Service Training

13.01

Edition 09.1999

# European On Board Diagnosis

## Trainer information (GB)

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# 1 Introduction

## 1.1 Legal Basis

On October 13, 1998, the European Union passed the EU guideline 98/69EC which directs all member states to introduce the EOBD. This guideline was implemented to national law in the Federal Republic of Germany.

The introduction of EOBD is not directly connected to the emissions standard of the European Union (EU II, EU III, EU IV) or of the Federal Republic of Germany (D2, D3, D4). Therefore, the deadline for the introduction and the associated transition period must be considered to be independent of the emissions standard.

### 1.1.1 Deadline for introduction

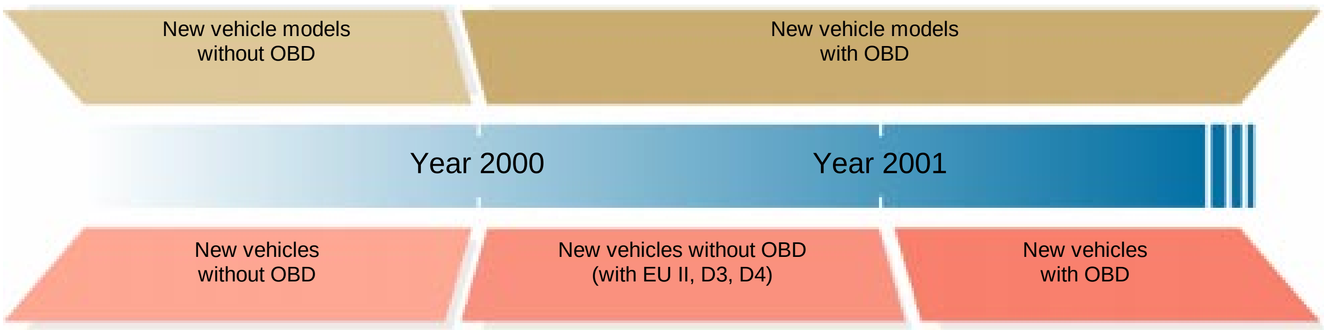
The automobile industry receives only an initial acceptance for the new vehicle models as of January 1, 2000, when these have an EOBD.

### 1.1.2 Transition period

The transition period affects vehicle models which have received an initial acceptance before December 31, 1999 and have fulfilled the EU II, D3 or D4 emissions standard. The buyer may still register these vehicles until December 31, 2000. After this date, even the vehicle models already in use are required to have an EOBD.

The EOBD legislation does not affect vehicles which the buyer has registered before December 31, 1999.

**Initial acceptances in the automobile industry**




**Registration of buyers' new vehicles**

## 1.2 Overview

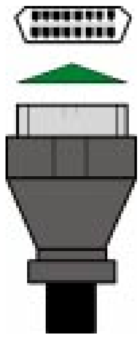
The obvious components of the EOBD are the K83 exhaust gas indicator lights and the diagnosis interface in the passenger compartment. All further functions and diagnoses will be performed by the engine control unit automatically without the driver being aware of the constant checking of his emissions-relevant vehicle technics.

### 1.2.1 K83 exhaust gas indicator light


If an error should occur in the vehicle which impairs the emissions quality, the error is stored in the fault memory and the exhaust gas indicator light is turned on.

If the catalytic converter could be damaged by a combustion misfiring, the exhaust gas indicator light flashes.

### 1.2.2 Diagnosis interface



The stored EOBD data can be retrieved via the diagnosis interface. The error codes have been standardised, so that the data can be captured by any Generic Scan Tool (OBD data display terminal). The diagnosis interface must be within easy reach of the driver’s seat.

### 1.2.3 Monitoring

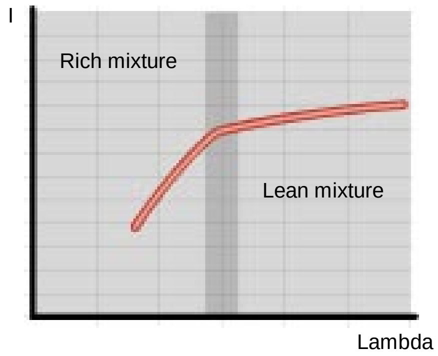
EOBD monitors:

- the electrical functioning of all components which are of importance for the emissions quality.
- the operation of all vehicle systems which affect the emissions quality (e.g. lambda probes, secondary air system).
- the operation of the catalytic converter.
- when the engine misfires.
- the CAN data bus.
- the error-free operation of the automatic gearbox.

# 2 New vehicle systems

## 2.1 Broad-band lambda probe

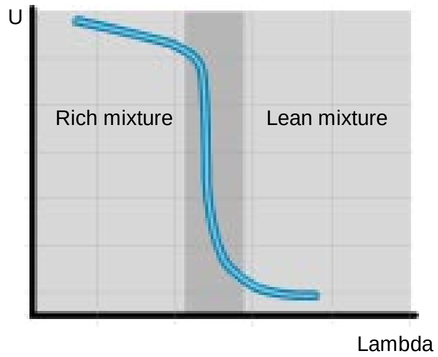
**Broad-band lambda probe**




Current I

The broad-band lambda probe (LSU – universal lambda probe) is a new generation of lambda probes which is used as a pre-catalytic converter probe.
The output of the lambda value no longer appears as a discontinuous, increasing voltage curve, rather an almost linear increase in current. In this manner, the lambda value can be measured over a larger measuring range (broad-band).
Conventional finger probes (LSH - lambda probe heating) or planar lambda probes (LSF – planar lambda probe) are also called jump probes due to their discontinuous voltage curves.

**Planar lambda probe**



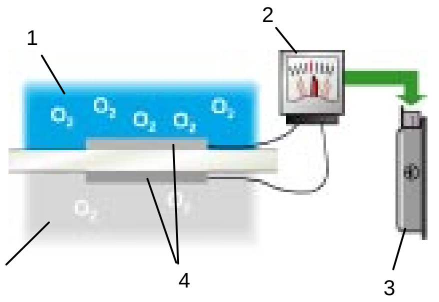

Voltage U

A planar lambda probe (LSF) is used for the post-catalytic converter probe.
The discontinuous measuring range of a planar lambda probe with lambda value of approx. = 1 is sufficient for the monitoring function of the post-catalytic converter probe.

## 2.1.1 Operation

The lambda value for linear lambda probes is not determined by a change of voltage, but by a change in current. The physical processes are still the same.

