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GENERAL CRITERIA FOR TECHNICAL FACILITIES WITH RESPECT TO THE CORRECT MOTOR VEHICLE AND COMBUSTION ENGINE DIAGNOSTICS AND IN THE CONTEXT OF ENVIRONMENTAL PROTECTION

Kazimierz Lejda, Edyta Zielińska

Rzeszow University of Technology
Al. Powstańców Warszawy 6, 35-959 Rzeszów, Poland
tel./fax: +48 17 854 31 12, e-mail: klejda@prz.edu.pl

Abstract

This article presents the most important requirements to be met by technical facilities dealing with motor vehicle diagnostics. Among the requirements that were highlighted were those regarding the adequate location and marking of the vehicle testing station, the necessary equipment adjusted to the needs and the range of offered services as well as technical specifications and staff qualifications. The paper also focuses on the requirements concerning the assessment of the condition of combustion engines. The significance of combustion engine diagnosis by service station methods and with the use of relevant tools and devices was emphasized.

Key words: *technical facility, vehicle testing stations, combustion engine, dedicated environmental standards*

1. Introduction

The increasing number of motor vehicles on the Polish roads results in increased demand for diagnostic tests and related specialist technical facilities. Qualified staff and appropriate equipment are of great importance in technical facilities as they are to guarantee that the use of the tested vehicle is safe and that their services are carried out to high standards [1,6]. In terms of security of vehicle users as well as of environmental protection, vehicle testing stations are important technical facilities. Their fundamental objective is to localize the faults in the vehicle assemblies and sub-assemblies without disassembling the vehicle or with the removal of only some of its parts. This objective is pursued by comparing the current vehicle condition with the nominal parameters corresponding to the structural systems, assemblies and sub-assemblies in good working order. Such comparison allows assessing the fitness or unfitness of the vehicle for further use.

In motor vehicle diagnostics, the technical assessment of combustion engines is important because their structures are currently undergoing rapid development and improvement. The development of engine structures is highly influenced by the applicable regulations in respect of the environmental standards and barriers for motor vehicles. The necessity of replacing traditional fuels with alternative energy sources is another equally important reason for the development of engine structures. This involves the introduction of hithertounknown solutions related to the new generation of assemblies, sub-assemblies and control systems as well as to new research

methodologies, diagnostic equipment with high performance parameters and, in the end, diagnostic personnel with knowledge appropriate to the contemporary solutions.

2. Significance and requirements regarding vehicle testing stations and the related research

Technical testing of means of motor transport is done in vehicle testing stations which should be located in places where there is demand for this kind of services, and where they are visible and accessible to potential customers. They also should be appropriately marked. The marking involves fitting the station with a suitable blue signboard with a white inscription containing an identification code, an indication of the type of station and the opening hours. In order for a vehicle testing station to be able to properly carry out technical tests, it must have at least one control station and an external station for acoustic measurements [4,11].

The activity of technical facilities designed for vehicle diagnostics should have little or no adverse effect on the environment and should be characterized by a minimal impact on the air quality and the acoustic climate as well as on the quality of life of the inhabitants of the nearby area. The operation of a vehicle testing station, e.g. the work of its equipment can cause noise that might be bothersome to the people in the environment. Such noise should be eliminated by using sound and thermal insulation in the facility as well as tight entrance and exit gates and tight windows. It is also important to only use the equipment within the station's opening hours and in accordance with their intended purpose. All wastes generated as a result of the operation of the vehicle testing station should be sorted and stored separately in a designated place until they reach the amount required by the authorized waste collecting company but not longer than for 3 years. It should be noted that the separators can only be cleaned by specialized companies. Particular caution should be taken when dealing with hazardous waste. Before such waste is collected by an authorized company, it must be stored in tight containers made of materials resistant to the components contained in that waste, on hard and gap-free surface, in a place protected against unauthorized entry.

The basic diagnostic tasks include assessing the current condition of the vehicle, anticipating its future conditions for appropriate scheduling of the diagnostics and service, and deciding on the end of life of worn-out means of motor transport. The diagnosis of motor vehicles can be made as:

- part of the periodic or/and constant tests and of the assessment of the vehicle condition by means of the instruments installed in the vehicle (on-board diagnostic systems),
- part of the periodic tests and the assessment by means of attachable instruments (external diagnostic systems),
- a combination of the above-mentioned diagnostic techniques.

