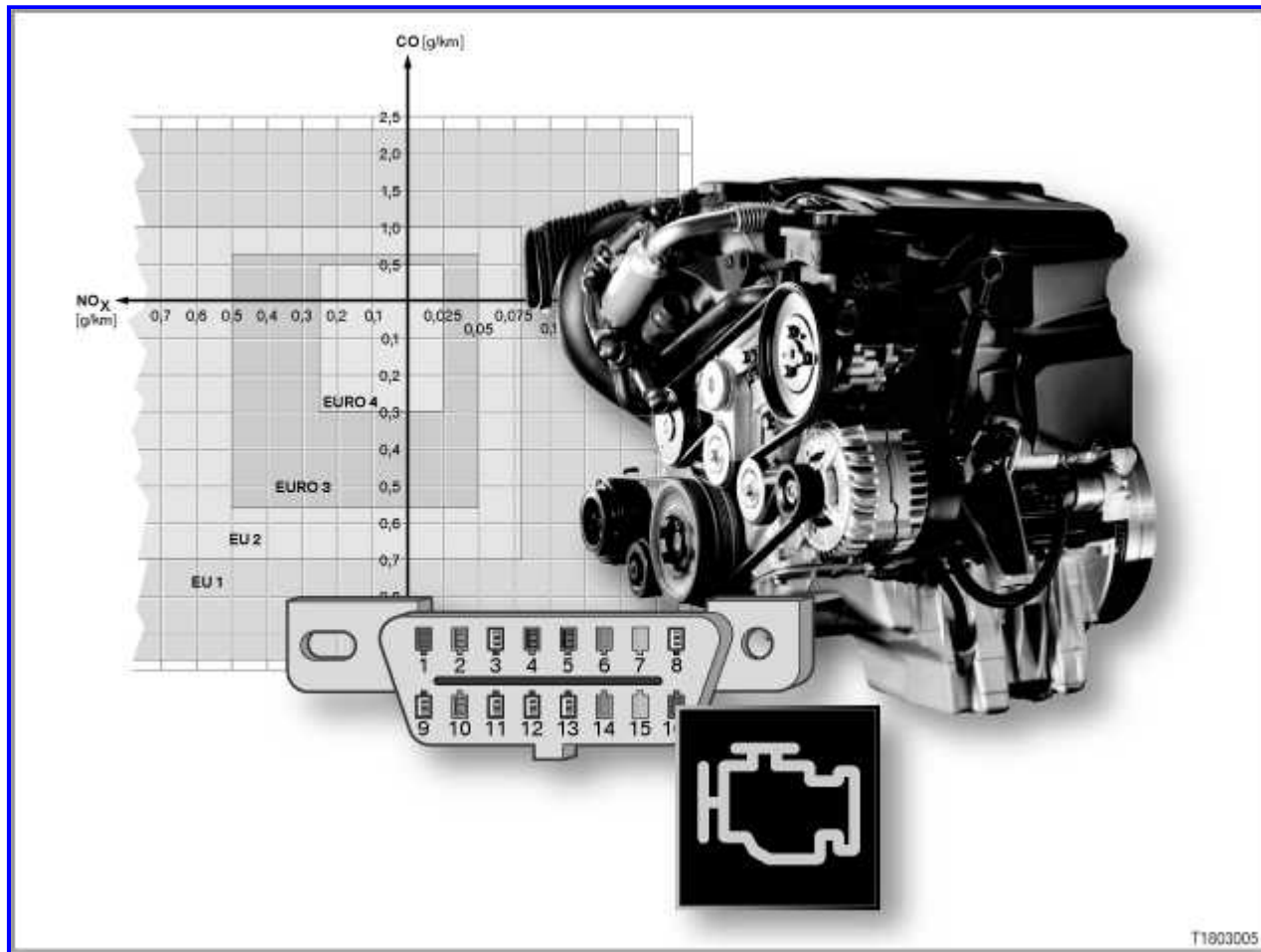


18 02 03 (062)

