ON BOARD DIAGNOSTICS (OBD) RESEARCH IN CONDITIONS OF CHASSIS DYNAMOMETER AND ROAD TESTS

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Abstract

Subject matter of the paper is test results on the chassis dynamometer and road test results in reference to the on-board (OBD) system diagnostics of car vehicles. Test results of vehicles on the chassis dynamometer in temperatures of +22ºC and two sub-zero –7ºC and –12ºC, and also test results of road in reference to chosen car vehicles are presented in the paper. The ineffective work of the system in temperatures below –7ºC was observed. Test results on the chassis dynamometer with test results of road ones are compared. The time $t_{0.9}$ as the measure of the efficiency of the work of the OBD system is proposed. One gave the proposal of certification of approval research in reference to OBD systems. The paper presents in particular: road emissions of a car during the NEDC (UDC + EUDC) European drive cycle, road emissions of a car during the NEDC (UDC + EUDC) European drive cycle in low temperature chamber (–7ºC) in comparison to emissions in temperature –12ºC, road emissions of a car during the European drive cycle in comparison to emissions at oxygen sensor disconnected before catalytic reactor, vehicle speed recorded in road traffic, comparison idea of road cycle piece with pattern cycle similar from point of view speed course, covering coefficients of recorded time for drive cycles, relations between parameters influencing on OBD system reaction time for defect appearing.

Keywords: *transport, vehicle, chassis dynamometer, road researches, OBD, exhaust emissions*

1. Introduction

In the last term activity and degree advancing operation of the system on-board diagnostics OBD systematically goes up. At the time of carried on researches damages identified registered codes of damages were observed. These damages concerned mainly executive elements which essentially their own function in the system undergoes to the fastest work off. Besides, the exceptional practical utility on-board diagnostic systems at the location of damages and verifications rightness executed repairs and identifications of the vehicle were observed. Investigations of vehicles operated in Poland at an angle of the implementation of a system OBD, carried out on several hundred vehicles showed that makers of vehicles equipped it into transmission system of data Keyword 2000 (49% all examined vehicles) or ISO (35% vehicles) and in the not large only degree into transmission systems VPW and PWM (respectively7% and 9%). Most frequent are monitors of oxygen concentration sensors, the catalytic reactor, system elements, fuel system and combustion. Least frequent are monitors air condition, system ventilating of the crank case and system of the ventilation fuel tank. The number of sensors installed in vehicles is significant: in 97% investigated vehicles there appeared: the position sensor of the throttle, the air consumption, the air temperature and coolant liquid, speed of the vehicle and the rotational speed of the engine. Characteristic is the lack of the sensor of the pressure of the fuel.

2. Researches on chassis dynamometer and on road-

Researches were carried out on chassis test bench in 3 ambient temperatures (22ºC, -7ºC and -12ºC). The influence of ambient temperatures on the work of diagnostic monitors investigated. Test results indicate that the system EOBD almost to end of the third phase of the UDC cycle supervises no investigated elements of emissive risk of vehicle in the ambient temperature -12ºC in which the car was conditioning. Only in the outside urban cycle EUDC it appears. According to the regulations ECG UNO 83.05 maker of the vehicle can cause becoming active EOBD the system in temperatures below -7ºC in which the car was conditioning before the engine starting. Fig. 1 presents of example realization the monitor of the NEDC the test at temperature of 22ºC. Fig. 2 presents realization the monitor of the NEDC the test at temperature of -12ºC

Fig. 3 and 4 presents obtained data concerning of the pollutant emission: CO, HC and NO_x. Fig. 5 indicates that the road-emission of CO, HC and NO_x in the all UDC cycle in temperatures -7ºC and -12ºC is higher respectively 39 times CO, 34 times HC and 6 times NO_x than the emission of these substances in the temperature accomplishing of the test +22ºC for investigated vehicle. Only in first 195s phase of the UDC urban cycle of the NEDC test it is emitted at an average approx. 90% CO and 80% HC full emission of these substances in the test.

In sub-zero environment temperatures, biggest influence of temperature on the emission in which the car was conditioned before the engine starting appears in the first phase of the cycle UDC. The emission CO and HC in this phase it is for the temperature of 7şC higher, respectively from 11 to 16.5 times and from 3 to 7 times and for the temperature of 15ºC, respectively from 14 to 17 times and 4 to 7.5 times than for the temperature +22ºC. The efficiency of the operation of the system EOBD investigated object appears within the range ambient temperatures from -7ºC to 22ºC.

The ineffective operation of the OBD system it was observed in temperatures realisation of the test below -7ºC, what is not accordable with operative regulations in this range.

