After studying this chapter, you will be able to:
- Identify HVAC system diagnostic and test equipment.
- Identify types of refrigeration system service equipment.
- Explain the concept of dedicated refrigeration system service equipment.
- Identify engine cooling system test and service tools and equipment.
- Identify HVAC control system service tools.
- Identify HVAC and cooling system service information.

Diagnostic and Test Equipment

The following equipment must be obtained to perform any refrigeration or other HVAC system diagnosis. This equipment is also used to perform some HVAC service and replacement.

Gauge Manifolds

Gauge manifolds are the most basic of all refrigeration system tools. The gauge manifold is used as both a diagnosis and a service tool. The technician must have R-134a specific gauge manifolds to service R-134a and R-12 refrigerants. Most technicians have their own gauge manifolds. Manifold gauges are used to remove contaminated or unknown blend refrigerants from the air conditioning system, reducing the chance for cross-contaminating a service machine. In shops that perform a large volume of air conditioning work, technicians often have their own gauge manifolds as part of their toolset.

All gauge manifolds have the same basic parts, although there are some variations among manufacturers. The major parts of a common gauge manifold are shown in Figure 3-1. Refer to this figure as you read the following paragraphs.

Manifold Body and Hand Valves

The manifold body is made of brass or aluminum. Passages are drilled in the body to connect the other manifold parts. Some manifold bodies have a sight glass to observe the flow of refrigerant. Hand valves are used to control the flow of refrigerant through the passages of the manifold body. A cross-section of the manifold body and hand valves is shown in Figure 3-2. Note the internal passages are arranged so the gauges can read refrigeration system pressures when the valves are closed.

The hand valves used on R-12 and R-134a gauge manifolds are usually arranged in the same way, or on a slant or in front of the manifold. These different arrangements make manifold identification easier. Valve wheels for the high and low sides are identified by color. The low side handwheel is made of blue plastic or has a blue decal on its center. The high side handwheel is made of red plastic or has a red decal.
Gauges

The gauges used with a refrigeration gauge manifold are either analog (indicator needle), which resemble other pressure gauges, or digital. See Figure 3-3. In an analog gauge, the position of the needle in relation to the numbers on the gauge face indicates the pressure or vacuum in the refrigeration system. Digital gauges provide a numerical reading indicating system pressure or vacuum.

All gauge manifolds have high and low pressure gauges. A few older gauge manifolds have three gauges. The third gauge was used to measure compressor output. Older high side gauges are calibrated from 0-500 psi (3445 kPa). Newer high side gauges may be calibrated from 0-250 psi (1723 kPa). Low side gauges are calibrated from 0 to 100-250 psi (689-1723 kPa). In addition to the pressure scale, low side gauges have a provision for measuring 0-29.9" of vacuum (approximately 50 microns). Vacuum measurements are explained later in this chapter.

R-134a and R-12 Gauges

There are no major differences between R-134a and R-12 gauges. The internal operation of each type of gauge is the same. The difference is the calibration of each gauge, and the markings on the gauge faces. R-134a and R-12 gauge manifolds cannot be interchanged.

Manifold Hoses

Manifold hoses are tubes of high strength nylon or fabric cord covered by neoprene rubber. Most hoses are rated to withstand 500 psi (3445 kPa) pressures. At each end of the hose is a connector that allows it to be attached to the gauge manifold and the refrigeration system. Hoses used with a gauge manifold have connectors designed to match the refrigerant being measured by the gauges. Compare the hose connectors in Figure 3-4. These hoses can be replaced if damaged or worn, however, they are not interchangeable. Most hoses are colored blue for the low side and red for high. The center hose is usually yellow.

Hose Fittings and Adapters

Many gauge manifolds are equipped with fitting adapters, shut-off valves, and other features. These are attached to the hoses. Typical valves are used to isolate refrigerant present in the hoses. This keeps refrigerant loss to a minimum. R-12 refrigeration systems made since 1986 have different size service fittings to prevent the technician from accidentally crossing the high and low side connections. Adapters are used to allow the same gauge manifold to be used on these refrigeration systems. See Figure 3-5. Adapters are not needed on R-134a systems since they use standardized fittings.

Attaching and Reading Gauges

To attach and read the gauge manifold, first make sure the hand valves are closed. Then remove the refrigeration service fitting caps and attach the hoses. Remember the blue hose attaches to the low side of the system, and the red hose is connected to the high side. R-134a and R-12 hose connectors have different fittings, and therefore, different attachment methods. R-12 fittings are threaded. The hose connector is also threaded and is screwed onto the fitting. R-134a fittings are somewhat similar to those used on air hoses. The hose connector is a quick disconnect with an isolation valve. Once the connectors are installed, open the hose isolation valves as needed. Do not open the hand valves on the manifold body.

