



SWANSEA METROPOLITAN UNIVERSITY

PRIFYSGOL FETROPOLITAN ABERTAWE

Emissions Control and Diagnostics

Exhaust Gas Recirculation

- EGR is an emission control that lowers the amount of NO_x formed during combustion
- N₂ and O₂ molecules are separated into single atoms during combustion. These free atoms bond to form NO, NO₂ and N₂O as described before
- These are generically known as NO_x
- NO_x formation increases dramatically for combustion temperatures over 1370° C

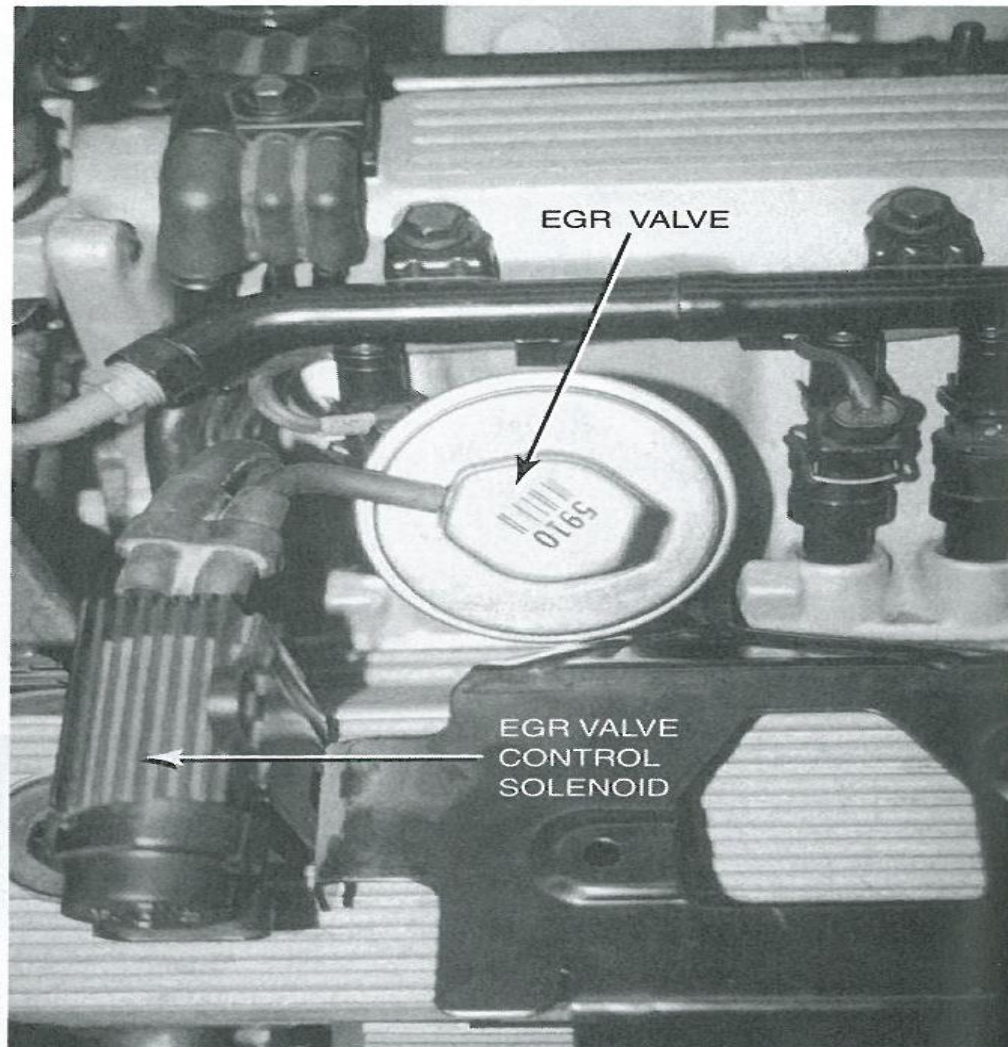
- NO_x formed below 1370 C can be controlled by the exhaust catalytic converter.
- To handle the large amounts generated above that temperature can be achieved by:
 - Enrich the air/fuel mixture
 - Lowers peak combustion temperature but...
 - Increases HC and CO as well as reduces fuel economy (not a good option)
 - Lower the compression ratio
 - Will decrease NO_x somewhat but very low compression...
 - Decreases efficiency leading to rising HC and CO
 - Dilute the mixture
 - By introducing exhaust gas into the intake
 - Displaces some of the air
 - Absorbs temperature
 - Does not contribute to the combustion

