latin word *lamina*, which means "thin plate." *Laminar flow*, therefore, refers to the way in which an undisturbed fluid flows—smoothly and in layers.

1.23 Laminar flow across a flat surface acts like a deck of playing cards tossed onto a table. The bottom card sticks to the table, the next card moves a little farther, the third card moves a bit farther than that, and so on. If you could see them, laminar airflow patterns in a round duct would look like the concentric rings (actually tubes) in a tree trunk. But the tubes would be in motion, with the central core moving the fastest, and the thin outermost tube (touching the duct wall) being the slowest.

1.24 Smoothly drawn flow lines on a diagram, called *streamlines*, show the shape of laminar flow. Very thin smoke trails released into a laminar airflow make the streamlines visible. This method is often used in wind tunnels to show the airflow around model buildings, automobiles, and aircraft. An object that does little to disrupt the laminar flow pattern is said to be *streamlined*. The process of shaping objects to reduce their air resistance is known as *streamlining*.

1.25 Unlike laminar flow, *turbulent flow* is rough and irregular. It contains many spiral or circular currents, called *eddy currents*. This kind of flow is illustrated by the smoke stream rising from a lighted cigarette, held motionless in a draft-free room. For a few inches, the smoke stream is laminar, but then it breaks up into a whirling pattern of turbulent flow as shown in Fig. 1-6 on the next page. Turbulence caus-

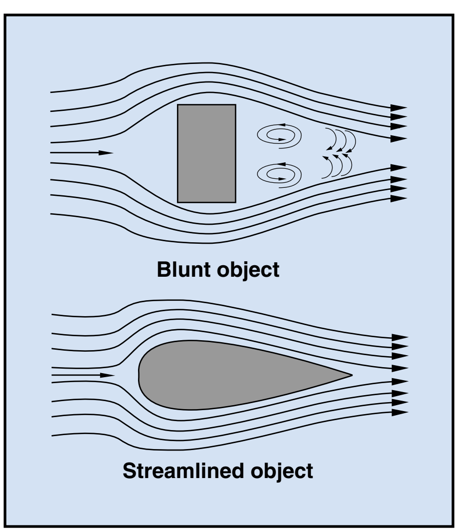
Fig. 1-6. Flow patterns in cigarette smoke



es most of the frictional resistance in an air-distribution system.

1.26 The designers of air ducts study laminar and turbulent flow to achieve the greatest efficiency in air distribution. It is important that you understand these flow patterns so that you do not unknowingly change the flow in an air-handling system from one kind to another.

Fig. 1-7. Constant-velocity airflow around two objects



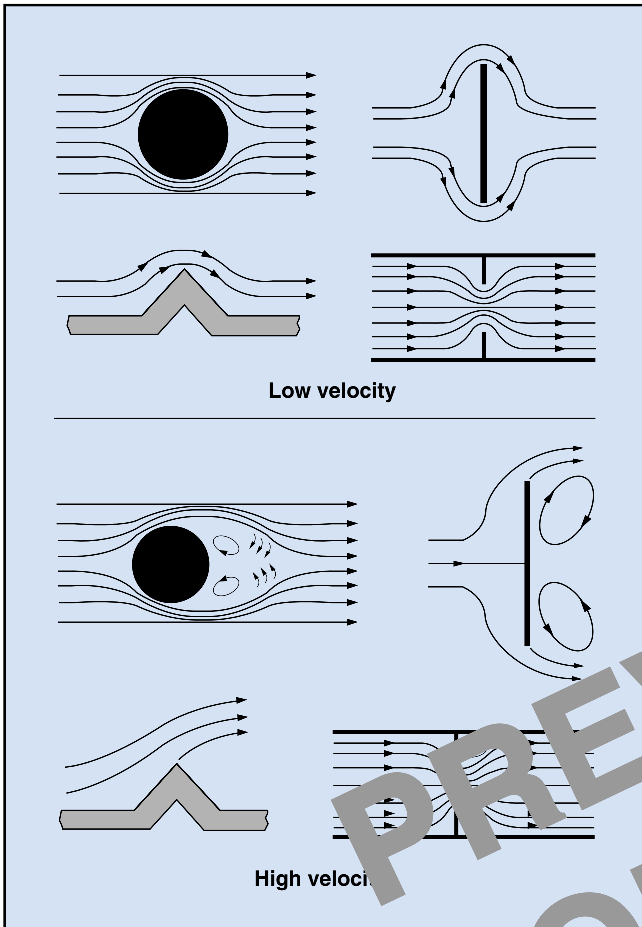
1.27 An air-distribution system requires both kinds of airflow, but in different places and for different reasons. Laminar flow is desirable in the long stretches of ductwork where frictional resistance must be kept as low as possible. Turbulent flow is needed within the conditioned space, so that incoming air becomes thoroughly mixed with the air already in the space.

