exhaust emissions, bus depot, depot technical stations

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ORGANIZING A BUS DEPOT – SELECTED ASPECTS

Summary. Urban transportation problems are particularly noticeable within cities of over 100 thousand inhabitants. In these cities buses are a primary means of transport, but lack of low-floor and poor interior design does not encourage passengers to use them. However, the qualities that give the most negative feedback on the public transpiration are the technical condition of buses, excessive noise and exhaust emission. Technical backsides of the bus depots that constantly maintain the technical readiness of the required number of vehicles play an important role to ensure high quality standards. New European Union legislation is very helpful in such. New laws and regulations deal with the safety issues and environmental protection matters, to which the urban transportation depots must be strictly adjusted. This article refers to these documents and presents depot technical stations, which equipment needs to be upgraded in the first place.

ORGANIZACJA ZAJEZDNI AUTOBUSOWEJ – WYBRANE ASPEKTY

Streszczenie. Problemy transportu miejskiego zauważane są szczególnie w miastach powyżej 100 tys. mieszkańców. Środkiem transportu są przede wszystkim autobusy, których wyposażenie wnętrza, brak niskiej podłogi i stylistyka nie zachęcają pasażerów do korzystania z tego rodzaju oferty. Jednak to stan techniczny autobusów, nadmierny hałas i emisja spalin budzą najwięcej negatywnych opinii na temat transportu zbiorowego. Ważne zadanie w zapewnieniu wysokich standardów jakościowych pojazdu wykonują zaplecza techniczne zajezdni autobusów, których celem jest stałe utrzymanie w gotowości technicznej wymaganej liczby pojazdów. Pomocne są w tym nowe przepisy prawne Unii Europejskiej. Dotyczą one przede wszystkim przestrzegania zasad bezpieczeństwa i ochrony środowiska. Bazy transportu miejskiego muszą się do nich bezwarunkowo dostosować. Artykuł, odwołując się do tych dokumentów UE, prezentuje stanowiska techniczne zaplecza, których wyposażenie powinno być zmodernizowane w pierwszej kolejności.

1. INTRODUCTION

On September 25, 2007, the European Union Commission launched public consultations on the Green Paper – Towards a new culture for urban mobility [4]. The document emphasizes – among others – a great significance of unification of minimal environmental standards for operation of

vehicles in order to reduce the impact of road transport on the environment. It is further noted that "the gradual decrease of standards in the future could lead to the constant upgrade or decommissioning of heavily polluting vehicles"[5].

An important step towards the elimination of inefficient vehicles from the roads was made a few years earlier. The Directive 2000/30/EC of the European Parliament and of the European Council (along with the Directive 2003/26/EC adapting to technical progress Directive 2000/30/EC as regards to speed limiters and exhaust emissions of commercial vehicles) defined the rules of the road inspections of vehicles running within the European Union [6]. The Directive lists twelve points that may be checked. Every two years Member States must report to the Commission on the number of commercial vehicles checked over the previous two years, broken down into seven classes listed in the Directive and by country of registration, and the items checked and deficiencies discovered (Art.6). The Commission shall forward this information to the European Parliament.

The UE legal acts developed in the following years were related to maintenance and inspection of the vehicles involved in traffic. Such involvment was determined at the level specified in the valid homologation plus it determines the minimum of Community standards and methods of testing the components.

These regulations apply, in some extent, to the public transportation buses. This implies the need for increasing the attention to the technical condition of vehicles leaving the depot every day. Such task is in the hands of the facilities, especially for daily maintenance and diagnostics.

2. REQUIREMENTS REGARDING TECHNICAL INSPECTION OF THE BUSES

Provisions included in the Commission Directive 2009/40/EC [1] and the amending Directive 2010/48/EU "on roadworthiness tests for motor vehicles"[3] make a long-awaited response to the need of ensuring the best conditions of safety and environmental protection. The effects of uncontrolled development of private transportation with a considerable share of vehicles of low technical condition can particularly be seen within the cities. Far more difficult situation can be noticed in public transportation. The checkouts on city buses having been performed so far shows a number of their malfunctions. These include leaks of the exploitation fluids, leaking pneumatic systems, faulty brakes, wheel hubs damage, considerable slack in components of the suspension system, and others.