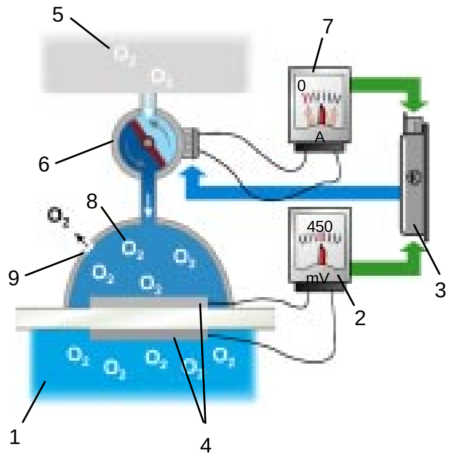
### Planar lambda probe




1 External air
2 Probe voltage
3 Engine control unit
4 Electrodes
5 Exhaust

The key element is a ceramic body which is coated on both sides (Nernst cell). This coating takes over the function of electrodes, where one electrode layer comes into contact with external air and the other with the exhaust. A potential difference is established between the electrodes by differing concentrations of oxygen in the external air and the exhaust. This voltage will be evaluated for determination of the lambda value in the engine control unit.

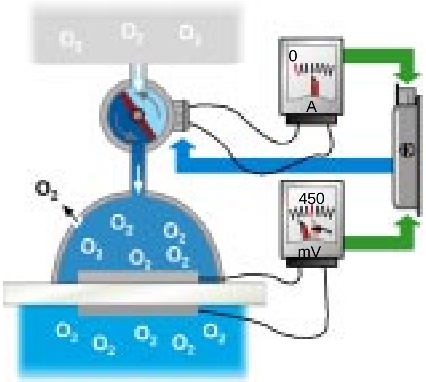
### Broad-band lambda probe



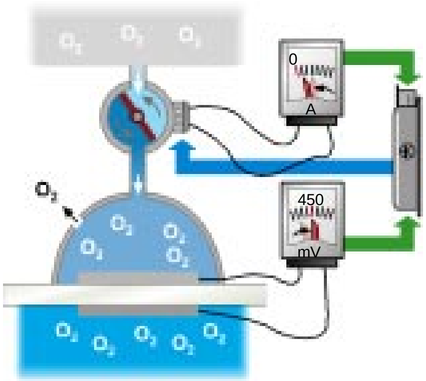

6 Miniature pump (Pump cell)
7 Pump current
8 Measuring area
9 Diffusion channel

This probe also produces a potential difference with the help of two electrodes which is the product of the differing concentrations of oxygen. It is different to the discontinuous lambda probe, in that the voltage of the electrodes is kept constant. This process is carried out by a miniature pump (pump cell) which supplies the electrodes on the exhaust side with enough oxygen to ensure that the voltage between the electrodes remains a constant 450 mV. The current consumption of the pump is converted by the engine control unit into a lambda value.

- Control example 1

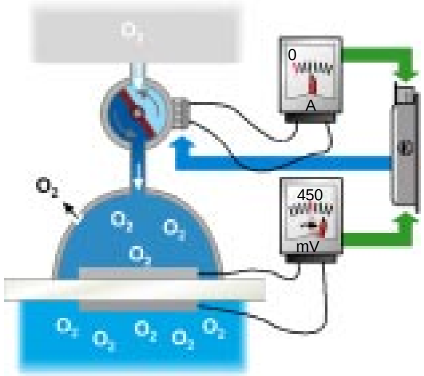



The fuel-air mixture becomes leaner. This means that the oxygen concentration in the exhaust increases and that the pump cell pumps more oxygen into the measuring area than can escape through the diffusion channel. This changes the oxygen ratio in respect of the external air and the voltage between the electrodes drops.

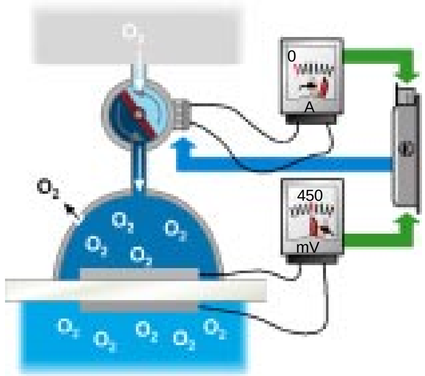



In order to re-establish the voltage of 450 mV between the electrodes, the oxygen content on the exhaust side must be reduced. The pump cell must then pump less oxygen into the measuring area. The pump performance is then reduced. The engine control unit converts the current consumption of the pump cell into a lambda value and changes the mixture composition accordingly.

- Control example 2




When the fuel-air mixture becomes too rich, the oxygen content in the exhaust decreases, the pump cell delivers less oxygen into the measuring area and the voltage of the electrodes increases.
In this case, more oxygen escapes through the diffusion channel than the pump cell delivers.




The pump cell must increase its capacity, so that the oxygen content increases in the external air chamber. The electrode voltage is reset to the value of 450 mV in the process and the current consumption of the pump is converted into a lambda control value by the engine control unit.

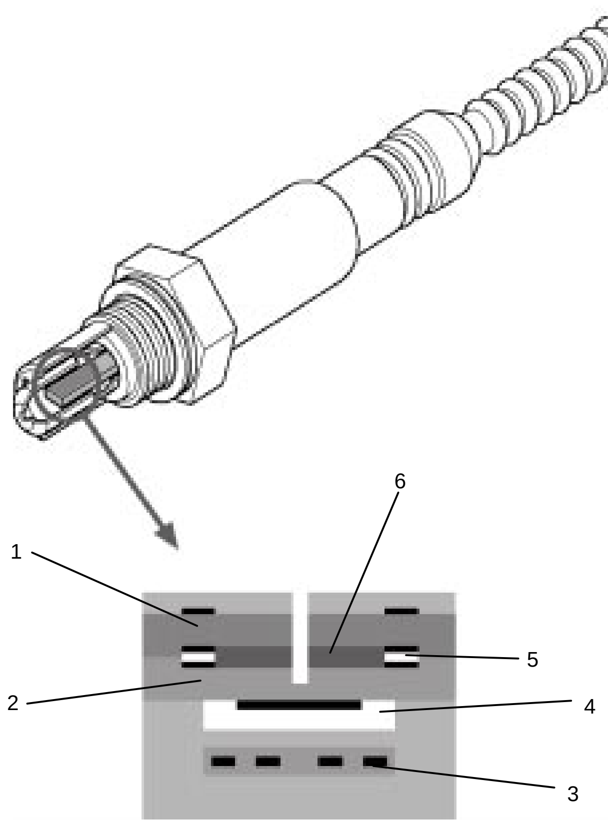
The pump cell operates by a purely physical process. Due to a positive voltage of the pump cell, negative oxygen ions are drawn through the oxygen-permeable ceramic.

The linear lambda probe and the engine control unit make up one system. The lambda probe must be suited to the engine control unit.

