Basic proceeding of diagnosis and strategy of decision on OBD II system

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One of the methods to reduce emission of toxic components is continuous control over engine elements that are directly or indirectly responsible for level of emission of these components. Introduction of these requirements caused creation of on board diagnostic definition and utilizing innovation definition self-diagnostic.

Self-diagnostic is to minimise the volume of substances generated by the combustion engines polluting the natural environment.

The first rules of on board diagnostic were published in 1981. The standard had been improved in the next years, until the condition of today and also in the future, which result is presently used OBD II (*On Board Diagnostic II*) system, and in the close future - OBD III.

Basic concept of on board diagnostic is a diagnostic monitor. For example: The OBD II regulation requires two type o misfire detection. The first requirement is for the detection of misfire before it is frequent enough to cause a vehicle's emission to exceed 1,5 times the standard, or before the misfire rate is high enough to cause a vehicle to fail an I/M test. Monitor is a test run by the PCM (*Power train Control Module*) on components and subsystem to see if they are working properly.

Keywords/ emission, monitor, fault, diagnostic, sensor, engine.

1. INTRODUCE

During the '70s and early '80s manufactures started using electronic means to control engine functions and diagnose engine problems. This was primarily to meet EPA emission standards. Trough the years On Board Diagnostic systems have become more sophisticated. OBD II, a standard introduce in the mind –'90s, provides comprehensive monitoring of engine and emission systems [1, 2, 3, 5, 6, 12].

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2. MORE IMPORTANT PROBLEMS CONNECTED WITH ON BOARD DIAGNOSTIC

OBD II has more ability than the ever before to know what is going on inside an engine. The main reason is the increased emission output when something goes astray, but more important to protect catalytic converter from being damaged by excessive hydrocarbon or carbon monoxide. Due to this, new area are monitored, including catalytic converter conversion efficiency and crankshaft speed to determine engine misfires.

To understand OBD II logic, we will first start with a few basic terms [4] (for example):

- *freeze frame* – stores vehicles information at the moment an emissions system test that will have an affect on emission (fig. 1), if EOBD (*European On Board Diagnostic*) detects a failure , the following data must be saved in a freeze frame [12]:
  - calculated load,
  - engine speed,
  - fuel/air regulation Fuel Trim (if available),
  - fuel pressure (if available),
  - intakemanifoldpressure (if available),
  - vehicle speed,
  - engine coolant temperature,
  - fuel control system status - open-loap, close-loap (if available),
  - the failure code,

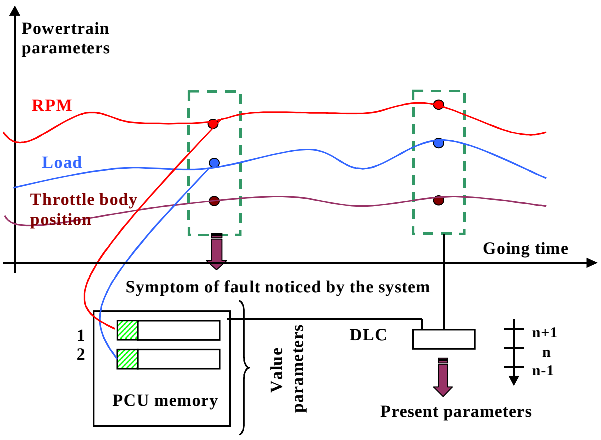

Fig. 1 Definition of „freeze frame" and present parameters [11]

- *OBD II drive cycle* – it is purpose is to run all of the on board diagnostic so that I/M (*Inspection and Maintenace*) read flags will set,
- *misfire monitor* – regulations require misfire monitoring under cruise, acceleration idle conditions. The diagnostic must determine whither there is single or multiple cylinder misfire, then identify the offenders. One of the major obstacles to program and identify misfire software is the effect of rough roads on misfire detection [4, 10].

OBD II/EOBD system should be controlled:

- defective catalyst,
- defective lambda sensor,
- engine misfire,
- defective fuel/air regulation,
- failure in a component, that will cause increased emissions, above the limits.

3. METHODS OF COMMUNICATION WITH ODB II/EOBD SYSTEM

3.1 Malfunction indicator light

The OBD II system is particularly aimed at toxic substance emission and its major task is a continuous supervision over the level of toxic substance emission from the following systems: exhaust and fuel supply. Critical emission elements are placed under such supervision, as well elements whose faults can indirectly increase toxic substance emission through effecting the central computer system with its ins and out. A detection of any fault is signal to the driver with the light signal MIL and registered in the memory of the central entity in the form of standard fault code and other helpful data.

