

The *impeller* is mounted on the motor shaft with a shaft key. It is the main component of a centrifugal compressor and moves at the same speed as the compressor. The refrigerant is moved by centripetal force inward towards the centre.

The *volute* is required to hold the gas that is moved by the impeller. A volute is spiral shaped, and the spiral opening gets larger from the intake to the outlet.

The *oil pump* is necessary to maintain the positive oil pressure required on a centrifugal compressor. The oil pump has a separate power feed because it runs independently of the compressor motor. The pump sits in the oil sump, submerged in oil.

The *thrust bearing* is a form of roller element bearing, and it is mounted at the end of the motor shaft. Bearings handle the weight of the motor and the thrust created from the impeller onto the motor shaft.

The *labyrinth seal* is used to keep the oil and refrigerant inside the compressor from flowing to other areas of the compressor or system. This type of seal has an intricate path for the refrigerant or oil to flow through, which prevents leakage. It is typically made from a softer material than the component it seals against, ensuring that the labyrinth seal fails before the other component does.

Open Drive Centrifugal Compressor

An *open drive semi-hermetic centrifugal compressor* is similar to a hermetic centrifugal compressor, but it requires an external motor to drive it. This compressor requires a shaft seal to prevent oil and refrigerant from leaking out of the pressurized refrigeration system. The seal must be properly aligned and lubricated or it leaks. The drive motor mounts externally to the compressor, and the two are linked with a flexible coupling or belt drive.

Figure 20 shows the internal components of an open centrifugal compressor.

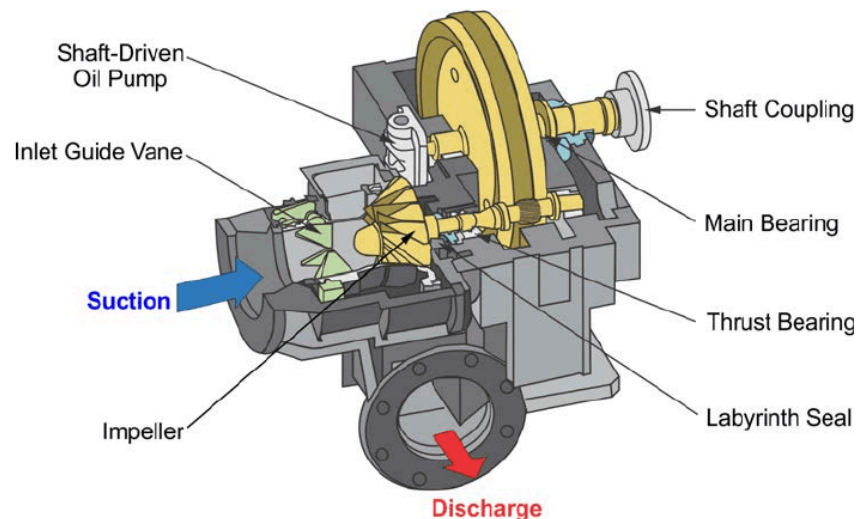


Figure 20 - Open centrifugal components.

Objective Four

When you have completed this objective, you will be able to:

Define terms related to compressor mechanical components.

Compressor Mechanical Components

The following definitions help you identify and understand industry terminology when dealing with compressor mechanical components.