- By introducing exhaust gas in the intake NO_x emissions are cut without major engine performance and fuel economy impact
- Is it also neutral in the creation of other exhaust emissions
- EGR ads between 6 and 10% of exhaust gases in the intake
 - It mixes with and takes the place of some of the mixture
 - Exhaust gas is inert and therefore takes no part in the combustion
 - Results in lower combustion temperature and less NO_x
 - It is usually routed via a tube from the exhaust manifold to the EGR valve that controls the amount to be delivered
 - Tube usually made very long to allow exhaust gases to cool down
 - From the EGR valve it will be fed to openings in the intake

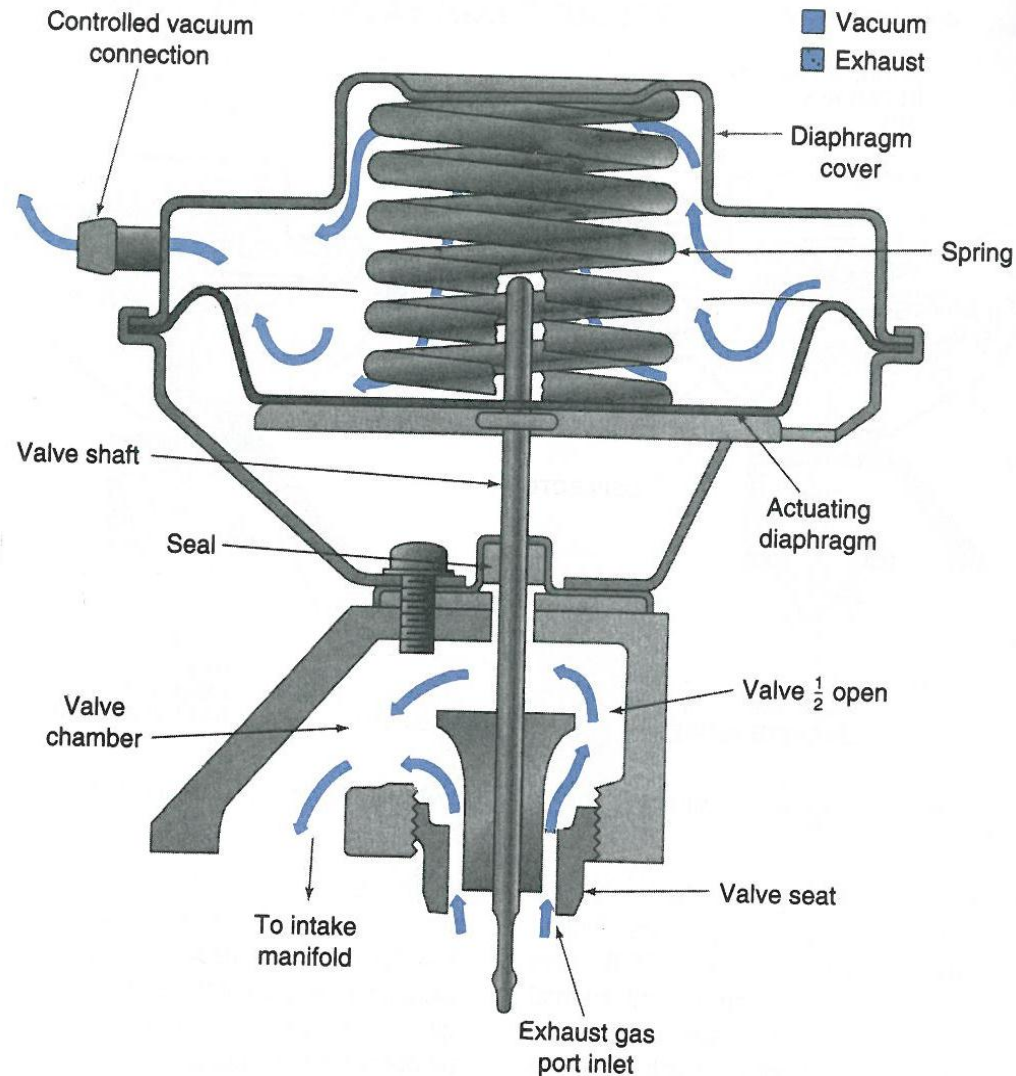
EGR valve



SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



EGR operation



- Because combustions temperatures are loweres EGR is not used when:
 - Engine is at idle
 - Engine is cold *and*
 - Wide open throttle. Why?