### 2.1.2 Design

The previously mentioned “components” are only a few millimetres long on the broad-band lambda probe.

**Cross-section of the probe element**




1 Oxygen pump cell with electrodes
2 Nernst pump cell with electrodes
3 Probe heating
4 External air channel
5 Measuring area
6 Diffusion channel

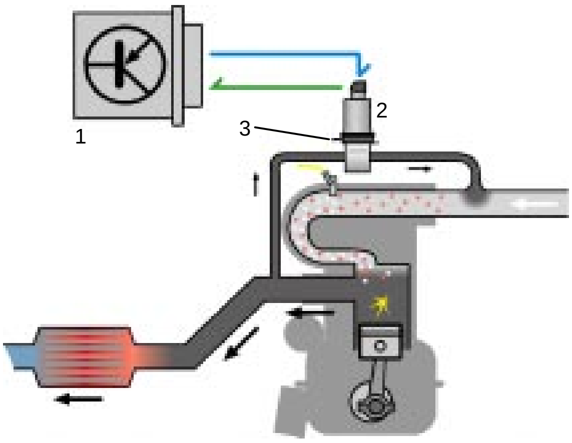
When the broad-band lambda probe has to be replaced, the cable and plug must also be replaced, because the probe element, the cable and the plug are mutually harmonised.

## 2.2 Electrical exhaust gas recirculation

There is only one valve for the **electrical** exhaust gas recirculation:

Exhaust gas recirculation valve N18

This valve is directly controlled by the engine control unit and electromagnetically adjusts the opening stroke for the exhaust gas recirculation. The potentiometer for G212 exhaust gas recirculation reports to the engine control unit the actual opening stroke of the valve.



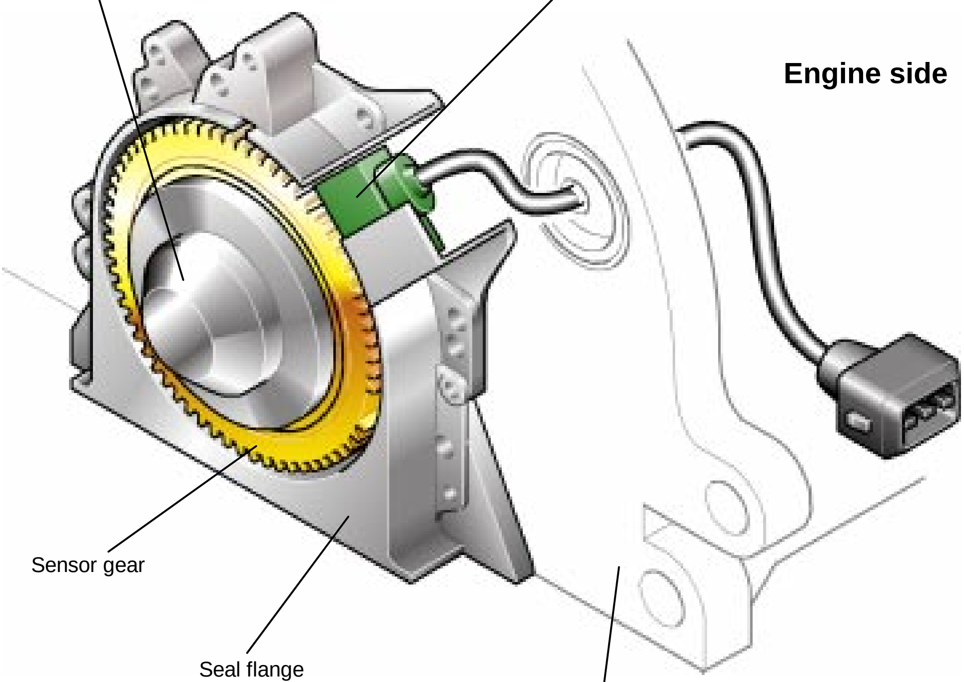

1 Engine control unit
2 Exhaust gas recirculation valve
3 Air vent

The air vent may only be connected to pure air (filtered external air).

When the exhaust gas recirculation valve is replaced, the seal must be replaced at the same time.

## 2.3 Integrated shaft seal sensor

A new generation of engine speed sensors G28 will be used in some engines - the Integrated Shaft Seal Sensor.
The sensor is situated in a seal flange for the crankshaft on the gearbox side of the engine. The sensor gearwheel (60-2 teeth) is pressed into precisely the correct position on the crankshaft.
The seal flange and sensor are produced by two different manufacturers and, for this reason, can differ in their designs.



# 3 EOBD versions

## 3.1 Basic forms of the engine control

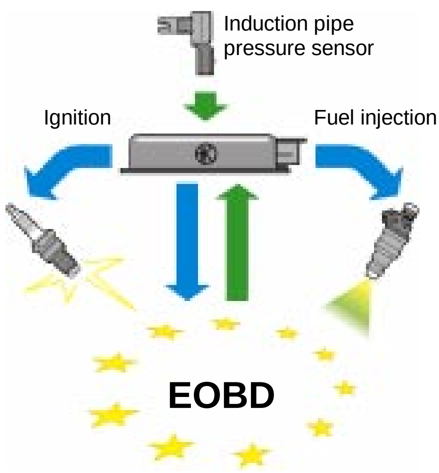
A basic division is made between the engine management systems in the way, in which operational conditions are determined in the induction pipe (air mass or induction pipe pressure). This division does not relate to specific manufacturers of engine control units because both forms are usually available.

The intake air quantity or the induction pipe pressure is required for the calculation of

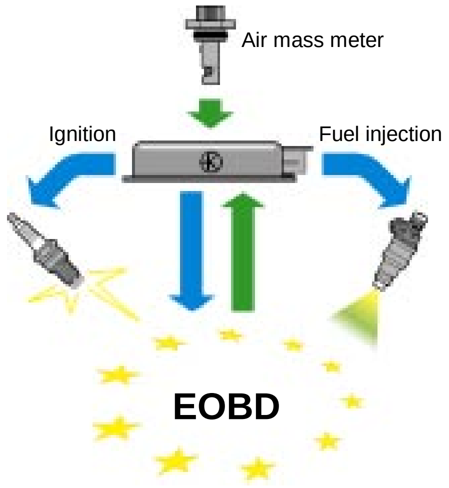
- the ignition time,
- the fuel injection time and
- the EOBD monitoring of the fuel tank vent line and exhaust gas recirculation systems.

### 3.1.1 Induction pipe pressure systems

The intake air quantity is determined by the induction pipe G71 sensor for these engine management systems.
An air mass meter G70 is not included in these systems.



