

# Basic Technology Series

## Fundamentals of Car Air Conditioning

2007  
Air Conditioning  
#004

### IN THIS ISSUE

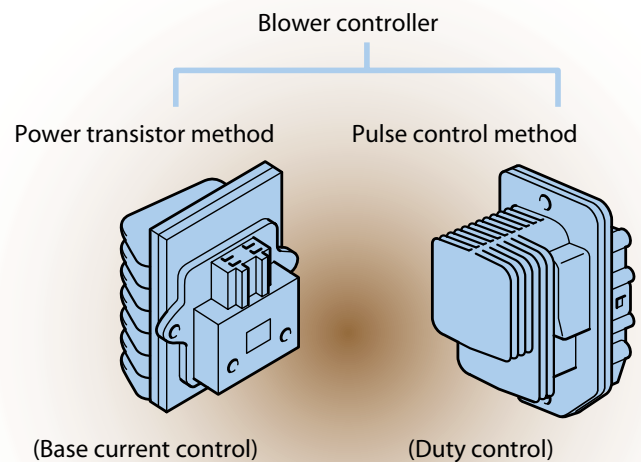
- Air Flow Volume Control
- Air Inlet Control
- Compressor Control
- Self-Diagnostic Function
- Precautions in Handling the Refrigeration Cycle
- Troubleshooting
- Inspecting the Refrigeration Cycle
- Replacing Parts
- Recharging the Cycle with Refrigerant
- Performance Test

## Air Flow Volume Control

The air flow volume changes according to the blower fan motor speed.

On automatic air-conditioning systems the ideal air flow volume is computed with the computer, and the blower control signal is output to the blower controller (control device).

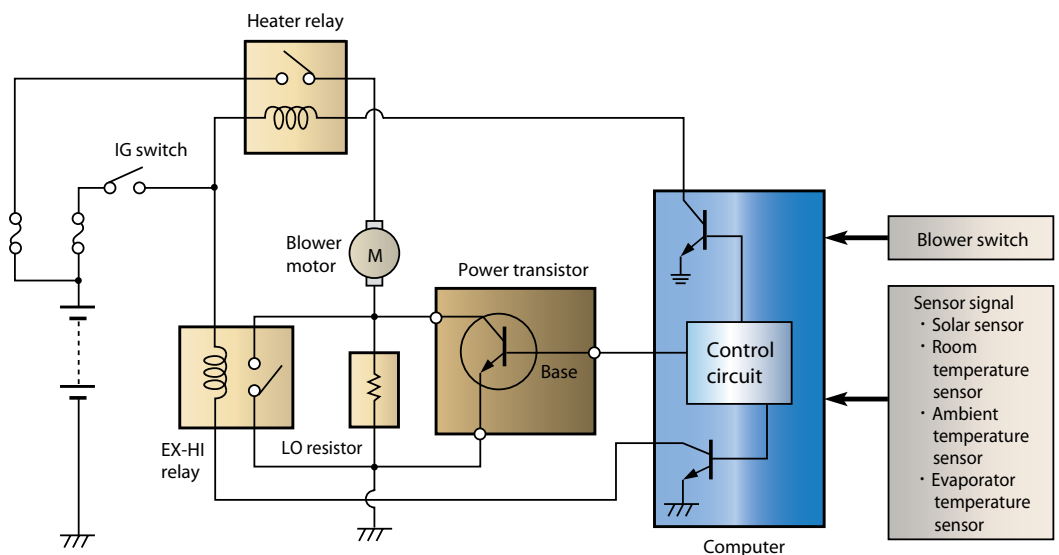
The blower controller adopts the power transistor method and the blower pulse control method.



### Blower Controller

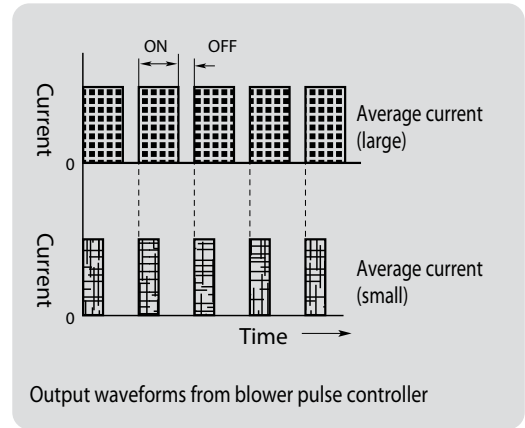
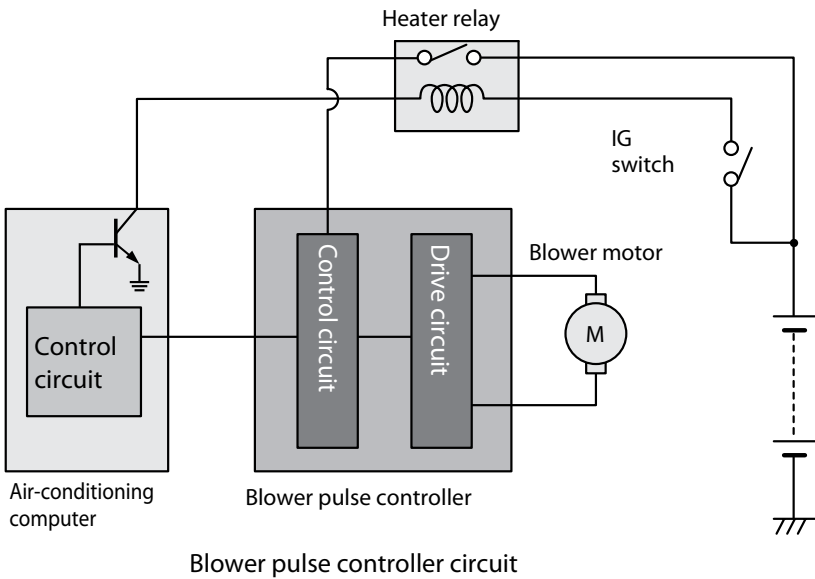
#### Power Transistor Method

The computer controls the base current of the power transistor according to blower control signals, thus allowing stepless changing of the blower motor speed. During maximum cooling (heating) and low blower speed, a combination of the EX-HI relay and LO resistor is used for control.



