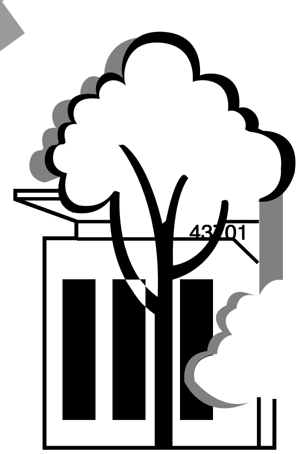
HEAT PUMPS

Lesson One

Introduction to Heat Pumps



TPC Training Systems

44101

Lesson

1 Introduction to Heat Pumps

TOPICS

What Is a Heat Pump?
Basic Heat Pump Operation
Advantages of Heat Pumps
Heat Pump Cycles
Cooling Cycle
Heating Cycle
Defrost Cycle
Kinds of Systems
Balance Point
Degree-Days
Unit Sizing
Operating Costs

OBJECTIVES

After studying this Lesson, you should be able to…

- Explain how a heat pump differs from standard air-conditioning equipment.
- List the benefits of heat pump systems.
- Describe the heating, cooling, and defrost heat pump cycles.
- Define *degree-day.*
- List considerations in sizing heat pumps.

KEY TECHNICAL TERMS

British thermal unit (Btu) 1.08 the quantity of heat needed to raise the temperature of one pound of water 1°F

Vapor line 1.14 the piping that carries refrigerant vapor in either direction in a heat pump

Subcooling 1.17 cooling a liquid below its condensation temperature

Liquid line 1.19 the piping that carries refrigerant liquid in either direction in a heat pump

Flash gas 1.20 the portion of the refrigerant that evaporates instantaneously, cooling the rest of the refrigerant as it passes through the metering device

Superheat 1.21 heat added to a vapor above its evaporating temperature

Degree-day 1.39 a unit, often used in energy cost estimations, calculated by subtracting the average temperature for a certain day from 65°F

When the heat pump was first introduced to the heating and air-conditioning industry, few design considerations were given to its practical operation. Some believed that the heat pump was a simple system, just an air-conditioning unit with some extra valves installed to change the refrigerant flow. However, manufacturers who built heat pumps based on this concept produced units that were a constant source of trouble and seldom operated as intended. The early heat pumps did not produce the desired amount of heat and were very expensive to operate. Little thought was given to training people to install, service, and maintain the units. As a result, the heat pump gained a bad reputation, which it has not entirely overcome in some areas.

As heat pump technology has improved, heat pumps have gained in usefulness and popularity. Today's heat pump systems can operate efficiently and economically and are built to permit convenient maintenance and repair.

What Is a Heat Pump?

1.01 Any system designed to move heat from one place to another is a form of heat pump. As the term is used today, however, a heat pump system is basically an air-conditioning system equipped with certain components that permit it to reverse the refrigerant flow to provide satisfactory year-round operation at a reasonable cost. During the cooling cycle, the heat pump absorbs heat from an indoor space and discharges the heat outdoors. During the heating cycle, the heat pump absorbs heat from an outdoor heat source and discharges it into the indoor space.

1.02 People often ask where the heat comes from during the heating cycle. The answer is that heat is always present in outdoor air at any temperature greater than absolute zero (-459°F or -273.15°C). Therefore, a great amount of heat can be extracted from the outdoor air even in very cold weather. Heat is always available at outdoor temperatures that normally call for indoor heating.

1.03 The heat content of outdoor air increases as its temperature increases. That is, air at 0°F contains more heat than air at -30°F, and air at 30°F contains more heat than air at 0°F. Basically, the heat pump can extract this heat because the liquid refrigerant in the outdoor coil evaporates at a temperature lower than the temperature of the outdoor air. The refrigerant absorbs the heat from the warmer outdoor air.

1.04 The compressor pumps the refrigerant into the indoor unit. The total heat—that is, the heat absorbed by the refrigerant plus the heat of compression—is then released into the indoor space to raise the temperature to the desired comfort level. In addition, the indoor unit is usually equipped with auxiliary heat strips downstream of the indoor fan to help heat the space when outdoor temperatures are low and when the heat pump is in the defrost cycle.

1.05 The efficiency of a heat pump is calculated by how much heat the system can take from the outdoor air and discharge inside the conditioned space. Manufacturers today are constantly finding ways to increase the efficiency of heat pump systems without increasing the cost of operation.

Basic Heat Pump Operation

1.06 Heat pump systems are usually total electric systems. However, some newer systems can be operated with fossil-fuel heating systems. Fossil fuels include natural gas, liquefied petroleum (LP) gas, and fuel oil. The heat pump is designed to move heat from indoors to outdoors in the cooling cycle and from outdoors to inside the structure during the heating cycle. As with other air-conditioning systems, heat is moved from one place to another by means of the refrigerant in the system. This process produces four to five times the heat output of strip heaters with the same energy input, as is discussed further in Lesson Three.

1.07 To understand how the unit can move heat in both directions, you must understand the refrigeration cycle. The primary refrigeration cycle components for heat pump use are illustrated in Fig. 1-1 on the following page. Although the name *heat pump* is used specifically for these systems, any air-conditioning system is also a heat pump in that it pumps the heat from indoors to outdoors in the summertime.