Exhaust standard EURO 4 and E-OBD for diesel engines

M47TU, M57TU



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Introduction

Exhaust emission standard EURO 4 is mandatory across Europe from 01.01.2005 for newly homologated vehicle types ('homologation' = registering a production vehicle in the international registrations list). Exhaust emission standard EURO 4 is mandatory from 01.01.2006 for the registration of all new vehicles. Exhaust emission standard EURO 4 further reduces the limit values for pollutants in exhaust gas. [\[more ...\]](#)

In addition, in Europe from 01.01.2004 the European on-board diagnosis (E-OBD) is legally required for all diesel engines in passenger cars. [\[more ...\]](#)

This BMW Service Technology also includes a list of fault codes for the E-OBD. [\[more ...\]](#)

The 4-cylinder diesel engine M47TU is installed in the E46 (RHD since 09/2003, LHD since 03/2004) with manual gearbox and exhaust emission standards EURO 4. In 03/2004 exhaust emission standards EURO 4 was also implemented in the 6-cylinder engine M57TU. [\[System overview ...\]](#)

On the M57TU the E60/E61 was equipped for the first time with a diesel particle filter. The diesel particle filter separates out the soot particles in the exhaust gas with a high level of filter performance (> 95 %). The nitrogen oxide emissions do not affect the diesel particle filter. The nitrogen oxide pollutant emissions are reduced by measures inside the engine. The new diesel particle filter developed by BMW does not deliver the customer any disadvantages relating to:

- Scope of maintenance work
- Fuel consumption
- Engine power
- Noise comfort

The diesel particle filter is currently designed for approx. 200,000 kilometres (monitoring by means of Condition Based Service). The use of a fuel additive in regeneration of the diesel particle filter is **not** necessary (fuel additive reduces the ignition temperature of the soot).

Brief component description

To comply with exhaust emission standard EURO 4, the following components in the M47TU/M57TU are new or have been modified:

- Oxygen sensor

A Lambda oxygen sensor is necessary for compliance with exhaust-gas limit values.

The oxygen sensor is required for the quantity mean value adaptation of the injectors.

The Lambda oxygen sensor measures the fuel‐air ratio. In the event of deviations, the DDE adapts the exhaust-gas recirculation rate to suit the change in air/fuel ratio.

[\[more ...\]](#)

- Injector

The injector characteristic map is adapted to suit the fuel injection rate.

A design change has given the injection system a constant characteristic curve. That means that changes in the injection period can directly impact changes in the fuel injection rate.

[\[more ...\]](#)

- Charging pressure actuator (electrical actuator drive on the exhaust turbocharger)

The exhaust turbocharger has a variable turbine geometry (VNT = "variable turbine geometry" from the English term "Variable Nozzle Turbine"). To achieve compliance with exhaust emission standard EURO 4 an electrical charging pressure actuator now adapts the variable turbine geometry (previously, an electromagnetic pressure converter adjusted the variable turbine geometry).

By virtue of the increased adjustment speed and the more rapid response to changes, greater precision is achieved in respect of charging pressure control.

[\[more ...\]](#)

- **Cylinder head and piston**

The cylinder head has a geometrically revised swirl port and swirl port.

To improve mixture preparation, the shape of the piston recess has been modified. This has also give rise to a change in the coolant duct in the piston.

[\[more ...\]](#)

- **Exhaust gas recirculation cooler**

The exhaust-gas recirculation cooler is now longer. The exhaust-gas recirculation cooler therefore has increased cooling power. With the new exhaust-gas recirculation cooler, the exhaust-gas temperature is reduced by approx. 100 °C (in the driving cycle for EURO 4).

[\[more ...\]](#)

- **Diesel particle filter (only M57TU in the E60, E61)**

The diesel particle filter has a catalytic coating which absorbs soot particles from the exhaust gas. Continuously, the stored soot particles are incinerated once the exhaust gases reach a temperature of approx. 350 °C.

Cyclically, the stored soot particles are incinerated once the exhaust gases reach a temperature of approx. 600 °C.

