Diagnosis and Repair

Systematic Diagnosis

As with any mechanical system, you should conduct a Systematic Diagnosis of the complaint to repair a nonfunctioning A/C system. Systematic Diagnosis is:

- Based on a clear understanding of how the system works or should work.
- A logical, systematic approach to the process of finding the malfunction.

Toyota Six-Step Diagnosis Process

1. Verify the complaint
2. Determine the related symptoms
3. Analyze the symptoms
4. Isolate the cause
5. Correct the cause
6. Check for proper operation

System Checks

A complete check of the mechanics and performance of the A/C system will quickly reveal areas in need of attention. You can perform simple and easy-to-do “sight, sound and touch” checks of the A/C system. These include:

1. Verify outlet temperature (35°–45° F) with a Performance Test (see Performance Testing in this section).
2. Coolant Level – An overheated engine will not achieve full cooling performance.
3. Compressor drive belt tension – At full load, the compressor requires high drive torque to drive the belt. The *Vehicle Repair Manual* specifies the correct tension.

Note: A blinking A/C light indicates a compressor speed problem from a slipping, oily or damaged drive belt; slipping, damaged or incorrectly shimmed compressor clutch; overcharged system causing a slipping belt or compressor clutch; damaged, loose or intermittently shorted A/C compressor wire. The least likely causes include an actual compressor lock-up condition or a malfunctioning lock-up sensor on the compressor.

4. Listen for the loud “click” that indicates the compressor clutch has engaged (energized). Observe any unusual compressor noises. Confirm that the electric fans immediately run at low speed.

Note: Some variable displacement compressors do not use a compressor clutch so no audible sound will be heard.

5. Look into the sight glass (on receiver-drier, if available):
   - It should appear clear, as liquid refrigerant with a few bubbles of vapor flowing out of the receiver-drier (an almost empty system will also appear clear).

Sight Glass

Note: Sight glass not accurate method to properly charge system.

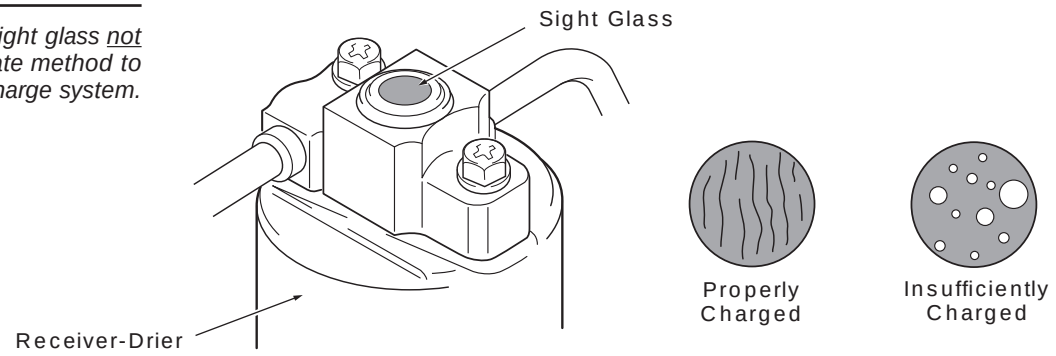

Fig. 4-1
752f401

   - Excessive bubbles may indicate an undercharged system.
   - A cloudy flow indicates the desiccant has escaped from its bag container or there is moisture in the system.
   - If there is no movement visible, just cloudy streaks, the system is empty.

6. Carefully touch accessible refrigerant lines to confirm system operation:
   - Low-pressure lines should feel cold to the touch. In humid weather, moisture may condense on these lines.
   - High-pressure lines should be hot to the touch.
   - A high-pressure line that feels cold indicates a pressure drop due to an obstruction in the system such as a clogged fitting or a crushed refrigerant line.

Need for Periodic Maintenance

Periodic maintenance is required on all A/C systems. Ideally, a leak-free system should keep running for many miles, but a variety of conditions can cause the system to malfunction or to not operate at peak efficiency:

- Systems with conventional rubber hoses will suffer a gradual loss of refrigerant. Moisture will also enter the system through these hoses due to the porosity of the hose material. Both problems will be aggravated by heavy A/C use in humid climates.
- Newer, nonpermeable hose materials reduce refrigerant loss through rubber hoses. However, A/C systems still gain moisture and gradually lose refrigerant through the compressor shaft seal. During long periods of system inactivity, the seals lose their oil coating and sealing ability.
- Water can enter the system and form weak solutions of hydrochloric and hydrofluoric acids. These acids will wear out internal components and may lead to pinhole leaks in the system.
- Normal wear and tear of moving parts inside the compressor and expansion valve will reduce system efficiency and may clog small passages in the system.

A/C-Specific Maintenance and Inspection

These situations may cause the system to not cool, and not show any mechanical failure. Because of this, the A/C system requires periodic maintenance to restore it to an efficient operating condition. Periodic maintenance includes the following:

- Visually inspect the system for airflow restrictions, drive belt tension and obvious component failure.
- Check system operating pressures to confirm low charge condition.
- Recover the refrigerant from the vehicle.
- Evacuate the system to remove any moisture.
- Partially charge and check the system for leaks.
- Repair any leaks as needed.
- Recharge the system and check its performance, including the fan system.
- Remove any debris or dirt from condenser fin surfaces.

Diagnostic Trouble Codes (DTCs)

Automatic A/C systems use an electronic control unit to control the refrigeration and the air distribution systems. To diagnose the system, the A/C ECU provides several Diagnostic Trouble Codes (DTCs) to help identify the malfunction. Periodic maintenance includes checking for DTCs. An OBD II scan tool connected to the vehicle's Data Link Connector can also read DTCs in the system. In addition, the scan tool may be able to check the operation of various A/C system actuators.