### 3.1.2 Air mass systems




The air mass meter G70 takes over the task of determining the intake air quantity. For this reason, the induction pipe pressure sensor G71 is not necessary.

Air mass meters G70 **and** induction pipe pressure sensors G71 are installed in turbo engines, because the induction pipe pressure meter needs to also measure the charge pressure.

### 3.1.3 Vehicles, engines and engine control units

Next, the various engine control units and engine management systems are assigned to the platforms with the associated vehicles and engines.

- Platform A00: VW Lupo
- Platform A0: VW Polo

| Engine | Code | Engine management | Air quantity detection |
|---|---|---|---|
| 1.0l Bucket tappet petrol engine 37 kW | ALL | Bosch Motronic ME 7.5.10 | Induction pipe pressure |
| 1.4l Bucket tappet petrol engine 44 kW | | Bosch Motronic ME 7.5.10 | Induction pipe pressure |
| 1.4l 4V Petrol engine 55 kW | AKQ | Magneti Marelli 4LV | Induction pipe pressure |
| 1.4l 4V Petrol engine 74 kW | ANM | Magneti Marelli 4LV | Induction pipe pressure |
| 1.6l Petrol engine 88 kW | | Magneti Marelli 4LV | Induction pipe pressure |
| 1.6l Petrol engine 92 kW | | Siemens Simos 3 | Air mass |

- Platform A: VW Golf, VW Bora, VW New Beetle

| Engine | Code | Engine management | Air quantity detection |
|---|---|---|---|
| 1.4l 4V Petrol engine 55 kW | AKQ | Bosch Motronic ME 7.5.10 | Induction pipe pressure |
| 1.6l Petrol engine 74 kW | AKL | Siemens Simos 3 | Air mass |
| 1.8l 5V Turbo petrol engine 110 kW | AGU | Bosch Motronic ME 7.5 | Air mass |
| 2.3l V5 Petrol engine 110 kW | AGZ | Bosch Motronic ME 7.1 | Air mass |
| 2.8l VR6-4V Petrol engine 142 kW | | Bosch Motronic ME 7.1 | Air mass |
| 2.0l Petrol engine crossflow cylinder head 85kW | AEG (New Beetle only) | Bosch Motronic M 5.9.2 | Air mass |

- Platform B: VW Passat, VW Sharan

| Engine | Code | Engine management | Air quantity detection |
|---|---|---|---|
| 1.6l Petrol engine 74 kW | AHL | Siemens Simos 3 | Air mass |
| 1.8l 5V Petrol engine 92 kW | ADR | Bosch Motronic ME 7.5 | Air mass |
| 1.8l 5V Turbo petrol engine 110 kW | AEB | Bosch Motronic ME 7.5 | Air mass |
| 2.3l V5 Petrol engine 110 kW | AGZ | Bosch Motronic ME 7.1 | Air mass |
| 2.8l VR6-4V Petrol engine 142 kW | ACK | Bosch Motronic ME 7.1 | Air mass |
| 2.9l VR6-4V Petrol engine 150 kW | (Sharan only) | Bosch Motronic ME 7.1 | Air mass |
| 2.0l Petrol engine 85 kW | (Sharan only) | Bosch Motronic ME 7.1 | Air mass |

- T4

| Engine | Code | Engine management | Air quantity detection |
|---|---|---|---|
| 2.0l Petrol engine 85 kW | | Bosch Motronic ME 7.1 | Air mass |
| 2.3l Engine with 5 cylinders in line 115 kW | | Siemens Simos 3 | Air mass |
| 2.9l VR6-4V Petrol engine 150 kW | | Bosch Motronic ME 7.1 | Air mass |

## 3.2 Engine control units and diagnoses

By using the following table, you should be able to see more clearly which EOBD diagnosis has already been described in SSP 175 and which diagnosis will be described in this trainer information report.

| EOBD diagnosis | SSP 175 | Page |
|---|---|---|
| Comprehensive components monitoring | ✓ | |
| Voltage curve shift and adaptation of the pre-catalytic converter probe | ✓ | |
| Lambda probe heating diagnosis | ✓ | |
| Control limits diagnosis of the post-catalytic converter | | 18 |
| Movement diagnosis of the post-catalytic converter | | 19 |
| Fuel tank vent line flow diagnosis | ✓ | |
| Fuel tank vent line modulation diagnosis | | 20 |
| Combustion misfire – Irregular running procedure | ✓ | |
| Combustion misfire – Instantaneous analysis procedure | | 21 |
| Exhaust gas recirculation pressure diagnosis | | 23 |
| Electric throttle activation | SSP 210 | |
| CAN data bus - data diagnosis | | 24 |
| Secondary air - flow diagnosis | | 25 |
| Charge pressure limits diagnosis | | 26 |

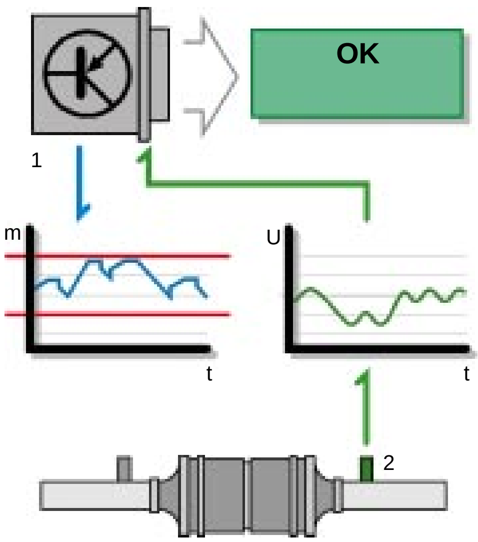
Please note that the different engine control units use different diagnostic procedures.

# 4 Diagnostic procedure

## 4.1 Control limits diagnosis of the post-catalytic converter

The lambda control value has prescribed control limits. If these control limits are exceeded, the EOBD assumes that there is an error in the post-catalytic converter probe or in the exhaust system (air leak).

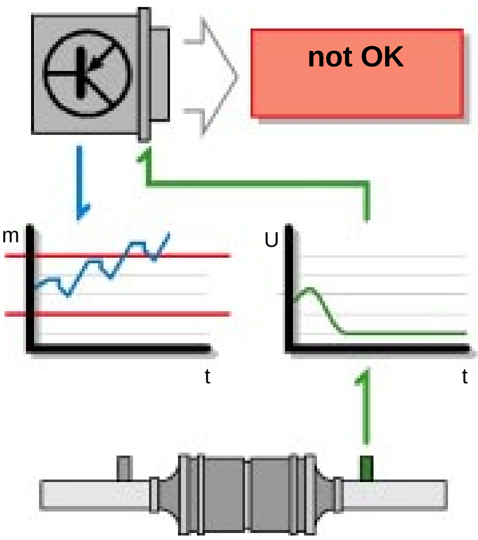
- Lean fuel-air mixture and correct regulation




The post-catalytic converter probe detects an oxygen increase in the exhaust emissions through a drop in voltage and indicates this to the engine control unit.
The engine control unit then increases the lambda control value and the fuel-air mixture is made richer. The voltage in the post-catalytic converter is raised and the engine control unit can also lower the lambda control value again.