Term	Definition
articulated connecting rod	A connecting rod that connects a piston to a compressor.
blade/vane	A component of a rotary compressor that seals the refrigerant against the sides of the cylinder as the rotor spins around, compressing the gas. Some rotary compressors use one blade/vane; other compressors use more than one blade/vane. The terms <i>blade</i> and <i>vane</i> refer to the same component, but usage varies depending upon the manufacturer or publication.
compression chamber	A cylinder on a rotary compressor. The rotor spins the vane against the side of the compression chamber.
compression rings	Rings mounted in grooves at the top of a piston to help prevent refrigerant from leaking past the pistons.
compressor shell	A hermetic compressor metal outer casing or enclosure that keeps the components of the system sealed inside.
connecting rod	A component on a reciprocating compressor that joins the piston to the crankshaft.
crankcase	The lower housing that holds the compressor oil on a reciprocating compressor.
crankshaft	A component that takes the rotational motion from the motor and converts it into the reciprocating motion used to drive the pistons in the cylinders.
crankshaft seal	Another term for a floating seal or shaft seal.
cylinder head	A reciprocating compressor part that is bolted to the top of the cylinders.
discharge check valve	A one-way valve at the outlet of the compressor discharge.
discharge port	An opening in the compressor cylinder head by which the compressed gas leaves the compressor.
drive shaft	An external shaft that turns the crankshaft of an open compressor.
driven scroll	The moving scroll that is attached to the motor shaft of a scroll compressor.

Term	Definition
eccentric crankshaft	A crankshaft with a connecting rod that attaches to a section of the crank that is larger in diameter than the rest of the crank. The section that the connecting rod attaches to has a different centre than the crankshaft.
exhaust valve	A one-way check valve used on a reciprocating compressor to prevent suction gas from leaving the cylinder during the compression stroke.
female rotor	A rotor that is used in a screw compressor. It is driven by the male rotor and moves in the opposite direction of the male. The male rotor lobes fit into the female inter-lobes. Gas is compressed as it enters the screws and is compressed between the male and female rotors.
floating seal	A seal mounted on the end of the crankshaft before the crankshaft leaves the compressor body. It is needed on an open drive compressor to prevent refrigerant and oil leakage around the crankshaft bearings. Another term for a crankshaft seal or shaft seal.
fusible plug	A safety device installed in a pressurized vessel to vent refrigerant when the pressure vessel temperature is too hot.
gate rotor	A rotor used on a single screw compressor to hold refrigerant vapour as it is being compressed. A gate rotor is driven by the single screw.
helical screw rotor	A rotor used on a helical screw compressor. Two screw shaped rotors are intertwined and rotate in opposite directions. One rotor is attached to a driving force that propels both rotors to compress refrigerant that enters on one end of the rotors and exits at the opposite end.
high side	The discharge pressure side of a compressor or the condenser side of a refrigeration or air conditioning system.
impeller	The primary component of a centrifugal compressor. It is mounted on the motor shaft and increases the flow and pressure of the refrigerant as it spins the refrigerant in a radial direction.
inlet guide vanes	Vanes that direct the gas into the centre of the compressor's impeller.
intake valve	A valve in the head of a reciprocating compressor. It allows refrigerant to flow into the cylinder on the down stroke of the piston.
internal motor protector	A motor protection device mounted on the motor winding or in the motor winding. It senses an overheating condition or excessive amperage draw. Also called a thermal protector.

Term	Definition
labyrinth seal	A type of seal used in a centrifugal compressor. Typically, it does not wear out like a traditional seal does. It uses elaborate drilled passageways and the radial force of a centrifugal compressor to seal two chambers off from each other. When refrigerant flows into a passageway or coil, the radial force keeps it inside the passageway and does not allow more refrigerant or oil to flow past it.
low side	The suction side, or the evaporator side, of the system.
magnetic trap	A device used inside a compressor to pick up small particles of metal from the oil.
male rotor	A rotor that is used on a screw compressor. It is connected to the motor and drives the female rotor in the opposite direction. The male rotor lobes fit into the female inter-lobes. Gas enters the screws and is compressed between the male and female rotors.
muffler	A device that quiets the exhaust of a reciprocating compressor. The internal design of the muffler reduces the noise caused by pulsations from gas entering the compressor cylinder to the quieter sound of gas exiting the compressor cylinder.
oil pump	A positive displacement oil mover designed to lubricate the bearings, journals and moving parts inside a compressor.
orbital scroll	The scroll that is attached to the motor on a scroll compressor. It moves inside the stationary scroll, where it compresses refrigerant against the stationary scroll.
piston	A device used in a reciprocating compressor. It attaches to a connecting rod that attaches to a crankshaft. The piston moves up and down or side to side inside a compressor cylinder, and it draws suction gas into the cylinder. On the upstroke, it compresses that same gas to a pressure which opens the discharge valve, and the gas leaves the cylinder.
pressure relief valve	A valve used on a reciprocating compressor. It is designed to vent excessive discharge pressures from the high side back into the low side of the system in order to protect the compressor from high pressure damage.
rolling element bearings	Bearings used to support motor shafts or motor cranks. They consist of two round bearing rings pressed together with ball bearings inside the two rings.
rotor	A screw compressor component that is driven by the motor.
rupture disc	A safety device on a centrifugal compressor that works like a relief valve. If the pressure gets too high, the disc ruptures and refrigerant vents to atmosphere.