The determination of the general vehicle condition without differentiating the individual components of the motor vehicle is an essential task throughout the diagnostic procedure. The aim of the test, called a vehicle inspection, is to check whether the car as a whole is roadworthy. Even one negative result in the test called fault location means that the car is unroadworthy and should undergo the second testing phase and the condition assessment, i.e., be tested for its components that might require to be adjusted, repaired or replaced. Vehicle diagnosis contributes to [8]:

- enhanced usability of motor vehicles and increased performance of the transport process by:
  - minimizing vehicle downtimes,
  - reducing the number of vehicle repairs,
- reducing the costs of use of motor vehicles by:
  - narrowing the scope of service,
  - minimizing the costs of spare parts and rationalizing the workforce,
  - minimizing service intensity,
- extending the efficiency of motor vehicles,

- enhancing safety, i.e. improving the resistance of vehicles to faults in their function that are the cause of the hazard to that system and the cooperating systems.

The result of regular diagnostics is greater use of the vehicle (ca. 20%), reduced fuel consumption (ca. 15%), reduced wear of spare parts (ca. 20%) and increased mileage before overhaul (ca. 1.5 times) [7].

Specialist equipment that meets the applicable criteria is essential in vehicle diagnostics. The required equipment includes devices and instruments for [10]:

- lifting the vehicle for the tests to be made,
- assessing the braking system performance,
- assessing the correctness of the wheel alignment,
- checking and adjusting the tyre pressure,
- assessing the correctness of the levelling and adjustment of the vehicle lights,
- assessing the sound intensity,
- measuring exhaust smoke density in Diesel engines,
- checking the function of the vehicle-trailer electrical connector,
- checking the function of the trailer's overrunning brake,
- checking for suspension play,
- determining the composition of exhaust gas,
- checking the wheel alignment and the vehicle axis,
- assessing the function of the vehicle silencers,
- diagnosing the vehicle with the use of the on-board computer,
- determining the light transmission coefficient for the vehicle windows,
- location of leaks in the vehicle's gas system.

The equipment of a vehicle testing station can be used to carry out technical inspections of vehicles, if it has been subject to conformity assessment and bears the CE marking (if required by the conformity assessment regulations). A vehicle testing station should also have the required declarations of conformity for its devices and instruments, made in the Polish language or in another language along with the Polish translation. Keeping the documents related to periodic operational and metrological checks as well as to technical inspections is also an important requirement imposed on vehicle testing stations.

As well as the equipment, qualified staff, or the diagnosticians (Fig. 1) are also important in vehicle testing stations. They have [9]:

- university degrees in automotive sciences and substantiated 6-month traineeship in a vehicle inspection station (VIS) or in a garage at control or repair stand,
- secondary technical education with a speciality in automotive industry and substantiated one-year traineeship in a vehicle inspection station (VIS) or in a garage at control or repair stand,
- university degrees in sciences other than automotive and substantiated one-year traineeship in a vehicle inspection station (VIS) or in a garage at control or repair stand,
- secondary technical education with a speciality in a field other than automotive industry and substantiated 2-year work in a vehicle inspection station (VIS) or in a garage at control or repair stand.

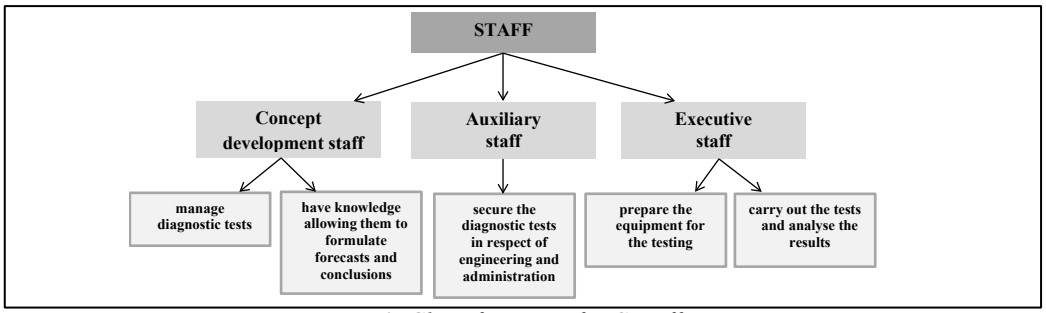

Fig. 1. Classification of VIS staff

3. Diagnosis of combustion engines

A combustion engine is a very important assembly for the diagnosis of a motor vehicle. The engine can be diagnosed using designated tools and devices. In engine diagnostics, organoleptic and primarily service station methods are applied. The division of engine diagnostic procedures is shown in Table 2 where the main functional systems have been taken into account. It should be noted that in order to correctly formulate the diagnostic assessment, the registered parameters of the individual assemblies or sub-assemblies should not change during the diagnosis of the entire vehicle or its assemblies.

