



Self-study Programme 424

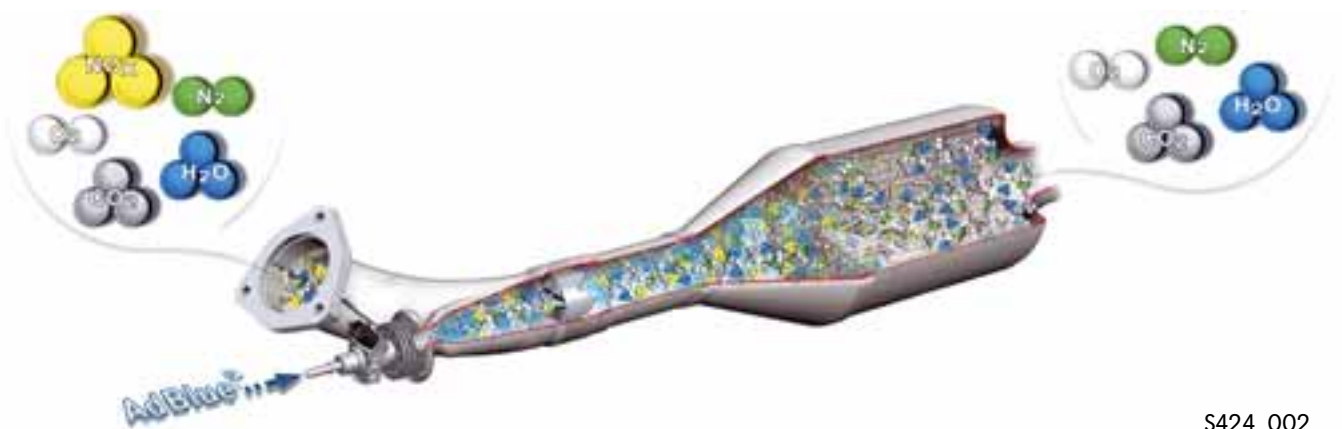
**Exhaust Gas Aftertreatment System
Selective Catalytic Reduction**

Design and Function



In addition to the continuous improvement of internal combustion within the engine, the global tightening of exhaust emissions limits for passenger cars and commercial vehicles with diesel engines also necessitates increasingly higher-performance exhaust gas aftertreatment systems.

With the Selective Catalytic Reduction exhaust gas aftertreatment system, Volkswagen is making a further contribution towards environmental and climate protection.



In this self-study programme, you will obtain information on an exhaust gas aftertreatment system which reduces harmful nitrogen oxides (NO_x) in the exhaust gas and is fitted in passenger cars with diesel engines.

The self-study programme portrays 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.



**Attention
Note**



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Introduction



Selective Catalytic Reduction in the Passat Blue TDI

The reduction of pollutant emissions is an important challenge in automotive engineering.

In the past, Volkswagen has been extensively involved in pushing forth the development of clean diesel engines, and therefore assuming responsibility for environmental protection. Examples include efficient and economical TDI technology plus high-performance injection and exhaust gas aftertreatment systems.

The SCR system is a new exhaust gas aftertreatment system. It is used to reduce the nitrogen oxides contained in exhaust gas.

The abbreviation **SCR** stands for **Selective Catalytic Reduction**.

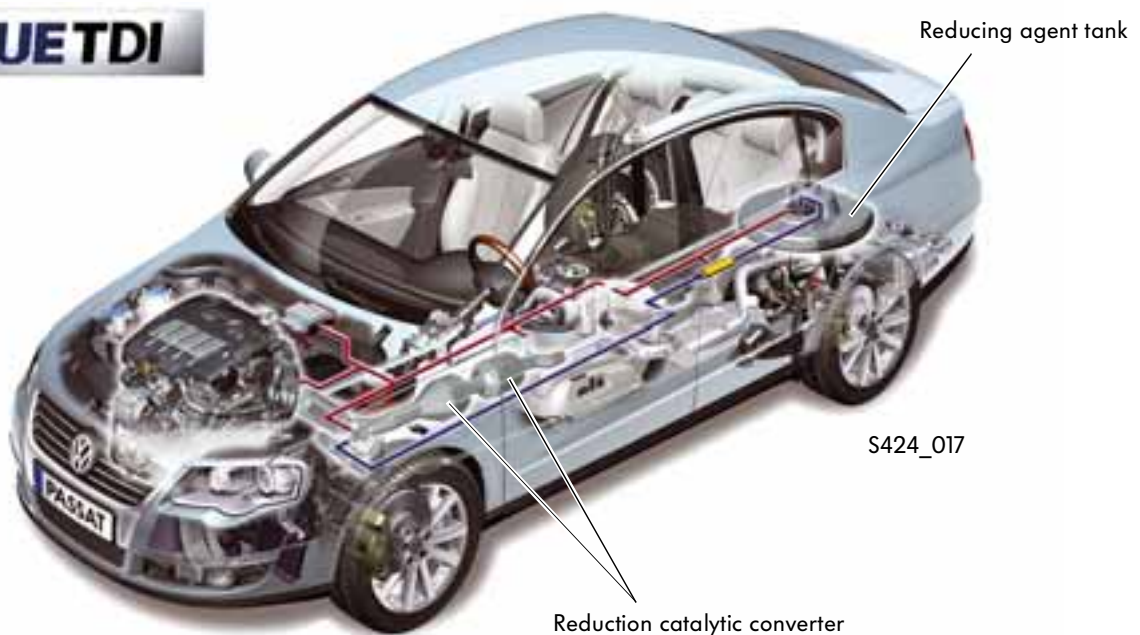
With this technology, the chemical reaction of reduction is selective. This means that, out of all exhaust gas constituents, only the nitrogen oxides are specifically reduced.

In the reduction catalytic converter, the nitrogen oxides (NO_x) contained in the exhaust gas are converted into nitrogen (N_2) and water (H_2O). To achieve this, a reducing agent is continuously injected into the exhaust gas flow upstream of the reduction catalytic converter. The reducing agent is contained in a separate, additional tank.

In automotive engineering, SCR technology has already been in use for some time in commercial vehicles and buses.

At Volkswagen, the Passat Blue TDI in combination with the 2.0l 105 kW common rail TDI engine is being equipped with the SCR catalytic converter technology for the first time. It is therefore the precursor of a series of innovatively clean Blue TDI models.

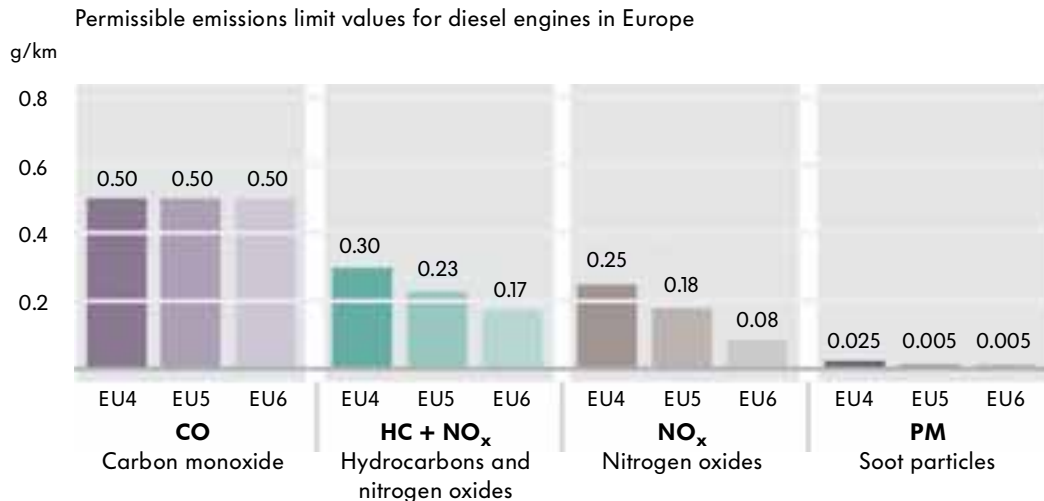
The Passat Blue TDI with SCR system





Emissions standards

With the SCR system, the engine currently complies with the most stringent emissions standards. It already achieves the EU6 emissions standard, which will be enforced in Europe from 2014 onwards.



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The 2.0l 105 kW CR TDI engine

Technically, the 2.0l 105 kW TDI engine with common rail fuel injection system fitted in the Passat Blue TDI is based on the 2.0l 103 kW CR TDI engine first installed in the Tiguan.

Technical data

Engine code	CBAC
Type	4-cylinder in-line engine
Valves per cylinder	4
Displacement	1968 cm ³
Stroke / bore	95.5 mm / 81 mm
Maximum output	105 kW at 4200 rpm
Maximum torque	320 Nm at 1750 to 2500 rpm
Compression ratio	16.5:1
Engine management	Bosch EDC 17
Fuel	Diesel, DIN EN 590
Exhaust gas cleaning	Exhaust gas recirculation, oxidation catalytic converter, diesel particulate filter, SCR system
Emissions standard	EU6



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You will find further information on this engine in self-study programme No. 403 "The 2.0l TDI Engine with Common Rail Injection System".

Introduction



Nitrogen oxides

Nitrogen oxides are the collective term for chemical compounds consisting of nitrogen and oxygen (e.g. NO, NO₂ ...).

They occur during combustion in the engine as a result of high pressure, high temperatures and surplus oxygen.

The nitrogen oxides are partly responsible for forest damage caused by "acid rain" and for smog formation.



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Nitrogen oxide reduction measures

Before the SCR catalytic converter system was designed to help reduce nitrogen oxide, a range of different technical solutions were in place to reduce nitrogen oxide emissions.

Emission reduction can be achieved via measures within the engine. Effective optimisation of combustion ensures that pollutants do not occur in the first place.

The measures within the engine include:

- Designing intake and exhaust ports for optimal flow conditions
- High injection pressures for good mixture formation
- The design of the combustion chamber, e.g. the design of the piston recess and the reduction of the compression ratio



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Exhaust gas recirculation

During exhaust gas recirculation, some of the exhaust gas is returned to the combustion process. The reduction in the fuel-air mixture's oxygen concentration which is achieved in this process slows combustion down. This leads to a reduction in the peak combustion temperature and therefore reduces nitrogen oxide emissions.



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Exhaust gas recirculation valve N18

Exhaust gas recirculation cooling

In order to reduce the nitrogen oxides even more effectively during exhaust gas recirculation, the recirculated exhaust gases are passed through a cooler when the engine has reached its operating temperature.

This additionally reduces the combustion temperature and enables an increased volume of exhaust gases to be recirculated.

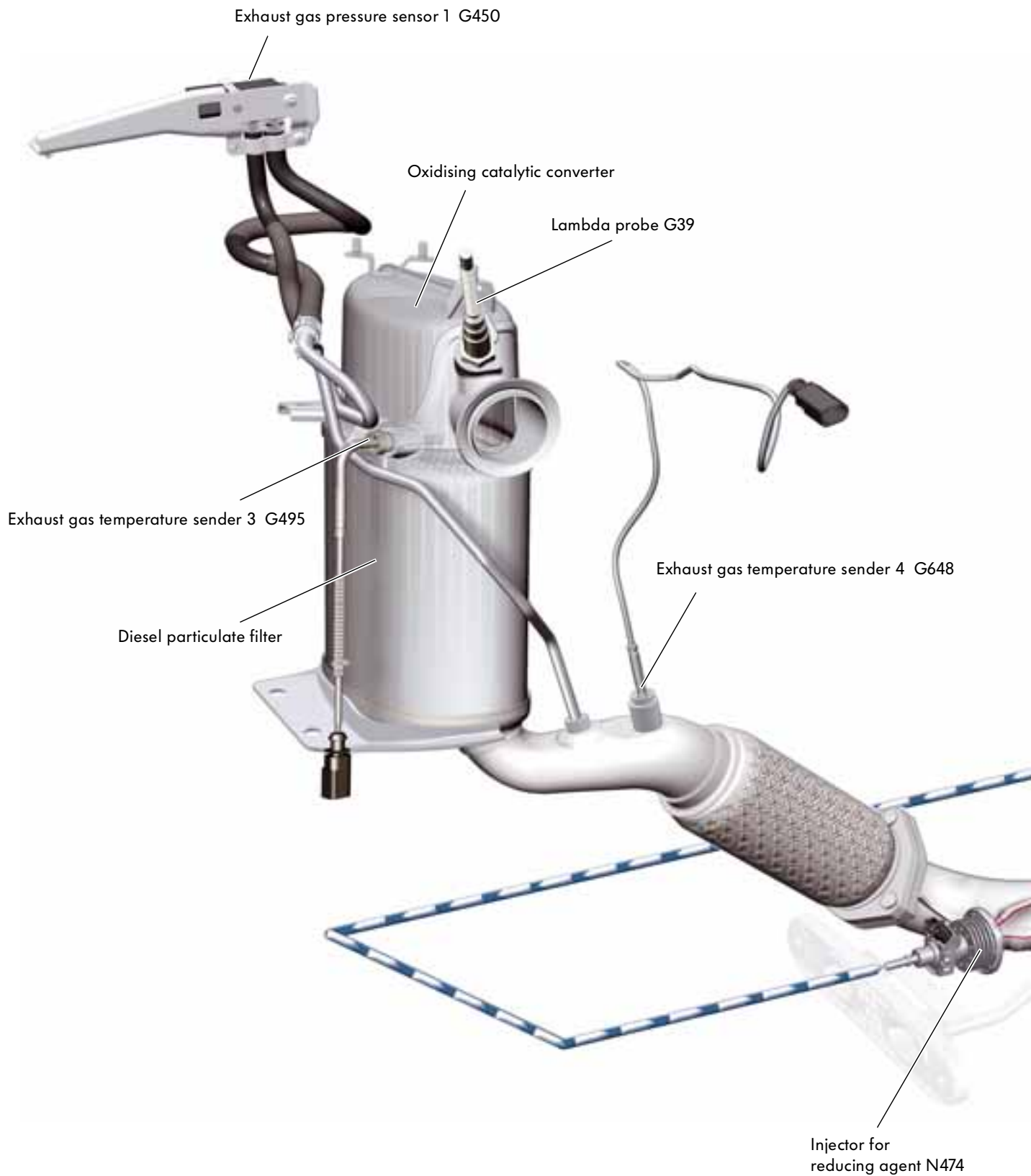


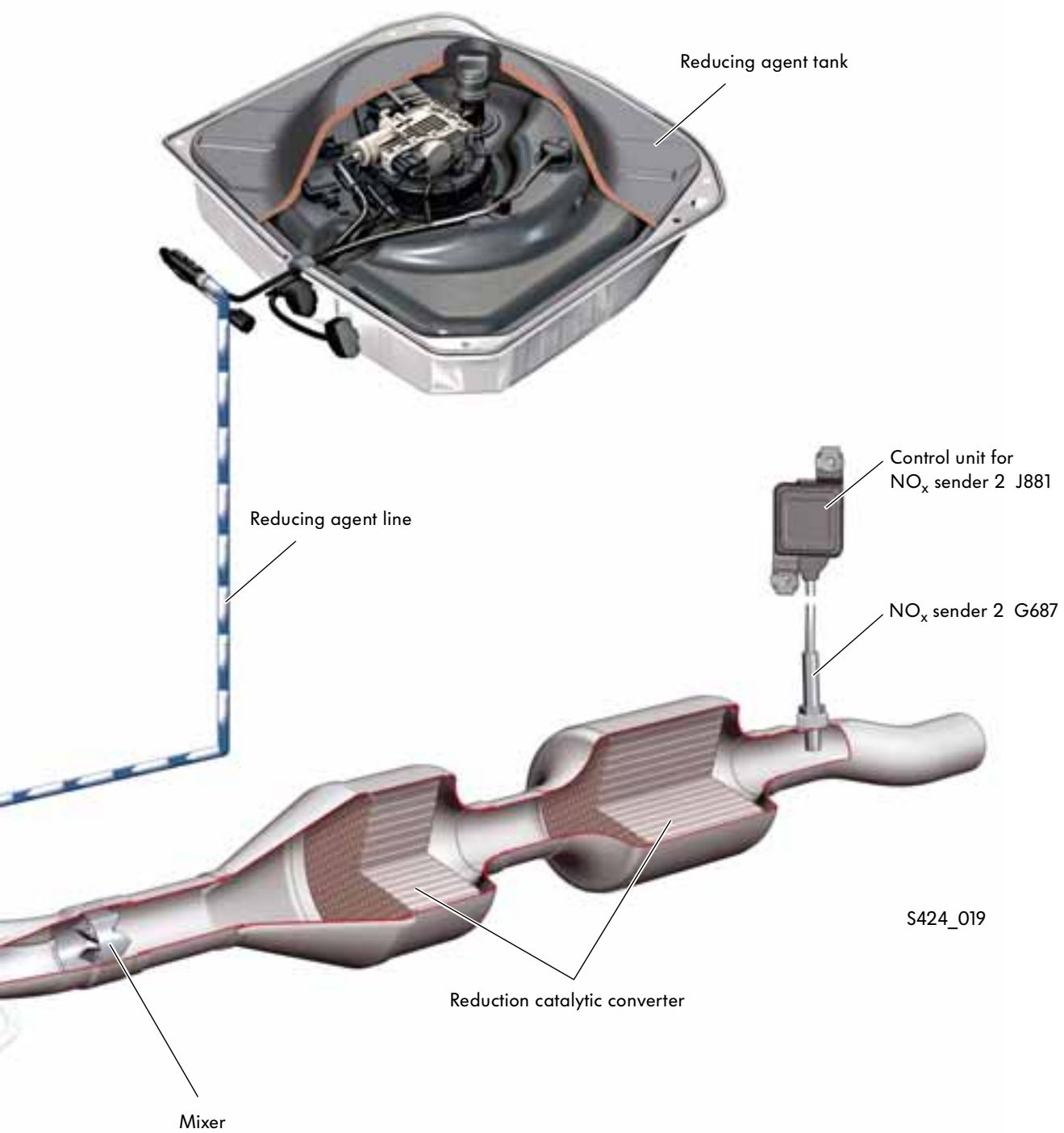
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Cooler for exhaust gas recirculation

