Compressors

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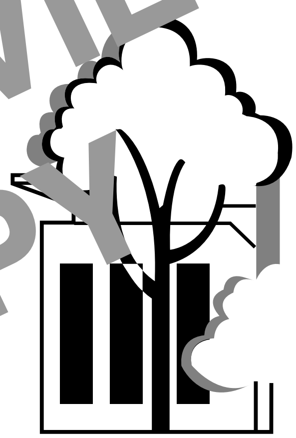
COMPRESSORS

Lesson One

Introduction to Compressors



TPC Training Systems

43301

Lesson

1 Introduction to Compressors

TOPICS

Function of the Compressor
Types of Compressors
Open Compressors
Hermetic Compressors
Reciprocating Compressors
Rotary Compressors
Helical (Screw) Compressors
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Compressor Replacement Considerations

OBJECTIVES

After studying this Lesson, you should be able to…

- List the five kinds of air conditioning and refrigeration compressors.
- Contrast the operation of positive-displacement and kinetic-displacement compressors.
- Explain how each kind of the five kinds of compressor raises the pressure of the refrigerant vapor.
- Define *staging* and *cascading* and explain why each is used.
- List important considerations in compressor replacement.

KEY TECHNICAL TERMS

Kinetic 1.04 related to motion
Hermetic 1.05 airtight
Staging 1.35 using multiple impellers (or compressors) to produce high compression ratios
Cascade system 1.46 uses two or more complete refrigeration systems to obtain very low temperatures

Most people who work with air conditioning or refrigeration equipment consider the compressor the "heart" of any system. When maintaining or troubleshooting a system, the compressor is generally the focal point of any investigation. For example, the pressure and temperature conditions of the refrigerant entering and leaving the compressor tell you how the system is performing. When problems do occur in the compressor, they often point to problems in other components of the refrigeration system. In short, understanding compressor operation can be a very important diagnostic tool.

In this Lesson you will be introduced to the five basic types of compressors, their main parts, and how these parts work together to compress refrigerant vapor. You will also learn the differences between open and hermetic compressors and the advantages, disadvantages, and common uses of each. This Lesson also covers the reasons for using multiple compressor systems and their basic design.

Function of the Compressor

1.01 The compressor is the refrigeration system component that raises the pressure and temperature of the refrigerant vapor high enough for it to condense when exposed to the condensing medium. In performing its function, the compressor draws the cold refrigerant vapor from the evaporator through the suction line. Then the compressor raises the pressure and temperature of the vapor by compressing it (reducing its volume), and forces it out the discharge line to the condenser.

1.02 Because the compressor and condenser work together to condense the refrigerant vapor, the compressor is often considered part of the *condensing unit*. The compressor also functions with the metering device to maintain the pressure difference between the high side and low side of the system. Thus the compressor is a very important component in the refrigeration system.

Types of Compressors

1.03 The five kinds of compressors used in refrigeration systems are: *reciprocating*, *rotary* (vane), *helical* (screw), *scroll*, and *centrifugal*. The reciprocating, rotary, helical, and scroll compressors are *positive-displacement compressors*. Positive-displacement compressors use a piston or other device to reduce the volume of the refrigerant vapor in a compression chamber, as shown in Fig. 1-1. At one time, reciprocating compressors were the type most widely used in the refrigeration and air conditioning industry. However, because of their relatively high cost and low efficiency, they are being phased out in favor of helical, rotary, and the relatively new scroll compressors.

1.04 The centrifugal compressor is a *kinetic-displacement compressor*. It works on a different principle from the positive-displacement types. The word *kinetic* refers to motion. A kinetic-displacement compressor compresses the refrigerant vapor by using an impeller (which is similar to a fan) to force the vapor from a large chamber to a small tube at high speed, as shown in Fig. 1-2 on the following page. As you can see, the volume of the chamber is not mechanically reduced as it is in a positive-displacement compressor.

1.05 Each of the five basic types of compressors can be classified as either open or hermetic, depending upon how it is combined with the motor that drives it. The motor on an *open compressor* is outside the compressor shell. The motor and compressor assembly of a *hermetic compressor* are sealed together inside a shell or housing. *Hermetic* means airtight.

Fig. 1-1. Compression by positive displacement

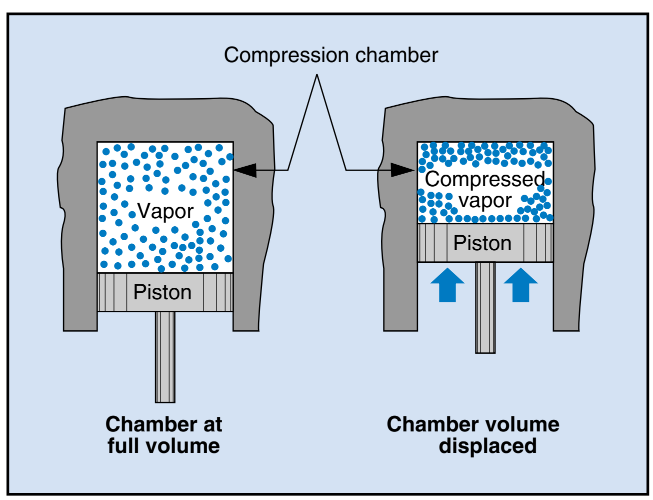
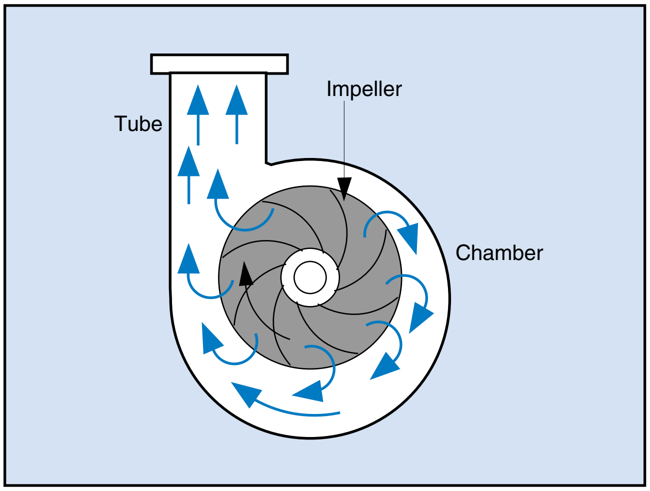


Fig. 1-2. Compression by kinetic displacement



Open Compressors

1.06 The motor on an open compressor drives the compressor either through a drive shaft and couplings, or through a drive belt and pulleys. Units that have a drive shaft are called *direct-drive open compressors*. Units powered through a belt and pulleys are called *belt-drive open compressors*. Most belt-drive open compressors are reciprocating compressors. Figure 1-3 shows both types.