Chart of A/C

DTC No. (See Page)	Detection Item	Trouble Area	Memory
00	Normal	—	—
11*[1] (05–470)	Room temperature sensor	• Room temp. sensor • A/C amplifier (Heater Control Housing) • Harness or connector between room temp. sensor and A/C amplifier (Heater Control Housing)	O (8.5 min. or more)
12*[2] (05–473)	Ambient temperature sensor circuit	• Ambient temp. sensor • Harness or connector between ambient temp. sensor and A/C amplifier (Heater Control Housing) • A/C amplifier (Heater Control Housing)	O (8.5 min. or more)
13 (05–475)	Evaporator temperature sensor circuit	• Evaporator temp. sensor • Harness or connector between evaporator temp. sensor and A/C amplifier (Heater Control Housing) • A/C amplifier (Heater Control Housing)	O (8.5 min. or more)
14 (05–478)	Water temperature sensor circuit	• Harness or connector between ECM and A/C amplifier (Heater Control Housing) • ECM • A/C amplifier (Heater Control Housing)	–

Fig. 4-2
752f402

On some vehicles, the scan tool may not be able to retrieve DTCs in the system. If this is the case, DTCs can be read by observing a blinking pattern on the Malfunction Indicator Lamp (MIL) or by a display on the A/C control panel. The procedure to access DTCs in this manner is described in the *Vehicle Repair Manual* and in Section 7 of this *Student Handbook*.

DTC Check on A/C Control Panel

- *Code appears on panel.*
- *Multiple codes flash alternately.*

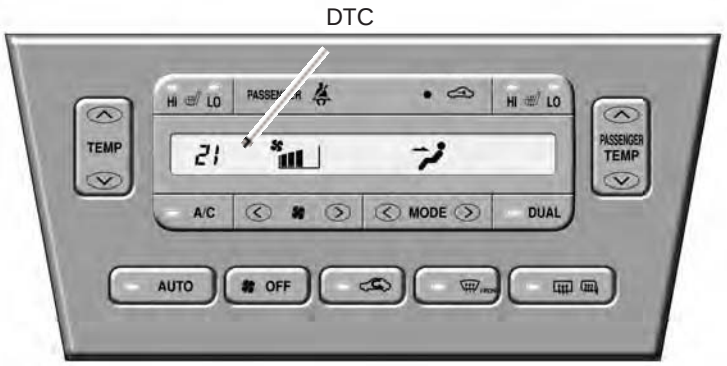

Fig. 4-3
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Special Tools

Here are some special tools needed to service and test the A/C system:

Thermometer

- **Thermometer** – Essential to compare vent outlet temperature with ambient (outside) temperatures during performance checks and for checking system pressures.

A/C Pressure Gauge

- **A/C Pressure Gauge** – Determines how much refrigerant is in the system. It also provides a convenient location to attach other service equipment to the system. The A/C pressure gauges can be part of a Manifold Gauge Set or built into a Charging-Recovery Station. Two gauges are connected to the system; one for the low-pressure side and the other for the high-pressure side. The gauges and hoses follow a standard color code. The low side is **blue** and the high side is **red**. Each gauge shows the pressure in that part of the system.

When part of a Manifold Gauge Set, the valves (marked Low and High), allow one or both inlets to connect to a central passage (thus the term "manifold"). A third hose fitting is reserved for charging or evacuating the system.

The center hose of a manifold gauge set connects to a refrigerant tank for charging or to a vacuum pump for evacuating the system. Charging the system must only be performed on the low-pressure ("suction") side. This prevents dangerous pressure from developing in the refrigerant supply tank.

A/C Pressure Gauge Connection

Note: Pressure gauges are built into the latest recovery machines.

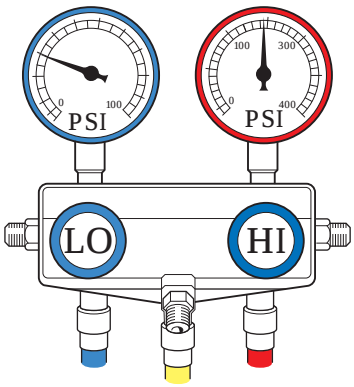


Fig. 4-4
752f404

The static charge (system pressure with system OFF) is also of value when troubleshooting. The "rule of thumb" is a 1:1 ratio on the gauge reading; approximately 1 psig for every 1° F of ambient temperature. Thus, on an 80° F day, the system should have approximately 80 psig static pressure.

CAUTION: For your safety, ensure each hose is connected to the correct service port in the system. On older CFC-12 systems, the two fittings may be the same size: the high-side fitting is always a smaller diameter line, and the low-side fitting is in a larger diameter line. If in doubt, consult the *Vehicle Repair Manual* and carefully follow the refrigerant path to confirm each fitting.

The following chart describes the pressures in a fully charged system given the ambient (existing) temperature in the test area. Because humidity places a higher load on the A/C system, pressures will vary within the range shown depending on the relative humidity. These pressures also assume adequate airflow over the condenser: Position an external fan to blow air through the front bumper opening, particularly on rear-wheel drive vehicles with a belt-driven fan.

Normal Refrigerant System Pressures

Ambient Temp °F	High Side PSIG, HFC-134a	Low Side PSIG, HFC-134a	High Side PSIG, CFC-12	Low Side PSIG, CFC-12
60	120-170	7-15	120-150	5-15
70	150-250	8-16	140-180	8-16
80	190-280	10-20	160-250	10-18
90	220-330	15-25	200-280	12-25
100	250-350	20-30	220-300	15-30
110	280-400	25-40	250-320	20-35

(These pressures are also listed in the *Vehicle Repair Manual* in metric units of °C and kg/cm2.)

It is normal for the gauge needles to fluctuate (change reading) as the clutch cycles ON and OFF and the heat load changes, but they should not swing wildly. In addition:

- If the test pressure is below the ranges indicated, this indicates an undercharged system that cannot exchange heat efficiently.
- Normal low-side pressure along with a much greater than normal high-side pressure indicates air in the system.
- When both pressures are above range, the system is overcharged or insufficient air is flowing through the condenser.
- If both gauges show equal pressures in the 60-80 psig range, this indicates a fully charged system with an inoperative compressor. Additional conditions and specific component failures can be diagnosed based on gauge readings as shown in the *Vehicle Repair Manual.*
- Correct refrigerant charge amount is listed both in the *Vehicle Repair Manual* and on an underhood label, which also list the correct compressor oil type.

