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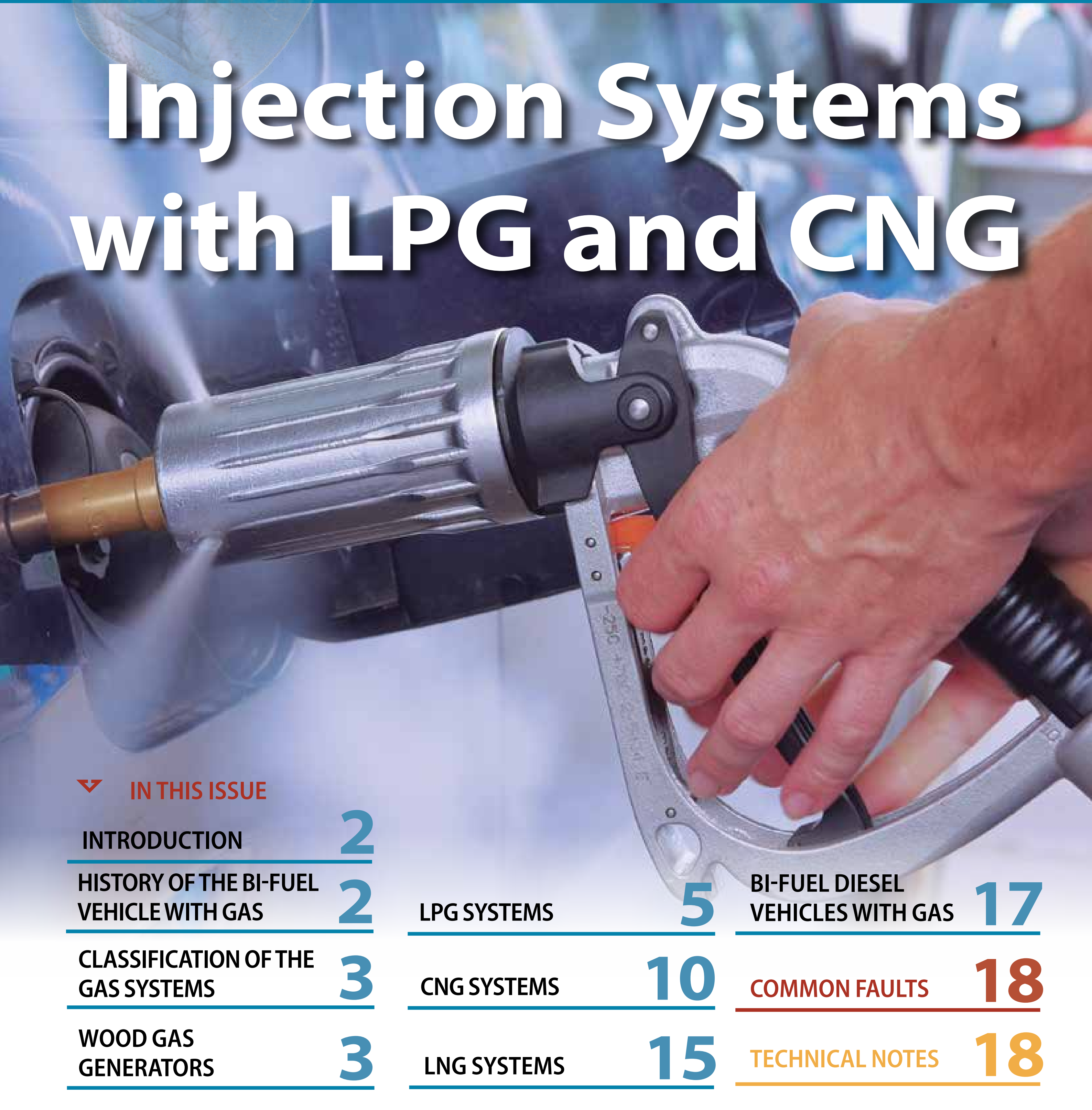
Eure!TechFLASH

THE UP-TO-DATE TECHNICAL INSIGHT IN AUTOMOTIVE TECHNOLOGY & INNOVATIONS

EDITION 20

Injection Systems with LPG and CNG



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EureTechFlash is an AD International publication (www.ad-europe.com)

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INTRODUCTION

The increasingly restrictive anti-pollution standards are obliging car manufacturers to develop more efficient and environmentally friendly vehicles. One of the technologies recently promoted by manufacturers is the development of gas fuelled engines, a modification that has been applied for many years as an economic solution.

Bi-fuel vehicles are characterised by the use of internal combustion engines that can run on two different fuels, normally petrol and a compressed gas (LPG, CNG or LNG). Nevertheless, diesel engines can also be found (particularly in industrial vehicles) that work with diesel and some of the aforementioned gases.

The use of these gases provides the following advantages:

- A cleaner fuel together with a notable reduction of CO2 and polluting emissions (NOx, CO, PM, etc.).
- It is a more economic fuel than petrol.
- The combustion engine suffers much less wear than one that uses solely petrol, as the gas leaves a lower quantity of residues and does not contaminate the oil.
- The engine is quieter with lower vibrations when running on gas.
- The great majority of petrol vehicles can be converted to LPG, as the operation is very similar and the installation of the necessary equipment is not very complicated.
- A longer range can be achieved when using two fuels.

Nevertheless, there are some drawbacks:

- The price of converting a vehicle to gas is high.
- The consumption in mass of fuel is between 5 and 10% higher with gas with respect to running on petrol.
- The engine power is reduced by up to 10%, depending on the gas.
- The number of service stations for refuelling may be limited, depending on the country, especially for CNG and LNG.
- Refuelling is slightly more complicated than the traditional refuelling of petrol and diesel vehicles.
- In non-specific engines, the use of additives is necessary to prevent drying and premature wear of the valve seats.

HISTORY OF THE BI-FUEL VEHICLE WITH GAS

The use of different gases as a fuel has been known for centuries, although their application was limited to lighting until the electric light bulb was invented in 1879. Between 1900 and 1912, it was found that unrefined natural gasoline had a very strong tendency to evaporate due to the presence of "unstable" substances in the fuel.

Around 1911, the American chemist Walter Snelling demonstrated that the evaporation was due to the propane and butane present in the gasoline. He developed a simple method in which he managed to deliberately separate these gases from the gasoline to later liquefy them at a reasonable pressure. This discovery marked the beginning of a new fuel that was called Liquefied Petroleum Gas (LPG), which could be transported in the liquid state and used in the gaseous state.

The first vehicles fuelled with gas ran on uncompressed gas and became popular during the First World War due to the scarcity of petrol, this was even more the case in the Second World War. At this time, although gas was much cheaper, its drawbacks were considerable. As no effective means for its compression were available, a very large storage vessel was required, and the use of bags located on the roof rack was introduced.

The enormous bag was completely filled before the journey and would gradually go down during it. However, bridges, tunnels, branches and other obstacles could damage the bag, as well as high speed. Exceeding 50 km per hour was not advisable under any circumstances.

Between the end of the First World War and the post-war period of the second, the difficulties of supplying oil and its derivatives to a large part of the global market resulted in many existing private and agricultural vehicles switching to running with a technology called gasification.

The imperfect combustion of certain solids produces carbon monoxide, which as a gas still has some calorific value. If water is added to the reaction as well, hydrogen can be generated which is also a fuel.

