Condensers and Cooling Towers

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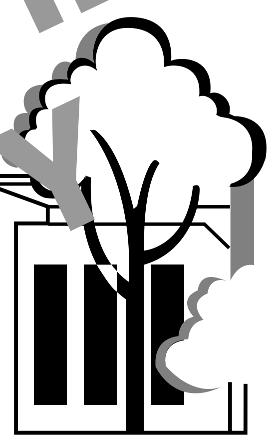
CONDENSERS AND COOLING TOWERS

Lesson One

Air-Cooled Condensers



TPC Training Systems

43501

Lesson

1 Air-Cooled Condensers

TOPICS

The Function of a Condenser
Condenser Capacity
Air-Cooled Condenser Construction
Types of Air-Cooled Condensers
Effects of Ambient Temperature
Pumpdown Circuit
Low-Ambient Controls
Receivers
Pressure-Relief Devices
Air-Cooled Condenser Maintenance
Troubleshooting Air-Cooled Condensers

OBJECTIVES

After studying this Lesson, you should be able to…

- Contrast the two types of air-cooled condensers—natural draft and forced air.
- Describe the construction of an air-cooled condenser, including the tubes, fins, headers, and subcooling circuit.
- Name the factors that affect condenser capacity.
- Explain the effects of ambient temperature on the capacity of an air-cooled condenser.
- Describe various types of low-ambient controls for air-cooled condensers.
- Explain how spring-loaded pressure-relief valves and fusible plugs protect against possible explosions caused by high pressure.
- List the periodic maintenance procedures common to most air-cooled condensers.

KEY TECHNICAL TERMS

Condenser 1.01 refrigeration system component that removes and rejects heat from the hot refrigerant vapor
Condensing unit 1.01 compressor and condenser mounted on a single base
Subcooling circuit 1.15 increases the capacity of the condenser
Ambient temperature 1.21 temperature of the air surrounding a system
Fan cycling 1.33 stopping and starting condenser fans in response to temperature
Receiver 1.36 liquid refrigerant storage tank

At one time, air-cooled condensers were used only in small air-conditioning and refrigeration systems—generally those under 3 tons. However, air-cooled condensers are now being used in larger industrial and commercial systems because they are easy to install, inexpensive to maintain, and require no water. Because they use no water, they do not require protection from freezing in the winter.

This Lesson begins by examining the function of a condenser. It then describes how condensers remove heat and the factors that determine their capacity to remove heat. You will be introduced to the types and construction of air-cooled condensers, receivers and receiver components, low-ambient controls, and pressure-relief devices. Finally, you will read about how to maintain and troubleshoot air-cooled condensers.

The Function of a Condenser

1.01 The *condenser* is the refrigeration system component that removes and rejects heat from the hot refrigerant vapor. This heat comes from two sources:

- the heat absorbed in the evaporator
- the heat of compression added by the compressor.

Because the compressor and condenser work together to condense refrigerant vapor, these two components are sometimes combined on a single base and called a *condensing unit*, as shown in Fig. 1-1. The compressor draws in vapor containing heat absorbed in the evaporator. The compressor then prepares the vapor for the condenser by raising the pressure and temperature until the saturation temperature is above the temperature of the condensing medium. In the process, the compressor adds more heat (the heat of compression) to the vapor, and raises the amount of superheat.

1.02 The compressor then pumps this superheated vapor through the discharge line into the condenser. The condenser cools the refrigerant in three stages:

1. The vapor gives up sensible heat as it is cooled to saturation temperature (desuperheating).
2. The vapor gives up latent heat and condenses to a liquid.
3. The temperature of the liquid is reduced below its saturation temperature (subcooled) to increase the refrigerating effect.

The three stages of cooling are represented on the pressure-enthalpy (P-H) diagram in Fig. 1-2.

Fig. 1-1. Air-cooled condensing unit

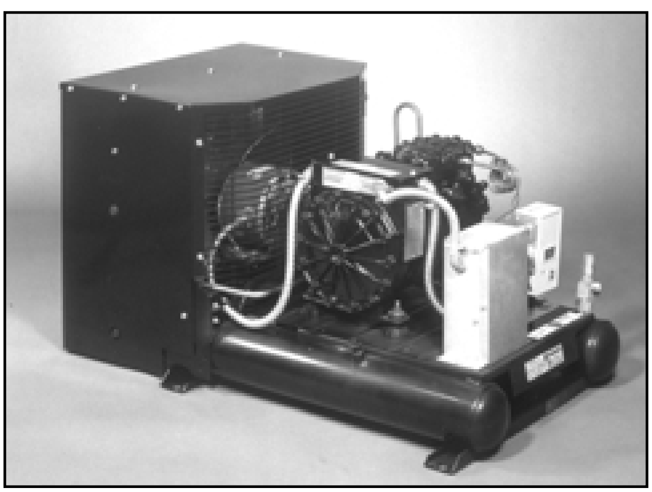


Fig. 1-2. P-H diagram showing the three stages of refrigerant cooling in a condenser

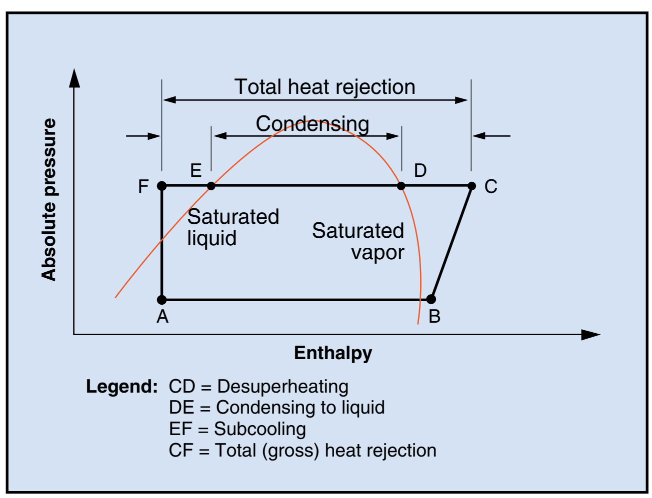
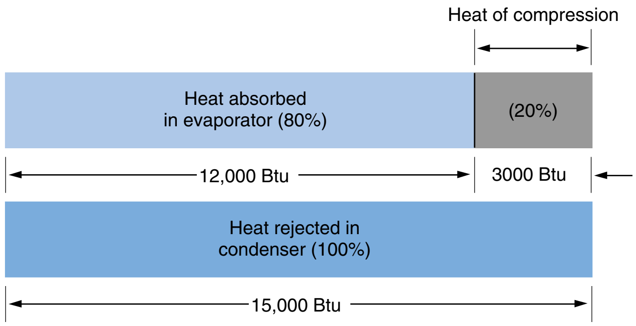


Fig. 1-3. Heat rejected by the condenser equals heat absorbed in the evaporator plus the heat of compression



1.03 The condenser removes heat from the vapor by transferring it first to the walls of the condenser tubes, and then from the tubes to the cooling medium. The cooling medium can be air, water, or a combination of the two. This Lesson covers air-cooled condensers and related components. You will learn about other kinds of condensers and related equipment in later Lessons of this Unit.