Directive 2010/48/UE specifies the categories of vehicles to be tested on roadworthiness and frequency of testing (Appendix I). It also sets the scope and methods of testing, and the basic criteria of rejecting the technical condition of a vehicle, giving the most common examples of detected malfunctions (Appendix II). For instance—regarding the bus doors—the following may occur: malfunction, poor technical condition, and damage to the emergency door opening system, damage to the door remote control or warning devices, and failure to comply with the requirements of the approval.

An important effect of changes applied to the EU legislation should be, next to the safety problems, reducing of exhaust emission of all vehicles, including the buses. Regular inspections will contribute to the reduction of the most polluting vehicles. In the case of diesel engines, the measurement of exhaust gases is considered to be an adequate indicator of the technical condition of vehicles regarding the emission of gases. The possibility of ensuring fair competition between the public transportation companies is also significant.

In some cases the Member States have the right to withdraw from the Directive and its agreements [1, 3]:

- They may set an earlier date for the first mandatory test of roadworthiness and, when appropriate, require the vehicle for testing prior to registration by taking regular measurements of exhaust and pollution level (Art.5(a));
- They may shorten the time interval between two following compulsory tests (Art.5(b)); They may include the optional equipment for mandatory testing (Art.5(c));
- They may increase the number of items to be tested (Art.5(d));

- They may introduce some compulsory additional special technical tests (Art.5(e));
- They may set, for the vehicles registered in its territory, the higher values of minimal performance sufficiency of the brakes than those specified in Appendix II, and introduce the test of loading vehicle, but such requirements do not go beyond the initial authorization for a particular vehicle type (Art.5(g)).

Table 1

Minimal requirements regarding technical inspection of the buses - braking system, exhaust emissions

Vehicle systems and components	Scope of the inspection	Method and equipment
1. Braking system	Mechanical condition and operation; performance and efficiency of the service brake; efficiency and performance of the secondary (emergency) braking system (if exists as a separate system); efficiency and performance of the parking braking system; performance of the endurance braking system; anti-lock breaking system (ABS); electronic brake system (EBS)	Visual inspection; a device for static brake testing or by a road test using either an indicating or recording decelerometer
2. Nuisance	Noise suppression system; exhaust emissions; electromagnetic interference suppression	Visual inspection; conducting the standing noise tests by a noise meter; exhaust gas analyzer

An important feature of testing the technical condition of vehicles should be simplicity, short turnaround time and low costs throughout their life cycle. The inspection shall cover at least the items mentioned above and is performed due to minimal requirements and methods shown in Table 1 and 2, and based on the EU Directive [3, 5]. The tests are carried out using available techniques and equipment without disassembly of the vehicle. All items listed below are subject to mandatory inspection during periodic vehicle testing.

The Directive 2010/47/EU, which "adapts to technical progress Directive 2000/30/EC of the European Parliament and the Council on roadworthiness tests for motor vehicles in use within the European Community" is the second provision aiming to improve the safety on roads and environmental protection [2].

The Article 2 of the Directive makes the Member States to enforce all necessary legislative, executive and administrative regulations so they comply with the Directive by January 1, 2012 the latest. The Appendix I of the Directive contains a sample sheet of the road inspection report, which also includes a list of all items to check on the back. This is to help the inspectors and make their work easier. The Appendix II sets out the rules and regulations for testing or checking the braking equipment and exhaust emission at the road inspection. Applying these methods shall increase the efficiency of the road inspections when it comes to the permanent technological progress.

Presented set of necessary control measures defines a model of technological performance of the backsides bus depot facilities. The number of buses of the public transportation companies defines the scope of audit work and how many repairs need to be performed as a result of backside bus depot facilities.

3. BASIC SCHEMA OF THE SERVICE OF BUSES IN A BUS DEPOT

3.1. Description of activities of daily maintenance

Figure 1 shows a typical course of technological process of a daily maintenance. Different process cycles may have a different order and different number of movement phases within the depot. The following is an example taken from a depot located somewhere in Silesia.

