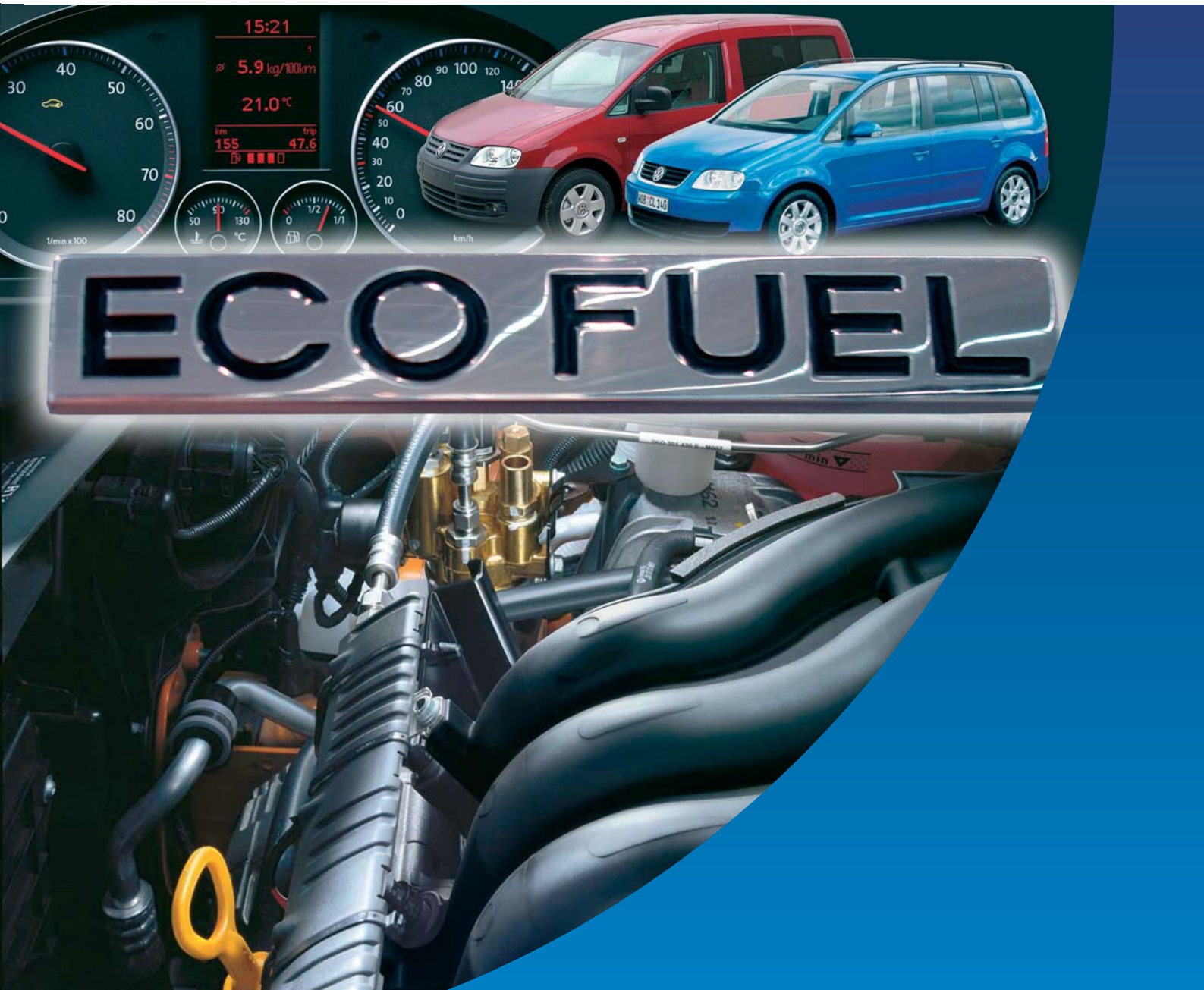
Service Training

Self-study Programme 373

EcoFuel Natural Gas Drive in Touran and Caddy

Design and Function



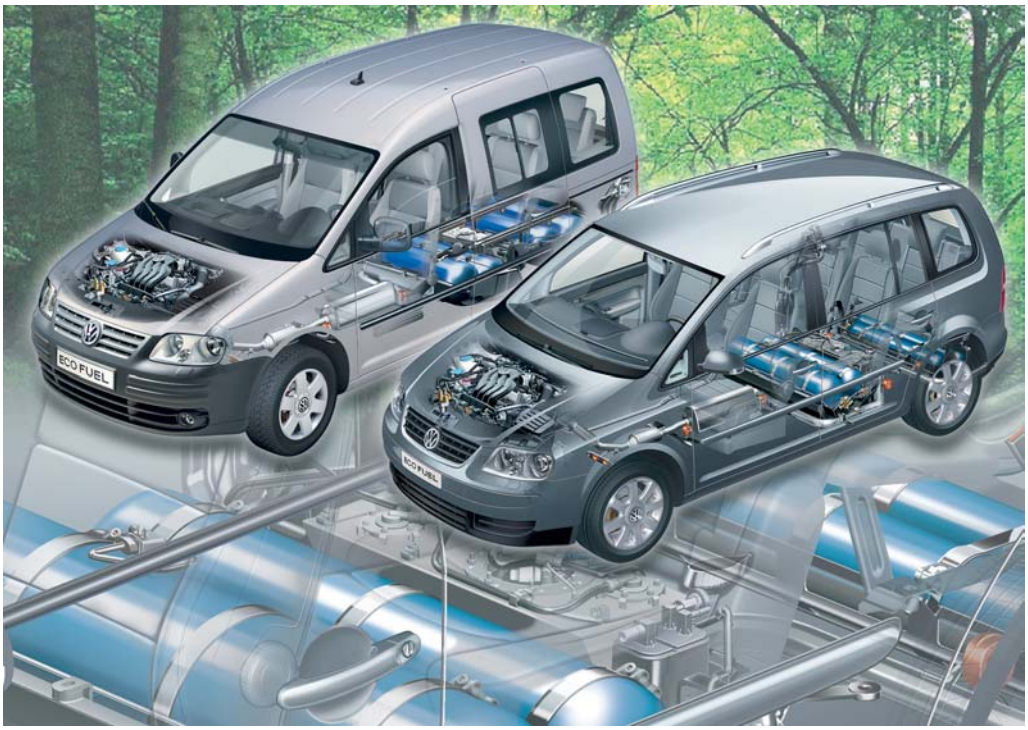
Why natural gas?

Driving with natural gas relieves the burden on the environment.
The emissions of carbon monoxide and nitrogen oxide are reduced by over 50%. Furthermore, when natural gas is burnt, the amount of carbon dioxide produced is 20-25% less than with conventional petrol engines.

Also, from an economic viewpoint, driving a natural gas vehicle is a serious alternative because of the rising petrol and diesel prices.

This self-study programme describes the design and function of vehicles for natural gas operation. The petrol mode in natural gas vehicles is only slightly different to when you drive vehicles that run exclusively on petrol.

You will find basic information on the topic of natural gas in self-study programme no. 262 “Natural gas — an alternative fuel for motor vehicles”.



S373_064

NEW

Important Note

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

For current testing, adjustment and repair instructions, refer to the relevant service literature.

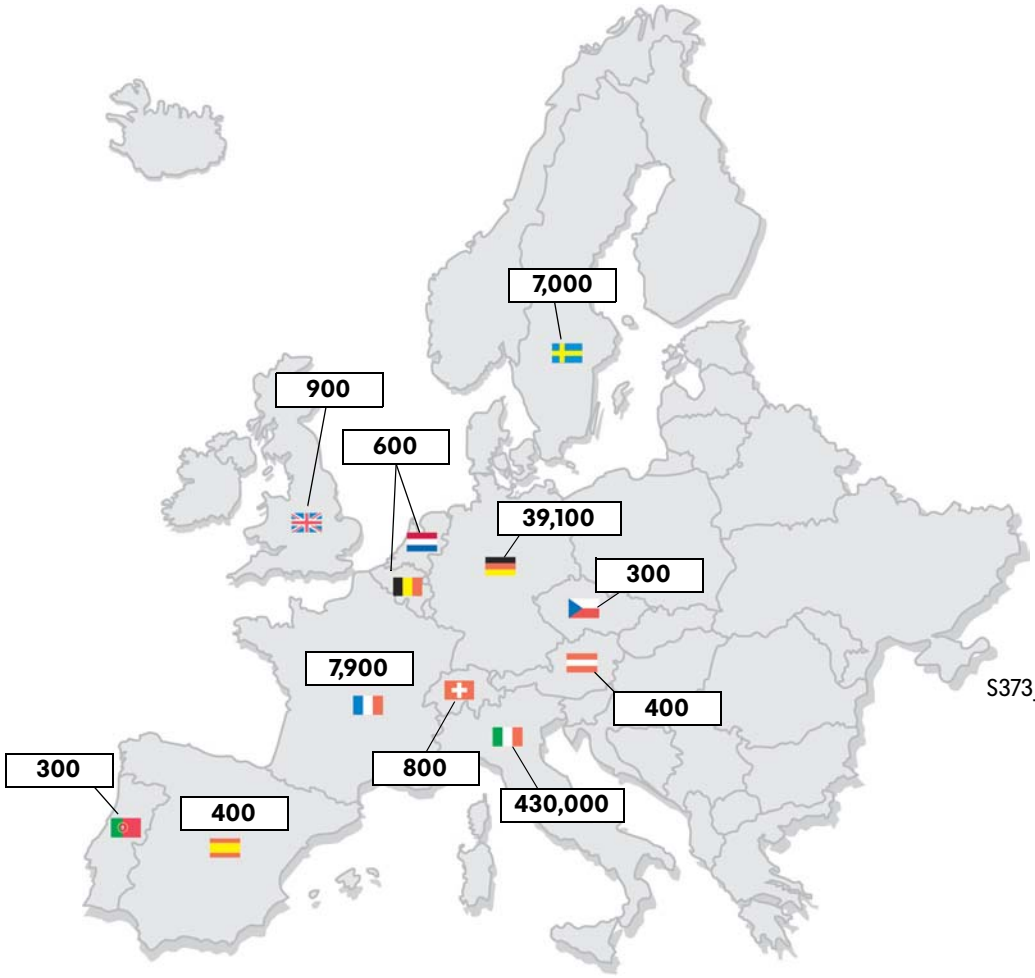
Contents

Introduction

Vehicle population

There are currently around 0.5 million natural gas vehicles in Europe.
Italy accounts for over 430,000 of these natural gas vehicles.