System design

Exhaust system with SCR system

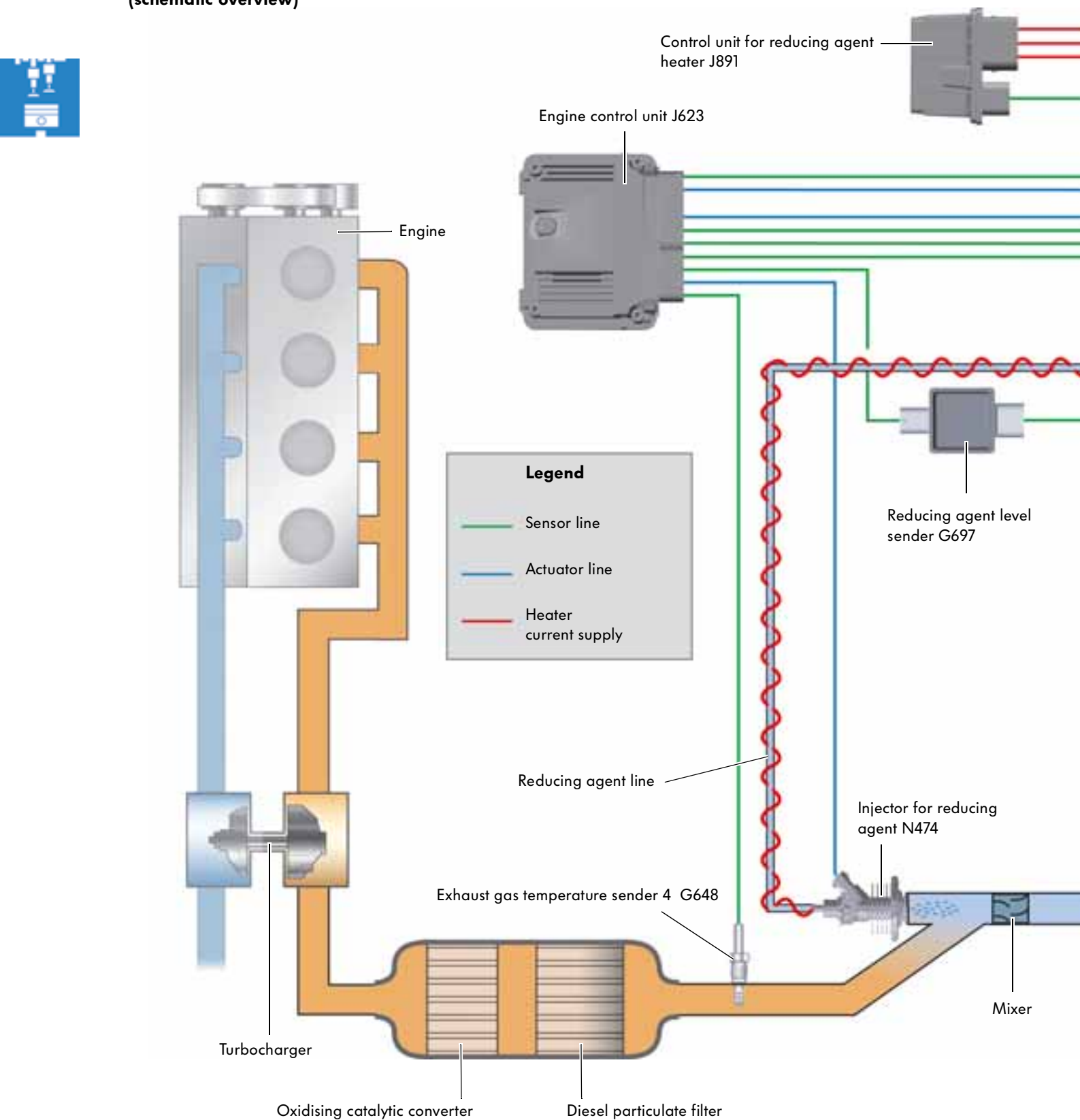


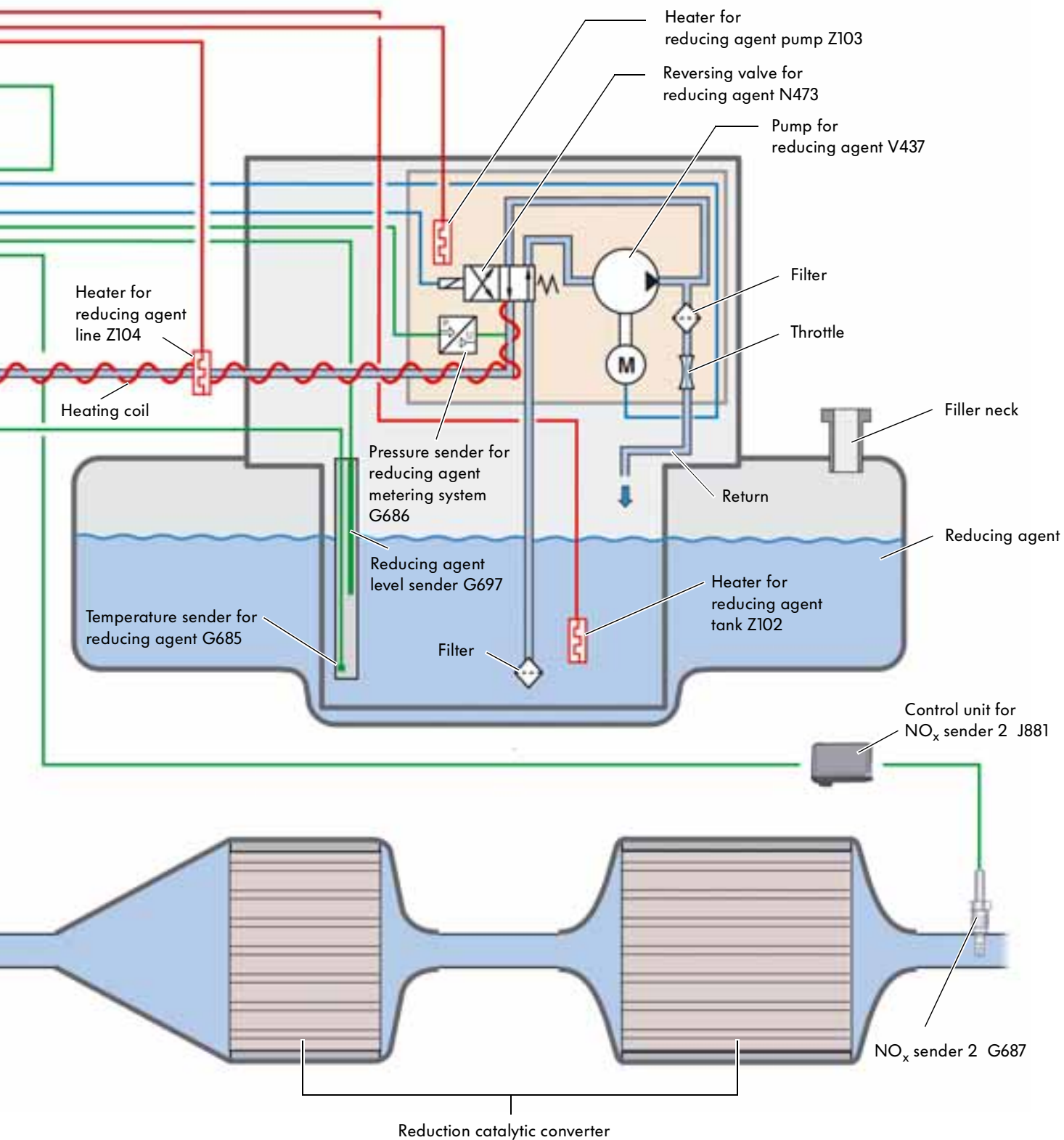


System design

SCR system

(schematic overview)





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Functional principle

Functional principle of the SCR system

The reduction catalytic converter has reached its operating temperature at approximately 200 °C. Information on the reduction catalytic converter's exhaust gas temperature is received by the engine control unit from exhaust gas temperature sender 4 G648.

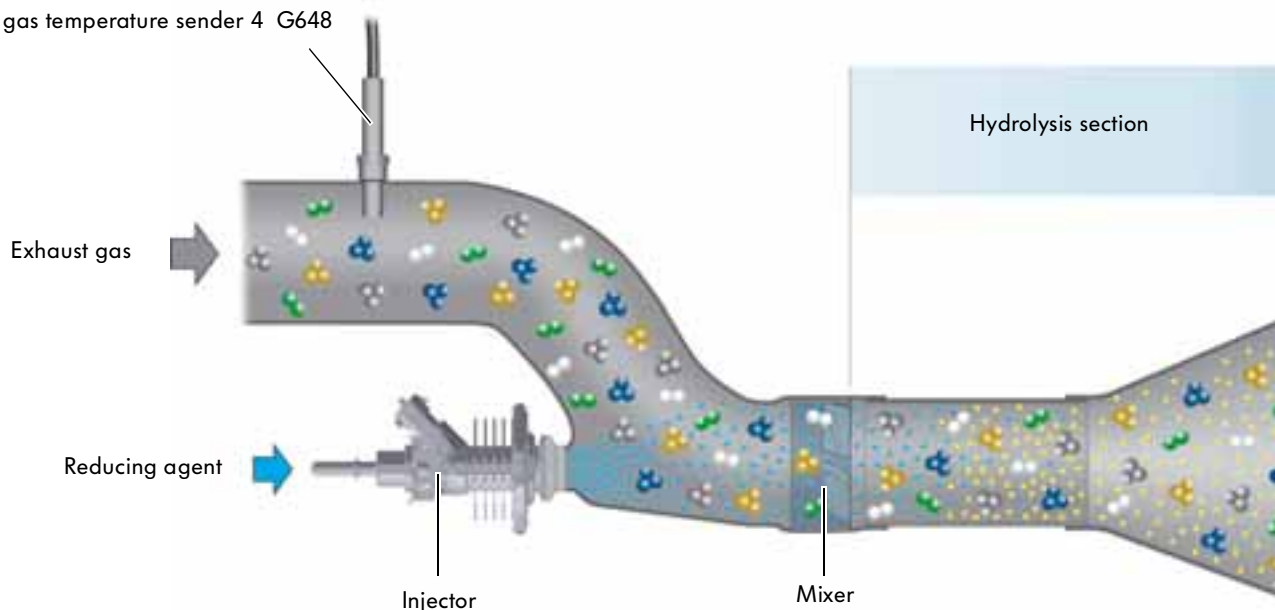
The AdBlue® reducing agent is sucked out of the reducing agent tank by the reducing agent pump and sent through the heated supply line to the injector for reducing agent at a pressure of approx. 5 bar.

The injector for reducing agent is actuated by the engine control unit and injects the metered reducing agent into the exhaust system. The injected reducing agent is carried along by the exhaust gas flow and is evenly distributed in the exhaust gas by the mixer. On the route to the reduction catalytic converter, which is called the hydrolysis section, the reducing agent is broken down into ammonia (NH_3) and carbon dioxide (CO_2).

In the reduction catalytic converters, the ammonia (NH_3) reacts with the nitrogen oxides (NO_x) to form nitrogen (N_2) and water (H_2O).

The SCR system's efficiency is registered by NO_x sender 2 G687.

Exhaust gas temperature sender 4 G648



Exhaust gas constituents



Carbon dioxide



Water



Nitrogen oxide



Oxygen



Nitrogen



AdBlue® reducing agent



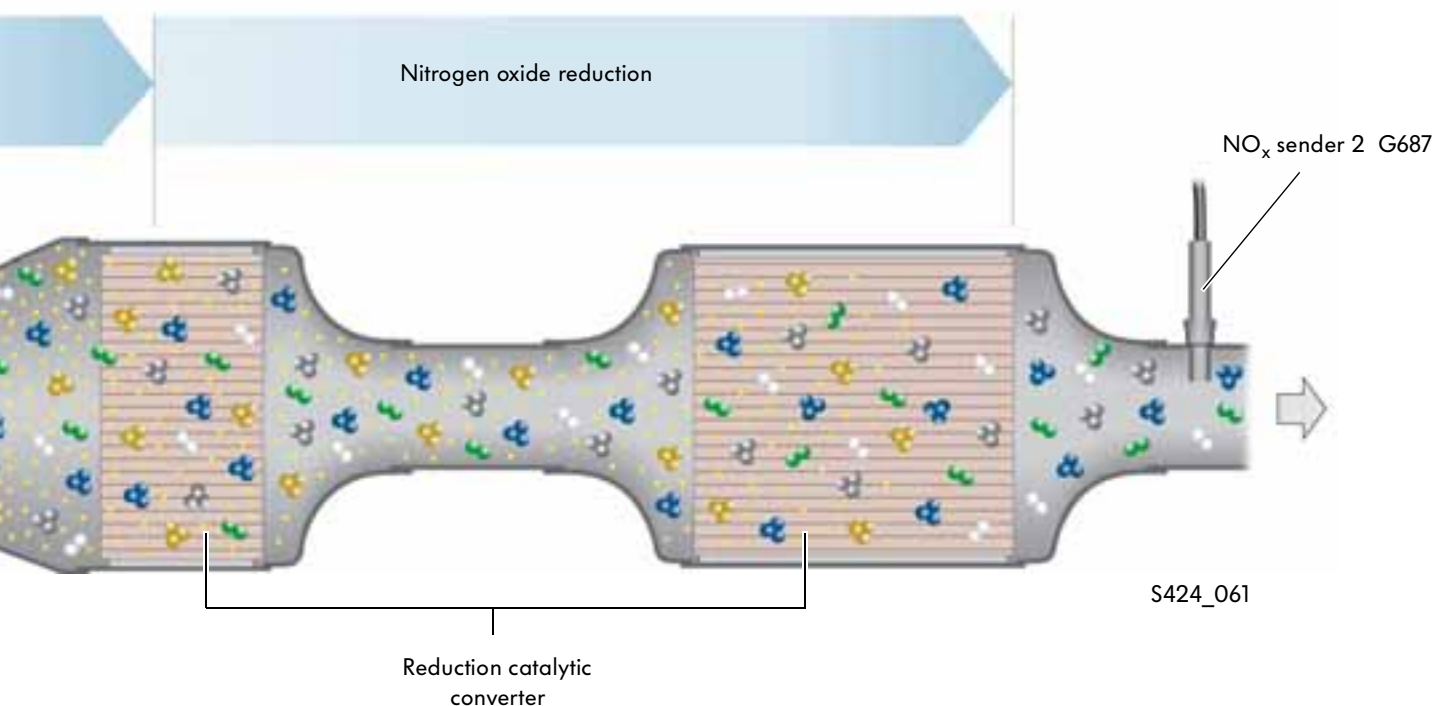
Ammonia - NH_3

The following prerequisites must be met for the engine control unit to inject the reducing agent:

- The reduction catalytic converter has reached its operating temperature of approx. 200 °C.
- There must be guaranteed that sufficient liquid reducing agent is available for injection at low exterior temperatures.

Under the following conditions, injection of the reducing agent is interrupted by the engine control unit:

- If the mass exhaust gas flow is too low, e.g. during idling.
- If the exhaust gas temperature falls too far and drops below the reduction catalytic converter's operating temperature.



The design of the reduction catalytic converters corresponds to that of an oxidation catalytic converter with a honeycomb-shaped ceramic body.

The reduction catalytic converter's coating consists of copper zeolith. This accelerates the speed of the nitrogen oxide reduction process.

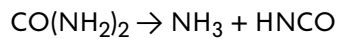
Functional principle

Hydrolysis section

The hydrolysis section is located between the injector for reducing agent and the reduction catalytic converter. The ammonia (NH_3) required to reduce the nitrogen oxides is formed there from the reducing agent (urea solution). This is carried out via a thermolysis and hydrolysis reaction on the part of the injected reducing agent.

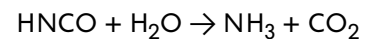
When the reducing agent is injected into the hot exhaust gas flow, the water initially evaporates.

During thermolysis, the reducing agent (urea solution) is broken down into ammonia and isocyanic acid.

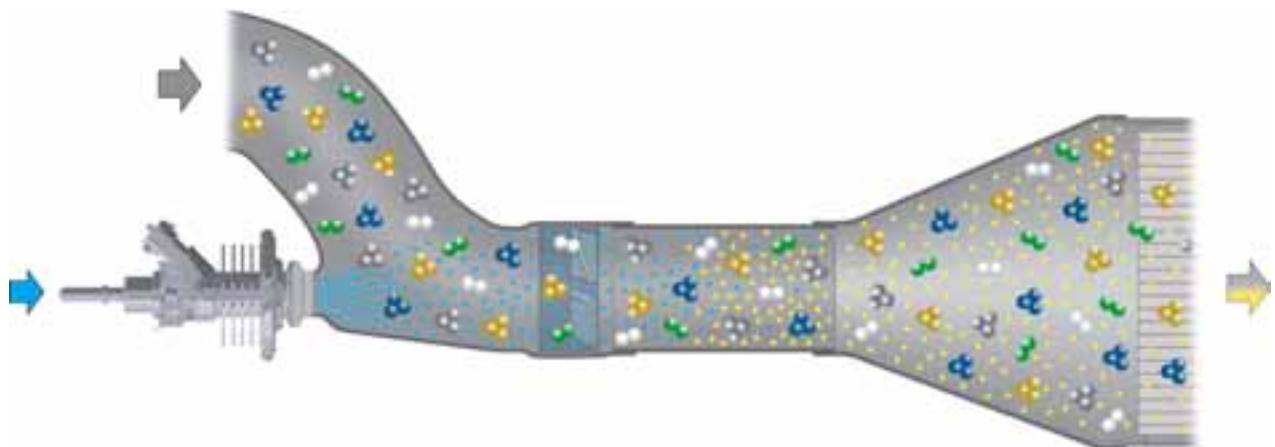


Urea → ammonia + isocyanic acid

This is followed by hydrolysis, in which the isocyanic acid reacts with the water contained in the exhaust gas. This leads to the creation of an additional ammonia and carbon dioxide molecule.



