Combustion and EGR Part 3

In the last part of this EGR series, the Institute of the Motor Industry (IMI) continues looking at the combustion process and exhaust gas recirculation (EGR), along with possible faults.

There are four methods of EGR feedback that are used to monitor and control EGR:

Variations in manifold pressure and/or airflow

When the EGR is commanded, the exhaust gases replace some of the inducted air. This will show as a reduction in air flow in the induction tract and an increase in any manifold pressure (petrol). The weakness in this strategy is that any fault in the MAP, MAF or IAT sensor will confuse the feedback.

EGR poppet valve position sensor

The valves can be motorised or a controlled solenoid and will include a sensor which provides a feedback voltage to the PCM. This reports the position of the poppet valve. It does not report actual flow, but armed with information from MAF/MAP, it can create a much more accurate picture of EGR operation.

Delta pressure feedback EGR DPFE

This uses a differential pressure sensor which monitors the pressure drop created when exhaust gases flow through a restriction or orifice. This means that the actual flow is monitored, not just the command. This gives a much clearer picture of EGR operation and can produce some accurate and descriptive digital trouble codes when it malfunctions.

Wide band oxygen sensor

Some newer vehicles are fitted with a wide band oxygen sensor, which truly closes the EGR loop. The careful balance between airflow, EGR flow and throttle butterfly position can be accurately controlled by monitoring the air/fuel ratio from the exhaust gases.

Symptoms of EGR faults

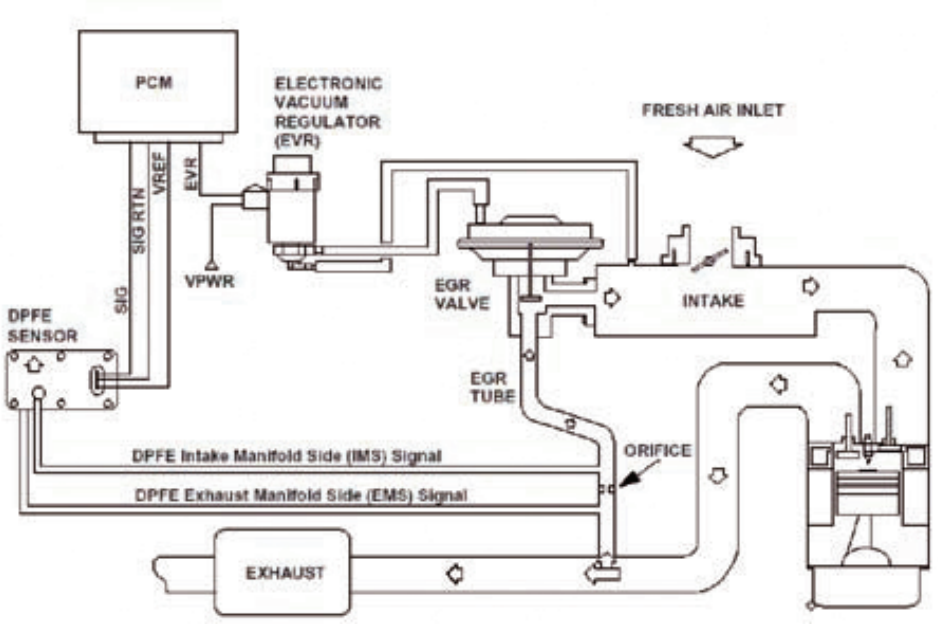
Petrol and diesel engines use EGR differently and symptoms and diagnostic procedures can differ, so we will deal with them separately.

Petrol Engines (Spark Ignition or SI)

Petrol engines use EGR to improve fuel efficiency by reducing pumping losses and knock control, as well as the control of NOx. It is only used when certain conditions apply. The EGR system has a number of overrides that prevent or reduce the computer EGR commands. Some of them are well known, but others are overlooked by most technicians.