Tab. 2. Combustion engine diagnostics broken down by functional systems

Tests on the engine	Description of operations
Diagnosis of the piston cavity	**Compression pressure measurement** • Compression pressure in the working space is measured using manometers with a defined measuring range that depends on the type of engine. • Before the test, allow the engine to warm up to normal operating temperature. • Remove all spark plugs or fuel injectors in the Diesel engine. • Screw the unit terminal in one of the holes or put it up the socket. • Actuate the starter with the accelerator pedal fully depressed (and do so for each cylinder). • Compare the obtained results with the data provided by the manufacturer.
	Cylinder tightness test • Tightness is tested using so called tightness testers. • Before the test, allow the engine to warm up to normal operating temperature. • Screw out all the plugs or injectors from the engine. • Position the piston of the tested cylinder in the end of the compression stroke, connect the tester to the cylinder on one side and to the compressed air system on the other. • Open the compressed air valve and read off the tightness on the unit. • Compare the obtained results with the values adopted as the criterion. • Leaks are located using a sounding rod. Use it to sound the places with blowthroughs.
Diagnosis of the timing gear system	• Checking the timing gear belt or chain and determining the play values • Remove the valve cover to check for play in the timing gear system and determine the play values using a feeler gauge. • Compare the measurement results with the data provided by the manufacturer.
Diagnosis of the cooling system	• Check the thermostat for proper operation by determining the temperature, at which thermostat opens and the flow begins. • Checking the cooling system for tightness: - Attach the instrument to the equalizing tank or the radiator, generate 0.5 bar pressure and use a manometer to check whether the pressure holds. - If the pressure falls, this may indicate that the system is not leaktight. • Checking the cooling system fluid for usability: - Once the fluid is taken up from the tank, the unit shows its freezing point. - The result is to be compared with the manufacturer's requirements.
Diagnosis of the lubrication system	• Oil pressure measurement to be taken with the use of a manometer: - Before starting the test, check the oil level, top it up if needed. - Warm the engine up to its normal operating temperature. - Screw out the oil pressure sensor and mount the manometer tip in that place. - Start the engine and check oil pressure. - Compare the obtained results with the data provided by the manufacturer. • Oil quality test to be carried out with the use of a special tester: - Take up oil and place it in the tester's measuring unit. - Compare the result with the data provided by the manufacturer. • The system is checked for tightness visually.

Diagnosis of the fuel system	• Checking the system components and the fuel pump for tightness, and the injectors for performance efficiency. • The fuel pump test is carried out with the use of a manometer: - Connect the fuel pipe to the manometer using a T-connection. - Start the engine and note the manometer readings. - Compare the obtained result with the data provided by the manufacturer. • Testing the injectors on a special test stand; Remove the injector from the vehicle and check injection pressure and the quality of fuel atomization.
Measuring exhaust smoke density	• Measuring with a filter-type smoke meter, the operation of which consists in pumping out a specific amount of exhaust gas from the exhaust pipe and let it go through special paper and a filter in the optical measuring system. • Measuring with a light obscuration smoke meter that measures exhaust gas transparency (the degree of absorption of the luminous flux filtering through exhaust gas).

The condition of the diagnosed engines must comply with the technical conditions specifying their optimal performance. Reaching the so called maximum permissible or critical parameters for the engine condition refers to the specific running time of the engine that may be operational or non-operational but still within the usability limits. During the diagnosis with the engine running, special care should be taken to ensure that exhaust gas is removed safely and the noise emission is within limits. The test stand should be separated from the other stands or stations where other systems of the vehicle are diagnosed without the necessity of switching the engine on. Exhaust gas should be released outside through a piping system, with the close vicinity of the testing station taken into account so as not to create any risk for the environment. The composition of exhaust gas also provides information on the engine condition. If the composition is improper, it indicates that one or more engine components do not work properly. The noise emitted during the test should be eliminated, e.g. by the application of specially structured facility walls that can limit the noise emissions to outside.