1.28 Turbulent flow is also required in the air handler. This turbulence prevents the air from stratifying (piling up in layers) before passing over the heating or cooling coils. If it did, part of the coil (either the upper or the lower half) would exchange more heat than the other, resulting in inefficiency. Turbulent flow helps to provide an even temperature distribution across the face of the coil. It also improves the efficiency of air filters. For these reasons, the air handler has a *mixing box* (look back to Fig. 1-1), which creates maximum turbulence in the entering air.

1.29 Unless turbulence is needed, any object placed in the airstream should be as streamlined as possible. Figure 1-7 compares the airflow around a blunt object with the flow around a streamlined object. As you can see, the streamlined object offers much less resistance to flow. It takes much less energy to push the airstream past this object than past the blunt object. Likewise in the air handler, it costs a good deal in energy to push (or draw) air through the air filter and across the coils of the heat exchanger—the major obstacles in the airstream.

1.30 The same concept applies to the ductwork, especially if the airstream is moving at a fairly high velocity. Figure 1-8 compares low- and high-velocity airflow around certain obstacles. Note the eddy currents created by the higher velocities. These pictures illustrate why the interior surface of a high-velocity air duct must be clean and free from obstructions, while the interior surface characteristics of a low-velocity system are less important. In Lesson Three you will learn how ductwork is fabricated, how it is bent around corners, and how it is brought from one cross-sectional size to another in ways that keep fluid friction to a minimum.

Fig. 1-8. Comparison of low- and high-velocity airflow around various obstacles



The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from the back of the book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. The two functions of an air-handling system are to condition and ________ the air.	1-1. DISTRIBUTE Ref: 1.01
1-2. For people to be comfortable, ________ must be low enough to permit evaporation of moisture from the skin.	1-2. RELATIVE HUMIDITY Ref: 1.08
1-3. As air moves through an air-handling system, it transports ________ and ________.	1-3. HEAT; WATER VAPOR (MOISTURE) Ref: 1.14
1-4. Air is easily set in motion by a slight difference in ________ between two points.	1-4. PRESSURE Ref: 1.17
1-5. Pressure in an air-handling system is usually measured in what unit?	1-5. INCHES OF WATER COLUMN or INCHES OF WATER GAUGE Ref: 1.18
1-6. The force that opposes flow in an air-handling system is called ________.	1-6. FLUID FRICTION Ref: 1.21
1-7. Name the two types of airflow.	1-7. LAMINAR and TURBULENT Ref: 1.22
1-8. Air handlers often contain a(n) ________ to create turbulence in the entering air.	1-8. MIXING BOX Ref: 1.28

Pressure Relationships

1.31 In order for air to flow through the air-handling system, the air must overcome the fluid friction. It is the function of the fan or fans in the system to overcome this friction. A fan produces the pressure difference that overcomes system resistance. The greater the resistance, the more pressure required and the larger the fan must be to produce it.

