

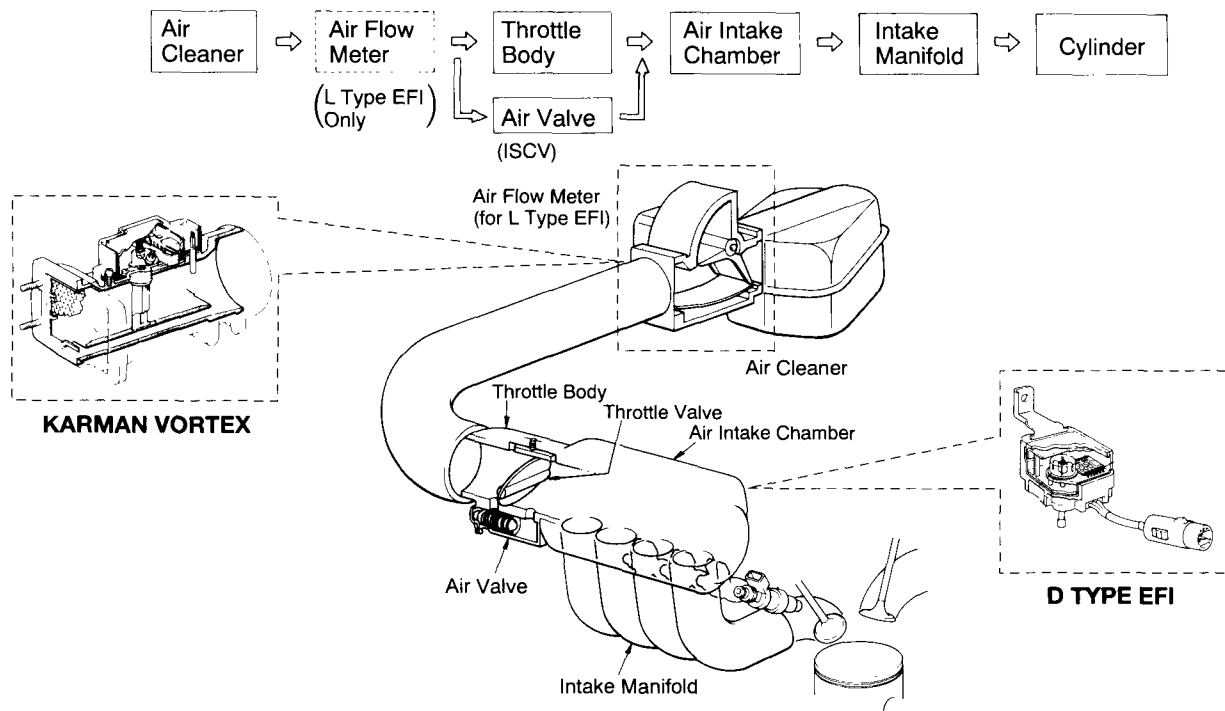
Overview Of The Air Induction System

The purpose of the air induction system is to filter, meter, and measure intake air flow into the engine. Air, filtered by the air cleaner, passes into the intake manifold in varying volumes. The amount of air entering the engine is a function of throttle valve opening angle and engine rpm. Air velocity is increased as it passes through the long, narrow intake manifold runners, resulting in improved engine **volumetric efficiency**.

Intake air volume is measured by movement of the air flow meter measuring plate or by detecting **vortex frequency** on engines equipped

with L type EFI. On engines equipped with D type EFI, air volume is measured by monitoring the pressure in the intake manifold, a value which varies proportionally with the volume of air entering the engine.

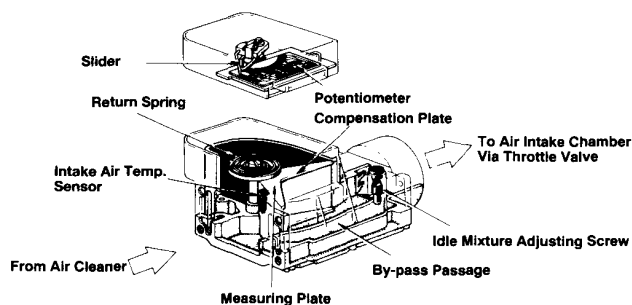
The throttle valve directly controls the volume of air which enters the engine based on driver demand. Additionally, when the engine is cold, it is necessary for supplementary air to by-pass the closed throttle valve to provide cold fast idle. This is accomplished by a bi-metallic or wax type air valve or by an ECU controlled Idle Speed Control Valve (ISCV).



Air Induction System Components

Vane Air Flow Meter (L Type EFI)

The vane type air flow meter is a commonly used air volume measurement device on Toyota EFI engines. The meter consists of a measuring plate, which is spring loaded closed by a return spring, and a **potentiometer** attached to the plate, which varies an electrical signal to the ECU as the position of the plate changes. Air volume entering the engine is directly proportional to the amount of movement detected from the measuring plate. Additionally, the air flow meter incorporates a fuel pump enable contact which breaks the ground circuit of the circuit opening relay if the engine stops running.



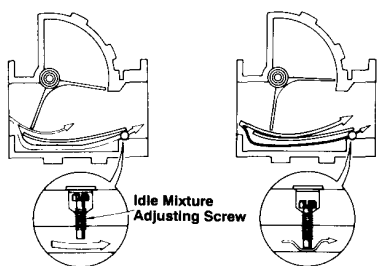
The air flow meter is placed in series between the air cleaner and the throttle body, thereby measuring all air which enters the engine. Integrated with the air flow meter is an intake air temperature sensor and an idle mixture by-pass passage.