If the combustion gases quality is deteriorating, then the combustion gases warning lamp after fulfilling each time the record and switching on conditions, must immediately signal with continuous light two driving cycles (fig.2).

Example: misfiring – system checks in every drive conditions if:

- the number of unsuccessful ignitions is so high, that it may cause damage of the catalyst,
- the number of unsuccessful ignitions causes 1,5 times increase of emitted combustion gases limited by the standard.

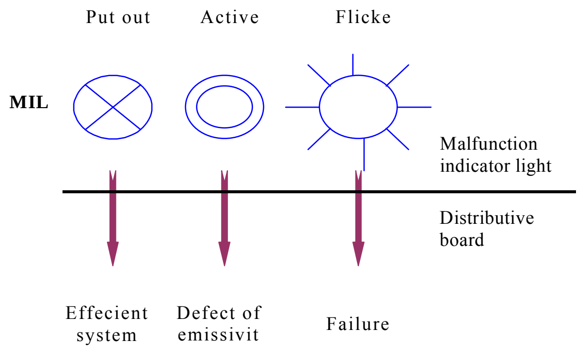

Fig. 2 Diagnostic information from OBD II/EOBD system

If the fault is recorded in the controller memory the diagnostic devices can read it out. In case of strategy that requires more than two initial driving cycles to activate MIL, the manufacturer must provide the data or calculations, from which will clearly result, that the monitoring system is effective in these conditions as well, and accurate in elements faults finding. MIL must clearly indicate, for example by flashing light, that engine is misfiring that may cause catalyst damage to the degree defined by the producer. MIL indicator must be activated when the key of ignition switch is in "key on” position before starting the engine and after engine starting, if no abnormality was detected before.

3.2 Structure of diagnostic trouble code

Any damage of the controlled system results in a signal being sent to the central steering entity where the data will be read and analysed, then the steering entity will decide what shall be done further. This means that the steering entity is equipped with the fault analysing algorithm of for example: the operation of the catalytic converter in the present time and the signalling light of the OBD II system informing of a fault can light up during the ride. The main goal of such system operation is informing the driver of an increased emission of toxic substances by his vehicle. The functioning of the signalling light of the OBD II system is different in new cars than in the old models (fig. 3).

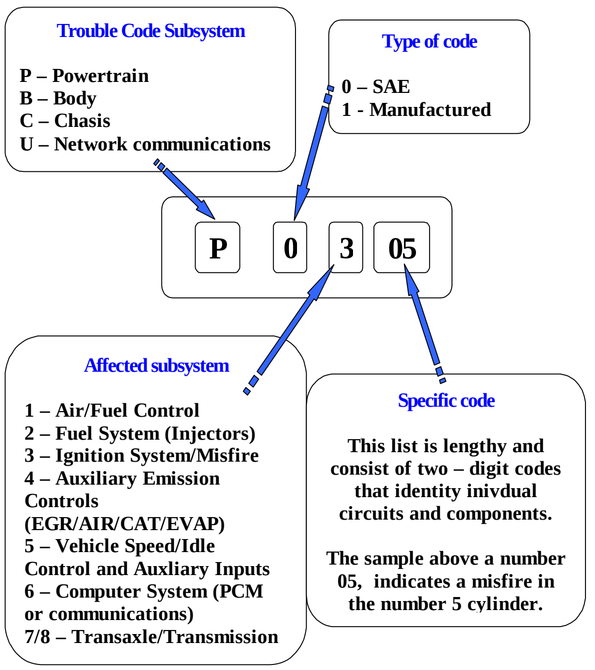

Fig. 3 Anatomy of DTC

OBD system should record the codes starting from the codes of emission control system condition until the codes of Air Bag and ABS systems. There must be separate codes for correct defining operation of emission control systems and operation of those emission control systems which full evaluation may be performed only during vehicle operation. Trouble codes activating MIL because of damage or excessive emission must be recorded and the trouble code must identify the type of faulty operation. Information about the cruise done by the vehicle from the moment of MIL activation must be accessible any moment through the serial port in standard connector.

There are two categories of DTC that apply to OBD II [9, 14]:

Type A:

- emission related,
- request illumination of the MIL after one failed driving cycle,
- stores a freeze frame DTC after one failed driving cycle.

Type B:

- emission related,
- sets a Pending Trouble Code after one failed driving cycle,
- clears a Pending Trouble Code after one successful driving cycles,
- turns on the MIL after two consecutive failed driving cycles,
- stores a freeze frame after two consecutive failed driving cycles.

