Air Fuel Control

The Stoichiometric mixture of 14.7:1 is critical to emission control

Using a scan tool you can monitor “Fuel Trim” to see if engine is running rich or lean.

Positive fuel trim means the computer is adding extra fuel (too lean). Negative trim shows too rich.

If fuel trim is over 10% (positive or negative) you might check fuel pressure.
Base Fuel Control

The PCM calculates all fuel quantities based on a specific fuel pressure.

The Fuel pressure and the pressure regulator must be accurate to ensure proper fuel trim and fuel control.

The PCM does not monitor fuel pressure.
Base Fuel Control

The PCM calculates all fuel quantities based on a specific fuel pressure

The Fuel pressure regulator must be accurate

The PCM does not monitor fuel pressure
Base Fuel Control

Fuel pressure that is too high = too rich
Fuel pressure that is too low = too lean

Correct fuel pressure is one of the FIRST things to check
Check Fuel Pressure

Test fuel pressure with No Vacuum to the fuel pressure regulator

AND

Test Fuel Pressure with 20” vacuum applied to the fuel pressure regulator

There should be 10 PSI difference

Some systems have no pressure regulator
Replacing Fuel Filters

Restricted fuel filters may allow proper fuel pressure with LOW fuel volume.

This will cause engine to run lean especially under load.
Replacing Fuel Filters

Fuel filters are often under about 60 psi even when the engine is OFF!

Be sure to relieve all fuel pressure before replacing fuel filters

Be sure to pressurize and carefully check for leaks at filter any time you have removed or replaced it.
Types of Fuel Injection

CIS
Continuous Fuel Injection

TBI
Throttle Body Injection

PFI
Port Fuel Injection
CIS
Continuous Injection System

Used by European (Robert Bosh) vehicles

May be mechanical or computer controlled

Constantly injects fuel at each intake port.

Fuel pressure is increased at the injector to add more fuel
TBI
Throttle Body Injection

Fuel is injected above the throttle plate

PCM turns injectors on and off

More fuel is added by leaving injector on longer

All PCM calculations assume correct fuel pressure
PFI
Port Fuel Injection

One fuel injector for each cylinder

Fuel pressure regulator keeps the quantity of injected fuel constant

All PCM calculations assume correct fuel pressure
Port Fuel Injection

Injectors can be fired once per engine cycle
Single Fire

Injectors may be fired twice per engine cycle
Double Fire

Injectors are fired simultaneous or in groups

Sequential fuel injection fires individual injectors just before each intake stroke
Basic Maintenance

Injectors must be kept clean

Leaking ‘O’ rings can cause a lean misfire

Shorted injector windings can burn out the PCM
A leak in this ‘O’ ring may cause a lean miss.
Cold Enrichment

Why do cold engines need riches mixture?

Less fuel will vaporize

What sensor is used to enrich cold engines?

ECT

Engine Coolant Temperature sensor
High Resistance when Cold!
Low Resistance when Hot!

COOLANT TEMPERATURE SENSOR

COMPUTER

5 V

VOLTAGE SENSING CIRCUIT
ECT

Most defects in the Engine Coolant Temperature sensing circuit make PCM think the engine is colder.

This will cause a rich mixture.

Compare actual temperature to scan tool data.
Using the ODB-II room!
Cold Idle

Cold engines idle at a higher RPM

This is achieved by an IAC

Idle Air Control
Idle Air Control

Many systems will open the IAC while the engine is cranking or starting.

This is why many engines have no measureable cranking vacuum
Main Fuel Metering

The Stoichiometric mixture of 14.7:1 is critical to emission control

PCM uses sensors measure the engine “load” to determine how much fuel to add

Load sensors are the MAF, the VAF, and the MAP sensors
MAF
Mass Air Flow Sensor

Measures volume, temperature and humidity of incoming air

Will be inaccurate if “hot wire” is dirty or contaminated

Will be inaccurate if there are any air leaks between the sensor and the intake valve.
VAF
Vane Air Flow sensor

Some systems measure the volume of incoming air.

This is less accurate as temperature and humidity also affect the oxygen content of a given volume of air.

Any air or vacuum leaks will fool the engine into running lean.
ENGINE OFF, NO AIRFLOW

FLAP CLOSED, NO VOLTAGE

ENGINE IDLING, LOW AIRFLOW

FLAP SLIGHTLY OPEN, LOW VOLTAGE

HIGH SPEED/LOAD, MORE AIRFLOW

FLAP FARTHER OPEN, MORE VOLTAGE
Speed Density

Does not directly measure incoming air

Uses a MAP sensor...

... Temperature sensor

... Throttle Position sensor

... and RPM sensor

Indirectly calculates engine load
MAP
Manifold Absolute Pressure Sensor

Measures manifold pressure (vacuum)

Any vacuum leak will be measured and more fuel will be added

Idle speed will increase

May send a varying voltage, or frequency
Figure 2-10 Silicon diaphragm pressure sensor
FIGURE 7-12  Manifold absolute pressure sensor. Courtesy of Ford Motor Company.
Closed Loop Feedback

Sensors are monitored and the correct fuel quantity is calculated

Oxygen sensor is monitored to adjust “fuel trim”

O₂ (Oxygen) sensor provides the feedback
O2S & HO2S

Oxygen sensor must be hot to operate

Many Oxygen sensors have a heating element to keep them at operating temperature

Signal of 0.2V (200mV) to 1.1V (1100 mV)

Any signal below 450mV is considered “lean”
O2S & HO2S

Any air leak in the exhaust will send a “false” lean signal

Any cylinder misfire will send unburned oxygen into the exhaust and cause a lean signal

A worn out O2S will send a lean signal
O2S & HO2S

Any lean signal will have the PCM add fuel

“False” lean signals will cause the vehicle to run rich
Closed Loop Feedback

When in closed loop the fuel control attempts to maintain a stoichiometric mixture

The Load sensor, ECT (Engine Coolant Temperature) sensor and $O_2$ sensors are critical
Open Loop

At times the stoichiometric mixture is not wanted

Idle, cold operation, high load (power) and acceleration all call for extra fuel and are considered “open loop”

When in open loop the feedback from the oxygen sensor is ignored by the PCM
TPS
Throttle Position Sensor

The TPS asks for extra fuel when it is quickly opened

The TPS asks for extra fuel when the throttle is held wide open

The TPS asks for extra fuel when the engine is at idle
TPS
Throttle Position Sensor

Many Acceleration, Power and Idle problems can be traced to a defective TPS

Check voltage signal with an oscilloscope to catch small voltage dropouts