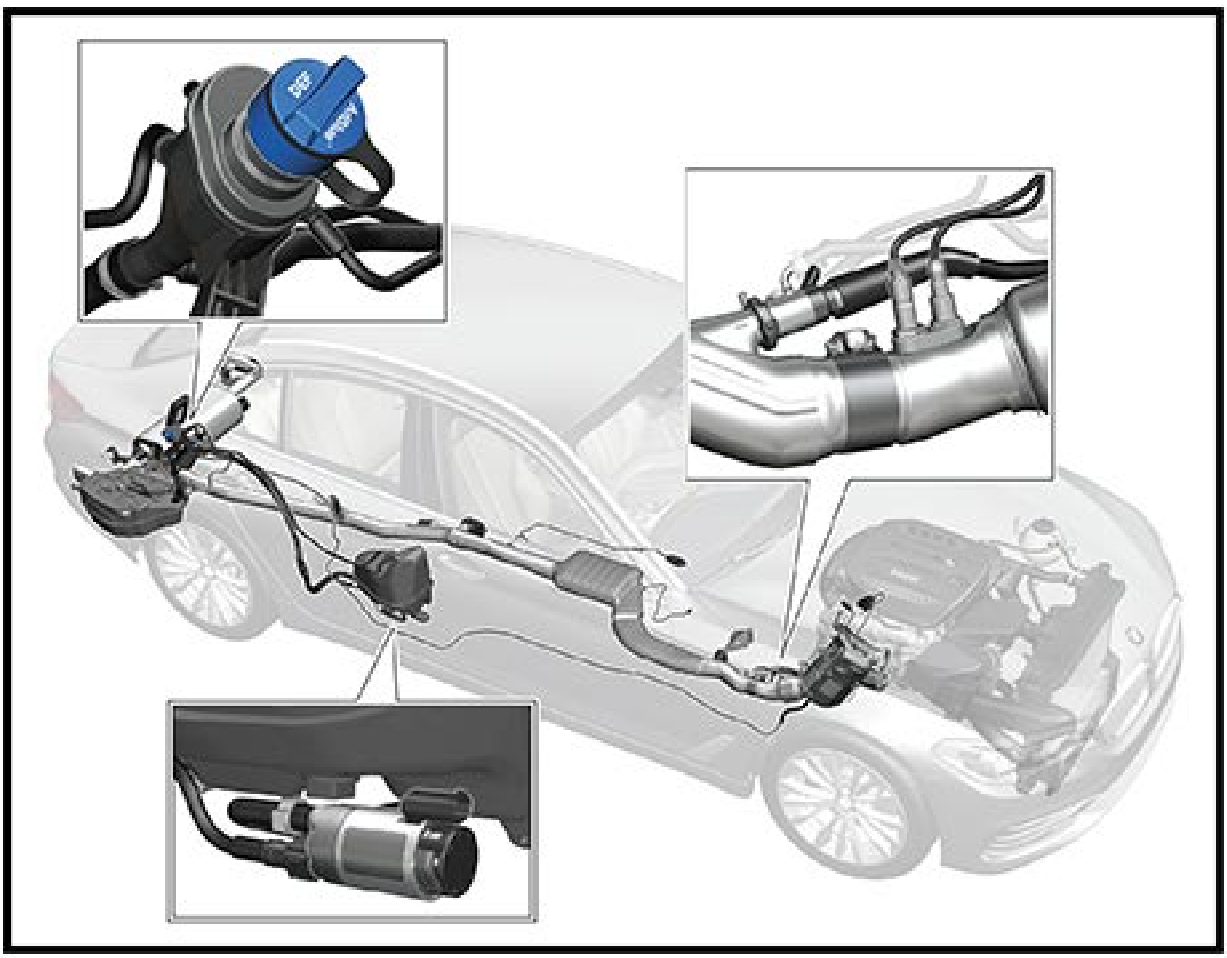
Reference Manual

SCR 3 (US)



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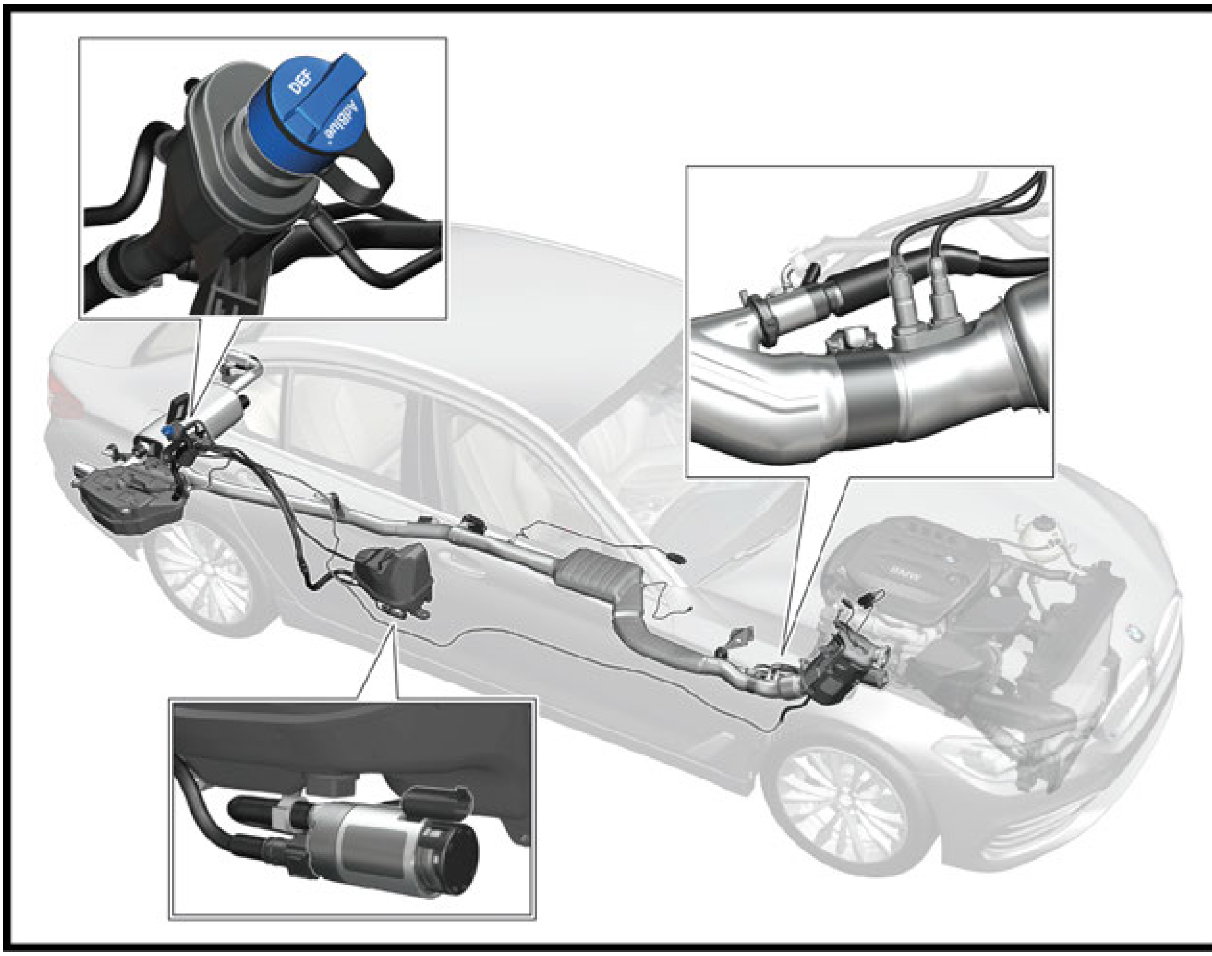
SCR 3 (US)



Edited for the U.S. market by:
BMW Group University
Technical Training
ST1705 5/1/2017

BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as the result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the BMW Group Technical Qualification and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **September 2016**
Technical training.

SCR 3 (US)

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1. Introduction

The abbreviation SCR stands for **S**elective **C**atalytic **R**eduction. This is currently the most effective system for the reduction of Nitrogen Oxides in the exhaust gas.

This system has been used by BMW in the US market diesel models since 2008. It was introduced as SCR1 (first generation) with the launch of the E70 diesel and followed by the E90 diesel both using the M57 engine. Later BMW introduced the second generation of SCR to the US market (SCR 2) with the launch of the F02, F10, F15, F30 and F31 which used N57TU and N47TU engines. In 2017 BMW gradually introduced the third generation (SCR3) in the US and in Europe for specific models. These models use the most current BMW diesel engines from the “B” family of engines. The B57 engine was introduced in US market with the launch of the 5 Series G30, later in 2017.

Compliance with the stringent emission standards in the US market and now the need to meet EURO 6 exhaust emission standards in ECE would not have been possible solely with the systems already known such as NSC (Nitrogen Oxide storage catalytic converter), EGR (low-pressure exhaust-gas recirculation) and DPF (Diesel Particulate Filter) and the internal engine measures in the current BMW diesel engines. The combination of all these emission systems is necessary to meet the latest requirements, especially in the cold-start phase, where the SCR system is not yet operational.

The special feature of the SCR system is the use of a urea/water mixture (AdBlue®), which is used to reduce NO_x. The only downside of the system is the added components and that enough of this diesel fluid must be carried in the vehicle to ensure the system operation and emission efficiency. This urea/water mixture is generally known under the brand name **“AdBlue®”**.

The system is managed at BMW under the marketing name **“BMW BluePerformance”**.

1.1. Exhaust emissions regulations

To provide a better understanding of the high costs relating to the exhaust emission system of diesel vehicles, this section contains a short overview of the European exhaust emission regulations.

In 1988, the California Air Resources Board (CARB) in the USA introduced On-Board Diagnosis systems (OBD systems) to monitor the operational reliability of emission-relevant systems for the first time.

The goal of On-Board Diagnosis (OBD) was no longer just to ensure compliance with the exhaust emission standards for approval of new vehicles, but also to monitor the legal limit values during the entire service life of the vehicle.

OBD II is an expanded set of standards and practices developed by SAE and adopted by the EPA and CARB (California Air Resources Board). It came into effect by January 1, 1996 in the US and was introduced as law in the European Union in October 1998. A new feature in comparison with OBD I was monitoring of the monitoring systems.

To illustrate the evolution of the emissions standards the following graphic shows the development of the statutory exhaust emission standards from EURO 3 to EURO 6 as well as the development of the corresponding OBD limit values.

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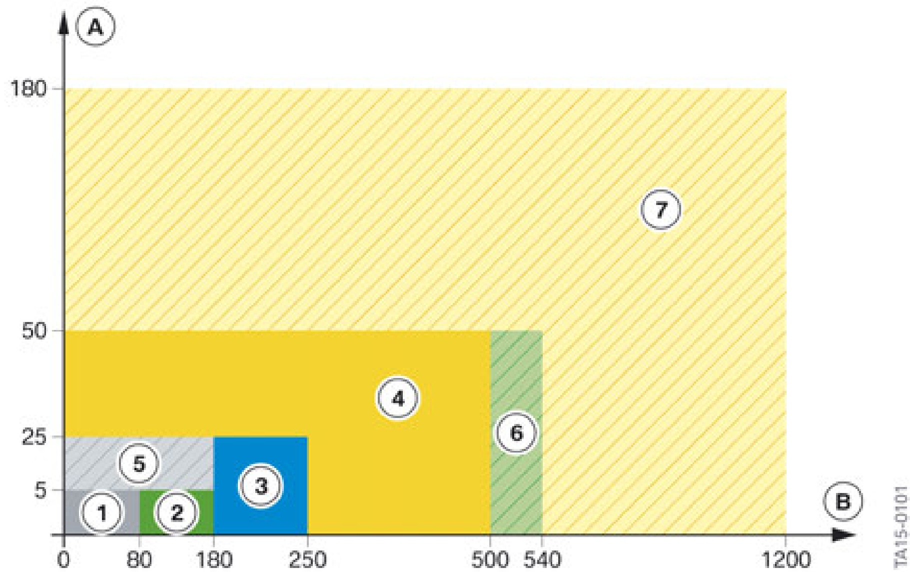
1. Introduction



Graphic comparison of limit values of EURO exhaust emission standards and OBD limit values

Index	Explanation
A	Particulate mass (PM) [mg/km]
B	Nitrogen oxides (NO_x) [mg/km]
1	Exhaust emission limit values EURO 6
2	Exhaust emission limit values EURO 5
3	Exhaust emission limit values EURO 4
4	Exhaust emission limit values EURO 3
5	OBD limit values of exhaust emission regulation EURO 6
6	OBD limit values of exhaust emission regulation EURO 5
7	OBD limit values of exhaust emission regulation EURO 3/4

The legislation on the EURO 6 On-Board Diagnosis (OBD) limit values will be introduced in 2 stages. The first stage has been in force since 1 September 2014, and the second planned stage will be implemented as from 1 September 2017. This document deals only with the OBD limit values in the first stage.

Various new systems and sensors are required in the exhaust emission systems of the diesel engines in order to ensure that tomorrow's requirements are already met today.

SCR 3 (US)

1. Introduction

1.1.1. Differentiation of systems for emission reduction in diesel engines:

Systems for internal engine measures:

- High-pressure EGR (exhaust-gas recirculation)
- Low-pressure EGR (exhaust-gas recirculation)

Exhaust re-treatment systems:

- Oxidation catalytic converter
- NO_x storage catalytic converter (NSC)
- Diesel particulate filter (DPF)
- Selective catalytic reduction (SCR)

1.1.2. Sensors needed for exhaust re-treatment in diesel engines

- DPF differential pressure sensor
- AGR pressure sensor
- EGR temperature sensor
- Oxygen sensors
- Exhaust temperature sensor
- NO_x sensors
- Diesel particulate sensor

SCR 3 (US)

2. Summary

2.1. History

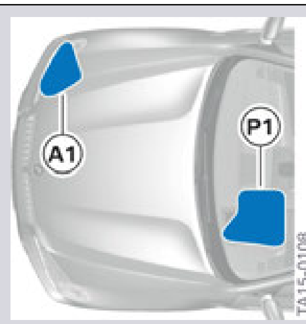
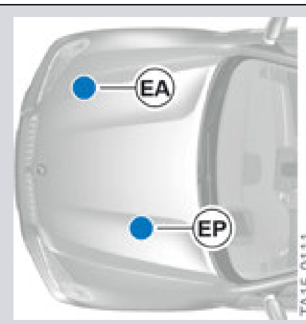
2.2. BMW models (US) with SCR technology

The following table provides an overview of which SCR generation is used in which models.

Series	Model	Engine	Standard	SCR	Active tank	Passive tank	SOP
E70	X5 xDrive35d	M57D30T2	LEV II	SCR 1	6.4 L	16.5 L	12/08
E90	335d	M57D30T2	LEV II	SCR 1	7.4 L	14.4 L	12/08
F10 LCI	535xd	N57D30O1	ULEV II LEV II*	SCR 2	15 L	—	07/13
F02 LCI	740xd	N57D30O1	ULEV II LEV II*	SCR 2	15 L	—	07/13
F15	X5 xDrive40d	N57D30O1	ULEV II LEV II*	SCR 2	13.7 L	15.3 L	9/13
F30, F31	328xd	B47D20O1	ULEV II LEV II*	SCR 2	8.7 L	9.4 L	07/13
G30	530d	B57D30O0	ULEV125 LEV III*	SCR 3	12.5 L	8.5 L	7/17

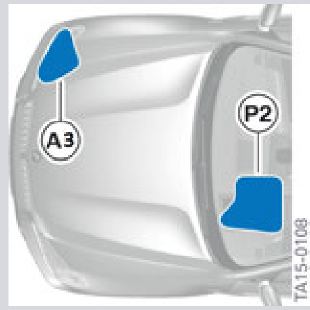
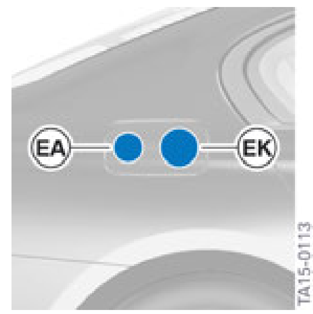
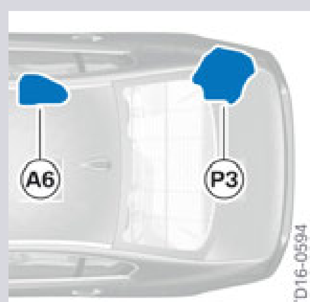
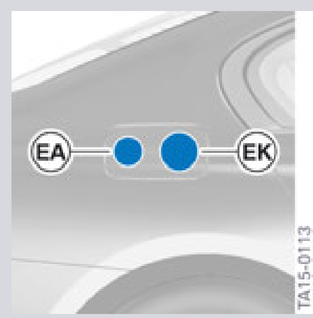
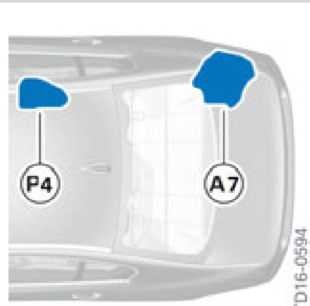
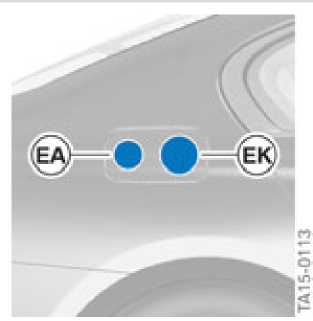
*** ULEV II is a certification standard that is part of the California LEV II program. A few years ago, CARB issued new rules and regulations that are called the LEV III program. We are currently in the transition period where both types of certifications are allowed. LEV III will be fully phased-in by the 2020 model year. The 540d xDrive is planned to be certified as ULEV 125 under the California LEV III program.**

2.2.1. Installation locations of SCR components (US only)

Models	Installation location of SCR control unit	Installation location of SCR tank	Installation location of SCR filler neck
E70 (SCR 1)			

SCR 3 (US)

2. Summary

Models	Installation location of SCR control unit	Installation location of SCR tank	Installation location of SCR filler neck
F15 (SCR 2)			
F02, F10 single- branch (SCR 2)			
F30, F31 two- branch (SCR 2)			
G30 (SCR 3)			

2. Summary

Index	Explanation
S1	Rear SCR control unit
S2	Front SCR control unit
S3	DDE control unit (with integrated SCR control unit)
A1	Active tank version 1 with 6.4 l (E70)
A3	Active tank version 3 with 13.7 l (F15)
A4	Active tank version 4 with 15 l (F10, F02)
A6	Active tank version 6 with 8.7 l (F30, F31)
A7	Active tank version 7 with 12,5 l (G30)
P1	Passive tank version 1 with 16.5 l (E70)
P2	Passive tank version 2 with 15.3 l (F15)
P3	Passive tank version 3 with 9.4 l (F33, F31)
P4	Passive tank version 4 with 8.5 l (G30)
EA	Filler neck, active tank
EP	Filler neck, passive tank
EK	Filler neck, fuel tank

2.2.2. Differences in the system technology

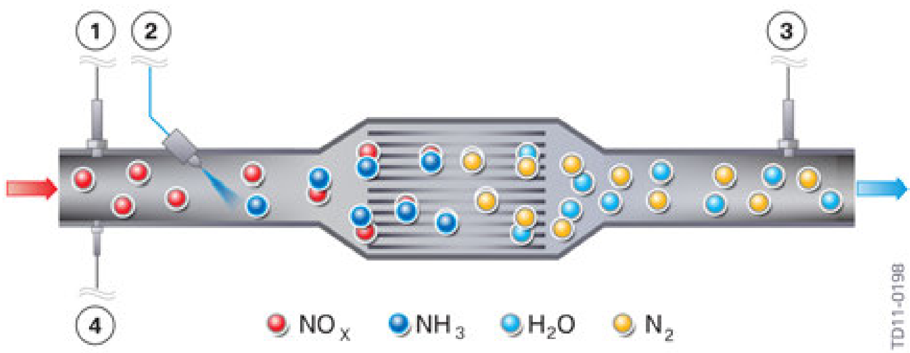
	SCR 1	SCR 2	SCR 3
SCR control	DDE	SCR control unit	SCR control unit
SCR strategy	DDE	DDE	DDE
Filling level sensor, passive tank	Sensor (selective)	Ultrasonic (continuous)	Ultrasonic (continuous)
Filling level sensor, active tank	Sensor (selective)	Ultrasonic (continuous)	- Piezo element (quality sensor) - Ultrasonic sound (continuous)
Pressure sensing	Pressure sensor	Computational model	Pressure sensor
Discharge hole	Yes	No	No
Coolant-cooled SCR metering module	No	Yes	Yes
Quality sensor urea/water mixture (AdBlue®)	No	No	Yes
Filler connections	2	1 (2 in F15)	1
System supplier	Bosch	Bosch	Continental

2.3. Chemical function

The Selective Catalytic Reduction (SCR) is a system for the reduction of Nitrogen Oxides (NO_x) [which includes nitrogen monoxide (NO) and nitrogen dioxide (NO_2)] in the exhaust gas. The system uses a reducer agent (containing a urea/water mixture known as AdBlue®) which is directly injected into the exhaust gas after the diesel particulate filter.

In response to the reducer agent (urea/water mixture - AdBlue®) a reaction therefore takes place in the SCR catalytic converter that causes the reduction of Nitrogen Oxides (NO_x).

Selective Catalytic Reduction (SCR) is currently the most effective emission control system for the reduction of NO_x. During its function it achieves an efficiency of almost 100% and over the entire vehicle operation about 90%. The difference can be found in the time that the system requires to be operational after a cold start.



Functions of the SCR

Index	Explanation
1	NO_x sensor before the SCR catalytic converter
2	Metering module
3	NO_x sensor after the SCR catalytic converter
4	Temperature sensor after the diesel particulate filter

The urea/water mixture (AdBlue®) is injected into the exhaust system via the metering module before the SCR catalytic converter. The Digital Engine Electronics (DDE) calculates how much has to be injected. The Nitrogen Oxide content in the exhaust gas is calculated via the NO_x sensor before the SCR catalytic converter. This value is then used to determine the exact amount of urea/water mixture (AdBlue®) that is required to be injected in order to completely reduce the Nitrogen Oxides.

The urea/water mixture (AdBlue®) transforms into ammonia in the exhaust system. The ammonia reacts with the Nitrogen Oxides (NO_x) in the SCR catalytic converter to create nitrogen (N_2) and water (H_2O).

There is a second NO_x sensor located after the SCR catalytic converter which is used to monitor its function.

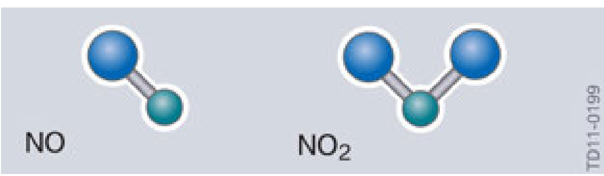
2. Summary

An exhaust temperature sensor, located after the diesel particulate filter (before the SCR catalytic converter and the metering module), also influences the SCR function. Because the injection of the urea/water mixture (AdBlue®) will only begin after a temperature of at least 170° C (338° F) is reached in the exhaust system.

2.3.1. Chemical reaction

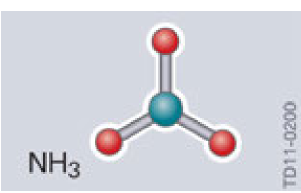
The SCR system is designed to significantly reduce the Nitrogen Oxides (NO_x) in the exhaust gas. The Nitrogen Oxides occur in two different forms:

- Nitrogen monoxide (NO)
- Nitrogen dioxide (NO_2)



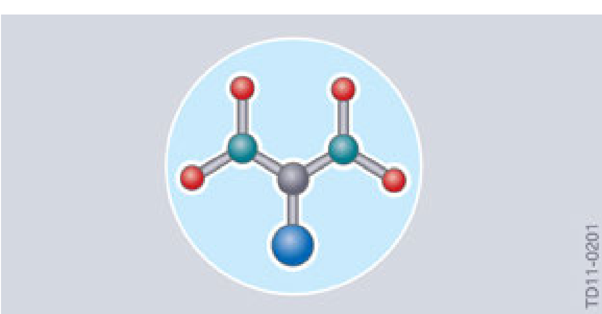
Nitrogen oxides

Ammonia (NH_3) is used for the reduction of the Nitrogen Oxides in combination with a special catalytic converter.



Ammonia

The ammonia is delivered via a urea/water mixture (AdBlue®).



