All previous chapters concentrated on HVAC components and how various HVAC systems operate. This chapter begins the discussion of HVAC service. In this chapter, you will learn how to diagnose refrigeration system problems and quickly identify defective parts. The seven-step troubleshooting process outlined here will enable you to quickly locate and correct refrigeration system problems. Be sure you know how to perform every diagnosis and service procedure in this chapter. You will need all of the information presented here to successfully complete the remaining chapters in this text.

**Strategy-based Diagnostics**

In the past, it was fairly easy to find and locate a problem, since most vehicle systems were simple and common to many, if not all vehicles. As vehicles became more and more complex, the methods used to diagnose them became obsolete and in some cases, inapplicable. Technicians who were accustomed to using the older diagnostic routines, or no routine at all, began to simply replace parts hoping to correct the problem, often with little or no success. Unfortunately, this process was very expensive, not only to the customer, but to the shop owner as well.

In response to this problem, a routine involving the use of logical processes to find the solution to a problem was devised for use by technicians. This routine is called **strategy-based diagnostics**. The strategy-based diagnostic routine involves the use of a logical step-by-step process, explained in the next sections. Variations of strategy-based diagnostics are used in many fields outside of automotive repair. A flowchart of this process as recommended by one vehicle manufacturer is shown in Figure 15-1.

**The Importance of Proceeding Logically**

When troubleshooting any refrigeration system or other HVAC system problem, always proceed logically. **Logic** is a form of mental discipline in which you weigh all factors without jumping to conclusions.

To work logically, the first thing you must know is how the refrigeration system works and how it affects and is affected by its components as well as other vehicle systems. This has been covered in earlier chapters. The knowledge you have gained can be put to use when a refrigeration system problem occurs.

The second thing you need is a logical approach. To diagnose a problem, think about the possible causes of the problem, and just as important, the things that cannot cause it. You can then proceed from the simplest things to check, to the most complex. Do not guess at possible solutions, and do not panic if the problem takes a little while to find. If you remember these points, you will be able to diagnose most refrigeration and HVAC problems with a minimum of trouble.

**The Seven-Step Troubleshooting Procedure**

Troubleshooting is a process of taking logical steps to reach a solution to a problem. It involves reasoning through a problem in a series of logical steps. The seven-step process will, in the majority of cases, be the quickest way to isolate and correct a problem. Refer to Figure 15-2 as you read the following sections.

**Step 1—Determine the Exact Problem**

Do not expect the vehicle’s driver to tell you what is wrong in a way that will immediately lead you to the problem area. Most drivers will state the problem in layman’s terms, such as “It doesn’t cool,” or “The air conditioner is noisy.” The first step is to determine the exact problem. You determine the driver’s exact complaint and its symptoms. Many times, the complaint has nothing to do with the HVAC system. This process involves talking to the driver and road testing the vehicle.

**Talking to the Driver**

Obtaining information from the driver is the first and most important part of troubleshooting. Information from the driver will sometimes allow you to bypass some preliminary testing and go straight to the most likely problem. In one sense, the driver begins the diagnostic process by realizing the vehicle has a problem. Question the vehicle driver to find out exactly what he or she is unhappy about. Try to get an accurate description of the problem before beginning work on the vehicle. Try to translate the driver comments into commonly accepted automotive diagnostic terms. The easiest way to do this is with a series of basic questions:

- When does the problem occur?
- How often does the problem occur?
- Does the problem only occur in a certain mode or all modes?
- Do you hear any unusual noises?
- Are there any unusual odors?
- Does air come out of the wrong vents when the problem occurs?
- Does air come out of the wrong vents when the problem occurs?
- Did the vehicle have any recent HVAC service, cooling system service, or any other type of repairs?
- Did the problem start suddenly, or gradually develop?
Assessing Driver Input

While taking into account what the driver says, try to estimate his or her attitude and level of automotive knowledge. Because drivers are not usually familiar with the operation of automobiles, they often unintentionally mislead technicians when describing symptoms or may have reached their own conclusion about the problem. In describing vehicle problems, drivers have been known to use hand gestures, body language, and even simulate noises they have heard. While this can sometimes be fun to watch, keep in mind it is a part of the diagnostic process. Many times, important clues can be found simply by observing a driver's physical actions while describing a particular problem.

In many cases, the person bringing in the vehicle has already formed an opinion as to what is wrong. These opinions are a common occurrence, often based on poor or incomplete understanding of vehicle operation, advice from uninformed friends, or other failures to fully comprehend the problem. The best course is to listen closely to the driver's description of the symptoms. Some drivers will be sensitive to even slight changes, and may be overreacting to a normal condition. Never accept a driver's or another shop's diagnosis until you can verify it.

Often, the owner is concerned about the cost of repairs. Some will even downplay the symptoms, hoping for an inexpensive repair. Very few vehicle owners are unconcerned about the cost of vehicle repairs and maintenance. Do not give any type of uninformed estimate, even though you may have a good idea of the problem. Giving an estimate without diagnosis is a mistake made by many technicians. This practice invites one of two things to occur: either the recommended repair will not correct the problem or it will frighten the driver, who may decide to take his or her vehicle to another shop or not have the repair done at all. Explain that the charge for diagnosing the problem is actually more cost effective than paying for a service, which in many cases may not fix the problem. Before going on to the road test, be sure you have a good idea of the driver’s complaint.

Road Testing

In the case of many HVAC problems, it is usually not necessary to perform an extensive road test. However, in some cases, performing a short road test is the fastest way to confirm a problem. Before beginning a road test, make a few quick checks to ensure the vehicle can be safely road tested. Walk around the vehicle’s exterior and make a note of any damage that is present. Check each tire to ensure they are inflated properly and in good condition. Also make sure that all safety-related equipment, such as the turn signals and horn are working properly.

