Technical Training Product Information.

Advanced Diesel with BluePerformance.

BMW Service

The information contained in the Product Information and the Workbook form an integral part of the training literature of BMW Technical Training.

Refer to the latest relevant BMW Service information for any changes/supplements to the Technical Data.

Information status: June 2008

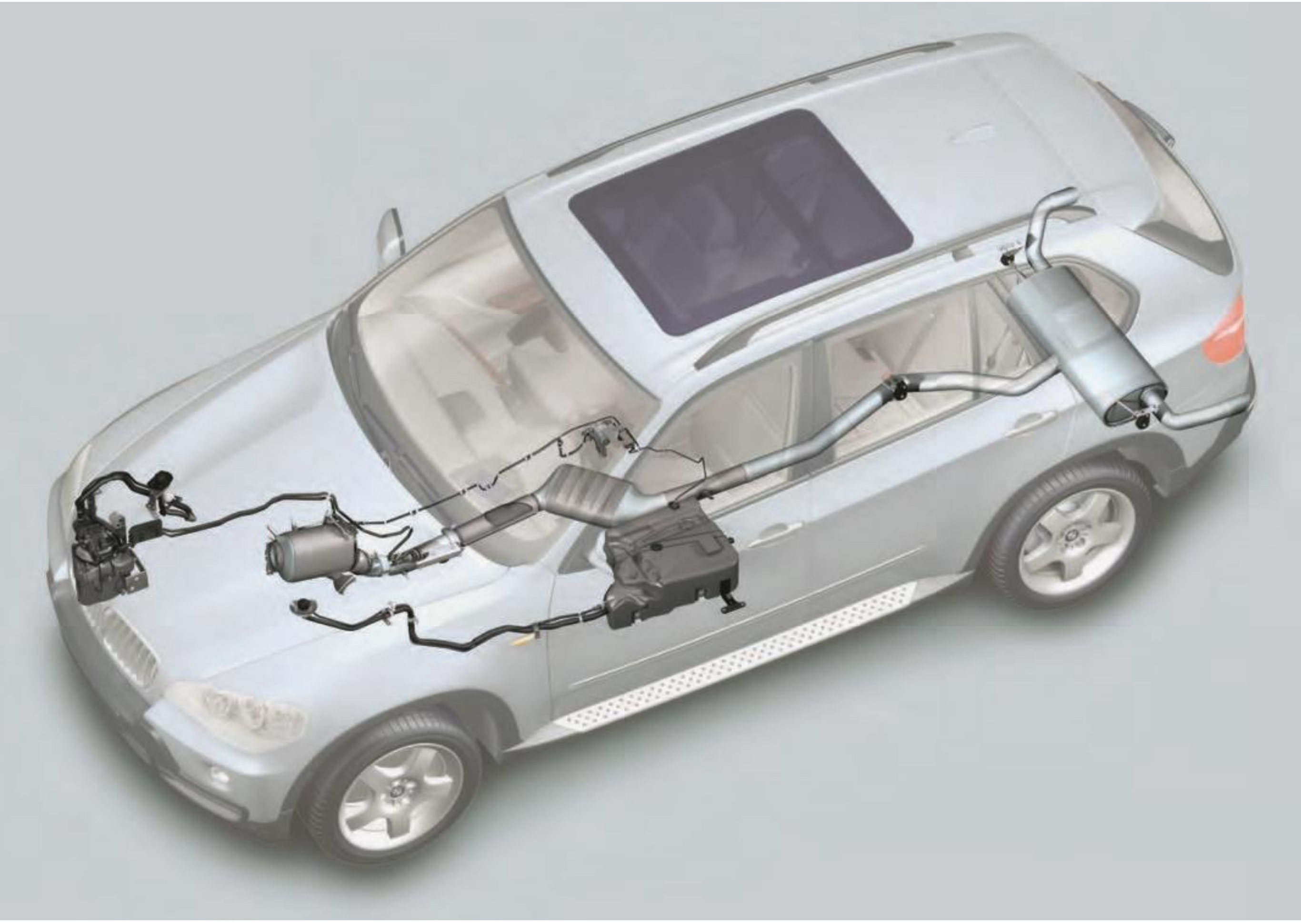
Contact: conceptinfo@bmw.de

Product Information. Advanced Diesel.

Diesel engine for North America

Selective Catalytic Reduction (SCR)

Low pressure exhaust gas recirculation (LP EGR)



Notes on this Product Information

Symbols used

The following symbols are used in this Product Information to improve understanding and to highlight important information:

3 contains important safety information as well as information that is necessary to ensure smooth system operation and must be adhered to.

1 identifies the end of a note.

Information status and national variants

BMW vehicles conform to the highest safety and quality standards. Changes in terms of environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between this Product Information and the vehicles available in the training course.

This documentation describes left-hand drive vehicles. In right-hand drive vehicles, the arrangement of some controls or components may differ from the illustrations in this Product Information. Further differences may arise as the result of the equipment variants used 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.

Contents.

Advanced Diesel.

Objectives.

Advanced Diesel.

Product information and working reference for practical applications.

This Product Information provides information on the design and function of the M57D30T2 US engine.

This Product Information is structured as a working reference and complements the subject material of the BMW Aftersales Training seminar. The Product Information is also suitable for self-study.

As a preparation for the technical training program, this Product Information provides an insight into the diesel engine for the US market. In conjunction with practical exercises carried out in the training course, its aim is to enable course participants to carry out servicing work on the M57D30T2 US engine.

Technical and practical background knowledgeofthecurrentBMWdieselengines willsimplifyyourunderstandingofthesystems described here and their functions.

Models.
Advanced Diesel.

Engine variants

Model	Model series	Engine	Cylinder capacity in cm^3	Bore/stroke in mm	Power in kW/bhp at rpm	Torque in Nm at rpm	Market launch
335d	E90	M57D30T2	2993	90/84	200/265 4200	580 1750	11/08

X5 xDrive35d	E70	M57D30T2	2993	90/84	200/265 4200	580 1750	11/08

Models with the M57D30T2 US engine at the time of market launch in Autumn 2008.

1 - BMW 335d

2 - BMW X5 xDrive35d

History of the M57 engine

The M57 engine is by far one of the most successful engines at BMW. It is fitted in numerous models right across the vehicle range. It plays the part of the extremely powerfultop-of-the-rangeengine,forexample in the 3 Series just as effectively as the wellbalanced entry class engine in the 7 Series. 10 years have already passed since its introduction and many improvements have been made during this period. In particular the re-engineering that took place in 2002 and again in 2005 ensure that the M57 engine is still state-of-the-art.

The following table shows an overview of the individual models equipped with the M57 engine.

Engine	Model	Model series	Cylinder capacity in cm^3	Power output in (kW/bhp)	Torque in Nm	Engine management	First used	Last used
M57D30O0	530d	E39	2926	135/184	390	DDE4.0	9/98	3/00
M57D30O0	730d	E38	2926	135/184	410	DDE4.1	9/98	3/00
M57D30O0	330d	E46	2926	135/184	390	DDE4.0	9/99	3/03
M57D25O0	525d	E39	2497	120/163	350	DDE4.0	3/00	2/04
M57D30O0	530d	E39	2926	142/193	390	DDE4.0	3/00	5/04
M57D30O0	730d	E38	2926	142/193	430	DDE4.1	3/00	7/01
M57D30O0	X5 3.0d	E53	2926	135/184	410	DDE4.0	4/01	9/03

M57D30O1	730d	E65	2993	160/218	500	DDE506	9/02	3/05
M57D30O1	330d	E46	2993	150/204	410	DDE506	3/03	9/06
M57D30O1	530d	E60	2993	160/218	500	DDE508	3/03	4/04
M57D30O1	X3 3.0d	E83	2993	150/204	410	DDE506	9/03	9/05
M57D30O1	X5 3.0d	E53	2993	160/218	500	DDE506	9/03	9/06
M57D25O1	525d	E60	2497	130/177	400	DDE509	4/04	3/07
M57D25O1	525d	E61	2497	130/177	400	DDE509	4/04	3/07
M57D30O1	530d	E60	2993	160/218	500	DDE509	4/04	9/05
M57D30O1	530d	E61	2993	160/218	500	DDE509	4/04	9/05
M57D30T1	535d	E90	2993	200/272	560	DDE606	9/04	3/07
M57D30T1	535d	E61	2993	200/272	560	DDE606	9/04	3/07

Engine	Model	Model series	Cylinder capacity in cm^3	Power output in (kW/bhp)	Torque in Nm	Engine management	First used	Last used
M57D30O2	730d	E65	2993	170/231	520	DDE626	3/05	9/08
M57D30O2	330d	E90	2993	170/231	500	DDE626	9/05	9/08
M57D30O2	330d	E91	2993	170/231	500	DDE626	9/05	9/08
M57D30O2	530d	E61	2993	170/231	500	DDE626	9/05	in production
M57D30O2	530d	E61	2993	170/231	500	DDE626	9/05	in production
M57D30O2	730Ld	E66	2993	170/231	520	DDE626	9/05	9/08
M57D30O2	X3 3.0d	E53	2993	160/218	500	DDE626	9/05	in production
M57D30U2	325d	E90	2497	145/197	400	DDE606	9/06	in production

M57D30U2	325d	E91	2497	145/197	400	DDE606	9/06	in production
M57D30O2	330d	E92	2993	170/231	500	DDE626	9/06	in production
M57D30T2	335d	E90	2993	210/286	580	DDE626	9/06	in production
M57D30T2	335d	E91	2993	210/286	580	DDE626	9/06	in production
M57D30T2	335d	E92	2993	210/286	580	DDE626	9/06	in production
M57D30T2	X3 3.0sd	E83	2993	210/286	580	DDE626	9/06	in production
M57D30U2	325d	E92	2497	145/197	400	DDE606	3/07	in production
M57D30U2	525d	E60	2497	145/197	400	DDE606	3/07	in production
M57D30U2	525d	E61	2497	145/197	400	DDE606	3/07	in production
M57D30O2	330d	E93	2993	170/231	500	DDE626	3/07	in production
M57D30O2	X5 3.0d	E70	2993	173/235	520	DDE626	3/07	in production
M57D30T2	535d	E60	2993	210/286	580	DDE626	3/07	in production
M57D30T2	535d	E61	2993	210/286	580	DDE626	3/07	in production
M57D30U2	325d	E93	2497	145/197	400	DDE606	9/07	in production
M57D30T2	635d	E63	2993	210/286	580	DDE626	9/07	in production
M57D30T2	635d	E64	2993	210/286	580	DDE626	9/07	in production
M57D30T2	X5 3.0sd	E70	2993	210/286	580	DDE626	9/07	in production
M57D30O2	X6 xDrive30d	E71	2993	173/235	520	DDE626	5/08	in production
M57D30T2	X6 xDrive35d	E71	2993	210/286	580	DDE626	5/08	in production

Introduction.

Advanced Diesel.

A diesel engine for North America

Impressive power and performance as well as exemplary efficiency have contributed to making BMW diesel engines an attractive as well as future-oriented drive technology. This technology is now being made available to drivers in North America.

BMW is introducing this diesel technology to the USA and Canada under the name "BMW Advanced Diesel". The introduction is an integral part of the EfficientDynamics development strategy, which has become a synonym for extremely low CO_2 emissions not surprising when considering its extremely low fuel consumption. EfficientDynamics is not solely an instrument for reducing fuel consumption but rather it is designed as an intelligent entity with increased dynamics. Not withoutgoodreasontheM57D30T2engineis referred to as the world's most agile diesel engine.

History

In 1892, Rudolf Diesel applied for a patent for his first self-igniting combustion engine. Initially, this large, slow-running engine was intended for stationary operation only. The intricate engine structure and complicated injection system meant production costs were high. The first simple diesel engines were not particularly comfortable and powerful-revving machines. It was not possible to mistake the distinctive sound of the harsh combustion process in the diesel engine when cold (diesel knock).Comparedtothesparkignitionengine, it offered a poorer power/weight ratio, acceleration characteristics and lower specific output.

"Miniaturization" could be realized only by improving materials and the manufacturing process during the course of commercial vehicle production. Although the first diesel vehicle was presented as early as 1936, it was not before the 1970s that the diesel engine became accepted as a viable drive source. The breakthrough came in the 1980s when the diesel engine was finally refined enough to be a real alternative to the spark ignition engine. At this time, in view of the improved dynamics and acoustics the decision was made to introduce the diesel engine in series production vehicles at BMW.

1 - Rudolf Diesel and his engine

1983

The M21D24 engine introduced for the first time in the E28 as the 524td featured an exhaust turbocharger and had a displacement of 2.4 litres. It was derived from the M20 6cylinder petrol engine and developed 85 kW/ 115 bhp. Both engines could therefore be built on the same production facilities.

At that time, the performance with a top speed of 180 km/h and acceleration from 0 to 100 km/h in 13.5 seconds set new standards in the dynamics of diesel motor vehicles. The 524td was therefore given the nickname "Sport diesel".

ThiswasthefirstdieselengineatBMWand,at the same time, the last for a long time in the US market.

2 - BMW 524td with M21 engine

1985

The M21 was also built as a naturallyaspirated diesel engine as from September 1985, making it possible to offer a costeffective "entry-level engine". This engine made a name for itself in the 324d (E30) as the smoothestrunningauto-ignitionengineonthe market.

1987

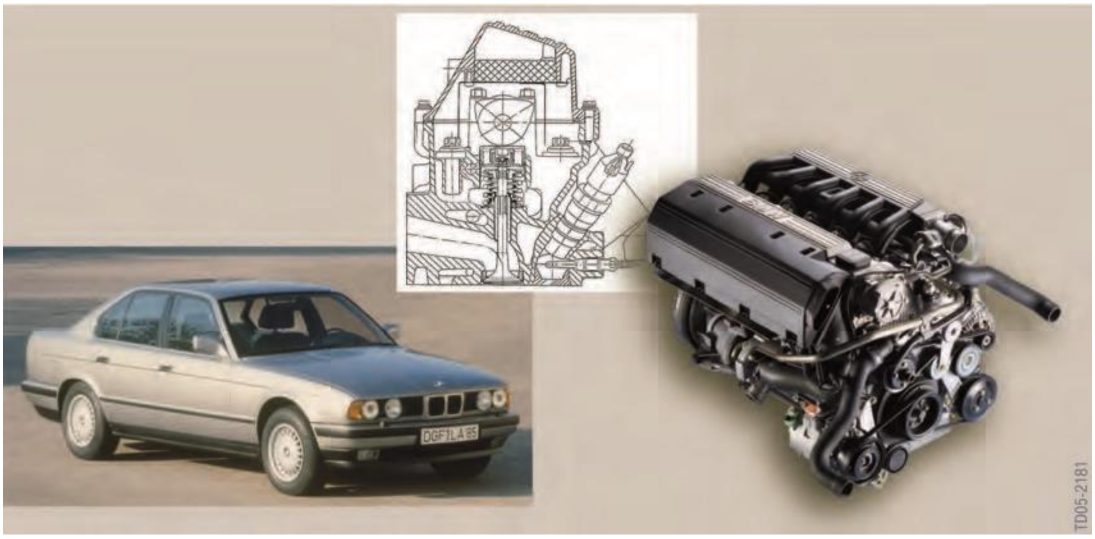
As the world's first carmaker to do so, BMW introduced the electronic engine management system, the so-called Digital Diesel Electronics (DDE). Faster and more exact than a mechanical control system, the electronics effectively controls:

- Exhaust emission characteristics
- Fuel consumption characteristics
- Noise emission
- Engine running refinement.

1991

1991 saw the debut of the newly developed M51D25 engine which, with intercooling and an output of 105 kW/143 bhp was the most powerful diesel engine in its class throughout the world. It replaced the M21 engine and was fitted with a crankcase based on a completely new design.

The engine was offered in the output variants 115 bhp and 143 bhp. Exhaust emission and full load smoke were reduced by a V-shaped main combustion chamber in the piston.



3 - BMW 525tds with M51 engine

1994

hollow-cast camshaft mounted in 5 bearings as well as a cylinder head cover the isolated

The M41 engine was the first 4-cylinder diesel structure-borne noise. enginetobeusedatBMW.Itwasderivedfrom the M51D25 engine and shared 56 % of its This engine was fitted in various models of the components. New features included the E36 series.

1998

In 1998 BMW built the most powerful 4cylinder diesel engine - the M47 with direct fuel injection.

With 100 kW developed from 2 litre displacement, a performance level was achieved which up until then was the reserve only of petrol engines. This corresponds to a specific output of 50 kW or 68 bhp.

4 - BMW 320d with M47 engine

Motor sport provided the best proof of the efficiency and reliability of the new diesel technology. BMW celebrated a historic success on the Nürburg Ring.

With the 320d, a diesel engine won a 24 hour race for the first time in motor sports history in 1998. This victory came not only due to the fact that it needed

5 - BMW 320d touring car with M47 engine

fewer pit stops for refuelling but also because the BMW drove the fastest lap times.

1999

The first V8 diesel engine, the M67D40 engine, with 4 litre displacement was presented in the E38 which developed an output of 175 kW. BMW proved its technical authority with the, at that time, world's most powerful passenger vehicle diesel engine with common rail fuel injection and 2 exhaust turbochargers.

The engine is fitted with a crankcase made from high-strength cast iron with vermicular graphite (GGV), an aluminium cylinder head and a two-piece oil sump.

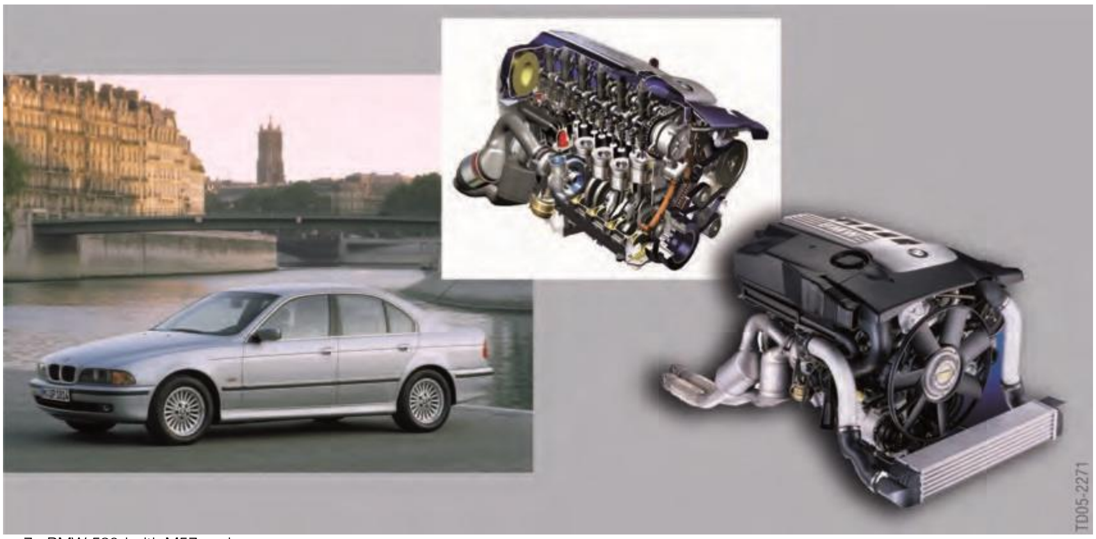
6 - BMW 740d with M67 engine

2001

The M47TU with the second generation common rail injection system and DDE5 boosted the power output to 110 kW/150 bhp.

The M57D30 engine is a further development of the M51D25 engine. It has a cast iron casing fitted with a light alloy cylinder head with 4-valve technology. The M57 engine is theworld'sfirst6-cylinderin-line dieselengine in a passenger vehicle that is equipped with future-oriented common rail injection technology.

This new, highly complex electronically controlled fuel injection system perfectly satisfies the demands for high and constant injection pressure over the entire injection period. The engine offers substantially lower fuel consumption compared to swirl-chamber engines, superior performance and smooth engine operation under extreme conditions.



7 - BMW 530d with M57 engine

2004

The M57TU TOP engine with 2-stage turbocharging is introduced as the most powerful diesel engine (E60 and E61). One smallandonelargeturbochargerisusedinthe 2-stage turbocharging system. The diesel engine in the 535d develops 40 kW/54 bhp more than at the same displacement (3.0 litres) in the 530d.

The power output is 200 kW/272 bhp. The maximum torque of 560 Nm is reached at 2000 rpm. With this extraordinary engine, Luc Alphand won not only the diesel classification of the Paris-Dakar Rally, but also came fourth in the overall rankings.

8 - BMW X5 3.0d with M57TU TOP engine

2005

The M57TU2 engine is fitted in the E65. In addition to the increase in output and torque, it boasts the following technical features:

- Reduced weight through aluminiumcrankcase
- 3rd generation common rail system withpiezo-injector and a fuel rail pressure of 1600 bar
- Compliance with the exhaust emissionregulation EURO 4 and diesel particulate filter as standard
- Optimized electric boost pressure actuatorfor the turbocharger with variable turbine geometry.

9 - BMW 730d with M57TU2 engine

2005

The M67 engine in the E65 was comprehensively reengineered in the same year. The aim was to achieve a distinct boost in dynamics by increasing power output and reducing weight. In the case of the M67 specifically this aim is reflected in an increase in power output of 16 % while simultaneously reducing the engine weight by 14 % - and achieved without increasing fuel consumption.

This was mainly achieved through a new, lightweight aluminium crankcase and by increasing the displacement to 4.4 litres.

10 - BMW 745d with M67TU engine

2006

In 2006, the M57TU TOP engine was reengineered and equipped with the same technical details as the M57TU2, such as an aluminium crankcase and piezo-fuel injectors. This engine was given the designation M57D30T2. It was introduced simultaneously into the 3 Series as the 335d and in the X3 as the 3.0sd. This re-engineering resulted in further-improved power characteristics, enhanced smooth operation and a significant reduction in fuel consumption. This engine forms the basis for re-introducing diesel technology into the USA after more than 20 years.