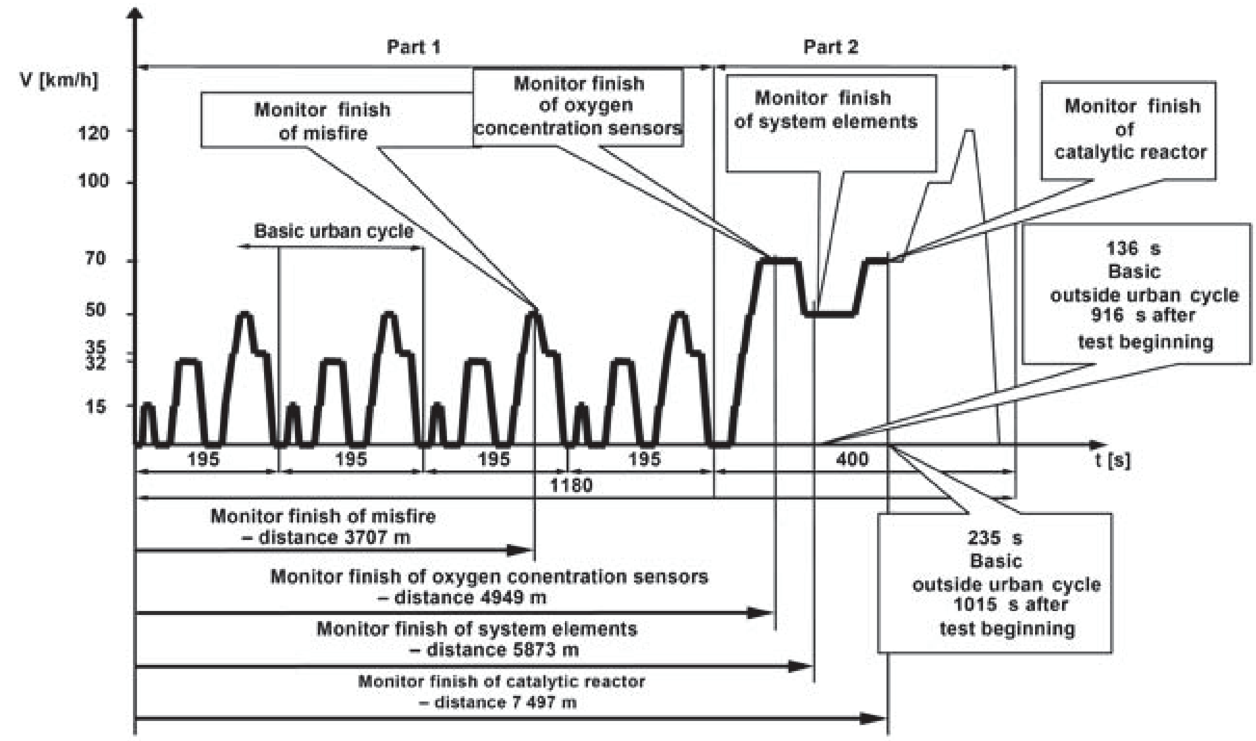

Fig. 1. Monitor realization of the NEDC test in temperature +22ºC

Fig. 9 and Tab. 1 presents distribution of coefficients for the registered realization of the FTP cycle for six road-registrations, cover at several different lengths and values of the error.

Fig. 9 presents covering coefficients of recorded time for drive cycles. Fig. 9 presents: 1- similar fragments in length 10 s and the margin of error ±1 km/h, 2 - similar fragments in length 15 s and the margin of error ±1 km/h, 3 - similar fragments in length 15 s and the margin of error ±2 km/h, 4 - similar fragments in length 20 s and the margin of error ±2 km/h, 5 - similar fragments in length 25 s and the margin of error ±2 km/h, 6 - similar fragments in length 30 s and the margin of error ±2 km/h.

