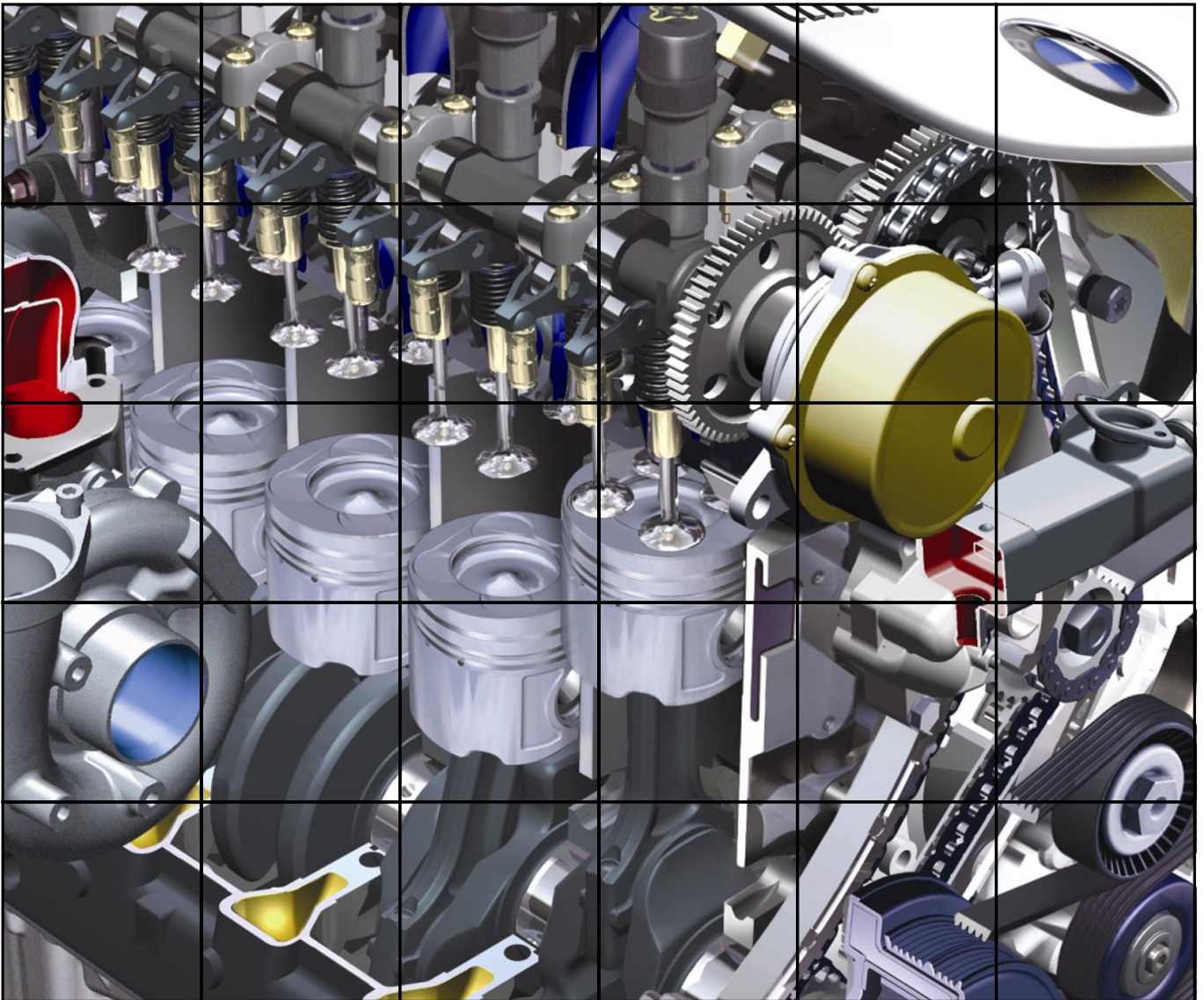


BMW Service

M57TU Engine Participant Manual



NOTE

The information contained in this participant's manual is intended for participants of the Aftersales Training.
Refer to the relevant "BMW Service" information for any changes/supplements to the Technical Data.

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M57TU-EURO 4

Introduction

For the first time, the M57TU engine in the E60 will be equipped with a diesel particle filter (DPF). The diesel particle filter in the E60 is necessary in order to comply with EURO 4 legislation. Model series with a smaller engine that fulfil EURO 4 requirements without a diesel particle filter will not be equipped with this filter. The diesel particle filter filters out particles contained in the exhaust gas at high filtration efficiency (> 95%). The diesel particle filter has no influence on nitrogen oxide (NOx) emissions. These emissions are reduced in the engine. The second generation filter system newly developed by BMW differs from the systems known to date from other manufacturers (first generation diesel particle filters). There are no disadvantages for the customer with regard to maintenance requirements, fuel consumption and engine power output. The system is maintenance-free and designed to match the service life of the vehicle. A fuel additive for filter regeneration is not necessary in connection with the BMW system.

- History

The M57TU engine is installed in the following model series:

Engine	Model series	Power output (kW/bhp) at rpm	Torque (Nm) at rpm	Exhaust emission stage	Engine control
M57D30TU	E46	(150/204) 4000	(410) 1500-3250	LHD = EURO 3 RHD = EURO 3	DDE 506
M57D30TU	E60	(160/218) 4000	(500) 2000-2750	LHD = EURO 3 RHD = EURO 3	DDE508
M57D30TU Euro 4	E60 (as from 03/04)	(160/218) 4000	(500) 2000-2750	LHD = EURO 4 RHD = EURO 4	DDE509
M57D30TU	E65	(160/218) 4000	(500) 2000-2750	LHD = EURO 3 RHD = EURO 3	DDE 506
M57D30TU	E53	(160/218) 4000	(500) 2000-2750	LHD = EURO 3 RHD = EURO 3	DDE 506
M57D30TU	E83	(150/204) 4000	(410) 1500-3250	LHD = EURO 3 RHD = ---	DDE 506

LHD = Left-hand drive, RHD = Right-hand drive

- Changes

Series of changes were implemented on the M57TU in order to achieve EURO 4 exhaust emission values in the E60. The diesel particle filter (DPF) represents only a part of these changes. With the installation of the M57TU in the E83, the following measures relating to the exhaust emission have already been implemented on the engine and described in the E83 trainer background material:

- Introduction of fuel injectors MV+
- Modified valve seat of tangential port in cylinder head
- Gas-tight swirl flaps (swirl port)
- Modified piston crown recess
- Larger exhaust gas recirculating cooler (EGR) with increased cooling capacity
- Volume mean value adaptation (lambda adaptation)

The following changes are additionally made in the E60 to ensure the EURO 4 exhaust emission limit values are reliably reached:

- Exhaust system with diesel particle filter (DPF) with catalytic coating
- Digital diesel electronics DDE 509 with:
 - Expanded software
 - Exhaust pressure sensor
 - 2 Exhaust gas temperature sensors
 - Throttle valve
 - Turbocharger (VNT) with electric actuator

- Engine designation

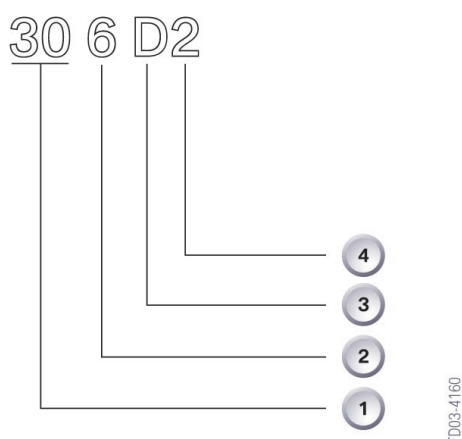
To identify the engine, the engine number and the engine designation are punched on the engine block. The engine designation is located on the left side of the engine block.