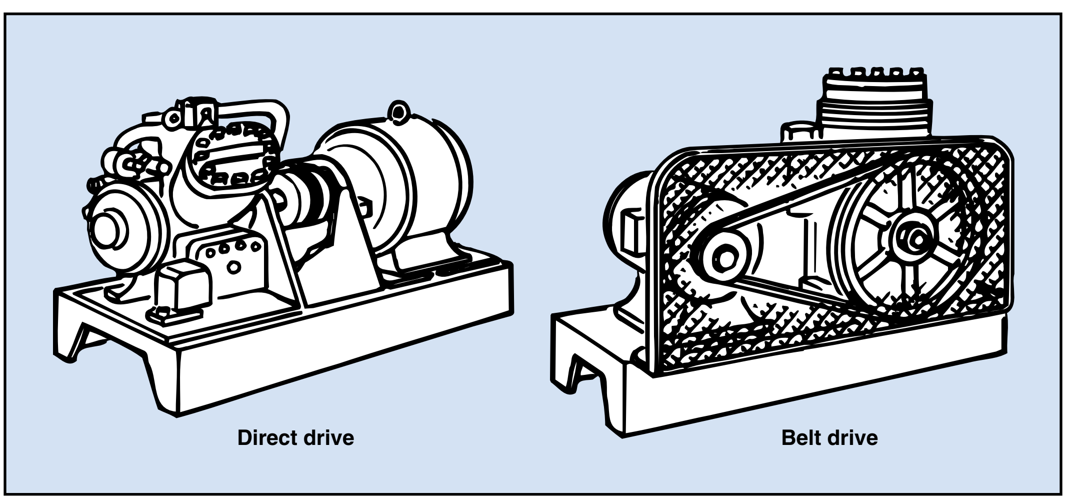
1.07 The chemical industry is the largest user of open compressors today, because chemical processing often requires specially designed systems that must meet specific operating conditions. Some of these systems must be very flexible, and all systems must be easy to service to keep process lines running. Open compressors meet these requirements. For example, you can easily change motor size on an open compressor to meet specific conditions. And you can install a motor to run on dc current or special voltages. On belt-drive types, you can change compressor speed by simply changing pulley sizes.

1.08 Open compressors have one major disadvantage, however. The seal around the drive shaft where it passes through the compressor housing can wear out from friction caused by dirt or lack of oil. Or, the seal can dry out if the system is shut down for long periods, such as for the winter. A worn or dry seal allows refrigerant and oil to leak out, and moisture to enter the system. A low refrigerant charge reduces the system's capacity, low oil can cause compressor damage, and moisture combines with the refrigerant to form acids.

Hermetic Compressors

1.09 Unlike open compressors, *hermetic compressors* do not require a seal, because the motor is part of the compressor assembly and is sealed inside the compressor shell. The shell on a hermetic compressor is either bolted together or welded together. Figure 1-4 shows a hermetic compressor with a bolted shell. It is usually called a *semi-hermetic compressor*. It is bolted together and has gaskets between the parts of the shell to make the shell airtight. It is sometimes called a *bolted hermetic compressor* or a *serviceable hermetic compressor*. You can service these compressors because you can disassemble them.

Fig. 1-3. Direct-drive and belt-drive open compressors



1.10 A *full hermetic compressor,* like the one shown in Fig. 1-5, is also called a *sealed hermetic compressor* or *welded hermetic compressor*. The only way to service it is to cut through the shell. This feature is a major disadvantage, because most shops do not have the equipment required to open and reseal a full hermetic compressor. Thus you must replace the entire unit if a full hermetic compressor breaks down. You can sometimes trade in the damaged unit to the manufacturer.

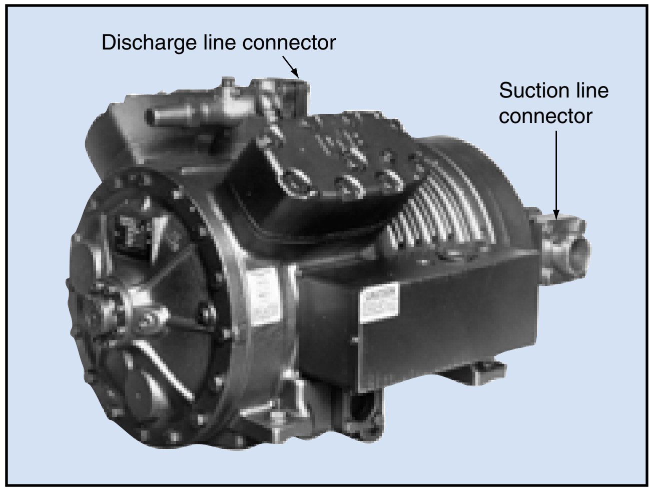
1.11 Most hermetic compressors operate by drawing the cold vapor from the suction line into the assembly over the motor windings. The cold vapor absorbs motor heat and cools the motor. The motor heat in turn helps vaporize any liquid refrigerant that might otherwise reach the compressor.

1.12 The motor adds very little superheat to the vapor in high-temperature refrigeration systems. But it can add too much superheat to the refrigerant in low-temperature systems. The result is that the discharge temperature becomes too high. This condition causes the refrigerant oil to break down and not lubricate the compressor. The high heat can also burn the compressor valves and cause the formation of acid in the system if there is any air or moisture in the system. Thus, you will often see air-cooled or water-cooled hermetic motors used in low-temperature systems.

1.13 *Air-cooled hermetic motors* are usually used when the system has an air-cooled condenser. Either the condenser fan or a separate fan blows air over the compressor motor. *Water-cooled motors* are used when the system has a water-cooled condenser. The condenser water passes through a water jacket or cooling tubes around the motor housing before it goes to the condenser.

1.14 A disadvantage of hermetic compressors is that a motor burnout can contaminate the entire refrigeration system. A motor burnout is caused by a short circuit or overheating in the motor windings. As a result, the insulation in the motor windings can burn, producing moisture, acid, soot, varnish, and hard carbon. All of these burnout products can enter the refrigeration system, because the motor is in the system. If they do, you must clean them out of the system completely to prevent another breakdown.

Fig. 1-4. Semi-hermetic compressor



Reciprocating Compressors

1.15 Reciprocating compressors use a piston to reduce the volume in a cylinder and compress the refrigerant vapor. There are two basic kinds: *single acting* and *double acting*. In the single-acting type, compression takes place only on one side of the piston. Compression takes place on both sides of the piston in the double-acting type.