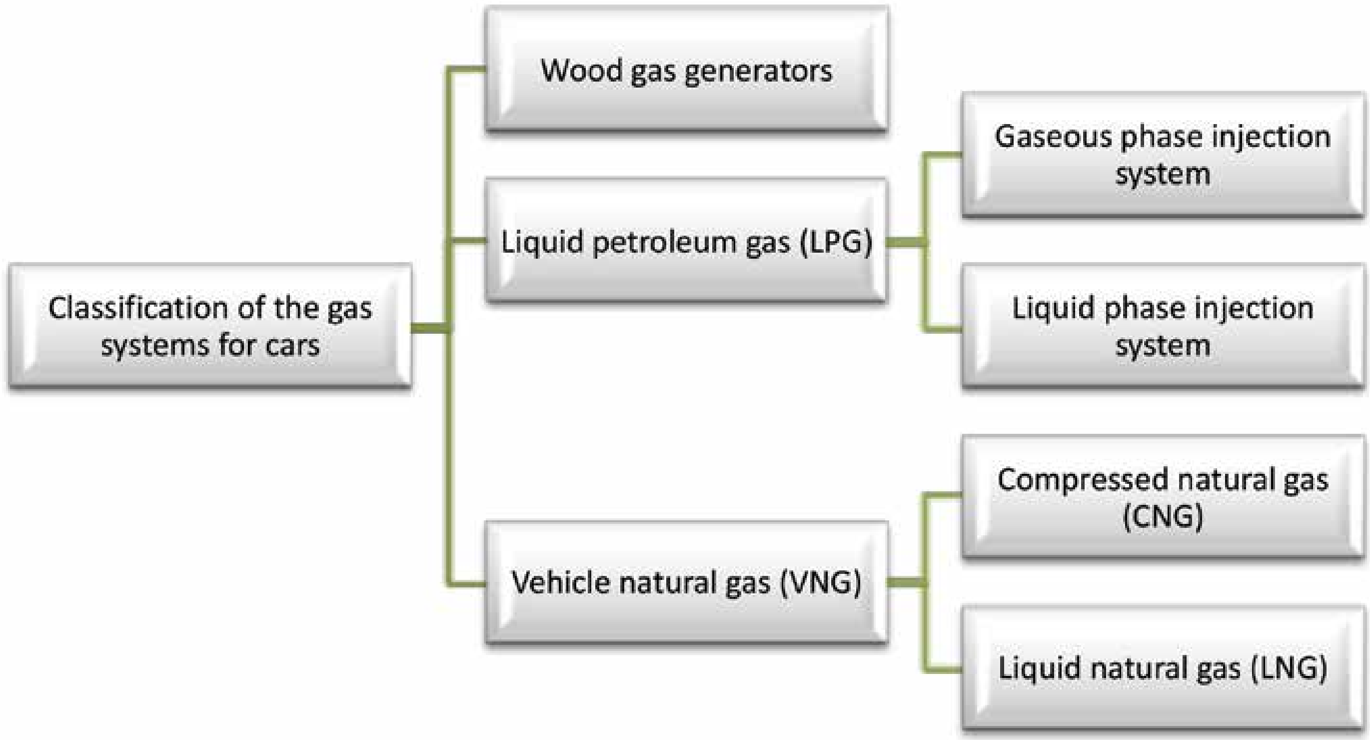
In the second half of the 20th century, thanks to the introduction of metal gas bottles, fuelling engines with LPG gas was perfected and the sector grew at the rate of the availability of bottling refineries and distributors. Marketing in the compressed state replaced the oversized bag with a relatively small metal bottle that could easily be replaced for another when the gas was consumed.

Natural gas extracted from the ground was also used to run a combustion engine. This gas was called vehicle natural gas (VNG) and was marketed in two variants: compressed natural gas (CNG) and liquid natural gas (LNG). In 1939, the Italian company Tartarini was the first in the world to design a CNG installation for use in road transport. Its operation is similar to that of LPG, but it is stored at much higher pressures in order to achieve sufficient energy density.

Currently, only LPG and VNG systems are used for vehicles.

CLASSIFICATION OF THE GAS SYSTEMS

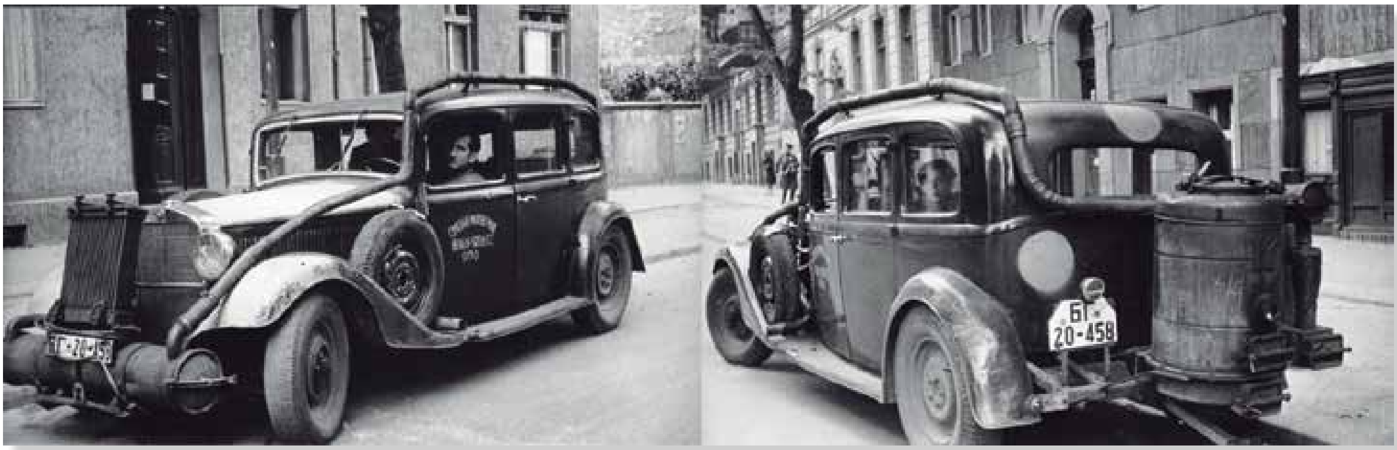
Throughout the history of the car, numerous systems have been used for motor vehicles to run on gas. The most notable are wood gas, liquid petroleum gas (LPG), compressed natural gas (CNG) and liquid natural gas (LNG). In the case of LPG, there are two variants: the gaseous phase injection system and the liquid phase injection system.



WOOD GAS GENERATORS

The wood gas generator is a device installed in petrol vehicles in order to gasify a solid fuel.

When wood, charcoal or any other chopped material with a high content of carbon is partially burnt, combustible gases are generated. Burning solids in closed vessels with a deficit of air produces significant quantities of carbon monoxide (CO), which can be used as a gaseous fuel in combustion engines that have been adapted for this purpose. The pre-compression of the mixture in these engines facilitates ignition and complete oxidation of the CO, releasing heat. When using this system, solid fuels can be used to drive internal combustion engines at times when there is a scarcity of petrol or other compatible liquid fuels.

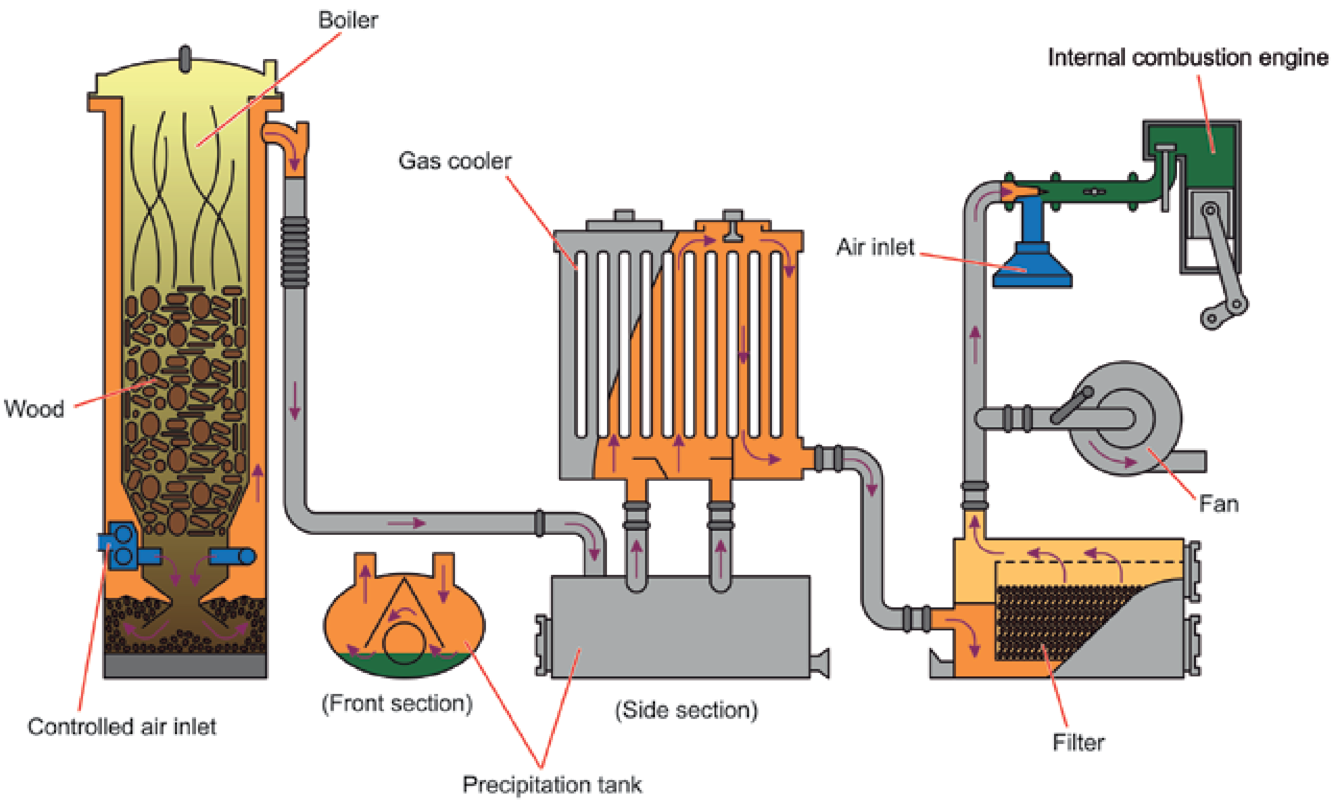


The gasification process that converts organic material into gas has been used since 1870 to obtain lighting gas in places where supplying specific fuels was difficult.

