NADA ŠTRUMBERGER, D. Sc.
Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Republika Hrvatska
E-mail: mira@fpz.hr
ŽELJKO ŠEKERIJA, B. Eng.
Lucent Technologies
Brigittenauer Lande 50-54, 1000 Wien, Austria
E-mail: zeljko_sekerija@yahoo.co.uk
DRAGAN PERAKOVIĆ, M. Sc.
Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Republika Hrvatska
E-mail: dragan.perakovic@fpz.hr

Traffic Safety and Ecology
Review
U. D. C.: 656.13:662.959.2
Accepted: Jul. 22, 2002
Approved: Mar. 18, 2003

AUTOGAS IN ROAD TRAFFIC

ABSTRACT

LPG is an international abbreviation for liquefied petroleum gas, i.e. autogas. Today, there are about 5 million vehicles in the world that use autogas and the number is constantly growing. One of the reasons lies in its efficiency which is proven in the 50% lower fuel price and in the lower maintenance price of the automotive parts! From the ecological aspect, autogas is a much, much lesser polluter which does not let out fumes, lead, solid particles and sulphur oxides into the atmosphere, generating at the same time less carbon dioxide and non-degradable hydrocarbons. Because of its characteristics autogas has favourable impact on the engine. The engine durability is increased by about 35% compared to petrol, the engine operates more quietly, the cylinders wear out less, the oil lasts longer in the engine, the durability of the catalyst and the lambda tube is doubled. Complete combustion of the gas-air mixture in the engine cylinders does not result in fuel losses in the exhaust gases. The exhaust gases are cleaner.

KEY WORDS

LPG, autogas, road traffic, environmental protection

1. INTRODUCTION

LPG is the international abbreviation for *liquefied petroleum gas* (for the Croatian expression *Ukapljeni Naftni Plin* the abbreviation *UNP* is used in the *Regulations*) a mixture of propane and butane, and in literature the terms propane-butane, UNP, GPL, BTP may be found, whereas autogas is a standard name.

Experiments with the gas as fuel started at the beginning of the 19th century.

Philippe Lebon (1801), William Cecyl (1817), Samuel Brown (1823), Lemuel Wellman (1833) and *Etienne Lenoir (1860)* constructed an engine using gas as propulsion. These studies have solved the technical and the operation problems, and *Christian Reithman* used them to develop designs to produce a two-cylinder engine (1876). After the gas-propelled engine started to be manufactured, the production results were excellent, over 30,000 engines, and then the idea was born to manufacture a faster petrol engine, produced in 1882 at *Daimler & Mayback*. After that, the gas engines were replaced by petrol engines, and since 1886 they have been used in automotive industry. One of the reasons why in the history petrol started to be used as automotive fuel rather than autogas, is the problem of transporting autogas. At that time, the process of compressing autogas, in order to make the transport easier, had not been known. Between 1920 and 1940, at the time of great economic crisis and breakdown of the Wall Street, there was a great increase in using the gas engines due to the low gas prices, only to be abandoned with the arrival of the economic stability.