Vehicle population in Europe



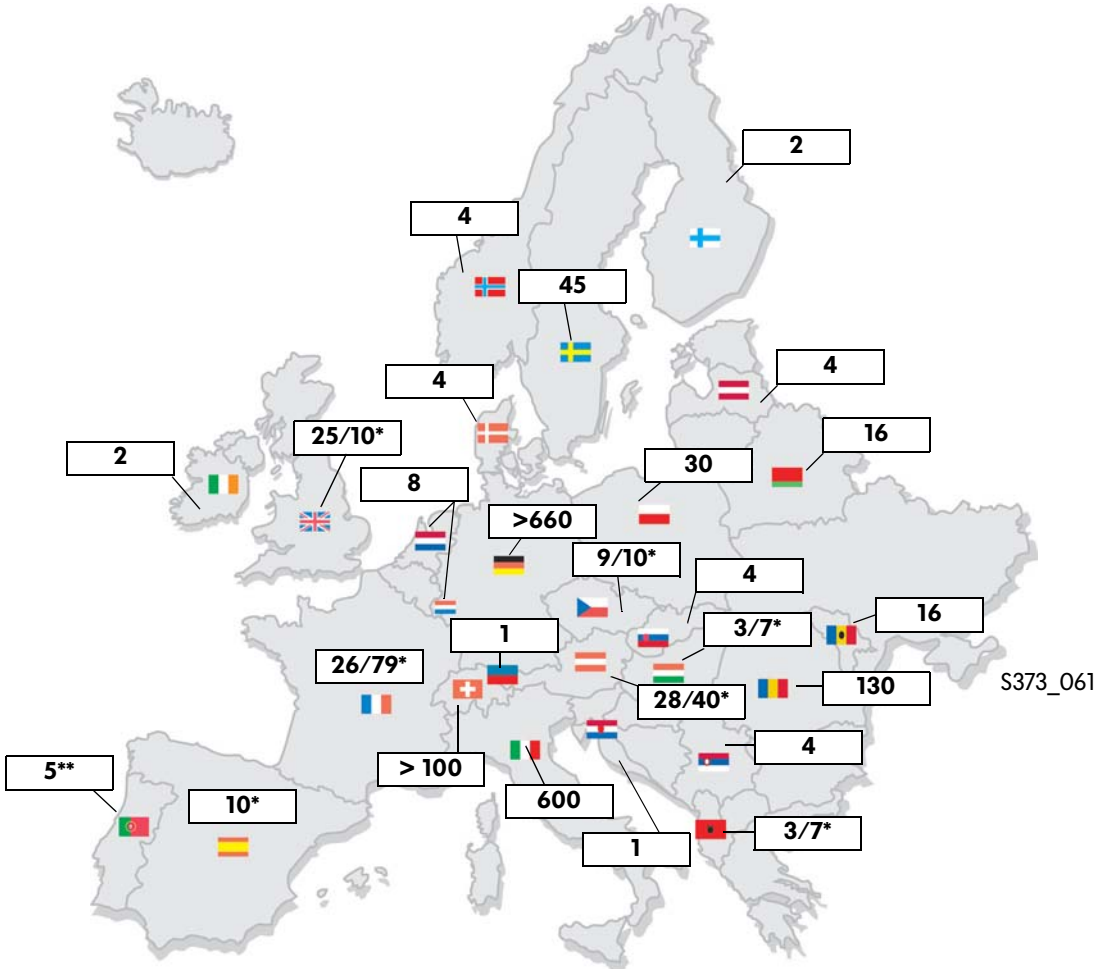
The Caddy and Touran EcoFuel will be launched in the following European countries in 2006:

- Belgium
- Denmark
- Germany
- Estonia
- Finland
- France
- Greece
- Italy
- Latvia
- Lithuania
- Luxembourg
- Netherlands
- Austria
- Poland
- Portugal
- Sweden
- Slovakia
- Slovenia
- Spain
- Hungary
- Czech Republic

Bulgaria and Rumania will follow in 2007.

Service station network

The development of the network across Europe is varied.
In Italy, Switzerland and Germany, the supply of natural gas vehicles is not a problem. There are already over 660 natural gas garages in Germany. That should rise to 1,000 garages by the end of 2007. Drivers looking for natural gas garages can use special guide maps or, in Germany, for example, a national text message service that informs the driver about the nearest natural gas garage in relation to his location.



* non-public garages
** only for buses

You will find further information and addresses of natural gas garages in Germany on the Internet at **www.erdgasfahrzeuge.de** and **www.gibgas.de**.

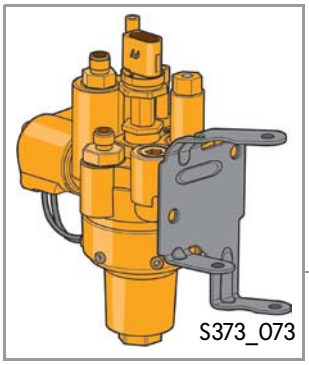
Natural Gas Drive Components

Touran EcoFuel

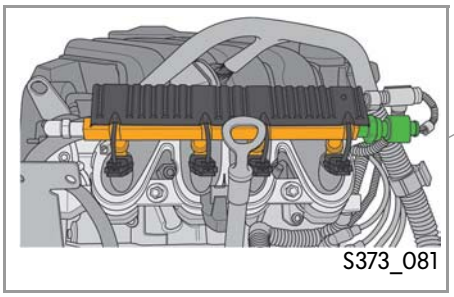
The Touran EcoFuel has the following additional components compared with the Touran with petrol engine:
- a gas filler neck
- four underfloor natural gas tanks each with a tank shut-off valve and a total capacity of approx. 115 litres
- a gas pressure regulator
- a gas fuel rail with four gas injection valves and the gas fuel rail sensor G401
- a back-up petrol tank with 13 litres capacity

General vehicle data

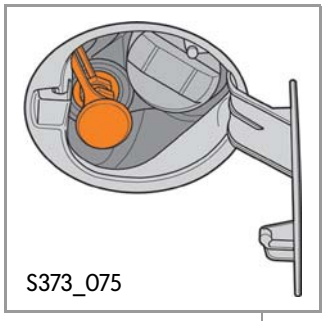
- 80kW/109hp output
- natural gas and petrol operation
- 1 engine control unit for both natural gas and petrol operating modes
- capacity of natural gas tanks approx. 18kg natural gas
- consumption approx. 5.9kg natural gas every 100km
- range in natural gas mode approx. 310km
- range in natural gas mode together with back-up petrol tank approx. 440km