## Blower Pulse Control Method

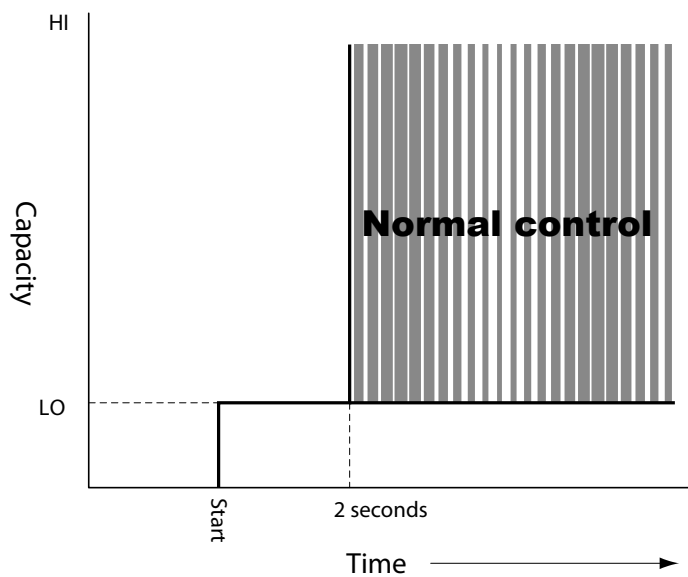
The blower pulse controller carries out duty control of the electric current to the blower motor by means of signals from the computer. This method involves direct control of the blower motor current. This eliminates the need for the EX-HI relay and LO resistor required for the power transistor method. The blower pulse controller has an internal control circuit as well as a safety device for corrective control when the blower is locked. Thus, if a blower current higher than a set value is sent continuously for about 1 second or longer, the controller judges that the blower motor is in a lock state and turns the blower OFF. With duty control there is changing of the ratio of ON/OFF time for the current to the motor in order to control the amount of the average current. If the ON time is longer, the motor speed becomes faster. If the OFF time is longer, the motor speed becomes slower.



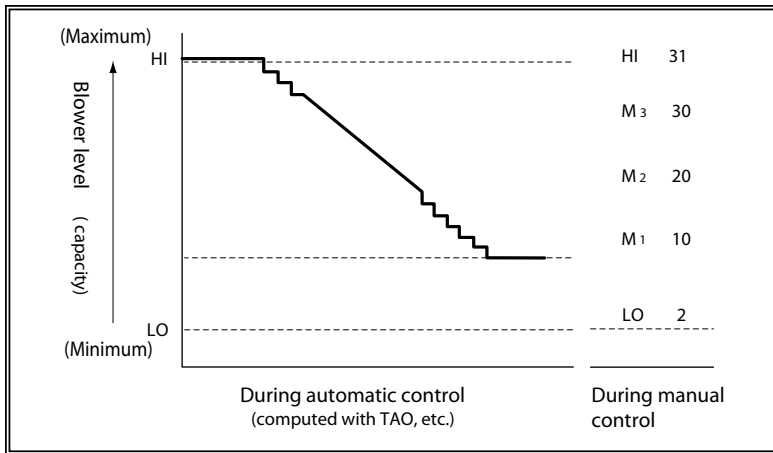
## Starting Time Control

When starting the blower, there is LO speed operation for about 2 seconds. This is followed by normal control.

This protects the blower controller from the large starting current when starting the blower motor.



## Manual Control



The air flow volume is changed by the position of the blower switch. The computer sends the blower control output signal to the controller that corresponds to the computed air flow volume. Then there is automatic control so that it agrees with the computed air flow volume.

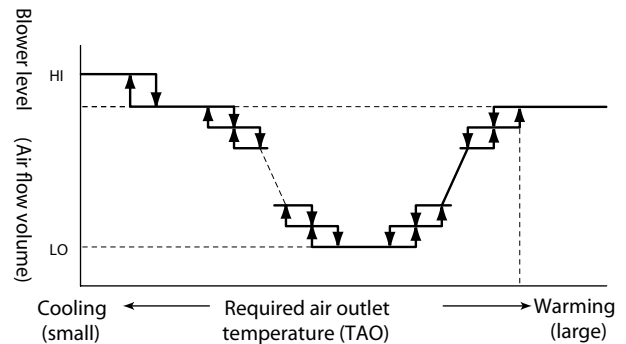
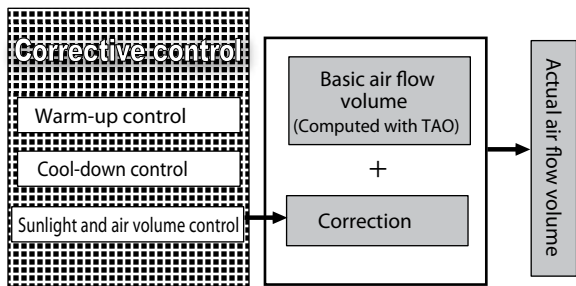
## Auto Control

When the AUTO switch on the control panel is turned ON, depending on the input conditions from the sensors there is stepless (multistep) air flow volume control, warm-up control, cool-down control and sunlight correction control.

### Stepless (Multistep) Air Flow Volume Control

According to the required air outlet temperature (TAO) the computer automatically controls the blower controller to carry out stepless (multistep) control of air flow volume.

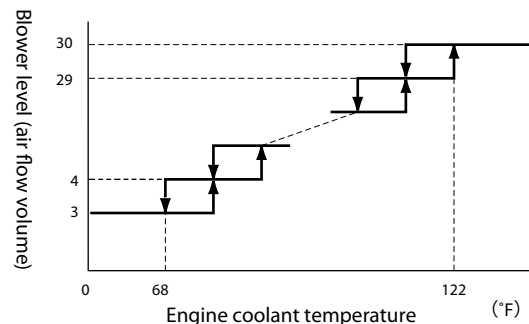
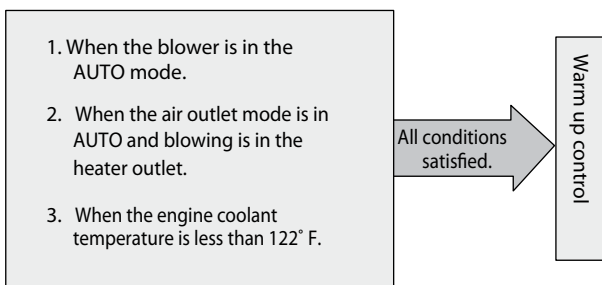
This air flow volume (air flow volume according to TAO) is the basic air flow volume. Various corrections are made on this value to compute the actual air flow volume.



### Warm Up Control

If the engine coolant temperature is low immediately after starting the engine so that warming up of the engine is necessary, warm-up control is carried out. This is a function that prevents cold air from being blown from the heater outlet while the engine coolant temperature is still low.

For example, if the engine coolant temperature is 86° F or less, the blower motor turns OFF. When the temperature is between 86-122° F, there is automatic control of air flow volume according to coolant temperature. When the temperature is 122° F or higher there is normal control.