Term	Definition
Scotch yoke	A device used in a reciprocating compressor that eliminates the need for a piston and a connecting rod. The two components become one in this design. The cylinder and piston increase in length.
screw compressor	A rotary compressor that draws suction gas into the rotating screws. Two counter-rotating screws compress the refrigerant gas.
scroll compressor	A hermetic compressor that uses two interconnecting scrolls. One scroll moves, and the other scroll is stationary. The shape of the scrolls allows gas to be drawn into one chamber of the scrolls, while another chamber discharges refrigerant at a higher pressure and temperature.
service valve	A valve used on larger semi-hermetic and open compressors to allow the compressor to be isolated from the refrigeration or air conditioning system.
shaft seal	Another term for a crankshaft seal or floating seal.
sight glass	A glass window on a compressor crankcase used to observe the oil level and condition.
slide valve	A capacity control system used on screw compressors. It changes the entrance point of the suction gas that is entering the male and female rotors. The compressor capacity can be changed by shortening the length of the screws.
solenoid valve	An electrically actuated valve used for capacity control on semi-hermetic compressors and scroll compressors.
stationary scroll	The non-moving scroll in a scroll compressor. The orbital, or driven, scroll moves in a motion to trap refrigerant against the walls of the stationary scroll.
suction port	The opening in the compressor through which suction gas enters.
swash plate compressor	Another term for wobble plate compressor.
thermal protector	Another term for internal motor protector on a compressor.
thrust bearing	A bearing used on a centrifugal compressor to counteract the thrust created by the radial flow of refrigerant caused by the impeller.
turning vanes	Another term for inlet guide vanes.

Term	Definition
unloader	A form of capacity control on a semi-hermetic compressor. When the electric solenoid actuator coil is energized, the unloader holds the compressor suction valve open. This prevents the compressor from moving the suction vapour through the unloaded cylinder.
valve plate	A steel insert that contains the discharge and suction valve assemblies on a semi-hermetic compressor.
volute	A component used in a centrifugal compressor. The impeller moves the refrigerant in a radial motion into the volute. The refrigerant enters the volute. The shape of the volute reduces the refrigerant's velocity, but increases its pressure.
wobble plate compressor	A compressor used in the automotive industry that allows compression on the intake and the discharge strokes of the piston. Also referred to as a swash plate compressor.

Objective Five

When you have completed this objective, you will be able to:

Describe compressor components and their applications.

Compressor Components and Applications

The different types of compressors are suitable for different applications. Compressors can be categorized by their construction and by their applications. Manufacturers often select the five most common compressor types for specific types of installations because of the way these compressors operate under different operating conditions.

Screw Compressor Applications

Screw compressors are usually used in large capacity industrial applications. They are available in semi-hermetic and open drive configurations and are manufactured in capacities ranging from 10 cubic feet per minute (cfm) to 3000 cfm. These compressors function best in high volume, low saturated suction pressure applications. Capacity control is exercised through a slide vane that limits the compressor's compression ratio.