Figure 1 - Liquefied Gas in Europe

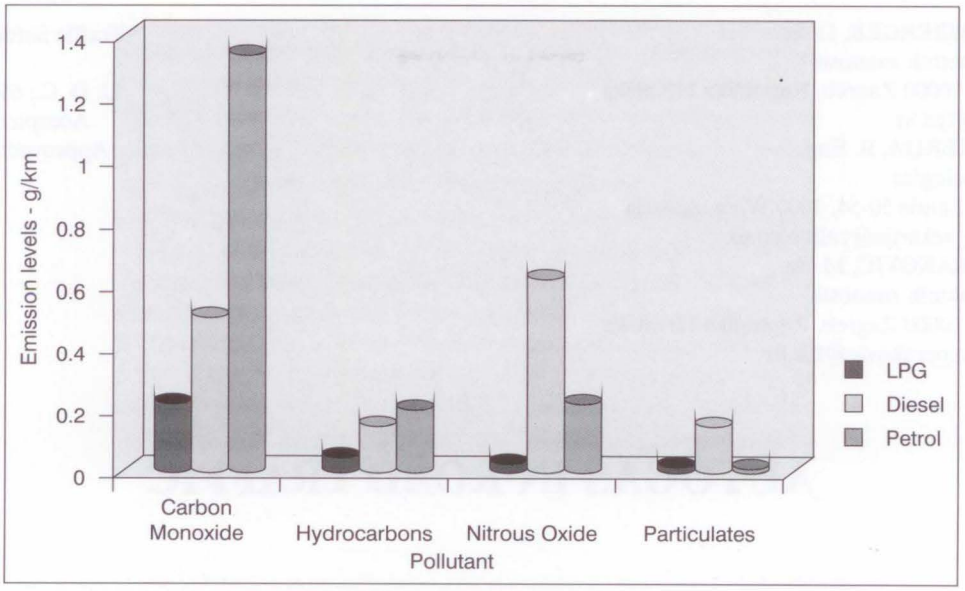

Figure 2 - Emissions tests on light duty vehicles after 50,000 milles

1.1. Gas in the World

It is very difficult to determine the number of gas propelled vehicles in the world, but the current estimates indicate about 5 million, and the number is increasing constantly. In Great Britain, which has the highest concentration of vehicles on its roads, the number of gas propelled vehicles is very low, about 50,000, and therefore the government is introducing incentive measures in order to raise this number by 2004 to 250,000.

In Japan, which has big problems with the density of population, all the TAXI vehicles have to have gas propulsion. This is also the reason why Japan has been recording the greatest increase of gas propelled cars lately. Until recently, Italy had the greatest number of gas propelled cars, which is on the second place with about 1,200,000 cars, followed by the Netherlands with 800,000, South Korea with 790,000, and finally Australia with 530,000.

In Europe, an example of using autogas in public transport is Vienna, where autogas has been used for the last 30 years because of the energy efficiency and the environmental reasons. Currently, there are 550 buses that use autogas in public transport.

In some European countries where gas had not been used as alternative fuel, after a number of economic studies and studies of environmental impacts, the number of gas-propelled vehicles started to grow. For example, in Spain, the government has started testing the use of gas in public transport, using as example the town of Valladolid, where a contract was signed to convert 110 buses to gas as fuel, and after that the project is expected to expand to 15 major Spanish cities.

In the big cities of eastern Europe (Moscow, Kiev, Budapest, Prague), the government has recognised the positive effects of autogas in environmental protection, and because of high concentration of vehicles in the downtown area, they have adapted the new laws to autogas as a very environmentally friendly fuel.

In other parts of the world, as e.g. in Taiwan, big automotive manufacturers install gas engines in serial production. About 10,000 taxis already use gas in order to reduce the costs. In California, the technically most developed region of the world, the resolution on environmental protection recommends, apart from electricity, propulsion of vehicles using autogas and methane.

According to an estimate by the National Propane Gas Association (NPGA), in 2010, only in the USA, there will be 17 million gas propelled vehicles.

In meeting the increasing requirements for environmental protection and the increasingly rigorous standards regarding concentration of harmful gases in the atmosphere, autogas should become one of the primary fuels in automotive industry.

2. EFFICIENCY

In calculations it is necessary to take into consideration that the autogas consumption is about 10% greater than petrol consumption. The efficiency is reflected in the almost 50% lower fuel price, and reduced costs of vehicle maintenance.

The gas vehicle autonomy depends on the size of the tank and fuel consumption. On longer relations, with a smaller tank and average consumption it is possible to travel more than 450 km. However, it has to be remembered that gas installations mean that the vehicle can still use petrol without any changes, that is, that in fact the vehicle may use two types of fuel. Taking this into consideration, the vehicle autonomy is about

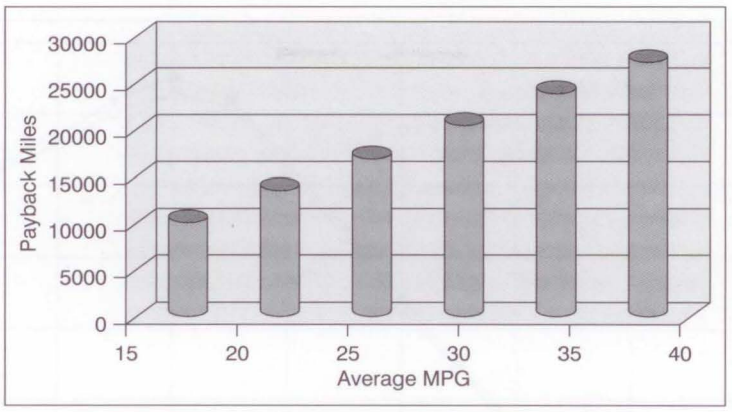

Figure 3 - Autogas Conversion Payback (inc.VAT)

Figure 4 - £10 fuel-Mileage

1,000 km without having to visit a gas filling station or a petrol station.