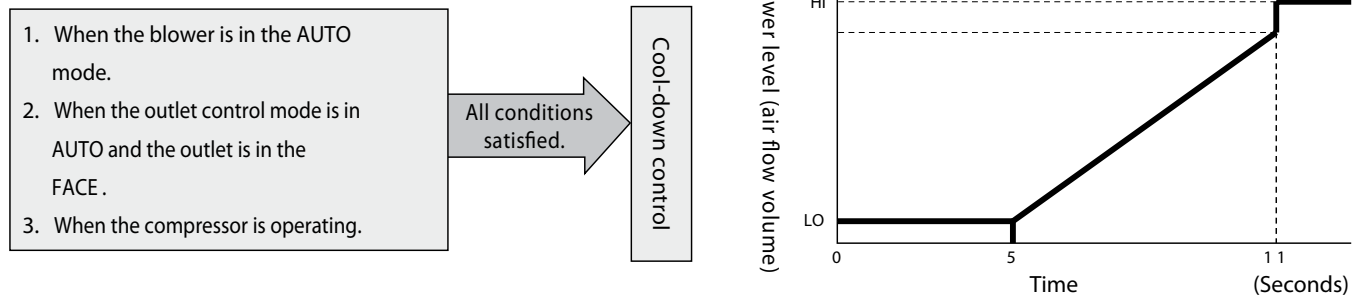


## Cool-Down Control

When the ambient air temperature and room temperature are somewhat high so that it is necessary to blow cool air, the cool down control is carried out. This function prevents the blowing of warm air from the FACE outlet immediately after starting the engine.

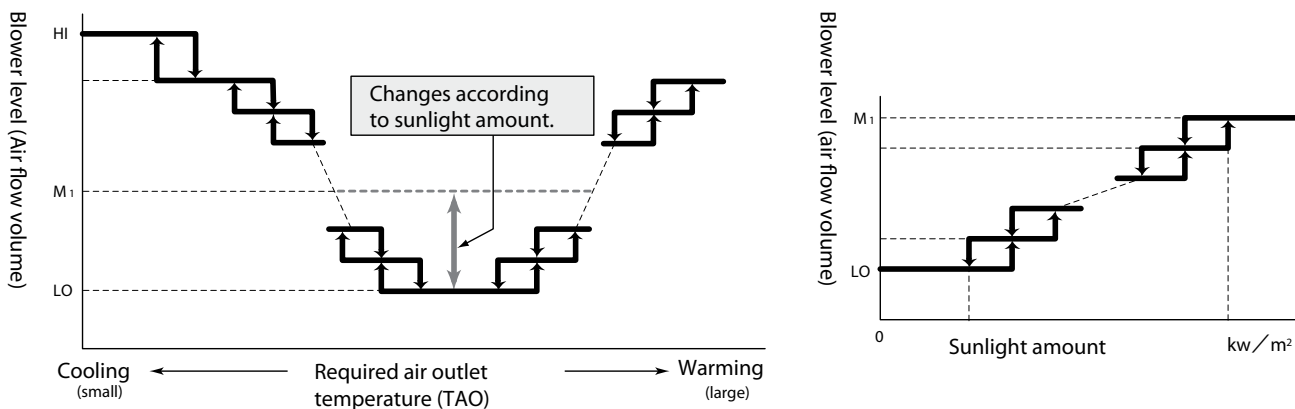
For example, in the five second period after the blower fan motor starts rotating, the blower level is fixed at LO and the evaporator is cooled. In the six seconds following this, with comparing air flow volumes of the cool-down control as shown in the figure below and basic air flow volume the lower air flow volume is automatically selected to control the systems. Following this there is normal control.

There is also a feature where, if the evaporator temperature becomes 86 degrees F or higher, the blower motor turns OFF for several seconds to cool the evaporator.



## Sunlight Air Flow Volume Control

When the outlet mode is in FACE, a signal from the solar sensor (sunlight amount) causes control of the blower LO level (minimum air flow volume) of the base control to raise the air flow volume in accordance with the amount of sunlight. This increases the feeling of cooling.



## Air Inlet Control

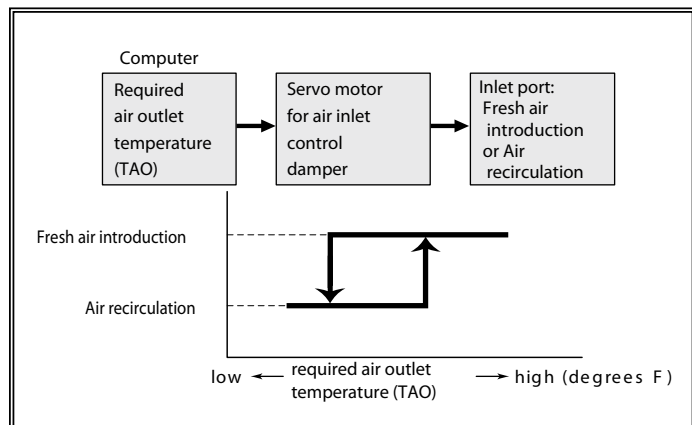
Changing of the air inlet mode is carried out by the servo motor with the air inlet control damper.

### Manual Control

Switching to the inlet port in accordance with the manual switch position on the control panel.

### Auto Control

The inlet port switches automatically between fresh air introduction and air recirculation according to the required air outlet temperature (TAO).