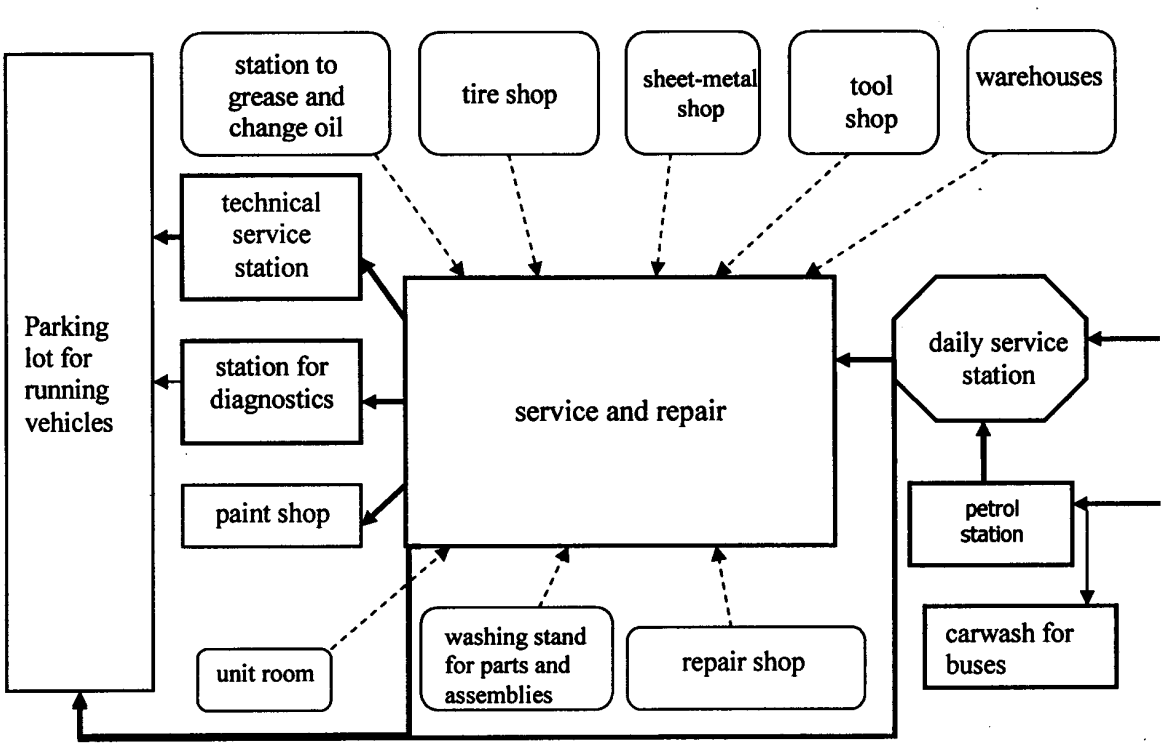

Fig. 1. Functional diagram of the bus technical resources
Rys. 1. Schemat funkcjonalny autobusowego zaplecza technicznego

- After the scheduled time of operation ends buses entering the depot stop at the reception desk to stamp a vehicle card. Then, after a driver has logged in to the system using a special electronic card assigning him or her to a particular bus, they run to the gas station to refuel; distributors are running. A computer in a dispatch center registers any amount of fuel topped off. The distributors operate with the capacity of 100 cubic decimeters of fuel per minute. Thus, the average refueling time is about 2 minutes long. The daily fuel consumption of 150 vehicles is about 18 thousand cubic decimeters.
- The bus enters an automatic car wash with the wash time of 1.5-2 minutes. At the next station each bus is being cleaned inside. This activity takes approximately 2 minutes. Immediately after the cleaning process is completed, a portable fume extraction system is being applied.
- Entering a daily maintenance hall (with a pit), a diagnostician on duty assesses the level of exploitation fluids, inspects the interior and exterior lighting, as well as chassis and tires, with particular emphasis on aspects that affect safe driving. If needed, a mechanic orders additional repairs performed at a separate post due to current maintenance status. The inspection lasts around 1.5-2 minutes. Generally, the performance of braking system and the setting of lights at this point are not inspected.