Engine number

The engine number is an 8-digit numerical combination representing the production location and production data in coded form.

Engine designation

The engine designation provides an indication of the displacement, the number of cylinders, the engine concept and the distinguishing index of the respective engine.

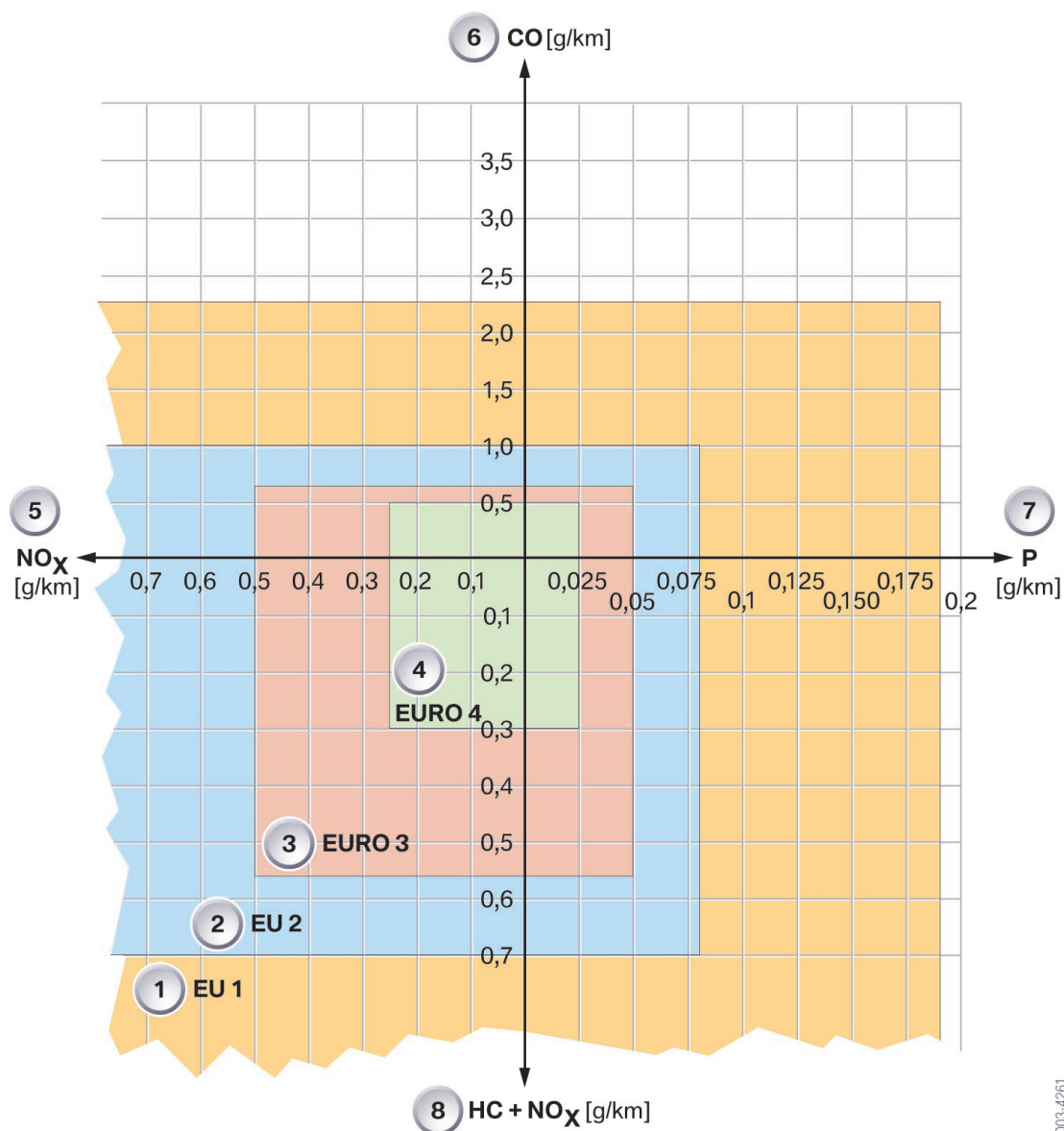


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Fig. 1: Engine designation

Index	Description	Index	Description
1	Displacement: 3 litres	3	Engine concept: Diesel
2	Number of cylinders: 6	4	Distinguishing index: 1 = M57 2 = M57TU

- Exhaust emission limits



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TD03-4261

Fig. 2: Development of the exhaust emission limits EU 1 to EURO 4

Index	Description	Index	Description
1	Exhaust emission standard EU 1 (since 1992)	5	Nitrogen oxide (NO _x)
2	Exhaust emission standard EU 2 (since 1996)	6	Carbon monoxide (CO)
3	Exhaust emission standard EURO 3 (since 2000)	7	Soot particles (C)