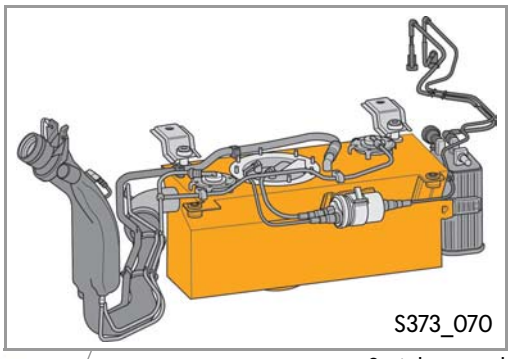
Gas pressure regulator



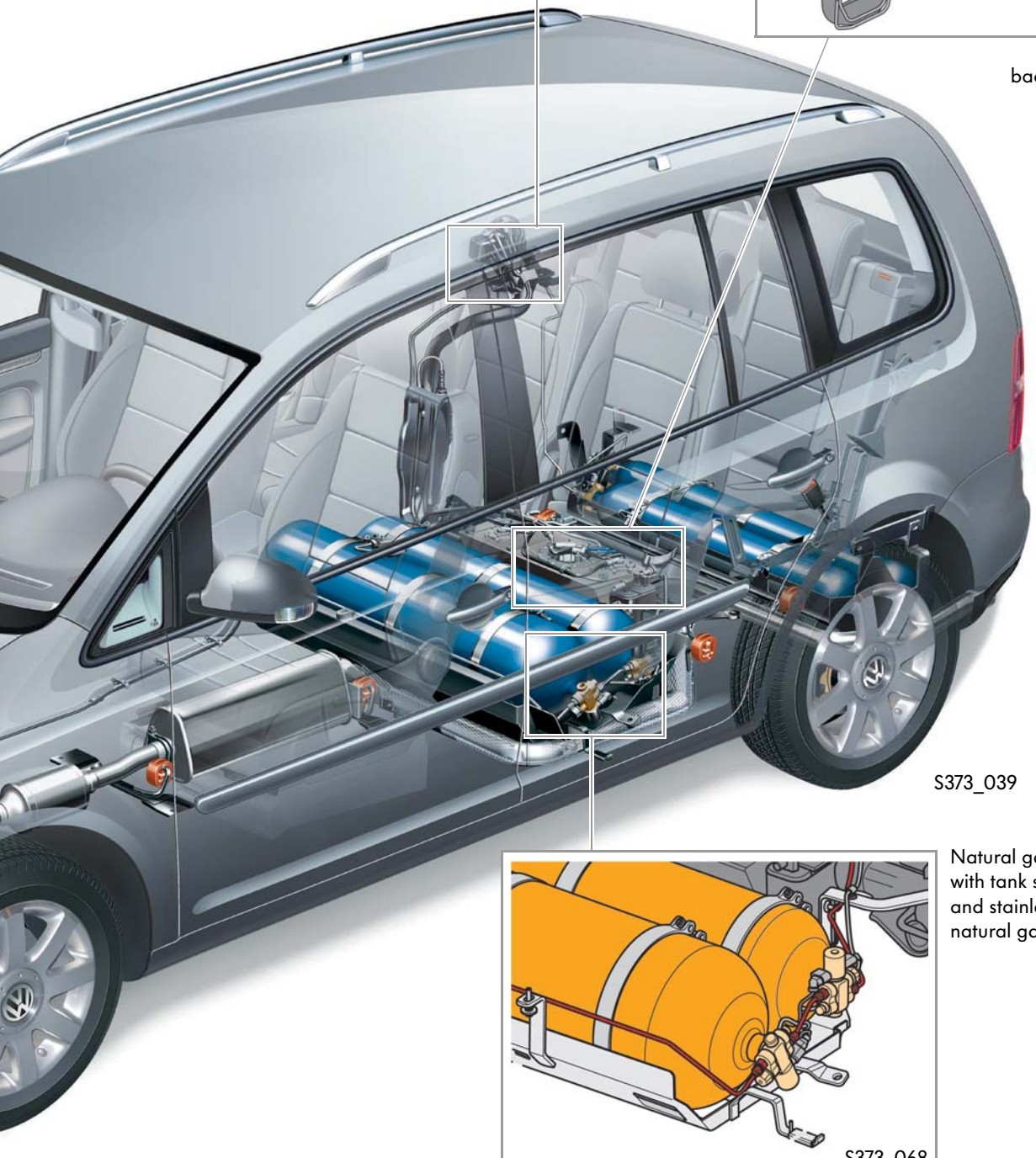
Gas fuel rail with gas injection valves


S373_075

Gas filler neck


S373_070

Stainless steel
back-up petrol tank


S373_039

S373_068

Natural gas tanks
with tank shut-off valves
and stainless steel
natural gas pipes

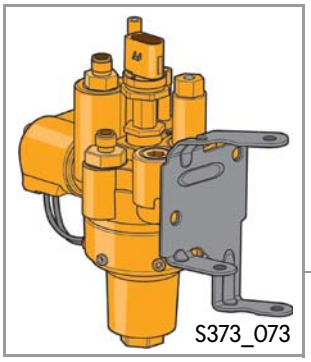
Natural Gas Drive Components

Caddy EcoFuel

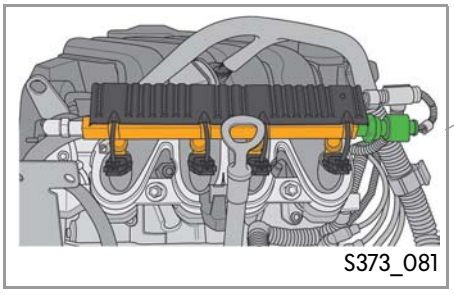
The Caddy EcoFuel also has the following additional components:
- a gas filler neck
- four underfloor natural gas tanks each with a tank shut-off valve and a total capacity of approx. 160 litres
- a gas pressure regulator
- a gas fuel rail with four gas injection valves and the gas fuel rail sensor G401
- a back-up petrol tank with 13 litres capacity

General vehicle data

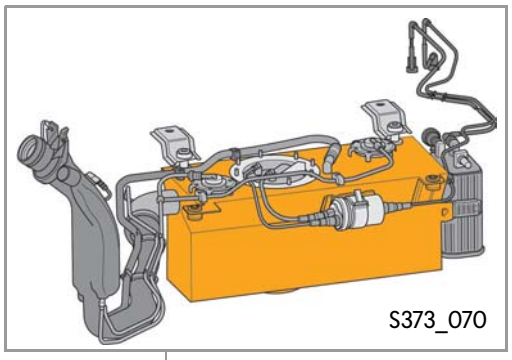
- 80kW/109hp output
- runs on natural gas and petrol
- 1 engine control unit for both natural gas and petrol operating modes
- capacity of natural gas tank approx. 26kg natural gas
- consumption approx. 6.0kg natural gas every 100km
- range in natural gas mode approx. 430km
- range in natural gas mode together with back-up petrol tank approx. 570km



Gas pressure regulator

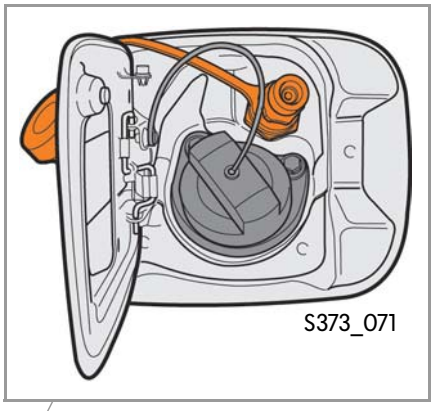


Gas fuel rail with gas injection valves



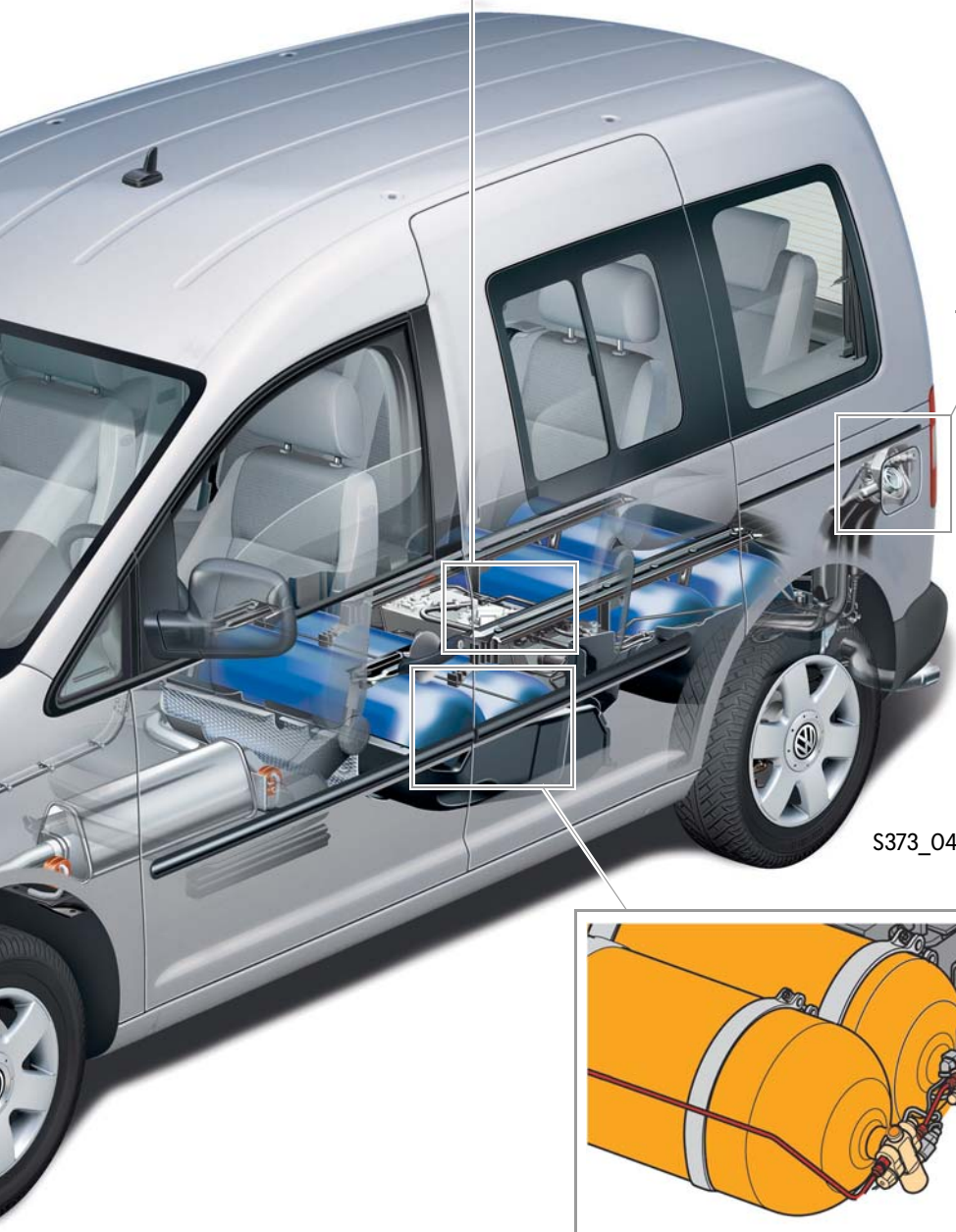
S373_070

Stainless steel back-up petrol tank



S373_071

Gas filler neck



S373_040

S373_114

Natural gas tanks with tank shut-off valve and stainless steel natural gas pipes

The 2.0l/80kW natural gas engine

This engine that has been optimised to run on gas is based on the 2.0l 85kW petrol engine. It is built in Mexico and basically differs from its petrol-driven relatives in terms of piston shape, the valve drive and the injection system. The engine is used both in the Touran EcoFuel and in the Caddy EcoFuel.