Recovery-Recycling-Recharging Station

Recovery-Recycling-Recharging Station – A self-contained unit that connects to the A/C system. This unit monitors system pressures as well as recycles, evacuates and recharges the system with the correct amount of refrigerant. These stations usually contain pressure gauges to connect to and to monitor system pressures. There is additional information in this section.

Recovery-Recycling-Recharging Station

- *Refrigerant type specific for CFC-12 or HFC-134a systems.*
- *Used for recovery, recycling, evacuation and recharging.*

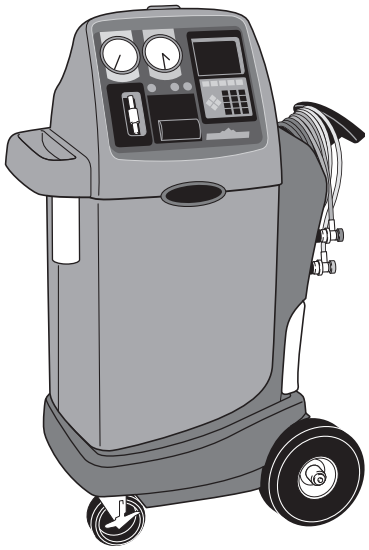


Fig. 4-5
752f405

Leak Detection

Leak Detector – Low gauge readings usually indicate the system has a leak. A small quantity of refrigerant in the system generally indicates a small leak. However, the gauge can't tell you where to locate the leak. A simple visual inspection may reveal large leaks, especially those that result from body damage. Oil stains are usually found around any refrigerant leak. System fittings are the most likely sources of leaks.

When the leak is not obvious, a leak detector can be used to pinpoint the source. Finding a leak this way requires some refrigerant in the system. You can find a leak if the vehicle has high-side pressures greater than 60 psig. If system pressure is lower than this, add no more than one pound of refrigerant to the system, then test. After leak testing, use the recovery station to remove the refrigerant before opening the system for repairs.

The most accurate way to find leaks is with an electronic leak detector. Modern units can detect leaks as small as one ounce per year. The detector contains an audible or visual signal to indicate a leak. Finding leaks with a leak detector is a skill that requires patience and knowledge of the principles of refrigerants.

Electronic Leak Detector

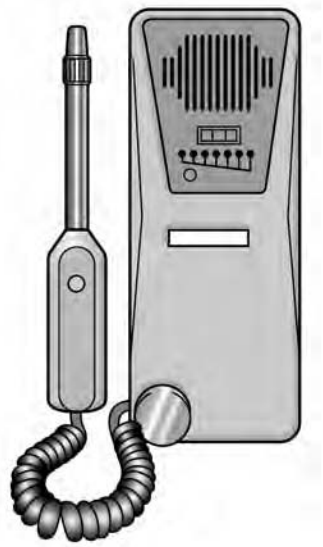


Fig. 4-6
752f406

Here are some tips using a leak detector:

- Refrigerants are three to four times heavier than air. Thus, the leak will be easiest to find below the leak source.
- Look for streaks of oil around suspected leak areas.
- Leaks on the high-pressure side may be easier to find when the system is operating.
- Leaks on the low-pressure side may be easier to find when the system is not running.
- Small leaks will be easier to detect when the system is OFF and no fans are blowing air.
- After locating a suspected leak, use compressed air to blow residual gas from the area.
- Many leak detectors do not sense at the tip, but rather inside the unit. Allow time for the sampled air to be drawn into the unit by moving the tip no faster than one inch per second.
- To check for refrigerant leaks in the evaporator, probe the evaporator drain tube under the vehicle after clearing any mud or water from the area. With the A/C system OFF, cycle the A/C blower motor ON briefly to blow any refrigerant through the drain tube.
- To detect leaks inside the plenum (air distribution housing), switch the fan OFF for a minute then click it ON momentarily to force any leaking refrigerant gas to the outlet vents where the leak can be detected.

Older leak detection techniques rely on a torch flame that changes color in the presence of CFC-12. Due to the danger of potential phosgene gas poisoning, do not use this type of detector. Colored and ultraviolet dyes have also been used, but there's a danger of staining interior fabrics using these dyes.

Leak-Testing Dyes

Toyota does **not** recommend using leak-testing dyes as their long-term residual effects have not been fully tested. Some dyes lose their effectiveness over time and leaks are not accurately detected once the product has dried away from the leakage area. Leaks located within an evaporator case or in a hard-to-see location may also go undetected and repeated applications of dyes during repeated checks can raise the level of contamination of the system lubricant with unknown adverse effects. Dyes are often injected with a new charge of PAG oil. Repeated dye applications will result in "over oiling" the system requiring thorough cleaning and flushing of the system.

System Sealant ("Stop Leak") Products

Toyota does **not** recommend the use of A/C system sealants for minor repair of leaks or as a preventative additive during system service. Sealants may cause gumming of system passages and may even result in magnetic clutch engagement problems if the leak is at the compressor front seal. Warranty reimbursement could be denied if a subsequent component failure is linked to the use of sealants in a Toyota system (Denso®), the air conditioning supplier company, does not recommend sealant products in the system. If not performed properly, flushing out residual sealant gum may result in serious consequences.

Several charging station equipment manufacturers have stated that their equipment is damaged by the use of both system sealant and refrigerant dye products being present in the A/C system. Damage by contamination is not included in the equipment warranty and cannot be repaired at the dealership.

Refrigerant Identifier

Refrigerant Identifier – Verifies the type of refrigerant in an A/C system. Refrigerant supply and system cross contamination is unfortunately very common in the industry. Unprofessional retrofitting, illegal top-offs and unapproved drop-in replacement refrigerants can contaminate dealership equipment and storage container supplies. Decontaminating equipment can be very expensive. A good rule is to use the refrigerant identifier equipment on every vehicle that enters your service department for A/C service or testing even if your dealership originally retailed the vehicle.