EGR is disabled under the following conditions:

- Idle
- Wide open throttle
- Warm-up
- High inlet air temperature
- Low barometric pressures (or high altitudes)
- Overrun and/or braking



A Typical EGR system on a petrol or spark ignition (SI) engine

To disable EGR in these circumstances, information is needed from these sensors:

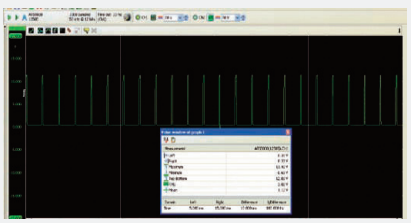
- Throttle position sensor (TPS)
- Inlet air temp (IAT))
- Atmospheric pressure sensor
- Manifold absolute pressure(MAP)
- Mass air flow (MAF)
- Vehicle speed sensor (VSS)
- Park/Neutral switch (PNP)

At all other times the quantity of recirculation is modulated by the computer to a value determined by the software in the ECU. It is continually monitored to ensure that the EGR command values give the correct EGR feedback values within certain tolerances. It is only when these tolerances are exceeded on a number of occasions, and for a

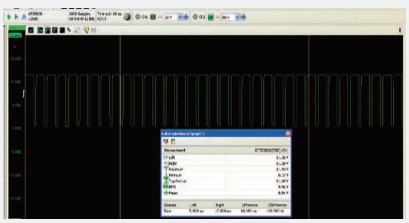
Check the PWM signal to the valve using an oscilloscope

If all these tests check out then the EGR strategy comes under the microscope. Any wandering in the sensor values, especially mass air flow, can cause the EGR to operate out of parameter and flag up a DTC or cause a driveability problem.

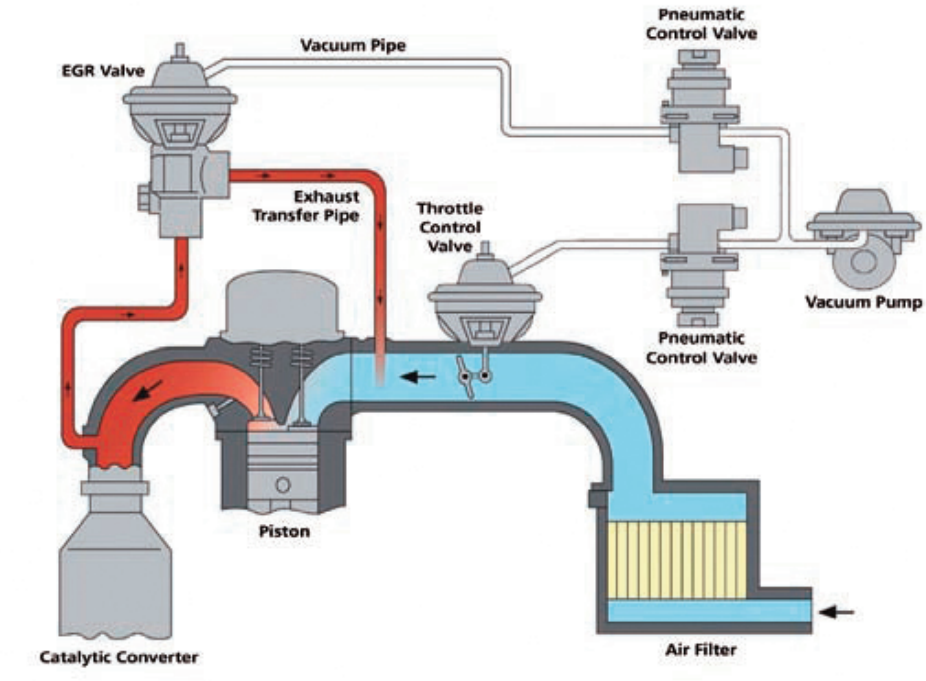
It is worth mentioning that some head scratching faults in the EGR and fuelling area can only be resolved by a re-flash of the ECU. It is worth checking for technical service bulletins specific to the vehicle you working on.



EGR Pulse Width Modulation (PWM) on a diesel engine at idle



EGR Pulse Width Modulation (PWM) on a diesel engine at higher RPMs



A Typical EGR system on a diesel or compression ignition (CI) engine

specific length of time, that the ECU will flag up trouble codes relating to EGR.

Unfortunately, because the information from the sensors is used to control other parts of the engine management systems, the codes flagged up may not directly identify an EGR fault, or an EGR fault may be identified when a fault lies with a common sensor.

Take, for instance, a faulty mass airflow meter. O2 sensor Lambda control allows the system to operate with a slightly out of calibration MAF sensor without putting the MIL on. The EGR system is not always so tolerant of a faulty MAF, and can cause driveability problems. Take a look at short and long term fuel trim to see how accurate the engine load parameter is.