1.32 To condition the air in a space properly, the pressure difference created must be large enough to cause the air to flow steadily from the conditioned space to the air handler and back to the conditioned space again, forming a circuit. Referring to Fig. 1-5, you see that this circuit is divided into two halves:

- return ducts from the conditioned space to the air handler
- supply ducts from the air handler to the conditioned space.

1.33 Figure 1-5 also shows that the conditioned space forms a connecting link, not only between the two halves of the flow path, but also with atmospheric pressure. Thus, the air-handling system is not a completely closed container. Instead, it is only "semi-enclosed," with a pressure difference created only when the fan is running. Furthermore, when the fan is running, the pressure is slightly higher than atmospheric in the supply half of the system and slightly lower than atmospheric in the return half.

1.34 **Positive/negative pressures**. Because the conditioned space is normally at atmospheric pressure, the pressures in the duct system must be either higher or lower than atmospheric pressure for the air to move. When the fan is running, the return-air ductwork has negative pressure, causing air to flow from the conditioned space (atmospheric pressure) into the ductwork and on to the air handler. Meanwhile, the supply-air ductwork has a positive pressure, causing air to flow from the air handler through the ducts and into the normal atmosphere of the conditioned space. Thus, pressure is measured in (–) in. wg in the return ductwork, and in (+) in. wg in the supply ductwork.

1.35 **Internal duct pressure**. In effect, the air handler creates its own environment within the ductwork. This "micro-environment" has a two-part pressure, just as the earth's atmosphere does. One part is a *static pressure* (P_s) which acts in all directions at once. (In the earth's atmosphere, this pressure is called *barometric pressure*.) Static pressure in a duct can be thought of as the potential pressure to create an airflow—the higher the static pressure, the greater the airflow potential. Whether the pressure is negative or positive does not affect the airflow potential. It only determines the direction the air will flow, either toward or away from the fan.

1.36 The second part of the pressure in a duct is called *velocity pressure* (P_v) and it acts only in the direction of the airflow. (In the earth's atmosphere, this can be compared to the pressure that we feel from the wind.) Velocity pressure is proportional to the velocity of the airflow squared—if the air velocity is doubled, the velocity pressure will be four times as great. This pressure can be thought of as the pressure due to air motion.

1.37 Because static and velocity pressures always occur together, they can be measured together. The combined pressure reading is called *total pressure* (P_t). A later Lesson in this Unit describes instruments used to measure pressure.

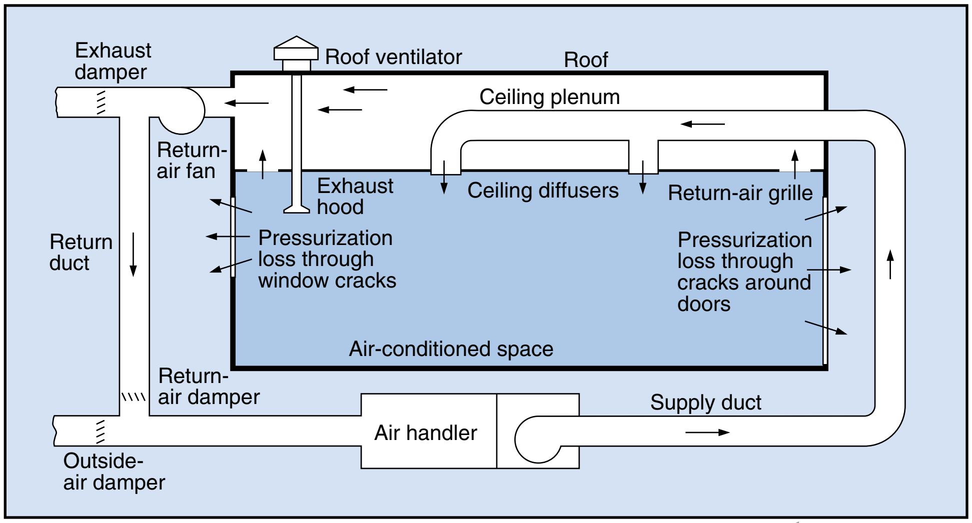
Controlling Ventilation and Pressurization

1.38 In addition to helping control temperature and humidity, the air-handling system also controls system ventilation and pressurization. Both these processes involve adjusting dampers along the same distribution circuit you learned about in the preceding section.