M57TU-Engine

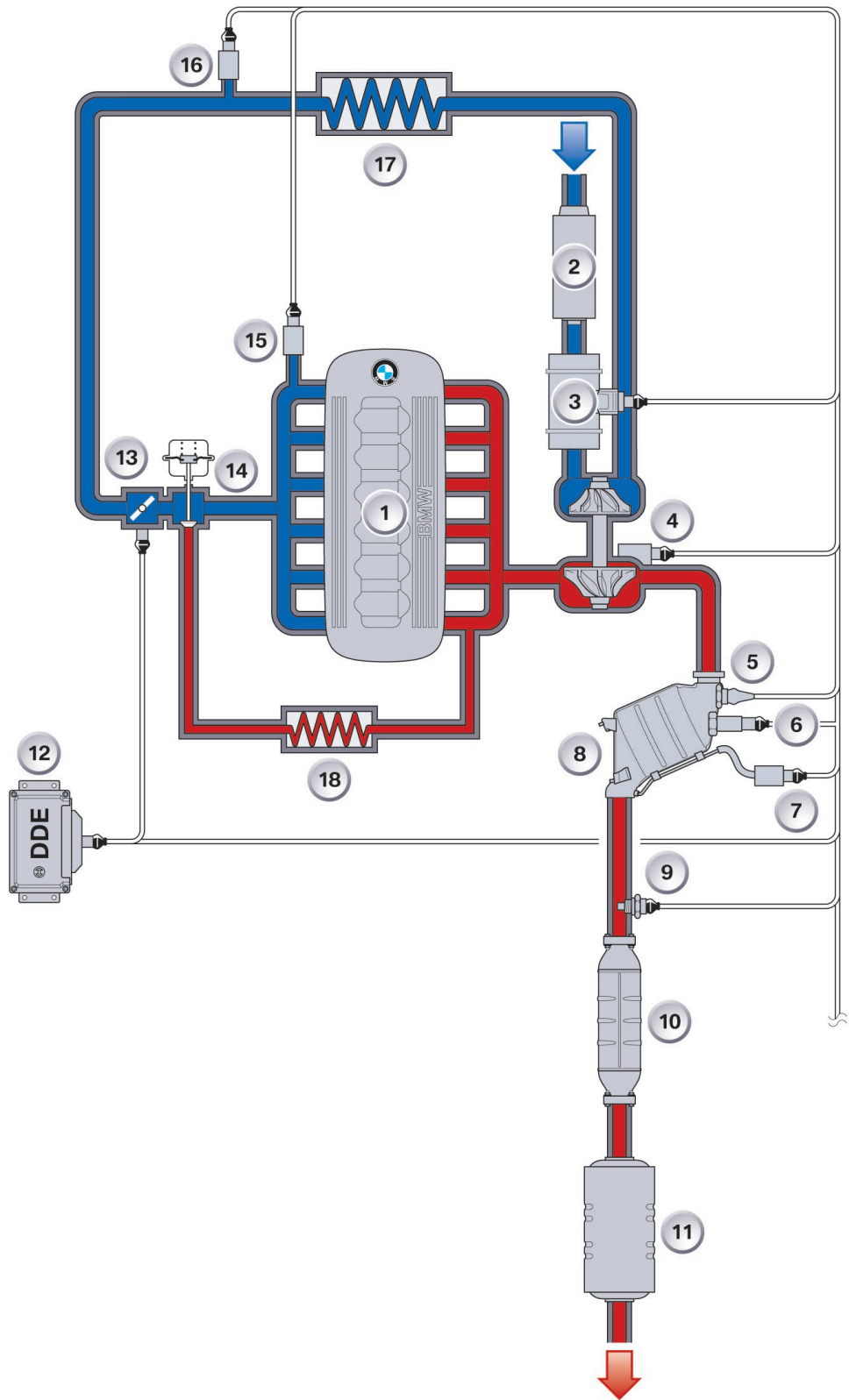
Index	Description	Index	Description
4	Exhaust emission standard EURO 4 (as from 2005)	8	Hydrocarbons (HC) and nitrogen oxide (NO _x)

Exhaust gas composition

The exhaust gases produced by the diesel engine contain the following constituents:

- Carbon monoxide (CO)
- Uncombusted hydrocarbons (HC)
- Soot (C)
- Carbon dioxide (CO₂)
- Nitrogen oxide (NO_x)
- Water (H₂O)
- Oxygen (O₂)
- Sulphur dioxide (SO₂)
- Sulphuric acid (H₂SO₄)

System overview



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Fig. 3: System overview of exhaust treatment

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M57TU-Engine

Index	Description	Index	Description
1	M57TU engine EURO 4	10	Diesel particle filter (DPF)
2	Air cleaner	11	Rear silencer
3	Hot-film air mass meter (HFM)	12	Digital diesel electronics (DDE)
4	Turbocharger (VNT)	13	Throttle valve
5	Exhaust gas temperature sensor 1	14	Exhaust gas recirculation, EGR valve
6	Oxygen sensor (Bosch LSU 4.9)	15	Boost pressure sensor
7	Pressure sensor	16	Intake air temperature sensor
8	Oxidation catalytic converter	17	Intercooler
9	Exhaust gas temperature sensor 2	18	EGR cooler

Components

- Exhaust system

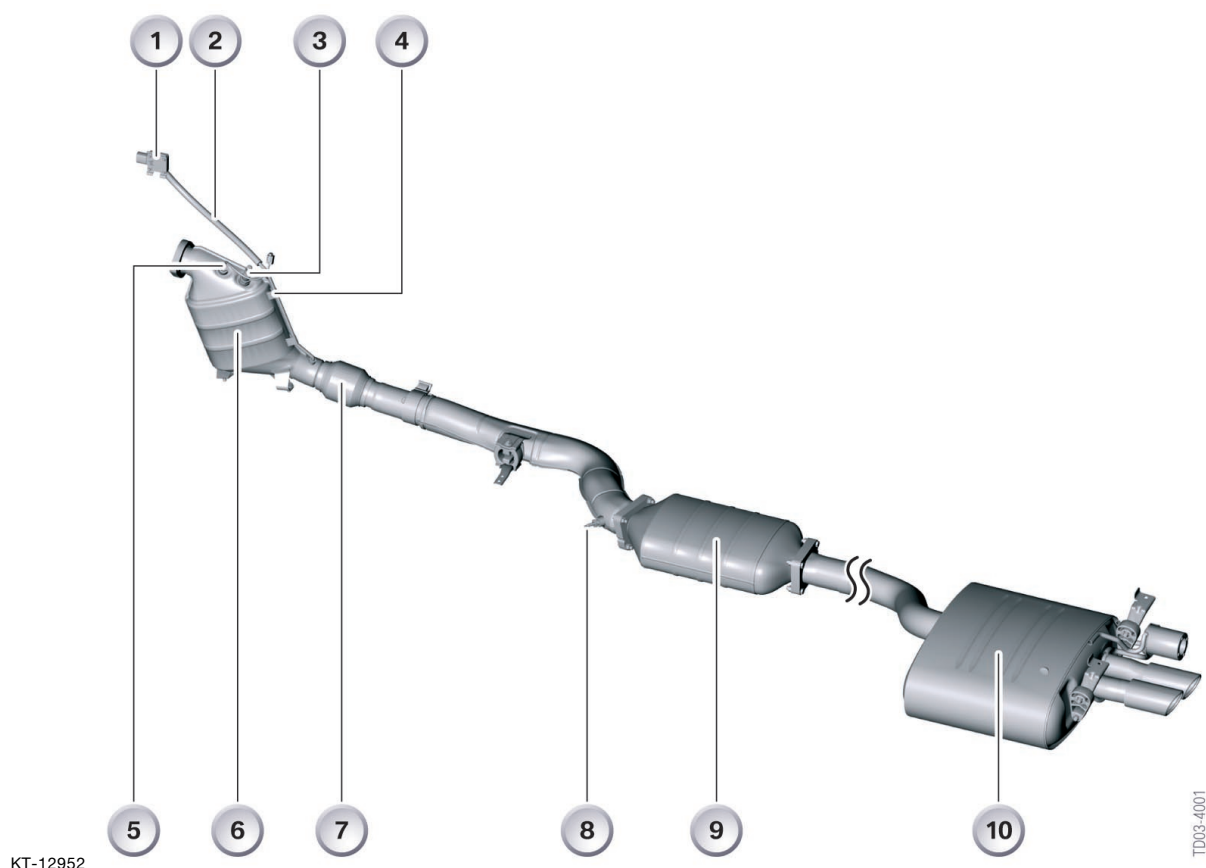
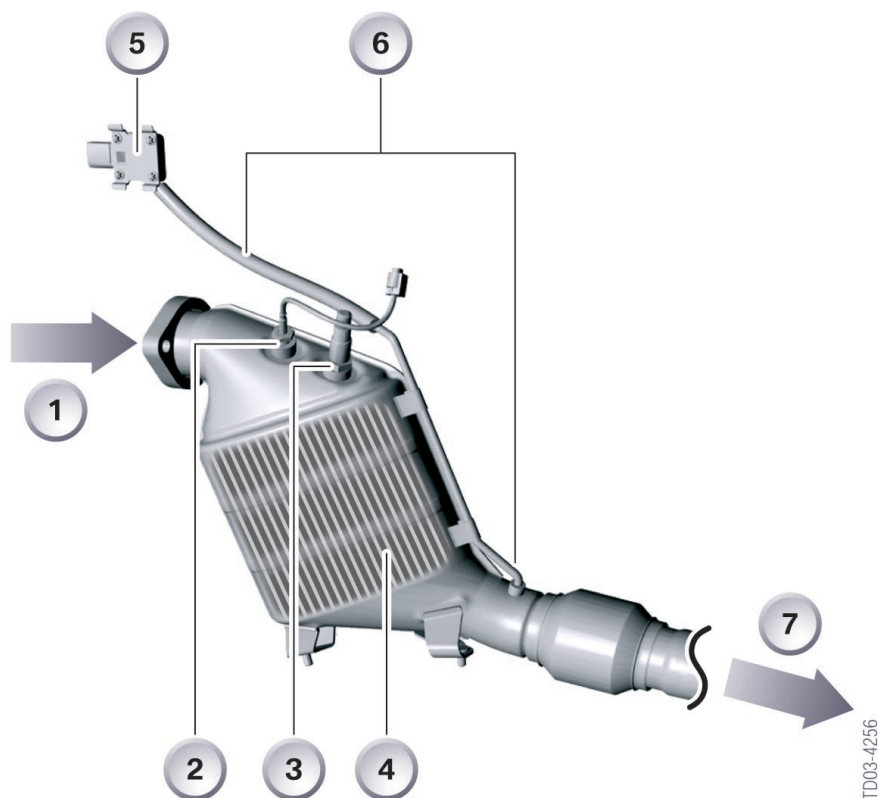