It is also highly advisable to check every new supply container of replacement refrigerant purchased before connecting it to your charge station, regardless if you obtained it from a familiar source. Follow the refrigerant identifier equipment manufacturer's procedures and recommendations on judging for cross contamination. Keep a "contaminated refrigerant" container on hand that is well marked for the recovery and disposal of contaminated refrigerant the identifier has detected. Keep the above special contaminated refrigerant container separate from noncontaminated supplies and dispose of it properly at an authorized recycler when it is filled to capacity. Do **not** just release contaminated refrigerants to the atmosphere. This is both harmful to the environment and very costly if you are caught. Be sure you are certified to handle and recycle refrigerants by an accredited association such as MACS or ASE. Not being certified can be expensive in fines and loss of business.

Refrigerant Identifier

- *Prevents cross-contamination.*
- *Detects air in system.*
- *Reads in %.*

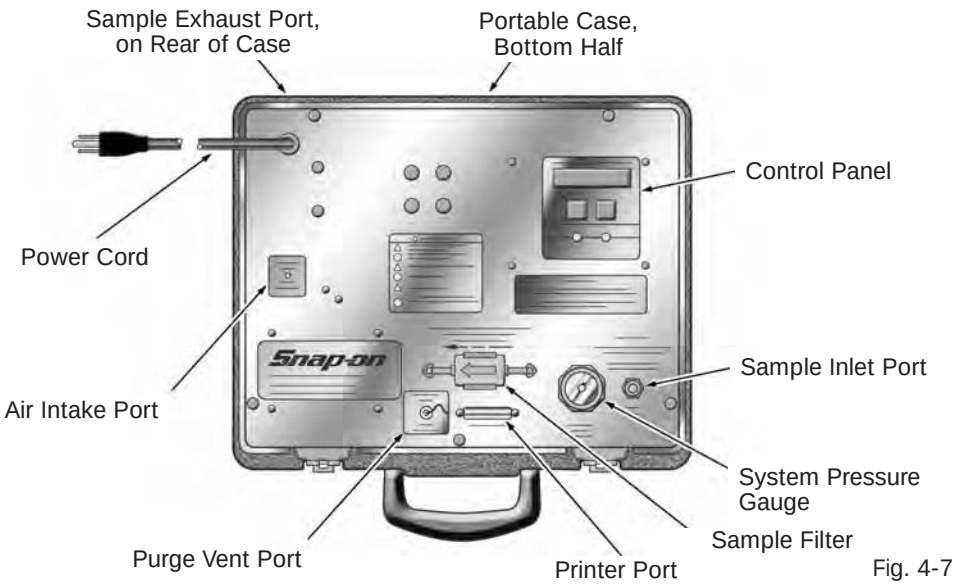


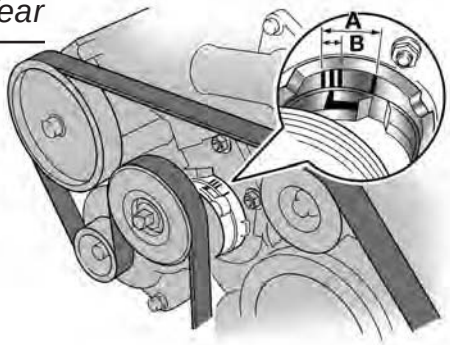
Fig. 4-7
752f407

Drive Belt Tension Gauge

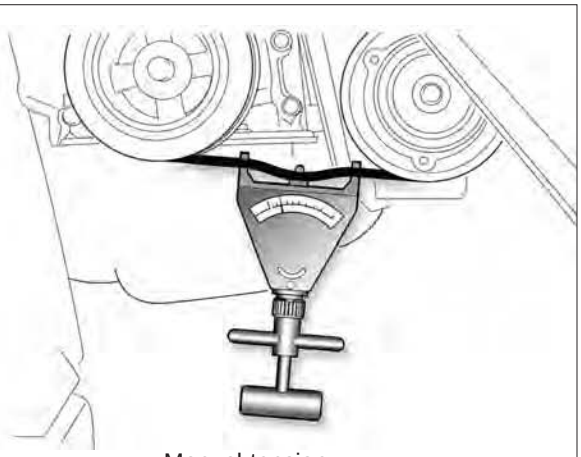
Drive Belt Tension Gauge – Accurately measures the tension of multiribbed belts. Multiribbed belts do not tolerate stretch as much as V-belts.

- Insufficient tension will result in belt slippage.
- Excessive tension puts extreme loads on the front compressor shaft bearing.
- There are different tension specs for new versus used belts.
- Serpentine drive belts drives may have a scale on an automatic belt tensioner to indicate belt wear. If the arrow falls outside the scale area, replace the belt.

Belt Tension and Wear



Automatic tensioner belt wear range:
A = "Normal" range
B = New belt range



Manual tension measurement with gauge

Fig. 4-8
752f408

Miscellaneous Special Tools

- **Hand Vacuum Pump** – Used to test vacuum-operated devices.
- **Torque Wrench** – Along with adapters, a torque wrench is needed to tighten fittings to the proper torque. A set of four, fixed preset, open-end SST torque wrenches are available in the appropriate sizes.
- **Quick Disconnect Tool** – Removal tool to separate high and low pressure refrigerant lines using a nonthreaded fitting. The tool frees the clamp which allows the refrigerant lines to separate.

Quick Disconnect Tool

• For quick disconnect fittings.

• Two sizes.