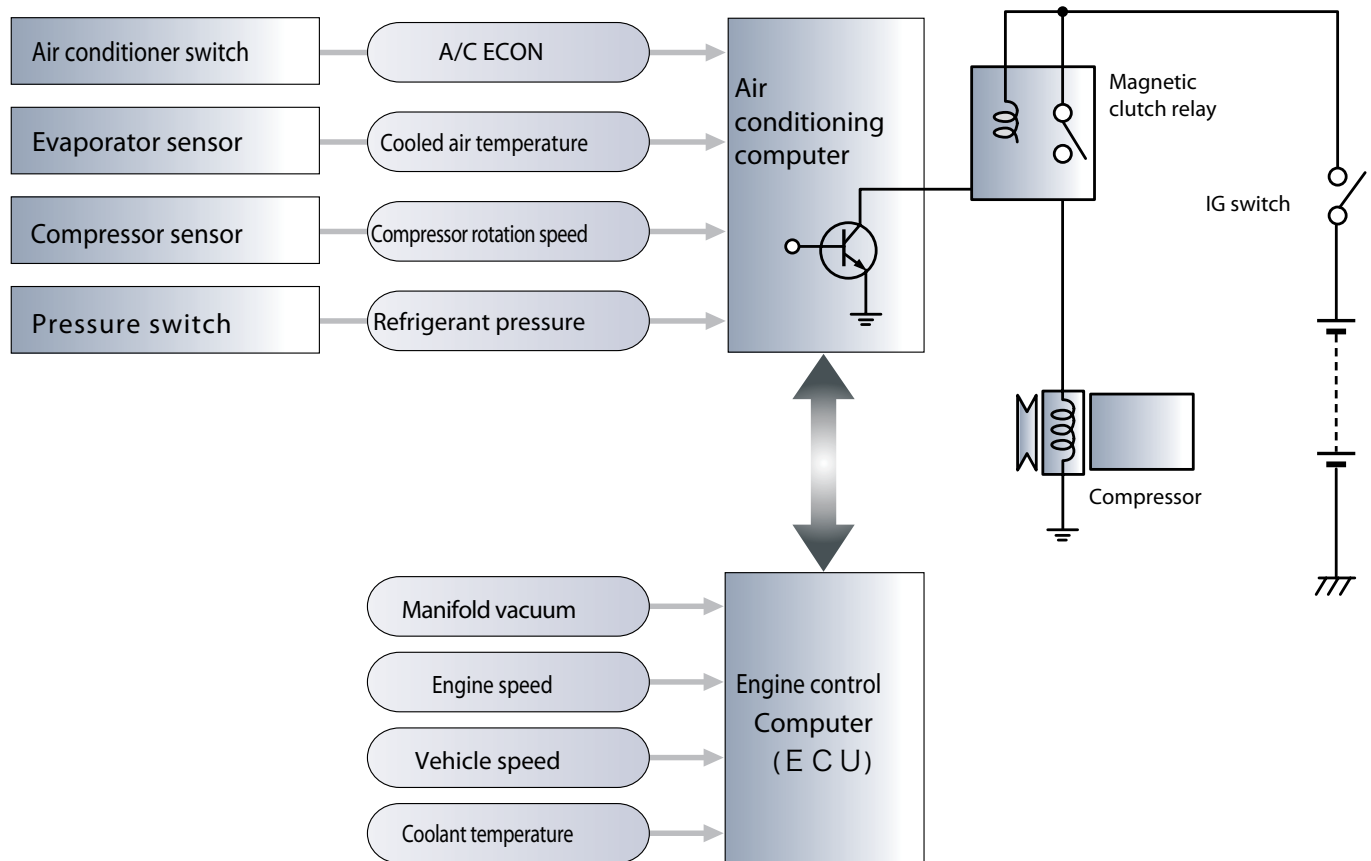


# Compressor Control

In a compressor control system the air conditioning computer (or engine control computer) automatically turns the compressor off and on by judging the passenger compartment room temperature, engine speed, and driving condition, via the use of sensors.

## ■ Outline of the Control System

The computer detects the OFF and ON status of the air conditioner, cooled air temperature, operation status of the compressor, and the engine and driving conditions, and automatically conducts fine-tuning for optimum control. A large percentage of engines are now electronically controlled. With electronically controlled engines, the engine control computer determines whether to switch the compressor ON or OFF based on the engine and driving conditions, and sends control signals to the air conditioning computer that controls the compressor.



“The air conditioning computer adeptly controls the compressor to turn the compressor ON and OFF by receiving signals from the engine control computer.”

## ■ Contents of the Control System

The contents of the control system partially vary according to the type of vehicle or air conditioner; however, the standard items and contents are listed below.

Item	Purpose	Contents of the Control System
1 A/C-ECON control	<ul style="list-style-type: none"> <li>Improved fuel consumption</li> <li>Frost prevention</li> </ul>	Controls the cooled air temperature. <ul style="list-style-type: none"> <li>A/C mode: The compressor is turned off at a temperature of 37°F or lower.</li> <li>ECON mode: The compressor is turned off at a temperature of 50°F or lower.</li> </ul>
2 Engine speed control	<ul style="list-style-type: none"> <li>Prevention of engine stall</li> </ul>	The compressor is turned off at lower engine speeds (approximately 500 rpm or lower).
3 Air conditioning cut off during acceleration	<ul style="list-style-type: none"> <li>Improved acceleration</li> </ul>	The compressor is turned off during acceleration for a certain time period (for a few seconds).
4 Variable capacity control	<ul style="list-style-type: none"> <li>Improved fuel consumption</li> </ul>	With the variable capacity type compressor (electric powered type), the compressor capacity is controlled by the thermal load.
5 Air conditioning cut off at high coolant temperature	<ul style="list-style-type: none"> <li>Reduce load on engine</li> </ul>	The compressor is turned off when the temperature of the engine coolant increases to a certain temperature (approximately 212°F).
6 Judgement of abnormality in refrigerant pressure	<ul style="list-style-type: none"> <li>Device protection</li> </ul>	The compressor is turned off when an abnormality occurs in the refrigeration cycle.
7 Judgement of a lock up compressor	<ul style="list-style-type: none"> <li>Protection of belts wrapped together with other parts.</li> </ul>	If the compressor locks up, the belt wrapped around the power steering pump is protected.

Note: The standard values used in the control system description above are only examples.

## ■ A/C - ECON Control

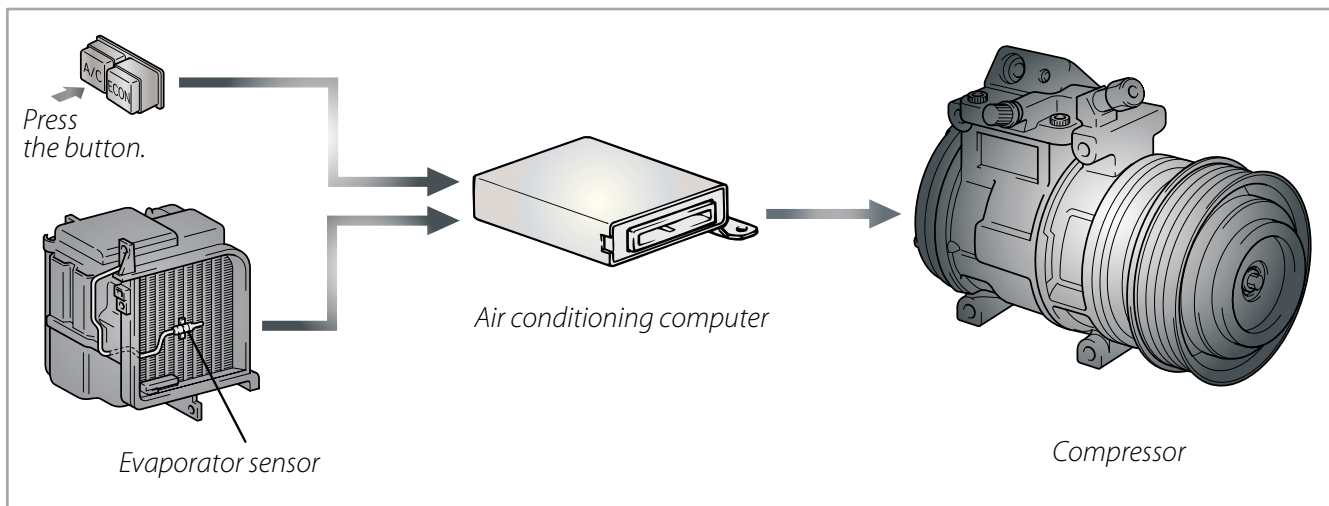
The A/C-ECON control turns the compressor off and on, according to the operation mode of the air conditioning switch.