Warning: Do not road test a vehicle that is not safe to drive. Low or no brake pedal, tires with exposed steel or cloth cord, and slipping transmissions are all examples of problems that would render a vehicle unsafe.

Turn the steering wheel and make sure the steering system does not have excessive play. Depress the brake pedal to ensure the brake system has at least a minimal pedal. Also make sure the vehicle has enough fuel to conduct a road test. Do not adjust anything in the passenger compartment, such as mirror, seat, and tilt steering wheel position, other than what is absolutely necessary. If the radio is on, turn it off so that you can listen for unusual noises.

Wear your seat belt at all times during the road test. Try to duplicate the exact conditions under which the driver says the problem occurs. Unfortunately, duplicating some conditions is not always possible. Always try to road test the vehicle with the owner. This will ensure you are both talking about the same problem, and will save valuable diagnostic time.

Drive slowly as you leave the service area to ensure that the vehicle or cause personal injury. Make one or two slow speed stops to verify the brakes work properly. Drive the vehicle carefully and do not do anything that could be viewed as misuse of the vehicle.

While road testing, obey all traffic rules, and do not exceed the speed limit. It is especially important to keep in mind that you are under no obligation to break any laws while test driving a customer’s vehicle. Also be alert while driving. It is easy to become so involved in diagnosing the problem, that you forget to pay attention to the road or the traffic around you. If it is necessary to look for a problem or monitor a scan tool’s readout while the vehicle is driven, get someone (not the vehicle’s owner) to drive for you. Once you have verified the problem exists, proceed to Step 2.
Diagnosing Intermittent Problems

If the problem does not occur either in the shop or during the road test, it is tempting to dismiss it as the owner’s imagination or as normal vehicle operation, but the problem may well be real. **Intermittent problems** are the most difficult to diagnose, because they usually occur only when certain conditions are met. Intermittent malfunctions can be related to temperature, humidity, certain vehicle operations, or in response to certain tests performed by a vehicle computer. While most problems in the HVAC system are usually easily spotted, like other vehicle systems, it can develop problems that occur intermittently.

When dealing with an intermittent malfunction, always try to recreate the exact conditions in which the problem occurred. Unfortunately, most drivers do not relate intermittent problems to external conditions. Intermittent problems cannot always be duplicated. If a road test of reasonable duration does not duplicate the problem, it is time to try other types of testing. It is essential the principles of strategy-based diagnostics be followed closely when diagnosing intermittent malfunctions.

Note: On modern vehicles, body computers control some of the refrigeration, heating, and air flow components. This is true even on vehicles with manual controls. Before beginning diagnosis, use a scan tool to retrieve any trouble codes and perform other diagnostic tasks. Using a scan tool can save diagnostic time.

**Step 2—Check for Obvious Problems**

Most of your time in Step 2 will be spent checking for obvious causes of the problem, including possible causes that can be easily tested. Visual checks and simple tests take only a little time, and might save more time later. As a minimum, open the hood and check the following items before you start the engine and HVAC system:

- **Retrofit label.** A retrofit label indicates the original refrigerant has been replaced with a substitute. If the retrofit was done properly, the service fittings should be different from the originals. Always use a refrigerant identifier whether a retrofit label is present or not.
- **Service fittings.** The type and style of the service fittings are the other indication the system may have been retrofitted to another refrigerant. Note the size, shape, and location of the high and low side fittings. Keep in mind some vehicles have an additional fitting that was used at the factory, and should not be used. Service fittings are also the cause of some refrigerant leaks.
- **Obvious refrigerant leaks.** Since refrigerant oil leaks out with the refrigerant, leaks can usually be spotted by the presence of oil at the leak site. **Figure 15-4** shows some typical refrigeration system leak locations.
- **Belt condition.** Check the belt for tightness and condition. Sometimes you may find the belt is missing. Also check the condition of the belt pulleys. If the belt is missing or badly burned, try to turn the compressor by hand to ensure it is not locked up.
- **Refrigeration lines and hoses.** Check for obvious damage such as frayed rubber or cuts. Also look for leaks or improper bends in lines and hoses.
- **Compressor clutch.** Check for evidence of slippage, excessive clearance, and overheating. **Figure 15-5.** This check is especially important if the belt is damaged.
Radiator fan. Check for bent or missing blades and loose attaching bolts. If the fan is electric, make sure the motor works properly.

Fan clutch (when used). If the center of the fan clutch is leaking oil, the front of the clutch will be oily. Look for other obvious problems such as loose or missing compressor mounting bolts, loose electrical wires, dented or damaged system components, and missing shrouds around the condenser and radiator. Check vacuum hoses to ensure they are not cracked, misrouted, or disconnected. Check the vehicle dashboard for damaged HVAC controls. Operate the dashboard controls and ensure they are working. Look for levers that are stuck or do not appear to be connected, sticking pushbuttons or knobs, or hissing noises when certain modes are selected. Turn the ignition key to the on position and check if the blower operates on all speeds, and if any indicator screens or other electrical indicators are working.

If the system appears to be electrical or electronic, you may want to visually check the fuses, related electrical connections, and grounds. In many cases, these simple checks will uncover the problem, or give you a likely place to start in Step 3.

Refrigerant Identification

Check the refrigerant type to determine whether it agrees with the manufacturer’s label or retrofit label. Even if the label and fittings indicate the system has not been retrofitted, it is a very good idea to check the refrigerant composition. Figure 15-6 shows a refrigerant identifier being used to check an air conditioner. The type of refrigerant should match the retrofit label (if present) and the type of service ports. A good refrigerant identifier will also check for unknown refrigerants, R-22 blends, and for contamination by unknown gases.