Fig. 1-5. Full-hermetic compressor

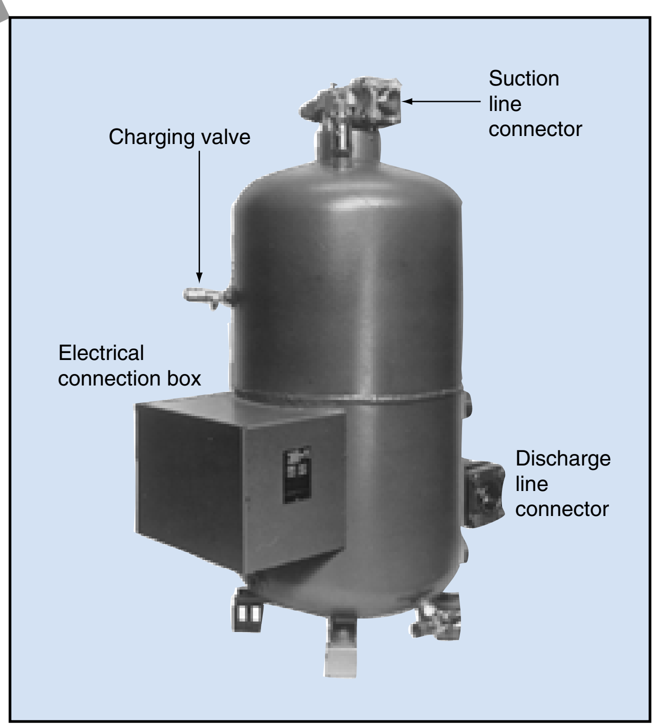
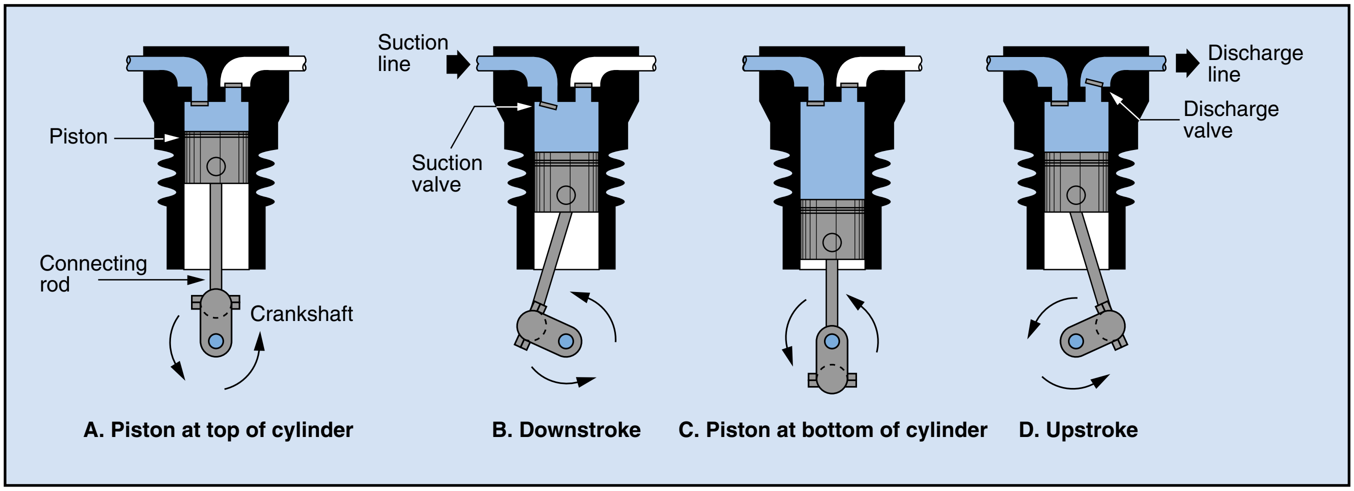


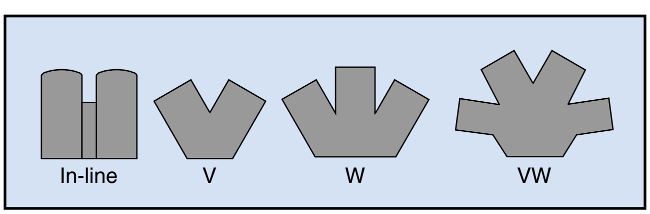
Fig. 1-6. The single-acting reciprocating compressor



1.16 **Single-acting reciprocating compressors.** The single-acting reciprocating compressor is the most common type of reciprocating compressor found in both air conditioning and refrigeration applications. As shown in Fig. 1-6, a rod connects the piston to a crankshaft, and a motor turns the crankshaft to force the piston up and down. Valves between the suction and discharge lines and the cylinder control the flow of refrigerant vapor into and out of the cylinder.

1.17 To follow through one complete cycle of a single-acting reciprocating compressor, start with the piston at the top of the cylinder in Fig. 1-6A. Both the suction valve and discharge valve are closed as the piston starts its downstroke. As the piston moves down, the volume of the cylinder increases and the pressure in the cylinder decreases because the cylinder is sealed. When the pressure in the cylinder becomes lower than the suction-line pressure, the suction pressure opens the suction valve, as shown in Fig. 1-6B, and refrigerant vapor begins flowing into the cylinder. The piston continues to increase the volume in the cylinder and draw in suction vapor until it reaches the bottom of its downstroke. The valve to the suction line closes the instant the piston reaches the bottom of the cylinder and stops increasing the volume in the cylinder. Thus the cylinder is again sealed, as shown in Fig. 1-6C.

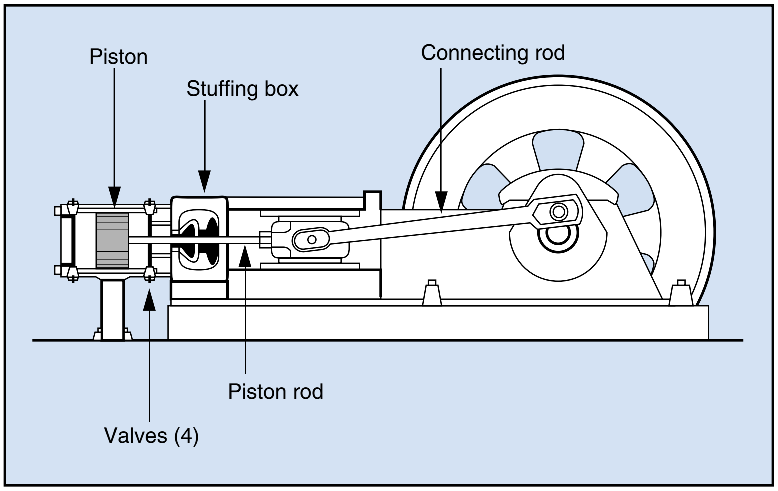
Fig. 1-7. Cylinder arrangements in reciprocating compressors



1.18 Next the piston moves up and decreases the volume in the cylinder, compressing the refrigerant vapor and increasing its pressure. The vapor's temperature also increases because of the mechanical energy expended by the compressor. This is called the *heat of compression*. When the vapor pressure in the cylinder becomes higher than the vapor pressure in the discharge line, the cylinder pressure opens the discharge valve. The piston continues upward and forces the compressed vapor out the discharge line and into the condenser, as illustrated in Fig. 1-6D. The discharge valve closes the instant the piston reaches the top of its upstroke and stops decreasing the volume in the cylinder. The cycle then begins again.

