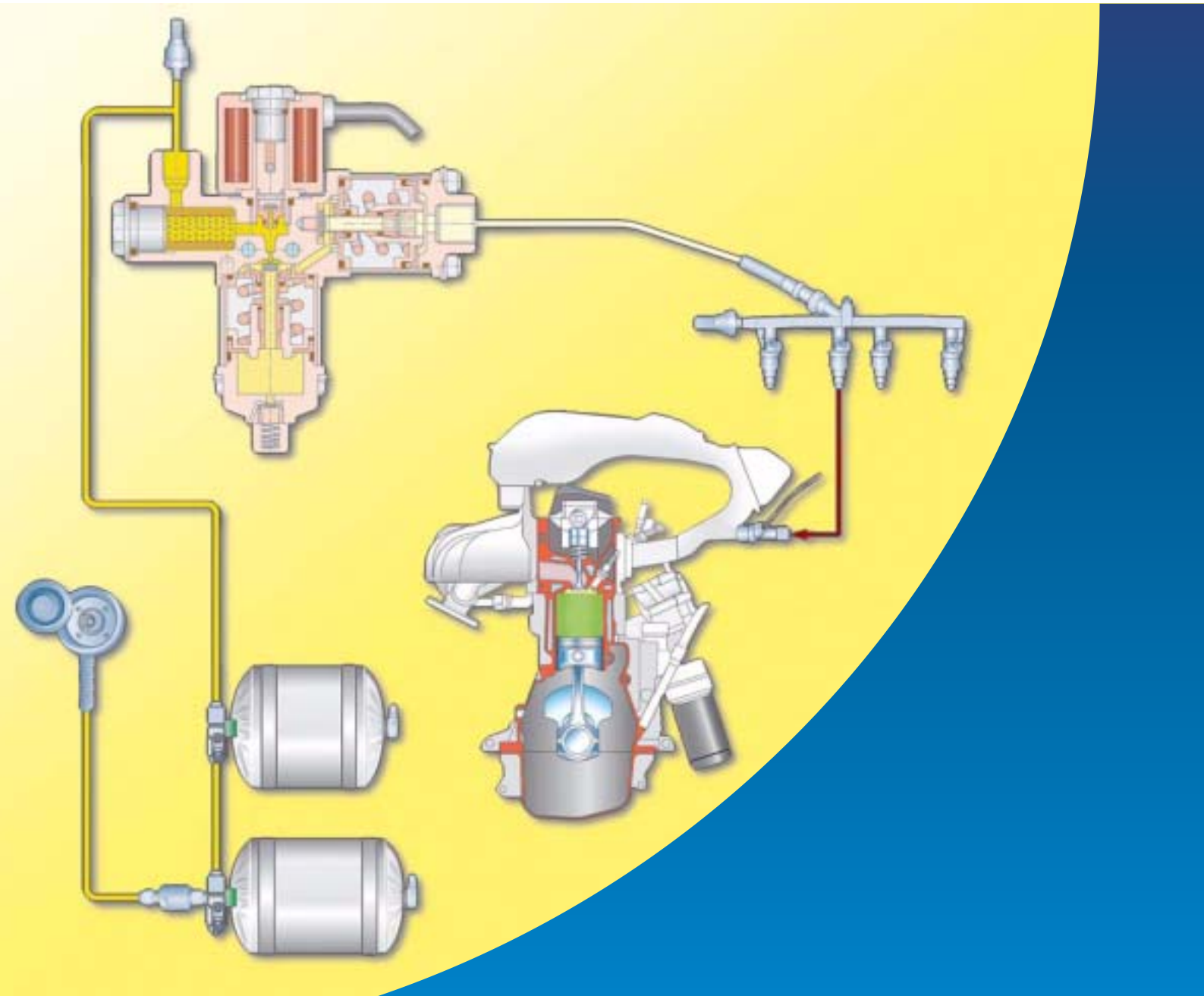
Service Training

Self-study programme 262

Natural gas - an alternative fuel for motor vehicles

Design and function



Within the process of reducing harmful emissions caused by traffic in built-up cities and the rising costs of petrol and diesel fuel, more emphasis is being placed on natural gas as an alternative power source to drive motor vehicles.

Gas as a power source to drive vehicles is not a modern invention. It has a long history. Even the first internal combustion engine - the patent for which was applied for by Nikolaus Otto in 1876 - was developed in the Deutz AG gas engine factory.

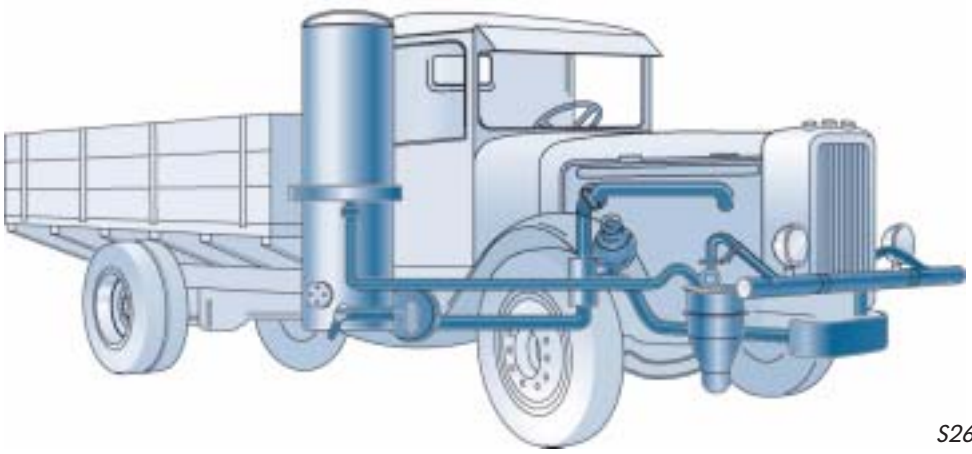
Within the scope of further motor vehicle engine development, gas technology, as well as other drive concepts, was always a source upon which engineers could fall back on - mostly in times of emergency.
This lead to vehicles being equipped with storage tanks, in which town gas or a mixture of propane/butane was filled, or the gas was generated directly in gas generators from wood or *anthracite* while the vehicle was in motion.

In this day and age, Volkswagen offers the Golf BI FUEL as a series production vehicle with *bivalent* natural gas drive (vehicle can be driven with natural gas or petrol).

The Transporter '91 ➤ can be equipped with a retrofit option for bivalent natural gas powered operation.

Please note that there will be country-specific differences with regards to legal requirements.

With this self-study programme we would like to introduce you to the special features of the bivalent natural gas drive system for Volkswagen vehicles (centred around the framework conditions in Germany).



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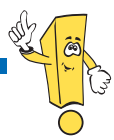

Warning
Note

The self-study programme represents the design and function of new developments!
The contents will not be updated.

For instructions on testing, adjusting and repairs, please refer to the relevant service literature.

At a glance

Introduction

Natural gas

At the start of the 90s, public interest was centred more and more around motor vehicle traffic as the main cause of pollution and excessive noise in built-up cities. Only terms such as “summer smog” and “acid rain” are referred to.

For the *emissions* of gas components nitrogen oxide (NO_x), hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2) and soot particles, strict limit values were established.

The use of *alternative* fuels, such as natural gas, makes an effective contribution towards improving the environmental situation.

Natural gas is created under similar conditions to that of oil and is produced as a by-product of oil extraction.
It is also found in single geological deposits.
It is lighter than air and mixes well with the air.
It burns “softly”.

As a flammable gas, natural gas is the most environmentally compatible *fossil* energy source. It comprises in essence of 80 - 99 % *methane* (CH_4). The rest is built up of carbon dioxide, nitrogen oxide and low value hydrocarbon additions.

The lower the carbon content of an energy source, the lower the carbon related emissions, such as carbon dioxide, carbon monoxide and soot particles.

Natural gas can be used as a fuel directly in internal combustion engines without any chemical changes necessary. In this way, there is a considerable saving in costs compared to the measures necessary in processing oil to petrol and diesel. However, it may be necessary to clean or dry the natural gas depending on the source from which is was extracted.

The availability of natural gas *resources* is greater than that of mineral oil. This way there is a means of interchanging the exclusive dependence on oil.

For reasons of safety, the odourless natural gas is supplemented with strong smelling additives in Germany.
This makes it possible to detect natural gas by smell even in the smallest of quantities.

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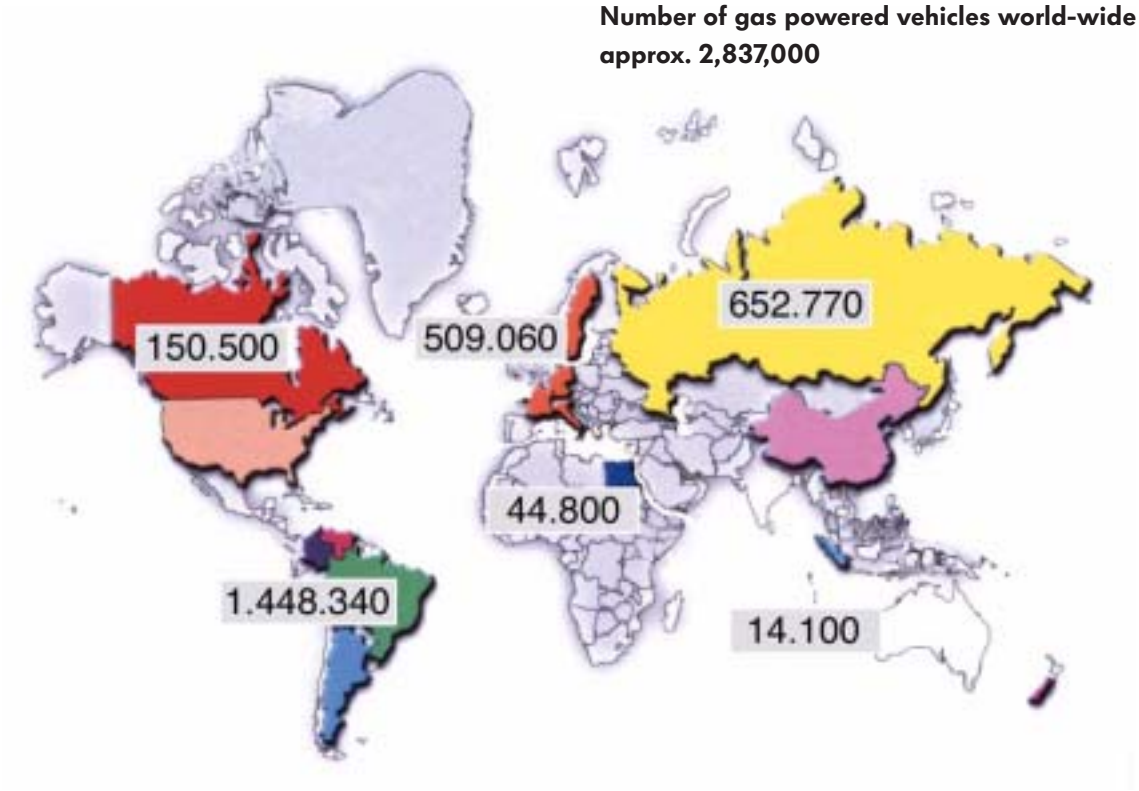
Number of gas powered vehicles

The number of gas powered vehicles was calculated using international natural gas powered vehicle statistics, as of the second half of 2003.

Number of gas powered vehicles world-wide approx. 2,837,000



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The number of vehicles world-wide is currently about 665 million.
Approx. 2.8 million of these are registered as natural gas powered vehicles.
The leading countries here are those with high natural gas deposits, such as Argentina with approx. 951,000 gas powered vehicles.

In Europe, Italy is way ahead of other countries with 434,000 vehicles, thanks to a good natural gas infrastructure.
In Germany, currently about 20,000 vehicles run on natural gas. Half of these are Volkswagen models which were specially converted for this purpose.

Introduction

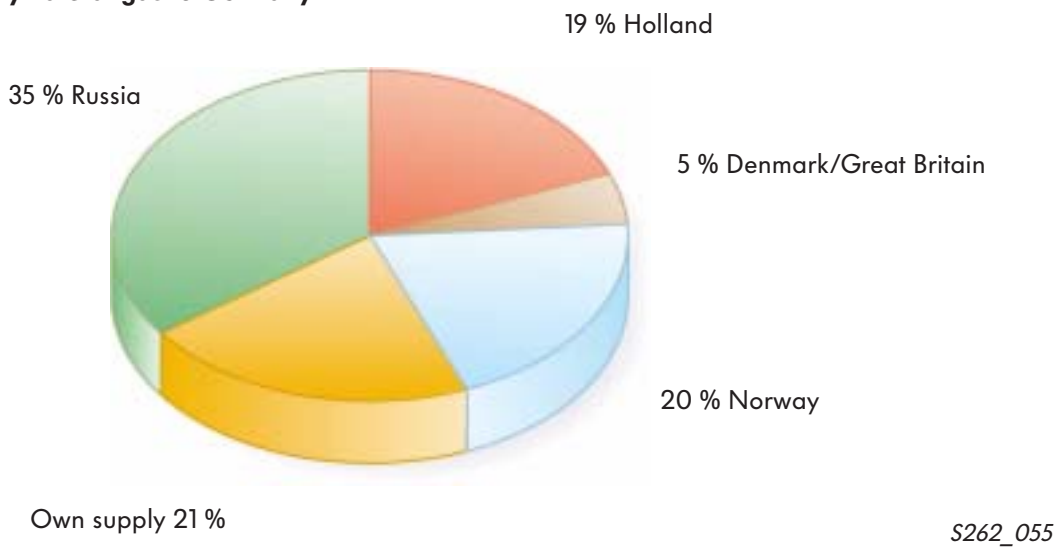
Raw natural gas

The term natural gas includes all gaseous hydrocarbon compounds that originate from the earth and are flammable.
Like oil and coal, natural gas belongs to the group of natural, flammable organic raw materials.
The main element of natural gas is methane – a chemical composition of hydrocarbon and hydrogen.
It can be used in engines without further processing.

The number of natural gas deposits that were created over millions of years and are stored by natural means are enormous by comparison.
If the current amount extracted per year is maintained, the world-wide reserves of natural gas known to man will last 2 and a half times longer than the oil reserves.

Due to the fact that sources can be found all over the world, the dependence on individual countries for supply is low.

Countries that supply natural gas to Germany



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Do not confuse natural gas with:
LPG (**L**iquefied **P**etroleum **G**as), also known as auto gas or liquid gas; comprises mostly of *propane* and *butane*.
It is created as a by-product of petrol production and is therefore directly dependent on the oil reserves.

Qualities of natural gas

Natural gas deposits can be found, for example, in the north of Germany, in the Netherlands, in the North Sea, in Norway and in Russia (a main producer and supplier to Germany).

Different qualities of natural gas are offered depending on the natural gas supplier.

With an increase in the network of natural gas suppliers, a mixture of the individual qualities will be offered as a composite gas.

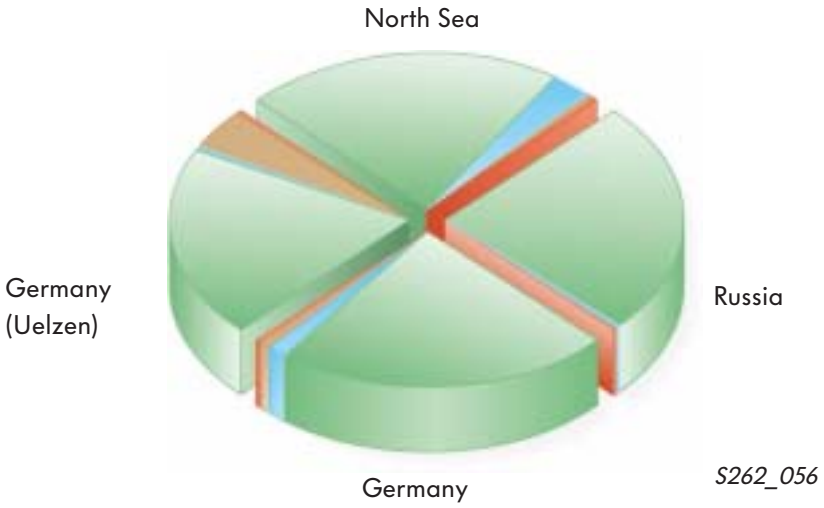
Qualities of natural gas in Germany:

The difference in quality is based on the *calorific value* of the natural gas.

Depending on the calorific value, a differentiation is made between H gas (high) and L gas (low). The different calorific values of H gas and L gas result in different fuel consumption figures.

Monthly average figures for purposes of orientation regarding different gas qualities

	North Sea H gas	Russia H gas	Germany L gas	Germany (Uelzen) L gas
Calorific value [kWh/m^3]	11.1	10.0	8.9	8.2
Methane (CH_4) [Vol. %]	87.1	97.8	86.8	79.8
Ethane (C_2H_6) Propane (C_3H_8) [Vol. %] Butane (C_4H_{10})	10.9	1.3	6.7	1.8
Nitrogen (N_2) [Vol. %]	2.5	0.8	2.7	17.6
Carbon dioxide (CO_2) [Vol. %]	0.5	0.1	1.0	0.8



Natural gas compared to other fuels

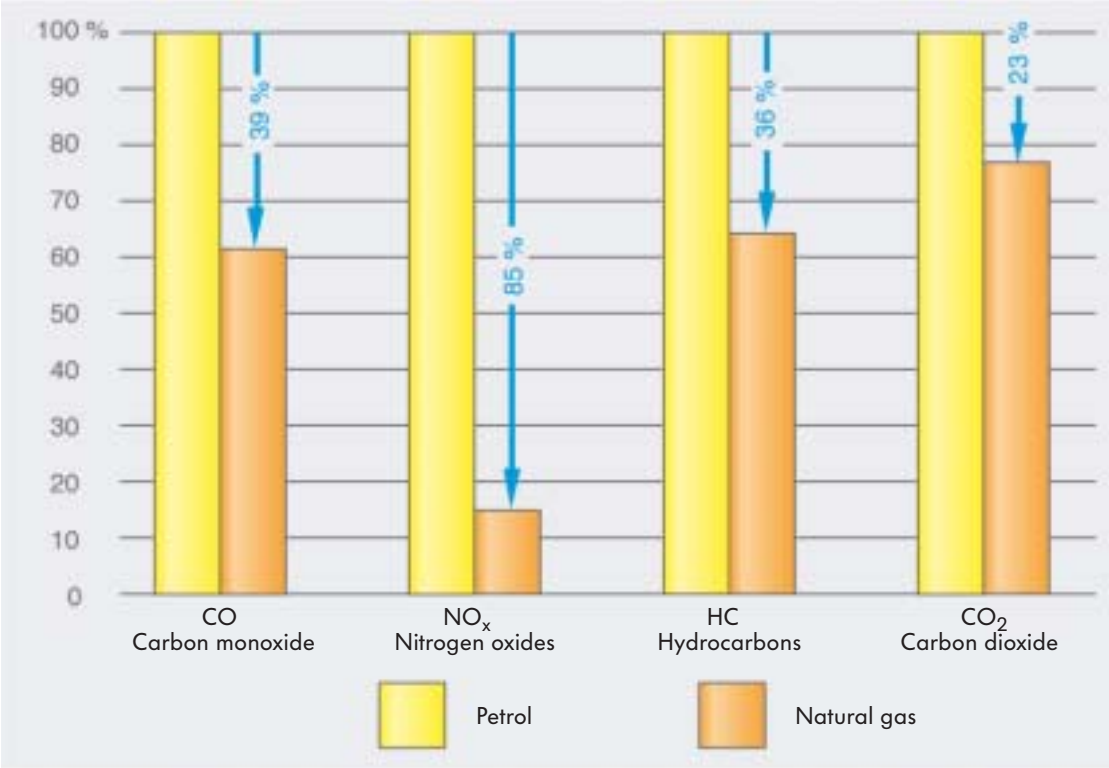
Exhaust emissions

The chart shown below shows the reduction of exhaust gas emissions for a light commercial vehicle in comparison between a natural gas and petrol powered engine.

Reduction in emissions with natural gas operation

Emissions test on light commercial vehicle with 2.5 l/85 kW petrol engine in European driving cycle.

Relative harmful emissions (%)



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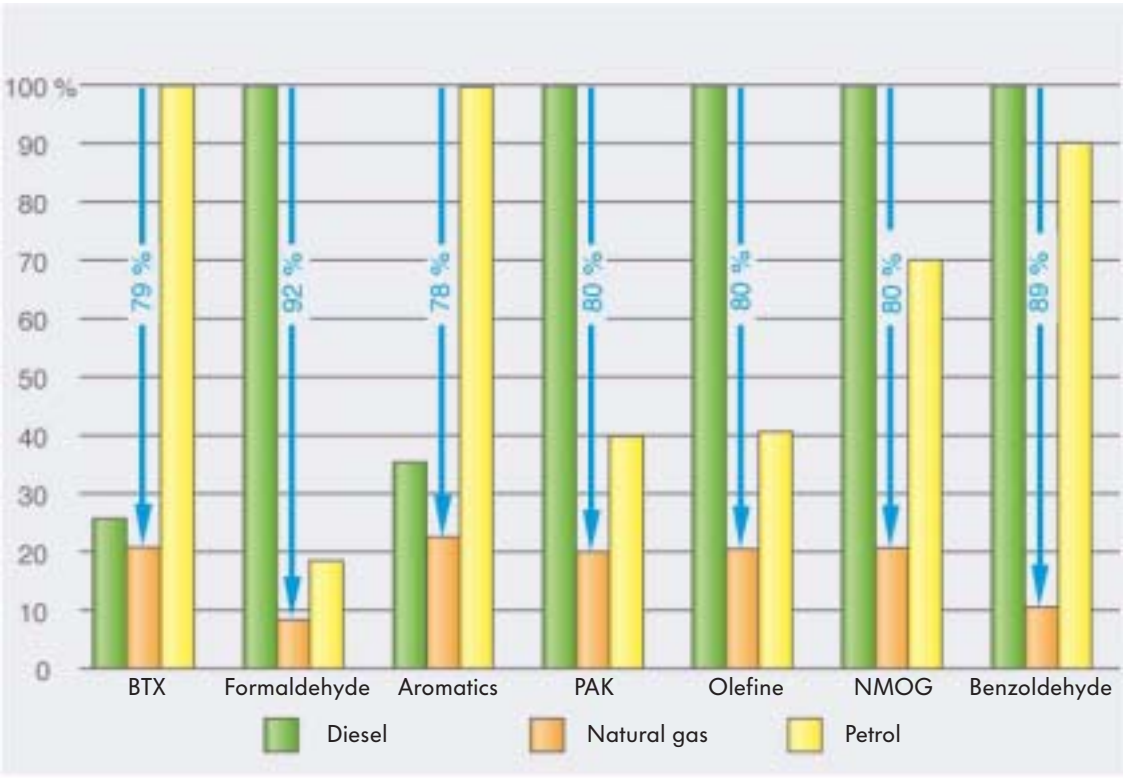
Comparison of non-limited emissions

The chart below shows the reduction in exhaust gas emissions for non-limited exhaust gas components, using a light commercial vehicle as an example, with diesel, petrol and natural gas operation compared against each other.



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Non-limited exhaust gas components are:

BTX - **B**enzene, **t**oluol and **x**ylene
Aromatic carbon compounds, solvents

Formaldehyde -
Disinfectant, pungent smelling gas

Aromatics -
Benzol compounds

PAK -
Polycyclic aromatic hydrocarbons

Olefin - Unsaturated, chain-like hydrocarbons

NMOG - **N**o **m**ethane **o**rganic **g**ases. The sum of all hydrocarbons, excluding aromatic compounds.

Benzoldehyde - Short lived by-products of aromatic compounds

Introduction

Observations regarding the economy

The costs play a decisive role in the acceptance and spread of natural gas powered vehicles.

Significant criteria for procurement of a natural gas powered vehicle are:

- More environmentally friendly system compared to diesel or petrol engines
- The *amortisation* period for the additional price on procurement
- The fuel costs
- Reduced road taxes
- Local financial benefits from gas suppliers
- Local exclusion from restricted access zones where traffic causes smog, for example
- The tank filling station network

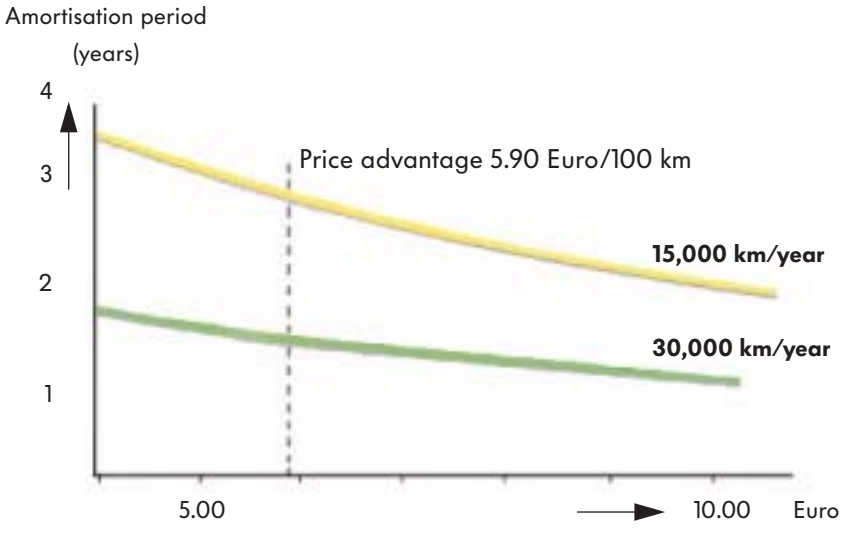
The cost of buying a natural gas powered vehicle is higher than that of a similar vehicle with petrol or diesel engine.