Idle Mixture Air By-pass Circuit

For proper calibration of the engine air/fuel ratio at idle speed, an idle mixture air by-pass circuit is incorporated into the air flow meter. A screw is used to adjust the amount of air which by-passes the measuring plate. This screw is adjusted and sealed at the factory to discourage improper adjustment and tampering. There are no provisions or specifications for field adjustment.

After factory calibration of the air flow meter, a two-digit number is stamped into the meter casting near the idle mixture adjusting screw. This number indicates the distance from the casting to the flat surface of the screw and can be used as a reference if the idle mixture screw has been tampered with.

The calibration number can be interpreted by referring to the examples in the following chart.



Standard Measurement of Idle Mixture Adjusting Screw

Number on casting	Distance from casting surface to top of screw
30	13.0 mm
26	12.6 mm
24	12.4 mm

Fuel Pump Circuit Control

A fuel pump switch is incorporated into the air flow meter to prevent the fuel pump from running unless the engine is running. Any movement of the air flow meter measuring plate will cause the fuel pump switch contact to close. When the engine is not running, the measuring plate forces the fuel pump switch contact open, preventing the circuit opening relay from operating. For more information on the fuel pump electrical circuit, refer to section 3, "Fuel Delivery and Injection Control."

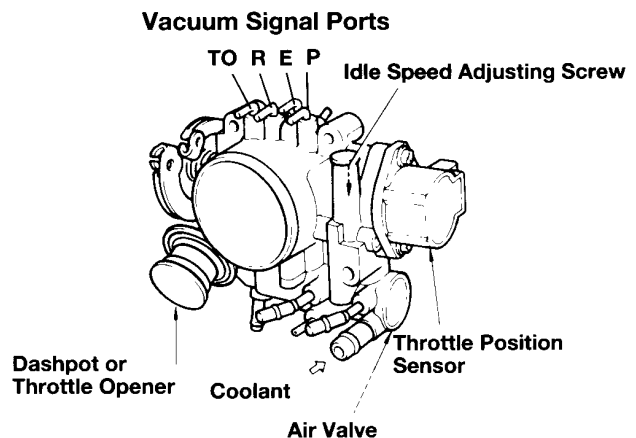
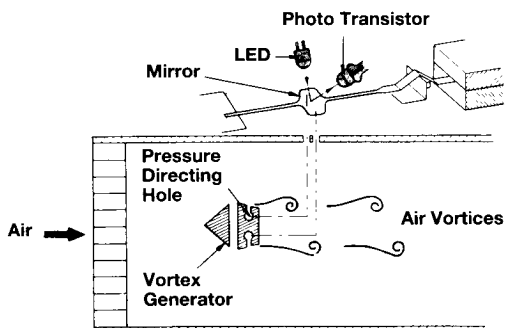
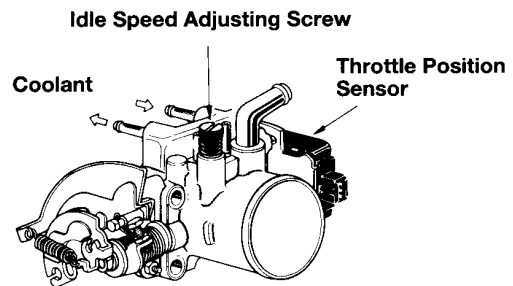
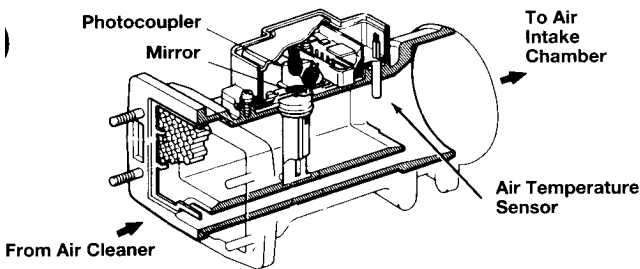
Karman Vortex Air Flow Meter (L Type EFI)

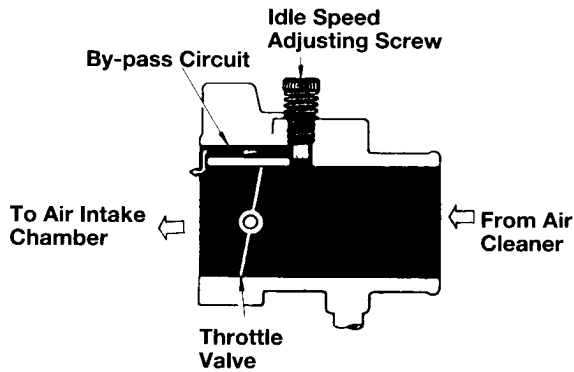
The Karman vortex air flow meter is used only on limited applications (7M-GTE and Lexus 1UZ-FE & 2JZ-GE engines). The meter is smaller and lighter than the vane type meter and offers less resistance to incoming air flow.

The sensor operates on the principle of measuring the vortices created as air flows past a pillar shaped vortex generator. The frequency with which these vortices are created increases in direct proportion to the amount of air flowing across the vortex generator. Vortex frequency is detected by a photocoupler and converted into a variable frequency digital signal by the sensor. An intake air temperature sensor is also incorporated into the Karman vortex air flow meter. For more information about operation of this air flow meter and its signals, refer to section 5, "Electronic Engine Controls."

Throttle Body

The throttle body consists of the throttle valve, the idle air by-pass circuit, the throttle position sensor, and also houses various ported and manifold vacuum sources to operate emissions devices. Throttle icing is prevented by use of an engine coolant cavity located adjacent to the throttle valve.