Urea/water mixture (AdBlue®)

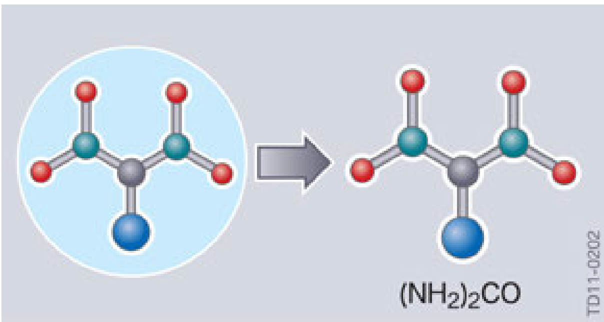
The urea/water mixture (AdBlue®) is injected via the metering module into the exhaust system after the diesel particulate filter. The required quantity must be exactly metered or otherwise Nitrogen Oxides or ammonia would escape the exhaust system at the end of the process. The following description of the chemical processes explains further.

2. Summary

2.3.2. Transformation of the urea/water mixture (AdBlue®)

The equal distribution of the urea/water mixture (AdBlue®) in the exhaust gas and the transformation into ammonia takes place in the exhaust pipe before the SCR catalytic converter.

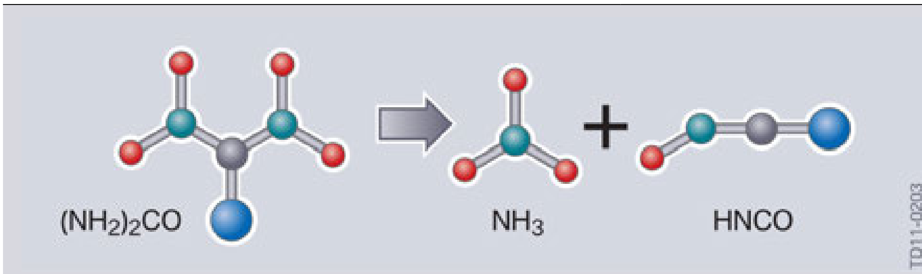
First, the urea dissolved in the urea/water mixture (AdBlue®) ($(NH_2)_2CO$) is released.



Releasing the urea from the urea/water mixture (AdBlue®)

The transformation of the urea into ammonia takes place in two stages.

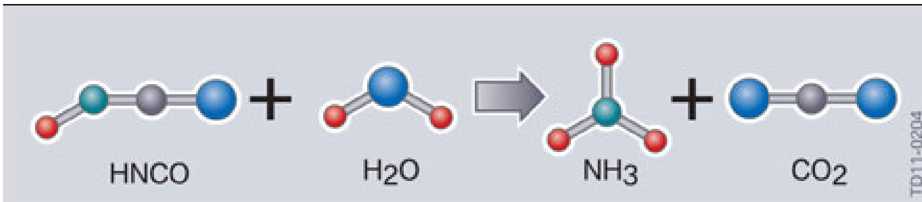
Thermolysis	
Explanation	During thermolysis, the urea/water mixture (AdBlue®) is split into two products by heating.
Starting products	Urea ($(NH_2)_2CO$)
Result	Ammonia (NH_3) Isocyanic acid (HNCO)
Chemical formula	$(NH_2)_2CO \rightarrow NH_3 + HNCO$



Thermolysis: Urea becomes ammonia and isocyanic acid

During thermolysis, only a part of the urea/water mixture (AdBlue®) is transformed into ammonia. The rest is isocyanic acid which is transformed in a second step explained below.

Hydrolysis	
Explanation	The isocyanic acid, that was created during the thermolysis, is transformed (again) into ammonia and carbon dioxide (CO_2) during hydrolysis through the addition of water.
Starting products	Isocyanic acid (HNCO) Water (H_2O)
Result	Ammonia (NH_3) Carbon dioxide (CO_2)
Chemical formula	$HNCO + H_2O \rightarrow NH_3 + CO_2$



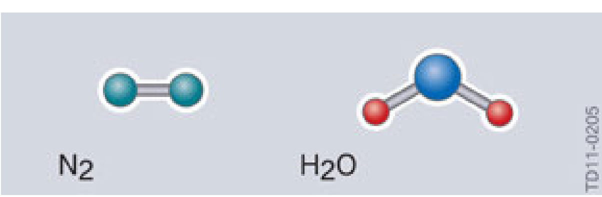
Hydrolysis: Isocyanic acid reacts with water and becomes ammonia and carbon dioxide

The required water is also delivered via the urea/water mixture (AdBlue®).

Therefore, after the hydrolysis step the entire urea is transformed into ammonia and carbon dioxide.

2.3.3. NO_x reduction

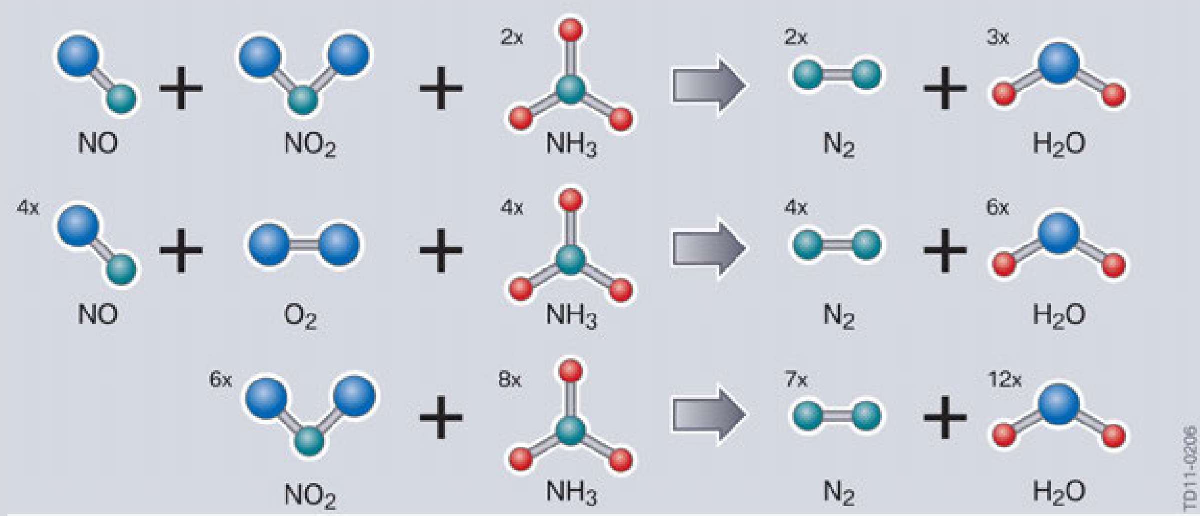
The Nitrogen Oxides (NO_x) are transformed into harmless nitrogen and water in the SCR catalytic converter.



Nitrogen and water

2. Summary

Reduction	
Explanation	The SCR catalytic converter enables a "docking" of the ammonia molecules. The Nitrogen Oxide (NO_x) molecules meet the ammonia molecules and the reaction begins. This, in turn, releases energy. This is valid both for NO as well as NO_2.
Starting products	Ammonia (NH_3) Nitrogen monoxide (NO) Nitrogen dioxide (NO_2) Oxygen (O_2)
Result	Nitrogen (N_2) Water (H_2O)
Chemical formula	$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$ $4NO + O_2 + 4NH_3 \rightarrow 4N_2 + 6H_2O$ $6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$



NO_x reduction: Nitrogen oxides react with ammonia and become nitrogen and water

It is possible to recognize that at the end of the chemical reaction each individual atom has found its place again. So, there are the exact same amount of elements on the left side as on the right. This only happens if the ratio of urea/water mixture (AdBlue®) to Nitrogen Oxides is correct.

If too little urea/water mixture (AdBlue®) is injected then Nitrogen Oxides (NO_x) may escape the system. If too much urea/water mixture (AdBlue®) is injected then ammonia escapes, which could lead to unpleasant odors and environmental damage. This is referred to as “ammonia slip” which also may occur if the temperatures in the exhaust system are to low for the ammonia to react or the SCR catalyst is defective. See SCR control section for more information.

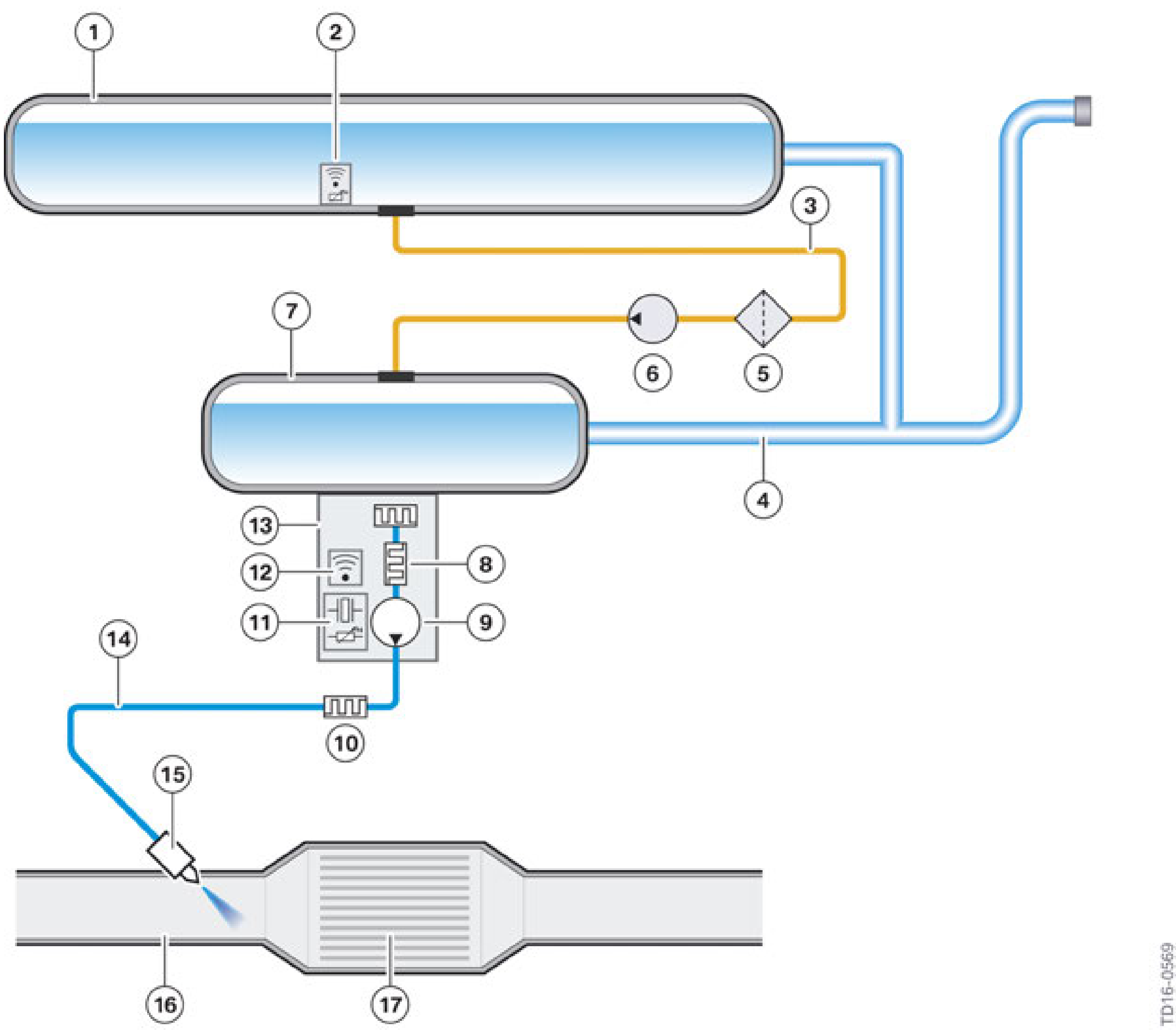
SCR 3 (US)

3. SCR 3

3.1. Overview

Selective Catalytic Reduction 3 (as the name implies) is the third generation of the SCR system used by BMW. The urea/water mixture (AdBlue®) is carried in the vehicle in one or two tanks, depending on the model. The BMW 5 Series Diesel (G30) uses a two tank system. This ensures sufficient volume to guarantee a high range for the NO_x emission control system.

The following graphic shows a **simplified** schematic diagram of the system:



SCR 3, simplified schematic diagram of the SCR system based on the example of the G30

Index	Explanation
1	Passive tank
2	Tank flange with level sensor and temperature sensor — passive tank
3	Transfer line
4	Filler connection

3. SCR 3

Index	Explanation
5	Fine filter
6	Recirculating pump unit
7	Active tank
8	Heating active tank and tank flange module
9	Pump
10	Heating metering line
11	Filling level sensor/urea/water mixture (AdBlue®) quality sensor and temperature sensor active tank
12	Fuel level sensor
13	Tank flange module active tank
14	Metering line
15	Metering valve
16	Exhaust system
17	SCR catalytic converter

The reason why two SCR tanks are used (depending on the series) is that different installation areas are available due to the packaging space. This allows for the necessary volumes to be transported, in order to guarantee the required top-up intervals for covering long distances between refilling.

Because the urea/water mixture (AdBlue®) freezes at -11 °C (12.2 °F), the active tank needs to be heated. The passive tank however does not use heating. This saves energy, by not having to heat the entire volume of the urea/water mixture (AdBlue®) .

The urea/water mixture (AdBlue®) is delivered from the active tank to the SCR metering module via the metering line which is also heated.

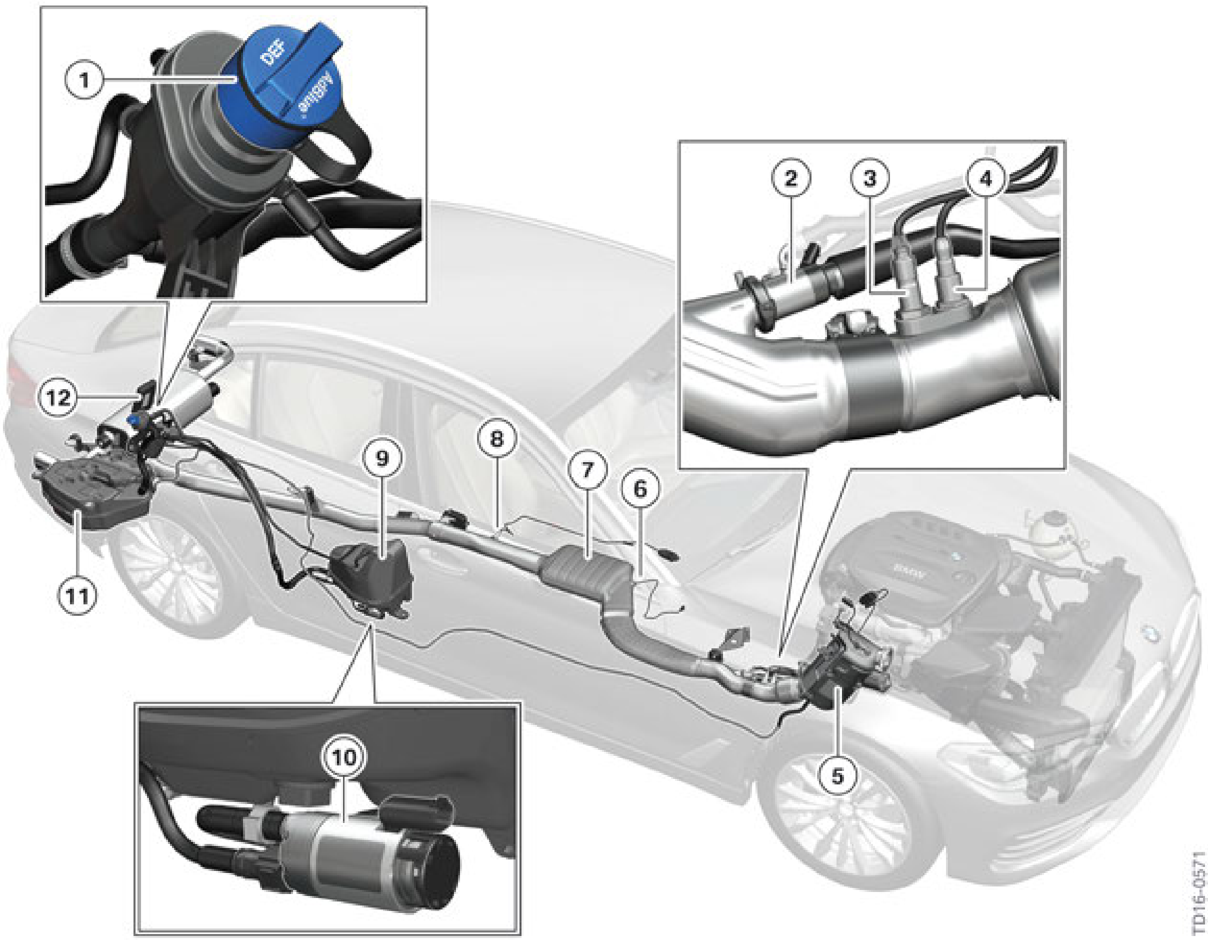
Because the passive tank is not heated; the recirculating pump unit regularly ensures that the urea/water mixture (AdBlue®) is pumped from the passive tank to the active tank.

Although some current BMW models may use just one tank (active) this training material partly describes and illustrates the (G30 with the B57 engine for the US market) system version with two tanks. The functions are generally identical in the version with one tank. The additional components required for a two-tank system can be dropped for a single-tank system.

SCR 3 (US)

3. SCR 3

3.1.1. Installation locations



Installation locations of SCR 3 components using on the G30

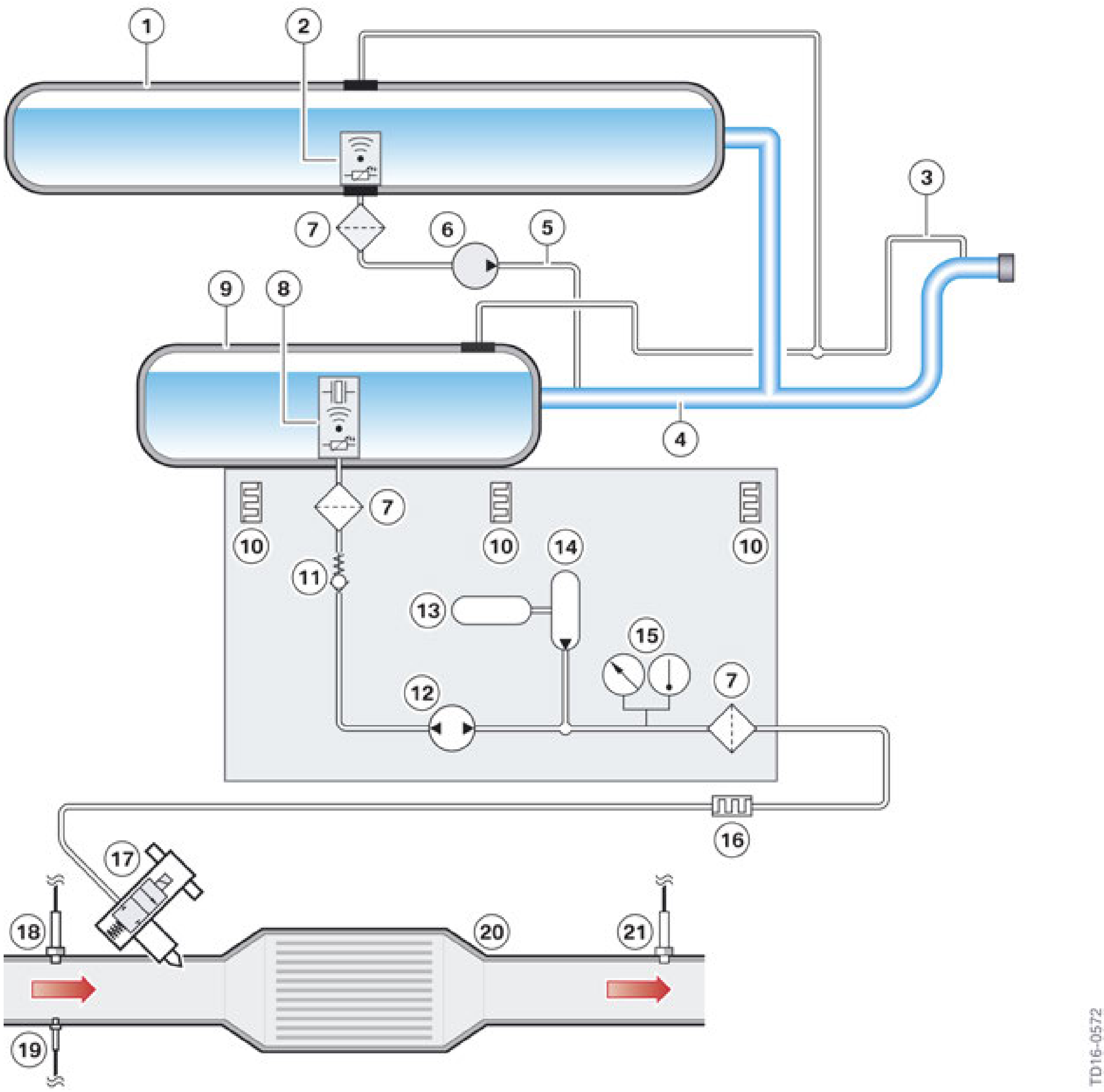
Index	Explanation
1	Urea/water mixture (AdBlue®), filler connection with fluid filler cap
2	Metering module
3	NO_x sensor before the SCR catalytic converter
4	Oxygen sensor
5	NO_x storage catalytic converter and diesel particulate filter
6	Exhaust-gas temperature sensor after diesel particulate filter
7	SCR catalytic converter
8	NO_x sensor after SCR catalytic converter

3. SCR 3

Index	Explanation
9	Passive tank
10	Recirculating pump unit
11	Active tank
12	SCR control unit

The G30, with the B57D30O0 engine, uses an active tank with a capacity of 12.5 l, located in the vehicle underbody on the rear right behind the wheel, and an 8.5 l passive tank, located in the vehicle underbody on the rear right in front of the wheel. The filler connection for the urea/water mixture (AdBlue®) is located in the fuel filler flap (at the right rear) beside the fuel filler neck (diesel fuel).