1.19 The sizes and uses of single-acting reciprocating compressors vary widely in both air conditioning and refrigeration. You will find small, one-cylinder models in water coolers, refrigerators, and window air conditioners. Models having up to 16 cylinders are used in commercial and industrial refrigeration and air conditioning systems. The cylinders in multiple-cylinder compressors can be arranged in-line, in a V, a W, or a VW, as shown in Fig. 1-7. They are available as direct-drive and belt-

Fig. 1-8. Double-acting horizontal reciprocating compressor



drive open types, and both full- and semi-hermetic types. Hermetic reciprocating compressors range in size from under 1 hp up to 20 hp. The other types go up to 100 hp or more.

1.20 **Double-acting reciprocating compressors.** The first refrigeration compressors were double-acting reciprocating compressors with a horizontal cylinder. A few of these compressors are still operating in industry. They have the same basic parts as the single-acting type, but the cylinders have suction and discharge valves at both ends, as shown in Fig. 1-8. The piston is rigidly attached to a rod that passes through a stuffing box at one end of the cylinder. A connecting rod links the piston rod to the crankshaft.

1.21 As the piston moves in one direction, it compresses the refrigerant vapor ahead of it, and draws in refrigerant vapor behind it. When the piston reaches the end of the stroke and reverses its direction, the two sides of the piston reverse functions. This feature gives the compressor the name "double-acting."

1.22 Double-acting compressors are large, heavy machines requiring a strong foundation. They have a long piston stroke and operate at low speed. The stuffing box is the critical part of these compressors. The pressure and temperature on the box alternate from suction conditions to discharge conditions. And, as the piston rod slides back and forth through it, friction generates a great deal of heat. Thus oil is pumped through the box to lubricate the seal and carry away some of the heat. Some liquid refrigerant also passes through an expansion valve and into a passage around the seal to carry away heat.

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. Name the five kinds of compressors used in refrigeration systems.	1-1. RECIPROCATING, ROTARY, HELICAL, SCROLL, AND CENTRIFUGAL Ref: 1.03
1-2. A reciprocating compressor is an example of a(n) ________-displacement compressor.	1-2. POSITIVE Ref: 1.03
1-3. A centrifugal compressor is an example of a(n) ________-displacement compressor.	1-3. KINETIC Ref: 1.04
1-4. The chemical industry is the largest user of ________ compressors.	1-4. OPEN Ref: 1.07
1-5. The compressor motor is sealed inside the shell of a(n) ________ compressor.	1-5. HERMETIC Ref: 1.09
1-6. A disadvantage of a hermetic compressor is that a motor ________ can contaminate the system.	1-6. BURNOUT Ref: 1.14
1-7. What reduces the volume of the cylinder in a reciprocating compressor?	1-7. A PISTON Ref: 1.15
1-8. Double-acting reciprocating compressors have the same basic parts as single-acting models, except that the cylinders have ________ at both ends.	1-8. SUCTION AND DISCHARGE VALVES Ref: 1.20

Rotary Compressors

1.23 The *rotary* compressor, like the reciprocating compressor, is a positive-displacement compressor. However, the rotary compressor uses a rotor instead of a piston to reduce the volume in the compression chamber. Two basic designs are available: *single vane* and *multiple vane*.

1.24 Figure 1-9 shows an end view of a *single-vane rotary compressor* with the end cover plate removed. As you can see, the cylindrical rotor is offset on a shaft so that it touches the larger cylindrical compression chamber only at one point. The shaft turns the rotor in the chamber. The spring-loaded vane is mounted in the compressor housing. It rides on the rotor and seals against it to separate the intake and discharge sides of the rotor. A thin film of oil between the vane and rotor provides lubrication and forms a vapor seal.

1.25 *Multiple-vane rotary compressors* have vanes mounted in the rotor itself instead of in the compressor housing, as shown in Fig. 1-10. Either springs or centrifugal force hold the vanes against the wall of the compression chamber. The rotor itself never contacts the chamber wall in the multiple-vane design.

1.26 A single-vane rotary compressor raises the pressure of the refrigerant vapor as follows. Starting with the rotor in the position shown in Fig. 1-11A, the rotor has sealed the suction port, and the chamber is