1.39 **Ventilation**. To reduce accumulated odors and smoke in a space, the recirculated air is diluted with outdoor air. This "fresh air" is assumed to be of better quality than the recirculated air. The process of adding outdoor air to an enclosed space is called *ventilation*. The outdoor air supplied to the space is called *ventilation air*. The outside-air dampers, shown in Fig. 1-1 and Fig. 1-2, control the intake of ventilation air. Usually there is a minimum-limit setting on these dampers so that some small amount of outside air always enters the system. At certain times, 100% outside air can be called for.

1.40 Any additional air brought into the system must somehow leave the system to keep the building

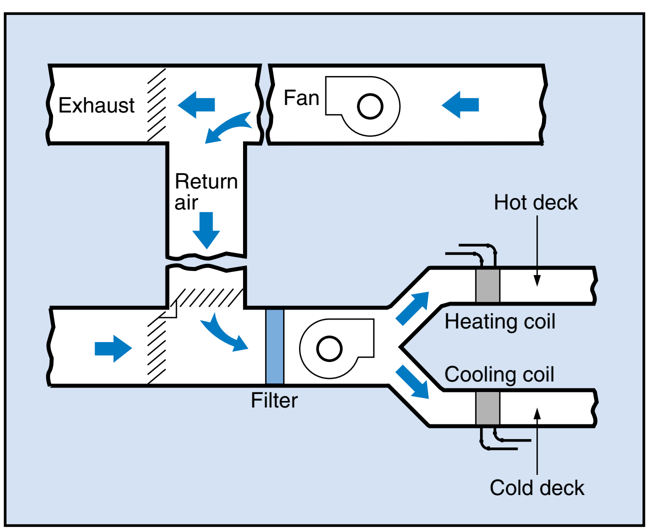
Fig. 1-9. Pressurized space showing supply and return paths



from becoming excessively pressurized. Extra air is vented to the atmosphere through a relief-air damper. This damper acts like the safety valve or pressure-limiting valve in other fluid systems.

1.41 In many systems, exhaust fans assist the air-relief process. These fans usually exhaust air through large louvered dampers protected by heavy metal screens. Roof ventilators sometimes supplement the main exhaust fans. Connected by ducts to hoods of various sizes, they exhaust fumes from machinery or chemical reactions. A certain amount of air also passes in and out through cracks around windows and doors.

Fig. 1-10. Hot and cold decks of dual-duct system



1.42 **Pressurization**. Sometimes a surplus of ventilation air is purposely brought into a building to give a slight positive pressure to the conditioned space. Because air moves from a higher pressure space to a lower pressure space, this pressurization prevents unwanted nonconditioned air from infiltrating back into the conditioned space—through those same cracks around the doors and windows. By maintaining a static pressure in the conditioned space slightly higher than in adjacent, nonconditioned spaces, air will leak out of the space, not in to it. Figure 1-9 shows a typical pressurized air-conditioned space.

1.43 Air not exhausted or lost through pressurization is returned to the system and is called *return air*. This air is sometimes removed from the conditioned space by a separate return-air fan. In other systems, as you saw in most of the earlier examples, a single fan supplies both the positive pressure for supply air and the negative pressure for return air. In either case, return air passes through the return-air damper, as shown in Fig. 1-1 and Fig. 1-2, and mixes with outdoor air in the mixing plenum. The cycle then starts all over again.

Dual-Duct Systems

1.44 The type of air-handling system you have studied so far in this Lesson is called a *single-path* or *single-duct system*, because all the air flows along a single supply duct and its branches. Another type is the *dual-path* or *dual-duct system*. This type of system allows for individual temperature control in many different zones of the building, using the same central equipment.