Legislation

Since the first exhaust emission legislation for petrol engines came into force in the mid1960s in California, the permissible limits for a range of pollutants have been further and further reduced. In the meantime, all industrial nations have introduced exhaust emission legislation that defines the emission limits for petrol and diesel engines as well as the test methods.

Essentially, the following exhaust emission legislation applies:

- CARB legislation (California Air ResourcesBoard), California
- EPA legislation (Environmental ProtectionAgency), USA
- EU legislation (European Union) andcorresponding ECE regulations (UN Economic Commission for Europe), Europe
- Japan legislation.

This legislation has lead to the development of different requirements with regard to the limitation of various components in the exhaust gas. Essentially, the following exhaust gas constituents are evaluated:

- Carbon monoxide (CO)

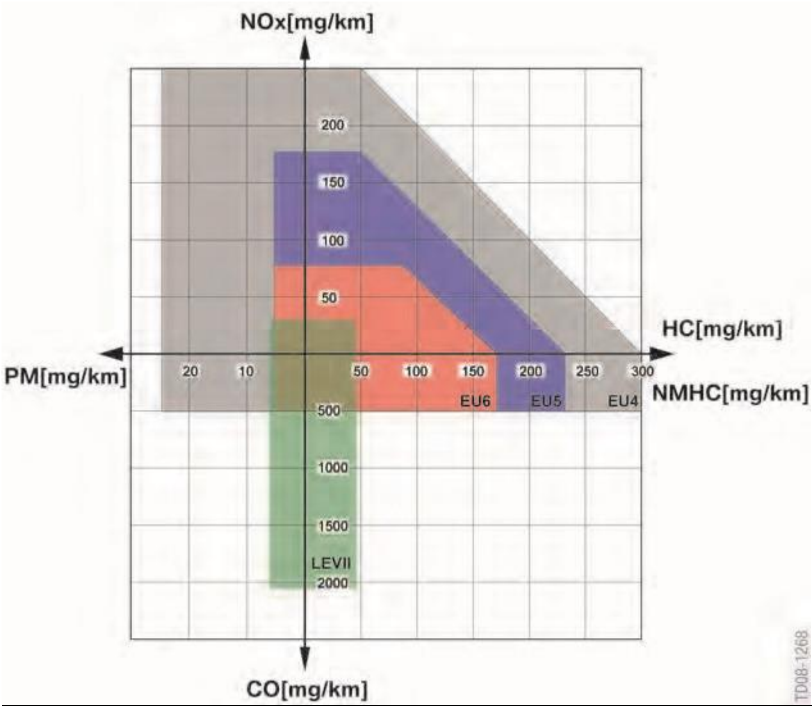
11 - X3 3.0sd with M57TU2 TOP engine

- Nitrogen oxides (NO_X)
- Hydrocarbons (HC)
- Particulates (PM)

It can generally be said that traditionally more emphasis is placed on low nitrogen oxide emissions in US legislation while in Europe the focus tends to be more on carbon monoxide.

The following graphic compares the standard applicable to BMW diesel vehicles with the current standards in Europe. A direct comparison, however, is not possible as • different measuring cycles are used and

- different values are measured forhydrocarbons.



12 - Comparison of exhaust emission legislation

Standard	Valid from	CO [mg/km]	NO_x [mg/km]	HC + NO_x* [mg/km]	NMHC** [mg/km]	PM [mg/km]
EURO 4	01.01.2005	500	250	300	-	25
EURO 5	01.09.2009	500	180	230	-	5
EURO 6	01.09.2014	500	80	170	-	5
LEV II	MY 2005	2110	31	-	47	6

* In Europe, the sum of nitrogen oxide and hydrocarbons is evaluated, i.e. the higher the HC emissions, the lower the NO_x must be and vice versa.

** In the USA, only the methane-free hydrocarbons are evaluated, i.e. all hydrocarbons with no methane

Although the European and US standards cannot be compared 1:1 it is clear that requirements relating to nitrogen oxide emissions are considerably more demanding.

Overview of innovations, modifications and special features

Diesel engines generally have higher nitrogen oxide emission levels than petrol engines as diesel engines are normally operated with an air surplus.

For this reason, the challenge of achieving approval in all 50 states of the USA had to be met with a series of new technological developments.

The following table provides an overview of the special features of the M57D30T2 US engine. They are divided into various categories.

- New development signifies a technologythat has not previously been used on BMW engines.

- Modificationsignifiesacomponentthatwasspecificall y designed for the

  M57D30T2 US engine but does not

Europe version as well as fundamentalvehiclesystemsspecifictodi esel engines.

Component	New development	Modification	Adopted	Remarks
Engine mechanical system		7		Very few modifications have been made to the basic engine. The modifications that have been made focus mainly on ensuring smooth engine operation. A significant feature, however, is the OBD monitoring of the crankcase breather.
Air intake and exhaust system	7			The most extensive changes were made to the air intake and exhaust system. For instance, low pressure exhaust gas recirculation (low pressure EGR) is used for the first time at BMW on the E70. In addition to other minor adaptations, there are substantial differences in the sensor and actuator systems.
Cooling system		7		In principle, the cooling system corresponds to that of the Europe versions, however, it has been adapted to hot climate requirements.
Fuel preparation system		7		The functional principle of the fuel preparation system does not differ from that of the Europe version, however, individual components have been adapted to the different fuel specification.

  represent a technical innovation.

- Adopted describes a component that hasalready been used in other BMW engines.

This Product Information describes only the main modifications to the M57D30T2 engine compared to the

Component	New development	Modification	Adopted	Remarks
Fuel supply system			7	The fuel supply system is vehicle-specific and corresponds to the Europe version. Thereare,however,significantdifferencesto petrol engine vehicles.
SCR system (Selective Catalytic Reduction)	7			The SCR system is used for the first time at BMW. Nitrogen oxide emissions are drastically reduced by the use of a reducing agentthatisinjectedintotheexhaustsystem upstream of a special SCR catalytic converter. Since the reducing agent is carried in the vehicle, a supply facility, made up of two reservoirs, is part of this system.
Engine electrical system			7	The engine is equipped with the new DDE7 (digitaldieselelectronics)controlunitthatwill beusedinthenextgenerationdieselengines (N47, N57). The preheater system also corresponds to the N47/N57 engines.
Automatic transmission			7	The automatic transmission corresponds to that in the ECE variant of the X5 xDrive35d. The gearbox itself has already been used in the US version of the X5 4.8i, however, a different torque converter is used for the diesel model.

Technical data

The following table compares the M57D30T2 US engine with petrol engines that are offered for the same models.

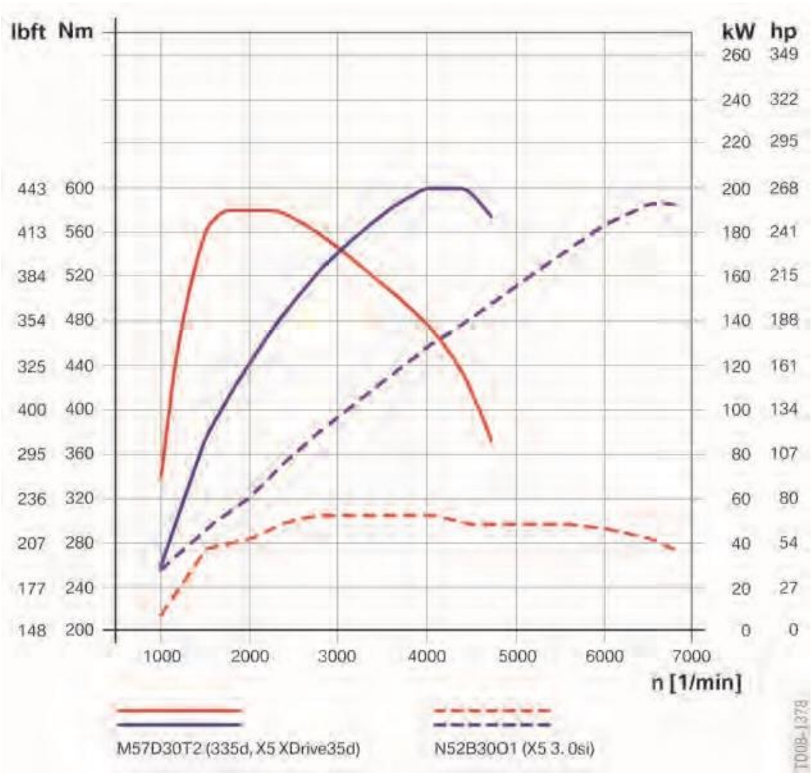
Designation		N52B30O1	N54B30O0	N62B48O1	M57D30T2
Type		Straight 6	Straight 6	V8	Straight 6
Displacement	[cm^3]	2996	2979	4799	2993
Firing order		1-5-3-6-2-4	1-5-3-6-2-4	1-5-4-8-6-3-7-2	1-5-3-6-2-4
Stroke/bore	[mm]	88.0/85	88.9/84	88.3/93	90.0/84
Output at engine speed	[kW/hp*] [rpm]	193/260 6600	225/300 5800	261/350 6250	200/265 4200
Torque at engine speed	[Nm/lbft] [rpm]	305/225 2500	407/300 1400	475/350 3500	580/428 1750
Governed engine speed limit	[rpm]	7000	7000	6500	4800
Power output per litre	[hp/l]	86.7	100	72.9	89.3
Compression ratio	ε	10.7	10.2	10.5	16.5
Cylinder spacing	[mm]	91	91	98	91
Valves/cylinder		4	4	4	4
Intake valve ∅	[mm]	34.2	31.4	35.0	27.4
Exhaust valve ∅	[mm]	29.0	28.0	29.0	25.9
Main bearing journal ∅ on crankshaft	[mm]	56	56	70	60
Big-end bearing journal ∅ on crankshaft	[mm]	50	50	54	45
Fuel specification	[RON]	98	98	98	
Fuel	[RON]	91-98	91-98	91-98	Diesel

Engine management	MSV80	MSD80	ME9.2.3	DDE7.3
Exhaust emission standard US	ULEVII	ULEVII	ULEVII	LEVII

* SAE-hp

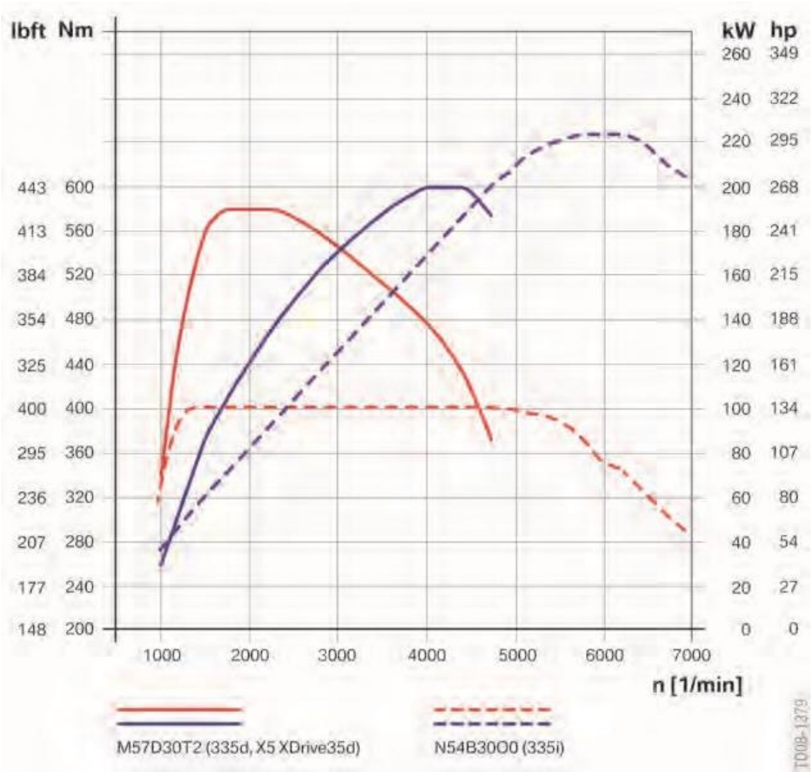
Full load diagrams

To get an idea of the performance of the load M57D30T2 US engine, it is compared to various petrol engines in the following full diagrams.



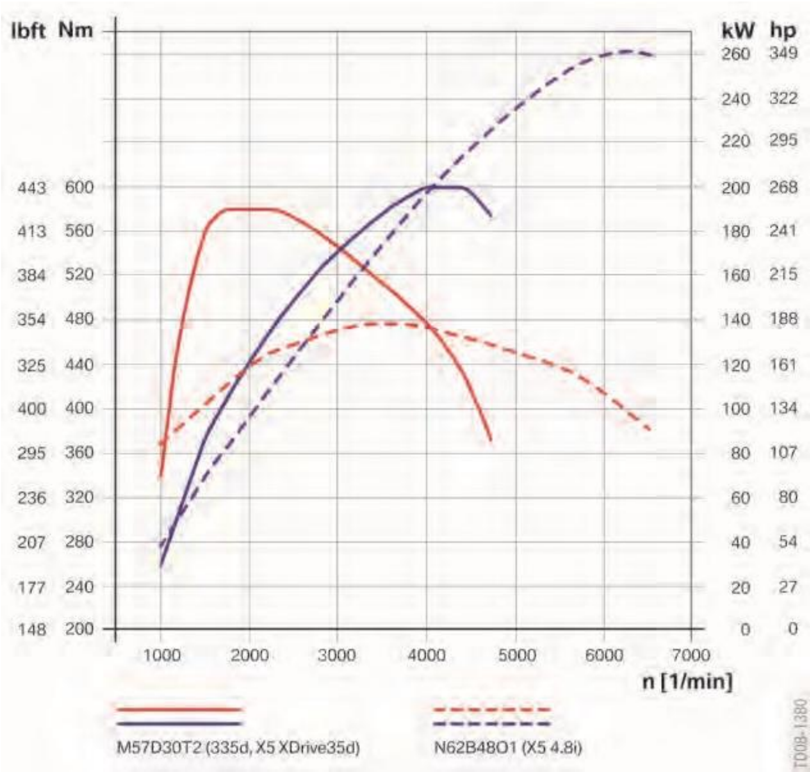
13- M57D30T2 US enginecompared to N52B30O1 engine

By comparing these two 3 litre engines it can be clearly seen that, despite virtually identical power output, the maximum torque of the diesel is almost double as high.



14 - M57D30T2 US enginecompared to N54B30O0 engine

This enormous difference in maximum torque turbocharged 3 litre petrol engine that has a is also apparent when comparing the considerably higher nominal power output.



15- M57D30T2 US enginecompared to N62B48O1 engine

Even the 4.8 litre V8 engine cannot achieve the maximum torque of the 3 litre diesel engine.

However, the decisive factor is the low engine speeds at which the diesel engine develops this high torque. This means that more power is available in this range. In terms of power output, the diesel engine is superior to any of these petrol engines up to an engine speed of 4000 rpm.

System components. Advanced Diesel.

Engine mechanical system

Only slight modifications have been made to the engine mechanical system compared to the Europe version.

The modifications include:

- Crankcase
- Crankshaft and big-end bearings
- Pistons
- Crankcase breather.

Crankshaft and big-end bearings

Only lead-free crankcase and big-end bearings are used in the M57D30T2 US engine. This conforms to requirements relating to environmental protection and the disposal of end-of-life vehicles.

Crankcase

In contrast to the Europe version, the M57D30T2 US engine has a larger reinforcement panel on the underside of the crankcase.

The reinforcement panel now covers four of the main bearing blocks for the crankshaft.

In principle, the reinforcement panel serves to enhance the stability of the crankcase. However, the enlargement was realized solely for acoustic reasons.

Never drive the vehicle without the reinforcement panel. 1

Pistons

The piston pin has a greater offset than in the Europe version. The offset of the piston pin means that the piston pin is slightly off centre. This provides acoustic advantages during changes in piston contact. The acoustic advantages of increasing the offset are further developed particularly at idle speed.

Crankcase breather

The crankcase breather in the US version is

1 -Blow-by pipe

generally heated. In addition, operation of the crankcase breather is OBD monitored (On Board Diagnosis). This is because a leaking system would produce emissions.

The only probable reason for a leak in the system would be that the blow-by pipe is not connected to the cylinder head cover. To facilitate protection of this situation by the OBD,theheatinglineisroutedviaaconnector tothecylinderheadcover(2).Essentially,this connector serves only as a bridge so that actuation of the heating system is looped through. The plug connection is designed in such a way that correct contact is made only when the blow-by pipe has been connected correctly to the cylinder head cover, i.e. the contactfortheheatingsystemisnotclosedif the blow-by pipe is not connected to the cylinder head cover. OBD recognizes this situation as a fault.

Index	Explanation
1	Cylinder head cover
2	Blow-byheaterconnectorforOBD monitoring
3	Blow-by heater connector at wiring harness
4	Filtered air pipe
5	Intake air from intake silencer
6	Blow-by heater connector at blow-by pipe

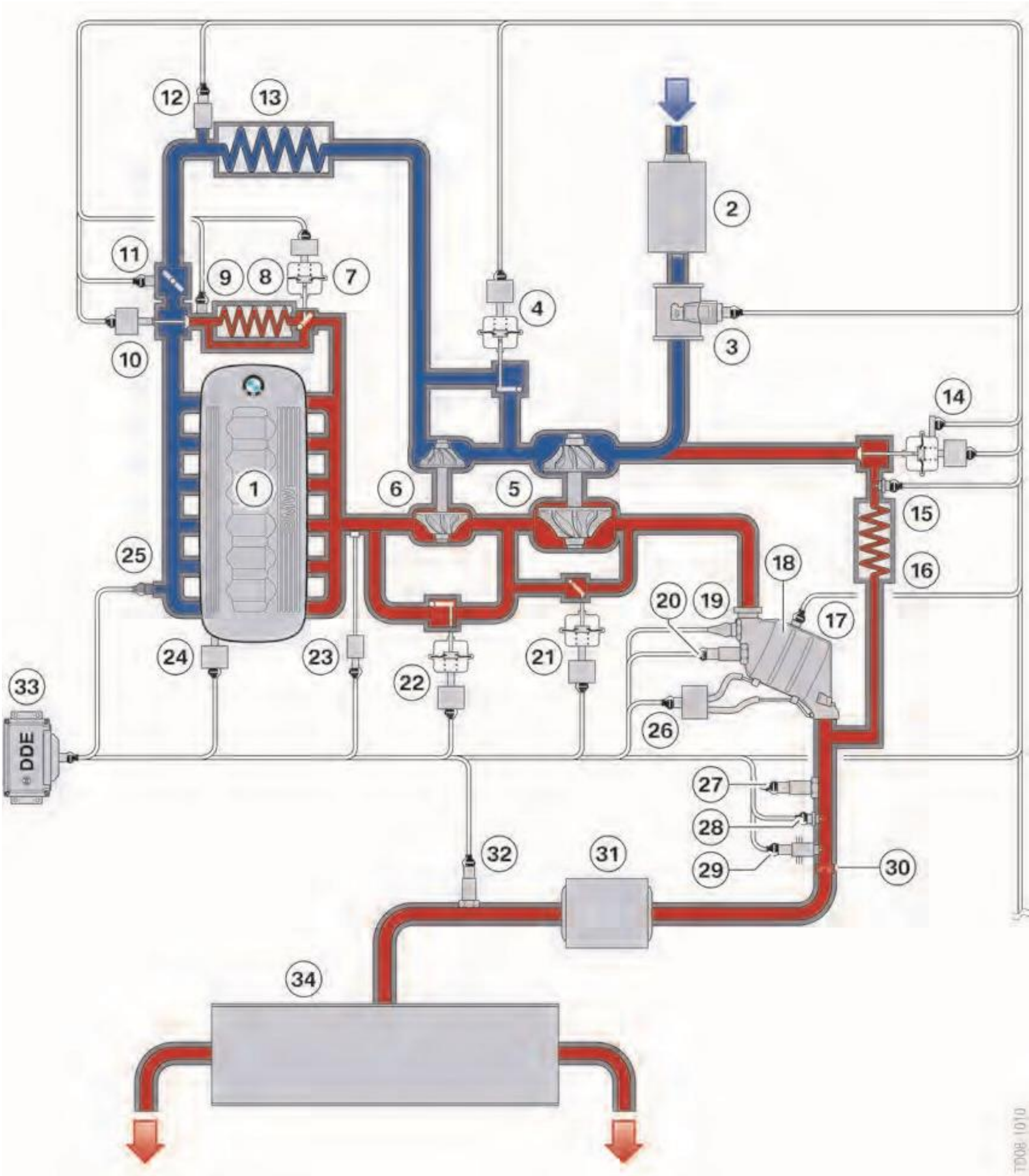
7	Intake air to exhaust turbocharger
8	Blow-by pipe

3 If the blow-by pipe is not connected to the cylinder head correctly, the OBD will activate the MIL (Malfunction Indicator Lamp). 1

Air intake and exhaust system

The M57D30T2 US engine exhibits the following special features in the air intake and exhaust system:

- Electric swirl flaps
- Electric exhaust gas recirculation valve (EGR valve)
- Low pressure EGR
- Turbo assembly adapted for low pressureEGR.