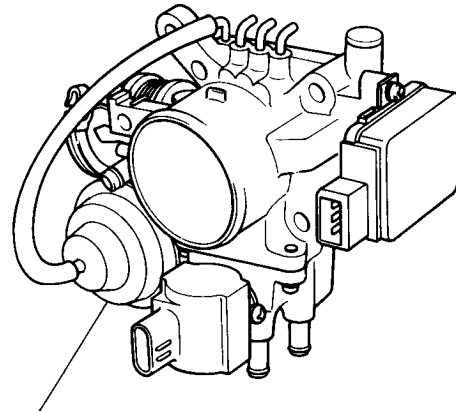
Idle Air By-pass

During idle operation, the throttle valve is almost completely closed. Idle air enters the engine through an adjustable throttle air by-pass screw which varies the amount of air which can flow past the closed throttle valve. By turning this screw clockwise, throttle bypass air is reduced, causing a decrease in idle speed. Conversely, turning the screw counterclockwise will increase idle speed by allowing more air to pass the closed throttle valve.

On engines equipped with an ECU controlled ISCV, this throttle air by-pass screw is seated at the factory, and there are no provisions for curb idle adjustment. Idle air is varied by the ECU through control of the ISC Valve position.

Decel Dashpot and Throttle Opener Systems

A decel dashpot or throttle opener is mounted to the throttle body on some engines. The decel dashpot is designed to keep the throttle valve from closing too suddenly during deceleration. The throttle opener is designed to hold the throttle valve open slightly after the engine is turned off.



Throttle Opener or Dashpot

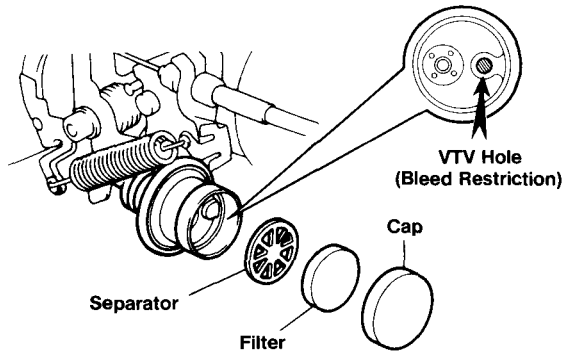
Non ECU Controlled Throttle Opener

Starting with 1990 3S-FE and 5S-FE engines, a simple throttle opener diaphragm was added to the throttle body. The throttle opener diaphragm is spring loaded in the extended position, holding the throttle valve open slightly when vacuum is not applied to the diaphragm. When the engine is started, manifold vacuum from the TO port retracts the throttle opener for normal curb idle.

The intent of the throttle opener system is to keep the throttle valve slightly open after the engine is turned off.

Non-ECU Controlled Dashpot

On some engines, a simple dashpot is used. When the throttle is open, the dashpot diaphragm spring extends the control rod, allowing atmospheric pressure to enter the diaphragm chamber through a small bleed restriction (VTV).



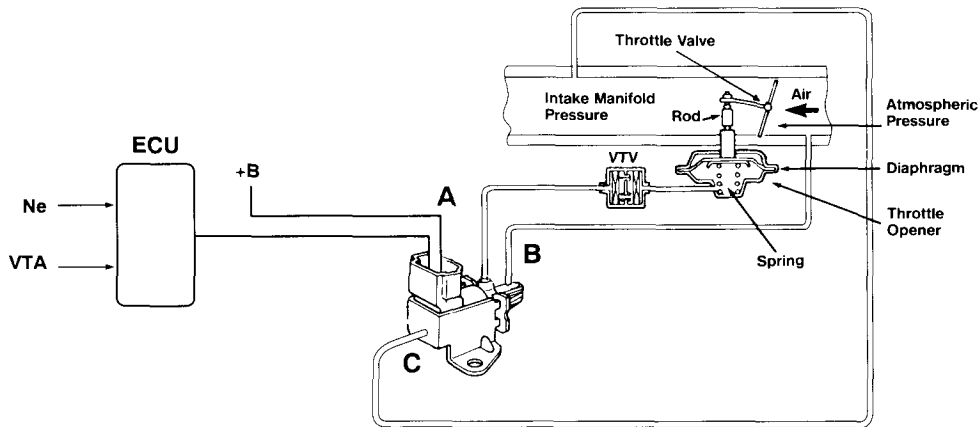
When the throttle closes, the throttle return spring pushes the dashpot control rod toward the retracted position. Atmospheric pressure trapped in the diaphragm chamber slowly bleeds through the restriction, causing the throttle to close slowly.

ECU Controlled Combination Throttle Opener/Dashpot

Dashpot and throttle opener functions are combined into one ECU controlled system on some late model engines like the '91 3E-E. This system uses an ECU controlled VSV to switch vacuum to the throttle opener/dashpot diaphragm.

- When the engine is stopped, spring tension extends the control rod, causing the throttle to open.
- When the engine is running above a given rpm, the ECU energizes the VSV, allowing atmospheric pressure to bleed into the throttle opener/dashpot diaphragm through the Vacuum Transmitting Valve (VTV). This allows spring tension to extend the control rod.
- When the throttle angle closes beyond a specified point during deceleration, the ECU de-energizes the VSV, allowing manifold vacuum to bleed through the VTV and act on the diaphragm. This causes the control rod to gradually retract, slowly closing the throttle valve.

The idle air by-pass screw, dashpot, and throttle opener do not require routine adjustment. In the event that these components have been tampered with, refer to the appropriate repair manual for adjustment procedures of curb idle, dashpot, throttle opener, and A/C idle up.

