11

Other System Components

Objectives

After studying this chapter, you will be able to:

- ❑ Identify condensing and evaporator units.
- ❑ Describe the condition of refrigerant in various accessory components.
- ❑ Describe the purpose of system accessory components.
- ❑ Identify component variations.
- ❑ Name accessory components and describe the purpose of each.
- ❑ Install and use a gauge manifold.
- ❑ Discriminate between components in domestic and commercial systems.

Important Terms

absorb	liquid receiver
adsorb	liquid receiver service valve
aspirator hole	moisture indicator
backseated	noncondensibles
charging	overcharge
condensing unit	pigtail
cracked	pointer flutter
desiccant	recalibration
dip tube	recovery
discharge service valve	Schrader valve
evacuating	sight glass
evaporator unit	suction accumulator
filter-drier	suction service valve
frontseated	undercharged
gauge manifold	vacuum pump
heat exchanger	
hydrostatic expansion	

11.1 Evaporating and Condensing Units

As described in Chapter 10, the basic refrigeration system consists of seven components: evaporator, suction line, compressor, hot gas discharge line, condenser, liquid line, and refrigerant control.

These components can be further grouped into condensing and evaporating units. The ***condensing unit*** consists of the equipment necessary to reclaim the refrigerant gas and convert it back to a liquid. The condensing unit, **Figure 11-1,** contains the compressor, condenser, hot gas discharge line, condenser fan, electrical panel box, and some accessory components. The ***evaporator unit*** consists of the evaporator, refrigerant control, evaporator fan, and some accessory components. The suction and liquid lines connect the evaporator unit with the condensing unit to complete the system.

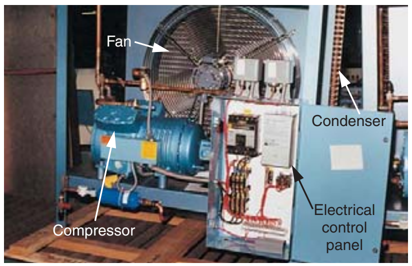


Figure 11-1. *A condensing unit for a commercial installation, consisting of a compressor, condenser, fan, and electrical control panel. The unit may be located far away from the evaporating unit. (Dunham-Bush)*

The condensing unit must be located outside the refrigerated space, positioned so ambient air can cool the condenser. The evaporator absorbs heat from the refrigerated space, while the condenser discharges heat into ambient air. These two *heat exchangers,* therefore, must be well separated from each other.

The suction and liquid lines connecting the two units may be either long or short. On a domestic refrigerator-freezer, for example, they would be quite short: the evaporator unit is in the freezer compartment and the condensing unit is below the refrigerator section. See **Figure 11-2.** This is a *self-contained* system because the condensing and evaporating units are located within the same cabinet.

In a remote or *split* system, the condensing and evaporating units are not in the same cabinet. While the evaporator is located inside the area to be cooled, the condensing unit is likely to be on the building's roof or outside at ground level. The condensing unit must be located where it is acceptable to discharge heat. The suction and liquid lines connecting the two units may be quite long. A residential central air conditioning system, **Figure 11-3,** is an example of a split system. Commercial split systems are essentially the same, but the components are larger.

Refrigeration systems are designed to remove heat faster than it can leak into a cabinet or room. The more

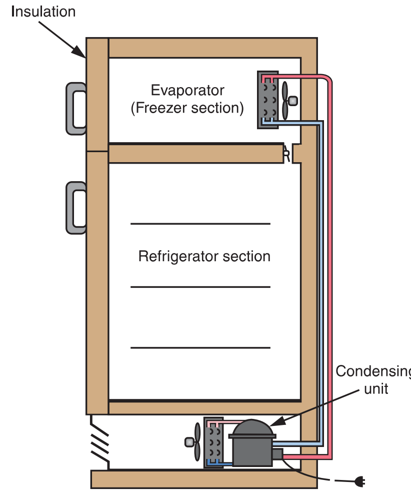


Figure 11-2. *A domestic refrigerator-freezer is a self-contained unit.*

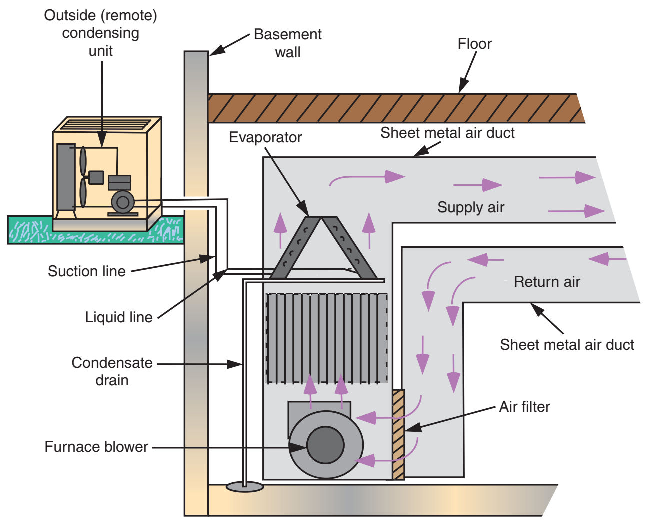


Figure 11-3. *A residential central air conditioning system is a typical split system. The evaporating and condensing units are separated, and copper tubing connects the inside (evaporating) unit with the outside (condensing) unit.*

heat leakage, or load, the bigger the system must be. Other than size, all systems are fundamentally the same. Those that appear more complicated simply have additional components to make them more efficient and serviceable.

11.2 Other System Components

To understand the operation of any system, you need to know how individual components work and affect the system. A malfunction by one component will impact the operation of other components. Different components, or combinations of components, make the system more efficient, versatile, and serviceable. For example, many accessory components facilitate checking system operation and performing repairs. Some components keep the system clean. Others provide a means for isolating sections for repairs. It is important to understand the purpose, theory, and operation of these components. Being able to identify them and understand their functions will help you troubleshoot and service a system.

11.2.1 Liquid Receiver

The ***liquid receiver*** is an important accessory in large systems. It is installed in the liquid line and serves as a storage tank for excess liquid refrigerant. See **Figure 11-4.** Ideally, the refrigerant should boil off inside the evaporator at the same rate it is being changed to a liquid state in the condenser. Such a balance is generally achieved in domestic systems, which operate at a fairly

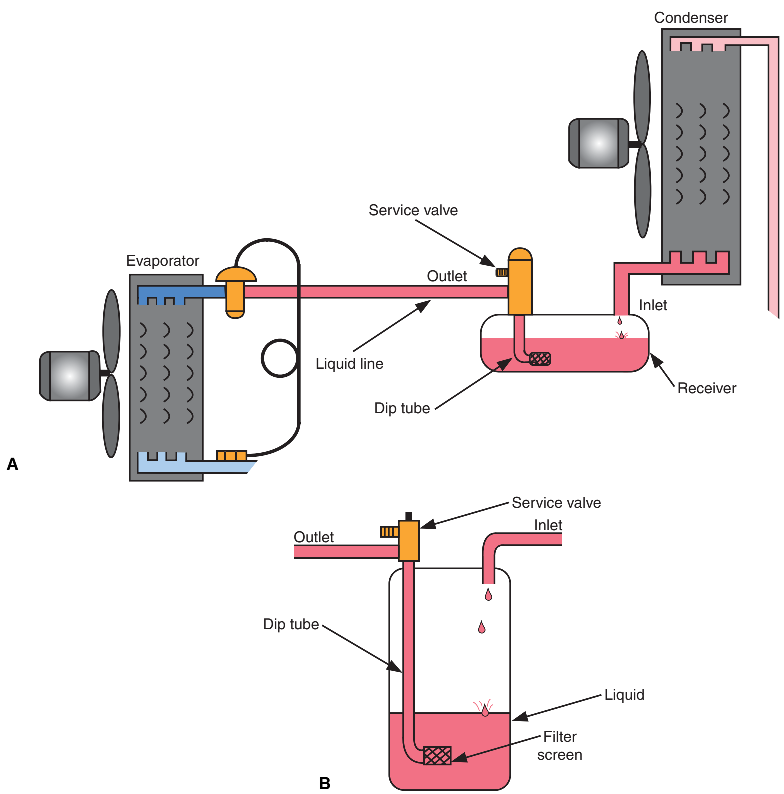


Figure 11-4. *Liquid receivers act as reservoirs for excess liquid refrigerant in large systems. Receivers are located in the liquid line. Both horizontal and vertical types are used, depending upon the application. A—Horizontal receiver. B—Vertical receiver.*

steady rate. Larger commercial systems, however, require varying amounts of refrigerant at different times, depending upon the heat load on the evaporator. Therefore, a reserve of refrigerant must be available.

Liquid receivers are not used in domestic refrigeration systems. The cost is prohibitive, and domestic systems use a capillary tube for the refrigerant control. The amount of refrigerant in domestic systems is critical. Because excess refrigerant accumulates in the condenser and reduces its capacity, even a one-half-ounce ***overcharge*** (excess of refrigerant) will cause high head pressure.

Commercial systems normally use a thermostatic expansion valve for the refrigerant control, which permits the use of a liquid receiver. (Refrigerant controls are fully explained in Chapter 16.) Commercial systems allow for some excess refrigerant; the liquid receiver acts as a storage place for the excess. The amount of refrigerant in a commercial system is not critical unless it is ***undercharged*** (has insufficient refrigerant).

Commercial systems require large quantities of refrigerant to operate, so the liquid receiver must be large enough to hold all the refrigerant in the system plus any excess. All refrigerants are expensive, and the ability of the receiver to hold the entire refrigerant charge is very desirable when the system must be opened for repairs.

The liquid receiver should be no more than 80% full when holding the entire system charge. Since all liquids expand (occupy more space) when heated, the extra 20% capacity allows for liquid expansion within the receiver. The principle is called ***hydrostatic expansion.***

The liquid receiver is usually located close to (or below) the condenser. Liquid from the condenser drips into the receiver inlet. As shown in Figure 11-4, the receiver outlet contains a ***dip tube*** that extends to about one-half inch from the bottom of the receiver. The dip tube ensures that only liquid (no vapor) enters the liquid line at the receiver outlet.