Isocyanic acid + water → ammonia + carbon dioxide



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Thermolysis = thermolysis is a chemical reaction in which an initial substance is broken down into several products by means of heating.

Hydrolysis = hydrolysis is the cleavage of a chemical compound via its reaction with water.

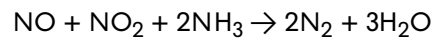
Good mixing and the even distribution of reducing agent and exhaust gas are very important! Before entering the SCR catalytic converter, the reducing agent must have evaporated completely. The more even the distribution, the higher the efficiency of the reduction catalytic converter.

Reduction catalytic converter

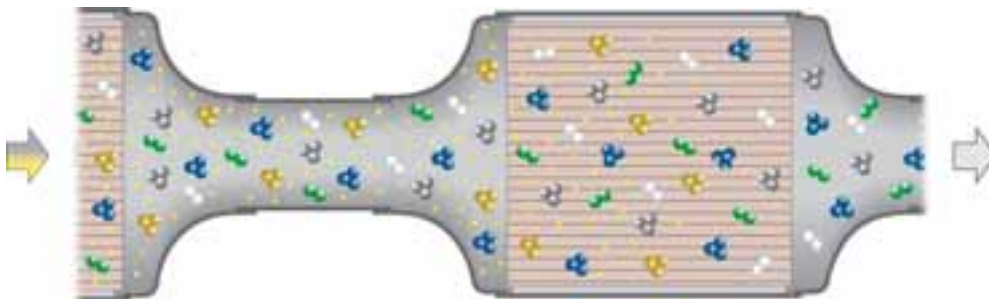
Functional principle of nitrogen oxide reduction

Nitrogen oxide reduction takes place in the reduction catalytic converters. This means that the nitrogen oxides (NO_x) give up their oxygen molecules during the reduction process or, to express it differently, the oxygen molecules are withdrawn from the nitrogen oxides. In the reduction catalytic converter, the nitrogen oxides ($\text{NO} + \text{NO}_2$) react with the ammonia (NH_3) to form nitrogen (N_2) and water (H_2O).

The correct NO and NO_2 ratio in the exhaust gas for the reduction process is formed in the oxidation catalytic converter. The oxidation catalytic converter's coating is designed for the SCR system.



Nitrogen monoxide + nitrogen dioxide + ammonia → nitrogen + water



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Following the reduction process, the following substances are then contained in the exhaust gas:



Carbon dioxide



Water



Oxygen



Nitrogen

Functional principle

Overview of the system

Sensors



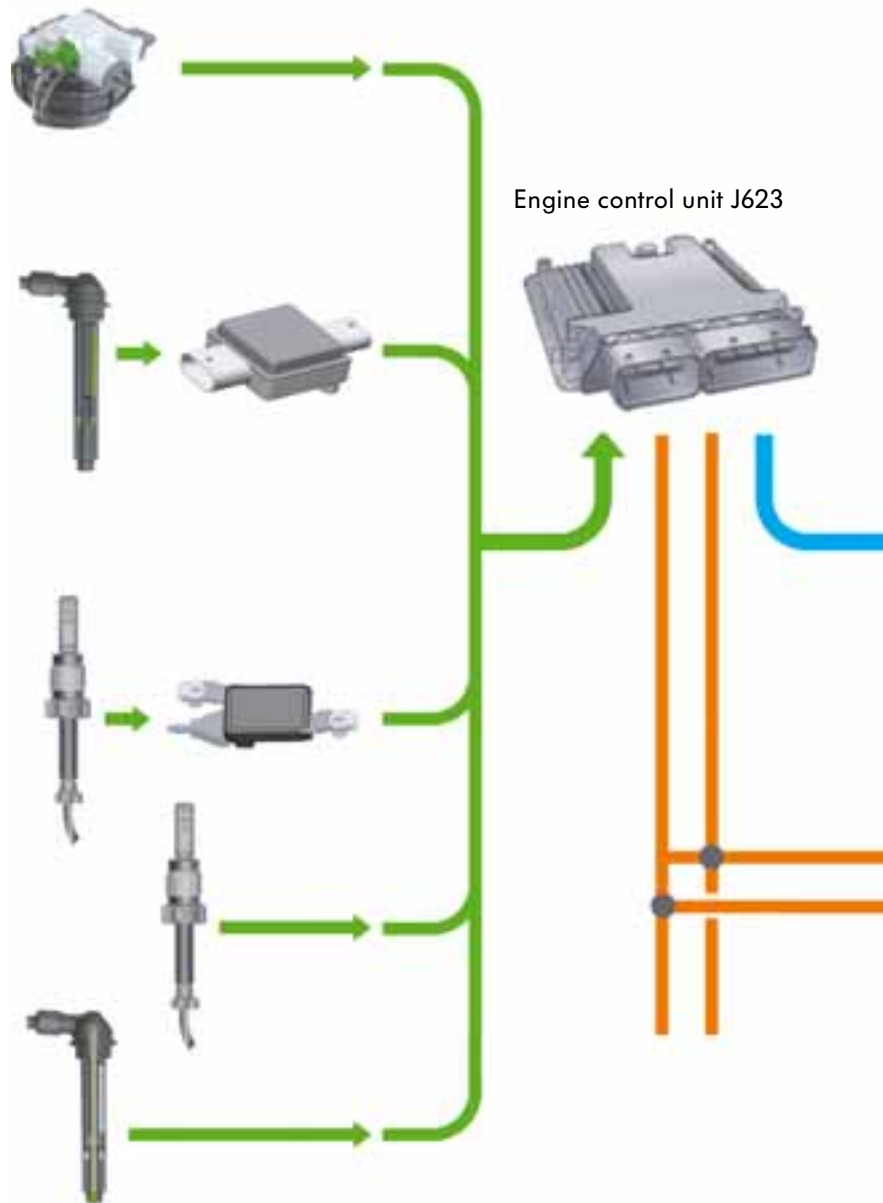
Pressure sender for reducing agent metering system G686

Reducing agent level sender G697
Reducing agent level evaluation unit G698

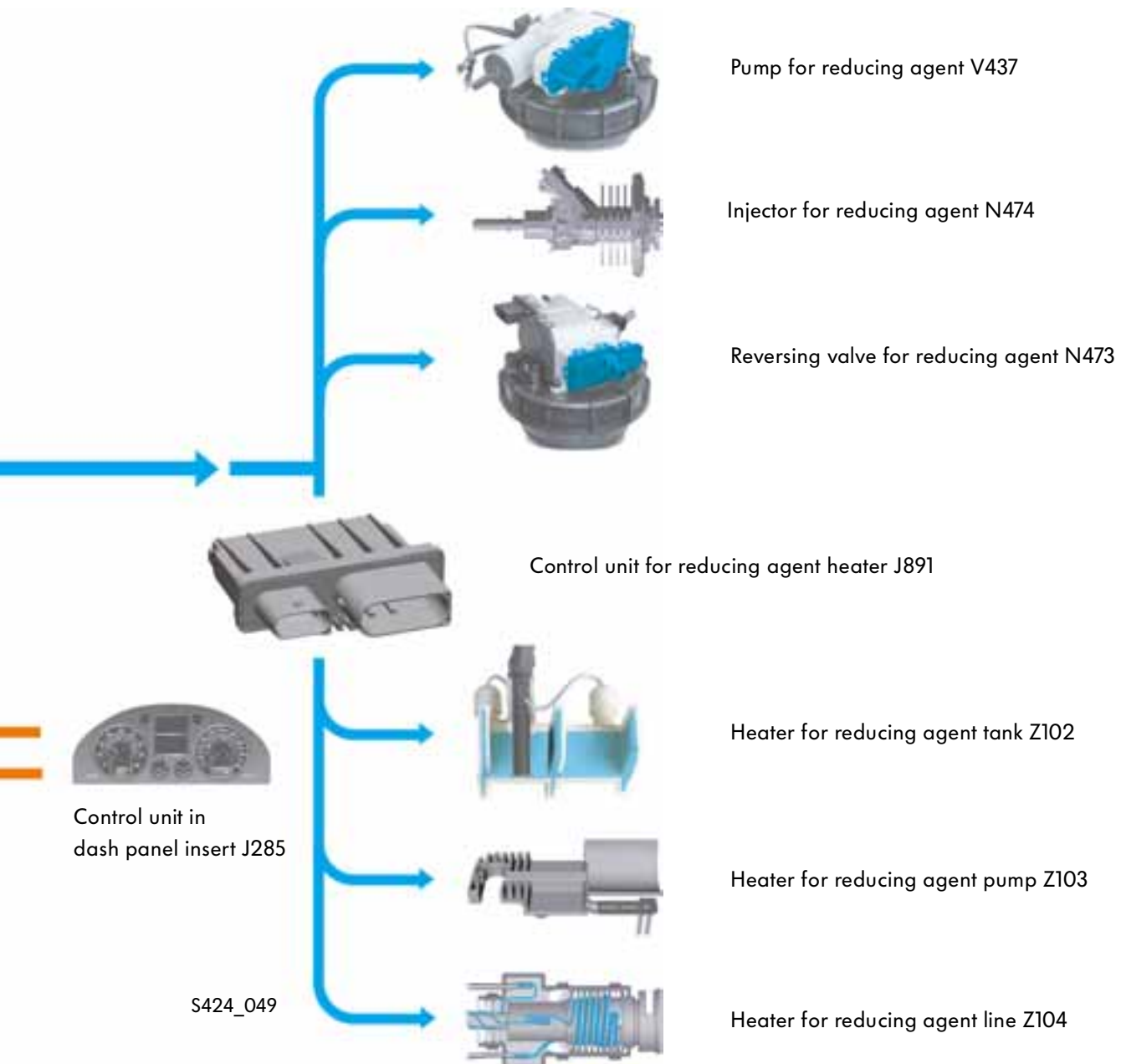
NO_x sender 2 G687
Control unit for NO_x sender 2 J881

Exhaust gas temperature sender 4 G648

Temperature sender for reducing agent G685



Actuators



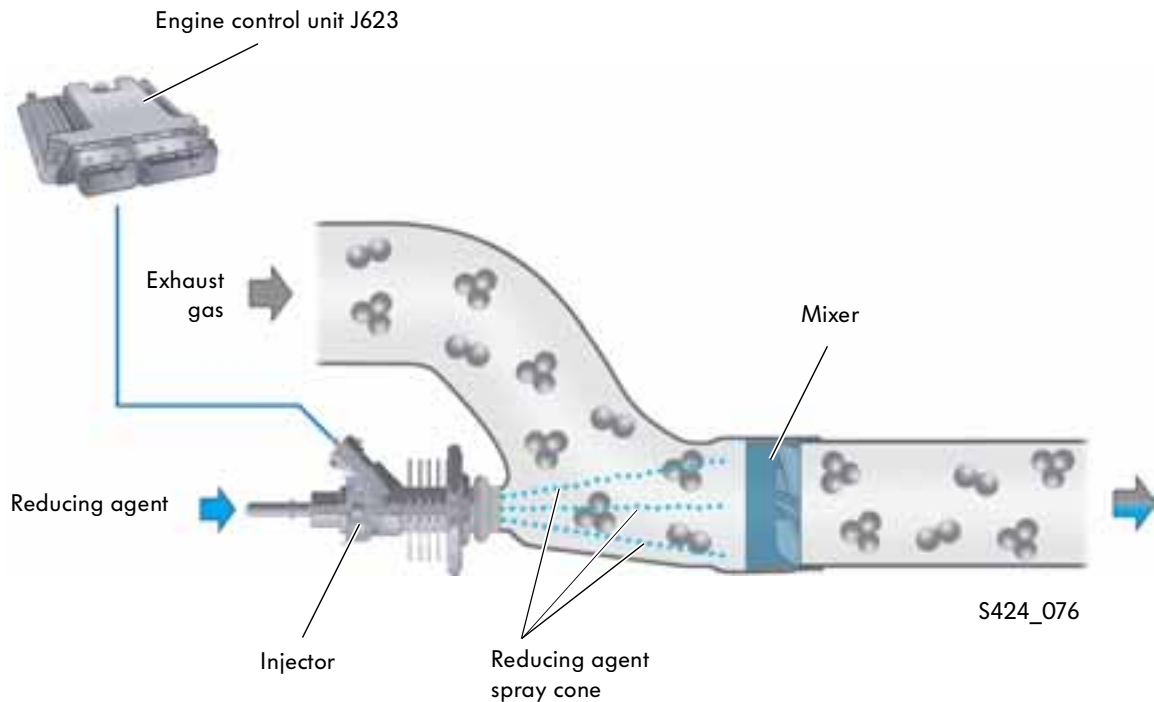
Reducing agent injection

Injector for reducing agent N474

The injector for the reducing agent is secured to the s-shaped exhaust pipe system with a clamp.

Task

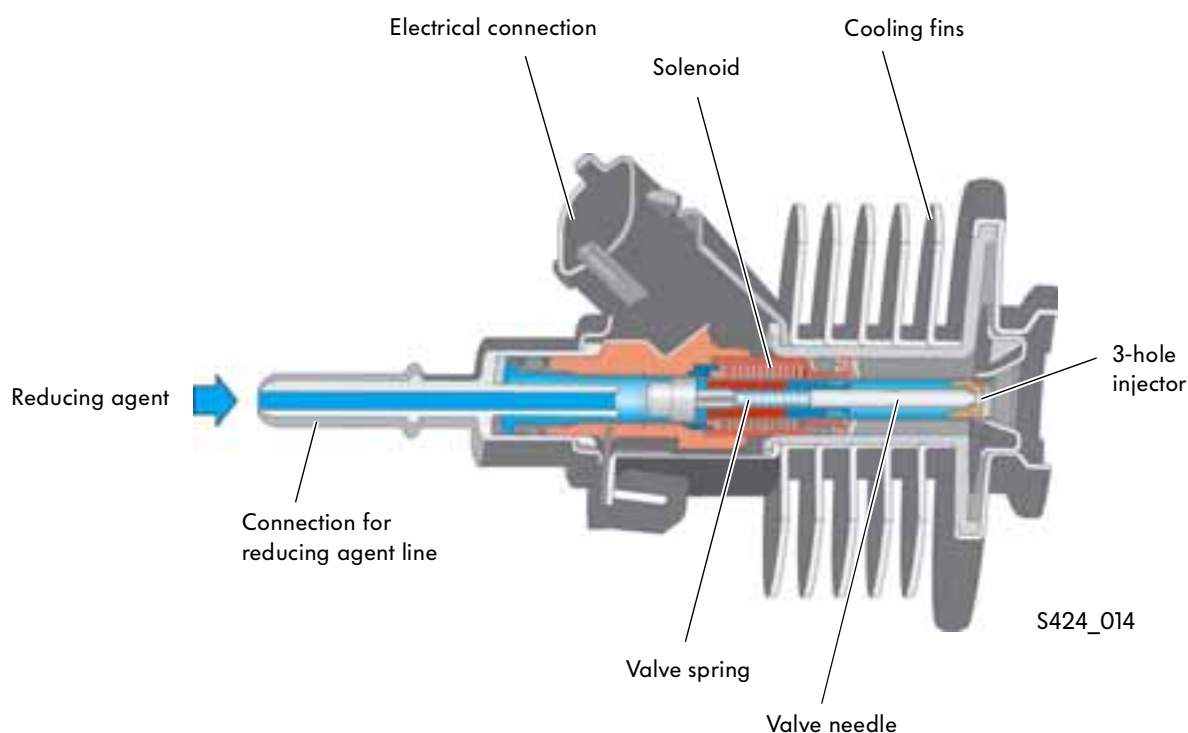
It has the task of metering the reducing agent into the exhaust gas flow. To do this, it is actuated by the engine control unit with a pulse-width-modulated signal.



Due to the position of the injector on the s-shaped exhaust pipe system, the reducing agent is injected axially to the exhaust gas flow direction. This avoids spray cone deflection and therefore ensures that

the reducing agent is mixed well and distributed evenly in the exhaust gas flow. Thanks to these design measures, the reducing agent is rapidly and completely mixed into the gas phase.

Design



How it works

The reducing agent pressure, which is generated by the reducing agent pump, is present at the injector. In its resting position, the valve needle seals the outlet bores due to the valve spring force.

The solenoid is actuated by the engine control unit in order to inject the reducing agent. This leads to the creation of a magnetic field, which raises the valve armature and the valve needle. The valve opens and reducing agent is injected.

If the solenoid is no longer actuated, the magnetic field collapses and the valve needle closes due to the valve spring force.

Effects in the event of failure

In the event of a defective injector, no reducing agent can be injected into the exhaust system.

