

Diagnosis and Testing

General Equipment

Ford diagnostic equipment

Principles of Operation

European On-Board Diagnostics (EOBD)

EOBD is a diagnostic system integrated into the powertrain control module (PCM). This system continuously monitors vehicle emission components. The system includes a malfunction indicator lamp (MIL) which indicates when there is a concern that can affect emissions or the system malfunctions. Data stored within the module DTC memory can be accessed using a generic scan tool or WDS.

EOBD is mandated within European Union regulations from the year 2000 for passenger vehicles with petrol engines and from 2003 onwards for passenger vehicles with diesel engines.

EOBD Functions:

- Establishes when and how emissions control faults must be indicated.
- Actuates emission control malfunction indicator lamp (MIL) and fault memory.
- Indicates operating conditions in which the concern occurred (freeze frame data).
- Standardized output of operating data such as engine speed, engine coolant temperature etc.
- Standardized names and abbreviations for components and systems.
- Standardized DTCs for all manufacturers.
- Standardized communication with the diagnostic equipment.
- Standardized 16-pin data link connector (DLC) in area of the instrument panel.
- Concern display must be possible using a generic scan tool.

EOBD consists of the following elements:

Warm-up Cycle

The warm-up cycle is an operation that consists of key on, engine start and a coolant temperature increase of 22°C, exceeding 71°C on completion.

Drive Cycle

A drive cycle commences when the engine is started (cold or warm) and ends when the engine is switched off.

Trip

A trip begins when the engine is started and is complete when all the EOBD monitors have completed a self-test. This may take place over a number of drive cycles. On diesel variants, the information gathered from one drive cycle is not carried over to a subsequent cycle or cycles.

When a concern has been rectified, particularly after electronic engine control components have been changed, the DTC memory, which is part of the EEPROM must be cleared of all trouble codes. When the DTC memory has been cleared, the code P1000 (known as the readiness code) is set in the PCM memory, which indicates that since the EEPROM has been cleared, not all of the monitoring systems have completed their tests. P1000 can only be cleared by carrying out a trip, which includes driving the vehicle under variable conditions of speed, load and time so that all of the monitors are completed. As P1000 will not

illuminate the MIL it is not necessary to carry out the trip before returning the vehicle to the customer.

Freeze Frame Data

When a concern is detected, various data is stored depending on application including:

- Diagnostic trouble code.
- Vehicle speed.
- Engine coolant temperature.
- Engine speed.
- Engine load.
- Mixture formation trim value (trim value for engine wear) (All except vehicles with diesel engine).
- State of oxygen sensor control (open and closed loop) (All except vehicles with diesel engine).
- Distance covered since the concern was first registered.

Monitors

The purpose of the monitors is to continuously check the operation of the emission related sensors and actuators. It then establishes if they are operating within specified tolerances. All monitors carry out their functions in such a way as to be unnoticeable by the driver of the vehicle. Each one is carried out under specific conditions of load, speed and engine temperature. The Comprehensive Component Monitor, Combustion Misfire Monitor and Air/Fuel Ratio Monitor operate continuously. The remaining monitors are only invoked under certain operating conditions. On diesel variants, all of the monitors operate under normal driving conditions: There are no monitors which intervene and cause special operating modes to enable the monitors to work. Some diesel monitors are non-continuous. This means that in a drive cycle, monitoring is done as and when suitable driving conditions exist and potential faults are accumulated and compared with acceptance criteria. Examples of this type are the turbocharger boost pressure and exhaust gas recirculation (EGR) monitors on vehicles with common rail fuel injection.

