COMPRESSOR AND VACUUM PUMPS

COMPRESSORS

FUNCTION OF THE COMPRESSOR

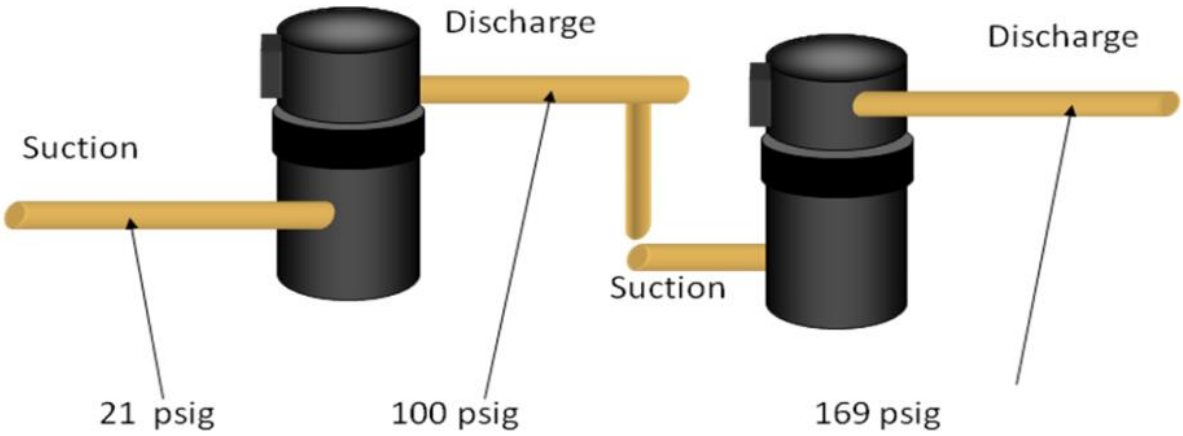
- Considered the heart of the refrigeration systems
- Compressors are vapor pumps
- Responsible for increasing the pressure on the discharge side of the system
- Responsible for maintaining the flow

COMPRESSION RATIO

- Compares pumping conditions for compressors
- Defined as the high side pressure (psia) divided by the low side pressure (psia)
- High compression ratio can lead to overheated compressor oil
- High compression ratio leads to reduced refrigerant flow through the system
- Reduced refrigerant flow reduces system capacity

TWO-STAGE COMPRESSION

- Lowers the compression ratio
- Utilizes two compressors
- One compressor discharges into suction of the other
- Also referred to as compound compression
- single compressor system exceeds 10:1
- Often used in low-temperature commercial and industrial storage applications



TYPES OF COMPRESSORS

- Reciprocating
  - Fully welded, hermetic compressors
  - Semi-hermetic compressors
  - Open-drive compressors
  - Belt-driven and direct-drive compressors
- Screw compressors
- Rotary compressors
- Centrifugal compressors
- Scroll compressors (spiral compressors)

Reciprocating compressors

- Reciprocating or Piston compressors are the most common machines available on the market.

- They are positive displacement compressors and can be found in ranges from fractional to very high horse powers.
- Positive displacement air compressors work by filling an air chamber with air and then reducing the chamber's volume.
- Reciprocating compressors work in a very similar manner as does as internal combustion engine but basically in a reverse process.
- They have cylinders, pistons, crankshafts, valves and housing blocks.

WELDED HERMETIC RECIPROCATING COMPRESSORS

- Motor and compressor contained in a welded shell
- Cannot be field serviced
- Typically a "throw-away" compressor
- Considered to be a low-side component
- Cooled by suction gas from the evaporator
- Lubricated by the splash method

SEMI-HERMETIC COMPRESSORS

- Bolted together, can be field serviced
- Housing is made of cast iron
- Has a horizontal crankshaft
- Smaller compressors are splash lubricated
- Larger compressors use pressure lubrication systems
- Often air cooled
- Piston heads are located at the top of the compressor

OPEN DRIVE COMPRESSORS

- Can be direct drive or belt-driven compressors
- Must have a shaft seal to prevent leakage

- Bolted together, can be field serviced
- Belt-driven compressors have the compressor and motor shafts parallel to each other
- Belt-driven compressors use belts and pulleys
- Direct drive compressors have the compressor and motor shafts connected end to end