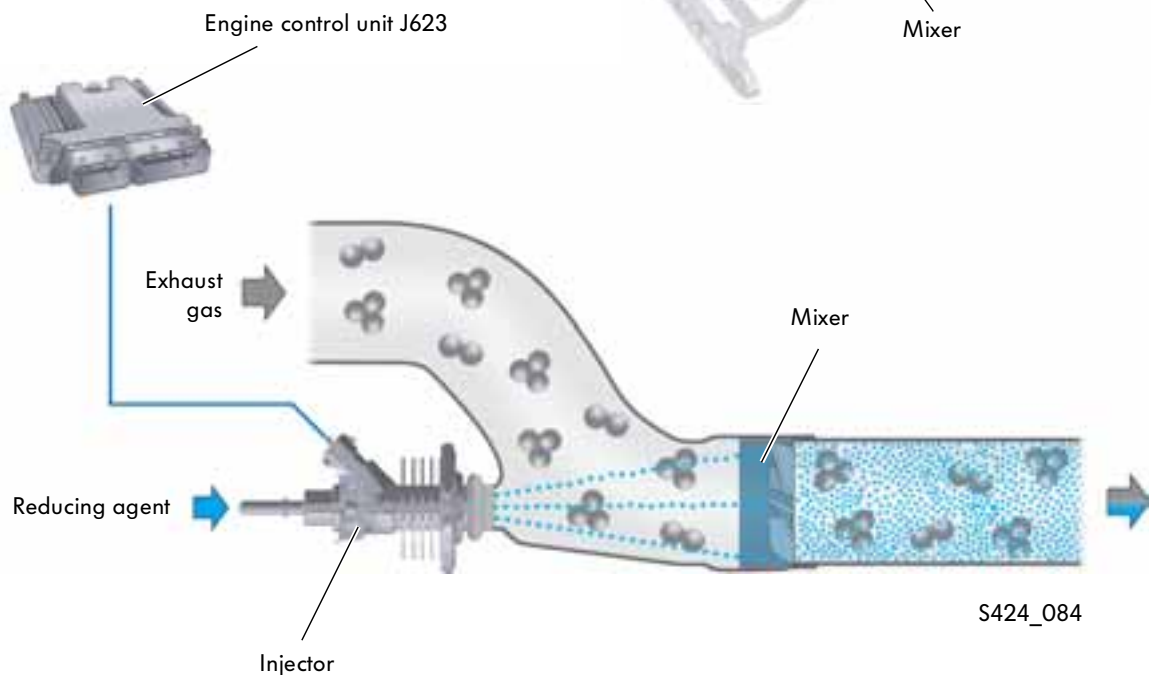
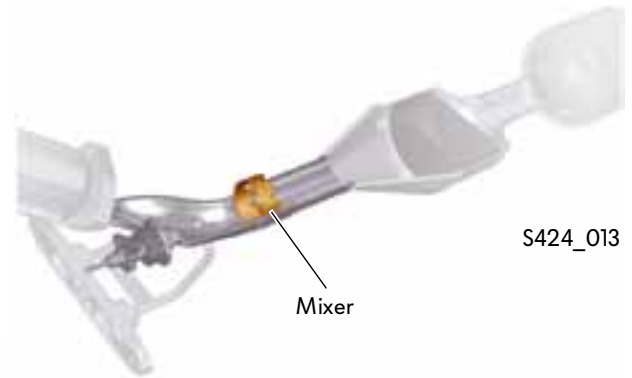
Adherence to the emission values is no longer possible.

The exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are switched on.

Reducing agent injection

Mixer

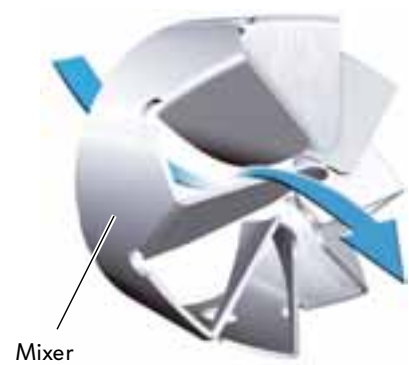
In the exhaust system, a mechanical mixer for the injected reducing agent is located directly downstream of the s-shaped pipe.



The mixer primarily functions as an impact surface for the injected spray droplets. The position of the plate mixer has been selected in such a way that the spray cone of the injected reducing agent hits the impact surface as much as possible.

On encountering the impact surface, the spray droplets are reduced in size. This allows the injected reducing agent to evaporate and mix into the gas phase faster. It also prevents larger spray droplets from impacting onto the reduction catalytic converter.

The geometry of the mixer also causes the exhaust gas flow to swirl. This leads to better mixing and even distribution of the spray droplets in the exhaust gas flow.



Calculation of the quantity of reducing agent injected

The required reducing agent injection quantity is calculated by the engine control unit and depends on the following factors:

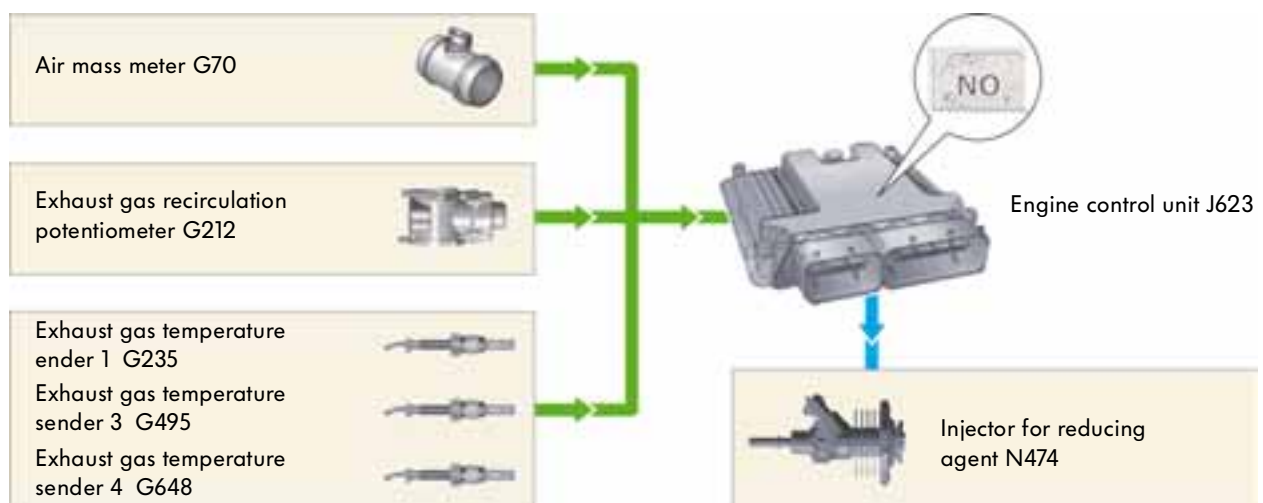
- Engine operating status
- Exhaust gas temperature
- Nitrogen oxide content in the exhaust gas mass flow

Nitrogen oxide content in the exhaust gas mass flow

The nitrogen oxide content which enters the reduction catalytic converter is determined via a map-dependent calculation model in the engine control unit.

The calculation model is based on a theoretical nitrogen oxide content in the exhaust gas mass flow.

The exhaust gas mass flow corresponds to the air mass flow in the intake port, which is determined by the air mass meter, and the injected fuel mass.



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Ammonia storage in the reduction catalytic converter

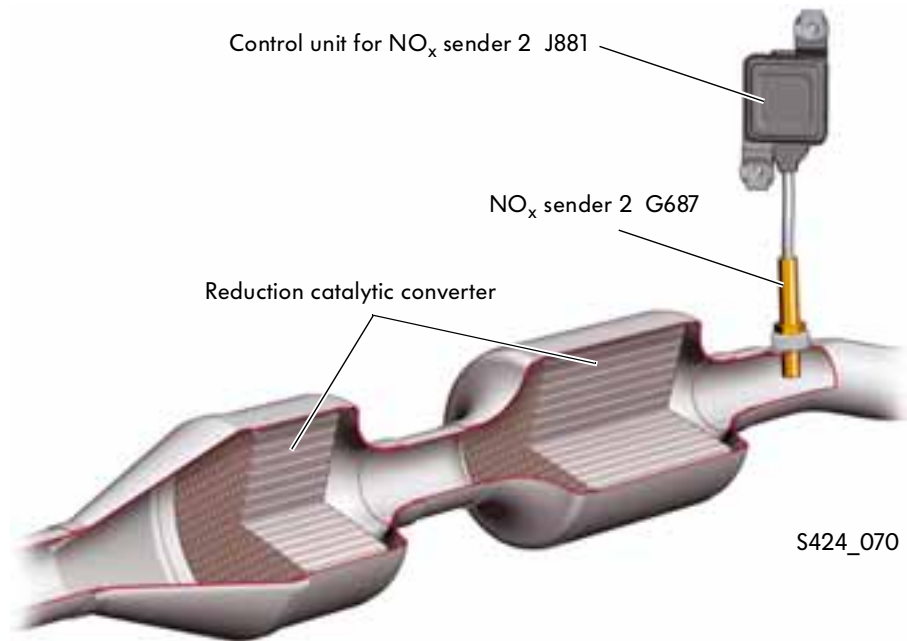
At certain engine operating points, e.g. during idling or at low exhaust gas temperatures, ammonia can be stored in the reduction catalytic converter. This stored ammonia is used to reduce a higher percentage of the nitrogen oxides in the exhaust gas under favourable operating conditions.

The stored volume of ammonia is also determined using a model calculation in the engine control unit, and is used as an additional influencing parameter in calculating the injected quantity.

Nitrogen oxide sensor

NO_x sender 2 G687

NO_x sender 2 G687 is bolted into the exhaust pipe directly downstream of the reduction catalytic converter. The nitrogen oxide content in the exhaust gas is determined with it and is evaluated by the control unit for NO_x sender 2 J881.



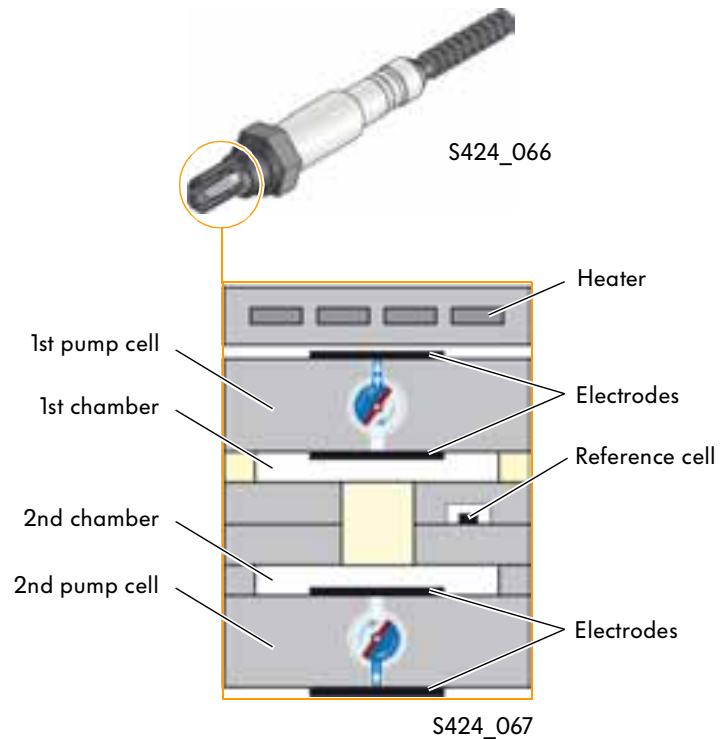
Signal use

In order to monitor the function of the SCR system as part of European On-Board Diagnosis, the effectiveness of the reduction catalytic converter is determined with the aid of the signal from the NO_x sender. To do this, the measured value is compared with a nitrogen oxide calculation model in the engine control unit. If the system falls below a specific efficiency, the exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are activated and a fault is entered in the fault memory.

The NO_x sender's signal currents lie in the micro-ampere range. To achieve high measuring accuracy, the signals are not transmitted via a long line to the engine control unit J623, but are evaluated over a short route by the control unit for NO_x sender. The control unit for NO_x sender processes the signals and transmits them to the engine control unit. The NO_x sender and the control unit for NO_x sender form a single unit and must be exchanged together in the event of a fault.

Design

The NO_x sender consists of two chambers, two pump cells, several electrodes and a heater. The sensor element consists of zirconium dioxide. This substance has the characteristic that, when electrical voltage is applied, the negative oxygen ions migrate from the negative electrode to the positive electrode.



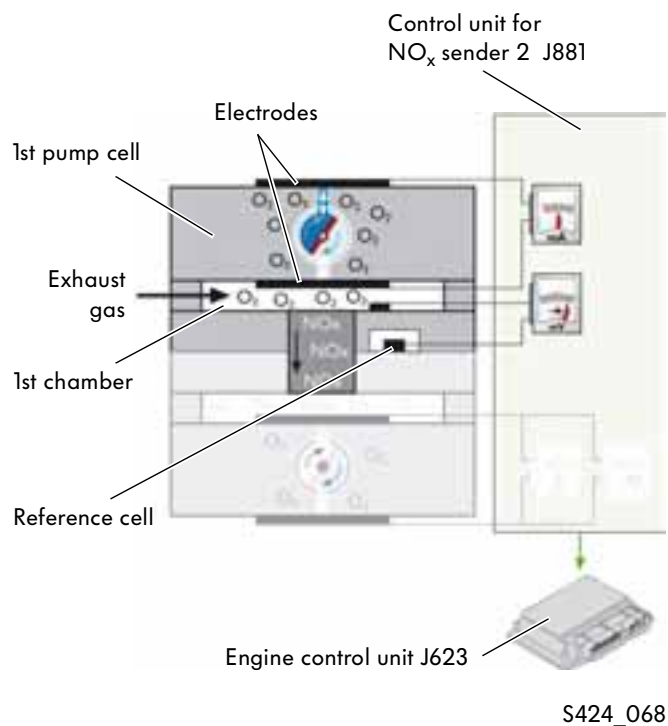
Function of the NO_x sender

The manner in which the NO_x sender functions is based on oxygen measurement and can be determined from a broadband lambda probe.

Function of the first chamber

Part of the exhaust gas flows into the 1st chamber. In the 1st chamber, the oxygen concentration is reduced to enable the low nitrogen oxide content in the exhaust gas to be measured.

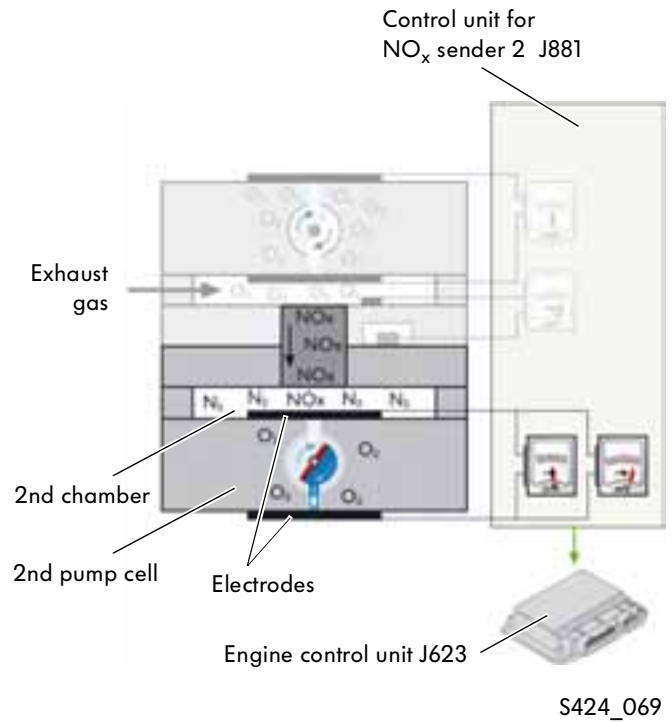
Due to different oxygen contents in the exhaust gas and the reference cell, an electrical voltage can be measured at the electrodes. The control unit for NO_x sender 2 regulates this voltage to a constant value. This value corresponds to an air-fuel ratio of $\lambda \approx 1$. In this case, the pump cell pumps oxygen out or in, therefore regulating the oxygen concentration in the 1st chamber to a specific value.



Nitrogen oxide sensor

Function of the second chamber

The exhaust gas flows from the 1st into the 2nd chamber. The NO_x molecules in the exhaust gas are separated at a special electrode into N_2 and O_2 . As the inner and outer electrodes are regulated to an even voltage of 400 mV, the oxygen ions migrate from the inner to the outer electrode. The oxygen pump current which flows is a measure of the nitrogen oxide content in the 2nd chamber. As the oxygen pump current is proportionate to the nitrogen oxide content in the exhaust gas, it can be used to determine the nitrogen oxide content.



Effects of signal failure

In the event of signal failure, a fault is entered in the engine control unit's fault memory; the exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are switched on.



The NO_x sender is only switched on, together with its heater, when it is ensured that no condensation is able to destroy the sensor ceramic. To achieve this, the temperature in the exhaust system must be so high that the dew point temperature of water is exceeded and that no further condensed water can be found in the sensor.

AdBlue® reducing agent

The ammonia required to reduce the nitrogen oxides is not used in its pure form, but in the form of a urea solution. In its pure form, ammonia acts to irritate the skin and mucous membranes, and additionally has a penetrating odour. A fluid, which is universally referred to under its brand name, AdBlue®, throughout the automotive industry, is used as the reducing agent for the SCR system.

AdBlue® is a very pure, transparent 32.5 % solution of urea in water. It is manufactured synthetically.

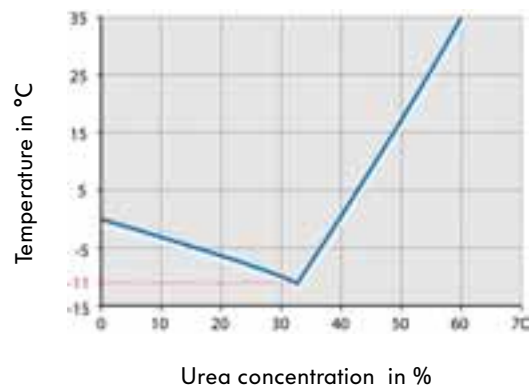


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Freezing point of AdBlue®

AdBlue® has a urea content of 32.5 % , because the reducing agent has the lowest freezing point of -11°C at this mixture ratio.

Deviation from the mixture ratio due to an excessively high urea or water content causes the freezing point of AdBlue® to be raised.



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Characteristics of AdBlue®

- AdBlue® freezes at temperatures below -11°C .
- AdBlue® breaks down at high temperatures (approx. 70°C - 80°C) . This results in the formation of ammonia and therefore possible odour pollution.
- Contamination with foreign substances and bacteria may render AdBlue® unusable.
- Leaked and crystallised urea causes white flecks. These flecks must be removed with water and a brush (as soon as possible).
- AdBlue® has a high creep capability. Electrical components and connectors must be protected against AdBlue® penetration.