Some large receivers are equipped with two service valves, one at the inlet and one at the outlet. These receivers, **Figure 11-5,** also contain a fusible plug or pressure relief valve as a safety device. The plug or valve relieves any sudden increase in pressure to an unsafe level. Such an increase might occur in a fire, for example. The spring-loaded pressure relief valve, **Figure 11-6,** opens automatically when a specified pressure is reached in the receiver. The pressure at which the valve opens is adjustable within a given range. The fusible plug, **Figure 11-7,** is a relief device designed to melt at a specified temperature. It releases the refrigerant if an unsafe temperature (and corresponding unsafe pressure) is reached.

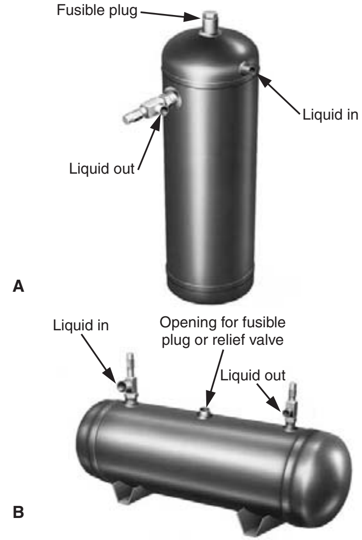


Figure 11-5. *Large liquid receivers with pressure-relief devices. A—Vertical receiver with fusible plug installed. B—Horizontal receiver with provision for either fusible plug or relief valve. (Standard Refrigeration Company)*

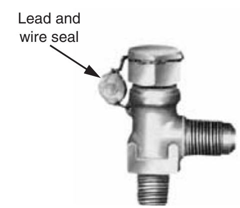


Figure 11-6. *The spring-pressure relief valve opens at a specified pressure, then closes again when pressure drops below that level. The pressure at which the valve opens is adjustable within a given range. The lead and wire seal prevents tampering with the valve pressure setting. (Standard Refrigeration Company)*

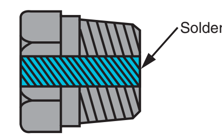


Figure 11-7. *A fusible plug has an opening sealed with solder that melts at a specified temperature, usually 165°F to 210°F (74°C to 99°C).*

Some very large receivers are equipped with a dial-type gauge or a liquid level sight glass to indicate how much liquid refrigerant is in the receiver. As noted, liquid level in the receiver should never be more than 80% of its capacity when holding the entire charge of the system.

11.2.2 Service Valves

A service valve is an accessory that serves no operating function but is indispensable when work must be performed on the system. Service valves are provided on commercial systems for troubleshooting and making repairs. They are not factory-installed on domestic systems but often are installed by technicians when servicing is needed. The valves make it possible to block off certain sections of the system for servicing or for reading operating pressures using the gauge manifold. The ***gauge manifold*** is a pressure-checking device that has compound and high-pressure gauges, control valves, and hose connectors from the service valves. The service technician must fully understand where service valves are located and how they operate.

Service valve locations

Service valves on commercial systems are normally placed in three strategic locations, **Figure 11-8.** The

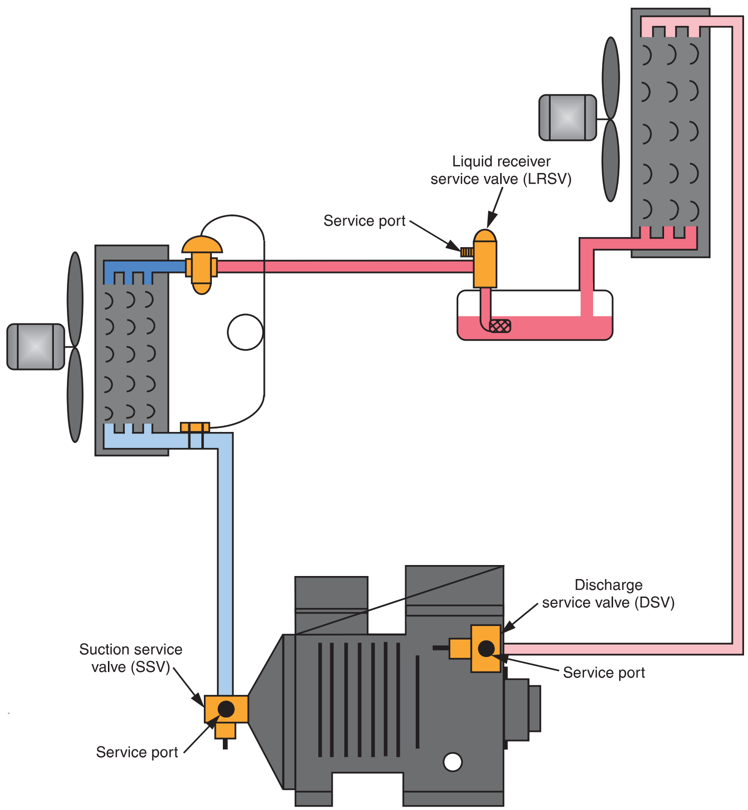


Figure 11-8. *Service valves are normally located at three specific places. These locations permit easy access to the system for servicing.*

valves provide access for pressure readings, and can be used to control system operation and isolate sections to diagnose problems. Failure to use these valves properly may result in wrong diagnoses, excessive service time, and unnecessary loss of refrigerant.

Suction service valve. The ***suction service valve*** (SSV) is located on the low-pressure side of the system between the compressor and the suction line. Usually, the valve is bolted to the compressor, and the suction line is connected to the valve. The location permits the technician to:

- ❑ Read the system's low-side pressure while the compressor is running.
- ❑ Restrict the flow of refrigerant entering the compressor.
- ❑ Completely stop the refrigerant from entering the compressor.

Discharge service valve. The ***discharge service valve*** (DSV) is located on the high-pressure side of the system. Normally, the valve is bolted to the compressor, and the hot gas discharge line is connected to the valve. The location permits the technician to:

- ❑ Read the system's high-side pressure while the compressor is running.
- ❑ Restrict the flow of gas leaving the compressor.
- ❑ Completely stop the gas from leaving the compressor.

WARNING: Never frontseat (close) this valve while the compressor is running. Discharge pressure will rapidly reach extremely high, unsafe levels.

By placing a service valve on each side of the compressor, it is possible to obtain high- and low-side pressure readings at a single location, the compressor. The valve arrangement makes it possible to completely isolate, or block off, the compressor (when it is not running) from the rest of the system.

Liquid receiver service valve. The ***liquid receiver service valve*** (LRSV) is located in the liquid line, at the liquid receiver outlet. The LRSV is welded to the liquid receiver, and the liquid line is connected to the valve. The location permits the technician to:

- ❑ Read the system's high-side pressure while the compressor is running.
- ❑ Restrict the flow of refrigerant leaving the receiver.
- ❑ Completely stop the liquid refrigerant from leaving the receiver (while the compressor is running).

Some large commercial systems include another service valve located at the liquid receiver *inlet.* This provides a method to isolate the receiver from the rest of the system by closing (frontseating) both receiver valves. Closing both valves traps most of the refrigerant inside the liquid receiver.

Service valve ratchet wrenches

Service valves vary in size along with the size of the system. Valve stem sizes vary as well, requiring service valve wrenches of different sizes. The ratchet-type wrench with four sizes of openings, **Figure 11-9,** is the most popular; it fits most valve stems and is easily reversed. This tool is a *must* in every technician's tool kit.

Figure 11-9. *The most popular type of service valve wrench is a ratchet-type. It has four sizes of openings and is easily reversed. (Robinair Mfg. Corp.)*

Service valve operation

All service valves are designed to function in the same manner, regardless of location, size, or shape. While all service valves have three openings, only two are controlled by the valve stem. The opening to the compressor (or receiver) is always open. The valve stem controls the inlet (or outlet) and the service port. See **Figure 11-10.**

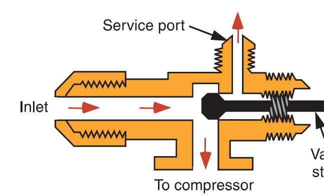


Figure 11-10. *Service valves have three openings: the inlet or outlet (where the refrigerant enters or leaves the valve), the opening to the compressor or liquid receiver, and the service port opening. The valve stem is able to close either the inlet/outlet or the service port, but not the third (compressor) opening.*

Suction service valve (backseated). With the valve stem in the ***backseated*** position, **Figure 11-11,** the flow of refrigerant from the suction line to the compressor is unrestricted. However, the service gauge port is blocked off (closed) — the normal position of the valve stem when the system is operating.

Suction service valve (cracked). To obtain a pressure reading at the suction service valve, the valve stem must first be in the backseated position to close off the gauge port. Then, you can remove the cap from the gauge port and connect the blue hose from the compound gauge on the gauge manifold. Next, the service valve stem is ***cracked*** (opened by turning the stem about *one or two turns* to the right). See **Figure 11-12.** This opens the gauge port, and the compound gauge immediately registers the pressure reading.

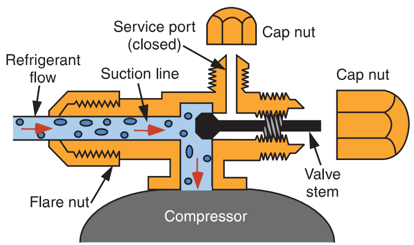


Figure 11-11. *Suction service valve with stem in the backseated position. This is the normal operating position of the valve stem.*

"Cracking the valve" does not restrict the flow of refrigerant to the compressor. The procedure permits you to read the low-side pressure while the system is operating.

Suction service valve (frontseated). When the SSV is ***frontseated*** (valve stem screwed *all the way* to the right), the inlet opening is closed off. See **Figure 11-13.** This frontseated position prevents refrigerant gas from entering the valve. However, the gauge port is open to the compressor. Remember that the compressor opening cannot be closed by the valve stem. The valve stem controls only the gas inlet and the gauge port opening.

If the SSV is frontseated while the compressor is running, the compressor will immediately show a good vacuum on the compound gauge because the suction gas cannot enter the compressor. This procedure is used to check the operation of the compressor. Failure of the compressor to pull a good vacuum when the SSV is frontseated indicates a problem with the compressor valve reeds. **CAUTION:** When the service valve port is open, avoid allowing the compressor to draw moisture-laden atmospheric air into the system.