It was the French chemical engineer Georges Christian Peter Imbert, born in 1884, who perfected the technique for obtaining combustible gas from wood in the first quarter of the 20th century by creating a portable system for cars. Based on his design, necessity led to hundreds of variants appearing that were adapted to all types of vehicles. In some locations, the scarcity of fuels became such that variants of the system were constructed that were not based on wood or carbon as a raw material, but on calcium carbide that on reacting with water produced acetylene.

The wood gas generator consists of a large metal container that is used as a boiler in which the solid fuel is placed that will undergo partial combustion. For the invention to function correctly, the boiler requires a controlled inlet of air so that the wood does not burn completely due to the scarcity of oxygen. The solid fuel is partially oxidised in order to increase the formation of carbon monoxide (CO), which does not occur when combustion is complete.

The carbon monoxide produced is conducted by means of pipes to a precipitation tank, a cooler for increasing the density and a filter for retaining the solid impurities. The treated gas enters the petrol engine cylinders mixed with air where it explodes when the ignition system generates the ignition spark.



Due to the low energy content of carbon monoxide, the performance of an engine supplied with wood gas was very low. The reduced power did not allow the vehicle to travel at high speeds and it sometimes could not get up slopes. For this reason, mechanisms were incorporated into many installations to enrich the mixture in an ad hoc way, such as water vapour systems adding hydrogen to the combustion reaction. Other installations had a small tank for petrol or alcohol connected to the engine and a stop-cock that was only opened when it was necessary to overcome an obstacle.

Another problem of the wood gas generator was the large volume of components necessary to produce sufficient gas. Adapting the system for lorries and buses was less complicated, as it could be installed at the rear or even on the extensive roof, but it was quite complicated for cars. Sometimes if there was insufficient space for the boiler, it was installed on a trailer behind the vehicle.

Adapting a vehicle with a petrol engine to run on wood gas was not a complicated task. The adaptation could be done in a short time with few materials. Over time special kits arrived, under various patents, intended to facilitate the assembly task. Some vehicles, such as the Volkswagen Beetle, were manufactured at certain times with the wood gas generator installed as standard. The refilling of solids in this model was done through a hole in the bonnet.

LPG SYSTEMS

Liquid petroleum gas (LPG) is the liquid mixture of the gases dissolved in petroleum, principally propane and butane. Although they are both gases at ambient temperature and pressure, they are easy to liquefy by moderately increasing the pressure, which gives them their name.

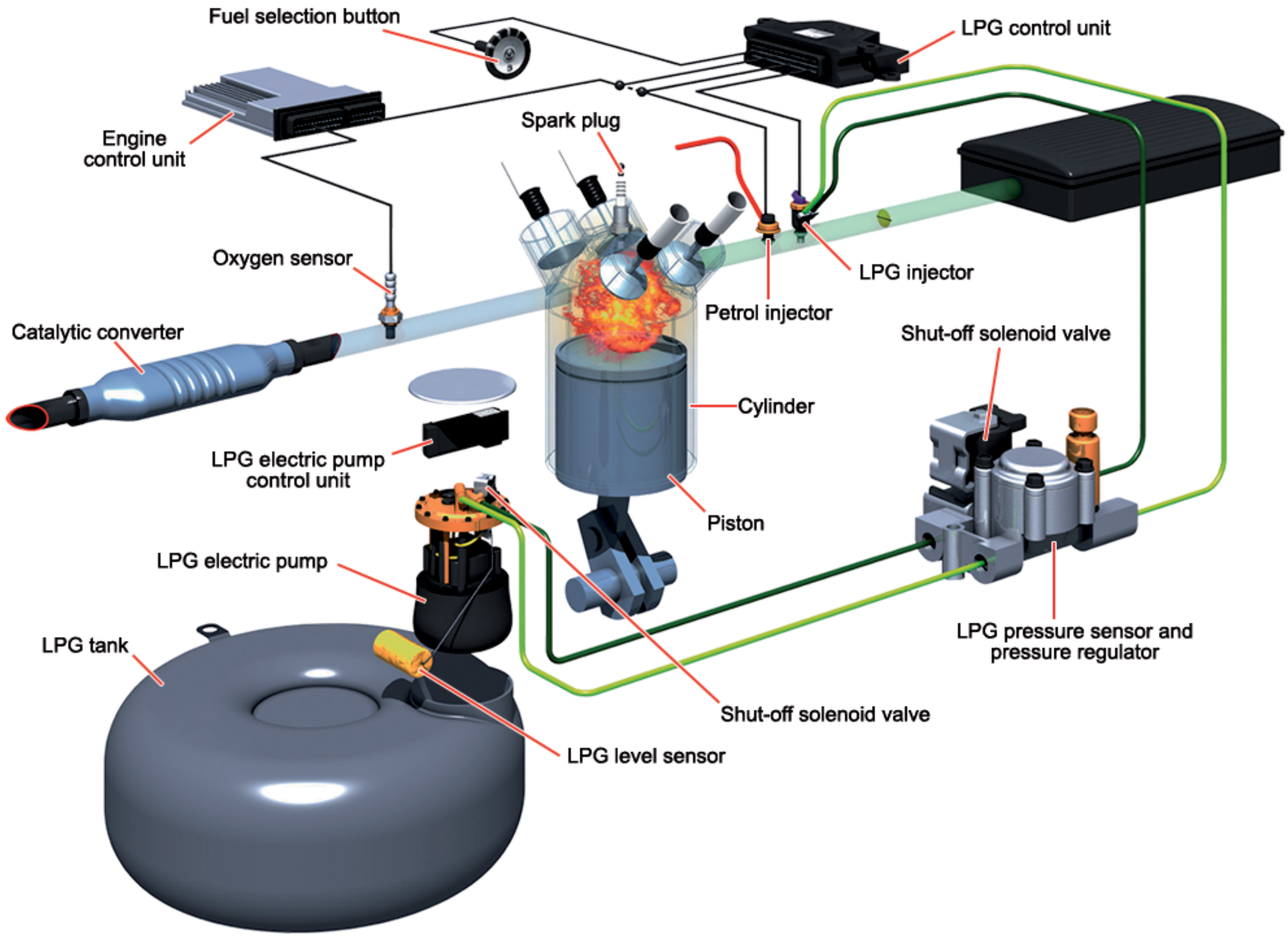
LPG is obtained in two ways. 60% of production is obtained directly in the gaseous state during the exploitation of oil fields, while the remaining 40% is produced during the refining of the crude oil. Therefore, LPG is a secondary product that exists naturally.

Gaseous phase injection system

This system is the most common as it does not require significant mechanical changes to the vehicles. The system has a tank, pipes, electronic components and an injection system. The conversion of petrol engines to run on LPG injected in the gaseous state is simple, especially in indirect injection models.

The dosing of the fuel is carried out directly in the gaseous phase and indirectly, i.e. in the intake manifold and at low pressure.

The main advantage of LPG, apart from its price, is that proportionally it produces less pollutants than a petrol engine, although it has the disadvantage of consuming a greater mass of fuel and the total power of the engine is reduced by approximately 10%. Another drawback is that the engine cannot be started directly with LPG as its density varies substantially depending on the pressure and temperature of the air in the intake manifold. Therefore, cold starting must be carried out with petrol and then change automatically to gas when the engine reaches the sufficient temperature.



The system has a tank where the LPG is stored in a liquid state at an approximate pressure of 8-10 bar which is filled up to 80% of its total capacity. The tank incorporates a solenoid valve, that acts as a shut-off valve, and a manual valve for shutting off the flow to the pipes in case of emergency, or when the vehicle is stopped for long periods of time.

The fuel is conducted in the liquid state from the LPG tank to the pressure regulator through pipes. There is another shut-off solenoid valve in the regulator. The regulator has the function of reducing the pressure of the LPG to approximately 1 bar, this changes the state from liquid to gas to facilitate its dosing for injection.

The low-pressure gas is conducted to the injection rail where the LPG injectors are located. These injectors can be directly located in the intake manifold or, depending on space, the dosed gas can be conducted to the manifold by means of small pipes.