The diagnosis of modern combustion engines is largely based on the verification of the performance data registered in the OBD (*On Board Diagnostics*) system. At present, the OBD II standard is in force (its European equivalent is EOBD) and applies to malfunctions that could increase emissions of toxic compounds from the exhaust system and fuel consumption in the fuel system [3,5]. Such malfunctions relate to the assemblies and components within the power transmission system that are responsible for the emission of toxic compounds. When the OBD system has detected a malfunction, it illuminates the Malfunction Indicator Light (MIL) to inform the driver about a failure, and registers the failure in the CPU memory in a very simple form of a standard malfunction code. In addition, the system aims to detect malfunctions related to security, such as failures of the brake systems or air bags. The OBD II system uses two types of codes: Type A for failures that contribute most to the increase in emissions and make the control indicator light up when the failure occurs for the first time; and Type B for failures that could increase emissions but to a lesser extent than those of Type A; the illumination of the control indicator is a result of a two-time occurrence of the failure. The indicator will go out once the fault is repaired. It is possible to remove the fault codes from the computer memory only with the use of a diagnostic unit or after disconnecting the controller from the power supply. Figure 2 shows an encrypted, five-digit coding system.

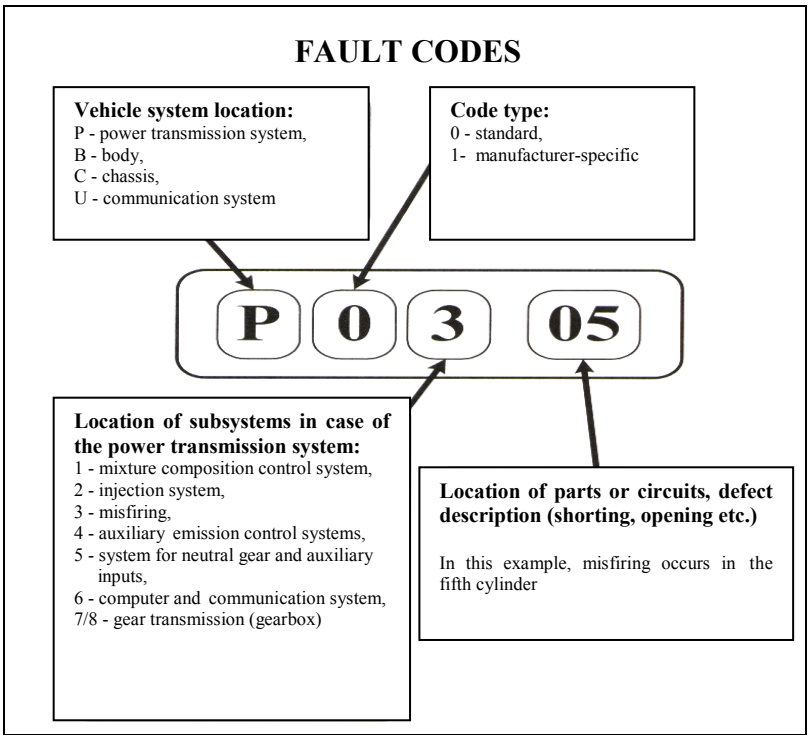

Fig. 2. Encrypted OBD II system fault codes [2]

The increasing requirements regarding the service life and reliability of combustion engines and the minimization of the costs of use and the adverse impacts on the neighbourhood create the necessity to acquire information on the condition of the vehicle during its use (Fig. 3).