S373_065

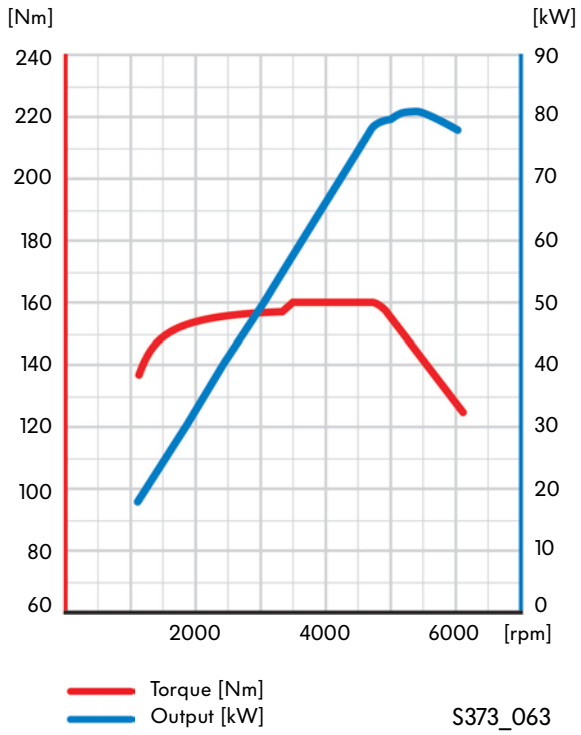
Special features

- configured for natural gas operation
- single-spark ignition coil
- reinforced inlet valves and valve seat rings for inlet and outlet
- modified piston shape
  (flat piston instead of double compression piston with combustion chamber)

Technical data

Engine code	BSX
Type	4-cylinder in-line engine
Capacity [cm^3]	1984
Bore [mm]	82.5
Stroke [mm]	92.8
Valves per cylinder	2
Compression ratio	13.5 : 1
Maximum output	80kW at 5400 rpm
Maximum torque	160Nm at 3500 rpm
Engine management	Motronic ME 7.1.1
Fuel	Natural gas (high), natural gas (low) with reduced performance and range, Super plus unleaded petrol (RON 98)
Exhaust gas treatment	Lambda control
Emissions standard	EU4

Torque and output curve

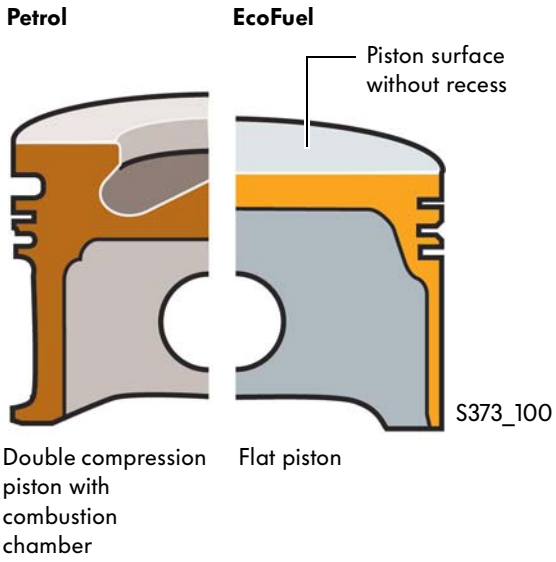


S373_063

Engine mechanics

The engine has been revised to run on natural gas. Natural gas has an anti-knock index of 130 RON. This has allowed the compression ratio to be increased to 13.5 to 1. The higher compression has been achieved by using flat pistons.

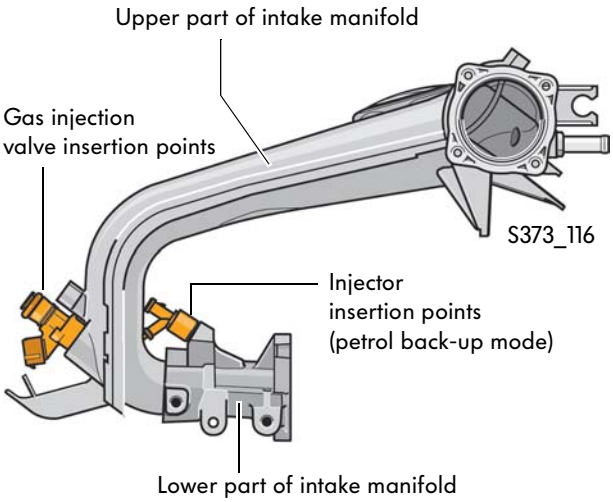
No additives have been added to the natural gas. Therefore no deposits can collect on the valve seats and valve heads of the inlet valves.
Due to the higher loading, the inlet valves and the valve seats on the inlet and outlet have been reinforced.



Intake manifold

The intake manifold is made up of two parts.
The upper part of the intake manifold is made from plastic and forms the engine cover. The lower section of the intake manifold is made from diecast aluminium.

The intake manifold pressure sender G71 is fitted in the upper part of the intake manifold. The gas injection valves are inserted into the upper part of the intake manifold. The injection valves for petrol mode are located in the lower part of the intake manifold.



Compared with petrol engines, gas engines produce a slightly different sound. This is partly caused by a fall in pressure occurring at the valves when the gas injection valves open.

Natural Gas Supply

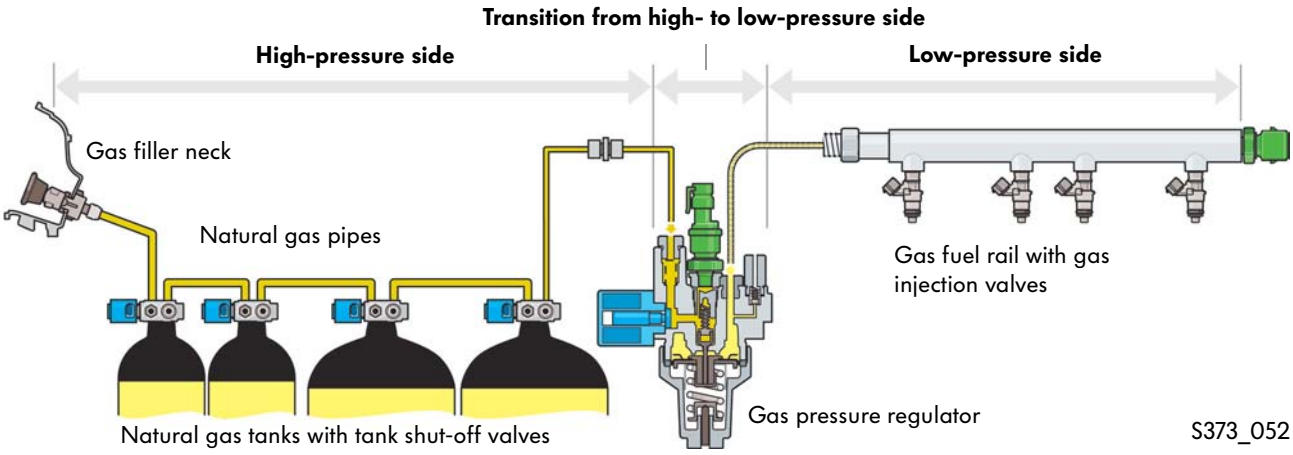
Natural gas

Natural gas is a combustible natural gas that is found in underground traps. It consists of a mixture of hydrocarbons.
The exact composition depends on the source of the natural gas. The main component is methane. The proportion of methane is decisive for the combustion. The higher the proportion of methane, the higher the energy yield.
Natural gas is available in two qualities as its composition varies depending on the source: High and low gas.
High gas has a methane proportion of approx. 87% to 99%, low gas of approx. 80% to 87%.

Natural gas system

In the following section, we will show you the basic features of the design and function of the natural gas system.
We will distinguish between:

- the high-pressure side,
- the transition from the high-pressure to the low-pressure side and
- the low-pressure side.