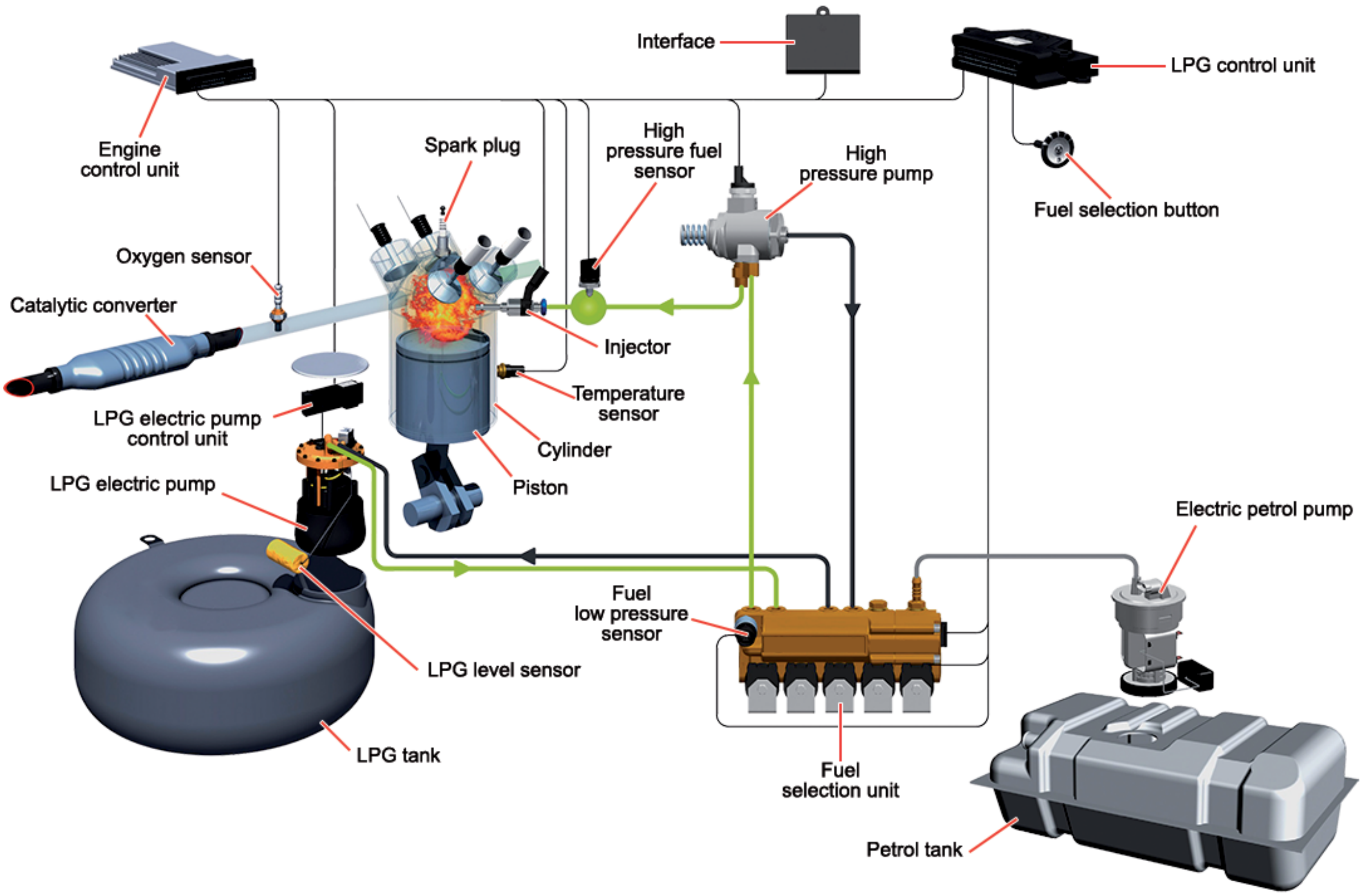
The entire system is managed by a specific control unit that communicates with the engine control unit so that the change of fuel can be carried out correctly, and the necessary information obtained for the dosing of the GAS mass. A filter may be located in any part of the circuit between the tank outlet and the rail inlet to remove impurities from the LPG. There is usually a pressure sensor located between the pressure regulator outlet and the injection rail.

The LPG gas has the characteristic property of drying out the intake/exhaust valves and their seats. To overcome this disadvantage, vehicle manufacturers fit special valves in models equipped with factory-installed LPG systems. In converted vehicles, a special additive mixed in the petrol tank must be used.

Liquid phase injection system

This is the most modern LPG injection system which doses the fuel in the liquid state and at high pressure. It can be used both in petrol engines with indirect injection technology and in current direct injection engines, such as TSI, TFSI, PureTech, etc.

LPG injection in the liquid phase reduces the temperature of the air/fuel mix to achieve a similar effect to the intercooler, which gives better performance and efficiency of the engines. The performance is equivalent to that obtained with petrol, bringing the operation of the engine into line with the characteristics and values for which it was designed, and even increasing its performance. The dosing of LPG in the liquid state allows the engine to be started with gas.



The LPG is maintained in the liquid state during the entire process, it is introduced into the cylinders through the same injectors as the petrol and it is compressed with the same high-pressure pump. When injecting in the liquid phase, the maximum combustion temperature is reduced.

The most important component in the system is the fuel selection unit, which swaps the supply between petrol and LPG without problems. The petrol and gas enter the selection unit and the selected fuel flows to the high-pressure pump, which regulates the pressure of the liquid before it is injected into the engine, depending on the work requirements and the selected fuel.

System components

LPG tank

Stores the gas in the liquid state at a pressure between 8 and 10 bar. It can be located in the spare wheel well, in the boot or under the vehicle. It includes a fill level sensor, the shut-off solenoid valve and safety components for shutting off the gas flow manually.

Shutdown solenoid valve

Its function is to interrupt or allow the flow of the LPG in accordance with that required by the control unit. There may be two in the circuit, one at the tank outlet and another at the pressure regulator inlet.

Pressure regulator

Its function is to regulate the flow of the LPG to change the liquid to the gaseous state and supply it at a constant pressure. Inside, there is a calibrated orifice for the liquid and an expansion chamber where it is converted into gas and the pressure is reduced to 1-2 bar.

Pressure sensor

This is usually located on the injection rail and its function is to measure the pressure of the LPG in the gaseous state.

Filter

Its function is to eliminate any impurities that the LPG may contain. It is usually installed in the area of the circuit where the gas is in the gaseous state, but can also be located in the liquid state area.

LPG injectors

These are responsible for injecting the LPG into the intake manifold and there is normally one for each engine cylinder. The injectors are usually located on the injection rail and at a certain distance from the intake manifold. The dosed gas is conducted through flexible pipes to the intake manifold.

LPG control unit

Its function is to calculate the mass of LPG required and manage the operation of the system. In order to do this, it receives information from the sensors and actuates the LPG injectors.

Fuel selection button

This is located in the passenger cabin within reach of the driver in the case of aftermarket equipment that does not automatically select the fuel. In some models, it also has the LPG tank level indicator.

Fuel selection unit

Its function is to select the fuel, LPG or petrol, that flows to the high-pressure pump and the dosing system. It is only used in liquid phase injection systems.

Pipes

The LPG supply pipes can be manufactured in steel, reinforced copper or another equivalent material.

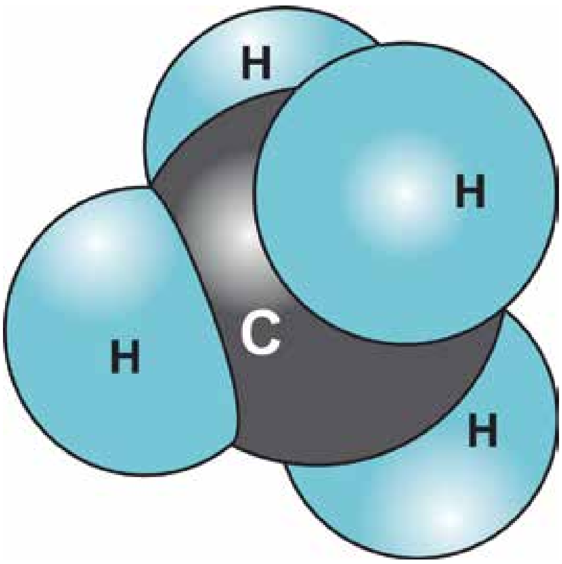
Refuelling

LPG gas refuelling is carried out from pumps at specific pressures. The LPG filler neck is not standardised, therefore there are different formats and adapters for refilling with LPG. The adapters are screwed into the nozzle located in the vehicle and act as intermediaries between the pump and the vehicle. The adapters usually incorporate flexible joints for sealing during refuelling which must be replaced when cracked or otherwise damaged.

When refuelling, the same safety measures must be taken as when refilling with petrol or diesel. It must be remembered that when uncoupling the pump at the end of the filling process, it is ejected sharply due to the accumulated gas between the filler neck and the pump.