Comprehensive Component Monitor (CCM)

When the CCM detects a component operating out of tolerance, it sets a Diagnostic Trouble Code (DTC), which is stored in the EEPROM. If the same concern is confirmed during the next trip the MIL will be switched on. The CCM monitors many components, sub-systems and signals. The following is a list of those that can effect emissions depending on application:

- Electronic Ignition (EI) System.
- Crankshaft Position (CKP) Sensor.
- Ignition Coil.
- Electronic Throttle Control Unit.
- Camshaft Position (CMP) Sensor.
- Air Conditioning (A/C) Clutch.
- Idle Air Control (IAC) Valve.
- Mass Air Flow (MAF) Sensor.
- Manifold Absolute Pressure (MAP) Sensor.
- Intake Air Temperature (IAT) Sensor.
- Engine Coolant Temperature (ECT) Sensor.
- Cylinder Head Temperature (CHT) Sensor.
- Heated Oxygen Sensor (HO2S).
- Catalyst Monitor Sensor.
- Charge Air Temperature Sensor.
- Knock Sensor (KS).
- Throttle Position (TP) Sensor.
- Vehicle Speed Sensor (VSS).
- Boost Pressure Sensor.
- Cam-Crank Phasing Sensor.
- EEPROM.
- High Pressure Fuel Injection Pump.

- Exhaust Gas Recirculation (EGR) Valve Monitor.
- Fuel Injectors.
- Turbocharger.
- Combustion Noise Monitor.
- Barometric Pressure (BARO) Sensor.

Combustion Misfire Monitor (All except vehicles with diesel engine)

The combustion misfire monitor operates independently of the others, and can detect misfires caused by the ignition system, fuel system or mechanical engine components. As each cylinder fires, a characteristic crankshaft acceleration is produced. The monitor detects irregularities in the acceleration pattern using the crankshaft position (CKP) sensor, thus detecting the misfire. It can also detect which cylinder has misfired. Combustion misfires can be categorized as follows:

Type A: These can cause catalytic converter damage due to excessive internal temperatures. If a certain number of misfires occur over a pre-determined number of engine revolutions, the MIL will be switched on to alert the driver of the concern.

Type B: These can lead to an increase in emissions to a point above the EOBD threshold. If the misfire is detected during a second trip, over a pre-determined number of engine revolutions, the MIL will be switched on. If the misfire does not occur over the next three trips, the MIL will be extinguished

Air/Fuel Ratio (AFR) Monitor (All except vehicles with diesel engine)

The HO₂S fitted before the catalytic converter (upstream) measures the oxygen content of the exhaust gas and the variations in it. This then enables the PCM to adjust the opening times of the fuel injectors to maintain the correct AFR. This is known as Short Term Fuel Trim (STFT). If the same variation is registered a pre-determined number of times, a permanent correction factor is applied. This is known as Long Term Fuel Trim (LTFT), which is stored in the EEPROM. When the correction factors exceed pre-determined limits a DTC will be set in the EEPROM. If a concern is detected in either the STFT or LTFT, and it is still present on a second trip, the MIL will be switched on.

Heated Oxygen Sensor (HO₂S) Monitor (All except vehicles with diesel engine)

This monitors the operation of the pre (upstream) and post (downstream) catalytic converter HO₂S sensors. It will detect deviations in air/fuel ratios (AFR) and sensor faults.

The HO₂S will cause emission increase when its response time increases too much. To diagnose a sensor a period is measured and the number of lean/rich transitions are counted. The sum of valid periods is then calculated. To avoid non-representative measurements, the period is valid only if the HO₂S has been below a low threshold and above a high threshold between 2 consecutive lean/rich transitions. A failure is declared when the sum of the measured periods exceeds the sum of the corresponding limit (held within the PCM) and the MIL is illuminated.

Catalytic Converter Efficiency Monitor (All except vehicles with diesel engine)

The efficiency of a catalytic converter is measured by its ability to store and later release oxygen to convert harmful gases. The efficiency is reduced if the converter becomes contaminated as it ages, and at high gas flow rates, because the exhaust gas does not remain in the converter long enough to complete the conversion process.