1.04 As illustrated in Fig. 1-3, the condenser must remove and reject both the heat that the evaporator absorbs and the heat of compression added by the compressor. Using an open compressor system as an example, the rule of thumb is that for every ton (or 12,000 Btu/hr) of cooling capacity, the condenser rejects 15,000 Btu/hr of heat. Hermetic compressors usually add more heat to the vapor, because the vapor absorbs heat from the compressor motor. The amount of heat the condenser must reject also depends on the system's condensing temperature and suction temperature, as shown in Fig. 1-4.

Condenser Capacity

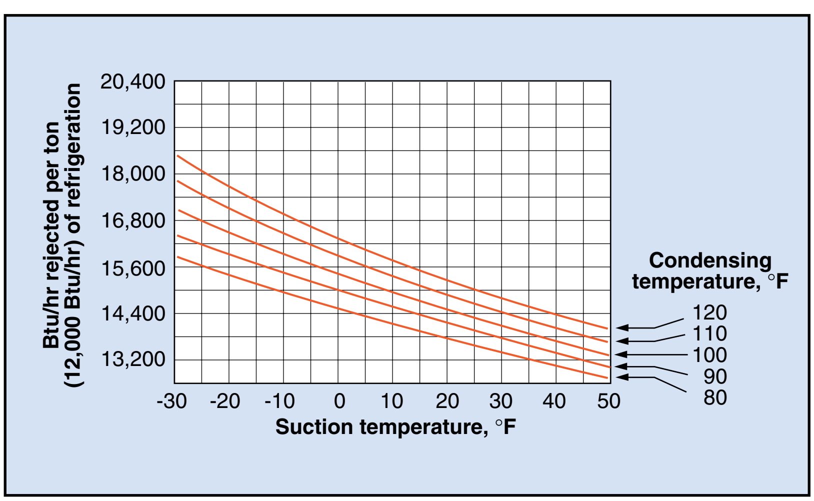
1.05 Condenser capacity describes the ability of a condenser to transfer heat from the hot refrigerant vapor to the condensing medium. The heat transfer capacity of a condenser depends upon four factors:

- the materials used to make the condenser
- the amount of contact between the condenser surface and the condensing medium
- the temperature difference between the condensing medium and the refrigerant vapor
- the cleanliness of the condenser.

1.06 **Materials.** Different materials have different abilities to transfer heat. Therefore, a designer can vary the size of a condenser of given capacity by selecting the appropriate materials—the better the ability of a material to transfer heat, the smaller the condenser can be.

1.07 **Amount of contact.** The designer can also vary the condenser capacity by controlling the amount of contact between the condenser surface and the condensing medium. This factor is controlled by varying the surface area of the condenser and the rate of flow of the condensing medium over the surface. The liq-

Fig. 1-4. Heat rejected by a condenser, per ton of refrigeration, in a system using R-12



uid refrigerant level in the condenser also affects the amount of contact between the refrigerant vapor and the condensing medium. The area of the condenser used for liquid subcooling cannot condense any vapor.

1.08 **Temperature difference.** Temperature difference is probably the most important factor affecting condenser capacity. As the temperature difference between the condensing medium and the refrigerant vapor increases, the heat-transfer rate (and therefore the condenser capacity) increases. Generally, this temperature difference cannot be controlled. However, if the temperature difference becomes so great that it presents a problem, devices are available that can change the amount of condensing surface and the airflow rate to control condenser capacity. You will learn later in this Lesson how these devices keep an air-cooled condenser operating within its designed capacity range as the temperature difference changes.

1.09 **Cleanliness.** The cleanliness of the condenser is the one factor that you can always control. Dirt on the condenser insulates it, slowing down the rate of heat transfer between the condenser surface and the condensing medium. Dirt can also restrict the airflow over the condenser and slow down the heat transfer rate. You will learn later in this Lesson how to clean condensers to keep them operating at their designed capacity.

Air-Cooled Condenser Construction

1.10 An air-cooled condenser is a coil of metal tubing through which refrigerant flows. The tubing is usually attached to plate-type fins to increase the surface area for heat transfer, as shown in Fig. 1-5. Thus, air-cooled condensers are constructed much like refrigerant-to-air evaporators. Condenser tubes are made of copper, aluminum, or steel. They range in size from 1/4 to 3/4 in. outside diameter, depending on the size of the condenser. Copper tubes are most common because copper has excellent heat transfer ability, needs no protection against corrosion, and is easy to form into tubes and coils. However, either steel or aluminum condensers must be used in ammonia systems, because ammonia reacts with copper. Steel tubes must be painted or galvanized to prevent corrosion.

1.11 Because the air temperature rises as it passes over each row of tubing, a single row of tubing provides the most efficient heat transfer. Because the temperature difference between the air and the refrigerant vapor decreases in each additional row of tubing, each row becomes less efficient. However, single-row condensers take up more space than multiple-row condensers. For this reason, single-row condensers are usually limited to small air-conditioning and refrigeration systems, such as domestic refrigerators and freezers, where space permits.

1.12 Larger systems require a more compact condenser—a small face area and several rows of tubing stacked in depth. Although the condenser in Fig. 1-5 has only two rows, condensers with up to six rows are common. Some condensers have seven or eight rows. More than eight rows of tubing is usually not efficient, however, because after passing through eight rows of tubing, the air temperature becomes too close to the condenser temperature to absorb any more heat.

1.13 Most air-cooled condensers have fins attached to the tubes to increase the surface area exposed to the air. This feature increases the amount of heat transferred from the condenser to the air. Fins are usually made of aluminum because of its light weight, although copper and steel fins are also used. The most common form of fin is the plate type shown in Fig. 1-5. These fins are placed over the tubing, and the tubing is expanded (either with a mandrel or by hydraulic pressure) until the tubing fits tightly in the fins. The number of fins ranges from 4 to 30 fins per inch. The most common range on industrial and commercial condensers is 8 to 16 fins per inch.