[\[more ...\]](#)

When the diesel particle filter is used, additional components are required for the Digital Diesel Electronics (DDE):

- **Throttle valve**

Under certain operation conditions, the throttle valve throttles the intake air. In combination with 1 to 2 post injections, this leads to an increase in the exhaust-gas temperature (regeneration of the diesel particle filter). [\[more ...\]](#)

- **Exhaust backpressure sensor upstream of the diesel particle filter, exhaust temperature sensor upstream of catalytic converter and exhaust-gas temperature sensor upstream of the diesel particle filter**

With the exhaust backpressure sensor, the level of load on the diesel particle filter is calculated when the vehicle is in motion. Whenever the diesel particle filter has built up too many soot particles, a regeneration cycle is initiated.

As a further parameter, the exhaust-gas temperature is measured upstream of the diesel particle filter. Measurement of the exhaust back pressure by the exhaust backpressure sensor is not sufficient in its own right (load-dependency).

From both these signals, the DDE calculates the precise loading for the diesel particle filter.

The exhaust temperature sensor upstream of catalytic converter monitors the exhaust-gas temperature upstream of the oxidation catalytic converter. Regeneration of the diesel particle filter cannot take place until an exhaust-gas temperature of approx. 350 °C.

[\[more ...\]](#)

- **Leaktight swirl flaps**

The M57TU has totally leaktight swirl flaps (electrically activated in the E46, otherwise activated by vacuum). This does not give rise at the lower end of partial load operation to any leakage around the swirl flaps, making an increase in swirl possible. In addition, with the electrical activation function, a tremendously wide variety of intermediate settings on the swirl flap can be achieved.

System functions

Despite component tolerances and influences on components over their operating time (e.g. wear), careful attention must be paid to these points: The emissions threshold values must be complied with to a sufficiently large safety distance. More extensive emission-related fluctuations can be anticipated in the first instance from the following components:

- Injectors
- Hot film air mass meter
- Rail pressure sensor

The tolerances of the components and the influences over the operating time on component must be compensated for. For compensation on the DDE (Digital Diesel Electronics) the following system functions exist:

- Injection quantity compensation
- Zero-quantity adaptation
- Mean quantity adaptation
- Regeneration of the diesel particle filter (only M57TU in the E60, E61)

Injection quantity compensation

Injection quantity compensation involves the definition of correction values for pre-injection and main injection of an injection system. The injection quantity compensation process is conducted at the end of the production process.

The tolerances given to the injectors on manufacture mean that the actual injected fuel quantity deviates slightly from the calculated fuel quantity. The extent of this deviation is established after production for every injector by measurements, conducted across several operating points.

From these measurements, an adjustment value (code) is generated for each injector.

The structure of the alphanumeric code depends on the exhaust emission standard applicable to that engine:

- Exhaust emission standard EURO 3: **six-digit** (e.g. 78SNGT)
- Exhaust emission standard EURO 4: **seven-digit** (e.g. 88S66NB)

During vehicle assembly, after installation of the DDE control unit, the adjustment value of each installed injector is stored in the DDE control unit. The adjustment values are allocated to the individual cylinders according to the installation of the injectors. With these adjustment values, the DDE control unit corrects the calculated fuel injection rates slightly and, in this way, it reduces the cylinder-specific deviation of the fuel injection rate.

Whenever injectors have to be replaced, it must be ensured that the stamped alphanumeric code of each injector is assigned to the correct cylinder in the DDE control unit.

The BMW diagnosis system has the service function "Injection quantity compensation". With this service function, the code for each cylinder can be changed and stored on the DDE control unit.

For cylinders for which no new adjustment value is entered, the old adjustment value is retained in the DDE control unit. Injection quantity compensation must also be performed if the DDE control unit is replaced and communication was no longer possible with the old control unit.

The codes for the injectors installed must be read off and stored in the DDE control unit.

Zero-quantity adaptation

Zero-quantity adaptation is the adaptation process which is used after the running-in phase (approx. 1500 km) for every single injector to assure the presence of a defined level of pre-injection.

To achieve compliance with exhaust emission standard EURO 4, precise metering of the very small fuel injection rate is required for pre-injection purposes.