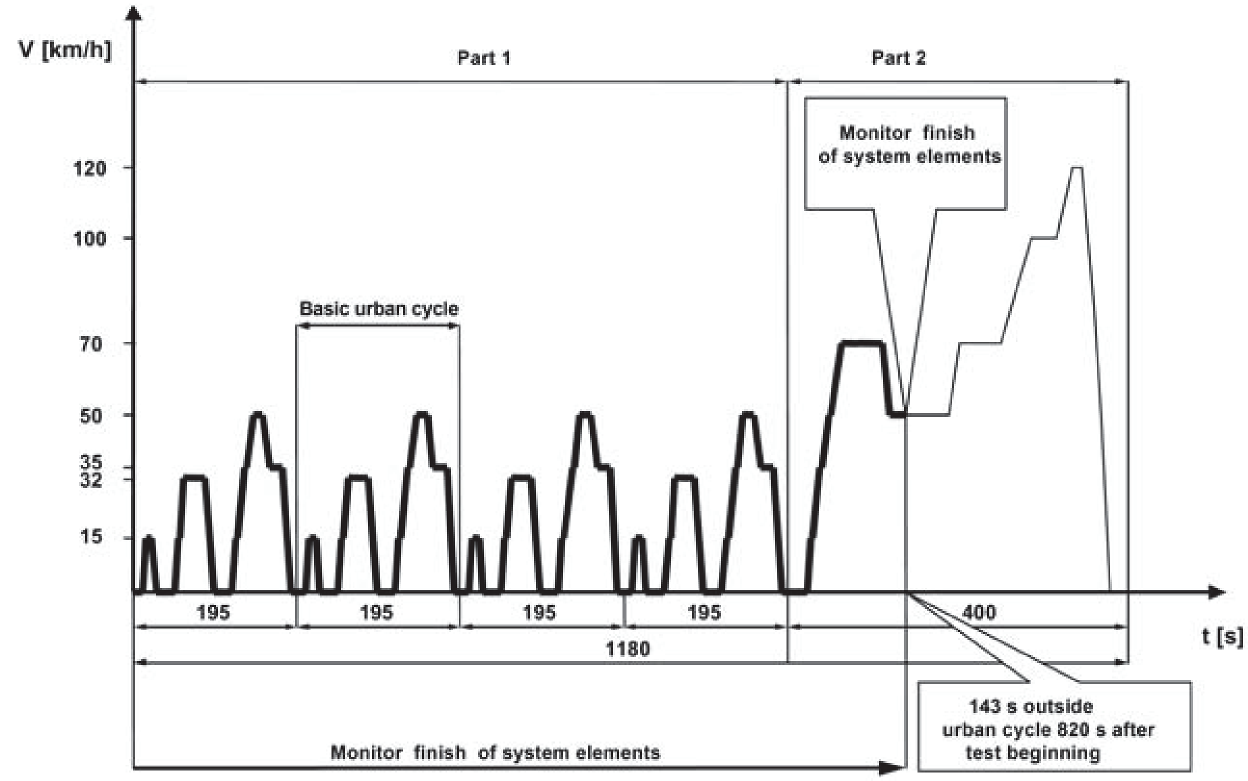

Fig. 2. Monitor realization of the NEDC test in temperature –12ºC

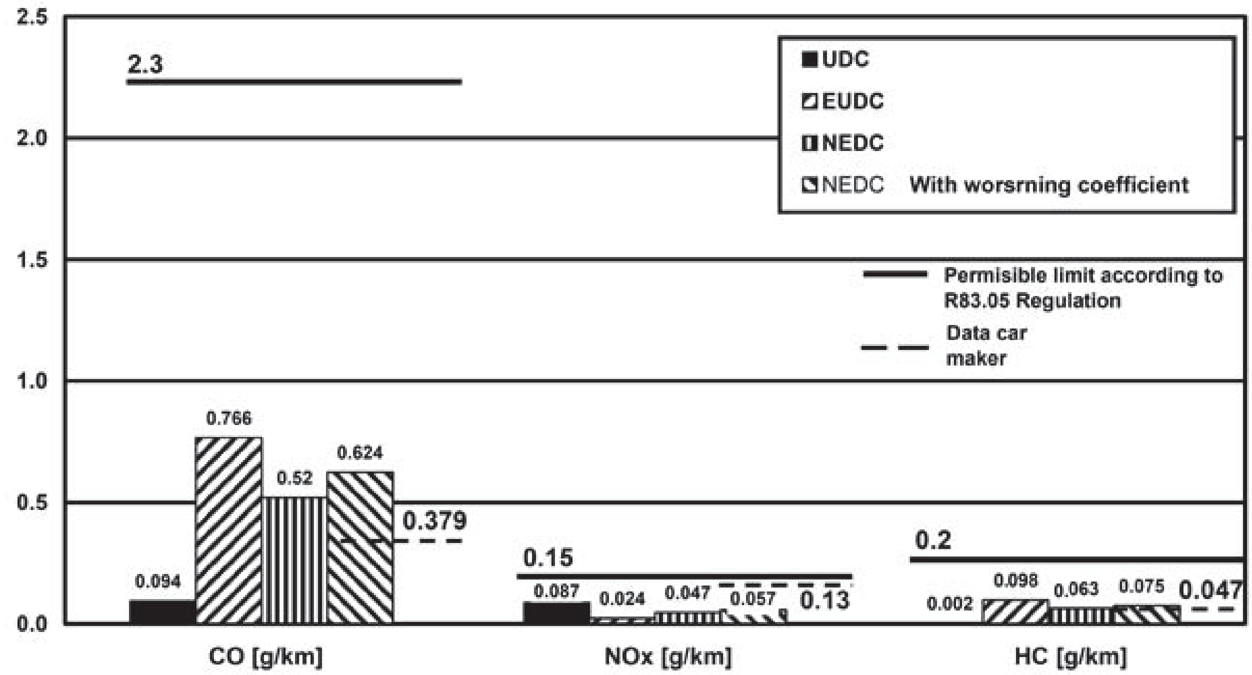

Fig. 3. Road emissions of a car during the NEDC (UDC + EUDC) European drive cycle