2 - Air intake and exhaust system - M57D30T2 US engine

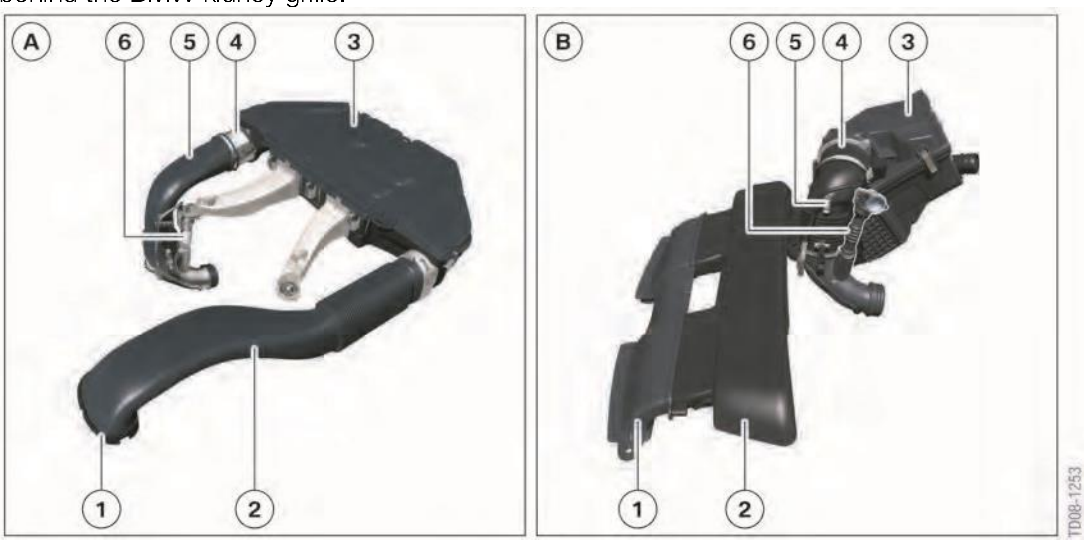
Index	Explanation	Index	Explanation
1	M57D30T2 US engine	18	Oxidation catalytic converter and diesel particulate filter
2	Intake silencer	19	Exhaust gas temperature sensor before oxidation catalytic converter
3	Hot-film air mass meter (HFM)	20	Oxygen sensor
4	Compressor bypass valve	21	Wastegate
5	Exhaust turbocharger, low pressure stage	22	Turbine control valve

6	Exhaust turbocharger, high pressure stage	23	Exhaust pressure sensor after exhaust manifold
7	Bypass valve for high pressure EGR cooler	24	Swirl flap regulator
8	High pressure EGR cooler	25	Boost pressure sensor
9	Temperature sensor, high pressure EGR	26	Exhaust differential pressure sensor
10	High pressure EGR valve	27	NO_X sensor before SCR catalytic converter
11	Throttle valve	28	Temperature sensor after diesel particulate filter
12	Charge air temperature sensor	29	Metering module (for SCR)
13	Intercooler	30	Mixer (for SCR)
14	Low pressure EGR valve with positional feedback	31	SCR catalytic converter
15	Temperature sensor, low pressure EGR	32	NO_X sensor after SCR catalytic converter
16	Low pressure EGR cooler	33	Digital Diesel Electronics (DDE)
17	Exhaust gas temperature sensor after oxidation catalytic converter	34	Rear silencer

Air intake system

Intake air system

The intake air system differs on the E70 and E90. Both vehicles draw in unfiltered air behind the BMW kidney grille.



3 - Air intake system E70 and E90

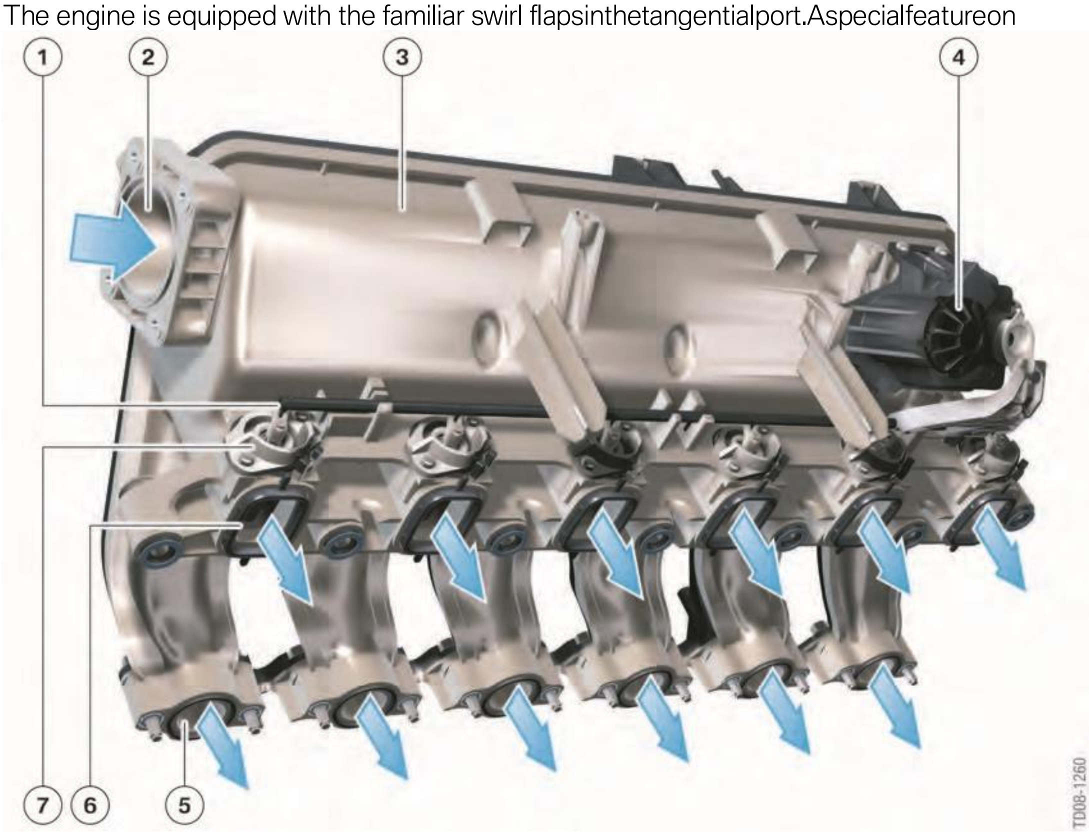
Index	Explanation	Index	Explanation

A	Air intake system E70	3	Intake silencer (air cleaner housing)
B	Air intake system E90	4	Hot-film air mass meter (HFM)
1	Intake	5	Filtered air pipe
2	Unfiltered air pipe	6	Blow-by pipe

On the E90, the intake silencer is located at thefrontrightoftheenginecompartmentfixed to the vehicle. On the E70, the intake silencer is fixed over the engine.

Swirl flaps

The engine is equipped with the familiar swirl flapsinthetangentialport.Aspecialfeatureon the US engine is the electric actuating system with positional feedback.

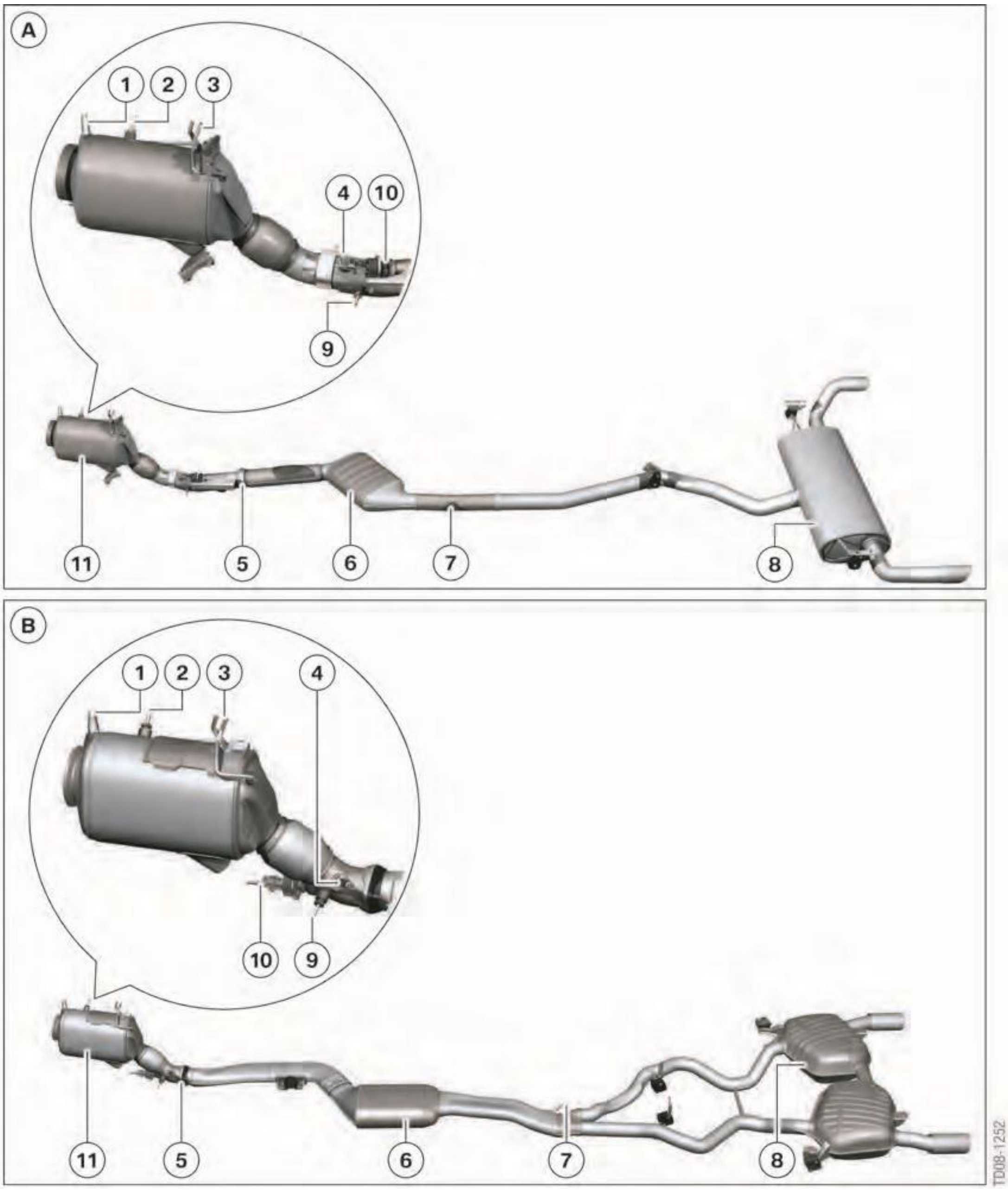


4 - Intake manifold with electric swirl flaps

Index	Explanation	Index	Explanation
1	Linkage for operating the swirl flaps	5	Swirl port
2	Connection to throttle valve	6	Tangential port
3	Intake manifold	7	Swirl flaps
4	Electric motor		

This system provides advantages in terms of control, however, it is also a prerequisite for meeting OBD requirements.

Exhaust system



5 - E70 and E90 exhaust systems

Index	Explanation	Index	Explanation
A	Exhaust system E70	6	SCR catalytic converter
B	Exhaust system E90	7	NO_X sensor after SCR catalytic converter
1	Oxygen sensor and concealed exhaust temperature sensor before oxidation catalytic converter	8	Rear silencer

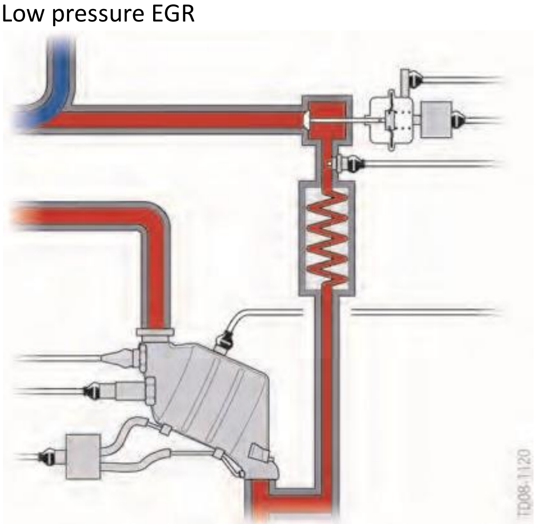
2	Exhaust gas temperature sensor after oxidation catalytic converter	9	Exhaust gas temperature sensor after diesel particulate filter
3	Differential pressure sensor	10	Metering module
4	NO_x sensor before SCR catalytic converter	11	Diesel particulate filter
5	Mixer		

Exhaust gas recirculation (EGR)

Exhaust gas recirculation is one of the available options for reducing NO_X emissions. Adding exhaust gas to the intake air reduces the oxygen in the combustion chamber, thus resulting in a lower combustion temperature.

The EGR systems in the E70 and E90 differ.
Both vehicles are equipped with the familiar EGR system. Due to its higher weight, the E70 additionally features low pressure EGR, used for the first time at BMW.

Low pressure EGR



6 - Low pressure EGR

The known EGR system has been expanded by the low pressure EGR on the E70. This system offers advantages particularly at high loads and engine speeds. This is why it is used in the heavier E70 as it is often driven in the higher load ranges.

The advantage is based on the fact that a higher total mass of exhaust gas can be recirculated. This is made possible for two reasons:

- Lower exhaust gas temperature

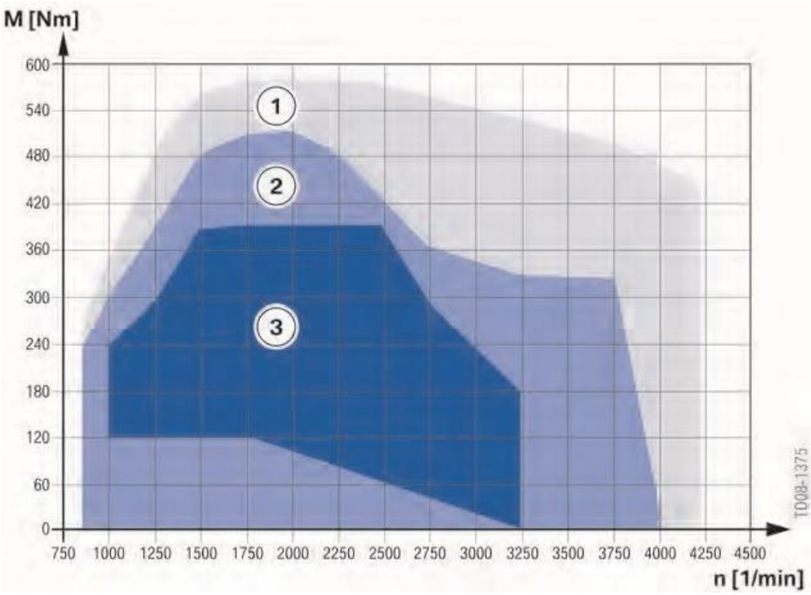
  The exhaust gas for the low pressure EGR is tapped off at a point where a lower temperature prevails than in the high pressure EGR. Consequently, the exhaust gas has a higher density thus enabling a higher mass.

  In addition, the exhaust gas is added to the fresh intake air before the exhaust turbocharger, i.e. before the intercooler, where it is further cooled. The lower temperature of the total gas enables a higher EGR rate without raising the temperature in the combustion chamber.

- Recirculation before the exhaustturbocharger

  Unlike in the high pressure EGR where the exhaust gas is fed to the charge air already compressed, in this system the exhaust gas is added to the intake air before the exhaust turbocharger. A lower pressure prevails in this area under all operating conditions. This makes it possible to recirculate a large volume of exhaust gas even at higher engine speed and load whereas this is limited by the boost pressure in the high pressure EGR.

The following graphic shows the control of the EGR system with low pressure EGR:

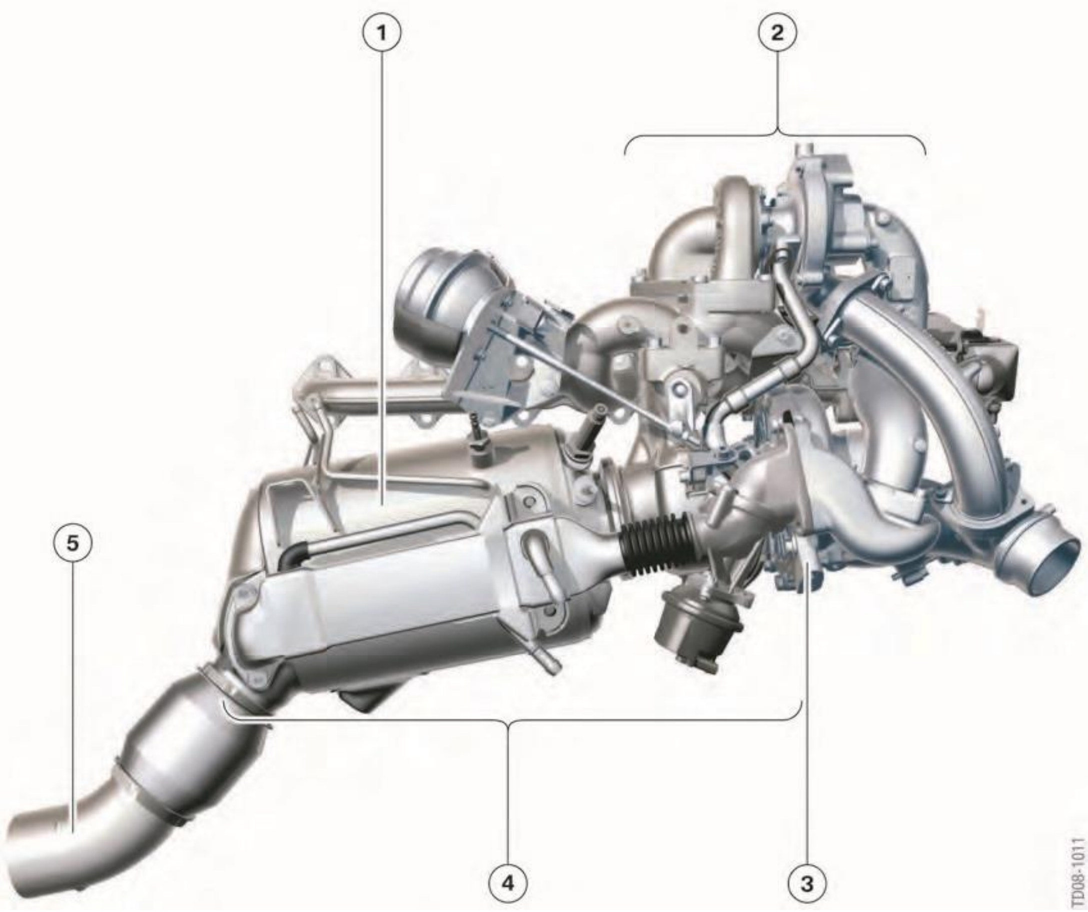


7 - Control of EGR system

Added to this, it is only activated at a coolant temperature of more than 55 °C. The low pressure EGR valve is closed as from a certain load level so that only the high pressure EGR valve is active again. This means the EGR rate is continuously reduced.

Index	Explanation	Index	Explanation
1	No exhaust gas recirculation	3	High and low pressure EGR are active
2	Only high pressure EGR is active		

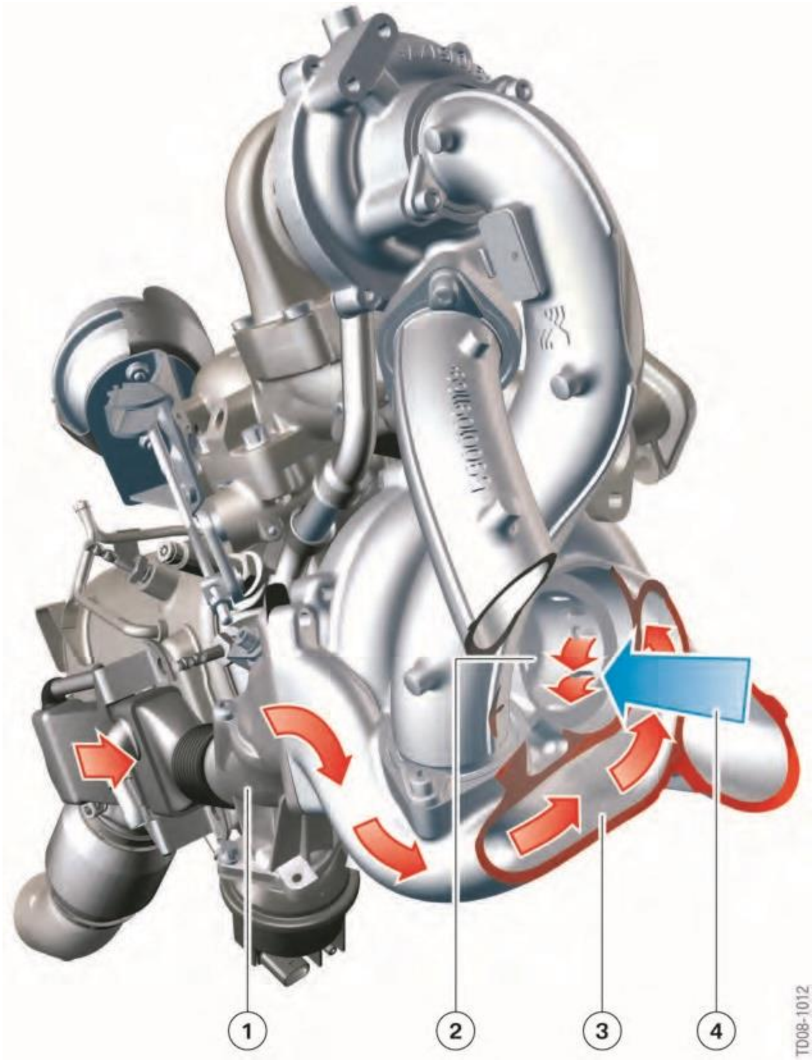
As already mentioned, the low pressure EGR hasthegreatestadvantageathigherloadsand is therefore activated, as a function of the characteristic map, only in this operating mode. The low pressure EGR, however, is never active on its own but rather always operatestogetherwiththehighpressureEGR.