Due to the deviation for the fuel injection rate over the operating time, the zero-quantity adaptation is performed continuously by the DDE control unit.

For every cylinder in coasting (overrun) mode, a small quantity of fuel is injected. This quantity is then varied until the desired torque rating is detected by the DDE. To calculate the torque rating, the irregular rotation of the crankshaft is incorporated in the equation. This irregular rotation is recorded on the crankshaft sensor.

This enables the DDE to detect the activation duration after which the cylinder starts to operate. The quantity of fuel injected during the zero-quantity adaptation period is used by the DDE as a correction value for the gearshift map of the pre-injection process.

The zero-quantity adaptation process switches from one cylinder to another in each overrun phase at:

- engine speed 1500 to 2500 rpm (engine at operating temperature)

The zero-quantity adaptation has no impact on fuel consumption because only a small quantity of fuel is injected into each cylinder (approx. 1 mm³).

Mean quantity adaptation

Mean quantity adaptation is the adaptation process at which the air/fuel ratio is corrected (partial load range). This correction is performed by adapting the amount of air by means of the exhaust-gas recirculation valve.

Whereas no additional components are required for the injection quantity compensation and for the zero-quantity adaptation, an oxygen sensor is required for the mean quantity adaptation. The oxygen sensor is a

broadband oxygen sensor with a constant characteristic curve.

The mean quantity adaptation is not a rapid control operation, but is instead an adaptive learning procedure.

An oxygen sensor deviation is "learned" in a characteristic map and stored for a sustained period in the DDE control unit (EEPROM).

The characteristic map must be reset (deleted) in EEPROM if any of the following components is replaced:

- Hot film air mass meter
- Injector
- Rail pressure sensor

To reset the characteristics map, the BMW diagnosis system offers the service function of "mean quantity adaptation".

Regeneration of the diesel particle filter (only with M57TU in the E60, E61)

The soot load in the diesel particle filter is established by the DDE from the engine operating points.

Regeneration of the diesel particle filter can be continuous and/or cyclical.

- **Continuous regeneration:**

In operating ranges at which the exhaust-gas temperature exceeds the ignition temperature of the soot (> 350 degrees Celsius), the soot particles are converted directly. This involves the soot particles being converted by a process of slow oxidation into carbon monoxide (CO) and carbon dioxide (CO₂).

The oxidation agent is the nitrogen dioxide present in the exhaust gas (NO₂). This nitrogen dioxide is formed from the nitrogen monoxide (NO) in the oxidation catalytic converter.

If the exhaust-gas temperature is not hot enough for this process, the soot particles are initially collected in the diesel particle filter and are then incinerated the next time that the exhaust-gas temperature increases.

- **Cyclical regeneration:**

If the driving style does not permit continuous regeneration of the diesel particle filter (e.g. long, sustained partial load operation in urban traffic and low exhaust-gas temperature), targeted regeneration is initiated.

This process is controlled by signals from the exhaust backpressure sensor and two exhaust-gas temperature sensors. Cyclical regeneration runs like continuous regeneration without significant implications on drivability.

Depending on the load condition of the engine, regeneration can take the form of targeted throttling of intake air in conjunction with 1 to 2 post-injections. This raises the exhaust-gas temperature to approx.. 600 degree Celsius. The residual oxygen in the exhaust gas (O₂) enables soot to be burned off. The regeneration of the diesel particle filter can take several minutes. The interval stages for regeneration depend on the operating conditions of the vehicle over its last 500 kilometres. At high exhaust-gas temperatures, there is less soot buildup as a result of continuous incineration of the soot particles.

In addition, every 700 to 2500 kilometres (depending on driving profile), regeneration of the diesel

particle filter can be initiated. In the event of failure of the exhaust backpressure sensor or of one of the exhaust-gas temperature sensors, the diesel particle filter is regenerated every 500 kilometres.

Notes for Service department

Observe the following information for service:

- General information: [\[more ...\]](#)
- Diagnosis: [\[more ...\]](#)
- Encoding/programming: ---
- Car & Key Memory: ---

No liability can be accepted for printing or other faults. Subject to changes of a technical nature