

Diesel Engine Management

In contrast to the ECE version of the M57D30T2 engine, the US version of the engine electrical system features following differences:

- Engine control unit DDE7.3
- Preheating system with LIN-bus link and ceramic heater plugs
- Additional OBD sensors
- Electrically operated swirl flap and EGR valve
- Additional actuators and sensors for the low pressure EGR system.

Engine Control Module

The new DDE7.3 engine control module is used on the US version M57D30T2 engine. The DDE 7 version is used due to the fact that the DDE 6 engine control module was not sufficient to accommodate the addition of the SCR system as well as additional OBD functions.

DDE 7 will be used on future generations of diesel engines including the N57 which will be available sometime later.

Sensors and Actuators

In the M57D30T2 US engine, the modifications to the sensors and actuators are restricted to the air intake and exhaust system.

Several new components have been added to this system.

The table below provides an overview. It shows a comparison between the E70 US and E90 US and the ECE variant (EURO4).

Sensors	EURO 4	E70 US	E90 US
Outside temperature sensor	X	X	X
Ambient pressure sensor	X	X	X
HFM	X	X	X
Intake air temp sensor (in HFM)	X	X	X
Charge air temperature sensor	X	X	X
Boost pressure sensor	X	X	X
Exhaust pressure sensor at exhaust manifold (before DPF)	X	X	X
Oxygen sensor	X	X	X
Exhaust gas temperature sensor before diesel oxidation catalyst (DOC)	X	X	X
Exhaust gas temperature sensor before diesel particulate filter (DPF)	X	X	X
Exhaust backpressure sensor before diesel particulate filter (DPF)	X	-	-
Exhaust differential pressure sensor	-	X	X
Temperature sensor after LP-EGR cooler	-	X	-
Temperature sensor after HP-EGR cooler	-	X	X
Exhaust gas temperature sensor before SCR catalyst	-	X	X

Sensors	EURO 4	E70 US	E90 US
NO _x sensor before SCR catalyst	-	X	X
NO _x sensor after SCR catalyst	-	X	X
Positional feedback swirl flaps	-	X	X
Positional feedback HP-EGR valve	-	X	X
Positional feedback LP-EGR valve	-	X	-
Blow-by connection	-	X	X

Actuators	EURO 4	E70 US	E90 US
Compressor bypass valve	EUV	EUV	EUV
Turbine control valve	EPDW	EPDW	EPDW
Wastegate	EPDW	EPDW	EPDW
Throttle valve	EL	EL	EL
Swirl flaps	EUV	EL	EL
High pressure EGR valve	EPDW	EL	EL
Low pressure EGR valve	-	EPDW	-
Bypass valve for HP-EGR cooler	-	EUV	EUV
SCR metering valve		EL	EL

EL

Electrically actuated

EUV

Vacuum controlled via electric changeover valve (on/off)

EPDW

Vacuum controlled via electro-pneumatic pressure converter (PWM controlled)

OBD Monitored Functions

The engine management has the additional task of monitoring all exhaust-relevant systems to ensure they are functioning correctly. This task is known as On Board Diagnosis (OBD).

The malfunction indicator lamp (MIL) is activated if the onboard diagnosis registers a fault. The events specific to US diesel engines that cause the MIL to light up are described in the following.

Diesel Oxidation Catalyst

The oxidation catalytic converter is monitored with regard to its conversion ability which diminishes with aging. The conversion of hydrocarbons (HC) during cold start is used as the indicator as heat is produced as part of the chemical reaction and it follows a defined temperature progression after the oxidation catalytic converter.

The exhaust gas temperature sensor after the oxidation catalytic converter measures the temperature. The DDE maps the temperature progression during cold start and compares it to calculated models. The result determines how effective the oxidation catalytic converter is operating.

A reversible fault is stored if the temperature progression drops below a predetermined value. If this fault is still determined after two successive diesel particulate filter regeneration cycles, an irreversible fault is stored and the MIL is activated.

SCR Catalytic Converter

The effectiveness of the SCR catalytic converter is monitored by the two NO_x sensors. The nitrogen mass is measured before and after the SCR catalytic converter and a sum is formed over a defined period of time. The actual reduction is compared with a calculated value that is stored in the DDE.

The following conditions must be met for this purpose:

- NO_x sensors plausible
- Metering active
- Ambient temperature in defined range
- Ambient pressure in defined range
- Regeneration of diesel particulate filter not active
- SCR catalytic converter temperature in defined range (is calculated by means of exhaust temperature sensor before SCR catalytic converter)
- Flow of exhaust gas in defined range.

Monitoring involves four measuring cycles. A reversible fault is stored if the actual value is lower than the calculated value. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Long-term adaptation is implemented, where the metered quantity of urea-water solution is adapted, to ensure the effectiveness of the SCR catalytic converter over a long period of time. To execute this adaptation procedure, the signal of the NO_x sensor after the SCR catalytic converter is compared with a calculated value. If variations occur, the metered quantity is correspondingly adapted in the short term.

The adaptations are evaluated and a correction factor is applied to the metered quantity.

The operating range for the long-term adaptation is the same as that for effectiveness monitoring.