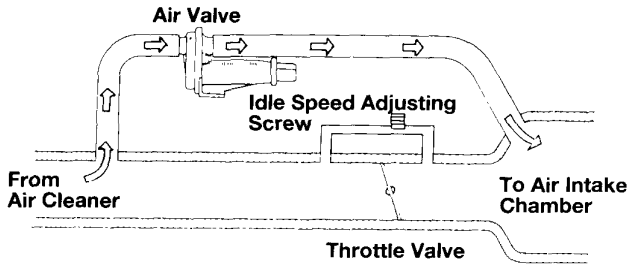


Driving Mode	VSV	Port A	Port B (Bleed)	Port C
Acceleration and Cruise	ON	○ — ○		
Deceleration	OFF	○ — ○ — ○		

- ECU turns VSV ON as throttle opens; rod extends
- ECU turns VSV OFF on deceleration; rod allows throttle to close slowly
- Engine OFF; rod extends, holding throttle open slightly

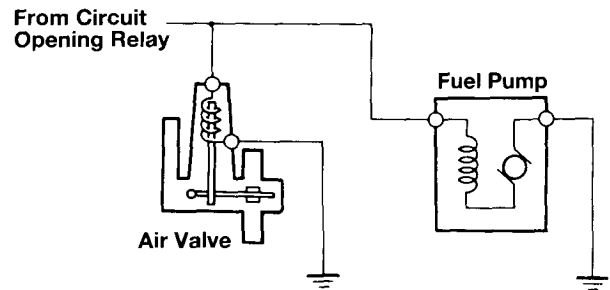
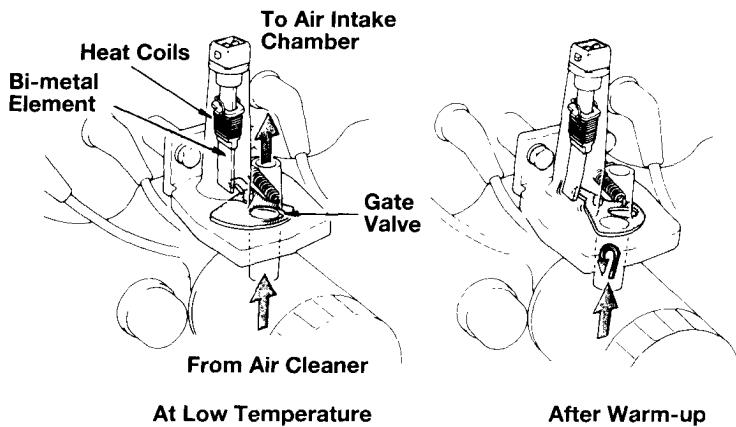
Air Valves

There are two types of non-ECU controlled air valves used on some engines to control cold engine fast idle. These valves, the electrically heated bi-metal type and the coolant heated wax type, vary the amount of air bypassing the closed throttle valve during cold engine operation.



Bi-metal Type Air Valve

This gate valve operates on the principle of a spring loaded gate balanced against a bi-metal element. The tension of the bi-metallic element varies the position of the gate as its temperature changes. The bi-metal element is heated by an electrical heater coil and by the temperature of the ambient air surrounding it. The air valve assembly is installed on the surface of the cylinder head to keep the gate valve closed during hot soak periods.

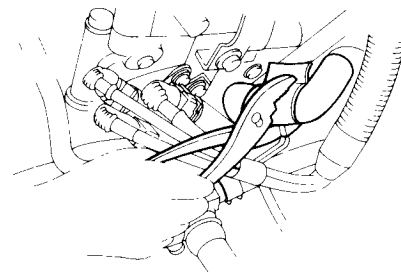
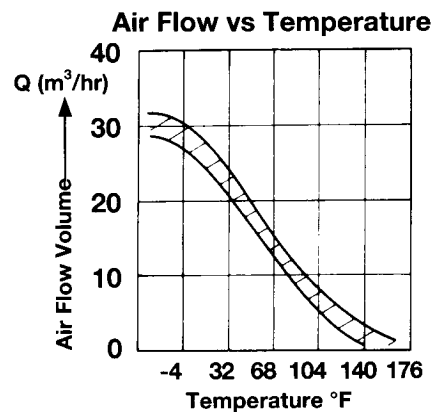


Heater current for the air valve is supplied by the circuit opening relay power contact, the same circuit which feeds the fuel pump.

Air valve operation can be quick checked by pinching off a supply hose and observing the rpm drop. When checked with a warm engine, the drop should be less than 50 rpm. When the engine is cold, the rpm drop should be high.

AIR VALVE TESTING

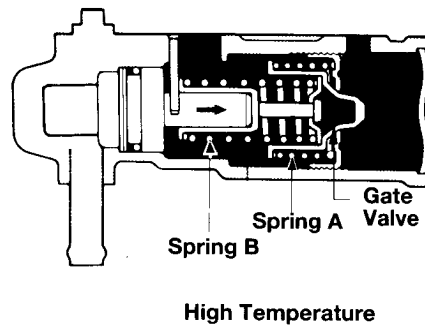
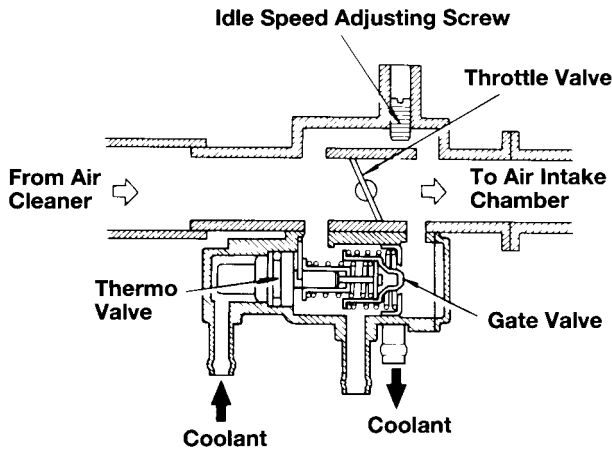
- Cold under hood temperature, high air by-pass volume
- Electric heater limits air valve "open" time
- Always some air flow due to valve design
- Pinch off hose to test
 - Cold engine/cold ambient temperature, large rpm drop
 - Cold engine/warm ambient temperature, small rpm drop
 - Fully warmed engine ≤ 50 rpm drop
- Additional inspections
 - Visual inspection of valve opening
 - Resistance check heater windings