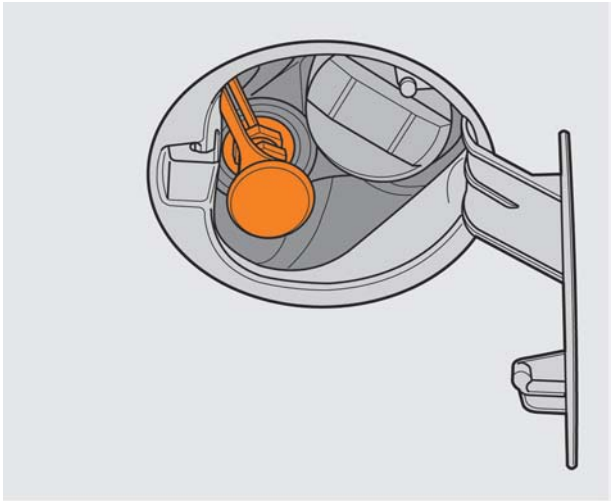


High-pressure side

The high-pressure side of the natural gas system is made up of:

- the gas filler neck,
- the stainless steel natural gas pipes and
- the natural gas tanks with tank shut-off valves.

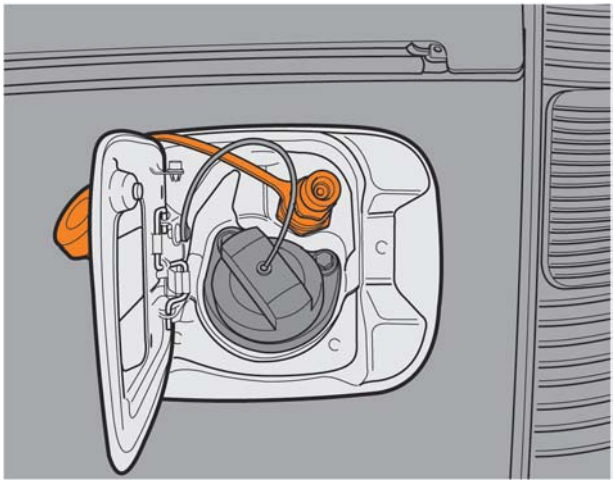
Gas filler neck on Touran



S373_036

The gas filler neck is under the tank filler cap on the right-hand side of the vehicle next to the petrol filler neck. The gas filler neck has a check valve and a metal filter. The gas filler neck is also protected against dirt with a cap.

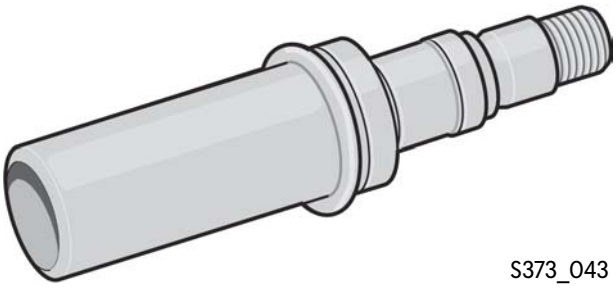
Gas filler neck on Caddy



S373_026

The Caddy tank filler caps are on the left-hand side of the vehicle. The gas and petrol filler necks are also under the same tank filler flap on this car.

Tank adapter



S373_043

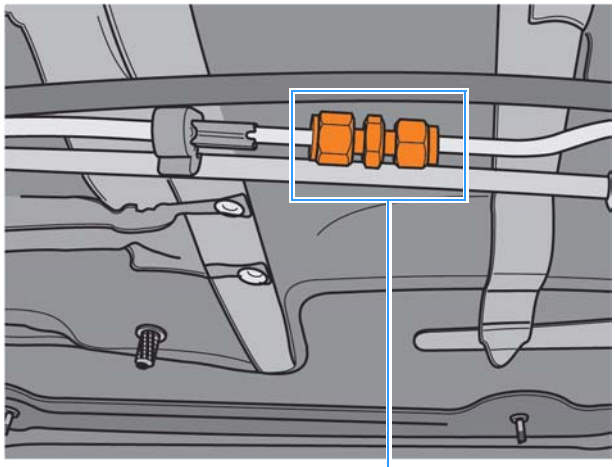
The tank adapter is required when driving in Italy because some older Italian garages still have filling connectors that do not correspond with the current standard.

Natural Gas Supply

Natural gas pipes

The natural gas pipes are made from stainless steel and are designed for pressures of up to 1000 bar. They connect the gas filler neck to the first tank shut-off valve, the four tank shut-off valves and the final valve to the gas pressure regulator.

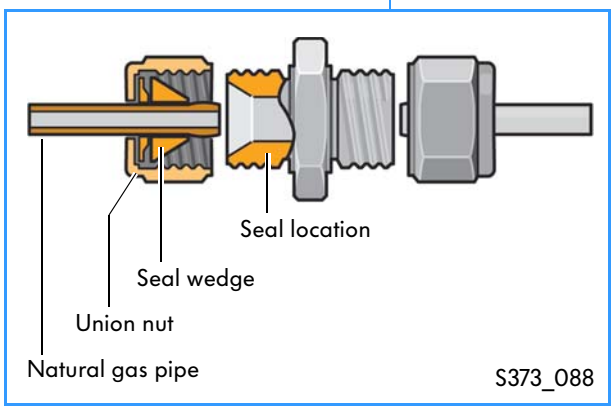
From the gas filler neck to the input of the tank shut-off valve on the fourth natural gas tank, the natural gas pipes have an outer diameter of 8 mm. This allows fast and quiet filling.
The outside diameter of this natural gas pipe is 6 mm from the output on the tank shut-off valve to the gas pressure regulator.



S373_033

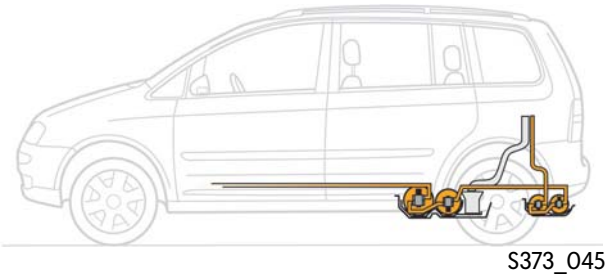
To ensure a good seal on the natural gas pipe, the individual sections are connected on both sides using double-ferrule compression fittings.

Between the engine and the depicted fitting on the underbody (behind the shaft outlet), all natural gas components on the Caddy and the Touran are the same.
Behind the fitting in the direction of the natural gas tank, they are laid differently depending on to the features of the car.
The natural gas pipe is laid parallel to the petrol line.

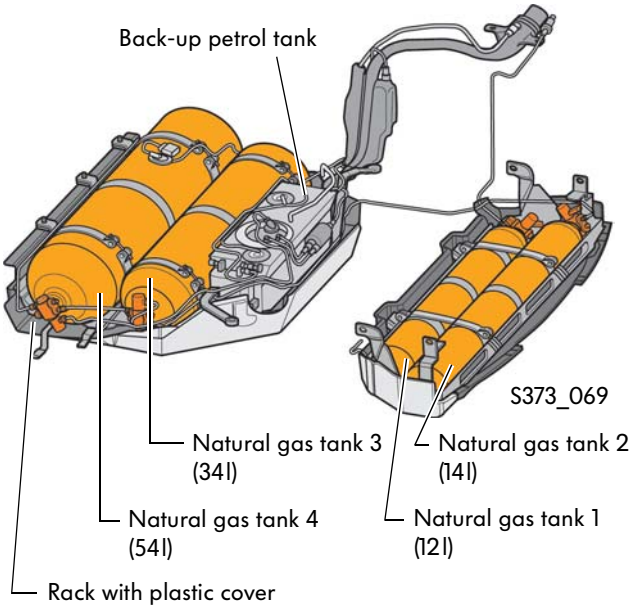


S373_088

Tank system



S373_045



S373_069

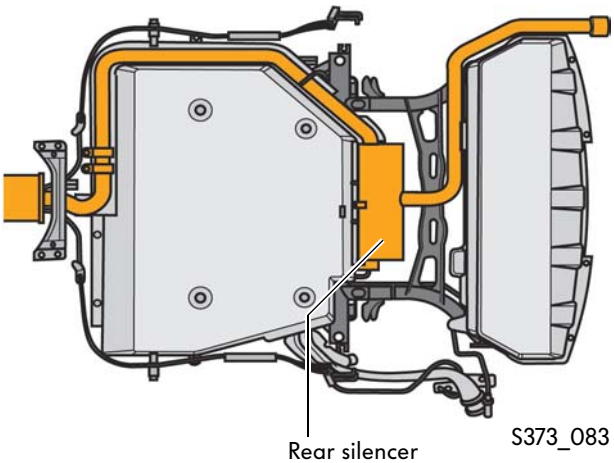
Tank system in Touran

Natural gas tank arrangement

The Touran EcoFuel has four natural gas tanks with a total volume of approx. 115 litres. All four natural gas tanks have different sizes in order to use the available space under the underbody in the best possible way.

The natural gas tanks are mounted on two tank racks. The front rack is bolted to the underbody in front of the rear axle. Two natural gas tanks and the back-up petrol tank are accommodated on it.
The capacity of the back-up petrol tank is approx. 13 litres.
The two smaller natural gas tanks are located on the tank rack behind the rear axle.