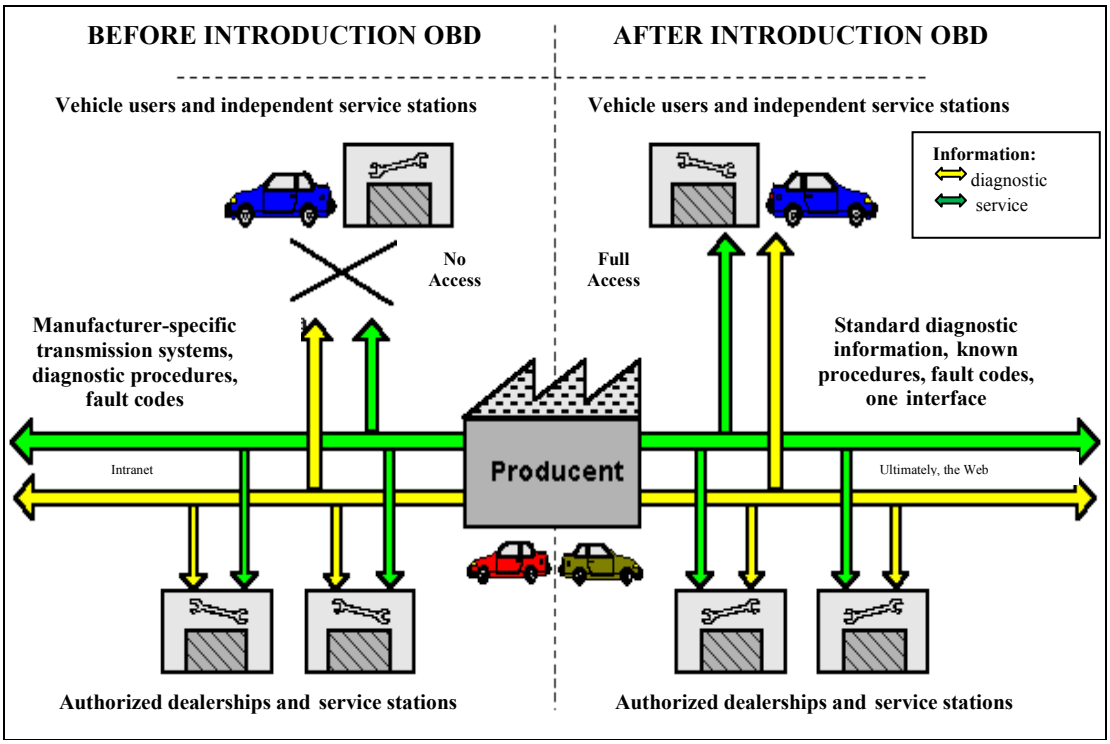

Fig. 3. Diagnostic information (availability) [2]

As a result of the introduction of the requirement to manufacture vehicles in conformity with the OBD II standard, it is now possible to access the data stored in the controllers for particular

systems. This solution creates new opportunities to diagnose the condition of these systems. Early detection of minor defects can prevent more serious failures that could affect the emission volume and the operating parameters of the engine. This is also essential in terms of economy because, the smallest the defect, the lower repair costs and the shorter vehicle downtime [7].

4. Conclusions

Technical facilities that are well organized in respect of the diagnostics of motor vehicles and combustion engines play a key role in ensuring the safe use of vehicles. Their good organization is also important in terms of environmental protection. Technical tests carried out on motor vehicles in vehicle testing stations help maintain them in proper condition as well as in constant roadworthiness. This is possible due to quick detection of even the smallest defects, before they become the cause of a serious failure or accident, or considerable environmental pollution.

In order to ensure high standards of their services, vehicle testing stations should invest in best quality devices and instruments, and engage the best specialists who must keep improving their skills. The necessity of improving the employees' skills during specialist training courses is due to the dynamic development of the automotive industry and to the modern motor vehicles that are more and more advanced in terms of their structural design and technology. Vehicle testing stations must also meet a number of legal requirements imposed on enterprises The relevant legislation forces on them both the dimensions for test stands, test equipment, testing procedures and the number and type of training courses the diagnosticians have to undergo in order to gain the right to perform vehicle diagnostics. The regulations applying to vehicle testing stations are aimed at eliminating those entities that do not meet the imposed requirements and cannot provide the adequate quality of their services.

Failures and malfunctions of all kinds, which could increase the emission levels, are a serious risk to the vehicle user who cannot diagnose it by himself or herself. The development of on-board diagnostic systems has contributed to the improvement in the assessment of emission performance as well as of the vehicle components, the wear or damage of which could have an impact in increased emissions of toxic substances from the vehicle. The best of the diagnostic systems that are currently in use is OBD II because it oversees the vehicle components that have an effect on the emission of toxins with exhaust gas. It can be expected, based on the studies conducted in the leading automotive concerns, that the nearest future will offer us systems capable of controlling and diagnosing the vehicle by means of radio waves or digital data transmission systems. Cars analysing their condition on their own, sending the information to the service station and scheduling the repair at the same time will represent substantial progress in the development of vehicle diagnostics.

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