Diagnosing Odor Complaint

Because of the dampness and cool conditions, the evaporator and blower case create an environment for the growth of mold and mildew. This problem is usually seen in areas with high humidity climes. Mold and mildew will cause the air coming out of the vents to have a musty smell. In most cases, the problem will disappear over time as climate conditions change. However, in some cases, the problem may persist due to leaks or other debris in the evaporator case or microbial growth on the evaporator core face. In these cases, the evaporator and case needs to be disinfected. If debris is present in the case, it must be removed or else the problem will return in a short period of time.

If the customer complains the windows frequently fog up coupled with the smell of coolant, a leaking heater core may be the cause. A massive refrigerant leak from the evaporator could cause refrigerant oil to be sprayed in the blower case, giving the air an oily smell. There are many other causes of blower case odors, ranging from malfunctioning electrical components to dead vermin in the case.

Step 3—Determine Which System Is Causing the Problem

The third step is to determine which HVAC system components or vehicle systems could cause the problem. The first step in doing so is to identify what a refrigeration problem is to decide whether or not the refrigeration system is defective. However, the refrigeration system is composed of mechanical and electrical parts and interacts with other vehicle systems. To determine the source of the problem, you must combine the information you obtained in Steps 1 and 2 with the knowledge you obtain by making a system performance test as part of this step.

Instead of looking for something obviously wrong, as you did in Step 2, you are using the performance test to check for something that could cause the specific problem. This will also help you to eliminate things that could not cause the problem, so in Step 4 you can concentrate on any suspected components.

Functional and Performance Tests

The following is a general system function and performance test. A functional test checks for proper system operation at different settings. The performance test checks the refrigeration and heating system components for proper pressures and temperatures. Some of the test procedures do not apply to every system. Always make sure you obtain and use the manufacturer’s procedures and specifications for function and performance tests.

The functional test can be performed without gauges or a refrigerant service center. Start the engine and allow it to run for five minutes. Then, perform the functional test steps outlined in the service information.

To make the performance test, shut off the engine, make sure the transmission is in Park or Neutral, and set the parking brake. Attach gauges or a refrigerant service center as shown in Figure 15-7. Ensure the high and low side hoses are attached properly.

Once the gauges are attached, check static pressure. A normally charged system will have 70–125 psi (482–861 kPa) when it has been inactive for about one hour. If the gauges show low or no pressure in the system, you can be sure there is a leak somewhere. Be sure the hoses do not contact any moving parts.

Install a temperature gauge in the vent nearest the evaporator, Figure 15-8. Then start the engine and set it to run at approximately 1500 to 2000 rpm (this will vary by manufacturer). Turn the HVAC control panel settings to the maximum cooling position and set the temperature control to the maximum cold position. Turn the blower speed switch to the high position and open the front windows.

Check the compressor clutch to make sure it is engaged. If the clutch does not engage, shut off the HVAC system and engine and check the clutch, relay, switches, and wiring. Basic electrical system checks were outlined in Chapter 4.

If the compressor clutch engages, allow the refrigeration system to operate for about five minutes to stabilize the gauge readings. Monitor the cooling system gauge or light to ensure the engine does not overheat. Observe the fan clutch or fan motor(s) and ensure they are operating and moving air through the condenser and radiator.

Caution: If the cooling system fans are not operating, or if the high side pressure exceeds 325 psi (2267 kPa), stop the performance test immediately and determine the cause.

Go through all the steps outlined in the service information for testing the system. A typical performance test chart is shown in Figure 15-9.

Note: Gauge readings will vary with temperature, humidity, system design, and type of refrigerant. For this reason, you should always refer to the manufacturer’s specifications before deciding the refrigeration system is defective.
The condition of the bubbles in the sight glass, temperatures, and pressure are affected by ambient temperature and relative humidity.

**Note:**
- Orange shading indicates a normal low-side reading.
- Purple shading indicates a normal high-side reading.
- Red shading indicates an abnormal reading.

If the pressure readings are within specifications, observe the evaporator outlet line. It should be covered with condensed moisture, possibly frozen. This is a visual sign the system is working properly. If the system uses an accumulator, touch the inlet and outlet tubes. **Figure 15-11.** If the system is fully charged and working properly, the temperature should be roughly equal at both pipes.

**Warning:** High pressure lines can become extremely hot. Touching a line for an extended period of time can result in a burn.

Briefly touch the low and high pressure lines. All high side lines should be hot while the low pressure lines should be cold. If the system uses a sight glass, check the glass for foaming. After the system has been running for five minutes on a reasonably warm day (70°F or 21°C), the glass should be clear. See the additional sight glass information included in Figure 15-12.

Check the temperature gauge in the outlet vent. Outlet temperature will vary with outside air temperature and humidity. As a general rule, the outlet temperature should be about 30°F (17°C) lower than the outside air temperature after the system has been operating for 5-10 minutes. If the gauge is not showing a reasonable drop in temperature, something is wrong.

**Table 15-10.** Gauge readings during normal system operation. The color areas indicate low and high side pressures, as well as the typical numerical values indicated on the bottom. The normal color region will be used in other gauge examples in this chapter.

![Image 15-10. Normal System Operation](image15.png)

**Figure 15-11.** Touching the lines going to and from the accumulator is a quick, but good test of system performance. Do not attempt this on receiver-drier systems.