3.1.2. System overview in detail



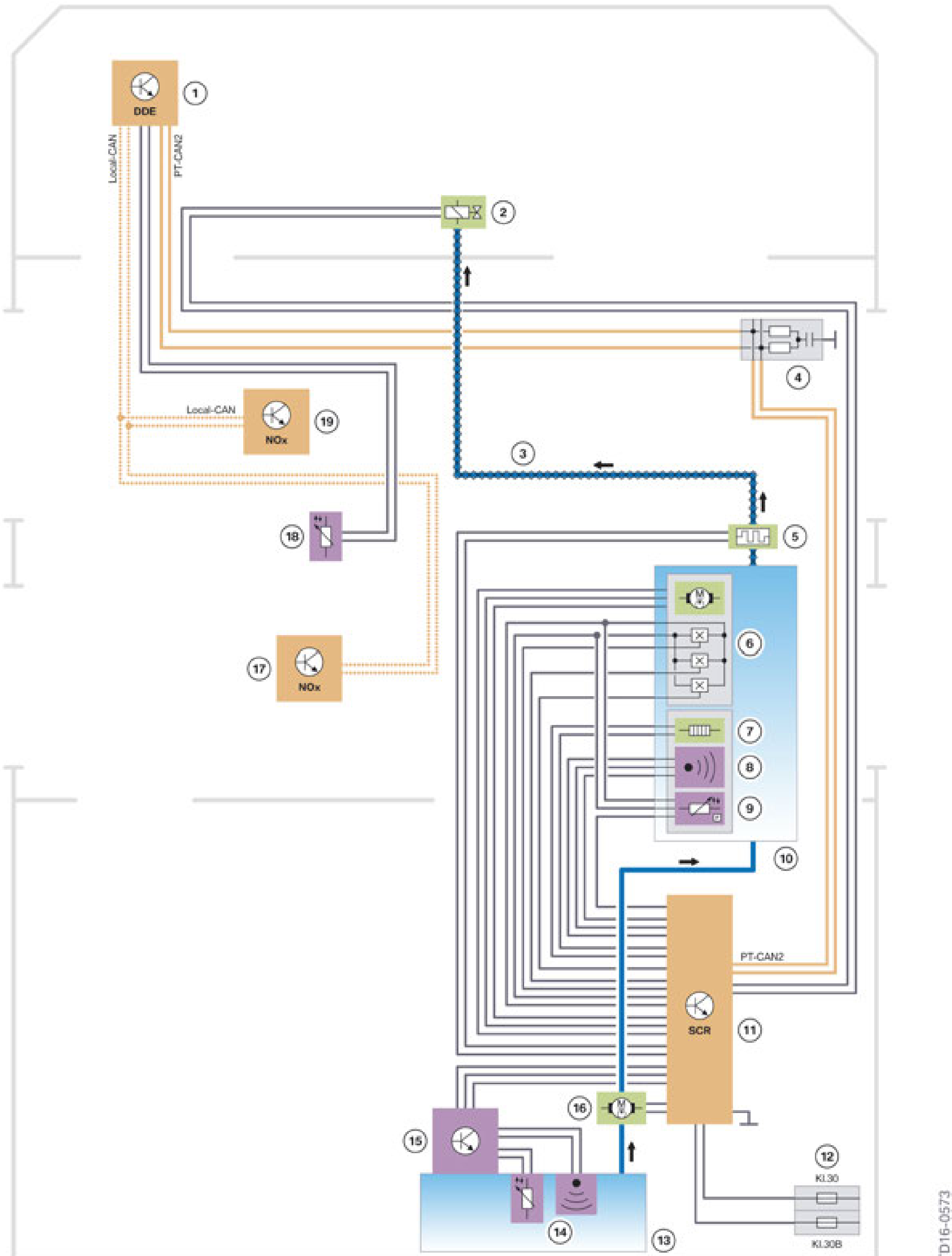
SCR 3 system overview

Index	Explanation
1	Passive tank
2	Tank flange, passive tank with level sensor and temperature sensor
3	Tank ventilation line
4	Fluid filler neck breather pipe
5	Transfer line
6	Recirculating pump unit

3. SCR 3

Index	Explanation
7	Filter
8	Tank flange, active tank with hydraulics, filling level sensor, quality sensor, heating and temperature sensor
9	Active tank
10	Heating
11	Shutoff valve (open with the pump installed)
12	Pump
13	Ice pressure damper
14	Pressure accumulator
15	Pressure sensor/temperature sensor
16	Heating metering line
17	Metering valve
18	NO_x sensor before the SCR catalytic converter
19	Exhaust-gas temperature sensor after diesel particulate filter
20	SCR catalytic converter
21	NO_x sensor after SCR catalytic converter

3.1.3. System wiring diagram



SCR 3 system wiring diagram (G30)

Index	Explanation
1	Digital Diesel Electronics (DDE)
2	Metering module
3	Metering line
4	PT-CAN coupler
5	Heating metering line
6	Pump motor with hall effect sensor
7	Tank flange module heating
8	Filling level sensor and quality sensor
9	Temperature sensor and pressure sensor
10	Active tank flange module
11	SCR control unit
12	Fuses, supply of SCR control unit
13	Passive tank
14	Level sensor and temperature sensor, passive tank
15	Evaluation unit, passive tank
16	Recirculating pump unit
17	NO_x sensor before the SCR catalytic converter
18	Exhaust-gas temperature sensor
19	NO_x sensor after SCR catalytic converter

3.2. Functions

3.2.1. SCR control

SCR control takes place in the SCR control unit and in the DDE (Digital Diesel Electronics).

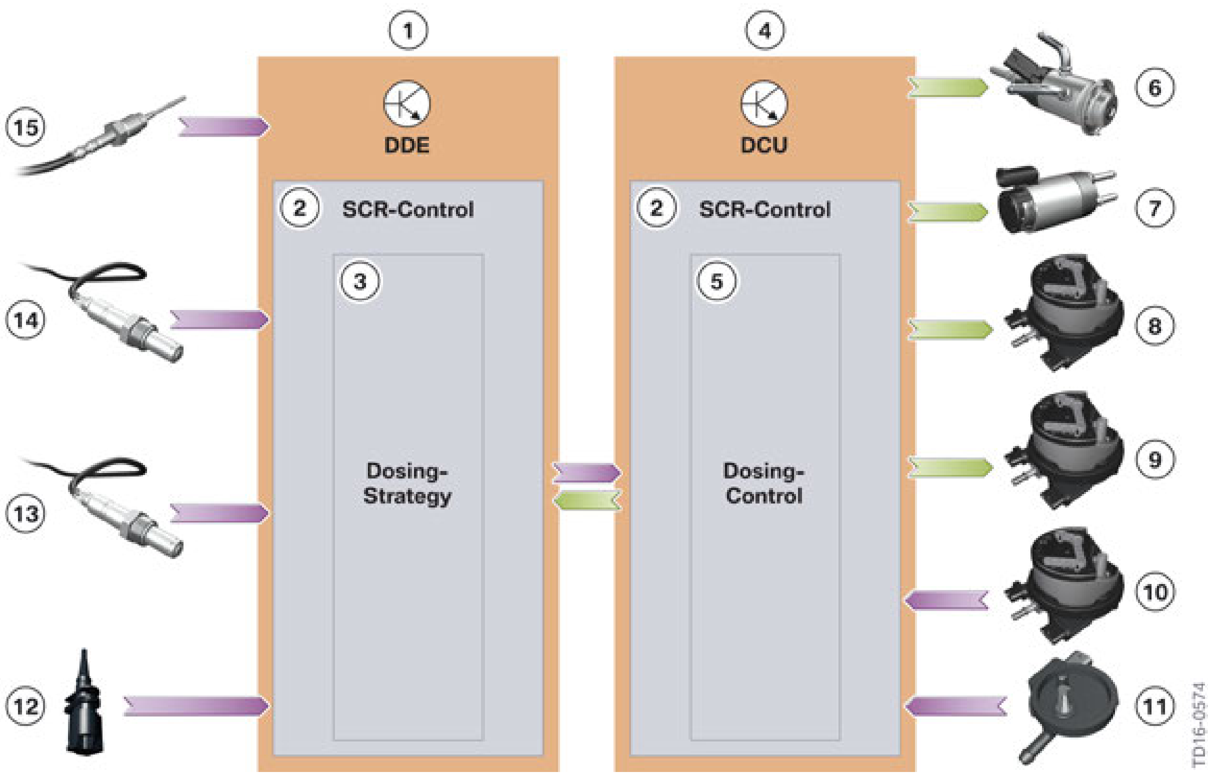
The SCR control is divided into the SCR metering system control, which is implemented by the SCR control unit, and the metering strategy, which is defined by the DDE.

The SCR control unit assumes the following functions:

- System functions CAN communication and network management
- Control of the urea/water mixture (AdBlue®) pumps, metering line filling/metering line emptying and pressure build-up/pressure reduction
- Control of the urea/water mixture (AdBlue®) metering module, implementation of the metering volume set by the Digital Diesel Electronics (DDE)
- Control of the urea/water mixture (AdBlue®) heaters

3. SCR 3

- Evaluation of the level sensors and temperature sensors
- Evaluation of the quality sensor urea/water mixture (AdBlue®)
- Monitoring functions
- On-board diagnosis OBD monitoring
- Controlling the heating in the active tank and metering line
- Controlling the pump transfer function from the passive tank (if installed) to the active tank



SCR 3, SCR control

Index	Explanation
1	Digital Diesel Electronics (DDE)
2	SCR control
3	Metering strategy
4	SCR control unit
5	Dosing system control
6	SCR metering module with heating in the metering line
7	Recirculating pump unit
8	Pump in the active tank flange
9	Heaters in the active tank flange

3. SCR 3

Index	Explanation
10	Filling level sensor, quality sensor, pressure sensor and temperature sensor in the tank flange active tank
11	Level sensor and temperature sensor in tank flange, passive tank
12	Outside temperature sensor
13	NO_x sensor before the SCR catalytic converter
14	NO_x sensor after SCR catalytic converter
15	Exhaust-gas temperature sensor

The Digital Diesel Electronics (DDE) assumes the following functions:

- Evaluation of the Nitrogen Oxide sensor
- Evaluation of the exhaust-gas temperature sensor
- Calculation of the urea/water mixture (AdBlue®) amount and transmission to the SCR control unit via PT-CAN
- Control of the switch off scenario

Metering strategy

The metering strategy in the Digital Diesel Electronics (DDE) is the part of the SCR control that calculates how much urea/water mixture (AdBlue®) is injected at which time.

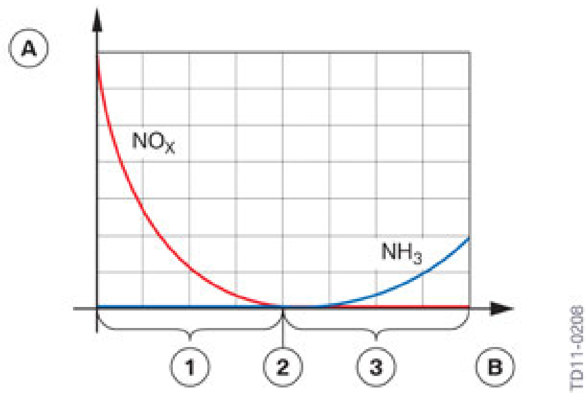
The signal of the NO_x sensor before the SCR catalytic converter is used for the calculation of the quantity in normal operation. This calculates the amount of Nitrogen Oxide in the exhaust gas and transmits the value to the Digital Diesel Electronics (DDE).

However, the NO_x sensor must reach its operating temperature in order to begin measuring. Depending on the ambient temperature this can take up to 15 min. Until this point, a substitute value is calculated by the DDE for the determination of the Nitrogen Oxide quantity in the exhaust gas.

In order to monitor the system there is a second NO_x sensor located after the SCR catalytic converter. It measures whether there are still Nitrogen Oxides present in the exhaust gas at that point. If this is the case, then the fluid injection rate of the urea/water mixture (AdBlue®) is adapted accordingly. The NO_x sensor does not, however, just measure the Nitrogen Oxides, but also ammonia, but is unable to make a distinction between the two.

If too much urea/water mixture (AdBlue®) was injected, the Nitrogen Oxides are completely reduced. However, there is an increased risk of what is known as "ammonia slip” or leakage; in other words ammonia escapes from the SCR catalytic converter. The signal value increases as the NO_x sensor measures again. Therefore, the target is set to when the sensor signal reaches a minimum value (item 2 in the graph below).

3. SCR 3



Nitrogen oxide and ammonia emissions diagram for the SCR system

Index	Explanation
A	Calculated value of the NO_x sensor
B	Injected quantity of urea/water mixture (AdBlue®)
1	Insufficient quantity of urea/water mixture (AdBlue®) injected
2	Correct quantity of urea/water mixture (AdBlue®) injected
3	Too large a quantity of urea/water mixture (AdBlue®) injected

However, this is a long-term adaptation and not a short-term control as the SCR catalytic converter has a memory function for ammonia.

Metering system control

The metering system control in the SCR control is thus the implementing function. It implements the requirements set by the metering strategy. This includes both the metering and the injection of the urea/water mixture (AdBlue®) as well as the supply of the urea/water mixture (AdBlue®).

In the following the tasks of the metering system control in normal operation are listed:

Metering of the urea/water mixture (AdBlue®):

- Implementation of the required target amount of urea/water mixture (AdBlue®)
- Return of the required urea/water mixture actual quantity (AdBlue®)

Supply of the urea/water mixture (AdBlue®):

- Provision of the metering ability (fill lines and pressure build-up) under certain ambient conditions (temperature)
- Empty lines at after-run
- Activation of the heating

3. SCR 3

3.2.2. Supply of the urea/water mixture (AdBlue®)

The Selective Catalytic Reduction (SCR) system requires a constant supply of urea/water mixture (AdBlue®). This medium must be stored in the vehicle and made available as quickly as is necessary under all ambient conditions. This means that the urea/water mixture (AdBlue®) should be always available at the metering valve under a required pressure.

3.2.3. Metering of the urea/water mixture (AdBlue®)

The metering strategy establishes what quantity of the urea/water mixture (AdBlue®) should be injected. The metering system control now ensures the implementation of this requirement. The metering activation is a part of the function from which the actual opening of the metering valve is determined.

Depending on the load level of the engine and speed of the vehicle, the metering valve injects with a frequency of 0.55 Hz to 20 Hz.

In order to inject the right amount the metering control calculates the following:

- Duty cycle for the actuator of the metering valve in order to determine the injection period
- Activation delay to compensate for metering valve inertia

The metering system control also calculates the actual metered amount and sends this back to the metering strategy.

The metering amount is also calculated over a longer period of time. This long term calculation is reset upon filling.

In order to fulfil these tasks various functions are necessary that are described in the following.

Heating

As the urea/water mixture (AdBlue®) freezes at a temperature of -11 °C (12.2 °F) the system must be heated.

The heating has the following tasks:

- Monitoring of the temperatures in the active tank and its surrounding area
- Thawing of a sufficient amount of urea/water mixture (AdBlue®) and the components required for metering at system start up
- Prevention of freezing of the relevant components during operation
- Monitoring of the components of the heating system

The following components are heated:

- Active tank via flange module
- Metering line (from the active tank to the metering module)

3. SCR 3

The heating of the active tank is adjusted depending on the temperature in the active tank and the ambient temperature. The required control of the heating for the metering line and the heating for the tank flange module are based on the current values of the ambient temperature and the temperature of the urea/water mixture (AdBlue®).

The heater circuits are supplied with power by a semiconductor switch. The power semiconductors is designed as high side switch; it is controlled directly by the control unit. With help of a measuring shunt, the SCR control unit calculates the actual current, flowing over the heating elements. The SCR control unit can also perform a function check of the heater circuits and thus detect any faults which are stored in the fault memory.

A temperature model is used for the heating of the components in order to establish the metering readiness.

The following three basic parameters are set in the temperature model so that metering readiness can be reached.

The following values are defined by law and must be observed:

- At - 25 °C (-13 °F), metering readiness is reached after 45 minutes.
- At - 15 °C (5 °F), metering readiness is reached after 20 minutes.
- At - 9 °C (15.8 °F), metering readiness is reached after 3 minutes.

The following table shows the metering readiness in relation to the temperature:

SCR 3, metering readiness temperature

Index	Explanation
t [min]	Time in minutes
°C	Temperature in degree Celsius

At a temperature below - 9 °C (15.8 °F) in the active tank, metering readiness is delayed, i.e. a defined time is waited until a pressure build-up attempt begins. This time is constant from - 9 °C (15.8 °F) to - 16.5 °C (2.3 °F) as the temperature up to which the urea/water mixture (AdBlue®) is frozen cannot be ascertained. At less than -16.5 °C (2.3 °F), the heating period until a pressure build-up attempt is extended.

Generally heating up the metering line is significantly faster which is why the temperature in the active tank is decisive for the period until a pressure build-up attempt has been undertaken. If there is significantly lower ambient temperature than the temperature in the active tank it can occur that the warm-up phase of the metering line becomes longer. Then the ambient temperature is used for the delay of the metering readiness.

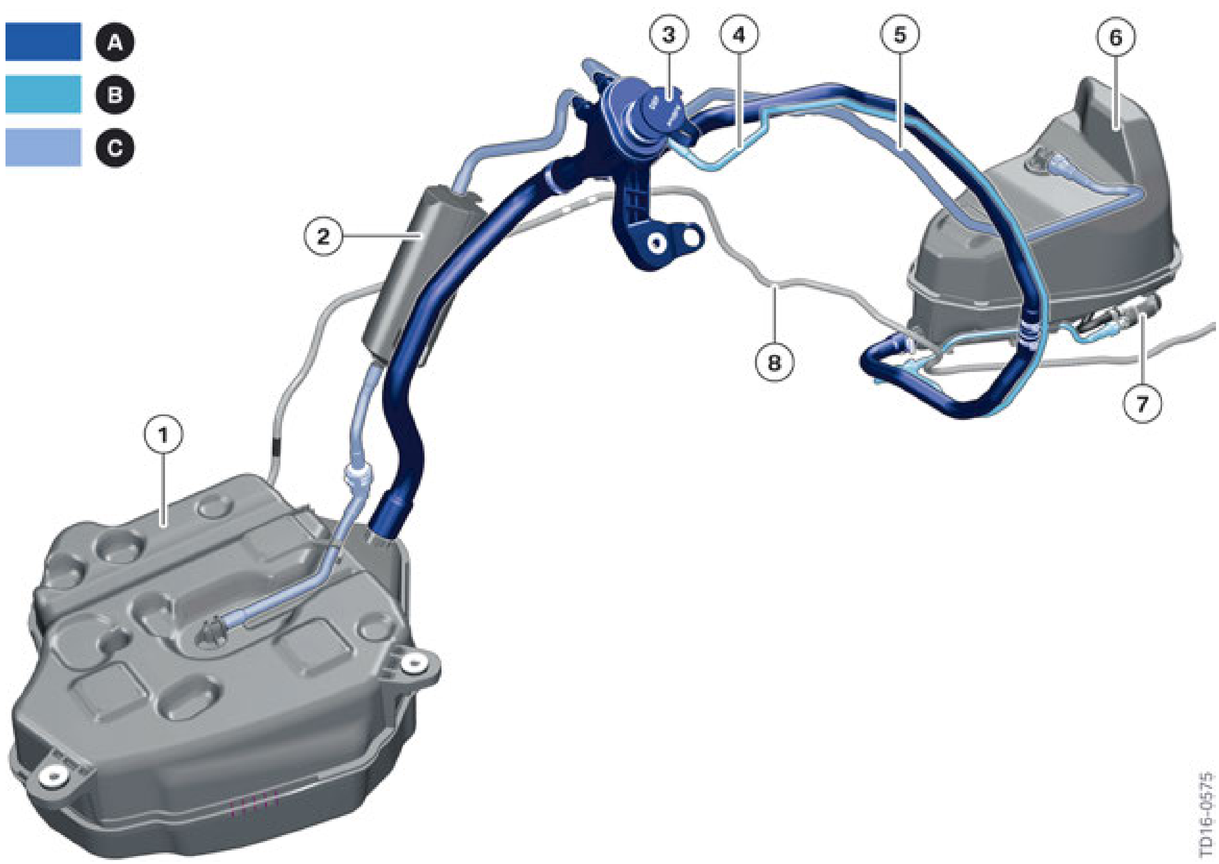
Recirculated pumping

As storing the urea/water mixture (AdBlue®) requires two tanks (depending on the series) a recirculated pumping is required.

The delivery of urea/water mixture (AdBlue®) from the passive to the active tank is described as recirculated pumping.

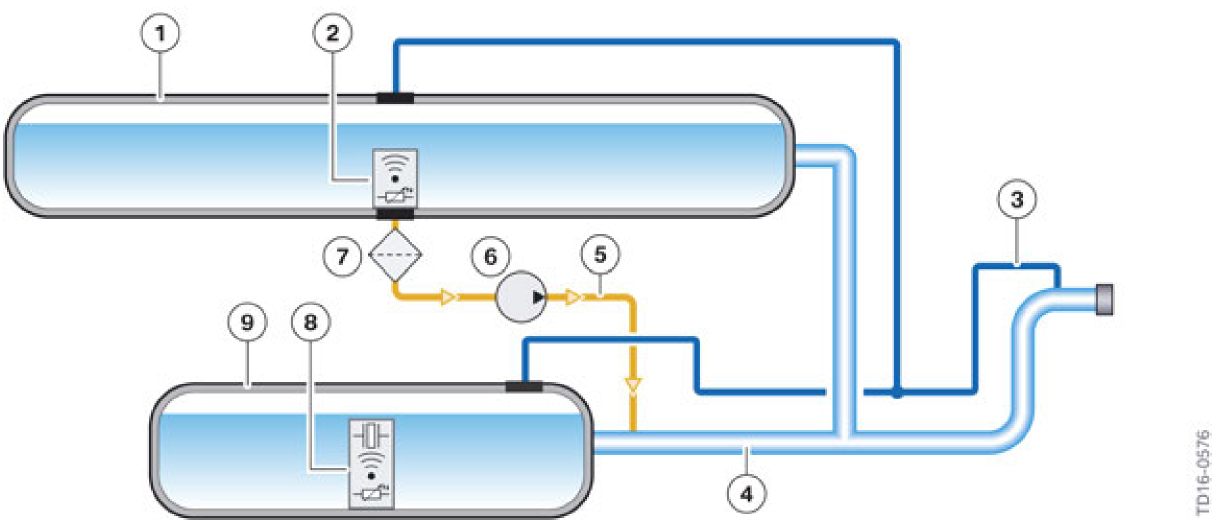
During transfer pumping, the transfer pump pumps the urea/water mixture (AdBlue®) from the passive tank into the filling pipe. Because the filling pipe in the active tank is located below the filling pipe of the passive tank, the urea/water mixture (AdBlue®) does not return to the passive tank, but flows into the active tank.

The following image illustrates the installation position of the components:



Pipes of SCR 3 tank system (G30)

Index	Explanation
A	Fluid filler neck breather pipes
B	Transfer lines
C	Tank ventilation lines
1	Active tank
2	Bubble container
3	Filler cap with active tank and passive tank filling line
4	Transfer line
5	Tank ventilation line
6	Passive tank
7	Recirculating pump unit
8	Metering line



SCR 3, transfer pumping

Index	Explanation
1	Passive tank
2	Temperature level sensor, passive tank
3	Tank ventilation line
4	Fluid filler neck breather pipe, active tank — passive tank
5	Transfer line
6	Recirculating pump unit
7	Filter
8	Temperature sensor, filling level sensor and quality sensor active tank
9	Active tank

3. SCR 3

The following preconditions must be met for recirculated pumping:

- There is urea/water mixture (AdBlue®) in the passive tank.
- The ambient temperature is above a minimum value of -7 °C (19.4 °F) for at least ten minutes in the case of a longer engine switch-off time.
- The ambient temperature is above a minimum value of 0 °C (32 °F) for at least ten minutes in the case of a shorter engine switch-off time.
- A free volume of 300 g (10 oz) is reached in the active tank.
- Active tank and passive tank contain a liquid urea/water mixture (AdBlue®) (tank temperature below - 5 °C (23 °F)).

Then enough time is spent pumping until the active tank is full again. If the "full" level is reached before this, then transfer pumping is stopped.

If there is a fault in the fluid level sensor then there is no pumping.

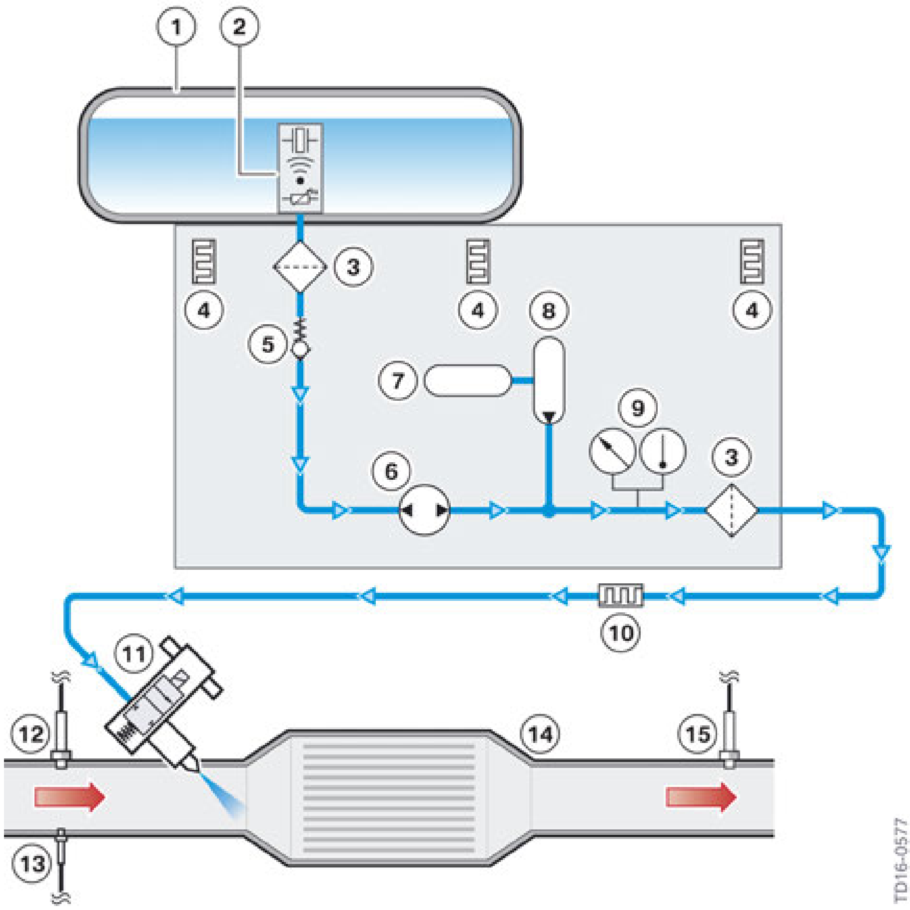
Delivery

The urea/water mixture (AdBlue®) is delivered from the active tank to the metering module. This pump located in the tank flange module handles this task. The tank flange module requires the following components for this:

- Filter
- Pump
- Pressure accumulator
- Pressure sensor
- Temperature sensor
- Filter
- Metering line
- Heating, metering line, if required
- Metering valve

SCR 3 (US)

3. SCR 3



SCR 3, delivery

Index	Explanation
1	Active tank
2	Temperature sensor, filling level sensor and quality sensor active tank
3	Filter
4	Heating
5	Shutoff valve (open with the pump installed)
6	Pump
7	Ice pressure damper
8	Pressure accumulator
9	Pressure sensor/temperature sensor
10	Heating metering line
11	Metering module

Index	Explanation
12	NO_x sensor before the SCR catalytic converter
13	Exhaust-gas temperature sensor after diesel particulate filter
14	SCR catalytic converter
15	NO_x sensor after SCR catalytic converter

The pump motor is activated by three-phase alternating current from the SCR control unit. Hall effect sensors monitor the direction of rotation and pump speed. The value for the speed specification is calculated by the SCR control unit based on the signal from the pressure sensor.