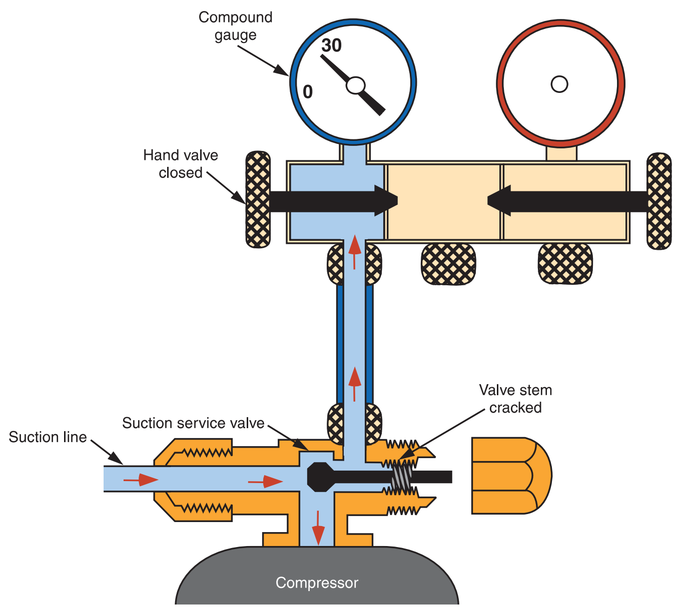


Figure 11-12. *The suction service valve with the stem in the "cracked" position permits the technician to read the low-side pressure while the system is in operation.*

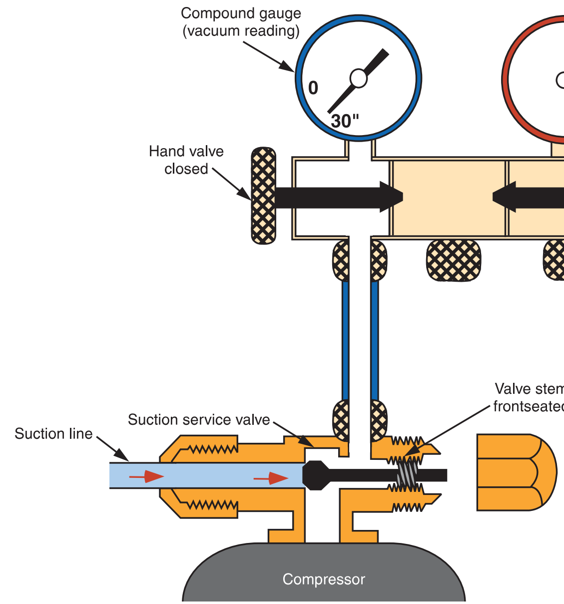


Figure 11-13. *The suction service valve with the stem in the frontseated position permits the technician to take a compressor vacuum reading. The inlet is closed, so no refrigerant gas can reach the compressor.*

Service valves on small commercial units have a built-in 1/4″ (6.4 mm) male flare fitting at the gauge port (as previously illustrated) for attaching a hose from the gauge manifold. Larger service valves may have one or two openings at the gauge port, plugged with a 1/8″ (3.1 mm) male pipe plug. To attach the gauge hose to the service valve, remove the plug and install a 1/8″ (3.1 mm) MPT × 1/4″ (6.4 mm) MFT half-union, as shown in **Figure 11-14.** All technicians keep half-unions readily available.

Discharge service valve operation

Just like the suction service valve, the discharge service valve has three openings and three possible valve stem positions. See **Figure 11-15.** However, the DSV controls high-pressure gas *leaving* the compressor rather than low-pressure gas *entering* the compressor. The opening from the compressor cannot be closed. The gauge port opening is available for the technician to install the red hose from the high-pressure gauge, making it possible to obtain a discharge pressure reading while the system is running.

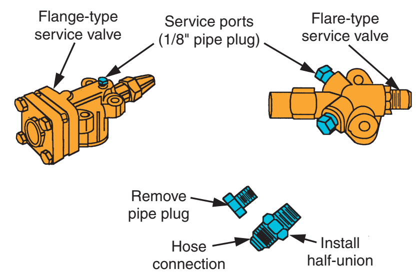


Figure 11-14. *Replacing pipe plugs on valves with half-unions.*

The valve is backseated for normal operation and when connecting the red hose from the gauge manifold. After connecting the red hose, the valve is cracked open and the discharge pressure is immediately revealed on the high-pressure gauge.

The discharge service valve should *never* be frontseated (screwed all the way in) when the compressor is running because it will close the hot gas

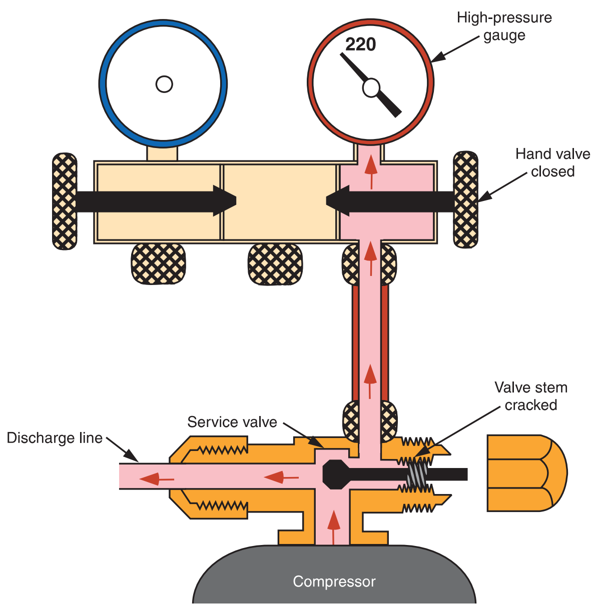


Figure 11-15. *The discharge service valve with the valve stem in the cracked position permits the technician to read the discharge (high-side) pressure while the system is in operation.*

discharge line. The high-pressure gas cannot escape, so very high pressure will develop rapidly in the service valve. This extreme pressure may blow the hose off the valve or cause the compressor to shut off on a safety control.

If the compressor is shut off for replacement, both the discharge service valve and the suction service valve are frontseated to isolate the compressor from the system. Both service valves are unbolted from the compressor, the old compressor is removed, and the service valves are rebolted to the new compressor after it is installed. The procedure saves the refrigerant in the system, except for a small amount of gas trapped inside the old compressor.

Gaskets are provided with each new compressor for use between the compressor body and the service valves. Old gaskets should be removed with a pocketknife and the mating surfaces cleaned. Be careful not to scratch or cut the mating surfaces. Coat the new gaskets with refrigeration oil before installing them. The oil expands the gaskets slightly so they can be squeezed between the mating surfaces for a leakproof fit.

Liquid receiver service valve

The liquid receiver service valve is welded or screwed into the receiver outlet, and the liquid line is connected to it with a flare nut. This service valve operates just like the suction and discharge valves, except it controls the liquid leaving the receiver. As shown in **Figure 11-16,** the valve is backseated during normal operation. The valve can be cracked to read high-side pressures at the receiver valve or frontseated to completely stop liquid refrigerant from leaving the receiver.

Pumping down the system. The technician often has to manually "pump down the system," meaning remove all refrigerant from the low-pressure side and pump it over to the high-pressure side of the system. Pumping down is accomplished by frontseating the liquid receiver service valve while the system is running. The compressor removes refrigerant from the low-pressure side of the system all the way back to the valve. The compressor is then turned off. The valve reeds inside the compressor head should prevent refrigerant gas from flowing back into the

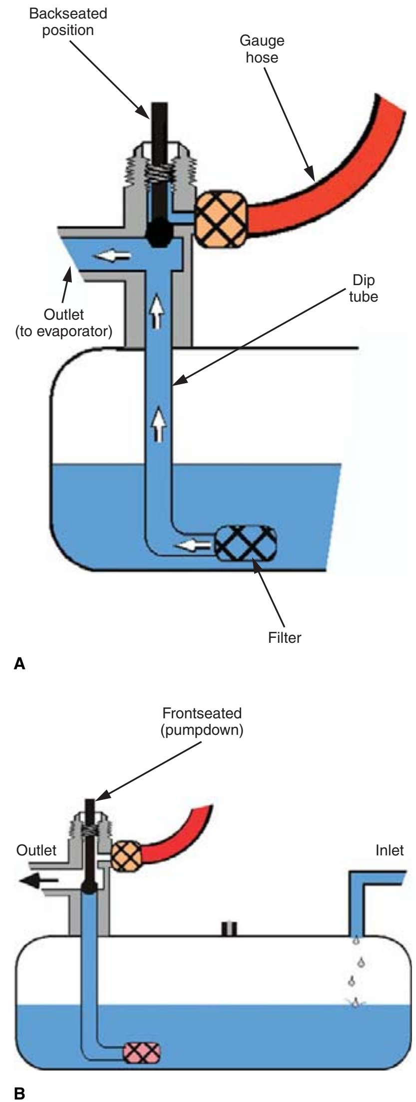


Figure 11-16. *Liquid receiver service valve. A—The valve is backseated for normal operation. B—The valve is frontseated to pump down the system.*

low-pressure side of the system. If necessary, the suction service valve can be frontseated after the system is pumped down.

Whenever a system is pumped down, its low-pressure side is usually in a good vacuum. The system should not be opened while in a vacuum because moisture-laden atmospheric air will rush in. A vacuum pump would be needed to remove the unwanted gases.

Liquid receiver with two service valves. Large liquid receivers sometimes have two service valves, one at the inlet and one at the outlet of the receiver, **Figure 11-17.** Two valves make it possible to pump down the system, then frontseat both receiver valves. The procedure isolates the liquid receiver, which contains most of the refrigerant in the system (some gas remains in the condenser and the hot gas discharge line). The procedure would be used to make repairs to the condenser, for example. Pumping down the system saves most of the refrigerant.

The service valve on the inlet to the receiver also makes it easy to purge air from the receiver. Whenever atmospheric air enters the system, it becomes trapped in the liquid receiver. Atmospheric air is considered noncondensible and remains a gas as it travels through the condenser. Therefore, it becomes trapped in the top of the liquid receiver.