After all operations are completed, the fume extraction system is automatically disconnected and, when the vehicle is running within normal parameters, it may leave for a parking lot. The bus that requires repair goes to the shunting crew and after the repair is finished it may leave for the parking lot. The vehicle performance needs to be confirmed by the diagnostician and a shift's master. In the morning drivers stamp the vehicle card and hit the road. The average time of going through the daily maintenance hall from the refueling to the leaving the hall is 8 minutes. Therefore, such work schedule allows handling 150 vehicles within 5 hours.

3.2. Diagnostic Function

Due to the legislative changes mentioned above and related to roadworthiness tests of the motor vehicles, the diagnostic equipment as well as the scope of diagnostic duties should undergo some modifications. The testing stations these days are being equipped with diagnostic devices to perform a variety of tests on the braking systems, suspension systems and chassis. These devices should be able to cooperate with a computer system that collects and analyzes data on the technical condition of the vehicle.

The testing station includes the following: a pit and a hoist, control and measurement equipment, as well as a horizontal surface with the measuring and control devices and a measuring bench. Such measuring benches make a testing surface level designed to measure the settings of wheel geometry and vehicle lights at the entire length of the pit.

The following may be expected in the hall of vehicle control [7]:

- checking the brakes on the wheels on a roller device,
- overall evaluation of the braking system,
- inspection of the steering wheel system, suspension and chassis by tugging,
- overall evaluation of the vehicle body,
- inspection of fuming,
- inspection of tires and checking the pressure
- checking the setting of lights,
- checking the electrical and signaling parts,
- initial and detailed setting of wheel geometry,
- vehicle control and adjustment by the equipment to diagnose full load malfunctions.

The production line is equipped with the following: rail exhaust extraction system, heating system, water supply and sewerage system, compressed air system, wiring system to supply the devices, ventilation system with a hot air blowing function, the pit of 70-90 centimeters wide and 150 centimeters deep, with the inner steps or moving platforms that allow performing the checkups comfortably.

The pit is equipped with the following: 24V lighting, fixed, scattered and portable, concentrated if necessary on the parts of vehicles, shelves for tools inside the pit, elevated pit hoist, adapted to lift at least 100kN, ventilation and drains with a mud box, side railing system. Other specifications are included in the MTiGM regulation [8].

Table 2

Minimal requirements regarding technical inspection of the buses

Vehicle systems and components	Scope of the inspection	Method and equipment
1. Identification of the vehicle	Vehicle identification number/ chassis number/ serial number	Visual inspection
2. Steering	Mechanical condition; steering wheel, column and handle bar; steering play; Electronic Power Steering	Visual inspection; a pit or hoist
3. Visibility	Field of vision; condition of windows; rear view mirrors or other devices of such function; windscreen wipers; windscreen sprinkles; defogging system	Visual inspection
4. Lights, reflectors and electrical equipment	Headlights; front and rear position lights, side marker lights and end outline marker lights; stop lights; turn indicators and hazard warning lights; front and rear fog lights; reversing lights; rear registration plate light; reflectors, reflecting markings and rear reflecting plates; mandatory lighting equipment control lights; electrical wiring; additional lights and reflectors; batteries	Visual inspection; a device to check the position of lights; a pit or hoist
5. Axles, wheels, tires, suspension	Axles; stub axles; wheel bearings; wheel hub; wheels, tires, suspension	Visual inspection; a pit or hoist; wheel play detectors
6. Chassis and chassis attachments	Chassis or frame and parts attached to them; cab and bodywork	Visual inspection; a pit or hoist; wheel play detectors; leak detection devices in the case of use of LPG/CNG systems
7. Other equipment	Fire extinguisher; locks and vehicle anti-theft devices; warning triangle; audio warning signal; speedometer; tachograph (if installed or required); speed limitation device (if installed or required); odometer if available; Electronic Stability Control (ESC) if installed	Visual inspection; electronic equipment
8. Supplementary tests for vehicles of the M 2 and M 3 type	Doors; emergency exits; windows defogging and defrosting systems; air-conditioning and heating systems; seats; interior lighting and destination signs; gangways and standing areas; stairs and steps; passenger communication system; information signs; requirements regarding the transport of children; requirements regarding the transport of disabled people; other special equipment	Visual inspection