Section of exhaust gas system with rear silencer



S373_083

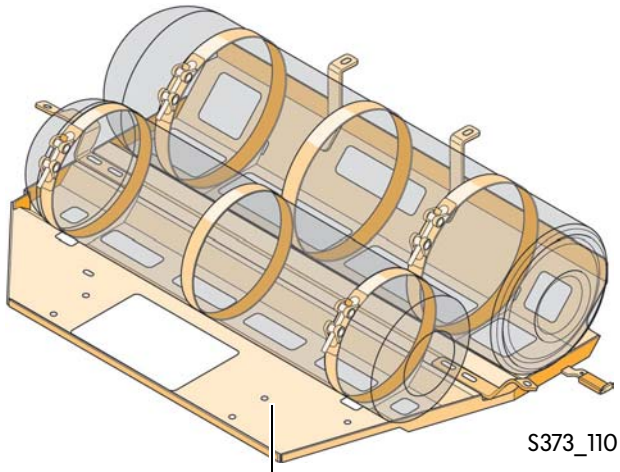
The exhaust gas system layout has been adapted to the natural gas tank location. This arrangement also prevents the natural gas tank being warmed and thus the pressure in the natural gas tanks rising.

Natural Gas Supply

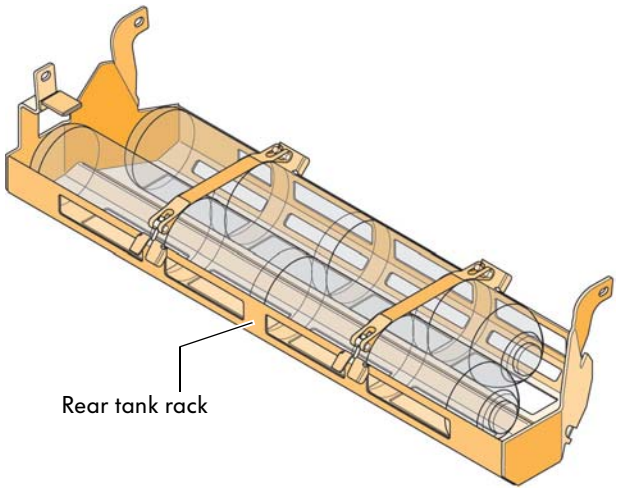
Tank racks with plastic cover

The two tank racks carrying the natural gas tanks and the back-up petrol tank in the Touran are tub-shaped and made from steel sheet. The racks are bolted to the underbody with mounting lugs and have the additional function of protection the natural gas tanks, for example, if the vehicle bottoms out on bad roads. The natural gas tanks are fastened securely to the tank racks with two plastic covered metal straps. To remove the natural gas tank, the tank racks have to be removed from the vehicle.

The tank rack in front of the rear axle carries the two large natural gas tanks with 54 and 34 litres capacity as well as the back-up petrol tank.
The smaller tank rack behind the rear axle carries the two smaller natural gas tanks with 14 and 12 litres capacity.

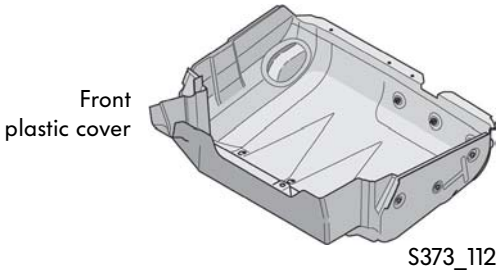


S373_110

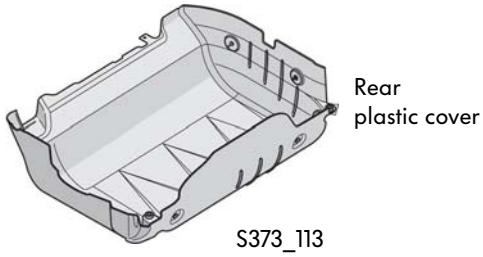


S373_111

Each tank rack has its own plastic cover that protects the natural gas tanks, the tank shut-off valves, the natural gas pipes and the back-up petrol tank against stone chips and dirt.



S373_112



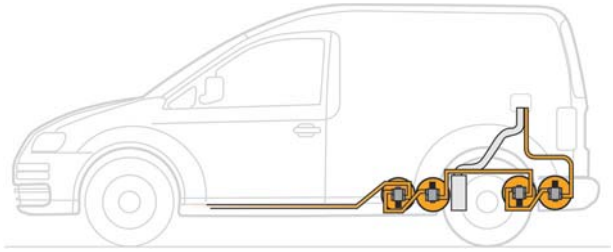
S373_113

Tank system in Caddy

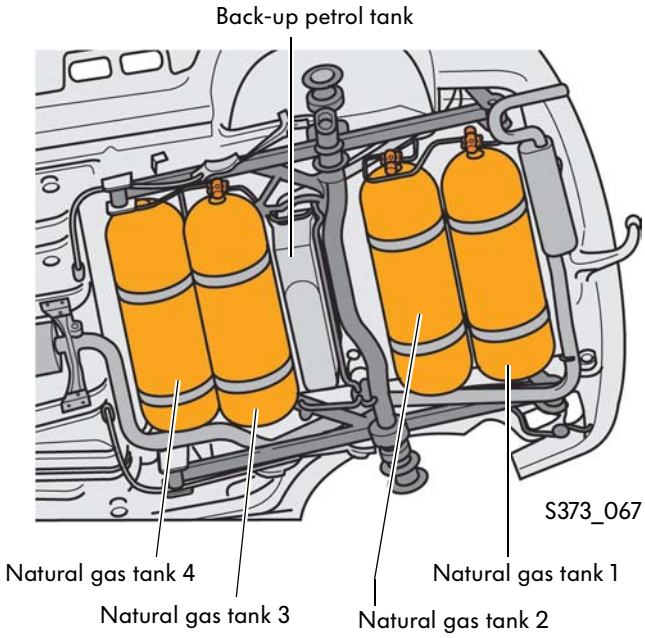
Natural gas tank arrangement

The four natural gas tanks in the Caddy EcoFuel each have a capacity of 40 litres. As on the Touran, two natural gas tanks are mounted in front of the rear axle and two natural gas tanks behind it.
The back-up petrol tank is located between the front natural gas tanks and the rear axle.

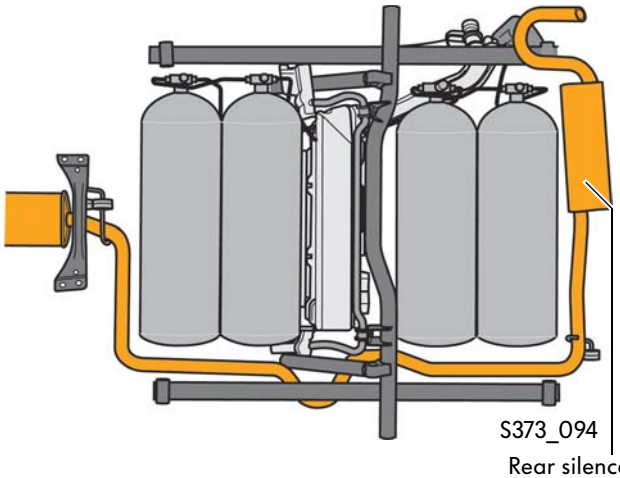
Unlike the Touran, the natural gas tanks on the Caddy are held under the underbody with straps. There is a plastic cover similar to the Touran.



S373_066



S373_067



S373_094
Rear silencer

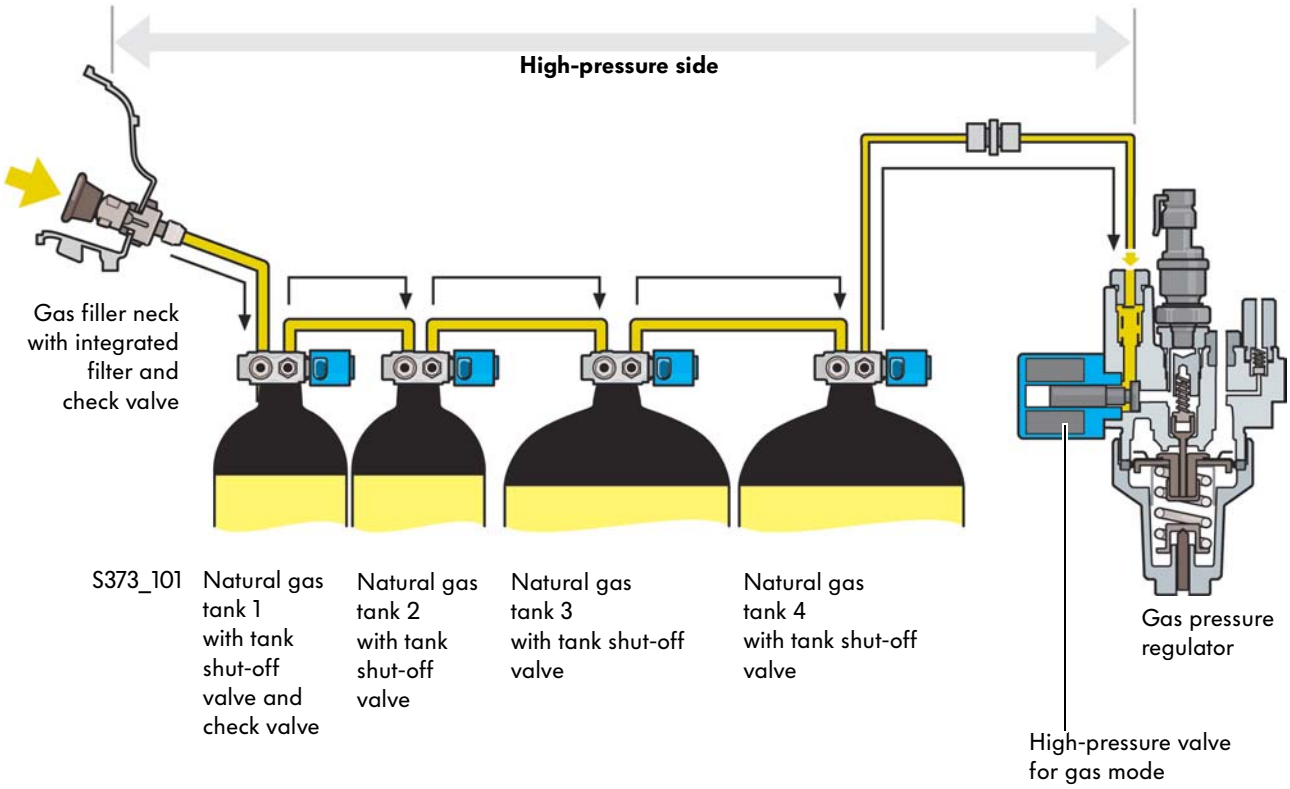
The exhaust gas system runs completely along the front passenger side past the natural gas tanks.
The rear silencer is mounted crossways behind the rear natural gas tank.