Screw compressors are very expensive to manufacture because of the extensive machine work they require and the close tolerances of the screws. They require a greater than average supply of lubrication oil.

Scroll Compressor Applications

Scroll compressors are used for high temperature air conditioning installations. Currently they are available only in hermetic configurations with horsepower ranging from 2 hp to 60 hp. They are quiet and efficient with nearly 100% volumetric efficiency when operated under design conditions. These compressors tolerate liquid floodback because they do not have suction valves and rarely have discharge valves.

However, scroll compressors are more expensive to manufacture than other types of compressors because they require very close tolerance machine work. They cannot tolerate any solid particles in the refrigerant flow without sustaining significant internal damage. They do not pump when their design rotation is reversed, and running some manufacturers' scroll compressors with the incorrect rotation for extended periods causes mechanical damage. Most scroll compressors must be run constantly at full capacity because only one scroll compressor manufacturer currently has the technology to provide capacity control.

Rotary Compressor Applications

Rotary compressors are usually used for newer small capacity domestic and commercial applications. They are available in hermetic and semi-hermetic configurations. These compressors are especially well-suited to very low saturated suction pressures.

Rotary compressors are used in domestic refrigerators and deep vacuum pumps. Capacity control is exercised by drive motor speed control. However, a rotary compressor's design limits its capacity. Because it has only one cylinder, increasing its capacity involves increasing the size of the cylinder. Rotary compressors are expensive to manufacture because of the larger cylinder size and the tight tolerances required.

Reciprocating Compressor Applications

Reciprocating compressors are among the oldest types of compressors in common usage. They are available in hermetic, semi-hermetic and open drive designs and are used in applications that range from fractional horsepower (hp) to hundreds of horsepower. They can be used with most types of refrigerants and refrigerant oils. Reciprocating compressors are suitable for most applications, including many domestic, commercial and industrial installations. Historically, this type of compressor has been the work horse of the industry.

However, reciprocating compressors contain many moving parts, are noisy and are inefficient at low saturated suction pressures. They are also easily damaged by liquid floodback.

Centrifugal Compressor Applications

Centrifugal compressors are used for large capacity air conditioning chiller applications. They are available only in semi-hermetic and open drive configurations. They are especially well-suited to high volume, high saturated pressure, and saturated vapour applications. Centrifugal compressors are among the most efficient types of compressors. Capacity control is exercised through the use of inlet guide vanes that throttle the volume of suction vapour entering the compressor.

One of the disadvantages of centrifugal compressors is their size. A large mechanical room is usually required to house them. In addition, they are expensive to produce and operate because of their tonnage requirements and because they require more accessories than other types of compressors. Centrifugal compressors require pumps, cooling towers, water treatment, welded steel waterlines and increased electrical feed, all of which add to the initial cost and to maintenance costs.

Objective Six

When you have completed this objective, you will be able to:

Describe the compression process and the flow of gas through the compressor.

Compression Process and Flow

Compressors change the low-pressure saturated vapour into a higher pressure, higher temperature, super-heated vapour. This process is different for each compressor type.

Screw Compressor

A screw compressor uses two intertwined screw rotors or helical rotors to compress the refrigerant. Gas enters the suction port. The two rotors, a female and a male, compress the refrigerant between the lobes of the rotors. Gas exits the end of the two rotors through the discharge outlet. The male is the driving force rotor because it is attached to the motor and turns in the opposite direction of the female.

Figure 21 illustrates the flow of gas through a helical rotor. The male rotor has four lobes, and the female rotor has six lobes.

- In Figure 21A the suction gas enters the two rotors.
- The two rotors compress and move the gas from the suction inlet (Figure 21A) into the compressor (Figure 21B).
- The gas is drawn into the rotors and starts to compress (Figure 21C).
- The gas progresses through the rotors (Figure 21D) towards the discharge outlet (Figure 21E).

NOTE

The dark shading in the diagram indicates a pocket of gas moving through the two rotors from the suction inlet to the compressor discharge.