1.45 The distinctive feature of the dual-duct system is a split conditioning chamber in the air handler. The split forms a hot deck and a cold deck, as shown in Fig. 1-10. Connected to these decks are two separate supply-duct systems, traveling in parallel to all the conditioned spaces. At each space, the hot and cold ducts connect to a mixing box. From there, a mixed-air duct leads to a ceiling diffuser or wall-mounted register. The layout of an entire dual-duct system is shown in Fig. 1-11.

1.46 Control dampers in each mixing box allow the proper mixture of warm and cold air to enter the conditioned space. These dampers can be actuated in parallel by a single motor, as shown in Fig. 1-12A, or by two separate motors, as in Fig. 1-12B. The motors, in turn, respond to signals from the zone thermostat. When the zone requires heat, the hot-air damper opens and the cold-air damper closes. When cooling is needed, the opposite actions take place. The air mixture can also be adjusted anywhere between these two extremes.

1.47 Most mixing boxes have mechanical constant-volume controllers to maintain a constant flow of air into the conditioned space, no matter what proportion of hot and cold air is called for. These controllers are usually spring-loaded dampers that open when the static pressure in the duct decreases and close when the pressure rises. In two-motor mixing boxes, a static-pressure sensor can be used to compensate for uneven airflow.

1.48 Another feature of the mixing box is the *sound attenuator*—a set of baffles and/or packing material lining the interior of the box. The baffles shield the air outlet so that any sound originating in