CNG SYSTEMS

Natural gas can be used in vehicles with petrol engines compressed to pressures of 200-250 bar to achieve a sufficient energy density. It principally consists of methane (CH4) in a proportion of up to 97%. This gas exists naturally in the ground and is obtained by direct extraction. For the detection of leaks, odorants are added. It is distributed under two names depending on its origin and the percentage of methane:



- **High-Gas**: This has a percentage of methane between 79.8% and 98%.
- **Low-Gas**: This has a percentage of methane between 80% and 87%.

The energy density of 1 kg of CNG is higher than any other available fossil fuel, therefore a lower quantity of fuel is required to produce the same energy. This means that engine performance is not reduced when running on CNG, unlike with LPG. The energy of 1 kg of CNG is equivalent to:

- 2.0 litres of LPG.
- 1.5 litres of diesel.
- 1.3 litres of petrol.

	High gas	Low gas
Calorific value in kW/m3	11.1 - 10.0	8.9
Methane (CH4) %volume	79.8 - 98	80 - 86.8
Ethane (C2H6) %volume **Propane (C3H6) %volume** **Butane (C4H10) %volume**	9.9 -1.3	6.7
Inert gases % volume	3.0 - 0.9	6.5
Colour	Colourless	
Odour	Odorised with tetrahydrothiophene	
Boiling temperature	from -195 ºC to -155 ºC	
Ignition temperature	from 575 ºC to 625 ºC	
Relative density (air=1)	0.55 to 0.75. Lighter than air	
Octane rating	up to 130 octane	
Energy content 1 kg	13 kWh approximately	

Natural gas has the lowest environmental impact of all the fossil fuels due to the high hydrogen-carbon ratio in its composition. It is lighter than air, therefore leaks of this gas dissipate into the atmosphere and do not contaminate the soil or water. As a fuel for vehicles, it reduces nitrogen oxide (NOx) emissions by 90%, and does not produce sulphur compounds or solid particulates.

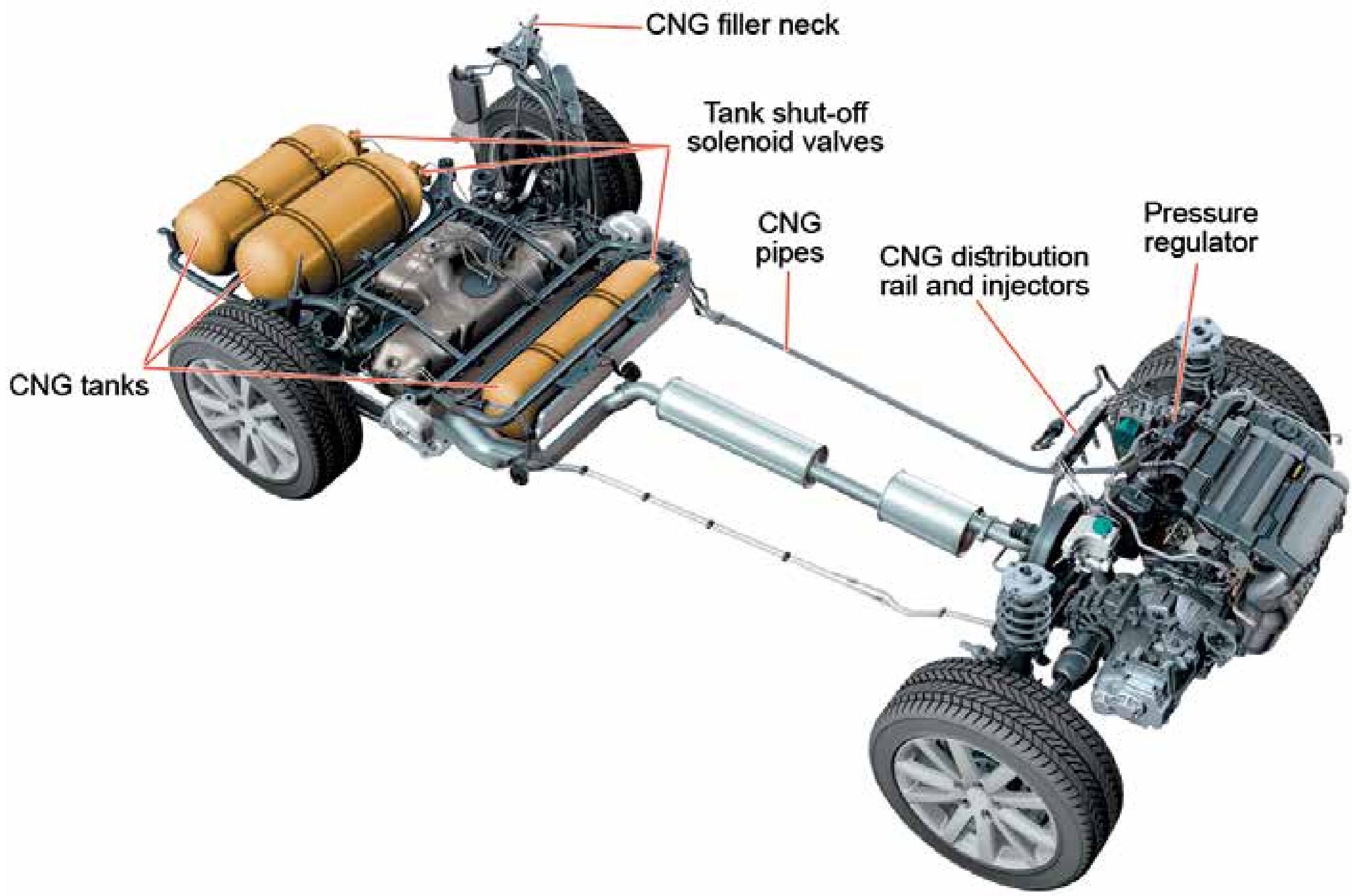
System operation

The supply of CNG is similar to that of LPG in the gaseous phase, as this is also indirectly injected into the intake manifold, however, it works at different pressures both for storage and dosing. Like other systems, it has specific sensors and actuators that are managed by an independent control unit, or the same control unit that manages the petrol injection in the case of vehicles that come with the factory-installed CNG system.

In contrast to LPG, CNG can be used to cold start an engine, with the exception of the following cases:

- **Faults in the system**: if there is a component fault or leaks are detected, the control unit can cut off the gas supply and continue with petrol.
- **Coolant temperature below -10°C**: The gas injector needles can become stuck at these temperatures. For this reason, the ECU starts the engine with petrol while applying a small electrical current to the injector coils to warm them.
- **After refuelling with CNG**: the ECU must recognise the quality and quantity of the CNG contained in the tanks; this process can take a couple of minutes and therefore the engine runs on petrol during this time.

The CNG system does not usually have a fuel selection button like other gas systems, and the engine has modified components or it must use specific additives. The natural gas supply circuit is divided into two sections according to the pressure:



High pressure

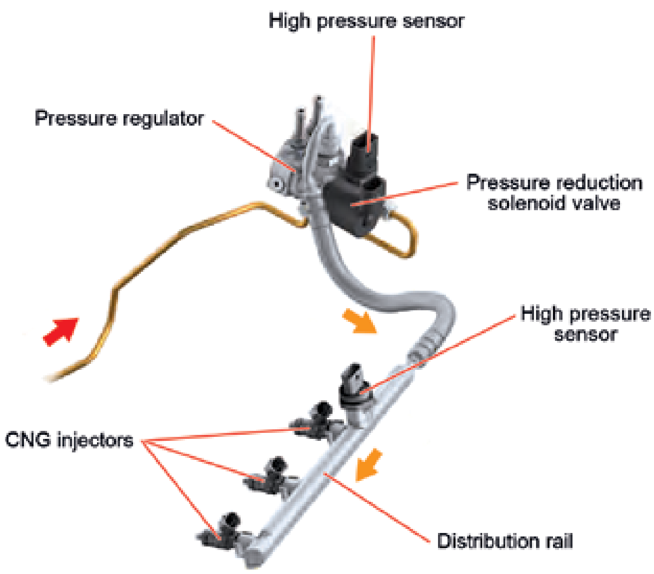
The natural gas is stored in tanks in the gaseous state at a pressure of approximately 200 bar. Each tank has a shut-off solenoid valve that controls the flow of gas from the tanks to the outlet pipes. The solenoid valves open electrically when the system is free of faults and an attempt is made to start the engine. The gas is conducted to the pressure regulator through the pipes at the same pressure as in the tank.

The tanks are interconnected by pipes, for their simultaneous emptying and filling. In this section of the circuit, there is a pressure sensor that assesses the amount of gas that remains in the tanks and its pressure.

Low pressure

The natural gas is stored in tanks in the gaseous state at a pressure of approximately 200 bar. Each tank has a shut-off solenoid valve that controls the flow of gas from the tanks to the outlet pipes. The solenoid valves open electrically when the system is free of faults and an attempt is made to start the engine. The gas is conducted to the pressure regulator through the pipes at the same pressure as in the tank.