After having completed the installation no certification is needed. The gas installation only needs to be recorded and technically inspected.

The gas installations need to be controlled after the travelled 20,000 km or once a year. Rarely does the device need replacing or servicing before having travelled 50,000 km.

2.1. Influence on the Engine

Due to its characteristics, autogas has a favourable impact on the engine:

- quieter and smoother engine operation,
- engine life time is increased by about 35%,
- complete combustion of the gas-air mixture in the engine cylinders does not lead to fuel losses in exhaust gases,
- longer durability of engine oil (it keeps its own characteristics for a longer period of time, because it does not degrade with petrol),
- does not allow creation of corrosion which results from the presence of additives added to petrol in order to improve its qualities,
- higher octane number (rating),
- doubles the lifetime of the catalyst and lambda tube, because gas does not contain either sulphur or lead,
- cleaner exhaust gases.

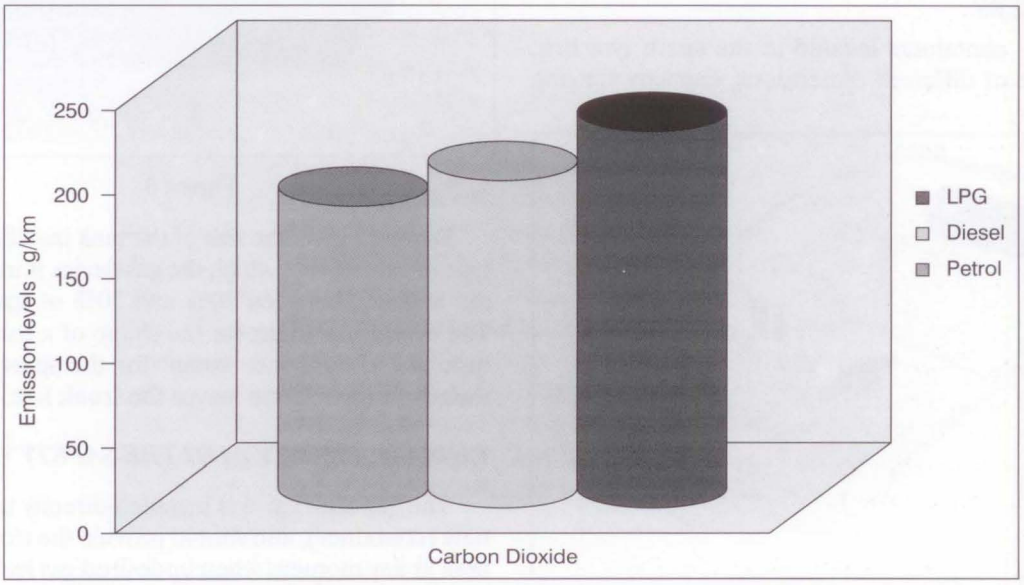

Figure 5 - Carbon Dioxide Emission Tests on light duty vehicles after 50,000 miles