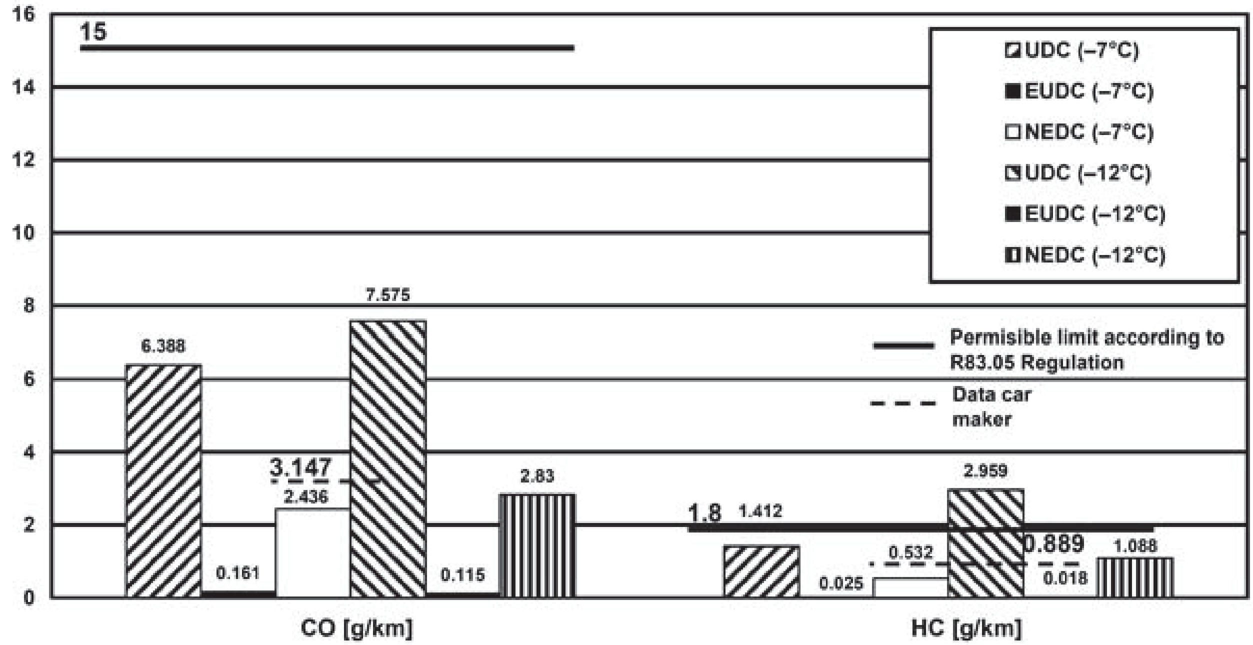

Fig.4. Road emissions of a car during the NEDC (UDC + EUDC) European drive cycle in low temperature chamber (–7ºC) in comparison to emissions in temperature –12ºC