Fig. 4: E60 exhaust system with diesel particle filter

Index	Description	Index	Description
1	Pressure sensor	6	Oxidation catalytic converter
2	Hose	7	Decoupling element
3	Oxygen sensor (Bosch LSU 4.9)	8	Exhaust gas temperature sensor 2
4	Pipe	9	Diesel particle filter (DPF)
5	Exhaust gas temperature sensor 1	10	Rear silencer

The exhaust system features welded heat shields from the decoupling element (7) up to the DPF (9).

Oxidation catalytic converter



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Fig. 5: Oxidation catalytic converter

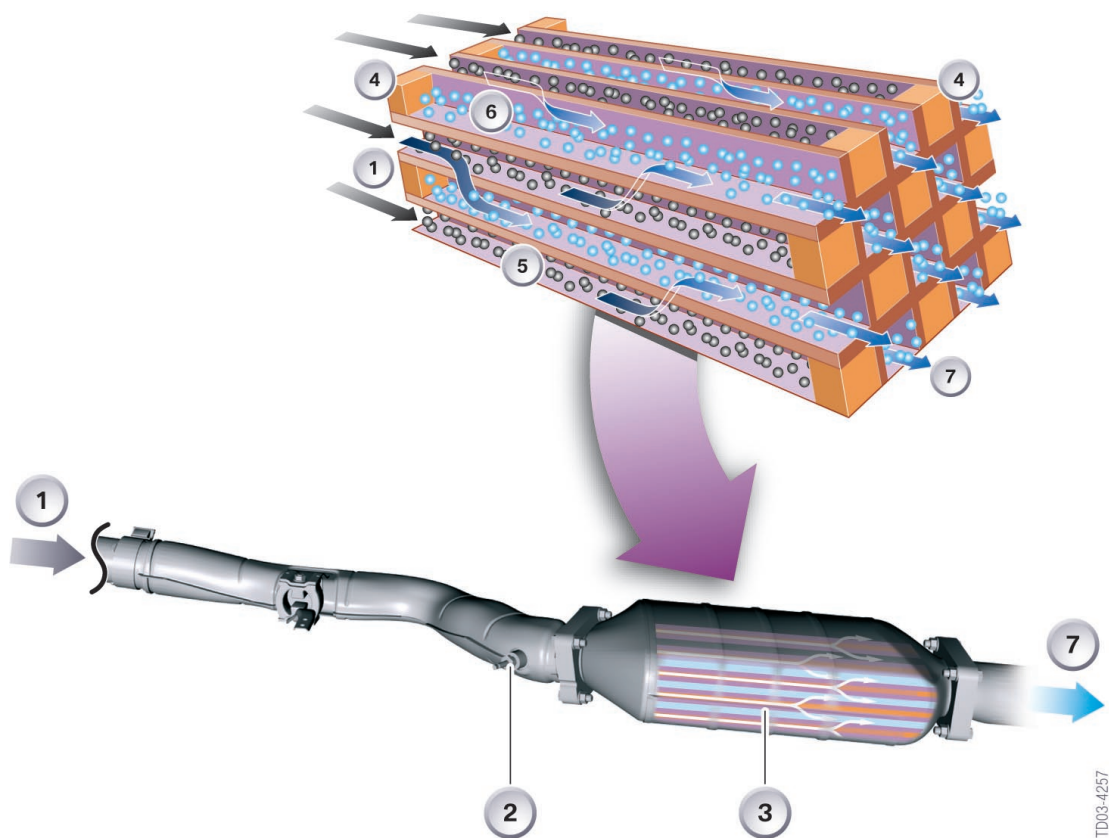
Index	Description	Index	Description
1	Exhaust gas from engine	5	Exhaust pressure sensor
2	Exhaust gas temperature sensor	6	Feed line to exhaust gas pressure sensor
3	Oxygen sensor	7	Pre-cleaned exhaust gas to diesel particle filter
4	Ceramic carrier	---	---

The near-engine oxidation catalytic converter is responsible for converting the following exhaust gas components over the entire operating range:

- Carbon monoxide (CO) in carbon dioxide (CO_2)
- Hydrocarbons (HC) in water (H_2O) and carbon dioxide (CO_2)
- Nitrogen monoxide (NO) in nitrogen dioxide (NO_2)

The soot particles, however, flow through the oxidation catalytic converter unhindered. The oxidation catalytic converter is additionally used to increase the temperature during regeneration of the diesel particle filter. The ceramic carrier (cordierite) features a platinum-based oxidation coating.

Diesel particle filter (DPF)



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TD03-4257

Fig. 6: Function of diesel particle filter

Index	Description	Index	Description
1	Pre-cleaned exhaust gas from oxidation catalytic converter with soot particles	5	Inlet channel
2	Exhaust gas temperature sensor	6	Outlet channel
3	Diesel particle filter (DPF)	7	Cleaned exhaust gas without soot particles to rear silencer
4	End of filter element	---	---

The diesel particle filter is located downstream of the oxidation catalytic converter on the vehicle underbody. The filter element consists of a ceramic monolith made of high temperature-resistant silicon carbide. The filter element is 50% porous and features a platinum-based catalytic coating. This coating reduces the soot ignition temperature for the purpose of ensuring effective regeneration of the diesel particle filter.

The total weight of the DPF is about 7.5 kg.