To calculate the amortisation period, an average additional price of 2,500 Euro was used, with consideration given to the possible promotion schemes.

The advantage in price comes from the lower fuel costs with natural gas operation.

Amortisation period of natural gas system compared with petrol version

A price advantage of 5.90 Euro/100 km was used in the example.



Price advantage - natural gas/petrol

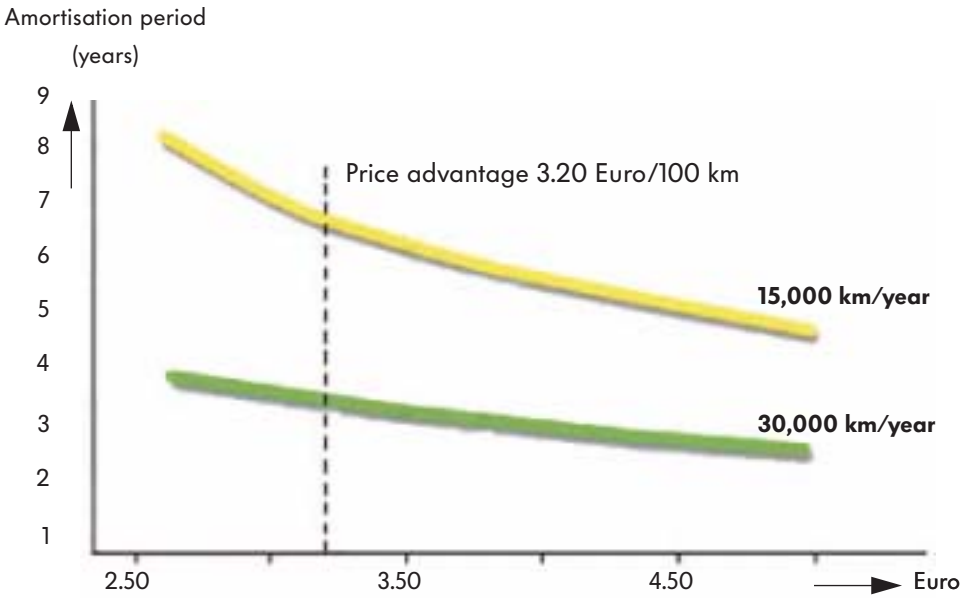
Depending on the annual mileage, amortisation periods of under 2 years up to a maximum of 4 years are calculated.

Amortisation period of natural gas system compared with diesel version

A price advantage of 3.20 Euro/100 km was used in the example.

Comparison with a diesel version results in a longer amortisation period due to the lower price difference (diesel/natural gas).

On the diesel version, the amortisation period is between 3 and 7 years, depending on the annual mileage.



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Price advantage - natural gas/diesel

The amortisation period is shortened if:

- the difference in fuel prices (natural gas to petrol/diesel) rises,
- the annual mileage increases,
- the purchase price for a natural gas powered vehicle drops.

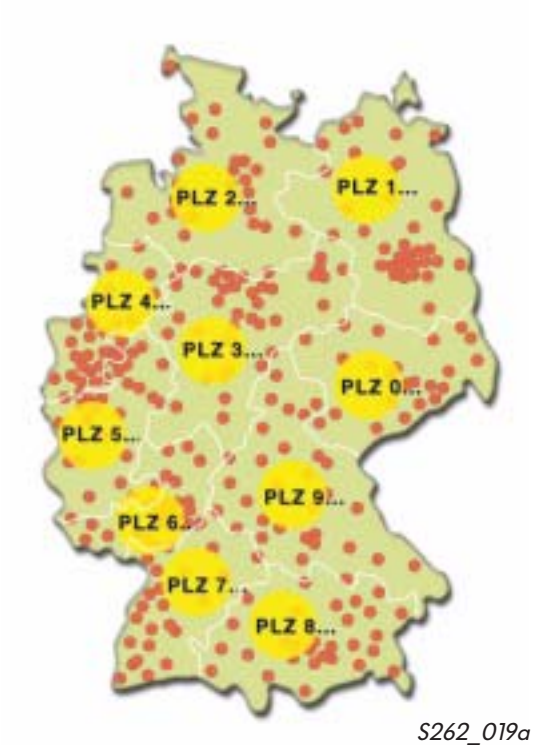
Introduction

The supply of natural gas

Natural gas filling station network in Germany

At the start of 2004, the natural gas filling station network comprised of over 400 stations. By the year 2007, there will be approx. 1000 natural gas filling stations.

A list of the natural gas filling stations in Germany - in order of area code - can be **called up by fax**.
The first number of the respective area code must be placed at the end of the fax number when doing this.
Example: Dusseldorf area code **4**....)
Fax number: 0190- 516 169 628**4**



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Europe

There are natural gas filling stations in almost all European countries.
A filling station network has been started in the north of Spain.

With the exception of Italy, the same standardised filling connection (as that used in Germany) is used in all other countries.

If travelling in Italy, it is advisable to carry an adapter in the vehicle.

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Adapter for Italian filling connection

Further information, including addresses of natural gas filling stations, can be obtained by calling **(0180 2 23 45 00)** at the local rate, at any time day or night.
This information and more can be found on the internet at **www.erdgasfahrzeuge.de** and **www.gibgas.de**.

Refuelling

The procedure for refuelling is based on the TK15 type of tank coupling.

Refuelling is as simple, safe and fast as for other types of fuel.

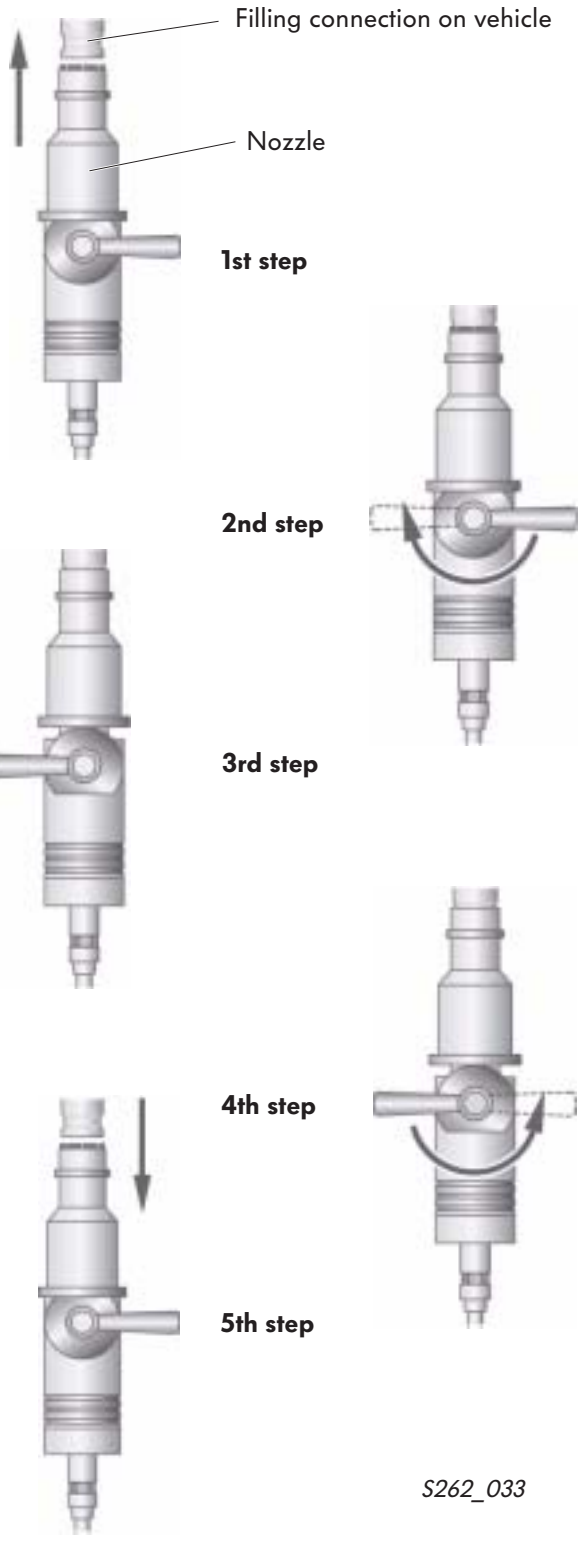
1st step: Take nozzle out of pump and **set** lightly on the filling connection of the vehicle;

2nd step: Filling lever on nozzle should be **turned 180°** in clockwise direction;
When doing this, the nozzle is locked on the filling connection at the same time to allow the refuelling process to commence;

3rd step: Refuel by pressing the start button on the pump;
When the maximum tank pressure is reached the refuelling process is stopped. Refuelling can be stopped at any time by pressing the stop button on the pump;

4th step: Once refuelling has been stopped, **turn back** filling lever **180°** in anti-clockwise direction. This results in nozzle and gas line pressure being reduced automatically by means of ventilation, and the lock is released;

5th step: Remove nozzle from filling connection of vehicle and place **back** in pump;



The weight of natural gas is calculated directly in relation to the volume and therefore the amount filled is shown in kilograms.
One kilogram of natural gas has a volume of approx. 6.2 litres.

Introduction

Comparison and laws affecting the use of gas

The following compares the **advantages and disadvantages** of using natural gas as a fuel:

Advantages:

- A cheap and little used source of energy for those who travel regularly
- Low mineral oil tax rate fixed until the end of 2020 across Germany
- Promoted in varying degrees regionally by communities and natural gas suppliers (e. g. by loans, refuelling vouchers or contribution towards conversion costs)
- Harmful emissions considerably lower than petrol and diesel fuel
- Combustion results almost completely in water
- Can be used in conventional petrol engines without chemical change
- Well suited for bivalent use
- High resistance to knocking
- No change in insurance
- Deposits of natural gas will last considerably longer than raw oil
- No loss through vaporisation when refuelling
- Lighter than air, evaporates upwards
- Environmentally friendly thanks to low harmful emissions
- Burns more “softly”
- Emissions almost completely free of particulates

Disadvantages:

- Compared with petrol operation, a reduction in engine performance if optimised petrol engine is kept
- Special installation, safety and monitoring regulations have to observed due to the high pressure tanks
- The additional fuel volume for bivalent operation must be accommodated on the vehicle
- The natural gas tanks made from steel are an additional load on the vehicle, whereby plastic tanks do not cause this problem
- Currently, the filling station network in Germany is not very dense, though as of 2004 there are more than 400 stations
- Higher purchase price
- Special inspections (vehicle/technical testing) of natural gas tanks necessary at additional cost every 3 to 10 years, depending on design
- Low range if vehicle is powered by gas

S262_014

Legal requirements currently applicable in Germany

The StVZO (road traffic and vehicle registration act) applies in Germany for registration, periodical testing and vehicle modification measures.
For gas powered vehicles, there are additional regulations ...

– with regards to **motor vehicle emissions**

The use of natural gas helps to reduce the negative impact on the environment from exhaust gas emissions, which are controlled by strict regulations.

As of 01.01.2000, emissions have to fulfil the EU III standard. Once the EU IV standard comes into force in 2005, there will be an even greater restriction on emissions.
Until then, tax benefits can be gained for vehicles that already fulfil the EU IV emissions standard.

A vehicle that has been converted for use with natural gas is also entitled to these tax benefits until 2005, providing it fulfils the EU III/D4 standard.

– with regards to **natural gas**

The following guidelines apply for conversion, testing, operation and registration of natural gas powered vehicles.

Guideline 757 of the VdTÜV (association of vehicle and technical testing centres)

EN13423
Handling of natural gas powered vehicles

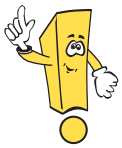
ECE-R110
ECE-R115

Safety data sheet G609 from the DVGW (German organisation for gas and water trades)

GSG
(law on equipment safety)

Pressurised container regulations

Further information regarding *legal requirements* can be found in the chapter entitled “Glossary”.



The legal requirements currently applicable in Germany are being revised by the Federal Ministry of Transport, Construction and Housing.
Among other things, the revision is designed to establish the following two points:
– Maximum period of use for natural gas tank: 20 years
– Natural gas system to be inspected every 36 months for suitability by natural gas vehicle specialist
The final version of the revised legal requirements was unavailable at the time of publication.

Work on the high pressure side of the natural gas system should only be carried out by trained specialists with special certificate of trade proficiency.

The Transporter ‘91 ➤ bivalent

The Transporter ‘91 ➤ with petrol engine 2.5 l/85 kW (engine code AET) can be converted for *bivalent* operation with a natural gas system.

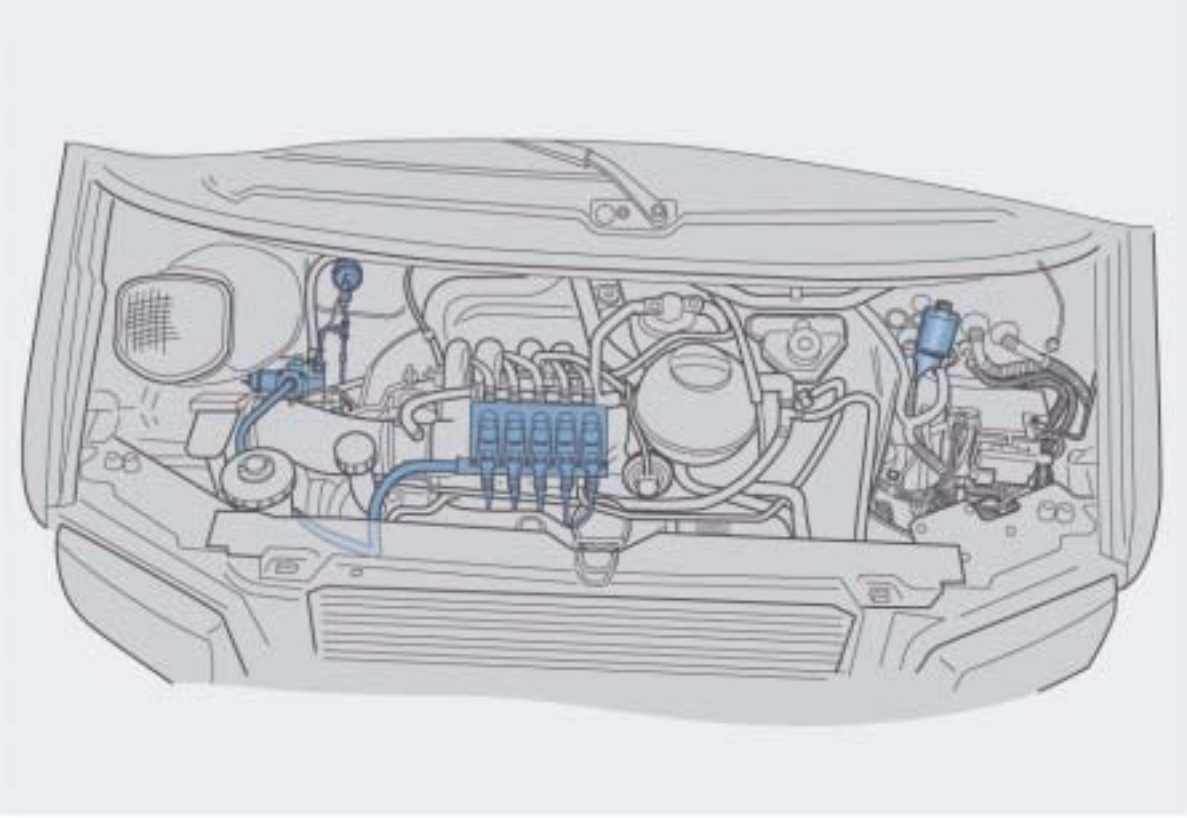
Bivalent operation means that the vehicle can be run on petrol and also natural gas.

Bivalent operation is made possible by conversion of the components specific to natural gas in addition to the components for petrol operation. Changing over from one type of fuel to the other is either automatic or via an operating mode changeover switch, which is actuated by the driver.

Combustion chamber and ignition system stay as standard on the bivalent version. Adaptations are made, with regards to the fuel used, in the engine management system, the maps and the lambda probes.

Unlike the Golf BI FUEL, an additional control unit is installed on this type of vehicle for natural gas operation.

Bivalent steel tanks are used to store the natural gas on the Transporter ‘91 ➤.



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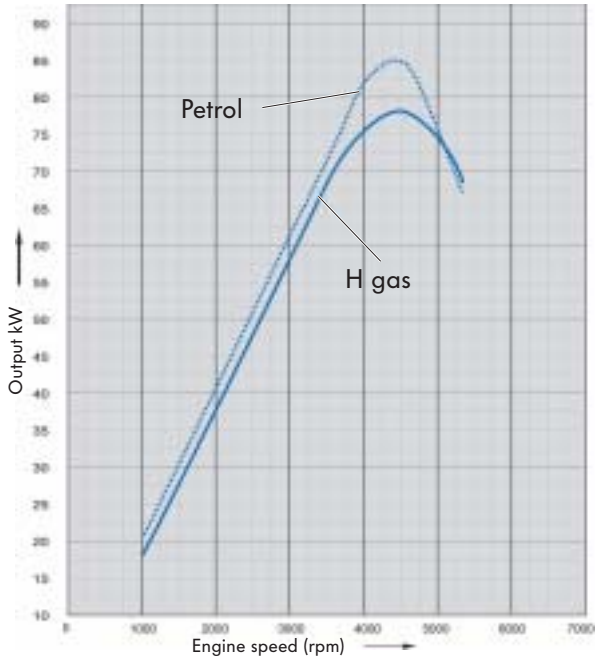
Technical data: Transporter '91 ➤ bivalent

Engine code	AET
Capacity	2.5 l
Engine type	5-cylinder in-line engine
Valves per cylinder	2
Bore	81.0 mm
Stroke	95.5 mm
Compression ratio	10.0 : 1
Engine management	Petrol: Simos 5S Natural gas: Metatron
Maximum output: Petrol Natural gas (H gas)	85 kW at 4500 rpm 78 kW at 4500 rpm
Maximum torque: Petrol Natural gas (H gas)	200 Nm at 2200 rpm 190 Nm at 3300 rpm
Fuel	Petrol with 95 RON / natural gas
Exhaust gas treatment	Exhaust gas recirculation; catalytic converter
Emissions standard: Petrol Natural gas (H gas)	EU III commercial vehicles EU III commercial vehicles

Comparison between petrol and natural gas: Transporter '91 ➤ bivalent

Output



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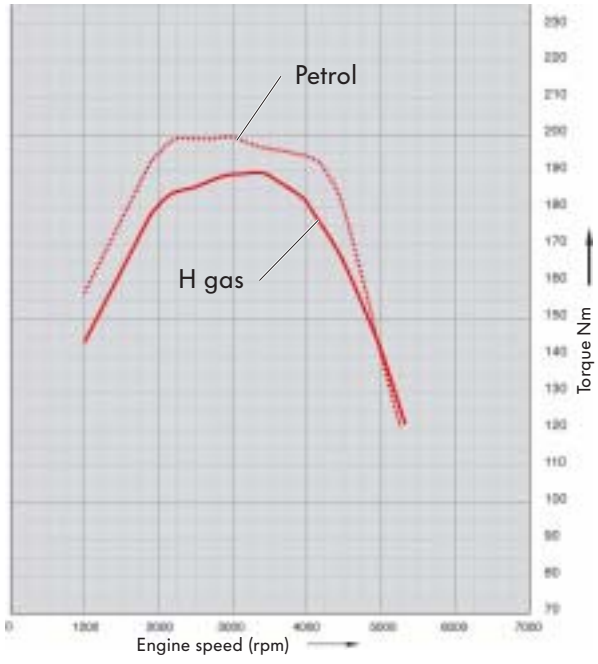
Torque



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The Golf BI FUEL

This vehicle is offered exclusively with the 2.0 l/85 kW engine (engine code BEH).

In the Golf BI FUEL, only one Motronic control unit is installed for both modes of bivalent operation and there are optimised maps for each mode.

The relevant maps and functions for petrol or natural gas operation are selected depending on the mode of operation.

Natural gas has a knock resistance of 130 RON.
RON (**R**esearch **O**ctane **N**umber) means: knock resistance determined in trials.

This high resistance to knocking means that natural gas burns softer than petrol.
The engine noise is pleasant and quieter.

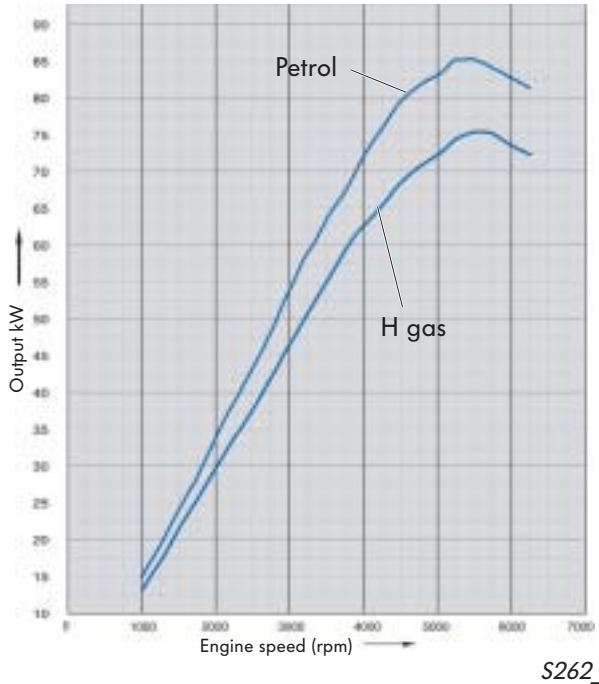
S262_044a

Technical data: Golf BI FUEL

Engine code	BEH
Capacity	2.0 l
Engine type	4-cylinder in-line engine
Valves per cylinder	2
Bore	82.5 mm
Stroke	92.8 mm
Compression ratio	10.5 : 1
Maximum output: Petrol Natural gas (H gas)	85 kW at 5250 rpm 75 kW at 5500 rpm
Maximum torque: Petrol Natural gas (H gas)	175 Nm at 3250 rpm 151 Nm at 3750 rpm
Engine management	Motronic ME 7.1.1 (G)
Fuel	Petrol with 95 RON / natural gas
Exhaust gas treatment	Exhaust gas recirculation; catalytic converter
Emissions standard: Petrol Natural gas (H gas)	EU IV EU III/D4

Comparison between petrol and natural gas: Golf BI FUEL

Output



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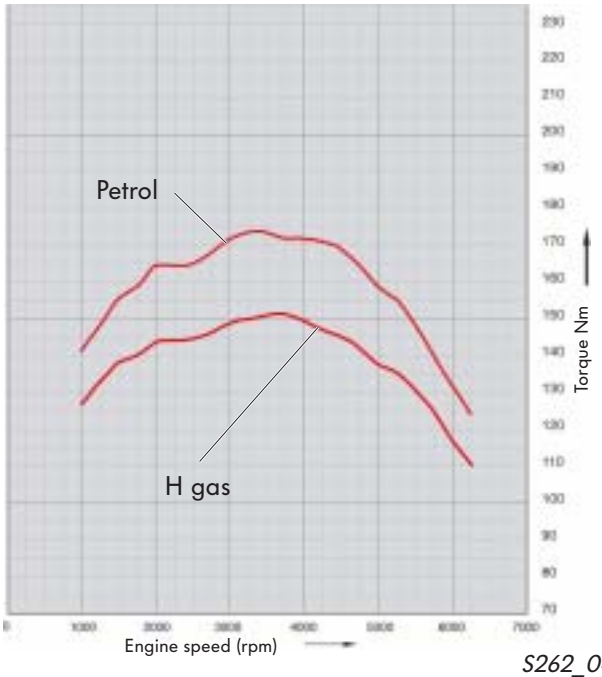
Torque



S262_043

Natural gas storage

The different methods of storing natural gas fuel

Natural gas can be stored in two different ways:

- *CNG* storage (Compressed Natural Gas)
- *LNG* storage (Liquefied Natural Gas)

CNG storage

In order to make a sufficient quantity available for natural gas operation, the natural gas is compressed to a maximum of 200 bar with this method.
Special pressurised gas containers are required for this type of storage.

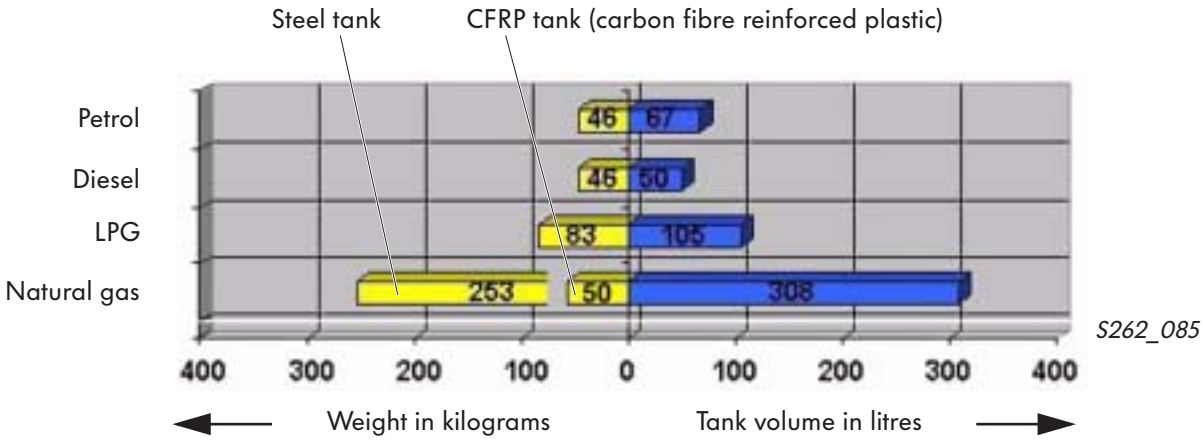
This is favoured by Volkswagen.

