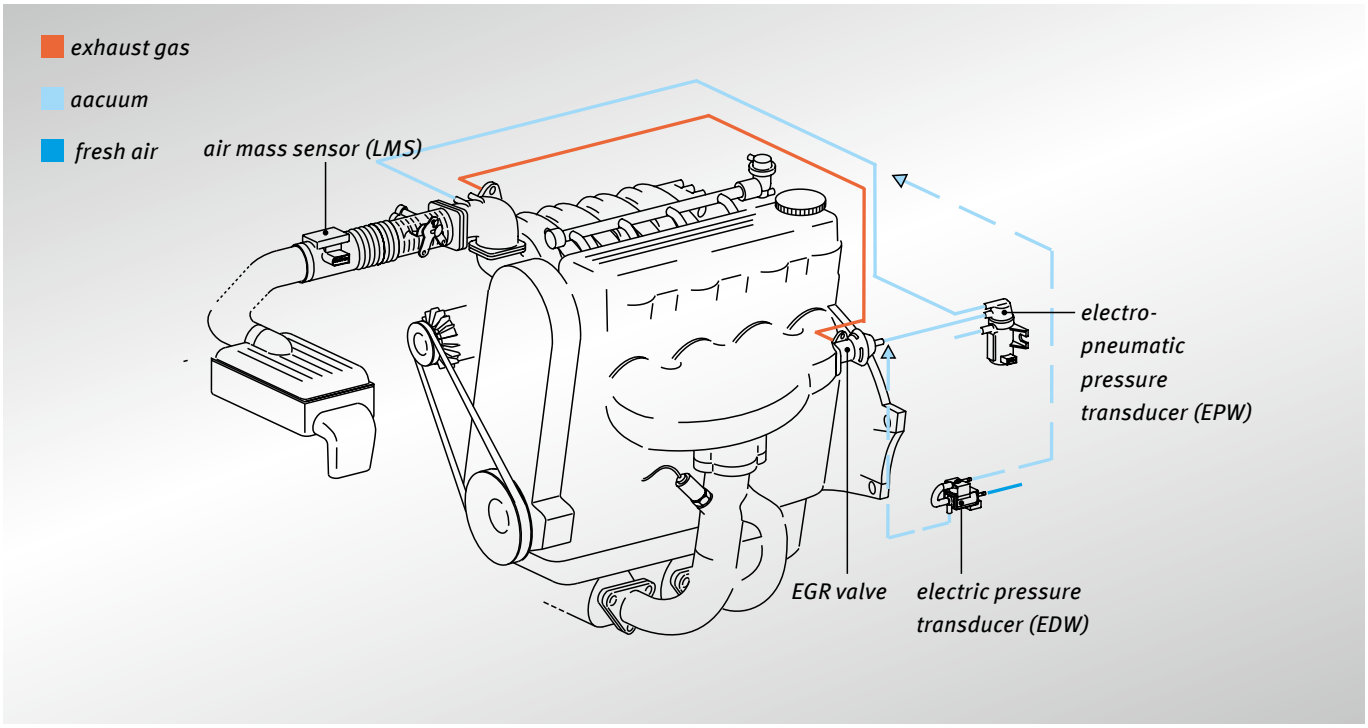

Fig. 33: exhaust gas recirculation in a petrol engine (with pneumatic EGR valve), schematic

4.5 Exhaust gas recirculation (EGR)

Mixing the exhaust gas with the intake air reduces the oxygen content of the fuel/air mixture. This reduces the combustion temperature in the cylinders. Depending on the operating point, this produces a reduction in nitrogen oxide (NOx) in the exhaust gas by up to 50%.
In addition, in diesel engines the particle formation is lowered by approx. 10%, and the noise emissions are reduced.
In petrol engines the lower fuel consumption can be detected. Thus a regulated addition of exhaust gas can influence the exhaust gas behaviour of the vehicle according to the load conditions. Thus exhaust gas recirculation (EGR) is an effective process for reducing nitrogen oxide emissions.
Therefore it is monitored for functioning in the OBD II standard.