The exhaust gasses (1) flow from the oxidation catalytic converter to the inlet channels of the DPF. The inlet channels (5) of the filter element are closed at their ends (4). Each inlet channel has four encompassing outlet channels (6).

The soot particles are deposited on the platinum coating of the inlet channels. The soot particles remain here until they are combusted by an increase in the exhaust temperature. The cleaned exhaust gas flows through the platinum-coated, porous filter walls out of the outlet channels.

Filter regeneration

1. Immediate conversion of the soot particles takes place within the operating ranges where the exhaust gas temperature is above the soot ignition temperature ($>300\text{ }^{\circ}\text{C}$). During this process, the soot is converted by slow oxidation to carbon monoxide (CO) and carbon dioxide (CO₂). The nitrogen dioxide (NO₂) contained in the exhaust gas serves as the oxidation agent.
2. If the temperature is not high enough for this process, the particles are initially collected in the filter element and then burnt off when the exhaust gas temperature increases.

3. Specific regeneration is initiated if vehicle operation, e.g. prolonged partial load operation (town traffic) and low exhaust temperatures does not permit automatic regeneration of the diesel particle filter. This process controlled by the pressure sensor and the two temperature sensors takes place without noticeable effects on the vehicle performance. Corresponding to the load, this regeneration process is performed by specifically throttling the intake air combined with 1 or 2 subsequent injection cycles. In this way, the exhaust gas is increased to a temperature of approx. 620 °C. The soot is now burnt off by the residual oxygen content (O₂) in the exhaust gas. The regeneration process can take several minutes. The regeneration intervals greatly depend on the load collective of the vehicle over the last 500 kilometres. There is a minimum deposit of soot at high exhaust temperatures due to continuous burn-off of the soot particles.

Filter regeneration is initiated every 700 - 2500 km (depending on driving profile) in addition to the sensor measurement. The diesel particle filter is regenerated every 500 km in the event of the pressure sensor or the temperature sensors failing.

Note

On no account should fuel additives, e.g. valve cleaner, cold start accelerator containing substances that form ashes (metallic compounds) be used. Such additives produce high levels of ash that result in the diesel particle filter clogging.

Digital diesel electronics (DDE)

- Introduction

The DDE 509 is used in connection with the M57TU Euro 4 engine with diesel particle filter (DPF). Compared to the previous DDE508, the DDE509 has been expanded by following functions:

Software

- Evaluation of exhaust gas temperature sensors and of exhaust gas pressure sensor to calculate the load status of the DPF.
- Control of DPF regeneration.
- Volume mean value adaptation MMA (lambda adaptation same as DDE506 in E83).

Hardware

- Lambda IC in DDE control unit for evaluating oxygen sensor.
- Exhaust gas temperature sensor upstream of oxidation catalytic converter.
- Exhaust gas pressure sensor upstream of diesel particle filter (DPF).
- Exhaust gas temperature sensor upstream of DPF.
- Bosch LSU 4.9 oxygen sensor upstream of oxidation catalytic converter.

History

The following engine control systems are used for the M57TU engine:

Model series	DDE
E46	DDE 506
E60 as from 03/04	DDE508 DDE509
E65	DDE 506
E53	DDE 506
E83	DDE 506

- System overview

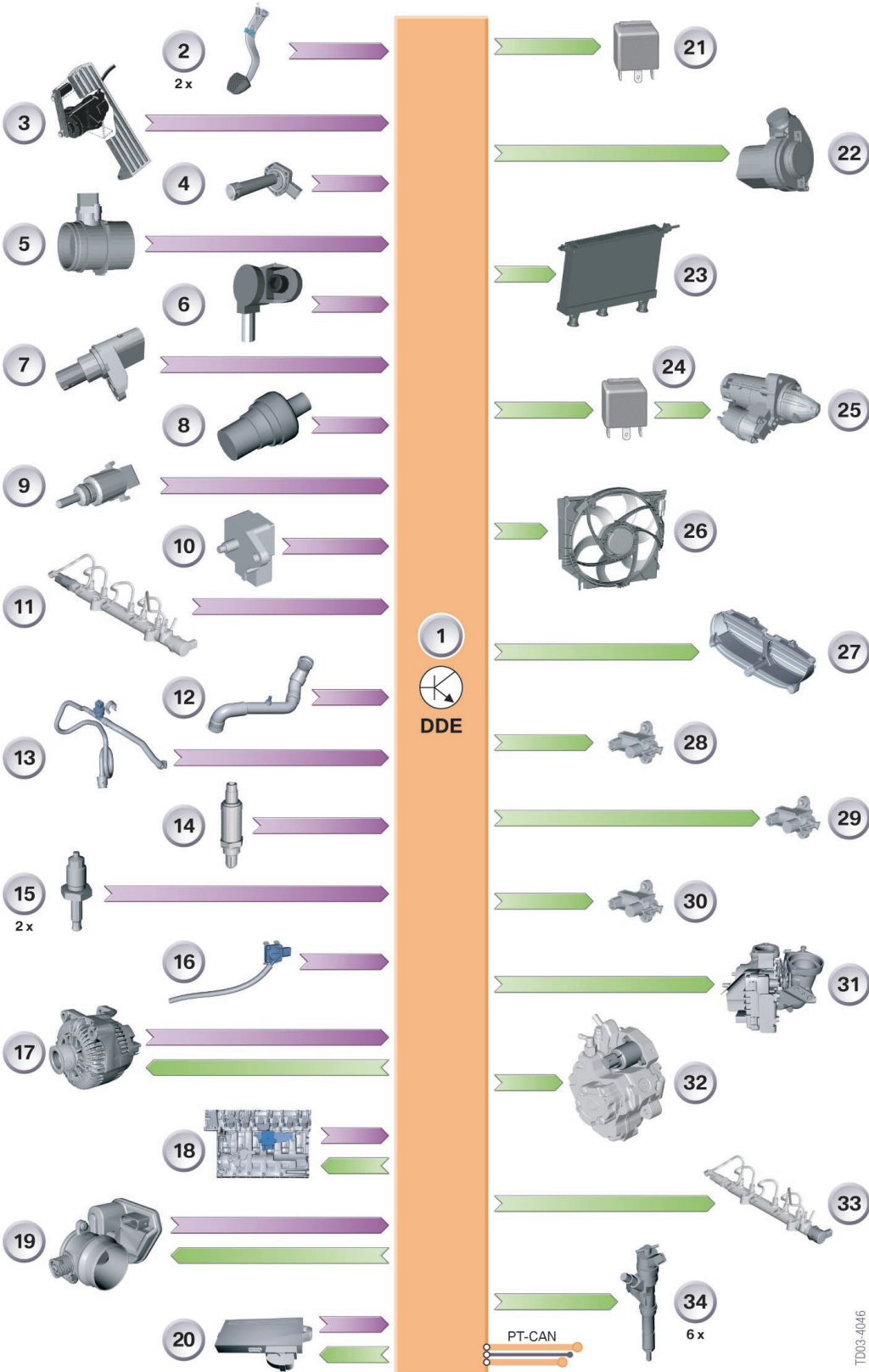
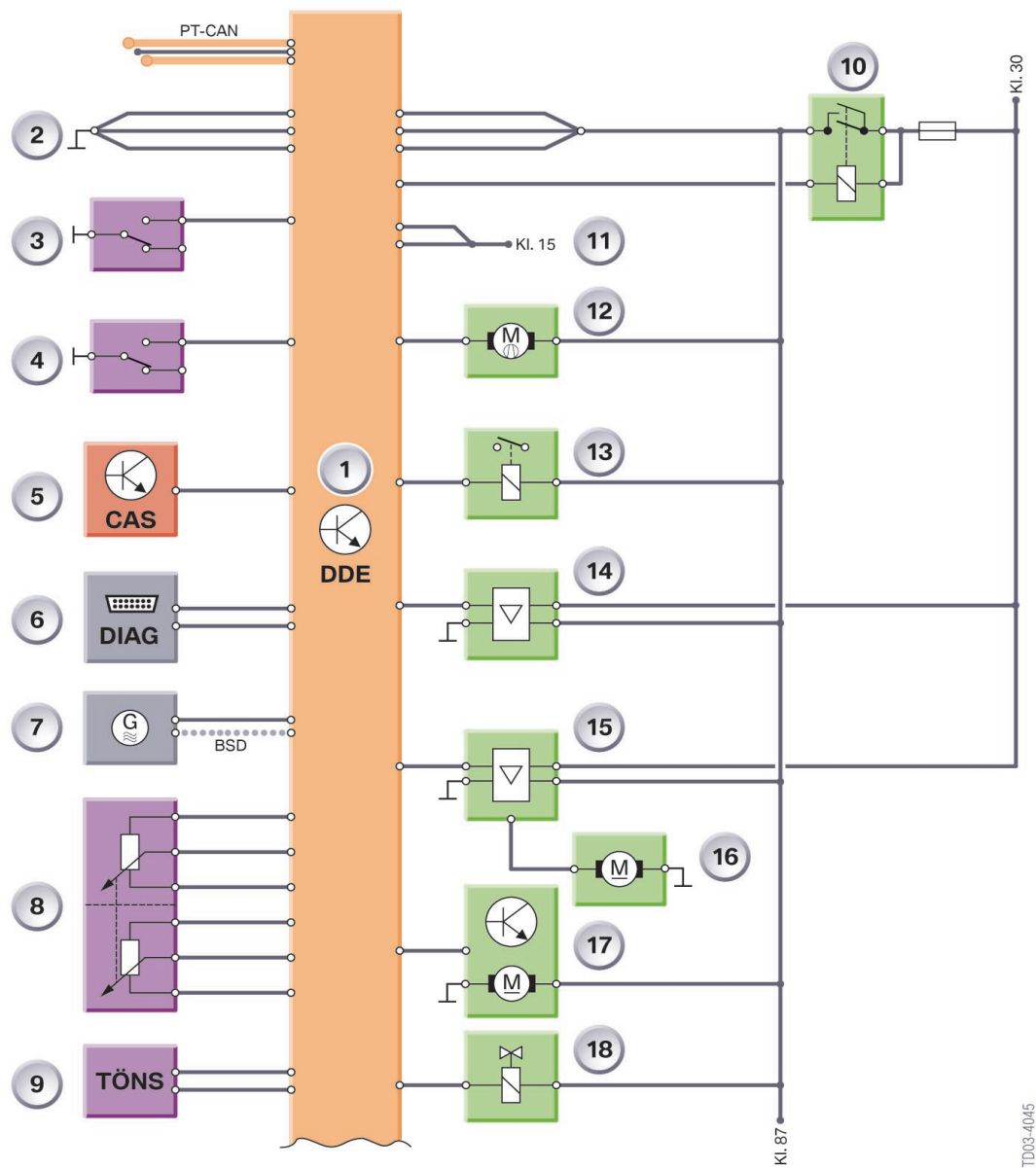