Once the hoses are in place, you can read the static pressures. Static pressures are the pressures in the refrigeration system when the system is not operating. If the system has been off for 30 minutes or more, the high and low side pressures should be almost the same (within a few pounds or kPa). Other uses for the gauge manifold will be covered in the chapters where they apply.

Temperature Gauges

Temperature gauges are used to test the temperature of the air exiting the HVAC system vents and to check the temperature of the engine coolant. The two main types of temperature gauges are mechanical and electronic. They are discussed in the following paragraphs.

Mechanical Temperature Gauge

The mechanical temperature gauge, Figure 3-6, relies on an internal bimetal spring to register temperature differences. The bimetal spring is a coil of wire made of two kinds of metal. Each metal expands at a different rate as its temperature changes. Therefore, changes in temperature cause the coil to tighten and loosen. The coil is attached to the gauge pointer. Movement of the pointer against the gauge face indicates the temperature.

Electronic Temperature Gauge

The electronic temperature gauge uses infrared waves to measure temperature. Infrared waves are waves similar to light waves, although they cannot be seen. Temperature
changes in an object cause the infrared waves given off by the object to change. A sensor in the gauge reads the change in infrared waves as a temperature change. Internal circuitry converts sensor readings to digital temperature readouts. See Figure 3-7.

Leak Detectors

Leaks in the refrigeration system will cause the system to lose its refrigerant charge. Loss of refrigerant will cause the system not to work properly and could also damage the ozone layer. In many cases, it is difficult to determine the exact location of the leak as well as how severe it is. Leak detectors are needed to accurately locate leaks. The various kinds of leak detectors are discussed in the following sections.

Electronic Leak Detectors

Using an electronic leak detector is the most accurate way of locating leaks. Electronic detectors use a small solid state sensor that can detect extremely small leaks. The detector also has a probe used to draw refrigerant into the sensor. The detector tip may contain a filter to catch oil and debris. Most electronic leak detectors will make a ticking noise which increases in frequency as the detector encounters refrigerant. Large leaks cause the ticking to a high pitched squeal. Many electronic leak detectors have an LED display which indicates the leak rate. The detector may use different color LEDs as the refrigerant concentration increases. Some electronic leak detectors can automatically determine the type of refrigerant in the system.

A typical electronic leak detector, Figure 3-8, always uses a small internal battery to power the unit. The detector will also have an on-off switch, and may contain a range selector switch to allow for checking large and small leaks.

To use an electronic leak detector, turn on the detector switch. Adjust the sensitivity to produce an occasional ticking. Then pass the detector probe end under the suspected refrigerant leak areas. Since refrigerant is heavier than air, it will flow downward from a leak. If refrigerant is leaking, the detector rate of ticking will increase. Large leaks will cause a high pitched squeal. When through using the detector, turn the control switch to the off position and replace the detector in its case.

Dye

Dye is used to locate minute leaks. The dye is injected into the refrigeration system and allowed to circulate for a few minutes. Some of the dye will leak out along with any refrigerant and stain the components at the site of the leak.

Older refrigerant dyes were colored orange and were contained in a small can resembling a one pound refrigerant can. The can was connected to the system low side through the gauge manifold. With the system operating, the dye was drawn into the system. After the dye circulated for a few minutes, the technician could look for the presence of orange dye. Dye cans are still used in some areas.

Modern dye injectors are designed to inject a fluorescent dye directly into the refrigeration system, Figure 3-9A. The detector is attached to one of the system service ports and the handle is turned to force the dye into the system. After dye has circulated through the operating system for a few minutes, the technician shines an ultraviolet light, such as the one shown in Figure 3-9B, on the suspected leak points. If any of the dye has leaked out, it will glow under the ultraviolet light.

Halide Flame Detector

The halide flame detector is not as accurate as an electronic detector. It will, however, detect relatively large refrigerant leaks. The halide detector consists of a propane cylinder attached to a burner, Figure 3-10. A sensing hose draws refrigerant from the suspected leak area. A copper reaction plate improves the combustion process between the refrigerant, propane, and air.

Warning: Halide flame leak detectors are very dangerous. They should only be used if no other detection method is available. A refrigerant identifier should be used before using a halide detector to reduce the chance of fire or an explosion. They should only be used with R-12 systems.

To use a halide leak detector, light the burner. After a few minutes operation, the reaction plate will glow dull red. Adjust the flame as necessary, then pass the free end of the sensing hose under any suspected leak areas. If refrigerant is present, the flame will change color. Small leaks will cause the flame to develop a greenish tint. A large leak will cause the flame to turn bright blue.

When the leak detecting process is finished, tightly close the propane valve and allow the tester to cool before returning it to storage. The propane valve should be closed tightly when the flame detector is not in use.

