# Mobile test stand for the automotive LPG system

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**ABSTRACT:**

This article presents a mobile test stand in the form of a motor vehicle with an installed LPG fuel supply system. The vehicle is fitted with instrumentation recording numerous operating parameters of the propulsion unit petrol and LPG supply system. Tests under actual operating conditions may be carried out at such a test bench. The study presents a detailed description of the installed LPG system, as well as the instrumentation for measuring and recording the tested indicators and operating parameters of the drive unit. The research opportunities of a mobile test stand were discussed. The commissioning tests were also performed in the form of power measurements on the chassis dynamometer with both petrol and LPG fuel. The obtained results indicate the correct operation of the power supply systems.

## Mobilne stanowisko badawcze samochodowej instalacji LPG

**Słowa kluczowe:** badania eksploatacyjne, instalacja LPG, zużycie paliwa

**STRESZCZENIE:**

W artykule przedstawiono mobilne stanowisko badawcze w postaci pojazdu samochodowego z zamontowaną instalacją zasilania paliwem LPG. W pojeździe zainstalowano aparaturę rejestrującą liczne parametry pracy układu zasilania jednostki napędowej paliwem benzynowym i LPG. Na tak zbudowanym stanowisku badawczym można będzie przeprowadzać badania w rzeczywistych warunkach eksploatacyjnych. W pracy przedstawiono szczegółowy opis zamontowanej instalacji LPG, a także opisano aparaturę pomiarowo-rejestrującą badane wskaźniki i parametry pracy jednostki napędowej. Omówiono możliwości badawcze wykonanego mobilnego stanowiska badawczego. Wykonano również badania rozruchowe w postaci pomiarów mocy na hamowni podwoziowej przy zasilaniu silnika paliwem benzynowym jak i LPG. Uzyskane wyniki świadczą o poprawności działania układów zasilania.

## 1. INTRODUCTION

The energy consumption of the means of transport is up to 25% of the energy produced globally [1]. To a large extent, this energy is produced from petroleum fuels. For example, in the US, this share is up to 97% [2]. This has a significant impact on the economy and in particular on the ecological environment of transport. Due to the combustion of 1 kg of petrol, approximately 3 kg of carbon dioxide is released into the atmosphere in the combustion engine [2]. Motor vehicles form a particularly large group in transport. This causes cars to produce as much as half of the carbon dioxide emitted by all transport [3]. In addition, the automotive flue gas contains a number of toxic components. One way to improve the environmental and especially economic aspects of the car operation is to use gaseous fuels of LPG or CNG type. In Poland, propane-butane gas (liquid petroleum gas) is the most popular fuel. The tests presented in the study [4] allowed to conclude that the operating costs of a passenger car powered by LPG gas fall within the range of 50–56% of the expenditure on the purchase of unleaded petrol with an octane number equal to 95. These costs depend on the fuel consumption of the car influenced by numerous factors [5, 6]. This article presents the measurement instrumentation which allowed to determine both this, wear and other operation figures of the gas vehicle system.

## 2. LPG FUEL SUPPLY SYSTEM

The LPG fuel engine supply system was installed in the Renault Thalia car manufactured in 2003. The truck was equipped with eight-valve, free suction spark ignition engine with capacity of 1390 $cm^3$ and capacity of 55 kW. This drive unit can be supplied with both 95-octave petrol and LPG gas. The second of the above mentioned fuels is supplied by THE STAG LPG system. It consisted of a toroidal tank with a capacity of 42 $dm^3$, a multi-valve Tomasetto Achille, an STAG R02 reducer and an ACW01 injection block. The STAG R02 reducer (Fig. 1) is designed for the power supply system of motors with power not exceeding 100 kW. It allows a reduction of the input gas pressure not exceeding 30 bar to an output pressure of 0.9÷1.5 bar. The body of this equipment is made using aluminum alloy pressure casting technology and a plastic cover in ACtherm system that protects the gas from intense cooling, which significantly affects the thermal inertia. This allows the reducer to heat quickly, allowing the engine to switch from petrol to LPG after a relatively short time. The test results presented in the study [4] indicate that the share of driving a car on gas is as much as 96%.

**Figure 1** STAG R02 reducer

An important component of the LPG gas propulsion unit supply system is the injection strip. As already mentioned, the acw01 strip was used in the TESTED car (Fig. 2). It allows to operate within a wide temperature range from -20°C to 120°C. The gas operating pressure is typically within the range of 0.95÷1.2 bar, although the strip can operate even with a gas pressure of 4.5 bar. Short injector opening and closing times (2.1 ms and 1.5 ms respectively) ensure accurate fuel dosing to each cylinder inlet duct separately. The body of the injection strip in question is also made of aluminium alloy and the brass connection ends make its durability very high [7].