1 Engine control unit
2 Post-catalytic converter probe
m Lambda control value
U Voltage
t Time

- Lean fuel-air mixture and exceeding the control value limit

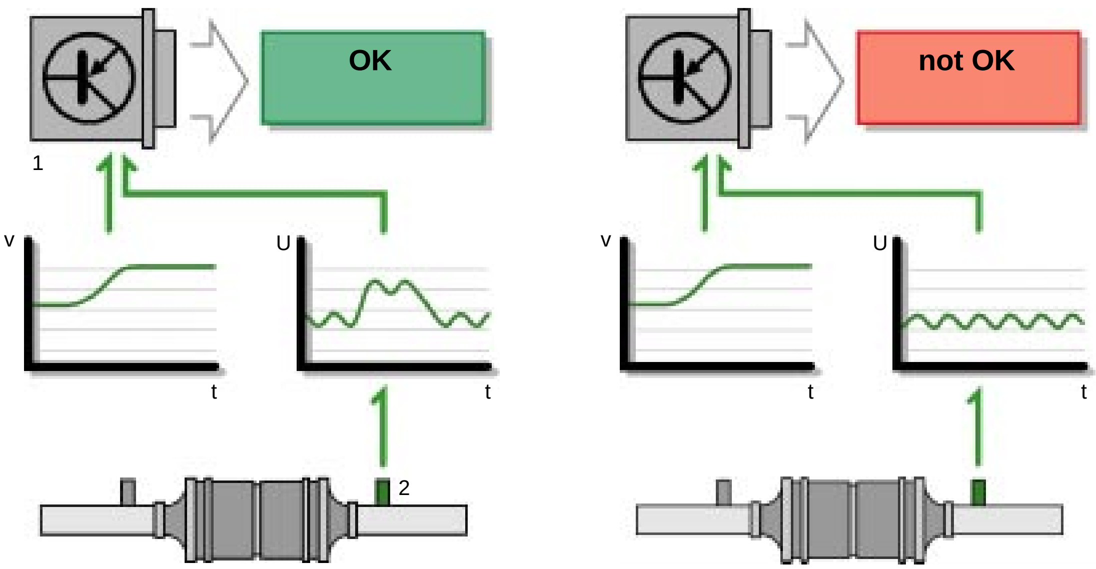



In this case too, the post-catalytic converter probe detects an oxygen increase in the exhaust emissions through a drop in voltage and indicates this to the engine control unit.
The engine control unit then increases the lambda control value and the fuel-air mixture is made richer. Despite the fact that this mixture is made richer, the probe's voltage remains low, due to the error, and the engine control unit continues to increase the lambda control value until the control limit is exceeded, thus enabling the error to be recognised.

## 4.2 Movement diagnosis of the post-catalytic converter

The post-catalytic converter probe's operability is also monitored. The engine control unit checks the probe's signals during acceleration and deceleration.
During acceleration, the fuel-air mixture becomes richer, the oxygen concentration in the exhaust gas falls and the probe voltage must increase. The situation is just the opposite during deceleration. The fuel feed is turned off, the oxygen concentration in the exhaust gas rises and the probe voltage must decrease. If the expected reaction of the post-catalytic converter does not occur, the engine control unit will detect that the post-catalytic converter probe is defective.

**Vehicle acceleration, as an example**

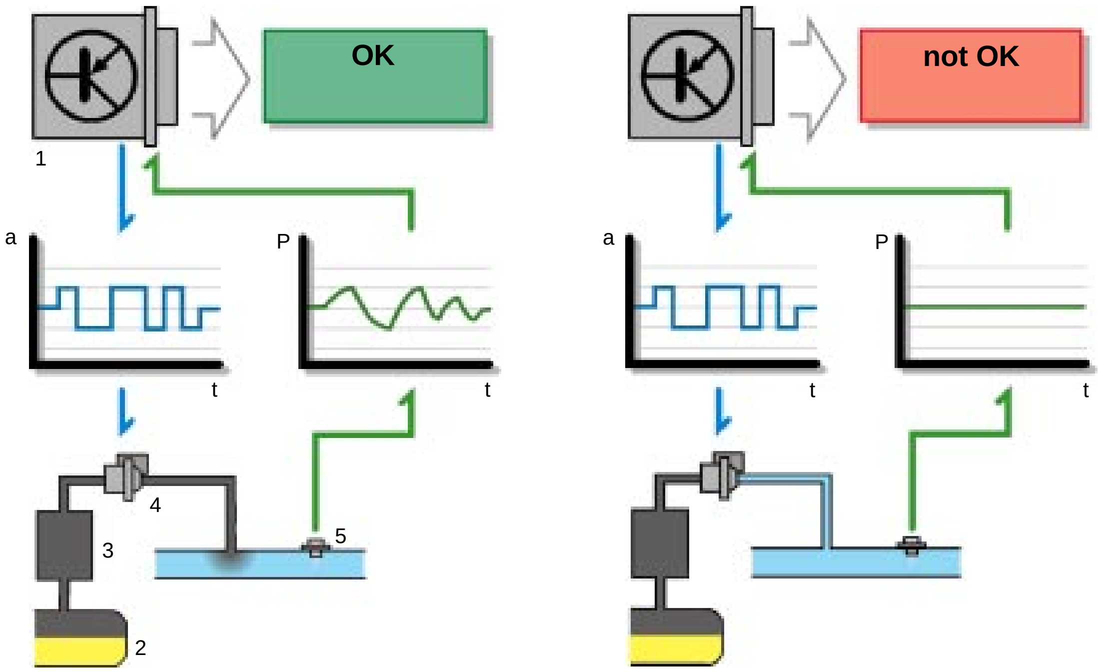



1 Engine control unit
2 Post-catalytic converter probe

v Vehicle speed
U Voltage
t Time

## 4.3 Fuel tank vent line – modulation diagnosis

This diagnosis performs checks at its own test intervals. The solenoid valve for the activated carbon filter system will be opened more and less by the engine control unit in a prescribed rhythm. The induction pipe pressure "modulated" by this is detected by the induction pipe pressure sensor and evaluated by the engine control unit.