Fig. 1-1. Refrigeration cycle

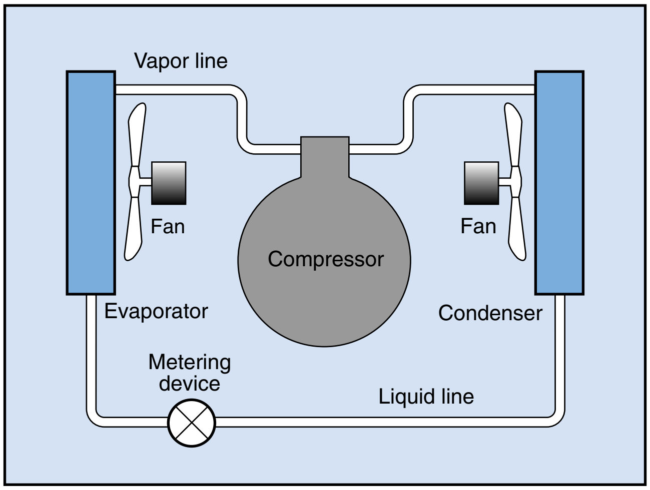
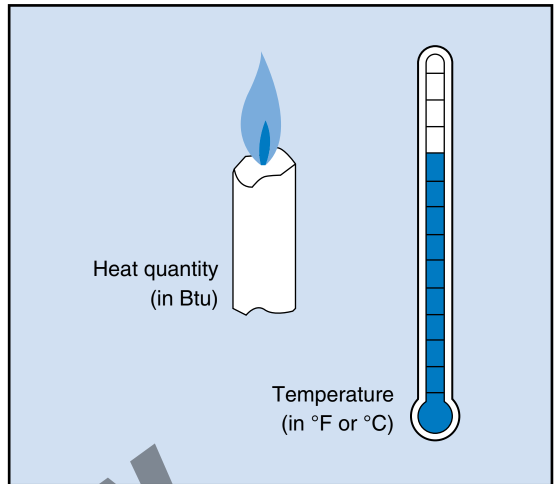


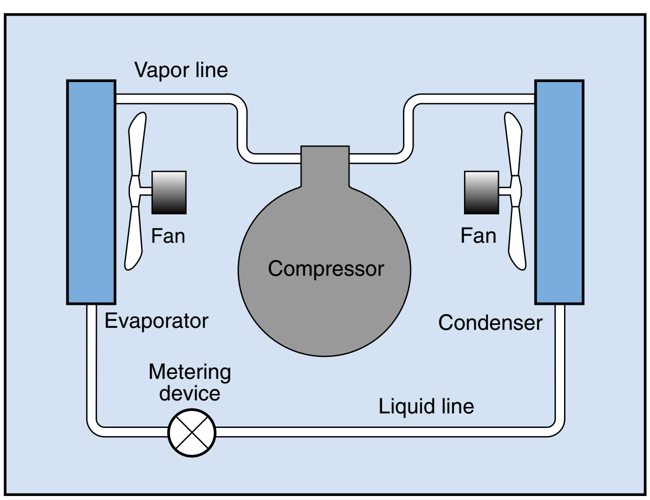
Fig. 1-2. Heat and temperature



1.08 Heat has two characteristics—quantity and temperature. It is important that you understand both if you are to do your job well. The quantity of heat is measured in *British thermal units (Btu)*, the amount of heat needed to raise the temperature of one pound of water 1°F. Temperature is measured with a thermometer in degrees Fahrenheit (°F) or degrees Celsius (°C). These concepts are illustrated in Fig. 1-2.

1.09 The compressor in the heat pump system operates much like any other kind of pump. It can be compared with a pump that moves water from a lower place to a higher place, as shown in Fig. 1-3. However, the pump (compressor) in a heat pump system moves the heat by pumping refrigerant in an enclosed system. The compressor pumps the heat outdoors in summer and indoors in winter.

Fig. 1-3. Pumping water to higher level



1.10 When the compressor compresses the refrigerant into a smaller space, both the pressure and temperature of the refrigerant increase. Less work is needed to remove heat from outdoor air at 45°F and release it at 72°F than to remove heat from air at 0°F and release it at 72°F.

Advantages of Heat Pumps

1.11 Heat pump systems provide more even temperatures in a building than fossil-fuel heating systems can provide. The reason is that a heat pump system does not blow a blast of hot air into the conditioned space as fossil-fuel systems often do. The lower discharge air temperature causes the unit to run longer, thereby smoothing out the temperature variations between the ON and OFF cycles experienced with other kinds of heating systems.

1.12 The lower supply air temperature of a heat pump helps keep the relative humidity inside the space at a higher level than other kinds of heating systems provide. The higher relative humidity keeps the building and furnishings from drying out and possibly being damaged. It is also healthier for the occupants of the building because it does not dry out the nasal passages, thus helping prevent bacteria from entering the lungs and causing problems. In most installations, the relative humidity inside the space is high enough so that a humidifier is not needed.

1.13 Heat pump systems are less expensive to operate than electric resistance heating systems because they make use of existing heat rather than generating heat. Because a heat pump is used throughout the year, the cost per hour of operation for the original cost of the unit is less.

Heat Pump Cycles

1.14 Three refrigerant cycles, or modes of operation, are used in most heat pump systems:

- cooling
- heating
- defrost.

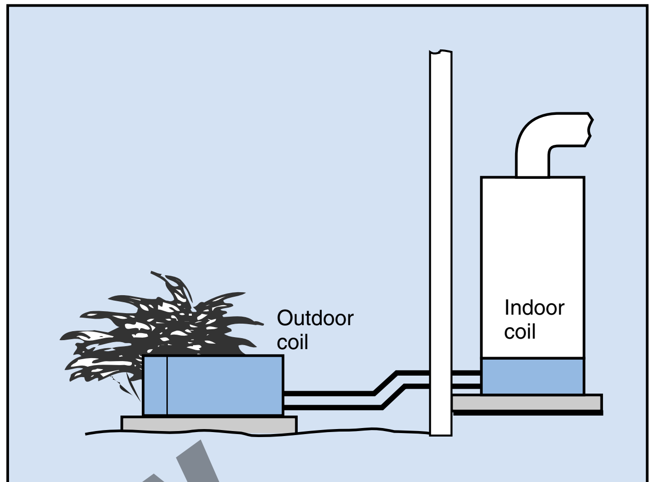
Specialized terminology is used for discussing heat pump systems. Use of this terminology can help prevent misunderstandings that might otherwise occur during discussions of components having more than one function. Logically enough, the coil inside the building is called the *indoor coil* and the coil in the outdoor unit is called the *outdoor coil*, as shown in Fig. 1-4. The *vapor line* carries refrigerant vapor in either direction.

Cooling Cycle

1.15 The cooling cycle is used to remove heat from inside the conditioned space and maintain that space at a temperature lower than its surroundings. During this process, the indoor air is cooled, dehumidified, and filtered to maintain the desired conditions inside the space. The conditioned air is distributed throughout the space by means of ductwork. Heat removal is accomplished by placing the refrigeration system in the cooling mode at the indoor thermostat. Although this discussion could start at any point in the refrigeration system, for convenience it will start at the discharge valve of the compressor and complete the cycle back to the same point.