Trouble codes – DTC are defined by SAE standard and must be uniformly used by all manufacturers, they are made up of five alphanumeric characters – one literal symbol and four digital symbols, for example P0305.

Trouble code and also information about the cruise and so called “freeze frame” may be removed from the OBD system, if the same trouble is no more recorded during completion of at least 40 engine heating cycles.

3.3 Data link connector

All cars and light trucks built and sold in United Europe after January 1, 2000, were required be OBD II equipped.

Standard DIN ISO 9141 – 2 include:

- diagnostic link connector - DLC and location places (fig. 4) [9, 13],
- description Generic Scan Tools – GST,
- definition of Diagnostic Trouble Code - DTC.

The OBD II law requires a standardized connector in every car and light truck. Additionally, the law requires that the vehicle support least one of four protocols: J1850 VPW, J1850 PWM, ISO 9141-2 and Keyword 2000.

Diagnosis by the device enables:

- readout and erasing of fault memory,
- pointing the data related to fault finding,
- diagnosis data printout.

The legislator has determined that the manufacturer should prepare the diagnostic system in a way that enables any OBD – Generic – Scan Tool to read the data.

The following signals are available through the diagnosis connector:

- diagnose-failure codes,

- engine coolant temperature,
- fuel control system status (close loop, open loop),
- fuel trim,
- ignition timing advance,
- air flow rate,
- engine speed,
- throttle position speed,
- secondary air status (upstream, downstream or atmosphere),
- calculated load value,
- vehicle speed,
- fuel pressure.

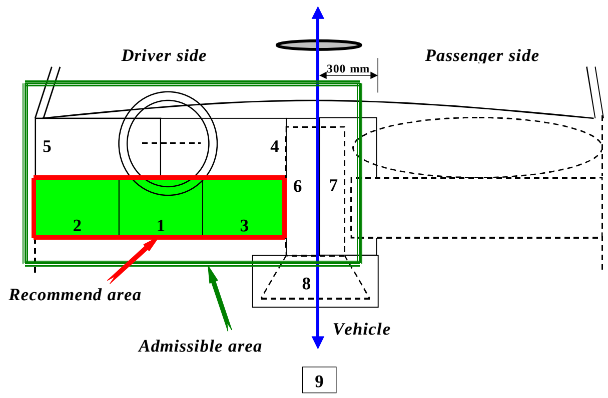

Fig. 4 Location places of DLC in vehicle

4. RESULTS OF TESTED VEHICLES IN POLAND

Stored fault functions may be read out by the monitoring devices Scan – Tool type, which is connected by diagnostic connector.

We taken advantage of polish diagnostic scanner made in Poland by one of polish company - AUTOMEX S.A:

- **AMX 530** - a hardware interface allowing the user to access data from the OBD II/EOBD diagnostic network with the help of an IBM PC and Windows 98/2000/ME/NT software. With a portable computer, it is possible to perform diagnostic tests while the vehicle is moving. The program is provided with enhanced utility functions and a built-in database containing descriptions of malfunctions and faults typical of various individual manufactures. The presentation of data collected during the vehicle testing can be viewed in graphic form. There are also three supported languages to choose from: Polish, English, and German. (fig.5),
- **AMX 550** - a hardware OBD enhanced scan tool contained in a hand-held case with a graphic display panel and a built-in trouble codes reading device. Apart from performing diagnostic functions conforming to SAE standards, it also enables monitoring parameters during driving. The tool performs superbly in comprehensive testing of vehicles in detecting faults and malfunctions and validating the conducted repairs. The results of the OBD diagnostic procedures can be presented in graphic form. The tool is self-supported, which means that in order to take advantage of its functional capabilities it is not necessary to use a PC. There are also three supported languages to choose from: Polish, English, and German.

Devices automatically identify with one of four classes of data communication bus in automotive vehicles and automatically enter into transmission.

Those devices was tested during diagnosis American vehicles made between 1996 and 1999 and new cars produced in Europe and Asia.

Those devices achieved the gold medal on Poznań International Fair in Poland in AutoMotoShow 2001.
We tested 50 vehicles with spark ignition engines and diesel engines, which we can buy on polish market. Diagnostic link connector was located in different places in cockpit of vehicles (table 1). Tested vehicles characterize be different level of functionality ODB II/EOBD system (table 2). Level of diagnostic procedure and installed sensors illustrate on fig. 6 ÷9.

