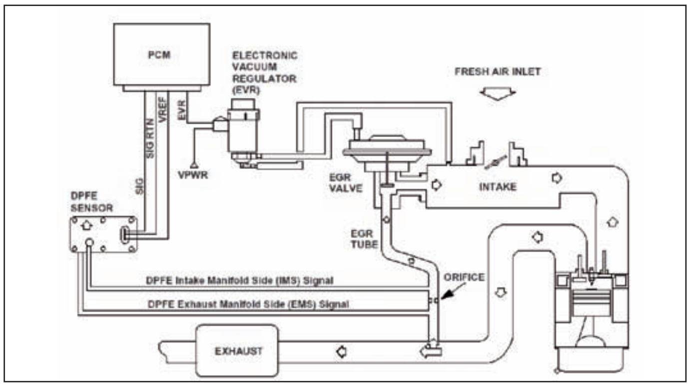
Combustion and EGR: PART Three

The previous articles in this series discussed the need for EGR and how it is achieved. Here, we look further into its operation and how to identify symptoms caused by faults in the system.

There are four methods with EGR feedback:

1. Variations in the 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.

2. EGR poppet valve position sensor. The valves can be motorised or 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.



3. 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 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 goes wrong.

4. 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

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

Petrol Engines (SI)

SI 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

To do this it needs information 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 PCM. 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 specific length of time that the PCM 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 identify directly 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.

Too much EGR flow 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 stops after cold start
- Engine stops at idle after deceleration
- Vehicle surges during cruise
- Rough idle

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 fault

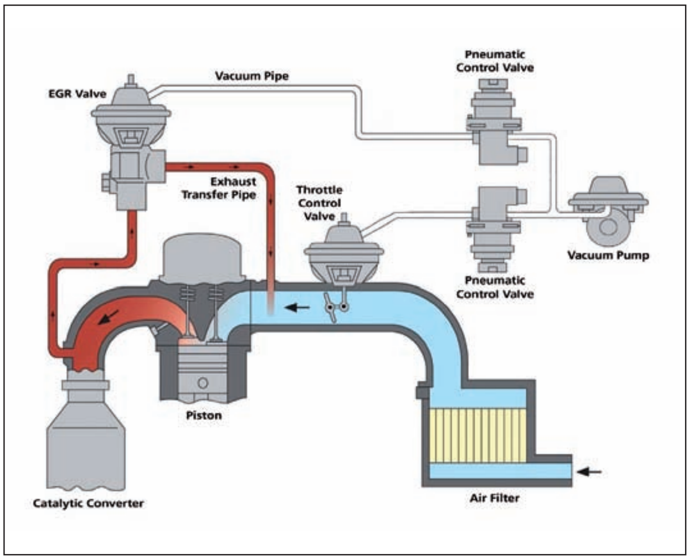
Excessive EGR will cause a rise in MAP. Use a vacuum gauge or scantool to monitor manifold pressure. It should be steady at between 300-400 mb (30-40kPa) at idle. Higher than this and suspect a faulty EGR or an air leak

Too little or no EGR flow can allow combustion temperatures to get too high during acceleration and load conditions. This could cause:

- Pinking (detonation)
- Engine overheating
- Emission test failure

Look at EGR command and feedback on the scan tool; check fuel trims and operation of the sensors listed above.

Diesel engines (CI)



CI engines use EGR to control NOx. Unlike the SI 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 +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. Result: Black smoke. ▶

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Q: A 2004 Nissan Primera 2.2D has a history of engine hesitations during acceleration. There have been no DTCs and all the engine management components are proving to be within specification.

A: A failure in the fuel injection pump produces similar symptoms to those you describe. This is applicable to all Nissans with a YD diesel engine that uses a Denso HP3 fuel injection pump. The hesitation can occur when the suction control valve, fitted to the fuel injection pump, fails to operate correctly.

To test the suction control valve you will need diagnostic equipment connected to the data link connector that can read and display data from the fuel pump. Pressure testing equipment (gauges) must not be connected directly to the fuel system. Whilst accelerating, the pump current (mA) should decrease and the fuel pressure (mPa) should increase. If the hesitation occurs during the test, when accelerating, you will see the pump current and fuel pressure decrease. In this case the most likely cause is the suction control valve.

To confirm this, switch the engine off, disconnect the suction control valve and all the injectors. Crank the engine while checking the fuel rail pressure. The pressure reading indicated on the diagnostic equipment should exceed 100 mPa. If it does, the high pressure pump is OK and the suction control valve is at fault

Q: A 2006 Saab 9-3 1.9 TiD with a Z19DT engine code has an engine hesitation and the engine management system has logged DTC P0340, camshaft position sensor. This DTC will clear but comes back as soon as the engine is started. We have changed the camshaft position sensor and tested the wiring to the ECM, which has good terminal connections and is complete without any breaks. Because nothing else has shown a fault, we have also had the ECM tested. However this has proved to be good as well.