The technician can remove ***noncondensibles*** by turning the system off and frontseating the receiver inlet valve. This blocks off the valve inlet and opens the service port to the top of the receiver. The noncondensibles now can be removed through the service port. The procedure requires the use of a refrigerant recovery device until all noncondensibles are removed from the receiver, and the head pressure returns to normal.

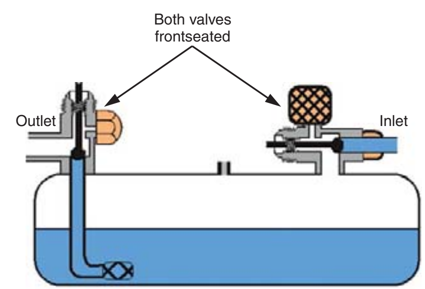


Figure 11-17. *Service valves at both the inlet and outlet of the liquid receiver allow isolation of the receiver. Most of the system's refrigerant, in liquid form, can be trapped there. Noncondensibles can be purged through the service port of the inlet valve.*

Service valves for domestic systems

Manufacturers of domestic systems, such as refrigerators and freezers, seldom have factory-installed service valves. These systems are totally hermetic (sealed systems); the service technician must install service valves as needed. There are two basic types of valves installed by technicians: clamp-on valves and core-type valves.

Clamp-on valves. These valves are known by various names, (including saddle valve and line-piercing valve), but all are used in the same way: they straddle the tubing and clamp into place, then use a depressor pin to puncture a hole in the tubing. See **Figure 11-18.** Gaskets and seals inside the valve prevent refrigerant from leaking around the punctured hole. The valve provides an access port for attaching a hose from the gauge manifold.

Once these clamp-on valves are installed on the suction or hot gas discharge lines, they become a permanent addition to the system. They also become a source of future problems due to possible leakage at the hole. Clamp-on valves should only be used for troubleshooting one of two problems:

- ❑ The compressor runs but does not compress properly.
- ❑ The system is entirely out of refrigerant due to a leak.

The pressures indicated on the gauge manifold will reveal which of the two problems exists. If the gauges reveal the *same pressure* on each side of the system, the compressor is defective (has bad valve reeds) and must be replaced. If the gauges reveal *no pressure* on either side of the system, the unit has a leak and has lost all refrigerant.

Both problems involve expensive repairs that require breaking into the hermetic system. The tube-piercing saddle valves are used for diagnosis only and should be replaced by ***Schrader*** (core-type) ***valves*** if repairs are authorized.

Schrader (core-type) valves. The recommended method for breaking into and resealing a hermetic system is to install a Schrader valve. See **Figure 11-19.** Most hermetic compressors are factory-equipped with an extra copper tube (a ***pigtail***) that allows access to the suction pressure inside the hermetic shell. A Schrader valve is easily brazed to the end of the pigtail.

Access to the high-pressure side is usually difficult because the hot gas discharge line must be cut and a wrought copper tee installed to provide an opening for installing a valve. The valve is brazed to the branch opening on the tee.

Schrader valves have cores similar to those on automobile tires. Because of the special gaskets used, the valve core must be removed before brazing. It can be replaced after the joint has cooled. The hoses on the gauge manifold have a built-in device to depress the core when the hose is connected to the valve.

The seal cap for a core valve contains a rubber gasket to help prevent leaks. The cap should *always* be installed when the valve is not in use.

11.3 The Gauge Manifold

The gauge manifold is the technician's most valuable tool. It is used to determine the operating characteristics inside the system. The gauge manifold,

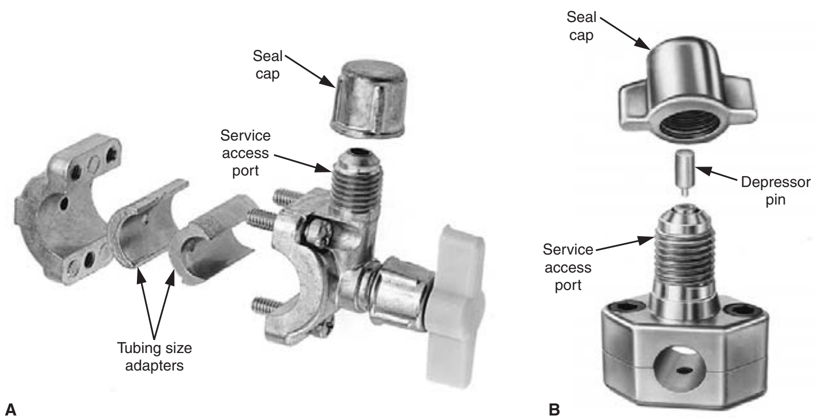


Figure 11-18. *Saddle valves. A—The valve is clamped over the tubing to provide an access port for diagnosing system problems. Adapters permit use on different tubing sizes. B—The depressor pin punctures the tubing when the cap is tightened. Then, the pin is removed, and the cap seals the access port.*

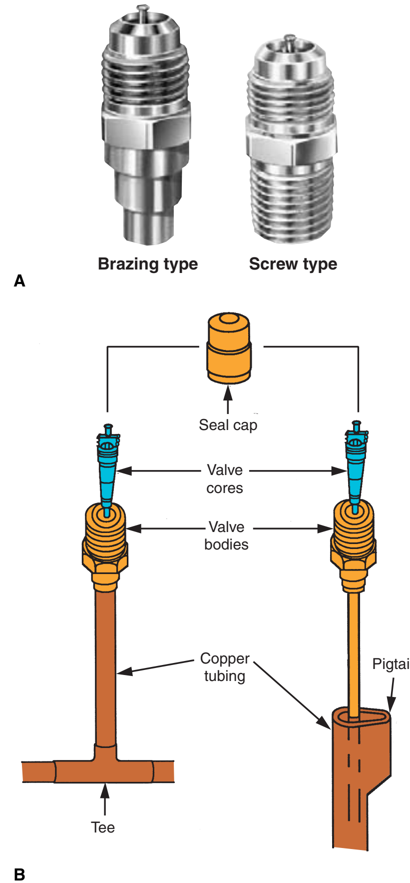


Figure 11-19. *Schrader valves are installed for permanent service access to domestic systems. A—Brazing-type and screw-type Schrader valves. (J.B. Industries) B—Because heat will affect the gasket material, the cores must be removed while the valve body is being brazed to the tubing.*

as noted earlier in this chapter, is a pressure-checking device with both compound and high-pressure gauges. See **Figure 11-20.** It also has control valves and connectors for hoses to the service valves. The gauges reveal the system's operating pressures which, in turn, help the technician determine the needed repairs. The manifold is also used while performing the repairs.

Learning how to use the gauge manifold properly will save countless hours diagnosing field problems, determining their causes, and deciding their solutions. Without

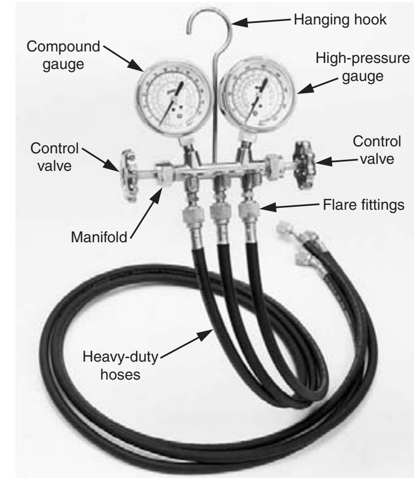


Figure 11-20. *The gauge manifold is the technician's basic tool for determining system pressures. It is equipped with two gauges, two control valves, and three connection hoses. (Uniweld)*

11.3.1 Pressure Gauges

The gauge manifold has two gauges for a wide range of readings. See **Figure 11-21.** The compound gauge (blue) is designed for connection to the low-pressure side of the refrigeration system. It has scales to show pressure readings from 0 psig to above 120 psig (828 kPa), and vacuum from 0 in. Hg to 30 in. Hg. The high-pressure gauge (red) is designed for connection to the high-pressure side of the refrigeration system; it typically shows only pressure readings (0 psig to 500 psig or 0 kPa to 3450 kPa).

The rapid compression strokes of the compressor pistons sometimes create pressure pulsations that cause the gauge pointer to swing above and below the actual pressure reading. Called ***pointer flutter,*** it does not indicate problems with the compressor or any other type of defect. The correct pressure reading is obtained at the center of the flutter. Special pressure gauges, **Figure 11-22,** are available with a built-in pulsation dampener to prevent pointer flutter.

The saturation temperature-pressure relationship for one or more refrigerants is included on the dial face of refrigeration gauges. The outside scale on the dial face (black numbers) indicates gauge pressure (psig). The three inner scales (red numbers) indicate Fahrenheit saturation temperatures that correspond with the pressure for each of the three refrigerants. To read the scales properly, simply follow the line of the needle to the proper temperature scale to determine the temperature that corresponds with the pressure reading.

R-22, and R-502. The scales are a convenience and do not affect the gauge pressure readings. Consult a saturation temperature-pressure card for other refrigerants.

Remember that refrigeration gauges only reveal *saturation* temperature for a given pressure. The gauges do *not* reveal superheat (temperature above saturation) or subcooling (temperature below saturation). Because the gauges only read saturation, a thermometer is used to determine if the actual temperature is above or below the saturation point (superheat or subcooling).