Fig. 1-9. Single-vane rotary compressor

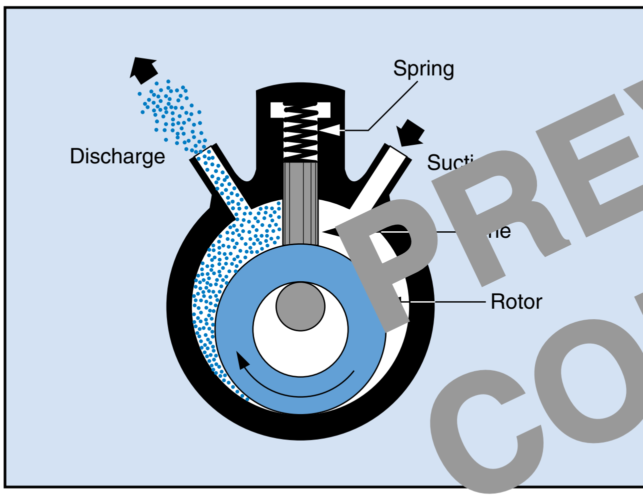


Fig. 1-10. Multiple-vane rotary compressor

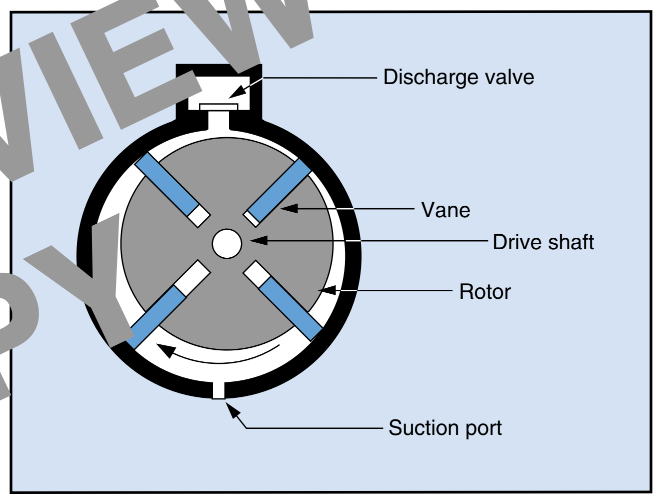


Fig. 1-11. Compression cycle in a rotary compressor

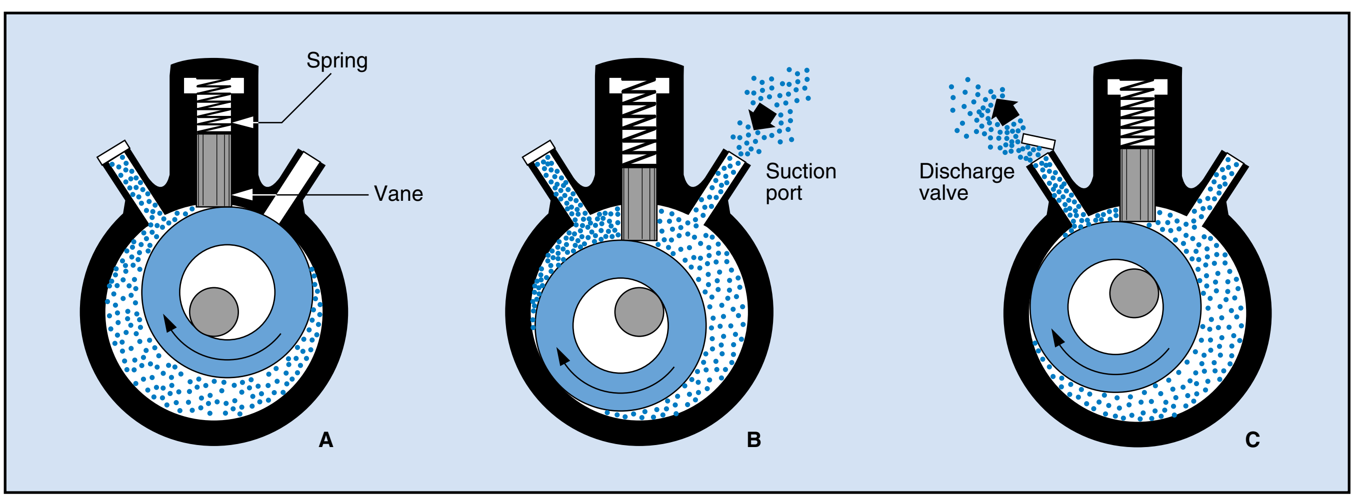


Fig. 1-12. Compression cycle of a helical compressor

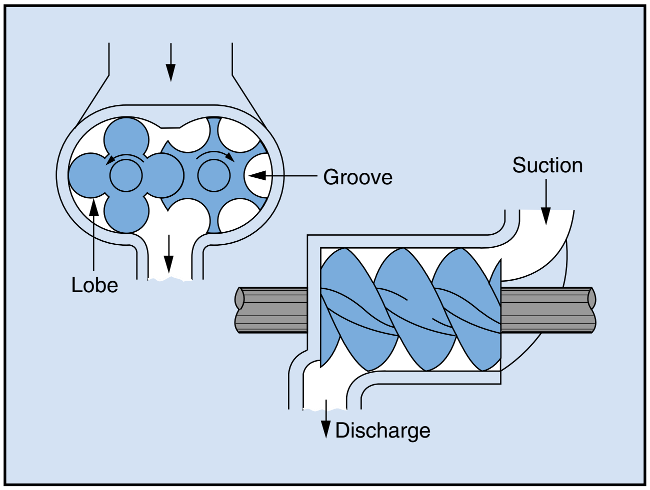
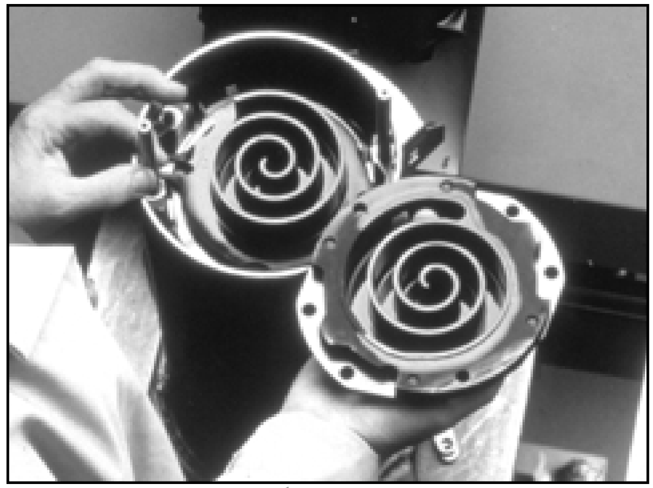


Fig. 1-13. Spiral-shaped scrolls from a scroll compressor



full of suction vapor. As the rotor turns, it compresses the refrigerant vapor ahead of it because the volume of the chamber between the rotor contact point and the vane is being reduced, as shown in Fig. 1-11B. At the same time, the suction port is uncovered, and the rotor is drawing in suction vapor behind it because the volume is increasing on the back side of the rotor between its contact point and the vane. When the vapor pressure in the chamber ahead of the rotor becomes higher than discharge line vapor pressure, the discharge valve opens and the compressed vapor enters the discharge line, as shown in Fig. 1-11C. As the rotor's contact point passes the vane, the cycle starts again. The multiple-vane types operate the same way, except that compression takes place between the vanes.

1.27 Rotary compressors have no suction valves. Some have a check valve in the suction line to prevent the discharge vapor from leaking back to the evaporator when the compressor stops running. The vapor can leak back because the rotary compressor cannot hold a seal between the vane and rotor, or between the vanes and chamber wall when it is not running.

1.28 Rotary compressors are available as direct-drive open compressors and as both full and semi-hermetic types. Most of these compressors are used in household refrigerators and small air conditioners up to 5 ton capacity. Because rotary compressors require very close fits and clearances, very few large ones are made. However, some large, multiple-vane rotary compressors, up to 600 hp, are used as booster compressors in low-temperature industrial systems, such as food freezing plants.

Helical (Screw) Compressors

1.29 The *helical* compressor (also called a *screw* or *rotary-screw compressor*) is another kind of positive-displacement compressor. In this compressor, the refrigerant vapor is compressed between meshing male and female helical rotors. Figure 1-12 shows the compression cycle of a helical compressor. Suction vapor flows in to fill the space between the lobes of the unmeshed rotors and the walls of the cylindrical housing. As the rotors turn and start to mesh, they trap the vapor in the space between the lobes, called the *interlobe space*. Further rotation reduces the interlobe space, and the meshing rotors compress the vapor. Finally, the interlobe space becomes exposed to the outlet port, and the compressed refrigerant vapor discharges toward the condenser.

1.30 Helical compressors have no discharge valves. Most designs do have a sliding valve under the rotors to control compressor capacity. Helical compressors, unlike reciprocating and rotary types, operate smoothly and quietly. Their rotating motion makes them almost vibration free, even when operating at high speed and capacity.

1.31 Most helical compressors range in size from 20 tons up to 1500 tons. They are not economical to produce in small sizes. Both direct-drive open and semi-hermetic types are used in industrial refrigeration and air conditioning.

Scroll Compressors

1.32 Scroll compressors are a fairly new development in the air conditioning and refrigeration industry. They offer both simplicity and durability. They are currently being manufactured in sizes up to 15 tons. From the outside, they look like small reciprocating compressors. Their operaton, however, is very different.