BELT-DRIVE MECHANISMS

- Motor pulley is called the drive pulley
- Compressor pulley is called the driven pulley
- Pulleys can be adjusted to change compressor speed
- Drive size x Drive rpm = Driven size x Driven rpm
- Shafts must be properly aligned
- Pulleys with multiple grooves must used matched sets of belts

DIRECT-DRIVE COMPRESSOR CHARACTERISTICS

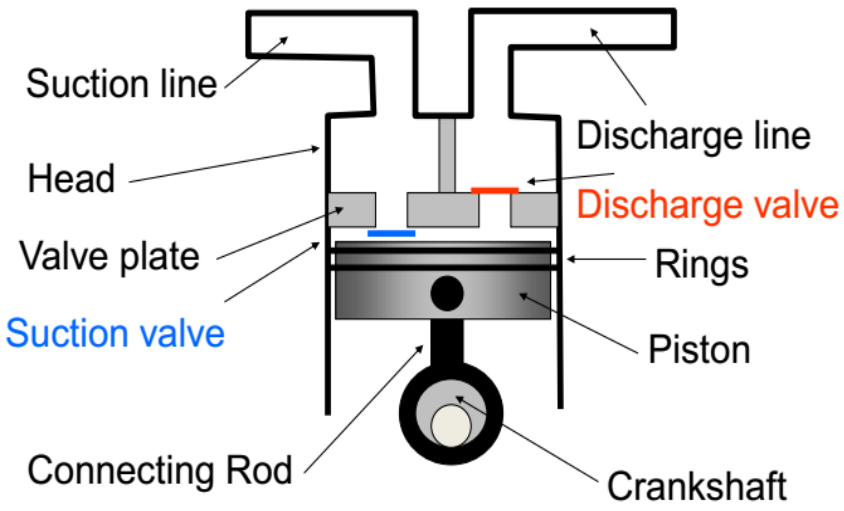
- Direct drive compressors turn at the same speed as the motor used
- Motor shaft and compressor shaft must be perfectly aligned end to end
- Motor shaft and compressor shafts are joined with a flexible coupling

RECIPROCATING COMPRESSOR COMPONENTS

- Crankshaft
  - Transfers motor motion to the piston
  - Creates the back and forth motion of the piston
- Connecting rods
  - Connects the crankshaft to the pistons
- Pistons
  - Slide up and down in the cylinder

- Used to compress and expand the refrigerant

- Refrigerant cylinder valves (suction)
  - Durable, flexible steel
  - Located on the bottom of the valve plate
  - Open when refrigerant is introduced to the pump
- Refrigerant cylinder valves (discharge)
  - Durable, flexible steel
  - Open when refrigerant is discharged from the pump
  - Located on the top of the valve plate



RECIPROCATING COMPRESSOR COMPONENTS

Compressor head

- Holds the top of the cylinder and its components together

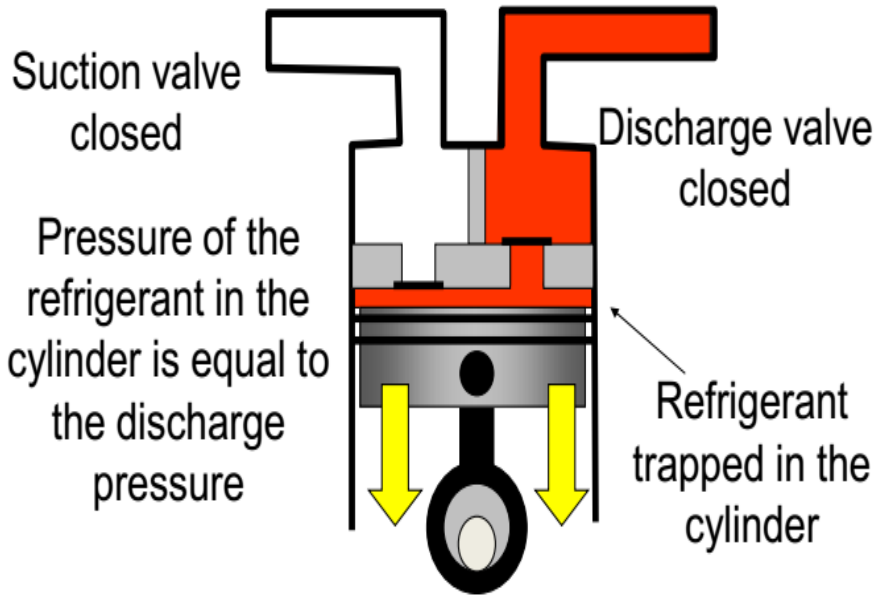
  - Contains both high and low pressure refrigerant
- Mufflers
  - Designed to reduce compressor noise
- Compressor housing
  - Encases the compressor and sometimes the motor