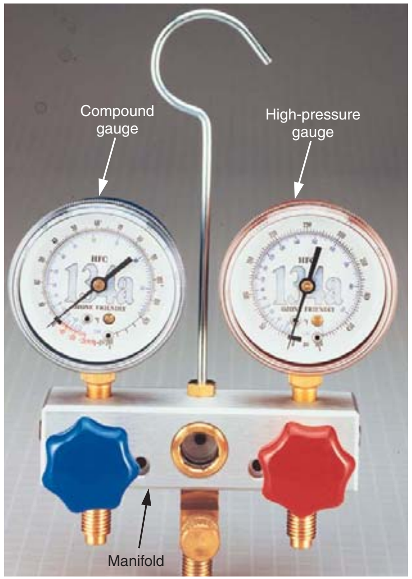


Figure 11-21. *The compound gauge is used for both pressure and vacuum readings, while the high-pressure gauge is used only for pressure readings. (TIF Instruments, Inc.)*

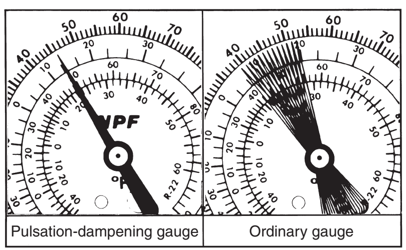


Figure 11-22. *A special gauge with a pulsation dampener eliminates pointer flutter, making more accurate readings possible. (Uniweld)*

For efficient operation of the system, the amount of superheat or subcooling at various points must be determined and controlled. For example, a pressure reading at the suction service valve for R-134a may be 12 psig (83 kPa), which corresponds to 10°F (–12°C) saturation temperature. However, if a thermometer is clamped to the suction line at the inlet to the suction service valve, the reading would be about 25°F (–4°C). The difference in temperature readings amounts to 15 degrees Fahrenheit (25 – 10 = 15) or 8 degrees Celsius. Therefore, the refrigerant vapor contains 15 degrees Fahrenheit (8 degrees Celsius) of superheat as it enters the suction service valve.

Recalibrating gauges

Refrigeration gauges are sensitive instruments, initially calibrated to produce accurate readings. While these gauges can withstand some abuse, they should be handled with care. It is not unusual for the gauges to require ***recalibration*** in the field because of use and handling.

To gain access to the recalibration screw, the clear crystal face on the gauge must be unscrewed, **Figure 11-23.** The recalibration screw is located on the gauge face, just below the needle hub. The hose on the manifold body immediately beneath the gauge is removed to expose the inlet port to atmospheric pressure. A suitable screwdriver is used to slowly turn the recalibration screw until the pointer lines up with zero (atmospheric).

11.3.2 Manifold Body

The compound gauge and the high-pressure gauge are directly connected to the hoses by special bypass gas passages through the manifold body. A hose connection is located directly beneath each gauge. The gas passage between each gauge and its connecting hose is *never closed.* See **Figure 11-24.** The two hand

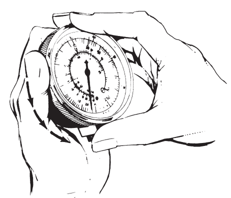


Figure 11-23. *Unscrew the clear crystal of the gauge to reach the recalibration screw on the dial face. For accurate readings, gauges must be recalibrated, or zeroed, periodically. (Imperial Eastman)*

valves located at each end of the manifold control access to the center hose only. These valves *do not* control the bypass gas passages to the gauges.

The center hose is for adding refrigerant to a system (***charging***), removing refrigerant from a system (***recovery***), or emptying a system with a vacuum pump (***evacuating***). Each of these procedures requires the hand valves be opened properly to gain access to the center hose. Both valves are normally closed and should be opened only when access to the center hose is needed. The left-hand valve controls access to the center hose via the low-pressure side and the right-hand valve via the high-pressure side. Opening both hand valves opens the center hose to both gauges.

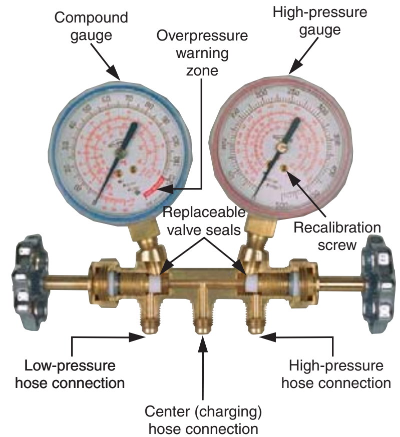


Figure 11-24. *Cross section of the gauge manifold body. The hand valves are used only for access to the center hose. (Uniweld)*

11.3.3 Refrigeration Hoses

Refrigeration hoses are designed to withstand working pressures of 500 psig to 750 psig (3450 kPa to 5175 kPa). The hoses are normally color-coded: *blue* for low pressure, *red* for high pressure, and *yellow* for the center connection. The hoses are also designed to remain flexible under most temperature conditions for easy handling. Each hose has a straight connector at one end and an angled (45°) connector at the other, **Figure 11-25**. The straight ends connect to the 1/4″ flare fittings on the manifold body. The angled ends easily connect to the proper service valve by finger-tightening. Angled ends contain a valve-core depressor for connection to Schrader (core-type) valves.

A special gasket inside the angled hose end provides a leakproof seal on the service valve or Schrader valve. The gasket can become badly worn due to long use or abuse, but it is easily replaced. Replacement gaskets are available from your local supplier. Before fully hand-tightening refrigerant hoses, purge them of air by allowing a tiny amount of refrigerant to escape through them.

11.4 Purging and Venting

"Purging" and "venting" are terms that describe two repair procedures involving the release of refrigerant to the atmosphere.

Purging describes the necessary process of releasing a small quantity of refrigerant from the hose ends after connection to a system. Purging removes atmospheric moisture and air from the service hoses, thus preventing contamination of the system. Small releases of refrigerant due to purging, connecting, or disconnecting hoses is not prohibited by the Clean Air Act.

Some service procedures require the removal of all pressure (refrigerant) from the system prior to performing repairs. Older service procedures simply removed the pressure by *venting* (releasing) the system refrigerant to the atmosphere. Because of ozone depletion, the deliberate release of refrigerant to the atmosphere is prohibited by federal law. New recovery equipment and procedures for saving the refrigerant for reuse are described in Chapter 13.

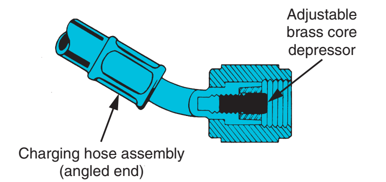


Figure 11-25. *A refrigeration hose is designed to withstand high pressures and temperature extremes. The straight connector attaches to the manifold body; the angled connector attaches to the service valve or Schrader valve.*

11.4.1 Evacuating the System

"Evacuation" means to clean a system with a ***vacuum pump*** to remove all gas and moisture. Evacuation is done before charging a system with refrigerant. **Figure 11-26** shows the arrangement for evacuating a system.

The yellow hose is connected to a two-stage vacuum pump. The vacuum pump removes moisture from the system by reducing pressure so the moisture boils (vaporizes) at normal atmospheric temperatures. In a perfect vacuum, water changes state from liquid to vapor at –90°F (–68°C). Moisture is removed from the system as a vapor by the vacuum pump.

Reducing pressure too quickly will cause the water to boil rapidly and the remaining water to freeze. Water expands when it freezes, and expansion could cause tubing to burst or leak. Excess moisture should be removed before evacuation by blowing the system out with nitrogen at 150 psig to 300 psig (1035 kPa to 2070 kPa).

Two-stage vacuum pumps, **Figure 11-27,** are

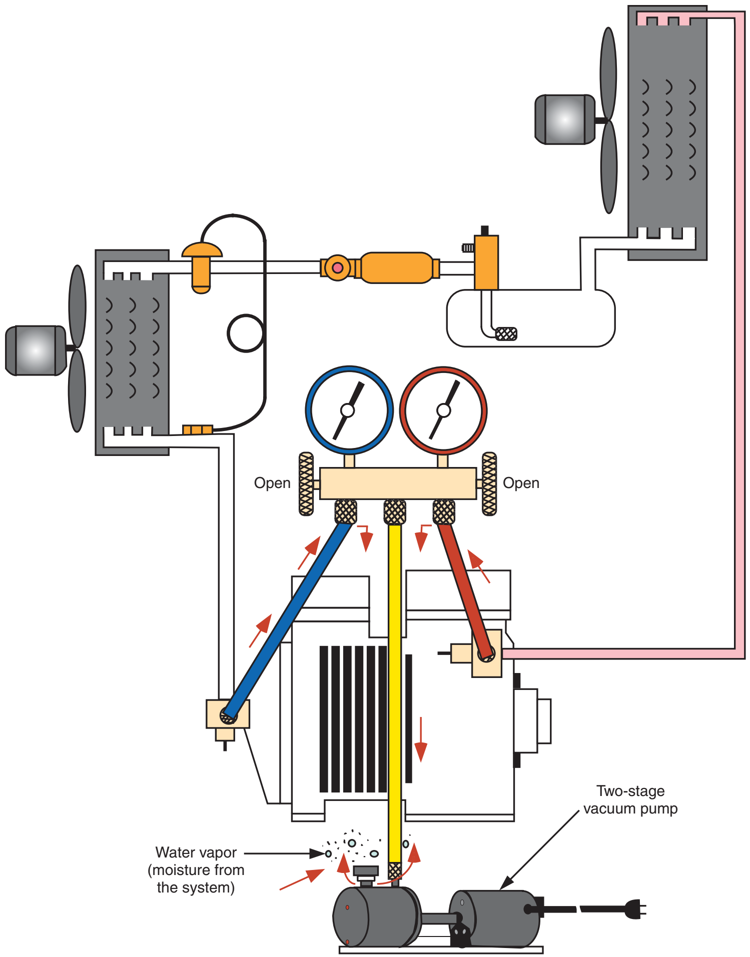


Figure 11-26. *Typical arrangement for evacuating a refrigeration system. The two-stage vacuum pump reduces system pressure low enough to vaporize any moisture and withdraw the vapor from the system.*

necessary to reduce the pressure sufficiently and hold it at a reduced level long enough for the moisture to vaporize and be removed. A second pumping chamber enables the pump to obtain a lower vacuum. In a two-stage pump, the exhaust of the first pumping stage is discharged into the intake of the second pumping stage, rather than to the atmosphere. The second stage pumps at a lower pressure and pulls a deeper vacuum on the system than the first stage could by itself. Two-stage vacuum pumps are capable of pulling down to an extremely low vacuum, but a vacuum seldom goes below 500µ (microns) under field conditions. The two-stage vacuum pumps are able to reach and hold a low vacuum for prolonged periods of time.

Figure 11-28 provides conversion factors for evacuating or dehydrating a system with a vacuum pump.