1 Engine control unit
2 Fuel tank
3 Activated carbon filter
4 Solenoid valve for activated carbon filter system
5 Induction pipe pressure sender

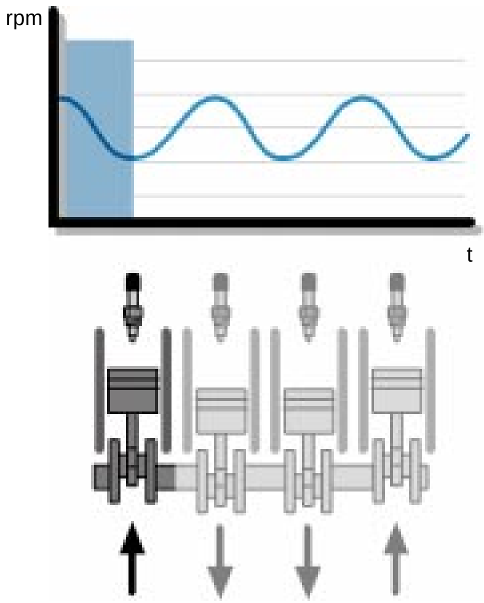
a Solenoid valve opening stroke
t Time
P Pressure

## 4.4 Combustion misfiring – Instantaneous analysis procedure

The instantaneous analysis procedure, as well as the irregular running procedure detect the cylinder-select combustion misfiring from the engine speed sensor signal G28 and the Hall probe G40. The difference lies in the evaluation of the engine speed signal. The instantaneous analysis procedure compares the irregular speed, produced by the ignition and the compression, by set calculations in the engine control unit. The basis for these calculations is the torque which depends on the load and engine speed, the inertia and the resulting engine speed characteristic.
The engine's torque fluctuations thereby calculated are more indicative than the results of the combustion irregularity procedure (combustion misfire yes/no). However, the engine speed characteristic must be analysed for each engine type and stored in the engine control unit.

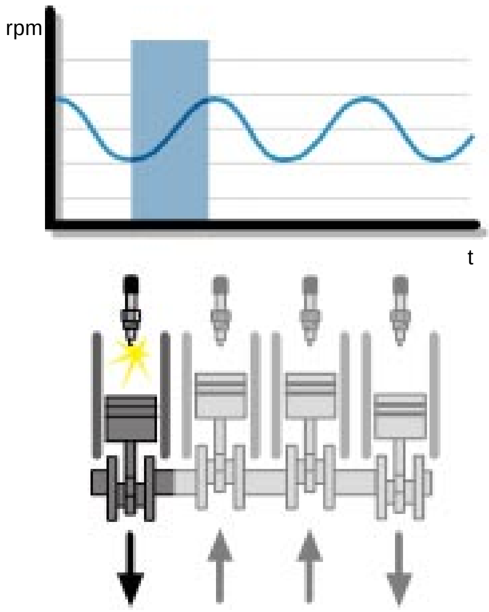
For purposes of simplification, only the 1st cylinder will be considered in this example.

- Irregular engine speed



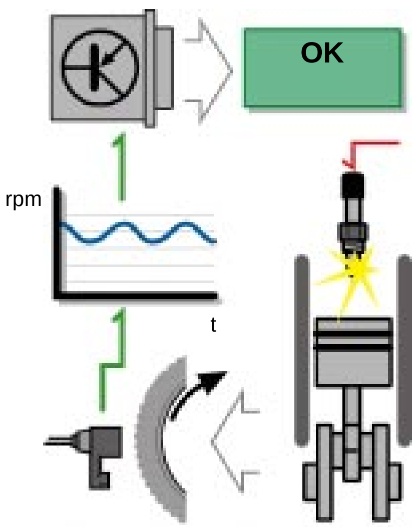

During the compression, the engine's movement energy is used to compress the fuel-air mixture. The engine's speed decreases.

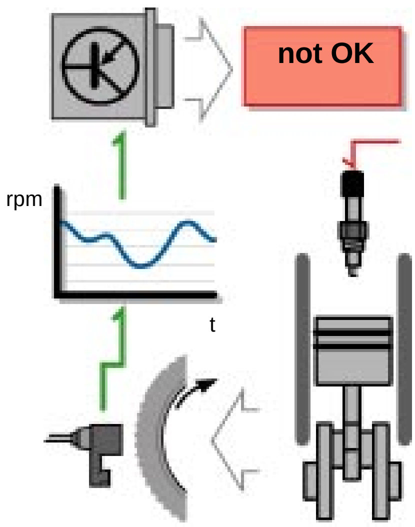
rpm Engine speed
t Time

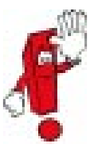



Ignition occurs after compression and the engine speed will be accelerated. In this manner, the engine speed fluctuates during each combustion due to compression and ignition.
When all four cylinders are considered, the individual speed fluctuations overlay and yield a resultant characteristic. This curve is measured by the engine speed sensor and is checked by the engine control unit by the computation with the characteristic values for the engine.