Notes on handling AdBlue®:

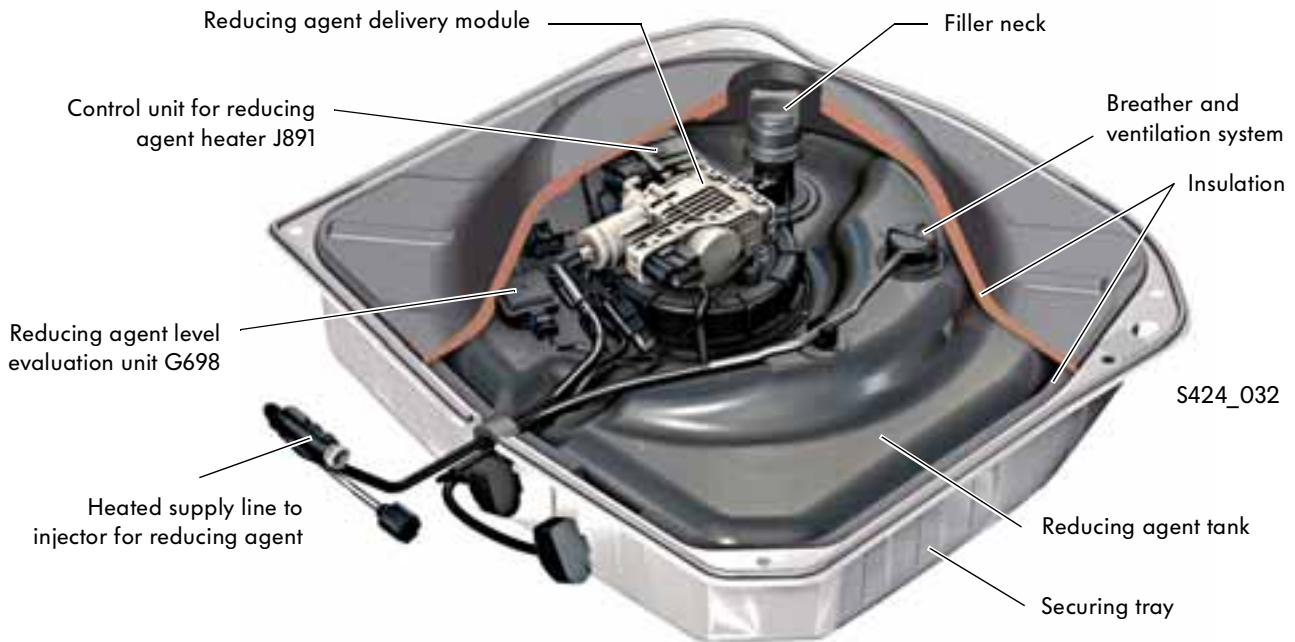
- Only use AdBlue® from original containers according to the manufacturer's approved standard.
- Drained AdBlue® must not be reused in order to avoid contamination.
- The reducing agent tank must only be filled using the containers and adapters approved by the manufacturer.
- The reducing agent can irritate the skin, eyes and respiratory organs. If this fluid comes into contact with skin, it should be immediately washed off with plenty of water. If necessary, seek medical advice.



Tank system

Reducing agent tank system

The reducing agent tank is manufactured from plastic and is located beneath the spare wheel well in the Passat Blue TDI. The tank has a capacity of approx. 16.8 litres.



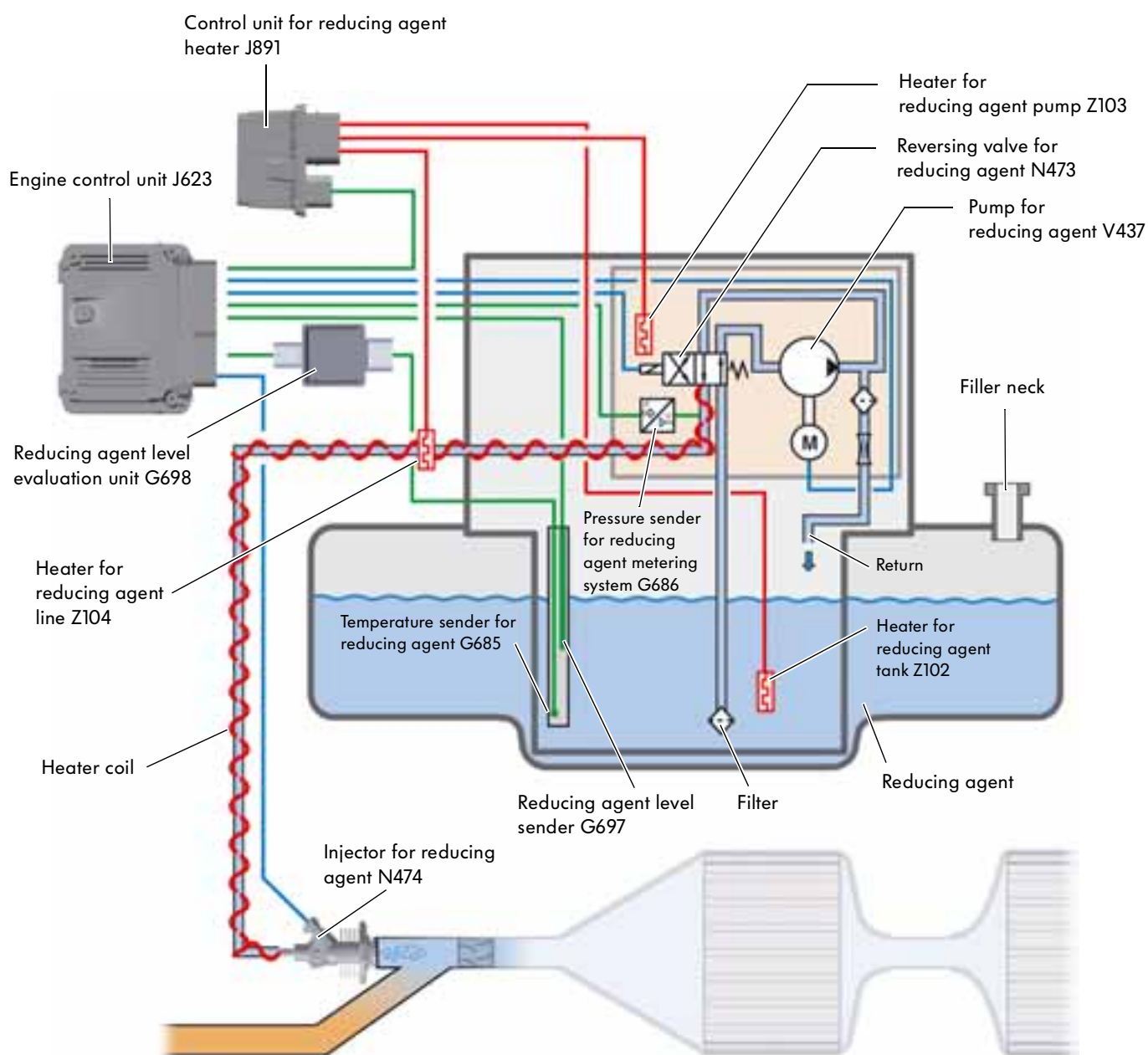
- Reducing agent delivery module – the delivery module contains the sensors and actuators for delivering the reducing agent in the reducing agent tank system.
- Reducing agent level evaluation unit – the evaluation unit measures the level in the reducing agent tank.
- Control unit for reducing agent heater – the control unit actuates the reducing agent tank system heaters.
- Polypropylene foam insulation – the insulation serves to protect the reducing agent from high and low ambient temperatures.
- Breather and ventilation system – the reducing agent tank system is a system which is virtually sealed from the outside. This is achieved by means of a sintered material located in the breather and ventilation system connections. Reducing agent tank pressure compensation therefore always takes place over a long period of time.



When filling the reducing agent tank, it must be ensured that a sufficiently large expansion volume remains for the reducing agent in the tank. Only ever fill the reducing agent tank with the intended containers and filling systems. This guarantees the correct filling speed and prevents overfilling the tank. In addition, all gases from the tank are trapped in the containers and do not therefore enter the atmosphere.

Never use a funnel or the like to fill the reducing agent tank, and do not independently pour reducing agent into a refill bottle for filling the tank!

Schematic structure of the reducing agent tank system



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Tank system

Reducing agent delivery module

The reducing agent delivery module is secured with locking lugs in the tank and a locking ring on the upper side of the tank. The following components are integrated into the delivery module:



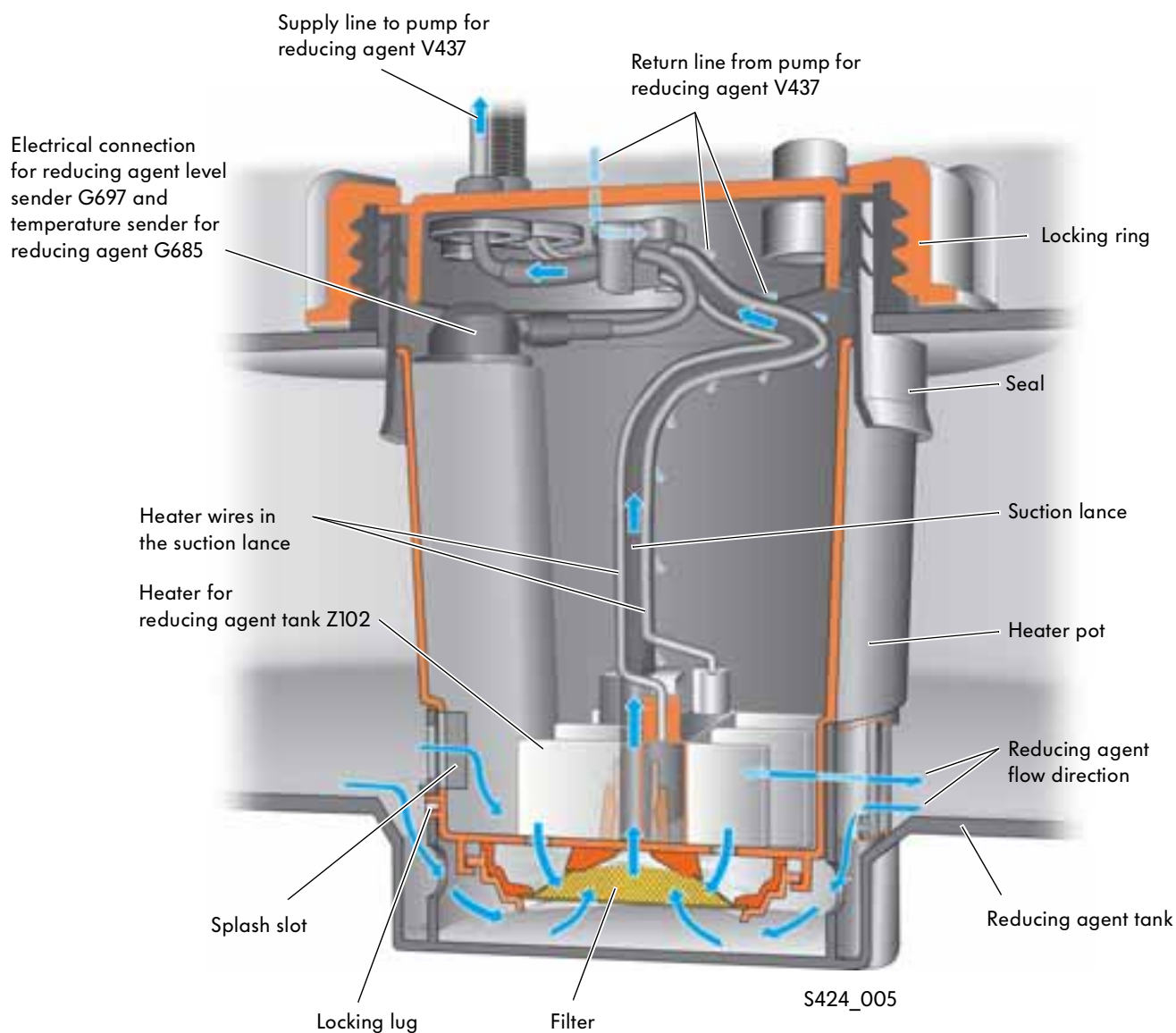
Rear view



View from below



Heater pot



The reducing agent is sucked out of what is called the heater pot via a suction lance and a filter by the reducing agent pump. The filter is intended to avoid damage to the SCR system caused by particles of dirt in the reducing agent. A heater in the heater pot ensures that SCR operation is possible even at low exterior temperatures. The reducing agent flowing back from the pump drips back into the heater pot on the outer side of the suction lance.

The reducing agent enters the heater pot from the tank via splash slots. At low temperatures, the splashing motion of the reducing agent from the heater pot thaws out the frozen reducing agent in the tank.

Tank system

Pump for reducing agent V437

The pump for reducing agent is a diaphragm pump. It is driven by a brushless direct current motor. The pump for reducing agent is integrated into the delivery module housing and is actuated by the engine control unit.

Tasks

The pump for reducing agent's tasks differ depending on the position to which the reversing valve is switched:

- When the ignition is switched on and the operating conditions for the SCR system are met, the pump delivers the reducing agent from the tank to the injector at a pressure of approx. 5 bar.
- When the diesel engine is switched off, it pumps the reducing agent out of the delivery line from the injector and back into the tank.

How it works

The engine control unit actuates the motor with a pulse-width-modulated signal. The motor drives the diaphragm pump via a connecting rod. When the SCR system is active, the reducing agent is sucked out of the tank via the diaphragm pump and is pumped into the delivery line.

Effects in the event of failure

If the pump for reducing agent fails, the SCR system is unable to function.

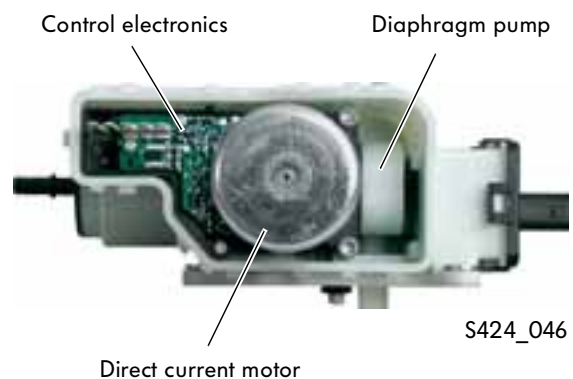
The exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are switched on.



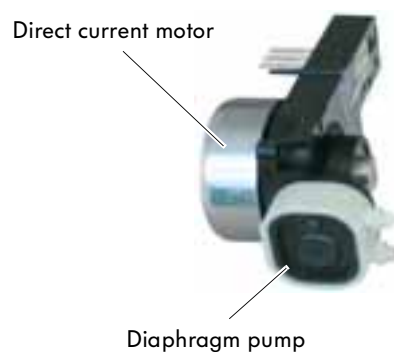
Pump for reducing agent V437

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Pump for reducing agent



S424_046



S424_050

Pressure sender for reducing agent metering system G686

The pressure sender for reducing agent metering system is screwed into the delivery module. It determines the current for the reducing agent delivery pressure and transmits a voltage signal to the engine control unit.

Pressure sender for reducing agent metering system G686



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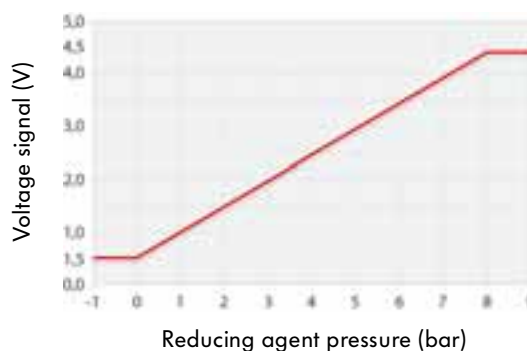
Signal use

Based on the signals, the engine control unit calculates the current reducing agent pressure in the line to the injector. This enables the engine control unit to regulate the pump motor's speed and therefore adapt the pump's required delivery rate.

Effects of signal failure

If the signal from the pressure sender for reducing agent metering system fails, reducing agent metering is switched off. The SCR system is unable to function. The exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are switched on.

Voltage-pressure chart
(transmission function)



S424_022



Tank system

Reversing valve for reducing agent N473

The reversing valve for reducing agent is a 4/2-way directional control valve. It is integrated into the reducing agent delivery module.



Reversing valve for reducing agent N473

S424_010



S424_039

Reversing valve for reducing agent N473

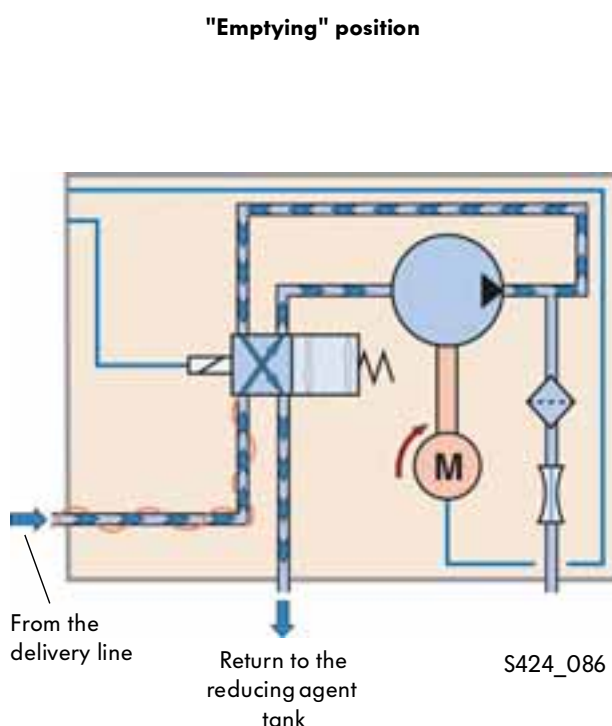
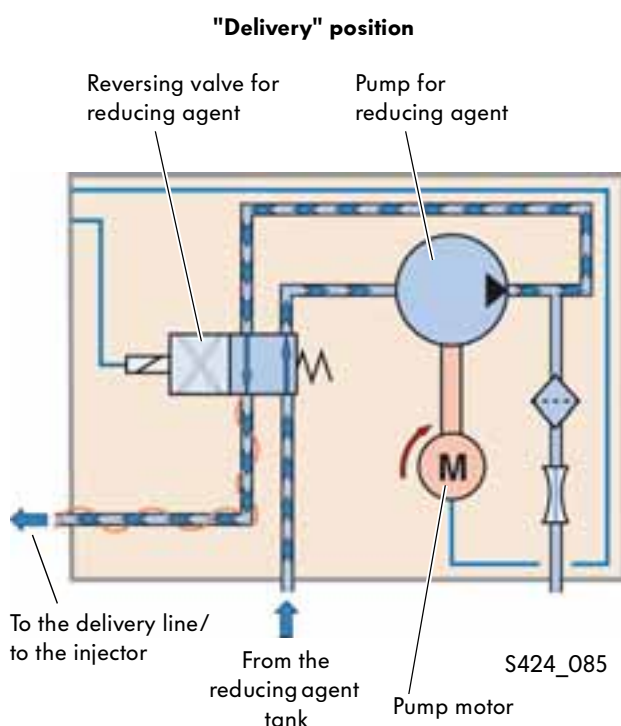
Task

When the diesel engine is switched off, the reversing valve for reducing agent reverses the direction of reducing agent delivery. As a result, the reducing agent is returned from the delivery line to the reducing agent tank. This precautionary measure prevents the reducing agent from freezing in the delivery line and in the injector at low exterior temperatures.