LNG storage

Since natural gas is always in a gaseous state, it is cooled down considerably with this method. The natural gas turns into a liquid at a temperature of minus 161 °C and can be stored in this state.
For storage and transportation, special cooling tanks are required.
This type of storage is used mainly for purposes of natural gas distribution.

Space requirement and weight of different fuels

In order to attain the same range with different types of fuel, the tank volumes must be different.
The diagram below shows the required tank volume (blue) and the weight of the tank (yellow) for the different types of fuel.



LNG should not be confused with **LPG** (**L**iquefied **P**etroleum **G**as), also known as auto gas or fluid gas. LPG becomes liquefied at a pressure of 5 to 10 bar.
It can be stored in a similar way to petrol at a pressure of 10 to 20 bar.

The natural gas tank

At Volkswagen, two different types of natural gas tanks are used for storage of CNG:

- Steel tanks
- *CFRP* natural gas tanks (carbon fibre reinforced plastic)

Steel tanks

In the Transporter '91 ➤ bivalent, two steel tanks of the same sort are used.
These are sturdy and cheap but relatively heavy.

A steel tank weighs approx. 80 kilograms and has a volume of approx. 80 litres.
An 80 litre tank volume of natural gas equates to a weight of approx. 12.9 kilograms.

Steel tanks in the Transporter '91 ➤ bivalent

S262_058

Natural gas storage

CFRP natural gas tanks
(carbon fibre reinforced plastic tank)

In the Golf BI FUEL, two different types of natural gas tanks made from carbon fibre reinforced plastic are installed. These two natural gas tanks have a total capacity of 74 litres and together they weigh 34 kilograms.
A 74 litre tank volume of natural gas weighs 11.9 kilograms.

The natural gas tanks of the Golf BI FUEL are installed in the luggage compartment.
A separate cover protects the natural gas tanks from external influences and damage.

Due to the large amount of space required for the gas tank, the Golf BI FUEL is only available as an estate.

CFRP natural gas tank in the Golf BI FUEL

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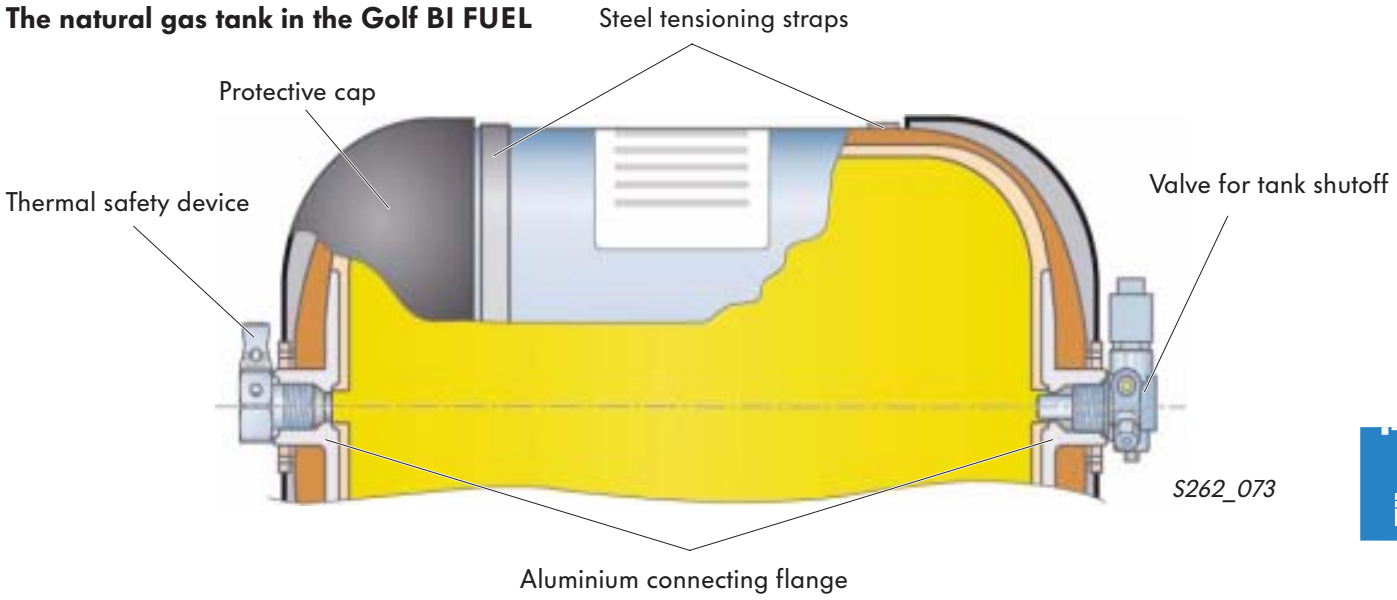
Extract from pressurised container regulations:
The natural gas tanks should only be installed and covered to a degree that enables periodical inspections to be carried out without difficulty and without the need for tools.

The natural gas tank in the Golf BI FUEL



The natural gas tank of the Golf BI FUEL comprises of a *polyethylene* base structure, which is surrounded by several carbon fibre reinforced *epoxi-resin* layers.

There are aluminium connecting flanges on both ends of the tank as a means of mounting the thermal safety device and the tank shutoff valve.

To protect the ends of the natural gas tank there are protective caps. These protective caps comprise of a *polycarbonate* outer skin and a *polystyrol* inner layer.

The natural gas tanks are attached in the vehicle by two steel tensioning straps.

The thermal safety device is part of the natural gas tank and should not be removed.

Natural gas storage

The tank inspection intervals

The natural gas tanks should only be filled if their period of certification is still valid.
Once the period expires, filling is only permissible after an inspection has been carried out.
For this reason, the natural gas tanks must be checked at regular intervals by an approved body (vehicle or technical inspectorate).

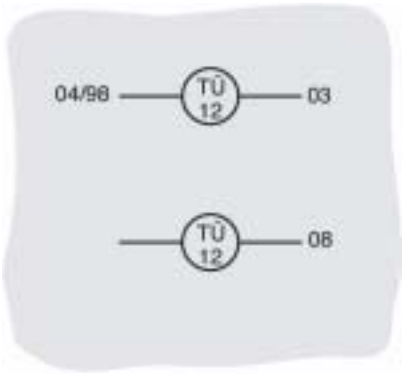
Test certificates for natural gas tanks

The pressurised container regulations require the natural gas tanks to be marked clearly.

Transporter '91 ➤ bivalent

Stamped test certificates on steel tanks

- TÜ 12 — Number and identification code of test station
- 04/98 — Month/year of first test
- 03 — Year of first periodical inspection
- 08 — Year of second periodical inspection



S262_050

In this example, the inspections are carried out every five years.
A new test certificate is stamped on the tank each time an inspection is carried out.

Seal on gas filling connection

- 12 — Number of testing station
- 04/2008 — Month/year of periodical inspection

S262_036

Year and month of inspection

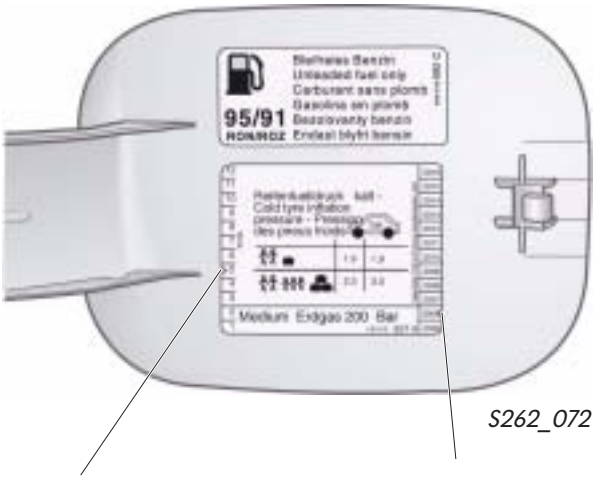
All periodical inspections must be carried out in the same month as the first inspection.
The first inspection is carried out prior to initial filling by the manufacturer.
For all periodical inspections thereafter, the vehicle owner/vehicle operator is responsible.

Golf BI FUEL

Information on fuel tank flap

On the inside of the fuel tank flap on the Golf BI FUEL there are warning notices.
In addition to the normal data, the following natural gas relevant details can be found:

- Quality of natural gas, medium (H/L gas)
- Maximum fill pressure, 200 bar
- Date next safety inspection of natural gas tank is due, example here shows month 05/year 2006



S262_072

Next month:
05

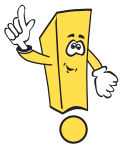
Next year:
2006

Natural gas tank information

The natural gas tanks of the Golf BI FUEL feature data plates.
All natural gas relevant details can be gleaned from the adjacent data plate.
The natural gas relevant details are:

- Date of first visual inspection, month 05 - year 2003
- Operating pressure at 15 °C, 20 MPa equates to 200 bar
- Test pressure, 33 MPa equates to 330 bar
- Operating temperature, –40 °C to +65 °C
- Date of last use month 05 - year 2023
- Filling medium, natural gas (CNG)

S262_086



The legal requirements currently applicable in Germany are being revised by the Federal Ministry of Transport, Construction and Housing.
Among other things, the revision is designed to determine the following two points:

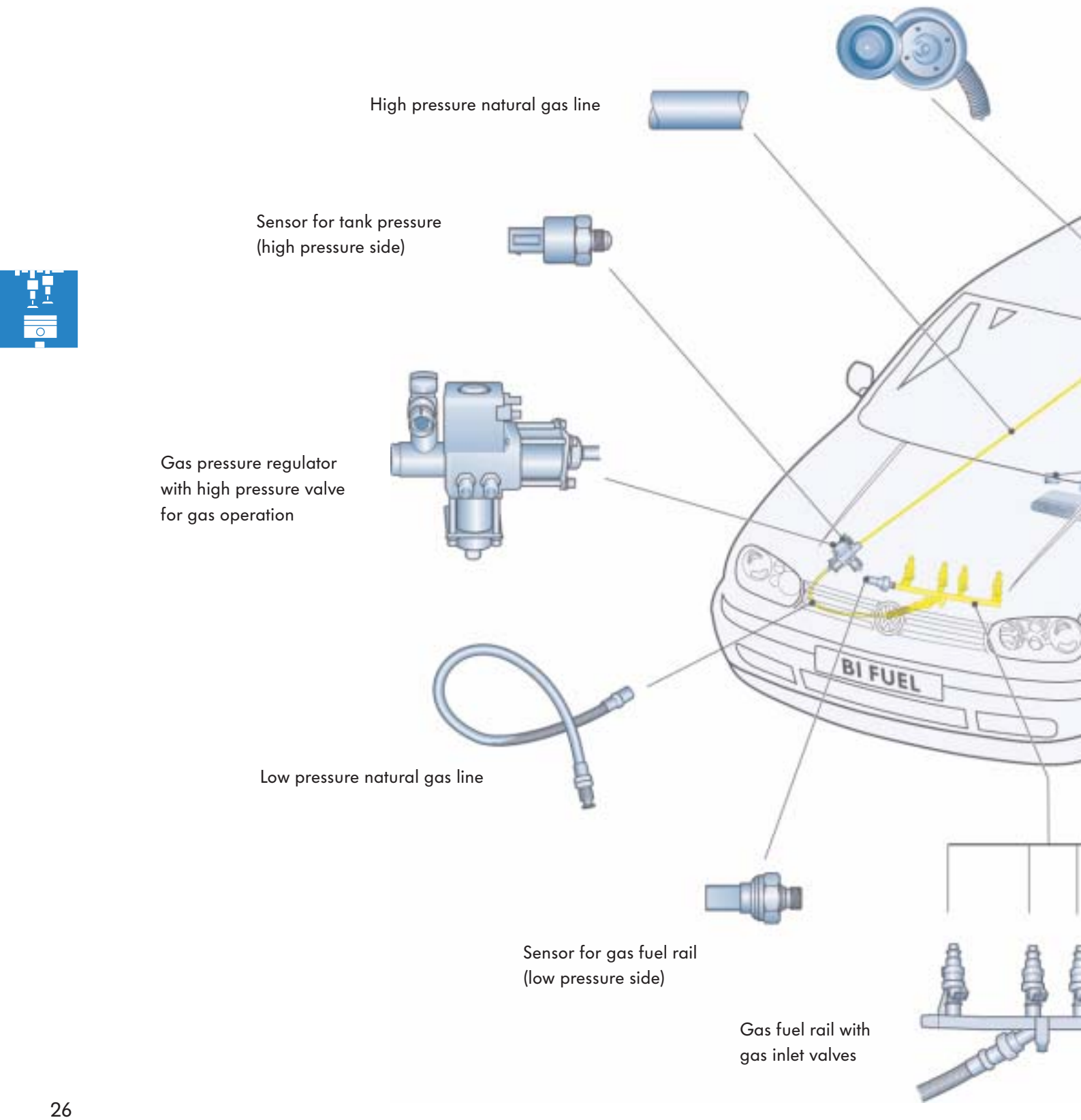
– Maximum period of use for natural gas tank: 20 years
– Natural gas system to be inspected every 36 months for suitability by natural gas vehicle specialist

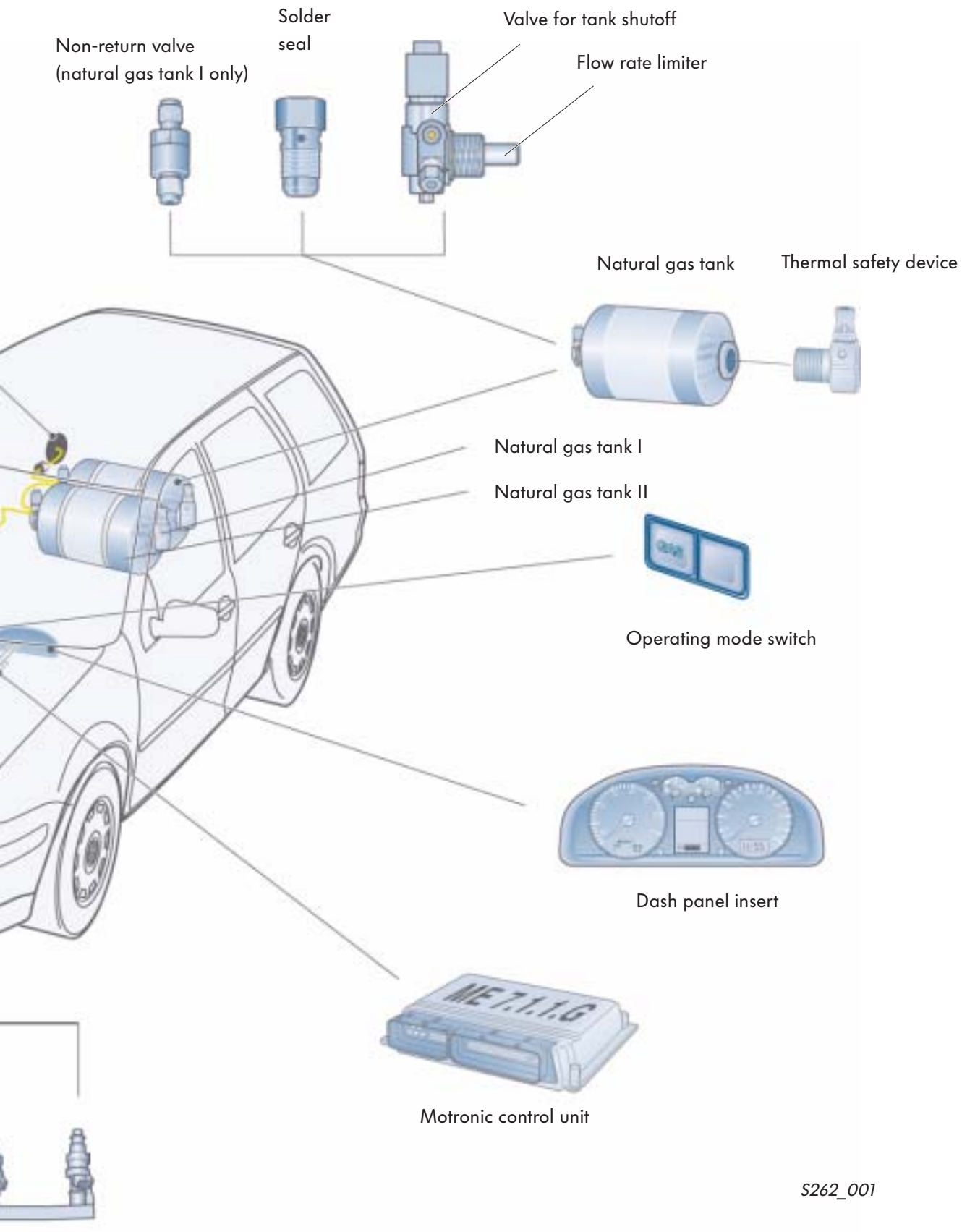
The final version of the revised legal requirements was unavailable at the time of publication.

Natural gas components in Golf BI FUEL

Overview of components

This component overview is based on the Golf BI FUEL system and shows all the parts required for gas operation.



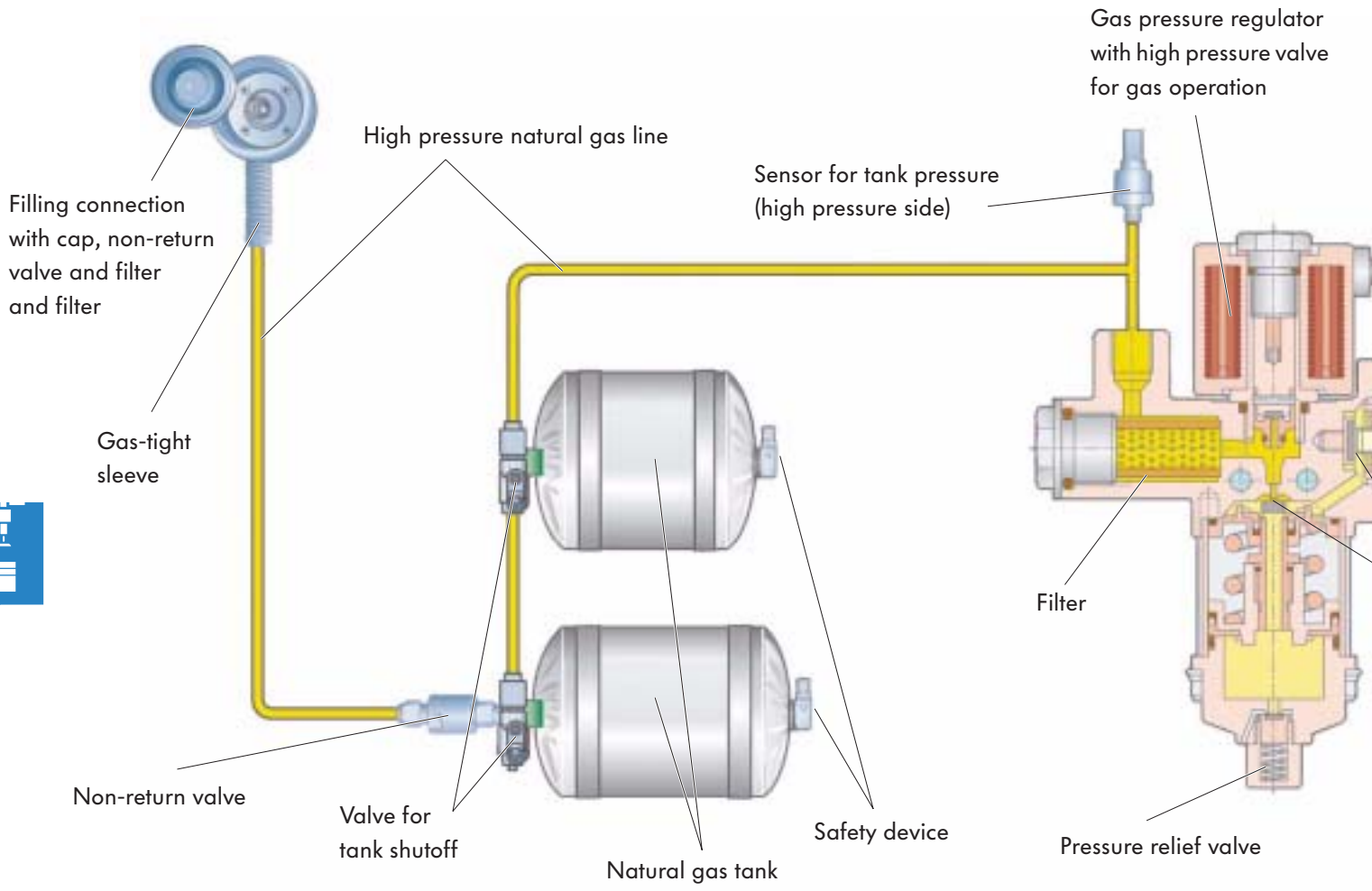

Non-return valve
(natural gas tank I only)
Solder
seal
Valve for tank shutoff
Flow rate limiter
Natural gas tank
Thermal safety device
Natural gas tank I
Natural gas tank II
Operating mode switch
Dash panel insert
ME7.1.1.G
Motronic control unit

S262_001

Natural gas supply in Golf BI FUEL

System overview of natural gas supply

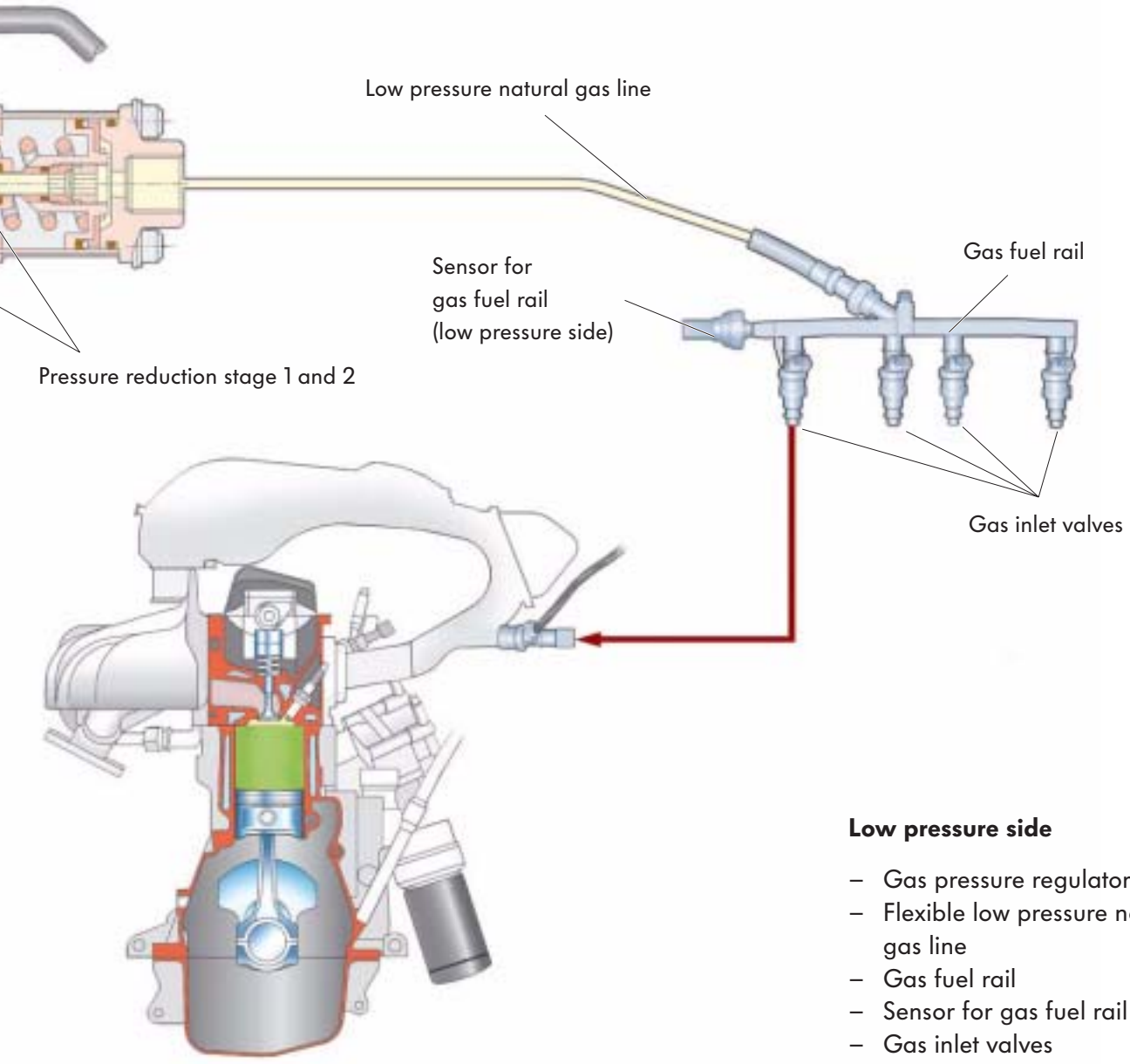
Flow diagram of natural gas relevant components for high and low pressure side



High pressure side

- Filling connection with cover cap, non-return valve and filter
- Gas-tight sleeve for pressure line within vehicle
- Natural gas tank
- Non-return valve
- Valve for tank shutoff with:
  - Electromagnetic shutoff valve
  - Mechanical shutoff valve
  - Solder seal
  - Flow rate limiter
- Thermal safety device
- High pressure natural gas line
- Sensor for tank pressure
- Gas pressure regulator with
  - High pressure valve for gas operation
  - Filter
  - Two pressure reduction stages
  - Pressure relief valve

The interface between the high and low pressure side is provided by the gas pressure regulator.