8 - Installation position LP EGR

Index	Explanation	Index	Explanation
1	Diesel particulate filter	4	Low pressure EGR
2	Turbo assembly	5	Exhaust system
3	Exhaust turbocharger, low pressure stage		

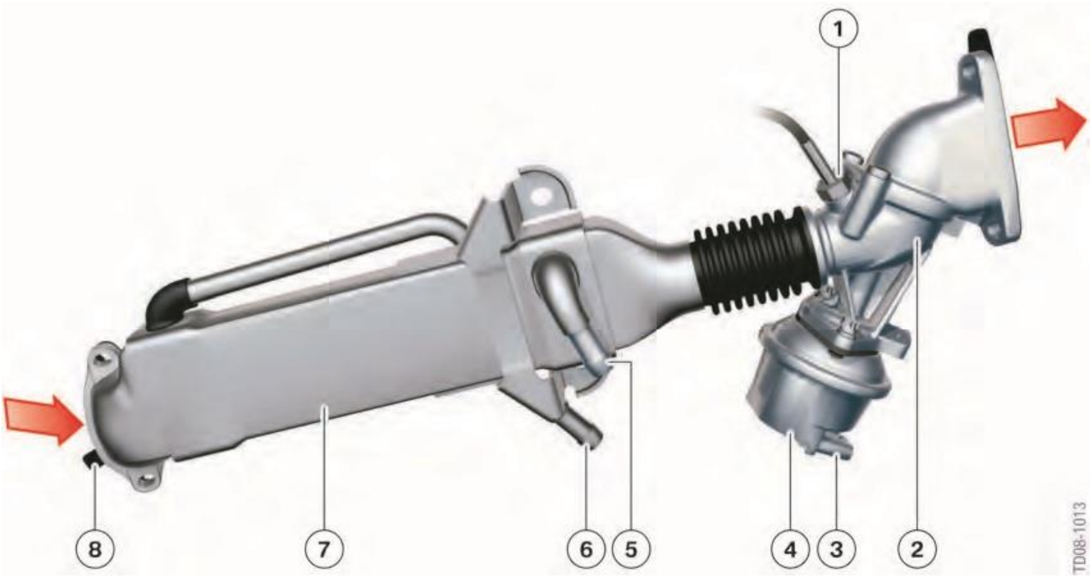
The low pressure EGR system is located on exhaust gas is branched off directly after the the right-hand side on the engine directly next diesel particulate filter and fed to the intake air to the diesel particulate filter and the low before the compressor for the low pressure pressure stage of the turbo assembly. The stage.



9 - Low pressure EGR intake

nation
ressure EGR port
ered air intake

The following graphic shows the components of the low pressure EGR:



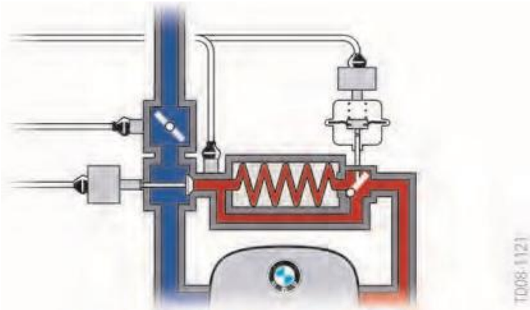
10 - LP EGR components

Index	Explanation	Index	Explanation
1	Temperature sensor, low pressure EGR	5	Coolant infeed
2	Low pressure EGR valve	6	Coolant return
3	Connection for positional feedback	7	Low pressure EGR cooler
4	Vacuum unit for low pressure EGR valve	8	Sheet metal gasket with filter

There is a fine meshed metal screen filter located at the exhaust gas inlet from the diesel particulate filter to the low pressure EGR system. The purpose of this filter is to ensure that no particles of the coating particularly in a new diesel particulate filter can enter the low pressure EGR system. Such particles would adversely affect the compressor blades of the exhaust turbocharger. 3 The metal screen filter must be installed when fitting the low pressure EGR cooler to the diesel particulate filter otherwise there is a risk of the turbocharger being damaged. 1

High pressure EGR

The exhaust gas recirculation known to date is

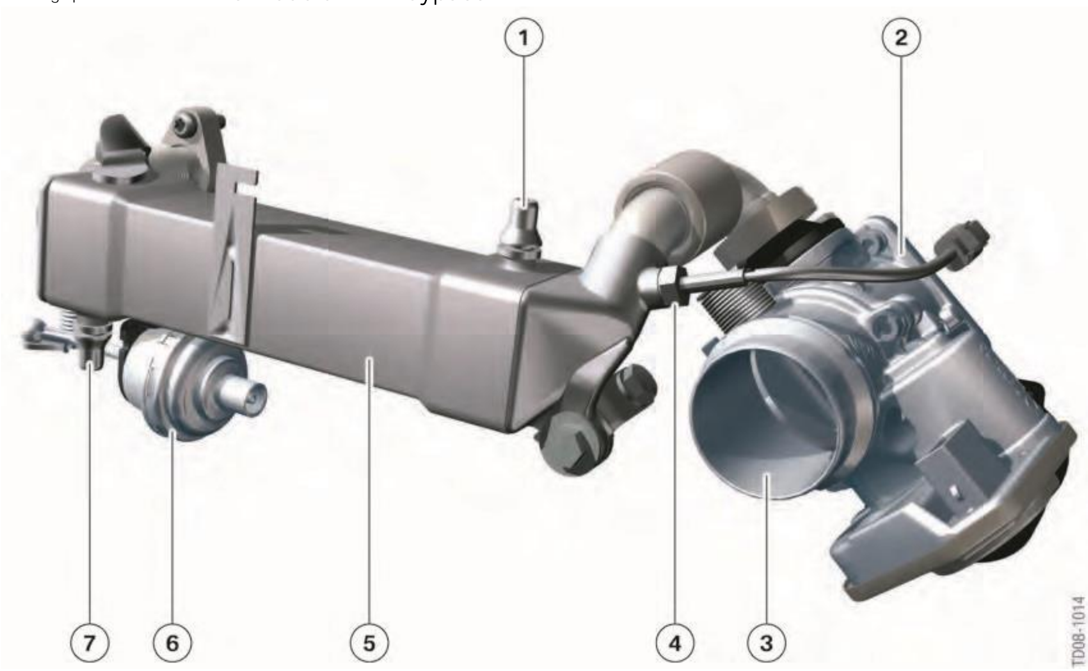


11 - High pressure EGR

referred to here as the high pressure EGR in order to differentiate it from the low pressure EGR.

Compared to the Europe version, the high pressure EGR is equipped with the following special features:

- Electric EGR valve with positional feedback
- Temperature sensor before high pressure EGR valve
- EGR cooler with bypass.



12 - High pressure EGR system

Index	Explanation	Index	Explanation
1	Coolant infeed	5	High pressure EGR cooler
2	High pressure EGR valve	6	Vacuum unit of bypass valve for high pressure EGR cooler
3	Throttle valve	7	Coolant return
4	Temperature sensor, high pressure EGR		

The electric actuating system of the EGR valve enables exact metering of the recirculated exhaust gas quantity. In addition, this quantity is no longer calculated based solely on the signals from the hot-film air mass meter and oxygen sensor but the following signals are also used:

- Travel of high pressure EGR valve
- Temperature before high pressure EGRvalve
- Pressure difference between exhaust gaspressure in the exhaust manifold and boost pressure in the intake manifold.

This enables even more exact control of the EGR rate.

The EGR cooler serves the purpose of increasing the efficiency of the EGR system. However, reaching the operating temperature as fast as possible has priority at low engine temperatures. In this case, the EGR cooler can be bypassed in order to heat up the combustion chamber faster. For this purpose, a bypass that diverts the coolant is integrated in the EGR cooler. This bypass is actuated by a flap which, in turn, is operated by a vacuum unit. The bypass is either only in the "Open" or "Closed" position.

Exhaust turbocharger

The US engine is equipped with the same variable twin turbo as the Europe version, however, the turbo assembly is modified due to the low pressure EGR.

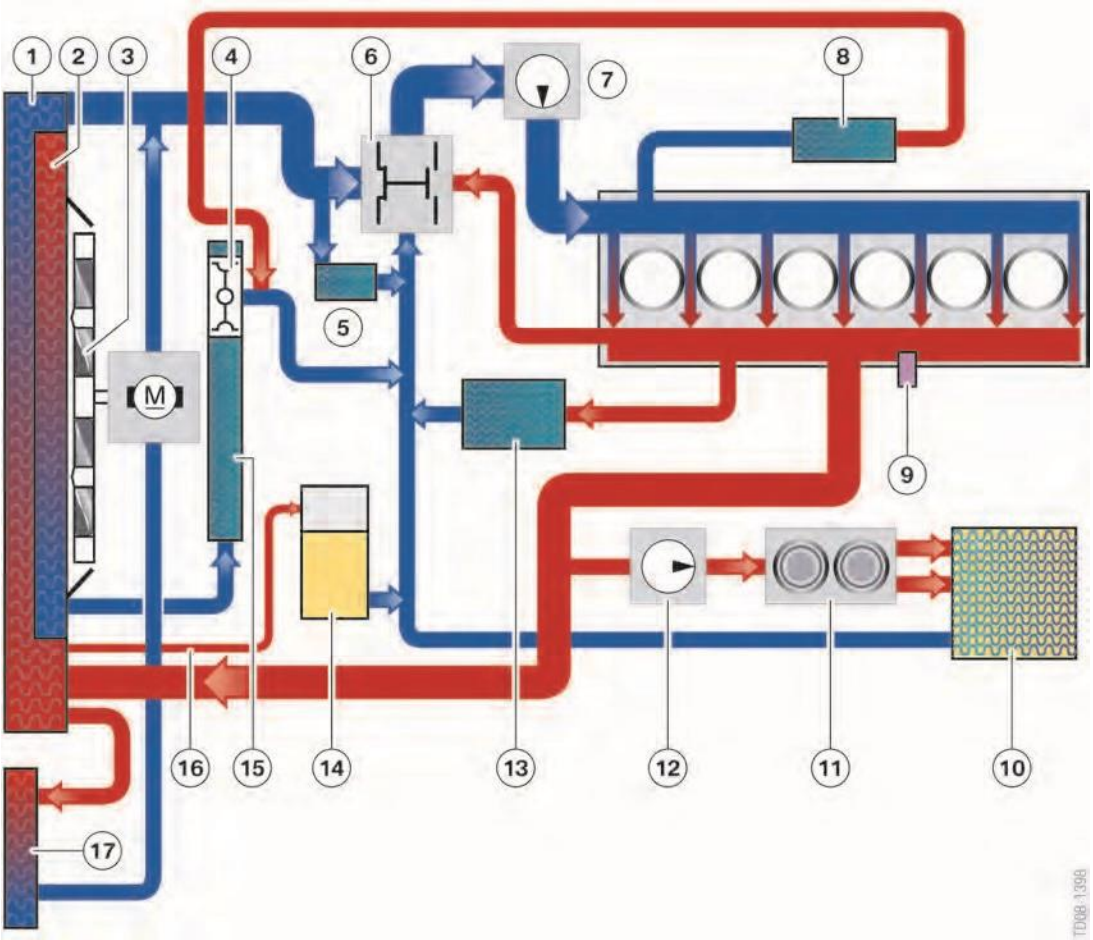
On the one hand, the inlet for the low pressure EGR is located on the compressor housing for the low pressure stage. On the other hand, the compressor wheels are nickel-coated to protect them from the exhaust gas.

Cooling system

Thecoolingsystem,isinpart,vehicle-specific. TheE70andE90differwithregardtotheEGR In principle, there are scarcely any differences cooler. Since the E70 is equipped with a low between the cooling systems on petrol and pressure EGR system, it has a second EGR diesel engines. cooler, the low pressure EGR cooler.

The two basic differences compared to petrol engines are:

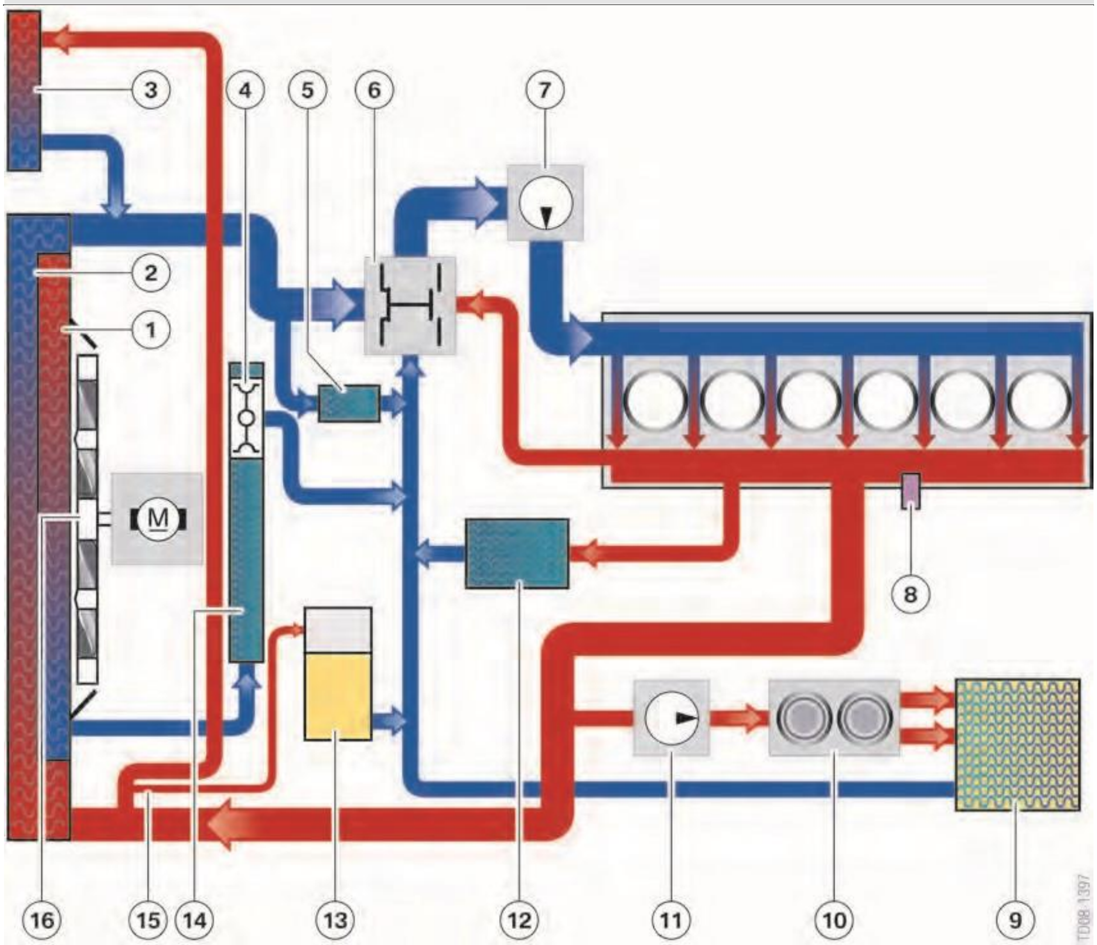
- No characteristic map thermostat
- EGR cooler.



13 - X5 xDrive35d cooling system

Index	Explanation	Index	Explanation
1	Radiator Coolant-to-air heat exchanger	10	Heating heat exchanger
2	Gearbox cooler Coolant-to-air heat exchanger	11	Duo-valve
3	Electric fan	12	Auxiliary coolant pump
4	Thermostat, gearbox oil cooler	13	Engine oil cooler Engine oil-to-coolant heat exchanger
5	High pressure EGR cooler	14	Expansion tank
6	Thermostat	15	Gearbox oil cooler Gearbox oil-to-coolant heat exchanger
7	Coolant pump	16	Ventilation line

8	Low pressure EGR cooler	17	Additional radiator Coolant-to-air heat exchanger
9	Coolant temperature sensor		

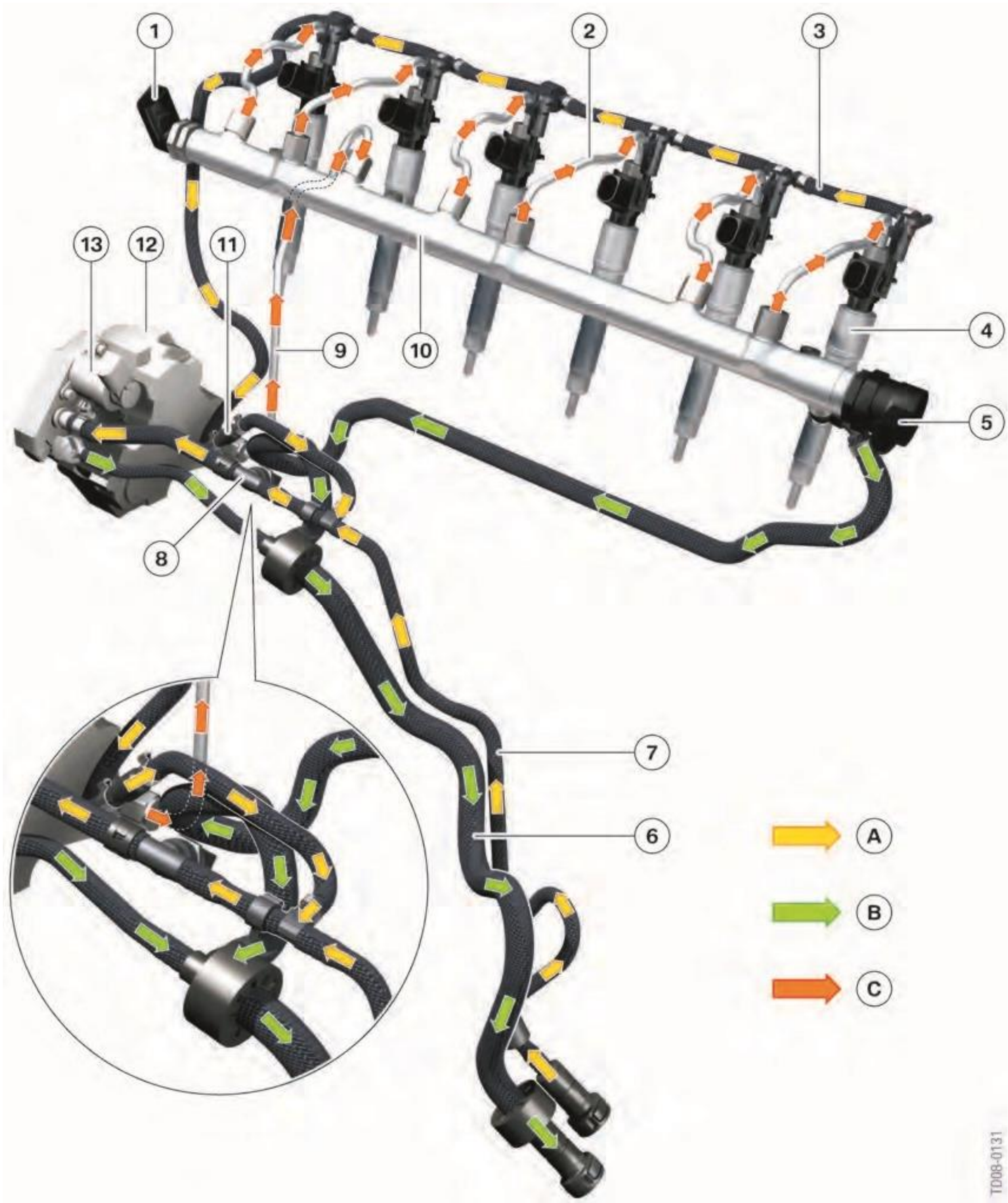


14 - 335d cooling system

Index	Explanation	Index	Explanation
1	Gearbox cooler Coolant-to-air heat exchanger	9	Heating heat exchanger
2	Radiator Coolant-to-air heat exchanger	10	Duo-valve
3	Additional radiator Coolant-to-air heat exchanger	11	Auxiliary coolant pump
4	Thermostat, gearbox oil cooler	12	Engine oil cooler Engine oil-to-coolant heat exchanger
5	High pressure EGR cooler	13	Expansion tank

6	Thermostat	14	Gearbox oil cooler Gearbox oil-to-coolant heat exchanger
7	Coolant pump	15	Ventilation line
8	Coolant temperature sensor	16	Electric fan

Fuel preparation system



15 - Fuel preparation system, M57D30T2 US engine

Index	Explanation	Index	Explanation
A	Fuel feed	6	Return line
B	Fuel return	7	Feed line
C	Fuel high pressure	8	Fuel temperature sensor
1	Fuel rail pressure sensor	9	High-pressure line
2	High-pressure line	10	Fuel rail
3	Leakage oil line	11	Restrictor
4	Piezo injector	12	High-pressure pump
5	Fuel rail pressure control valve	13	Volume control valve

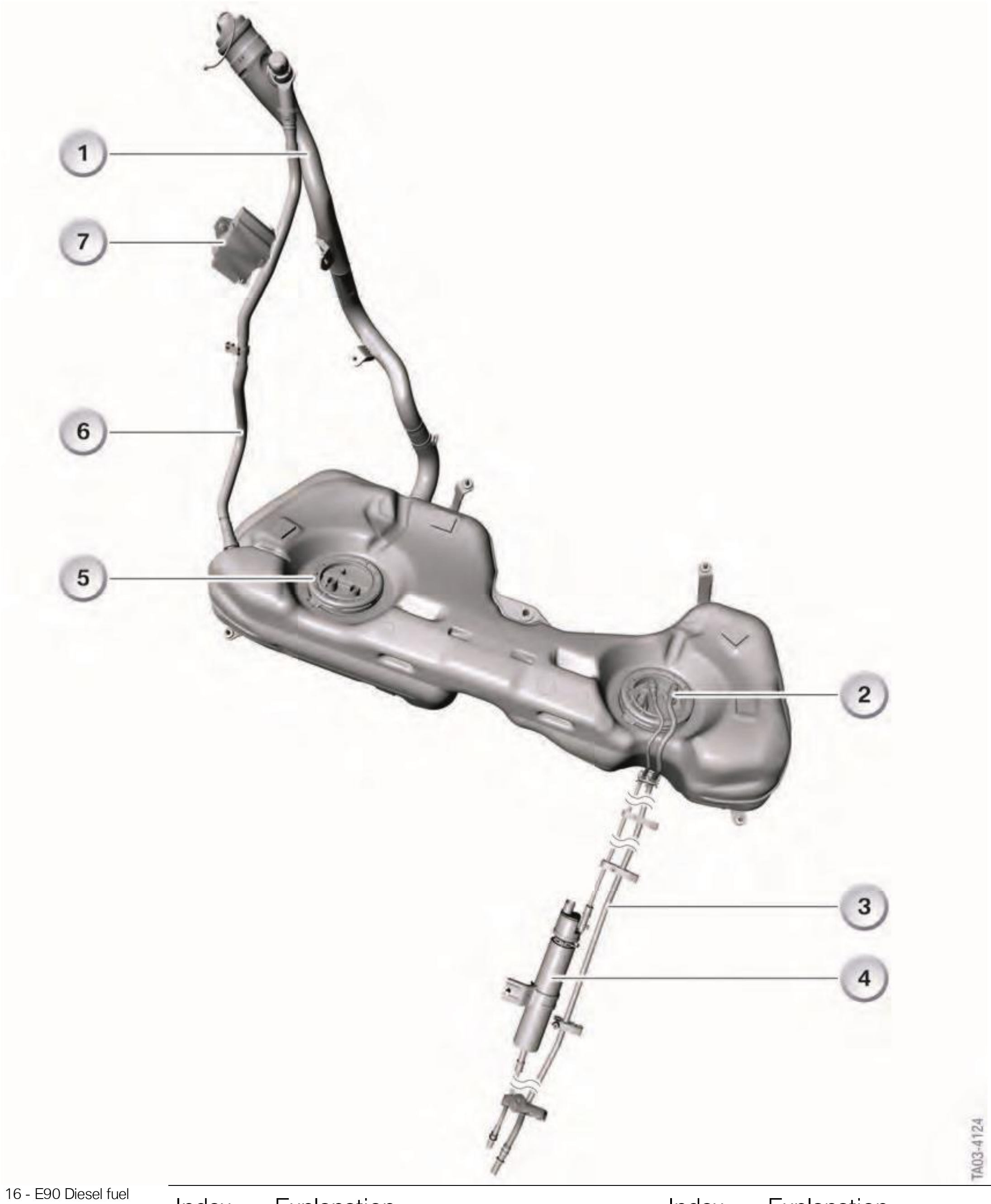
The fuel preparation system differs neither in terms of design layout nor function from the Europe version. However, some components have been adapted to the different fuel specification.