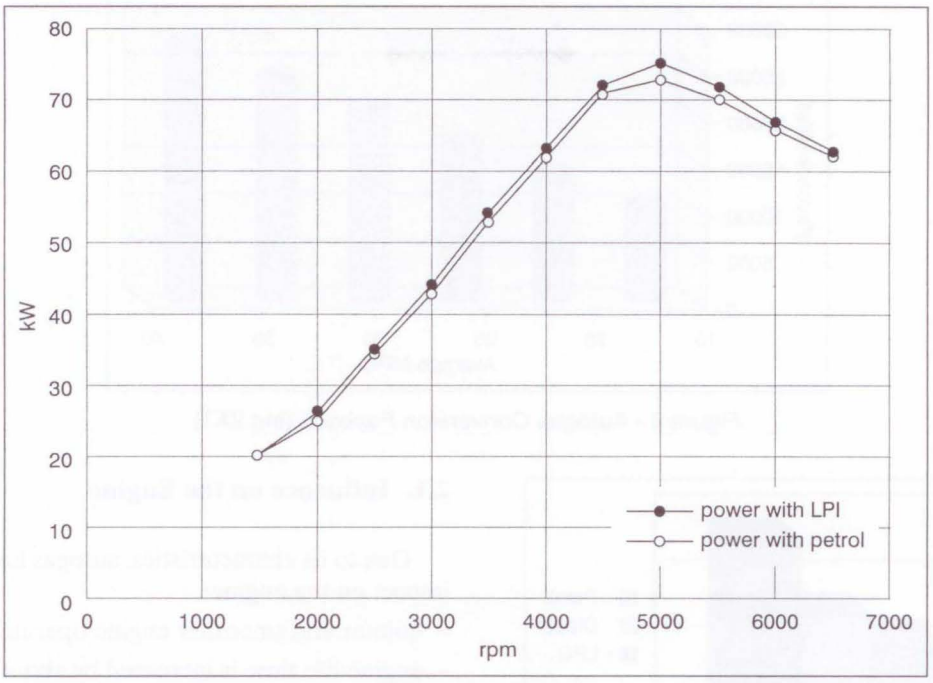

Figure 6

2.2. Influence on the Speed and Vehicle Performance

With the installation of a conventional gas installation, about 5% is lost in speed, and about 10% in power, whereas the running of the engine is quieter and smoother. In flying injection the loss of power is almost negligible, and according to tests performed by gas device manufacturers, it is less than 2%.

3. INSTALLATION OF AUTOGAS IN LIGHT DUTY VEHICLES

CONTAINERS

a) *round* - containers located in the spare tyre box, may be of different dimensions, capacity ranging from *35*l to *70*l, depending on the make of the vehicle,

b) *cylindrical* - located in the car trunk, capacity ranging from *35*l to *110*l, of different lengths and diameters depending on the make of the vehicle.

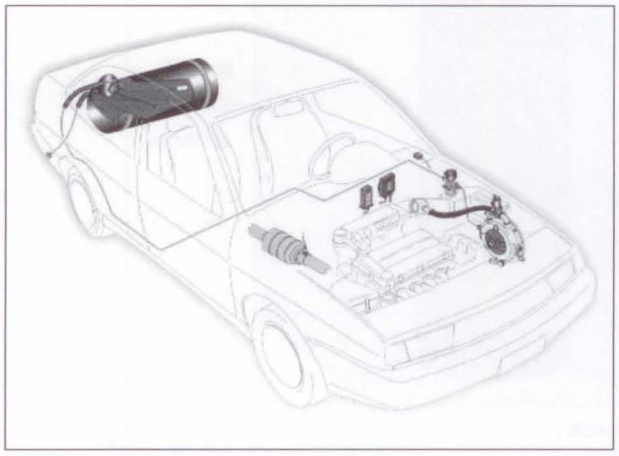

Figure 7

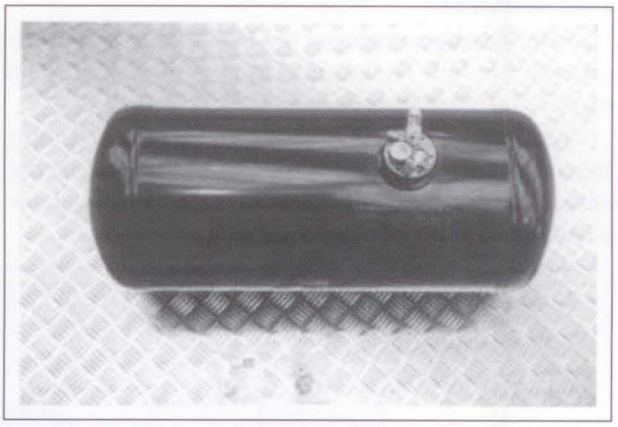

Figure 8

Depending on the size of the tank installed and the type of vehicle into which the gas device is installed, on the average, between 20% and 30% of space is lost. The cylindrical tanks (in the shape of a car tyre), are installed in the space meant for the spare tyre, and thus their installation leaves the trunk free.