Fig. 1-5. Air-cooled condenser

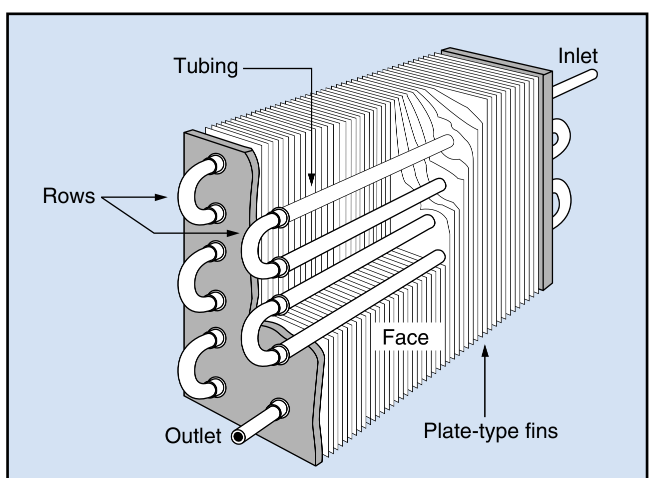


Fig. 1-6. Headers on a remote air-cooled condenser, horizontal type

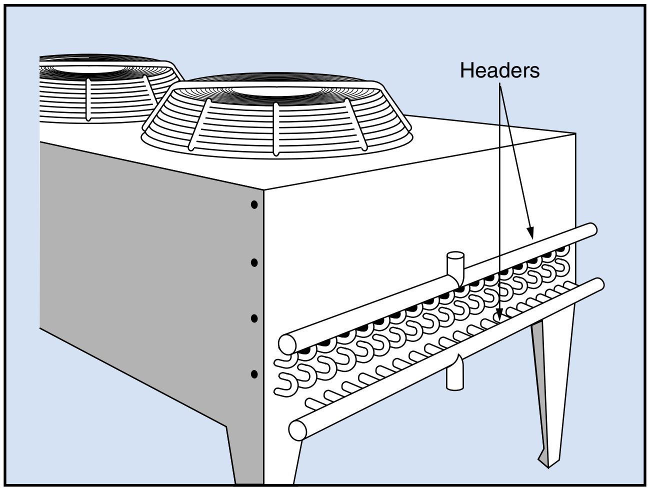
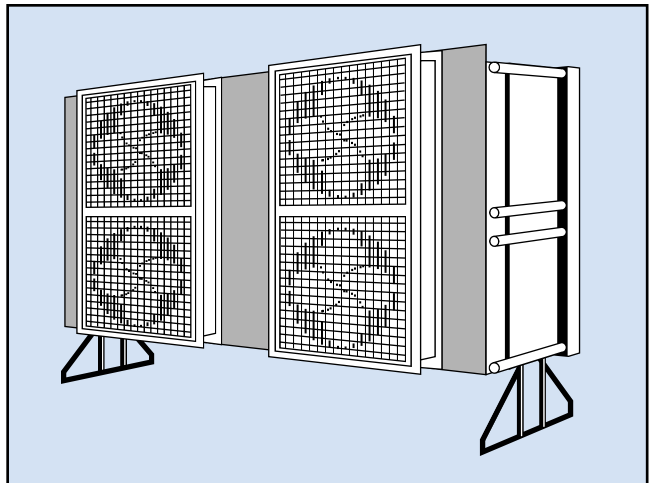


Fig. 1-7. Vertical remote air-cooled condenser



1.14 Large air-cooled condensers contain two or more circuits of tubing connected in parallel by pipes called *headers*, as shown in Fig. 1-6. A supply header distributes the hot refrigerant vapor to the parallel circuits. The return header collects all the liquid refrigerant. In this arrangement, only part of the refrigerant condenses in each circuit, and the condensed refrigerant does not fill the circuit as quickly as it does in a single circuit condenser. This arrangement also gives each circuit more condensing surface, thus making the parallel circuit more efficient.

1.15 Some air-cooled condensers contain a separate *subcooling circuit* to increase the capacity of the system. Generally, each degree of subcooling increases system capacity by about 0.5%. The subcooling circuit is usually located within the main condenser housing. However, the liquid refrigerant first flows from the main condenser to the receiver, and then passes through the subcooling circuit on its way to the metering device.

Types of Air-Cooled Condensers

1.16 There are two types of air-cooled condensers: natural draft and forced air. In the *natural-draft condenser*, heat transfers from the condenser coils to the air by natural convection. In *forced-air condensers*, fans—either propeller or centrifugal—force the air over the condenser coils to increase heat-transfer capacity. Because the rate of heat transfer is slower in natural-draft condensers, they require a larger surface area compared to a forced-air condenser of the same capacity. Therefore, natural-draft condensers are used only in household refrigerators and freezers and other small-capacity applications.

1.17 Forced-air condensers are either base mounted or remote. Different designs are available for indoor and outdoor locations. *Base-mounted air-cooled condensers*, using propeller fans, are mounted on a base along with the compressor, receiver, and various controls. The condensing unit shown in Fig. 1-1 is an example. These units are used on packaged refrigeration systems, such as reach-in refrigerators and beverage coolers, and split air-conditioning systems. Those used on refrigeration systems are usually mounted in or near the unit inside a building. Those units used for split air-conditioning systems are usually mounted outside the building, either on a foundation placed on the ground or on the roof.

1.18 *Remote air-cooled condensers* are used on systems above 10 tons, and are available up to 125 tons. Systems above 125 tons usually have two or more condensers. Both horizontal and vertical air-cooled condensers are available. Both kinds are shown in Fig. 1-6 and Fig. 1-7. They can be located either inside or outside a building.

1.19 Outdoors, air-cooled condensers can be mounted on a foundation on the ground, on the roof, or on the side of the building—away from walls or other obstructions to airflow. Outdoor condensers usually use propeller fans because these fans have low resistance to airflow and free air discharge. Condensers require from 600 to 1200 cfm of air per ton of capacity. Propeller fans can move this volume of air if the resistance to airflow is low. To prevent any resistance to airflow, the fan intake on vertical outdoor condensers usually faces the prevailing winds. If this arrangement is not possible, the air discharge side is usually covered with a shield to deflect opposing winds.

1.20 Remote condensers located inside the building usually require ductwork to carry air to and from the unit. The ductwork restricts airflow to and from the condenser, and causes a high air-pressure drop. For this reason, inside condensers usually use centrifugal fans, which can move the necessary volume of air against the resistance to airflow.

Application 1-1

When installing an outside condenser unit next to a building, make sure you follow the manufacturer's recommendation for clear air entry. There must be no barriers to the free flow of air near a condenser. If installed too near a building wall or a roof overhang, a condenser can be "starved" for air whenever a high wind blows. Even a truck parked near the condenser at a time of peak load can reduce the flow of needed air.