S262_028

Low pressure side

- Gas pressure regulator
- Flexible low pressure natural gas line
- Gas fuel rail
- Sensor for gas fuel rail
- Gas inlet valves

Natural gas supply in Golf BI FUEL

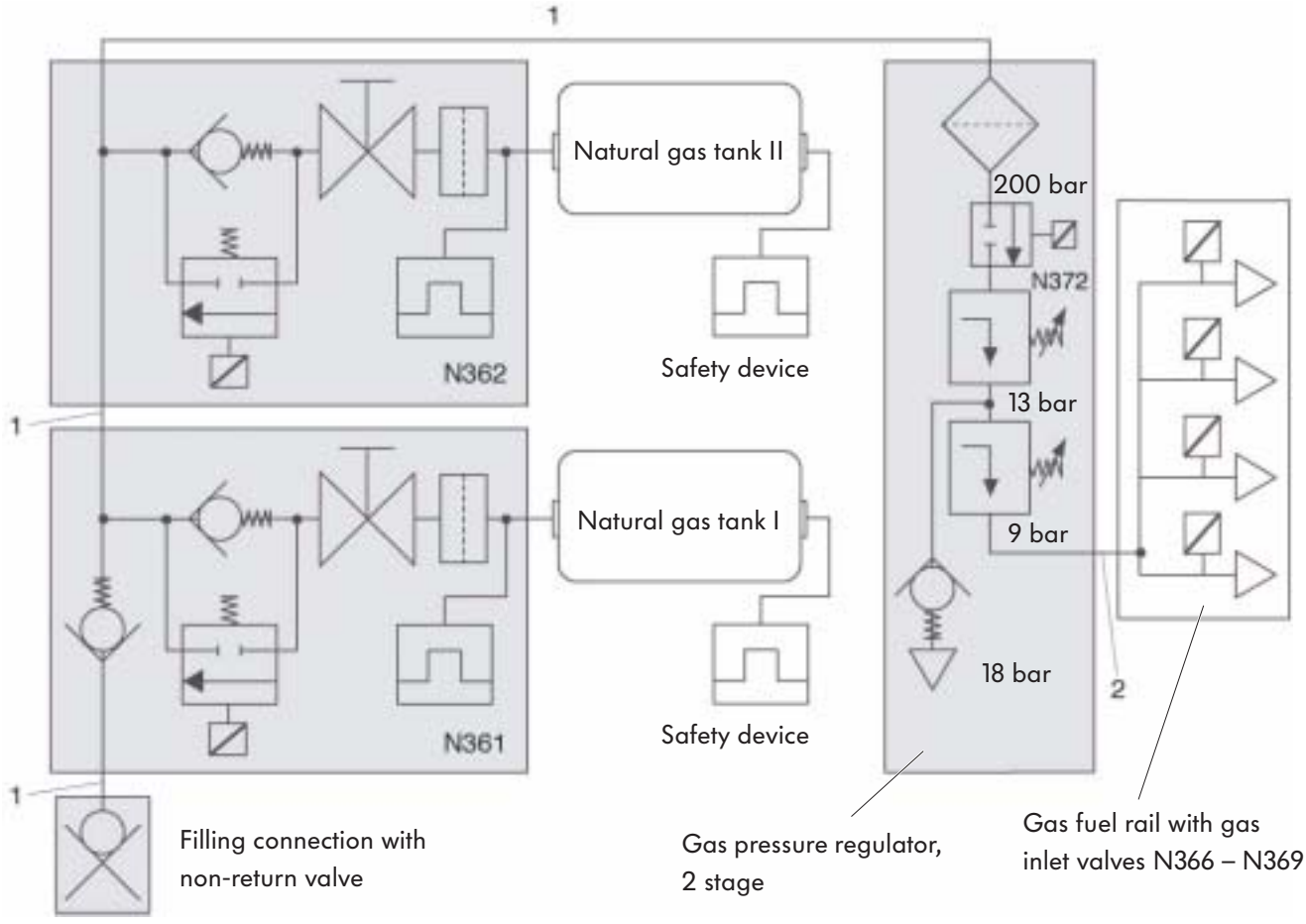
Flow chart of natural gas supply system

In the flow chart below, all of the components of the natural gas system can be seen.

On the following pages, the individual components of the natural gas system are described in detail.

The flow chart shows the direction of flow and the parts as symbols.
All components are shown in the rest state.

Flow chart



S262_110

Key

1 - High pressure natural gas line
2 - Low pressure natural gas line

N361 - Valve 1 for tank shutoff
N362 - Valve 2 for tank shutoff
N372 - High pressure valve for gas mode

The high pressure side

Filling connection, type NGV-1
(*NGV* - Natural Gas Vehicle)

It can be found on the rear right of the vehicle. It is covered by a retractable cover.

A particulate filter and a non-return valve are integrated in the filling connection.

The filter is maintenance-free. It cleans itself when pressure is released in the tank supply line to the nozzle.

S262_059

High pressure natural gas line

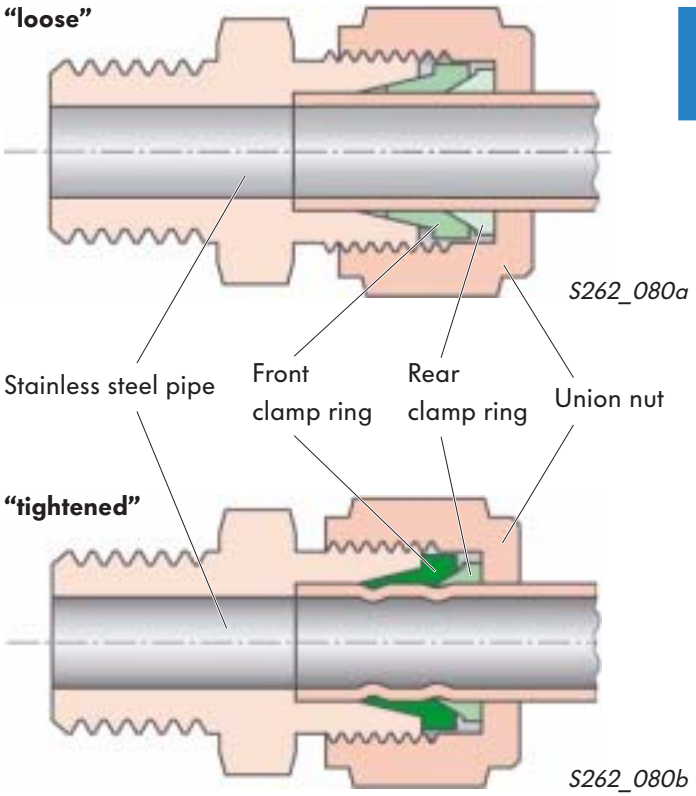
The high pressure natural gas line is made of stainless steel and is designed for pressures above 200 bar.

It joins the filling connection with the tank and this in turn with the gas pressure regulator. It is routed firmly along the body.

To ensure good gas-tight properties, the individual elements are joined together with a double clamping ring connection.

The high pressure natural gas line is routed on the underside parallel to the petrol line.

Double clamping ring connection



S262_080a

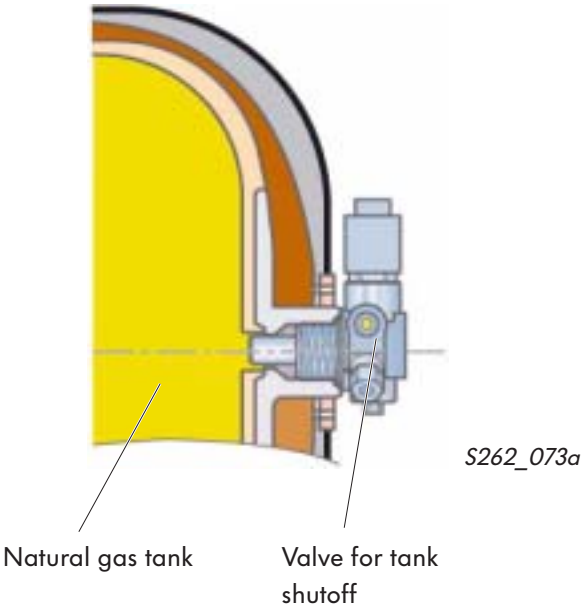
S262_080b

The natural gas components installed on the inside of the vehicle must be equipped with a gas-tight sleeve.

Natural gas supply in Golf BI FUEL

Valve 1 and 2 for tank shutoff N361 and N362

A tank shutoff valve is screwed into the right end of each natural gas tank.
When facing the direction of normal travel, the tank shutoff valve 1 N361 is installed on the rear gas tank (natural gas tank I).
Tank shutoff valve 2 N362 can be found on the front natural gas tank (natural gas tank II).

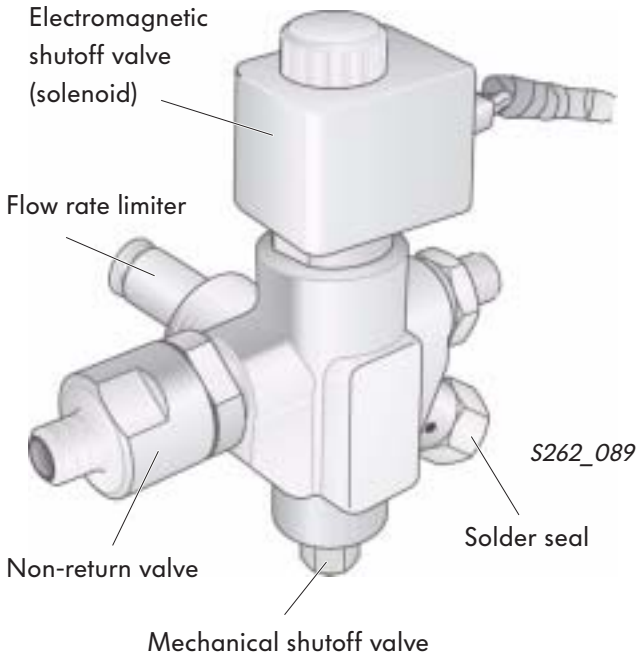


Purpose

The tank shutoff valves regulate the supply of natural gas within the vehicle.
With the components listed as follows, they each form a safety device:

- Electromagnetic shutoff valve
- Solder seal
- Mechanical shutoff valve
- Non-return valve (natural gas tank I only)
- Flow rate limiter

Tank shutoff valve in removed state



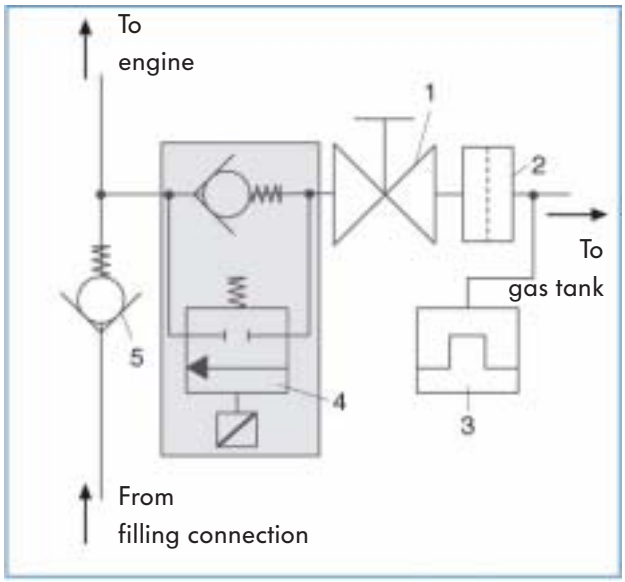
The tank shutoff valves have a tapered thread and must therefore not be reinstalled once unscrewed.
If a tank shutoff valve is loosened, it must be replaced with a new one.

Diagram showing flow of tank shutoff valves 1 and 2

The adjacent chart shows the direction of flow and all of the components of the tank shutoff valve as symbols.

Both tank shutoff valves have the same design.

1 - Mechanical shutoff valve
2 - Flow rate limiter
3 - Solder seal
4 - Electromagnetic shutoff valve
5 - Non-return valve (natural gas tank I only)

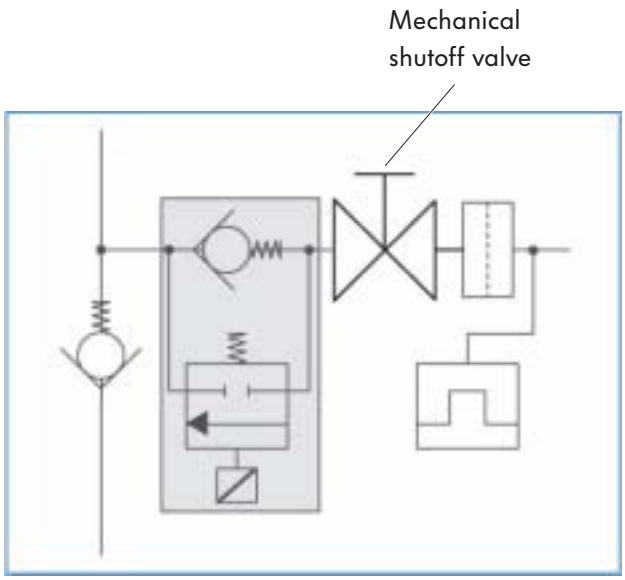


S262_090

Mechanical shutoff valve

The mechanical shutoff valve is highlighted in the adjacent diagram.
The natural gas tank can be sealed gas-tight with an open-jaw spanner via the mechanical shutoff valve.

For reasons of safety, the connection of the solder seal is not sealed even when the shutoff valve is closed.



S262_091

If there is a smell of gas or repair measures are necessary, the mechanical shutoff valve must be closed.

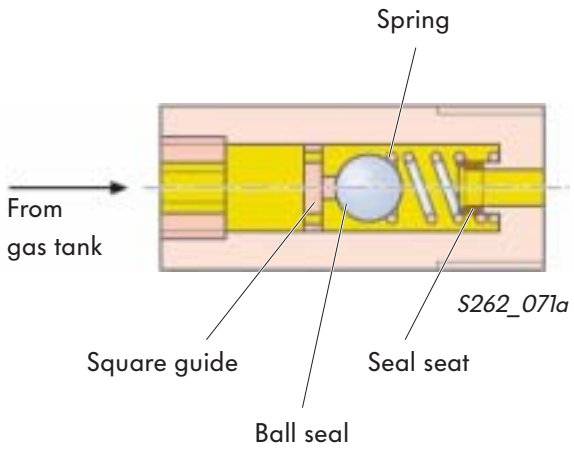
Natural gas supply in Golf BI FUEL

Flow rate limiter

The flow rate limiter (restriction in flow) is a safety valve and can be found on tank shutoff valve 1. It prevents accidental and rapid outlet of natural gas from the tank in the event of damage to the natural gas lines.

The flow rate limiter is adjusted by the spring so that it closes at a pressure difference of 2 bar.

Flow rate limiter "open"



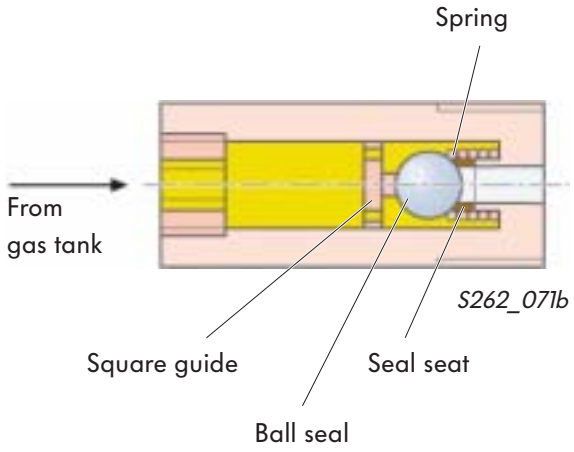
Function

If the natural gas line is torn away or starts leaking, the pressure in the natural gas line will drop within a short space of time by 2 bar.

This sudden drop of pressure results in the pressure in the natural gas tank rising considerably above the pressure difference of 2 bar and pushes the ball seal into the seal seat via the square guide.

The natural gas tank is thereby sealed and no more natural gas can escape.

Flow rate limiter "closed"

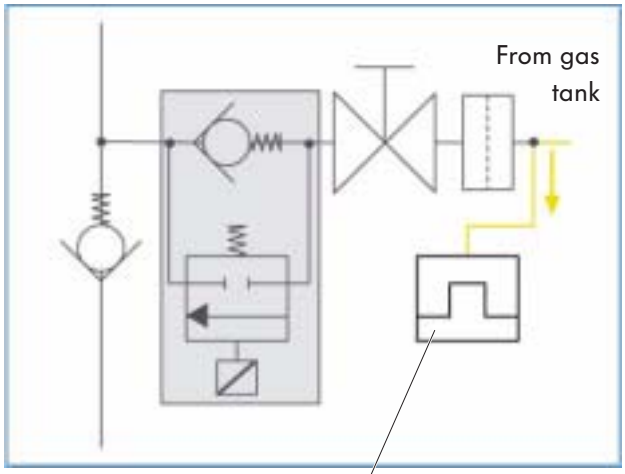


After repair work to a damaged natural gas line has been carried out, a closed flow rate limiter can be opened again by replenishing the natural gas system.

Solder seal

The solder seal is also installed in the tank shutoff valve.
It prevents the natural gas tank from bursting as a result of an excessive increase in pressure caused by fire.

The solder seal is installed so that a direct discharge is possible at any time.



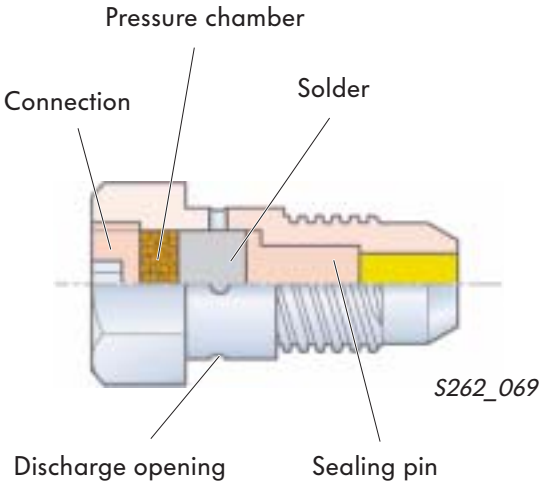
Function

The melting point of the solder in the seal is approx. 110 °C.

If the solder seal reaches a temperature of approx. 110 °C as a result of a fire, it will begin to melt.
The solder seal is housed in the porous pressure chamber.

The natural gas can escape from the natural gas tank via the discharge holes and flare off in a controlled manner.

This thereby prevents the natural gas tank from bursting as a result of excessive pressure.

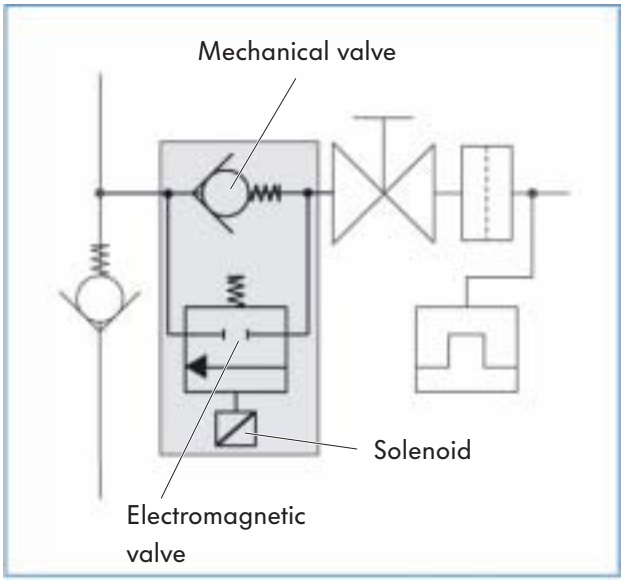


During normal operation, the porous pressure chamber prevents the solder from draining away by the application of gas pressure.

Natural gas supply in Golf BI FUEL

Electromechanical shutoff valve

The electromechanical shutoff valve is highlighted in the adjacent diagram.
It consists of an electromagnetic valve with a solenoid and a mechanical valve.
The electromagnetic valve is closed when not energised and completely seals the natural gas tank.



S262_092

Function

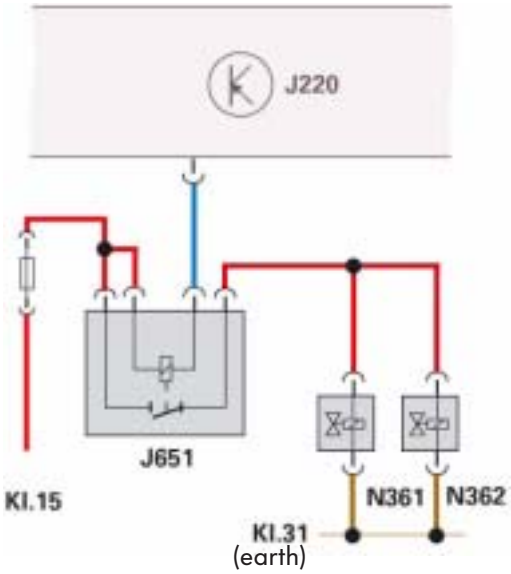
The electromagnetic shutoff valves open if the ignition is switched on (term. 15).
To do this, the Motronic control unit J220 actuates relay 1 for shutoff valve J651.

If the electromagnetic shutoff valves are open, the complete high pressure side is subjected to pressure.

Effects of signal failure

If the electromagnetic shutoff valves are not actuated or are defective, natural gas operation is not possible.

Electrical circuit diagram

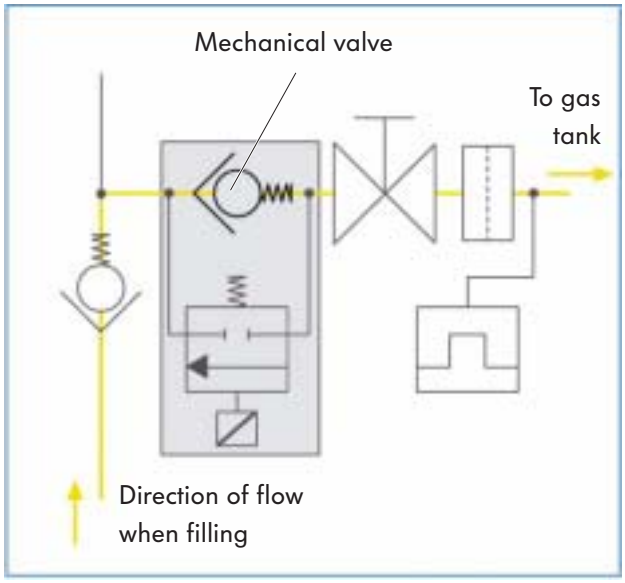


S262_093

If a crash signal is triggered, the electromagnetic shutoff valves are closed automatically.

Electromagnetic shutoff valve when tank is being filled

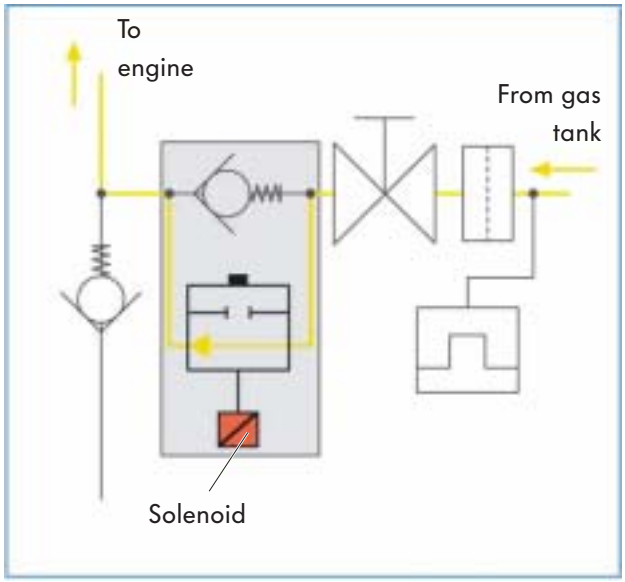
The adjacent picture shows the direction of natural gas flow in colour during replenishment. When the vehicle is being replenished, the fuel is filled into the natural gas system of the Golf BI FUEL at a pressure of 200 bar.
The mechanical valve in the electromagnetic shutoff valve is opened mechanically against spring pressure by the pressure of the natural gas during replenishment.
The gas flows into the natural gas tank.
Once a pressure of 200 bar is reached in the gas tank, the mechanical valve closes again under spring pressure.



S262_094

Electromagnetic shutoff valve opened electrically

In order that natural gas can be made available to the engine for natural gas operation, the electromagnetic shutoff valve has to be actuated. Once the solenoid is energised, the electromagnetic valve opens and gas finds its way from the natural gas tank to the engine.



