Engine Mechanical

The engine control and emissions sub-systems all rely on good mechanical condition of the engine to operate normally and effectively. Mechanical malfunctions effect exhaust emissions and driveability, both directly and indirectly:

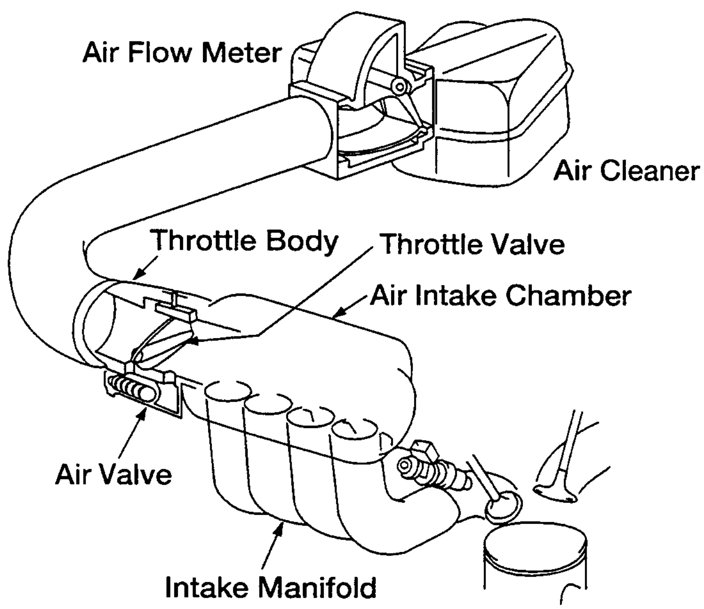
- Directly, any mechanical malfunction will likely cause significant increases in exhaust emissions by causing misfire, allowing combustion gasses to escape past exhaust valves or piston rings, by altering air/fuel ratios, or any number of other possibilities.

- Indirectly, mechanical malfunctions change the composition of catalyst feed gas, preventing the catalytic converter from operating efficiently.

Examples of mechanical problems that can increase exhaust emission output include; low cylinder compression causing poor combustion and/or misfire, worn oil control rings that allow excessive engine oil (HC) to be consumed during combustion, etc. Remember, always check the integrity of basic engine mechanical systems before moving on to more complex engine or emission sub-systems.

Air Induction System

The Air Induction System must accurately meter and measure intake airflow or emission or driveability concerns will result.



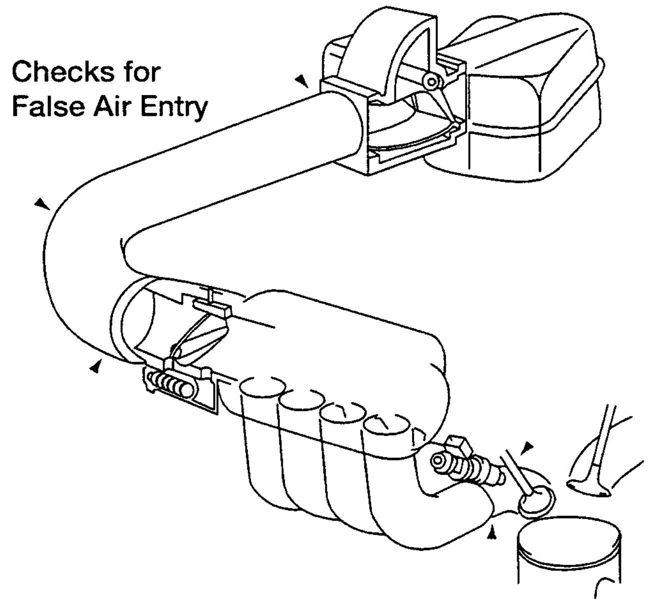
Air Induction System

The air induction sub-system meters and measures engine air based on driver demand. In the event that unmetered air enters the engine or if it is not measured accurately, the unbalanced air /fuel ratio will cause increases in exhaust emissions and/or driveability concerns. The following areas of the air induction system may require your attention when troubleshooting an emissions or driveability concern.

False Intake Air Entry
If unmeasured air enters engines equipped with L-type injection, they may exhibit lean surges, misfire and rough idle. Lean operating conditions can also cause increases in hydrocarbons, due to misfire, and in NOx due to leaner air/fuel ratios, increased combustion temperatures and decreased reduction catalyst efficiency.