1.16 When the heat pump is in the cooling mode and the thermostat demands cooling, the compressor starts running. The compressor compresses the refrigerant to a pressure and temperature higher than that of the cooling medium used to condense the refrigerant vapor. As shown in Fig. 1-5 on the following page, heat-laden refrigerant leaves the compressor discharge valve and is pumped to the outdoor section after flowing through the four-way reversing valve.

Fig. 1-4. Location of indoor and outdoor coils

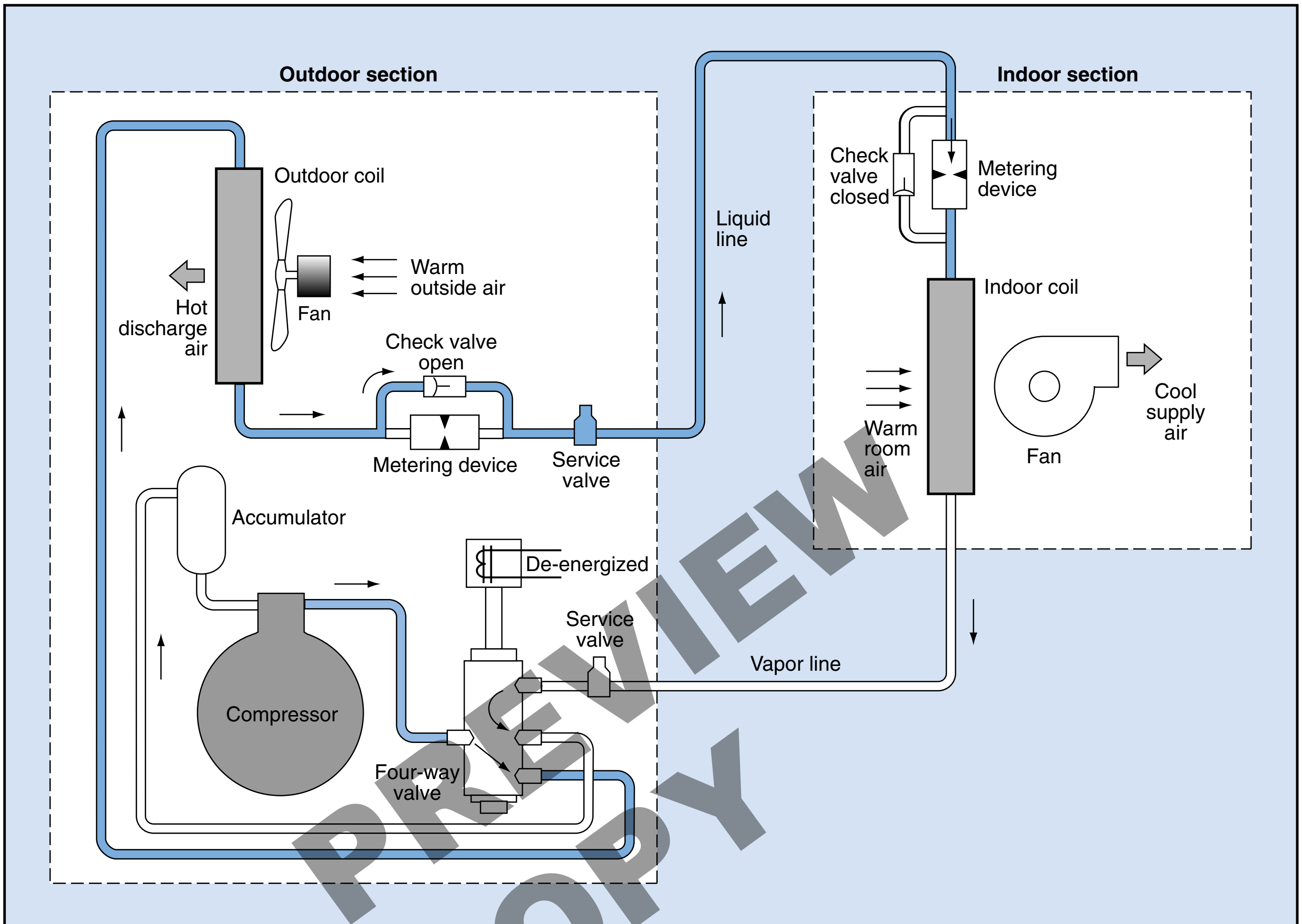


1.17 In the outdoor section, the fan blows air over the coil, cooling the refrigerant. As the unit rejects the heat moved from inside the space plus the heat of compression, the refrigerant changes into a warm, high-pressure liquid. That is, as the heat is removed, the temperature is lowered and the refrigerant condenses to a liquid. During most cooling cycles, the refrigerant is cooled below the condensation temperature by the cooling medium, which is usually air. This extra heat removal is called *subcooling*. Subcooling increases the efficiency of the unit.

1.18 At the outlet of the outdoor coil, a metering (flow-control) device and a check valve are installed. These devices direct the flow of refrigerant according to the cycle in use at the time. During the cooling cycle, the refrigerant flows through the check valve and bypasses the metering device, as shown in Fig. 1-5.

1.19 The warm, high-pressure liquid refrigerant then flows through the *liquid line* to another check valve and metering device combination at the inlet to the indoor coil. Here the flow is the opposite of the flow out of the outdoor coil. Now the check valve blocks the passage of refrigerant, causing it to flow through the metering device, as shown in Fig. 1-5.

Fig. 1-5. Heat pump in cooling mode



1.20 As the warm, high-pressure liquid passes through the metering device, its pressure and temperature decrease. The refrigerant is now a cool, low-pressure mixture of liquid and vapor. Some of the liquid is evaporated, forming *flash gas*. As this portion of the refrigerant evaporates, it removes heat from the remainder of the refrigerant, thus cooling the liquid refrigerant down to the evaporating temperature. Flash gas causes about a 20% loss in the refrigerating effect of the heat pump unit, as in all other direct-expansion cooling cycles. Subcooling helps to reduce this loss because, at a lower temperature, less flash gas is needed to cool the liquid refrigerant.