How it works

When the diesel engine is switched off, the reversing valve for reducing agent reverses the direction of reducing agent flow. To achieve this, the lifting magnet is actuated via a coil. The coil is actuated by the engine control unit. Via a guide plate, the lifting magnet then switches the valve to the "emptying" position.

The pump motor, which only rotates in one direction, pumps the reducing agent from the delivery line back into the reducing agent tank.



Effects in the event of failure

In the event that the reversing valve for reducing agent fails, the reducing agent may possibly freeze in the delivery line and in the injector at low exterior temperatures.

If the valve remains in the "emptying" position, pressure build-up in the system is not possible.

The exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are actuated.



The process for emptying the delivery line takes approx. 60 seconds.

The vehicle battery must not be disconnected during this time, as the risk of reducing agent freezing in the delivery line at low exterior temperatures may occur.



Tank system

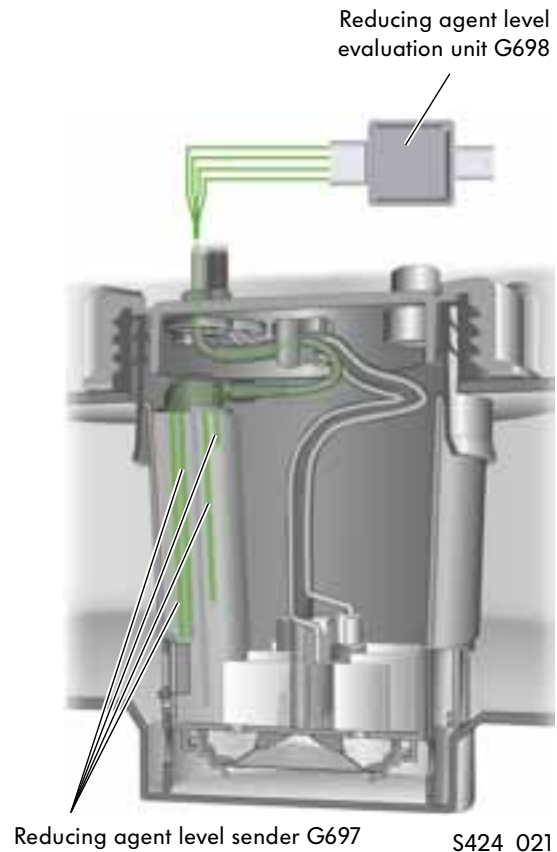
Reducing agent level sender G697 with reducing agent level evaluation unit G698

The reducing agent level sender is a sensor with 4 stainless steel level sensors. It is located directly in the heater pot.

The evaluation unit evaluates the signals from the reducing agent tank sender and transmits a pulse-width-modulated signal (PWM signal) to the engine control unit. It is secured externally, to the top of the tank.

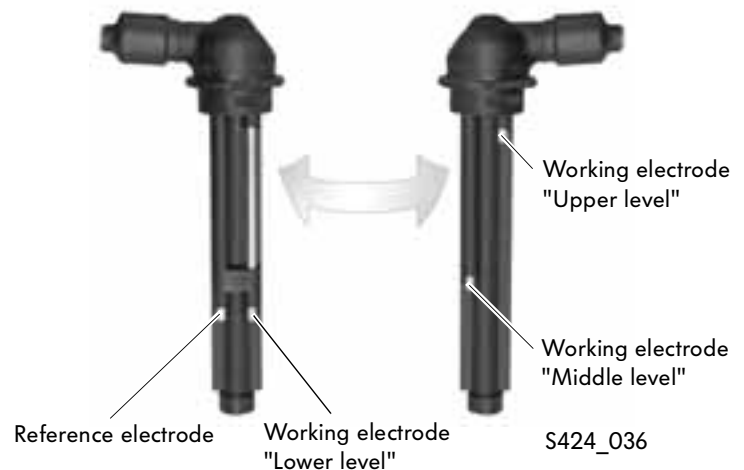
Task

The evaluation unit uses the signals from the reducing agent tank sender to determine 3 different reducing agent tank levels. The 3 different measured level values are required for different display warning stages for refilling the reducing agent.



Design

The 4 stainless steel level sensors serve the evaluation unit as operating and reference electrodes.



How it works

The electrical conductivity of the reducing agent between the fluid level sensors (working electrodes) and the reference electrode is used to determine the tank's fluid level.

At short intervals, the evaluation unit applies an alternating voltage to the working electrodes and the reference electrode.

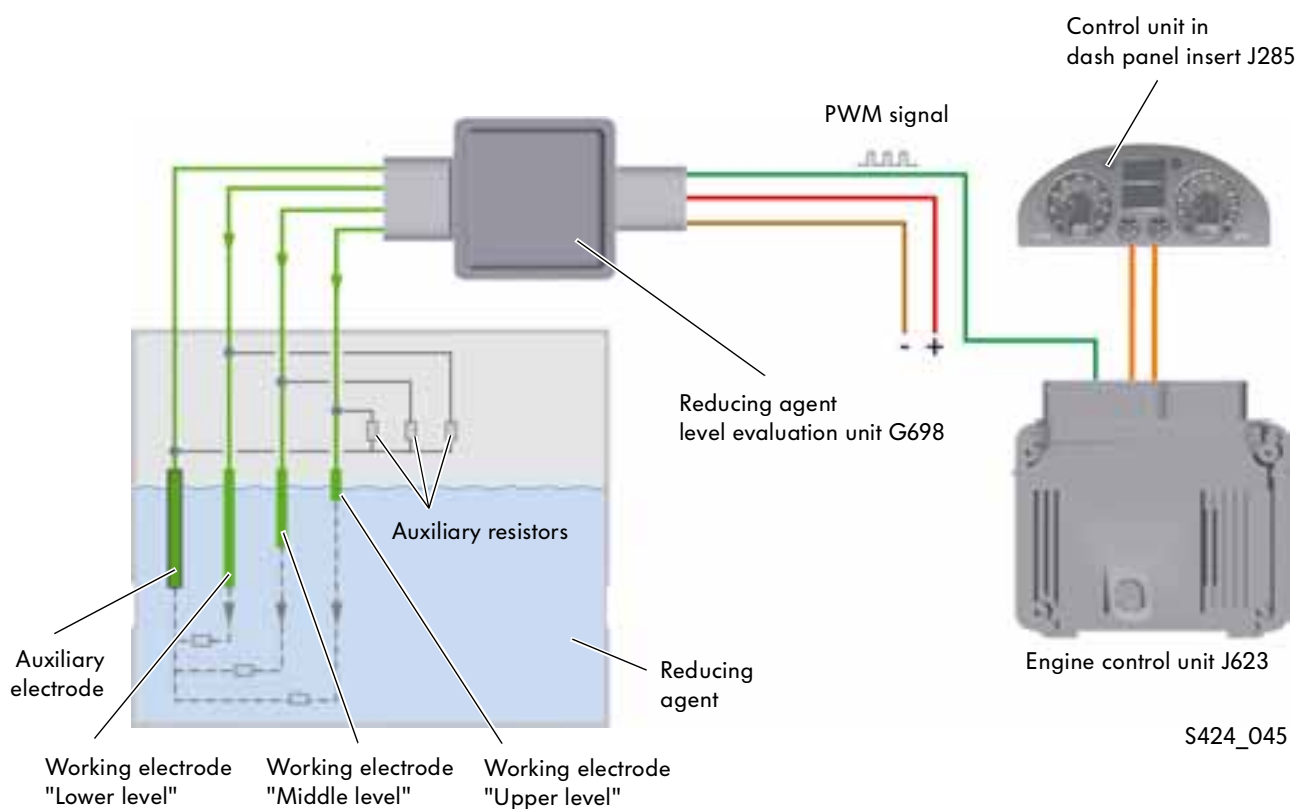
An electrical current is able to flow between two fluid level sensors (working electrode and reference electrode) when both are immersed in the reducing agent.

Based on the electrical conductivity, the evaluation unit determines whether the fluid level is above or below the relevant measuring sensor.

The resistance between the two measuring sensors changes due to the presence and absence of the reducing agent. This change in resistance is registered by the evaluation unit and is processed as a signal for the engine control unit. "Splash conditions" are electronically "dampened" by the evaluation unit.

Refilling is detected by the system after a delay due to the "electronic damping".

In order to point out to the driver that reducing agent should be replenished in the event of low fluid levels, the engine control unit transmits a signal to the control unit in dash panel insert J285.



S424_045



Tank system

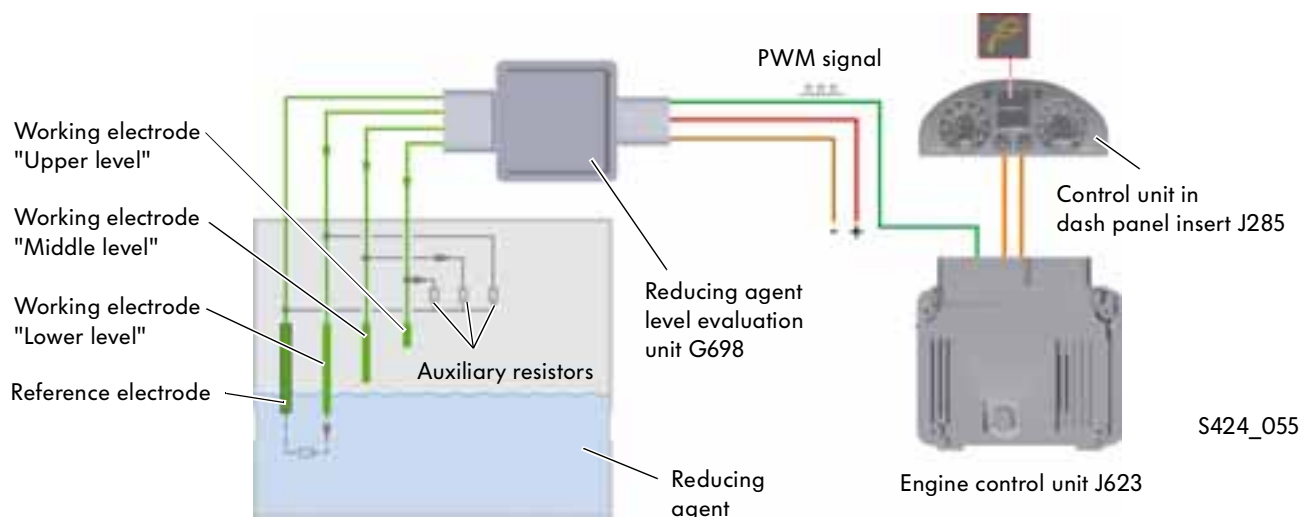
Example of a warning for a declining fluid level

If the fluid level falls below the "middle level" measuring sensor, the current between the "middle level" working electrode and the reference electrode no longer flows via the reducing agent medium but via the auxiliary resistor belonging to the "middle level" working electrode. The current also flows via the relevant auxiliary resistor in the case of the "upper level" working electrode. The current flows via the reducing agent in the case of the "lower level" working electrode. The auxiliary resistor's resistance is many times higher than that of the reducing agent. From this changed resistance value, the evaluation unit recognises that the fluid level has fallen below this level. This signal is processed by the evaluation unit and transmitted to the engine control unit.

In order to point out to the driver that reducing agent should be replenished in the case of this level, the engine control unit transmits a signal to the control unit in dash panel insert. In the dash panel insert display, the driver is requested to fill up with fluid via a warning lamp, and the remaining range which can still be covered is displayed to him. The remaining range is calculated by the engine control unit from the mean reducing agent consumption volume and the residual reducing agent volume.

The auxiliary resistors also serve to diagnose open circuits and to check plausibility.

The measuring principle does not function in the case of frozen reducing agent, as no reliable resistance value can then be determined.



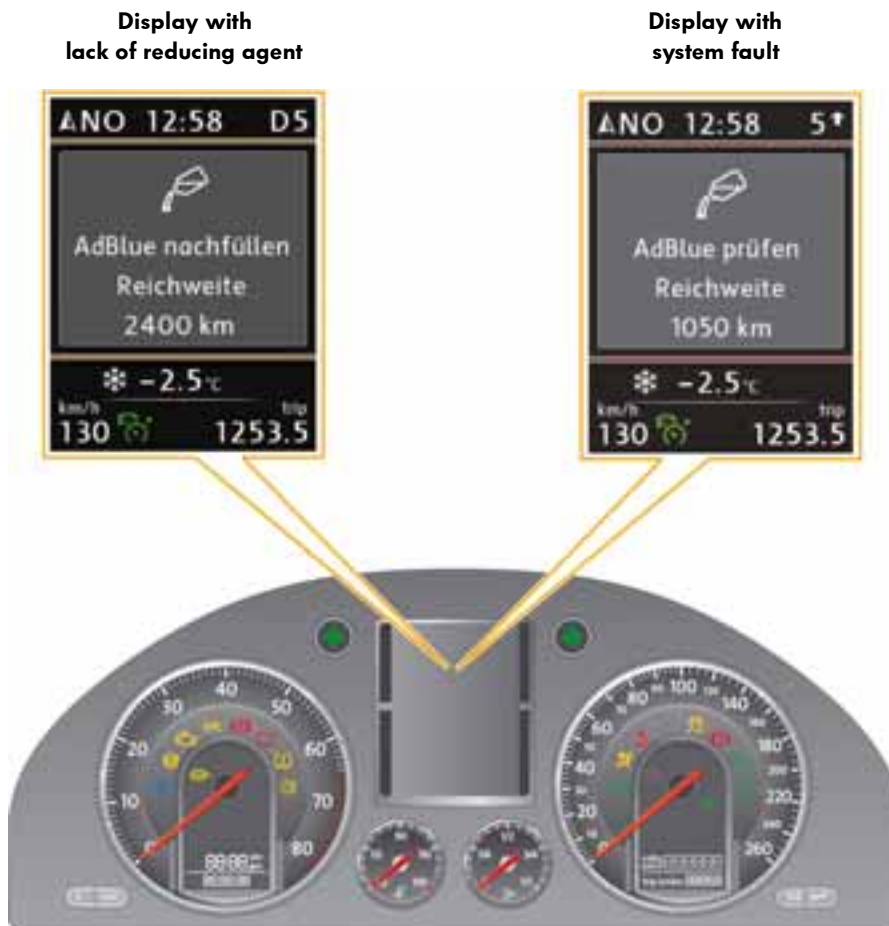
Effects of signal failure

If the tank sender signal fails, the reducing agent tank's fluid level cannot be registered.

However, the SCR system remains active. The AdBlue® warning display for a system fault lights up in the display and the exhaust emissions warning lamp K83 is switched on.

AdBlue® display in the dash panel insert

The AdBlue® display is located in the dash panel insert display. It lights up to tell the driver to replenish the reducing agent at an early stage or to indicate a system fault.



S424_028



Legal specifications §







If an additional reducing agent is used for exhaust gas aftertreatment, the legislation on the Euro 5 emissions standard requires a ban on repeated starting as soon as the following conditions are met:

- Insufficient reducing agent is contained in the tank.
- Reducing agent metering (injection) is not possible due to system faults.
- The quality of the reducing agent is inadequate.
- Reducing agent consumption deviates from the specified value.
- The reducing agent catalytic converter is defective.

AdBlue® display concept

AdBlue® display in the dash panel insert for insufficient reducing agent

If the volume of reducing agent in the tank falls below a specific level, the driver is requested to replenish AdBlue® in three warning stages.

Remaining range	Acoustic warning	Display in the Premium/ Highline dash panel insert	Indications for the driver
From 2400 km	1 x gong 		This indication appears if the vehicle can only cover the remaining range specified in the text with the volume of reducing agent. The driver is requested to replenish the reducing agent. An acoustic warning signal sounds as an additional indication.
From 1000 km	1 x warning buzzer 		This indication appears if the vehicle can only cover the remaining range specified in the text with the volume of reducing agent. The driver is requested to replenish the reducing agent. The driver is additionally informed that starting the engine will no longer be possible if the engine has been switched off after covering the remaining range. An acoustic warning signal sounds as an additional indication.
0 km	3 x warning buzzer 		This indication appears if there is no longer any reducing agent in the tank. The driver is informed that starting the engine is not possible and is requested to replenish the reducing agent. Three successive warning signals are sounded as an additional indication.

Display in the Lowline dash panel insert
(The display is depicted via a test run in English)



From a remaining range of 2400 km, the prognosis on the currently remaining AdBlue® range can be displayed via the multi-function display in the dash panel insert.