Fig. 5 Notebook connected to DTC

Table. 1 Locate of DLC in example tested vehicle; 1,2… – recall to fig.12

Model	Placement	Remarks
Alfa Romeo 156 1,9 JTD	2 - cover	
Citroen C5 2.0i 16V	2 - cover	Coin cover pulled down

Fiat Punto	2 – cover	Fuse cover
Ford Mondeo	1 – open	At pedals
Hyundai Sonata V6	3 - open	Towards pedals
Opel Corsa 1.2 16V	8 - cover	In front of gearshift
Peugoet 206 2.0 HDI	2 – cover	Coin to remove cover
Rover 25 & 45	6 - open	Towards pedals
Seat Leon	8 - cover	Botttom af shelf
Toyota Yaris 1.5 sport	2 - open	
Seat Ibiza 1,4	1 - cover	Behind shelf
VW Golf	8 - cover	Behind cover above ashtray

Table 2 Specification of sensors in example tested vehicles

1	2	3	4	5	6	7	8	No	
Nissan Primera	Daewoo Tacuma	Fiat Seicento 2000	Renault Megane Coupe 2.0 IDE	Volvo S80 2.4 L 2001	Ford Focus 1.4 2001	Fiat Stilo 1.2 16V 77 kW	Opel Astra II - Diesel	**Model of vehicle**	
1	1	1	1	1		1		T-colling	**Sensors**
1	1	1	1	1		1		Kor kr. B 1/2	
1	1	1	1	1		1		Kor B ½	
0	0	0	0	0		0		P-fuel	
0	1	1	1	0		1		P-charge	
1	1	1	1	1		1		n-engine	
1	1	1	1	1		1		V-vehicle	
1	1	1	1	1		1		α-wz	
1	1	1	1	1		1		T-air	
1	0	0	0	1		0		G-air	
1	1	1	1	1		1		α-wz	
1	1	1	1	0		1		O_2B2	
1	1	1	1	1		1		O_2B2	
0	0	0	0	1		1		Test O_2	

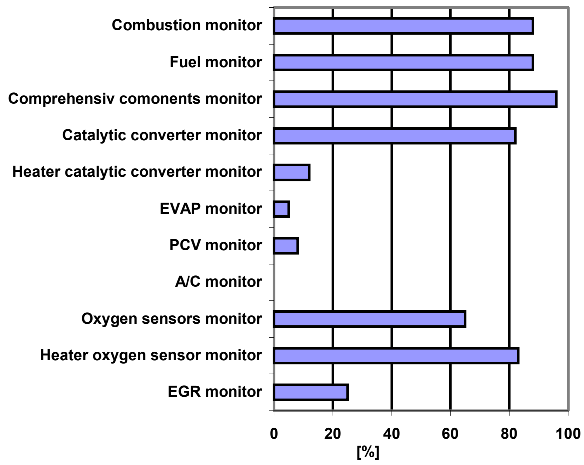

Fig. 6 Participation percentage of diagnostic procedure in tested vehicles with spark ignition engine

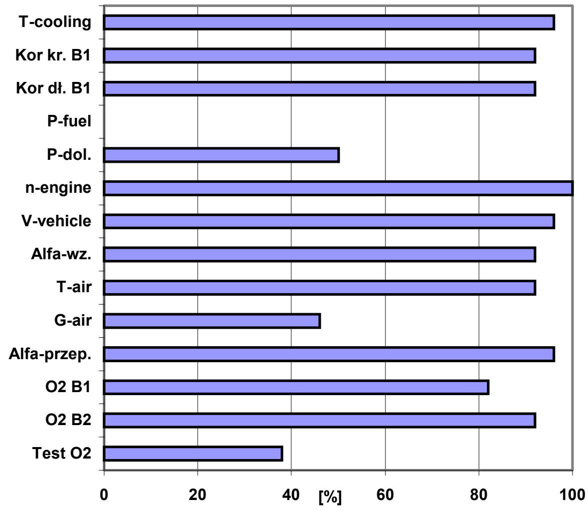

Fig. 7 Participation percentage of sensors in tested vehicles with spark ignition engine