TANK EQUIPMENT WITH THE SAFETY VALVE

The gas tank valve is installed directly into the gas tank (container), and should provide the closing of the tank at any moment when undesired gas leak from the tank needs to be prevented. The equipment prevents

Tank size (water Capacity)	LPG content Capacity (litres)	Diameter (mm)	Depth (mm)
30 Ltr	24 Ltr at 80% maximum fill	270	635
40 Ltr	32 Ltr at 80% maximum fill	300	670
47 Ltr	37.6 Ltr at 80% maximum fill	230	1295
50 Ltr	40 Ltr at 80% maximum fill	300	670
55 Ltr	44 Ltr at 80% maximum fill	360	650
60 Ltr	48 Ltr at 80% maximum fill	300	980
70 Ltr	56 Ltr at 80 % maximum fill	320	980
85 Ltr	68 Ltr at 80% maximum fill	360	945
100 Ltr	80 Ltr at 80% maximum fill	360	1100
120 Ltr	96 Ltr at 80% maximum fill	360	1300

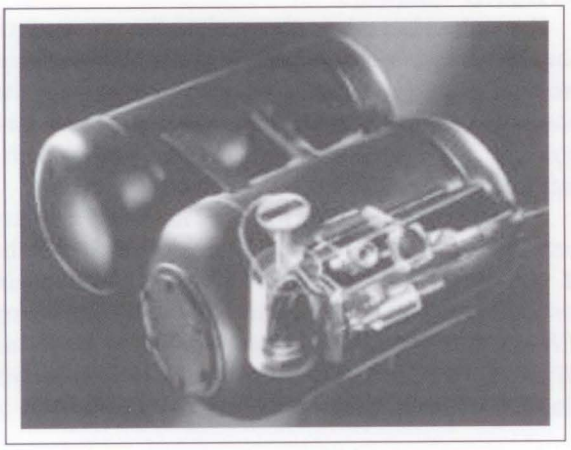

Figure 9

Figure 10

formation of excessive (too high) pressure in the tank and limits the gas flow in case of uncontrolled gas leakage from the tank.

With the increase in temperature, the pressure rises as well and therefore the tank can be filled up to 80% in order to avoid the sun explosion. The manufacturers test the tanks to a pressure of 30 bars, so that in practice, the tanks would not explode even if filled up to 100%. Beside all these safety measures, the tank itself is fitted with a valve that in case of high pressure has the role of relieving the tank. Thus, any possibility of explosion is eliminated. The container and the safety equipment are designed in such a way that even in case of fire they would not explode, and in case of a more severe traffic accident they have proven to be an additional shield against impact.

VENT

The Regulations have stipulated that the space accommodating the gas tank has to be aired. Therefore the space inside the car body, accommodating the tank, should be fitted with a device that will prevent creation of excessive pressure due to a possible gas leak, thus at the same time allowing efficient airing of the area.

REFUELLING CONNECTION

is a device which allows gas refuelling of the tank.

There are several possibilities of installing the connection:

a) next to the opening of petrol refuelling,
b) on the vehicle bumper or any other location chosen by the customer as long as it complies with the Regulations requirements.

SWITCH

is the device that is used for switching from gas to petrol and vice versa, located in the vehicle cabin, usually on the dashboard or any other suitable and visible place.

There are ready-made switches adapted by form and function, depending on the type and make of the vehicle.

The newer generation of switches also has an installed fuel level indicator.

CENTRAL UNIT

Electrical device allowing the vehicle to use gas is connected to the existing central unit in the vehicle.

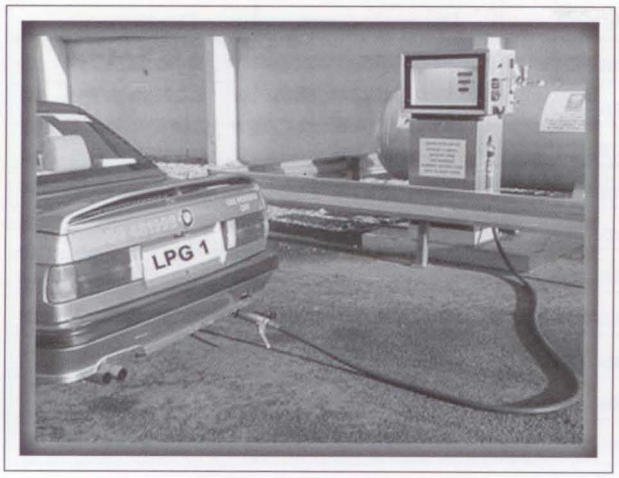

Figure 11 - Autogas Refuelling

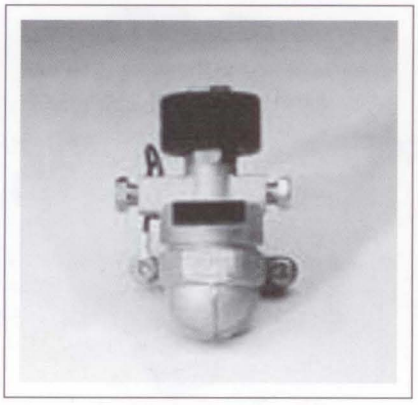

Figure 12

All types of central units of the latest generation are installed, which are digital and have automatic adjustment and precise regulation of fuel mixture.