S262_095

Natural gas supply in Golf BI FUEL

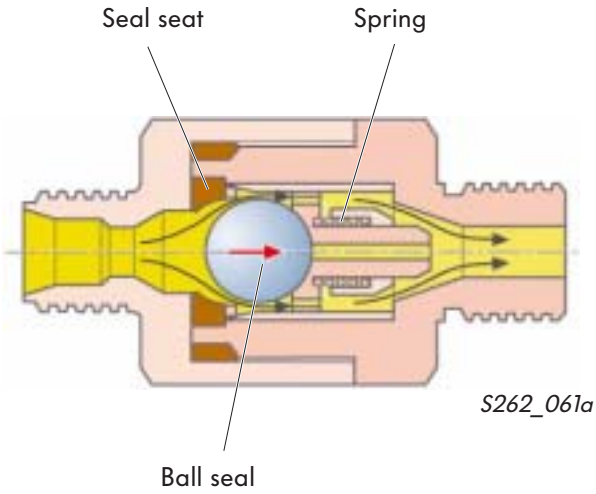
Non-return valve

The non-return valve prevents accidental back flow of natural gas in the lines and to the outside via the filling connection.
Two non-return valves are installed in the Golf BI FUEL.

One non-return valve can be found directly on the filling connection.
The second non-return valve can be found on tank shutoff valve 1 (natural gas tank I).

Valve “open”

During replenishment, the gas is filled from the pump at high pressure and this forces the ball seal off the seal seat against spring pressure. Gas finds its way into the tank.

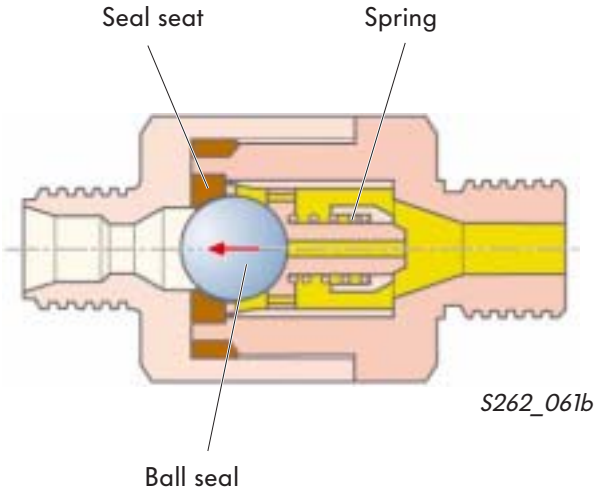


S262_061a

Valve “closed”

If pressure is missing at the left of the ball seal when replenishment is complete, spring pressure and internal tank pressure push the ball seal back into the seal seat.

Back-flow of the gas is thereby prevented.



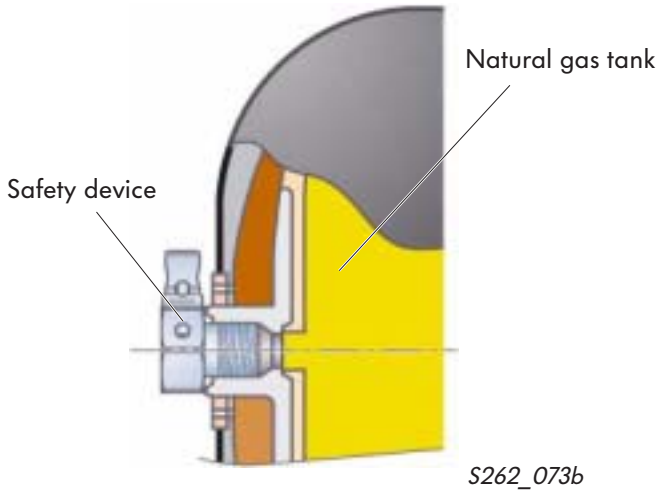
S262_061b

To reach the high demands on safety, guideline 757 of the VdTÜV (association of vehicle/ technical testing stations) prescribes the installation of two non-return valves between the filling connection and the natural gas tank.

Thermal safety device

To increase safety in the event of a fire, there is an additional thermal safety device on the left end side of each natural gas tank in the Golf BI FUEL.

This thermal safety device comprises of a housing into which a tube - a so-called *cuvette* - is screwed.
This tube is filled with a special fluid. After a certain time, the fluid expands at a predetermined temperature by a prescribed value.

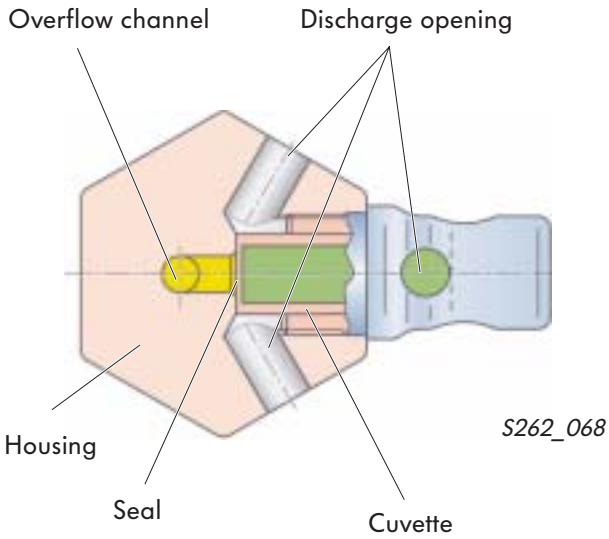


S262_073b

Function

In the event of a fire, the fluid in the cuvette expands so much from the build up of heat that the cuvette ejects at a temperature of 110 °C after approx. seven seconds.

Once the cuvette ejects, the seal is opened.
Gas can escape from the natural gas tank via the overflow channel, the ejected cuvette and the discharge openings.
The natural gas can flare off into the open in a controlled manner.
This thereby prevents the natural gas tank from bursting.



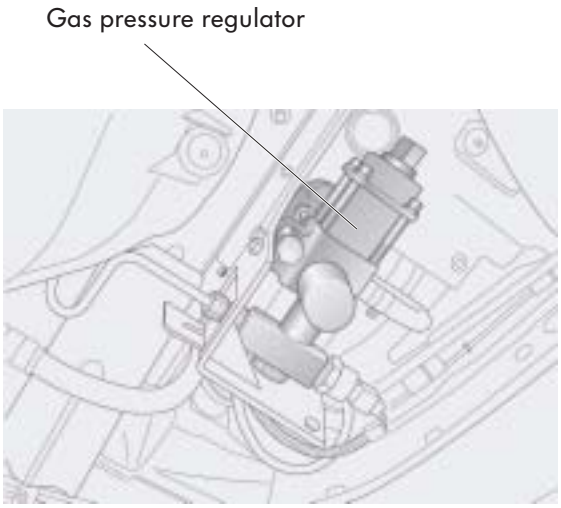
S262_068

The thermal safety device should not be loosened.
It is part of the natural gas tank and can only be renewed by the manufacturer of the natural gas tank.

Natural gas supply in Golf BI FUEL

Gas pressure regulator

The gas pressure regulator of the Golf BI FUEL is housed on the front right longitudinal member in the wheel housing.
It features a plastic cover as a means of protection against water splashes and stone chips.



S262_064

Shown without plastic cover around gas pressure regulator

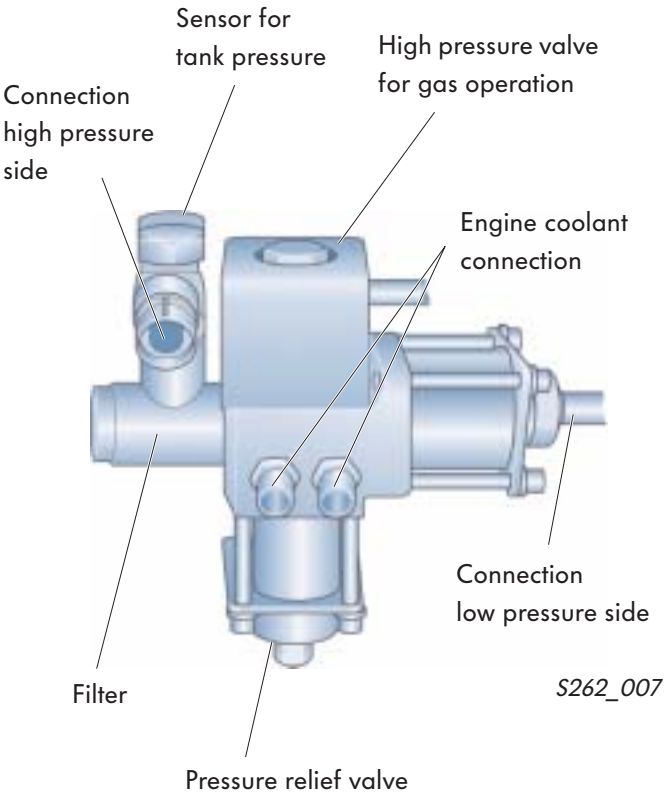
Purpose

The gas pressure regulator reduces natural gas pressure in two stages from a maximum 200 bar to approx. 9 bar.
It thereby separates the high pressure side from the low pressure side.

Design

The gas pressure regulator is another form of safety device and features the components listed as follows:

- Engine coolant connections
- Filter
- Sensor for tank pressure, G400
- 1st pressure reduction stage
- 2nd pressure reduction stage
- High pressure valve for gas mode, N372
- Pressure relief valve



S262_007

Up to the gas pressure regulator in the natural gas tank there could be a maximum pressure of 200 bar.

Engine coolant connections

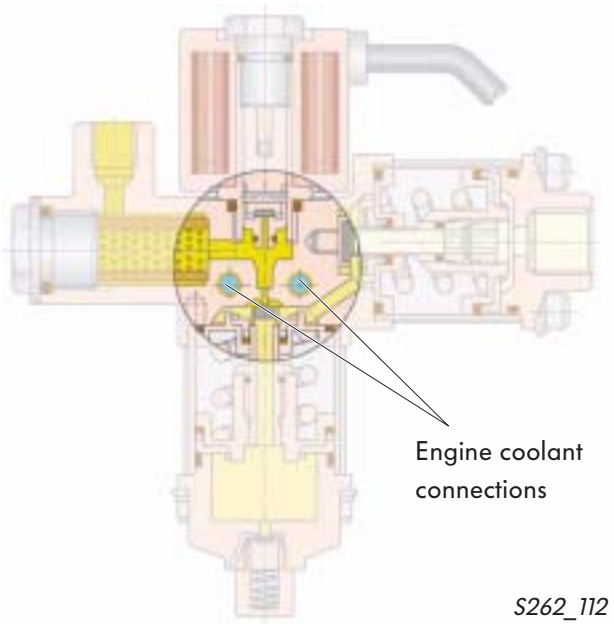
The gas pressure regulator reduces pressure on the high pressure side from a maximum 200 bar to approx. 9 bar on the low pressure side.

This reduction in pressure occurs by means of *expansion* of the natural gas.

The results in a rapid drop in temperature that could ice up the gas pressure regulator.

Purpose

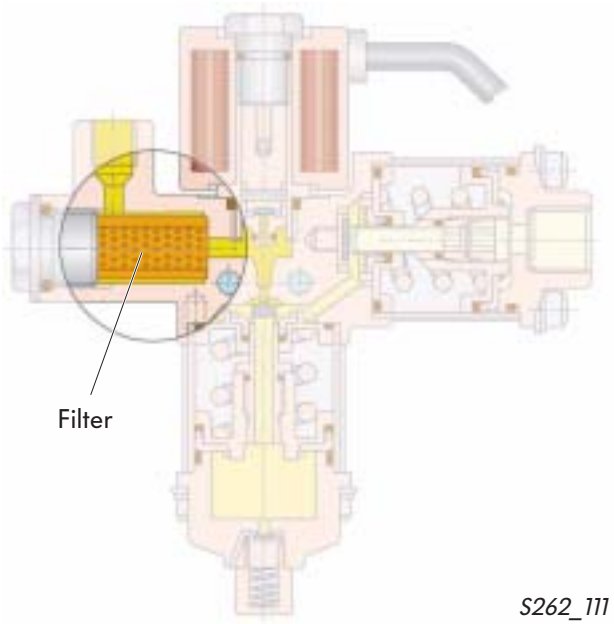
The gas pressure regulator is connected to the small coolant circuit via the engine coolant connections.
By means of these connections, the temperature of the gas pressure regulator is maintained at engine operating temperature, i. e. approx. 100 °C. Icing up is thereby prevented.



S262_112

Filter

Installed in the gas pressure regulator is a maintenance-free filter on the high pressure side. This serves as a means of filtering out any contaminants in the natural gas to prevent damage occurring to the sensitive components on the low pressure side.



S262_111

Natural gas supply in Golf BI FUEL

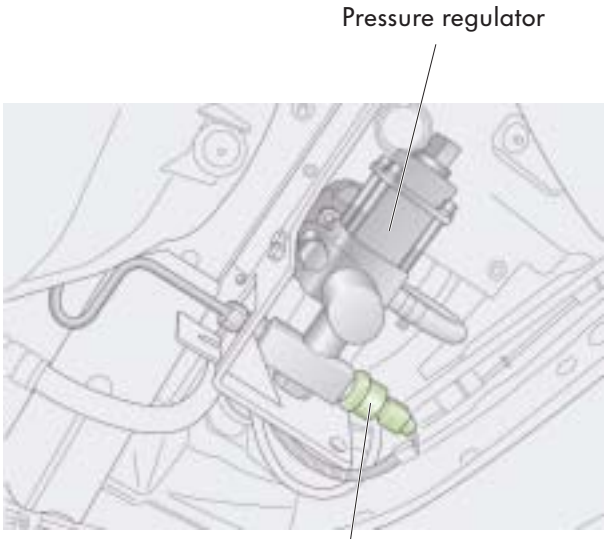
Sensor for tank pressure G400

The sensor for tank pressure is fitted to the gas pressure regulator.

Purpose

The sensor for tank pressure calculates the gas pressure on the high pressure side directly before the first pressure reduction stage.

The Motronic control unit requires the signal from the tank pressure sensor in order to actuate the natural gas fuel gauge G411 in the dash panel insert.
The signal is still needed in order to change over to natural gas operation.

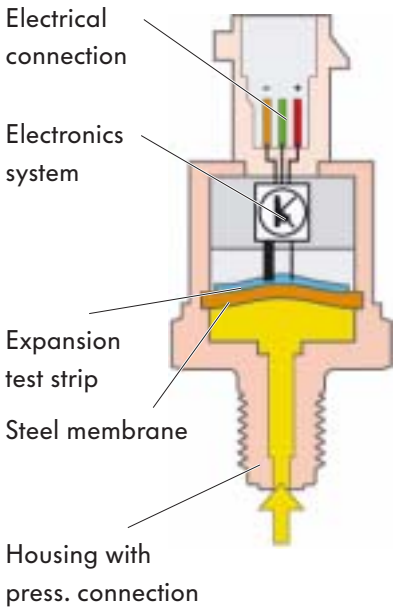


S262_064a

Design

The tank pressure sensor comprises of:

- Housing with pressure connection
- Sensor element
  (steel membrane and expansion test strip)
- Electronics system
- Electrical connection



S262_097

Effects of signal failure

If there is no signal from the tank pressure sensor at the Motronic control unit or if the sensor is defective, gas operation is not possible.

Function

Gas pressure on the high pressure side makes its way to the sensor element via the pressure connection on the tank pressure sensor.

The sensor element comprises of a steel membrane, on which the expansion test strip is located.

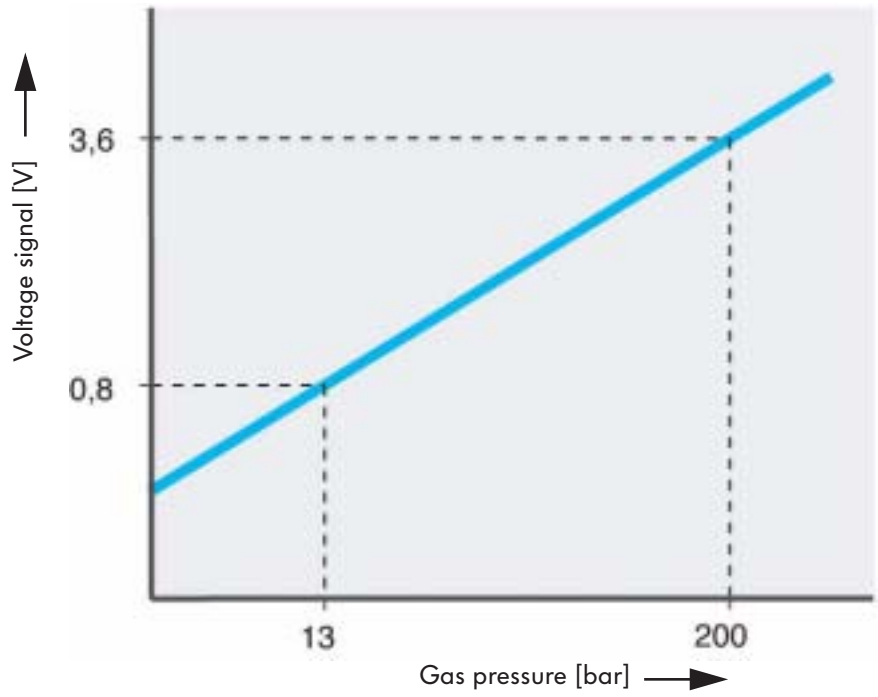
A change in pressure alters the bending radius of the steel membrane and thereby also the expansion test strip.

This results in a change in the resistance value of the expansion test strip.

As pressure rises, the resistance value drops and voltage increases.

The electronics system is supplied with 5 volts of power.
The electronics system calculates a voltage signal from the current resistance value and transmits this to the Motronic control unit.

Voltage pressure chart



S262_098

At a pressure of below 13 bar, the Motronic control unit switches automatically to petrol mode.

Natural gas supply in Golf BI FUEL

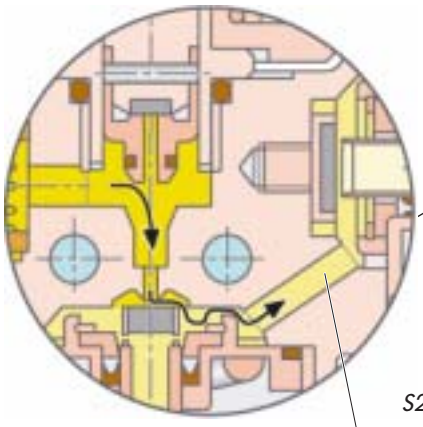
From high pressure to low pressure

The pressure of the natural gas on the low pressure side must be approx. 9 bar.
In order to maintain a pressure of 9 bar as constant as possible, the natural gas pressure must be reduced from a maximum 200 bar in two stages. This drop in pressure occurs in the two reduction stages in the gas pressure regulator.
To do this, the high pressure valve for gas mode N372 must be open.

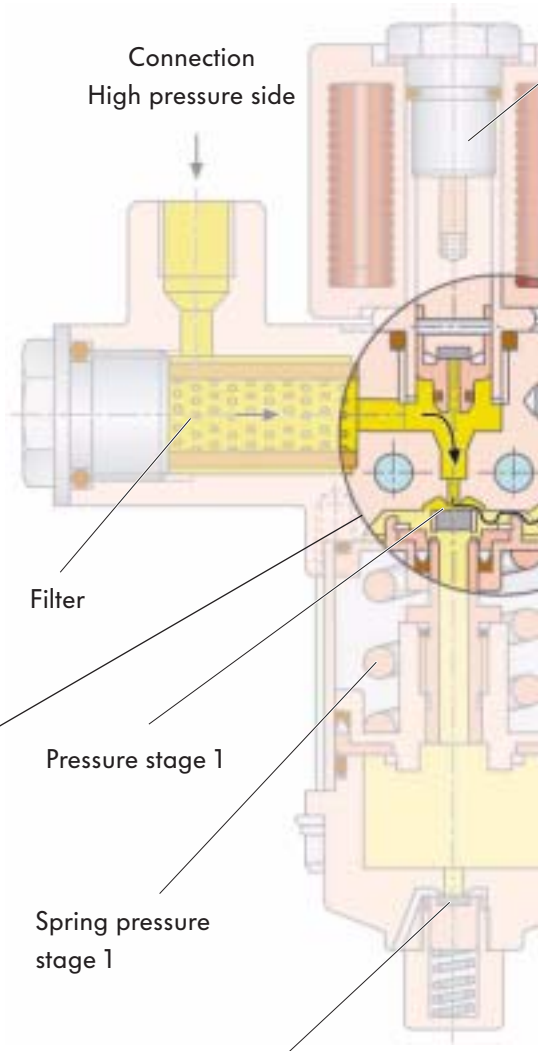
1st pressure reduction stage

In the 1st pressure reduction stage, the gas expands (arrow) against stage 1 spring pressure. Gas pressure is reduced from a maximum 200 bar to 13 bar.
The gas, now reduced in pressure, makes its way to the 2nd pressure reduction stage via the overflow channel.

1. Pressure reduction stage



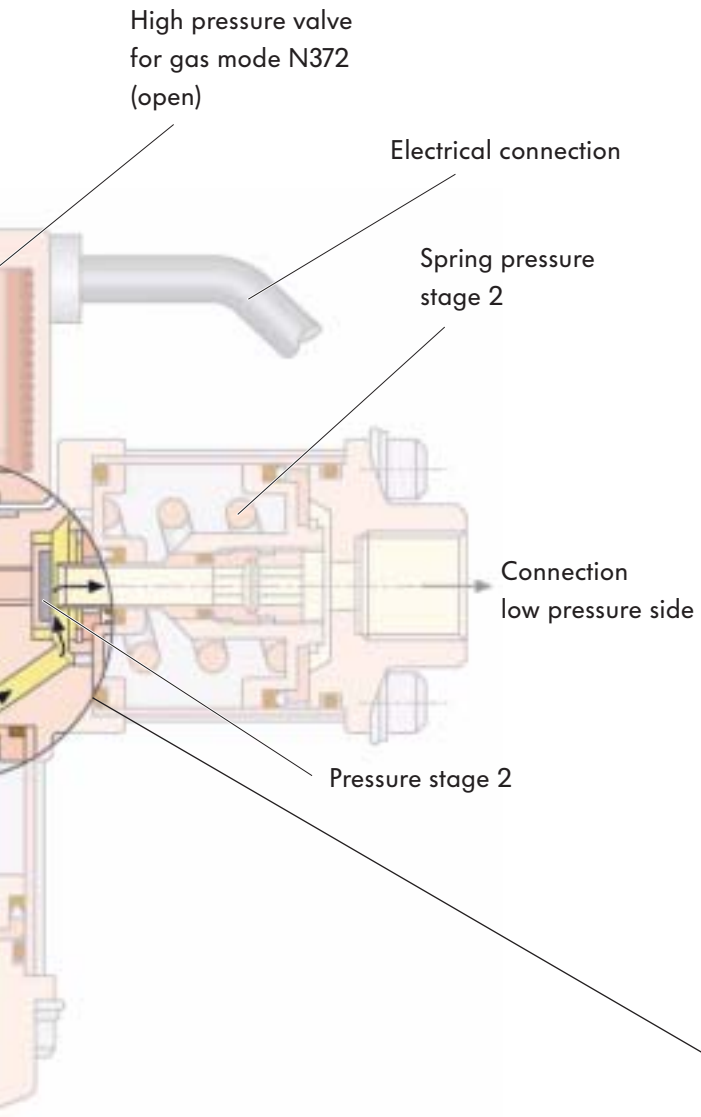
S262_049a



Tank pressure up to maximum 200 bar

1. Pressure reduction stage to 13 bar

2. Pressure reduction stage to 9 bar

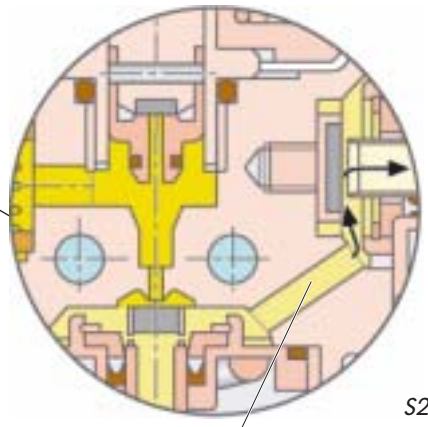


S262_049

2nd pressure reduction stage

In the 2nd pressure reduction stage, the gas expands (arrow) against stage 2 spring pressure. At the connection on the low pressure side, the natural gas is reduced from 13 bar to approx. 9 bar and is made available to the gas fuel rail. The pressure in the gas fuel rail can be between 8.0 and 9.5 bar.

2nd pressure reduction stage



S262_049c

Natural gas supply in Golf BI FUEL

High pressure valve for gas mode N372

The high pressure valve for gas mode is an electromagnetic shutoff valve.
It is installed directly on the gas pressure regulator and comprises of a solenoid and a valve.
The high pressure valve for gas mode is closed when not energised and controls the supply of gas to the engine.

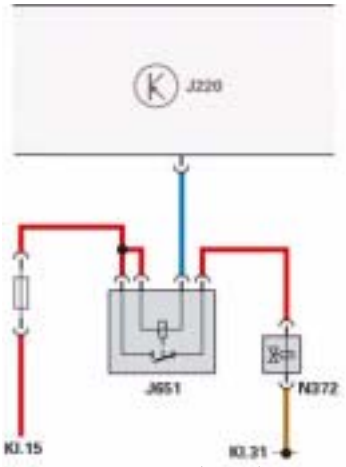
Function

When ignition is switched on (term. 15), the Motronic control unit (J220) actuates the high pressure valve (N372) via relay 1 of the shutoff valve (J651) to facilitate opening.