- EGR also helps control detonation
 - Since these occur due to high pressures and temperatures
 - It allows for great ignition advance
 - Sooner ignition without detonation means more power and efficiency

EGR operation

Positive and Negative back pressure

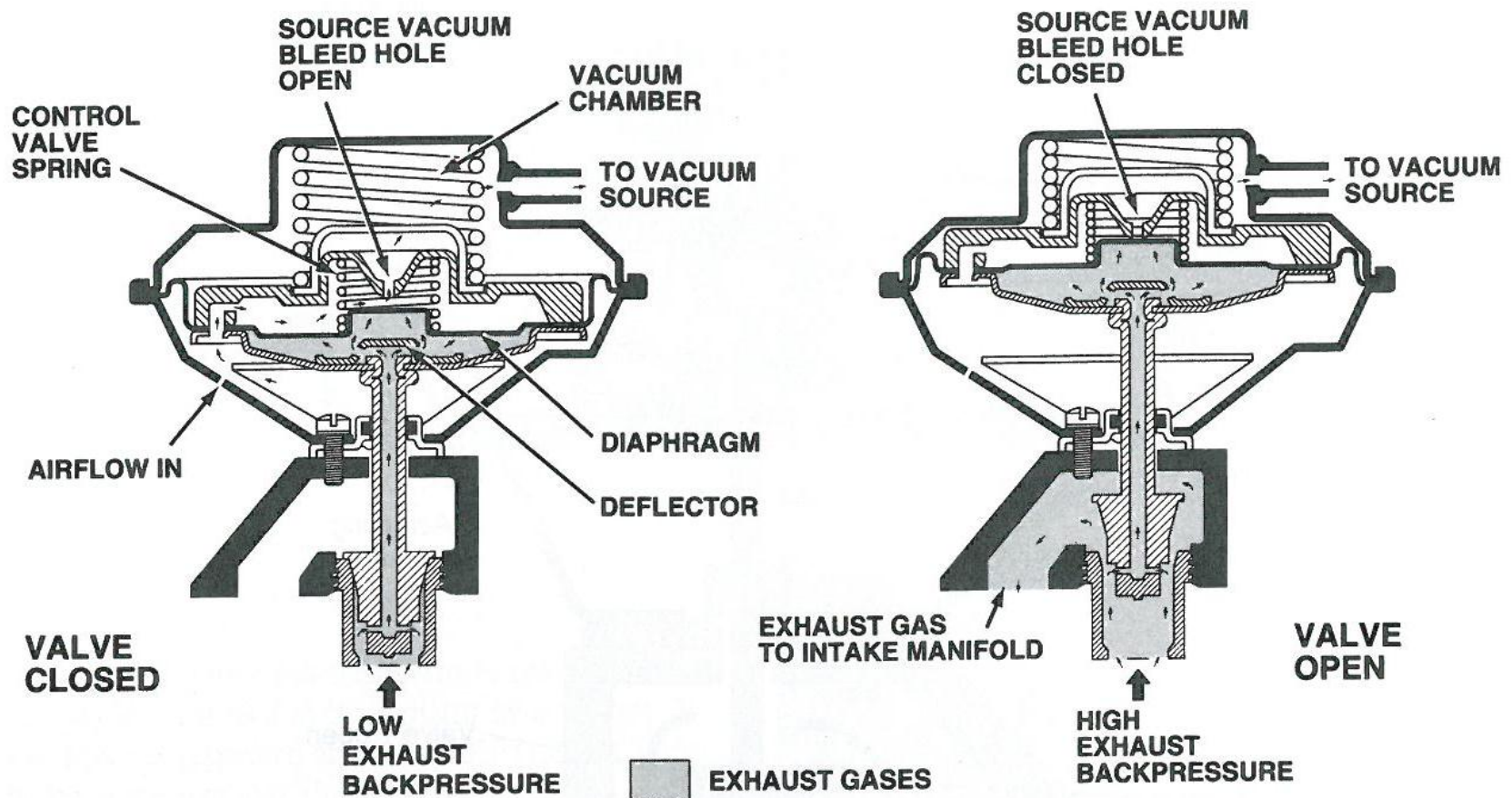
- Positive back pressure EGR valves
 - A smaller valve inside the main EGR valve bleeds off any vacuum so that the main valve is closed
 - This type require a positive back pressure in the exhaust
 - At idle and low rpm low load, EGR is not needed and back pressure is low and the EGR valve won't open even if there is vacuum.
- Negative back pressure
 - On exhaust stroke the engine emits an exhaust “pulse”
 - Each pulse is a positive pressure
 - Behind each pulse is a small area of low pressure
 - EGR valves react to this by closing a small internal valve that allows the main EGR to be opened by vacuum. i.e. negative back pressure