During the system start, the pump is activated at a fixed speed, and the line is thus filled up to the SCR metering module; pressure build-up then starts. Only then does the pressure regulation take place.

When filling the metering line a small amount of the urea/water mixture (AdBlue®) is injected into the exhaust system as the metering valve is open.

During pressure regulation, i.e. normal operation with metering, the pump is activated in such a way that a relative pressure of 5.5 bar is applied to the metering line. SCR 3 uses volumetric delivery, in other words, the volume of urea/water mixture (AdBlue®) delivered by the pre-supply pump is also actually injected at the metering valve.

The quantity is determined by the opening period and opening stroke of the metering valve. However, this is so low that no noticeable pressure drop occurs in the metering line under normal driving conditions.

To maintain the relative system pressure of 5.5 bar, the system is supported by a pressure accumulator in case of high urea/water mixture (AdBlue®) requirements. These high urea/water mixture (AdBlue®) requirements could occur, e.g. during an abrupt transition from idle to full throttle (dynamic start at traffic lights). To prevent a pressure drop in this case, the urea/water mixture (AdBlue®) request is supported by the pressure accumulator.

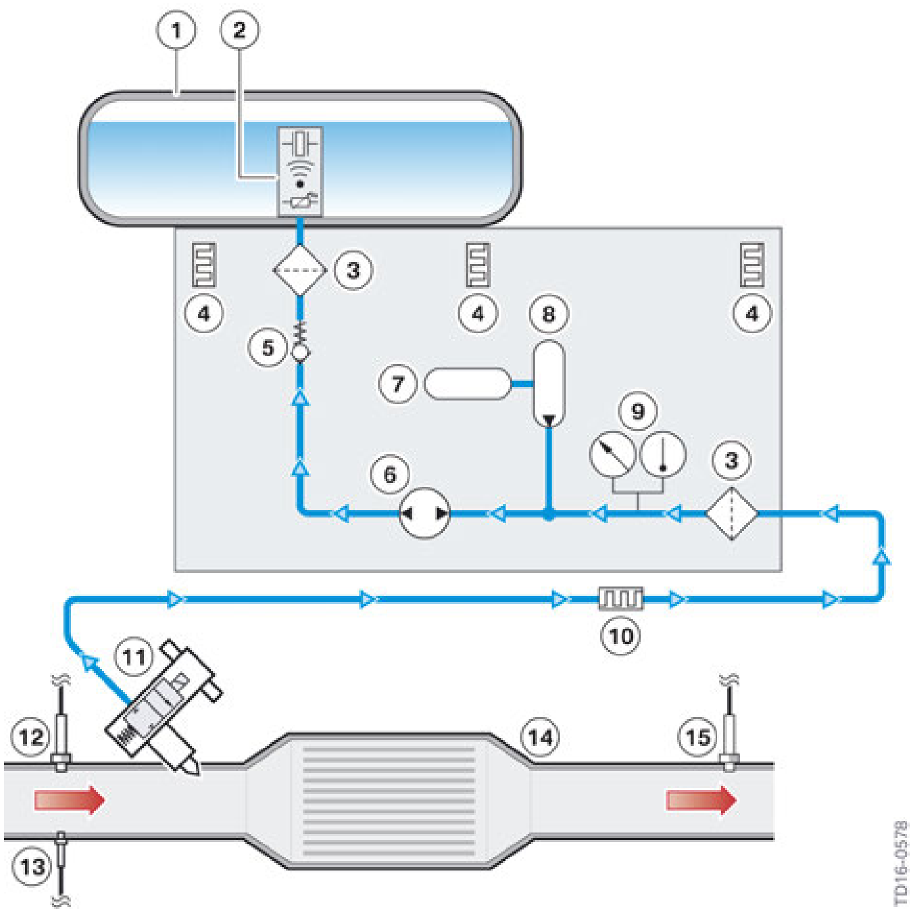
Draining function

After stopping the engine, the pump on the tank flange module is activated and the metering line and the metering module are drawn off. The SCR metering module is still about 50% full of urea/water mixture (AdBlue®) after this. Complete drawing off of the SCR metering module is not possible due to the available time. The amount drawn off is such that a defined volume is available, preventing any urea/water mixture (AdBlue®) that freezes can expand. The tank flange module requires the following components for this:

- Metering valve
- Metering line
- Heating, metering line, if required
- Filter
- Temperature sensor
- Pressure sensor

3. SCR 3

- Pressure accumulator
- Pump
- Filter



SCR 3, drawing off

Index	Explanation
1	Active tank
2	Temperature sensor, filling level sensor and quality sensor active tank
3	Filter
4	Heating
5	Shutoff valve (open with the pump installed)
6	Pump
7	Ice pressure damper
8	Pressure accumulator
9	Pressure sensor/temperature sensor
10	Heating metering line

Index	Explanation
11	Metering module
12	NO_x sensor before the SCR catalytic converter
13	Exhaust-gas temperature sensor after diesel particulate filter
14	SCR catalytic converter
15	NO_x sensor after SCR catalytic converter

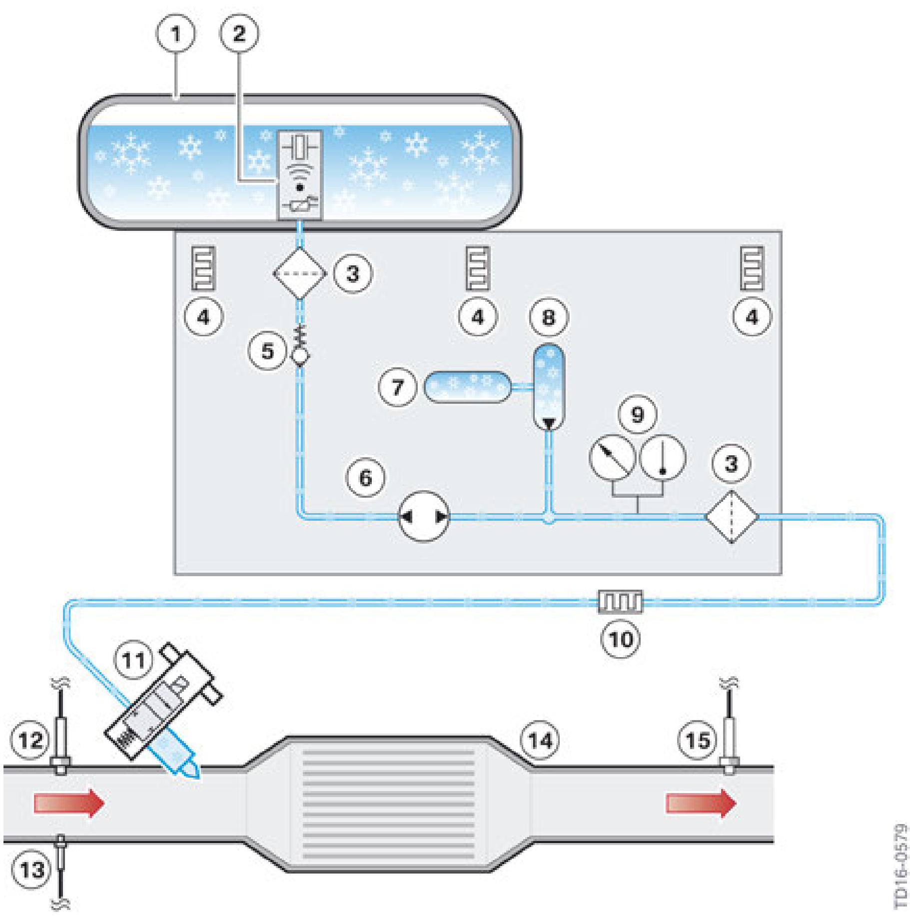
Even if the system has to be switched off due to a fault or, e.g if the minimum temperature in the active tank can no longer be maintained, it is drawn off.

It should by all means be avoided that a urea/water mixture (AdBlue®) remains in the metering line or metering module which could freeze.

When drawing off the metering valve is open.

Frozen

If the ambient conditions (below - 11° C / 12.2 °F) cause the urea/water mixture (AdBlue®) to freeze, the components of the tank flange module are protected by ice pressure dampers.



SCR 3, frozen

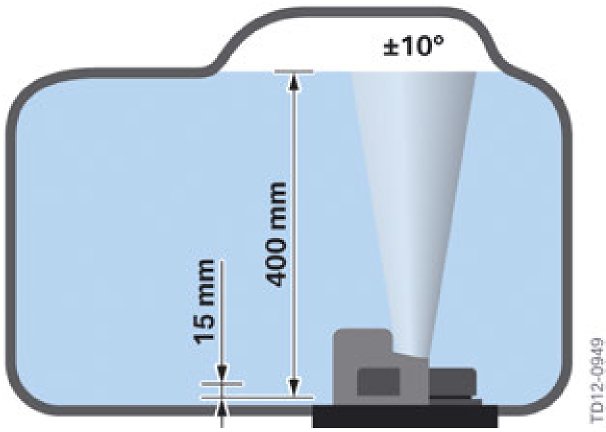
3. SCR 3

Index	Explanation
1	Active tank
2	Temperature sensor, filling level sensor and quality sensor active tank
3	Filter
4	Heating
5	Shutoff valve (open with the pump installed)
6	Pump
7	Ice pressure damper
8	Pressure accumulator
9	Pressure sensor/temperature sensor
10	Heating metering line
11	Metering module
12	NO_x sensor before the SCR catalytic converter
13	Exhaust-gas temperature sensor after diesel particulate filter
14	SCR catalytic converter
15	NO_x sensor after SCR catalytic converter

The diaphragm in the ice pressure damper allow volume expansion in the internal lines of the tank flange module; the expansion is designed for the residual amount of urea/water mixture (AdBlue®) present in the SCR tank flange module. The resulting volume increase in the ice pressure damper protects the internal components of the tank flange due to ice formation. The ice pressure damper is located in the pressure accumulator.

Filling level measurement passive tank and temperature measurement

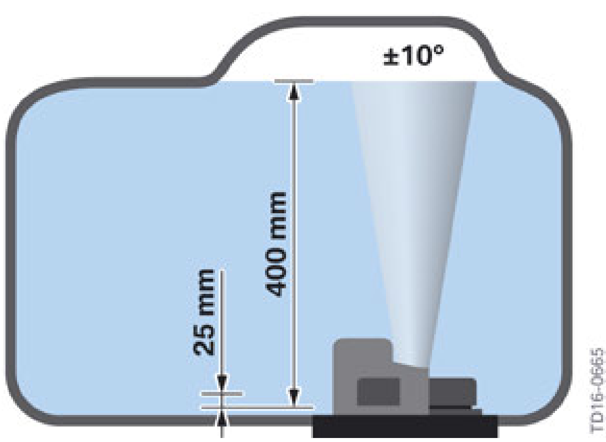
The passive tank (if installed) contains a filling level sensor and a temperature sensor which are identical in design to the SCR 2. This is an ultrasonic sensor (direct piezo element) for the filling level; it can measure filling levels in a range of 15 mm to 400 mm. The temperature sensor is recessed into the tank flange and relies on the NTC (negative temperature coefficient) principle. The filling level sensor and temperature sensor signals are not sent directly to the SCR control unit, but to an evaluation unit in the tank flange, since the SCR control unit cannot process the results of the ultrasonic sensor and temperature sensor directly. The evaluation unit converts the ultrasonic value and measured value of the temperature sensors to a pulse-width modulated signal (PWM signal), which can be processed by the SCR control unit.



SCR 3, passive tank ultrasonic sensor filling level measurement range

Active tank level measurement and temperature measurement

The sensor unit in the active tank contains a filling level sensor and the temperature sensor. An ultrasonic sensor (direct piezo elements) recessed in the sensor unit is used for filling level measurement. The filling level sensor relies on a piezo element based on the principle of ultrasonic sound operating time measurement; it records filling levels in a range of 25 mm to 400 mm. Both the direct and inverse piezo effect are used for this. In other words, the piezo element operates as a sensor and a receiver. The piezo element emits an ultrasonic pulse, which is reflected by the urea/water mixture (AdBlue®). The required operating time is a measure of the stroke travelled. The temperature sensor is also recessed into the tank flange and relies on the NTC (negative temperature coefficient) principle. The filling level sensor and temperature sensor signals are not sent directly to the SCR control unit, but to a sensor unit, since the SCR control unit cannot process the results of the piezo elements and temperature sensors directly. The sensor unit converts the piezo element values and the measured values from the temperature sensors into a SENT protocol, which the SCR control unit can process.

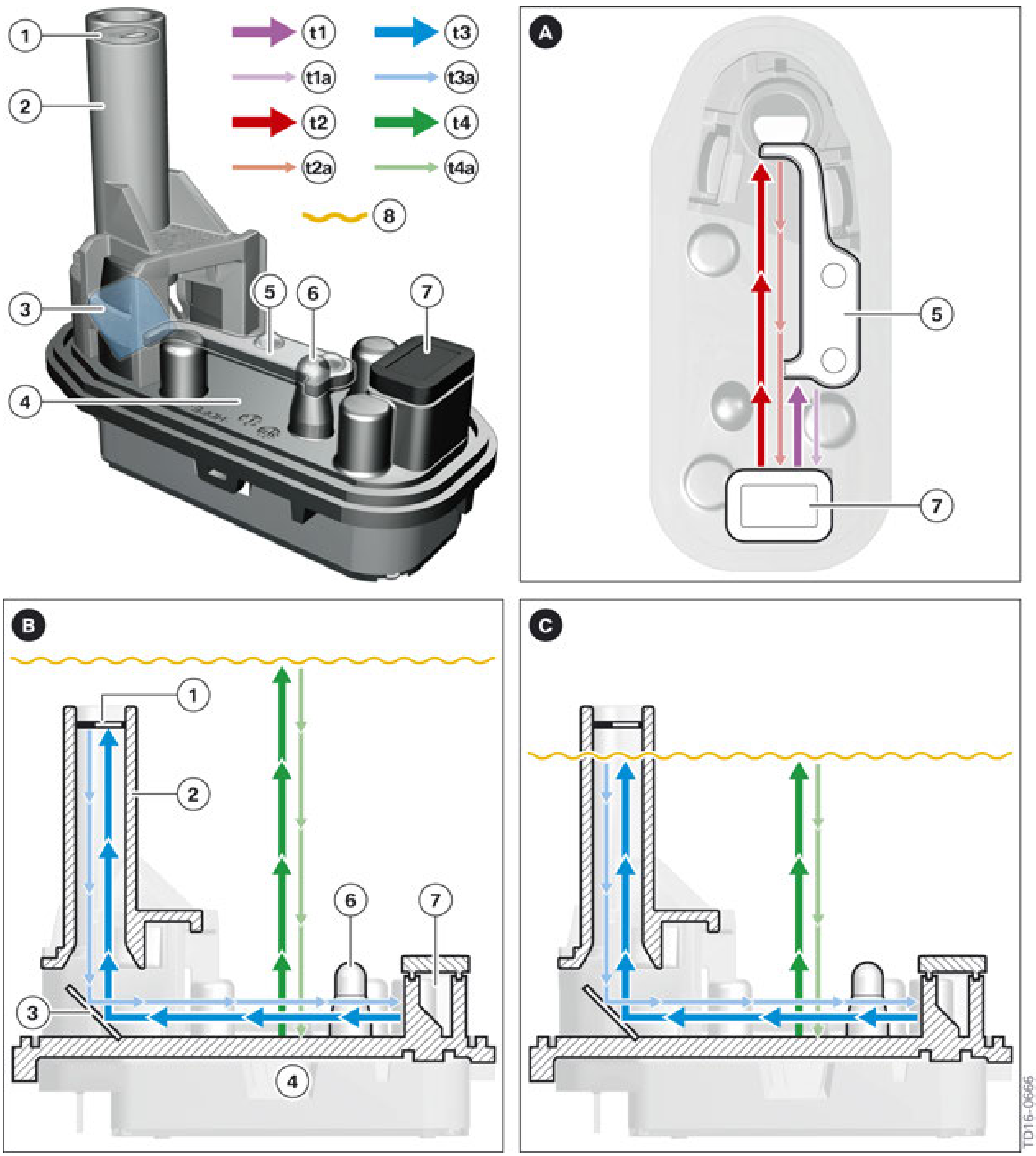


SCR 3, active tank ultrasonic sensor filling level measurement range

The sensors are active in the RESIDING-PAD-DRIVING states (Awake-Testing-Ready).

Urea/water mixture (AdBlue®) Quality monitoring/filling level measurement active tank (combined piezo element)

As well as the direct filling level measurement, an additional filling level measurement combined with quality monitoring is used for the SCR 3. The combined quality monitoring/filling level measurement is implemented using a combined piezo element.



SCR 3, direct piezo element/combined piezo element

Index	Explanation
A	Urea/water mixture (AdBlue®) quality sensor/sound propagation time reference measurement
B	Urea/water mixture (AdBlue®) filling level measurement, filling level high
C	Urea/water mixture (AdBlue®) filling level measurement, filling level low/ plausibility measurement
t1	Urea/water mixture (AdBlue®) quality sensor/sound transmitting channel 1
t1a	Urea/water mixture (AdBlue®) quality sensor/sound receiving channel 1
t2	Urea/water mixture (AdBlue®) quality sensor/sound transmitting channel 2
t2a	Urea/water mixture (AdBlue®) quality sensor/sound receiving channel 2
t3	Filling level measurement/sound transmitting channel 1 (17 - 58/59 mm)
t3a	Filling level measurement/sound receiving channel 1 (17 - 58/59 mm)
t4	Filling level measurement/sound transmitting channel 1 (25 - 400 mm)
t4a	Filling level measurement/sound receiving channel 1 (25 - 400 mm)
1	Reflector
2	Measuring tube/filling level
3	Passive reflector for determining the filling level
4	Direct piezo element
5	Reflector plate for urea/water mixture (AdBlue®) quality
6	Temperature sensor
7	Combined piezo element
8	Urea/water mixture (AdBlue®) filling level

During the filling level measurement using the combined piezo element, it is possible to monitor the filling levels in a range of 17 mm to 58/59 mm.

For a high urea/water mixture (AdBlue®) filling level as shown in Graphic B, the filling level measurement is conducted using the direct piezo element. If the urea/water mixture (AdBlue®) filling level is below the level of the measuring tube as shown in Graphic C, the measured values of the combined piezo element are used in addition to the direct piezo element measured values. This allows the plausibility of the two sensors to be monitored and also ensures a precise measured value when the urea/water mixture (AdBlue®) capacity is low.

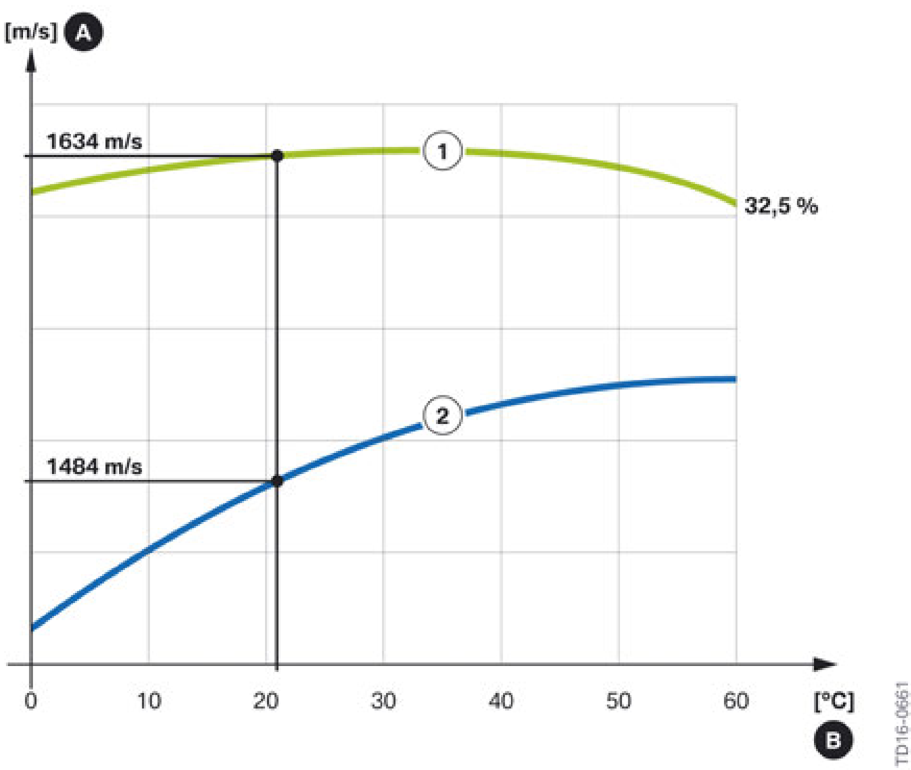
Urea/water mixture (AdBlue®) quality monitoring

The sound propagation time for the urea/water mixture (AdBlue®) quality monitoring is determined from two measurements; as shown in Graphic A. The measured sound propagation from transmitting the ultrasound signal t2 to receiving the ultrasound signal t2a is used as a measurement. The second measurement is based on the sound propagation times for the values t1 and t1a. The measured values are subtracted in order to determine the urea/water mixture (AdBlue®) quality downstream. **(t2+t2a)-(t1+t1a).** The value obtained this way is the reference value for the urea/water mixture (AdBlue®) quality.

Speed of sound

The speed of sound in a material depends on the material's chemical nature and thus the material constant. This means that the sound's propagation speed assumes a different value in each chemical compound. That means: For a fluid composed of two components, the system's sound velocity changes characteristically with the composition so that the respective composition can be determined using a sound velocity measurement when the concentration dependence is known (calibration measurement).

The sound velocity is strongly dependent on the temperature. A calibration measurement is therefore only valid for a certain temperature. If the intention is to take measurement at other temperatures, the calibration curve must be re-measured at this temperature.



SCR 3, urea/water mixture (AdBlue®) concentration

Index	Explanation
A	Speed of sound
B	Temperature
1	Urea/water mixture (AdBlue®)
2	Water

The reference values for sound velocities for the respective temperatures of the urea/water mixture (AdBlue®) are saved in the SCR control unit. This allows the control unit to compare the actual values with the nominal values and display any deviation in the urea/water mixture (AdBlue®) quality using the malfunction indicator lamp.

The ultrasound sensors are connected to the electronic sensor unit via a conductor path. In the sensor unit, the ultrasound values are converted into a SENT protocol which can then be processed by the SCR control unit.

The combined urea/water mixture (AdBlue®) quality sensor/filling level sensor is active in the RESIDING-PAD-DRIVING states.

⚠

To avoid overfilling the urea/water mixture (AdBlue®) refill using the KRUSE bottle/dispenser or the service filling hose to ensure that a defined air gap remains in the tank. This air gap is required so that the filling level sensors based on the runtime measurement can deliver a measuring result. If there is no air gap between the upper filling level and the tank housing, the sound waves will not be correctly reflected and this will lead to the filling level sensors malfunctioning.

Pressure monitoring

A combined pressure/temperature sensor with a measuring range of – 1 bar to 13 bar is used to monitor the system pressure of the SCR 3. The measured values of the pressure sensor are transmitted to an electronic evaluation unit in the electronic sensor unit. In the sensor unit, the pressure values are converted into a SENT protocol which can then be processed by the SCR control unit.

The pressure sensor is active in the RESIDING-PAD-DRIVING states.

SENT protocol

Single **E**dge **N**ibble **T**ransmission

Single **E**dge **N**ibble **T**ransmission is a simple digital interface standardized in the automotive industry and used for communication between sensors and control units.