Effects of signal failure

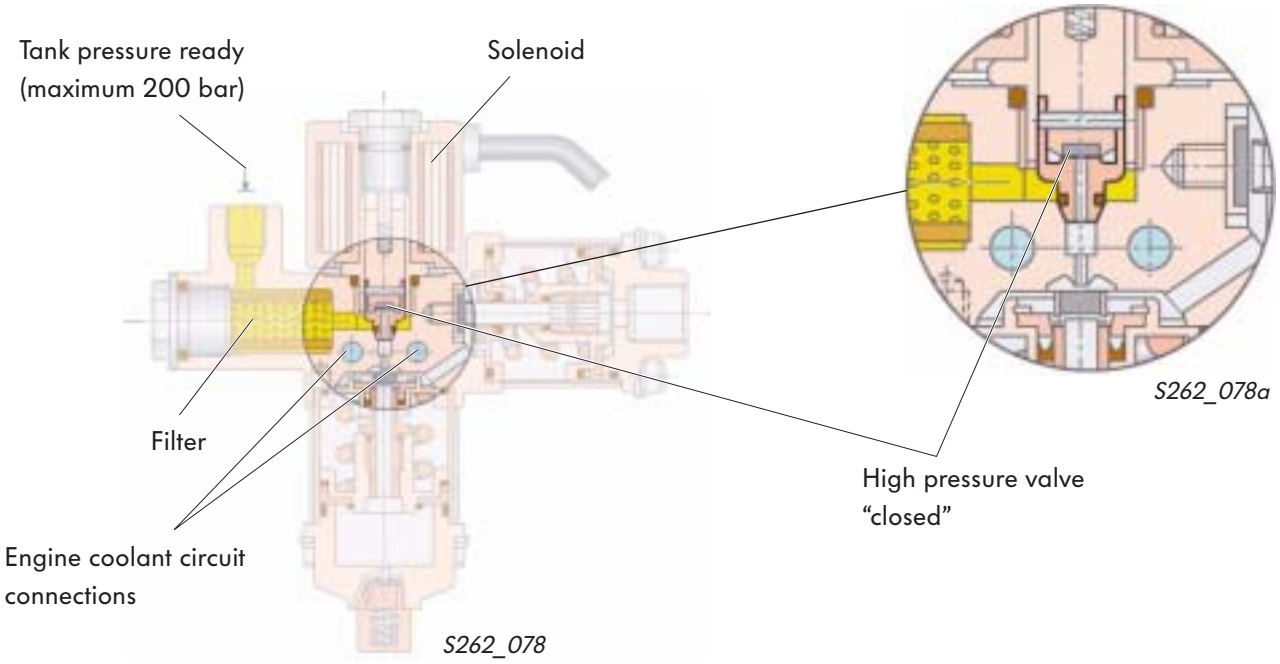
If the high pressure valve for gas mode is not actuated or is defective, natural gas operation is not possible.

Electrical circuit diagram



S262_114

High pressure valve “closed”



S262_078

S262_078a

The valve is closed automatically when a crash signal is triggered.

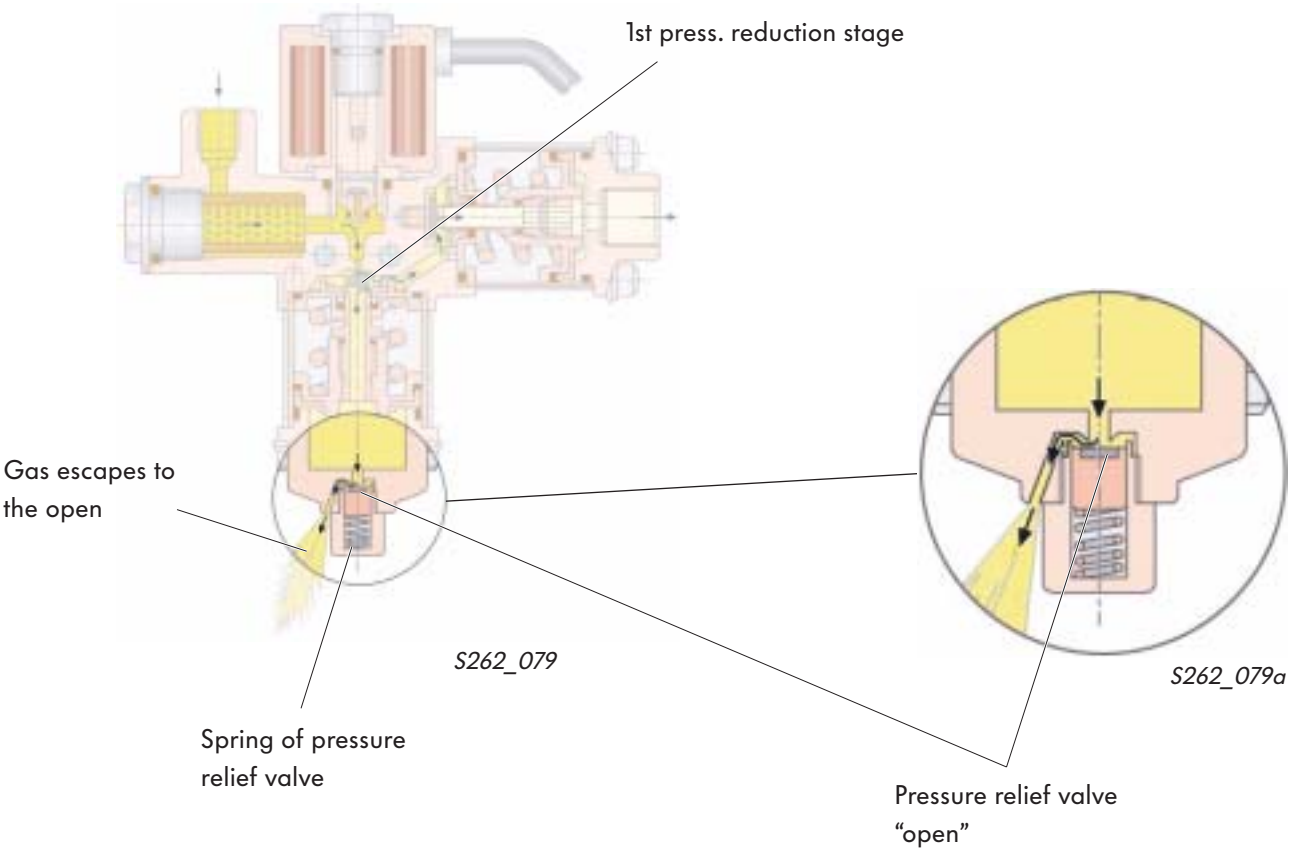
The low pressure side

Pressure relief valve

The pressure relief valve is integrated in the 1st pressure reduction stage and increases safety in the gas system.
It operates purely mechanically by means of the pressure relief valve spring.

The pressure relief valve spring is set to a pressure of 18 bar.
At a pressure of 18 bar in the 1st pressure reduction stage, the spring washer of the pressure relief valve is pushed back against spring pressure.
The pressure relief valve opens and natural gas escapes to the open.

In this way, damage to the gas pressure regulator and to the low pressure side is avoided.



Tank pressure up to maximum 200 bar

1. Pressure reduction stage > 18 bar

Natural gas supply in Golf BI FUEL

Low pressure natural gas line

The low pressure side starts directly after the 2nd pressure reduction stage in the gas pressure regulator. Natural gas pressure is approx. 9 bar.

Due to the low pressure, a flexible low pressure gas line (steel flex line) is installed from the gas pressure regulator to the gas fuel rail.

The movement of the engine brought about by load changes is compensated for by the flexible low pressure natural gas line.

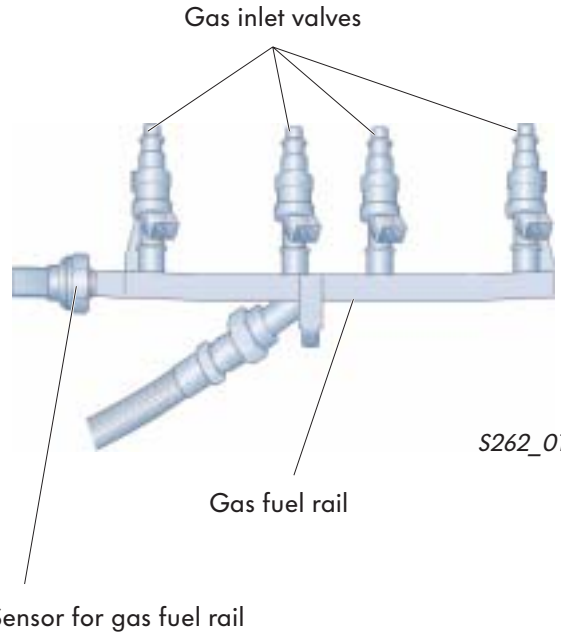
S262_009

Gas fuel rail

The gas fuel rail is also installed on the intake manifold of the engine.

The four gas inlet valves N366 to N369 and a gas fuel rail sensor G401 are installed on the gas fuel rail.

Similar to the common *rail* system on a diesel engine, the gas is distributed to the inlet valves via a “gas fuel rail” or “gas rail”.



S262_010

Gas inlet valves N366 to N369

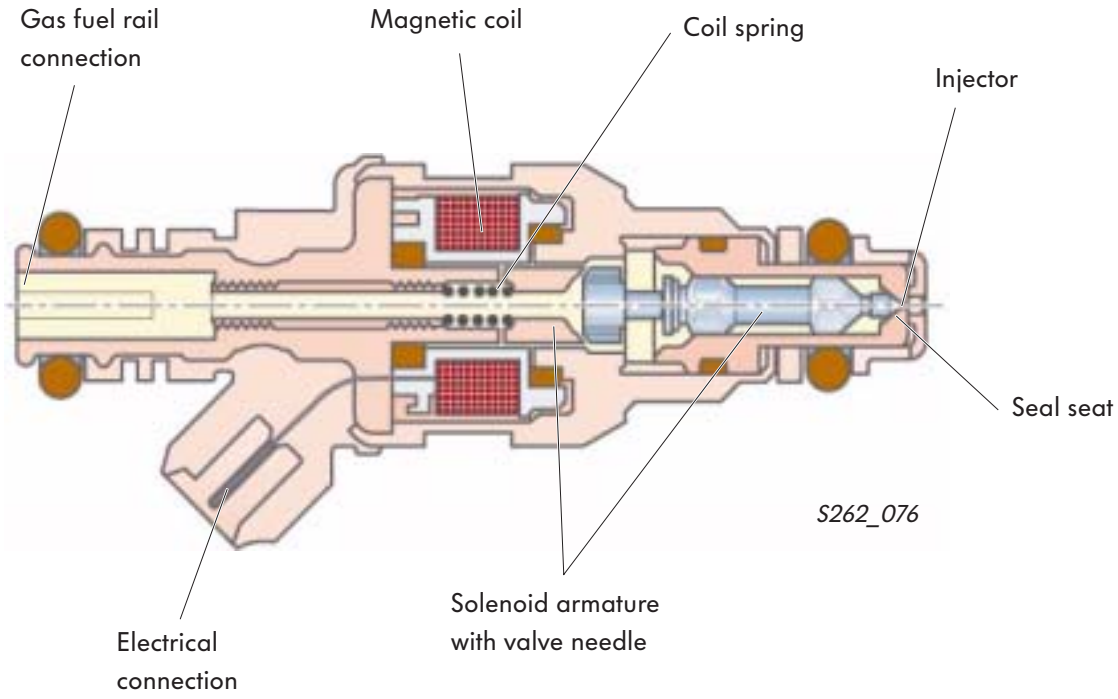
The natural gas enters the inlet port sequentially and selectively of the respective cylinder via an electronically controlled gas inlet valve at a pressure of approx. 9 bar.

The design and function of the gas inlet valve is essentially the same as an electromagnetic petrol injector valve.
There is an electrical connection and a magnetic coil in the valve housing.
The valve group is formed by the valve body and the valve needle that passes through it with solenoid armature attached.

The valve is closed when the magnetic coil is not energised. The coil spring and gas pressure on the low pressure side push the valve needle in the seat of the valve outlet seal.

When the magnetic coil is energised, a magnetic field is generated. The solenoid armature is thereby pulled up and this lifts the valve needle off its seat. The injector is opened.
Natural gas makes its way into the combustion chamber via the inlet port.

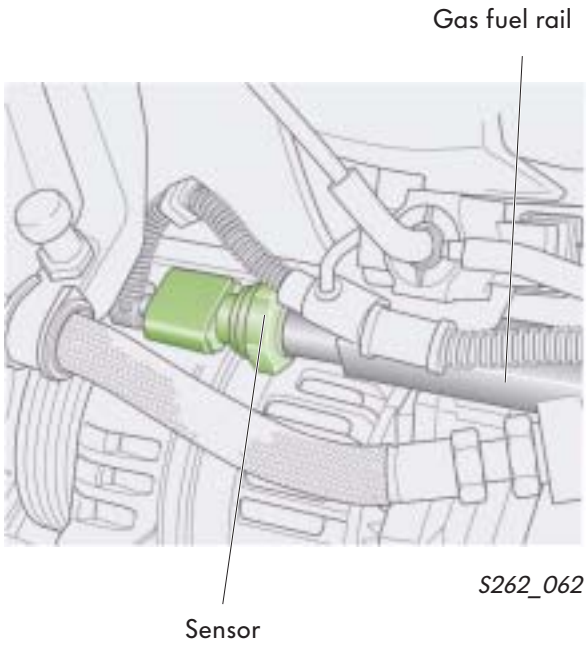
Gas inlet valve



Natural gas supply in Golf BI FUEL

Sensor for gas fuel rail G401

The gas fuel rail sensor is screwed into the right-hand side on the end of the gas fuel rail.



S262_062

Purpose

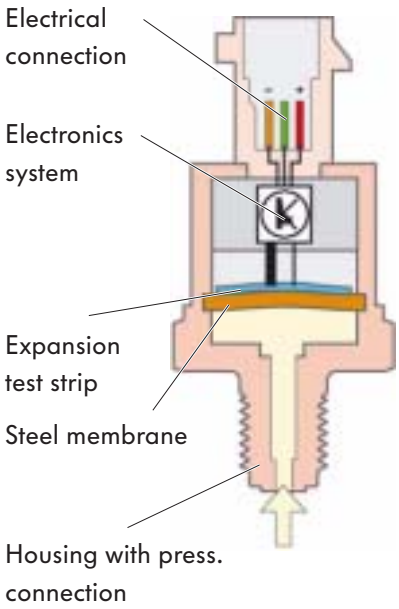
The gas fuel rail sensor determines the current gas pressure in the gas fuel rail.

The Motronic control unit requires the signal from the gas fuel rail sensor in order to determine the period of gas inlet at the valves and also to make any necessary adjustments.

Design

The gas fuel rail sensor comprises of:

- Housing with pressure connection
- Sensor element
  (steel membrane and expansion test strip)
- Electronics system
- Electrical connection



S262_099

The basic design and function of the gas fuel rail sensor G401 is identical with that of the tank pressure sensor G400.

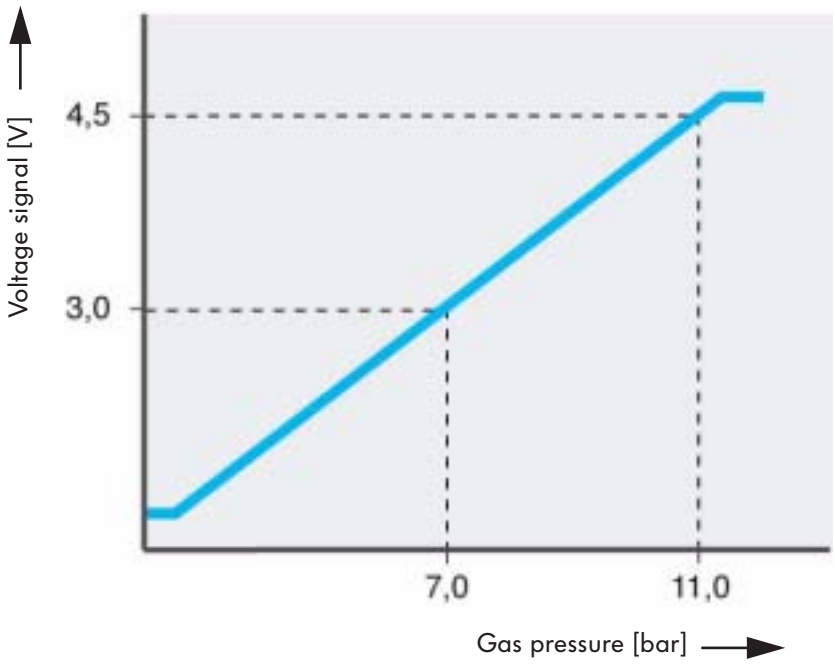
Function

The sensor element is supplied with +5 volts of power and comprises of a steel membrane to which expansion test strips are attached.
The resistance value of the expansion test strips drops as gas pressure rises.
The resistance value is picked up by the electronics system and is sent to the Motronic control unit as a voltage figure.

Effects of signal failure

If the gas fuel rail sensor is defective or if the voltage figure is not between 3.0 volts and 4.5 volts, the Motronic control unit switches automatically to petrol mode.

Voltage pressure chart



S262_113

Natural gas supply in Golf BI FUEL

The technical safety concept

In order to assure a high level of operating safety on natural gas powered vehicles, the natural gas is given an additive (*odorised*). In this way, even the slightest of leaks in the natural gas system can be detected by sense of smell.

The natural gas system of the Golf BI FUEL was developed with emphasis on crash safety and operating safety.
Therefore, the Golf BI FUEL fulfils the technical safety demands, for example, currently valid for a tail end crash.
Operating safety of the Golf BI FUEL is assured by the components listed as follows and their functions.

(1) Non-return valves in the filling connection and on the tank shutoff valve (natural gas tank I) prevent back-flow of gas via the tank valve.

(2) A gas-tight sleeve surrounds the gas lines routed within the vehicle.
The sleeve breaths downwards to the outside.

(3) The gas lines are made from stainless steel.

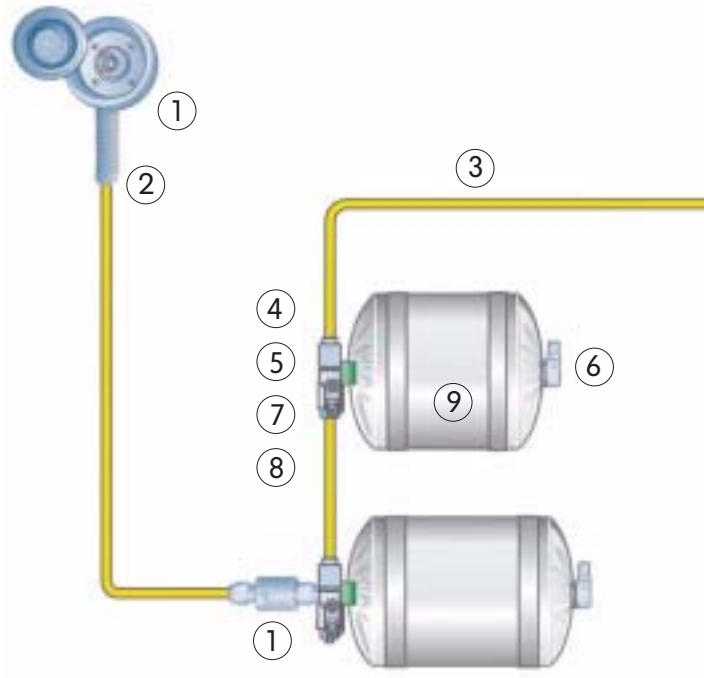
(4) All threaded connections feature double clamping ring connections.

(5) One solder seal and ...

(6) one thermal safety device per tank prevent excessive pressure increase in the event of a fire and thereby bursting of the tank.

(7) An electromechanical shutoff valve (1 per tank) closes: on changeover to petrol mode, in the event of power failure, engine stop or a crash.

(8) A flow rate limiter (1 per tank) prevents sudden dumping of the tank in the event of pipe breakage.



Work on the high pressure side of the natural gas system should only be carried out by trained specialists with special certificate of trade proficiency.

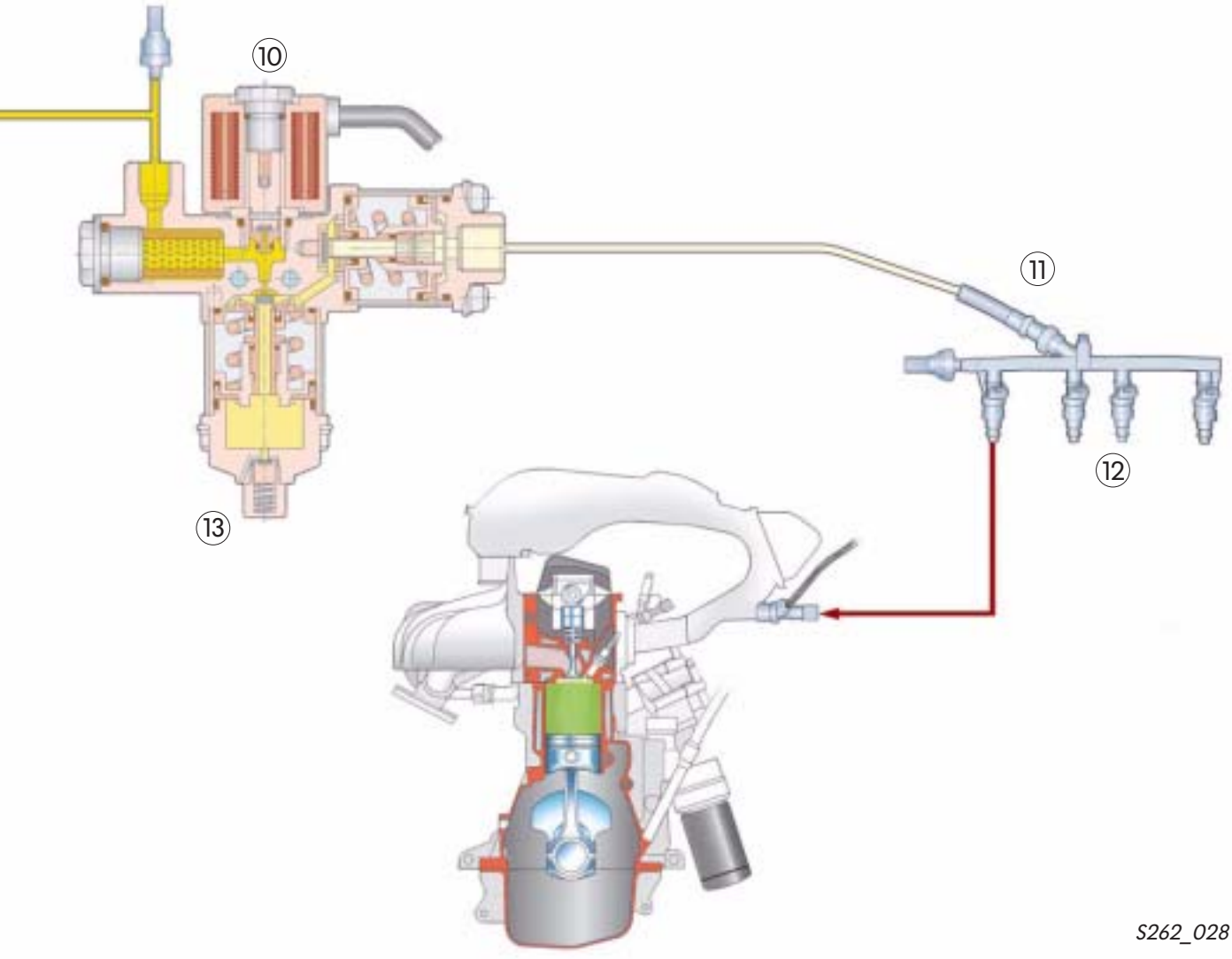
⑨ The natural gas tanks must be inspected regularly by a **GSG** specialist (**G**erätes**i**cherheits**g**esetz - German equipment safety regulations) in line with regulations concerning pressurised containers.

⑩ An electromechanical shutoff valve on the pressure regulator closes: on changeover to petrol mode, in the event of power failure, engine stop or a crash.

⑪ A flexible gas line on the low pressure side prevents cracks from vibrations.

⑫ The gas inlet valves only open when they have been actuated by the engine control unit.