Soap Solution

The soap solution method will find large leaks only, and should not be relied on to locate small leaks or leaks in inaccessible locations. It is primarily used to confirm what appears to be an obvious leak. Soap solution is sometimes the only detection method available if a system has been filled with a refrigerant other than R-134a or R-12.
A soap solution can be made by mixing a small amount of dishwashing liquid or other soap with water. The solution is then sprayed or poured on the suspected leak area. Leaking refrigerant will form bubbles. The size of the bubbles and how rapidly they form will increase with the size of the leak. Slight foaming will occur at the site of a small leak, while large bubbles will be seen at a serious leak. If large bubbles form at a rate faster than one per second, the leak can be considered severe.

Refrigerant Identifiers

To avoid contaminating the recycling equipment with incorrect or contaminated refrigerant, many air conditioning specialists identify the refrigerant before beginning service. A refrigerant identifier, Figure 3-11, is used to determine what kind of refrigerant is installed in a refrigeration system or storage container. Refrigerant identifiers are usually designed to tell whether the refrigerant is R-134a, R-12, or an unknown blend. Some refrigerant identifiers can also determine the percentage of each type of refrigerant, and identify contaminated refrigerant.

Disposing of Contaminated Refrigerant

When contaminated or unfamiliar refrigerant has been found, it must be stored in special containers pending its disposal. Contaminated refrigerant containers are gray with a yellow top. Contaminated refrigerant containers should be shipped to a reclaiming facility for recycling or disposal. Storage and recycling of contaminated and unfamiliar refrigerant was discussed in Chapter 2. More information on refrigerants is located in Chapter 6.

Electrical Test Equipment

The HVAC system contains many electrical components, wire harnesses, and electrical connectors that require testing. The technician will frequently have to diagnose electrical devices and wiring.

Figure 3-11. A refrigerant identifier should always be used before recovering refrigerant.

Note: Only digital multimeters should be used for air conditioning and other automotive work. Make sure any meter or test light has a minimum of 10 meg ohm impedance.

Test Lights

The test light is often used to check whether electricity is reaching a particular point in an electrical circuit, or to detect a circuit not allowing current to flow. The non-powered test light, Figure 3-12, can be used to probe electrical circuits to determine whether voltage is present. A powered test light resembles the non-powered light but has an internal battery. The battery supplies an electrical power source to determine whether a circuit is complete. Test lights can be useful when working on various parts of the HVAC electrical system, but must be used with care when working on any electronic system. The test light has the potential to severely damage electronic circuits. Avoid using test lights unless specifically instructed by the HVAC system manufacturer's service literature.

Figure 3-12. Non-powered test lights are useful for determining if voltage is present in a circuit.

Multimeters

Multimeters, such as the one in Figure 3-13, are devices for reading electrical values. Modern multimeters can read all common electrical values (voltage, resistance, and amperage). Many modern multimeters are digital types that display the electrical reading as a number. Analog multimeters use a needle, which moves against a calibrated background. Modern multimeters contain the individual meters discussed in the following paragraphs.

Caution: Electronic components can be damaged by careless use of multimeters. Always check the manufacturers' literature before testing any electronic part.

Most modern digital multimeters will select the correct range automatically. Attach the leads to the wires or terminals to be tested. When checking wires or relay contacts for continuity, the resistance should be at or near zero. Other parts, such as motor or solenoid windings and temperature sensors should have a specific amount of resistance. If the reading is zero or infinity, the part is defective. The resistance of temperature and sunload sensors should change with changes in temperature or exposure.

Figure 3-13. Multimeters contain several electrical testers, such as voltmeters, ammeters, and ohmmeters. (Fluke)

Voltmeter

The voltmeter section of the multimeter is connected to read voltage from a circuit. To read the voltage at an electrical connection, connect the leads to the positive side of the circuit and a ground. If necessary, select the proper voltage range, then observe the reading. The voltmeter can also be connected to read the voltage across a connection as current flows through it. If the connection has high resistance, current will try to flow through the meter, creating a voltage reading. Voltage higher than the specified figure means the connection must be cleaned or replaced.

Ohmmeter

An ohmmeter can be used to check electrical resistance values. Ohmmeters can also be used to check for complete circuits. To make an ohmmeter check, turn on the multimeter and set it to ohms.

Figure 3-14. Oscilloscopes can be used to diagnose problems in computer circuits. (MAC Tools)
Vacuum Pumps/Gauges

The hand-held vacuum pump and vacuum gauge, Figure 3-17, is used to apply and measure the effect of vacuum on HVAC system diaphragms and control valves. The pump assembly develops vacuum, which is measured on the gauge. To use the gauge, remove the hose to the vacuum operated device. Then operate the pump to apply vacuum to the device. Observe the gauge. If vacuum cannot be developed, or bleeds away rapidly, the unit is leaking. Also check for operation of the related linkage as vacuum is developed. If the linkage does not move when the vacuum is increased, the linkage or the door is stuck.

Figure 3-15. This belt tension gauge provides a direct reading of belt tension. (Ford)

Figure 3-16. The belt tension gauge shown here is set to the proper reading and then the belt is deflected.