![Image 15-12. Refrigerator System Operation](image16.png)
Next, unplug the blower motor connection. This is usually easiest to do at the resistor assembly. With the blower not turning, there is no heat load on the evaporator, and the compressor clutch should cycle off within 30 seconds. If the system uses an evaporator pressure control valve (STV, POA, VIR, EPR) pressure should drop to 28-30 psi (193-207 kPa).

System Undercharge
A system undercharge is the most frequent problem found in a refrigeration system. Depending on how much refrigerant is left in the system, gauge pressures will read much lower than normal, even when factoring in air temperature. Low pressure tubing and hoses will feel warmer while high pressure tubing will feel cooler. The outlet temperature will be higher than normal. If the system has a sight glass, bubbles or foam will be present. Figure 15-13 shows typical readings from an undercharged system.

The cause of a system undercharge is usually leaks, but could be caused by failing to fill the system with the proper charge. An undercharged system will not only provide inadequate cooling, but will fail to carry the necessary lubricants through the system. This can lead to reduced compressor life and eventual failure.

System Overcharge
System overcharge occurs quite frequently, in fact, almost as frequently as system undercharges. The first sign of a system overcharge is much higher than normal system pressures, Figure 15-14. Cooling will be affected as the evaporator, accumulator/ receiver-drier, and other system components are flooded with refrigerant.

In some cases, a system appearing to be overcharged contains air (sometimes called noncondensible gas or NCG). An overcharged system should be checked for leaks as the extra refrigerant may have been added because the system was undercharged. If no leaks are found, recover the refrigerant charge, evacuate, and recharge the system.

Restriction in Lines, Orifice Tubes, and Expansion Valves
System restrictions can easily be found by feeling the system’s lines, hoses, and components. If the high side becomes cool at any point before the orifice tube or expansion valve, that spot is restricted. A restriction in the high side is usually located at the orifice tube or expansion valve, depending on the system. However, restrictions in lines and components, such as evaporators and condensers, can occur. Figure 15-15 shows typical system pressures and symptoms when a line, orifice tube, or expansion valve is restricted.

Gauge pressures may be affected by the presence of a restriction. However, as mentioned earlier, variable displacement compressor systems may show little or no change. If a restriction is present, gauge pressures will usually be lower than normal and there will be no cooling. Orifice tube and expansion valve restrictions can be caused by a defective compressor, a ruptured desiccant bag, or contaminants such as dirt or corrosion. If the system uses a thermostatic expansion valve, the sensing bulb should be tested for proper operation. A defective expansion valve can give readings similar to a plugged orifice.

Refrigeration System Undercharged
Symptoms: Poor cooling, A/C outlet warm, rapid compressor cycling (orifice tube systems), sight glass has bubbles or foam.

<table>
<thead>
<tr>
<th>Low Side (Suction)</th>
<th>High Side (Discharge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Varies with ambient temperature)</td>
<td>(Varies with ambient temperature)</td>
</tr>
</tbody>
</table>

Refrigeration System Overcharged
Symptoms: Fair to poor cooling, continuous compressor operation (orifice tube systems), sight glass clear or foamy.

<table>
<thead>
<tr>
<th>Low Side (Suction)</th>
<th>High Side (Discharge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orifice Tube</td>
<td>High</td>
</tr>
<tr>
<td>Exp. Valve</td>
<td>Normal to High</td>
</tr>
<tr>
<td>VDOT</td>
<td>Normal to High</td>
</tr>
</tbody>
</table>

Restriction in Line, Orifice Tube, or Expansion Valve
Symptoms: Poor or no cooling, compressor cycles frequently, system pressure equals lower than normal when system is turned off (orifice tube systems), sight glass clear, blown thermal limiter (when used), High pressure lines have frost on them.

<table>
<thead>
<tr>
<th>Low Side (Suction)</th>
<th>High Side (Discharge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orifice Tube</td>
<td>Normal to Vacuum</td>
</tr>
<tr>
<td>Exp. Valve</td>
<td>Low</td>
</tr>
<tr>
<td>VDOT</td>
<td>Very Low to Vacuum</td>
</tr>
</tbody>
</table>

Defective Accumulator/Receiver-Drier
Usually, accumulators and receiver-driers are not the source of air conditioning system problems. However, they can cause other system problems, such as restrictions in the orifice tube or expansion valve should the desiccant bag rupture. On accumulators and driers with an oil bleed hole, compressor failure can be caused if this hole is restricted. A problem in an accumulator will usually show up as another problem in the system, and cannot be detected by gauge readings.
Note: On receiver-drier systems, if the receiver-drier is cool, the receiver-drier is defective.

Defective Compressor

After the engine and refrigeration system have been operating for five minutes, observe and listen to the compressor. Watch the clutch operation carefully. When the outside temperature is low, (60°F or 16°C) the clutch may cycle every 20 seconds. When the air temperature is high (90°F or 30°C), the clutch may cycle every one or two minutes or more. On very hot and humid days, the clutch may not cycle. On a vehicle with an evaporator control valve, the clutch should remain engaged. If the clutch cycles excessively, the system may have a low charge.

Some compressor problems are easy to diagnose. A noisy compressor has usually failed or is about to fail. If the compressor will not turn or makes an extremely loud noise when engaged, it may be seized. Adding oil to the refrigeration system sometimes quiet older compressors.

Other compressor problems are more difficult to detect. Diagnosing internal compressor problems requires skill at reading gauge pressures. Variable displacement compressors are sometimes difficult to diagnose as some of them are able to adjust pressure so that even a system restriction would cause only a very minor pressure change. Usually, a good indicator of possible internal compressor problems is slightly lower than normal high side pressure with a confirmed full system charge. However, before the compressor is suspected, the system should be checked for restrictions and proper refrigerant charge.