- Combustion misfiring detection using the engine speed signal



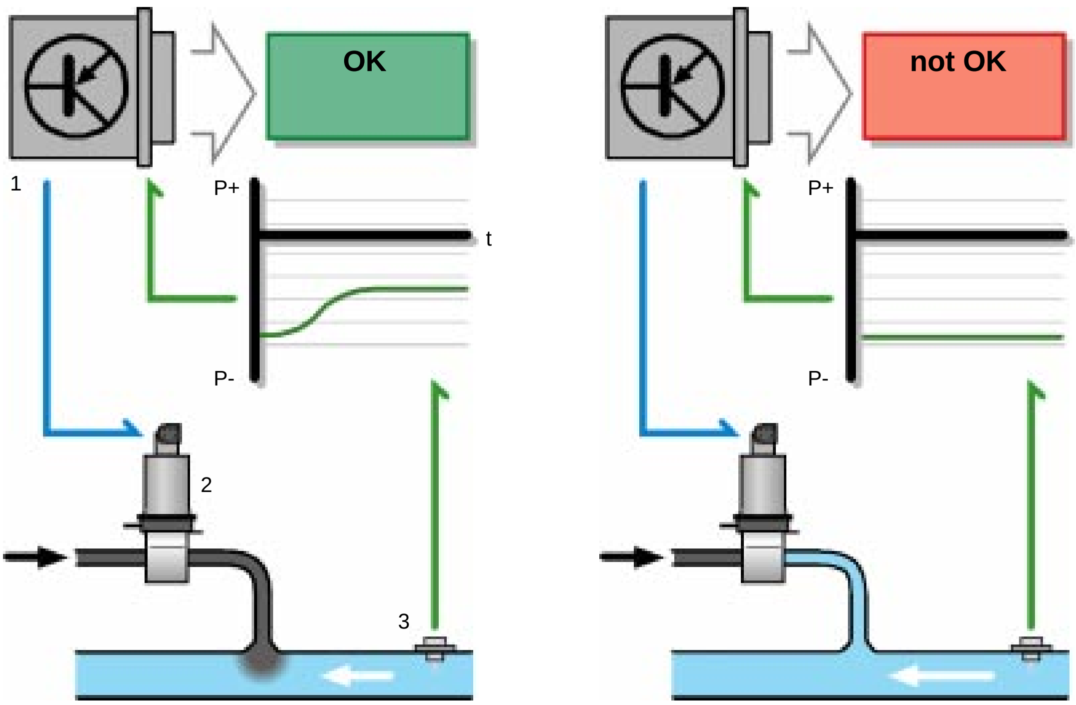



If the EOBD exhaust gas limits are exceeded due to combustion misfiring, the exhaust gas indicator light remains illuminated.
If, however, the catalytic converter may be damaged due to the combustion misfiring and the load speed is still within the dangerous range, the exhaust gas indicator light flashes and the appropriate cylinder's fuel feed is turned off.

## 4.5 Electrical exhaust gas recirculation – pressure diagnosis

When exhaust gas flows into the induction pipe, the induction pipe pressure sensor G71 detects an increase in pressure (less pressure). The engine control unit compares the increase in pressure in the induction pipe with the admitted exhaust gas quantity and can determine from this whether the exhaust gas recirculation (EGR) is functioning properly.

This diagnosis is only performed during deceleration because the fuel injection is turned off for the measurement due to the fact that it is a disturbance and the engine's intake capacity is very high.

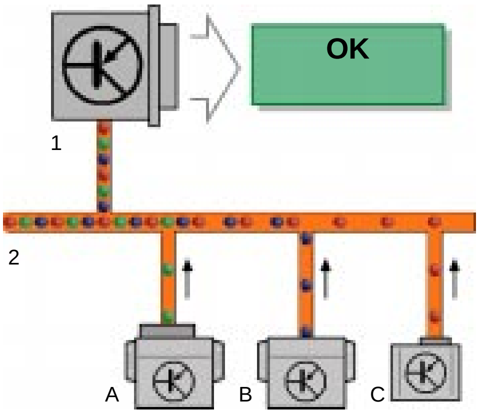



1 Engine control unit
2 Exhaust gas recirculation valve
3 Induction pipe pressure sensor

P+ Overpressure
P- Low pressure
t Time

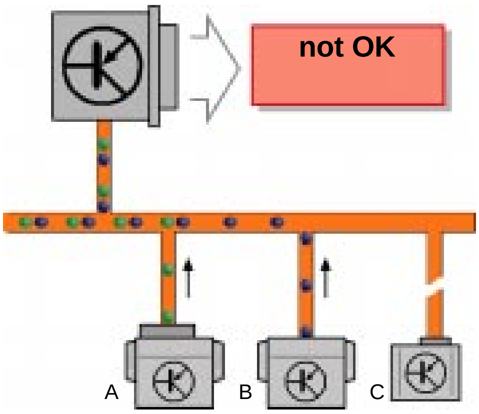
## 4.6 CAN data bus – data diagnosis

Each engine control unit recognises the electronic components which exchange information via the CAN data bus in each vehicle. If the minimum number of reports for a component is missing, an error is detected and stored.




**CAN data bus operability**

All connected components (in this case, control units) regularly send messages to the engine control unit. It recognises that no expected reports are missing and that data exchange is functioning properly.




**CAN data bus interrupted**

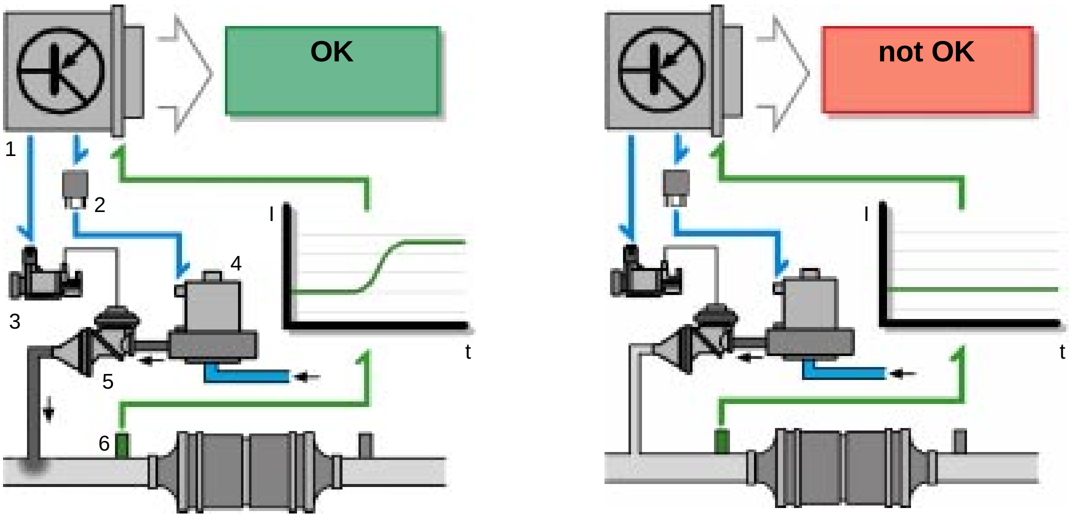
A component cannot send information to the engine control unit. The engine control unit detects the missing information, identifies the affected component and stores a corresponding error.

1 Engine control unit
2 CAN data bus

A-C Various control units in the vehicle

## 4.7 Secondary air system – flow diagnosis

Since the introduction of the broad-band lambda probe, the pre-catalytic converter probe signal has been used for the checks because the broad-band lambda probe delivers more detailed measurement results than a planar lambda probe, for example. The delivered air mass is computed then from the lambda difference (lambda, before and during the secondary air delivery).