A Belt tension gauge, Figure 3-15, is needed. To use the belt tension gauge, use the handle to push the center lever away from the two side levers. Slide the tool between the belt and release the handle. Then read the tension on the gauge. Another type of belt tension gauge is shown in Figure 3-16. This type of tension gauge measures belt tightness by measuring the belt deflection under a certain pressure. To use this kind of tension gauge, turn the gauge sleeve until the end of the sleeve is at the proper belt tightness marked on the barrel. Then push the metal bar downward until it lines up with the line on the lower end of the barrel. Next place the gauge on a flat section of belt and push downward until the metal sleeve reaches zero. If the metal bar is pushed above the gauge line, the belt is loose.

Figure 3-17. The small manual vacuum pump and gauge is used to produce a vacuum for checking vacuum operated accessories such as air door vacuum diaphragms and vacuum heater shutoff valves. It can also be used to check the operation of vacuum switches.

HVAC System Service Tools

Once the problem has been located, the HVAC system must be repaired. Many repairs can be made with ordinary hand tools. Many service jobs require wrenches with large jaw openings. These large size wrenches are used to loosen the large fittings used on many refrigerant lines. A few HVAC service jobs require special tools.

Compressor Service Tools

Most shops prefer to replace entire compressors rather than repair them. If a compressor is being repaired, the following tools may be needed to service the seals and internal parts. Servicing older compressors may require additional special tools. The technician should consult the proper service information for information about these tools.

Figure 3-18. Snap ring pliers are needed to remove snap rings from inaccessible locations.

Figure 3-19. Compressor shaft seal tools include special snap ring pliers as well as O-ring and seal tools. A—Seal remover and protector. B—O-ring installer. C—Compressor leak adapter.

Figure 3-20. In some cases, a refrigeration hose has to be manufactured. Sometimes the exact replacement hose is no longer available. In other cases, making a hose is much cheaper than obtaining an exact replacement. Making hoses requires the use of hose cutters and crimping tools.

Snap Ring Pliers

Special size and shape snap ring pliers are sometimes needed to remove compressor pressure switches, pulleys, and shaft seals. Some of these pliers are shown in Figure 3-18. In many cases, standard or universal snap ring pliers can also be used.

Compressor Service Tools

Compressor clutches and shaft seals cannot be removed with conventional tools. Several tools are needed to remove these and other compressor parts. They include special pliers to remove internal snap rings and holders to replace the seals and O-rings. See Figure 3-19.

If a replacement for an older compressor is not available, the original compressor may need to be overhauled instead of replaced. To overhaul a compressor, special internal service tools are needed.

Compressor Clutch Service Tools

Compressor clutch service often requires special tools to hold the clutch in place while other tools are used. These holding tools are sometimes called spanners. Other tools are used to remove pulleys or clutch bulbs from the compressor. Additional tools may be needed to press new clutch pulleys or clutch bulbs onto the compressor or clutch hub, as shown in Figure 3-20.

Pressure Test Equipment

To save unnecessary work, it is best to pressure test complex parts such as compressors after repairs are complete, but before the compressor is reinstalled. Special pressure test fittings allow the technician to pressurize the compressor on the bench. To prevent environmental damage, the compressor should be pressurized with nitrogen or another inert gas. Figure 3-21A shows a typical pressure tester using nitrogen. Nitrogen is supplied in large tanks such as the one in the left of the photo. This tester can also be used to test hoses. Hose testing adapters are shown in Figure 3-21B.

Pressure test equipment is used to apply and measure the effect of vacuum on HVAC system diaphragms and control valves. The pump assembly develops vacuum, which is measured on the gauge. To use the gauge, remove the hose to the vacuum operated device. Then operate the pump to apply vacuum to the device. Observe the gauge. If vacuum cannot be developed, or bleeds away rapidly, the unit is leaking. Also check for operation of the related linkage as vacuum is developed. If the linkage does not move when the vacuum is increased, the linkage or the door is stuck.

Figure 3-15. This belt tension gauge provides a direct reading of belt tension. (Ford)

Figure 3-16. The belt tension gauge shown here is set to the proper reading and then the belt is deflected.

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Figure 3-15. This belt tension gauge provides a direct reading of belt tension. (Ford)

Figure 3-16. The belt tension gauge shown here is set to the proper reading and then the belt is deflected.
Crimping Tools
Crimping tools are made to crimp, or form, a fitting around a hose end. The major difference between types of crimping tools is the size and shape of the collets. The collets actually contact the fitting and crimp it to the hose. There are two common kinds of hose fitting types, the barb fitting and the beadlock fitting. A different crimping machine is used to make each fitting type. Each machine and its related parts are dedicated and cannot be used to make the other type of crimped fitting.

Crimping tools can be operated by hand or by hydraulic pressure. A typical hand operated crimping tool is shown in Figure 3-23. Hand crimping tools are inexpensive and can do a good job of making a crimped hose. The hydraulic powered crimping tool, Figure 3-24, uses a small hydraulic pump to create the pressure needed to operate the hydraulic piston.