A

B

Figure 11-27. *Two-stage vacuum pumps are available in different sizes for varying applications. A—Small 1.6 cfm pump. (Thermal Engineering) B—Cart-mounted 15 cfm unit for use on large systems. (Robinair Mfg. Corp.)*

Evacuation procedure

1. Connect the red and blue hoses on the gauge manifold to the appropriate service valves. Crack open the service valves, and close the manifold hand valves.
2. Connect the center (yellow) hose to a two-stage vacuum pump, and start the pump. Very slowly crack open both manifold hand valves. *Be careful to avoid drawing oil out with the vacuum pump.* After one or two minutes, the compound gauge should read 15 in. Hg (15 inches vacuum). Then, both manifold valves can be fully opened. The vacuum pump should quickly reduce the system pressure to about 29 or 30 in. Hg. If the pump fails to pull an adequate vacuum, there is probably a leak in the system that must be found and corrected. After reaching a vacuum of 29 or 30 in. Hg, permit the vacuum pump to operate for at least *one-half hour.* Adequate time is needed for all moisture to vaporize and all refrigerant gas mixed with oil in the compressor crankcase to be evacuated. Large systems require more time on the vacuum pump.
3. *Before* shutting off the vacuum pump, close both manifold hand valves. Shut down the pump, and remove the yellow hose. At this point, all gases have been removed by the vacuum pump, and the refrigeration system is in a deep vacuum. The system should hold this vacuum, unless a leak permits atmospheric air to enter (or the vacuum pump has not been connected to the system long enough).

Leak detection. Closing the manifold valves and waiting to see if the system loses its vacuum is *not* a proper leak-detection method. The vacuum pump may have been stopped too early for proper evacuation, or the leak may be too small for atmospheric air to enter. Even with a perfect vacuum, the pressure differential between the inside and outside of the tubing is only 15 psi (103 kPa). It is poor procedure to leak test with such a low pressure differential. Most leak detection is accomplished with pressures of 200 psi to 300 psi (1380 kPa to 2070 kPa) because the refrigerant molecules are much smaller than air molecules. Various leak detection methods are discussed in Chapter 15.

11.4.2 Charging the System

During compressor operation, the pressure in the high-pressure side of the system is higher than the pressure in the refrigerant cylinder. If the manifold hand valve on the right side (high-pressure) is acci-

Conversion Factors

Inches of Mercury (Hg)	Pounds Per Square Inch Absolute (psia)	Millimeters of Mercury (mm Hg)	Microns	Boiling Temperature of Water (˚F/˚C)
0	14.696	760	760,000	212/100
10.24	9.629	500	500,000	192/89
22.05	3.865	200	200,000	151/66
25.98	1.935	100	100,000	124/51
27.95	0.968	50	50,000	101/38
28.94	0.481	25	25,000	78/26
29.53	0.192	10	10,000	52/11
29.67	0.122	6.3	6,300	40/4
29.72	0.099	5	5,000	35/2
29.842	0.039	2	2,000	15/–9
29.882	0.019	1.0	1,000	+1/–17
29.901	0.010	0.5	500	–11/–24
29.917	0.002	0.1	100	–38/–39
29.919	0.001	0.05	50	–50/–46
29.920	0.0002	0.01	10	–70/–57
29.921	0.0000	0	0	–90/–68

One Atmosphere = 14.696 psia (atmospheric pressure at sea leve)
= 760 mm Hg absolute pressure at 32˚F (0˚C)
= 29.921 in. Hg absolute at 32˚F (0˚C)

Figure 11-28. *Conversion factors for using a vacuum pump to evacuate or dehydrate a system.*

dentally opened, refrigerant will be pumped back into the cylinder. This could cause dangerous overpressure in the cylinder and rupture it. *Always feed the refrigerant charge into the low-pressure side of the system, and always feed refrigerant as a gas, not a liquid.*

The gauge manifold arrangement for charging a system is shown in **Figure 11-29.** *Charging is done with the system operating.* Follow this procedure:

1. Close both manifold hand valves. Check gauge pointers for accuracy of zero readings. Recalibrate if necessary.
2. Connect the low-pressure (blue) compound gauge hose to the suction service valve. Finger-tighten it. Crack open the service valve.
3. Connect the high-pressure (red) gauge hose to the discharge service valve; finger-tighten it. Crack open the *service* valve. (Remember the high-pressure *manifold hand valve* must remain closed.)
4. Connect the center (yellow) charging hose to the refrigerant cylinder. Make sure the container is in an upright position so you obtain gas, not liquid. Never charge liquid refrigerant into a system; it will damage compressor valve reeds or remove oil from bearings.
5. Fully open the valve on the refrigerant cylinder to transfer control to the gauge manifold.
6. With the system running, slowly open the left side (low-pressure) manifold hand valve. The pressure inside the refrigerant cylinder is higher than the low-side system pressure, so the gaseous refrigerant will be forced up through the center hose, through the left side of the manifold, into the blue hose, and into the system. The manifold valve on the right side (high-pressure) must remain closed during the charging procedure.
7. To observe the changing conditions of the low-side system pressure, occasionally close the left-side manifold valve, and check the compound gauge. Also, closely watch the high-pressure gauge during charging. Continue adding refrigerant to the system until both high and low pressures achieve normal status.
8. Backseat (close) both service valves, and close the valve on the refrigerant cylinder. Disconnect the hoses from the service valves, and screw the hose ends onto the "dummy" fittings at the manifold. Replace covers or caps on the service valves.

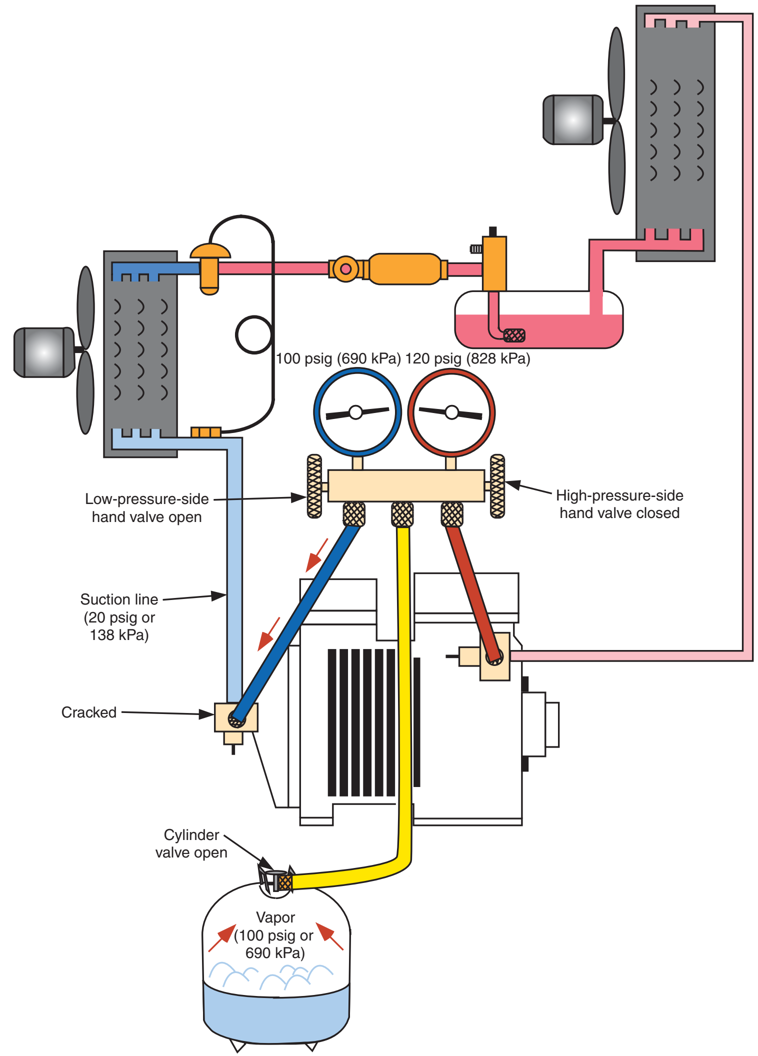


Figure 11-29. *Typical arrangement for charging a refrigeration system. The refrigerant cylinder pressure must be greater than the pressure in the suction line so the refrigerant is forced into the system.*

11.5 Filter-driers

Regardless of the care used in evacuating and charging a system, it is safe to assume the system is not completely free of moisture. A ***filter-drier*** installed in the system, **Figure 11-30,** will absorb the remaining moisture. It will also catch foreign particles circulating with the refrigerant.

On commercial systems, the filter-drier is normally installed in the liquid line, immediately after the liquid receiver. A second unit may be installed in the suction line as well, **Figure 11-31.** On domestic systems, the filter-drier is typically located at the condenser outlet.

11.5.1 Moisture Problems

Water or moisture is always present in refrigeration systems and must be kept to an absolute minimum. Acceptable limits vary from one system to another and from one refrigerant to another. Moisture is the primary factor in the formation of acids, sludge, copper plating, and corrosion. The service technician should always be alert to keep the moisture level of the refrigeration system as low as possible.

The main problems caused by moisture are:

- ❑ *Corrosion* that damages metal parts and adds contaminants to the system.
- ❑ *Formation of acid* that damages the motor windings.

Figure 11-30. *Filter-driers remove residual moisture from a system and trap foreign particles circulating with the refrigerant. (Sporlan Valve Co.)*

Since the motor windings are exposed to refrigerant, any acid that forms will cause a breakdown of the insulation and result in a motor burnout.

- ❑ *Freezing of moisture* in the orifice of the refrigerant control valve or capillary tube. Frozen moisture can block the flow of refrigerant and stop the operation of the system.

Other sources of problems within the system are dirt, sludge, rust, and foreign matter such as flux, copper or brass chips, and solder. These contaminants can damage piston cylinder walls or compressor bearings, or may plug capillary tubes and other refrigerant controls.