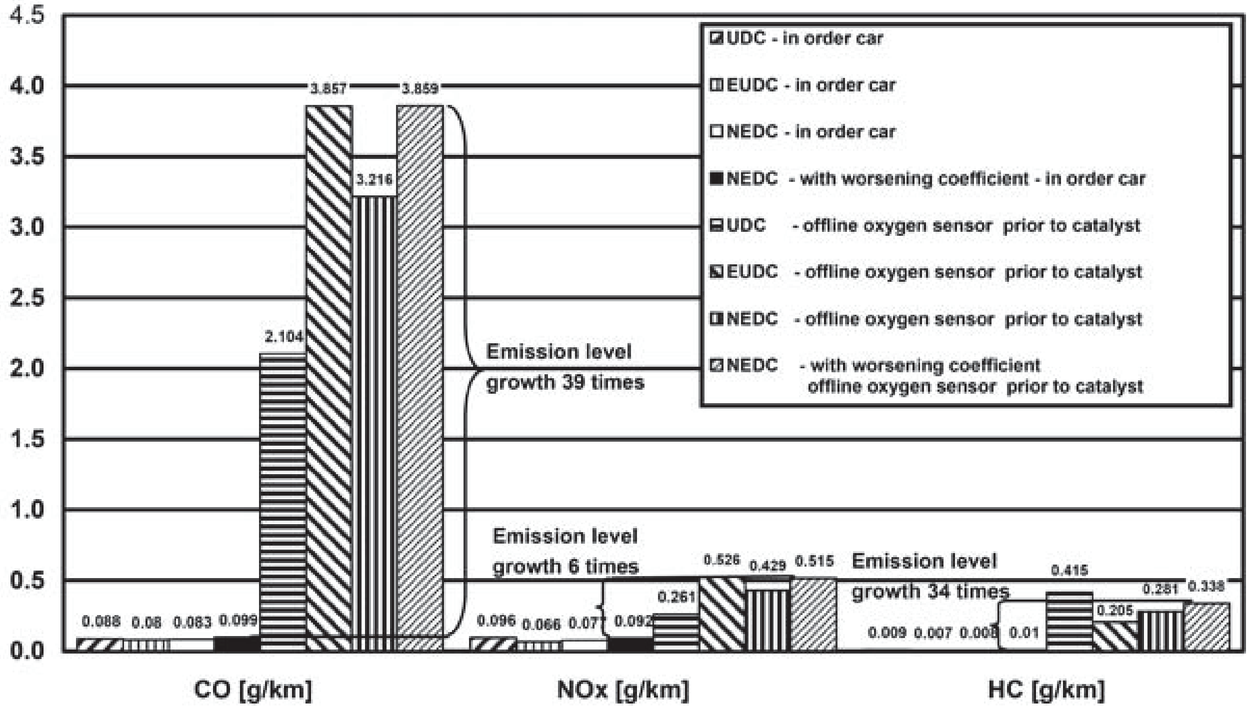

Fig. 5 Road emissions of a car during the European drive cycle in comparison to emissions at oxygen sensor disconnected before catalytic reactor

Fig. 6 represents courses speeds registered on the run of road which was used to comparative aims. Obtained results were set against standard course of the FTP speed of the driving cycle. Fig. 7 presents comparison idea of road cycle piece with pattern cycle similar from point of view speed course.

The comparison of results obtained for the registration of the FTP cycle, realized under conditions of chassis dynamometer and for the registration conditioned the real road traffic, admits of the statement that the accepted method data treatment gives reliable results. In the situation in which the coefficient of the cover for the realization of the FTP cycle carries out over 45%, for