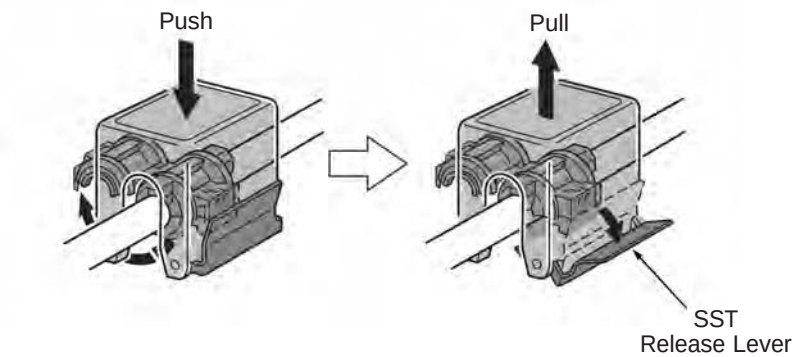


Fig. 4-9
752f409

- **Shaft Seal Protector Tool** – Compressor shaft seals can be replaced if they leak. This tool protects the shaft seal from tearing when installing the compressor front housing over the compressor shaft threads.

Shaft Seal Protector Tool

Used to protect shaft seal when installing front housing.

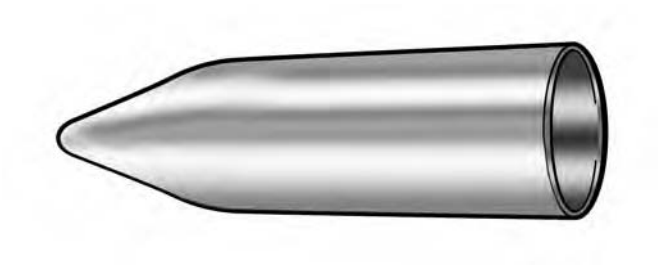


Fig. 4-10
752f410

- **Front Seal Driver-Installer** – This special tool allows easy removal of the compressor shaft seal from the front housing. It is also used to install the compressor seal.

Front Seal Driver-Installer

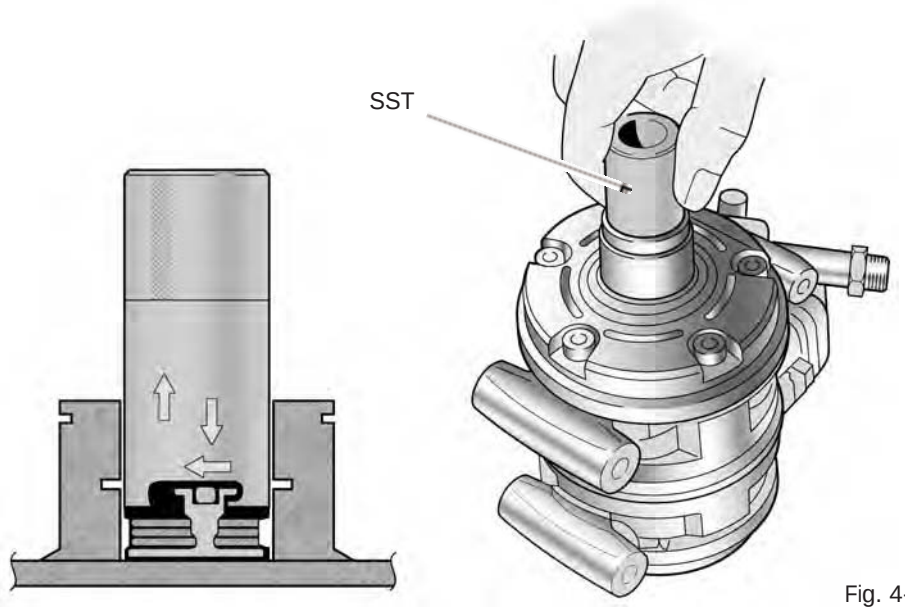


Fig. 4-11
752f411

Resource Materials

The *Toyota Repair Manual* for each vehicle is always the starting point for diagnostic and service information.

Repair Manual

- *Air conditioning and heating section.*
- *Diagnostic section.*

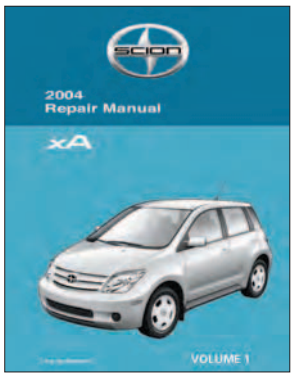


Fig. 4-12
752f412

The manual includes:

- *Symptomatic* troubleshooting charts
- Pressure gauge readings for various conditions
- Component locations and repair procedures
- Refrigerant charge quantity and oil quantity for component replacement

Toyota Electrical Wiring Diagrams (EWDs) also are needed to diagnose and repair. They contain location diagrams and testing specifications for electrical components.

EWD Manual

- *System schematics and power circuits.*
- *Connector locations.*
- *Ground locations.*

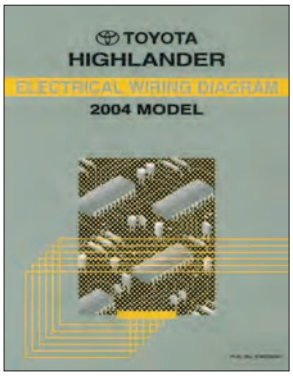


Fig. 4-13
752f413

Troubleshooting, Service and Repair Tips

A variety of maintenance conditions can affect the A/C system that may not be revealed by standard diagnostic procedures.

- If a system does not blow sufficient air, check for obstructions of the fresh air intake or body exhauster vents outside the vehicle.
- Restricted (clogged) fresh air filter behind glove box needs replacement.
- The expansion valve may fail in the open mode as a result of debris in the system (perhaps from a past malfunction). The expansion valve can also seize in the closed position due to a loss of lubricant. Apparent expansion valve failure may simply be a case of the capillary tube ("sensing bulb") not being in contact with the evaporator outlet line.
- Paper, leaves and mud can clog the condenser fins. This reduces system performance and can cause overheating and a blown fusible plug or relief valve. The debris can often be blown out with compressed air or a water hose. If necessary, special "combs" are available to straighten bent condenser fins.

Clearing Condenser Obstructions

Bugs or dirt will increase system pressures and reduce cooling efficiency.