RECIPROCATING COMPRESSOR EFFICIENCY

- Determined by initial compressor design
- Four processes take place during the compression process
  - Expansion (re-expansion)
  - Suction (Intake)
  - Compression
  - Discharge

COMPRESSION PROCESS – EXPANSION

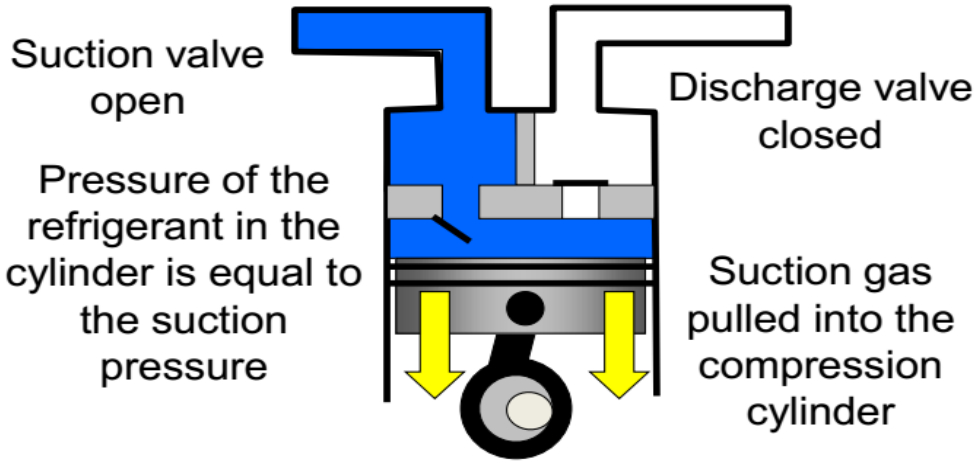
- Piston is the highest point in the cylinder
- Referred to as top dead center
- Both the suction and discharge valves are closed
- Cylinder pressure is equal to discharge pressure
- As the crankshaft continues to turn, the piston moves down in the cylinder



Piston moving downward in the cylinder

COMPRESSION PROCESS – SUCTION

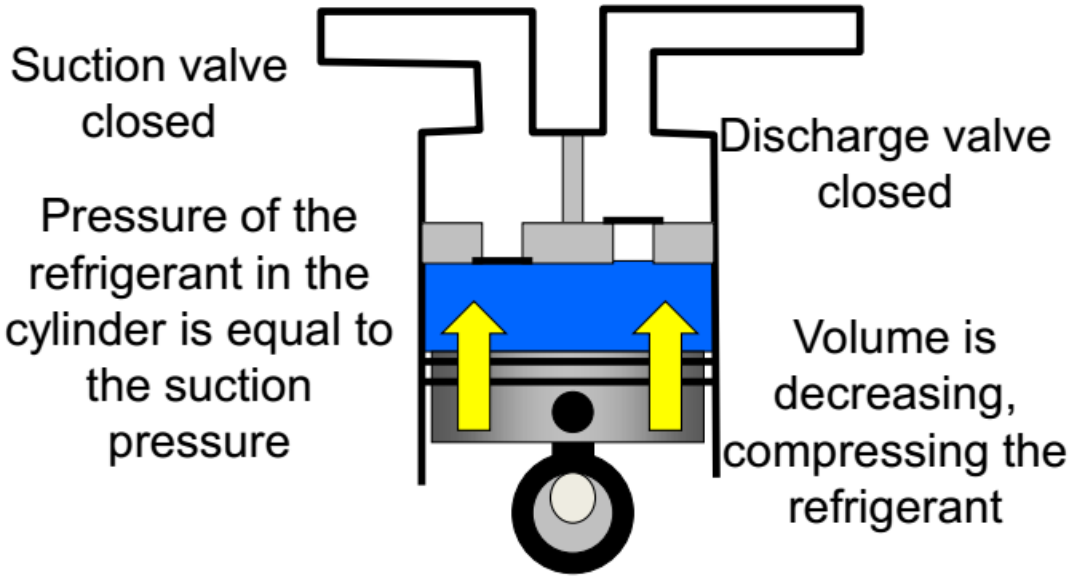
- As the piston moves down, the pressure decreases
- When the cylinder pressure falls below suction pressure, the suction valve opens
- The discharge valve remains in the closed position
- As the piston continues downward, vapor from the suction line is pulled into the cylinder
- Suction continues until the piston reaches the lowest position in the cylinder (bottom dead center)
- At the bottom of the stroke, suction valves close