It is a unidirectional, asynchronous voltage interface that requires only three lines. This is the usual 5 V / 12 V supply voltage, the signal voltage and the ground connection. The SENT protocol is characterized by its simplicity and resistance to fault signals. Another advantage is that the data is available in digital format in the sensor after the A/D conversion, meaning it can be processed further directly by the control unit.

3.2.4. Warning and switch off scenario

The SCR system is relevant for the exhaust-emission regulations. It thus fulfils an important emission requirement. If the system fails, the approval is void and the vehicle can no longer be operated. A very plausible case which leads to a system failure is that the supply of the urea/water mixture (AdBlue®) runs out.

Without urea/water mixture (AdBlue®) a further operation of the vehicle is not allowed, therefore the engine can no longer be started.

The control of the switch off scenario is subject to the Digital Diesel Electronics (DDE).

3. SCR 3

So that it does not come as a surprise to the driver, there is a warning and switch off scenario that begins long enough before the disabling of the vehicle so that the customers can comfortably either refill the urea/water mixture (AdBlue®) themselves or have it refilled by a BMW service department. According to legal regulations in the US the first warning must have a range of 1000 mls based on a linear counter.

Warning scenario

Warning level 1

At the start of the inducement (engine shut off scenario) a residual amount of DEF (about 3 liters depending on model) should in any case be enough for a range of 1000 mls. The “linear counter” is started from this point irrespective of the actual DEF consumption. The driver receives a priority 1 Check Control message (white), with a check control message showing the remaining range.

A range of **999 mls** is actually displayed to provide a safety reserve margin.

Check Control display: **“Refill Exhaust Fluid Reserve/AdBlue, range: 999 mls”**

SCR 3, Check Control message in the instrument cluster at warning level 1

At the same time, an instruction is also output via the Central Information Display (CID):

"Exhaust Fluid /AdBlue Reserve. Exhaust Fluid /AdBlue must be refilled. Have vehicle checked by your BMW Service Department."

From this point onwards, the available range is counted downwards linearly, irrespective of actual urea/ water mixture (AdBlue®) consumption.

Warning level 2

If the fluid level sensor has dropped below “empty” then the driver receives a priority 2 Check Control message (yellow). "Refill DEF" and the remaining range is displayed in miles. Although there is still a DEF reserve in the active tank (which would normally allow a range greater than 200 miles) a range of 199 mls is actually displayed to provide a safety reserve margin.

Check Control display: **“Refill Exhaust Fluid Reserve/AdBlue®, range: 199 mls”**

SCR 3, Check Control message in the instrument cluster at warning level 2

At the same time, an instruction is also output via the Central Information Display (CID):

“Refill Exhaust Fluid /AdBlue®”

“Note range! Exhaust Fluid /AdBlue® must be refilled, immediately, otherwise it will not be possible to restart the engine. Drive to the nearest BMW Service."

From this point onwards, the available range is counted downwards linearly, irrespective of actual urea/ water mixture (AdBlue®) consumption.

Warning level 3

If the range falls to 0 ml three lines are displayed instead of the range – next to the fuel gauge.

SCR 3, Check Control message in the instrument cluster range = 0 mls

Check Control display: "**Refill Exhaust Fluid/AdBlue®, range: — — —**"

At the same time, an instruction is also output via the Central Information Display (CID):

"Refill Exhaust Fluid /AdBlue®"

"Engine start without Exhaust Fluid /AdBlue® is no longer possible. Diesel Exhaust Fluid / AdBlue® must be refilled. Please drive to the nearest BMW Service Department"

Switch off scenario

When the range of 0 mls has been met the next engine start is prevented, **but only if the engine was switched off for more than three minutes.** This ensures being able to escape any dangerous situations.

The normally remaining 0.8 l are a safety reserve for the following scenarios:

- The vehicle is filled up with fuel and is started with a very low urea/water mixture (AdBlue®) range (e.g. 1 km). The urea/water mixture (AdBlue®) range reaches 0 km/mls but the vehicle can still be driven until the next engine shutdown. Here it is ensured that the vehicle is still operated with a functioning SCR system, even in this case.

⚠

For vehicles with PRD (Parking/Residing/Driving), the SCR control unit with the SCR 3 is also active in the Residing state, but is switch off after around ten seconds by the sub-power supply operation. The SCR control unit must be activated in the PAD state in order to ensure secure refilling detection. In addition, press the START-STOP button three times in quick succession. Observe the notes in the motor vehicle's operating instructions.

Incorrect filling

If an incorrect medium is filled, this will be displayed by the quality sensor's quality monitoring. However, this also manifests itself a few hundred miles later as the Nitrogen Oxide (NO_x) levels in the exhaust gas increase, despite sufficient injecting of the urea/water mixture (AdBlue®). If certain limit values are exceeded, the system identifies a wrong medium. From this point this is displayed by a Check Control symbol (display of range or a reduction of range is not displayed).

SCR 3, Check Control message in the instrument cluster in the event of wrong medium detected

Check Control symbol: "**Exhaust Fluid/AdBlue® wrong medium**"

At the same time, an instruction is also output via the Central Information Display (CID):

Exhaust Fluid/AdBlue® wrong fluid"

"Have the vehicle checked by your BMW Service Authorized Workshop."

System fault

A system fault is displayed and the range reduced if faults occur that prevent the urea/water mixture (AdBlue®) being metered or if there is a failure or fault with the communication between the Digital Diesel Electronics (DDE) and the SCR control unit.

SCR 3, Check Control message in the instrument cluster in the event of system fault

Check Control symbol: "**Exhaust Fluid/AdBlue® system fault"**

At the same time, an instruction is also output via the Central Information Display (CID):

Exhaust Fluid/AdBlue® system fault

"Have system checked by your BMW Service Department."

⚠

For the workshop to be able to start the engine for troubleshooting in the case of an **"AdBlue® system fault"**, or to support self-diagnosis by the SCR system, the ISTA diagnosis system includes the service function "Reset: SCR switch-off scenario". The reset function allows additional engine starts as well as an additional range of 50 km for self-diagnosis with the SCR 3 system. Further information in the chapter: "Service instructions for troubleshooting".

3.2.5. On-Board Diagnosis functions

The Digital Diesel Electronics (DDE) additionally has the task of monitoring all exhaust-relevant systems for their problem-free function. This task is described as an On-Board Diagnosis (OBD). If a fault is registered by the On-Board Diagnosis then the emissions warning light is activated.

In the following the most important SCR specific results are explained that lead to the lighting up of the emissions warning light.

SCR catalytic converter

The effectiveness of the SCR catalytic converter is monitored by the two Nitrogen Oxide sensors.

The Nitrogen Oxide mass is measured before and after the SCR catalytic converter and a sum is formed over a certain period. The actual reduction is compared to a calculated value which is stored in the Digital Diesel Electronics (DDE).

For this the following preconditions must be met:

- NO_x sensors plausible
- Metering active
- Ambient temperature in the defined area
- Ambient pressure in the defined area
- Diesel particulate filter regeneration not active
- SCR catalytic converter temperature in the defined area (is calculated using exhaust-gas temperature sensor before the SCR catalytic converter amongst others)
- Exhaust flow in the defined area

Monitoring includes four measuring cycles. If the actual value is lower than the one calculated a reversible fault is created. If the fault is determined in three successive driving cycles, then an irreversible fault is stored and the malfunction indicator lamp is activated.

In order to guarantee the SCR catalytic converter over a long period there is a metering-quantity adaptation in which the metered amount is adjusted to the urea/water mixture (AdBlue®). In order to undertake the adaptation the signal of the NO_x sensor after the SCR catalytic converter is continuously compared with a calculated value. If deviations occur here then the metering amount is adjusted in the short-term. The systematics of the adaptations is evaluated and a correction factor is applied to the metering amount.

If the correction factor exceeds a certain threshold a reversible fault is created. If the fault is determined in three driving cycles following one another then an irreversible fault is stored and the emissions warning light is activated.

3. SCR 3

Supply of urea/water mixture (AdBlue®)

For a problem-free function of the SCR catalytic converter the supply of urea/water mixture (AdBlue®) is necessary.

After the SCR catalytic converter reaches a certain temperature (calculated by the exhaust-gas temperature sensor in front of the SCR catalytic converter, amongst other things) the metering control tries a pressure build-up in the metering line. To allow this to happen, the metering module must also be closed and the pump must be activated for a certain amount of time.

If the pressure threshold cannot be reached within a certain amount of time then the metering module is opened in order to bleed the metering line. Subsequently a renewed pressure build-up is attempted.

If a set number of pressure build-up attempts take place unsuccessfully then a reversible fault is created. If the fault is determined in three successive driving cycles, then an irreversible fault is stored and the malfunction indicator lamp is activated.

This monitoring only runs once per driving cycle before the metering begins. If this monitoring is "passed" then the continuous pressure monitoring begins.

For the Selective Catalytic Reduction (SCR) a constant pressure of the urea/water mixture (AdBlue®) is necessary (5,5 bar). The actual pressure and the resulting pressure module are determined and monitored by the SCR control unit using the pressure sensor. The following values are checked:

- High pressure
- Vacuum
- Implausible pressure readings

If these limits are exceeded for a certain amount of time a reversible fault is created. If the fault is determined in three driving cycles following one another then an irreversible fault is stored and the emissions warning light is activated, the pressure in the SCR system is reduced fully and the SCR system shut down.

This monitoring takes place in active metering.

Level measurement of active tank

Two filling level sensors with piezo elements are used for the active tank. The plausibility of the sensors takes place in the sensor unit in which it is checked if the signals are logical.

In this case the sensor unit sends a plausibility fault via the SCR control unit to the Digital Diesel Electronics (DDE). A reversible fault is created. If the fault is determined in three successive driving cycles, then an irreversible fault is stored and the malfunction indicator lamp is activated.

This monitoring only takes place if the temperature in the active tank is above a certain value.

If the line between the sensor unit and at least one filling level sensor contact is interrupted, the fault is reported to the Digital Diesel Electronics (DDE). A reversible fault is created. If the fault is determined in three successive driving cycles, then an irreversible fault is stored and the malfunction indicator lamp is activated.

SCR 3 (US)

3. SCR 3

Suitable urea/water mixture (AdBlue®)

The SCR system is monitored with a wrong medium in terms of refilling. This monitoring begins when refilling is identified. The refilling identification is described in the SCR system extract.

Both monitoring of the urea/water mixture (AdBlue®) medium quality and the effectiveness of the SCR catalytic converter are referenced in order to detect an incorrect medium. If the fault is determined in the following driving cycle then an irreversible fault is stored and the emissions warning light is activated.

NO_x sensors

For the function and therefore also the monitoring of the NO_x sensor a so-called dew point must be reached. This ensures that no more water is in the exhaust that could damage the NO_x sensors.

If a fault is identified by the following monitoring of the NO_x sensor then: A reversible fault is created. If the fault is determined in three successive driving cycles, then an irreversible fault is stored and the malfunction indicator lamp is activated.

The following faults are identified:

- Identification signal or correction factor wrong.
- Interrupted line or short circuit between measuring probe and control unit of the NO_x sensor.
- Measured value outside of the defined area for a certain time.
- Operating temperature is not reached after a defined heating period.
- In coasting (overrun) mode (no Nitrogen Oxide expected) too great a distance from the measured value to zero is identified.
- In the transfer from the load in coasting (overrun) mode the signal of the NO_x sensor does not fall from 80% to 50% quickly enough (only NO_x sensor before the SCR catalytic converter).
- If, despite a spike in the signal of the NO_x sensor before the SCR catalytic converter there is not at least one defined change in the signal of the NO_x sensor after the SCR catalytic converter, then this counts as implausible.

Display and driver information

The SCR control unit delivers the combined data from the level sensor in the active tank and passive tank, if installed, to the Digital Diesel Electronics (DDE), which makes the data accessible to other bus users via the FlexRay and central gateway module (ZGM) or the Body Domain Controller (BDC).

3.3. System components

3.3.1. Passive tank

The name passive tank means that it is not heated.

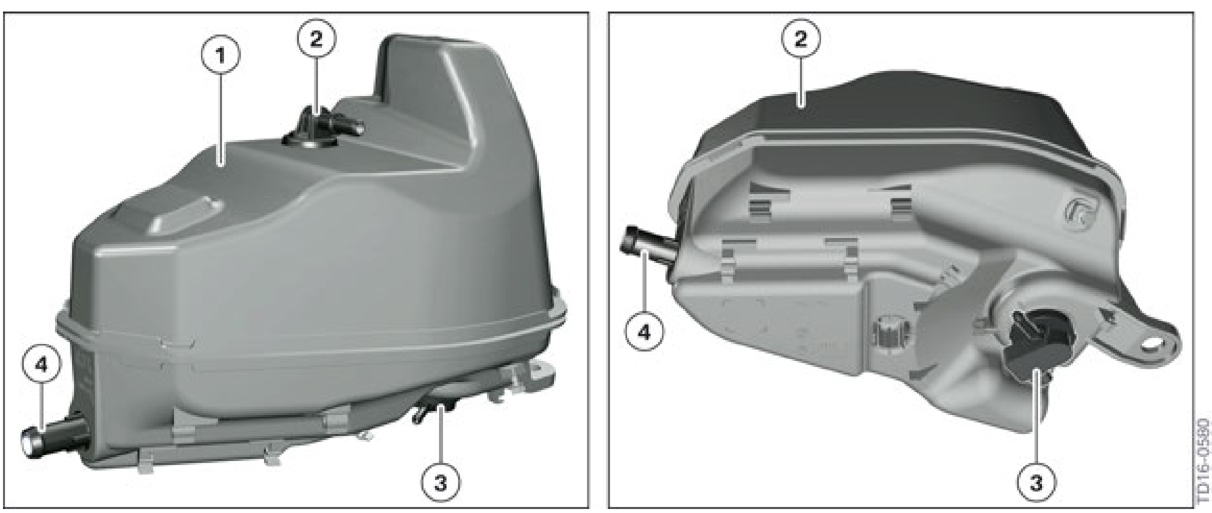
The following components belong to the passive tank:

- Tank flange with level sensor and temperature sensor
- Filling port
- Service vent line, fluid filler neck breather

Depending on the series, it is possible that the passive tank is insulated. The insulation comprises foam material and prevents quick freezing at low temperatures. As its installation location may also be near the exhaust system depending on the vehicle, it would also lead to a high introduction of heat to the urea/water mixture (AdBlue®).

If there are very low temperatures over a long period of time there is a possibility that the urea/water mixture (AdBlue®) might freeze completely in the passive tank. No re-pumping can then take place. In this case the active tank must be refilled more often.

The passive tank is filled via the active tank therefore it cannot be filled separately.



SCR 3, passive tank two-tank system

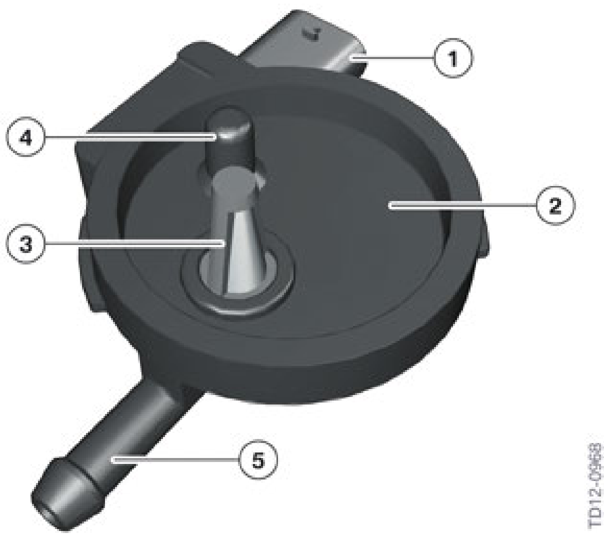
Index	Explanation
1	Passive tank
2	Service vent line and fluid filler neck breather
3	Tank flange with level sensor and temperature sensor
4	Filling port

Fuel level sensor

A level sensor is located in the tank flange of the passive tank.

The sensor works with a piezo element.

On extreme sloping positions or if the tank is frozen, the signal is at 15 mm. This corresponds to the signal of an empty tank. A level sensor is located, as described, in the active tank and in the passive tank.



SCR 3, tank flange in the passive tank

Index	Explanation
1	Electrical connection
2	Ultrasonic sensor
3	Strainer filling level
4	Flange with integrated temperature sensor
5	Transfer line connection

The tank flange of the passive tank cannot be replaced separately in service as it is welded to the passive tank.

Temperature sensor

The temperature sensor is integrated in the tank flange and cannot be replaced separately. The temperature sensor integrated in the tank flange is installed in the active tank and the passive tank.

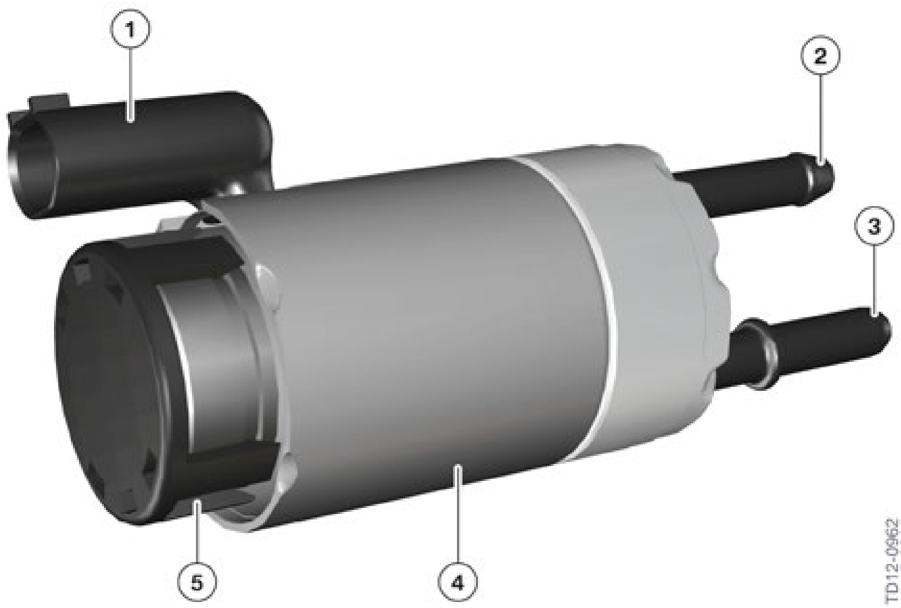
Ventilation

The passive tank has a service vent line and a fluid filler neck breather.

The service vent line and fluid filler neck breather lead to the filling pipe for the urea/water mixture (AdBlue®) at the fluid filler cap.

3.3.2. Recirculating pump unit

The recirculating pump unit assumes the delivery of the urea/water mixture (AdBlue®) from the passive tank to the active tank. The recirculating pump unit is only present if a two-tank system, i.e. passive tank and active tank, is installed.



SCR 3, transfer pump

Index	Explanation
1	Electrical connection
2	Intake side from recirculating line passive tank
3	Pressure side to recirculating line fluid filler neck breather pipe active tank
4	Pump body
5	Pump motor

The recirculating pump unit is a membrane pump. It functions similarly to a piston pump, only that the pump element is separated from the medium via a diaphragm. This means there are no problems concerning corrosion.

3.3.3. Active tank

The active tank is so-called because it is heated.

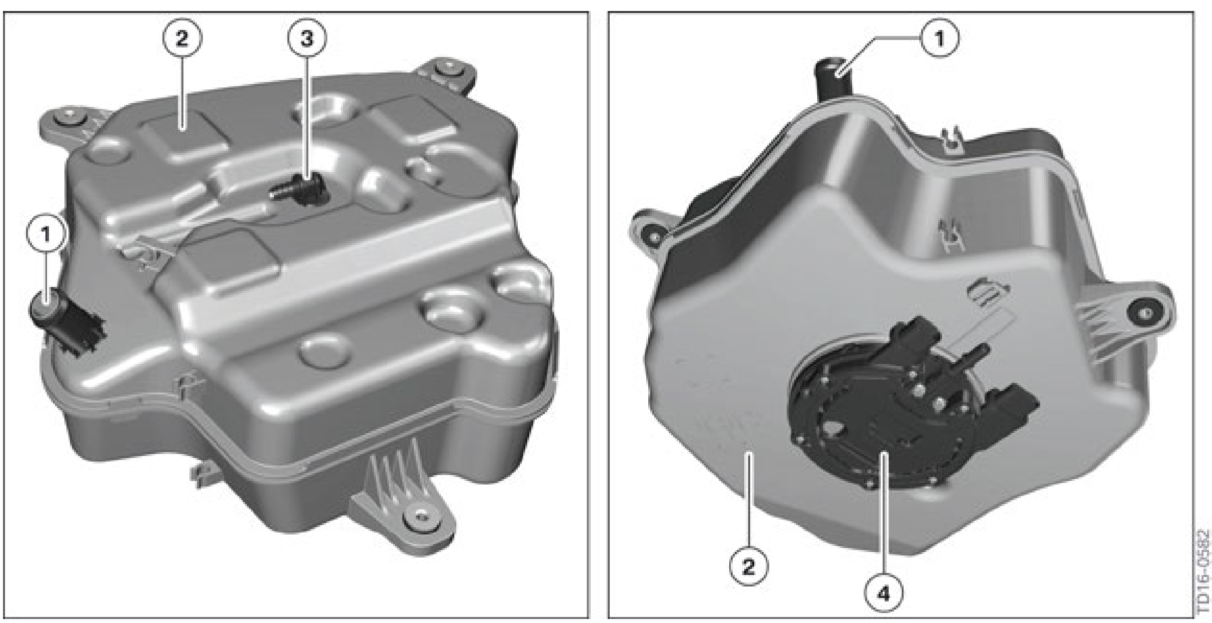
The following components belong to the active tank:

- Service vent line, fluid filler neck breather
- Tank flange module

Depending on the series, it is possible that the active tank is insulated. The insulation comprises foam material and prevents quick freezing at low temperatures. As its installation location may also be near the exhaust system (depending on the vehicle) which would result in unintentional heating of the urea/water mixture (AdBlue®).

⚠

Due to the possibility of incorrect refilling the Urea/water mixture (AdBlue®) filler necks are clearly marked as such. However, there is a danger of incorrect refilling by third parties. Incorrectly refilled urea/water mixture (AdBlue®) systems (in particular with materials containing mineral oil) may destroy the gaskets and seals in the SCR system.

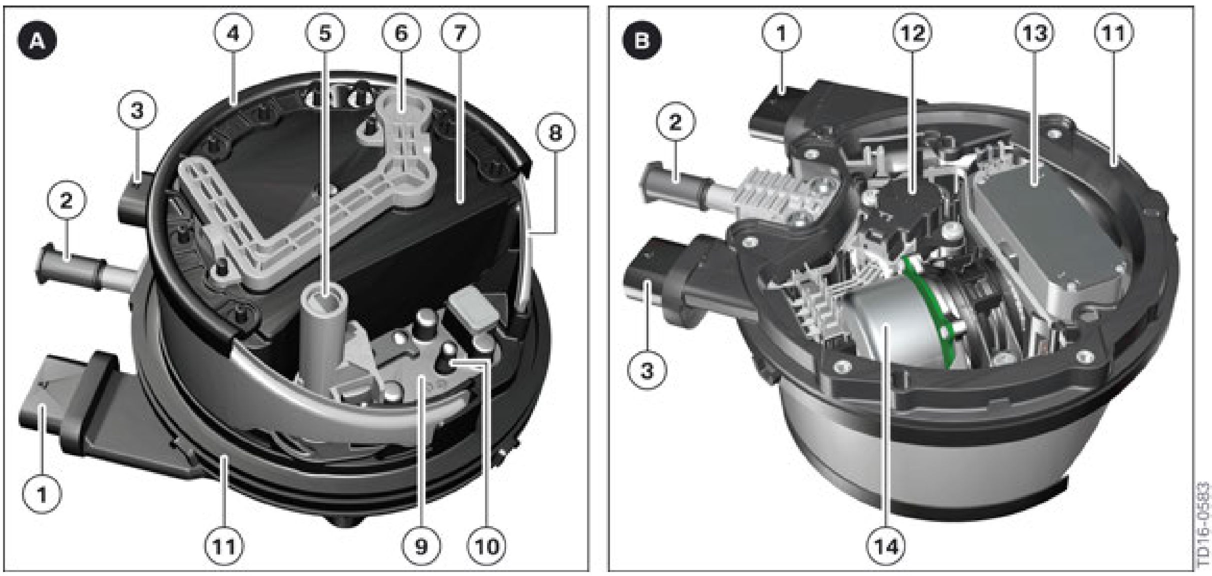


SCR 3, active tank

Index	Explanation
1	Filling port
2	Active tank
3	Service vent line and fluid filler neck breather
4	Tank flange module

3.3.4. Tank flange module

The tank flange module is located in the active tank and incorporates the heating element, a filter, temperature sensor, the combined urea/water mixture (AdBlue®) quality sensor/filling level sensor and a filling level sensor. The tank flange module also houses the pump as well as a pressure sensor and a pressure accumulator. The tank flange module cannot be replaced separately in service as it is part of the active tank.