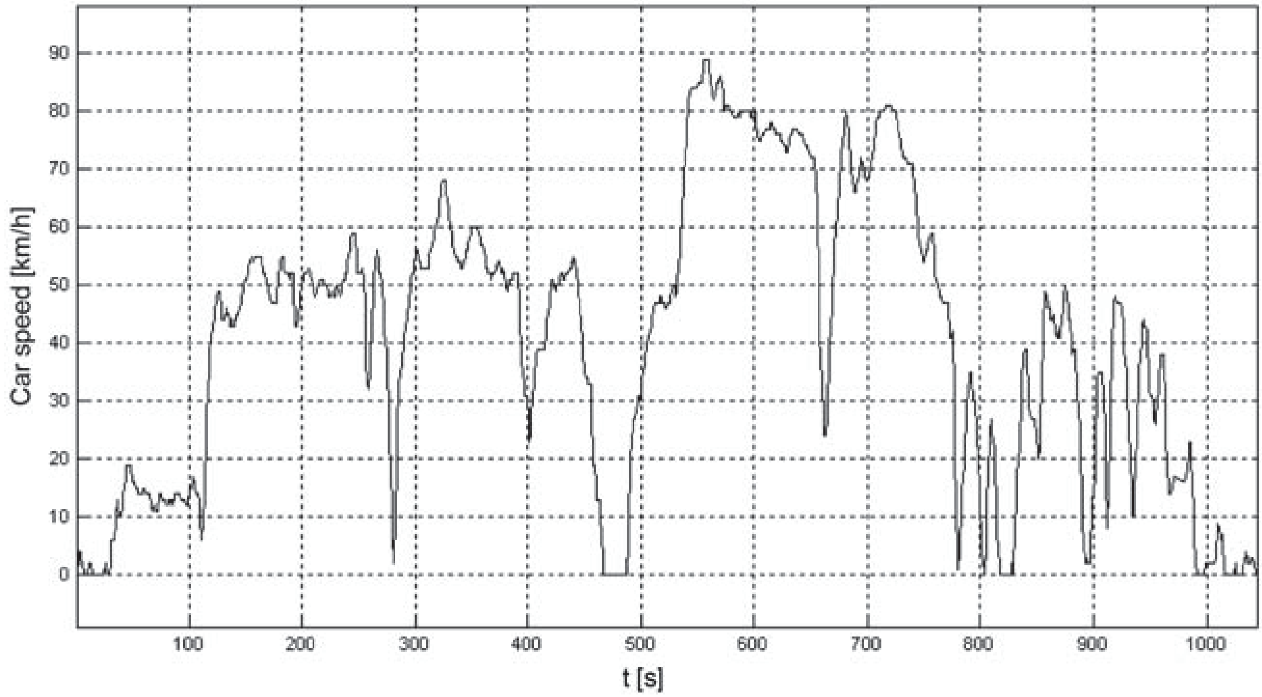

Fig. 6. Vehicle speed recorded in road traffic

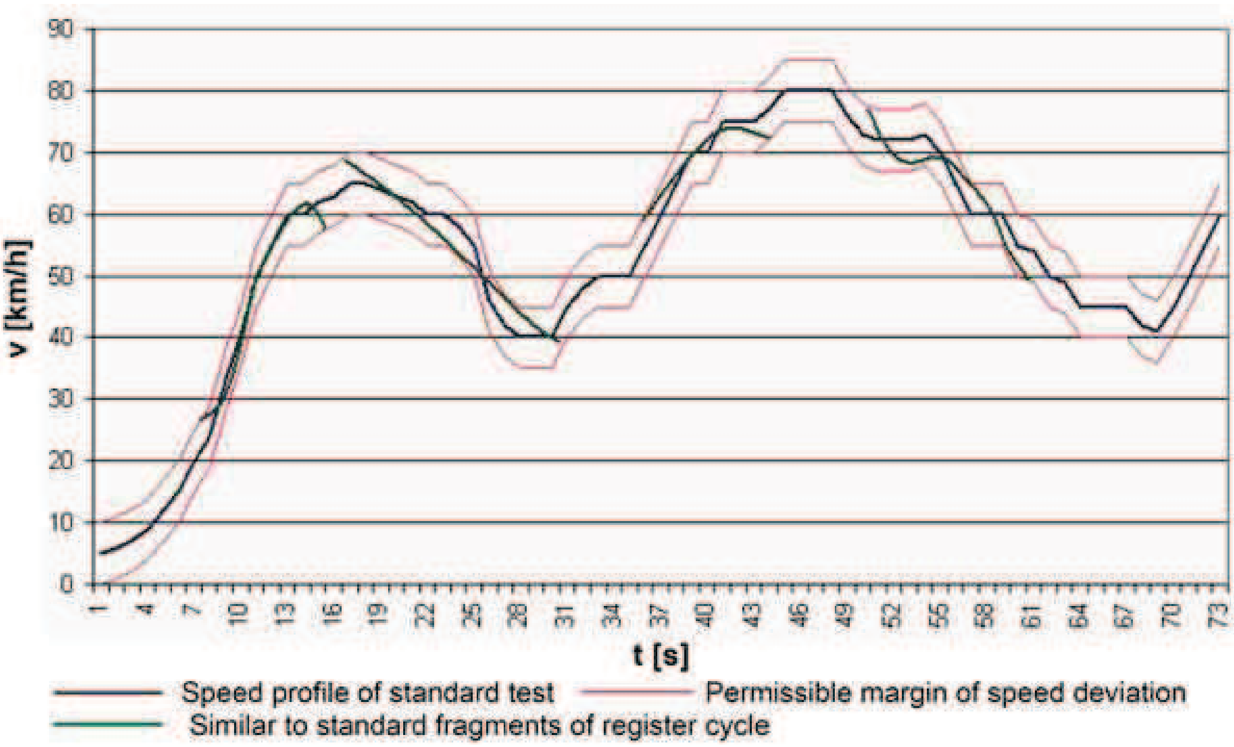

Fig. 7. Comparison idea of road cycle piece with pattern cycle similar from point of view speed course

term of t = 10s at fault ±1 km/h - slightly less (43%) it carries out for term of three times longer - at fault ±2 km/h. In case of the sixth registration which was characterised with the highest coefficient of the cover (15.3%) for time t = 10s and the error ±1 km/h, for time t = 30s and the error ±2 km/h the coefficient carried out only 6.55%, while for remaining registrations necessary turned out assumption of the greater error, so that it was possible finding of the similar fragment. At bigger times than t = 15s for the error ±2 km/h, the coefficient of the cover does not exceed 10%, while for the registration of the FTP cycle all the time remains on level several dozen percent.