3.3. Unit rooms

Pneumatic valves, electro-pneumatic valves, clutch plates and brake drums rolls are being repaired in the unit rooms. It is also a site where other parts are being repaired for the time being as well. This includes regeneration of the front and rear axle beams with all their accessories, axles and gearboxes. Some of the engine repair stations are separated from each other by curtains or doors to minimize the noise coming from the running machines, but they all may cooperate with the unit room as they are all connected by Demag. If necessary, the engine or any other heavy component can be easily transported.

The basic equipment include hydraulic presses, bench type hand millers, lathes with the equipment set, drilling machines, grinding machines for brake linings, machine tools for turning the brake drums and grinding wheels, stands to repair the engines, a manually driven hoist (1000 kg Demag), as well as all sorts of control and measuring instruments.

3.4. Station to grease and change of oil

A periodic replacement of lubricants is a primary maintenance function ensuring the use of all components and assemblies in the long run, as the oiling and lubrication has been expected by the manufacturer. The following make the core technical feature: hoist or pit with the hoist, greasers, oil tanks and oil fillers, equipment to collect the waste of oil.

A central control unit often monitors the oil distribution and collection of used oil. The system stores in its memory all data on the transactions, and therefore it is possible to obtain a number of reports with information on:

- performed transactions (date, name of the operator, quantity and type of issued products),
- current amount of liquid in tanks with the minimal acceptable levels of liquid usage of particular products (total and split by usage by individual users).

A logistic approach simplifies the supply and storage management.

3.5. Washing stand for parts and assemblies

A washing stand for the parts and assemblies is a preparation station to get all parts and assemblies ready for repairs. Due to pollution by oil and petroleum as a result of washing, and large amounts of silt and sand, such workstations must meet high environmental standards.

Cleaning of the suspension units and elements is being performed before scheduled repairs, and on a daily basis with daily maintenance, in order to verify and assemble the parts. Therefore, a high pressure cleaning equipment is essential for the proper and safe operation of the public transportation companies. Before buses get disassembled they undergo deep cleaning, which makes the work easier and faster, and reduces the contamination of the repair stations.

3.6. Station to change and repair wheels

The station for repairing and changing wheels should contain two modules: a station to repair and change wheels on vehicles, and additionally, on the repair stations. The sites where wheels are being repaired need to be equipped with tools for preliminary work, such as tire retractors, pneumatic grinders with discs and brushes, a vacuum cleaner to clean the tires, shelves and workbenches, tire racks, assembly room, and a frame with the testing connection to pump air. An extra separate station for bonding and dowelling tires is also being designated, with portable sleeves to extract of impurities. Additionally, a device to deepen the tread is in use.

The station to change wheels may be equipped with the stamp hoist to lift full-load vehicles, or a hoist to lift only one wheel. Of course bigger potential brings the stamp hoist as it can be used either to lift the entire vehicle or just one axle.

The other modules of technical facilities within the bus depot include: a carwash, body shop, gas station and a workshop.

4. CONCLUSIONS

A brief presentation of a technical backside system within a typical large bus depot includes many objects, subsystems and stations, which usefulness has been confirmed by years of experience. A fleet of buses varies from city to city. In addition to vehicles that should have been withdrawn from service long time ago, the public transportation companies own newly purchased buses from different manufacturers. In this situation most of the depots have been forced to perform all sorts of vehicle inspections, diagnostics and repairs of various types and makes of buses.

The basic equipment of the technical backsides is now being completed by a number of devices of new generation. The latest equipment, tools and materials that require special technical conditions, clean air, and proper humidity and temperature are in use. Hence, it is needed to build new systems to

ensure that the environmental requirements, occupational safety and fire protection requirements, among many others, are met. The technical backsides of the bus depots should be well managed, so applying new technological and logistical solutions, as well as information communication technology is a must.

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