11.5.2 Filter-drier Operation

Filter-driers in refrigeration systems work by

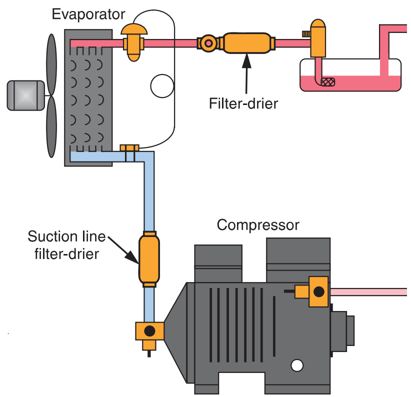


Figure 11-31. *On commercial systems, the filter-drier is usually installed in the liquid line, just after the liquid receiver. For additional protection, technicians sometimes install a second filter-drier, as shown, between the compressor and evaporator.*

bringing liquid refrigerant in contact with a substance that absorbs moisture in the refrigerant. The substance is called a drying agent, or ***desiccant,*** and is usually capable of removing acid as well as moisture.

If properly sized, the filter-drier will not restrict the flow of refrigerant, even when the desiccant is full of moisture and no longer effective. Desiccants are extremely sensitive to moisture and must be protected against it until ready for use. The factory seal on a filter-drier should not be removed until just before installation. Most filter-driers are direction-sensitive, meaning they must be oriented to the direction of refrigerant flow. Direction-sensitive filter-driers have an arrow printed on the body to indicate the proper direction of flow. See **Figure 11-32.**

Desiccants used in filter-driers include activated alumina, silica gel, and activated carbon, which ***absorb*** (soak up) moisture. They also include molecular sieves, which ***adsorb*** (collect substances on their surfaces in a condensed layer) contaminants from the refrigeration system. Desiccants are available in granular, bead, and block forms, **Figure 11-33.** Combinations of desiccants can be used in solid cores and have certain advantages over a single desiccant, such as absorption of a greater variety of contaminants.

Do not attempt to reactivate a used filter-drier. It should be discarded when no longer effective. The most common desiccants used today are activated alumina and molecular sieve; occasionally silica gel is used. For desiccants to be returned to their active states, they must be heated for four hours at temperatures ranging from 400°F to 600°F (204°C to 316°C). At these temperatures, all refrigeration oils decompose into sludges or acids. If a drier is reactivated after it

Figure 11-32. *This filter-drier is designed for attachment to the liquid line with flare fittings. Other types are designed for brazing into the line. Note the arrow indicating the proper direction of refrigerant flow through the device. To keep the desiccant at full effectiveness, the seal caps on the fittings should be left in place until just before the filter-drier is installed. (Alco)*

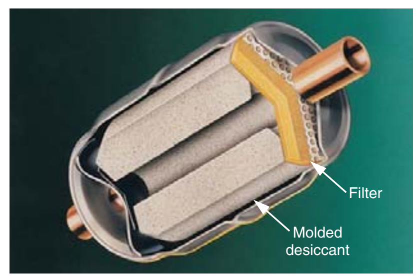


Figure 11-33. *Desiccant granules can be molded into a core for the receiver-drier, as shown in a cutaway view. (Sporlan Valve Co.)*

has been used, the oil will decompose into sludge and upon installation, will be released into the system. The sludge could clog small ports, such as expansion valves and capillary tubing.

On large commercial systems, a replaceable element filter-drier is used. The filter-drier is bolted together, and replacement cores are available in vacuum-packed metal containers. See **Figure 11-34.**

Special acid-removing filter-driers are available for field installation in the suction line. Such filter-driers are used to clean the system and protect a new compressor following a burnout.

Domestic filter-drier

Domestic systems (refrigerators and freezers) also have a filter-drier, but it is much smaller than those used on commercial systems. The body of the domestic filter-drier is made of copper and is brazed into the system at the outlet of the condenser, **Figure 11-35.** These filter-driers are normally direction-sensitive, but some small-capacity units are nondirectional.

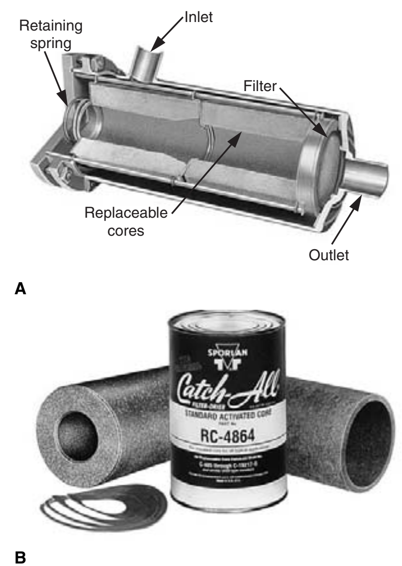


Figure 11-34. *Replaceable element filter. A—A cutaway view shows the installation of two cores (elements) in the receiver-drier shell. Access is by means of the bolted cover at the left. B—Replacement elements are packed in sealed cans that exclude moisture. Typical cores are shown. (Sporlan Valve Co.)*

Domestic systems need a filter-drier to ensure trouble-free operation. Due to the small amount of refrigerant circulating in the system, a single drop of excess moisture will cause a freeze-up. The components in the system are quite small; any foreign material will cause severe problems. When a domestic (hermetic) system is opened for repairs, the filter-drier should always be replaced.

Figure 11-35. *Small filter-drier intended for a domestic unit. The copper tubes at each end are brazed into the system at the condenser outlet. (Parker-Hannifin)*

11.6 Sight Glass

The ***sight glass,*** **Figure 11-36,** is a small window placed in the liquid line on commercial systems to provide a view of the flowing liquid. The sight glass serves as a valuable service aid: visible bubbles indicate problems within the system. Problems could be low refrigerant charge, low head pressure, insufficient subcooling, restrictions, or poor piping design. The sight glass is usually located close to the liquid receiver and immediately after the filter-drier, **Figure 11-37.**

The sight glass shows clear if the line is full of liquid and shows bubbles if the system is having problems. An occasional bubble is not unusual or harmful, but excessive bubbles indicate trouble in the system.

While the sight glass shows clear when full of liquid, it also shows clear when empty. To determine the correct situation, frontseat the liquid receiver service valve, and pump down the system while looking through the sight glass. An empty system shows no change. A full system, however, appears full, shows bubbles, and then appears empty.

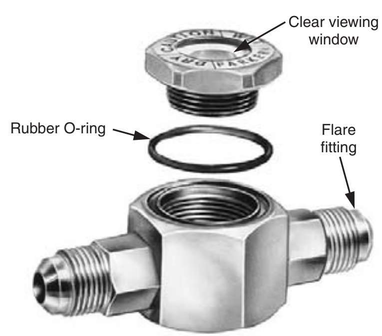


Figure 11-36. *Typical sight glass. The clear window allows the technician to "look inside" the system and diagnose problems by the appearance of the refrigerant. Sight glasses are available with various types of fittings to suit different system configurations. (Parker-Hannifin)*

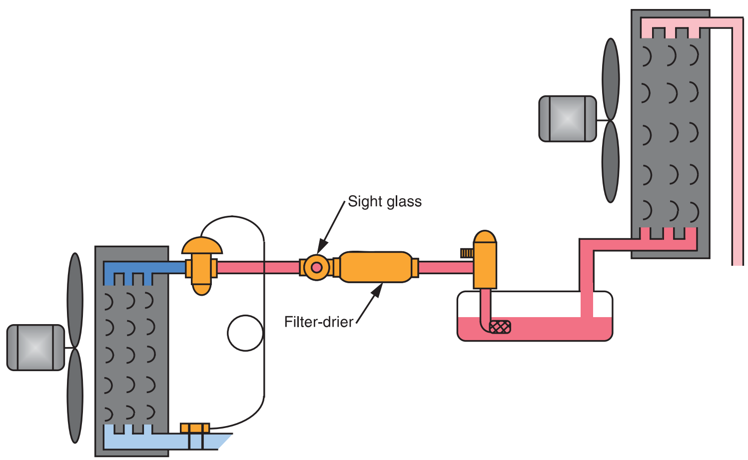


Figure 11-37. *The sight glass is normally installed immediately after the filter-drier in the liquid line.*

11.6.1 Sight Glass with Moisture Indicator

Most sight glasses have a ***moisture indicator*** centered within the viewing window, **Figure 11-38.** The indicator is highly sensitive to moisture, gradually changing color to reflect the moisture content in the refrigerant. The indicator element is completely reversible and changes color as often as the moisture content of the refrigerant varies.

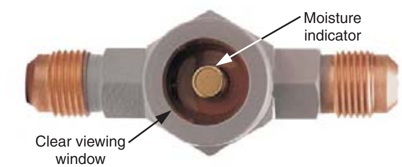


Figure 11-38. *Typical sight glass with a moisture indicator in the center. The indicator gradually changes color to reflect the presence or absence of moisture. (Sporlan Valve Co.)*

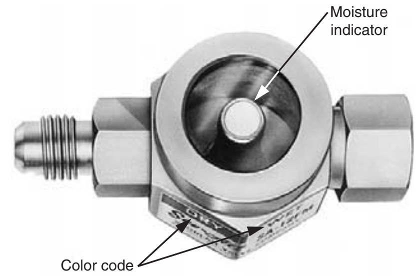


Figure 11-39. *Colors the moisture indicator uses to show wet or dry conditions are displayed on the sight glass rim or body. In this example, the color code is on a label attached to the body. Colors for each condition vary among manufacturers. (Sporlan Valve Co.)*

Some change in color takes place rapidly at the start-up of a new system or after the filter-drier is replaced. The system should operate for about 12 hours before you decide (based on the moisture indicator) that another filter-drier change is needed. Drying of the refrigerant should continue until the indicator element changes to the proper color.

All halogenated refrigerants (such as R-12, R-22, or R-502) accept very small amounts of moisture and still function properly. However, when these levels are exceeded, severe problems develop. The amount of moisture in a refrigeration system must be kept to an absolute minimum to provide trouble-free operation. Every precaution must be taken to prevent moisture from entering the system during installation or service operations. Any moisture that *does* enter the system should be removed quickly.

A color reference code is printed around the edge of the sight glass or on the front of the sight glass body, **Figure 11-39.** One manufacturer's color code varies from dark green (dry), to light green (caution), to bright yellow (very wet). Another manufacturer's indicator changes from dark blue (dry), to light blue (caution), to pink (very wet). A plastic or metal cap keeps the glass free of dust, dirt, and grease. The cap should always be replaced. Unlike commercial installations, domestic systems do not use a sight glass or moisture indicator.