False Intake Air Entry

Typical false air entry locations include; intake manifold gasket, intake air ducting, throttle shaft bushing, etc.



Engines equipped with D-type injection will exhibit an elevated engine idle speed if unmeasured air enters the induction system. Generally, this will not cause exhaust emissions to increase significantly.

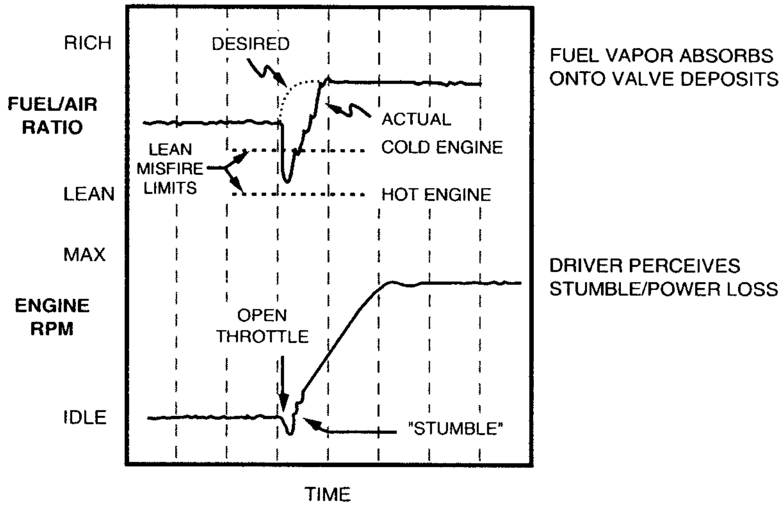
Intake Valve Deposits

Intake valve deposits are hardened carbon deposits which form on the back side of the intake valve. The degree of deposits vary depending on many factors like fuel properties, driving habits, and engine family. Intake valve deposits can cause driveability concerns as well as increased exhaust emissions.

Excessive intake valve deposits can cause an engine to run excessively lean while cruising and accelerating, and excessively rich during deceleration. During lean operating periods, NOx emissions are elevated. During rich operating periods, CO emissions are elevated. The amount of emissions increase has a linear relationship with the degree of deposits on the valves. At some point, deposits can effect emissions enough to put a vehicle out of compliance in an Enhanced I/M test.

Effects of Intake Valve Deposits

The graphs show the effects of intake valve deposits on both A/F ratio (top) and engine rpm (bottom). The symptoms are more noticeable during cold engine operation.



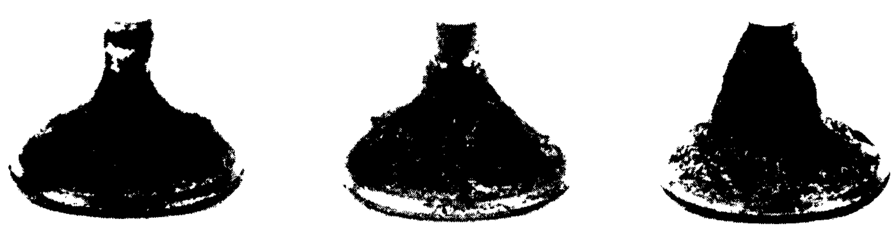
Effects of Intake Valve Deposits on Driveability

There are several common driveability symptoms which can be caused by intake valve deposits; stumble, hesitation and loss of power under load. Stumble and hesitation, especially when the engine is cold, are by far the most common problems caused by excessive intake valve deposits. The porous carbon deposits act like a sponge, absorbing enough fuel vapor to cause these symptoms.

Severe carbon deposits can also cause a loss of power at high engine rpm. When deposits accumulate sufficiently to restrict airflow through the intake valve, the volumetric efficiency of the engine is effected, causing the engine to loose power.