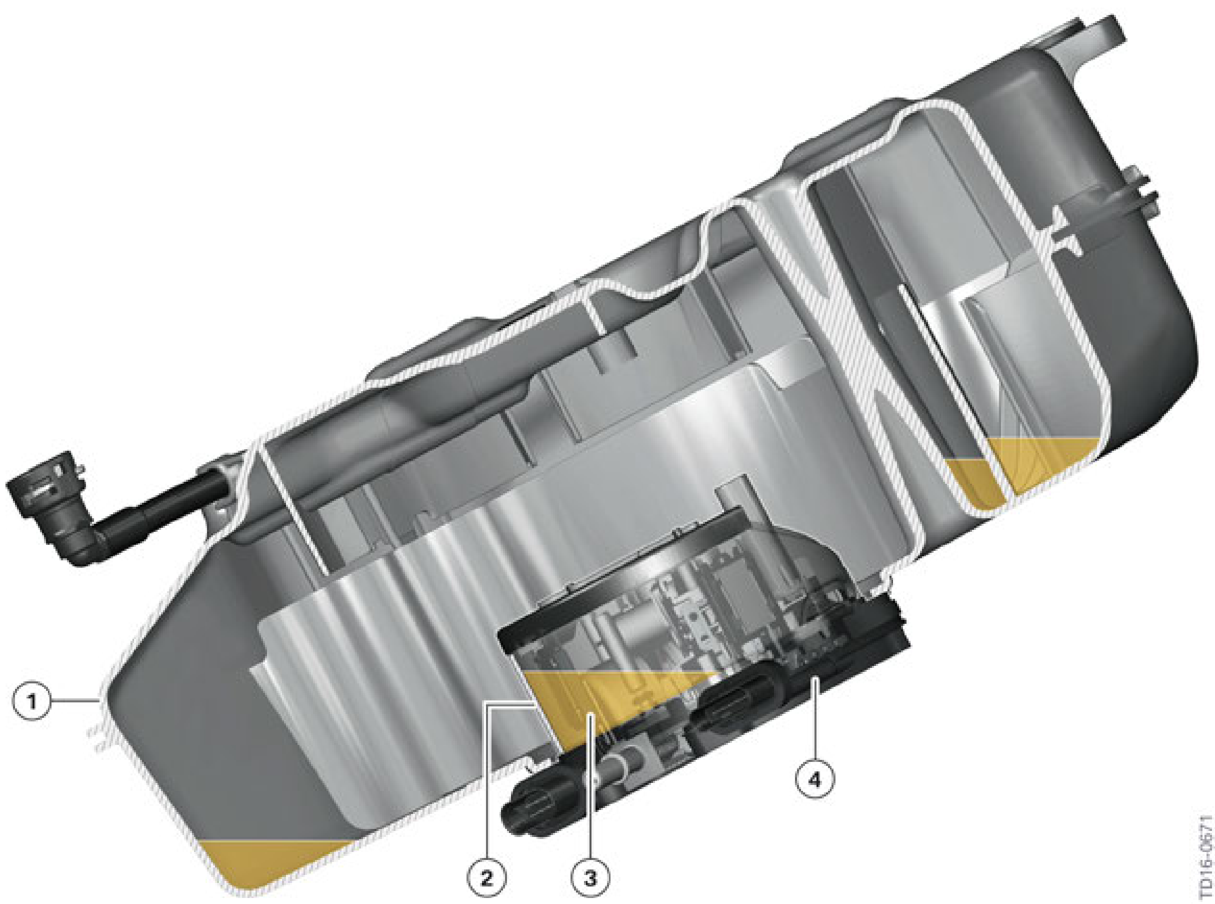
SCR 3, tank flange module

Index	Explanation
A	Top view of the tank module
B	Bottom view with service cover removed
1	Electrical connection for the heater and SENT protocols
2	Metering line connection
3	Electrical connection for voltage supply, the pump, hall effect sensors and filter
4	Bulkhead
5	Riser pipe filling level sensor (combined piezo element)
6	Pressure line
7	Tank flange module housing
8	Filter element
9	Filling level sensor (direct piezo element)
10	Temperature sensor

Index	Explanation
11	Carrier plate
12	Pressure sensor/temperature sensor
13	Sensor unit (temperature filling level urea/water mixture (AdBlue®) quality sensor)
14	Pump

Bulkhead

The tank flange module has a bulkhead in order to ensure there is enough urea/water mixture (AdBlue®) even when the vehicle is in extremely inclined position with a small amount remaining in the active tank. Thanks to this bulkhead and the design of the filter element around the tank flange module, it is ensured that there is enough urea/water mixture (AdBlue®) available up to a vehicle inclination of 45°.



SCR 3, tank flange module/bulkhead

3. SCR 3

Index	Explanation
1	Active tank
2	Bulkhead with filter
3	Urea/water mixture (AdBlue®) residual amount
4	Tank flange module

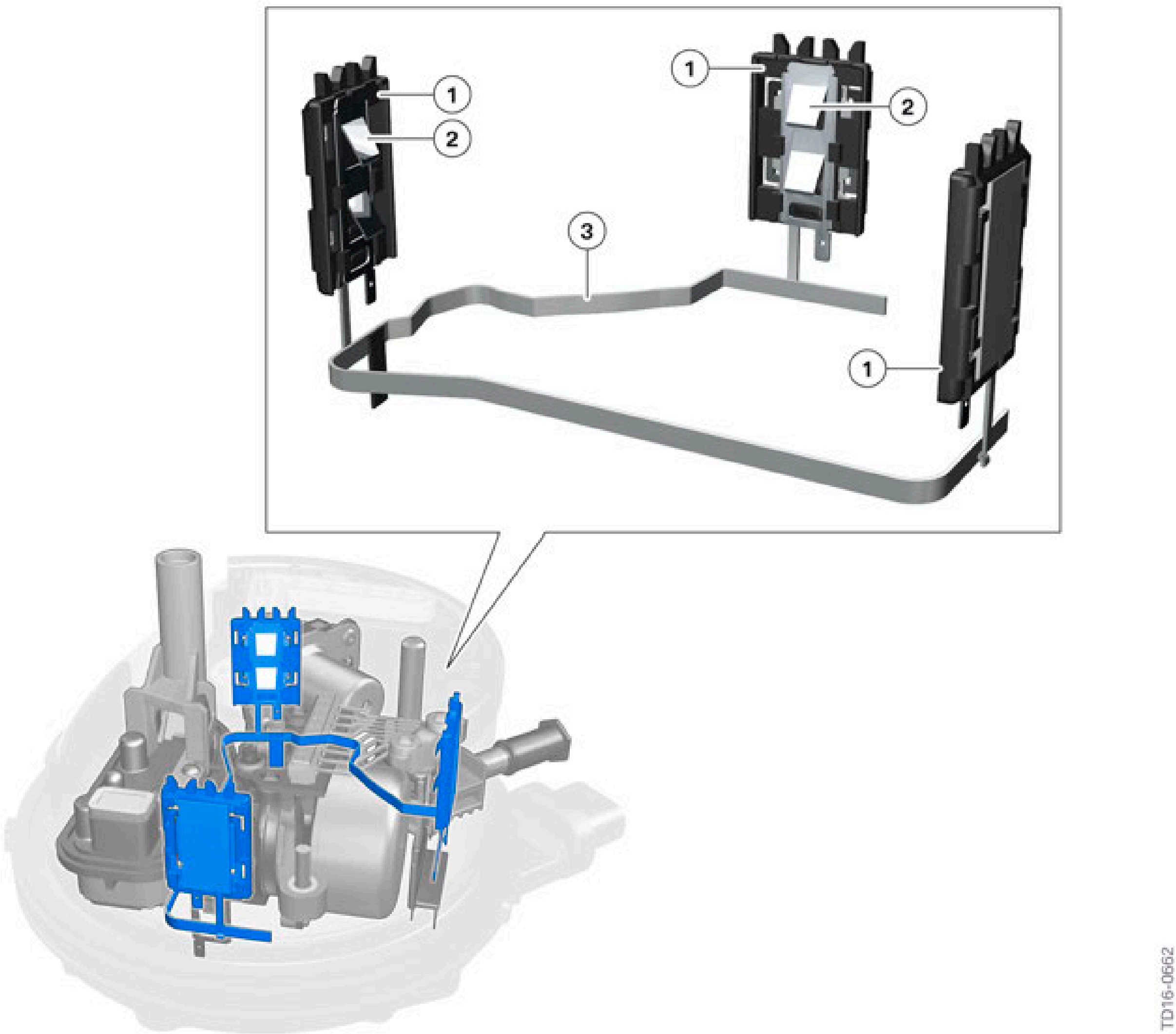
This combination of the bulkhead and filter element in the tank flange module guarantees a supply of urea/water mixture (AdBlue®) as follows:

- At an incline of 11° to 18°, a quantity of 220 g/h urea/water mixture (AdBlue®) for 30 min with at least 110 ml AdBlue®.
- At an incline of 45°, a quantity of 220 g/h urea/water mixture (AdBlue®) for 4 min with at least 20 ml AdBlue® .

It should be noted that the active tank must still have a remaining filling quantity of at least 2.5 l urea/water mixture (AdBlue®).

Heating elements

The three electric auxiliary heaters (positive temperature coefficient) are located in the tank flange module, so that at minimum temperatures liquid urea/water mixture (AdBlue®) is available for the journey. The positive temperature coefficient elements can be regulated or switched off independently upon reaching a certain limit temperature. Intrinsic safety is thus guaranteed which prevents damage or destruction in the event of a fault with the continuous power supply.



SCR 3, heating elements

Index	Explanation
1	PTC heating element
2	Spring clips for mounting
3	Electrical ring connector

The heating element in the tank flange module is supplied with electricity by a power transistor. The SCR control unit controls the heating elements via the power transistor and therefore can also monitor their function.

3. SCR 3

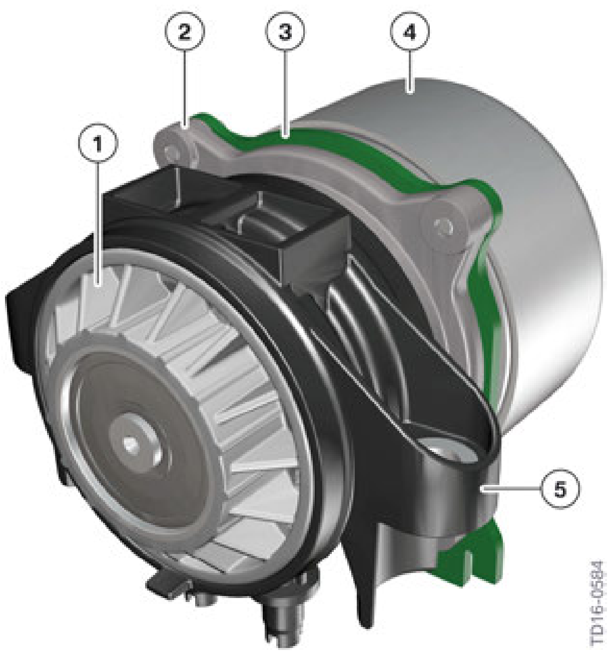
Pump

The pump is integrated in the tank flange module; it is secured by screws and located at the bottom of the active tank.

The pump works according to the orbital/eccentric principal and is driven by a three-phase brushless electric motor. The pump is therefore bidirectional; meaning it can be used to both, deliver and draw off, the urea/water mixture (AdBlue®).

A pressure accumulator on the output to the metering line exists downstream of the pump and prevents excessive pulsations in the metering line when the metering valve is open.

The pump is screwed on to the tank flange module at the bottom and can be accessed via the tank flange module's service cover.



SCR 3, pump

Index	Explanation
1	Pump cap
2	Motor flange
3	Mounting bracket (Blank)
4	Motor
5	Pump body

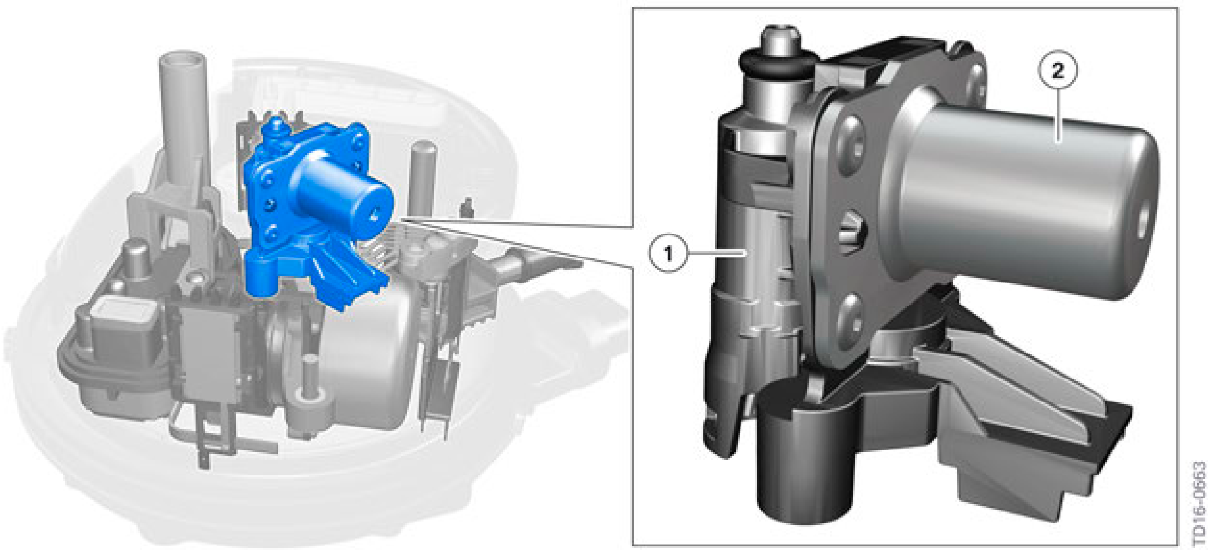
Three hall sensors are installed in the pump motor for recording its position and speed. The sensors share the 5 V voltage supply with the pressure sensor/temperature sensor.

There is a shutoff valve upstream of the pump that closes when the pump is removed. This therefore prevents the urea/water mixture (AdBlue®) from escaping when replacing the pump.

Pressure accumulator

To maintain the relative system pressure of 5.5 bar, the system is supported by a pressure accumulator in case of high urea/water mixture (AdBlue®) requirements. Furthermore, the pressure accumulator allows the pulsations to be dampened in the metering line when the metering valve is open.

An ice pressure damper integrated in the pressure accumulator housing protects the tank flange module components in case the urea/water mixture (AdBlue®) freezes.

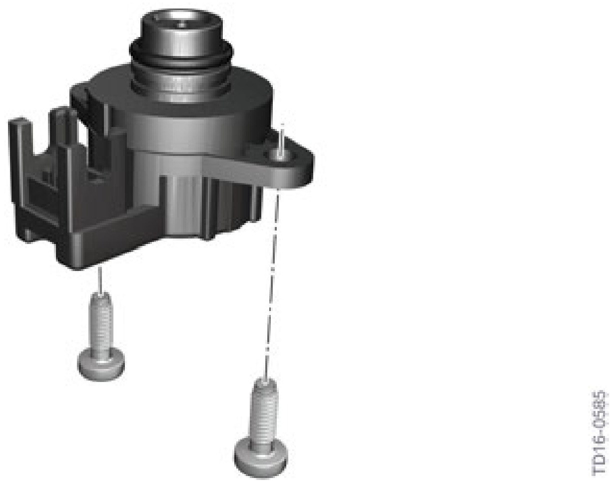


SCR 3, pressure accumulator

Index	Explanation
1	Housing with ice pressure damper
2	Pressure accumulator

Pressure sensor/temperature sensor

SCR 3 uses a pressure sensor to determine and monitor the pressure of the system. A temperature sensor is also integrated in the pressure sensor and can be used to sense the temperature of the urea/ water mixture (AdBlue®) in the tank flange module. The pressure sensor/temperature sensor signal is evaluated by the sensor unit and provided to the SCR control unit via a SENT protocol.



SCR 3, pressure sensor

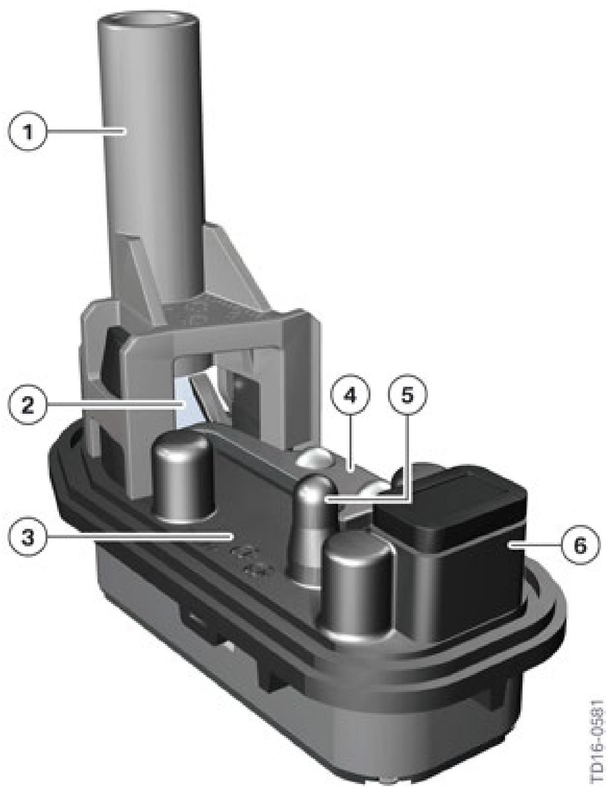
The pressure sensor/temperature sensor is screwed on to the bottom of the tank flange module and can be accessed via the tank flange module's service cover.

Sensor unit

The temperature sensor is an NTC sensor (Negative Temperature Coefficient) and it delivers the signal for the control of the heating elements.

The level sensor in the tank flange module delivers the value of the level for the entire active tank. The filling level sensor is implemented as a direct piezo element and works according to the ultrasound principle.

The combined urea/water mixture (AdBlue®) quality sensor/filling level sensor is a combined piezo element and delivers the value for the urea/water mixture (AdBlue®) composition and also the filling level.

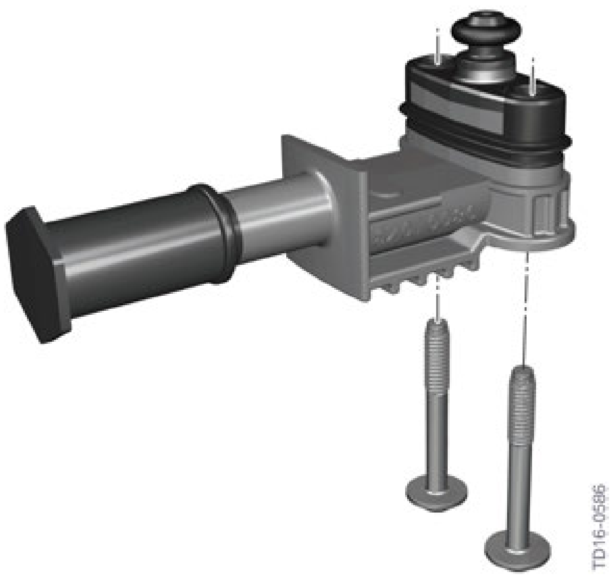


SCR 3, sensor unit

Index	Explanation
1	Measuring tube filling level
2	Passive reflector for determining the filling level
3	Direct piezo element/filling level sensor
4	Reflector plate for urea/water mixture (AdBlue®) quality
5	Temperature sensor
6	Combined piezo element (filling level/urea/water mixture (AdBlue®) quality)

Metering line connection

The metering line connection includes a fine filter that prevents particles penetrating the tank flange module. This could be combustion residues which enter the tank flange module via the open metering valve when the urea/water mixture (AdBlue®) is pumped back.

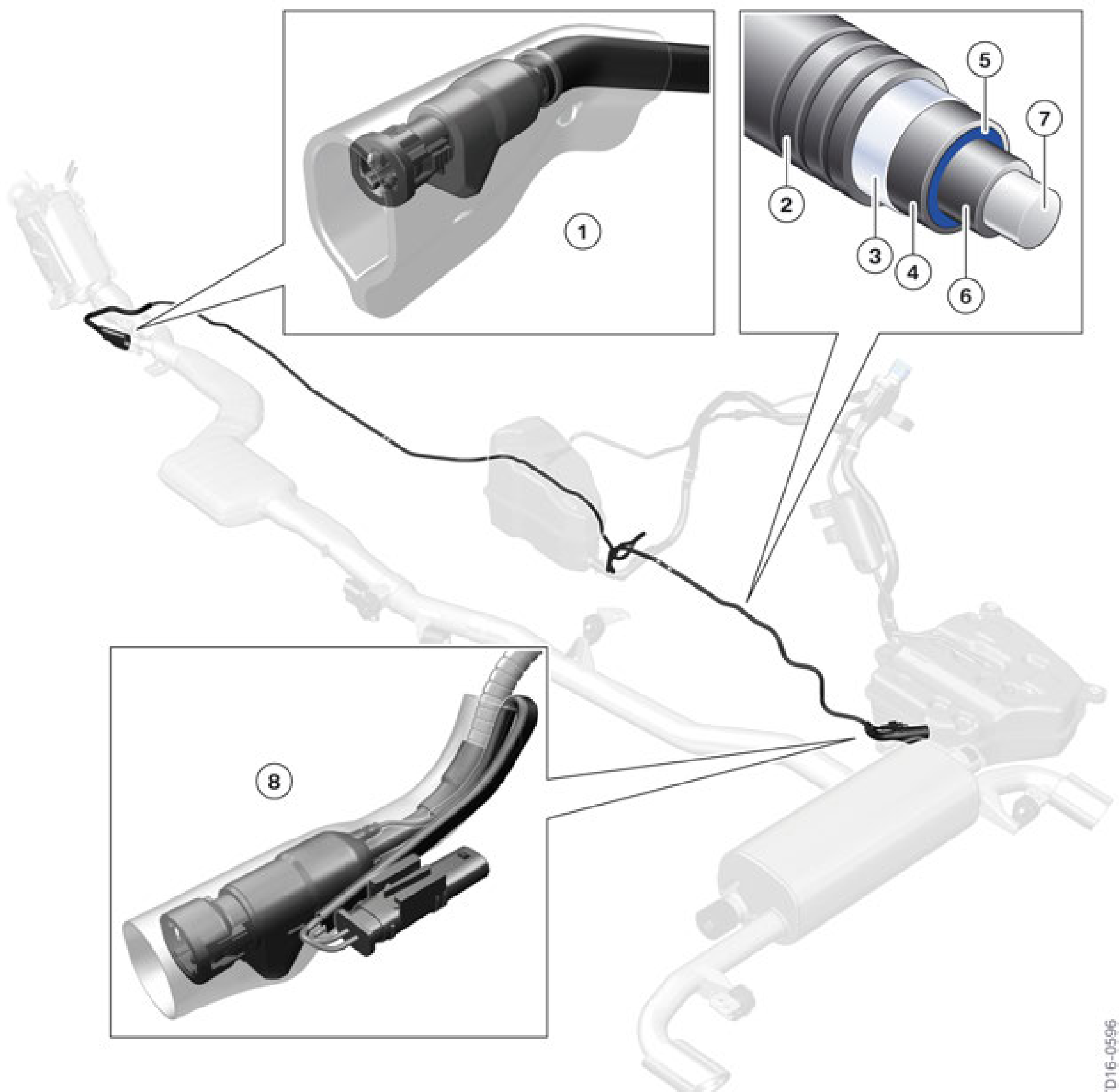


SCR 3, metering line connection

The metering line connection is screwed to the bottom of the tank flange module.

3.3.5. Heated metering line

Similar to the heating in the tank flange module for the active tank, the metering line is also electrically heated, when required, in order to prevent the urea/water mixture (AdBlue®) freezing.