Fig. 1-11. Typical dual-path all-air system

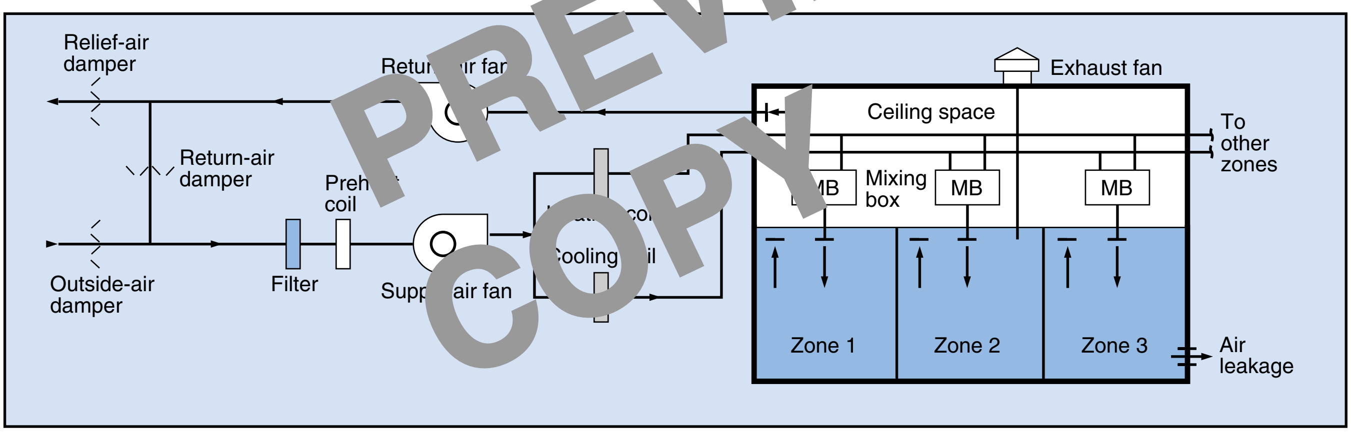


Fig. 1-12. One-motor and two-motor mixing boxes

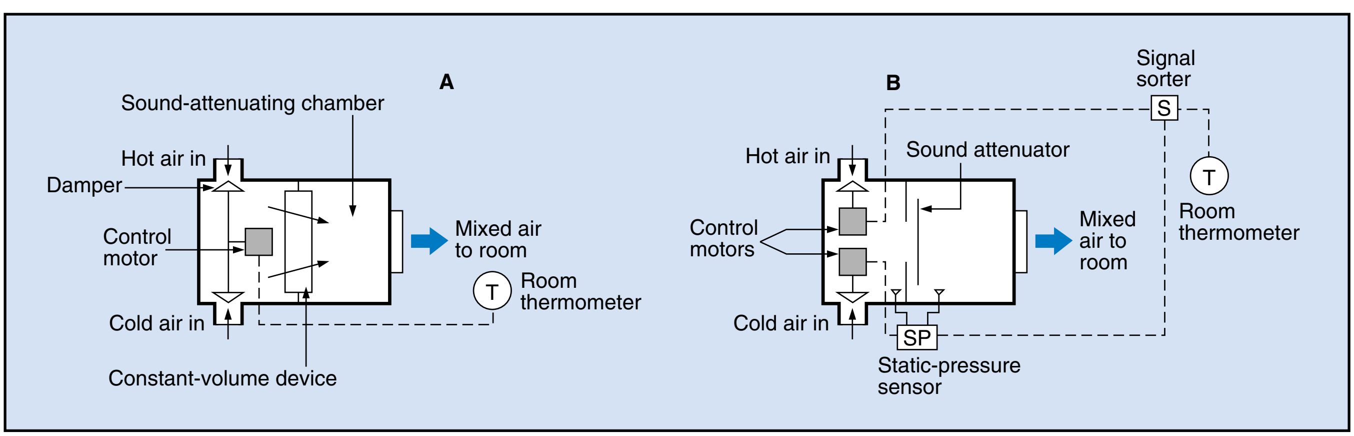
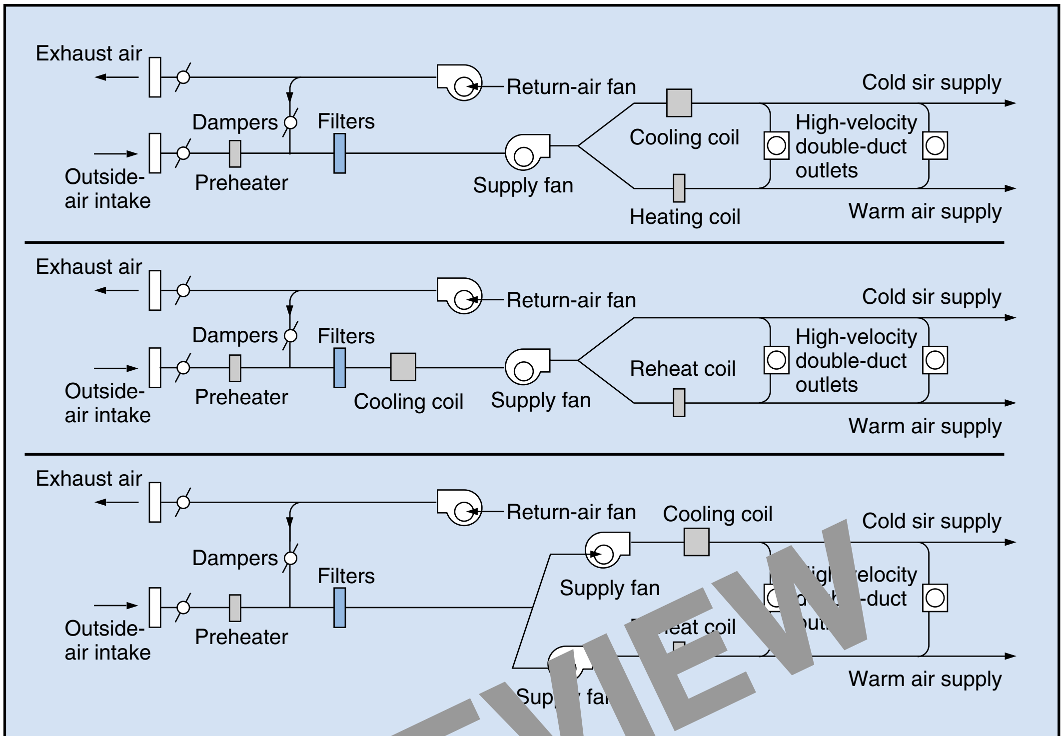


Fig. 1-13. Alternate arrangements of the dual-duct system



the air handler or in the ductwork is reflected back into the box and absorbed by the lining.