This monitor checks for the oxygen storage capacity (OSC) of the catalytic converter. During a controlled period, the catalyst monitor sensor signal is analyzed to evaluate the OSC of the catalyst. It represents the quantity of oxygen that is really used for the oxidation-reduction reaction by the catalytic converter. If a fault has occurred with the catalyst monitor sensor during the catalyst diagnosis, a sensor diagnosis is carried out. During the controlled diagnosis phase, the catalyst monitor sensor activity is measured and is compared to the OSC of the catalyst. If this activity is high (low OSC) the MIL will be illuminated. If throughout the controlled phase, repeated several times, the downstream sensor output has not moved, the closed loop mode is delayed in order to test the sensor. If the catalyst monitor sensor is set to rich, the injection time is forced to lean and

conversely if the downstream sensor is set to lean, the injection time is forced to rich until the sensor switches over or until the end of a delay. If this delay expires or the sensor does not switch, the sensor is treated as failed.

Combustion Noise Monitor (Vehicles with common rail fuel injection)

In diesel variants, the Combustion Noise Monitor is used to trim the fuel injection pulse lengths. Each fuel injector has an associated set of correction data that is determined during a production end of line test. The Combustion Noise Monitor is used to determine how the fuel injector characteristic changes from this initial calibration over the life of the fuel injector.

EGR Monitor (Vehicles with diesel engine)

The functionality of the EGR system is checked by comparing either the MAP sensor output or EGR valve lift potentiometer output (depending upon application) with expected values.

Diagnostic Requirements

Vehicles equipped with EOBD, can be diagnosed using the WDS. In order for the EOBD system to be invoked, a number of criteria must be met. After any repair, which could affect emissions, a trip must be carried out on the vehicle, to make sure that engine management system operates correctly.

Malfunction Indicator Lamp (MIL)

The MIL is located in the instrument cluster and is fitted to alert the driver to the fact that an abnormal condition has developed in the engine management system, that is having an adverse effect on emissions. In cases of misfires which are likely to cause catalytic converter damage, it is switched on immediately. With all other faults it will illuminate continuously from the second trip after the condition occurred. Under normal operation it should illuminate at key-on and go out almost as soon as the engine is started.

Diagnostic Trouble Codes (DTCs)

The DTCs given by the PCM are standardized, which means that generic scan tools can read results from all vehicles.

- The DTC is always a 5 digit alphanumeric code, for example "P0100".
- The first digit of a code (letter) identifies the system which has set the code. Provision has been made for a total of four systems to be identified although only the 'P' code is required for EOBD.
 - 'B' for the body
 - 'C' for the chassis
 - 'P' for the powertrain
 - 'U' for the network communications systems
- All of the "x0xxx" codes are standardized codes. However, any manufacturer can use additional codes over and above the standardized codes. These will be labelled "x1xxx"
- The third digit of a code (numeric) identifies the sub-system which has set the code.
 - 'Px1xx' for metering of fuel and air supply
 - 'Px2xx' for metering of fuel and air supply
 - 'Px3xx' for ignition system – combustion misfires
 - 'Px4xx' for auxiliary emission control equipment
 - 'Px5xx' for vehicle speed, idle setting and other related inputs
 - 'Px6xx' for trip computer and other related outputs
 - 'Px7xx' for transmission.
 - 'Px8xx' for transmission.
 - 'Px9xx' category to be determined
 - 'Px0xx' category to be determined
- When a concern occurs, the actions taken include storage of the relevant information and actuation of the MIL occurs in line with the relevant legislation.

Inspection and Verification

1. Verify the customer concern by operating the system.

2. Visually inspect for obvious signs of mechanical or electrical damage.

VISUAL INSPECTION CHART

Mechanical	Electrical
• Sensors • Actuators	• Fuse(s) • Wiring harness • Electrical connector(s) • Powertrain control module (PCM)

3. If an obvious cause for an observed or reported concern is found, correct the cause (if possible) before proceeding to the next step.
4. If the cause is not visually evident, verify the symptom and refer to the [Ford diagnostic equipment](#) to diagnose the system.

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