Grounds maintenance crews often plant decorative shrubs around condensers mounted near the building. Make sure that any shrubs are far enough away from the condenser so that they do not interfere with airflow. Keep the shrubs pruned back from the condenser. Likewise, do not install a condenser too close to existing bushes. Keep in mind that vegetation grows! Consider the size the surrounding shrubs will be in a few years. Do not install the unit in a way that makes it difficult to reach the control box.

Also be aware of what is overhead. If melting ice and snow from a roof overhang are allowed to drip onto fan blades and refreeze, the blades will become ice covered and break.

Effects of Ambient Temperature

1.21 *Ambient temperature* is the temperature of the air surrounding system equipment. In an air-cooled condenser, it is also the temperature of the air entering the condenser. Recall that the temperature difference between the air and the refrigerant vapor in the condenser affects condenser capacity. If the ambient temperature rises, the condensing temperature will also rise. Most air-cooled condensers are designed to operate with a temperature difference of about 25°F (14°C). The condensing temperature in a typical air-cooled condenser using air at 90°F (32°C) is about 115°F (46°C) as shown in Table 1-1 on the following page.

1.22 The main disadvantage of an air-cooled condenser is that it operates at a higher condensing temperature than a water-cooled condenser, as shown in Table 1-1. The higher condensing temperature causes the compressor to work harder, because it must raise the refrigerant vapor pressure and temperature higher. On the hottest days—when a system must work hardest to cool—the condensing temperature is also the highest because of the high ambient-air temperature.

1.23 Most air-cooled condensers in industrial and commercial refrigeration systems are located outdoors, and many must operate year-round. During the winter, the ambient temperature is very low, and therefore the condensing temperatures and pressures drop. The low pressure in the liquid line reduces the capacity of the expansion valve, because its capacity depends upon the pressure drop across the valve. The valve then starves the evaporator of refrigerant, the cooling capacity drops, and sometimes the evaporator coil freezes. To prevent winter operating problems, air-cooled condensers are equipped with some type of low-ambient capacity control. These controls will be covered later in this Lesson.

1.24 In winter, during the off cycle, an air-cooled condenser can become the coldest part of a refrigeration system. When this occurs, the refrigerant migrates to the condenser. This migration prevents pressure from building up in the evaporator during the off cycle, so the low-side pressure remains low. The low-pressure switch in the suction line stays open, and the compressor will be unable to start. To prevent startup problems, systems with outdoor air-cooled condensers for year-round applications usually have a pumpdown circuit.

Table 1-1. Condensing temperature vs. condensing medium

Condensing medium	Inlet temperature		Temperature rise		Outlet temperature		Leaving difference*		Condensing temperature	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Air	90	32	13	7	103	39	12	7	115	46
	95	35	13	7	108	42	12	7	120	49
	100	38	13	7	113	45	12	7	125	52
City water	70	21	20	11	90	32	10	6	100	38
	80	27	20	11	100	38	10	6	110	43
Cooling tower water	85	29	10	6	95	35	10	6	105	41

*Condensing temperature minus outlet temperature of condensing medium

Pumpdown Circuit

1.25 A pumpdown circuit consists of a normally closed solenoid valve in the liquid line between the liquid receiver and the evaporator. The refrigeration system's load-sensing thermostat controls the liquid-line solenoid valve instead of the compressor. The compressor is controlled by a low-pressure switch in the suction line.

1.26 When the system cools its load to the temperature set on the thermostat, the thermostat contacts open, allowing the liquid-line solenoid valve to close. This action stops the flow of refrigerant to the evaporator, but the compressor continues to run. Because no refrigerant is being fed into the evaporator, the compressor pumps the remaining refrigerant in the evaporator into the condenser and receiver, which causes the pressure in the evaporator and suction line to decrease. The low-pressure switch in the suction line stops the compressor when the suction-line pressure drops to the switch setting. The switch is usually set to stop the compressor before the pressure in the suction line drops below 0 psig.

1.27 Most of the refrigerant in the system is now in the condenser and receiver. When the thermostat again calls for cooling, the liquid-line solenoid valve opens and allows refrigerant to flow into the low-pressure evaporator. The refrigerant increases the suction-line pressure until the low-pressure switch trips and the compressor starts. The system then runs until the thermostat again closes the liquid-line solenoid valve.

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 heat rejected by a condenser is equal to the heat absorbed in the evaporator plus the ________.	1-1. HEAT OF COMPRESSION Ref: 1.01
1-2. Probably the most important factor affecting condenser capacity is the difference between the ________ and the ________.	1-2. CONDENSING MEDIUM, REFRIGERANT VAPOR Ref: 1.08
1-3. Why do many air-cooled condensers have fins attached to their tubes?	1-3. TO INCREASE SURFACE AREA EXPOSED TO THE AIR Ref: 1.13
1-4. The two main types of air-cooled condensers are ________ and ________.	1-4. NATURAL DRAFT, FORCED AIR Ref: 1.16
1-5. Outdoor condensers usually use ________ fans; indoor condensers usually use ________ fans.	1-5. PROPELLER; CENTRIFUGAL Ref: 1.19, 1.20
1-6. In air-cooled condensers, the condensing temperature should be approximately how much higher than the ambient temperature?	1-6. 25°F (14°C) Ref: 1.21
1-7. During the off cycle, refrigerant migrates to the outdoor ________ during cold weather.	1-7. CONDENSER Ref: 1.24
1-8. To prevent startup problems, outdoor air-cooled condenser systems that operate during cold weather usually have a(n) ________.	1-8. PUMPDOWN CIRCUIT Ref: 1.24

Low-Ambient Controls

1.28 Low-ambient controls reduce the condenser's ability to remove heat from the refrigerant when the ambient temperature is low. Two control methods are used to reduce the condenser capacity: refrigerant-side control and air-side control.

1.29 In *refrigerant-side control*, the condenser coil is flooded with liquid refrigerant. Because the portion of the condenser containing liquid refrigerant cannot condense refrigerant, flooding the condenser decreases its capacity. This method requires an excess charge of refrigerant to flood the coil, and a receiver to store the extra charge.

1.30 The most common method of flooding the condenser is to use a hot-vapor bypass valve like the one shown in Fig. 1-8. The valve is set to maintain a standard pressure in the condenser—for example about 80 psig for R-12, or about 140 psig for R-22. During normal summer operation, when the condensing pressure is high, the valve remains closed. During the winter season, when the ambient temperature causes the condenser pressure to fall below the valve setting, the valve moves toward the open position. This movement allows discharge vapor to flow directly into the receiver. The high-pressure vapor forces more liquid refrigerant from the receiver into the evaporator. As this extra refrigerant circulates through the system, some of it remains in the condenser, partly flooding it.