Wax Type Air Valve

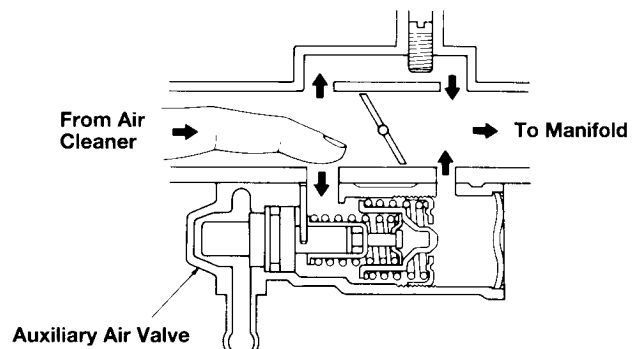
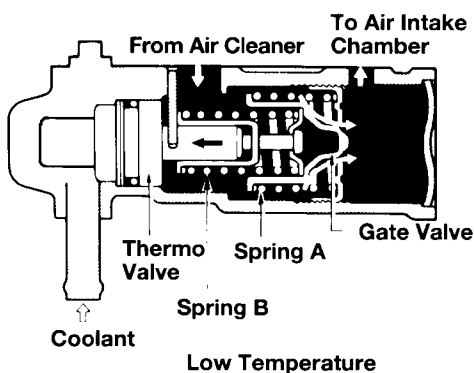
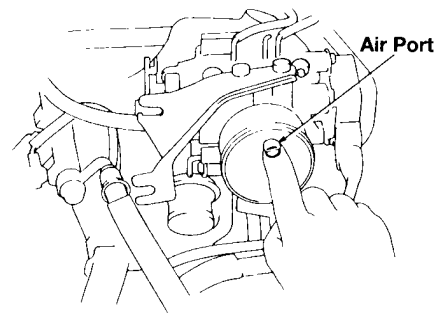
The wax type air valve is integrated with the throttle body and varies an idle air by-pass opening as coolant temperature changes. The valve works on the principle of a spring loaded gate valve balanced against a coolant heated, wax filled thermo valve.

As coolant temperature rises, the wax filled thermo valve expands allowing spring B to gradually close the valve (spring B is stronger than spring A). This causes engine rpm to decrease as air flow to the intake is decreased.



The wax type air valve should be fully closed by the time engine coolant temperature reaches approximately 80°C (176°F).

When coolant temperature is cold, the wax filled thermo valve retracts allowing spring A to push the gate valve open. This allows air to flow from the air cleaner side of the valve to the intake side of the valve.



- Cold engine, large rpm drop
- Fully warmed engine!~100 rpm drop

A good quick check for the wax type air valve is to observe engine rpm throughout the warm up cycle. Look for high rpm upon initial startup and gradual reduction to normal curb idle speed as the engine reaches normal operating temperature.

On D type EFI, the valve operation can also be checked by removing the air inlet pipe at the throttle body and blocking the fresh air port inside the throttle bore. When the engine is cold, engine rpm should drop greater than 100 rpm. Once the engine reaches normal operating temperature (~176°F), rpm drop should not exceed 100 rpm.

Intake Air Chamber & Manifold

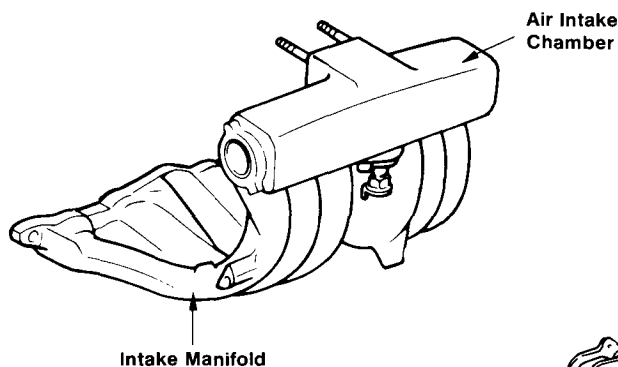
Port delivered Electronic Fuel Injection systems offer the advantage of not having to move fuel through the intake manifold. This allows for improved performance and emissions through optimum design of the intake air chamber and manifolds.

A large intake air chamber is provided to eliminate pulsation, thereby improving air distribution to each manifold runner. Long, narrow manifold runners are branched off to each intake port to improve air velocity at the intake valve. This design offers the following benefits:

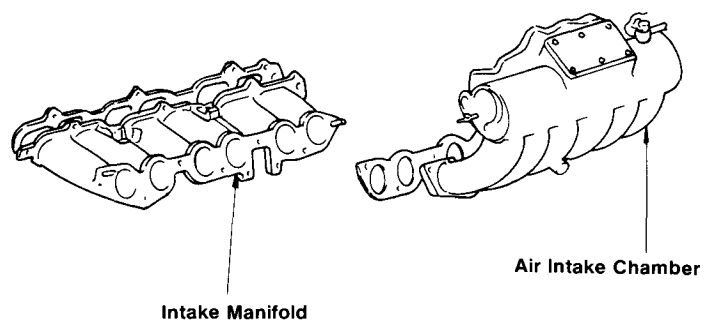
- Fuel puddling is eliminated, providing for leaner cold engine and power air/fuel ratios. This equates to reductions in emissions and improved fuel economy.
- Volumetric efficiency of the engine is improved, thereby improving engine torque and horsepower.