Defective or Restricted Condenser

A defective condenser will usually show up as a leak, allowing the refrigerant charge to escape. Because the condenser handles high refrigerant pressures, a leak will usually be evident, even without the use of a leak detector. However, a slow leak from the condenser will allow refrigerant oil to escape, possibly leading to compressor failure.

Restrictions in the condenser can be either internal or external. An internal restriction will create higher than normal gauge pressure readings. Figure 15-16. In some cases, a restriction may cause ice or frost to form on the condenser. An external restriction will cause higher than normal gauge readings due to the lack of air passing through the condenser.

Defective or Restricted Evaporator

A defective evaporator will usually show up as inadequate cooling caused by a leak in the core. A restriction in the evaporator may cause ice to form on the high pressure tube leading to the evaporator. Both problems will cause lower than normal system pressures.

Defective or Misadjusted Switch

A defective pressure or thermostatic switch can also cause problems. Usually, problems caused by one of these switches can be diagnosed by looking for a frozen condensation at the evaporator inlet. The compressor on an orifice tube system will operate continuously. Typical system pressures are shown in Figure 15-18. After all checks have been made, return the engine to idle, shut off the HVAC system and engine and go to Step 4.

Leak Detection

One of the most common refrigeration system diagnostic jobs you will do is locating leaks. It has been estimated that over 50% of all refrigeration problems are caused by system leaks. Leaks either cause performance problems or lead to failure of a system part, usually the

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**Figure 15-16.** Gauge readings for a defective compressor.

**Figure 15-17.** Gauge readings for a restricted condenser.

**Figure 15-18.** Gauge readings for a misadjusted or defective pressure switch.
compressor. Leak detection can be done by one of several methods. Visible evidence of oil on the refrigeration system fittings, compressor shaft, or evaporator drain hole means there is a leak. Oil, swelling, or a torn spot on the rubber covering of a hose usually means that refrigerant is leaking from the hose.

If an obvious leak cannot be found, test for leaks using one of the methods explained in the following paragraphs.

**Note:** Due to the expense and potential environmental damage of refrigerants, any leak detected, no matter how insignificant, must be fixed. Do not simply add refrigerant because the leak does not seem to be excessive.

### Ensure the System Is Charged

If there is no refrigerant in the system, none can leak out to be detected. To make a leak check, there should be at least a minimum low side refrigerant charge of 50 psi (345 kPa) with the engine off. Some leaks, especially those on the high side of the system, may require a higher charge. If an obvious leak is so severe the system will not hold any pressure, repair that leak first, then pressurize the system.

Some technicians prefer to pressurize completely empty systems with nitrogen. If the system has only recently begun leaking, there may be enough refrigerant left to be detected by a sensitive leak detector. Pressurizing with nitrogen will also allow the technician to find a relatively large leak by using the soap solution method. Refrigeration systems can be pressurized up to about 150 psi (1033 kPa) without damaging any of the low side components.

### Remove Stagnant Refrigerant Vapors

Any leak detection device will produce a false leak signal if it contacts refrigerant vapors built up under the hood or in the shop. Before starting the leak checking procedure, run the engine briefly to remove any vapors from the engine compartment. If you suspect refrigerant vapor has built up in the shop, clear the vapor using fans or the shop ventilation system.

### Using Leak Detection Devices

Modern HVAC shops use several leak testing devices. At one time, the flame type halide leak detector was widely used. Today, however, it has been largely replaced by electronic and dye detection devices. The following sections explain how to use various types of leak testing devices. Leak testing device construction was explained in Chapter 3.

#### Electronic Leak Detectors

**Electronic leak detectors** are more refrigerant sensitive than the other leak detection methods. Modern electronic detectors are extremely sensitive and can locate a leak as small as 1/2 ounce (15 ml) of refrigerant per year.

Begin the leak detection process by turning the detector on and allowing it to warm up for about one minute away from the refrigeration system components. Most leak detectors will make a ticking noise that increases as the probe encounters refrigerant. Large leaks raise the ticking to a high pitched squeal. Many leak detectors have a display which indicates the leak rate.

In some cases, the electronic detector’s sensitivity must be reduced when a large leak is present or when other engine fumes trigger the detector. A satisfactory initial detector sensitivity setting would be to detect a leak rate of about 1 1/2 ounce (45 ml) per year. The sensitivity adjustment knob is usually located on the detector face, Figure 15-19.

After setting sensitivity, slowly pass the sensing tip closely around possible leak areas and check for an increase in the ticking noise. Also remember to pass the tip under suspected leak areas. See Figure 15-20.

### Dyes

Another leak detection method involves using **dyes**. A dye is injected into the refrigeration system and allowed to circulate. The dye will leak out along with any refrigerant and stain the components at the site of the leak.

The first 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 orange dye at the site of leaks.

**Note:** The compressors on some vehicles are disabled by the engine control computer if the refrigeration system loses its charge. When this occurs, a trouble code is usually set. A scan tool is usually required to clear this code in order for the compressor to operate.

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Some technicians prefer to pressurize completely empty systems with nitrogen. If the system has only recently begun leaking, there may be enough refrigerant left to be detected by a sensitive leak detector. Pressurizing with nitrogen will also allow the technician to find a relatively large leak by using the soap solution method. Refrigeration systems can be pressurized up to about 150 psi (1033 kPa) without damaging any of the low side components.