1.33 The scroll compressor has two scrolls with spiral-shaped walls, as shown in Fig. 1-13. One scroll is fixed and the other is driven in an orbit by a device called a *swing link*. As the orbiting scroll moves within the fixed scroll, trapped refrigerant is forced into a progressively smaller volume and compressed. Scroll compressors have no valves or moving parts other than the moving scroll. The swing link lets the scrolls move apart if any liquid is present. This feature helps prevent damage to the compressor, which can be caused by the incompressable liquid.

Centrifugal Compressors

1.34 Centrifugal compressors are kinetic-displacement compressors. They are members of the turbine family and produce compression using a high-speed impeller or rotor. An example is shown in Fig. 1-14. In operation, the impeller draws the refrigerant vapor into its center from the suction line. The high-speed rotation of the impeller forces the vapor to the outside of the impeller and into the smaller volume of the diffuser tube at high speed, thus increasing the pressure.

1.35 A single-impeller compressor, like the one in Fig. 1-15, handles large volumes of vapor, but has a low compression ratio. A single-impeller compressor is called a *single-stage* machine. Centrifugal compressors having multiple impellers can produce high compression ratios. The use of multiple impellers to produce high compression ratios is called *staging*. The first (or low-stage) impeller discharges gas into the next impeller, and so on. Each stage raises the compression ratio, resulting in a high compression ratio at the discharge. It is for this reason that most centrifugal compressors are multistage.

1.36 The amount that one impeller will compress the vapor depends upon the impeller's tip speed. The *tip speed* is determined by the impeller's diameter and rpm. Some compressors use impellers only 6 to 8 in. in diameter, but rotate as fast as 30,000 rpm. Other centrifugal units use larger impellers and slower speeds.

Fig. 1-14. Compression in a centrifugal compressor

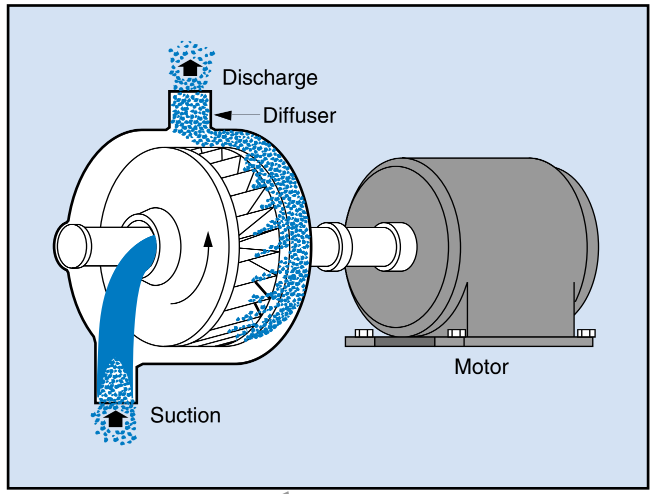
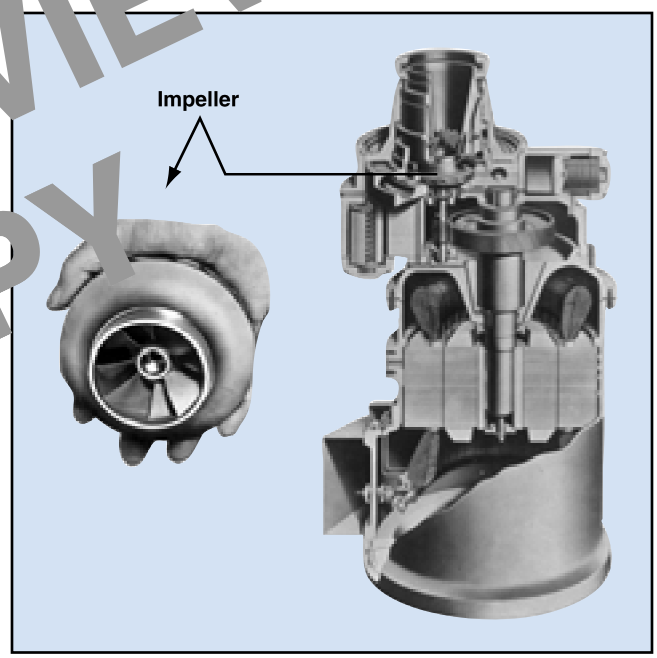


Fig. 1-15. Semi-hermetic single-impeller centrifugal compressor



1.37 Most centrifugal compressors are either direct-drive open or semi-hermetic. Some models have gears between the motor and the compressor. The gears raise the speed of the impellers above the speed of the motor. Single-stage and two-stage her-

Fig. 1-16. Parallel-compressor system

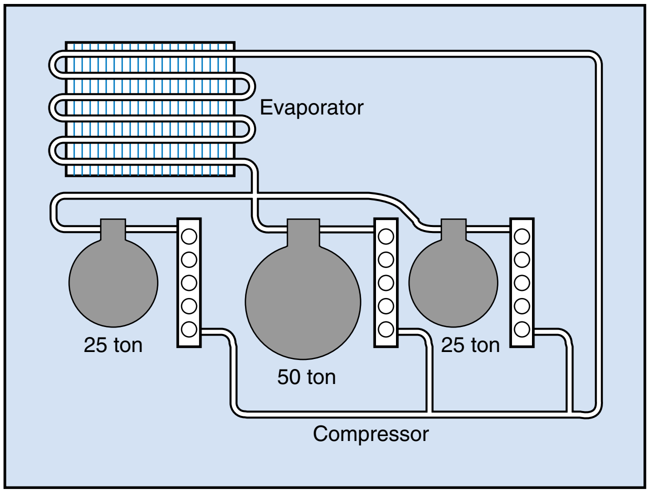
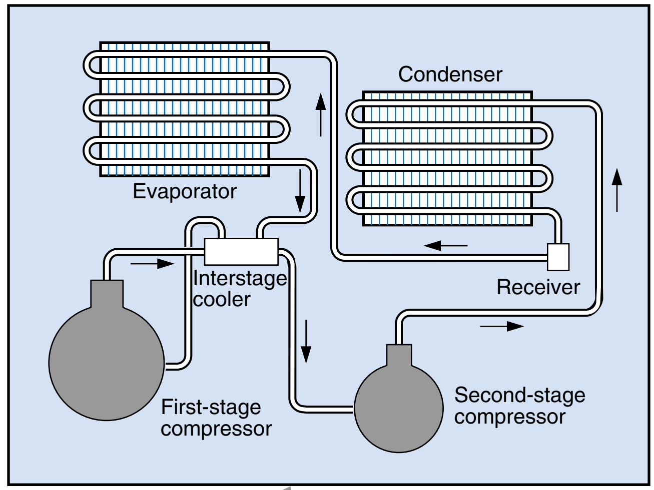


Fig. 1-17. Two-stage compression system for low-temperature refrigeration



metic centrifugal compressors from 50 to 3000 tons in size are used in commercial and industrial water chilling systems. Water is often used to cool the electric drive motors on centrifugal water chilling systems.