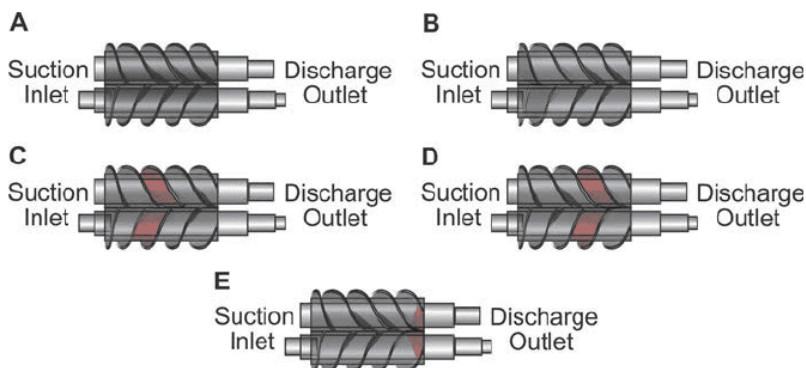


Figure 21 - Helical rotors.

Scroll Compressor

Compression on a scroll compressor uses two separate scrolls. One scroll is fixed and the other is orbital. The orbital scroll is attached to the motor and moves with the motor rotation. As the scroll orbits, it traps pockets of gas between it and the fixed scroll. The refrigerant moves from the outer ring near the intake to the centre of the two scrolls, where the discharge port is located.

Figure 22 shows how the two scrolls fit inside each other.

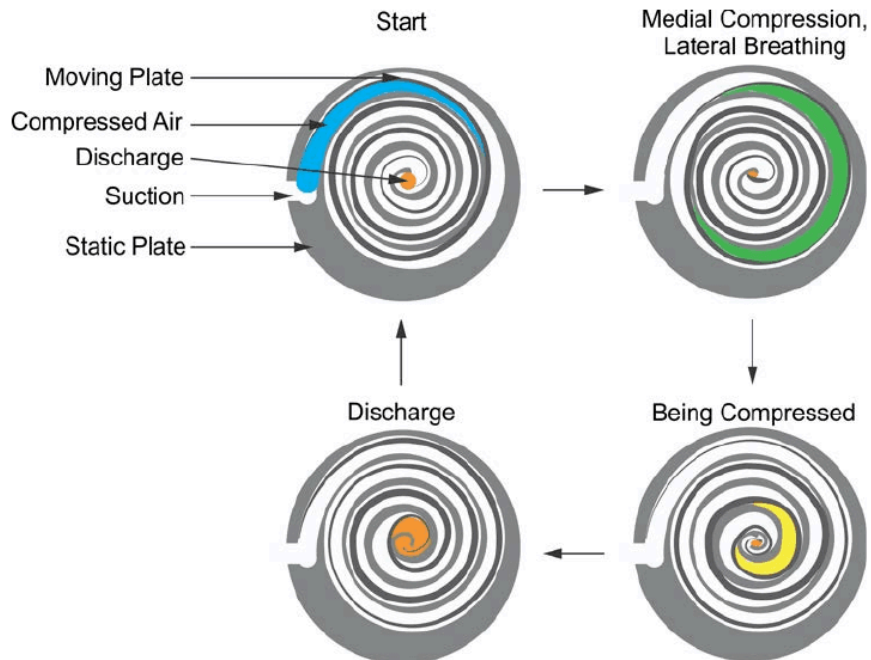


Figure 22 - Scroll compressor compression.

Rotary Compressor

A rotary compressor uses a movable vane to separate the high and low side and an eccentrically mounted rotor to compress the refrigerant vapour. The process is illustrated in Figure 23.

1. As the eccentric rotor rotates clockwise it draws refrigerant vapour through the suction valve (Figure 23A).
2. As the eccentric rotor continues to rotate clockwise it compresses the refrigerant vapour (Figure 23B).
3. When the refrigerant vapour pressure is high enough to overcome the spring on the discharge valve, the discharge valve opens (Figure 23C).
4. The discharge valve port discharges high-pressure refrigerant (Figure 23D).