To use either type of crimping tool, select the proper hose and hose fittings and lightly oil them. Then select the proper collets and place them into the crimping machine. Assemble the fitting on the hose end and place the hose and fitting in the crimping machine. Operate the machine to crimp the fitting. After the crimping operation is complete, make sure the crimp was made properly.

Figure 3-20. Clutch holding tools are often needed to keep the compressor clutch from turning while the center bolt or nut is removed. A—Hub holding tool. B—Pulley puller. C—Hub and drive plate remover and installer. D—Compressor pulley puller. E—Hub and drive plate remover/installer. F—Clutch hub installation tool. (Kent Moore)

Orifice Tube Tools
Many systems require an orifice tube tool to remove the orifice tube from the evaporator inlet. A typical orifice tube tool is shown in Figure 3-25. To use the orifice tube removal tool, the refrigeration system must be discharged. Once the refrigerant is removed, disconnect the fitting at the evaporator inlet and insert the orifice tube tool. Slightly turn the tool to engage the tangs of the tool and tube, then withdraw the tube. To install the new orifice tube, place it on the tool, then insert the tool and tube into the evaporator inlet. Slightly twist the tool to disengage it from the tube, then withdraw the tool.

Oil Injectors
Oil injectors are used to install lubricating oil in the refrigeration system without discharging the system. There are two kinds of oil injectors in common use. To use the type shown in Figure 3-26A, fill it with the proper type of compressor oil. Then with the HVAC system off, install the injector service fitting. Turn the forcing screw at the top of the injector to force the oil into the system. Then remove the injector from the fitting.

Another type of oil injector, Figure 3-26B, is installed in the hoses of the gauge manifold. To use this type of injector, pour the proper type of oil into the reservoir. Attach the oil injector to one of the manifold hoses. Attach the hoses to the refrigeration system and purge the hoses and injector as necessary. Then start the engine and place the HVAC system in maximum cooling. Allow the refrigeration system pressures to stabilize. Next, slightly open the high and low side valves. The difference in pressures will force the oil into the low side of the refrigeration system. Allow the system to operate long enough for all oil to enter the system, then close the valves and remove the injector and gauge manifold from the refrigeration system.

Refrigerant Service Equipment
The following section covers large shop equipment used to service the refrigeration system. During air conditioner service, the refrigeration system may need to be emptied of refrigerant, flushed of contaminants, placed under a vacuum, and recharged.
Recovery/recycling equipment is used to recover and recycle the refrigerant in a system. Refrigerant must be recovered and recycled to meet federal laws. Recycling equipment removes the refrigerant from a refrigeration system and stores it for reuse. When the refrigerant is needed, the equipment recycles (reinstalls) it into the same or another vehicle refrigeration system.

Most recovery and recycling machines also clean and dehumidify refrigerant for immediate reuse. The refrigerant may be stored in a standard 30 pound cylinder or in a separate charging tank. Most machines are designed to recycle R-134a or R-12 only. Recycling equipment is attached to the vehicle refrigeration system through hoses in the same manner as a gauge manifold.

**Dedicated Machines**

Different types of refrigerants cannot be mixed. Therefore, each refrigerant service machine can only be used with one type of refrigerant. These machines are called dedicated machines. An air conditioning service shop must have a separate dedicated machine for each type of refrigerant. In most shops, this means every machine used for R-134a must have a companion machine for use with R-12. If the shop uses a third refrigerant, a separate machine must be used for that refrigerant. Some newer units are combination types, which can service systems using either type of refrigerant. Typical recovery/recycling machines for R-12 and R-134a are shown in Figure 3-27.

**Combination Machines**

Many modern machines are combination machines. A combination machine combines many of the components discussed in this chapter into a single unit. Most combination units have gauges, vacuum pumps, storage tanks, charging scales, and various refrigerant pressure and contamination indicators. The operation of these units is the same as for individual units. However, selecting switches at the combination machine control console performs all of their functions.

**Flushing Equipment**

Occasionally a contaminated refrigeration system must be flushed. There are two ways to flush a system, open and closed loop. Open loop flushing is done with an air-operated blowgun, while closed loop flushing is performed with special flushing equipment. Both types are explained in the following paragraphs.

**Air-operated Guns**

An air-operated rubber tip blowgun, Figure 3-28, is often used for open loop flushing. Some versions of the blowgun use a tank and hose design that injects the solvent into the system using air pressure, Figure 3-29. Open loop flushing is always done with refrigerant compatible solvents. To use an air-operated gun for flushing, recover the refrigerant and disconnect the fittings from the component to be flushed. Attach a drain hose to the inlet opening of
the component, then pour about one pint of solvent into the outlet opening of the component. Use the blowgun to direct compressed air or nitrogen into the outlet end of the component. Use no more than 100 psi (689 kPa) air pressure. Always blow in reverse direction to the refrigeration flow first to loosen as much debris as possible. Add solvent and repeat until only clean solvent comes out. After the component has been reverse flushed, make at least one pass in the forward direction.