Piston moving downward in the cylinder

COMPRESSION PROCESS – COMPRESSION

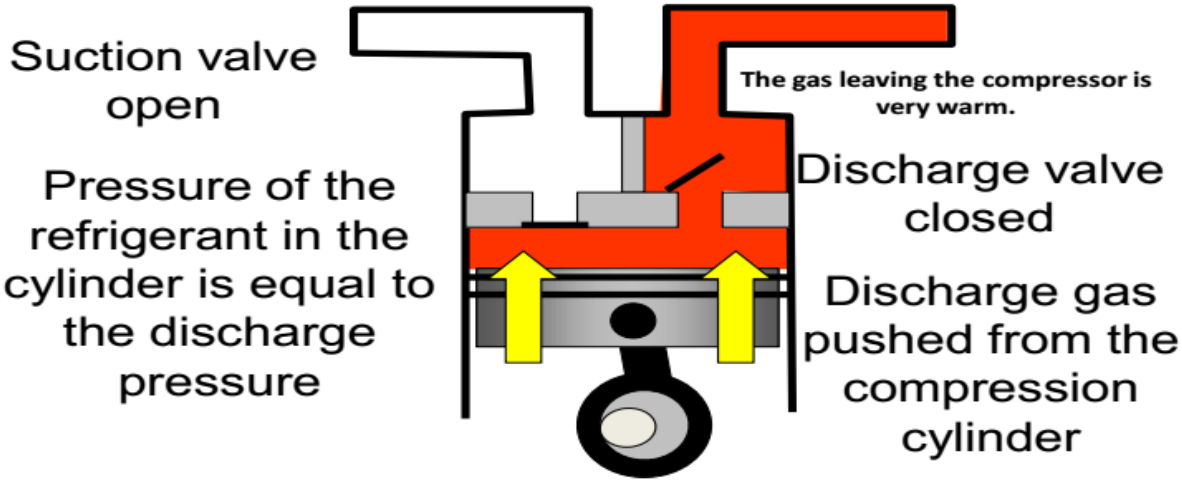
- Piston starts to move upwards in the cylinder
- The suction valve closes and the discharge valve remains closed
- As the piston moves upwards, the volume in the cylinder decreases
- The pressure of the refrigerant increases
- Compression continues until the pressure in the cylinder rises just above discharge pressure



Piston moving up in the cylinder

COMPRESSION PROCESS – DISCHARGE

- When the cylinder pressure rises above discharge pressure, the discharge valve opens and the suction valve remains closed
- As the piston continues to move upwards, the refrigerant is discharged from the compressor
- Discharge continues until the piston reaches top dead center