Excessive EGR will dilute the air/fuel mixture and make the engine run rough or stall. Excess flow weakens combustion and may result in the following conditions:

- Engine stalling after cold start
- Engine stalls at idle after deceleration
- Vehicle surges during cruise
- Rough idle

Excessive EGR will cause a rise in MAP. Use a vacuum or scan tool to monitor manifold pressure. It should be steady at between 3-400 mb (30-40 kPa) at idle. Higher than this and suspect a faulty EGR or an air leak.

Insufficient EGR can allow combustion temperatures to get too high during acceleration and load conditions. This could cause:

- Pinging (pre-detonation of fuel)
- Engine overheating
- Emission test failure

A blocked exhaust will cause sufficient backpressure, under load, to lift the EGR valve and fill the manifold with exhaust gases. This causes low power and an EGR feedback fault DTC. On MAP/Speed sensed engines, it may produce O2 sensor faults.
Look at EGR command and feedback on the scan tool, check fuel trims and operation of the sensors listed above.

Diesel Engines (Compression Ignition or CI)

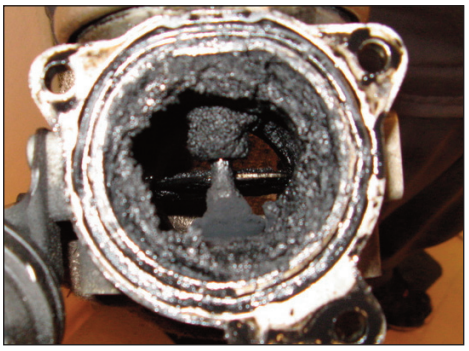
Diesel engines use EGR to control NOx. Unlike a petrol engine, EGR can be up to 60% of the intake. Too much EGR will show itself under acceleration as excessive black smoke. Diesel engines rely on an accurate MAF value to monitor EGR. In many systems, EGR feedback is determined as the difference between calculated gas flow (EGR + intake air)) and measured airflow. The gas flow is calculated based on engine capacity, speed, air pressure and temperature, This shows how important the airflow value is. If the airflow meter gives an air flow value greater than actual, EGR would be commanded to increase and the engine would be starved of air and black smoke will come out of the exhaust.

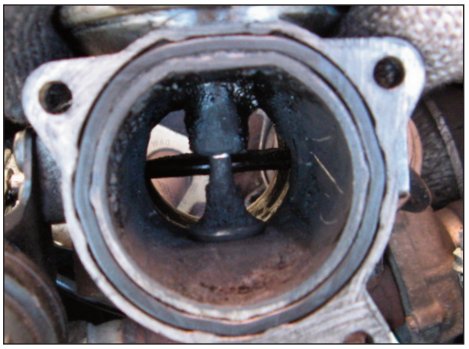
Actuators: testing and diagnosing

When diagnosing EGR systems, most people are more comfortable checking the mechanical bits first. Fortunately, that's where most problems lie. For this you are going to need a vacuum gauge and vacuum pump, or in the case of motorised actuators, a scan tool. Apply a vacuum to the actuator diaphragm. There should be a "clunk" sound when vacuum is released. For peace of mind, remove the EGR valve and bench test it. It will give you an opportunity to inspect its action and view the interior, especially the valve seat and passages.

The most common problem is clogging of the valve. This can happen naturally over time, or very quickly when a fault occurs. Think about a problem of a faulty airflow meter: Too much EGR produces high levels of particulates which then re-enter the engine through the EGR system, the particulates act as seeds for bigger particulates to latch onto and grow until the whole thing goes into a vicious cycle of black smoke. The valve eventually clogs with carbon, causing it to stick either open, closed or partially open or to become slow to react. EGR valves respond well to a good de-coke, but look further into what caused it to block in the first place.

When the passages are clear and the valve opens and closes properly, then the task is to determine if the valve is operating as commanded and if the commands are based on good sensor data. Understanding the operating strategy will help. Check the electro/pneumatic valve for operation, resistance and insulation. Use a vacuum gauge to check the vacuum supplied from the vacuum pump (diesel engine) or manifold (petrol engines).





A fouled EGR Valve, above, and the same valve, below, after it was cleaned with JLM EGR Valve Cleaner, available from Breen Distributors, Kanturk. After cleaning the EGR valve, look for other faults that could have caused the fouling