Until about 1998 predominantly pneumatic valves were used. In newer applications electric EGR valves (EEGR) are used almost exclusively.

Advantages of pneumatic valves:
- less weight
- good pushing force
- simple construction

Advantages of electric valves:
- no additional components
- quick functioning because they are actuated directly
- good to monitor
- do not require a vacuum to be switched

Exhaust gas lines connect the exhaust manifold to the EGR valve and the valve to the inlet port/intake manifold. In many cases EGR valves are attached directly to the exhaust manifold or the inlet port.
Fig. 33 shows two variants of exhaust gas recirculation with a pneumatic EGR valve. It is actuated by an electropneumatic pressure transducer (EPW) or an electric pressure transducer (EDW).

The vacuum in the intake manifold is used to operate the EGR valve. The valve opens and a certain amount of exhaust gas is fed back into the exhaust manifold and thus into the combustion.
Some EGR valves are equipped with potentiometers for position feedback. Position feedback allows both opening correction as well as permanent monitoring. Other EGR valves are additionally equipped with integrated temperature sensors for monitoring. Because high temperatures arising when electric EGR valves are used can cause malfunctions, these valves are connected to the coolant circuit for certain applications. The air mass sensor (LMS) in the intake system continuously measures the air mass supplied to the engine. In diesel vehicles the LMS signal is used to control the exhaust gas recirculation.

The control unit activates the exhaust gas recirculation in the case of pneumatic as well as electric valves based on the temperature, the air mass (load) and the engine speed. The position of the EGR valve is detected by a sensor (generally a potentiometer).

- In simpler or older systems pneumatically operated EGR valves are operated by an electric switch-over valve (EUV) by means of a vacuum. In the case of this simple system structure the EGR valve has only an open/close function.
- In newer systems the actuation is handled by an electropneumatic transducer (EPW) that is able to adjust the EGR valve continuously. This allows quick and very accurate adjustments to the respective operating points.
  Before the introduction of EPWs, electric pressure transducers (EDWs) were used.
- Electric EGR valves are actuated directly by the control unit.

Exhaust gas recirculation is switched on only in certain operating points.

- For diesel engines up to 3000 RPM and at an average load.
- For petrol engines above idle up to the upper partial load.
- Exhaust gas recirculation does not occur at full load. This does not affect the ultimate performance.

EGR valves for diesel applications have large open cross sections because of their high return rates.
They are often integrated in housing with a throttle valve (“EGR emulsion housing”).

Fig. 34: EGR valves for diesel applications

In petrol engine applications the cross-sections are considerably smaller.

Fig. 35: EGR valves for petrol engines

4.5.1 Monitoring

In OBD II (USA) the EGR system is monitored for functioning and effect.
In EOBD an electric monitoring of the components and a monitoring of the functioning is sufficient.
A test of the effectiveness is not required by the EOBD. Various manufacturers do supply EU vehicles that comply with OBD II standards.

Fig. 36: electric pressure transducer (EDW)

Electric pressure transducers consist of an electric switch-over valve (EUV) with added pressure limiter. They are similar in their function to an electric pneumatic transducer (EPW).

You will find further information on EDWs in Service Information SI 0027.

Different processes can be used to monitor the exhaust gas recirculation:

Measuring the pressure in the intake manifold
During the deceleration phase the EGR valve is opened briefly and the intake manifold pressure sensor registers the pressure increase.
The EGR valve is monitored for leaks by closing it briefly and testing the associated pressure reduction in the partial load range.

Measuring the intake manifold temperature
During the deceleration phase the EGR valve is opened briefly. The temperature sensor for the intake air registers the temperature rise by measuring the temperature of the incoming warm exhaust gas.

Measuring the temperature on the cold side of the EGR valve
When a valve is open the exhaust gas will cause the temperature on the cold side of the valve to rise. The increase in temperature is registered by a sensor. In addition the signals of the potentiometer are also registered.