A: This engine has a potential failing that can cause the DTC you have. If the vehicle is allowed to stutter or stall when driving off, the generated loads on the engine can cause the crankshaft timing belt sprocket key to break. If this occurs, the valve timing can slip and an engine management DTC P0340 will result. Check the valve timing and if found to be incorrect the timing belt sprocket and integrated keyway need to be examined. Damage to the sprocket key will require a replacement sprocket.

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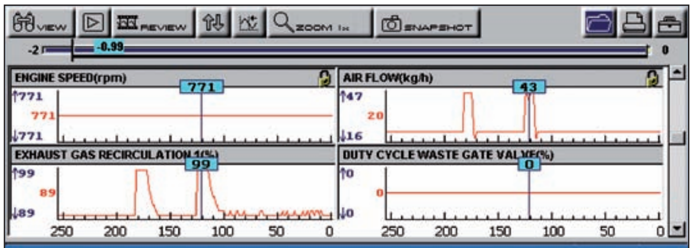


This is a graph of an EGR test performed on a PSA HDi 2.0 engine. The EGR pipe was removed on two occasions over the test period. Before removing the pipe the airflow measures 20kg/hr and on removal rises to a maximum of 47kg/hr showing EGR close to 60% of intake. On removal the PCM notes the reduction of EGR and tries to compensate with maximum EGR command.

Actuators

When diagnosing EGR systems most people are more comfortable checking the mechanical bits first, and 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 scantool.

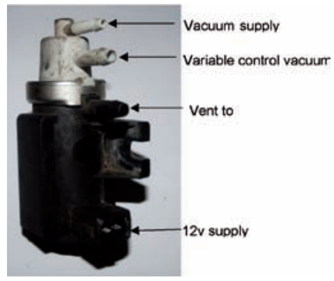
Apply a vacuum to the actuator diaphragm. There should be a "clunk" sound when the vacuum is released. For peace of mind remove it and bench test. It will give you an opportunity to inspect the insides, especially the valve seat and passages.

Most common problem is clogging of the valve. This can happen naturally over time, or very quickly when a fault occurs. Think about our problem with the fault airflow meter. Too much EGR produces high levels of particulates which then re-enter the engine through the EGR system. The particulars act as seeds for bigger particulates to grow on and the whole thing goes into a vicious cycle of black smoke. The valve eventually clogs with carbon which can cause it to stick open, closed or just 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.

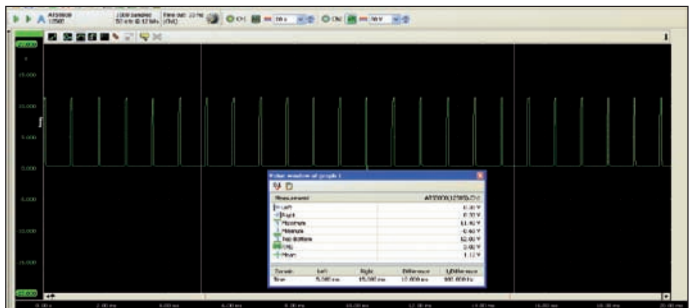
Check the electro-pneumatic valve for operation, resistance, insulation. Use a vacuum gauge to check the vacuum supplied from the vacuum pump (diesel) or manifold (petrol)

Check the PWM signal to the valve using an oscilloscope.

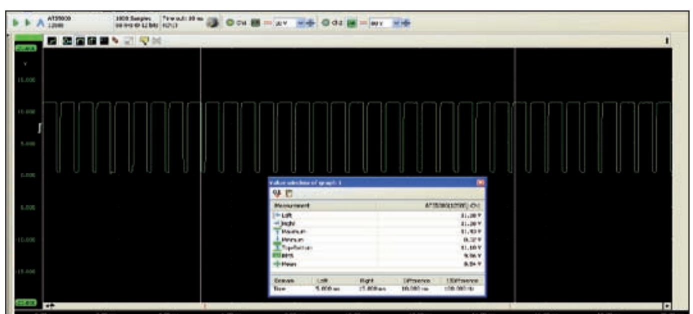


If all these tests check out then the ERG strategy comes under the microscope. Any 'wander' of the sensor values, especially mass air flow, can cause the EGR to operate out of parameter and flag up a DTC or cause a driveability problem.

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

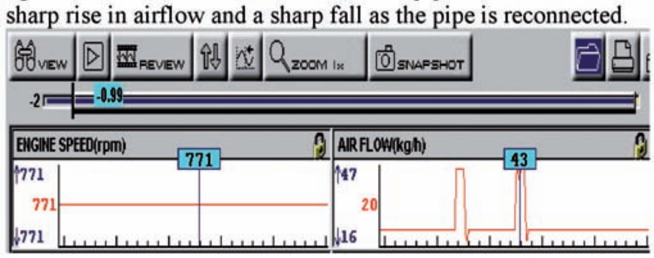


At idle (diesel)



Maximum speed (diesel)

A quick check on diesel engines using the scan tool.
With the engine warm and at idle; look at the mass air flow kg/hr. Now disconnect the EGR vacuum pipe. You should see a sharp rise in airflow and a sharp fall as the pipe is reconnected.



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