1.21 The cool liquid-vapor mixture then enters the indoor coil. Because the indoor fan blows warm building air over the coil, the coil temperature is warmer than the refrigerant liquid-vapor mixture, and heat moves from the warmer coil to the cooler refrigerant. This heat transfer causes the liquid refrigerant to boil (evaporate) as it absorbs heat, cooling and dehumidifying the indoor air. As the refrigerant continues to flow through the indoor coil, it picks up additional heat above the evaporating temperature. This additional heat is called *superheat*. Superheat causes the metering device either to open and allow more refrigerant into the coil or to close part way and reduce the flow of refrigerant into the indoor coil, depending on the heat pump mode.

1.22 The cool, low-pressure vapor then flows through the vapor line to the reversing valve, where it is directed into the accumulator. The refrigerant flow is slowed down by the accumulator so that any liquid refrigerant or oil will not be carried along with the refrigerant. This part of the cycle helps ensure that only refrigerant vapor enters the compressor suction valve.

The refrigerant vapor is then drawn into the compressor cylinder, where it is compressed, flows to the compressor discharge valve, and continues the cycle.

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 your book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. Outdoor air contains heat at any temperature above ________.	1-1. -459°F (-273.15°C) or ABSOLUTE ZERO Ref: 1.02
1-2. A heat pump produces ________ times the heat output of electric strip heaters with the same energy input.	1-2. FOUR TO FIVE Ref: 1.06
1-3. The quantity of heat is measured in ________, and temperature is measured in ________.	1-3. BRITISH THERMAL UNITS (Btu); DEGREES (°F or °C) Ref: 1.08
1-4. As refrigerant is compressed, its pressure and temperature ________.	1-4. INCREASE Ref: 1.10
1-5. Heat pump systems have ________ discharge and supply air temperatures than other kinds of heating systems.	1-5. LOWER Ref: 1.11, 1.12
1-6. Heat pump systems cost ________ to operate than electric resistance heating systems.	1-6. LESS Ref: 1.13
1-7. During the cooling cycle, the compressor pumps refrigerant to the ________ section.	1-7. OUTDOOR Ref: 1.16
1-8. Subcooling ________ the efficiency of a heat pump, whereas flash gas _______ the refrigerating effect.	1-8. INCREASES; DECREASES Ref: 1.17; 1.20

Heating Cycle

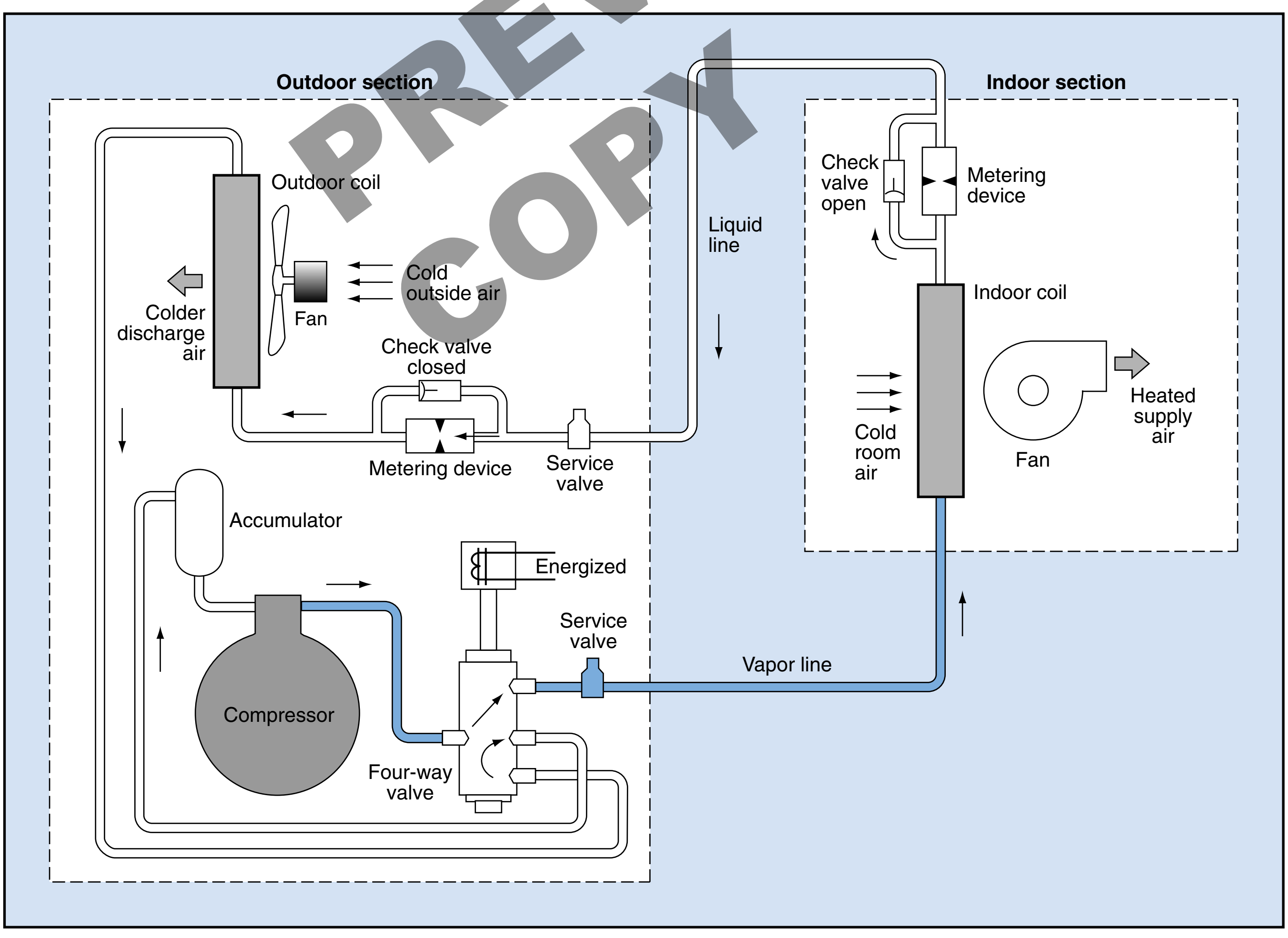
1.23 During the heating cycle, heat is picked up from the heat source and pumped into the indoor space. The heat source is usually outdoor air. The direction of refrigerant flow in the heating cycle is the opposite of the direction in the cooling cycle. When the thermostat demands heat, a reversing (four-way) valve changes position to direct the flow of refrigerant from the compressor into the indoor section, where heat is transferred to the air blowing over the indoor coil.