Registering the EGR potentiometer signals
Electric EGR valves (EEGR) and in part also mechanical EGR valves have a potentiometer that detects the position of the valve. There are applications with additional monitoring of the pressure or temperature in the intake manifold.

Plausibility check (especially for diesel engines)
In yet another type of monitoring, especially for diesel engines, the air mass is registered with and without exhaust gas in relationship to the engine speed.

Monitoring the air mass (especially for diesel engines)
In exhaust gas recirculation the intake air mass is reduced by the amount of recirculated exhaust gas. The air mass sensor registers this reduction in the air mass. In addition, the potentiometer signals are also monitored.

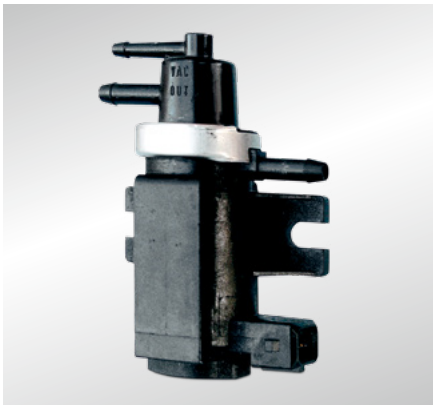

Fig. 37: electropneumatic transducer (EPW)

Monitoring the uneven running
During idling, the EGR valve is opened a small amount. Exhaust gas gets into the idle mixture and the idling becomes uneven. This uneven running is detected and used for the diagnosis.

Possible fault codes (with diagnostic instructions)

Errors in the exhaust gas recirculation system are indicated by fault codes P0400 – P0409.

Fault code	Possible causes/errors	Possible solutions/actions
P0400 EGR system - flow malfunction		
• there is no exhaust gas recirculation, or it is not detected • expected performance not reached • engine goes into limp home mode • driving behaviour is deficient • uneven idling	• the EGR valve does not open	• Check pneumatic EGR valve for functioning with vacuum hand pump. It doesn't open. If there is a vacuum, check the EGR valve for sticking or carbonisation; if the vacuum is not maintained, replace the EGR valve. If a pneumatic valve is not actuated, check the vacuum lines for continuity. • If there is sticking, replace the EGR valve and check the injection system and the oil vapour separator (blow-by separator) • Examine the EGR valve for visible damage or discolorations. In this case the exhaust gas back pressure could be too high or the actuation could be incorrect. Check the exhaust gas system for free flowing, and the boost pressure control valve and electric actuators for functioning. • Check the power supply to the EGR valve (connections, cables, plug-in connections and electric actuators) and check the electropneumatic transducer, electric pressure transducer, or electric switch valve. Replace the defective parts.
P0401 EGR system - flow insufficient detected		
too little exhaust gas is being recirculated	• the EGR valve does not open wide enough • width restricted by impurities (carbonisation) • EGR valve opening time too little • air mass sensor defective or soiled	• Check electric supply. • Check pneumatic supply (vacuum). • Take valve out and check its condition. • If there is sticking, replace the EGR valve and check the injection system and the oil vapour separator (blow-by separator). • Especially for electric EGR valves, check the supply and the sensors. • Check air mass sensors and replace if necessary.
P0402 EGR system - flow insufficient detected		
excessive exhaust gas recirculation	• the EGR valve opens to an extent that deviates from the set-point values • the valve does not close completely • air mass sensor defective or soiled	• Check sensors and supply. • Take valve out and check its condition. • If there is sticking, replace the EGR valve and check the injection system and the oil vapour separator (blow-by separator). • Check air mass sensors and replace if necessary.