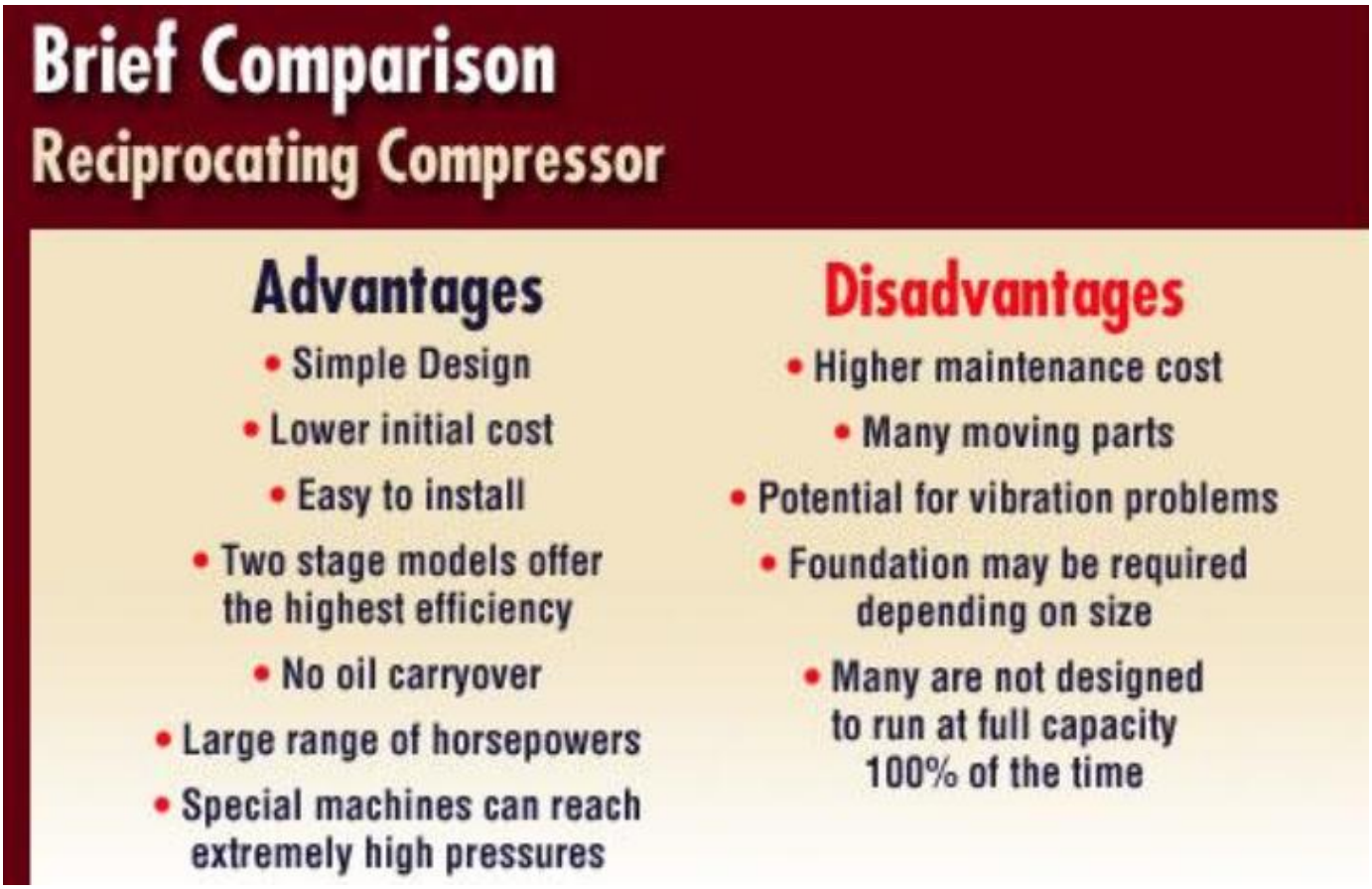
Piston moving up in the cylinder

LIQUID IN THE COMPRESSION CYLINDER

- If liquid enters the cylinder, damage will occur
- Liquids cannot be compressed
- Liquid slugging (entering of liquid refrigerant or liquid refrigerant and oil) can cause immediate damage to the compressor components
- Common causes of liquid slugging include an overfeeding metering device, poor evaporator air circulation, low heat load, defective evaporator fan motor and a frosted evaporator coil

SYSTEM MAINTENANCE AND COMPRESSOR EFFICIENCY

- High suction pressures and low discharge pressures keep the compression ratio low
- Dirty evaporators cause suction pressure to drop
- Low suction reduces compressor pumping capacity
- Dirty condensers increase head pressure
- Compression ratio is increased by dirty or blocked condenser and evaporator coils


Brief Comparison
Reciprocating Compressor
Advantages
• Simple Design
• Lower initial cost
• Easy to install
• Two stage models offer the highest efficiency
• No oil carryover
• Large range of horsepowers
• Special machines can reach extremely high pressures
Disadvantages
• Higher maintenance cost
• Many moving parts
• Potential for vibration problems
• Foundation may be required depending on size
• Many are not designed to run at full capacity 100% of the time