These components are:

- High-pressure pump
- Fuel rail
- Fuel injectors.

These adaptations are restricted to different coatings and materials on the inside.

Overview of fuel supply system



16 - E90 Diesel fuel supply system

Index	Explanation	Index	Explanation
1	Fuel filler neck	5	Right-hand service opening
2	Left-hand service opening	6	Filler vent
3	Fuel return line	7	Electric fuel pump controller
4	Fuel filter with heating system		

Design

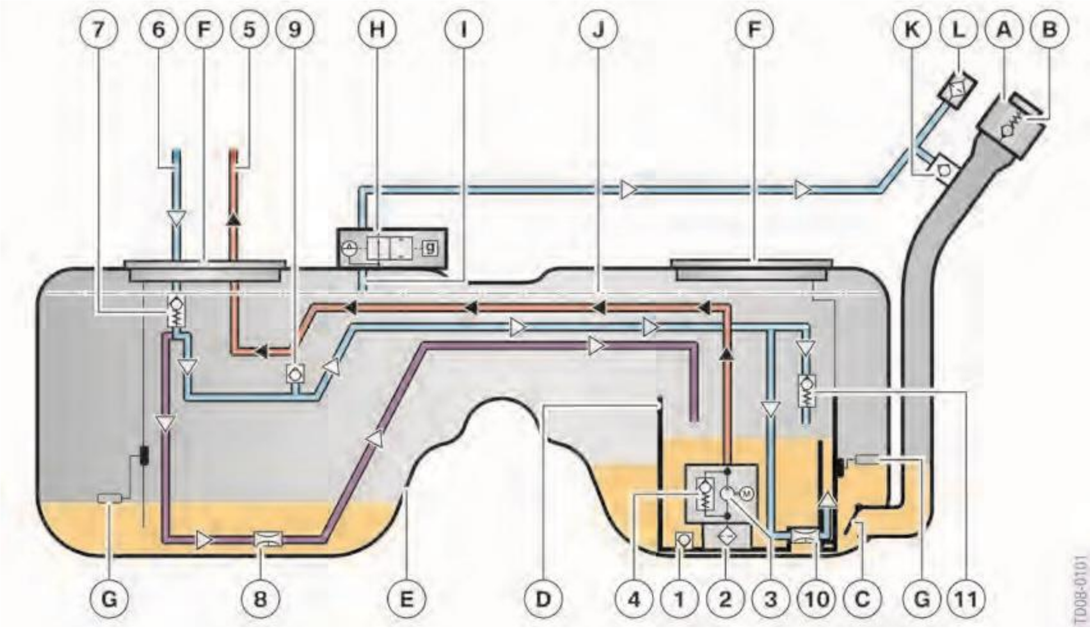
As for petrol engines, the fuel system is vehicle-specific. There are, however, several general and significant differences compared to petrol engine vehicles.
These are:

- The system includes a fuel return line
- The breather system is significantly simpler
- There is no carbon canister (AKF) and nofuel tank leakage diagnosis module (DMTL) • There is no pressure regulator

- The fuel filter is not located in the fuel tank.

The design layout of the fuel supply systems in the E70 and E90 are described in the following.

E70 with diesel engine



17 - Fuel tank on E70 with diesel engine

Index	Explanation	Index	Explanation
A	Fuel filler cap	1	Initial fill valve
B	Pressure relief valve	2	Intake mesh filter
C	Non-return valve	3	Fuel pump
D	Surge chamber	4	Pressure relief valve
E	Fuel tank	5	Feed line
F	Service cap	6	Return line
G	Lever-type sensor	7	Leak prevention valve
H	Filler vent valve	8	Suction jet pump
I	Connection	9	Air inlet valve
J	Maximum fill level	10	Suction jet pump
K	Non-return valve	11	Pressure relief valve
L	Filter		

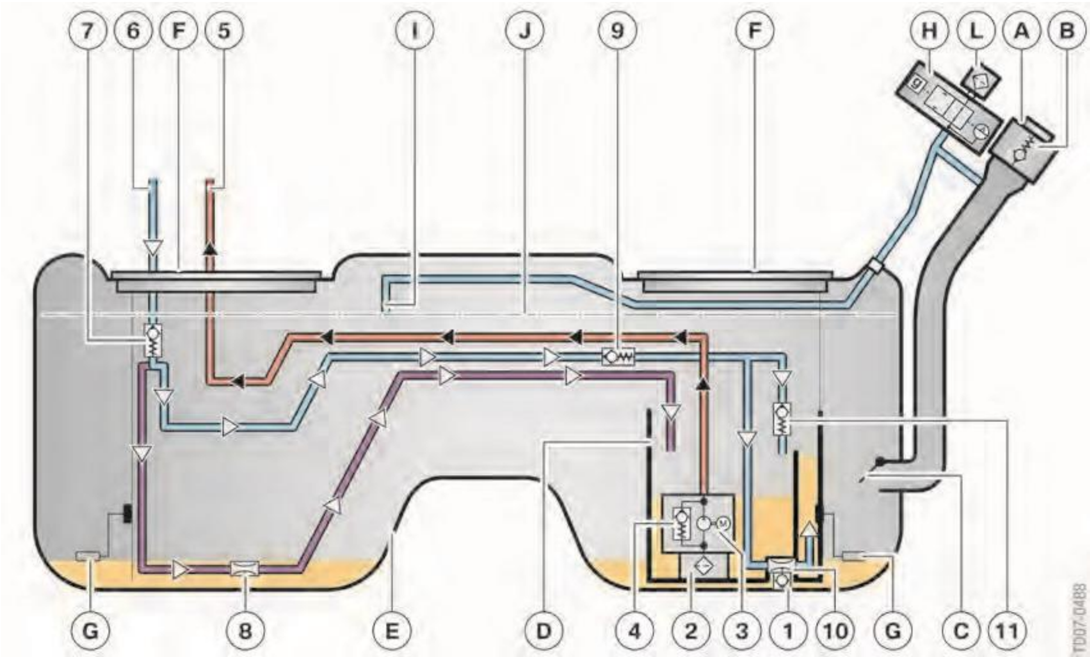
In addition to delivering the fuel to the engine, the fuel supply system also filters the fuel. The fuel tank contains an additional venting system.

The fuel tank is divided into two chambers because of the space available in the vehicle. The fuel supply system has two delivery units that are accommodated in the right and left fuel tank halves.

The fuel pump (3) with intake filter (2) is a part of the right-hand delivery unit. The surge chamber including a suction jet pump (10) with pressure relief valve (11) and initial fill valve (1) as well as a lever-type sensor (G) complete this delivery unit.

The suction jet pump (8), lever-type sensor A line leads from the filler vent valve (H) to the (G), leak prevention valve (7) and air inlet valve filter (L). The fuel filler pipe is connected to this (9) belong to the left-hand delivery unit. line via the non-return valve (K).

E90 with diesel engine



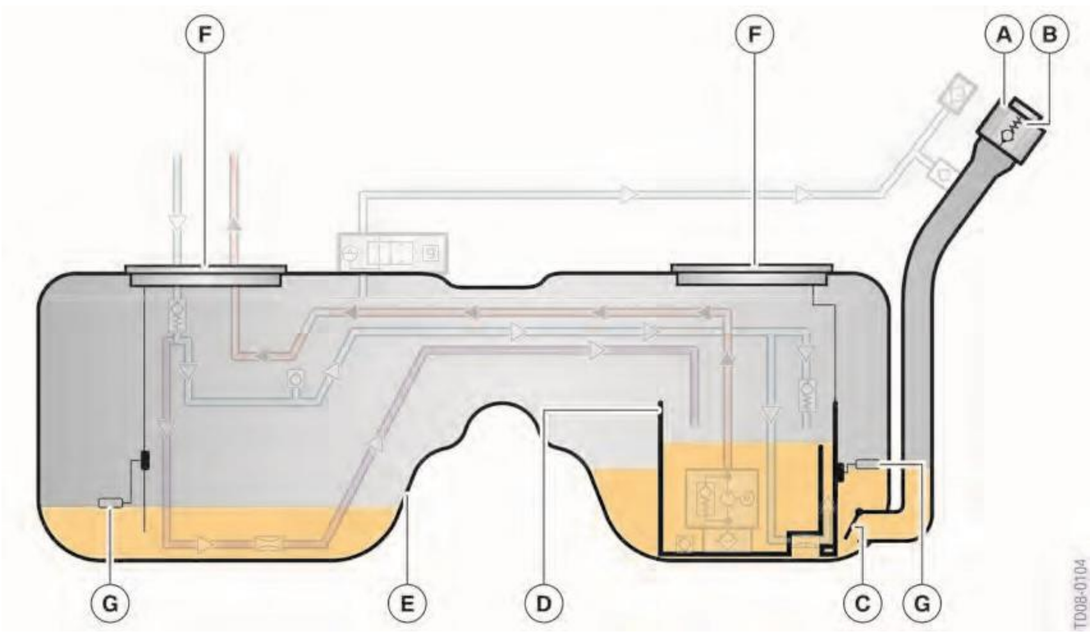
18 - Fuel tank on E90 with diesel engine

Index	Explanation	Index	Explanation

A	Fuel filler cap	1	Initial fill valve
B	Pressure relief valve	2	Intake mesh filter
C	Non-return valve	3	Fuel pump
D	Surge chamber	4	Pressure relief valve
E	Fuel tank	5	Feed line
F	Service cap	6	Return line
G	Lever-type sensor	7	Leak prevention valve
H	Filler vent valve	8	Suction jet pump
I	Connection	9	Non-return valve
J	Maximum fill level	10	Suction jet pump
L	Filter	11	Pressure relief valve

Functions of the fuel supply system

Fuel tank



19 - Fuel tank for E70 with diesel engine

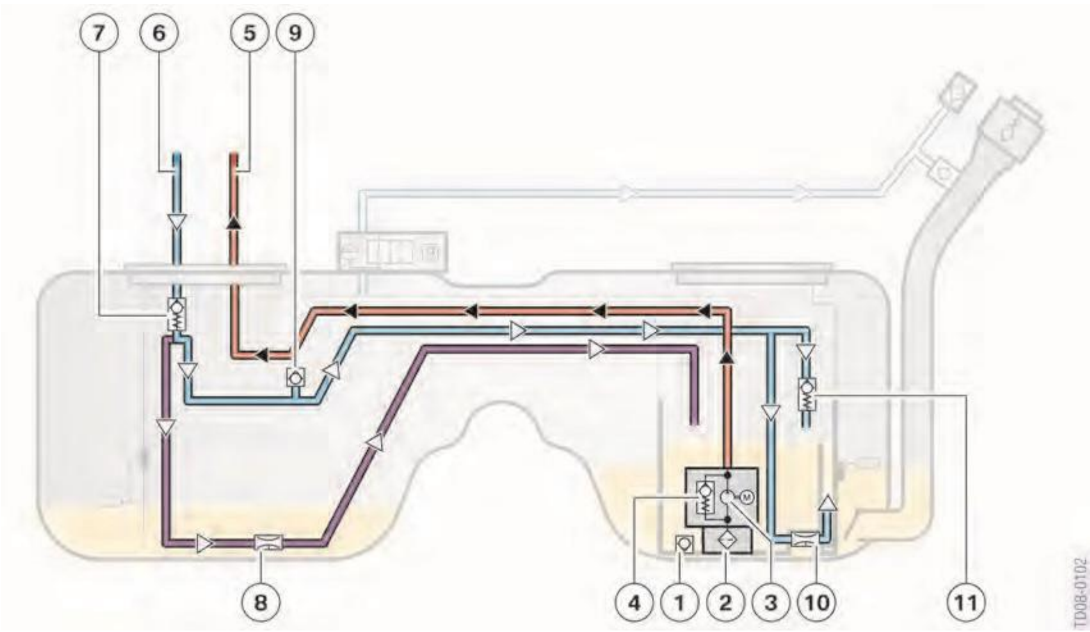
Index	Explanation	Index	Explanation

A	Fuel filler cap	E	Fuel tank
B	Pressure relief valve	F	Service cap
C	Non-return valve	G	Lever-type sensor
D	Surge chamber		

A pressure relief valve (B) is integrated in the Thefuelfilllevelcanbedeterminedviathetwo fuel filler cap (A) to protect the fuel tank (E) lever-type sensors (G). from excess pressure. A non-return flap (C) is The surge chamber (D) ensures that the fuel located at the end of the fuel filler neck. The pump always has enough fuel available for non-returnflap preventsthefuel from sloshing delivery. back into the fuel filler neck.

The components in the fuel tank can be reached via the two service caps (F).

Fuel supply system



20 - Fuel supply system for E70 with diesel engine

Index	Explanation	Index	Explanation
1	Initial fill valve	7	Leak prevention valve
2	Intake mesh filter	8	Suction jet pump

3	Fuel pump	9	Air inlet valve
4	Pressure relief valve	10	Suction jet pump
5	Feed line	11	Pressure relief valve
6	Return line		

In the event of the surge chamber being completely empty, the initial filling valve (1) ensures that fuel enters the surge chamber while refuelling.

The fuel reaches the fuel pump (3) via the intake filter (2), then continues through the delivery line (5) to the fuel filter. The fuel pump is located in the surge chamber. A pressure relief valve (4) is integrated in the fuel pump to preventpressureinthedeliverylinefromrising too high. As the engine switches off, the delivery line is depressurized but cannot run dry because, provided the system is not leaking, no air is able to enter it. In addition, after the fuel pump has switched off, the fuel pressure/temperature sensor is checked for plausibility.

Fuel that is required for lubrication and the function of high pressure generation flows back into the fuel tank via the return line (7). The fuel coming from the return line is divided into two lines downstream of the leak prevention valve (7). The non-return valve prevents the fuel tank from draining in the event of damage to lines on the engine or underbody. It also prevents the return line from running dry while the engine is off.

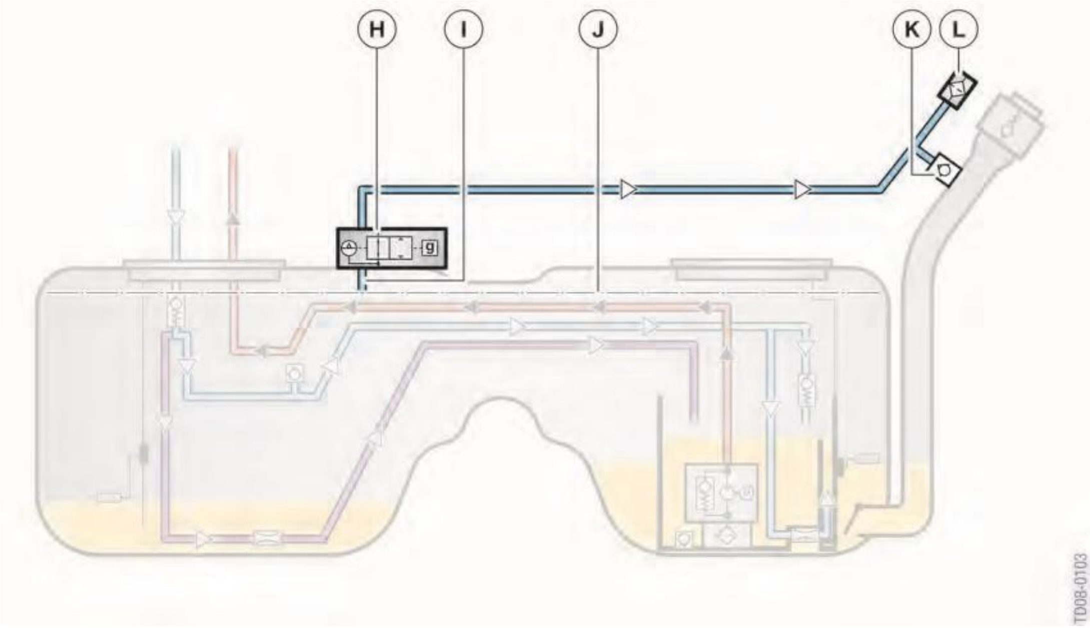
One of the lines guides the fuel into the surge chamber via a suction jet pump (10). The suction jet pump transports the fuel from the fuel tank into the surge chamber. If the fuel delivery pressure in the return line increases too much, the pressure relief valve (11) opens and allows the fuel to flow directly into the surge chamber.

An air inlet valve is used in the E70. The air inlet valve (9) ensures that air can enter the line when the engine is off, preventing fuel from flowing back from the right-hand half of the fuel tank to the left.

Instead of the air inlet valve (9) a non-return valve is used on the E90. The non-return valve ensures that, while the engine is off, fuel from the right-hand half of the fuel tank cannot flow back into the left-hand half. The return system remains completely filled with fuel.

A further line branches off into the left-hand half of the fuel tank after the non-return valve (7) and transports the fuel into the surge chamber via the suction jet pump (8).

Air supply and extraction



21 - Tank ventilation system for E70 with diesel engine

Index	Explanation	Index	Explanation
H	Filler vent valve	K	Non-return valve
I	Connection	L	Filter
J	Maximum fill level		

Fuel ventilation is ensured by means of the filler vent valve (H).

The filler vent valve is located in the fuel tank and uses the connection (I) to determine the maximum fill level (J). The filler vent valve contains a float that buoys upwards on the fuel when the vehicle is refuelled and blocks the filler ventilation. The fuel rises in the fuel filler and the fuel nozzle switches off.

A roll-over valve is also integrated in the filler vent valve to block the ventilation line when a certain angle of incline is reached and prevents fuel from draining out if the vehicle were to roll over.

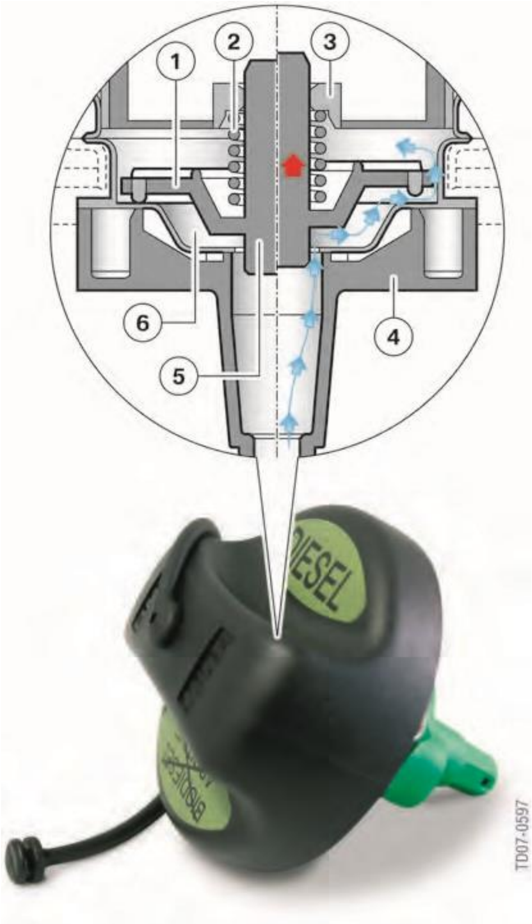
The non-return valve (K) prevents fuel from escaping via the ventilation when the vehicle is refuelled. During operation, air can flow into the fuel filler pipe and the fuel can flow from the fuel filler pipe into the tank.