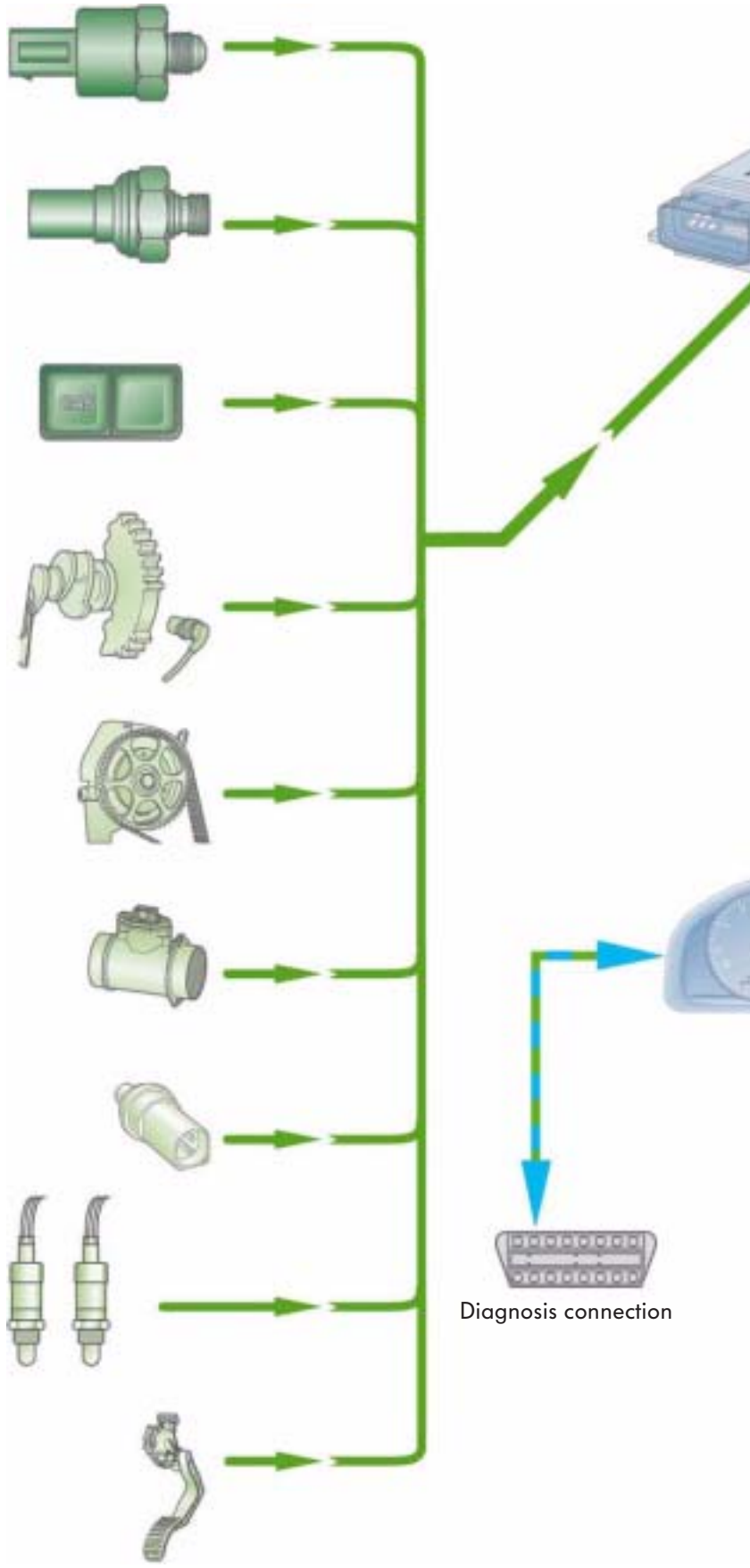
⑬ A pressure relief valve on the gas pressure regulator protects the low pressure side.

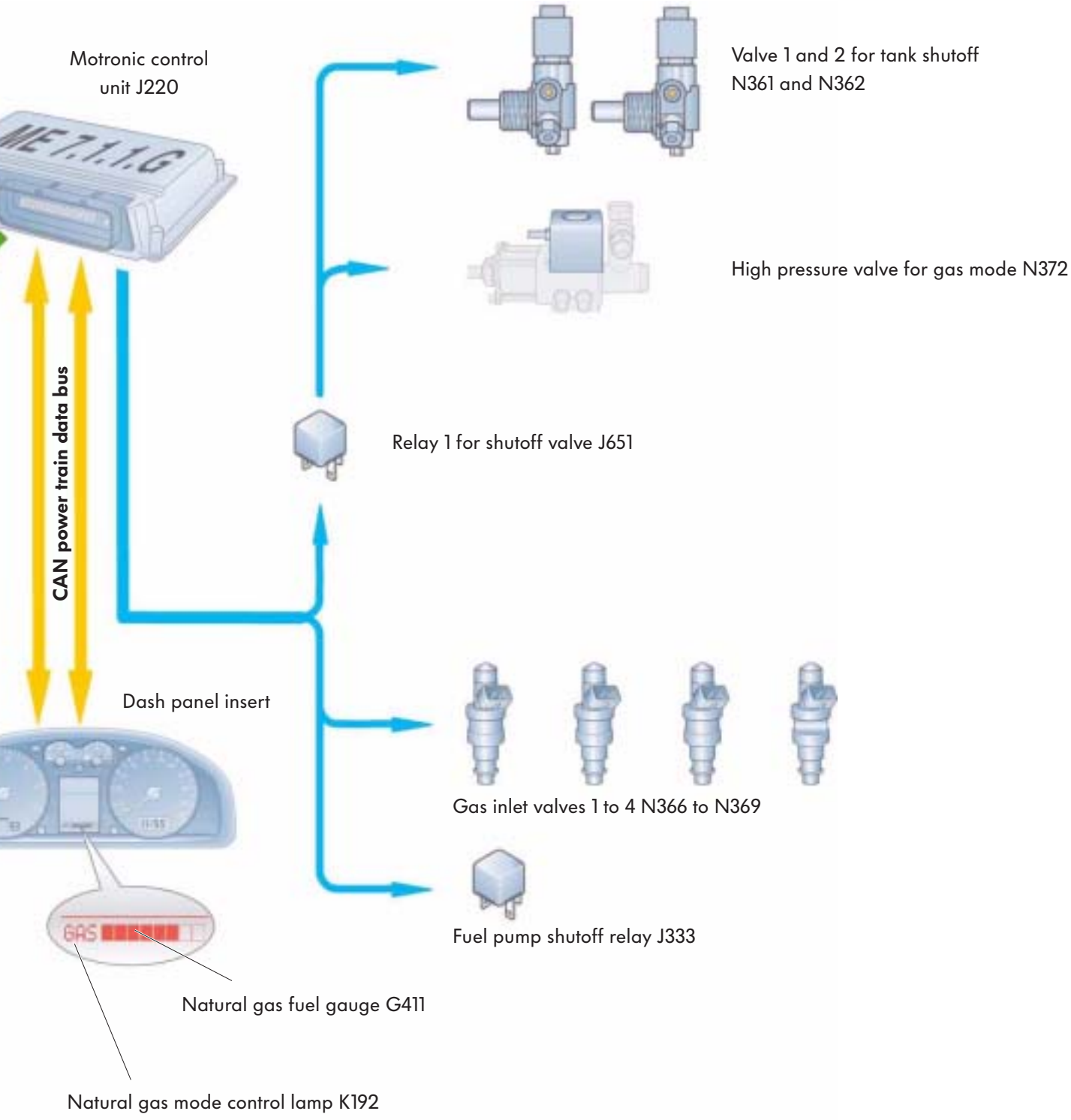


S262_028

Engine management

The system overview of sensors and actuators




Motronic control unit J220
ME7.1.1G
Valve 1 and 2 for tank shutoff N361 and N362
High pressure valve for gas mode N372
CAN power train data bus
Relay 1 for shutoff valve J651
Dash panel insert
Gas inlet valves 1 to 4 N366 to N369
Fuel pump shutoff relay J333
GAS
Natural gas fuel gauge G411
Natural gas mode control lamp K192

S262_060

The system functions

Operating mode switch E382

The operating mode switch can be used to change between natural gas and petrol operation.

If the operating conditions as follows are fulfilled, the Motronic control unit J220 switches over to natural gas operation:

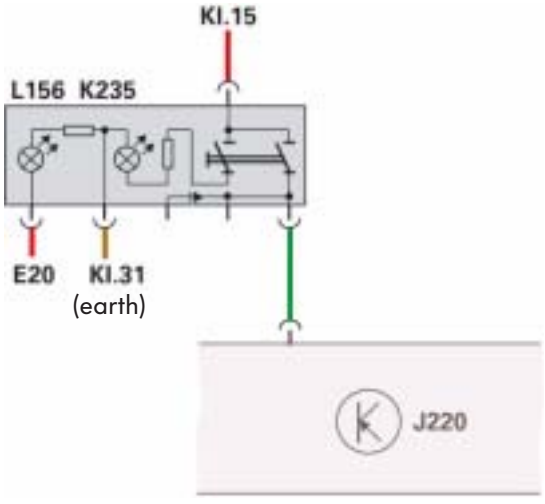
- Operating mode switch in position “GAS”
- Natural gas pressure on high pressure side greater than 13 bar
- Engine speed greater than 2000 rpm
- Engine in overrun
- Coolant temperature greater than 20 °C

S262_024

Electrical circuit diagram

The operating mode switch is supplied with power from terminal 15.
The double contact is closed in the “GAS” position. Control lamp 2 for natural gas operation K235 lights up.
The control lamp shows only the driver intention and not whether gas operation is actually active.

The switch illumination bulb L156 is supplied with power from the switches and instruments illumination regulator E20.



S262_101

Effects of signal failure

If the operating mode switch is defective, or if the Motronic control unit receives no signal, natural gas operation is not possible.

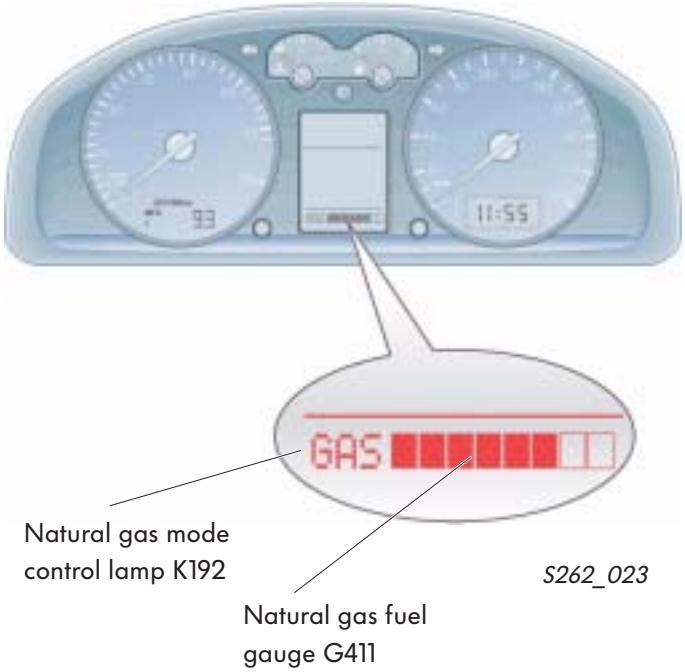
Dash panel insert

Housed in the dash panel insert are the displays for natural gas operation:

- Natural gas mode control lamp K192
- Natural gas fuel gauge G411

The **control lamp for natural gas mode K192** has two functions:

1. It only lights up in active gas mode.
2. It flashes if active gas mode is not possible.



S262_023

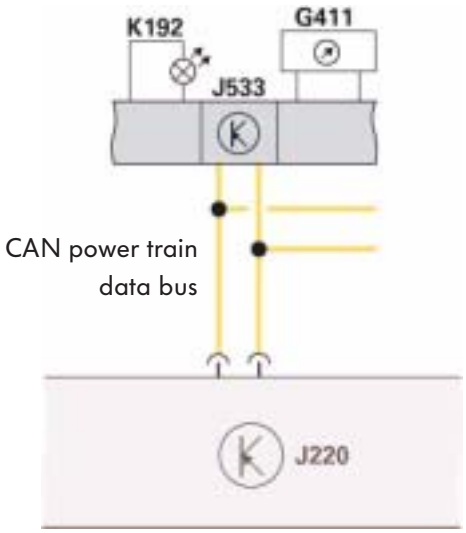
The **natural gas fuel gauge G411** has eight display segments that light up depending on the fill pressure of the gas tank.
If the gas tank is more than 90 % filled, all eight segments will light up.
No segments are lit below 10 %. The natural gas fuel gauge is always active when ignition is switched on.

Electrical circuit diagram

The Motronic control unit J220 sends information for actuation of the

- natural gas mode control lamp K192 and
- natural gas fuel gauge G411

via the CAN power train data bus to the databus diagnosis inferface J533 in the dash panel insert.



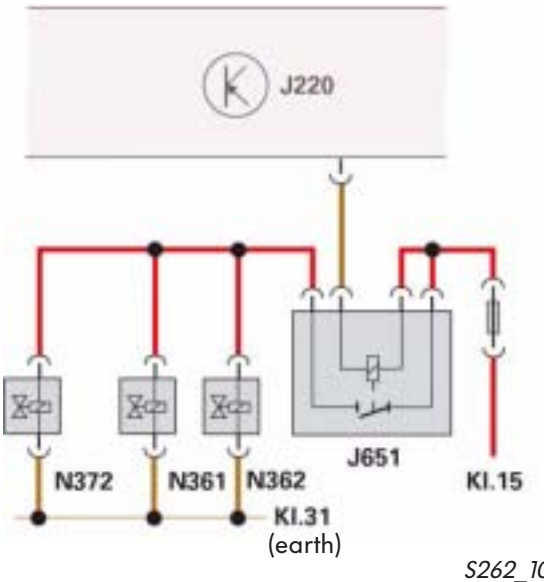
S262_102

Relay 1 for shutoff valve J651

Relay -1- for the shutoff valve is installed on the additional relay carrier above the relay board.

Actuation

The relay is actuated by the Motronic control unit J220 when ignition (term. 15) is switched on.



S262_103

Function

If relay -1- for the shutoff valve is actuated, the relay passes voltage from terminal 15 via a fuse to the tank shutoff valves N361/N362 and to the high pressure valve for gas mode N372.

In this operating condition, the prerequisites for natural gas operation are fulfilled.
All natural gas components are made ready for gas operation.

The Motronic control unit has not yet switched over to active natural gas operation.

If a crash signal is triggered, relay -1- for the shutoff valve is no longer actuated by the engine control unit.

Fuel pump shutoff relay J333

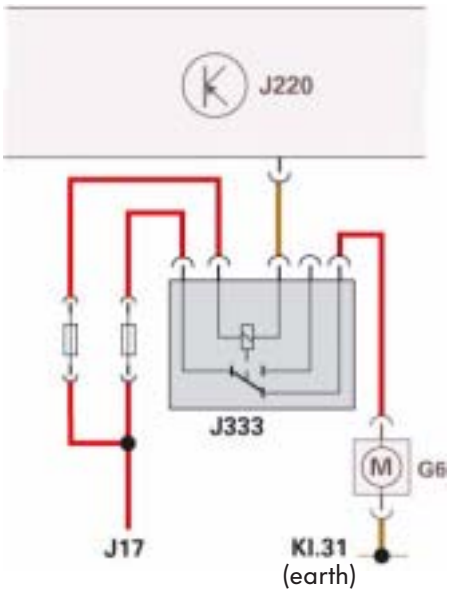
The fuel pump shutoff relay is installed on the additional relay carrier above the relay board.

Actuation

The relay is actuated by the Motronic control unit J220 if changeover to natural gas operation is selected.

To changeover to active natural gas operation, the following conditions have to be met.

- Ignition (term. 15) switched on
- Natural gas pressure on high pressure side greater than 13 bar
- Operating mode switch in position “GAS”
- Engine in overrun
- Engine speed greater than 2000 rpm
- Coolant temperature greater than 20 °C



S262_104

Function

If the fuel pump shutoff relay is actuated, the relay interrupts power supply between the fuel pump relay J17 and the fuel pump G6.

In this operating condition, all prerequisites for active natural gas operation are fulfilled.
The Motronic control unit has switched over to active natural gas operation. The engine is being run on natural gas.

If a crash signal is triggered, the fuel pump relays J17 and J333 are no longer actuated by the Motronic control unit.

Engine start

The engine is always started in petrol mode. In this way, the gas pressure regulator is warmed with engine coolant and there is no danger of it icing up.
Changing over into gas mode can take up to 60 seconds after a cold start.

Changing over to active natural gas operation

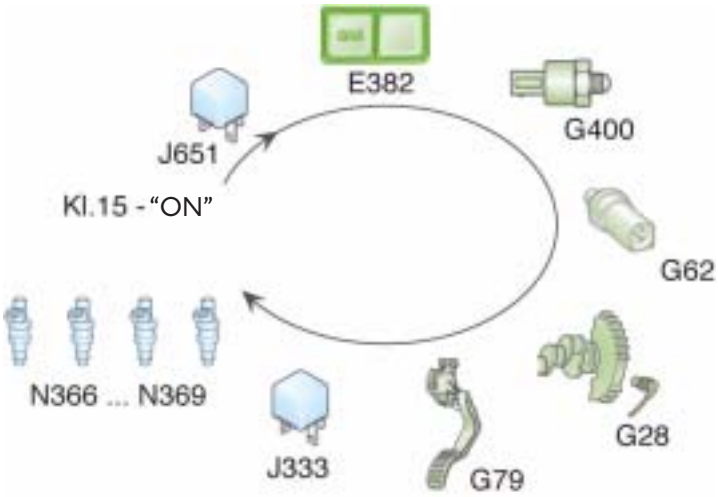
The Motronic control unit J220 switches over to active gas mode once the following prerequisites have been fulfilled:

- Ignition (term. 15) switched on
  (relay 1 for shutoff valve J651 is actuated by the Motronic control unit J220)
- Operating mode changeover switch in position “GAS”
- Sensor for tank pressure G400
  Natural gas pressure greater than 13 bar
- Coolant temperature sender G62
  Engine coolant temperature greater than 20 °C
- Engine speed sender G28
  Engine speed greater than 2000 rpm
- Accelerator pedal position sender G79
  Load detection, subsequently idling speed detection (overrun)

Once these conditions have been met, the Motronic control unit actuates the fuel pump shutoff relay J333. At the same time, the gas inlet valves N366 to N369 are actuated.

Changing back into petrol mode is possible at any time.

Function cycle



S262_105

If the engine cannot be started in petrol mode due to an empty fuel tank, an emergency start can be carried out.
The emergency start can be carried out up to five times in natural gas mode.
An engine start in gas mode is not possible thereafter.

Motronic control unit J220

The Motronic control unit is installed in the plenum chamber.

Stored in the Motronic control unit is a separate map for both petrol operation and natural gas operation.
By the application of two maps, it was possible to adapt the control unit to the respective requirements of the different types of fuel, as appropriate.
If natural gas mode is not possible, the Motronic control unit switches to petrol mode automatically.

S262_022

Lambda control

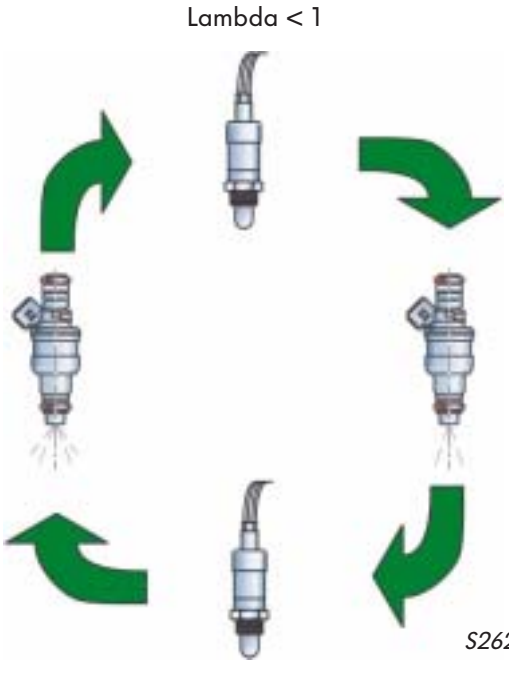
For complete combustion, a petrol engine requires, in theory, a mixture of 14.7 kg of air and 1 kg of fuel (petrol).
In the case of complete combustion, the air figure is λ (lambda) = 1.
In natural gas mode λ = 1 with an air to natural gas ratio of 5.41 : 1 [kg].

Function

The lambda probe monitors the mixture composition in natural gas mode as well.
If the value measured by the lambda probe exceeds λ = 1, the mixture is too lean.
The Motronic control unit extends the inlet period and thereby enrichens the mixture.

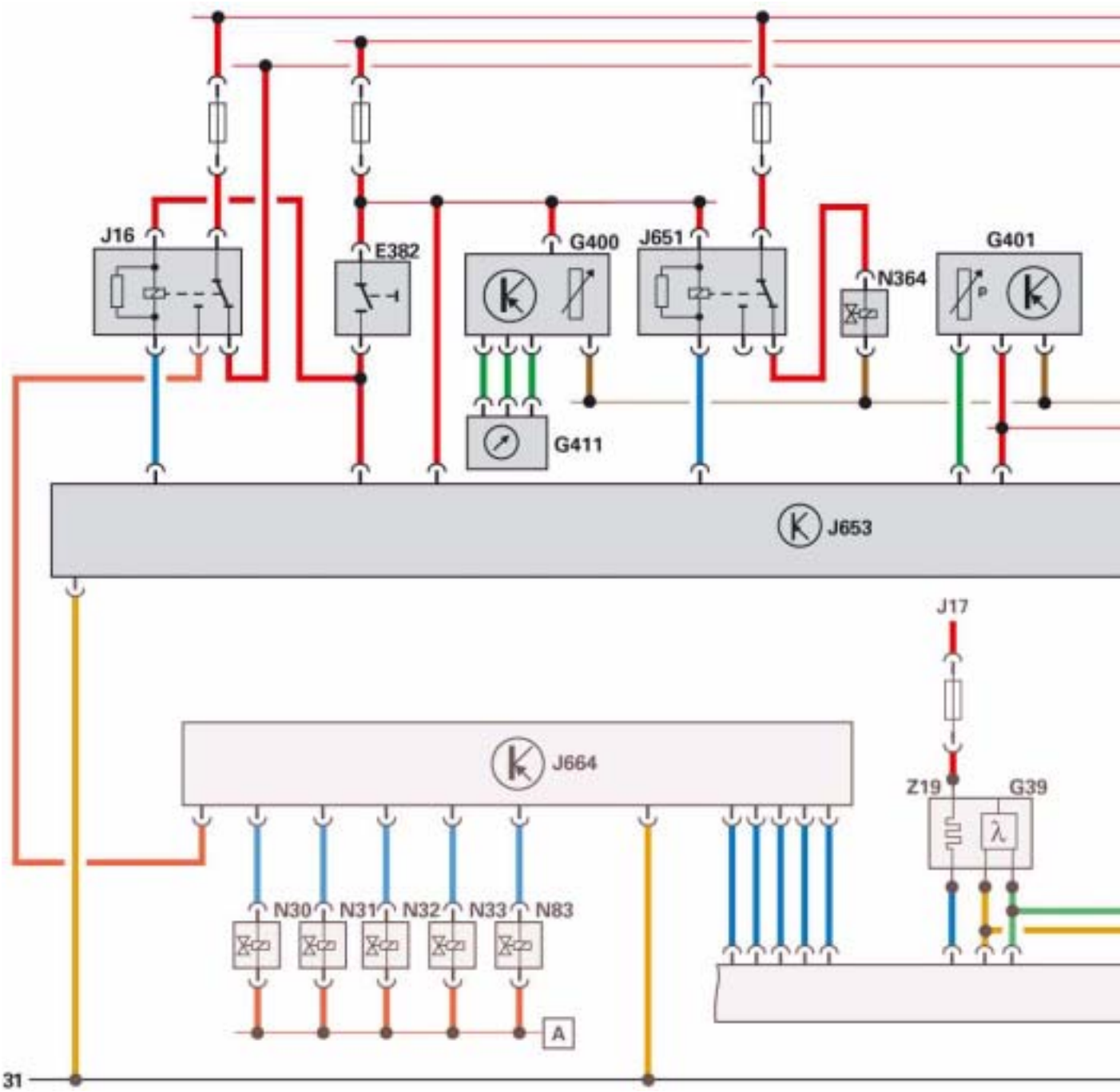
Effects of signal failure

In the event of failure or a defective lambda probe, natural gas operation continues in emergency running mode.