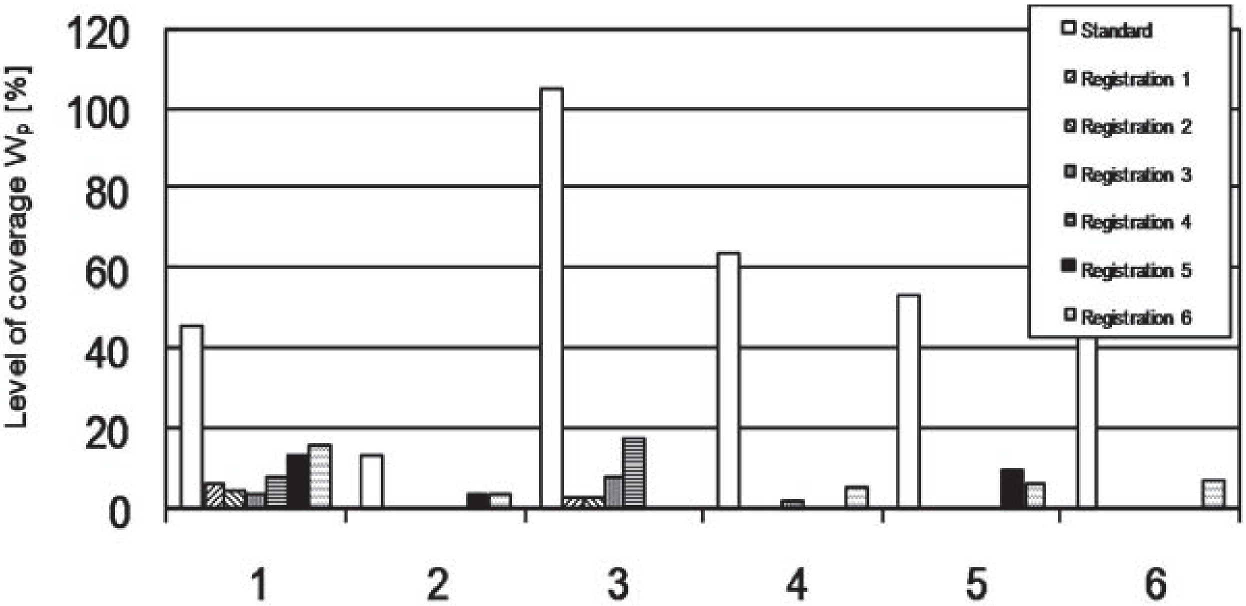

Fig. 8. Covering coefficients of recorded time for drive cycles

Tab. 1. Values of covering degree illustrated in Fig. 8, X means calculation lack for those data

	t = 10 s ΔV = 1 km/h	t = 15 s ΔV = 1 km/h	t = 15 s ΔV = 2 km/h	t = 20 s ΔV = 2 km/h	t = 25 s ΔV = 2 km/h	t = 30 s ΔV = 2 km/h
FTP	45.2	13.1	104.7	63.4	53.5	42.8
Registration 1	5.4	0	2.0	0	0	0
Registration 2	3.7	0	1.9	0	0	0
Registration 3	3.2	0	7.3	1.1	0	0
Registration 4	7.5	0	16.7	0	0	0
Registration 5	12.8	2.7	X	X	9.2	0
Registration 6	15.2	3.2	X	4.4	5.5	6.5

During research on the chassis dynamometer, especially in homologation research, the speed of the vehicle must contain within the range small deviations which do not exceed 1 km/h. Time increasing during which courses of the speed are similar, decreases the probability of meeting of the similar fragment.

3. The analysis of test results

The value of the indicator informing on the average reaction time of the OBD system on the appearance of the fault can be used as the measure of the efficiency of the system. The reaction time of the OBD system on the appearance of the fault on emissive character is sometimes not equal to zero. On that account, the single measurement as the indicator of the exploitive efficiency cannot be defined.

Continuous monitors will react most quickly on faults, realized all the working time, and in reference to non-contiguous monitors most quickly will react monitors whose realization is possible in widest range of service conditions.

The reaction time: A global indicator of the exploitive efficiency of the OBD system in the given vehicle (GE) is longest reaction time of the monitor of the OBD system on occurring of the fault on emissive character, from among all times t_{RS} for the given implementation of the OBD system:

$$GE = \max\{t_{RS}(M_1),..., t_{RS}(M_n)\}, \quad (1)$$

where: n - number of implemented monitors.