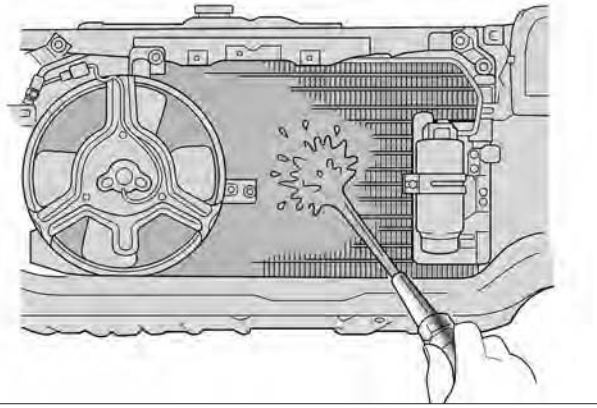


Fig. 4-14
752f414

- A system which does not produce cool air or blows a visible mist (even though the fan works) may have one of two malfunctions:*

  1. An iced evaporator. This can be caused by using MAX cooling with a low fan speed or a failure in the thermistor/amplifier unit (to be discussed in A/C controls).
  2. The evaporator drain hose may be clogged with leaves or mud which will cause the evaporator housing to fill with ice and water. This will restrict airflow. A wet carpet is one symptom of a clogged evaporator drainline.

  *Some mist or fog can normally occur on humid days when the system is first switched ON.

- A simple way to check the operation of the electric fan system is to unplug the coolant temperature switch or refrigerant pressure switch while the ignition is ON. This will result in the fans running at HIGH speed.

Note: Some models may require using a jumper wire to test operation, see W/D.

- Every system will slowly lose refrigerant through the front compressor seal, especially if the system is unused for long periods and the lip seal dries out. Earlier systems had greater refrigerant capacity, thus a slight amount of loss was minor. Later systems must maintain system efficiency with less refrigerant.
- A system with a leaking front seal is easily diagnosed by observing oil stains on the clutch and in front of the compressor. The seal is easily replaced and on some models it can be done without removing the compressor. When handling the front seal, always coat your fingers in oil to prevent body oils and acids from etching the delicate sealing surface.

Recover any refrigerant remaining in the system before removing the seal.

Compressor Seals

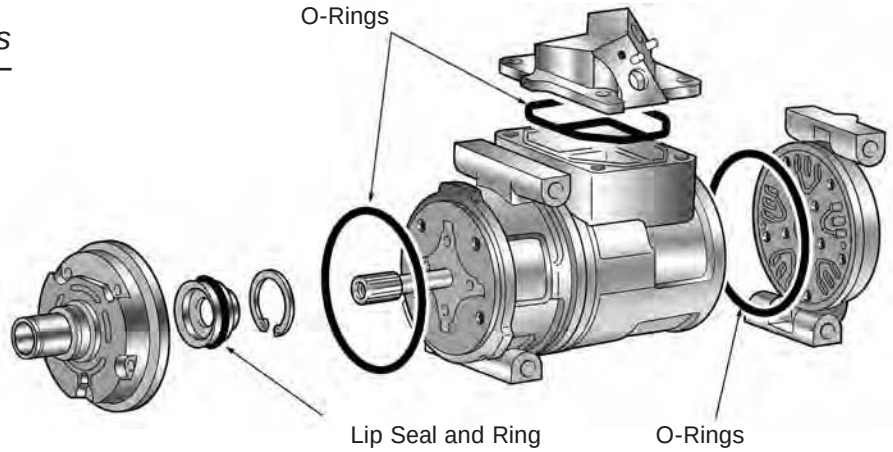


Fig. 4-15
752f415

Component Replacement

- Observe torque specifications. On threaded fittings, use two wrenches. Hold the male fitting stationary with a wrench while rotating the female fitting (nut). Use a torque wrench for final tightening.
- Always handle O-rings carefully. Handle with oil-covered fingers or with a toothpick.
- Always install the receiver-drier last. Keep it sealed until the last moment to prevent the desiccant from absorbing moisture. It will become totally saturated with 10 minutes of exposure to humid air.

Refrigerant Recovery

- Old system refrigerant must be recovered before any repair requires opening the A/C system.
- Always start by connecting a manifold gauge set to the service fittings.
- Carefully measure the oil removed from the vehicle with the recovery machine.

Minimum Evacuation Time

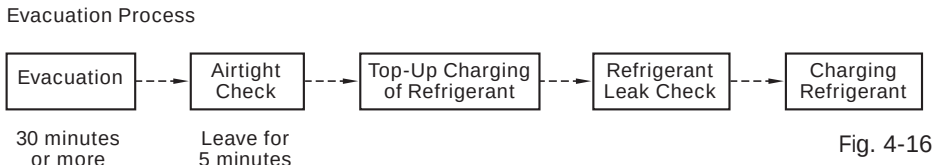


Fig. 4-16
752f416

Flushing Precautions

Flushing products and procedures are not recommended by Toyota, and parts should be replaced if debris contamination is suspected. Flushing does not always remove all debris trapped in the system. Remaining debris can dislodge later and damage the compressor or block the expansion valve. Flushing a system using CFC-12 or HFC-134a refrigerant requires recovery of refrigerant used without allowing it to escape into the atmosphere.

Aftermarket flushing products, while sometimes effective, may not be fully tested to determine any long-term residual damage or corrosion to the compressor, condenser, expansion valve, evaporator, hoses, seals or other system components. Metal particles embedded in internal hose passages cannot always be easily dislodged during flushing as they were forced into the hose under high pressure. Debris within a “parallel flow-style” condenser is very difficult to flush out as the flushing agent can just bypass the debris. Flushing agents must be thoroughly removed from a system to minimize any residual effects such as oil dilution, corrosion, or other damage. Using refrigerant to flush requires recovery of all refrigerant used in the process.

Evacuation

After completing repairs, evacuate the system to remove moisture. This is important for system durability as moisture will form metal-destroying acids and create ice blockage at the expansion valve. **Evacuation** means applying a strong vacuum to the system. This has the effect of lowering the boiling temperature of water which will boil out of the system (vaporize) at room temperature. With a system vacuum of 29.5 inches Hg at sea level, water will boil at 59° F (15° C).