1.24 When the heating mode is selected at the thermostat, the compressor starts running. The heat-laden refrigerant from the outdoor coil is compressed, adding the heat of compression, which increases the refrigerant temperature and heat content. The hot refrigerant vapor then flows through the reversing valve piston, which is now positioned to direct the refrigerant through the vapor line and into the indoor coil, as shown in Fig. 1-6.

1.25 The indoor air blows through the indoor coil. The refrigerant gives up its heat to the air because the air is cooler than the refrigerant. The warmer, filtered air is then blown into the conditioned space to maintain the desired temperature and ventilation conditions. As the refrigerant gives up its heat, it condenses into a high-temperature, high-pressure liquid. Some indoor coils include room for subcooling a portion of the liquid.

1.26 The warm, high-pressure liquid then leaves the indoor coil and flows through a combination check valve and metering device. The check valve opens to allow the liquid refrigerant to bypass the unused metering device, as shown in Fig. 1-6. Because the metering device is bypassed, the refrigerant remains a

Fig. 1-6. Heat pump in heating mode



warm, high-pressure liquid, which then enters the liquid line.

1.27 The liquid refrigerant flows through the liquid line to another combination check valve and metering device, as shown in Fig. 1-6. The check valve is installed to stop any flow of refrigerant through it in this direction. The refrigerant must flow through the metering device. At this point, the pressure and temperature of the refrigerant are lowered. Part of the liquid refrigerant flashes into gas, thus cooling the remaining liquid down to the evaporating temperature of the outdoor coil. As in the cooling cycle, the flash gas causes a loss in refrigeration effect of about 20%. If the refrigerant is subcooled in the indoor coil, this loss is reduced.

1.28 The cool, low-pressure liquid-vapor mixture then flows into the outdoor section. The outdoor fan blows outdoor air through the coil. The liquid refrigerant vaporizes and absorbs heat from the air flowing over the coil. When all of the liquid refrigerant is vaporized, the refrigerant absorbs some of the superheat. The metering device controls the amount of refrigerant entering the outdoor coil based on the amount of superheat.

1.29 The cool, low-pressure refrigerant vapor then flows through the reversing valve and into the suction-line accumulator. In the accumulator, any remaining liquid refrigerant is vaporized before the refrigerant enters the compressor suction valve. The low-temperature, low-pressure refrigerant vapor leaves the accumulator and flows through the compressor suction valve and into the compressor cylinder. There it is compressed into a high-pressure, high-temperature refrigerant vapor, and the cycle continues.

1.30 During the heating process, the indoor air is heated and filtered. The air is then blown through the air-distribution system to heat one or more spaces as desired. As discussed in a later Lesson in this Unit, this air should be directed so that it will not cause drafts.

Defrost Cycle

1.31 For most systems, the temperature of the air passing through the outdoor coil sometimes drops below freezing, 32°F (0°C). Any moisture in the outdoor air begins to condense out and collect on the coil surface. Because this frost reduces the efficiency of the unit, it must be removed periodically. The equipment manufacturer specifies which of several methods should be used to defrost the coil.

1.32 It is important to note that condensation can occur at outdoor ambient air temperatures higher than 32°F (0°C). The air may be at 40°F or even higher, depending on the amount of moisture in the air and the temperature of the evaporating refrigerant in the outdoor coil. These conditions together determine whether frost forms.