### A/C mode (very cold air)

Used for quick cooling, particularly during high summer temperatures.

### ECON mode (moderately cold air)

Used to generate moderately cold air, or for dehumidification, and this is especially useful for energy-saving driving.



## ■ Engine Speed Control

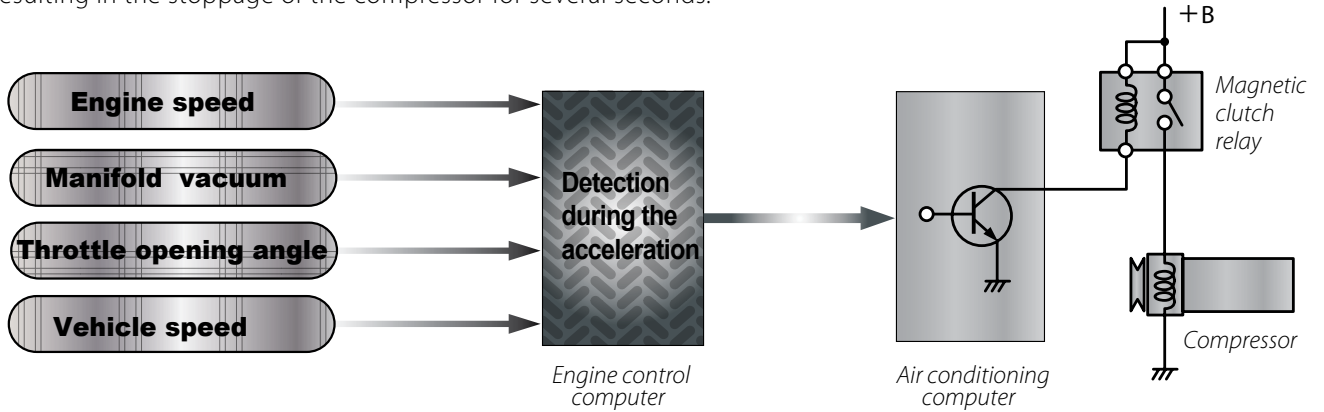
Due to low engine output during idling, the engine can stall if the compressor is functioning. The compressor should be shut off if the engine speed drops to a certain level, in order to prevent engine failure.

## ■ Air Conditioning Cut Off Control During Acceleration

The air conditioning cut off control stops the compressor during acceleration, in order to improve the acceleration performance.

The overall control at acceleration is judged by the engine control computer, based on the engine speed, manifold vacuum, throttle opening angle, vehicle speed, and other factors.

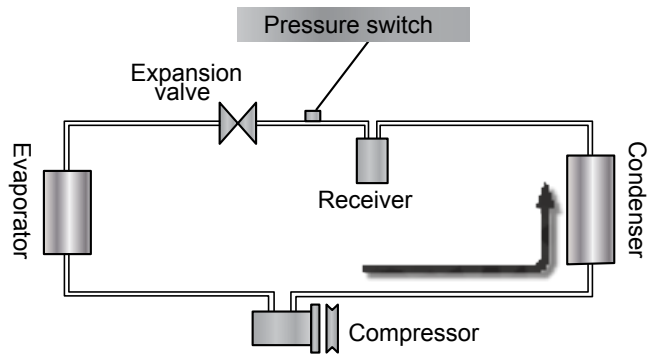
If judged to be in "acceleration mode" the engine control computer sends signals to the air conditioning computer, resulting in the stoppage of the compressor for several seconds.



## ■ Judgment of Abnormality in the Refrigerant Pressure

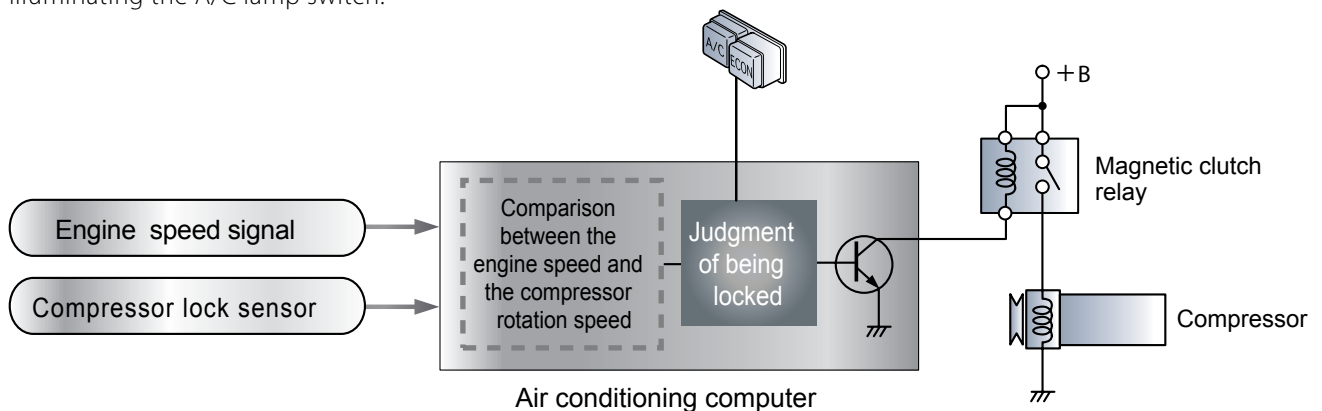
The pressure switch is attached to the high pressure side of the refrigeration cycle and is used to detect abnormality in the pressure and to stop the compressor. It prevents problems caused by abnormal pressure in order to protect the equipment in the refrigeration cycle.