The tanks are interconnected by pipes, for their simultaneous emptying and filling. In this section of the circuit, there is a pressure sensor that assesses the amount of gas that remains in the tanks and its pressure.



System components

CNG tank

One or more tanks can be used that are fixed to the vehicle by means of a steel frame to protect them from possible impact. Their location depends on the vehicle, although they are generally located in the boot or on the rear underbody. The tanks are linked by means of pipes to form a single functional unit. They are manufactured with special paint so they are more resistant to corrosion and scratching.

Shut-off solenoid valve

These are located at the inlet to each CNG tank. Their function is to allow or prevent the flow of gas from the tank to the pipes. The solenoid valves incorporate a one-way mechanical spring valve that allows the flow of gas to the tank during refuelling operations.

Pressure regulator

This carries out the controlled reduction of the CNG pressure from 200 bar to a range of between 5 and 9 bar.

High pressure sensor

Located at any point in the high-pressure circuit, generally in the pipe between the tanks and the pressure regulator. It detects the effective pressure in the accumulation system. It also informs the ECU when refuelling is carried out due to the increase in pressure in the tanks.

Low pressure sensor

Generally it is located on the distribution rail and measures the gas pressure in the low-pressure circuit. Some sensors can also measure the temperature.

CNG control unit

Its purpose is to manage the system so that it functions correctly. In order to do this, it receives information from the sensors and actuates the CNG injectors.

Distribution rail

The low-pressure gas accumulates here before being injected into the intake manifold. It has housings for the CNG injectors, and sometimes the low-pressure sensor.

Injectors

These are responsible for dosing the gas quantity required in each work cycle depending on the engine's working conditions by allowing it to flow to the intake manifold. There are as many injectors as the engine has cylinders.

Pipes

The pipes in the high-pressure section are manufactured in hardened and tempered steel and the joints are made with a double cone fitting to ensure leak tightness and prevent possible leaks.

Refuelling

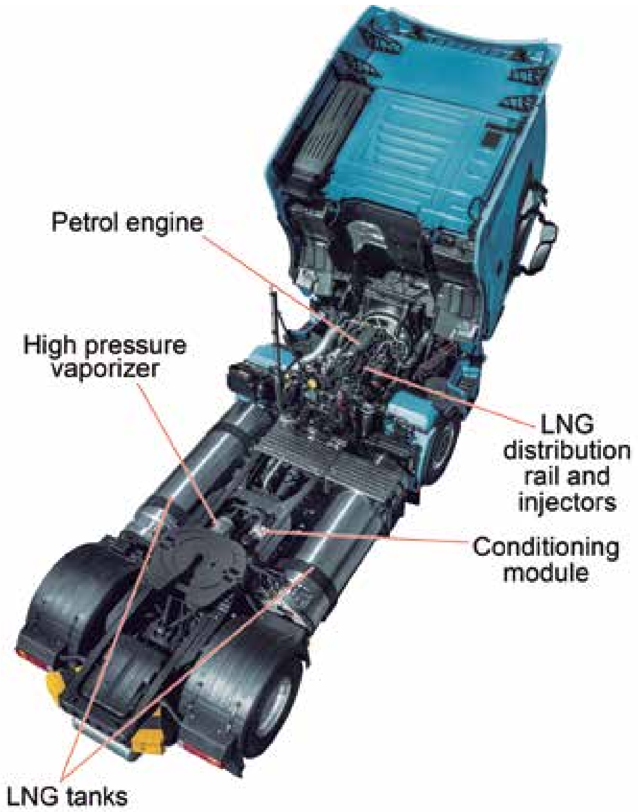
Refuelling with natural gas is simple, it is risk-free and is as quick as refilling with other fuels. The standard pressure in the tanks is 200 bar at a temperature of 15°C. To prevent the cold pressure dropping below 200 bar, the refuelling pressure will vary between 210 and 250 bar.

The filler neck incorporates a check valve with filter. The check valve prevents the CNG from leaking in the reverse direction during the gas refuelling operation, and the filter retains the coarsest impurities that the natural gas may contain. When the filling hose is withdrawn, the discharge of a small residual pressure cleans the filter, therefore the filter does not require maintenance.

The CNG pump indicates the charge value of the natural gas in kilograms. 1 kg of compressed natural gas at 200 bar in the tanks occupies an approximate volume of 6.2 litres.

LNG SYSTEMS

Liquid natural gas (LNG) is natural gas processed for transport in its liquid state. It is principally made up of methane (CH4), but, in contrast to CNG, it is stored and distributed in the liquid state at atmospheric pressure and at -162°C. To maintain the gas in its liquid state at cryogenic temperatures, each tank is made up of two concentric vessels. The inner vessel is stainless steel and the outer is carbon steel. The intermediate chamber for thermal insulation is filled with powdered perlite and the internal pressure is reduced by vacuum.



LNG is generally used in stationary engines for large industrial plants as it pollutes less than the diesel engine and the price of gas is relatively low. Nowadays, this technology is only available in mobile format for industrial vehicles, such as tractor and lorry cabs or large marine engines.

System operation

LNG can be used both in combustion engines (Otto) and compression ignition engines (Diesel). In the case of diesel engines, dual injection is carried out as a simultaneous supply with both fuels is necessary for operation. In spark ignition engines (petrol), the engine can function with just LNG. In both cases, the injection is carried out in the gaseous state, i.e. as CNG.

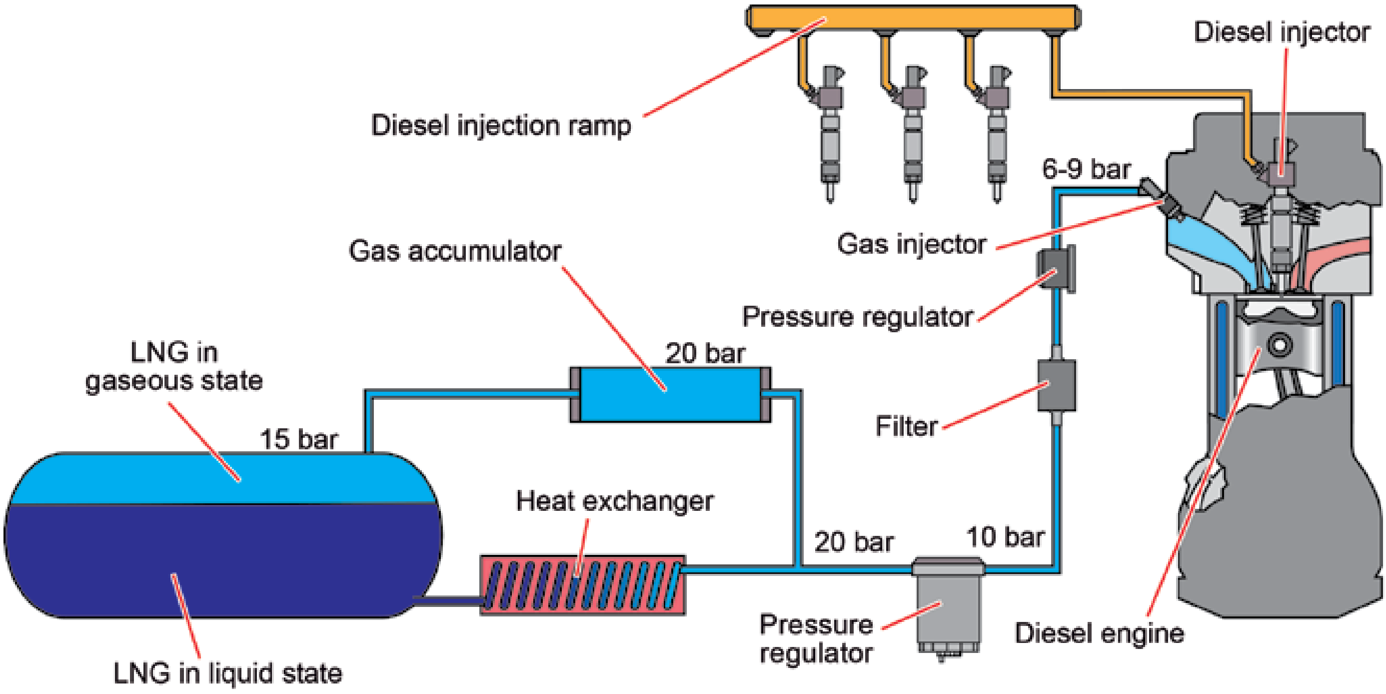
The working possibilities are the following:

Diesel engine with low-pressure gas indirect injection

The gas is injected in the same way as in CNG vehicles with indirect gas injection, the difference being that the LNG must be previously vaporised because it is in the liquid state in the tank.