Negative Back Pressure EGR



SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE

POSITIVE BACKPRESSURE EGR VALVE OPERATION





- Requires two following conditions:
 - Vacuum must be applied to the EGR itself
 - Usually via a ported vacuum in EFI systems
 - Often manifold vacuum controlled by a solenoid
 - Exhaust back pressure present to control internal valve
 - Allowing vacuum to move diaphragm
- Changes to the exhaust system like the introduction of a low restriction exhaust may compromise the operation of this type of valve.

- Use one or more solenoids to control vacuum
 - One used for shutting it off on idle, cold engine and WOT
 - If two are used one does the on/off the other vents the valve to reduce EGR by allowing atmospheric air in
- Later versions use a EGR position sensor
 - A linear potentiometer on top of the valve – EVP
 - Exhaust back pressure sensor - pressure feedback EGR (PFE)
- Digital valves
 - Not vacuum operated
 - 3 solenoids control different size orifices allowing for seven different flow rates
 - Gives higher accuracy and helps prevent carbon deposits

EGR position sensor



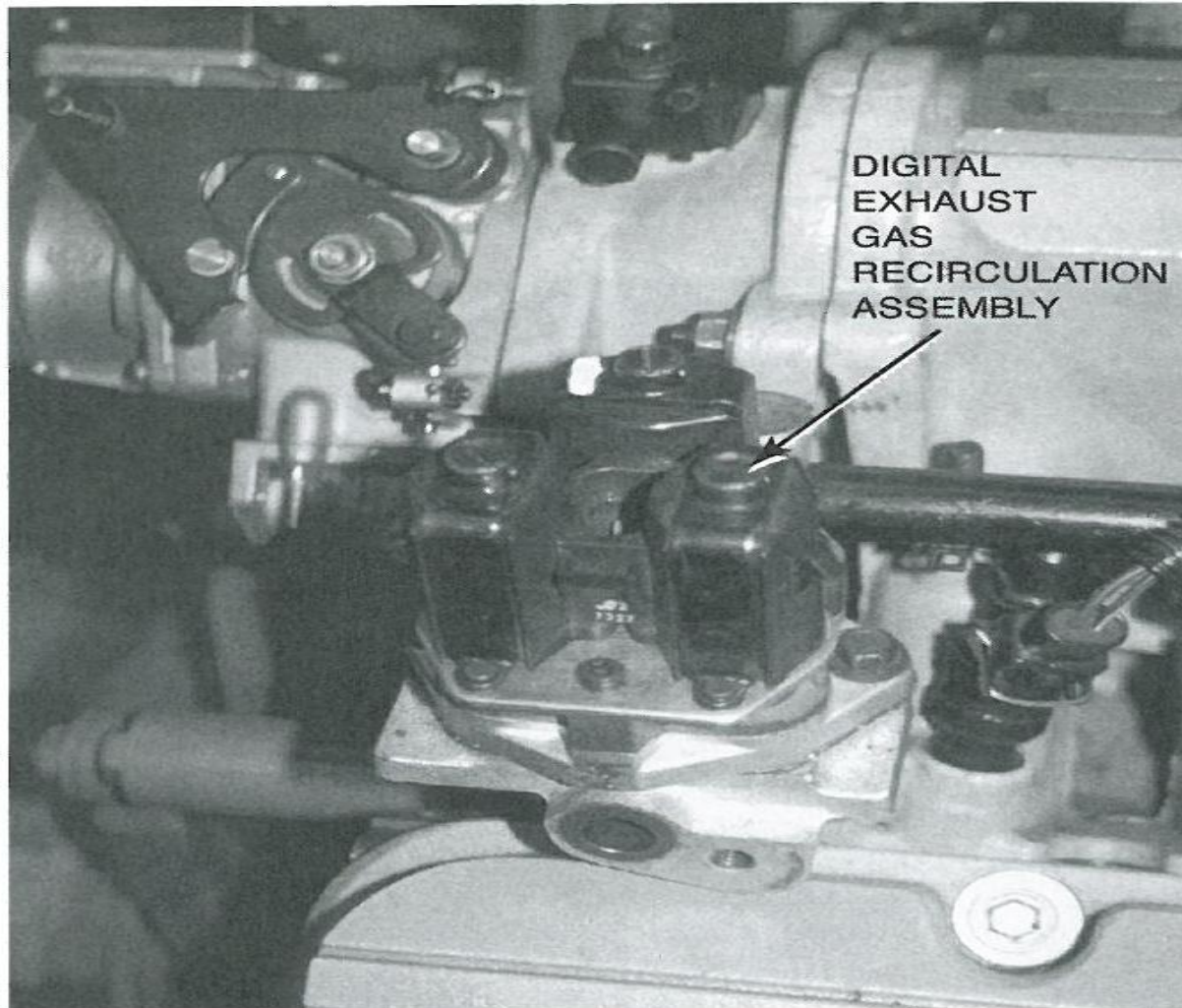
SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