Depending upon application, the intake air chamber and manifolds may be integrated or separate. Some Toyota engines utilize an ECU controlled variable induction system which optimizes manifold design for low and high speed engine operation. For more information on these systems, refer to "Other TCCS Related Systems."

INTEGRATED TYPE



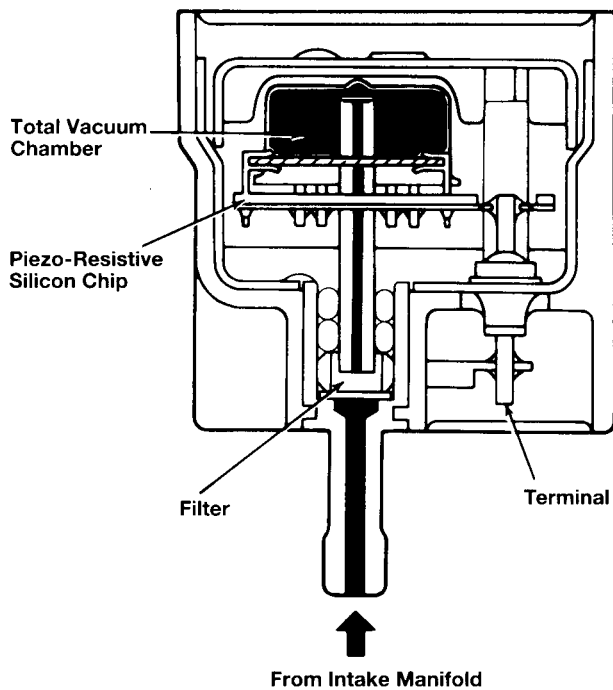
SEPARATE TYPE



Manifold Absolute Pressure Sensor (D Type EFI)

The D type EFI system eliminates the use of an air flow meter and uses a manifold absolute pressure sensor as a load measurement device instead.

Because pressure in the intake manifold is proportional to the amount of air entering it, the manifold absolute pressure sensor is used to measure air intake volume in the D type EFI system.



This sensor compares a variable pressure inside the intake manifold with a fixed reference pressure inside the sensor. A total vacuum chamber is placed on one side of a piezo-resistive silicon chip; manifold pressure is applied to the other side of the chip. As the chip flexes, the mechanical movement is converted into a variable voltage signal by the sensor. There are several different names used in reference to the Manifold Absolute Pressure sensor, depending on the publication you read. Two other common names used to refer to this sensor are PIM, or Pressure Intake Manifold, and Vacuum sensor.

For more information about operation of the manifold absolute pressure sensor and its signal characteristics, refer to "Electronic Engine Controls."

Idle-Up Systems

Air Conditioning Idle-up

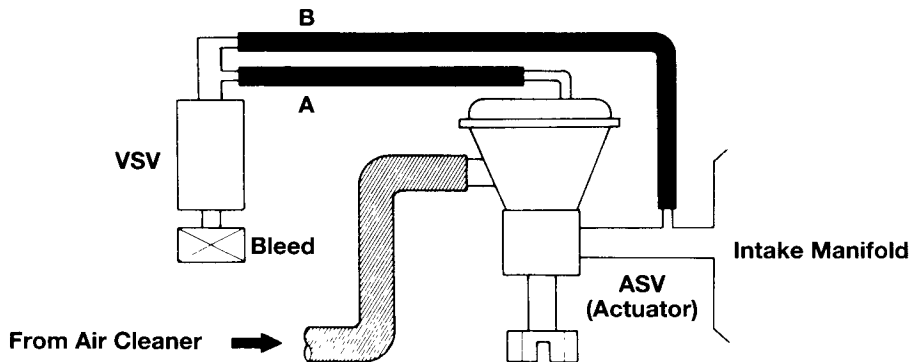
The air conditioning idle-up system is used to increase engine idle rpm any time the air conditioning compressor is in operation. The system shown is used on D type EFI applications where the ECU controlled Idle Speed Control Valve (ISCV) does not have an A/C idle-up feature. This system maintains engine idle stability during periods of A/C compressor operation. Additionally, it keeps compressor speed sufficiently high to ensure adequate cooling capacity at idle speed.

The A/C idle-up system consists of an A/C amplifier controlled Vacuum Switching Valve (VSV) and an Air Switching Valve (ASV) or actuator. By applying vacuum to the ASV diaphragm, fresh air from the air cleaner is by-passed into the intake manifold, increasing engine rpm.

When the VSV is energized, a manifold vacuum signal is applied to the actuator diaphragm of the ASV causing it to open the passage between the fresh air supply and the intake manifold. This extra air introduced directly into the intake manifold causes engine rpm to increase.

When the VSV is de-energized, the vacuum control signal to the ASV is blocked and any trapped vacuum is bled off of the diaphragm. This causes the ASV to block air flowing to the intake manifold, decreasing rpm.

The A/C idle-up system described above is not an ECU controlled system. For information on ECU controlled ISCV systems which control A/C idle-up speed, refer to "Engine Controls - Idle Speed Control Systems."