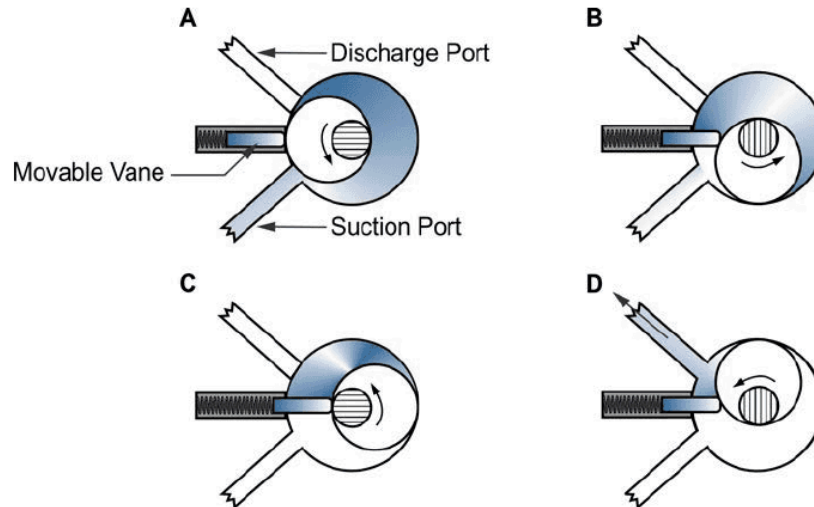


Figure 23 - Rotary compressor.

Reciprocating Compressor

The gas flow through a reciprocating compressor is a simple process. The steps are as follows.

1. The piston starts at *top dead centre* (TDC).
2. The drive motor uses the drive train to pull the piston down inside the cylinder.
3. The trapped vapour above the piston in the cylinder re-expands.
4. As the trapped vapour re-expands, its pressure drops.
5. When the trapped vapour pressure falls below the higher suction pressure, the reed valve flexes and allows refrigerant vapour into the cylinder.
6. The piston continues drawing refrigerant into the cylinder until it reaches the bottom of the stroke.
7. With the piston no longer in motion, the pressure inside the cylinder and the suction pressure equalize, allowing the suction reed valve to close.
8. The drive motor uses the drive train to push the piston up inside the cylinder.
9. As the piston is driven up inside the cylinder, the volume of the trapped refrigerant vapour is reduced, which increases its pressure.
10. When the pressure inside the cylinder is greater than the discharge pressure, the discharge reed valve flexes and allows the compressed refrigerant vapour to be discharged from the cylinder.
11. When the piston reaches the top of its stroke (TDC) it is no longer compressing vapour, and the pressure in the cylinder equalizes with the discharge pressure.
12. The equalized pressures allow the reed valve to flex closed, trapping a small amount of refrigerant vapour for re-expansion.

Figure 24 illustrates the steps in the refrigerant gas process inside of a reciprocating compressor.

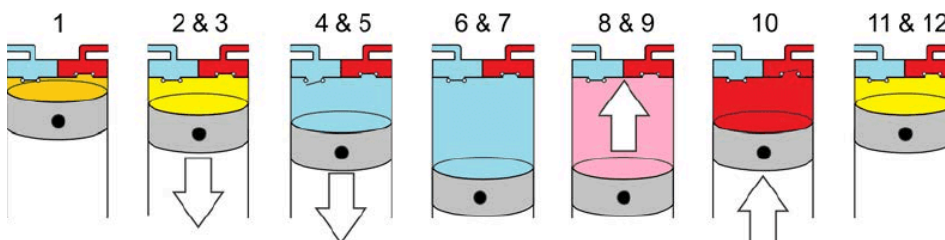


Figure 24 - Reciprocating compression.