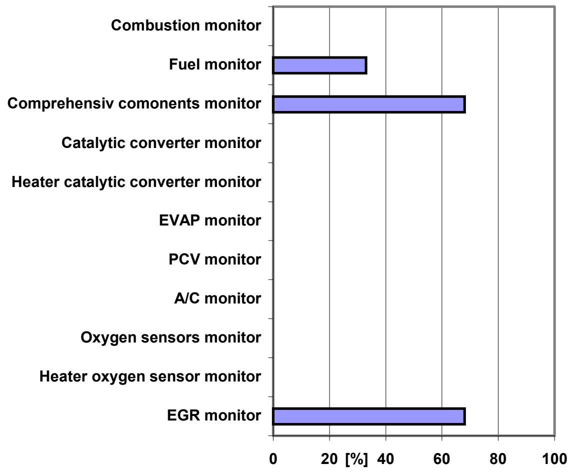

Fig. 8 Participation percentage of diagnostic procedure in tested vehicles with diesel engine

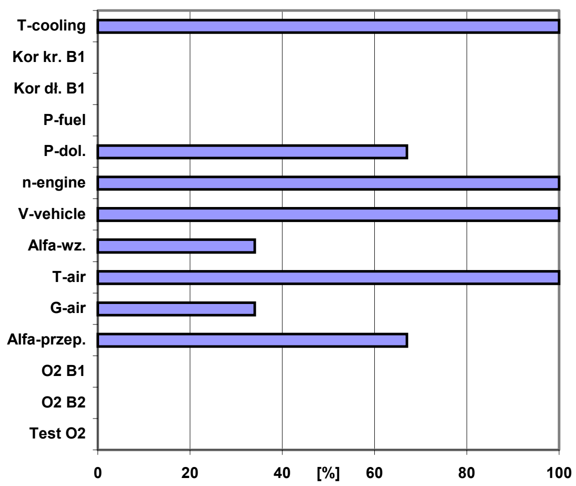

Fig. 9 Participation percentage of sensors in tested vehicles with diesel engine

5. RESUME

Future demands with reference to EOBD system in all vehicles:

- electronic control to concern limit emission of toxic components in exhaust gases,
- monitoring of period using cars after appearance failure,
- individually diagnosis of converter catalytic in all vehicles,
- introducing standard diagnostic code, protocols, diagnostic tools in all vehicles,
- making available to inform all services by producer,
- introduction of demands with reference to OBM (On Board Measurement) system.

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REFERENCES

[1] Auto Moto Serwis: „*Standard in on board diagnostic*”, No 2/97, page 15.

[2] AVL C & I: “*Current and Future Exhaust Emission Legislation”*. AVL List GmbH, Graz 10. 2000.

[3] Birnbaum R., Truglia J.: „*Getting to Know OBD II”*,. Manufactured in United States, 2001.

[4] Bochacz Ray T.: „*The workings of OBD II and it’s effect on modifications*” – www.dakota-truck.net.

[5] Caraceni A., Cioffi V., Garofalo F., Senatore A., Vittorioso G., Barberio C., Sargolia G.: „*Emission Control Technologies for EU Stage IV + EOBD on Small Cars (Part I)”:* Pre-screening of Potential Solutions. SAE Paper 1999-01-0775.

[6] Caraceni A., Cioffi V., Garofalo F., Senatore A., Vittorioso G., Barberio C., Sargolia G.: „*Emission Control Technologies for EU Stage IV + EOBD on Small Cars (Part II*): Pre-screening of Potential Solutions. SAE Paper 1999-00-1332.

[7] Directive 98/69/EC of the European Parliament and of the Council.

[8] Code of defect, „*Auto handbook”*, Wydawnictwo AUTO, Warszawa 1999.

[9] Mazurek S., Merkisz J.: „*Automotive vehicles on-board diagnostic systems – basic objectives and requirements of norm OBD II”*, Journal of Kones, Inernal Combustion Engines, 1999 Zakopane, Poland, pages: 186 – 207.

[10] Merkisz J., Rychter M.: „*OBD II system as a future methods diagnostic of vehicles*”, Maintenance and Realiability, No 1(13)/2002, pages: 38 – 51.

[11] Merkisz J.: „*On board diagnostic system OBD II/EOBD as a assessement tool of technical condition vehicles*” Diagnostyka a BRG, 25.05.2001 Poznań, Poland, pages: 37-57.

[12] Service materials: *„On-Board Diagnosis System II in VW New Beetle (USA)”*, Design and function.

ABBREVIATIONS

DLC	Diagnostic Link Connector
DTC	Diagnostic Trouble Code
EGR	Exhaust Gas Recirculation
EOBD	European On-Board Diagnostic
EPA	Environment Protection Agency
EVAP	Evaporation Prevention
MIL	Malfunction Indicator Light
OBD II	On-Board Diagnostic II
OBM	On Board Measurement
PCM	Power train Control Module