The moisture indicator is chemically engineered for long life, accuracy, and reliability. The same indicator can be used for all common refrigerants. The indicator element will show a wet condition before installation, but that is normal and simply reveals ambient humidity. Most sight glasses are installed with flare connections, but sweat types are also available.

11.7 Heat Exchanger

"Heat exchanger" is a general term to describe any device that transfers heat from one medium to another. However, in the commercial refrigeration industry, ***heat exchanger*** describes a particular component that transfers heat from the warm liquid line to the cold suction line, **Figure 11-40.** The heat exchanger performs two mutually beneficial tasks:

- ❑ It subcools the refrigerant in the liquid line before it reaches the refrigerant control valve, improving the system's efficiency.
- ❑ It superheats vapor inside the suction line with heat removed from the warm liquid line. This prevents liquid refrigerant from reaching the compressor.

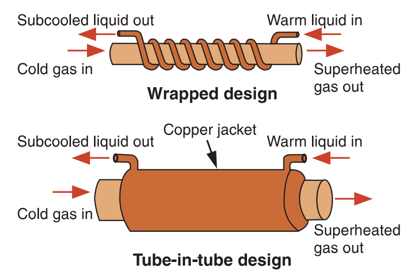


Figure 11-40. *A heat exchanger has a dual role: it subcools liquid refrigerant in one line and superheats refrigerant gas in the other. The two designs shown are common.*

The liquid line is wrapped around the suction line for several turns before traveling to the refrigerant control valve. Some heat exchangers use the highly efficient tube-in-a-tube design. In domestic models, the small capillary tube used for the refrigerant control is soldered to the suction line for almost its entire length.

Heat exchangers are designed to perform a dual function in a system and should not be added to, or removed from, a system without proper engineering information.

11.8 Suction Accumulator

The ***suction accumulator*** is a device that keeps liquid refrigerant from entering the compressor, **Figure 11-41**. The accumulator is a cylinder that acts as a trap to collect liquid refrigerant and permits only vapor to exit. Liquid entering the accumulator must boil off inside the device before exiting as a vapor.

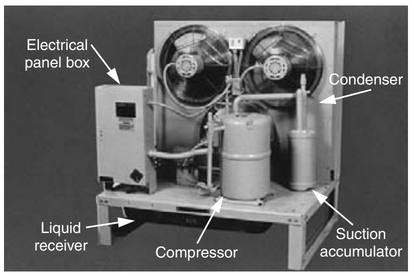


Figure 11-41. *Commercial condensing unit showing the relationship of the suction accumulator and the compressor. The accumulator keeps liquid refrigerant from reaching the compressor. (Hussmann Corporation)*

Domestic systems locate a small accumulator at the evaporator outlet, with the suction line coming out the top of the accumulator. This prevents liquid from entering the suction line. Liquid entering the bottom of the accumulator remains inside until the liquid boils. Only vapor can exit and enter the suction line at the top of the accumulator.

The accumulator is an upright cylinder with two openings in the top: the *inlet* and the *outlet,* **Figure 11-42.** The suction line is brazed to the inlet opening; any liquid refrigerant entering from the suction line falls to the bottom of the cylinder. The outlet opening has a dip tube that goes to the bottom of the cylinder, makes a 180° bend, and extends upward toward the top of the cylinder where only vapor can enter the tubing to the compressor suction service valve.

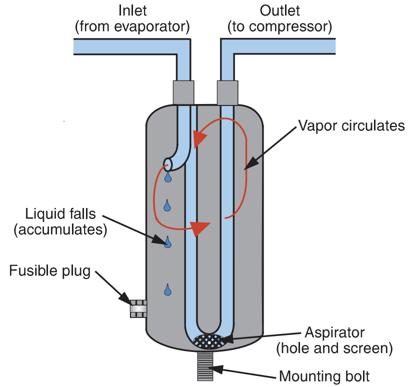


Figure 11-42. *Interior view of a suction accumulator. The 180° bend of the outlet tube permits only vaporized refrigerant to emerge from the accumulator.*

Liquid refrigerant is trapped in the bottom of the accumulator until it evaporates. A small hole (called an ***aspirator hole***) is drilled in the side of the 180° bend. The hole permits small quantities of oil to enter the outlet tube and be drawn back to the compressor. Without the aspirator hole, the accumulator would trap oil and deprive the compressor of proper lubrication. Small amounts of liquid refrigerant may enter the aspirator hole but evaporate before reaching the compressor; therefore, they are harmless.

Summary

Figure 11-43 illustrates a refrigeration system with all the components introduced in this chapter. Each component serves a specific purpose. A refrigeration system seldom has all these additional components, but some are found on every system. Many systems require the use of accessory components to properly control the movement and condition of the refrigerant.

This chapter was devoted to explaining how accessory components operate mechanically and *why* they are used on different systems. All systems are designed to control the movement and condition of the refrigerant. Later chapters will explain how the system itself is controlled. Troubleshooting and repairs cannot be performed correctly without understanding the effect of each component on the system. Being able to draw the entire system (as shown in Figure 11-43) from memory will be a plus as you study later chapters.

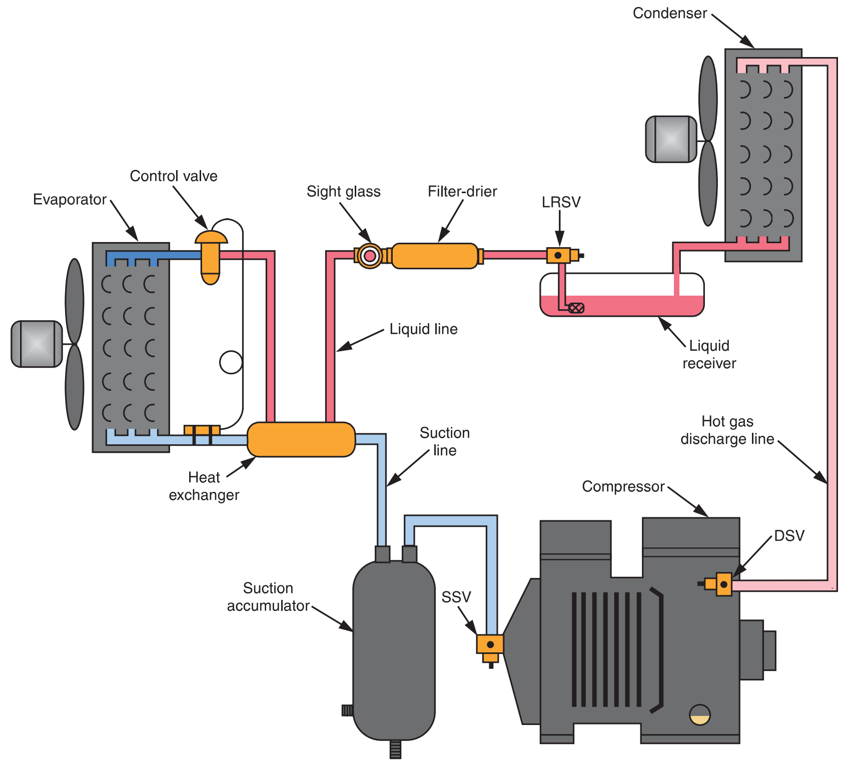
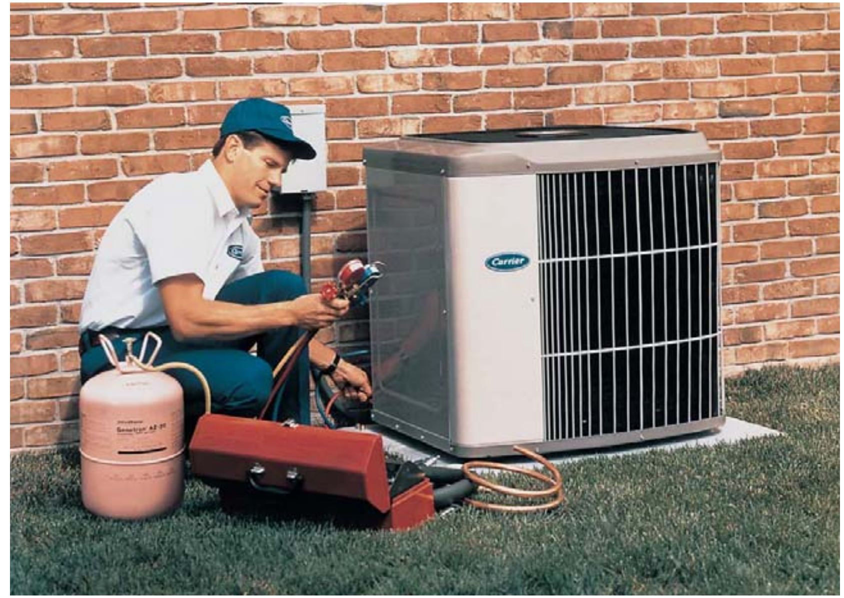


Figure 11-43. *Complete refrigeration system showing location of accessories.*

Test Your Knowledge

Please do not write in this text. Write your answers on a separate sheet of paper.

1. What two copper lines connect the evaporator section with the condensing unit?
2. Where is the condensing unit located on a domestic refrigerator?
3. What is the purpose of the liquid receiver?
4. The liquid receiver should never be more than _____% full when it contains the system's entire refrigerant supply.
5. Name three service valves used on commercial systems.
6. At which two service valves can you obtain high-pressure readings?
7. When a service valve is backseated, which opening is closed?
8. When a service valve is backseated and then cracked, which opening is closed?
9. Frontseating the suction service valve closes which opening?
10. What is the name of the fitting used on service valves to install gauges? What sizes and thread types are the fitting ends?
11. Name two types of service valves installed by technicians on domestic systems.
12. Hand valves on the gauge manifold control access to the _____ hose.
13. Are hand valves on the gauge manifold normally closed or open?
14. Where is the filter-drier located?
15. What is the purpose of the filter-drier?
16. What does a large number of bubbles in the sight glass indicate?
17. Where is the sight glass installed?
18. What is the purpose of the moisture indicator?
19. A heat exchanger has a dual purpose. Describe what it is.
20. Name all 15 possible system components, in order of refrigerant flow, beginning at the evaporator.



Refrigerant is charged into a system using a manifold gauge. (Allied Signal)