4. AUTOMOBILES WITH PLASTIC INLET NOZZLE (FLYING INJECTION)

In case of the latest vehicle generation, with the plastic inlet nozzle, the direct gas injection is installed. This reduces the power loss compared to petrol in the amount of ca. 2%, which is almost negligible.

The direct injection system, intended exclusively for vehicles with plastic inlet nozzle, complies with the strict criteria regarding exhaust gases - the EURO 3, i.e. EURO 4 standard.

From the gas tank to the engine, the system functions so that gas which is in the tank flows under high pressure as a liquid to the front part into the vaporiser where the cooling system heats it up and converts it from the liquid into the gaseous state, and as such it enters the engine.

Gas propulsion can be installed in almost all petrol running vehicles, and there is only a very small number of vehicles which have problems (e.g. some turbine running vehicles). The more recent technology (*FLYING INJECTION*) allows installation of gas into all vehicles, as well as into the engine generation with plastic inlet nozzles.

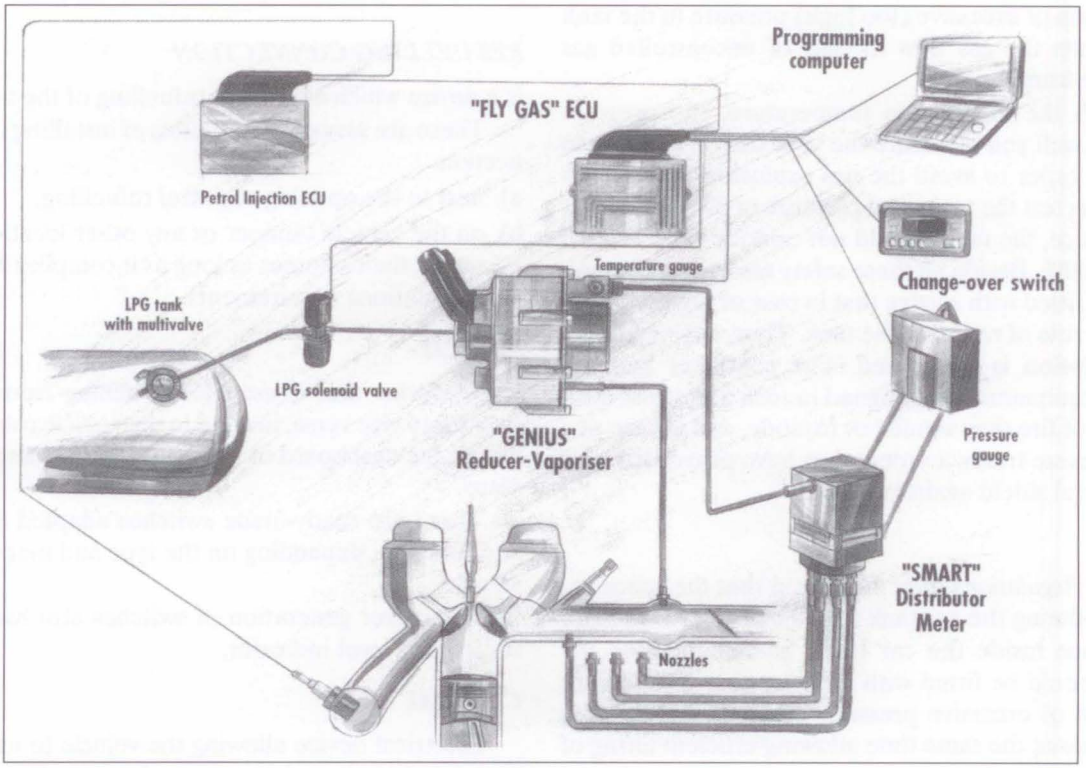

Figure 13

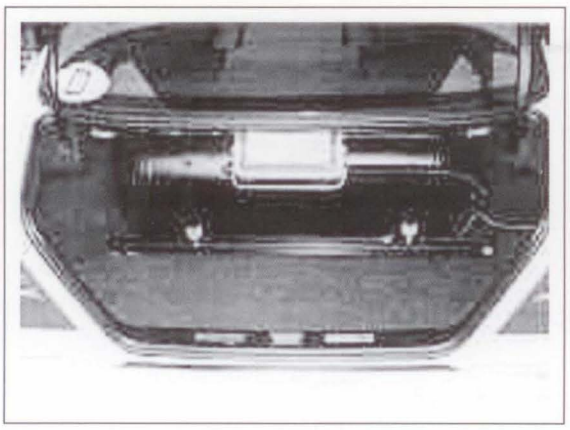

Figure 14

In off-road conditions the gas pipe cannot be damaged, because the pipe is installed in a part where it is protected.

In winter months, in case of older cars with carburettors, the ignition may become a problem, but there are no problems in case of injection engines, since the ignition always uses petrol, and depending on the system, after a certain number of engine revolutions, or upon reaching a certain engine operating temperature, it switches automatically to gas. (*FLYING INJECTION*).

7. CONCLUSION

The paper presents the autogas effect in environmental protection, especially in urban road traffic and in petrol engines. Positive laws and regulations should regulate the implementation of gas fuels so that all mass transport vehicles should be running on gas.

The usage of autogas as fuel provides a number of advantages, regarding the engine itself and the data on exhaust emissions are more favourable regarding the environment, and they comply with the strict criteria of exhaust emission standards EURO 3 i.e. EURO 4. The implementation of autogas as fuel is reflected in the lower price of fuel, longer life, e.g. quieter operation and more favourable emission of exhaust gases.