1.31 The flooding reduces the condenser's capacity, which causes a rise in condenser pressure. The vapor bypass valve then moves toward the closed position. The condenser continues to operate partly flooded. When the outdoor temperature rises, the condenser pressure also rises, forcing the liquid refrigerant from the condenser back into the receiver.

1.32 *Air-side control* reduces the condenser's capacity by varying the airflow through the condenser. Changing the amount of air flowing over the condenser affects the rate of heat exchange. The three most common methods of varying airflow are fan cycling, modulating damper control, and fan-speed control.

1.33 *Fan cycling* involves stopping and starting the condenser fans as needed in response to outdoor ambient temperature. Because one fan must be running at all times while the system is operating to prevent the pressure from becoming too high, this method can be used only on condensers having two or more fans. Thermostats that sense ambient-air temperature or condenser-pressure sensors automatically control the fan cycling. On a two-fan unit, one fan cycles to reduce the condenser capacity by as much as 45%. On a three-fan unit, two fans cycle to reduce the capacity by as much as 60%.

1.34 *Modulating-damper control* uses movable damper blades over the condenser face to control the

Fig. 1-8. Hot-vapor bypass low-ambient control system

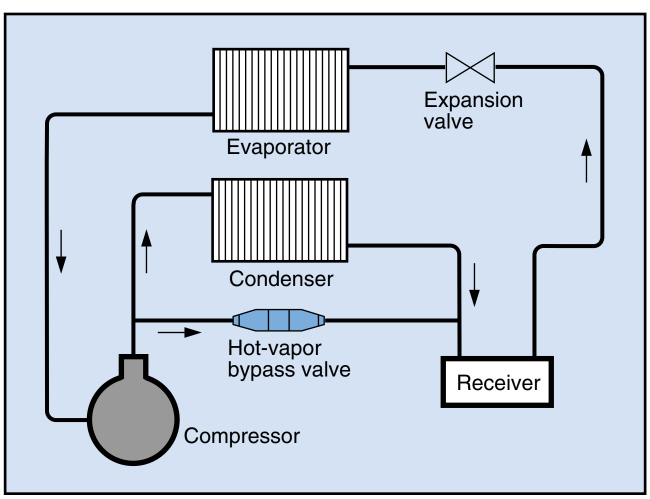


Fig. 1-9. Modulating-damper low-ambient control system

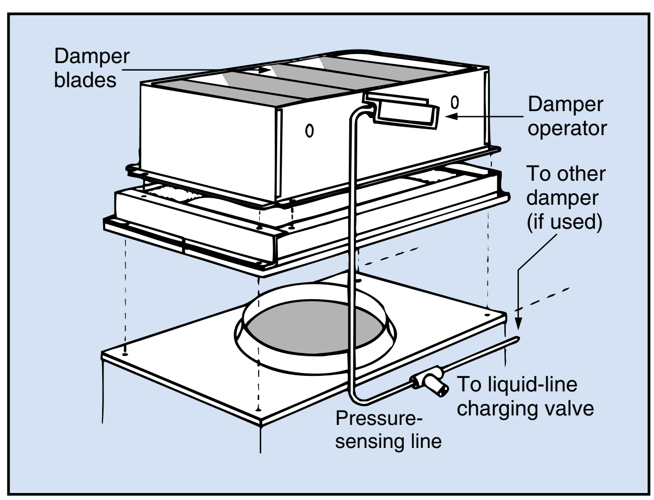


Fig. 1-10. Vertical and horizontal receiver tanks

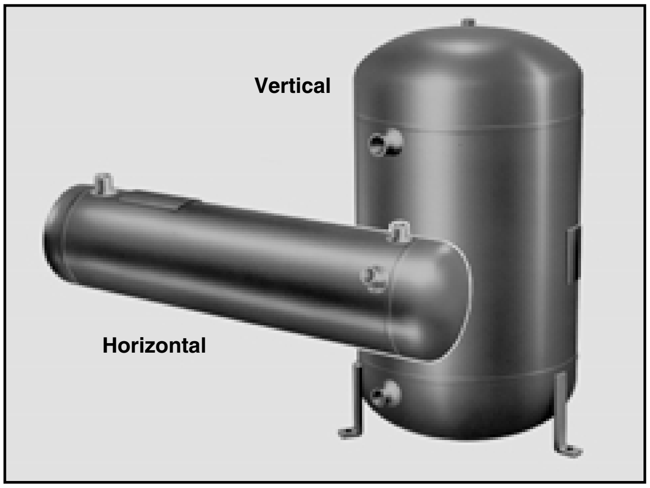
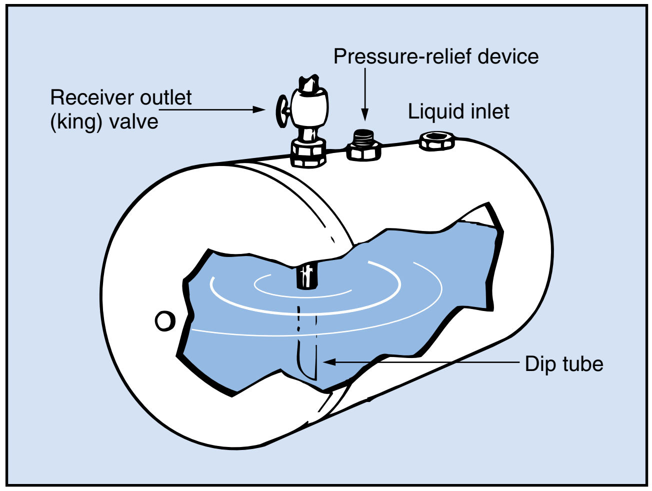


Fig. 1-11. Receiver with valves and fittings



amount of airflow, as shown in Fig. 1-9. This method is used on single-fan units and on multiple-fan units in combination with fan cycling. A pressure-sensing controller senses the condensing pressure and automatically controls a damper motor that adjusts the damper blades.

1.35 *Fan-speed control* uses multispeed fan motors to vary the airflow. Condenser pressure sensors automatically control the fan speed in most systems. This method is used on single-fan condensers and also on multiple-fan condensers in combination with fan cycling.

Receivers

1.36 A *receiver* is a storage tank used to hold the liquid refrigerant that is not circulating in the system. Small refrigeration systems using capillary tube metering devices should not have a receiver. Systems using a thermostatic expansion valve, however, sometimes require a receiver. Because the refrigerant is sometimes stored in the receiver when pumping down the system to make repairs or replace components, the receiver must be large enough to hold the entire system charge, plus about 20%. Systems that use condenser flooding for low-ambient control require a receiver large enough to hold the extra charge needed for flooding.