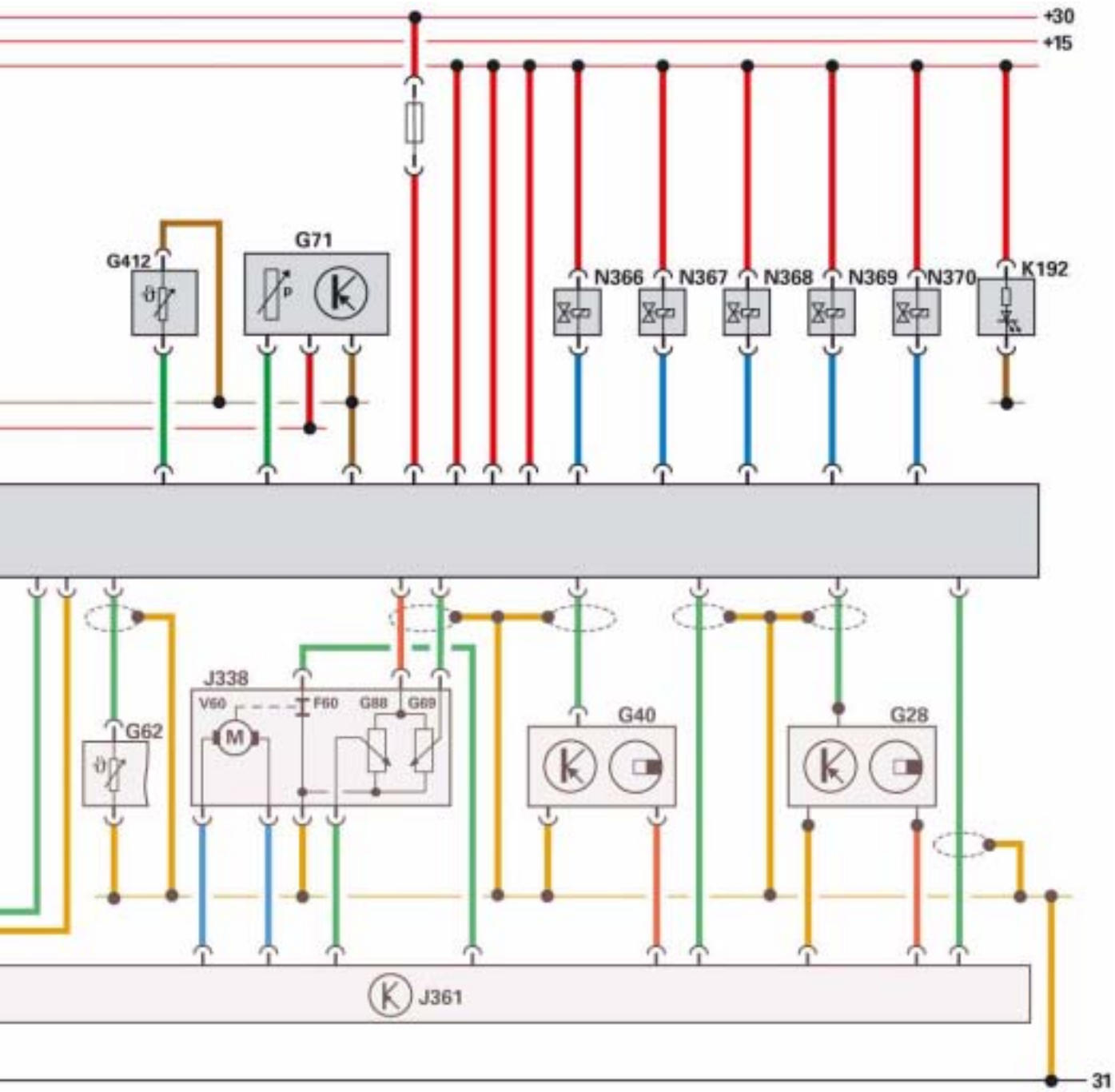


S262_106

The function chart, Transporter '91 ➤ bivalent



E382 - Operating mode changeover switch for petrol/ gas mode
F60 - Idling switch
G28 - Engine speed sender
G39 - Lambda probe
G40 - Hall sender
G62 - Coolant temperature sender
G69 - Throttle valve potentiometer
G71 - Intake manifold pressure sender
G88 - Throttle valve positioner potentiometer
G400 - Tank pressure sensor
G401 - Gas fuel rail sensor
G411 - Gas fuel gauge
G412 - Coolant temperature sender of natural gas
J16 - Power supply relay
J338 - Throttle valve module
J361 - Simos control unit
J651 - Relay 1 for shutoff valve
J653 - Bivalent operation control unit 1
J664 - Relay box for gas mode



S262_053

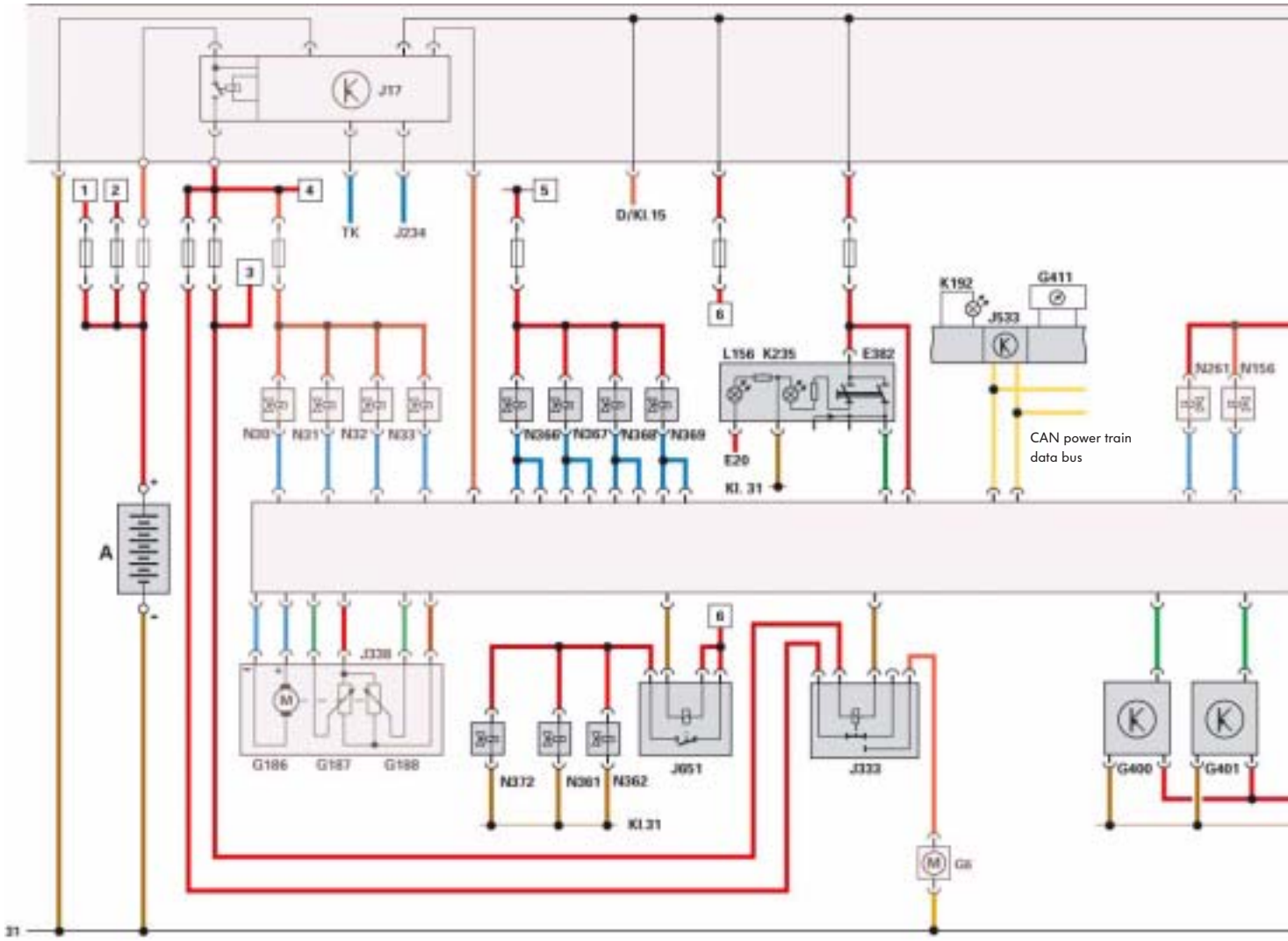
K192 - Natural gas mode control lamp
N30 ...
N33 - Injectors for cylinders 1 to 4
N83 - Injector for cylinder 5
N364 - Gas pressure regulator shutoff valve
N366 ...
N370 - Gas inlet valves for cylinders 1 to 5
V60 - Throttle valve positioner
Z19 - Lambda probe heating

Natural gas relevant components are shown in **bolder** colours in the chart.

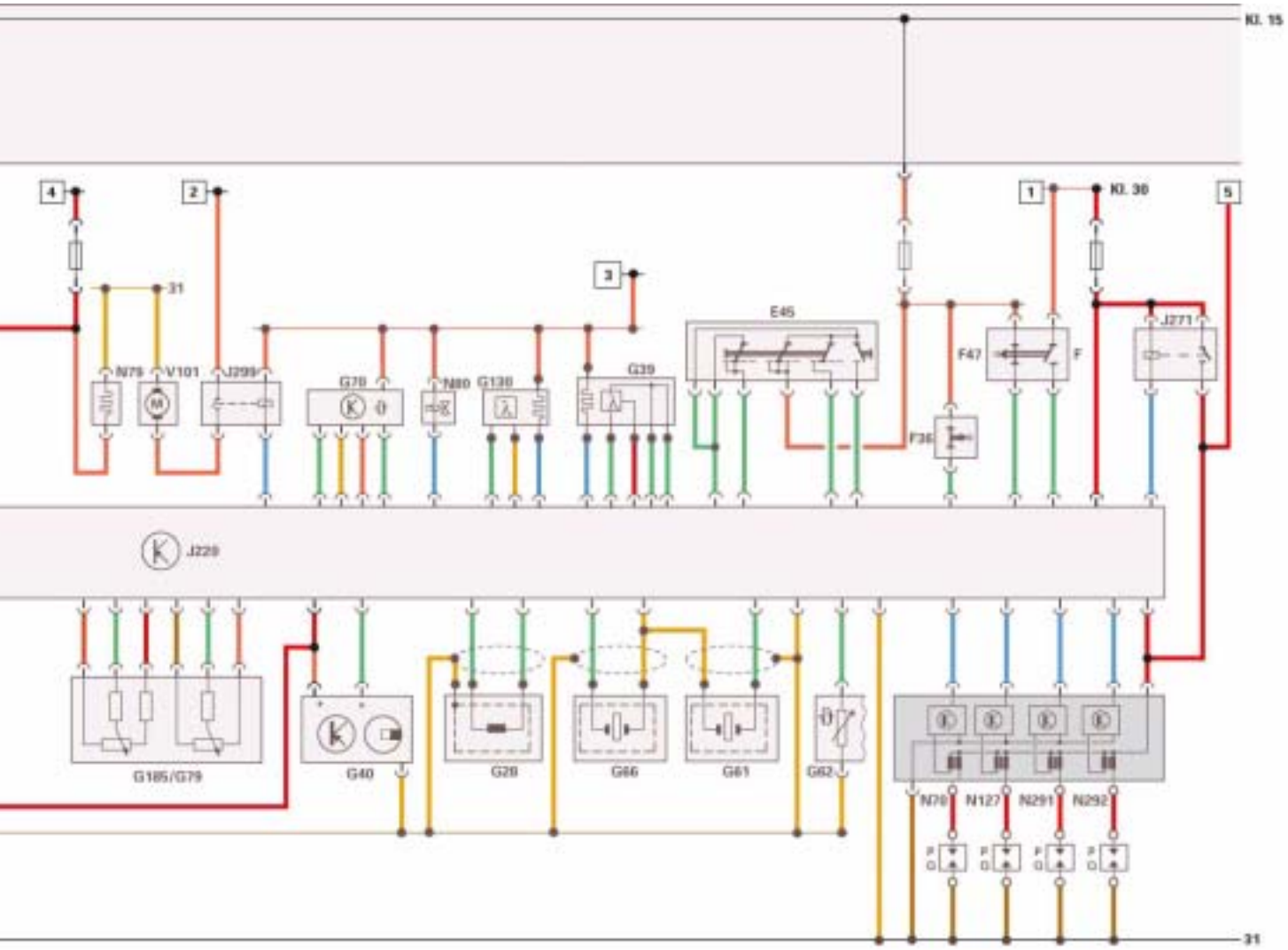
= Positive
= Earth

Engine management

The function chart, Golf BI FUEL



A - Battery
D/term.15 - Ignition switch/ignition ON
E20 - Switches and instruments illumination regulator
E382 - Operating mode changeover switch for petrol/ gas mode
G6 - Fuel pump
G186 - Throttle valve drive for electric throttle
G187 - Throttle valve drive angle sender 1 for electric throttle
G188 - Throttle valve drive angle sender 2 for electric throttle
G400 - Tank pressure sensor
G401 - Gas fuel rail sensor
G411 - Gas fuel gauge
J17 - Fuel pump relay
J220 - Motronic control unit
J234 - Airbag control unit
J333 - Fuel pump shutoff relay
J338 - Throttle valve module
J533 - Data bus diagnosis interface
J651 - Relay 1 for shutoff valve
K192 - Natural gas mode control lamp
K235 - Natural gas mode control lamp 2
L156 - Switch illumination bulb
N30 ...
N33 - Injectors for cylinders 1 to 4
N156 - Variable intake manifold changeover valve
N261 - Variable intake manifold changeover valve 2
N361 - Tank shutoff valve 1
N362 - Tank shutoff valve 2
N366 ...
N369 - Gas inlet valves 1 to 4
N372 - High pressure valve for gas mode
TK - Door contact



S262_032

E45 - CCS switch
F - Brake light switch
F36 - Clutch pedal switch
F47 - Brake pedal switch
G28 - Engine speed sender
G39 - Lambda probe
G40 - Hall sender
G61 - Knock sensor 1
G62 - Coolant temperature sender
G66 - Knock sensor 2
G70 - Air mass meter
G79 - Accelerator pedal position sender
G130 - Lambda probe after catalytic converter
G185 - Accelerator pedal position sender 2
J271 - Motronic power supply relay
J299 - Relay for secondary air pump

Term.31 - Earth
N70 - Ignition coil 1 with final output stage
N79 - Heater element for crankcase breather
N80 - Activated charcoal filter system solenoid valve 1
N127 - Ignition coil 2 with final output stage
N291 - Ignition coil 3 with final output stage
N292 - Ignition coil 4 with final output stage
P - Spark plug connector
Q - Spark plug
V101 - Motor for secondary air pump

Natural gas relevant components have **bolder** colours in the chart.

= Positive

= Earth

The legal requirements in Germany

In Germany, the following requirements must be fulfilled:

Certificate of trade proficiency

All service, maintenance and repair work on the high pressure side of the natural gas system should only be carried out by trained personnel with a special certificate of trade proficiency.

To achieve a sufficient standard of trade proficiency, a course of training must be completed that meets guideline 757 of the VdTÜV (association of technical and vehicle testing stations).

This training is offered by Volkswagen via the relevant sales centres as a training package “Specialist training for natural gas powered vehicles”.

Note on lock carrier

Legal demands on the workshop

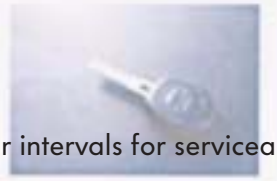
The requirements on the building in particular are detailed in the rules for trade associations ”BGR 157 vehicle maintenance”.

Further information about the requirements specific to buildings can be obtained from the dealership building advice centre.

The service intervals in Germany

The service intervals for petrol operation remain the same as normal. The instructions on how to carry out these measures can be found in ELSA (electronic service advice) in the chapter entitled “Maintenance”.

The **volume of petrol** should be completely renewed every six months in order to prevent malfunctions in the fuel system for petrol supply.



The components of the **natural gas system** must be inspected at regular intervals for serviceability (securely fitted and not damaged) and also operability.

Inspection of the natural gas system components and the legally prescribed safety inspection of the natural gas tank must be entered in the service schedule.

Further information regarding additional work on the natural gas system and the legally prescribed safety inspection of the natural gas tank can be found in ELSA (electronic service advice) in the chapter entitled “Maintenance”.

If the validity of the **test period** runs out, the natural gas tanks may not be filled.

The main technical inspection should be carried out in accordance with the regulations for vehicles with petrol engines.

The exhaust emissions test should be carried out in petrol mode.
It is advisable to carry out a test in natural gas mode.

1.1 Serviceplan
Golf Variant 2.0 BI FUEL
mit Benzin- und

The natural gas tanks should not be heated to above 60 °C. Therefore, before carrying out welding or paintwork repairs, the tanks should be emptied and removed.

The diagnosis

Transporter '91 ➤ bivalent

The Transporter '91 ➤ bivalent has a dedicated control unit for each of the operating modes "natural gas and petrol".

In **"petrol"** operating mode, the vehicle diagnosis, testing and information system VAS 5051 and the vehicle diagnosis and service information system VAS 5052 can be used.

VAS 5051

S262_046

VAS 5052

S262_045

The following operating modes can be chosen from:

- Guided fault finding
- Vehicle self-diagnosis
- OBD (On Board Diagnose)*
- Test instruments*
- Guided functions

* VAS 5051 only

For diagnosis in **"natural gas mode"**, a special computer program with diagnosis lead is used. For Transporter models that were retrofitted for gas operation, diagnosis and fault finding for natural gas mode is carried out via a special program on a laptop with evaluation box connected.
Further information can be obtained from IAV GmbH
(Ingenieurgesellschaft Auto und Verkehr, Carnotstraße 1, 10587 Berlin).

Golf BI FUEL

The vehicle diagnosis, testing and information system VAS 5051 and the vehicle diagnosis and service information system VAS 5052 are available for the Golf BI FUEL.

VAS 5051

S262_046

VAS 5052

S262_045

The following can be chosen from on VAS 5051:

- Guided fault finding
- Vehicle self-diagnosis
- OBD (On Board Diagnose)
- Test instruments
- Guided functions

The following modes of operation are available on VAS 5052:

- Guided fault finding
- Vehicle self-diagnosis
- Guided functions

Vehicle self-diagnosis

This mode of operation can be used as normal, though no further information is available via ELSA (electronic service advice).

Guided functions

These service functions are available in conjunction with basic CD V06.00.00 and the Volkswagen Brand CD V06.42.00.

Further information regarding the procedure and function of guided fault finding can be found in the operator's handbook on VAS 5051 in chapter 7.

Associated special tools and workshop equipment

Designation	Tool	Application
VAS 6227 Gas leak detector for natural gas vehicles	 S262_119	For detecting leaks in components of the natural gas system

Transporter '91 ➤ bivalent		
Assembly tool Note: This tool can be ordered from IAV in Berlin.	 S262_027	For removal and assembly of tank shutoff valves

Golf BI FUEL		
T 10218 Magnetic release tool	 S262_108	For emptying of the natural gas tank via the tank shutoff valves
T 10251 Assembly tool	 S262_109	For removal and assembly of tank shutoff valves
VAS 5302 Ring spanner set	 S262_115	For work on the natural gas system
VAS 5302/4	1/2"	
VAS 5302/6	3/4"	
VAS 5302/12	9/16"	

Glossary

Aldehyde:	(alcohol dehydrogenatus) Chemical composition that comprises of alcohol as a result of part water removal (dehydration); has powerful reducing effect
Alkene:	See olefine
Alternative:	Selection between two variants
Amortisation:	Gradual pay off of a loan based on a fixed schedule
Anthracite:	Hard, shiny coal substance
Aromatics:	Aromatic compound of hydrocarbon
Benzoldehyde:	Short lived by-products of aromatic compounds
Requirements*:	See below (page 74)
Bivalent:	One mode of operation can be selected from two (dual mode)
BTX:	Benzene, toluol, xylene aromatic carbon compounds
Butane:	Flammable gas (C_4H_{10}), heavier than air
CFRP:	Carbon fibre reinforced plastic
CNG:	Compressed natural gas - natural gas under pressure of 200 bar (methane CH_4), lighter than air
Composite:	Combination of several materials
Duroplast:	Plastic that maintains its shape, strength and rigidity from hardening
Emission:	Outlet of gases, soot or similar to the surrounding air (technical)
Epoxy-resin (EP):	Colourless to honey yellow synthetic resin, hard, tough and unbreakable
Ethane:	Flammable gas (C_2H_6), heavier than air colourless and odourless

Expansion:	Spatial increase
Formaldehyde:	Simplest form of aldehyde, pungent smelling gas, disinfectant
Fossil:	Preserved remains of a former geological age
Calorific value:	Indicates energy rating of a fuel
Immission:	Effect of air pollution, noise or similar regarded as nuisance to the environment
Cuvette:	Small (glass) vessel
LNG:	Liquefied natural gas - in liquid form at –162 °C (methane) lighter than air
LPG:	Liquefied petroleum gas - also known as auto gas or fluid gas (propane-butane composition at a pressure of 2 to 20 bar), heavier than air
Methane:	Simplest form of hydrocarbon (CH_4), flammable gas, lighter than air, raw element of organic chain, main element of natural gas
NGV1:	Natural Gas Vehicle - globally recognised refuelling system for high pressure natural gas replenishment
NMOG:	No methane organic gases; the sum of all hydrocarbons minus aromatic compounds
Monovalent:	Designed for just one mode of operation
Odour:	Smell, scent
Odorised:	With added aromas
Olefine:	Collective term for unsaturated hydrocarbons with straight hydrocarbon chains in the molecules; also known as alkene

Glossary

PAK:	Polycyclic, aromatic hydrocarbons
Polycarbonate (PC):	Glass clear, highly resistant, unbreakable thermoplastic (glass panes, symbol devices, fans ...)
Polyethylene (PE):	Colourless to milky thermoplastic; waxy smooth surface
Polystyrol (PS):	Colourless, glass clear thermoplastic
Propane:	Flammable gas (C_3H_8), heavier than air
Rail:	For distribution of fuel
Resources:	Reserves of raw materials
Thermoplastic:	Sythetic material that can be shaped at high temperatures
Valency:	(Chemical) value

*** Requirements**

Guideline 757 of the VdTÜV
(association of technical and vehicle testing stations)

This guideline affects the high pressure part of the natural gas system. It is valid only in Germany and controls e. g. the construction and operation of natural gas systems in motor vehicles.
The frequency of inspecting the natural gas tanks and retrofitting of natural gas systems, for example, are covered by this guideline.
The certification of trade proficiency for working on natural gas powered vehicles is also regulated by this guideline.

ECE-R110

(**E**conomic **C**ommission for **E**urope -
regulation 110)
Regulation 110 gives details on component and type approval as well as for a unified approach in dealing with natural gas powered vehicles.
This regulation is applied all over the world.

ECE-R115

(**E**conomic **C**ommission for **E**urope -
regulation 115)
This regulation provides details about retrofitting natural gas systems (LPG and CNG) in motor vehicles.

DIN-EN 13423
Handling of natural gas powered vehicles

DIN-EN 13423 is a German industrial standard and supplements guideline 757.
It provides details about handling, operation, purchase and scrapping of natural gas powered vehicles, for example.
The standard offers recommendations for owners, dealers and workshops.
DIN-EN 13423 was created in agreement with the DVGW (German organisation of gas and water trades).

Safety data sheet G609 from the DVGW (German organisation for gas and water trades)

This safety data sheet applies in Germany to the low pressure part of the natural gas system.

GSG

(law on equipment safety)
The GSG controls, for example, type approval and frequency of technical inspections of the natural gas system in motor vehicles.

Pressurised container regulations

These regulations provide details about operation and inspection of natural gas systems in motor vehicles.
At the start of 2003, the pressurised container regulations were replaced by the pressurised equipment regulations.

Test your knowledge

Which answers are correct?

One, more than one or all of the answers could be correct.

1. A completely filled natural gas tank is under a pressure of ...

- ☐ a) 20 bar.
- ☐ b) 100 bar.
- ☐ c) 200 bar.

2. Why is the gas pressure regulator included in the coolant circuit of the engine?

- ☐ a) Because the gas has to be preheated.
- ☐ b) In order to prevent icing up of the gas pressure regulator.
- ☐ c) To improve gas inlet into the engine.

3. In the gas fuel rail there is a pressure of ...

- ☐ a) 1 bar.
- ☐ b) 9 bar.
- ☐ c) 20 bar.

4. Which component combines the high pressure side with the low pressure side of the gas system?

- ☐ a) The non-return valve on the tank.
- ☐ b) The flexible fuel line.
- ☐ c) The gas pressure regulator.

5. Natural gas comprises essentially of ...

- ☐ a) Methane.
- ☐ b) Hydrogen and methane.
- ☐ c) Propane.

6. Natural gas is ...

☐ a) Lighter than air.
☐ b) Equally as heavy as air.
☐ c) Heavier than air.

7. Who is allowed to work on the high pressure side of the natural gas system?

☐ a) Any mechanic.
☐ b) Only a trained person with special certificate of trade proficiency.
☐ c) Only the head mechanic.

8. The use of natural gas has advantages for the ...

☐ a) Environment.
☐ b) Vehicle operator (costs savings).
☐ c) Natural gas supplier.

9. When can changeover between operating modes “petrol” and “natural gas” take place?

☐ a) Only when the vehicle is stationary.
☐ b) Only preceding “cold start”.
☐ c) Also while the vehicle is in motion.

10. From which address on the internet can further information about natural gas powered vehicles be obtained?

☐ a) www.zippo.de
☐ b) www.volkswagen.de
☐ c) www.erdgasfahrzeuge.de
☐ d) www.linde.de

Test your knowledge

11. What should be observed for repair work on the natural gas tank?

- ☐ a) No metallic objects should come into contact with the steel tensioning straps of the natural gas tank.
- ☐ b) All components of the natural gas tank may be loosened.
- ☐ c) The thermal safety devices must not be loosened.

12. Which safety devices prevent the natural gas tank from bursting or exploding in a fire?

- ☐ a) The thermal safety devices.
- ☐ b) The tank pressure sensor.
- ☐ c) The solder seals.
- ☐ d) The steel tensioning straps.

13. What should be observed if there is a sudden smell of gas?

- ☐ a) The vehicle must be parked as quickly as possible in an area where there are no people.
- ☐ b) Just the underside of the natural gas tanks should be checked for cracks.
- ☐ c) The mechanical shutoff valve must be closed.

14. Which statement is correct with regards to refuelling the natural gas system?

- ☐ a) The electromagnetic valves in the tank shutoff valves control refuelling.
- ☐ b) With ignition switched on, the natural gas fill level is controlled automatically by the tank shutoff valve.
- ☐ c) The mechanical valve closes automatically through spring pressure.
- ☐ d) The floats in the natural gas tanks close automatically at a pressure of 200 bar.

15. What should be observed with regards to carrying out welding work on the natural gas tanks?

- ☐ a) The natural gas tanks must be emptied and removed.
- ☐ b) The natural gas tanks should not be heated above 60 °C.
- ☐ c) The tank shutoff valve should not be loosened.

Answers:

1. c; 2. b; 3. b; 4. c; 5. a; 6. a; 7. b; 8. a, b, c; 9. c; 10. b, c; 11. c; 12. a, c; 13. c; 14. c; 15 a, b

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