### Remove Stagnant Refrigerant Vapors

Any leak detection device will produce a false leak signal if it contacts refrigerant vapors built up under the hood or in the shop. Before starting the leak checking procedure, run the engine briefly to remove any vapors from the engine compartment. If you suspect refrigerant vapor has built up in the shop, clear the vapor using fans or the shop ventilation system.

### Using Leak Detection Devices

Modern HVAC shops use several leak testing devices. At one time, the flame type halide leak detector was widely used. Today, however, it has been largely replaced by electronic and dye detection devices. The following sections explain how to use various types of leak testing devices. Leak testing device construction was explained in Chapter 3.

#### Electronic Leak Detectors

**Electronic leak detectors** are more refrigerant sensitive than the other leak detection methods. Modern electronic detectors are extremely sensitive and can locate a leak as small as 1/2 ounce (15 ml) of refrigerant per year.

Begin the leak detection process by turning the detector on and allowing it to warm up for about one minute away from the refrigeration system components. Most leak detectors will make a ticking noise that increases as the probe encounters refrigerant. Large leaks raise the ticking to a high pitched squeal. Many leak detectors have a display which indicates the leak rate.

In some cases, the electronic detector’s sensitivity must be reduced when a large leak is present or when other engine fumes trigger the detector. A satisfactory initial detector sensitivity setting would be to detect a leak rate of about 1 1/2 ounce (45 ml) per year. The sensitivity adjustment knob is usually located on the detector face, Figure 15-19.

After setting sensitivity, slowly pass the sensing tip closely around possible leak areas and check for an increase in the ticking noise. Also remember to pass the tip under suspected leak areas. See Figure 15-20.

### Dyes

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Always keep in mind that breathing the torch fumes will expose you to poison gas. (DaimlerChrysler)

Remember a torch is less efficient than an electronic detector.

Observe the flame as the hose moves under each leak tester. Since refrigerant is heavier than air, it should flow downward from a hose that has passed near a leak. A small leak will give the flame a greenish tint, while a bright blue flame indicates a large leak. Recheck the suspect area until the leak has been pinpointed. Do not breathe the fumes from the leak detector. When you are through using the flame detector, make sure the propane valve is closed tightly.

Step 4—Eliminate Other Causes of the Problem

In the fourth step, you think about the observations you made in Step 3 and begin eliminating the causes of the problem, one by one. Always begin by checking the components or systems that are the most likely sources of the problem. For instance, you may need to search for a hidden or slight refrigerant leak, as will be explained later in this chapter. In many cases, you may need to raise the vehicle, or remove shrouds or parts of the blower case. If there are no obvious problems, go on to make more involved checks. During this step, you should check for problems in related systems such as the blower motor, cabin filter (when used), and diverter doors. Checking related systems is very important if the refrigeration system pressures are good but the discharge air is not cold. You can spend a lot of time working on the refrigeration system if you do not realize the blend door cable is broken. Also check for unusual problems such as a condenser or evaporator core clogged with dirt, leaves, or lint.

Always Perform Additional Tests

Additional testing is especially important when the suspected part is a solid-state or an otherwise untestable device, such as an automatic temperature control assembly. Such parts are too expensive to simply replace without knowing for sure whether they are good or bad. Making further checks to confirm the problem is always a good idea, if only to increase your confidence about finding the defective part. Not many technicians are sorry they made further checks, but a lot of them are sorry they did not.

Deciding on Needed Work

Deciding on needed work is a process of interpreting the results of all diagnostic tests. It is simply a matter of taking all test readings and deciding what they mean. As discussed earlier, the test results can be simple observations of visible defects, detailed readings from elaborate test equipment, or any procedure in between.

Before condemning any part based on test results, mentally review its interaction within the system and with the various engine and vehicle systems. Then decide whether the part in question can cause the particular test reading or symptom. For instance, if the HVAC system is losing refrigerant and you have located a leak at the evaporator, do not assume it is the only source of leaks. Check the entire system thoroughly before giving an estimate.

Troubleshooting charts and other diagnostic information can be a great asset to this process, Figure 15-24. If researched and prepared correctly, the troubleshooting chart will list all the possible causes of the problem, allowing you to check everything in a logical sequence. Properly used, such information will speed up the checking and isolating process.

Step 5—Recheck the Cause of the Problem

In this step, the cause of the problem determined in Step 4 is rechecked. This step requires reviewing the various test procedures performed in the last step, and determining whether the suspect component is likely to be the source of the problem. It is often helpful to take a short break to consider all possible causes and determine if what you have found is the most likely cause of the problem or the only thing that could be defective. Review how the particular system works, and how the defect could cause the system problem.

Before going to the next step, recheck the condition of the suspect part as much as possible. Also recheck all other related parts. This will ensure you have not condemned the wrong part or overlooked another defect. For instance, if one O-ring is leaking, do not assume it is the only defective seal. Thoroughly check the rest of the refrigeration system for leaks.

Deciding on the Proper Repair Steps to Take

The amount and type of corrective action must also be determined. In some cases, the repair is as simple as reattaching a vacuum hose, removing grease, dirt, or debris from a sensor connection, or tightening a belt. In other cases, major unserviceable parts, such as the evaporator or condenser, must be replaced to correct the problem. To reduce the possibility of future problems, you should also service parts that interact with the defective part. An example is replacing a failed orifice tube when the compressor is replaced. In all cases, the technician must thoroughly determine the extent of the repairs before proceeding.

Factors that must be considered when deciding to adjust, rebuild, or replace a part are ease of adjustment, the need for special tools, cost of the replacement part, and the possibility the old part will fail again.

If a part is easily adjustable, you can try the adjustment procedure before rebuilding or replacing. Generally, most HVAC parts cannot be adjusted. If adjusting the part does not restore its original performance, the part can still be rebuilt or replaced with little time lost. If there is any doubt about whether an adjustment has corrected a problem, replace the part.