The pressure switch is normally attached between the receiver and the expansion valve to detect the refrigerant pressure.



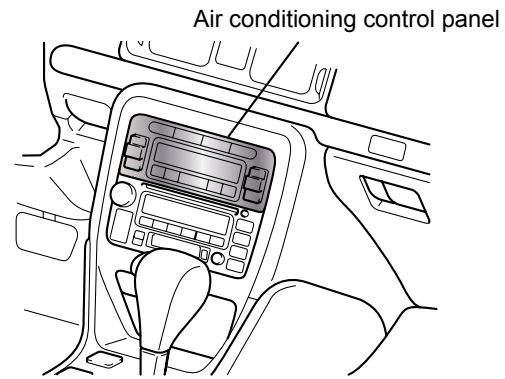
## ■ Judgment of a locked Compressor

In the case that the driving belt of the compressor is wrapped around the power steering pump, if the compressor continues to operate, the belt may break due to an abrasion or other problems, which will affect the function of the power steering. The compressor rotation is always monitored by a compressor lock sensor. If it is judged to be locked up, the air conditioning computer immediately stops the compressor and informs the driver of the abnormality by illuminating the A/C lamp switch.



# Self-Diagnostic Function

The self-diagnostic system detects areas with abnormalities. If an abnormality occurs in the air conditioning signal system of the air conditioning computer, the item code is output to the diagnostic computer, or indicator on the control panel.



## Function

### (1) Indicator check

Indicator functions and lamp burn out, are checked by flashing the indicators (lamps) on each air conditioner switch and each temperature preset indicator.

### (2) Sensor check

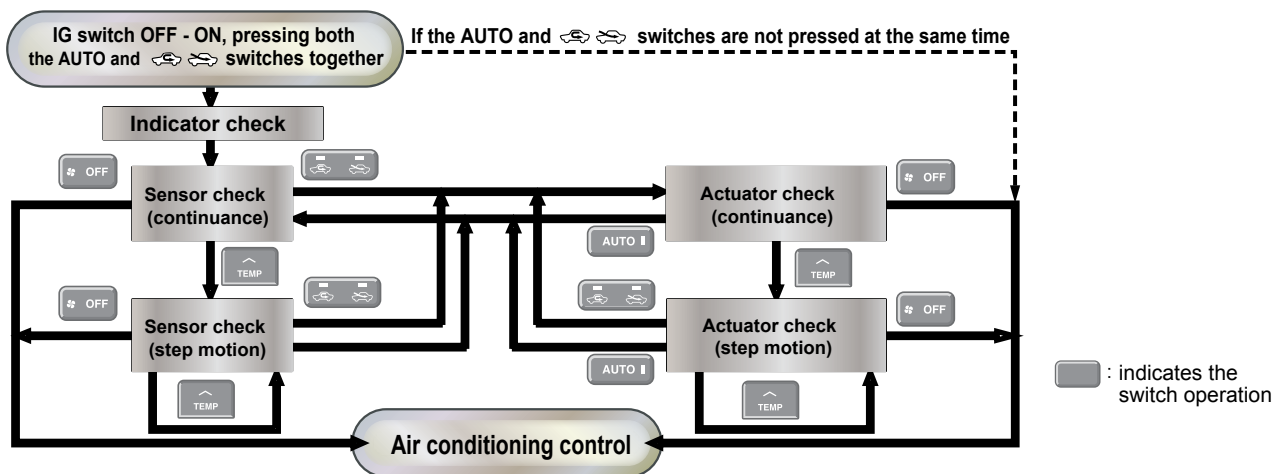
The sensor input signal is checked to determine whether the sensor function is normal, and then indicates the result. In the case where a problem is found, it indicates that if the problem remains or if it occurred in the past.

### (3) Actuator check

A motion pattern is output to each actuator (blower motor, air outlet control damper servo motor, air mix control damper servo motor or compressor, etc.) The inspector checks that each actuator operates in the manner designated by the computer.

## Operation and Indication

An example is shown below. If both the **AUTO** and switches are pressed at the same time, the diagnosis function automatically starts both the indicator check and the sensor check. After both checks are completed, the next check begins by the operation of the switches, as shown in the following figure.



• Sensor check (an example of diagnosis 12)



• Actuator check (an example of pattern 2)





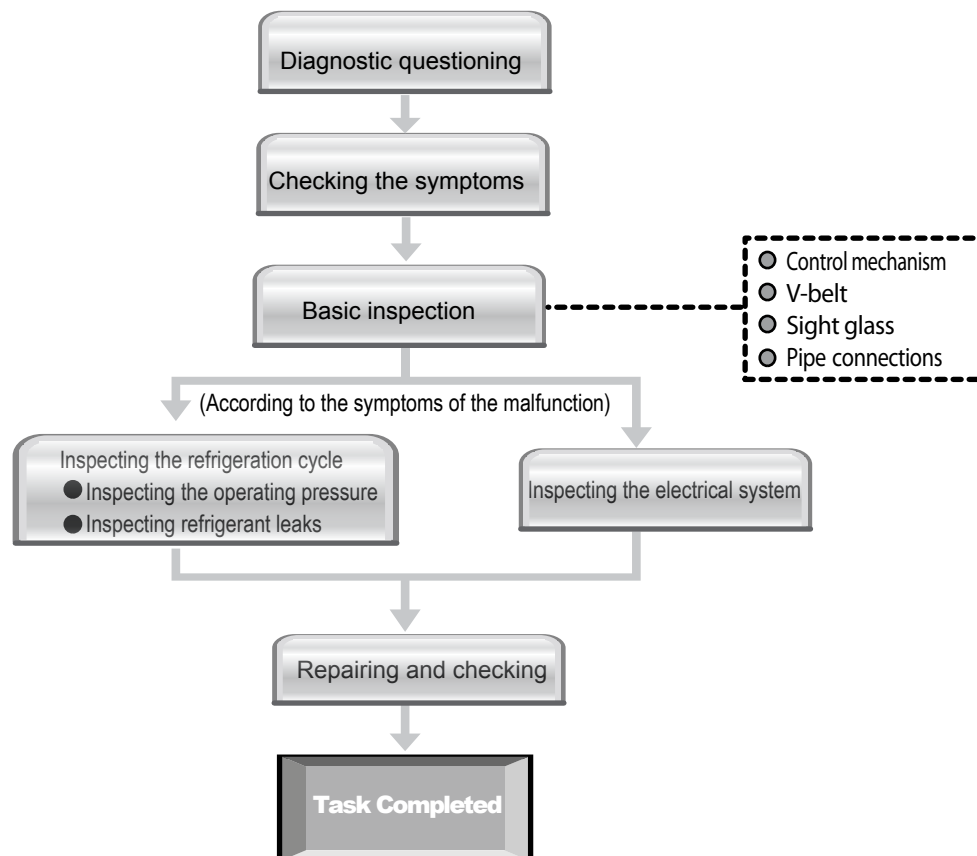
## Precautions in handling the refrigeration system

The refrigerant recharging process requires the handling of highly pressurized refrigerant gas, which could expose the person to a hazardous situation, it must be performed by a specialist who has been trained for this operation.