System Velocity

1.49 Figure 1-13 shows alternate arrangements of the main components of a dual-duct system. Not only will you find variety in the arrangement of these systems, but they can also be designed to deliver either a high- or low-velocity airflow. High-velocity systems push air through the main ducts at 2000 to 6000 fpm (feet per minute). Low-velocity systems (generally under 2000 fpm) require much larger ducts, as you will learn in Lesson Three. High-pressure, high-velocity air movers are often called *blowers*, while low-pressure, low-velocity systems use *fans*.

1.50 The velocity of conditioned air introduced into a space must be low enough to avoid causing drafts. However, it must be high enough to mix incoming air with the space air before it reaches people in the occupied zone. Within the occupied zone, airflow rates of approximately 20 fpm or less are considered still air—that is, not fast enough for mixing—while airflow rates of 65 fpm or greater are considered drafts.

1.51 To avoid the possibility of drafts, attenuator boxes are used in single-duct, high-velocity systems. *Attenuator boxes* are flat, large-volume chambers that serve as velocity reducers at each conditioned space. Air flowing into the attenuator box acts like a river flowing into a large lake in that velocity drops off quickly upon entering. Either a low-velocity duct will take the air to a diffuser from the attenuator box, or a diffuser can be attached directly to the box. In dual-duct, high-velocity systems, the mixing box serves as an attenuator box.

1-9. In an air-handling system, the pressure difference that overcomes fluid friction is produced by a(n) ________.	1-9. FAN or BLOWER Ref: 1.31
1-10. When the fan in an air-handling system is running, the return-air ductwork has a(n) ________ pressure.	1-10. NEGATIVE Ref: 1.34
1-11. In a duct, the ________ pressure acts only in the direction of airflow.	1-11. VELOCITY Ref: 1.36
1-12. The process of adding outdoor air to an enclosed space is called ________.	1-12. VENTILATION Ref: 1.39
1-13. To keep building pressure from becoming too high, extra air is vented through dampers, sometimes assisted by ________ fans.	1-13. RELIEF-AIR or EXHAUST Ref: 1.40, 1.41
1-14. What kind of air-handling system uses central equipment but allows for individual temperature control in many zones of the building?	1-14. DUAL-PATH or DUAL-DUCT SYSTEM Ref: 1.44
1-15. Many mixing boxes have a(n) ________ to reflect and absorb noise from the air handler or ductwork.	1-15. SOUND ATTENUATOR Ref: 1.48
1-16. Low-velocity systems require much ________ ducts than high-velocity systems.	1-16. LARGER Ref: 1.49

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. People are most likely to be comfortable at a temperature of ________ and a relative humidity of ________

- ☐ a. 70°F; 30%
- ☐ b. 75°F; 40%
- ☐ c. 80°F; 60%
- ☐ d. 85°F; 70%

1-2. The relative humidity in a conditioned space is reduced by the

- ☐ a. cooling coil
- ☐ b. filter bank
- ☐ c. heating coil
- ☐ d. spray humidifier

1-3. During the cooling cycle of an HVAC system, heat and moisture are transported from the ________ to the ________.