Rebuild or Replace?

In cases when a defective component can be rebuilt, the investment in materials and time must be weighed against the possibility that rebuilding the part may not fix the problem. It is often cheaper to install a new part than to spend time rebuilding the old one. Many repair shops, and even new vehicle manufacturers, are going increasingly to a policy of replacing complete assemblies.

You must determine if rebuilding is cost effective. However, keep in mind that most HVAC parts cannot be rebuilt. Parts that can be rebuilt include the compressor, radiator, and water pump.

In many cases, the customer will come out ahead with a new or remanufactured assembly instead of paying to rebuild an old part. The price of the new or remanufactured part is often less than the charge to rebuild the old part. These parts often come with a limited warranty from the remanufacturer and the assurance the part was assembled in a clean, controlled environment. The technician will often come out ahead, since the labor time saved rebuilding the old part can be devoted to other work.

Along with the cost of repairs, another factor that must be considered is the necessity to retrofit the vehicle to use another refrigerant. The cost of retrofitting will have to be included, especially if the parts being replaced are not normally serviceable during a retrofit.

Therefore, when deciding what to do to correct a problem, make sure that all parts that could contribute to the problem have been tested. In one form or another, every possible component and system should be tested. Then you can decide with assurance what components are defective.
**Special Tools**

Special tools are often needed to adjust or disassemble a complex assembly, such as a compressor. Often, the cost of the tool may exceed the price of a complete replacement assembly. However, special tools can be used again for the same type of repairs in the future, and may be a good investment. You should also figure in the initial cost of the tool versus the number of jobs that will be possible using that tool. If you expect to do a lot of the same type of repairs in the future, and the special tools are reasonably priced, they should be purchased.

**Contacting the Owner about Needed Work**

After determining the parts and labor necessary to correct the problem and before proceeding to actually make repairs, contact the vehicle owner and get authorization to perform the repairs. The best way is to show the owner the completed inspection form. Never assume the owner will want the work done. The owner may not have sufficient money for the repairs, may prefer to invest the money in another vehicle, or prefer to have someone else perform the repair work. The defective part or problem may be covered by the vehicle manufacturer’s warranty or a guarantee given by another repair shop or chain of service centers. In these cases, the vehicle must be returned to an approved service facility for repairs. If your shop is not one of these approved facilities, you cannot expect to be reimbursed for any more than diagnosing the problem.

If the vehicle is leased, the leaseholder is the actual owner. Depending on the terms of the lease, the leaseholder may be the only one who can approve any expenses in connection with the vehicle. Be especially careful if the vehicle is covered by an extended warranty or service contract. Extended warranties and service contracts are a form of insurance, and like all types of insurance, it is necessary to file a claim for any expenses. In some cases, the owner can file a claim after repairs are completed, while in other cases, approval must be granted from the insurer before the repair work can begin. Sometimes, the insurer will send an adjuster to inspect the vehicle before approval is granted.

Before talking to the vehicle owner, leaseholder, or extended warranty company concerning authorization to perform needed repairs, you should make sure you can answer three questions that will be asked. First, be prepared to tell exactly what work needs to be done, and why. Next, have available a careful breakdown of both part and labor costs. Third, be ready to give an approximate time when the vehicle will be ready. If you suspect a problem that requires further disassembly, be sure the customer understands that further diagnosis (and costs) may be needed before an exact price is reached.

**Step 6—Correct the Defect**

In Step 6, you correct the defect by making system repairs as needed. This repair can be as simple as tightening a loose fitting or may require replacement of almost every part in the refrigeration system. For repairs, refer to the procedures in the following chapters.

Be sure to completely fix the problem. Do not, for instance, correct leaks and let the vehicle go with a worn compressor. Keep in mind that disassembling the HVAC and refrigeration systems often uncovers other problems. Be sure to inform the owner about additional charges and get an ok before starting repairs.

**Step 7—Recheck System Operation**

Recheck system operation by conducting another performance test, checking refrigeration pressures and output temperatures. Do not skip this step, since it allows you to determine whether the previous steps corrected the problem. If necessary, repeat Steps 1 through 6 until Step 7 indicates the problem has been fixed. If you are satisfied the problem has been corrected, road test the vehicle to ensure there are no other problems and the repair you made actually corrected the customer’s problem.

**Follow-up**

Once the seven-step checking process has isolated and cured the immediate problem, your first impulse is to park the vehicle and get on to the next job. However, it is worth your time to think for a minute and decide whether the defect you found is really the ultimate cause of the problem. This process is known as follow-up.

For example, a customer brings a vehicle into the shop complaining of poor cooling and rapid compressor clutch cycling. The refrigerant is a little low, so you add about 1/2 pound and the clutch cycling returns to normal. Do not assume the vehicle is fixed until you ask yourself where that 1/2 pound of refrigerant went. In this case, there is most likely an undiscovered leak that may soon empty the refrigeration system. If you do not locate the real problem, the vehicle will be back soon, along with a dissatisfied customer.
Hidden defects are common, and may cause a vehicle to return again and again with the same defective part. Do not let the vehicle leave until you are reasonably sure the observed defect is the real source of the problem. Some hidden problems can be tricky, such as a high side seal that checks out ok with the engine off but leaks at high pressures, or a bad relay that runs a series of HVAC control modules. This is where good diagnostic skills and customer feedback can be helpful.

Whenever you work on a refrigeration system, always try to determine the real cause of a failure, even when the problem appears to be simple.