1.38 The main advantage of a centrifugal compressor is that it has few moving parts. It has no valves that can bend or break. There are no pistons, piston pins, or connecting rods to wear out. A centrifugal compressor rotates smoothly. Thus, it does not vibrate like a reciprocating or rotary compressor.

1.39 Centrifugal compressors must move a large volume of vapor. Also, their compression ratios are generally lower than positive-displacement compressors. For these reasons, their use is limited to large, higher-temperature applications, such as commercial and industrial air conditioning.

Multiple Compressor Applications

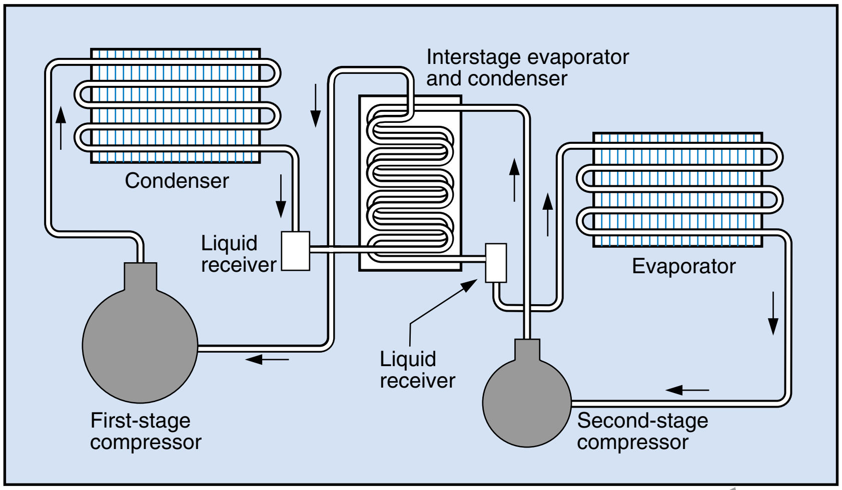
1.40 There are two situations that require more than one compressor in a system: systems that must operate at widely varying loads, and low-temperature refrigeration systems that must operate below -20°F (-28.9° C). Using two or more compressors to meet widely varying loads is sometimes called *parallel-compressor operation.* As many compressors as necessary can be run to meet the cooling load requirements. For example, the parallel compressor system in Fig. 1-16 uses two 25 ton and one 50 ton compressor. Thus, this system can supply 25, 50, 75, or 100 tons of refrigeration.

1.41 Low-temperature refrigeration systems use more than one compressor because one compressor cannot raise the refrigerant vapor pressure high enough for it to condense at the temperature of most condensing mediums. Two general designs of multiple-compressor systems are used for low-temperature refrigeration systems: *multiple-stage compression systems* and *cascade systems.*

1.42 **Multiple-stage compression systems.** Figure 1-17 shows a simple two-stage system using reciprocating compressors. The first-stage compressor draws the refrigerant vapor from the suction line and compresses it. Compressing the vapor also raises the vapor temperature. Thus, the second-stage compressor also raises the vapor temperature. If the vapor is not cooled between stages, it will be too hot when it leaves the second stage. The results will be burned valves and oil breakdown in the second-stage compressor. For this reason, the first-stage compressor discharges the vapor to an interstage cooler (which acts like a second condenser) to cool the vapor from the first-stage compressor before it reaches the second-stage compressor. Some systems use a water-cooled second-stage compressor instead of an intercooler.

1.43 The cooled vapor then flows from the liquid cooler to the second-stage compressor. The second-stage

Fig. 1-18. Two-stage cascade system for low-temperature refrigeration



compressor brings the vapor up to the pressure required for condensing, and discharges it into the condenser.

1.44 Two-stage refrigeration systems can cool down to about -150°F (-101.1°C). A three-stage system will reach temperatures below -150°F (-101.1°C) and down to -200°F (-128.9°C). A three-stage system works like a two-stage system, but it uses three compressors. You must cool the vapor between each stage, like you do in a two-stage system.

1.45 There are also reciprocating compressors that contain two stages. Part of the cylinders make up the first stage, and they discharge into the other cylinders, or the second stage. For example, three cylinders could make up the first stage, and discharge into the fourth cylinder. The cylinders in each stage can have different cylinder diameters, or *bores*. The pistons can also have different strokes. In any case, the discharge line of the first stage must be outside the compressor so that the vapor can be cooled before entering the second stage.

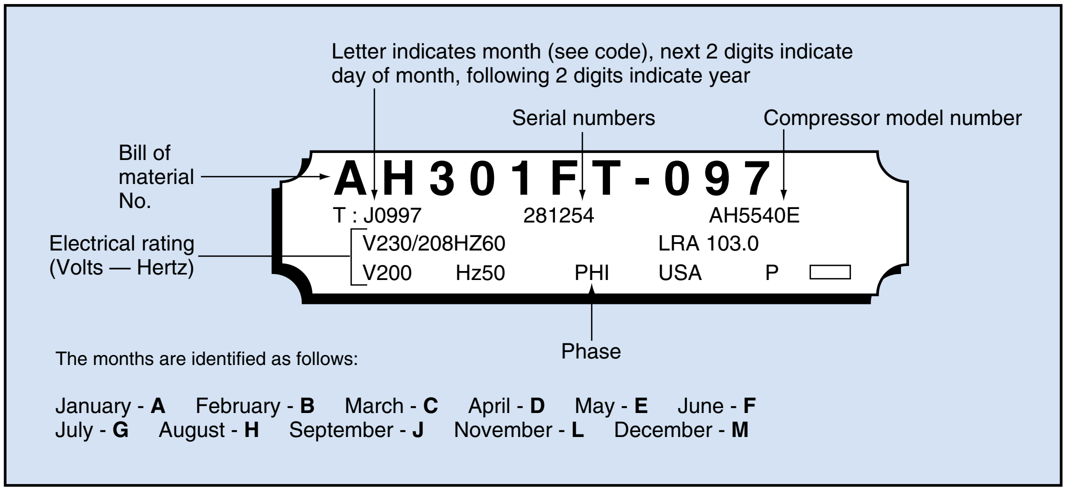
1.46 **Cascade system.** A *cascade system* uses two or three complete refrigeration systems to obtain very low temperatures. The evaporator of one system cools the condenser for the second system. Remember that the purpose of compressing the vapor is to raise its pressure enough so that it will condense at the temperature of the condensing medium. In the cascade system, one refrigeration system supplies a low-temperature condensing medium for the second system. Thus the second system does not have to raise the pressure of the vapor as high as it would have to without the first system's help.

1.47 Figure 1-18 shows a simple two-stage cascade system. The second-stage compressor compresses the vapor from the evaporator and discharges it into a refrigerant-cooled condenser. The first-stage system supplies the refrigeration for the second-stage condenser. Two-stage and three-stage cascade systems can supply refrigeration down to -200°F (-128.9°C).