The filter (L) prevents dirt or insects from entering the ventilation and blocking the line. 3 If the ventilation line does become blocked, fuel consumption during operation would cause negative pressure and the fuel tank would be compressed and damaged. 1

Index	Explanation
1	Valve head
2	Excess pressure spring
3	Brace
4	Bottom section of housing
5	Pressure relief valve
6	Sealed housing

Components of the fuel supply system

Pressure relief valve in fuel filler cap



The pressure relief valve ensures that, if there is a problem with fuel tank ventilation, any excess pressure that may form can escape and the fuel tank is not damaged.

If excess pressure forms in the fuel tank, this causes the valve head (1) and with it the entire pressure relief valve (5) to be lifted off the sealed housing (6). The excess pressure can now escape into the atmosphere. The excess pressure spring (2) determines the opening pressure. The excess pressure spring uses a defined pressure to push the pressure relief valve onto the sealed housing and is supported by the brace (3).

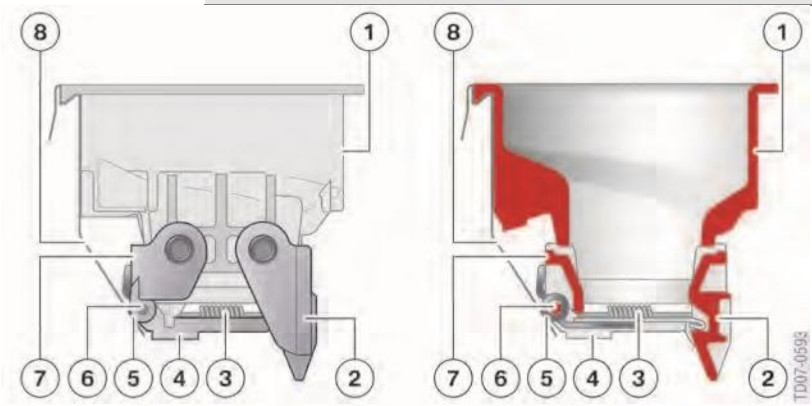
22 - Pressure relief valve

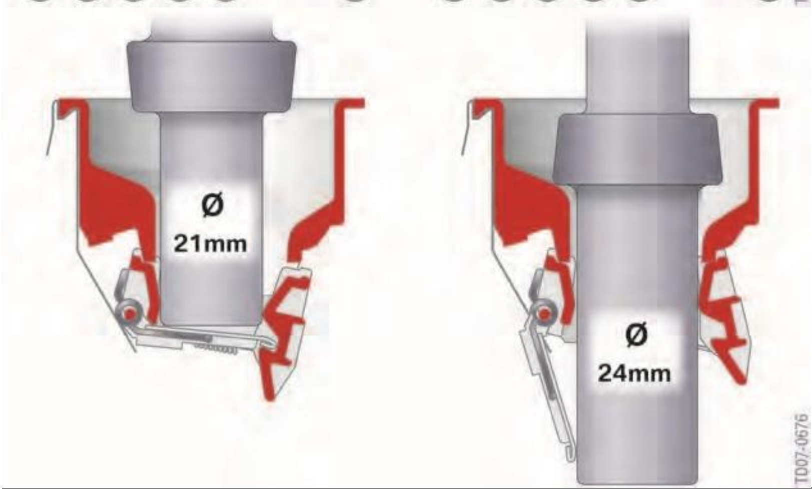
Protection against incorrect refuelling

Index	Explanation	Index	Explanation

23 - Protection againstincorrect refuelling

Ø 21 mm	Petrol fuel nozzle	Ø 24 mm	Diesel fuel nozzle





Index	Explanation	Index	Explanation
1	Housing	5	Torsion spring
2	Locking lever	6	Rivet
3	Tension spring	7	Hinged lever
4	Flap	8	Ground strap

24 - Protection againstincorrect refuelling

The protection against incorrect refuelling feature ensures that the fuel tank cannot be filled with gasoline. As the previous graphic shows, only a fuel nozzle with a diameter of approximately 24 mm can fit. If the diameter is approximately 21 mm, the flap

(4) does not open as the hinged lever (7) and the locking lever (2) cannot be pushed apart.

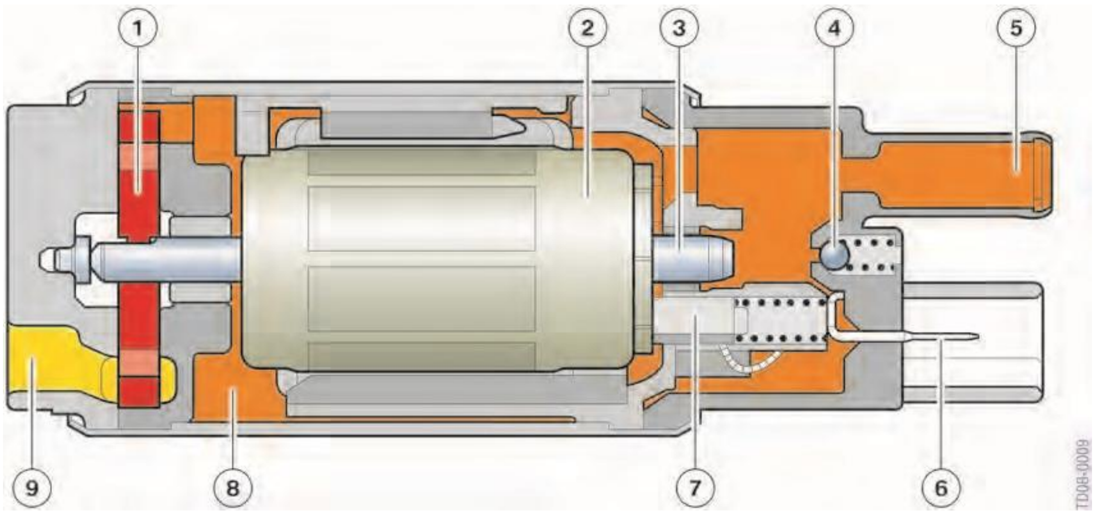
If a diesel fuel nozzle is inserted, this pushes the locking lever (2) and the hinged lever (7) at the same time. The hinged lever is pushed outwards against the tension spring (3) and releases the flap (4). This is only possible, however, if the hinged lever cannot move freely and is also locked in position by the fuel nozzle.

3 To open the protection against incorrect refuelling feature in the workshop, a special tool is required. 1

Fuel pump

Today's diesel vehicles are fitted with electric fuel pumps only. The electric fuel pump is designed to deliver a sufficient amount of fuel to lubricate and cool the injectors and the high-pressure pump and to satisfy the maximum fuel consumption of the engine. It has to deliver the fuel at a defined pressure. That means that when the engine is idling or running at medium power, the fuel pump delivers several times more than the amount of fuel required. The fuel pump delivers approximately three or four times the volume of maximum possible fuel consumption.

The electric fuel pump is located in the fuel tank. There it is well protected against corrosion and the pump noise is adequately soundproofed.



25 - Electric fuel pump

Index	Explanation	Index	Explanation
1	Impeller	6	Electrical connection
2	Drive shaft	7	Sliding contacts
3	Electric motor	8	Pressure chamber
4	Pressure relief valve	9	Intake section
5	Pressure connection		

The fuel pump on BMW diesel engines may either be a gear pump, a roller-cell pump or a screw-spindle pump. The following fuel pumps are used on USA vehicles:

Vehicle	Fuel pump
E70	Screw-spindle pump
E90	Gear pump

The operating principle of each of these types of pump is described below. The pump itself is driven by the drive shaft (2) of the electric motor (3). The electric motor is controlled by the electrical connection (6) and sliding contacts (7).

Passing first through the intake filter and then the remainder of the intake section (9), the fuel enters the impeller (1). The fuel is pumped through pressure chamber (8) on the electric motor, past the pressure connection (5) and onwards to the fuel filter and engine.

If the fuel delivery pressure increases to an impermissible value, the pressure relief valve (4) opens and allows the fuel to flow into the surge chamber.

Control

In principle, there are three different types of fuel pump control:

- Unregulated:
  The fuel pump operates with "ignition ON". If the engine is not started, the fuel pump switches off again after a defined period. If the engine is running, the fuel pump operates at maximum output and speed.
  The fuel is switched off with "engine OFF".
- Speed-regulated:
  The fuel pump operates with "ignition ON". If the engine is not started, the fuel pump switches off again after a defined period. The fuel pump is controlled by an interposed control unit (fuel pump controller) in response to a request signal from the DDE. The fuel pump controller monitors and regulates the pump speed. If the engine is switched off, so too is the fuel pump.
- Pressure-regulated:
  The fuel pump operates with "ignition ON". If the engine is not started, the fuel is switched off at a specific pressure. When the engine is running, the fuel pump is regulated on-demand by the interposed fuel pump controller in response to a load signal from the DDE in order to ensure a uniform fuel pressure at the inlet to the high-pressure pump.

Bothspeedregulationandpressureregulation have improved fuel economy, although it has been possible to improve fuel economy further still with pressure regulation. Other positive side effects include an increase in the fuel pump's service life, an unloading of the vehicle electrical system and a reduction in fuel pump noise.

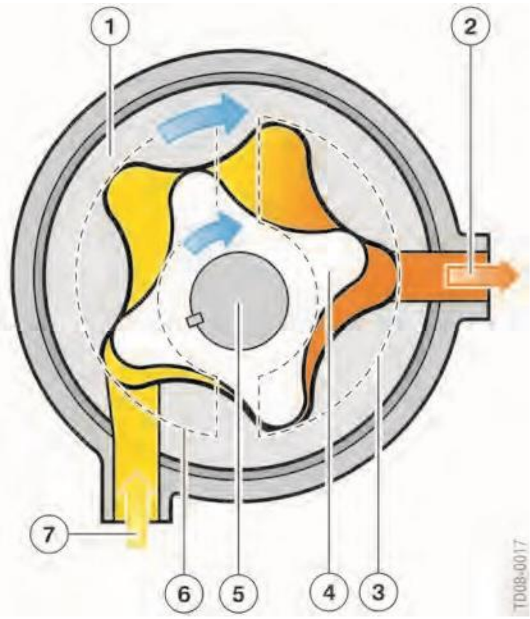
Vehicle	Control
E70	Pressure control
E90	Speed control

Gear pump

The type of gear pump used is a rotor pump.

The rotor pump comprises an outer rotor (1) with teeth on the inside, and an inner rotor (4) with teeth on the outside. The inner rotor is driven by the drive shaft (5) of the electric motor. The outer rotor is propelled by the teeth of the inner rotor and thus turns inside the pump housing.

The inner rotor has one tooth fewer than the outer rotor, which means that, with each revolution, fuel is carried into the next tooth gap of the outer rotor.



26 - Gear pump/rotor pump

Index	Explanation
1	Outer rotor
2	Fuel delivery to the engine
3	Pressure section

During the rotary motion, the spaces on the intake side enlarge, while those on the pressure side become proportionately smaller.

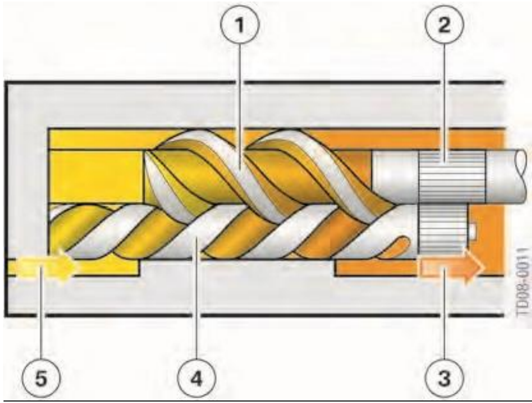
Thefuelisfedintotherotorpumpthroughtwo grooves in the housing, one on the intake side and one on the pressure side. Together with the tooth gaps, these grooves form the intake section (6) and pressure section (3).

4	Inner rotor
5	Drive shaft
6	Intake section
7	Fuel from the fuel tank

Screw-spindle pump

With the screw-spindle pump, two screw spindles intermesh in such a way that the flanks form a seal with each other and the housing. In the displacement chambers between the housing and the spindles, the fuel is pushed towards the pressure side with practically no pulsation.

In this way, the screw spindles pump fuel away from the fuel tank (5). The fuel is then fed to the engine (3) through the pump housing and the fuel delivery line.



27 - Screw-spindle pump

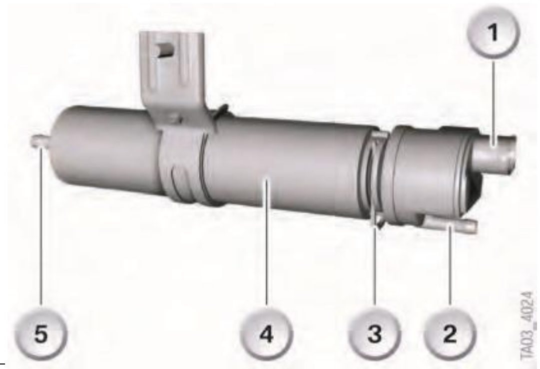
Index	Explanation
1	Drive shaft screw spindle
2	Gearwheel
3	Fuel delivery to the engine
4	Screw spindle
5	Fuel from the fuel tank

Fuel filter

The fuel filter with heater illustrated here was used in vehicle models with diesel engine and distributor injection pump. Later models with diesel engine and common rail system are equipped with the following fuel filters.

3 BMW recommends the use of parts and accessories for the vehicle that have been approved by BMW for this purpose. These parts and accessories have been tested by BMW for their functional safety and compatibility in BMW vehicles. BMW accepts product responsibility for them. However, BMW cannot accept any liability for nonapproved parts or accessories. 1

The job of the fuel filter is to protect the fuel system against dirt contamination. The highpressure pump and injectors in particular are very sensitive and can be damaged by even the tiniest amounts of dirt. The fuel delivered to the engine is always fed through the fuel filter. Contaminants are trapped by a paperlike material. The fuel filter is subject to a replacement interval.



28 - Fuel filter with heater (later vehicle models)

Index	Explanation
1	Fuel filter heater connection
2	Inlet into the fuel filter heating
3	Locking clamp
4	Fuel filter
5	Connection between fuel line and high-pressure pump

Fuel filter heater

The fuel filter heater is attached to the fuel filter housing and fixed with a locking clamp. The fuel flows through the fuel filter heating into the fuel filter.

Since winter-grade diesel fuel remains thin even at low temperatures, the fuel filter heater is not normally active when winter-grade diesel fuel is used. In order to save energy, the fuel filter heater is only switched on when the diesel actually becomes viscous due to low temperatures.

There are two different control systems depending on whether the fuel supply system is speed-controlled or pressure-controlled.

Speed-controlled system

The fuel filter heater is not controlled by the DDE. A pressure switch and a temperature sensor are located in the fuel filter housing.

Overview of selective catalytic reduction

The fuel filter heater is switched on when both of the following conditions are fulfilled:

- Temperature drops below a defined value
- A defined fuel delivery pressure isexceeded due to cold, viscous fuel.

If the filter is clogged, a corresponding signal is sent via a diagnosis line to the DDE. This is the case when, despite a sufficiently high temperature, the fuel pressure upstream of the filter does not drop.

Pressure-controlled system

The fuel filter heater is actuated by the DDE. A combined fuel pressure and temperature sensor upstream of the high pressure pump is used.

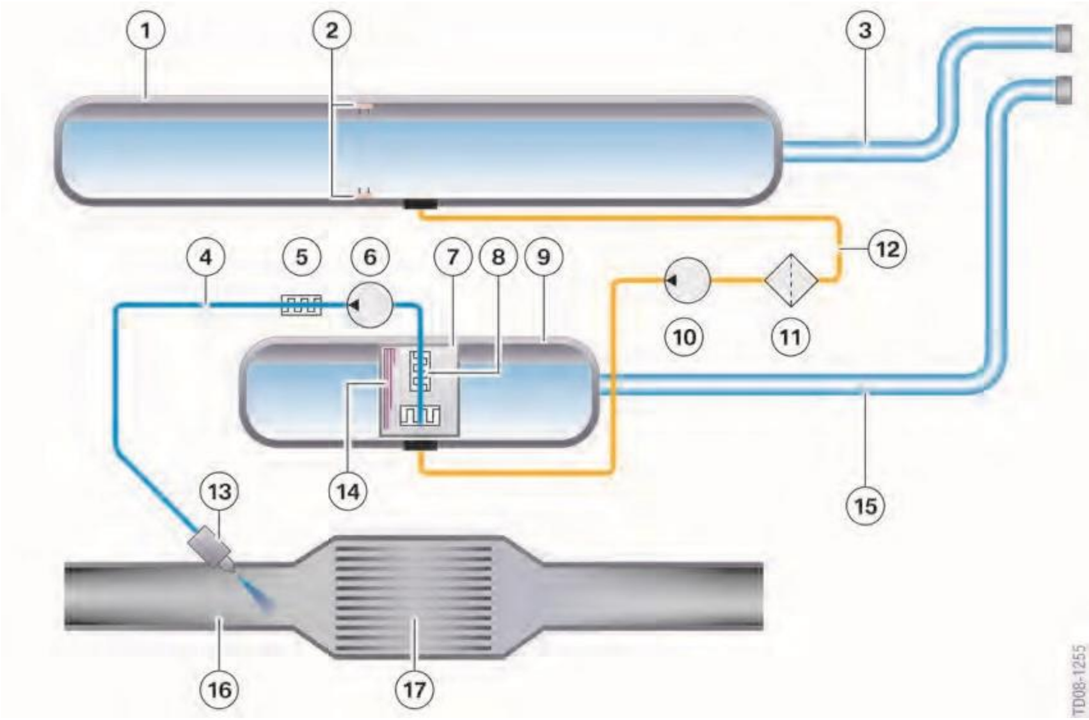
The fuel filter heater is switched on when both of the following conditions are fulfilled:

- Temperature drops below a defined value
- The required fuel pressure is not reacheddespite increased power intake of the electric fuel pump.

The DDE recognizes a clogged filter when the target pressure upstream of the high pressure pump is not reached despite a sufficiently high fuel temperature and high power intake of the electric fuel pump.

Selective catalytic reduction is a system for reducing nitrogen oxides (NO_X) in the exhaust gas. For this purpose, a reducing agent (ureawater solution) is injected into exhaust gas downstream of the diesel particulate filter.

The nitrogen oxide reduction reaction then takes place in the SCR catalytic converter.



29 - Simplified representation of SCR system

The urea-water solution is carried in two reservoirs in the vehicle. The quantity is measured out such that it is sufficient for one oil change interval.

The following graphic shows a simplified representation of the system:

Index	Explanation	Index	Explanation
1	Passive reservoir	10	Pump
2	Level sensors	11	Filter
3	Filler pipe, passive reservoir	12	Transfer line
4	Metering line	13	Metering module
5	Metering line heater	14	Level sensor
6	Pump	15	Filler pipe, active reservoir
7	Function unit	16	Exhaust system
8	Heater in active reservoir	17	SCR catalytic converter
9	Active reservoir		

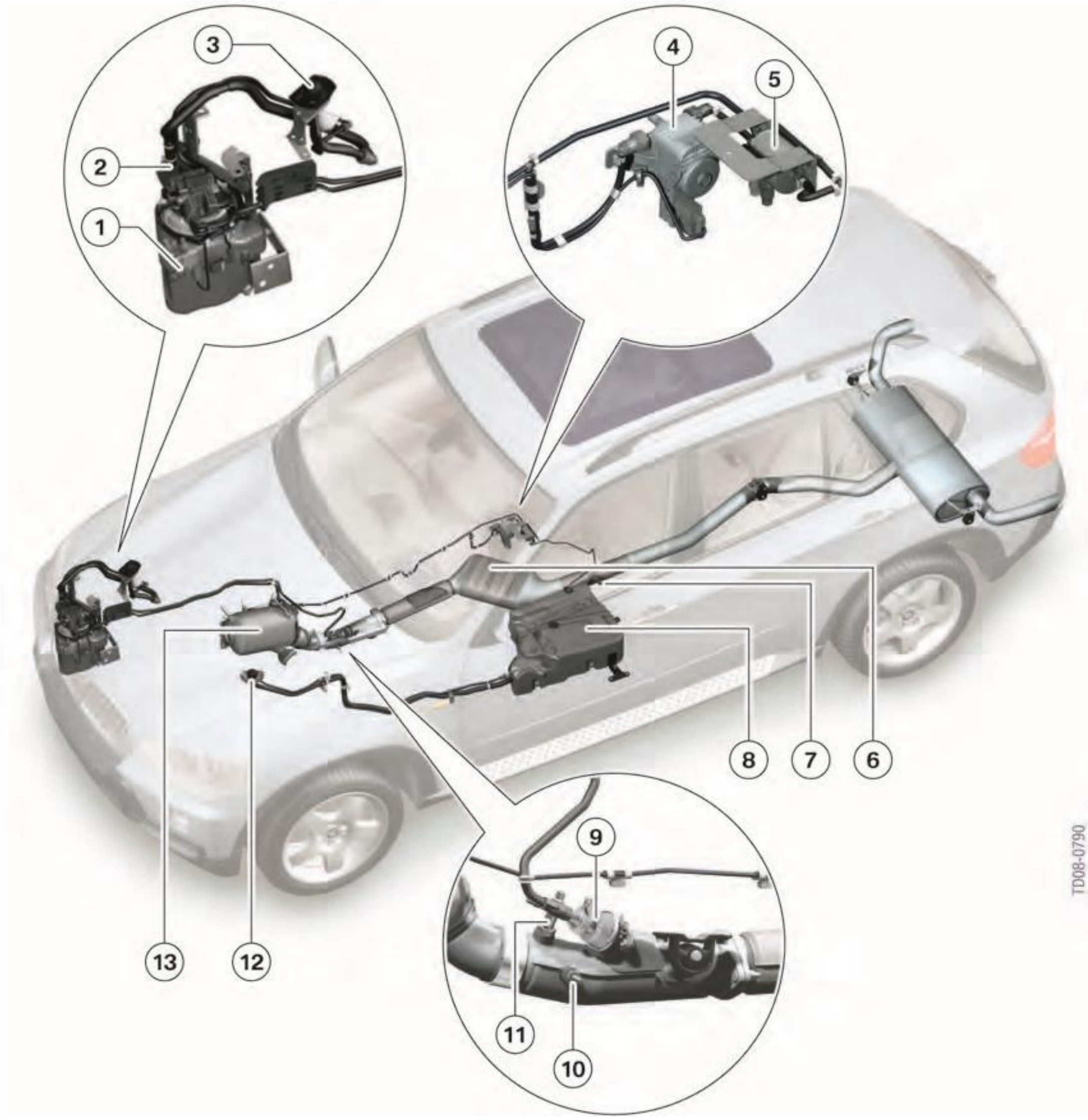
The larger, unheated reservoir is the passive reservoir. A pump regularly transfers the ureawater solution from the passive reservoir to the active reservoir.