Closed Flushing Systems

Closed flushing systems are machines that attach to the refrigeration system, and flush the system without taking any components loose. Closed flushing systems are special refrigerant cycling machines, or recovery and recycling machines adapted to direct the solvent through the system.

Closed loop flushing will not open completely blocked passages. It will remove oil and some contamination. To perform closed loop flushing, connect the machine to the system and follow the manufacturer's instructions.

Evacuation Pumps

Evacuation pumps are used to remove water (sometimes called moisture) from the refrigeration system.

Air Pressure Pumps

Air pressure evacuation pumps, Figure 3-31, use what is known as a venturi effect to operate. The flow of compressed air through an air pressure operated pump creates a small vacuum that is used to draw air from the refrigeration system. Air pressure operated pumps are cheaper but less effective than electrically operated models. Most air-operated pumps produce less vacuum than an electric pump, anywhere from one half to one inch less. This type of pump must be allowed to operate for longer periods than an electric model.

Recharging Equipment

Once all repairs are completed, the refrigeration system must be recharged. The simplest method of recharging the system is to use a gauge manifold, discussed earlier in this chapter. Remember from Chapter 2 that R-134a containers are always blue, while R-12 containers are white. Be careful not to mix refrigerants.

Charging Scale

A simple charging scale enables the technician to charge the refrigeration system by weight. (TIF Instruments) A charging scale allows the technician to charge a refrigeration system with the proper amount of refrigerant by weight. Charging by weight is the most accurate way to recharge a system. The charging scale somewhat resembles a bathroom scale, Figure 3-32. Most charging scales have digital readouts. To use a charging scale, place the refrigerant container on the scale platform and record its weight. Then add refrigerant to the system until the weight loss equals the amount of refrigerant to be added to the system. Some charging scales allow you to program the amount of refrigerant to be added to a system. Once the scale is activated, it will signal when the proper weight of refrigerant has been added.

Charging Stations

A charging station combines the features of other refrigeration service equipment into a single unit. The typical charging station has gauges and connecting hoses, a storage area for refrigerant cylinders, and a weighing scale or other device for ensuring the proper amount of refrigerant is installed. Figure 3-33 shows a typical charging station.

Air Purging Equipment

Most air purging equipment is built into refrigeration service devices such as recovery/recycling machines and charging stations. Purging is done automatically by the internal circuits of the device. A few charging stations are equipped with a manual purging device. This device consists of a dual needle gauge, Figure 3-34. When both needles are in the same position, all air has been purged. When the needles are in different positions, the refrigerant cylinder must be purged. To purge the cylinder, open the cylinder valve until the needles are in the same position.

Engine Cooling System Test Equipment

The cooling system is sometimes a source of HVAC problems. Cooling system test equipment is used to check the condition of the cooling system and the coolant. Typical cooling system test equipment is discussed in the following paragraphs.
The cooling system must be depressurized and cool before performing this test. The technician must refer to many sources of service literature to properly service HVAC systems. While modern HVAC systems operate from the same basic principles,
they are complex and vary between manufacturers. Minor changes may be made between model years, often chang-ing diagnostic and service procedures. The service literature described in the following paragraphs can simplify HVAC service by providing the latest information.

Factory Manual

The factory manual is published by the vehicle manufacturer or a publishing house contracted by the manufacturer. It contains all necessary service information for that one vehicle. Figure 3-40 shows some typical factory service information. Most modern factory service information now comes in volume sets for one vehicle. The major drawback to the factory manual is its relatively high cost, compared to the limited range of vehicles it can be used with. While this type of manual is extremely detailed, it may not be the best choice if only one system, such as the brakes, is to be serviced.

General Manual

The general manual contains the most commonly needed service information about many different makes of vehicles, such as brake, engine, and transmission specifica-tions, fuse replacement data, and sensor locations. General manuals also contain procedures for preventive mainte-nance and minor repairs.

At one time, general service information for every vehicle could be covered in one manual. Today, due to the large number of different vehicles available, this is no longer possible. Modern general manuals are divided into automobile and light truck editions. Publishers further divide their general automotive manuals into US, European, and Asian models.

The individual chapters of general manuals are grouped according to vehicle make, or several makes that are similar mechanically. Chapter subsections are devoted to particular areas of each make. General manuals also contain separate sections covering repair procedures that apply to all vehicles, such as engine overhaul, brake ser-vice, and starter/alternator overhaul. The major disadvantage of these manuals is the necessity of eliminating most of the information on specialized vehicle equipment, sheet metal, and interior.