Fault code	Possible causes/errors	Possible solutions/actions
P0403 EGR system – circuit malfunction		
• EGR signals wrong or implausible	• wear/soiling of the potentiometer in the EGR valve • temperature sensor defective	• Check signals and compare with set-point values.
P0404 EGR system – circuit measurement/power problem		
• exhaust gas recirculation outside set-point range • EGR signals wrong or implausible	wear/soiling in • potentiometer EGR valve • pressure sensor • temperature sensor • air mass sensor • electric plug-in connections and lines	• Check signals and compare with set-point values. • Check electric connections and lines.
P0405 EGR system – sensor A circuit low		
P0406 EGR system – sensor A circuit high		
P0407 EGR system – sensor B circuit low		
P0408 EGR system – sensor B circuit high		
• EGR signals wrong or implausible	wear/soiling in • potentiometer EGR valve • pressure sensor • temperature sensor • air mass sensor • electric plug-in connections and lines	• Check signals and compare with set-point values. • Check electric connections and lines.

Important note:
When there are malfunctions in the EGR system or damage to its components, the periphery must always be checked as well. Deposits can be caused by errors in the injection system or an oil content that is too high. In OBD, errors of this kind are detected only partially and are sometimes classified incorrectly.

Further information on EGR valves and ways to check can be found in our Service Informations, contain comprehensive troubleshooting tables.

Further fault codes that are of significance in connection with the EGR

P0100	mass or volume air flow circuit	malfuction
P0101	mass or volume air flow circuit	range/performance problem
P0102	mass or volume air flow circuit	low input
P0103	mass or volume air flow circuit	high input
P0104	mass or volume air flow circuit	intermittent
P0105	manifold absolute pressure/ barometric pressure circuit	malfunction
P0106	manifold absolute pressure/ barometric pressure circuit	range/performance problem
P0107	manifold absolute pressure/ barometric pressure circuit	low input
P0108	manifold absolute pressure/ barometric pressure circuit	high input
P0109	manifold absolute pressure/ barometric pressure circuit	intermittent
P0110	intake air temperature circuit	malfunction
P0111	intake air temperature circuit	range/performance problem
P0112	intake air temperature circuit	low input
P0113	intake air temperature circuit	high input
P0114	intake air temperature circuit	intermittent

Errors in the sensors affect the functioning of the exhaust gas recirculation. They can result in a “lack of power” or an “engine limp home”.

Diagnostic instructions

EGR valve

The most frequent causes of malfunctions are deposits in the valve plate or seat.
The consequences are:

- The valve is stuck and doesn't open.
- Deposits have caused the opening width to be reduced.
- The valve does not close completely.

Unusually heavy deposits can be caused by errors in the injections or by intake or charge air with a high oil content.
In diesel engines, deposits are also caused by soot.

Important note:
Examples of causes of very oily intake or charge air can be:

- Malfunctions in the crankcase ventilation (e.g. oil separator, engine exhaust valve).
- Increased blow-by gas emission due to increased wear on the pistons and cylinders.
- Malfunctions in the turbocharger (e.g. worn bearing, plugged oil return line).
- Exceeding of the maintenance intervals (failure to change oil and oil filter).
- Use of engine oil quality not suited for the application.
- Frequent short trips (especially during colder months, formation of oil/water emulsion that gets into the engine exhaust).
- Engine oil level too high.
- Worn valve stem seals or guides causing increased oil transfer into the inlet port.

Fig. 38: EGR valve (diesel) with heavy deposits and new

Solenoid valves (EUV, EDW, EPW)
The most frequent causes of malfunctions are water or dirt or leaky connecting hoses.
These faults are not always detected by the component diagnosis.
High ambient temperatures can cause sporadic malfunctions.
Malfunctions are seldom caused by incorrectly attached connecting hoses.

Air mass sensors (LMS)
See Section 4.6.3.

Further malfunctions in EGR valves:

- Potentiometers can send out faulty signals or fail when greater distances.
- When the exhaust gas back pressure is too great (exhaust pipe partially plugged) in diesel vehicles the EGR valve can be pushed open under higher loads. This "burns" the diaphragm and destroys the valve. This can be detected by the blue colouring of the valve chamber.

Important note:
A vacuum hand pump can be used to check the functioning of the pneumatic EGR valve.

Further details can be found in our Service Informations.