The reason for using two reservoirs is that the urea-water solution freezes at a temperature

of-11 °C.Forthisreason,thesmallerreservoir is heated but the larger reservoir not. In this way, the entire volume of the urea-water solution need not be heated, thus saving energy. The amount is sufficient, however, to cover large distances.

The small, heated reservoir is referred to as the active reservoir. A pump conveys the ureawater solution from this reservoir to the metering module. This line is also heated.

Installation locations in the E70

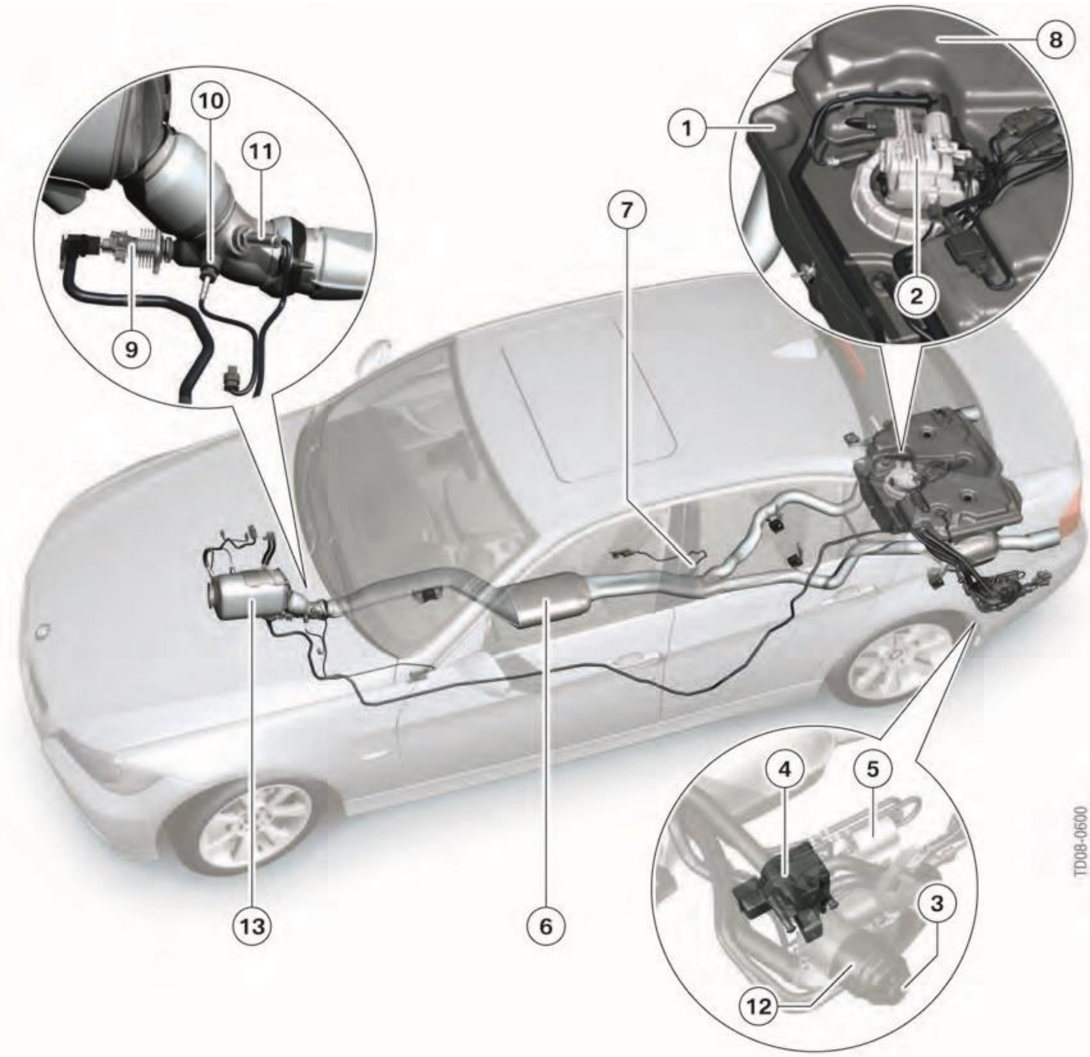


30 - Installations locations, E70 SCR system

Index	Explanation	Index	Explanation
1	Active reservoir	8	Passive reservoir
2	Delivery module	9	Metering module
3	Filler for active reservoir	10	Exhaust gas temperature sensor after diesel particulate filter
4	Transfer unit	11	NO_X sensor before SCR catalytic converter
5	Filter	12	Filler for passive reservoir
6	SCR catalytic converter	13	Oxidation catalytic converter and diesel particulate filter
7	NO_X sensor after SCR catalytic converter		

On the E70, the active reservoir, including the underbody, approximately under the driver's delivery unit, is located on the right-hand side seat. The transfer unit is installed on the right directly behind the front bumper panel. The in the underbody. Both fillers are located in the passive reservoir is located on the left in the engine compartment.

Installation locations in the E90

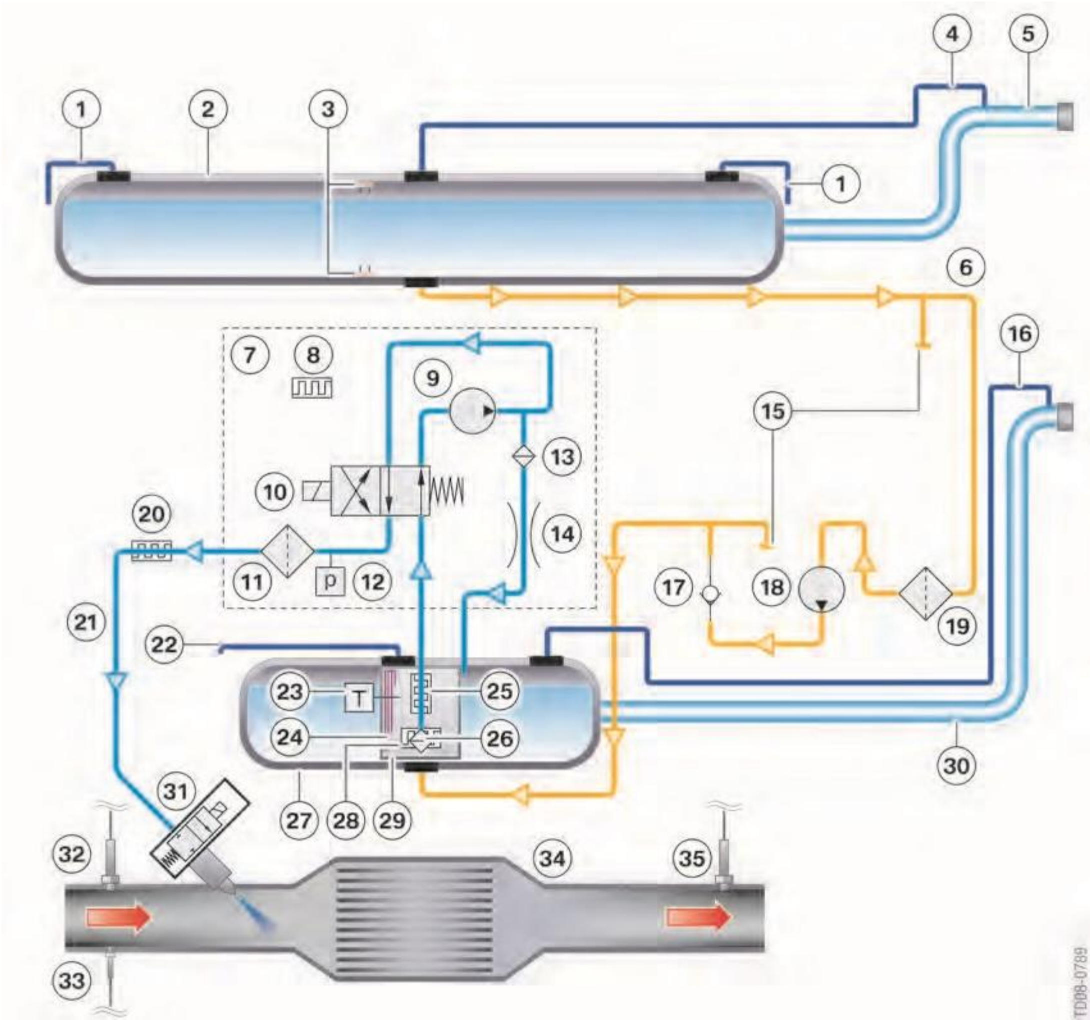


31 - Installations locations, E90 SCR system

Index	Explanation	Index	Explanation
1	Active reservoir	8	Passive reservoir
2	Delivery module	9	Metering module
3	Filler for active reservoir	10	Exhaust gas temperature sensor after diesel particulate filter
4	Transfer unit	11	NO_X sensor before SCR catalytic converter
5	Filter	12	Filler for passive reservoir
6	SCR catalytic converter	13	Oxidation catalytic converter and diesel particulate filter
7	NO_X sensor after SCR catalytic converter		

OntheE90,boththeactivereservoiraswellas the passive reservoir are located under the luggage compartment floor with the active reservoir being the lowermost of both. The fillers are located on the left-hand side behind the rear wheel where they are accessible through an opening in the bumper panel. The fillers are arranged in the same way as the reservoirs, i.e. the lowermost is the filler for the active reservoir. The transfer unit and the filter are located behind the filler.

Detailed system overview

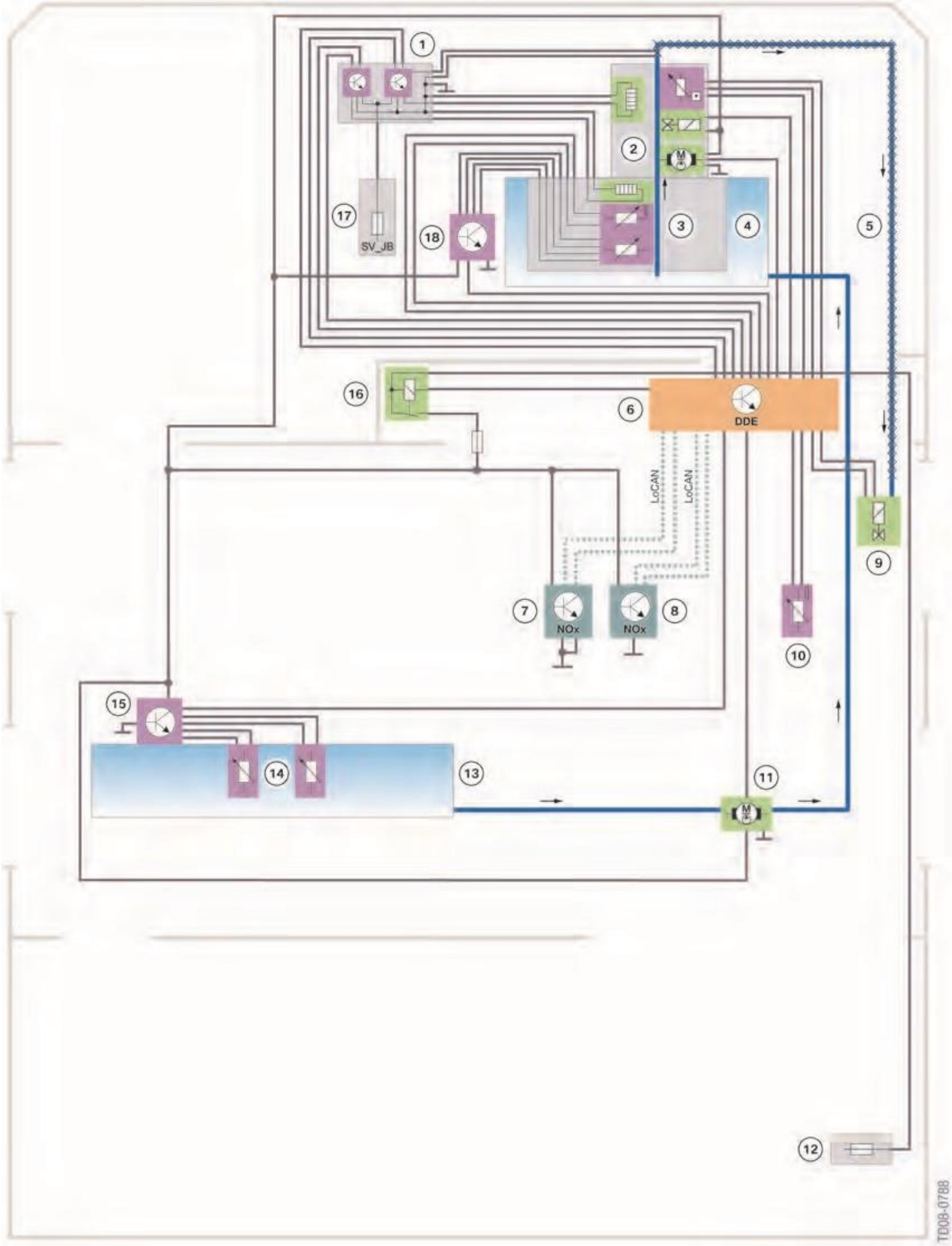


32 - SCR system overview

Index	Explanation	Index	Explanation
1	Operating vent	19	Filter
2	Passive reservoir	20	Metering line heater
3	Level sensors	21	Metering line
4	Filler vent	22	Operating vent
5	Filler pipe	23	Temperature sensor
6	Transfer line	24	Level sensor

7	Delivery module	25	Intake line heater
8	Delivery module heater	26	Filter
9	Delivery pump	27	Active reservoir
10	Reversing valve	28	Heating element in function unit
11	Filter	29	Function unit
12	Pressure sensor	30	Filler pipe
13	Filter	31	Metering module
14	Restrictor	32	NO_X sensor before SCR catalytic converter
15	Extractor connections	33	Exhaust gas temperature sensor after diesel particulate filter
16	Filler vent	34	SCR catalytic converter
17	Non-return valve	35	NO_X sensor after SCR catalytic converter
18	Transfer pump		

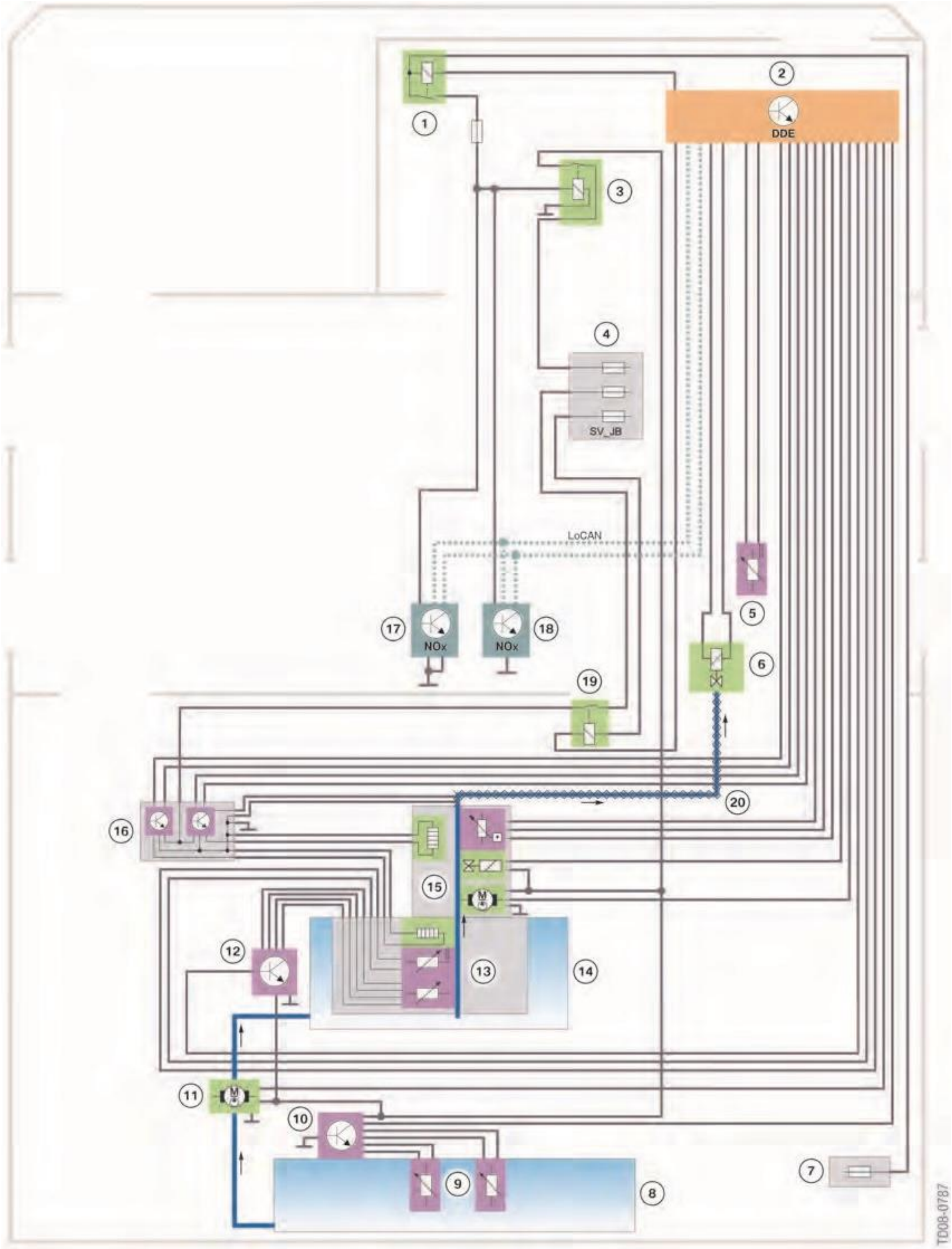
E70 System circuit diagram



33 - E70 SCR system circuit diagram

Index	Explanation	Index	Explanation
1	Heater module	10	Exhaust gas temperature sensor after diesel particulate filter
2	Delivery module with delivery pump, reversing valve, pressure sensor and heater	11	Transfer pump
3	Function unit with level sensor in active reservoir, temperature sensor and heater	12	Power distributor, battery
4	Active reservoir	13	Passive reservoir
5	Metering line heater	14	Level sensors in passive reservoir
6	Digital Diesel Electronics (DDE)	15	Evaluator, level sensors in passive reservoir
7	NO_X sensor after SCR catalytic converter	16	DDE main relay
8	NO_X sensor before SCR catalytic converter	17	Power distributor, junction box
9	Metering module	18	Evaluator, level sensor in active reservoir

E90 System circuit diagram



34 - E90 SCR system circuit diagram

Index	Explanation	Index	Explanation
1	DDE main relay	11	Transfer pump
2	Digital Diesel Electronics (DDE)	12	Evaluator, level sensor in active reservoir
3	SCR relay	13	Function unit with level sensor in active reservoir, temperature sensor and heater
4	Power distributor, junction box	14	Active reservoir
5	Exhaust gas temperature sensor after diesel particulate filter	15	Delivery module with delivery pump, reversing valve, pressure sensor and heater
6	Metering module	16	Heater module
7	Power distributor, battery	17	NO_X sensor after SCR catalytic converter
8	Passive reservoir	18	NO_X sensor before SCR catalytic converter
9	Level sensors in passive reservoir	19	SCR load relay
10	Evaluator, level sensors in passive reservoir	20	Metering line heater

Functions of selective catalytic reduction system

Selective catalytic reduction is currently the most effective system for reducing nitrogen oxides (NO_X). During operation, it achieves an efficiency of almost 100 % and approx. 90 % over the entire vehicle operating range. The difference is attributed to the time the system requires until it is fully operative after a cold start.

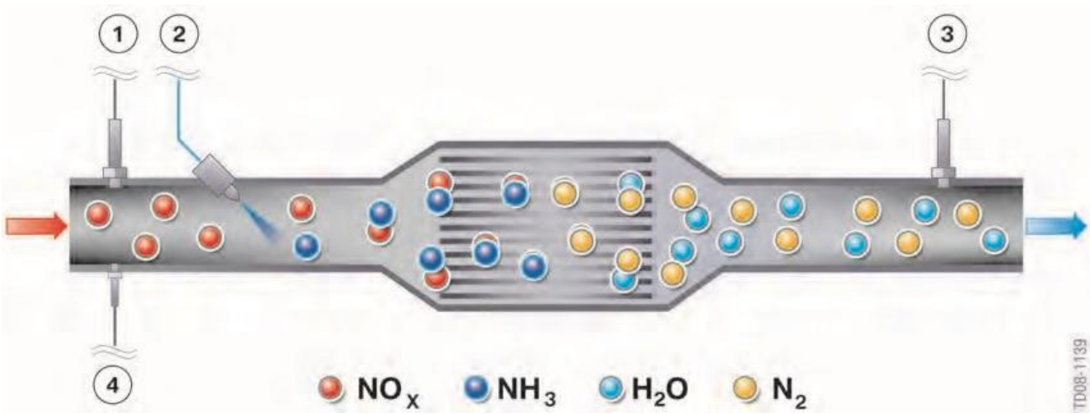
This system carries a reducing agent, ureawater solution, in the vehicle.