SCR 3, metering line

Index	Explanation
1	Hydraulic connection for metering module
2	Protective sleeve
3	Insulator
4	Outer tube

3. SCR 3

Index	Explanation
5	Line, urea/water mixture (AdBlue®)
6	Inner pipe
7	Heating wire
8	Connection for tank flange module (hydraulic connection of metering line — electrical connection of metering line heating)

The inner pipe of the metering line is a 4 mm pipe that contains the heating wire. The 4 mm pipe is surrounded by a 6 mm outer pipe which delivers the urea/water mixture (AdBlue®). The wall thickness of the 6 mm outer pipe is 0.5 mm.

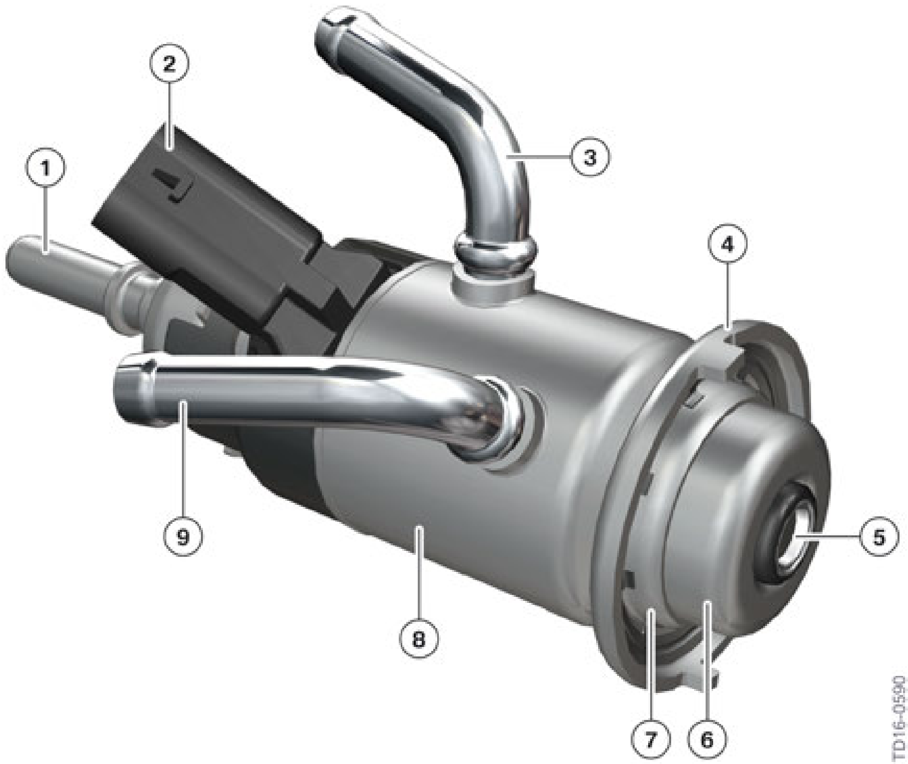
The heating element in the form of a ohmic heating wire is integrated inside the 4 mm pipe.

The metering line is thermally insulated in the 6 mm pipe by an insulator sleeve and then mechanically protected by a corrugated plastic coating.

⚠

The metering line is connected to the metering line connection on the tank flange via the quick-release couplings. The metering line can only be unlocked if it is completely pushed into the metering line connection on the tank flange. Only then can the quick-release coupling be unlocked and pulled off the metering line connection on the tank flange.

3.3.6. Metering module and mixer



SCR 3, metering module

Index	Explanation
1	Metering line connection
2	Electrical connection, metering valve
3	Coolant inlet
4	Mounting flange
5	Metering port
6	Thermal protection
7	Sealing ring groove
8	Heat sink
9	Coolant return

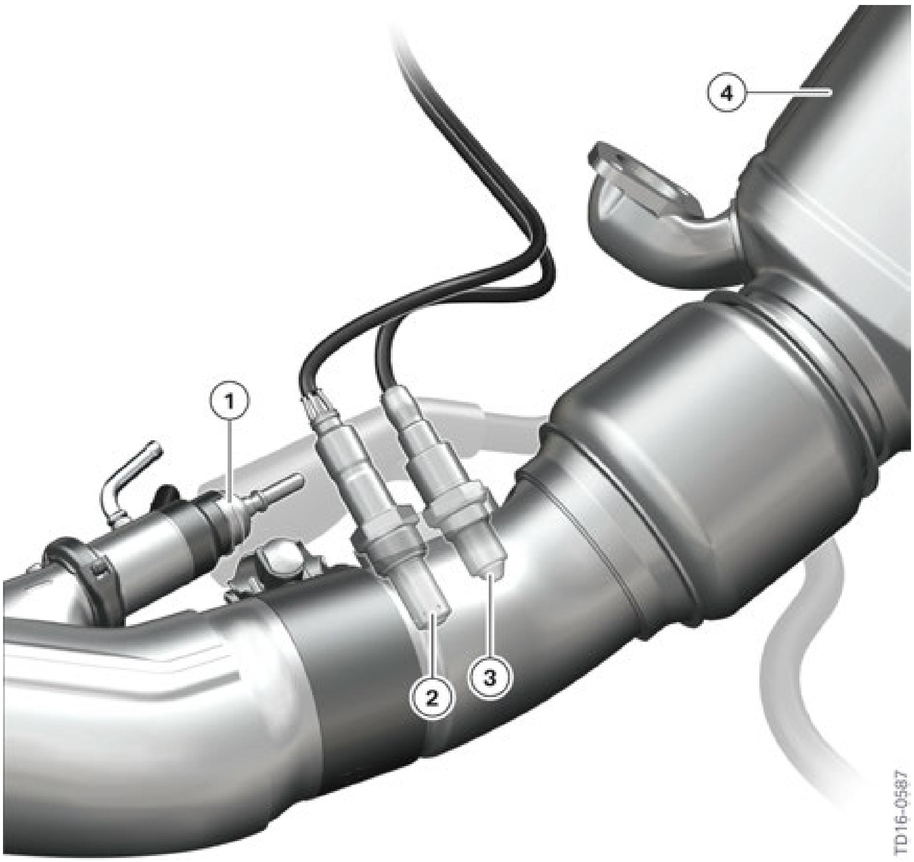
The metering module ensures the injection of the urea/water mixture (AdBlue®) into the exhaust pipe. It includes a valve that is similar to the fluid injector of a gasoline engine with intake fuel injection.

The metering module is not electrically heated, but is heated up by the exhaust system, therefore it has to be cooled using coolant from the engine cooling system. The temperature of the metering module is monitored via a calculation module in the SCR control unit. The electrical resistance of the coil, which changes depending on the temperature, is used as an input variable for the calculation module. The SCR control unit determines the temperature of the metering module from this resistance value.

SCR 3 (US)

3. SCR 3

The metering module is activated by a pulse-width-modulated (PWM) signal from the SCR control unit in which the duty cycle determines the opening duration of the valve.



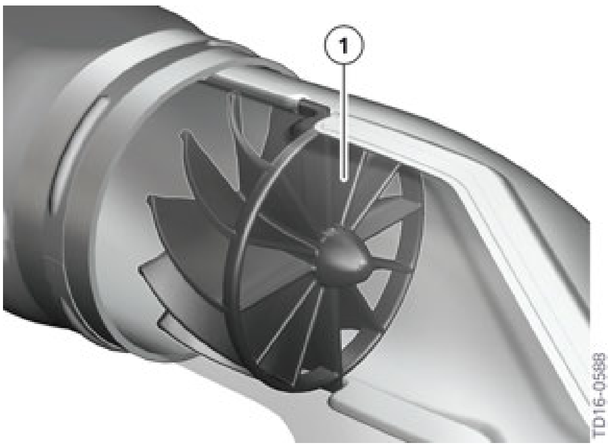
SCR 3, metering module installation location

Index	Explanation
1	Metering module
2	NO_x sensor before the SCR catalytic converter
3	Oxygen sensor
4	Diesel particulate filter

A cone-shaped insert is attached at the metering module. This prevents the urea/water mixture (AdBlue®) drying up and clogging the metering valve injector. The cone shape creates a flow that prevents the urea/water mixture (AdBlue®) from sticking to the walls of the exhaust system. Deposits of urea on the insert are burnt off as it is heated by the exhaust flow. A clogged metering valve is detected by monitoring the pilot flow.

Mixer

The mixer is located directly behind the metering module in the exhaust system. It swirls the exhaust flow in order to achieve a better mix of the urea/water mixture (AdBlue®) and the exhaust gas. This is necessary to ensure that the urea is fully transformed into ammonia.



SCR 3, mixer

Index	Explanation
1	Mixer

The mixer can be replaced separately in 6-cylinder engines. However in 4-cylinder engines, the mixer is part of the exhaust system and can only be replaced in conjunction with the corresponding component.

3.3.7. Urea/water mixture (AdBlue®) fluid filler cap

The urea/water mixture (AdBlue®) fluid filler cap includes a vent. This vent is necessary as both the filling of the SCR system and the tank ventilation are done via a combined fluid filler neck breather pipe and tank ventilation line.

The ventilation is achieved via a defined bore hole in the urea/water mixture (AdBlue®) fluid filler cap. Therefore, only fluid filler caps which are specific for the respective vehicle are used.

SCR 3, urea/water mixture (AdBlue®) fuel filler cap

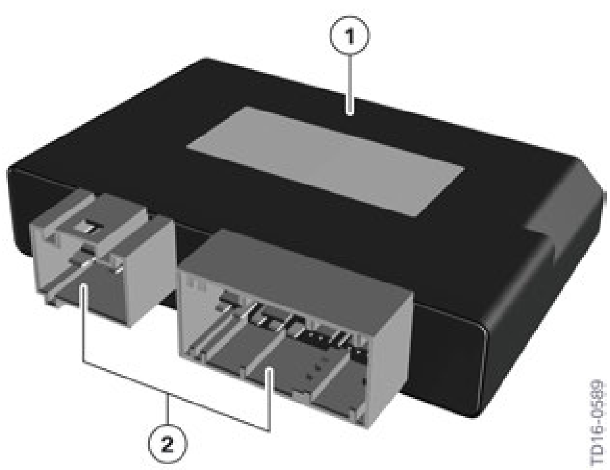
Index	Explanation
1	Urea/water mixture (AdBlue®) fluid filler cap
2	Handle
3	Vent

A replacement or use of other fluid filler caps may cause a malfunction of the SCR system.

3.3.8. SCR control unit

The SCR control unit must ensure that the inlet sizes for the metering specification of the Digital Diesel Electronics (DDE) are in the allowable range. The fluid levels of the urea/water mixture (AdBlue®) passive tank (no vehicle operation without fluid), the medium temperatures in the urea/water mixture (AdBlue®) passive tank and the metering line (AdBlue®, freezing point at -11 °C / 12.2 °F) and the pressure build-up metering line (ensures fluid injection rate) are also taken into account here.

The SCR control unit ensures that all available information is also available for other applications, for example the fluid level indicator and the remaining range display in the Central Information Display (CID) (not for US).



SCR 3, SCR control unit

Index	Explanation
1	Control unit
2	Connector strip

The correct and current installation locations of the SCR control unit can be found in the respective workshop systems (ISTA).

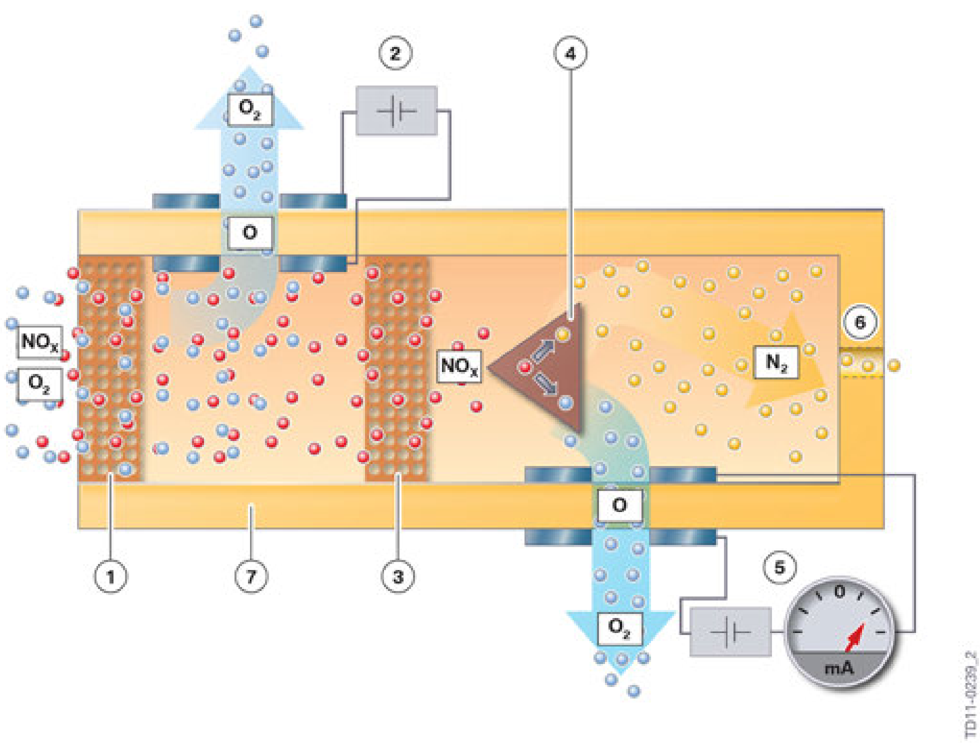
3.4. NO_x sensors

SCR 3, NO_x sensor

The Nitrogen Oxide sensor consists of a measuring probe and a corresponding control unit. The control unit communicates with the Digital Diesel Electronics (DDE) via the Local Controller Area Network.

The operation principle of a Nitrogen Oxide (NO_x) sensor can be compared to a broadband O2 sensor in that its function relies on an oxygen measurement to determine the Nitrogen Oxide content in an exhaust gas sample. The measuring procedure is based on the idea that the oxygen measurement relates directly to the Nitrogen Oxide measurement.

The following graphic illustrates the operating principle of this measurement procedure.



SCR 3, NO_x sensor function

SCR 3 (US)
3. SCR 3

Index	Explanation
1	Barrier 1 (NO_x and O_2 enter the sensor)
2	First chamber pump current (removes O_2 from the sample)
3	Barrier 2 (NO_x enters the second chamber)
4	Catalytic element (decomposes NO_x to N_2 and O_2)
5	Second chamber pump current (the resulting O_2 is measured to determine N_2)
6	Nitrate outlet (N_2 exits the sensor)
7	Solid electrolyte zirconium dioxide (ZrO_2)

As the exhaust gas streams through the NO_x sensor only O2 and Nitrogen Oxide are of interest. In the first chamber the oxygen from the sample mixture is ionized with the help of the first measuring cell and extracted by solid electrolytes. Via the electromechanical pump current of the first chamber an oxygen sensor signal can be taken. At this point in the process the "free" oxygen (not bonded to nitrogen) is removed from the exhaust gas sample.

Then the remaining Nitrogen Oxide (NO_x) goes through the second barrier and into the second chamber of the sensor. Here the NO_x is decomposed by a catalytic element into oxygen and nitrogen. The freed oxygen is then ionized as it passes through the solid electrolytes. The emerging pump current provides information on the quantity of the oxygen present in the sample. Based on this O2 quantity measurement, a conclusion can be made on the nitrogen content.

SCR 3 (US)

4. Urea/water Mixture

The urea/water mixture (AdBlue®) supplies the ammonia that is used for the reduction of the Nitrogen Oxides (NO_x) in the exhaust gas. In order to protect people and the environment against ammonia and in order to make it more manageable for transportation and tank processes it is available in liquid urea for the SCR procedure.

The recommended urea/water mixture is AdBlue®. The naming rights of AdBlue® are owned by VDA (German Association of the Automotive Industry). AdBlue® is a highly pure, limpid, synthetically created 32.5% urea solution that adheres to the DIN 70070/AUS32/ ISO 22241–1 standards.

AdBlue® trademark

The urea/water mixture used (AdBlue®) must therefore meet this standard.

4.1. Hazard and health concerns

The urea/water mixture (AdBlue®) is not poisonous. It is a watery solution from which (according to European chemical laws) there is no particularly hazard. It is not a hazardous material and (in terms of transportation laws) is not a dangerous good.

If, when handling the urea/water mixture (AdBlue®), traces of the product come into contact with the skin, it is sufficient to wash it off with lots of water. Therefore it is practically impossible to pose a risk to human health in this way.

4.2. Decomposability and disposal

The urea/water mixture (AdBlue®) can be used by microbes and is therefore very easily decomposable. From the urea/water mixture (AdBlue®) there is a very small danger for water and soil. In Germany the urea/water mixture (AdBlue®) is in the lowest water danger class (WGK 1). Due to its outstanding decomposability, small amounts of spilled urea/water mixture (AdBlue®) can be washed into the sewage system with lots of water without any problems.

4.3. Storage and durability

In order to prevent quality impairments due to impurities and a high inspection effort the urea/water mixture (AdBlue®) can only be stored in designated storage and container systems.

As the urea/water mixture (AdBlue®) becomes solid as it freezes at - 11 °C (12.2 °F) and decomposes more quickly at temperatures above 25 °C (77 °F), the storage and container systems are designed in such a way that a temperature range of - 11 °C to 30 °C (12.2 °F to 86 °F) is guaranteed.

4. Urea/water Mixture

If the recommended storage temperature of maximum 25 °C (77 °F) is observed then the urea/water mixture (AdBlue®) fulfils the requirements of the DIN 70070 standard for at least 12 months after its manufacture. If its recommended storage temperature is exceeded then this period is reduced. If the urea/water mixture (AdBlue®) cools to under - 11 °C (12.2 °F) it becomes solid. Upon heating the frozen urea/water mixture (AdBlue®) becomes liquid again and can be used again as normal without any loss of quality.

The urea/water mixture (AdBlue®) is normally odorless. If an unpleasant odor (strong smell of ammonia) occurs then this suggests the medium old and should not be used.

Direct ultraviolet radiation is to be avoided as it also degrades the medium.

4.4. Material tolerance

The contact of urea/water mixture (AdBlue®) with copper and zinc as well as their alloys and aluminium is to be strictly avoided as it leads to corrosion. However stainless steels and most plastics are no problem whatsoever.

⚠

For further information in relation to handling, first aid, storage and disposal, please consult the safety data sheet of the manufacturer.

4.5. Urea/water mixture (AdBlue®) — Compatibility with other materials

Components of the SCR system are incompatible with materials with a mineral oil. It therefore must be assured that the components of the SCR system do not come into contact with these. In the event of uncertainties whether SCR system components came into contact with materials with a mineral oil base or SCR system components were filled with materials with a mineral oil base, there are test strips available to check for mineral oil contamination of the urea/water mixture (AdBlue®).

⚠

In the event that these materials have been verified and components of the SCR system were damaged as a result of mineral oil contamination, the SCR system must be completely replaced.

⚠

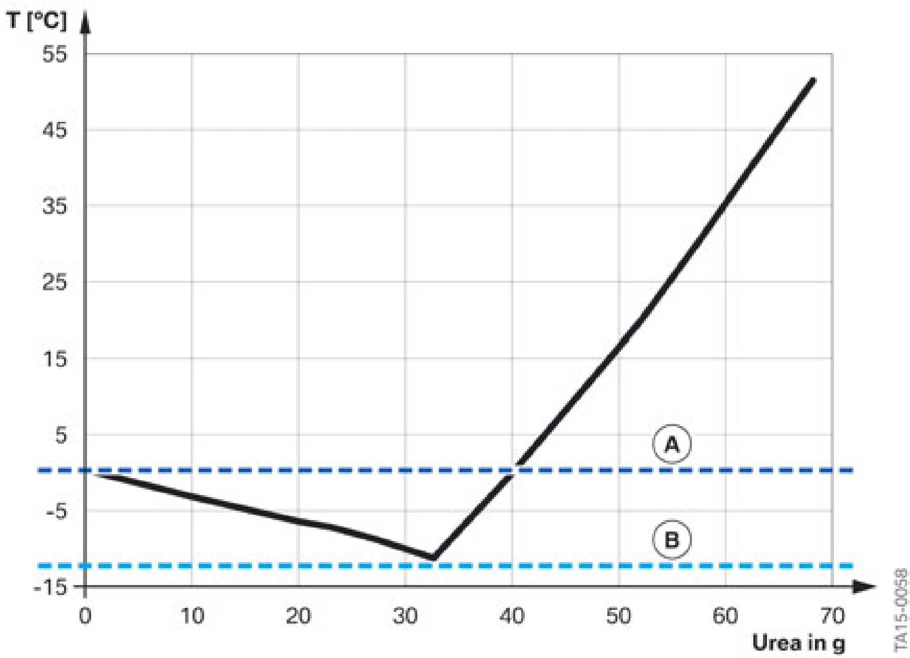
All tools used in Service must be kept far away from materials containing a mineral oil base when handling the urea/water mixture (AdBlue®). This applies, in particular, for special tools and tools which are used for filling and draining the urea/water mixture (AdBlue®).

4. Urea/water Mixture

4.6. Service instructions for the urea/water mixture (AdBlue®)

Depending on the vehicle model, different quantities of the urea/water mixture (AdBlue®) are carried in one or two SCR storage tanks. The AdBlue® urea/water mixture is used as a reducing agent to control NO_x. It is injected directly into the exhaust gas after the diesel particulate filter.

Since the urea is not present in pure form but in a mixture with water, it is possible that this urea/water mixture will freeze at extremely low ambient temperatures (- 11 °C/ 12.2 °F).



Schematic diagram of the freezing point of the urea/water mixture (AdBlue®) at various mixture ratios

Index	Explanation
A	Freezing point of water
B	Freezing point of the urea/water mixture (AdBlue®)
T [°C]	Temperature in degrees Celsius
Urea in g	Urea share in gram per 100 g solution

In order to guarantee the lowest possible freezing point of the urea/water mixture (AdBlue®), a mixture ratio between the urea and water of 32.5% is needed. This means that 100 g of the urea/water mixture (AdBlue®) solution contains 32.5 g urea and 67.5 g water.

If the required mixture ratio of 32.5% deviates from the actual ratio, this will lead to the following problems:

- Falling freezing point of the mixture
- Fault code entries due to adaptation of the metering quantities

4. Urea/water Mixture

Inadequate urea concentration:

If the urea concentration in the SCR tank is too low, this may result in fault code entries due to positive metering quantity adaptation. In this case, activation of the metering module is increased until the maximum control limit is exceeded.

Excessively high urea concentration:

The urea concentration in the SCR tank will increase in the event of evaporation of a large amount of water. This will cause a reduction in the freezing point. In addition, a higher urea concentration tends to result in flocculation, which can cause clogging and thus prevent pressure build-up.


TA15-0587

Flocculated urea

For this reason, it is recommended to check the concentration of the urea/water mixture when troubleshooting.

5. Information for Service

5.1. Refilling

The SCR system is generally maintenance-free. The service requirements are solely limited to refilling the urea/water mixture (AdBlue®).

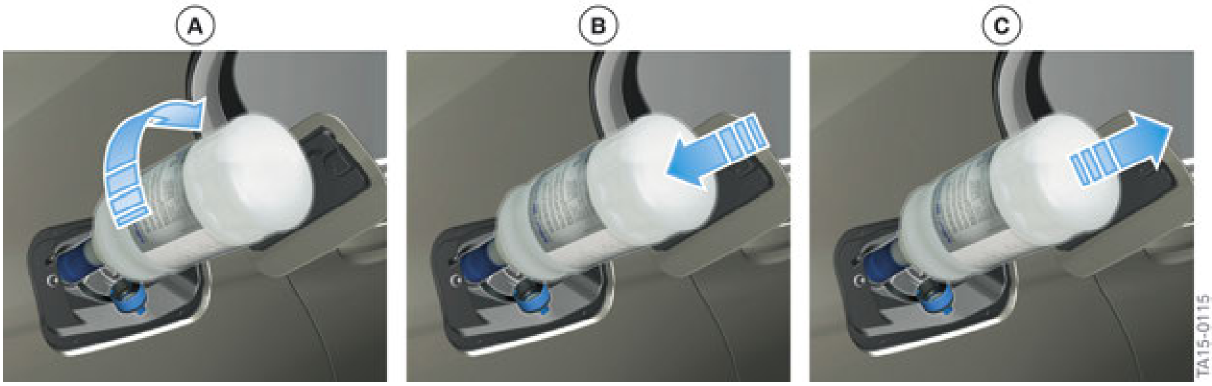
The refilling of active and passive tanks with urea/water mixture (AdBlue®) can either be carried out in Service or by the customer themselves.

Refilling on an incline of up to 5° in any direction is no problem as 90% of the maximum possible refilling is still achieved.