The reaction time of the OBD system is dependent on from many factors on the random character. From point of view analyses this time is also random variable, what represents Fig. 9

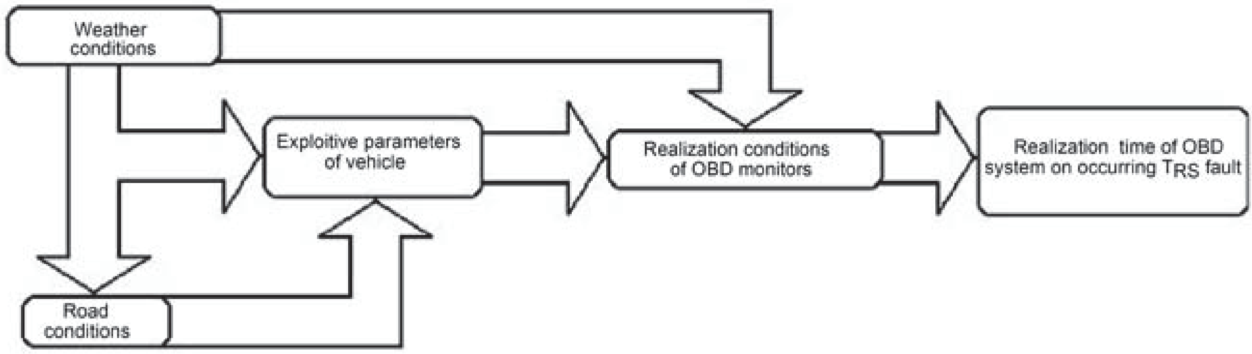

Fig. 9. Relations between parameters influencing on OBD system reaction time for defect appearing

Very essential is condition that the t_{RS} time can be treated as random variable in the case, when it is only a parameter registration taken into account in calculations. In fact it is because strictly determined with the appearance of favourable conditions of the realization of the suitable OBD monitor. Only which may be treated like this is the ambient temperature, taken into account by many diagnostic procedures. Remaining conditions of the realization of monitors connected with exploitive parameters of the vehicle and can be relative to: conditions of atmospheric, road conditions and the human factor. Weather conditions can be treated as completely random. A measure of the efficiency of the OBD system is driving time $t_{0.9}$, i.e. the run time with the probability of 0.9 all implemented monitors.

4. Conclusion

1. In investigated vehicles (at their relatively a lot of and varieties of types) in this also American on considerable course found for keeps registered codes of damages of main emissive elements of powertrain system which would signal excess acceptable emission levels. This concerned also the catalytic reactor and of oxygen concentration sensors. This observation does not mean automatically that the emission of these vehicles was really worked in within the range acceptable limiting values. For the purpose of the confirmation of such conclusion one should have carried out the full verification of OBD II systems, connected with performing of full tests toxity on chassis dynamometer.
2. Observed damages identified with registered codes of damages concerned mainly executive elements which essentially their own function in the system goes under to the fastest work off.
3. In American cars these were most often servo-motors of automatic gears.
4. In consideration of the design complexity on-board systems and variety and quantity of measured and accessible diagnostic parameters stated the necessity construction in Poland main system cumulation and distribution of diagnostic data.
5. A measure of the quantitative efficiency of the OBD system is time of the drive $t_{0.9}$ in characteristic service conditions, providing with probability of 90% realization of all diagnostic monitors. The conception of proposed indicator is based on the time criterion, not limitary (too little duration of driving cycle, low travelling speed, and low time stopping-place of idle run). This is absolute, but competent method estimation of the exploitive efficiency of the on-board diagnostics system.
6. Proposed OBD II driving cycle (course of vehicle speed) confirmed the realisability of all diagnostic monitors during its duration (for investigated vehicle model).

7. Proper is bring out changes in the research methodology, consisting in establish requirements of homologation tests of diagnostic monitors performed in lower ambient temperatures.
8. The independence of the method estimation efficiency from conditions of driving makes possible the estimation of the exploitive efficiency of monitors of the OBD system not only in the global manner, but also, after the achievement of additional registrations of exploitive parameters or external environment, gives opportunity estimation of efficiency in different working conditions. The implementation to homologation regulations demand connected with measurement of t_{RS} times will permit to guarantee that implementation to business trade vehicles equipped into diagnostic systems on the efficiency checked not only conditioned laboratory chassis dynamometer, but also in differentiated conditions of the real exploitation.
9. One proposes, so that an integral part homologation procedure of car vehicles, outside chassis dynamometer research, will be registration of the realization of monitors under conditions of the real exploitation, under conditions of street traffic and outside urban. Its course would be able to be based on directions and with the utilization special equipment.

Further works within the OBD range should contain:

- the elaboration of universal, in special events particular (for given type of vehicle) test EOBD for European cars,
- working out research stand, based on so called free "rolls" to the realization of the EOBD test in stations checking of vehicles,
- the continuous checking, the correction and the modernization of the EOBD test in connection with the awaited implementation of novel diagnostic monitors or existing modernizations, working up electronic simulators of damages of EOBD chosen monitors, first of all misfire and oxygen concentration sensors together with opportunity estimation work efficiency of the catalytic reactor, the appointment time $t_{0.9}$ for all novel homologised types of vehicles and vehicles exploited on the ground of Poland of equipped in EOBD/OBD II.

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