**Documentation of Repairs**

Part of the follow-up process includes writing on the repair order what the problem was, and what was done to correct the problem. This is called documentation and it is a vital part of the diagnostic process. Every repair order line should have three things. These three things are:

- What the driver’s complaint was.
- The cause of the complaint.
- What was done to correct the complaint.

This type of documentation not only allows the driver to clearly see what was done to correct the vehicle’s problem, it also supplies a good history of what has been done. Figure 15-25, if the vehicle should come back with a similar problem, it gives you or the technician working on the vehicle a place to start looking, without having to repeat some of the steps you took to find the problem.

**Remaining Calm**

One of the hardest principles of diagnosis is to remain calm. Mastering your own emotions is often the hardest thing to do, especially if you meet with a series of dead ends while looking for a problem or are having to deal with an angry customer, but it is necessary. Nothing will be accomplished by losing your composure. If you lose your composure, you will waste valuable time and possibly upset the customer. If you have picked up a tendency to overreact to situations, you must unlearn this behavior and teach yourself to remain calm. Only a calm person can think logically.

**Summary**

When troubleshooting any refrigeration system or other HVAC system problem, always proceed logically. The seven step troubleshooting process enables the technician to quickly locate and correct refrigeration system problems.

The first step is to determine the exact problem. This usually involves questioning the driver. A series of questions is the best way to determine the exact problem. In Step 2 check for obvious problems, or problems that can be easily tested. At this time attach gauges or a charging station and check static pressure. Excessively high or low pressures in the system indicate a problem. The third step is to determine which refrigeration system components or systems could cause the problem. Do this by conducting a system performance test. In Step 4 put together the information you gathered in the first three steps. Begin by checking the components or systems that are the most likely sources of the problem. In Step 5 double check the cause of the problem determined in Step 4. In Step 6 correct the defect and in Step 7 recheck system operation. Do this by conducting another performance test. If necessary, repeat Steps 1 through 6 until Step 7 indicates the problem has been fixed.

Locating leaks is one of the most common refrigeration system diagnosis jobs. Oil on the refrigeration system fittings, compressor shaft, or evaporator drain hole indicates a leak. If an obvious leak cannot be found, use one of the following leak testing methods. Before leak checking, always make sure there is some pressure in the system. Some technicians pressurize completely empty systems with nitrogen. At one time the flame type leak detector was widely used. Today, however, electronic leak detectors are more common. They are more refrigerant sensitive than flame leak detectors.

Another common leak detection method involves injecting a dye into the refrigeration system and allowing it to circulate. The dye will leak out with the refrigerant and stain the components at the leak. A soap solution test can be used to locate large leaks.
Review Questions—Chapter 15

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

1. Strategy-based diagnostics involves reasoning through a problem in a ______ of steps.
2. List in order the seven step troubleshooting process.
3. Try to talk to the vehicle driver to find out the ______ complaint.
4. If the brakes are almost completely inoperable, should you go on a road test?
5. If you do not locate the real HVAC system problem, what will happen?
6. The refrigerant system must be ______ for any leak testing procedure to work.
7. The ______ on some vehicles are disabled by the engine control computer if the refrigeration system loses its charge.
8. The most effective leak detector is the ______ type.
9. A troubleshooting ______ will often simplify diagnosis.
10. ______ is very important in the troubleshooting process.

ASE Certification-Type Questions

1. All of the following are good questions to ask the driver to help with diagnosis, except:
   (A) does it happen whenever the engine is running?
   (B) do you hear any unusual noises?
   (C) how do you plan to pay for this?
   (D) does the air come out of the vents or somewhere else?
2. Technician A says if the vehicle has been retrofitted, the service fittings should be different from the original fittings. Technician B says if the vehicle has been retrofitted, a retrofit label should be installed under the hood. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
3. A good refrigerant identifier will be able to check for all of the following, except:
   (A) unknown refrigerants.
   (B) unknown refrigerant oils.
   (C) R-22 blends.
   (D) contamination by unknown gases.
4. Technician A says high refrigeration system static pressure indicates the vehicle has been retrofitted. Technician B says low refrigeration system static pressure indicates a refrigeration system leak. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
5. All of the following are preliminary steps for the refrigeration system performance check, except:
   (A) set the parking brake.
   (B) install a temperature gauge in the vent nearest the evaporator.
   (C) turn the HVAC control panel settings to the off position.
   (D) open the front windows.
6. If during the refrigeration system performance test you notice the cooling fan(s) are not operating, which of the following should you do next?
   (A) Stop the performance test.
   (B) Lower the engine speed to idle.
   (C) Add coolant to the engine radiator.
   (D) Turn the HVAC switch to vent.
7. Technician A says disconnecting the blower on a system with an evaporator pressure control device should cause the evaporator pressure to drop to about 26-30 psi (193-207 kPa). Technician B says disconnecting the blower on a system with an evaporator pressure control device should make the clutch cycle off in about 30 seconds. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
8. Refrigeration system pressures are correct on a cycling clutch type refrigeration system. No cool air is coming from the vents. Which of the following is the least likely cause?
   (A) Blend door cable broken.
   (B) Dirt on the evaporator.
   (C) Disconnected vacuum line at the heater/air conditioner door.
   (D) Plugged orifice tube.
9. Halide torch refrigerant leak checkers are being discussed. Technician A says a disadvantage of these checkers is they only work on R-12 or R-22. Technician B says a disadvantage of these checkers is they produce a poisonous gas. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.
10. The dye type detector uses a fluorescent dye. This dye will glow when exposed to:
    (A) black light.
    (B) orange dye.
    (C) soap solutions.
    (D) open flame.