Intake Valve Deposits

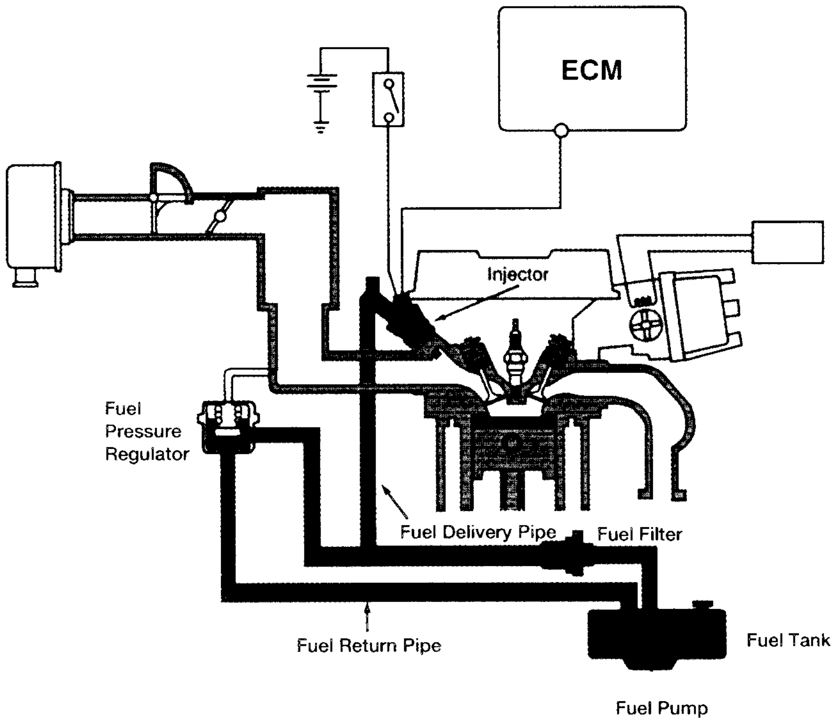
The following are examples of unacceptable intake valve deposit levels (require cleaning).



The best way to confirm excessive deposits is to visually inspect the valves using a borescope. If repairs are necessary, equipment is available to clean the valves without removing the cylinder head. Refer to Toyota Technical Service Bulletins for more information on procedures and special service tools.

Fuel Delivery System

The fuel delivery system is responsible for maintaining constant fuel pressure across the injectors, in addition to metering the correct amount of fuel into the intake manifold.



Fuel Delivery System

The fuel delivery and injection control system delivers fuel to the engine and meters the amount of fuel which is injected into the intake manifold. There are two factors which, under normal conditions, should determine the air/fuel ratio; **fuel pressure and injection duration**. In the event that either of these factors is incorrect, normal air/fuel ratio will be upset.

One factor which can upset the normal air/fuel ratio is unmeasured fuel. Leaking injectors, a leaking fuel pressure regulator diaphragm, crankcase oil diluted with gasoline, or a saturated evaporative emissions system can all cause an excessively rich air/fuel ratio.

Finally, the air fuel ratio can also be upset by restriction in the injector nozzle or problems with the injector spray pattern. Symptoms caused by fuel injector spray pattern and restrictions are similar to those caused by intake valve deposits; stumble, hesitation, loss of power, etc.

Fuel Injector Test Methods

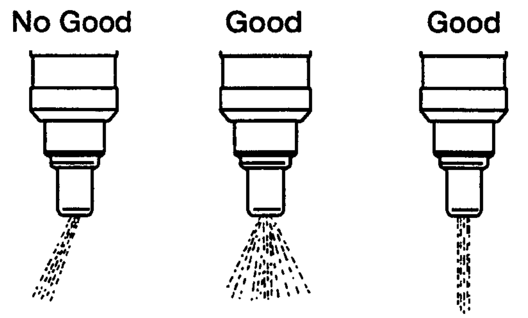
Testing fuel injectors for restriction and/or spray pattern can be accomplished one of two ways; visual inspection and pressure drop method.

Visual Inspection

Visual inspection requires that the suspect injector(s) be removed from the engine, connected to a test apparatus, and electrically energized for a fixed time period. The injector should deliver the specified volume and spray pattern should appear uniformly conical.

Injector Spray Patterns

Injectors should have a conical spray pattern and disperse fuel evenly.



Pressure Drop Test

The pressure drop method requires the use of a fuel pressure gauge and an injector pulse timer available from specialty tool vendors. Generally speaking, this test can be performed without removing the injector from the engine. By energizing the injector for a fixed pulse width and observing the pressure drop on the fuel system, the relative fuel flow can be compared for each injector. If all injectors exhibit a consistent pressure drop, it follows that all injectors are flowing the same volume of fuel. There are three shortcomings with this type of test which limit its usefulness, they are:

- Actual injector flow volume can not be determined, only relative flow
- Spray pattern cannot be observed during this test
- There are no specifications for the pressure drop test.