A reversible fault is stored if the correction factor exceeds a defined threshold. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Supplying Urea-water Solution

A supply of a urea-water solution is required to ensure efficient operation of the SCR catalytic converter.

Once the SCR catalytic converter has reached a certain temperature (calculated by the exhaust gas temperature sensor before the SCR catalytic converter), the metering control system attempts to build up pressure in the metering line.

For this purpose, the metering module must be closed and the delivery pump actuated at a certain speed for a defined period of time.

If the defined pressure threshold cannot be reached within a certain time, the metering module is opened in order to vent the metering line. This is followed by a new attempt to build up pressure.

A reversible fault is stored if a defined number of pressure build-up attempts remain unsuccessful. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

This monitoring takes place only once per driving cycle before metering begins. Continuous pressure monitoring begins after this monitoring run was successful.

A constant pressure of the urea-water solution (5 bar) is required for the selective catalytic reduction process. The actual pressure is measured by the pressure sensor in the delivery module and compared with a minimum and a maximum pressure threshold.

A reversible fault is stored if the limits are exceeded for a certain time. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

This monitoring run takes place while metering is active.

Level Measurement in Active Reservoir

A level sensor with three contacts at different heights is used for the active reservoir. The plausibility of the sensor is checked in the evaluator in that it checks whether the signals are logical.

For example, it is improbable that the "Full" contact is covered by the solution while the "Empty" contact is not. In this case, the evaluator sends a plausibility error to the DDE. This takes place at a pulse duty factor of 30% of the PWM signal. A reversible fault is set. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

This monitoring procedure only takes place if the temperature in the active reservoir is above a defined value.

If the line between the evaluator and at least one contact of the level sensor is interrupted, the fault is signalled to the DDE by a PWM signal with 40% pulse duty factor. A reversible fault is set.

If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Suitable Urea-water Solution

The SCR system is monitored with regard to refilling with an incorrect medium. This monitoring function starts when refilling is detected. Refilling detection is described in the section on the SCR system.

Effectiveness monitoring of the SCR catalytic converter is used for the purpose of determining whether an incorrect medium has been used. An incorrect medium is detected if the effectiveness drops below a certain value within a defined period of time after refilling.

A reversible fault is set in this case. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

In addition, the warning scenario with a remaining range of 200 mls is started.

NO_x Sensors

A dew point must be reached for effective operation and therefore also the monitoring of the NO_x sensor. This ensures that there is no longer any water in the exhaust system that could damage the NO_x sensors.

A reversible fault is set if the following monitoring functions detect a fault at the NO_x sensor. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

- Detection signal or correction factor incorrect
- Line break or short-circuit between measuring probe and control unit of NO_x sensor
- Measured value outside the defined range for a certain period of time
- Operating temperature is not reached after a defined heating time
- The distance from the measured value to zero is too great in overrun mode (no nitrogen oxides expected)
- During the transition from load to overrun mode, the signal of the NO_x sensor does not drop fast enough from 80% to 50% (only NO_x sensor before SCR catalytic converter)
- If, despite a peak in the signal of the NO_x sensor before the SCR catalytic converter, at least a defined change in the signal of the NO_x sensor after the SCR catalytic converter is not determined this is interpreted as implausible.

Exhaust Gas Recirculation (EGR)

During normal operation, the exhaust gas recirculation is controlled based on the EGR ratio. During regeneration of the diesel particulate filter, it is conventionally controlled based on the air mass.

The monitoring function also differs in this way: During normal operation a fault is detected when the EGR ratio is above or below defined limits for a certain period of time.

This applies to the air mass during regeneration of the diesel particulate filter. In order to monitor the high pressure EGR cooler, the temperature after the high pressure EGR cooler is measured with the bypass valve open and close with the engine running at idle speed. A fault is detected if the temperature difference is below a certain value.

For the low pressure EGR cooler (only E70), the measured temperature after the low pressure EGR cooler is compared with a calculate temperature for this position. A fault is detected if the difference exceeds a certain value.

Each of these faults is stored reversible. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Diesel Particulate Filter (DPF)

The diesel particulate filter is monitored by means of the differential pressure sensor. If the filter is defective, the differential pressure before and after the filter will be lower than for a new filter.

Monitoring starts when the flow of exhaust gas and the diesel particulate filter temperature exceed certain values. A fault is detected when the differential pressure drops below a defined threshold for a certain period of time.

Conversely, an overloaded/clogged diesel particulate filter is detected when the differential pressure exceeds a defined value for a certain period of time.

When regeneration of the diesel particulate filter is started, the time required until the exhaust temperature before the DPF reaches 250°C is measured. This time is set to zero if the engine runs for a longer period of time at idle speed or in overrun mode. A fault is detected if a defined time is exceeded before the temperature of 250°C is reached.

In this way, the response characteristics of the increase in exhaust temperature for DPF regeneration are monitored.

The system also monitors whether the exhaust gas temperature before the diesel particulate filter corresponds to the expected value after a defined period of time. If this is not the case although the control system has reached its limits, a fault is detected.

Also in this case, each of these faults is stored reversible. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.