**Figure 2** Common rail ACW01

The LPG system was controlled by the STAG Qbox Basic computer (Fig. 3). It is designed for vehicles driven by a 4-cylinder engine with indirect fuel injection. This controller includes a high performance 32-bit microprocessor that allows precise control of the LPG fuel rate, even when engine

operating conditions change. It allows, inter alia, to change the injection sequence, whether the measurement of the injection time of petrol, which determines the engine crankshaft speed and the potential petrol consumption that would have been demonstrated by the engine when operating on LPG fuel. The operating parameters of the system can be read from the controller using the wireless bluetooth interface. According to the manufacturer, the device may be retrofitted with new functions [7].


**Figure 3** STAG Qbox Basic controller


**Figure 4** STAG Next Wireless Interface


**Figure 5** Autogaz AC parameter recorder

## 3. MEASUREMENT SYSTEM FOR THE ENGINE PETROL AND LPG SUPPLY

For measurement purposes, the gas system of the car is equipped with a wireless Bluetooth STAG Next interface (Fig. 4). It allows you to read and adjust the operating parameters of your system using PC or smartphone or tablet. The system is also connected to the autogaz AC parameter recorder (Fig. 5). It makes it possible to record the parameters of the gas controller during vehicle operation. The data is stored on a built-in memory card from which it can be read via USB port and imported into AcGasSynchro. This device is a specific “black box” for the gas system.

At the end of the common rail there is installed a device to measure gas pressure, negative pressure in the manifold and gas temperature in the gas circuit. The PS-04 STAG measuring unit is designed for LPG (propane-butane) and CNG (methane) gas injection systems in all cars regardless of engine power, including turbocharged ones. It ensures optimum operation of the system regardless of gas quality, driving style and vehicle loading. It allows comparing the temperature drop between the gas phase of the gas in the reducer and injectors under different engine operating conditions and under different loads.

Recording of vehicle motion parameters and estimated consumption of petrol was possible thanks to a wireless diagnostic interface ELM-327 Bluetooth (Fig. 6) connected to the OBDII diagnostic socket in the car. It transmitted data wirelessly to the Samsung Galaxy 4 Mini smartphone with Torque Pro installed and running. During the tests, it was installed in a universal car holder and supplied via a USB connector, from an impulse 12/5 V Mean - well SD-25A-5 converter permanently installed in the vehicle to the side wall of the clipboard on the passenger side. This converter was also supplied by a car video recorder of the Mio 508 route. Figure 7 shows the smartphone used for testing running Torque Pro software used to record research data. It can be used to record large amounts of data made available by the vehicle’s on-board computer and by sensors installed in the smartphone (e.g. acceleration sensors). The measuring system also enabled the registration of geographical coordinates read from GPS satellite navigation. The smartphone screen displays the values of several selected parameters on an ongoing basis (Fig. 7). The data read by the ELM-327 was transmitted by radio to the Bluetooth smartphone. To ensure high accuracy of measurements, data was stored at a frequency of 2 Hz.


**Figure 6** Bluetooth Wireless Diagnostic Interface ELM-327


**Figure 7** Smartphone Samsung Galaxy 4 Mini running Torque Pro

## 4. COMMISSIONING TESTS FOR LPG MOBILE POWER SUPPLY STATION

After installing the LPG fuel propulsion unit power supply system and sensors and recorders, start-up tests were carried out in the form of power measurements on the chassis dynamometer with the engine supplied with petrol and LPG fuel. According to the obtained results, the motor had the capacity of 57.1 kW with petrol fuel at the rotational speed of 5695 rpm (Fig. 8).

For the LPG motor, there was a slight significant power drop of about 0.7 kW. Tightness tests of the gas installation and operation of the metering and data recording systems were also performed. Positive results of the commissioning tests confirm the correct operation of the installed systems, it should also be mentioned; that the mobile test station will be extended with additional measuring instruments.

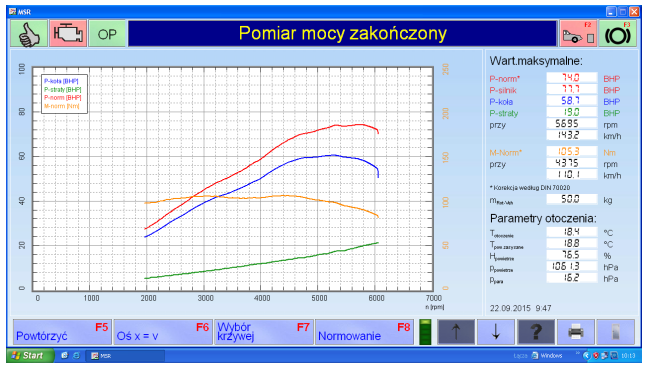


**Figure 8** Results of power measurments on chassis dynamometer

## 5. CONCLUSIONS

The set of apparatus installed in the vehicle makes it possible to conduct extensive performance tests related to the use of a passenger car fuelled with petrol and LPG gas. An important element is the fact of conducting long-distance tests at the mileage of 50 000 km, divided into stages with the length of 10 000 km. At each stage, the results of parameters and indicators of operation of the drive unit with petrol and LPG fuel will be collected and ANALYSED. The main direction of tests will be the economy of fuel gas supply. Additionally, tests of the technical condition of the motor, such as pressure compression measurements, shall be carried out.

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