Digital EGR



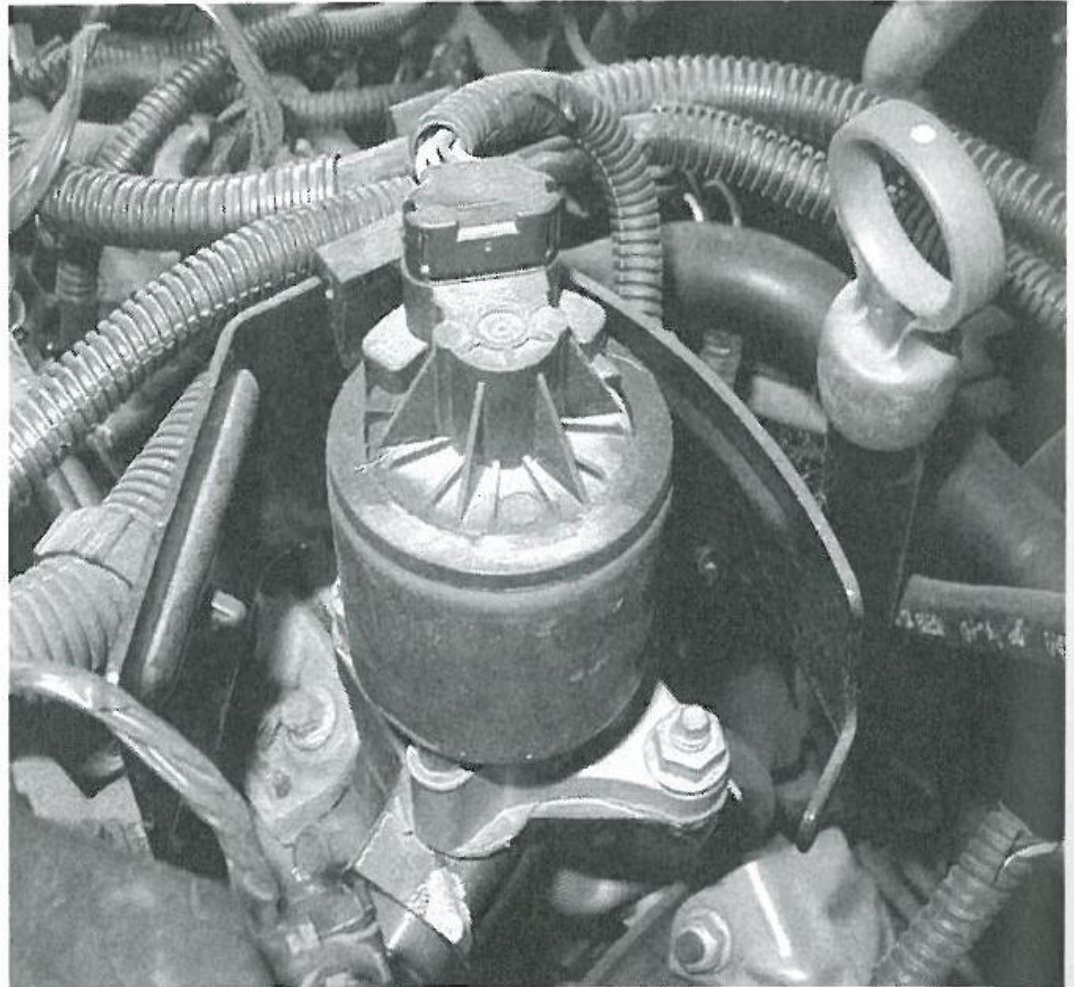
SWANSEA METROPOLITAN UNIVERSITY
PRIFYSGOL FETROPOLITAN ABERTAWE



Linear EGR

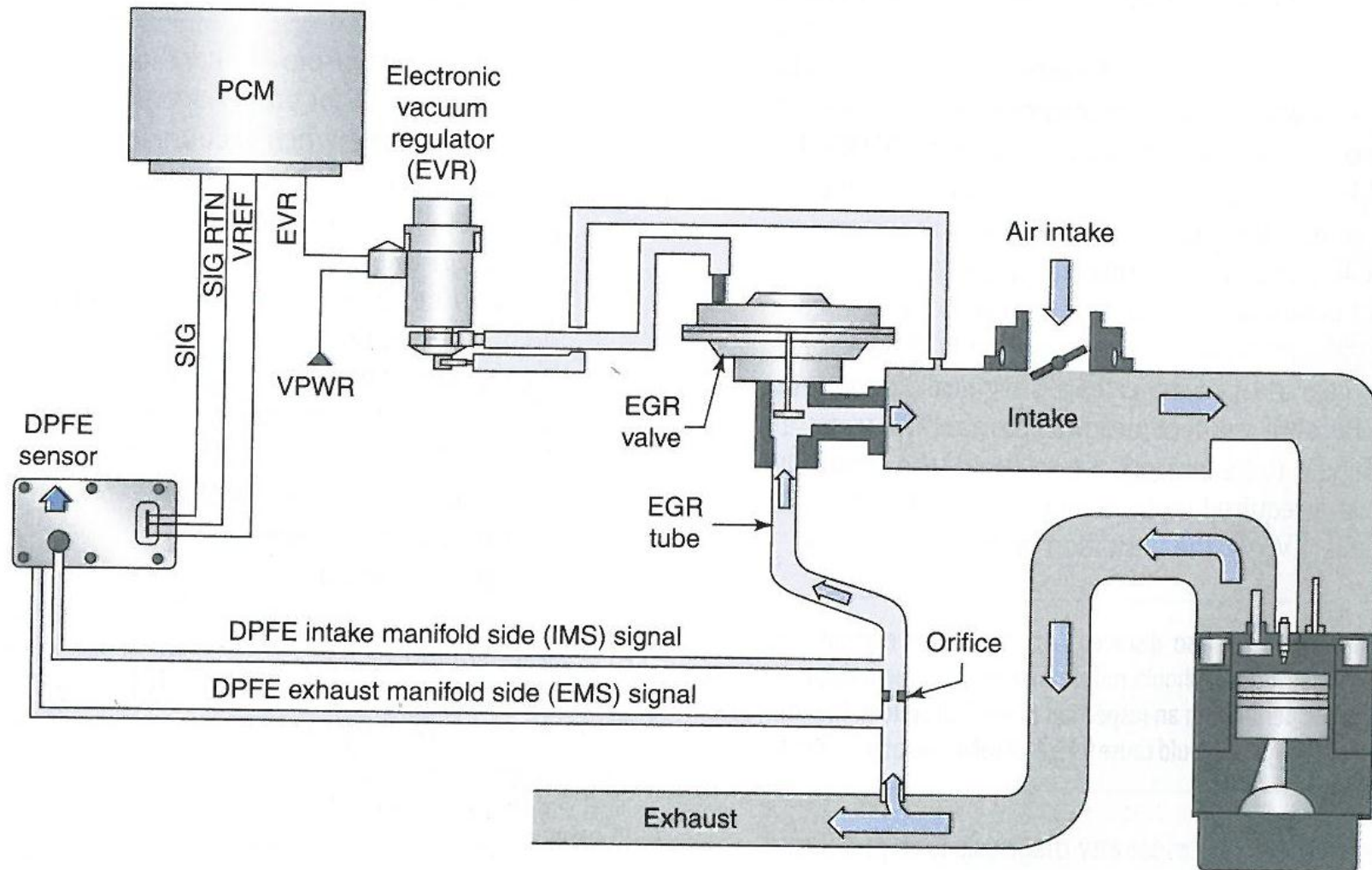


- Uses a pulse-width modulated solenoid to precisely regulate exhaust gas flow and a feedback potentiometer to inform the ECU of the position of the valve