A vacuum pump will create 29.5 inches of vacuum. The correction for higher altitudes is to subtract one inch per 1,000 feet above sea level. Connect the A/C service hoses to both service ports and evacuate for at least **30 minutes** before charging the system after repairs (newly installed

systems = 10 minutes). This process will remove any moisture in the system. However, this will not remove moisture from a saturated receiver-drier which should be replaced.

After evacuation, close both valves on the manifold gauges set. Allow the system to remain under vacuum for a few minutes as a final leak check before charging.

Refrigerant System Lubrication

Mobile air-conditioning systems require lubrication for the compressor and the expansion valve and to prevent corrosion inside the system. This is supplied by a special lubricating oil which mixes with the refrigerant and travels throughout the system.

The oil coats the inside of each component, lubricates the bearings, rings and seals of the compressor and the moving parts of the expansion valve. The oil carries debris to the filter inside the receiver-drier. Different oils are formulated for the A/C system depending upon the type of compressor design and refrigerant used. Use only the recommended lubricant as specified in the *Vehicle Repair Manual.*

A/C System Lubricating Oils

Compressor Type	Refrigerant	Recommended Oil	Part Number
Piston (reciprocating)	CFC-12	ND-6	07117-68040
Scroll or Rotary Through-Vane		ND-7	07177-68030
Piston (reciprocating)	HFC-134a	ND-8	08885-09107
Scroll or Rotary Through-Vane		ND-9	08885-09117
Hybrid Electric		ND-11	08885-09127
Delphi		RL-897	00289-AC897

Note: Do not mix different types of compressor oils together. Not all types are compatible. Drain oil from the recovery/recycling machine after each vehicle serviced.

Adding Oil After Repairs

When opening the A/C system for repairs, replace the correct quantity of lubricating oil into the system. After replacing a large component, the *Vehicle Repair Manual* specifies the exact amount of oil to recharge in addition to the amount removed during the recovery process. When replacing a compressor, remember that a new or remanufactured compressor usually has enough oil to fill the entire system. Therefore, you must compensate (add/remove) lubricant for the proper system amount.

Note: Excess oil reduces the thermal efficiency of the system. The process of leak checking with dyes adds even more oil into the system.

Refrigerant/Oil Proportion in System

- *When replacing parts in the system, some oil is lost and must be added.*
- *Replacement compressors have a full system amount of oil.*

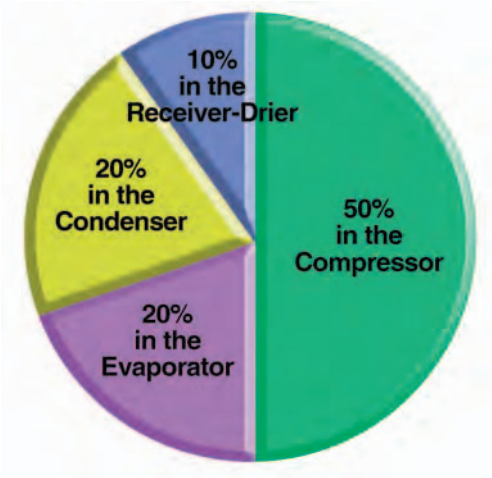


Fig. 4-17
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If no oil-retaining components are replaced, only add as much oil as was removed during the recovery process.

Add lubricating oil to the system after evacuation and before charging. Some charging stations include oil-charge capability, or a special bottle can used to meter the oil removed by the evacuation process.

Inline Filters

Aftermarket inline filters are commonly available in the market, however, they are not recommended by Toyota and certain precautions must be kept in mind.

- Inline filters can restrict flow and lessen performance or raise pressures in the system.
- Improperly installed or poor quality products can leak resulting in a comeback and possible system damage due to leakage and lubricant loss.
- Improperly installed or poor quality inline filters can fail over time and block the inlet port to the compressor or cause internal physical damage.
- Under-hood areas are limited in space and properly positioning a filter may be difficult.
- System hoses and pipes should not be cut or otherwise modified to prevent leakage or failure.

Performance Checking

The final step in a repair is to perform a final check of your work. This final performance check should include:

- Recheck belt tension with the gauge.
- Start vehicle, switch A/C ON, then recheck system pressures.
- Measure the dash vent outlet temperature. It should be 35° – 45° F depending on temperature and humidity conditions.
- Observe the operation of the electric cooling fans.
- Observe the operation of the idle up system.

Note:

When conducting a Performance Test, refer to the Repair Manual as to conditions such as doors open or closed, engine speed and outlet register temperatures. Actual temperatures will vary from the standard 35° – 45° F outlet temperature depending on temperature and humidity levels.

In order to allow vehicle and tool manufacturers to develop universal service equipment, there are principles and procedures for environmentally sensitive A/C repair. These standards have been created by the SAE in compliance with Section 609 of the Clean Air Act.

- **Recovery** refers to the containment of gases during use, processes and service.
- **Recycling** refines used refrigerant from mobile A/C systems to a purity standard for reuse.
- **Reclamation** refines used refrigerant from a variety of sources to a stricter-than-new standard.
- **Recharging** refers to charging an A/C system with refrigerant.
- **Underwriter's Laboratories (UL)** has developed testing procedures used to certify that recovery/recycling equipment meets the standards set by the SAE for automotive, light truck and RV use.

Recovery and Recycling Techniques

Recovery/recycling equipment all works essentially the same:

- **Oil separation** occurs in a heat exchanger and prevents hydraulic locking of the recovery machine compressor.
- **Moisture and acids** are trapped in a large-volume replaceable desiccant package.
- **Inline filter** (usually integrated with the desiccant) filters small particles from the refrigerant.
- **Moisture indicator** warns that moisture content exceeds allowable levels. This indicates the need to replace the desiccant.
- **Noncondensable gases** (air) settle by gravity to the top of the recovery tank. A gauge indicates when the air quantity exceeds the maximum and must be vented to the atmosphere.