The LNG in the tank - in the liquid state at -162 ºC and 15 bar approximately - is conducted to a heat exchanger using the engine coolant, where the fuel temperature is raised to change its state. When vaporised, the LNG converts into CNG at a pressure of approximately 20 bar. Then it is conducted to a pressure regulator to reduce the pressure to 10 bar. Lastly, the gas is filtered to remove any impurities and is made to pass through a second regulator to reach the final dosing pressure of between 6 and 9 bar.

The gas is injected into the intake manifold and is made to combust with the diesel injection. This dual combustion allows the quantity of injected diesel to be reduced, achieving more complete combustion which reduces the production of pollutants.



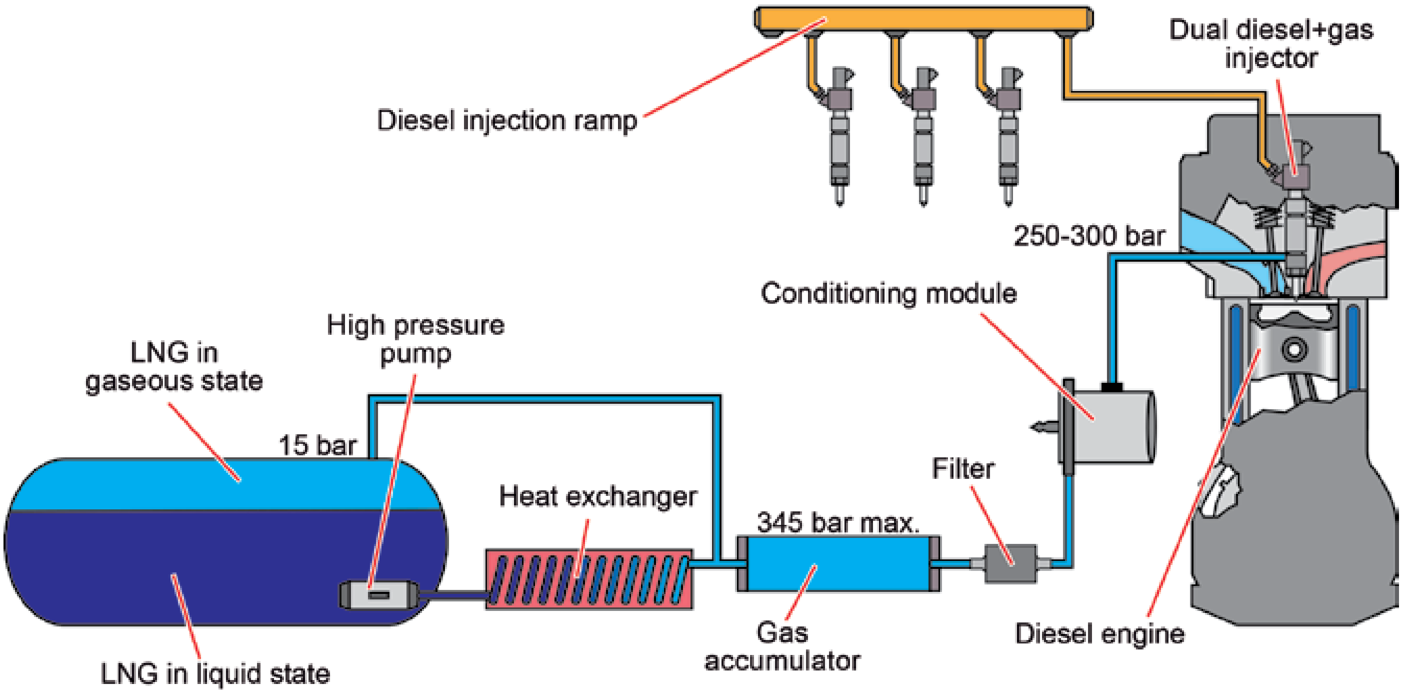
Diesel engine with high-pressure gas direct injection

This system injects the gas directly into the combustion chamber at high pressure. In order to do this, it uses a specific injector that allows diesel and gas to be injected simultaneously through separate lines.

The LNG in the liquid state (-162 ºC / 15 bar) is conducted to the heat exchanger through a high-pressure pump. The pump raises the pressure of the LNG to 345 bar and the heating changes its state to CNG.

The high-pressure CNG is stored in an accumulator. It is then filtered to remove possible impurities and is conducted to a conditioning module where the pressure is dropped to 250-300 bar.

It is then conducted to the injectors where it is introduced into the combustion chamber together with a small quantity of diesel to carry out the combustion.



Refuelling

Of all the gas systems that exist for motor vehicles, LNG is the most complicated to refuel. As this is a cryogenic liquid fuel, increased safety measures must be adopted and adequate personal protective equipment used. This equipment is made up of special gloves for low temperatures and a protective face shield, that is normally found at the supply point or service station itself.

Before refuelling, a crocodile clip must be fitted from the pump to the vehicle chassis, in order to eliminate possible static electricity accumulated by the vehicle. The connection nozzles on the pump hose and tank must then be blown with pressurised air in order to clean them.

Then the hoses can be connected to carry out the refuelling. As the LNG enters the tank, the hoses freeze on the surface as the LNG is at -162°C. When removing the hoses, skin contact must be avoided as this could cause cryogenic burns.

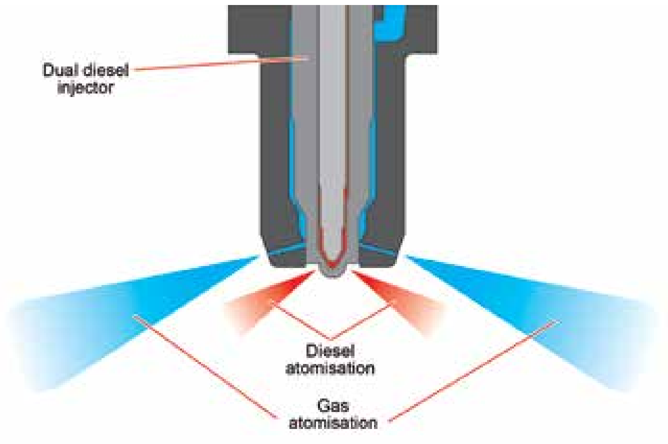
BI-FUEL DIESEL VEHICLES WITH GAS

Dual or combined supply is the only possibility for operation with gas for compression ignition engines, which do not have spark plugs to ignite the mixture and therefore use the heat liberated by combustion of a small proportion of diesel to ignite the gas.

This system allows a considerable saving of diesel, as some systems introduce a proportion of 95% gas and 5% diesel into the cylinder.

On the market, there are conversion kits that allow the diesel engine to be adapted to the gas system, and there are even diesel engines that are supplied already prepared for the complete changeover in countries whose internal regulations allow the conversion. Many heavy vehicle manufacturers market diesel models that are factory-equipped for gas, in special industrial vehicle ranges for public works and mining.

The most significant advantage of these types of engines is that they are more environmentally friendly, as they have managed to reduce CO and CO_2 by up to 25%, solid particulate emissions by up to 96%, and nitrogen oxides (NOx) by 85%. They also produce up to 50% less noise emission and vibrations compared to diesel engines, and the cost of operating with natural gas is 30% lower than with diesel and 50% lower than with petrol.



COMMON FAULTS

The most common faults in LPG and CNG systems are the failure of the specific sensors and actuators in the gas supply system.

In vehicles that are equipped for LPG, the fuel selection system can fail when changing from petrol to LPG and cause the engine to stop.

Also, over time, the pipes can deteriorate and leak which leads to the system becoming inoperative. The systems have been designed and tested for strict compliance with safety standards in case of collision, especially the tanks, although this possibility always exists for pressurised gas containers. Nevertheless, the possibility of fire is lower than in petrol vehicles, for example.

For the detection of gas leaks, there are numerous electronic sensors that warn of any leaks with an audible alarm. This inspection must be carried out periodically together with the maintenance of the vehicle.

On vehicles converted to run on gas, the adjustment of the air/fuel ratio can be tricky and very variable depending on the ambient temperature and the atmospheric pressure, so it requires frequent adjustment.

Moreover, if sufficient additive is not used to prevent the valves drying out, their deterioration is accelerated and can lead to jerking and stoppage of the engine.

TECHNICAL NOTES

This section describes the most common faults in the mechanical components and electronics of bi-fuel systems. Depending on the manufacturer and the different models, the number of faults occurring over the years can be considerable.

These faults are selected from the online platform: www.einavts.com. This platform has a series of sections that specify: make, model, line, system affected, and subsystem, which can be selected independently depending on the desired search.