Specialized Manual

Specialized manuals cover one common system of many types of vehicle. These manuals are often used to cover such topics as computerized engine controls, elec-trical systems, or brakes. They combine some of the best features of the factory and general manuals. They are often a good choice for servicing one particular system in many different makes and models of vehicles. One example of this type of manual is shown in Figure 3-41.

Figure 3-39. A combustion leak tester may be needed to deter-mine whether a cracked engine component or leaking gasket is causing exhaust gases to enter the cooling system. (Snap-On)

Figure 3-40. Factory manuals are used for one vehicle only. Most newer ones come in volume sets. (DaimlerChrysler, MVCC, Jack Klasey)

Figure 3-41. Many service information publishers, such as Motor and Mitchell publish overhaul manuals. In addition, overhaul manuals are available from vehicle manufacturers.

Figure 3-42. A common electrical schematic such as the one shown above is a road map for the electricity in a circuit. As part of the job, the HVAC technician is often called on to interpret schematics. (General Motors)

Schematics

Schematics are pictorial diagrams which show the path of energy through a system. This energy can take the form of electricity, vacuum, air pressure, or hydraulic pres-sure. Figure 3-42. Schematics do not show an exact replica of a system, but instead indicate the flow or process within the system. Some schematics show the exact flow of a form of energy while others show the general process of a par-ticular system. Schematics are often included as part of the service information, or may be supplied separately.

Tracing the flow through a schematic makes diagnosis easier by showing the exact path of electricity or other form of energy. Each line represents a single wire in the vehicle’s wiring harness. The schematic lines are labeled with numbers to colors to correspond with a specific color, or color and color stripe combination on the actual wires. The path can be traced by carefully following the lines from component to component. Always carefully note the color designations of the wires and any stripes or bands to ensure you are following the correct wire.

Troubleshooting Charts

Troubleshooting charts are summaries, or checklist versions, of the troubleshooting information about a par-ticular vehicle or system. Although the information is found in a longer form elsewhere in the service information, the troubleshooting chart allows the technician to quickly refer-ence the problem, the possible cause, and the solution. Figure 3-43 shows a typical troubleshooting flowchart. Some troubleshooting charts are arranged with the problem on the left-hand side of the page, the possible cause in the middle, and the corrective action on the right-hand side.

Technical Service Bulletins

Frequently, manufacturers issue technical service bulletins (TSB), for newer vehicles to their dealership personnel. These bulletins contain repair information that is used to describe a new service procedure, correct an unusual or frequently occurring problem, or update service
information. Many of the phone hotline and computerized assistance services receive these bulletins. They are a very good source of information to repair an unusual or frequently occurring problem. Subscriptions to these bulletins are also available through various services.

### Telephone Hotlines

If all other sources of information have been exhausted, the technicians may be able to call a **telephone hotline**. Some vehicle manufacturers, part suppliers, and service information publishers provide technical support services over a technical hotline. Calling these hotlines will connect you with a technical support person. Hotline personnel often have information gathered from actual repair and diagnosis situations. This is a way of obtaining real life information that would otherwise not be available. Manufacturer hotlines will also have access to the latest update information from manufacturers’ engineering departments.

Some vehicle manufacturers’ hotlines are available only to the technicians who work for a manufacturer’s dealership. Other hotlines are available by subscription. These hotlines can be accessed after a yearly fee is paid. Some parts manufacturers’ hotlines are available to anyone. These hotlines are intended to help the technician who has questions about the manufacturers’ parts.

### Computerized Assistance

Advancements in technology continue to provide auto technicians with new tools and resources. The availability of electronic media and the popularity of information on demand offer technicians many diagnostic and reference source options.

#### Scan Tools

Scan tools retrieve computer trouble codes and display them in a readable form on an LED or LCD screen. The push-button keypad is used to select functions and enter information. The first scan tools were used to display information about engine operating conditions, such as coolant temperature and ignition timing. New scan tools also access body and chassis computers to retrieve information about non-powertrain accessories, including the heating and air conditioning system.

Scan tools are connected to the vehicle’s **data link connectors**, usually called DLCs. All vehicles manufactured since 1996 have OBD II systems and use standard 16-pin diagnostic connectors. This enables OBD II scan tools to access the computerized systems of more than one vehicle manufacturer through the electronic control module (ECM). Modern scan tools may perform system checks by forcing certain vehicle components to operate. This can help the technician diagnose an intermittent performance problem by taking a “snapshot” of the sensor inputs and computer outputs while the problem is occurring. Some scan tools also have built-in multimeters and waveform meters. OBD II scan tools can be used to reprogram a vehicle’s computer (ECM) from a central computer located at the vehicle manufacturer’s service headquarters. OBD II scan tools can be updated with new vehicle or system specifications by downloading the information from a CD-ROM disc or an online source. Scan tools have become an essential part of engine performance and automotive repair. Some technicians even purchase scan tools for their own use.