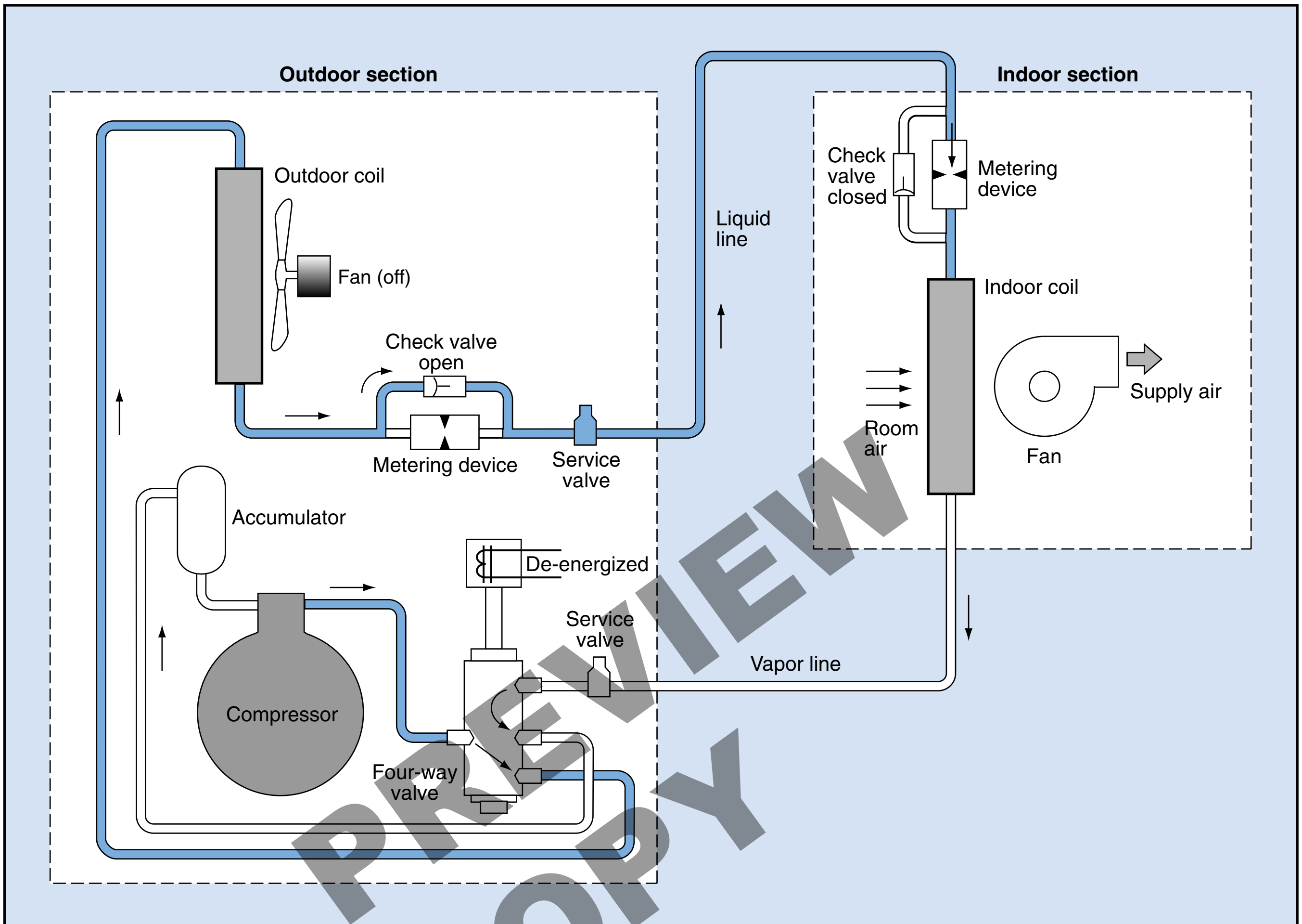
1.33 After the unit has run long enough so that a coating of ice has formed on the outdoor coil, typically about two hours, the unit goes into the defrost cycle. The defrost cycle melts the ice, giving the unit a fresh start. Defrosting is accomplished by changing the position of the reversing valve, which causes refrigerant to flow in the normal cooling direction. That is, the reversing valve directs the hot refrigerant vapor to the outdoor coil, causing the frost to melt from the coil. As shown in Fig. 1-7, refrigerant flows in the same direction for the defrost cycle as for the cooling cycle.

1.34 When a defrost cycle is called for, the outdoor fan stops so that the outdoor coil can warm up faster and melt the ice as quickly as possible. The indoor fan continues operating to circulate the air inside the conditioned space. Some of the auxiliary strip heaters are energized to temper the indoor air. The auxiliary heat strips are used because the indoor coil is now the evaporating (cooling) coil. It is absorbing heat from the indoor air to melt the frost from the outdoor coil.

1.35 When all the frost has been removed from the outdoor coil, the defrost termination control ends the cycle. The equipment manufacturer specifies which of several defrost termination controls is to be used. When the defrost is terminated, the reversing valve switches to the normal heating position, the outdoor fan starts, and the auxiliary heat strips are de-energized unless additional heat is needed inside the space.

1.36 The defrost cycle should be as short as possible to reduce energy used by the system. When the system is in the defrost cycle, energy consumption—and thus the cost of heating the space—is greatly increased, although little of the energy is used directly to heat the conditioned space.

Fig. 1-7. Heat pump in defrost mode



Kinds of Systems

1.37 There are many different kinds of heat pump systems. The air-to-air system is generally considered the most popular, although groundwater heat pumps are gaining in popularity. Other kinds include earth-coupled heat pumps, water-to-air, water-to-water, solar-assisted, dual-fuel, and geothermal heat pump systems. All of these systems will be discussed in detail in Lesson Two.