After switching the ignition off and on again, it may be that the "Remaining AdBlue® range" menu item last called up in the multi-function display switches to the "Fuel range" menu item.



When the minimum AdBlue® fluid level has been reached, at least 5.0 litres have to be poured in. This corresponds to approximately three of the commercially available refill bottles. Only this refill quantity guarantees that replenishing is recognised and that starting the engine is therefore possible again.








S424_026

AdBlue® display concept

AdBlue® display in the event of system faults

In the event of a fault in the SCR system, the NO_x sender may ascertain that the efficiency of the SCR catalytic converter is reduced. In such a case, the driver is informed as follows in the dash panel insert:

Remaining range	Acoustic warning	Display in the Premium/ Highline dash panel insert	Indications for the driver
From 1050 km			This indication appears if a fault has occurred in the SCR system. The driver is requested to have the AdBlue® system checked. The remaining range which can still be covered is additionally displayed.
From 1000 km	1 x warning buzzer 		This note appears if the vehicle can only cover the remaining range specified in the text. The driver is informed that starting the engine will no longer be possible if the engine has been switched off after covering the remaining range. He is requested to visit the nearest dealership to have the SCR system checked. An acoustic warning signal sounds as an additional indication.
0 km	3 x warning buzzer 		This indication appears if incorrect filling has been detected. The driver is informed that starting the engine will not be possible if the engine has been switched off and is requested to visit the nearest dealership. Three successive warning signals are sounded as an additional indication.

Display in the Lowline dash panel insert
(The display is depicted via a test run in English)



The display contents which are shown correspond to the dash panel insert with the German system and serve merely as an example.
Please refer to the corresponding operating manuals for the text contents in the relevant national languages for the display in the dash panel insert.



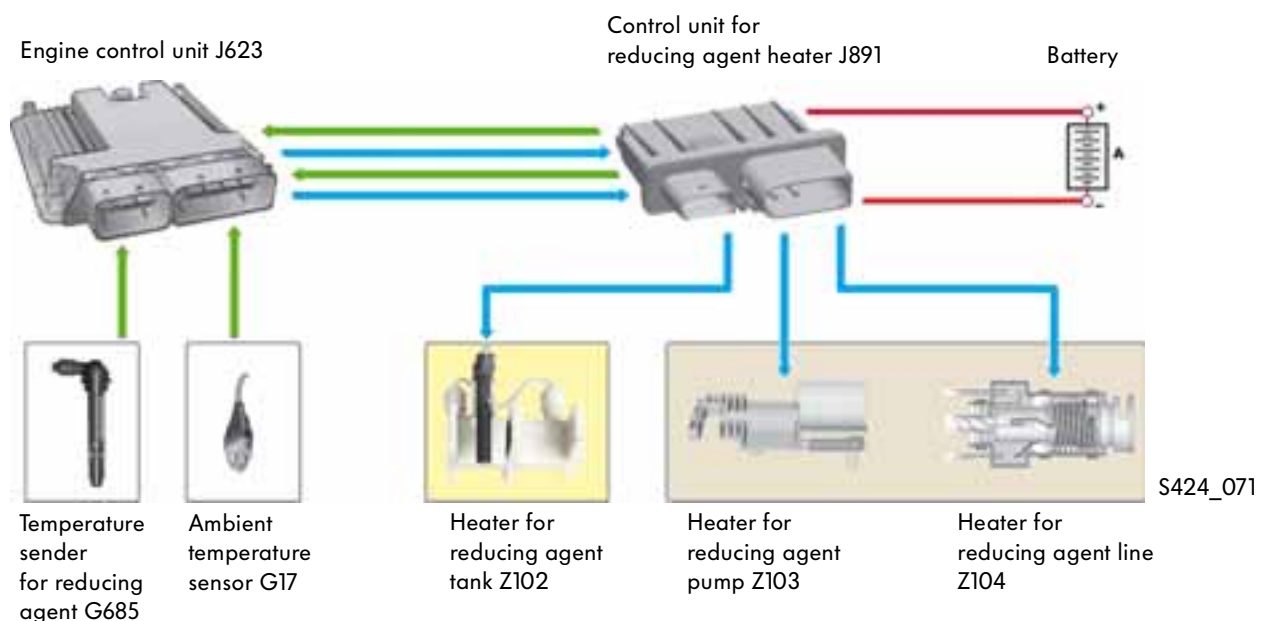
Heater system

Reducing agent heater system

Due to the possibility of the reducing agent's freezing at low exterior temperatures, the reducing agent tank, the pump for reducing agent and the line to the injector are each equipped with a heater. The heater system enables rapid SCR system operational readiness in the event of frozen reducing agent and ensures an adequate quantity of thawed reducing agent at all operating points.

Control unit for reducing agent heater J891

The control unit for reducing agent heater controls the electrical power supply for the SCR system's heaters. It is located on the upper side of the reducing agent tank and is actuated by the engine control unit.



The engine control unit recognises the reducing agent's heating requirements from the information provided by the ambient temperature sensor G17 and the temperature sender for reducing agent G685.

It then actuates the control unit for reducing agent heater J891, which activates the electrical power supply for the heaters. The engine control unit receives feedback regarding the heater current actually flowing from the control unit for reducing agent heater.

Heater current monitoring is prescribed as part of European On-Board Diagnosis (EOBD) in order to enable the failure of or a malfunction in this emissions-relevant component to be ascertained.

The control unit for reducing agent heater activates the SCR system's heaters.
The heater control system is sub-divided into two heater circuits.

	Heater circuit 1	Heater circuit 2
Activation	If the temperatures in the tank or in the ambient air are less than -7°C , the heater for reducing agent tank is activated via the control unit for reducing agent heater by the engine control unit.	If the temperatures in the ambient air are less than -5°C , the heater for pump for reducing agent and the heater for reducing agent line are activated via the control unit for reducing agent heater by the engine control unit.
Heating period for thawing	At temperatures from -7°C to -13°C , the heating period is approx. 20 minutes. At temperatures of -25°C and below, the heating period may increase up to 45 minutes. In this case, the reducing agent is actively thawed in order to attain metering readiness for the system.	At temperatures below -5°C , the heating period is approx. 100 seconds, increasing to 21 minutes at temperatures of -25°C .
Readiness heating	At temperatures below -7°C , the heating period for thawing is always followed by readiness heating. This takes approx. 5 minutes. Readiness heating serves to ensure that an adequate quantity of thawed reducing agent is provided at all operating points.	



Effects in the event of failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures.
The exhaust emissions warning lamp K83 (MIL) is switched on.

Heater system

Heater for reducing agent tank Z102

The heater for reducing agent tank is a heater element with a PTC resistor. PTC resistors have their highest conductivity when cold. They have a positive temperature coefficient (PTC). This means that their resistance increases as the temperature rises, leading to a reduction in the flow of current.

The heater element is cast in plastic and is located directly in the reducing agent tank's heater pot. The heater is actuated by the engine control unit via the final output stage.

Task

The heater for reducing agent tank has the task of heating the reducing agent in the heater pot in the case of low exterior temperatures or low temperatures in the reducing agent tank, in order to enable metering readiness for the SCR system in a short space of time.

How it works

If the temperatures in the tank or in the ambient air are less than -7°C , the heater for reducing agent tank is activated via the final output stage by the engine control unit.

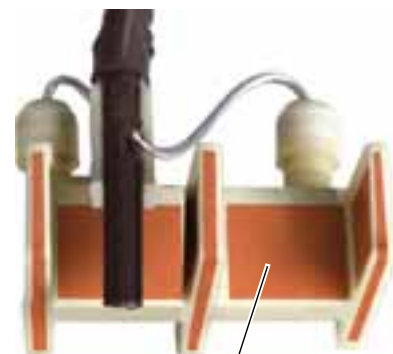
Effects in the event of failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust emissions warning lamp K83 (MIL) is switched on.



S424_020

Heater for reducing agent tank Z102



S424_037

Heater element

Heater for reducing agent pump Z103

The heater for pump for reducing agent is also a heater element with a PTC resistor. PTC resistors reveal their highest conductivity when cold. They have a positive temperature coefficient (PTC). This means that their resistance increases as the temperature rises, leading to a reduction in the flow of current.

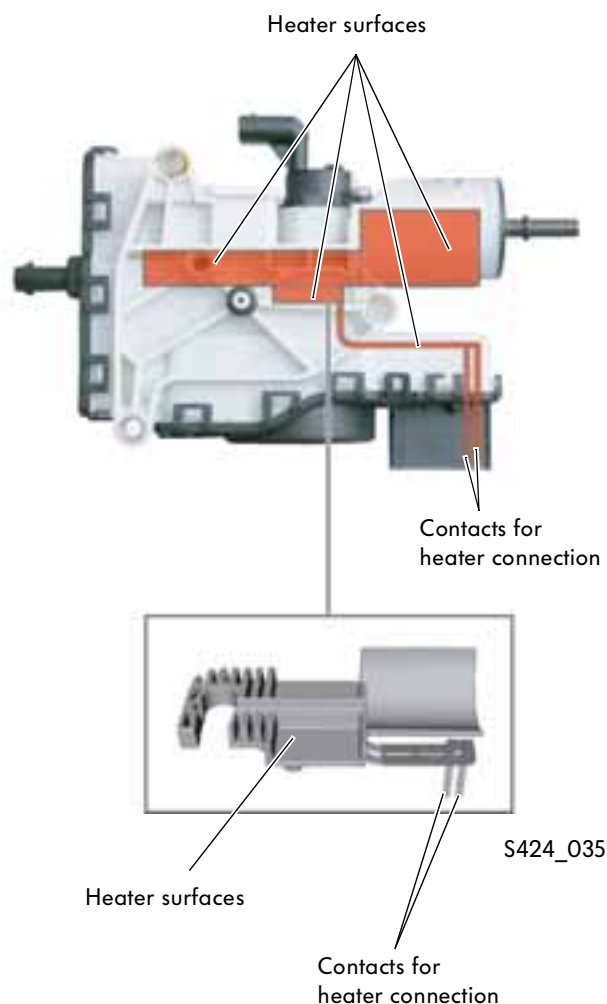
The heater element is cast into the delivery module and is located in the area of the pump for reducing agent, the reversing valve and the connection to the delivery line. The heater for pump for reducing agent is actuated by the engine control unit via the final output stage.

Task

The heater for pump for reducing agent has the task of heating the reducing agent in the area of the pump for reducing agent, the reversing valve and the connection to the delivery line in the event of low exterior temperatures. This ensures reliable SCR system operation even at low exterior temperatures.

How it works

If the temperature of the ambient air is less than -5°C , the heater for pump for reducing agent is activated via the final output stage by the engine control unit.



Effects in the event of failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust emissions warning lamp K83 (MIL) is switched on.

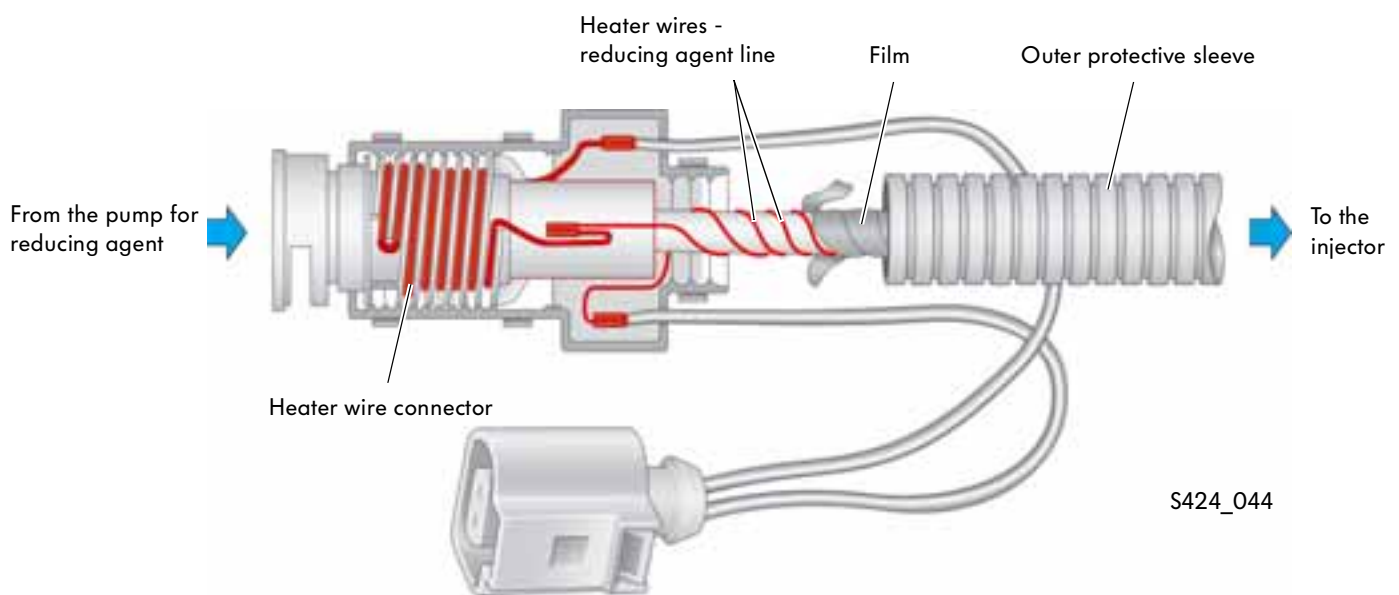


Heater system

Heater for reducing agent line Z104

The heater for the reducing agent line is a stainless steel resistor wire.

The resistor wire is wound in the form of a spiral around the delivery line and is protected from the outside by a plastic tube. The heater for reducing agent line is actuated by the engine control unit via the control unit for reducing agent heater.



Task

The heater for reducing agent line has the task of heating the reducing agent in the delivery line to the injector in the event of low exterior temperatures. This ensures reliable SCR system operation even at low exterior temperatures.

Effects in the event of failure

If the control unit for reducing agent heater fails, the reducing agent may freeze at low exterior temperatures. The exhaust emissions warning lamp K83 (MIL) is switched on.

How it works

If the temperature of the ambient air is less than -5°C , the heater current for the heater for reducing agent line is activated via the control unit for reducing agent heater.

Temperature sender for reducing agent G685

The temperature sender for the reducing agent is a sensor with a negative temperature coefficient (NTC). It is located in the housing of the reducing agent tank sender and measures the temperature of the reducing agent in the heater pot.

Signal use

The engine control unit uses the signal from the reducing agent temperature sender to switch on the heater for the reducing agent tank and the heater for pump for reducing agent.



Temperature sender for reducing agent G685

S424_056

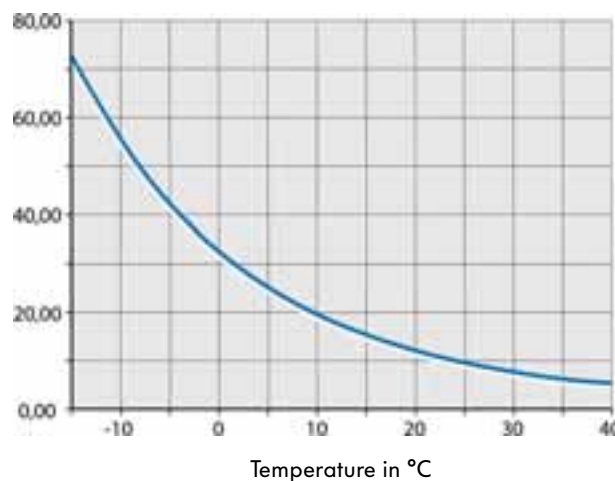
How it works

The temperature sender is a resistor wire with a negative temperature coefficient (NTC). This means that the sensor's electrical resistance decreases as the temperature of the reducing agent increases. The engine control unit uses the resistance signal to calculate the current temperature of the reducing agent.

Effects of signal failure

The exhaust emissions warning lamp K83 (MIL) and the AdBlue® warning display for system faults in the dash panel insert display are switched on.