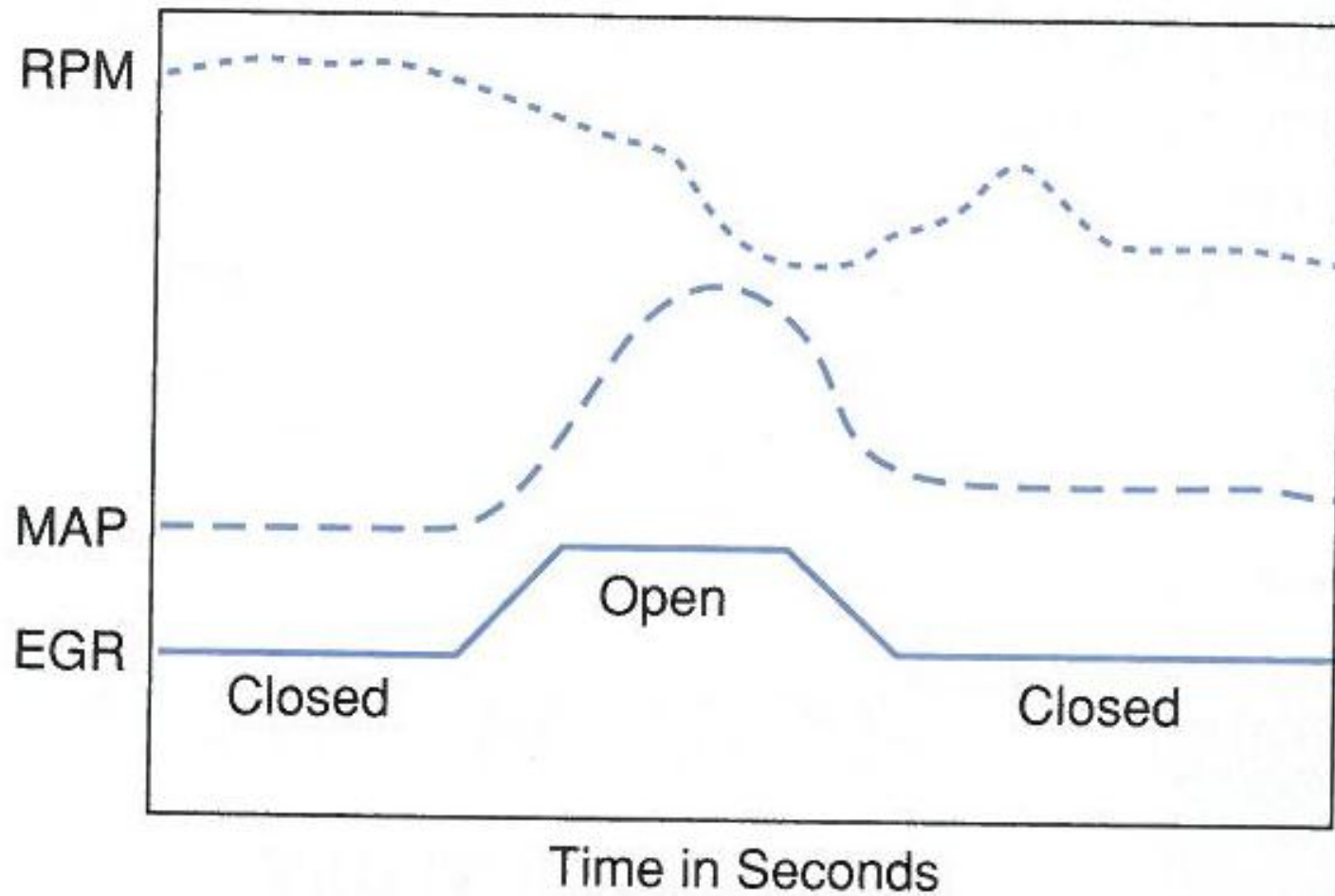
- ECUs are programmed to run tests on the EGR system under certain operating conditions
- The ECU opens and closes the valve and checks with the potentiometer that this has happened
 - If it doesn't a DTC is generated
 - Two consecutive fails and the Malfunction Indicator Light (MIL) comes on!
 - Some manufacturers used the Lambda sensor to check
 - Less O₂ when valve is opened and the more when closed
 - Other use a temperature sensor on the intake side of the EGR
 - When EGR open temperature rises due to hotter exhaust gases
 - Delta Pressure Feedback EGR (DPFE)
 - Compares the difference in pressure between two orifices on the EGR exhaust side

DPFE



- Another option is to compare Manifold Absolute Pressure (MAP) sensor readings when EGR valve is opened/closed
 - MAP reading should change a result of the adjustment to air/fuel ratio the lambda sensor will indicate as the O_2 value in the exhaust drops on EGR open
 - As with all the systems the ECU compares this changes to the values of a look up table
 - If the value falls outside a DTC is generated
 - Two consecutive failures and MIL comes on

MAP sensed EGR



- If the valve is not opening or the flow of exhaust gas is restricted the following will be noticeable:
 - Knock (detonation) during acceleration or cruise
 - High NO_x exhaust emissions
- If the valve is stuck open or partially open:
 - Rough idle or frequent stalling
 - Poor performance and response at low rpm
 - At idle speed engine vacuum should drop by 3 to 4 psi when a scan tool operated the valve. If it doesn't the valve is stuck.

- Operation checks
 1. Check the vacuum diaphragm to see if it can hold vacuum
 2. Apply vacuum from a pump and check for operation
 - The valve should move and the engine should be affected
 - If vacuum is not held valve is defective
 - If vacuum is held but engine not affected the passages may be restricted
 - Some EGR require back pressure so engine needs to be at fast idle
 3. Connect a vacuum gauge to the intake manifold vacuum source at idle (8-10 psi)
 - Raise the speed to 2500 rpm (again reading 8-10 psi or higher)
 - Activate the EGR: drop of less than 3 psi = passages clogged

- Replace EGR valve
- Clean the orifices
 - Cut 30 cm of stranded wire or cable
 - Flare the end and place it into the passage
 - Set a drill to reverse and as you turn it on the wire will pull its way through cleaning the carbon as it goes
 - Similar to a snake on a pipe