Should the urea/water mixture (AdBlue®) reserve not last until the next workshop visit a certain amount can also be refilled. A special bottle is available for this that is screwed onto the fluid filler neck. This special bottle, is known as the "KRUSE bottle" and guarantees filling of the system without the danger of overfilling, overflowing or spilling in the engine compartment or onto the paint surface.

Special bottles for urea/water mixture (AdBlue®)

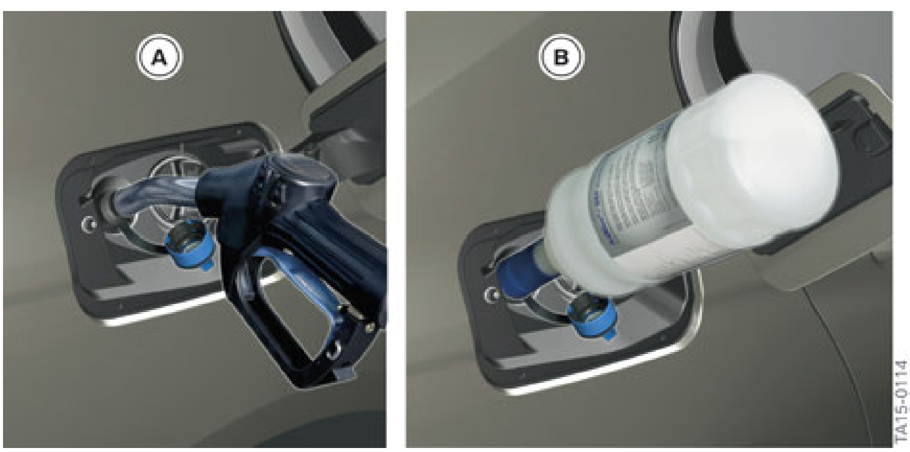
Refilling using the KRUSE bottle is possible via the urea/water mixture (AdBlue®) filler connection in the fuel filler flap as this bottle can empty at an angle of about 30°.



Filling procedure with KRUSE bottle

Index	Explanation
A	Fit bottle and turn to the limit position
B	Press down bottle (filling procedure)
C	Pull back bottle and unscrew

Should the starting of the engine already be prevented by the switch off scenario, one bottle is enough to get the engine to start again. Ideally two bottles should be used to stop the switch off scenario from occurring again straight away.



SCR filling with pump nozzle or KRUSE bottle

Index	Explanation
A	Filling procedure with pump nozzle
B	Filling procedure with KRUSE bottle

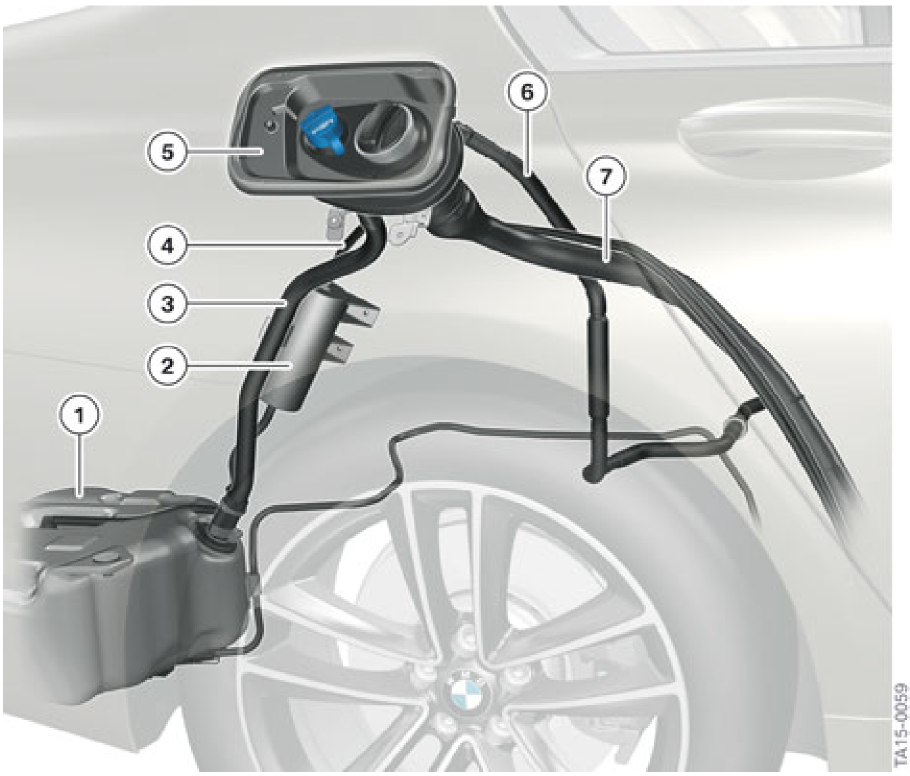
KRUSE refill bottles with 0.5 US gallons (1.89 l) can be ordered using the Electronics Parts Catalog (ETC). The current part numbers can also be found in the Electronic Parts Catalog (ETC).

The SCR system can also be topped off by using the urea/water mixture (AdBlue®) truck pump nozzles found at many filling stations (as of G12). The minimum quantity that can be filled from pumps at German filling stations is 2 l. It is not possible to purchase less than 2 l via a pump nozzle due to legal regulations in accordance with the German law on measurement and calibration.

5. Information for Service

The SCR filler neck is located next to the diesel filler neck behind the fuel filler flap and can therefore be easily accessed.

The system can be filled with delivery rates of up to 40 l per minute. The time for filling the 20 l tank is therefore reduced to 30 s in comparison with filling with the KRUSE bottle.



Bubble container of the SCR filler pipe in the G12 (not US)

Index	Explanation
1	SCR tank
2	Bubble container
3	Urea/water mixture (AdBlue®) filler pipe
4	Urea/water mixture (AdBlue®) ventilation line
5	Fuel filler flap
6	Ventilation line for diesel fuel
7	Filler pipe for diesel fuel

When filling the SCR tank, the air in the SCR tank is displaced by the urea/water mixture (AdBlue®). The air reaches the bubble container via a ventilation line. If the SCR is filled with a pump nozzle, the air is displaced very quickly. The flow rate thus increases due to the small diameter of the ventilation line. The urea/water mixture (AdBlue®) which was carried along due to the high flow rate is filtered out in the bubble container. This prevents the urea/water mixture (AdBlue®) from splashing out while refilling.

5. Information for Service

Since air is no longer displaced at the end of the filling procedure, the counterpressure in the filler pipe quickly increases. The pump nozzle then switches off automatically due to the increase in pressure in the filler pipe.

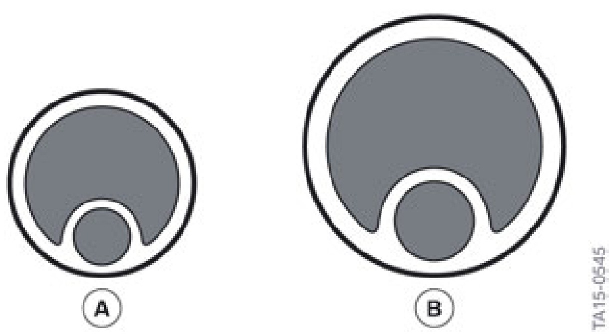
The additional volume of the bubble container is also used so that the SCR tank system can additionally accommodate small residual amounts that enter the filler pipe when the pump nozzle is withdrawn. This stops the urea/water mixture (AdBlue®) from overflowing.

⚠

The two filler necks for [diesel fuel and the urea/water mixture (AdBlue®)] have different designs and cannot be mixed up when using standard pump nozzles.

5.1.1. Misfiling protection

A significant advantage for the driver is the easily accessible filler neck of the SCR tank. However, the direct proximity to the filler neck of the diesel fuel tank means that there is a risk of confusion. Various design measures have therefore been implemented on the two filler necks so that confusion is practically excluded when refilling with standard pump nozzles.

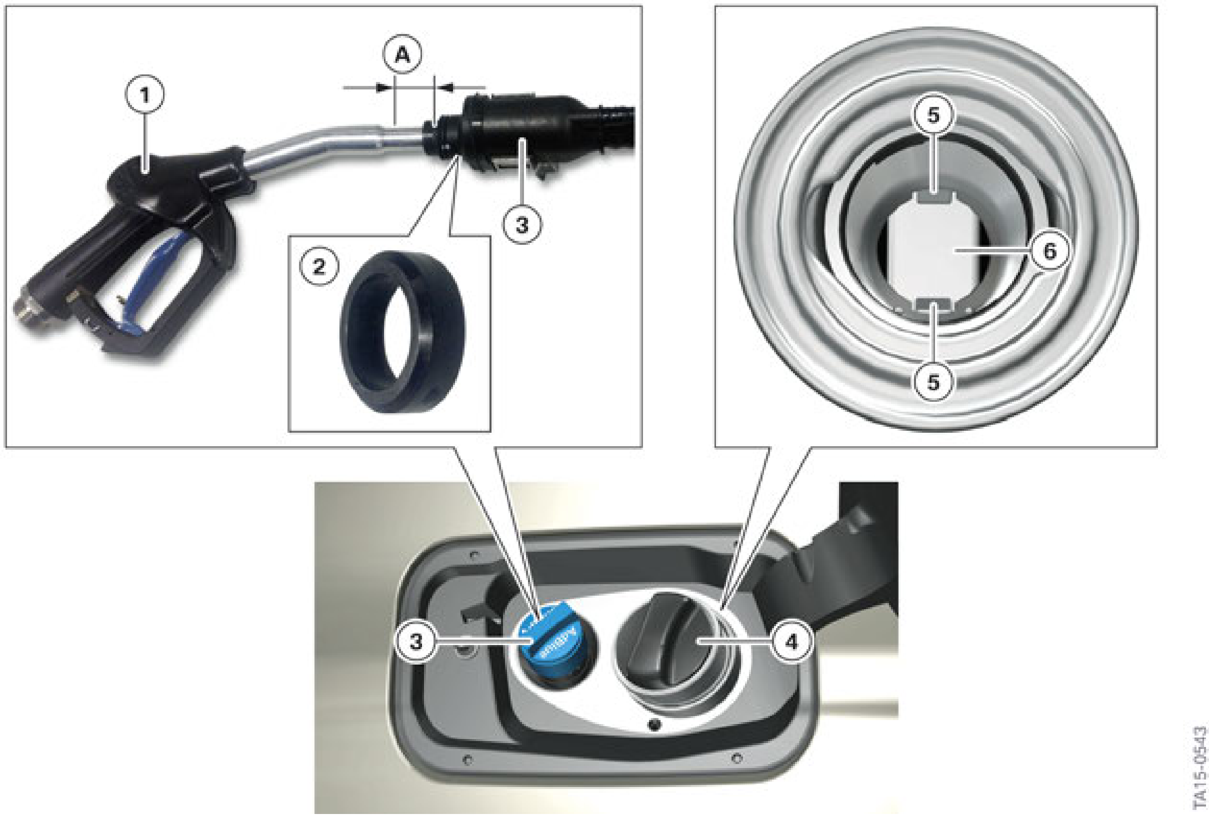


Urea/water mixture (AdBlue®) pump nozzle and diesel fuel pump nozzle

Index	Explanation
A	Urea/water mixture (AdBlue®) pump nozzle
B	Diesel pump nozzle

The above graphic shows the different diameters of the two pump nozzles. The larger diameter of the diesel pump nozzle means that it cannot be inserted in the filler pipe of the SCR filler neck. Incorrect filling of the SCR tank with diesel fuel is therefore improbable.

The following graphic shows the different design mechanisms of the two filler necks.



Misfiling protection in SCR filler neck and diesel filler neck (ECE G12 shown).

Index	Explanation
A	Insertion depth of the urea/water mixture (AdBlue®) pump nozzle
1	Urea/water mixture (AdBlue®) pump nozzle
2	Magnetic ring (permanent magnet)
3	SCR filler neck
4	Diesel filler neck
5	Locking pin
6	Flap

The flap (6) of the diesel filler neck is released only when both locking pins (5) are actuated by a pump nozzle with the correct diameter. After this, the flap (6) can be pressed to the side with the pump nozzle so that the nozzle can be inserted into the diesel filler neck up to the stop.

The SCR filler neck is fitted with a magnetic ring. When refilling with a urea/water mixture (AdBlue®) pump nozzle, it must be ensured that this is inserted into the SCR filler neck up to the stop. This prevents the urea/water mixture (AdBlue®) fluid from splashing out and also ensures that the pump nozzle is enabled via the magnetic ring. Urea/water mixture (AdBlue®) pump nozzles vary from country to country. Some of these urea/water mixture (AdBlue®) pump nozzles are equipped with a locking mechanism. When the locking mechanism is inserted through the magnetic ring, the locking mechanism is opened by the magnetic field and the filling procedure is enabled.

5. Information for Service

⚠

Depending on the urea/water mixture (AdBlue®) pump nozzle version, it is possible that the filling procedure cannot be started if the insertion depth is insufficient.

5.2. Refilling in Service

Ten liter canisters are available for refilling at the service workshop; these canisters are used in conjunction with a special tool. The parts numbers for the current special tools are available in the Aftersales Assistance Portal (ASAP).

Filling hose

If the system is fully drained then two canisters are required. Via the workshop system ISTA it can be checked whether both tanks, active tank and passive tank, were filled completely.

Refill canisters with a 10 l capacity can be ordered from the Electronic Parts Catalog (ETK). The current part numbers can be found in the Electronic Parts Catalog (ETK).

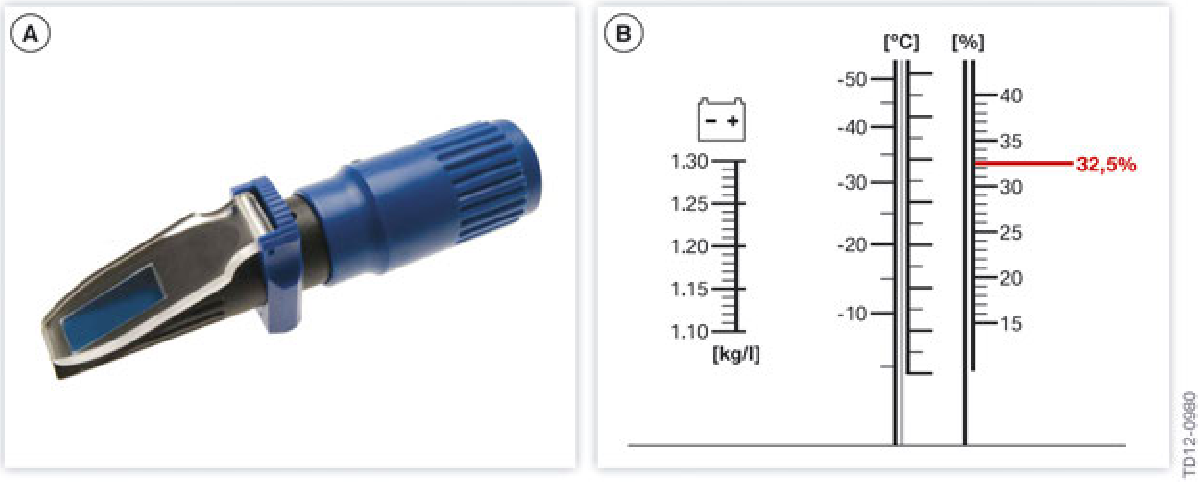
10 liter canister for urea/water mixture (AdBlue®)

⚠

Never refill the system without special tools from the canister as the system can become overfilled which leads to damages. Additionally, the danger of spilling into the engine compartment is very high. Various materials in the engine compartment will react when in contact to the corrosive properties of the urea/water mixture (AdBlue®).

5.3. Checking the concentration of the urea/water mixture (AdBlue®)

The quality of the urea/water mixture (AdBlue®) is checked using a refractometer, which measures the urea concentration. The part numbers for the current special tools are available in the Aftersales Assistance Portal (ASAP). Using the enclosed pipette, a drop of the medium to be tested is placed on the prism and the lid closed. The values are shown on the relevant scale using the light/dark boundary in the eyepiece.



Refractometer

Index	Explanation
A	Refractometer
B	Scales (battery acid density/coolant frost protection/urea/water mixture (AdBlue®))

Evaluation of the urea/water mixture (AdBlue®) concentrate:

- The values displayed should be within the tolerance value of 31.8 and 33.3 percent in weight.
- If the values are lower than the 31.8 percent in weight, the function of the urea/water mixture (AdBlue®) can no longer be guaranteed e.g. when urea/water mixture (AdBlue®) is degraded or aged by UV radiation. In any case the exhaust fluid therefore has to be replaced.
- Values higher than 33.3 percent in weight indicate a water leak in the SCR system, for example if a proportion of water in the urea/water mixture (AdBlue®) has evaporated.

⚠

The urea/water mixture (AdBlue®) must be replaced if the mixture ratio is incorrect. It is not allowed to correct the mixture ratio by topping up with water.

⚠

Urea/water mixture (AdBlue®) which has been drained and recovered cannot be reused without a check. Long storage times and the influence of high temperatures and UV light exposure have a subtle effect on the decomposition of the urea/water mixture (AdBlue®).

5.4. Draining the urea/water mixture (AdBlue®)

If it is necessary to drain the urea/water mixture (AdBlue®) within the framework of maintenance measures or repair measures or in the case of an excessive ageing, this must be done using suitable tools. There is no “drain plug” in the system, therefore it is not possible to drain the system without the spacial tools and extraction procedure.

⚠

The recovered urea/water mixture (AdBlue®) must be collected in a suitable plastic tank. The pump must be purged with water after each use and cleaned.

The urea/water mixture (AdBlue®) safety data sheet must be observed with regards to the handling and disposal procedures.

If the urea/water mixture (AdBlue®) has to be replaced, this can be performed using an extraction, test and filling unit in service.

- Part order number of extractor unit 220 V (Europe): 81 39 2 302 782
- Part order number of extractor unit 110 V (US): 81 39 2 302 919.

5.5. Statutory regulations for the OBD

All sensors, actuators and systems used to comply with the statutory emissions threshold values must be monitored by the Digital Diesel Electronics (DDE) using suitable measures. If sensor, actuator and system failures lead to the OBD emissions threshold values being exceeded, the system must inform the driver using the malfunction indicator lamp.

If a fault in OBD relevant systems or components is repaired, the law requires the system to carry out a self-check. This self-inspection must take place using a so-called conditioning run following repair during a service visit. Only once a successful conditioning run has taken place and the OBD has detected that the fault has been rectified will the malfunction indicator lamp be deactivated; at this point, the fault memory entries can also be deleted during a service visit Depending on the scope, a conditioning run can last between 30 and 60 km and should be conducted on main roads or highways where possible.

⚠

The current information and specifications in the documents in the Integrated Service Technical Application (ISTA) must be observed in each case.

5.6. SCR 2 diagnostic functions

5.6.1. SCR 2 system test

The system test for the SCR 2 enables various tests to be performed on the SCR system:

- Metering quantity test
- Injection pattern of the metering module
- Urea/water mixture (AdBlue®) quality
- Mixer
- NO_x sensor (SCR functional check)

5.6.2. SCR 2 functional check

The SCR functional check for the SCR 2 checks the temperature sensors, NO_x sensors and the SCR catalytic converter; the test results are then emitted. The SCR functional check is made up of 11 steps and lasts around 50 min. The steps and instructions in the ISTA test module must be observed.

⚠

The current information and specifications in the documents in the Integrated Service Technical Application (ISTA) must be observed in each case.

5.7. SCR 3 diagnostic functions

To make it easier to eliminate faults during service visits, the law now permits a system test (known as a "routine quality check") to be performed on the **"SCR 3"** in addition to the conditioning run; this system test can be performed in the workshop when the vehicle is stationary. Fault memory entries relevant to the SCR system can be deleted once the vehicle has passed a system test (routine quality check) during a service visit.

If any SCR components are replaced, a general start-up routine must be performed and the adaptation values reset.

The following table provides an overview of the activities that must be performed in the ISTA service functions if any components in the **"SCR 3"** system are replaced:

SCR components	Start-up routine	Reset adaptation values	System test (routine quality check)	Conditioning run
SCR control unit	●	●	●	
SCR delivery module	●	●	●	
Active tank	●	●	●	

SCR components	Start-up routine	Reset adaptation values	System test (routine quality check)	Conditioning run
Metering line	●	●	●	
Metering module	●	●	●	
NO_x sensor		●		●
SCR catalytic converter		●		●
Exhaust temperature sensor		●		●

5.7.1. System test (routine quality check) for SCR 3

The system test (routine quality check) for the SCR 3 can be called up under the service functions in the ISTA diagnosis system and lasts around 15 minutes. The metering module must always be removed for this system test (routine quality check) otherwise irreversible ammonia poisoning may take place in the SCR catalytic converter. For further steps, please follow the test module instructions in ISTA.

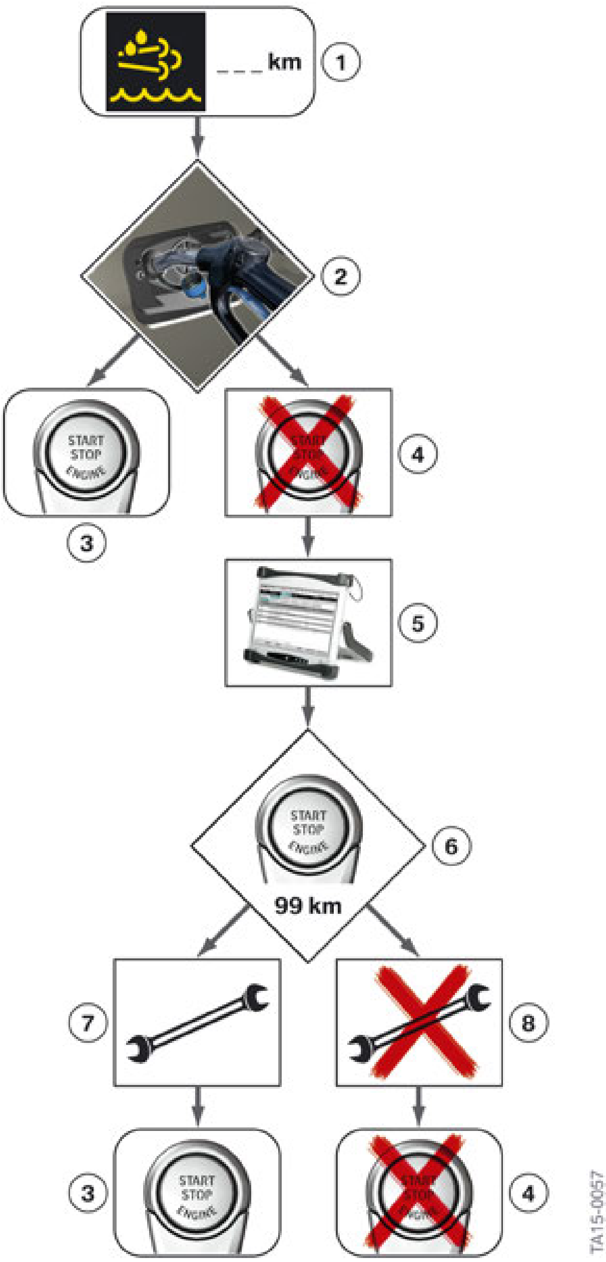
⚠

The current information and specifications in the documents in the Integrated Service Technical Application (ISTA) must be observed in each case.

5.8. Reset: SCR switch off scenario

Various (OBD-relevant) component defects or incorrect refilling in the SCR system can also prevent an engine restart when the engine is switched off. In order to allow the workshop to perform an engine start for troubleshooting, the BMW diagnosis system ISTA has a service function “Reset: SCR switch off scenario”. The reset function enables further engine starts and an additional range of 99 km for the SCR 2 system and 50 km for the SCR 3 system. If it was not possible to delete the current fault during the additional range of 99 km/50 mi, the switch-off scenario is activated again and prevents further engine starts until this fault is remedied and the fault memory entry deleted. Renewed activation of the reset function is no longer possible for this fault. If it was possible to delete the fault and it occurs again after some time, the reset function can be used for repeated troubleshooting for 99 km/50 mi.

5. Information for Service



Flow chart of a switch-off scenario due to an SCR fault

Index	Explanation
1	Fault in the SCR system
2	Elimination of the SCR fault
3	Engine capable of starting
4	Engine does not have start enable

SCR 3 (US)

5. Information for Service

Index	Explanation
5	Activate the SCR reset function
6	Engine start enabled for 99 km for SCR 2 and for 50 km for SCR 3 (one-off)
7	Repair successful
8	Repair failed

⚠

The current information and specifications in the documents in the Integrated Service Technical Application (ISTA) must be observed in each case.

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