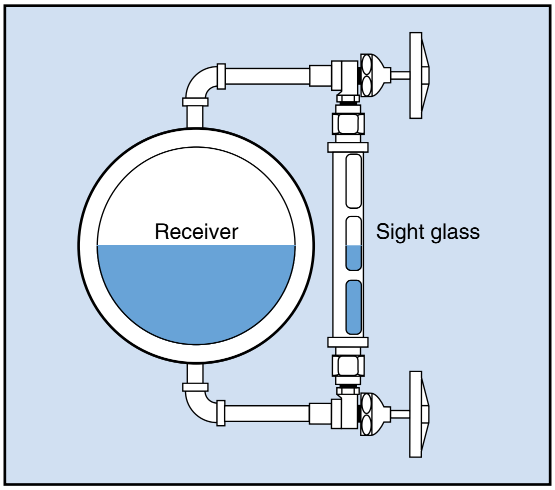
1.37 Both vertical and horizontal receivers are available. An example of each is shown in Fig. 1-10. Most industrial and commercial systems use the horizontal type. The receiver is located below the condenser, so that the condensed refrigerant flows directly into it.

1.38 A receiver is usually equipped with an outlet valve and a pressure-relief device, as illustrated in Fig. 1-11. The *outlet valve* (also called the *king valve*) is used to shut off refrigerant flow to the evaporator when pumping down the system for repairs and when charging the system. A *dip tube* on the outlet valve extends to about 1/2 in. from the bottom of the receiver. It allows only liquid to flow from the receiver. If the outlet valve is on the bottom of the receiver, as it is in some cases, it does not require a dip tube. The different types of pressure-relief devices are covered in the next section of this Lesson.

1.39 Receivers in ammonia systems often have a *purge valve* on top, because noncondensable gases in the system collect at the top of the receiver. You simply open the purge valve to vent these gases. Systems containing halocarbon refrigerants should not have purge valves. Noncondensable gases in the system usually indicate that moisture is also in the system. Purging the gases will not remove the moisture. To remove the moisture, you might need to remove the refrigerant, evacuate and dehydrate the system, and then recharge the system with clean, dry refrigerant.

1.40 Many receivers also have a liquid-level sight glass, as shown in Fig. 1-12 on the following page, for checking the refrigerant charge. You can see the liquid level in the sight glass.

Fig. 1-12. Receiver liquid-level sight glass



Pressure-Relief Devices

1.41 Pressure-relief devices minimize the possibility of explosion in case a malfunctioning control device or a fire causes the pressure in a system to rise to a dangerous level. Most building safety codes require that a pressure-relief device be installed on either the receiver or condenser. These devices open to allow refrigerant to escape, thus reducing system pressure if it rises above a safe level. The refrigerant is vented to the surroundings or to the outside of the building by means of a vent line, depending upon local code requirements. The two pressure-relief devices most commonly used in refrigeration systems are the spring-loaded pressure-relief valve and the fusible plug.

1.42 *Spring-loaded pressure-relief valves*, like the ones shown in Fig. 1-13, are the more common of the two devices because they respond directly to pressure. Also, they are often required by code on pressurized vessels above 3 ft^3 in volume. A spring holds the valve plunger and flat rubber disk against the valve seat. When the internal pressure exceeds the valve setting, the valve disk rises and vents refrigerant to lower the pressure. When the internal pressure drops below the valve setting, the valve reseats automatically. The pressure setting of a relief valve depends upon the pressure rating of the condenser or receiver on which it is installed. Normally, this setting is 200 psig for R-12 systems and 300 psig for R-22 systems. Check with the valve manufacturer for proper settings. Be aware that, once tripped, relief valves are likely to leak. Check for leaks at these valves on a regular basis.

1.43 *Fusible plugs* have an alloy core that melts at a predetermined temperature. An example is shown in Fig. 1-14. They respond only to heat and not to pressure. If a fire occurs, fusible plugs melt and vent the refrigerant before a dangerous internal pressure can be reached. A fusible plug does not reset, and the entire refrigerant charge vents if the plug melts. Therefore, you must install a new plug and evacuate and recharge the system before restarting it.

Air-Cooled Condenser Maintenance

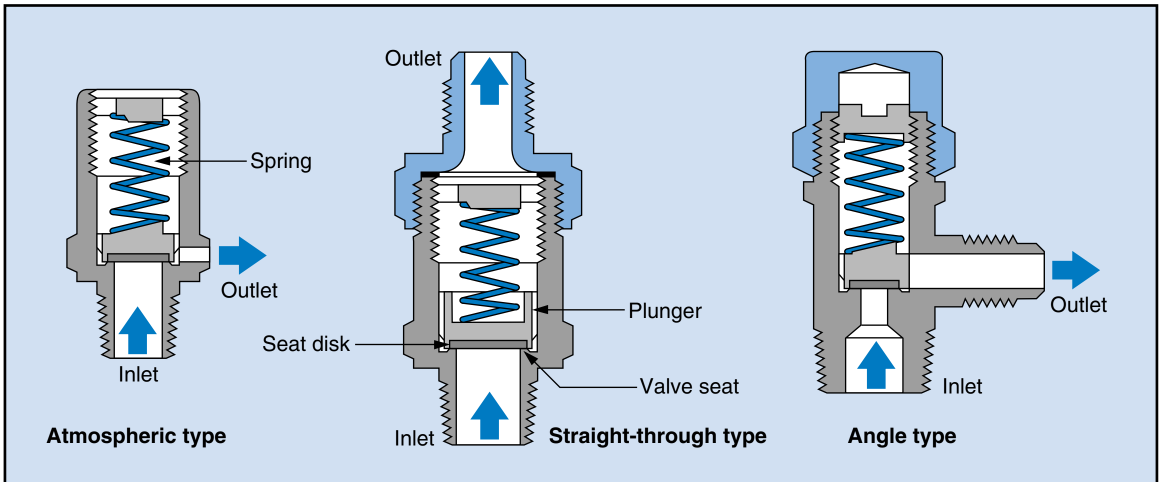
1.44 The main reason for performing preventive maintenance on air-cooled condensers is to maintain efficient heat transfer between the condenser and the air. To do this, you must keep the condenser coils and fins clean, and keep the condenser fans running. Most air-cooled condensers are mounted near the floor or ground. Thus, the condenser air picks up dirt, lint, leaves, paper, and other foreign materials and carries them to the condenser surface. These materials insulate the fins and coils, block the airflow through the condenser, and reduce the rate of heat transfer.