Fig. 7: System overview DDE509

M57TU-Engine

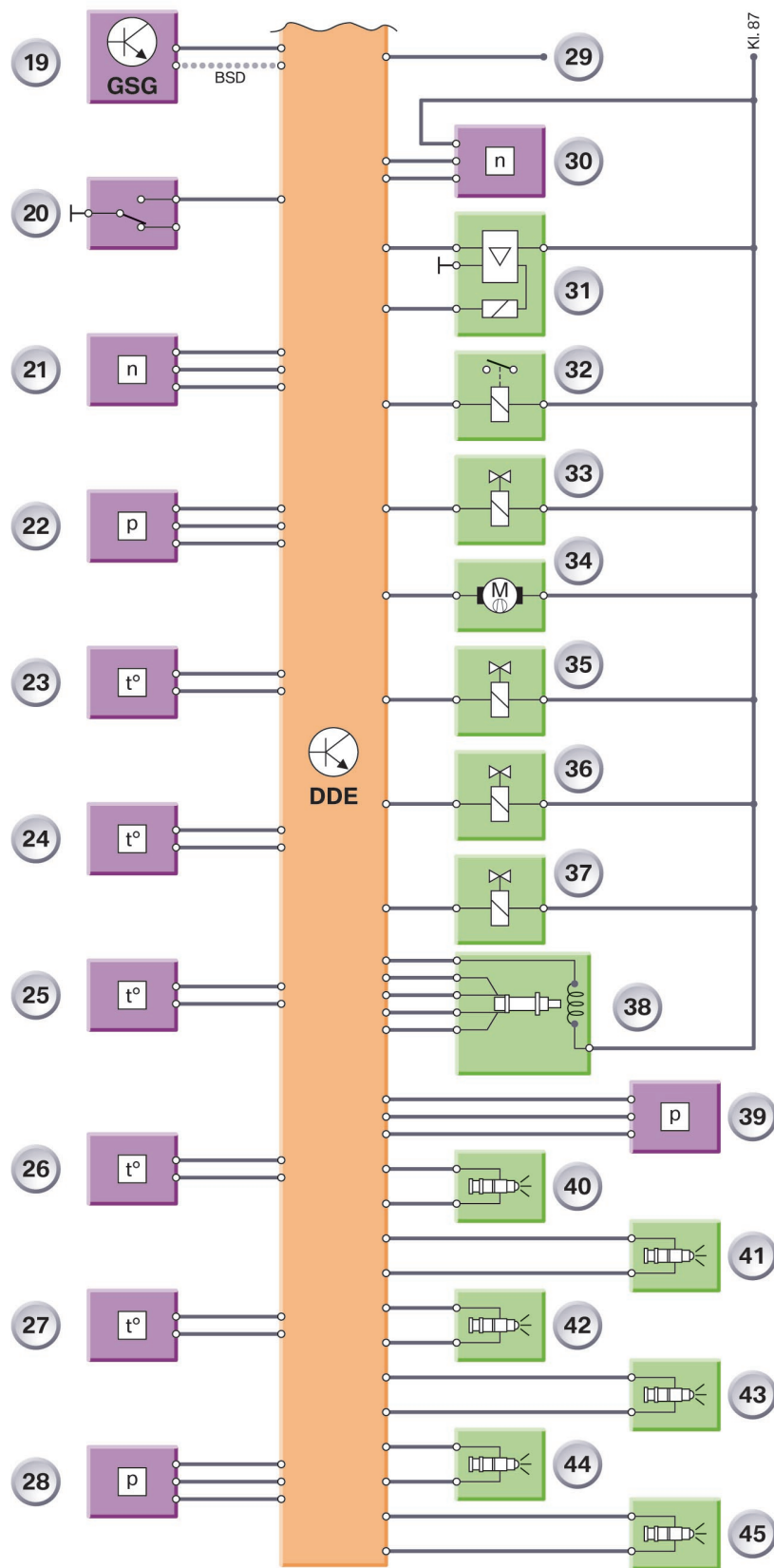
Index	Explanation	Index	Explanation
1	DDE control unit	18	Preheating control unit (GSG)
2	1 brake pedal switch and 1 clutch pedal switch	19	Throttle valve
3	Accelerator pedal module (FPM)	20	Car access system (CAS)
4	Thermal oil level sensor	21	DDE main relay
5	Hot-film air mass meter (HFM)	22	E-box fan
6	Camshaft position sensor	23	Auxiliary heater
7	Crankshaft position sensor (KWG)	24	Starter relay
8	Oil pressure switch	25	Starter
9	Coolant temperature sensor	26	Electric fan
10	Boost pressure sensor	27	Air flap control (LKS) E60 only
11	Rail pressure sensor	28	Valve for swirl flaps
12	Charge air temperature sensor	29	Valve for engine mount control
13	Fuel temperature sensor	30	Exhaust gas recirculation valve
14	Oxygen sensor	31	Actuator for turbocharger (VNT)
15	2 Exhaust gas temperature sensors	32	Volume control valve
16	Exhaust pressure sensor	33	Rail pressure control valve
17	Alternator	34	Fuel injectors 1-6