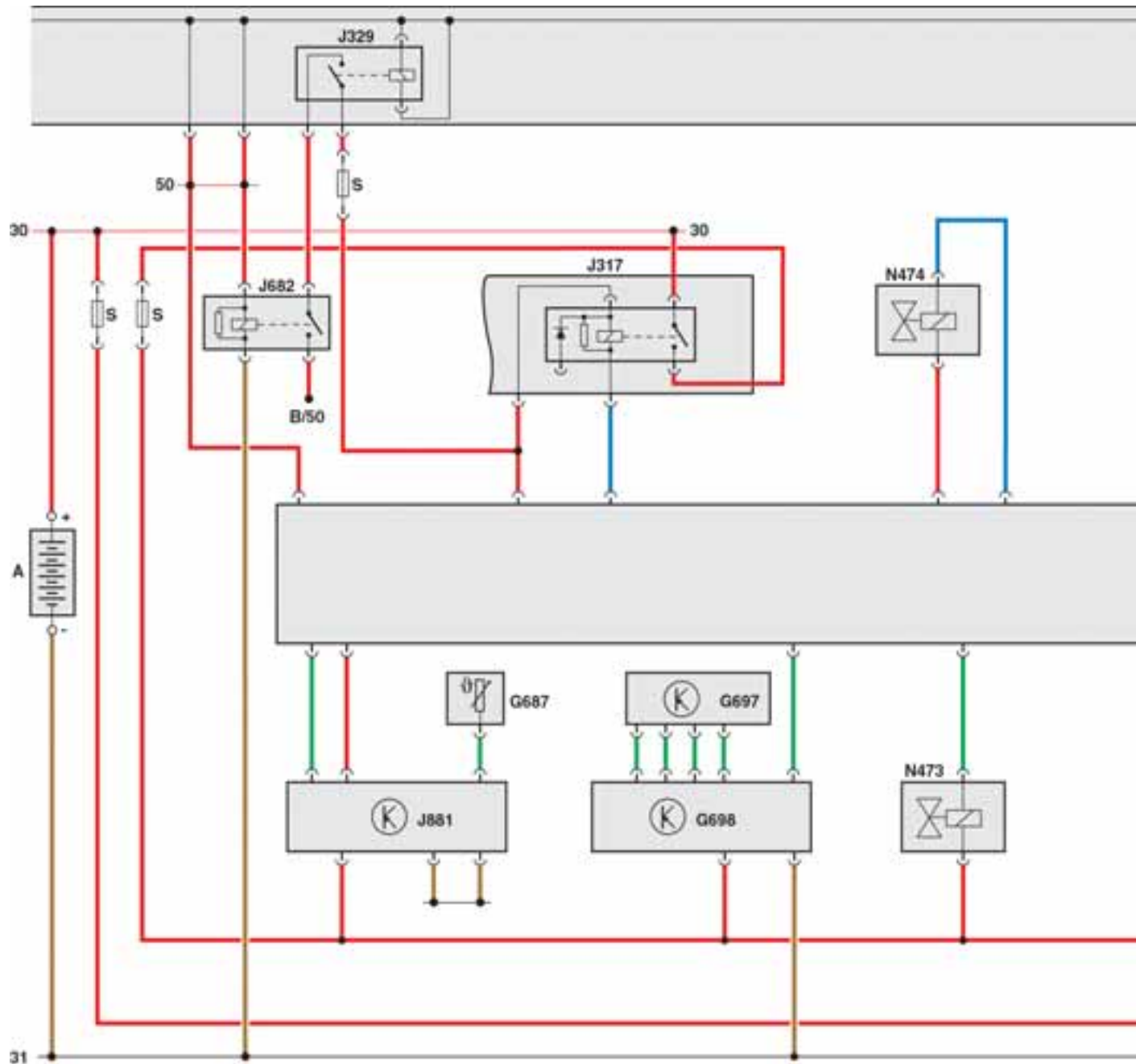
Resistance in kΩ



S424_090

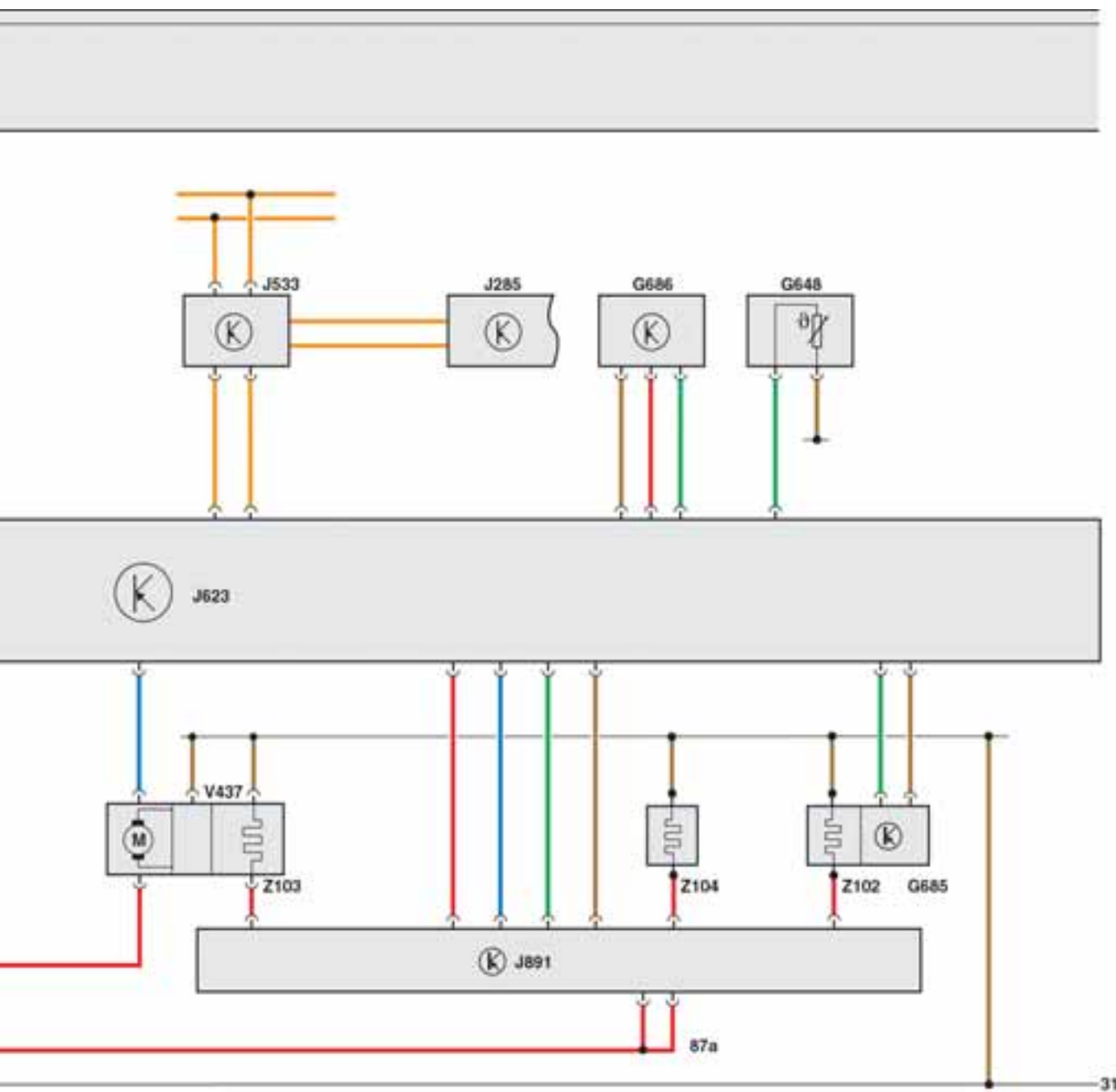


Functional diagram



Legend

A	Battery	J317	Terminal 30 voltage supply relay
B	Starter	J329	Terminal 15 voltage supply relay
G648	Exhaust gas temperature sender 4	J519	Onboard supply control unit
G685	Temperature sender for reducing agent	J533	Data bus diagnostic interface
G686	Pressure sender for reducing agent metering system	J623	Engine control unit
G687	NO _x sender 2	J682	Terminal 50 voltage supply relay
G697	Reducing agent level sender	J881	Control unit for NO _x sender 2
G698	Reducing agent level evaluation unit	J891	Control unit for reducing agent heater
J285	Control unit with display in dash panel insert	N473	Reversing valve for reducing agent
		N474	Injector for reducing agent





S424_077

- S Fuse
- V437 Pump for reducing agent
- Z102 Heater for reducing agent tank
- Z103 Heater for pump for reducing agent
- Z104 Heater for reducing agent line



- Input signal
- Output signal
- Positive
- Ground
- CAN BUS



Special tools and workshop equipment

Designation	Tool	Application
Filling device for AdBlue® VAS 6542	 <p>S424_041</p>	VAS 6542 is used for filling the reducing agent tank with AdBlue®. The VAS 6542/1 container has a capacity of 10 litres.
Mounting plate V.A.G 1383A/1	 <p>S424_092</p>	The mounting plate is used for securely mounting the container VAS 6542/1 during the filling process with the filling device for AdBlue® VAS 6542.



Designation	Tool	Application
Vacuum box VAS 6557	 <p>S424_094</p>	The vacuum box is used to extract the AdBlue® from the reducing agent tank.
Special wrench T50014	 <p>S424_093</p>	The special wrench is used to install the locking ring on the reducing agent delivery module.



Service

Refill bottle for the customer

Content: 1.89 litres (equivalent to half a gallon)

Filling concept:

In order to fill the reducing agent tank, the refill bottle must be screwed onto the tank filler neck by hand. Pressing the bottle releases an opening in the adapter fitting, and the AdBlue® is able to flow into the tank. During the filling process, the gases from the tank are trapped by the refill bottle and therefore do not enter the atmosphere.



S424_087

AdBlue® service station network

A universal AdBlue® supply has been guaranteed in Europe since 2005.

On the Internet site

"<http://www.findadblue.com>", you can locate the service stations at which AdBlue® is available in Europe.



S424_043



Which answers are correct?

One or several of the given answers may be correct.

1. What are the characteristics of the AdBlue® reducing agent?

- ☐ a) It freezes at temperatures below -11°C .
- ☐ b) It can be recognised by its striking blue colour.
- ☐ c) It lowers the reduction temperature of the nitrogen oxides.

2. What is the task of the NO_x sender 2 G687 in the SCR system?

- ☐ a) It is used exclusively to calculate the quantity of reducing agent which is injected.
- ☐ b) It is used to monitor the efficiency of the SCR system for EOBD.
- ☐ c) It determines the quantity of NO_x stored in the NO_x storage catalytic converter.

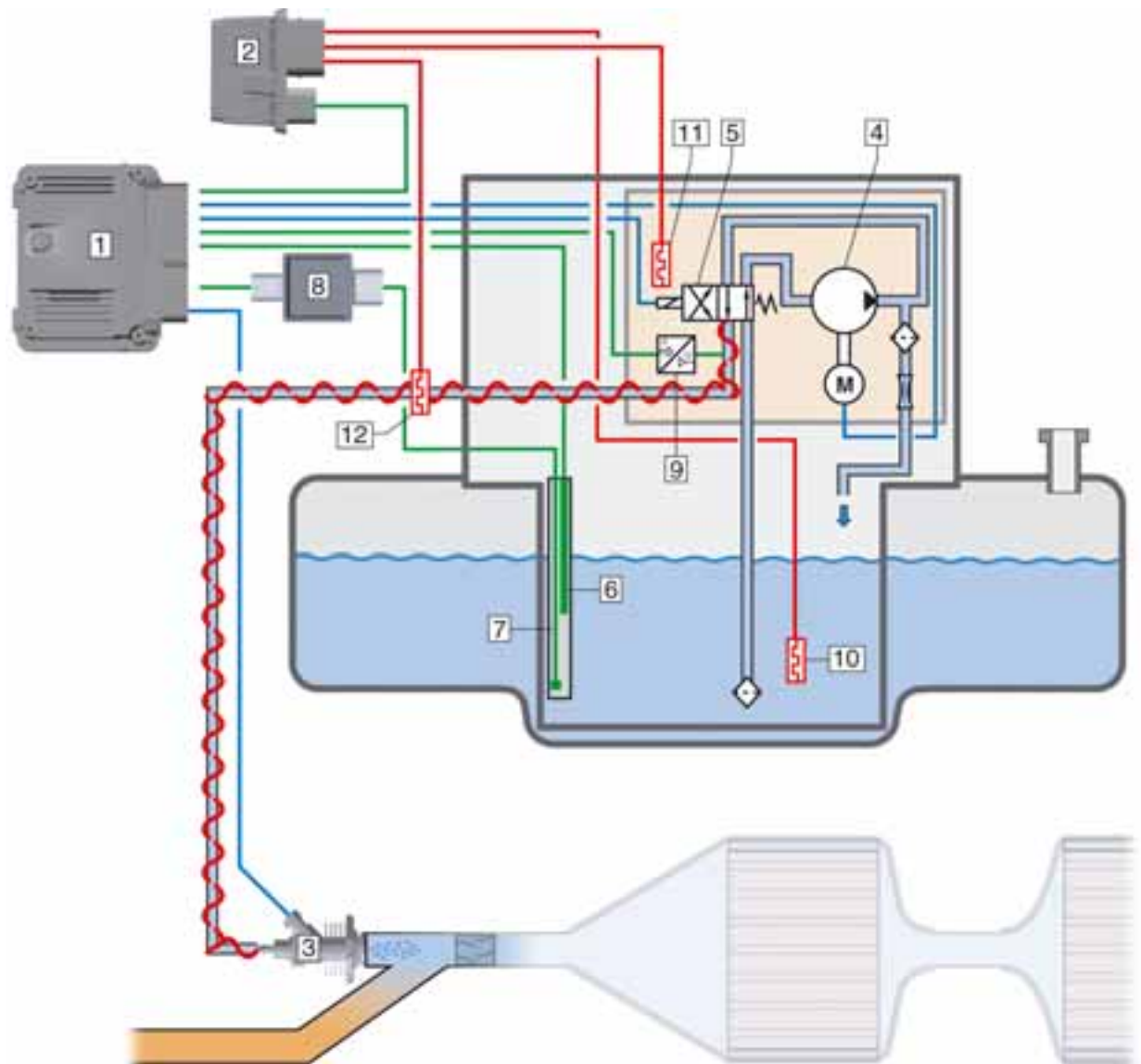
3. Which statement on reducing agent injection is correct?

- ☐ a) The reducing agent can be injected when the reduction catalytic converter has reached its operating temperature of approx. 200°C .
- ☐ b) It is only injected when the exterior temperature is higher than -11°C .
- ☐ c) The reducing agent is injected when a sufficient quantity of nitrogen oxides is stored in the reduction catalytic converter.



Test yourself

4. Please name the components!



S424_095

1 -

2 -

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12 -

5. What are the effects of a completely empty reducing agent tank?

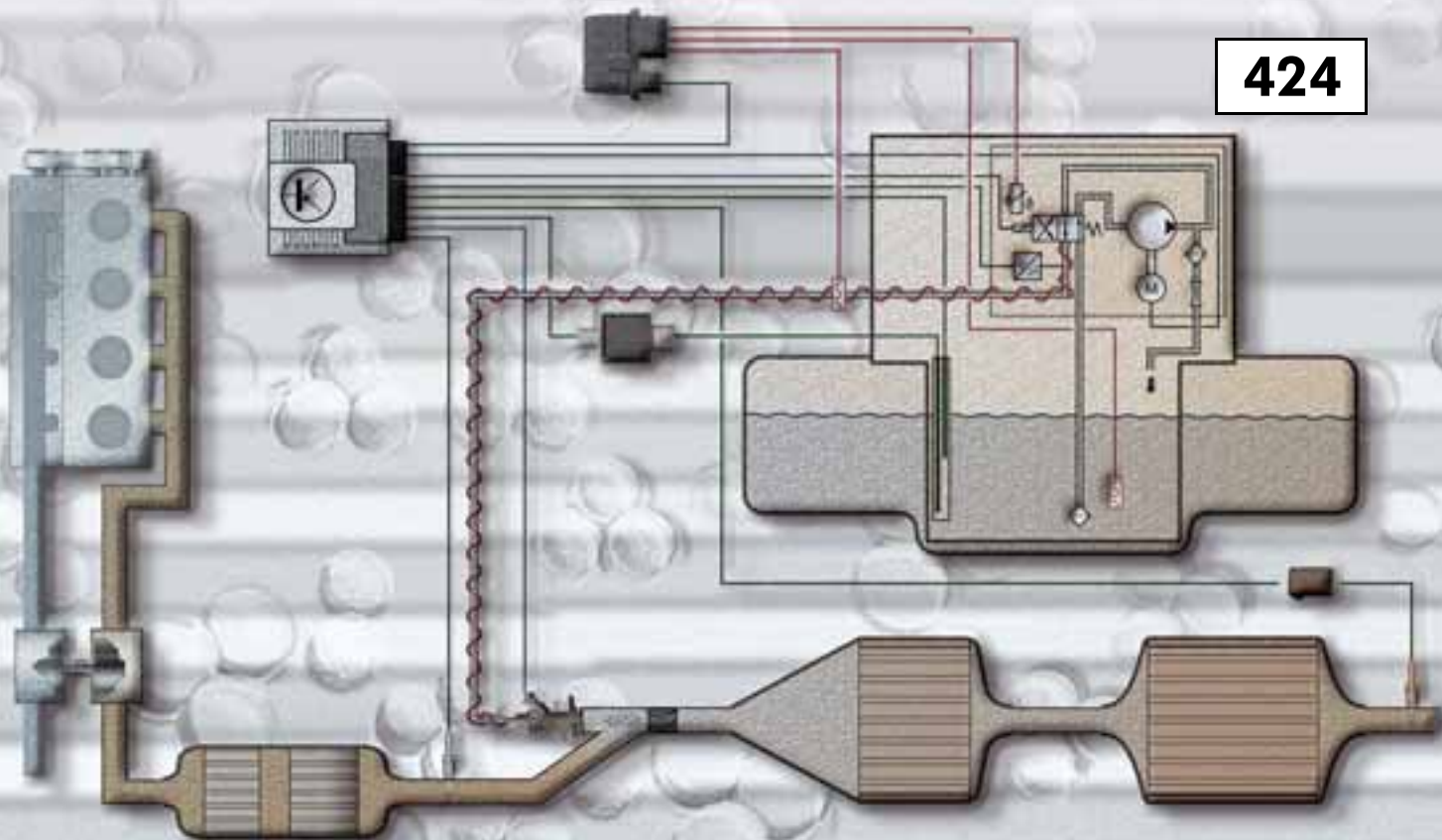
- ☐ a) The vehicle can continue to be driven; the nitrogen oxide contents in the exhaust gas merely increase.
- ☐ b) The driver can continue to drive for 1000 km in order to replenish the reducing agent.
- ☐ c) Repeated starting of the engine is blocked.

6. What is the task of the reversing valve for reducing agent N473?

- ☐ a) Due to the reversing valve for reducing agent, the reducing agent line from the pump to the injector is pumped empty when the ignition is switched off.
- ☐ b) The reversing valve for reducing agent reverses the rotational direction of the pump for reducing agent.
- ☐ c) Due to the reversing valve for reducing agent, the injector is cooled with reducing agent if there is a risk of overheating.

Answers:
1. a;
2. b;
3. a;
4. 1 = Engine control unit J623
2 = Control unit for reducing agent heater J891
3 = Injector for reducing agent N474
4 = Pump for reducing agent V437
5 = Reversing valve for reducing agent N473
6 = Reducing agent level sender G697
7 = Temperature sender for reducing agent G685
8 = Reducing agent level evaluation unit G698
9 = Pressure sender for reducing agent metering system G686
10 = Heater for reducing agent tank Z102
11 = Heater for pump for reducing agent Z103
12 = Heater for reducing agent line Z104
5. c;
6. a





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