- ☐ a. air handler; conditioned space
- ☐ b. condenser; air handler
- ☐ c. conditioned space; air handler
- ☐ d. humidifier; conditioned space

1-4. Convection currents are caused by differences in

- ☐ a. air exchange rate
- ☐ b. fluid friction
- ☐ c. pressure
- ☐ d. specific gravity

1-5. In an air-distribution system, laminar flow

- ☐ a. causes frictional resistance
- ☐ b. contains eddy currents
- ☐ c. is irregular
- ☐ d. is smooth and layered

1-6. Most frictional resistance in a duct system is caused by

- ☐ a. laminar flow
- ☐ b. turbulence
- ☐ c. streamlined objects
- ☐ d. convection currents

1-7. In an HVAC system, where is laminar airflow desirable?

- ☐ a. Entering the air filter
- ☐ b. Entering the heating or cooling coils
- ☐ c. In long stretches of ductwork
- ☐ d. Within the conditioned space

1-8. The higher the air velocity in a duct, the greater the chance for

- ☐ a. laminar flow
- ☐ b. natural convection
- ☐ c. reduced friction
- ☐ d. turbulent flow

1-9. When an air-conditioning system is running, negative pressures are found in the

- ☐ a. return-air duct and supply-air duct
- ☐ b. return-air duct only
- ☐ c. supply-air duct and conditioned space
- ☐ d. supply-air duct only

1-10. In a dual-duct system, the air temperature in each conditioned space depends on the operation of control dampers in the

- ☐ a. air handler
- ☐ b. mixing box
- ☐ c. thermostat
- ☐ d. return-air duct

SUMMARY

It is the function of an air-handling system to condition and distribute air. An air-handling system consists of the equipment used to adjust the air's temperature, relative humidity, movement, pressure and purity, as well as the ductwork connected to it. One of the goals of an air-handling system is to ensure human comfort. Another is to maintain the conditions necessary for an industrial process or manufactured product. The ASHRAE comfort chart can help you predict whether or not most people will be comfortable at given conditions.

An air-handling system operates a cycle—delivering fresh, conditioned air and removing stale air. As the air moves through the cycle, it transports heat and water vapor. A pressure difference between two points is needed to set the air in motion. Pressure in an air-handling system is usually measured in inches of water column or inches of water gauge. Pressure differences can be the result of natural convection currents or forced convection. In either case, the pressure difference must be sufficient to overcome fluid friction. Airflow in the system can be either laminar (smooth) or turbulent (rough). Both kinds are important in an air-handling system. Laminar flow is desirable in long stretches of ductwork, and turbulent flow is needed to mix the incoming air with the air already in a space.

Fans are used in air-handling systems to create the pressure difference needed to cause air to flow. The conditioned space is normally at or near atmospheric pressure. When the fan is running, the return-air ductwork has a negative pressure, and the supply-air ductwork has a positive pressure. The air in a duct has a two-part pressure. Static pressure acts in all directions at once. The second part is called velocity pressure. It acts only in the direction of flow. Together they are referred to as total pressure. Adding outdoor air to an enclosed space is called ventilation. Excess air is vented to the atmosphere through a relief-air damper, often with the help of exhaust fans. Sometimes a slight positive pressure is desirable to prevent infiltration of nonconditioned air into the space.

Some air-handling systems are single-path systems, while others are dual-path systems. Dual-path systems allow for individual temperature control in many areas of the building while using the same central conditioning equipment. High-velocity systems move air through the main ducts at 2000 to 6000 fpm, while low-velocity systems (which require much larger ducts) generally move air at less than 2000 fpm.

Answers to Self-Check Quiz

1-1. b. 75°F; 40%. Ref: 1.06

1-2. a. Cooling coil. Ref: 1.12

1-3. c. Conditioned space; air handler. Ref: 1.14

1-4. c. Pressure. Ref: 1.19, 1.20

1-5. d. Is smooth and layered. Ref: 1.22

1-6. b. Turbulence. Ref: 1.25

1-7. c. In long stretches of ductwork. Ref: 1.27

1-8. d. Turbulent flow. Ref: 1.30, Fig. 1-8

1-9. b. Return-air duct only. Ref: 1.34

1-10. b. Mixing box. Ref: 1.46

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