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Fig. 8: System circuit diagram DDE509, Part 1

TD03-4045



KT-12754

Fig. 9: System circuit diagram DDE509, Part 2

TD03-4076

M57TU-Engine

Index	Explanation	Index	Explanation
1	DDE control unit	24	Charge air temperature sensor
2	Ground connection	25	Fuel temperature sensor
3	Brake pedal switch	26	Exhaust gas temperature sensor 1
4	Clutch pedal switch	27	Exhaust gas temperature sensor 2
5	Car access system (CAS)	28	Exhaust pressure sensor
6	Diagnosis connector	29	Output, terminal 15 for other control units
7	Alternator	30	Camshaft position sensor
8	Accelerator pedal module (FPM)	31	Hot-film air mass meter (HFM)
9	Thermal oil level sensor (TÖNS)	32	Engine mount control
10	DDE main relay	33	Exhaust gas recirculation valve
11	Terminal 15	34	Actuator for turbocharger (VNT)
12	E-box fan	35	Valve for swirl flaps
13	Starter relay	36	Rail pressure control valve
14	Auxiliary heater	37	Volume control valve
15	Fan control unit	38	Oxygen sensor
16	Fan motor	39	Rail pressure sensor
17	Throttle valve	40	Fuel injector 1
18	Air-flap control (LKS)	41	Fuel injector 2
19	Preheating control unit	42	Fuel injector 3
20	Oil pressure switch	43	Fuel injector 4
21	Crankshaft sensor (KWG)	44	Fuel injector 5
22	Boost pressure sensor	45	Fuel injector 6
23	Coolant temperature sensor	---	---

- Components

Sensors

- Accelerator pedal module
- Hot-film air mass meter (HFM)
- Boost pressure sensor
- Coolant temperature sensor
- Fuel temperature sensor
- Rail pressure sensor
- Charge air temperature sensor
- Camshaft position sensor (NWG)
- Thermal oil level sensor (TÖNS)
- Crankshaft position sensor (KWG)
- Exhaust pressure sensor
- Exhaust gas temperature sensor upstream of oxidation catalytic converter.
- Exhaust gas temperature sensor upstream of diesel particle filter (DPF).
- Oxygen sensor (Bosch LSU 4.9 with constant characteristic)

Actuators

- Fuel injectors 1-6
- Volume control valve
- Pressure control valve
- Solenoid valve for turbocharger (VNT)
- Solenoid valve for exhaust gas recirculation
- Solenoid valve for swirl flaps
- Solenoid valve for engine mounts
- Electromagnet for air flap control (LKS) - (E60 only)
- E-box fan
- Electric motor throttle valve actuator

Switches

- Brake light switch/brake light test switch
- Oil pressure switch
- Clutch switch

Relays

- Main relay
- Starter relay

Interfaces

- Bit-serial data interface BSD (alternator, preheating control unit)
- PT-CAN

Exhaust gas pressure sensor

The exhaust gas pressure sensor is located outside the exhaust system on the cylinder head. It is connected by means of a hose and pipe to the exhaust pipe ahead of the diesel particle filter (DPF).

The exhaust gas pressure sensor measures the exhaust backpressure upstream of the DPF. The maximum permissible exhaust backpressure is 750 mbar. The DDE initiates regeneration of the diesel particle filter when the exhaust backpressure is too high (when the DPF has accumulated too many soot particles).

With the aid of a sheet metal diaphragm, the exhaust gas pressure sensor converts the exhaust backpressure into a travel range. Four pressure-sensitive resistors convert this travel range in the exhaust gas pressure sensor into a voltage signal (0 - 5 Volt). The measuring range of the exhaust gas pressure sensor is 600 to 2000 mbar absolute.

The exhaust gas pressure sensor is connected by means of three pins to the DDE. The DDE supplies the exhaust gas pressure sensor with ground and a voltage of 5 Volt. The voltage signal (0 - 5 Volt) is routed via the third pin to the DDE.

In the event of the sensors (exhaust gas pressure sensor, exhaust gas temperature sensors) failing, the DDE initiates filter regeneration every 500 km and a corresponding fault code is stored in the DDE fault code memory.

Exhaust gas temperature sensors

The two exhaust gas temperature sensors are located ahead of the oxidation catalytic converter and downstream of the diesel particle filter (DPF) in the exhaust system. The DDE uses the exhaust gas temperature to control the regeneration of the diesel particle filter (DPF). The exhaust gas temperature sensors are NTC resistors (the resistance drops as the temperature increases). Their optimum operating range is between 200 and 700 °C.

Exhaust gas temperature sensor 1

Filter regeneration may be initiated only after an exhaust gas temperature above 200 °C has been reached. Initiation of filter regeneration below a temperature of 200 °C would cause white smoke in the exhaust gas due to excess hydrocarbons (HC). The exhaust gas temperature sensor 1 (upstream of the oxidation catalytic converter) therefore does not enable filter regeneration before an exhaust gas temperature of 200 °C has been reached.

Exhaust gas temperature sensor 2

Measuring the exhaust backpressure by means of the exhaust gas pressure sensor alone would be load-dependent. For this reason, the exhaust gas temperature before the diesel particle filter is measured as a further variable. The DDE determines the exact load of the DPF from the two signals from the exhaust gas pressure sensor and exhaust gas temperature sensor 2.

Oxygen sensor

As already used on the E83 with M57TU engine and automatic transmission, volume mean value adaptation (lambda adaptation) is also used on the E60.