1.45 If a condenser fan fails, the airflow over the condenser stops completely on a single-fan unit, but is merely reduced on a multiple-fan unit. Whether the airflow is reduced by foreign materials or by fan failure, the condensing temperature and pressure rise, and the compressor must work harder. The compressor can overload or it can short-cycle if the system is equipped with a high-pressure cutout switch. Make certain to follow the equipment manufacturers' PM schedules and procedures in their service manuals to avoid problems caused by a dirty condenser or condenser fan failure. Their recommendations are usually based on average operating conditions. More frequent preventive maintenance might be necessary on condensers located in dusty areas. The following procedures are general guidelines to help you maintain condensers.

1.46 At least once each week, you should:

- Listen for any unusual fan or fan motor operating noises. Unusual noises or vibration can indicate a loose fan, fan blade, or pulleys; bad

Fig. 1-13. Spring-loaded pressure-relief valves



bearings; or an airflow blockage. Determine the cause of any unusual noise and repair if necessary.

- Look for and remove paper, leaves, plastic bags, and any other blockages covering the air intake.

- Look for leaks in or around the condenser. Oil on the condenser tubes or fins usually indicates a leak. If you suspect a leak, check it with a leak detector and repair any leaks found. Epoxy repair kits are available from refrigeration supply houses for patching small leaks in aluminum-tube condensers. Use silver solder to repair small leaks in copper and steel tube condensers. If a coil is leaking badly, it must be replaced.

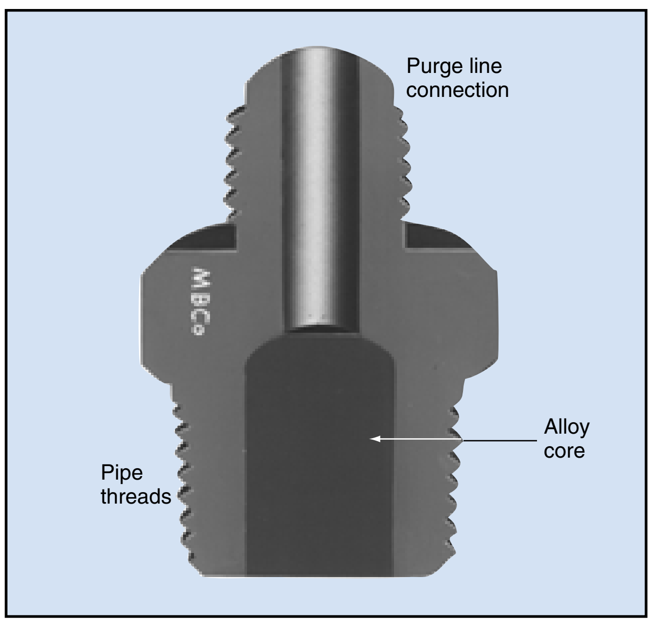
1.47 At least once every three months, you should:

- Clean the condenser coils. First, shut down and lock out the system so that the condenser fans will not start while you are cleaning the coils. Then, use compressed air or a vacuum cleaner to remove dust and dirt from the coils. Wash away heavy dirt with a water hose and use a long bristle brush if necessary. Use a nonflammable solvent cleaner to remove any grease. Be careful not to cut yourself on the condenser fins, and do not bend the fins.

- Straighten any bent fins. They block the airflow and reduce the surface area exposed to the air. Fin straightening tools are available from refrigeration supply houses.

- Check the screens over the air intake and outlet of ducted inside condensers for dirt or blockage. Clean them if necessary. Some indoor condensers that are not ducted and are located in dusty areas (in a textile plant, for example) have cleanable air filters over the

Fig. 1-14. Fusible plug



air intake. Clean these filters following the manufacturer's instructions.

- Clean the fan motors and lubricate the fan and motor bearings. Check the tightness and adjustment of thrust collars on sleeve bearings and the locking collars on ball bearings.

- Check all belts and pulleys for wear. Replace frayed or worn belts and cracked or chipped pulleys. Check the belt tension and the tightness of pulleys on their shafts. Check the pulley alignment.

- Check fan blades for tightness on the hub. Inspect the blades for bends or nicks that could affect their capacity to move air or cause the fan to be out of balance. Also look for any foreign material on the blades that could make the fan run out of balance.

Application 1-2

When is a condenser not a condenser? When it is dirty! A customer called his supplier and complained that the unit he had purchased the previous year was no good. He said the head pressure was too high even though he had just cleaned the coils. When asked how he had cleaned the coil, he answered that the coil was a draw-through type and that he had used a cleaner. He assured the supplier that the coil was clean and shiny.

The supplier suggested to him that the coil was still dirty—that he should take the condenser fan and fan guard off, climb into the unit, and use a high-pressure spray from the inside to the outside. When he objected, the supplier explained that the condenser coil had a deep bend in the middle and that dirt had accumulated at this bend. He was then told to blow the dirt out the same way it had come in.

After some argument, he agreed to try the suggestion. He called back the following week and told his supplier that he had followed his suggestion. He reported that dirt came flying out and the unit was now working perfectly. Then he said thanks.

Troubleshooting Air-Cooled Condensers

1.48 The first symptom of trouble in any condenser is high head pressure and the resulting loss of cooling capacity. If a system is designed to operate with R-22 at 105°F (41°C) condensing temperature and 210.8 psig head pressure, the refrigerant gas normally will be condensed to a liquid when the temperature of the air through the coil is below 95°F (dry bulb). A pressure rise above 210.8 psig might indicate that the condenser is not doing its job properly. Most condensers are sized for some subcooling to ensure that all the refrigerant leaves the condenser as a liquid. When a condenser fails to do its job (condensing and subcooling), first check to see if the ambient-air temperature is above design conditions.

1.49 Probably the most frequent cause of problems in an air-cooled condenser is restricted airflow caused by a coil clogged with leaves, twigs, paper, grime, and other debris. Also, if the atmosphere contains moisture, certain pollutants in the air can form acids that attack the copper tubing and the aluminum fins attached to it.

1.50 Restricted airflow due to location is also a common cause of air-cooled condenser problems. Remember that there must be no barriers to the free flow of air near a condenser. A wall or screen erected to hide a condenser that someone considers dirty or "out of place" in its surroundings can cause major airflow problems.

1.51 If the coil is clean, the airflow unrestricted, and the fan speed about right, but the pressure is still above condensing pressure, there might be air or other noncondensables in the system. With the compressor turned off, check the condenser temperature and discharge pressure. If the pressure is above the saturation pressure for that temperature, you probably have air and noncondensables in the system. Recover the refrigerant and evacuate the system to remove the noncondensables.

1.52 You can usually tell when an air-cooled condenser is not working properly. Either the system is not cooling, the head pressure is high, or the unit is cutting out on overload. The line from the condenser to the receiver might be warmer than normal. All of these symptoms indicate that the condenser is not condensing the refrigerant vapor fast enough. Refer to Table 1-2 for the recommended action to take when troubleshooting air-cooled condensers.