A/C Clutch	VSV	Port A	Port B	Bleed
ON	ON	○ — ○	○ — ○	
OFF	OFF	○ — ○	○ — ○	○ — ○

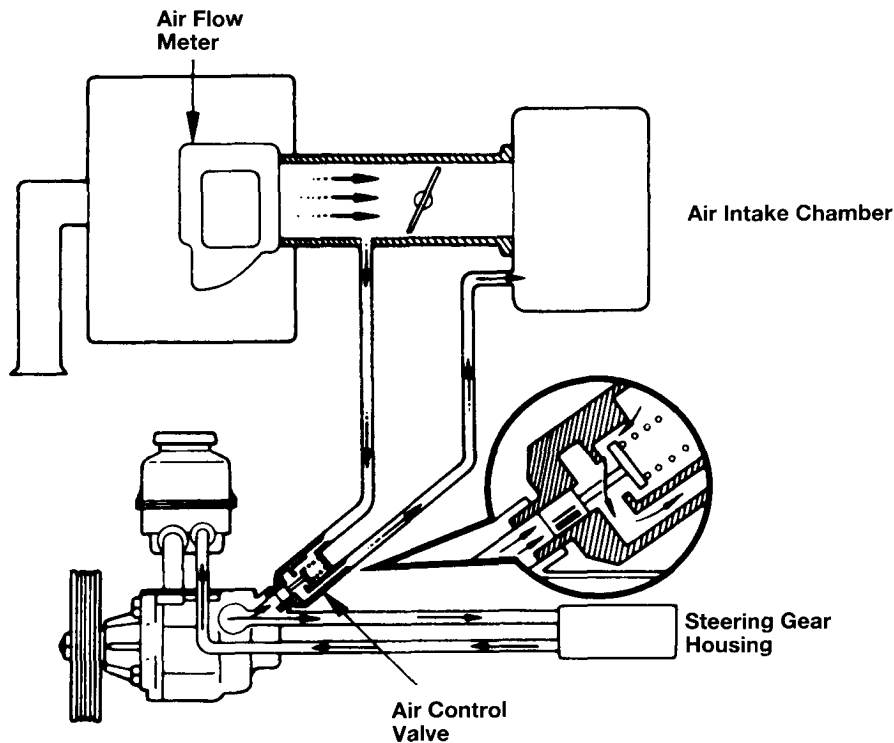
- Energized, VSV connects manifold vacuum to diaphragm. This opens passage between air cleaner and intake manifold
- De-energized, VSV vents actuator diaphragm to atmosphere

Power Steering Idle-up

The power steering system draws a significant amount of horsepower from the engine when the steering wheel is turned to either stop. This can have an adverse effect on vehicle driveability. To address this potential problem, many EFI engines equipped with power steering use a power steering idle-up system which activates whenever the steering wheel is turned to a stop.

The power steering idle-up system consists of a hydraulically operated air control valve and a vacuum circuit which by-passes the throttle valve. Whenever power steering pressure exceeds the calibration point of the control valve, the valve opens, allowing a calibrated volume of air to by-pass the closed throttle valve.

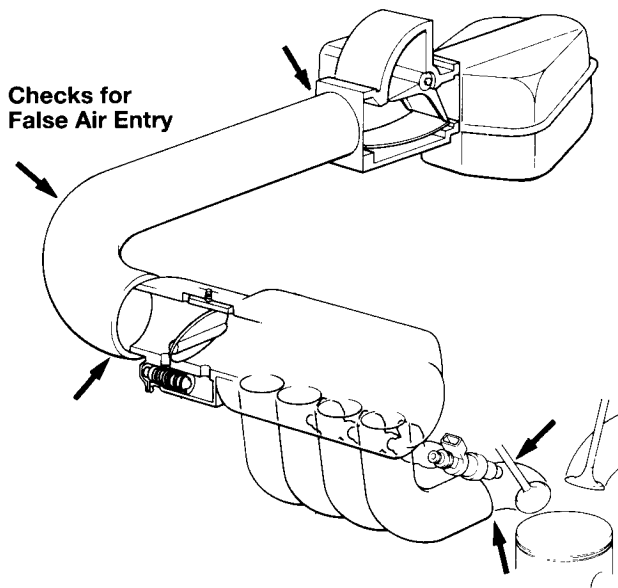
Because power steering pressure only exceeds the pressure calibration point of the valve when the steering wheel is turned to its stop, the system is only functional during very low speed maneuvering and at idle. The system can be tested by turning the steering wheel to a stop while listening for an rpm increase.



Common Service Concerns and Solutions

During service procedures, there are two concerns related to the air induction system which the technician should be aware of. These are false or unmeasured air entry into the intake system and deposit buildup on the back side of intake valves.

False Air Entry Into Induction System



False air is any air which enters the induction system unwanted and/or unmeasured. In addition to obvious leaks in the intake manifold, with an L type EFI system, false air can enter the induction system through the connecting pipe between the air flow meter and the throttle body as well as through leaks into the crankcase. Because this air is able to enter the intake manifold unmeasured, the result is an excessively lean air/fuel ratio. The end result of false air with L type EFI is rough idle, stumble, and/or flat spots.

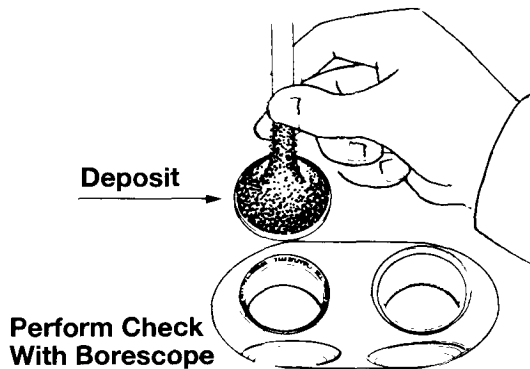
With the D type EFI system, false air is typically measured by the EFI system because it results in an increase in manifold absolute pressure. The end result is an engine that idles excessively high but with a relatively normal air/fuel mixture.