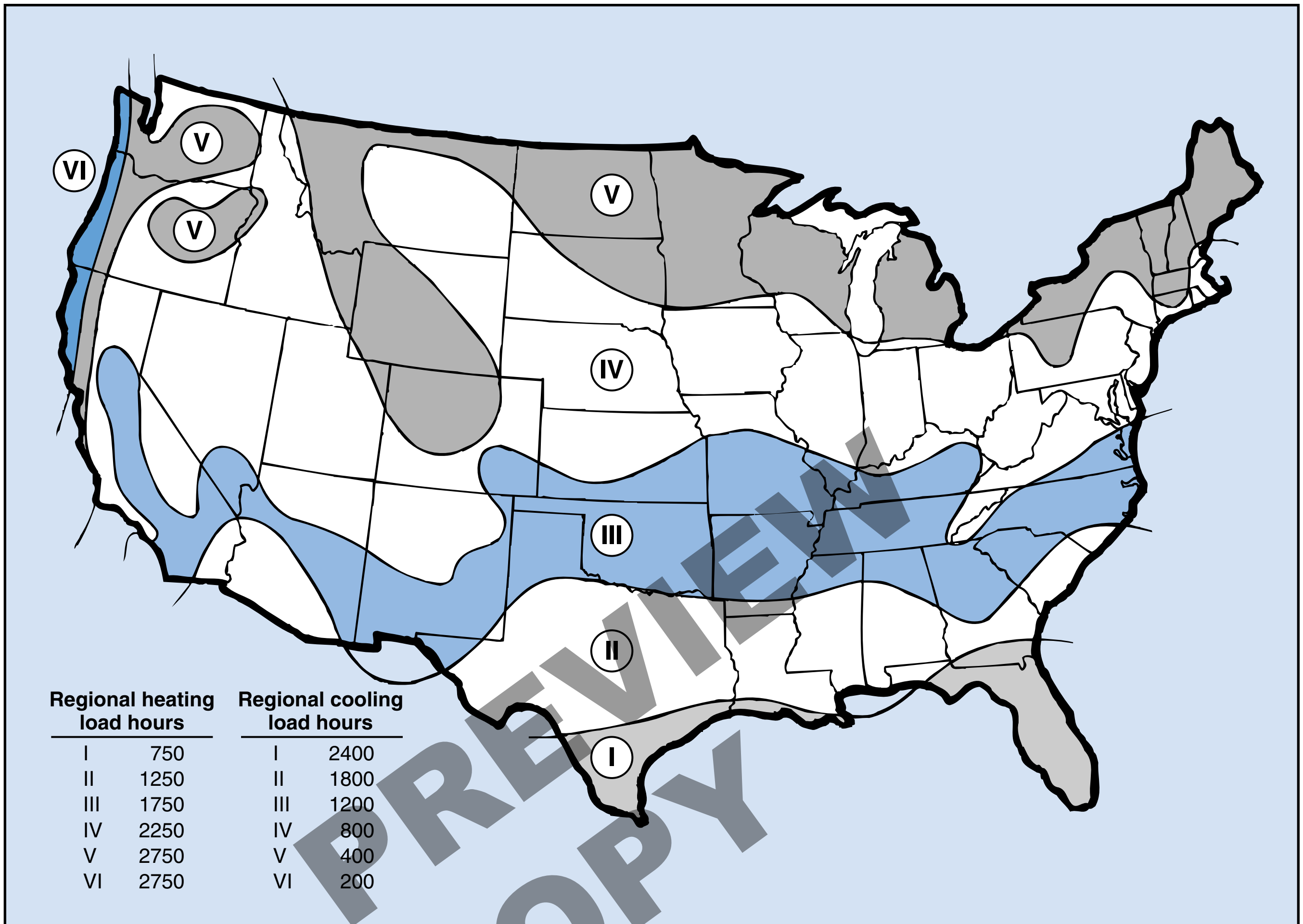
Balance Point

1.38 The *balance point* of a heat pump, sometimes called the *thermal balance point*, is the outdoor temperature at which the heat loss of the building equals the heat output of the heat pump. As the outdoor temperature falls below this point, heat from a source other than the heat pump is needed to maintain the desired comfort level in the building. A second stage on the indoor thermostat and an outdoor thermostat act together to bring on the heat strips that are installed in the outlet of the indoor unit. The balance point is the subject of Lesson Three.

Degree-Days

1.39 The *degree-day* is a unit used to determine the amount of heating or cooling that is needed on any particular day. The calculations are based on a 65°F outdoor temperature. A degree-day is calculated by taking the average (mean) of the highest and the lowest temperatures for a certain day and subtracting that average daily temperature from 65°F. For example, suppose the lowest recorded temperature for a certain day is 28°F and the highest recorded temperature for that day is 36°F. The average (mean) temperature for that day is:

Fig. 1-8. Heating and cooling load-hour regions



$$\frac{28°F + 36°F}{2} = 32°F$$

and

$$65°F - 32°F = 33°F.$$

Thus, there are 33 degree-days for that date. Degree-days may be added together by weeks, months, or for the entire season to permit a comparison of the heating and cooling needs for different years.

Unit Sizing

1.40 Heat pump systems are generally sized to match or slightly exceed the building heat gain during the cooling season. This method is used mainly for regions I, II, III, and IV, which are shown in Fig. 1-8. In colder climates—for example, region V—the heat pump unit is often deliberately oversized for the cooling load, although this approach may result in a system much larger than actually needed. The reason this method is used is that oversizing for the cooling load helps to ensure that there is enough heating capacity with a minimal amount of supplemental heat. However, the larger system may increase the initial costs and cause higher relative humidity inside the building during the cooling season.

1.41 A different method of addressing the sizing problem is to install a dual-speed or dual-compressor heat pump. These systems can provide the different capacities needed for the cooling and heating loads. Dual-speed heat pumps use a compressor that can operate at either a low or a high speed. A dual-compressor heat pump uses two compressors. The second compressor operates only when additional heating or cooling is needed.

1.42 Another way to approach the sizing of heat pumps is to use a variable-speed compressor, which provides better performance and comfort conditions than dual-speed or dual-compressor systems. When a variable-speed compressor is used, the indoor and outdoor fans can operate at nearly any speed needed to match the heating or cooling load. Variable-speed operation not only saves energy, but also improves the comfort level inside the building.

1.43 Most utility companies have guidelines for sizing heat pumps based on the electric rates in a particular area. Some have recommended that heat pump systems be sized based on the system balance point. As a general rule, the heat pump should be sized so that supplementary heat is used less than half the time during the heating season. If the balance point is calculated, the system can be sized to meet this guideline if the outdoor temperature is expected to fall between the balance point and 65°F for more than half the time.

Operating Costs

1.44 For heat pump systems, as for any heating or cooling system, operation represents the largest cost over the life of the equipment. The operating costs are often double or triple the initial cost of the equipment. Equipment operating costs depend on two considerations:

- the energy used by the system
- the price of the energy used.

1.45 The builder or building owner can control, to a great extent, the first consideration by ensuring the purchase of an efficient system. If an inefficient heat pump is installed, energy use will be high. Fluctuating energy costs have less effect on the operating costs of a heat pump than on other kinds of units that are not as efficient.

1.46 The amount of energy used to heat or cool a building is governed by a variety of considerations, including the following:

- climate
- heating and cooling equipment characteristics
- equipment operation
- control system.

The most accurate way to estimate energy use includes evaluation of the building design, occupant use and patterns, heating and cooling characteristics, and local weather data on an hour-by-hour basis. Some utility companies have developed computer programs that aid in the analysis of all these considerations.

1.47 Some simpler methods of cost estimating make use of heating degree-days, cooling degree-days, and the bin method. These methods will be discussed in detail in Lesson Three.