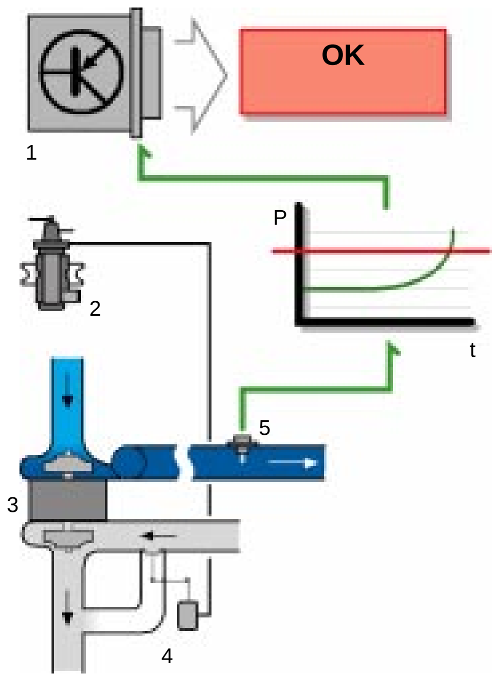



1 Engine control unit
2 Relay for secondary air pump
3 Secondary air valve
4 Secondary air pump
5 Combination valve
6 Pre-catalytic converter probe

I Probe current
t Time

## 4.8 Charge pressure limits diagnosis

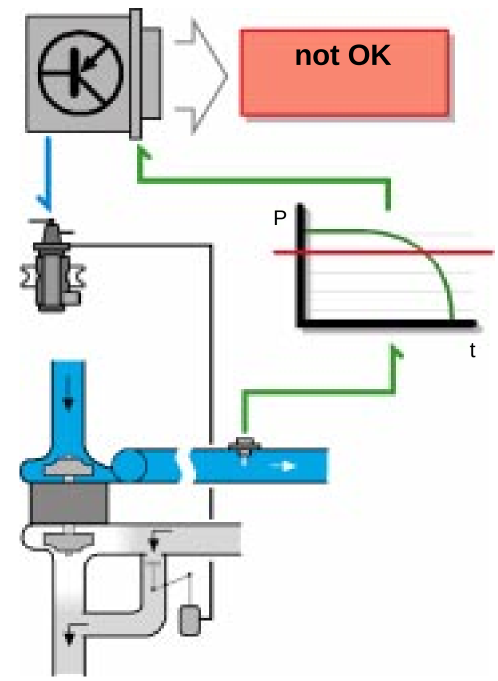
The charge pressure in turbo engines is checked to determine whether the maximum permissible charge pressure within the framework of the EOBD has been exceeded.




**The charge pressure limit has been exceeded**

The maximum permissible charge pressure has been exceeded due to an error in the charge pressure regulation. The induction pipe pressure sensor reports the actual charge pressure to the engine control unit and the engine control unit recognises the error.

P Pressure
t Time




**The protection function is triggered**

Signalling and storing the error is not sufficient in this case. The exhaust gas turbo charger must be turned off, so that the engine is not damaged. For this purpose, the turbo charger's "waste gate" through which the propulsive exhaust gases are re-routed is opened.

1 Engine control unit
2 Solenoid valve for limiting charge pressure
3 Exhaust gas turbo charger with charge pressure regulating valve
4 Waste gate
5 Induction pipe pressure sensor

# 5 Self-diagnosis

## 5.1 Readiness code

All electric components will be continuously checked to determine whether they are operating properly within the framework of the EOBD. Additionally, entire systems (e.g. exhaust gas recirculation) will also be checked by diagnostic procedures which are not continuously active.
In order to check whether these diagnoses have been performed, the readiness code is set. It consists of an 8-digit numerical code where each place can be occupied by 0 (diagnosis performed) or 1 (diagnosis not performed).

The readiness code is set by the engine control unit, if:

- the readiness code has been deleted.
- an error occurred whereupon the diagnoses will be carried out again.

The readiness code is not an indicator of errors which have occurred. It only states whether the diagnoses were performed.
If the continuous diagnoses have not caused any error entries, then the systems are working properly.
The fault memory should not be erased unnecessarily because the readiness code would also be reset or erased in the process.

Since all diagnoses are not available in all vehicles, the unused readiness code digits are usually set to “0”.

### 5.1.1 Displaying readiness code

There are two ways to read out the readiness code,

- with any generic scan tool of your choice (OBD data display terminal)
- or with the VAS 5051 vehicle diagnosis, measuring and information system.

### 5.1.2 Creating readiness code

The readiness code can only be created by performing the diagnoses.
There are three options for this:

- to perform a MVEG driving cycle.
  In normal operation, it is not usually possible to carry out an MVEG driving cycle after performing repairs.
- to perform a prescribed check routine (short trip) for each relevant vehicle system with the help of the VAS 5051 diagnosis system.
- to drive for a long enough period of time in average driving mode.

## 5.2 Generic scan tool (OBD data display terminal)

It must be possible to display errors and data relevant to exhaust gas detected by the engine control unit within the EOBD on any OBD data display terminal. Therefore, the recognised errors are stored using an SAE code. This SAE code is used by all OBD systems.

SAE code:

- **P0**xxx: Codes which the SAE (Society of Automotive Engineers) have established with set error texts. (Same for all automobile manufacturers)
- **P1**xxx: Codes prescribed by the automobile manufacturers which must be registered with the appropriate authorities. (Various meanings for the various automobile manufacturers).

It may only be connected with the diagnosis interface in the passenger compartment for the start-up procedure of an OBD data display terminal. The communication between the engine control unit and the OBD data display terminal is automatically established.

You will find the error tables for the SAE codes in the workshop manuals with the respective engine control unit.

An OBD data display terminal makes the following functions possible.

- Mode 1:
  Displaying diagnosis data relevant to exhaust gas (IST data, readiness code).
- Mode 2:
  Displaying operational conditions which occurred during the storing of an error. (Only occupied when an error has occurred.)
- Mode 3:
  Displaying errors relevant to exhaust gas which caused the exhaust gas indicator light to be activated.
- Mode 4:
  Deleting error codes, readiness codes and operational conditions (mode 2).
- Mode 5:
  Displaying lambda probe signals.
- Mode 6:
  Displaying readings from systems not constantly being monitored (e.g. secondary air system, fuel tank vent line system).
- Mode 7:
  Displaying errors which have not yet activated the exhaust gas indicator light.
- Mode 8:
  Not yet assigned in Europe.
- Mode 9:
  Displaying vehicle information (e.g. Ident. no., engine code, engine control unit type, software identification, software check sum).

## 5.3 VAS 5051 vehicle diagnosis, measuring and information system

You can display the readiness code with the VAS 5051 and perform the individual short trips for the vehicle systems required for the creation of the readiness code.
In addition to the functions of the OBD data display terminal, the VAS 5051 provides you with further adjustment, diagnosis and fault isolation functions. The fault isolation can be optimised by having access to all pertinent engine data.

### 5.3.1 Displaying readiness code

- Turn on the ignition.
- Select the “vehicle self-diagnosis” mode.
- Select the engine control unit with the address word “01”.
- Select the readiness code function “15”.

### 5.3.2 Performing short trips

You can call up the individual short trips by using the “04 - Introduce basic settings” function.
Various procedures have be set up for the different engine control unit versions.

You will find the measures and prerequisites for performing the short trips of the individual engine control unit versions in the respective workshop manuals.