DACIA

DACIA LOGAN (LS_) 1.4 MPI LPG (LS0C) (K7J 710), DACIA SANDERO 1.4 MPI LPG (K7J 714)	
Error codes	• P0300 - Ignition failure detected in one or more cylinders. • P0301 - Cylinder 1. False explosion detected. • P0302 - Cylinder 2. False explosion detected. • P0303 - Cylinder 3. False explosion detected. • P0304 - Cylinder 4. False explosion detected.
Symptom	Malfunction indicator lamp (MIL) on. Failure codes reported by the engine control unit. The vehicle displays one or more of the aforementioned fault codes. Power loss. The engine is operating irregularly. Engine stalls. **NOTE**: This technical note only affects those vehicles equipped with an LPG (Liquid Petroleum Gas) fuel system.
Cause	Valves not adjusted. Due to the use of LPG, the valves must be adjusted in accordance with the manufacturer's recommendations.
Solution	**Repair procedure:** • Read the fault codes recorded in the control unit with the diagnostic tool. • Confirm that one or more of the fault codes mentioned in the field are recorded. **Symptom of this note.** • Confirm that the symptoms indicated in the symptom field of this note occur. • Check that the vehicle has the recommended type of spark plugs fitted. • Adjust the valves every 30,000 km. • Carry out a second reading of the fault codes on the engine control unit with the diagnostic tool and confirm that the fault codes mentioned in the symptom field of this technical note are NOT displayed.

VOLKSWAGEN

VW GOLF PLUS (5M1, 521) 1.6 BiFuel (CHGA), VW GOLF VI (5K1) 1.6 BiFuel (CHGA)	
Error codes	• 00307 - P0133 - Oxygen sensor circuit 1, Bank 1, Slow Signal. • 04626 - P1212 - Bank 1, cylinder disconnection. • 16514 - P0130 - Oxygen sensor 1, block 1. Faulty circuit. • 16681 - P0300 - Ignition failure detected in one or more cylinders. • 16682 - P0301 - Cylinder 1. False explosion detected. • 16683 - P0302 - Cylinder 2. False explosion detected. • 16684 - P0303 - Cylinder 3. False explosion detected. • 16685 - P0304 - Cylinder 4. False explosion detected. • 18528 - P2096 - Bank 1, oxygen correction post-catalyst lean regulation limit exceeded. • 18627 - P2195 - Oxygen sensor 1 - bank 1 signal too lean. • 18628 - P2196 - Oxygen sensor 1 - bank 1 signal too rich.
Symptom	• Failure codes reported by the engine control unit. • LPG gas system warning light on. • The vehicle displays one or more of the aforementioned fault codes. • Engine jerks in LPG mode. • The engine switches from gas mode to petrol mode automatically. **NOTE**: This technical note only affects those vehicles equipped with an exhaust system adapted to the EU4 regulations. **NOTE**: This newsletter only affects those vehicles that are within a specific production date.
Cause	Gas flow defect in the LPG injectors.
Solution	**Repair procedure:** • Read the fault codes recorded in the engine control unit with the diagnostic tool. • Confirm that one or more of the fault codes mentioned in the field are recorded. **Symptom of this note.** • Check the petrol and LPG system with the appropriate diagnostic tool. • Carry out the corresponding diagnosis for the engine fault codes if “Incorrect system” is specified in petrol mode. • Mount the appropriate repair kit if the system check ends with “Incorrect system” in LPG mode and “correct system” in petrol mode. • Check the petrol and LPG system again with the appropriate diagnostic tool. • Delete the fault codes reported by the engine control unit (ECU) with the diagnostic tool. • Check the software version of the engine control unit. • Re-programme the engine control unit (ECU) with updated software if necessary. **NOTE**: There is a specific kit for carrying out the repairs indicated in this technical note.

RENAULT

RENAULT CLIO II (BB0/1/2_, CB0/1/2_) 1.6 16V (CB0T; CB0H) (K4M 708), RENAULT KANGOO Express (FC0/1_) 1.6 16V (K4M 752), RENAULT KANGOO (KC0/1_) 1.6 16V (K4M 752), RENAULT KANGOO (KC0/1_) 1.6 16V 4x4 (KC0P; KC0S; KC0L) (K4M 750), RENAULT KANGOO (KC0/1_) 1.6 16V bivalent (K4M 850), RENAULT KANGOO Express (FC0/1_) 1.6 16V 4x4 (FC0L; FC0P; FC0S) (K4M 750), RENAULT KANGOO Express (FC0/1_) 1.6 16V bivalent (K4M 850), RENAULT CLIO II (BB0/1/2_, CB0/1/2_) 1.6 Hi-Flex (CB0H) (K4M 748), RENAULT CLIO II (BB0/1/2_, CB0/1/2_) 1.6 (K4M 748), RENAULT KANGOO (KC0/1_) 1.6 Flex (K4M 730)	
Symptom	The engine stalls when idling in CNG mode. The engine stalls at low rpm. **NOTE**: The above symptom occurs at low rpm during sharp braking, parking or with the vehicle idling in CNG mode.
Cause	Defective adjustment of the idle timing advance in CNG mode.
Solution	**Repair procedure:** • Start the engine and wait for it to reach operating temperature. • Check the adjustment of the idle timing advance located on the injection control unit bracket. • Adjust the timing advance if it is not well adjusted. • Conduct a test on the road. • Switch off the overadvance if the checks carried out previously are NOT satisfactory.

an eye on automotive technology

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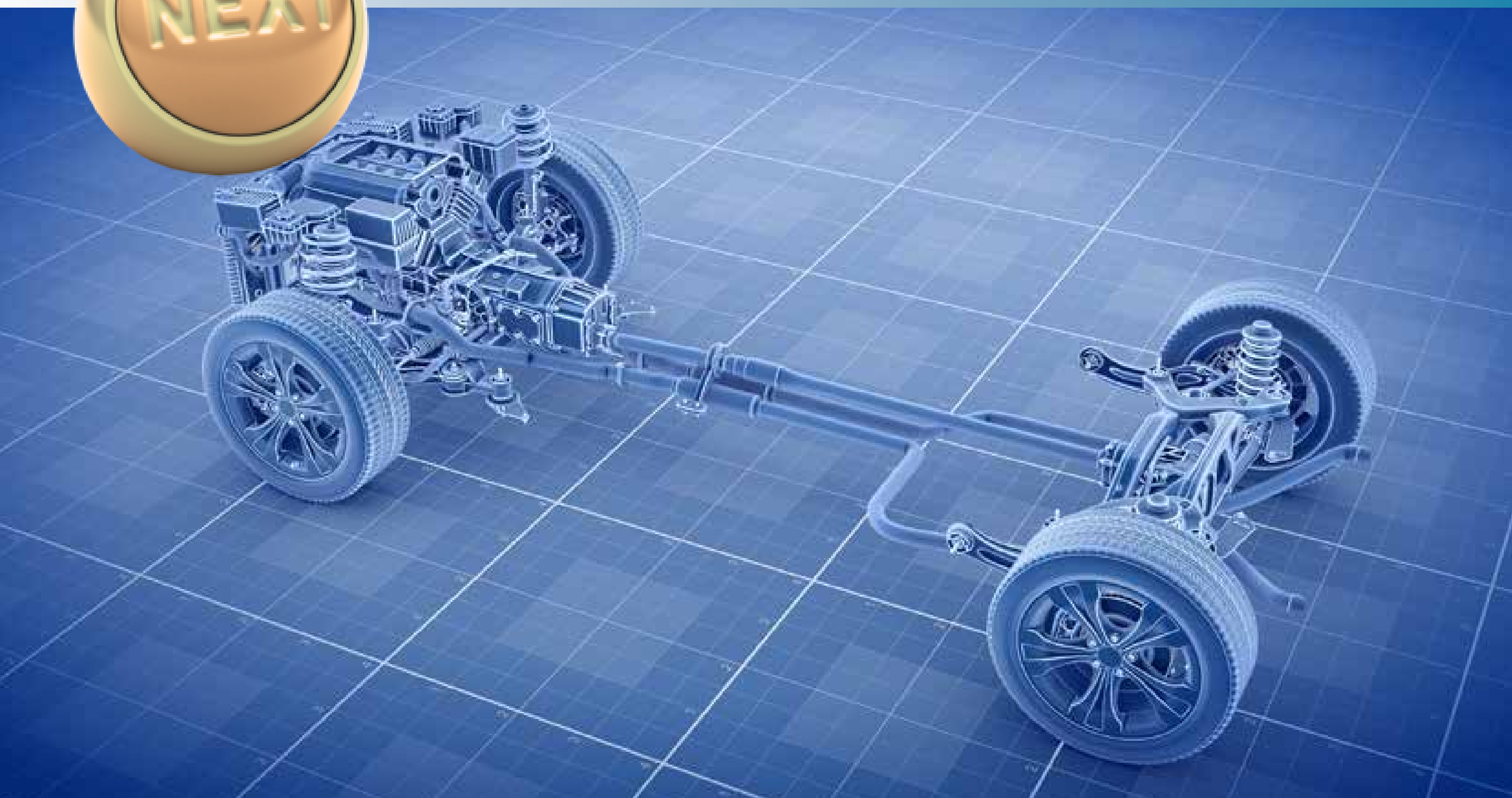

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