Most recovery/recycling stations perform all these processes in a single pass. With a **one-pass** machine, any recovered refrigerant in the storage cylinder is recycled and immediately ready for reuse. Some machines do not fully recycle during the recovery process. **Two-pass** machines operate in a recycle mode only after recovering refrigerant from the vehicle.

Note: Some recycling machines cannot identify the many different types of refrigerant gases that are on the market. It is important to never mix refrigerants in a single machine.

With various refrigerants being used in the aftermarket, it is important to use a **refrigerant identifier** to verify it is safe to recharge or to recover the refrigerant.

- Different refrigerants cannot be separated and may produce a mixture that has different or unpredictable properties.
- Severe permanent damage to the recovery/recycling machine is likely if an incompatible refrigerant is recycled.

Equipment Operation

All recovery/recycling equipment works about the same way in order to meet SAE standards. Control locations may vary and some functions which are automated on some machines may be manually operated on others. Connection to the vehicle A/C system is always through a pressure gauge set. The gauge set may be part of the recovery/recycling station.

A/C System Identification

CFC-12 Service Fittings	HFC-134a Service Fittings
Schraeder-type, all same size	SAE. Different sizes for High and Low pressure
High-pressure: Smaller OD/Red Low-pressure: Larger OD/Blue	

Noncondensables

With a one-pass machine, recycling is only necessary if the tank has been contaminated with excessive noncondensables or if the desiccant/filter is saturated.

At room temperature, refrigerant can be compressed or condensed into a liquid state. Air cannot. **Noncondensables** refer to gases in the recycling system that will not condense into a liquid. It is normal to see some amount of noncondensable gases after recycling. When the recycling process is complete, liquid refrigerant in the storage cylinder will settle to the bottom of the tank and any air will rise to the top where it can be vented from the PURGE fitting.

Based on the pressure/temperature characteristics of refrigerants versus air, a simple measurement can determine the presence of noncondensables in a room-temperature cylinder that has not been disturbed for at least 12 hours.

1. Measure the exact ambient temperature within 4 inches of the cylinder.
2. Measure the pressure of the gas in the cylinder.
3. Find the point where your pressure and temperature intersect on the chart:
   - If the point is below the black line, the refrigerant is safe to use.
   - If the point is above the black line, open the VENT or PURGE valve until the pressure falls to below the limit shown in the chart.

Noncondensables Chart

- *Air is a noncondensable.*
- *Refer to text on this page to use chart.*

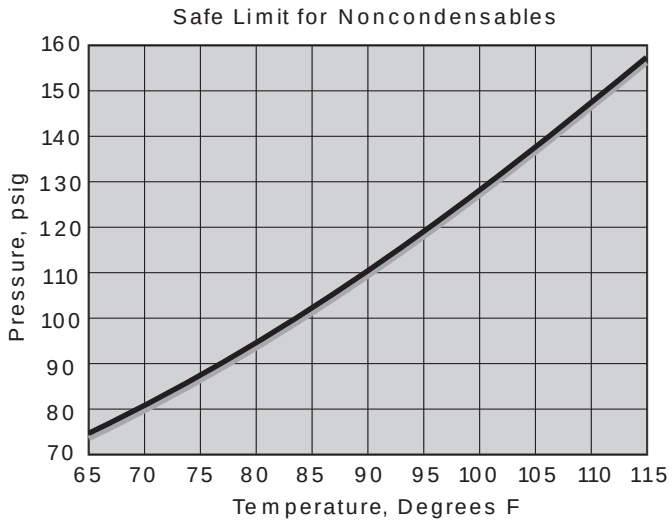

Fig. 4-18
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If the pressure cannot be brought within the limit shown, recycle the entire contents of the cylinder. Only cylinders of completely recycled refrigerant may be stored. Noncondensables may present a danger of tank corrosion or bursting under extreme conditions.

Recycling stations may include a double-needle pressure gauge that indicates noncondensables when the two needles are more than 10 psi apart. The gauge is only accurate if the refrigerant has been undisturbed for 12 hours. Some stations have an automatic purge function to vent condensables.

A recovery/recycling machine that continually gives indications of moisture or noncondensables should have a new filter-drier installed and then checked for leaks.

Storage Cylinders

Refrigerant cylinders (“tanks”) are designed to only hold a specific gas and have unique fittings for each gas to prevent contamination.

- CFC-12 cylinders are white or off-white
- HFC-134a cylinders are pale blue

The U.S. Department of Transportation (DOT) has developed safety standards for heavy-duty service cylinders that may be charged with recycled refrigerant. They are made of very thick gauge steel, painted on the inside for corrosion protection and include an over-pressure safety vent. These cylinders must be returned to the manufacturer for testing every five years. They are always marked with “DOT 4BA” or “DOT 4BW,” the date of manufacture and the maximum allowable content weight (WC-XX).

Service cylinders have three fittings:

1. **Liquid** fitting with a blue shut-off valve connects to a siphon tube that draws refrigerant from the bottom of the cylinder.
2. **Gas** fitting has a red valve and is connected to the top of the tank to add or remove gas from the cylinder.
3. **Vent** fitting without a control valve allows venting of noncondensables from the top of the tank.

Cap all fittings to prevent leakage when the cylinder is not used. New service cylinders are shipped with a charge of pure nitrogen. This must be vented to the atmosphere before using. Empty or new cylinders must be evacuated for at least five minutes before using to maintain refrigerant purity.

New refrigerant is shipped in **disposable** tanks of various sizes. These tanks should not be refilled or transported without proper packaging. Disposable tanks should only be filled with absolutely pure (“virgin”) refrigerant which meets extremely tight tolerances for moisture and noncondensable content.

Disposable cylinders have a single fitting connected to the top of the tank. Most charging stations work best with liquid refrigerant so the tank must mount upside down to place the fitting at the bottom. When a disposable container is empty:

- Recover any remaining gases into a recovery/recycling station.
- Close the service valve on the cylinder.
- Mark the cylinder “EMPTY” and dispose properly.