Autogas is the gas of the future for the petrol engines in road traffic.

The acceptable alternative fuel for Diesel vehicles is - bio diesel - clean methyl ester of rape-seed oil or as a mixture of gas oil and methyl ester of rape oil.

NADA ŠTRUMBERGER, D. Sc.
Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Republika Hrvatska
E-mail: mira@fpz.hr
ŽELJKO ŠEKERIJA, B. Eng.
Lucent Technologies
Brigittenauer Lande 50-54, 1000 Wien, Austria
E-mail: zeljko_sekerija@yahoo.co.uk
DRAGAN PERAKOVIĆ, M. Sc.
Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Republika Hrvatska
E-mail: dragan.perakovic@fpz.hr

SAŽETAK

AUTOPLIN U CESTOVNOM PROMETU

LPG je internacionalna skraćenica od liquefied petroleum gas koja u prijevodu znači ukapljeni naftni plin tj. autoplin (UNP). Danas u svijetu ima oko 5 milijuna vozila koja se pogone na autoplin te je ta brojka u stalnom porastu. Jedan od razloga je njegova ekonomičnost koja se dokazuje u 50% nižoj cijeni goriva te nižoj cijeni održavanja sastavnih dijelova automobila! S ekološkog aspekta autoplin je puno, puno manji zagađivač okoliša koji ne ispušta dim, olovo, krute čestice i sumporne okside, a ujedno proizvodi manje ugljičnog dioksida i nerazgradivih ugljikovodika. Autoplin zbog svojih karakteristika ima povoljan utjecaj na motor. Trajnost motora se uvećava za cca. 35 % u odnosu na benzin, tiši je rad motora, cilindri se manje troše, veća trajnost ulja u motoru, trajnost katalizatora i lambda sonde se udvostručuje. Potpuno sagorijevanje smjese plin-zrak u cilindrima motora ne dovodi do gubitka goriva u ispušnim plinovima. Ispušni plinovi su čišći.

KLJUČNE RIJEČI

UNP, autoplin, cestovni promet, zaštita okoliša

LITERATURE

[1] *Liquefied Petroleum Gas ("Autogas") Standards* - October 2001
[2] *"Alternative Fuel: Composition, Performance, Engines, and Systems."*: Society of Automotive Engineers, 2001.
[3] *"Design Innovations in Alternative Fuels Technologies."*: Society of Automotive Engineers SAE, 2001.
[4] *"Clean Cities - Environmental Showcase: Propane."*: U.S. DOE, 1999, hosted by Larry Hagman.
[5] *"Facts About CNG and LPG Conversion."*: U.S.
[6] *"Propane: The Fuel of Choice for the 21st Century."*: National Propane Gas Association, 1999.
[7] *"The Road to Clean Air."*: Natural Gas Vehicles, 1996.