## Troubleshooting procedure

Malfunctions of a car air-conditioning system can be broadly divided into those that are related to the refrigeration cycle or the electrical system.

Thus, to troubleshoot the system, it is necessary to thoroughly check the symptoms of the malfunction and the circumstances in which the malfunction occurred. Especially, if the symptom of the malfunction only occurs intermittently or cannot be duplicated, it is necessary to properly conduct diagnostic questioning in order to determine the circumstances in which the malfunction occurred. As a rule, troubleshooting is conducted in the sequence given below, based on the findings of diagnostic questioning.



# Inspecting the Refrigeration System

## Measurement Conditions

Beware that the inspection of the system when the ambient air temperature is low (below 15°C) could result in misdiagnosis because the refrigerant pressure does not increase.

Generally speaking, an inspection of the refrigeration system is performed under the conditions described below, in which the load on the car air-conditioning system is at its maximum level.

**Doors** ~~~~~ all open

**Engine RPM** ~~~~~ 1500 rpm

**Air-Conditioning Switch** ~~~~~ ON

**Temperature Control** ~~~~~ MAX COOL

**Blower Speed** ~~~~~ HI

**Fresh-Air/Recirculation** ~~~~~ RECIRCULATION

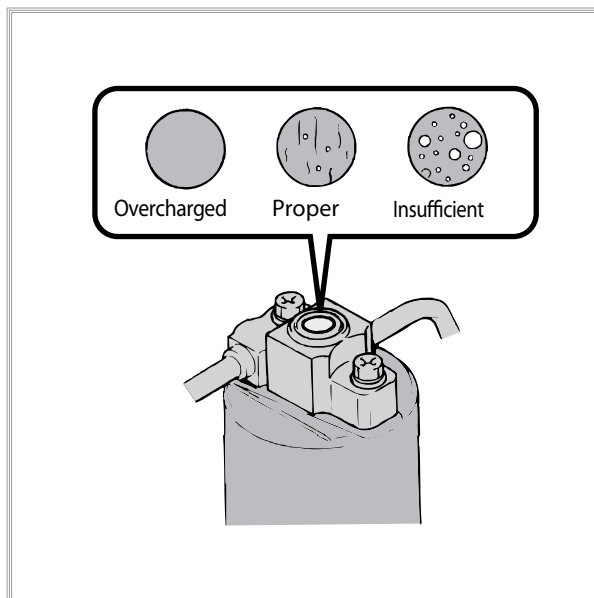
## Inspection Through the Sight Glass

Check the conditions of the refrigerant through the sight glass.

**Proper Amount** Practically no air bubbles are visible. When the engine speed is increased gradually from idle to 1500 rpm, the air bubbles disappear and the refrigerant becomes clear.

**Overcharged** No air bubbles whatsoever are visible. In this case, both the high and low pressure sides of the system are high, resulting in poor cooling performance.

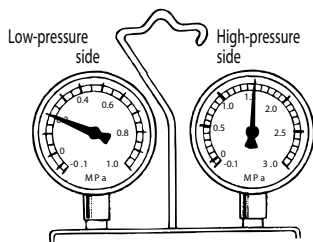
**Insufficient** Air bubbles pass continuously under the the sight glass.



## Inspection with Manifold Gauge Set

Connect manifold gauge set to the low and high pressure sides of the refrigeration system to determine the conditions according to the readings on the gauge set.

### Normal Condition



Under the measurement conditions given in 3-1:

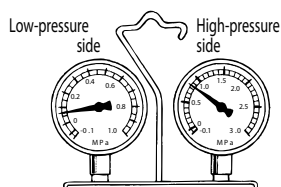
**Low-pressure side pressure** 0.15~0.25MPa  
(1.5~2.5Kgf/cm<sup>2</sup>)

**High-pressure side pressure** 1.37~1.57MPa  
(14~16Kgf/cm<sup>2</sup>)

*Note: The readings on the manifold gauge set could vary slightly depending on the circumstances.*

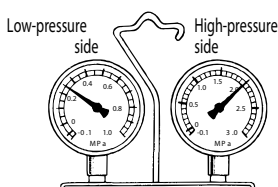
### Readings by Symptom (these are typical examples)

(1) Insufficient refrigerant



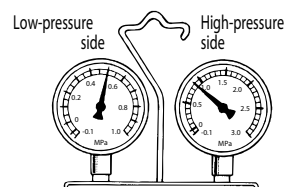
(The pressure is low both at the low-pressure and high-pressure sides.)

(2) Overcharged: Insufficient Cooling of Condenser



(The pressure is high both at the low-pressure and high-pressure sides.)

(3) Poor Compression of Compressor



(The pressure is high at the low-pressure side, and low at the high-pressure side.)

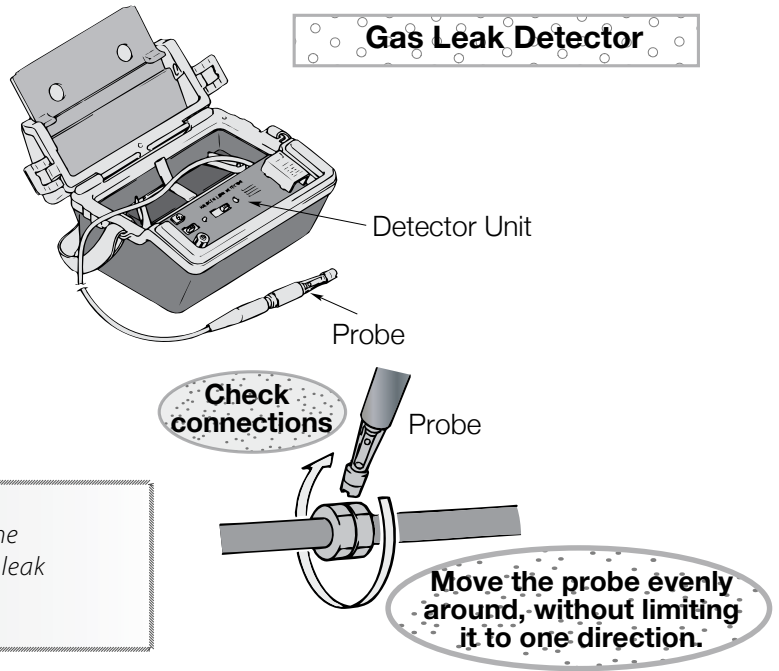
## Refrigerant Leak Inspection

If the basic inspection reveals the possibility of a refrigerant leak, use a gas leak detector to perform a leakage inspection.