There are several tests which can detect false air entry into the induction system. A good visual inspection of the intake air connector pipe and connection points as well as inspection of all vacuum hoses, engine oil filler cap, and dip stick seals are a must.

If this fails to identify a suspected leak, spraying carburetor cleaner around suspected leak areas while observing an infrared exhaust analyzer for carbon monoxide increase is another method to assist in leak detection.

Another method to locate suspected false air entry points is to pressurize the intake system with a regulated shop air supply (CAUTION: do not exceed 25 PSI). Spray a soapy water solution around all suspected leak areas. Simply listen and observe for bubbles to locate leak sources. This method requires sealing the air cleaner fresh air inlet and blocking the throttle valve open to pressurize the intake air connector pipe. The air pressure can be applied through any large manifold vacuum fitting.

Intake Valve Deposits



This condition manifests itself as hardened carbon deposits on the back side of the intake valves. It varies in degree depending on the engine, fuel quality, and customer driving habits.

Intake valve deposits present a dual problem. First, these deposits restrict the flow of air and fuel mixture into the cylinder, reducing volumetric efficiency and potentially affecting high rpm engine performance. Additionally, these carbon deposits act like sponges absorbing fuel vapor. This causes lean driveability problems, particularly during cold engine operation.

The best way to identify this condition is by symptom and then through visual inspection. A visual inspection can be performed using a borescope, SSI #00451-42889, to confirm the problem. The intake manifold can also be removed to confirm the existence and the degree of this condition.

The accompanying chart will help you to determine the appropriate action to take based upon visual inspection. Visual inspection can be performed without removal of the cylinder head or intake manifold by using a borescope, SSI 00451-42889. The engine can be manually rotated until the intake valve is fully open; then the borescope

can be inserted through a spark plug hole for inspection.

Repairs can be affected by use of SST 00002216401, a walnut shell type Carbon Cleaner Kit, and 00002-217256, a Universal Plate & Gasket Kit. These tools will allow removal of deposits without removal of the cylinder head.

Summary In this chapter, you have learned that the air induction system filters, meters, and measures air flow into the engine. By using multiple port injection, the intake system can be designed with long tuned intake runners to improve the engine's volumetric efficiency.

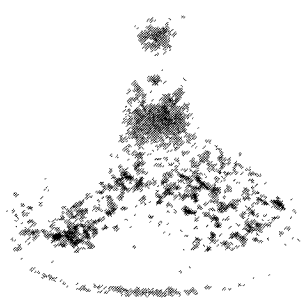
Air flow into the engine is controlled by the driver by opening and closing the throttle valve. As air enters the engine, it is measured by one of three different types of air flow meters with L type injection or by a manifold absolute pressure sensor with D type injection.

To improve engine idle quality during cold engine operation, some engines use a mechanical air valve to control air flow past the closed throttle valve. There are two different types of air valves used, one heated by engine coolant, the other heated electrically.

Depending on engine application, there are several different types of throttle control and idle-up devices used. Throttle body mounted devices provide a deceleration dashpot function and/or throttle opener function. Remotely mounted idle-up devices are used on some engines to control additional air flow into the engine when load from the A/C compressor or power steering pump are placed on the engine.

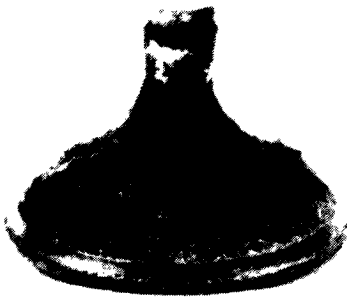
In section 3, Fuel Deliver & Injection controls, you will learn about the fuel delivery system.

INTAKE VALVE DEPOSIT RATING

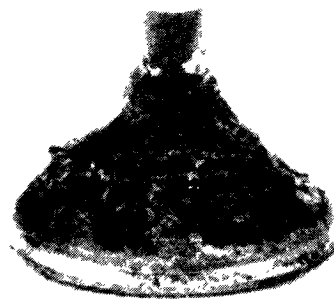


Cleaning is not necessary

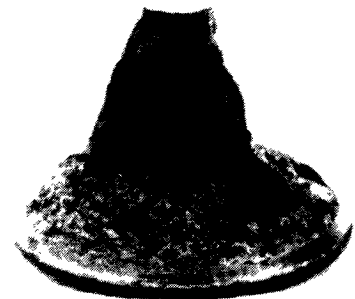
All Ratings below this line require cleaning



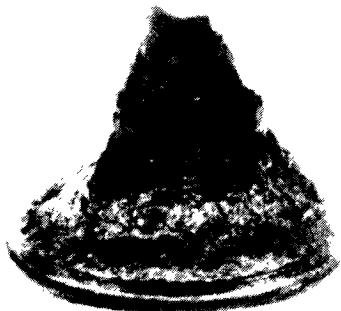
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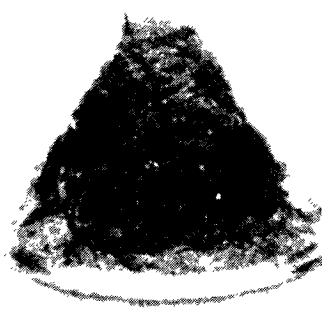
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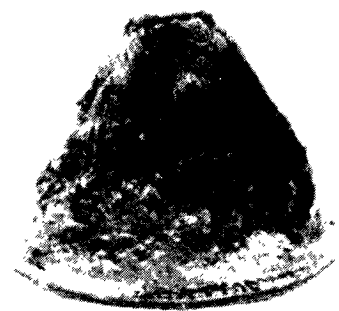
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