Natural Gas Supply

Filling procedure for EcoFuel

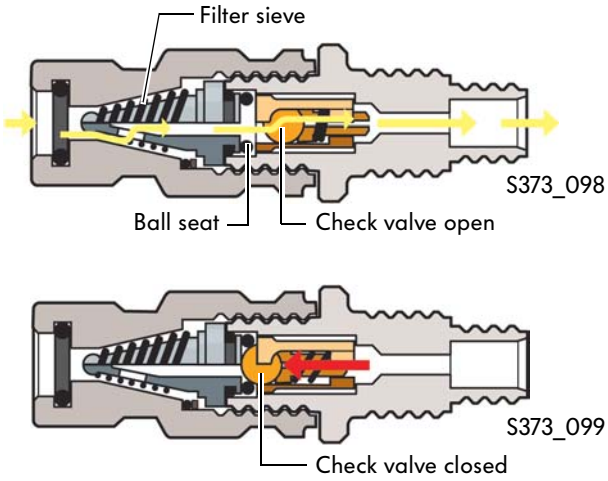
The natural gas flows into the gas filler neck with integrated filter and check valve through the natural gas pipes to the tank shut-off valve on the first natural gas tank. Here the natural gas flows through another check valve and pushes the valve in the tank shut-off valve upwards.
The natural gas now reaches the first natural gas tank. At the same time, the natural gas flows via the natural gas pipe to the tank shut-off valve on the second natural gas tank and, from there, to the tank shut-off valves on the two last natural gas tanks so these tanks are also filled.

The filling process is complete when the same pressure is present in the high-pressure side of the natural gas system as in the garage filling system (approx. 200 bar).
The natural gas gets as far the gas pressure regulator on the high-pressure side and can only be fed to the engine from there once the engine control unit powers the high pressure valve for gas mode and thus opens it.



Check valves

Check valve in gas filler neck

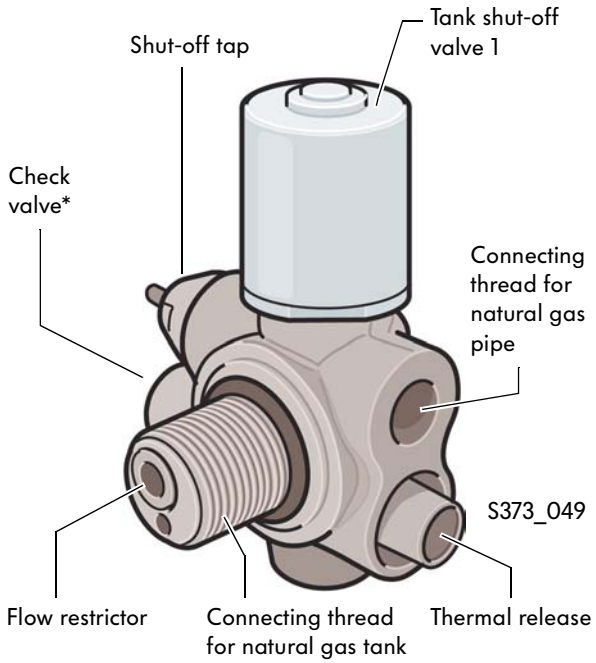


Two mechanical check valves are fitted on both natural gas vehicles. One valve is located on the gas filler neck, the other on the tank shut-off valve on the first natural gas tank.

How they work

The natural gas tank is filled at a high pressure of approx. 200 bar. This pressure pushes the valve ball out of its seat against the force of the pressure spring. The natural gas then flows through the filter sieve into the natural gas tanks.
Once the pressure on the input side of the valve drops, the springs and filling pressure reached in the natural gas tanks push the ball back into its seat. This prevents the gas flowing back.

Tank shut-off valve



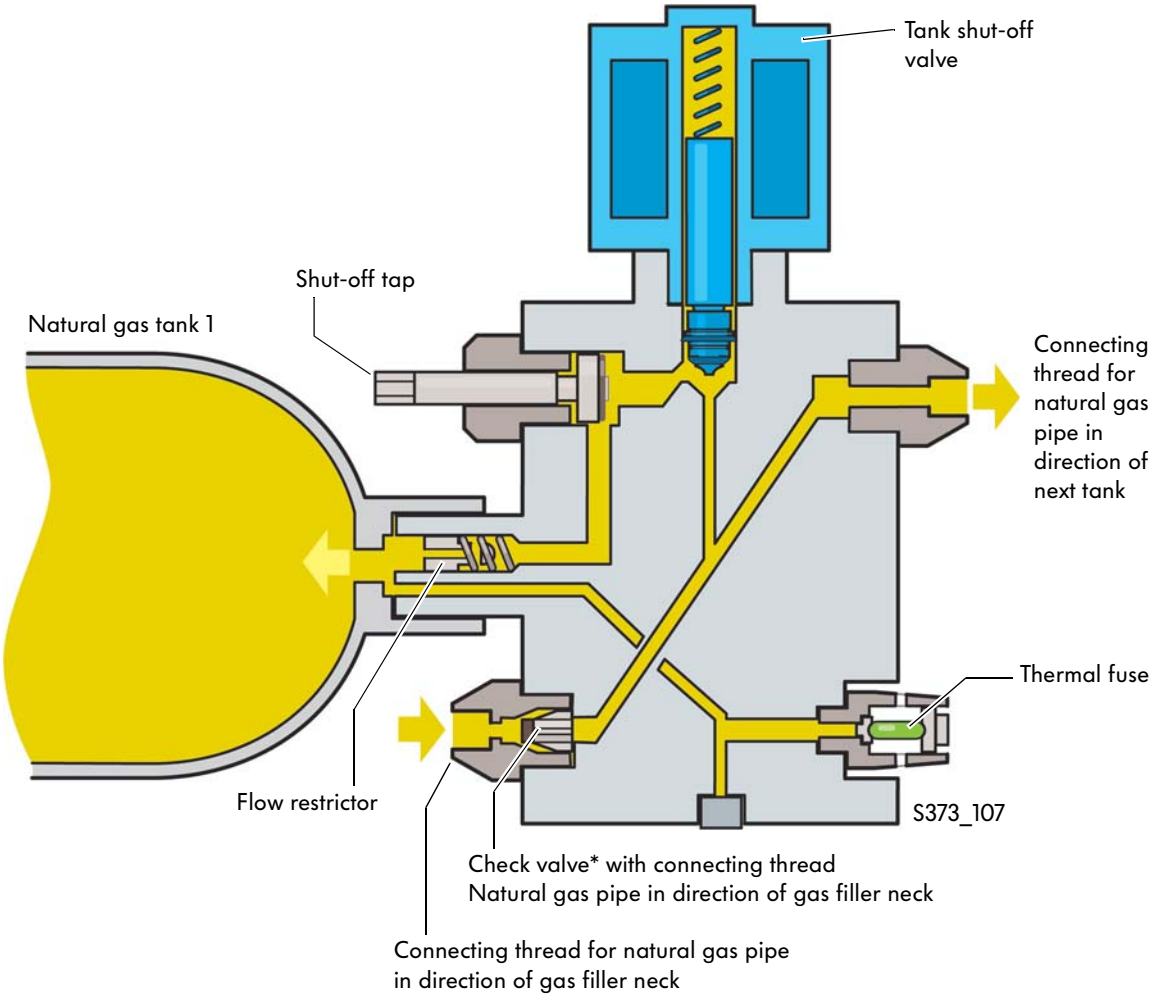
As described, each natural gas tank has a complex tank shut-off valve.
It consists of:

- the manual shut-off tap,
- the connecting thread for the natural gas tank,
- the connecting thread for the stainless steel natural gas pipe,
- the flow restrictor,
- a thermal fuse,
- a check valve* and
- the tank shut-off valves 1 to 4 N361, N362, N363 and N429 (depending on natural gas tank).

* only natural gas tank 1

Natural Gas Supply

Design



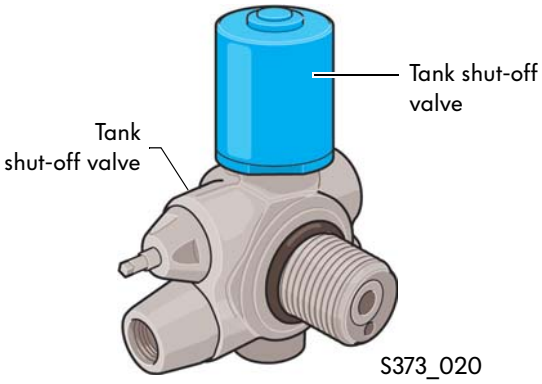
* only natural gas tank 1

The schematic diagram of the tank shut-off valve shows you the interaction of the valve components.