#### Flasher Modules

Flasher modules allow a vehicle’s ECM to be updated without using a scan tool. This allows a shop’s scan tool to be used for other jobs while the vehicle is being reprogrammed. The flasher module is attached to the vehicle’s data link connector and to a shop PC with standard cables.

To reprogram a vehicle computer with a flasher module:

1. Attach the flasher module to the vehicle DLC and the shop PC, **Figure 3-45**.
2. Access the manufacturer’s service information Web site or insert the appropriate CD-ROM.
3. Follow the instructions provided with the flasher module or CD-ROM.

Flasher modules create an interface between the vehicle ECM and the factory data to allow the ECM to be reprogrammed.
7. Older refrigerant dyes were _____ in color. 8. What color are contaminated refrigerant containers?

Modern service literature is often provided in the
Figure 3-46.

4. Define refrigeration system static pressure.
5. Mechanical temperature gauges make use of a _____ spring to register temperature changes.
6. The most accurate way to check for leaks is to use an(n) _____ leak detector.
7. Older refrigerant dyes were _____ in color.
8. What color are contaminated refrigerant containers?

Review Questions—Chapter 3

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

1. A refrigeration gauge manifold body is made of _____.
2. The blue handwheel on a gauge manifold indicates the _____ side valve.
3. Some R-12 refrigeration systems may have special service fittings. These fittings keep the technician from doing what?
4. Define refrigeration system static pressure.
5. Mechanical temperature gauges make use of a _____ spring to register temperature changes.
6. The most accurate way to check for leaks is to use an(n) _____ leak detector.
7. Older refrigerant dyes were _____ in color.
8. What color are contaminated refrigerant containers?

ASE Certification-Type Questions

1. All of the following statements about gauge manifolds are true, except:
(A) R-134a and R-12 manifolds are needed to service modern vehicles.
(B) Technicians often have their own gauge manifolds.
(C) the low side handwheel is a different color than the low side hose.
(D) a charging scale can measure vacuum.

2. Technician A says that a mechanical temperature gauge may be used to determine air temperature as it leaves the HVAC system vents. Technician B says that an infrared temperature gauge may be used to check the temperature of engine coolant. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

3. Raising pressure in the refrigeration system causes water to boil at _____ than normal temperatures.
4. A _____ is a unit of pressure.
5. An _____ must be allowed to operate for long periods.
6. What undesirable thing will happen if too much antifreeze is placed in a cooling system?
7. Technician A says that a spectrograph can measure coolant temperature. Technician B says that a hydrometer can measure coolant freezing point. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

8. All of the following statements about service literature are true, except:
(A) overhaul manuals contain comprehensive disassembly and reassembly information.
(B) a schematic is a graphic representation of an electrical or vacuum system.
(C) troubleshooting charts contain a series of logical steps.
(D) vehicle manufacturers publish general service information.

9. A service information CD-ROM contains which of the following?
(A) sales and public relations information.
(B) troubleshooting and other service information.
(C) parts and labor prices.
(D) addresses of paper manual providers.

10. Technician A says that a Web site containing vehicle service information is called a hotline. Technician B says that Web sites can be accessed through the Internet. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

Internet Resources

By using a computer on-line service, small shops can access any one of several automotive central information banks over the information superhighway. These banks can offer diagnostic tips, technical service bulletins, and other service information similar to the telephone hotlines described earlier. Many of these services have interfaces that make them easy for anyone to use. Most of these on-line assistance centers are operated by aftermarket companies, private organizations, and individuals. These organizations provide a way for technicians from around the world to help each other by way of e-mail.

Summary

There are two kinds of HVAC equipment: test equipment and service equipment. Some test equipment, such as gauge manifolds, are both diagnosis and service tools. Most test equipment is dedicated, that is, it can only be used for one purpose. In addition, many refrigeration system test and service tools can be used with only one type of refrigerant. HVAC test and service equipment can be simple (such as gauge manifolds or test lights) or extremely complex (such as charging stations and scan tools). When using any type of HVAC tools, always be careful not to damage the HVAC system or cause a release of refrigerant into the atmosphere.

Cooling system test and service equipment is used to check for leaks and pressure problems. Always allow the cooling system to cool off and remove all pressure before performing any test or service operations.

Many times the most important tools are the proper service literature or other sources of service information. Never guess at specifications or service procedures.

 Manuals on CD-ROM

Service literature, including service, parts, and labor time manuals are available in compact disc format. CD-ROM stands for compact disc-read only memory. A CD-ROM is a compact disc identical in appearance to music CDs. However, this type of CD contains service information. One CD-ROM can provide the same amount of information found in a complete series of printed manuals. Many CD-ROM manuals cover several model years of a particular manufacturer’s line of vehicles. Some of the newest CD-ROM manuals show actual, step-by-step footage of certain repair operations. The CD-ROM disc can be inserted in a computer with a CD drive. The information is then accessed and read on the computer monitor, Figure 3-46. The one drawback to CD-ROM manuals is they are much more expensive than a printed manual.