### Checking procedure

Connect the manifold gauge set to check the conditions of the refrigerant that remains in the refrigeration system. If the gauge pressure without air conditioning operation is below 0.4 MPa (4kgf/cm<sup>2</sup>G), recharge the system with refrigerant as necessary in order to raise the pressure in the system before checking for leaks. This helps to improve the precision of the leakage inspection.

*For the detailed inspection procedure, refer to the operation manual that is supplied with the gas leak detector.*



## Replacing Parts

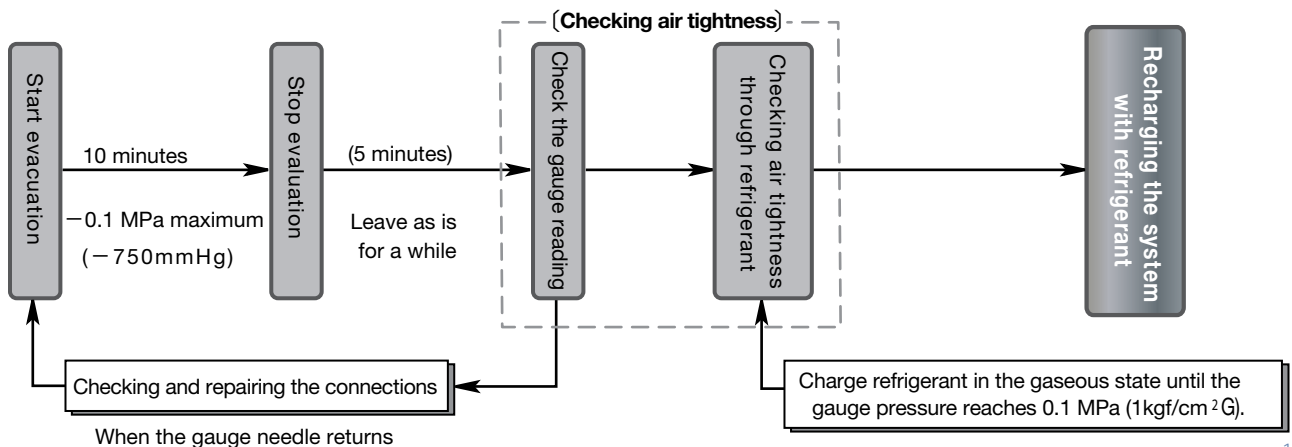
### Compatibility of the Air-Conditioning System

Refrigerant used in car air-conditioning systems, 134A (R134a) and CFC-12 (R12), are not mutually interchangeable. Therefore, exercise extreme caution in handling functional parts that comprise the refrigeration system and oil that lubricates the compressor because compressor oil and O-rings cannot be readily distinguished.

## Recharging the System with Refrigerant

### Evacuation

Replacing a part of the refrigeration system causes the system to be exposed to the atmosphere. Because air invariably contains some moisture, it is necessary to remove this moisture from the system. Even a small amount of moisture remaining in the system could cause a problem, such as freezing up in the small orifice of the expansion valve or corroding the valves in the compressor. Therefore, the moisture in the refrigeration system must be thoroughly removed before recharging the system with refrigerant. To remove moisture, a vacuum pump is used to evacuate the refrigeration system in order to vaporize the moisture. This process is called "evacuation."



## Refrigerant Recharging

After the evacuation of the system has been completed, the refrigeration system must be recharged with refrigerant. Because the volume of the refrigerant used in a system varies from model to model, it must be recharged with the proper volume.

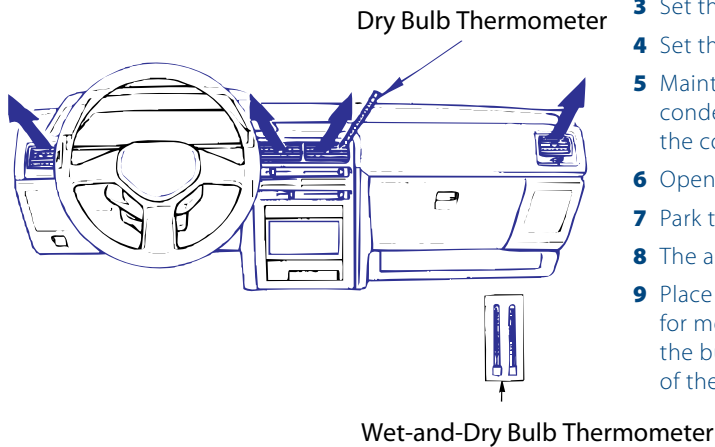
### WORK IS TO BE PERFORMED ONLY BY A SPECIALIST!


Because the refrigerant recharging process requires the handling of highly pressurized gas, which could expose the person to a hazardous situation, it must only be performed by a specialist.

## Performance Test

To test the cooling performance of an air-conditioning system, the temperatures at the air inlet and outlet are measured, and the resultant difference is compared against the standard performance chart.

### Test Conditions



- 1 Turn the blower switch to HI.
- 2 Turn the temperature lever to MAX COOL.
- 3 Set the mode to [  ].
- 4 Set the engine speed to 2000 rpm.
- 5 Maintain the refrigerant pressure at the condenser (substitute it with the high pressure side of the compressor) to 1.5 MPa (15.5 kgf/cm<sup>2</sup>).
- 6 Open all the doors of the vehicle.
- 7 Park the vehicle in the shade.
- 8 The air inlet temperature must be between 77°F to 95°F.
- 9 Place a wet-and-dry bulb thermometer (which is required for measuring the temperature) at the air inlet, and insert the bulb portion of a dry bulb thermometer into the center of the air outlet.

Operate the air-conditioning system under the conditions described above, and when the outlet air temperature has stabilized (approximately 5 to 6 minutes), measure the difference in temperatures between both dry bulb thermometers and the relative humidity of the inlet air.

### Viewing the Performance Chart

After obtaining the difference in the (air inlet and outlet) temperatures, find the applicable humidity from the air diagram. Then, apply the findings against the standard performance chart. If the point in which both values intersect at a right angle is in the shaded area shown in the diagram, the air-conditioning system is determined to be operating normally.