Compressor Replacement Considerations

1.48 Many factors must be considered when selecting a replacement compressor for a particular application. Generally, compressors have a horsepower rating. Compressors are also designed to operate within specific suction and discharge pressure ranges, and with specific types of refrigerant. The suction and discharge pressures and the type of refrigerant used in a system all depend upon the temperature range in which the system is operating. Therefore, make certain that a replacement compressor has the same horsepower rating, and is designed to operate at the same suction and discharge pressures, and with the same type of refrigerant in the system as the one you are replacing. When replacing hermetic compressors, also make sure the motor has the same electrical rating.

Fig. 1-19. Compressor nameplate information



1.49 The best place to find the information you need for compressor replacement is on the compressor nameplate (also called the serial plate). An example is shown in Fig. 1-19. For many full hermetic compressors under 5 tons (sometimes called *can* compressors), the information is stamped on a plate welded to the top or side of the compressor shell. On open compressors, the plate is usually fastened to the base or housing. Make sure to check all relevant nameplate information when you must select a replacement compressor. Manufacturers' catalogs usually list some important compressor details, such as electrical characteristics, capacity, and connection sizes.

1-9. The two basic designs of rotary compressor are ________ and ________.	1-9. SINGLE VANE and MULTIPLE VANE Ref: 1.23
1-10. In a multiple-vane rotary compressor, where does compression take place?	1-10. BETWEEN THE VANES Ref: 1.26
1-11. In a helical compressor, vapor is trapped and compressed in the ________.	1-11. INTERLOBE SPACE Ref: 1.29
1-12. A scroll compressor contains a spiral-shaped scroll that ________ within a fixed scroll.	1-12. ORBITS Ref: 1.33
1-13. A centrifugal compressor impeller's tip speed is determined by its ________ and ________.	1-13. DIAMETER and RPM Ref: 1.36
1-14. If you have a parallel-compressor system that uses four 20-ton compressors, what refrigeration loads can this system supply?	1-14. 20, 40, 60, and 80 TON Ref: 1.40
1-15. In a cascade system, the first refrigeration system supplies a low-temperature for the second system.	1-15. CONDENSING MEDIUM Ref: 1.46
1-16. You can find data needed for compressor replacement on the unit's ________.	1-16. NAMEPLATE Ref: 1.49

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

1-1. The refrigeration system compressor is often considered part of the

- ☐ a. condensing unit
- ☐ b. control system
- ☐ c. evaporator
- ☐ d. metering device

1-2. Which of the following is a kinetic-displacement compressor?

- ☐ a. Centrifugal
- ☐ b. Helical
- ☐ c. Reciprocating
- ☐ d. Scroll

1-3. What is the main disadvantage of an open compressor?

- ☐ a. Difficulty in cooling
- ☐ b. Inability to open shell
- ☐ c. Motor burnout contamination
- ☐ d. Seals can leak

1-4. In what position are the suction and discharge valves when the piston in a reciprocating compressor starts its upstroke?

- ☐ a. Both closed
- ☐ b. Both open
- ☐ c. Discharge only open
- ☐ d. Suction only open

1-5. In a single-vane rotary compressor, refrigerant vapor is compressed between the rotor contact point and the

- ☐ a. cylinder head
- ☐ b. interlobe space
- ☐ c. suction valve
- ☐ d. vane

1-6. The helical compressor compresses the refrigerant vapor between the

- ☐ a. helical rotor and discharge valve
- ☐ b. impeller and chamber wall
- ☐ c. lobes on meshing rotors
- ☐ d. rotor vanes

1-7. Which of the following best describes the operation of a scroll compressor?

- ☐ a. A moving scroll orbits within a fixed scroll
- ☐ b. A rotating scroll forces vapor into a smaller area
- ☐ c. A swing link compresses vapor within the interlobe space
- ☐ d. A swing link operates a rotating vane

1-8. A two-stage centrifugal compressor has two

- ☐ a. drive shafts
- ☐ b. impellers
- ☐ c. motors
- ☐ d. suction valves

1-9. A system using two or more complete refrigeration systems to obtain very low temperatures is called a ________ system.

- ☐ a. cascade
- ☐ b. coupled
- ☐ c. linked
- ☐ d. multiple-stage

1-10. What is your best source of information about a compressor, should it need replacing?

- ☐ a. Catalog
- ☐ b. Nameplate
- ☐ c. Operator
- ☐ d. Warranty

SUMMARY

The compressor is the refrigeration system device that raises the pressure and temperature of refrigerant vapor and forces it out the discharge line to the condenser. There are five basic types of refrigeration system compressors: reciprocating, rotary, helical, scroll, and centrifugal. The first four are *positive-displacement* compressors. The centrifugal compressor is a *kinetic-displacement* compressor. Each of these five types can be classified as either *open* or *hermetic*, depending on how it is combined with the motor that drives it.

A *reciprocating* compressor uses a piston to reduce the volume in a cylinder and compress refrigerant vapor. These compressors can be single acting or double acting. A *rotary* compressor can be single vane or multiple vane and uses a rotor to reduce the volume in the compression chamber. *Helical* compressors are sometimes referred to as rotary-screw compressors or simply as screw compressors. In these compressors, refrigerant vapor is compressed between meshing male and female rotors. *Scroll* compressors use two scrolls with spiral-shaped walls to compress the vapor as one orbits within the other. Finally, the *centrifugal* compressor uses a high-speed impeller to force refrigerant vapor into a small space, thus increasing its pressure.

Two situations commonly require the use of more than one compressor. Systems that must operate at widely varying loads use multiple compressors in parallel. Those that require very low temperatures use two or three compressors in series or they cascade refrigeration systems. *Cascade systems* use two or three complete refrigeration systems.

If you must replace a compressor, there are several things you must keep in mind when selecting that replacement—horsepower rating, suction and discharge pressure ranges, and type of refrigerant, for example. The compressor nameplate can give you a great deal of useful information, as can manufacturers' catalogs.

Answers to Self-Check Quiz

1-1. a. Condensing unit. Ref: 1.02

1-2. a. Centrifugal. Ref: 1.04

1-3. d. Seals can leak. Ref: 1.08

1-4. a. Both closed. Ref: 1.17, 1.18

1-5. d. Vane. Ref: 1.26

1-6. c. Lobes on meshing rotors. Ref: 1.29

1-7. a. A moving scroll orbits within a fixed scroll. Ref: 1.33

1-8. b. Impellers. Ref: 1.35

1-9. a. Cascade. Ref: 1.46

1-10. b. Nameplate. Ref: 1.49

Contributions from the following sources are appreciated:

Figure 1-4.	Dunham-Bush Inc.
Figure 1-5.	Dunham-Bush Inc.
Figure 1-13.	Copeland Corporation
Figure 1-15.	Westinghouse Electric Corporation