Table 1-2. Troubleshooting chart for air-cooled condensers

Complaint	Symptoms	Possible causes	Recommended action
Refrigerant is not condensing rapidly enough	System capacity is down; head pressure is up; and line from condenser to receiver is too warm	Fans are off	Turn on fans
		Fan motor burned out	Replace motor
		Drive belts broken	Install new drive belts
		Drive belts slipping	Tighten drive belts
		Drive pulleys slipping on shafts	Tighten drive pulleys
		Dirty condenser coil	Clean condenser coil
		Restricted airflow	Locate and remove obstruction
		Top speed of two-speed motor burned out	Replace motor
		Ambient controls not functioning	Check and repair or adjust controls

Application 1-3

A technician was working on a job in hot, dry country. The condenser was mounted on the ground on a 2-in. concrete pad. He opened the door and reached in. As he started working in the control box, he heard a shaking sound. He looked down and froze as he stared into the eyes of a rattlesnake!

When preparing to service an air-conditioning condenser unit, it's always a good idea to "look before you leap."

1-9. The two kinds of low-ambient control are ________ and ________.	1-9. REFRIGERANT SIDE, AIR SIDE Ref: 1.28
1-10. In refrigerant-side capacity control, the condenser coil is flooded by using a(n) ________ valve.	1-10. HOT-VAPOR BYPASS Ref: 1.30
1-11. What are the three most common methods of varying airflow through a condenser?	1-11. FAN CYCLING, MODULATING DAMPERS, FAN-SPEED CONTROL Ref: 1.32
1-12. Liquid refrigerant not circulating in a system is stored in the ________.	1-12. RECEIVER Ref: 1.36
1-13. Receivers in ammonia systems often have a(n) ________ on top to allow the removal of noncondensable gases.	1-13. PURGE VALVE Ref: 1.39
1-14. Safety codes usually require that a(n) ________ device be installed on either the receiver or condenser to minimize the possibility of explosion.	1-14. PRESSURE-RELIEF Ref: 1.41
1-15. What is the main reason for performing preventive maintenance on air-cooled condensers?	1-15. TO MAINTAIN EFFICIENT HEAT TRANSFER Ref: 1.44
1-16. What is probably the most frequent cause of problems in air-cooled condensers?	1-16. RESTRICTED AIRFLOW Ref: 1.49

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

1-1. The function of a condenser is to

- ☐ a. absorb heat
- ☐ b. control refrigerant flow
- ☐ c. increase system pressure
- ☐ d. reject heat

1-2. Fins added to most air-cooled condensers to

- ☐ a. eliminate the need for headers
- ☐ b. increase surface area
- ☐ c. insulate the tubes
- ☐ d. stabilize the tubes

1-3. The two main types of air-cooled condensers are

- ☐ a. air side and refrigerant side
- ☐ b. crossflow and counterflow
- ☐ c. forced air and natural draft
- ☐ d. propeller and centrifugal

1-4. Remote condensers, when located outdoors, usually use

- ☐ a. centrifugal fans
- ☐ b. ductwork
- ☐ c. propeller fans
- ☐ d. shielding against prevailing winds

1-5. If the ambient-air temperature is 85°F (29°C), the condensing temperature in an air-cooled condenser would normally be about

- ☐ a. 90°F (32°C)
- ☐ b. 95°F (35°C)
- ☐ c. 100°F (38°C)
- ☐ d. 110°F (43°C)

1-6. The function of a pumpdown circuit in an air-cooled condenser is to

- ☐ a. distribute refrigerant vapor to parallel circuits
- ☐ b. prevent startup problems during cold weather
- ☐ c. reduce compressor load on hot days
- ☐ d. store excess system refrigerant

1-7. Refrigerant-side capacity control involves ________ the condenser.

- ☐ a. draining
- ☐ b. flooding
- ☐ c. heating
- ☐ d. pressurizing

1-8. Which of the following devices must reach a certain temperature before it will open to relieve system pressure?

- ☐ a. Fusible plug
- ☐ b. King valve
- ☐ c. Purge valve
- ☐ d. Spring-loaded valve

1-9. Under average operating conditions, how frequently should you clean condenser coils?

- ☐ a. Daily
- ☐ b. Weekly
- ☐ c. Every three months
- ☐ d. Yearly

1-10. When a condenser fails to do its job properly, you should first check the

- ☐ a. ambient temperature
- ☐ b. expansion valve setting
- ☐ c. viscosity of the system oil
- ☐ d. volume of the cooling water

SUMMARY

In a refrigeration system, the function of the condenser is to remove and reject heat from the hot refrigerant vapor. This heat is both the heat absorbed in the evaporator and the heat of compression added by the compressor. The compressor and condenser together are sometimes called a condensing unit. Four factors affect the capacity of a condenser: the material of which it is made, the amount of contact between the condenser and the condensing medium, the temperature difference between the condensing medium and the refrigerant vapor, and the cleanliness of the condenser.

An air-cooled condenser is a coil of metal tubing through which refrigerant flows. Usually the tubing is attached to plate-type fins. Both single- and multiple-row condensers are available. The two basic types of air-cooled condensers are natural draft, which relies on natural convection, and forced air, which employs a fan. The main disadvantage of an air-cooled condenser is that it operates at a higher condensing temperature than a water-cooled condenser.

When ambient temperature is low, two control methods can be used to reduce condenser capacity—refrigerant-side control and air-side control. Refrigerant-side control involves flooding the condenser coil with refrigerant. Air-side control includes fan cycling, modulating damper control, and fan-speed control. Pressure-relief devices include spring-loaded pressure-relief valves and fusible plugs. The main reason for performing preventive maintenance on air-cooled condensers is to maintain efficient heat transfer between the condenser and the air. The first symptom of trouble in a condenser is usually high head pressure and a loss of cooling capacity—most commonly caused by restricted airflow.

Answers to Self-Check Quiz

1-1. d. Reject heat. Ref: 1.01

1-2. b. Increase surface area. Ref. 1.13

1-3. c. Forced air and natural draft. Ref. 1.16

1-4. c. Propeller fans. Ref: 1.19

1-5. d. 110°F (43°C). Ref: 1.21

1-6. b. Prevent startup problems during cold weather. Ref: 1.24

1-7. b. Flooding. Ref: 1.29

1-8. a. Fusible plug. Ref: 1.43

1-9. c. Every three months. Ref: 1.47

1-10. a. Ambient temperature. Ref: 1.48

Contributions from the following sources are appreciated:

Figure 1-1. Copeland Corporation
Figure 1-4. Extracted with permission of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers
Figure 1-10. Standard Refrigeration Company
Figure 1-12. Henry Valve Company
Figure 1-14. Mueller Brass Company