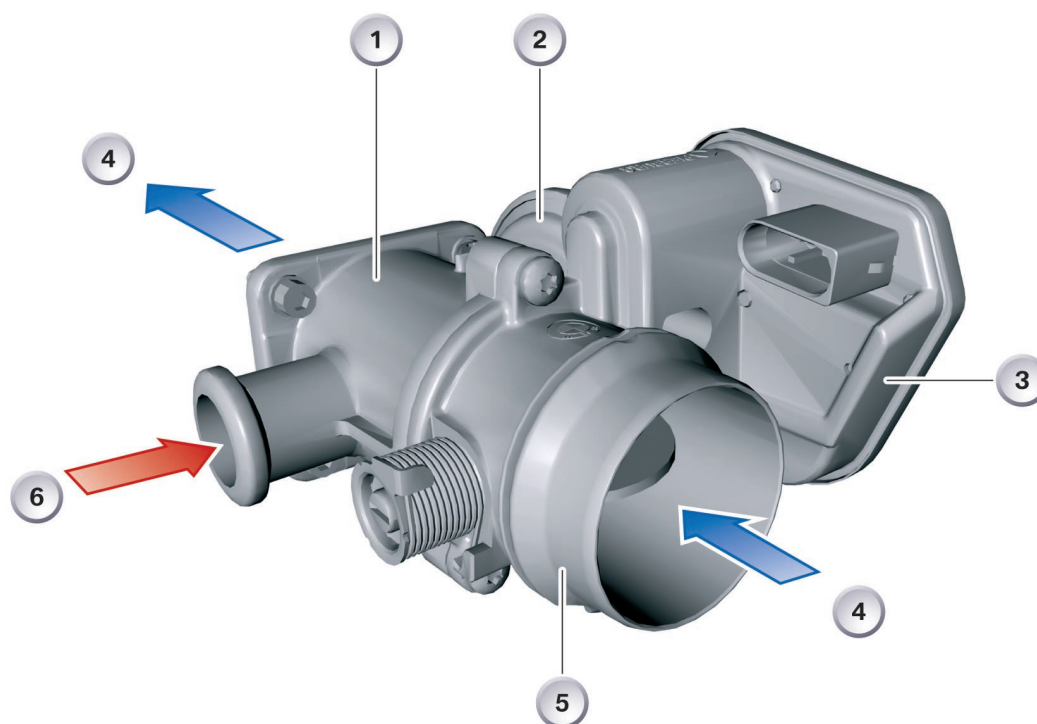
In connection with heavy vehicles, such as the E60 for example, it has proven more difficult to comply with the stipulated emission limits (EURO 4) with a similarly large safety margin as used on the smaller model series. This safety margin is necessary due to component tolerances and runtime influences of components relevant to emission. The emission-relevant components are the fuel injectors and the hot-film air mass meter (HFM). A mean injection volume over all cylinders is determined depending on the lambda value measured by the oxygen sensor and on the air mass measured by the hot-film air mass meter. This value is compared with the injection volume defined by the DDE.

If a variation is determined, by adjusting the EGR valve, the mass of fresh air is correspondingly adapted to the actual injection volume so as to establish the correct lambda value.

Volume mean value adaptation is not a "fast" control facility but rather an adaptive learning process, i.e. the injection volume error is learned in an adaptive characteristic map that is permanently stored in the EEPROM of the control unit.

The oxygen sensor (Bosch LSU 4.9 with constant characteristic) is located in the housing of the oxidation catalytic converter.

Throttle valve



KT-12750

TM03_4011

Fig. 10: Throttle valve

Index	Explanation	Index	Explanation
1	Exhaust gas recirculation, EGR valve	4	Intake air to engine
2	Vacuum unit	5	Throttle valve housing
3	Electric motor throttle valve actuator	6	Exhaust gas to EGR valve

The intake air is throttled by the electrically operated throttle valve for regeneration of the diesel particle filter (DPF). Throttling the intake air in combination with one or two subsequent injection cycles increases the exhaust temperature for regeneration of the DPF.

The throttle valve is located in the intake air line between the intercooler and the intake manifold. The throttle housing is firmly screwed to the vacuum-operated EGR valve. The throttle valve is further used to reduce the shut-down judder. Initially, the throttle valve is completely closed when the engine is turned off. The injection volume is reduced with a time delay. The shut-down judder is substantially reduced by the vacuum that occurs in the intake tract.

The DDE uses a PWM signal to control the electric throttle actuator motor. The voltage is supplied via terminal 87 and a ground connection in the engine wiring harness.

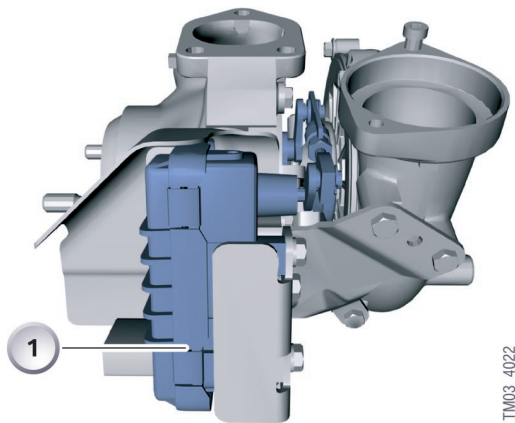
The electric throttle actuator motor consists of an electric motor and electronic circuitry with a Hall sensor. The electronic circuitry is responsible for the internal position control of the throttle valve. In this way, the throttle valve is set corresponding to the PWM signal. Position feedback to the DDE is not necessary thanks to the internal position control.

In the event of the throttle valve malfunctioning, the internal position control of the throttle valve connects the PWM signal to ground for 0.5 to 2 seconds (depending on the error message) and the DDE recognises a throttle valve fault. A total of four error messages are possible.

Exhaust turbocharger

As already known from the M67, the M57TU now also features an exhaust turbocharger with electrical adjustment of the guide vanes (blades). Compared to pneumatic adjustment, electrical adjustment of the guide vanes facilitates more exact control of the boost pressure.

Exact boost pressure control is necessary for complying with the exhaust emission standard EURO 4. The DDE uses a PWM signal to control the actuator motor. The position regulator and the diagnosis functions are integrated in the actuator motor (same as M67).



KT-12751

Fig. 11: Exhaust turbocharger with actuator (1)

In the event of a malfunction, the internal position control of the actuator motor connects the PWM signal to ground for 0.5 to 2 seconds (depending on the error message) and the DDE recognises a fault in the electric guide vane adjustment system.

- Diagnosis information

The soot particles, consisting of carbon (C), are burnt at a rate of 100% to produce CO₂ and CO. Nevertheless, approx. 0.6 g of ash remain in the DPF over every 1000 km. The ash collects in powder form in the rear third of the diesel particle filter. Consequently, after covering a distance of approx. 200,000 km, the backpressure slowly increases in the DPF and, as a result, the regeneration intervals become more and more frequent.

The remaining runtime of the DPF is calculated as part of condition-based services (CBS). The remaining time is calculated from the determined fuel consumption and the measured exhaust backpressure. The exact indication strategy has currently not yet been defined.

A corresponding entry is made in the fault code memory of the DDE as the filter generation frequency increases. Failure of signals from the exhaust gas temperature sensor and exhaust gas pressure sensor are also stored as fault codes in the DDE fault code memory.