When natural gas enters the first tank shut-off valve while you are filling up, it first has to flow through the return valve. Then the natural gas arrives at the valve in the tank shut-off valve module and pushes the valve disc upwards with a high pressure.
The route to the natural gas tank is now open and natural gas can reach the natural gas tank.

The natural gas passes the manual shut-off tap and then through the flow restrictor into the natural gas tank.

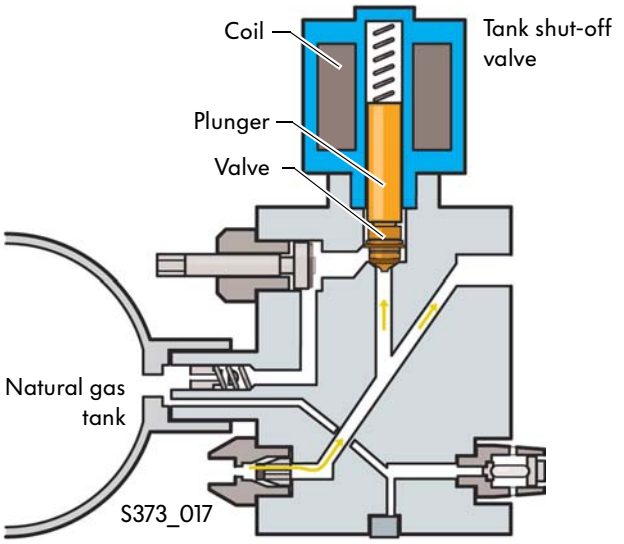
A separate fine channel connects the natural gas tank directly to the thermal fuse.

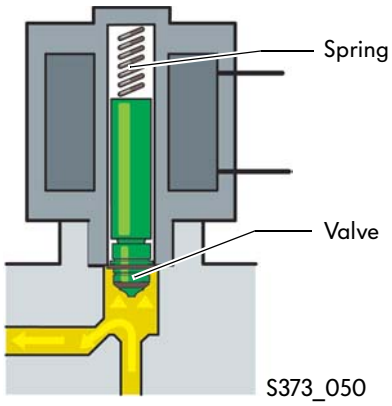


Tank shut-off valves 1 to 4 N361, N362, N363 and N429

The tank shut-off valves are solenoid valves and are controlled by the engine control unit in natural gas mode.
They are part of the tank shut-off valve.
The tank shut-off valves close the access to the natural gas tanks. In natural gas mode, they are opened by the engine control unit.
They are opened by the filling pressure of the natural gas when you fill up.

Cross-section of tank shut-off valve





Filling pressure opens valve

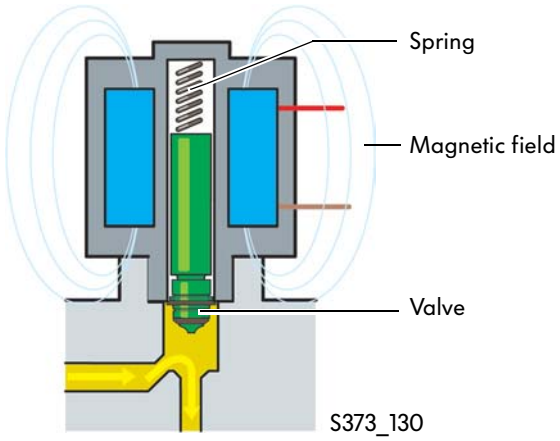
Operation duringnatural gas filling

The tank shut-off valve is not powered while the car is filled. Due to the high, filling pressure when the car is filled up, the valve is pressed upwards against the spring force and opens the route to the natural gas tank. Once you have finished filling up, the spring pushes the valve downwards and closes the path to the natural gas tank.

Natural Gas Supply

Operation innatural gas mode

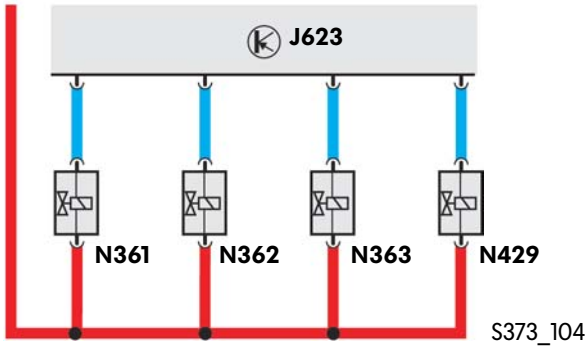
The engine control unit powers the tank shut-off valve. The magnetic field pulls the valve upwards and opens the route to the natural gas tank. When the natural gas mode is ended, the engine control unit switches the tank shut-off valve off and the valve is pushed downwards by the spring. The access to the natural gas tank is closed.



Effect upon failure

When not powered, the tank shut-off valves are closed. If all valves are not activated or they are faulty, natural gas operation is not possible. As soon as a valve is working, the vehicle continues in natural gas mode as natural gas is available from this natural gas tank. All tank shut-off valves are diagnosis capable.

Electrical circuit



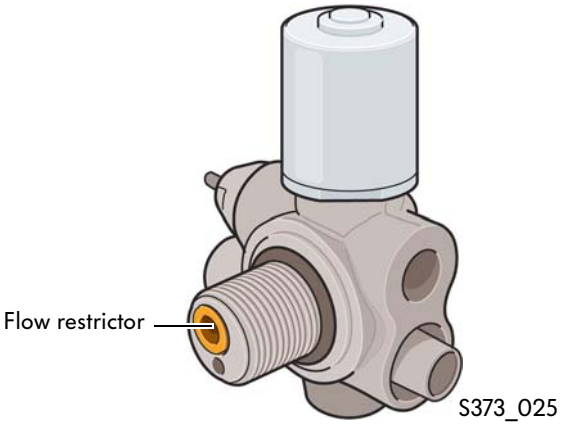
When a crash signal is issued, the tank shut-off valves are closed automatically.
The airbag control unit sends a signal to the engine control unit via the CAN data bus.

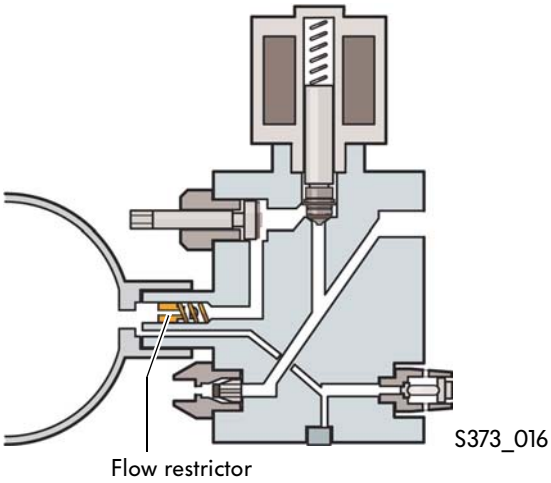
Flow restrictor

The flow restrictor is a safety valve and is located in the connecting flange for the natural gas tank.

Task

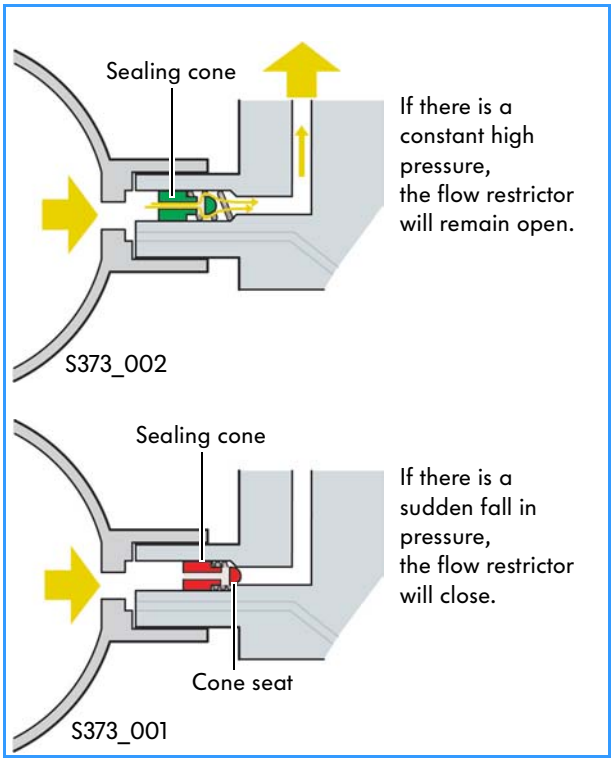
It prevents unwanted, sudden flows of gas from the natural gas tanks after the natural gas pipe has been damaged or if the gas pressure regulator is faulty.





How it works

If the natural gas pipes are suddenly damaged, the pressure in the pipe system will fall suddenly. If the pressure in the natural gas tank is approx. 2 bar higher than the pressure in the natural gas pipe, the sealing cone will be pressed into the cone seat by the pressure in the natural gas tank.
The natural gas tank is now sealed and no natural gas can escape from the natural gas tank.



Natural gas is odourless. An odorant is added to the natural gas to detect small leaks in natural gas systems.