Incorrect Injection Duration

In addition to the problems mentioned above, false sensor input from any of the **six major input sensors** can also cause the air/fuel ratio to shift sufficiently to cause driveability and/or emissions concerns. If engine load is incorrectly calculated, fuel requirements are also miscalculated, resulting in a driveability or emissions concern. This type of a condition can be identified by reading sensor signals and comparing them to standard values. With this type of condition, the ECM adaptive fuel program will probably be making major corrections to bring the air/fuel ratio back into a neutral range (stoichiometry).

Fuel Trim Data Interpretation

As shown, fuel trim parameters and interpretation methods differ depending on the vehicle's diagnostic system.

Diagnostic System	Long Fuel Trim Data Parameter	Normal Operating Range *possible problem indicated outside of this range	Diagnostic Interpretation
OBD (w/o serial data)	Learned Voltage Feedback (LVF)* *Access at VF1 terminal of check connector, TE1 off	2.50 ± 1.25 volts	LVF represents command to injection system 5.0 volts = lean condition 0 volts = rich condition
OBD (with serial data)	Target A/F	2.50 ± 1.25 volts	Target A/F represents command to injection system 5.0 volts = lean condition 0 volts = rich condition
OBD-II	Long FT	0% ± 10%	Long FT represents command to injection system > 10% = lean condition < 10% = rich condition

The best way to confirm that a neutral air/fuel ratio is being delivered to the engine, is to monitor the **adaptive fuel correction** to injection duration. This can be accomplished several different ways, depending on the engine being tested:

1. OBD vehicles without serial data: Use a voltmeter on terminal VF1 at DLC 1 (check connector)

2. OBD vehicles with serial data: Use a scan tool to monitor Target A/F data

3. OBD-II vehicles: Use a scan tool to monitor Fuel Trim data

A Few Words on Fuel

Effects of Octane Rating on Engine Performance and "Knocking"

When diagnosing any customer concern related to poor engine performance or engine "knocking", always suspect fuel quality, or more specifically the octane rating of the fuel being used. The octane rating is a reflection of the fuel's ability to withstand engine knock, and is rated by its Antiknock Index (or pump octane rating). This number is displayed on a yellow sticker on the side of each gas pump.

Since octane requirements differ from vehicle to vehicle, always check in the Owner's Manual for vehicle's exact octane requirement and verify with the customer that their concern is not the result of low octane fuel. On vehicles with Knock Control systems, low octane may not cause the engine to knock, since the system has the ability to retarded spark advance; however, the engine may perform poorly as a result of a conservative spark advance strategy. If the engine knocking or performance concern is not the result of a sub-system problem, you may want to suggest to the customer a change in fuel grade or retailer.

Gasoline Volatility and Seasonal Fuel Blends

Volatility refers to a fuel's ability to change from a liquid to a vapor. This characteristic of fuel is very important in maintaining satisfactory vehicle driveability. If fuel volatility is too low, hard starting and poor warm-up driveability problems may result. If fuel volatility is too high, vapor lock, hot driveability problems, and excessive evaporative emissions may result.

Since fuel vaporization is naturally sensitive to ambient temperature change, refiners typically provide a more volatile fuel blend in the winter to provide easy start-up and cold weather driveability. Conversely, in the summer, a less volatile fuel blend is provided to lessen the chance of vapor lock or hot driveability problems.

Occasional driveability concerns may arise when retailers change blends between seasons (typically spring or fall). For example, if a change was made to a winter blend, yet the weather remained uncharacteristically hot, a hot driveability problem may arise (and vice versa).

Oxygenated Fuels

As a result of the 1990 Clean Air Act Amendments, the use of oxygenated and reformulated fuels has already occurred in many metropolitan areas across the United States. Oxygenated gasoline contain oxygen carrying compounds (usually ethanol or MTBE) that chemically enleans the AT mixture. This leaner AT mixture results in lower carbon monoxide (CO) emissions from the tailpipe.

A few points require clarification concerning oxygenated fuels. First, late model feedback control vehicles may see a slight fuel economy loss (around 2%) when using oxygenated fuels. This occurs as a result of feedback system enrichening the mixture when the O2 sensor detects the additional oxygen provided by the fuel. Second, fuel system components in older model vehicles may experience swelling (hoses, O-rings, gaskets, etc.) from the alcohol used in some oxygenated fuels. The Owner's Manual contains detailed information on the allowable percentages of both MTBE and ethanol.