1-9. The heat source for a heat pump is usually ________.	1-9. OUTSIDE AIR Ref: 1.23
1-10. In the heating cycle, the compressor pumps refrigerant to the ________ coil.	1-10. INDOOR Ref: 1.23, 1.24
1-11. In the heating cycle, flash gas forms in the ________ device at the entrance to the ________ coil.	1-11. METERING; OUTDOOR Ref: 1.27
1-12. Any liquid refrigerant is vaporized In the heat pump ________ before entering the compressor.	1-12. ACCUMULATOR Ref: 1.29
1-13. Refrigerant flow for defrost is the same as in the ________ cycle.	1-13. COOLING Ref: 1.33
1-14. During the defrost cycle, the ________ fan stops.	1-14. OUTDOOR Ref: 1.34
1-15. Degree-days are calculated by subtracting the average temperature for a certain day from ________.	1-15. 65°F Ref: 1.39
1-16. Heat pump systems are often sized to match or exceed the ________ load.	1-16. COOLING Ref: 1.40

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

1-1. Unlike standard air-conditioning equipment, the heat pump

- ☐ a. includes components to reverse the refrigerant cycle
- ☐ b. includes indoor and outdoor compressors
- ☐ c. pumps water through the system
- ☐ d. usually runs on fossil fuels

1-2. A heat pump can extract heat from cool outside air because

- ☐ a. liquid refrigerant evaporates at a temperature lower than that of the air
- ☐ b. refrigerant vapor condenses at a temperature lower than that of the air
- ☐ c. strip heaters heat the air around the outdoor coil
- ☐ d. the heat of compression is added to the air

1-3. The quantity of heat is measured in

- ☐ a. Btu
- ☐ b. cfm
- ☐ c. °F or °C
- ☐ d. kW

1-4. Because the supply air temperature is lower than in other systems, the heat pump

- ☐ a. has longer ON and OFF cycles
- ☐ b. has shorter ON and OFF cycles
- ☐ c. provides higher relative humidity
- ☐ d. provides lower relative humidity

1-5. In the outdoor section during the cooling cycle, the refrigerant is

- ☐ a. saturated
- ☐ b. subcooled
- ☐ c. superheated
- ☐ d. vaporized as flash gas

1-6. Flash gas forms in the heat pump system as refrigerant

- ☐ a. liquid is subcooled
- ☐ b. passes through the check valve
- ☐ c. passes through the metering device
- ☐ d. vapor is superheated

1-7. During the heat pump heating cycle, the check valve at the ________ is open.

- ☐ a. entrance to the indoor section
- ☐ b. entrance to the outdoor section
- ☐ c. outlet of the indoor section
- ☐ d. outlet of the outdoor section

1-8. During the heat pump defrost cycle,

- ☐ a. heat strips are de-energized and the indoor fan is turned OFF
- ☐ b. heat strips are energized and the outdoor fan is turned OFF
- ☐ c. the compressor cycles ON and OFF
- ☐ d. the compressor pumps refrigerant to the indoor coil

1-9. How many degree-days are there for January 9 in Hometown if the highest and lowest recorded temperatures are 72°F and 22°F?

- ☐ a. 7
- ☐ b. 18
- ☐ c. 43
- ☐ d. 50

1-10. The best equipment for providing different capacities for heating and cooling loads is a

- ☐ a. dual-compressor heat pump
- ☐ b. dual-speed heat pump
- ☐ c. larger reversing valve
- ☐ d. variable-speed compressor

SUMMARY

A heat pump provides cooling in warm weather and heating in cool weather. Heating is possible because outdoor air contains heat at any temperature above absolute zero. The higher the temperature, measured in degrees, the greater the heat content, measured in British thermal units. A reversing valve directs the flow of refrigerant from the compressor to pump the heat outdoors in the summer and indoors in the winter. Heat pumps offer more even temperatures than other equipment, provide greater humidity during the heating season, and are less expensive to operate than other electric heating systems.

During the cooling cycle, heat-laden refrigerant flows from the compressor to the outdoor section, where it rejects the indoor heat and condenses to a warm, high-pressure liquid, which is usually subcooled, thus increasing the efficiency of the unit. The refrigerant flows through a coil outlet check valve in the liquid line, bypassing the metering device. At the inlet to the indoor section, the refrigerant is blocked by a check valve and passes through a metering device, where some of the liquid evaporates, forming flash gas to cool the remainder of the liquid to evaporating temperature. Flash gas reduces the efficiency of the unit, but subcooling reduces this loss. Indoors the cool liquid-vapor mixture evaporates, absorbs heat from the warmer room air, and is superheated. The cool, low-pressure vapor flows to the accumulator, where liquid refrigerant drops out. Refrigerant vapor enters the compressor and continues the cycle.

During the heating cycle, the reversing valve directs the refrigerant from the compressor to the indoor section, where hot refrigerant vapor transfers heat to the cooler room air. The refrigerant condenses into a high-temperature, high-pressure liquid, leaves the indoor coil by means of a check valve in the liquid line, and passes through a metering device at the outdoor coil, where flash gas forms to lower the temperature of the remaining refrigerant. Cool liquid-vapor refrigerant enters the outdoor coil, where it vaporizes, absorbs heat, and is superheated. The vapor enters the accumulator, where any liquid is removed, and flows to the compressor, where the cycle continues. Electric heat strips provide additional heat if necessary.

Any frost or ice that forms on the outdoor coil must be removed periodically because it greatly reduces system efficiency. During the defrost cycle, heat pump operation is the same as for the cooling cycle except that the outdoor fan is stopped and some of the heat strips are energized. The defrost cycle increases energy consumption, and thus operating costs, considerably.

A degree-day, one means of estimating heating or cooling needs, is calculated by subtracting the average temperature for a certain day from 65°F. Heat pumps are often sized to match or exceed the cooling load. Heat pumps with variable-speed compressors generally provide greater comfort at less cost than dual-speed or dual-compressor systems. Operating costs for any heat pump system depend largely on its energy consumption.

Answers to Self-Check Quiz

1-1. a. Includes components to reverse the refrigerant cycle. Ref: 1.01

1-2 a. Liquid refrigerant evaporates at a temperature lower than that of the air. Ref: 1.03

1-3. a. Btu. Ref: 1.08

1-4. c. Provides higher relative humidity Ref: 1.12

1-5. b. Subcooled. Ref: 1.17

1-6. c. Passes through the metering device. Ref: 1.20

1-7. c. Outlet of the indoor section. Ref: 1.26

1-8. b. Heat strips are energized and the outdoor fan is turned off. Ref: 1.34

1-9. b. 18. Ref: 1.39

1-10. d. Variable-speed compressor. Ref: 1.42

Contributions from the following sources are appreciated:

Figure 1-5. Courtesy of Carrier Air Conditioning
Figure 1-6. Courtesy of Carrier Air Conditioning
Figure 1-7. Courtesy of Carrier Air Conditioning
Figure 1-8. The Electrification Council