The urea-water solution is injected into the exhaust pipe by the metering module upstream of the SCR catalytic converter. The DDE calculates the quantity that needs to be injected. The nitrogen oxide content in the

exhaust gas is determined by the NO_X sensor before the SCR catalytic converter. Corresponding to this value, the exact quantity of the urea-water solution required to fully reduce the nitrogen oxides is injected.

A temperature sensor in the exhaust pipe after the diesel particulate filter (i.e. before the SCR catalytic converter) and the metering module also influences this function. This is because injection of the urea-water solution only begins at a minimum temperature of 200 °C.

36 - Nitrogen oxides



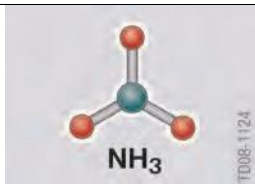
35 - SCR functions

Ammonia (NH_3) is used for the purpose of reducing the nitrogen oxides in a special catalytic converter.

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

The urea-water solution converts to ammonia in the exhaust pipe. In the SCR catalytic converter, the ammonia reacts with the nitrogen oxides to produce nitrogen (N_2) and water (H_2O).

A further NO_X sensor that monitors this function is located downstream of the SCR catalytic converter.



37 - Ammonia

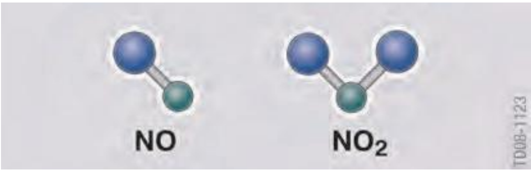
The ammonia is supplied in the form of a ureawater solution.

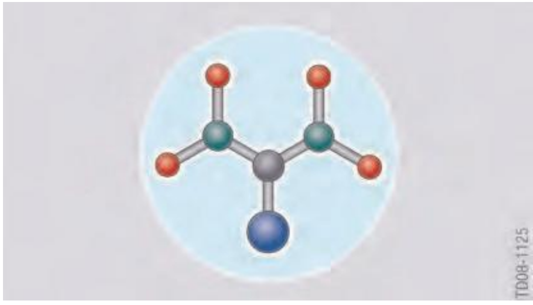
Chemical reaction

ThetaskoftheSCRsystemistosubstantially reduce the nitrogen oxides (NO_x) in the exhaust gas. Nitrogen oxides occur in two different forms:

•Nitrogen monoxide (NO)

•Nitrogen dioxide (NO_2).





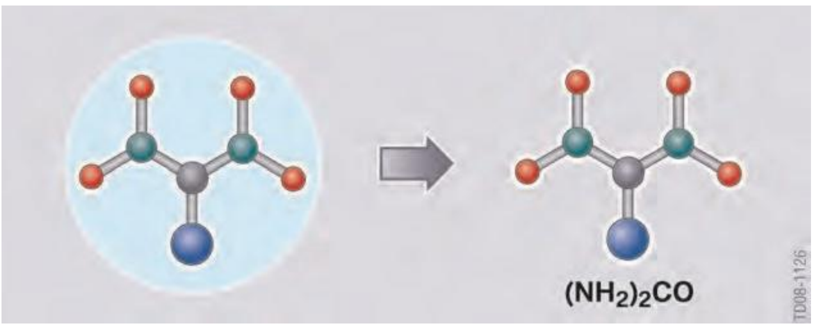
38 -Urea-water solution

The urea-water solution is injected by the metering system into the exhaust system downstreamof thedieselparticulate filter.The required quantity must be metered exactly as otherwise nitrogen oxides or ammonia would emerge at the end. The following description of the chemical processes explains why this is the case.

Conversion of the urea-water solution

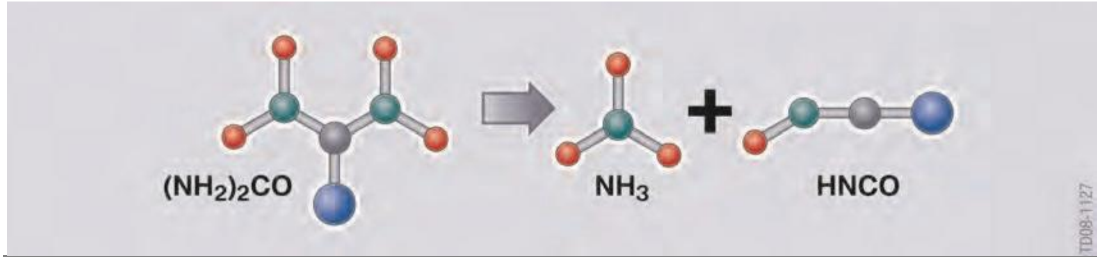
The uniform distribution of the urea-water solution in the exhaust gas and the conversion to ammonia take place in the exhaust pipe upstream of the SCR catalytic converter.

Initially, the urea ($(NH_2)_2CO$) dissolved in the urea-water solution is released.



39 - Release of urea from the urea-water solution

The conversion of urea into ammonia takes place in two stages.

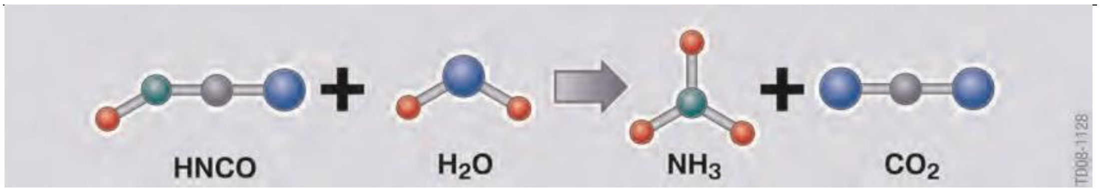


40 - Thermolysis: Urea converts to ammonia and isocyanic acid

Thermolysis	
Explanation:	During thermolysis, the urea-water solution is split into two products as the result of heating.
Initial product:	Urea ($(NH_2)_2CO$)
Result:	Ammonia (NH_3) Isocyanic acid (HNCO)
Chemical formula:	$(NH_2)_2CO \rightarrow NH_3 + HNCO$

This means, only a part of the urea-water solution is converted into ammonia during thermolysis. The remainder, which is in the form of isocyanic acid, is converted in a second step.

Hydrolysis	
Explanation:	The isocyanic acid that was produced during thermolysis is converted into ammonia and carbon dioxide (CO_2) by the addition of water in the hydrolysis process.
Initial products:	Isocyanic acid (HNCO) Water (H_2O)
Result:	Ammonia (NH_3) Carbon dioxide (CO_2)
Chemical formula:	$HNCO + H_2O \rightarrow NH_3 + CO_2$

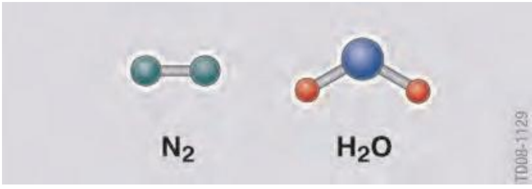


41 - Hydrolysis: Isocyanic acid reacts with water to form ammonia and carbon dioxide

The water required for this purpose is also Therefore, following hydrolysis, all the urea is provided by the urea-water solution. converted into ammonia and carbon dioxide.

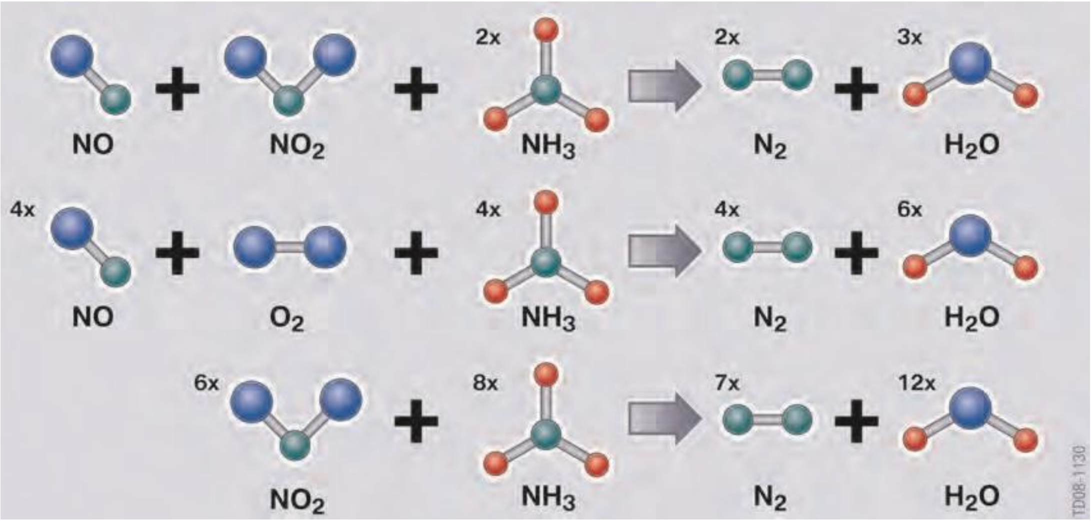
NO_x reduction

Nitrogen oxides are converted into harmless nitrogen and water in the SCR catalytic converter.



42 -Nitrogen and water

Reduction	
Explanation:	The catalytic converter serves as a "docking" mechanism for the ammonia molecules. The nitrogen oxide molecules meet the ammonia molecules and the reaction starts and energy is released. This applies to NO in the same way as to NO_2.
Initial products:	Ammonia (NH_3) Nitrogen monoxide (NO) Nitrogen dioxide (NO_2) Oxygen (O_2)
Result:	Nitrogen (N_2) Water (H_2O)
Chemical formulae:	$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$ $4NO + O_2 + 4NH_3 \rightarrow 4N_2 + 6H_2O$ $6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$

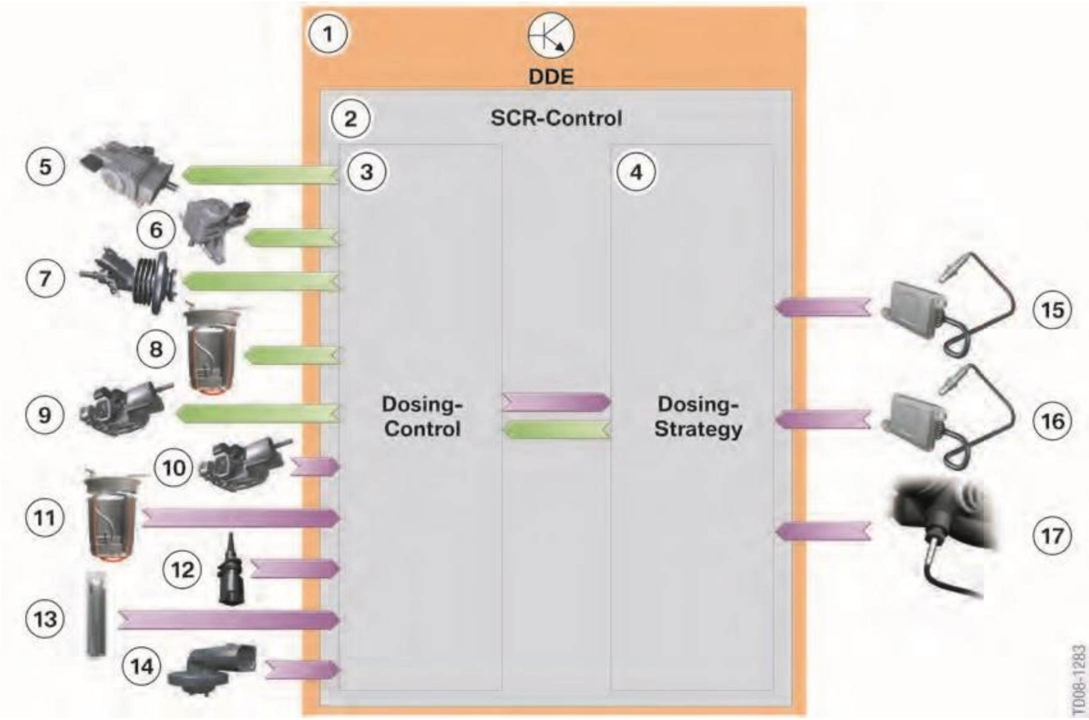


43 - NO_x reduction: Nitrogen oxides react with ammonia to form nitrogen and water

It can be seen that each individual atom has found its place again at the end of the process, i.e. exactly the same elements are on the left as on the right. This takes place only when the ratio of the urea-water solution to nitrogen oxides is correct. Nitrogen oxides would emerge if too little urea-water solution were injected. By the same token, ammonia would emerge if too much urea-water solution were injected, resulting in unpleasant odour and possible damage to the environment.

SCR control

The SCR control is integrated in the digital and diesel electronics (DDE). The SCR control is divided into the metering system control the metering strategy.



44 -

Index	Explanation	Index	Explanation
1	Digital diesel electronics DDE7	10	Pressure sensor
2	SCR control	11	Temperature sensor in active reservoir
3	Metering system control	12	Outside temperature sensor
4	Metering strategy	13	Level sensor in active reservoir
5	Injection pump	14	Level sensor in passive reservoir
6	Transfer pump	15	NO_X sensor before SCR catalytic converter
7	Metering module	16	NO_X sensor after SCR catalytic converter
8	Heater	17	Exhaust temperature sensor
9	Reversing valve		

Metering strategy

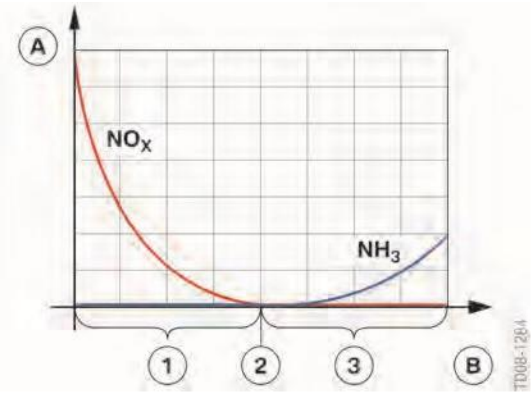
The metering strategy is an integral part of the SCR control that calculates how much areawater solution is to be injected at what time.

During normal operation, the signal from the NO_X sensor before the SCR catalytic converter is used for the purpose of calculating the quantity. This sensor determines the quantity of nitrogen oxide in the exhaust gas and sends the corresponding value to the DDE.

However, the NO_X sensor must reach its operating temperature before it can start measuring. Depending on the temperature, this can take up to 15 minutes. Until then the DDE uses a substitute value to determine the amount of nitrogen oxide in the exhaust gas.

A second NO_X sensor is installed after the SCR catalytic converter for the purpose of monitoring the system. It measures whether there are still nitrogen oxides in the exhaust gas. If so the injected quantity of the ureawater solution is correspondingly adapted. The NO_X sensor, however, measures not only nitrogen oxides but also ammonia but cannot distinguish between them.

If too much urea-water solution is injected, although the nitrogen oxides are completely reduced so-called "ammonia slip" occurs, i.e. ammonia emerges from the SCR catalytic converter. This in turn causes a rise in the value measured by the NO_x sensor. The aim, therefore, is to achieve a minimum of the sensor value.



45 - Nitrogen and ammonia emission diagram

Index	Explanation
A	Value output by NO_x sensor
B	Injected quantity of urea-water solution
1	Too little urea-water solution injected
2	Correct quantity of little urea-water solution injected
3	Too much urea-water solution injected

This, however, is a long-term adaptation and not a short-term control process as the SCR catalyticconverterperformsastoragefunction for ammonia.

Metering system control

The metering system control could be considered as the executing part. It carries out therequirementssetbythemeteringstrategy. This includes both the metering, i.e. injection as well as the supply of the urea-water solution.

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

Metering of the urea-water solution:

- Implementation of the required targetquantity of urea-water solution
- Feedback of the implemented actualquantity of urea-water solution.

Supplying urea-water solution:

- Preparationofmeteringprocess(fillinglinesandpress urebuilt-up)undercorresponding ambient conditions (temperature) • Emptying lines during afterrunning
- Heater actuation.

In addition, the metering system control recognizes faults, implausible conditions or critical situations and initiates corresponding measures.

The metering strategy determines the quantity of urea-water solution to be injected. The metering

Metering of the urea-water solution

system control executes this request. A part of the function is metering actuation that determines the actual opening of the metering valve.

Depending on the engine load, the metering valve injects at a rate of 0.5 Hz to 3.3 Hz.

The metering actuation facility calculates the following factors in order to inject the correct quantity:

- The duty factor of the actuator of themetering valve in order to determine the injection duration
- Actuation delay to compensate for thesluggishness of the metering valve.

The signal from the pressure sensor in the metering line is taken into account to ensure an accurate calculation; the pressure, however, should remain at a constant 5 bar.

The metering system control also calculates the quantity actually metered and signals this value back to the metering strategy.

The metering quantity is also determined over a longer period of time. This long-term calculation is reset during refuelling or can be reset by the BMW diagnosis system.

Supplying urea-water solution

A supply of a urea-water solution is required for the selective catalytic reduction process. It is necessary to store this medium in the vehicle and to make it available rapidly under all operating conditions. In this case 'making available' means that the urea-water solution is applied at a defined pressure at the metering valve.

Various functions that are described in the following are required to carry out this task.

Heater

The system must be heated as the urea-water solution freezes at a temperature of -11 °C.

The heating system performs following tasks:

- To monitor the temperature in the activereservoir and the ambient temperature
- To thaw a sufficient quantity of urea-watersolution and the components required for

metering the solution during system startup

- To prevent the relevant componentsfreezing during operation
- To monitor the components of the heatingsystem.

The following components are heated:

- Surge chamber in active reservoir
- Intake line in active reservoir
- Delivery module (pump, filter, reversingvalve)
- Metering line (from active reservoir tometering module).

The heating systems for the metering line and delivery module are controlled dependent on the ambient temperature.

The heater in the active reservoir is controlled as a function of the temperature in the active reservoir.

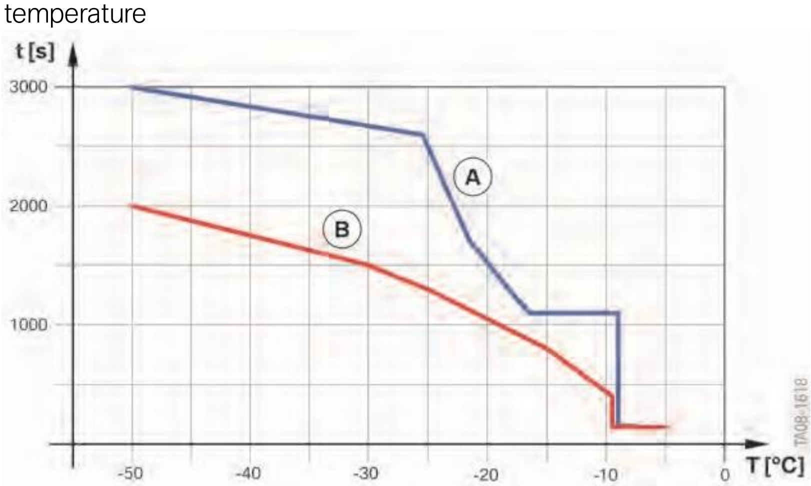
Theheatingcontrolisadditionallygovernedby the following conditions:

Temperature in active reservoir and ambient temperature are the same	Condition 1	Condition 2	Condition 3	Condition 4
Ambient temperature and temperature in active reservoir	> -4 °C	< -4 °C	< -5 °C	< -9 °C
Metering line heater	Not active	Not active	Active	Active
Active reservoir heater	Not active	Active	Active	Active
Metering standby	Established	Established	Established	Delayed

Metering standby is delayed at a temperature below -9 °C in the active reservoir, i.e. a defined waiting period is allowed to elapse until an attempt to build up pressure begins. This time is constant from -9 °C to -16.5 °C as it is not possible to determine to what extent the urea-water solution is frozen. At temperatures below -16.5 °C, the heating time is extended until an attempt to build up the pressure is made.

Heating the metering line generally takes placemuchfaster.Therefore,thetemperature in the active reservoir is the decisive factor for the period of time until an attempt to build up the pressure is undertaken. However, it is possible that the heating time for the metering line is longer at ambient temperature considerablylowerthanthetemperatureinthe active reservoir. In this case, the ambient temperature is taken for the delay in metering standby.

The following graphic shows the delay as a function of the temperature sensor signals.



46 - Diagram - metering standby delay times

Index	Explanation	Index	Explanation
A	Delay as a function of temperature in active reservoir	B	Delay as a function of ambient temperature
t [s]	Delay time in seconds	T [°C]	Temperature in degrees Celsius

The graphic shows that, with the same temperature signals, the delay time relating to the temperature in the active reservoir is longer than the delay caused by the ambient temperature.

Only the times at temperatures below -9 °C are relevant as they are shorter than 3 minutes at temperatures above -9 °C. 3 minutes is the time that the entire system requires to establish metering standby (e.g. also taking into account the temperature in the SCR catalytic converter). This is also the time that is approved by the EPA (Environmental Protection

Agency) as the preliminary period under all operating conditions. This time is extended significantly at very low temperatures.

The following example shows how the delay time up to metering standby is derived at low temperatures.

Example: Ambient temperature: -30 °C, temperature in active reservoir: -12 °C

The vehicle was driven for a longer period of time at very low ambient temperatures of 30 °C. The heater in the active reservoir has thawed the urea-water solution. The vehicle is now parked for a short period of time (e.g. 30 minutes). When restarted, the temperature in the active reservoir is -12 °C.

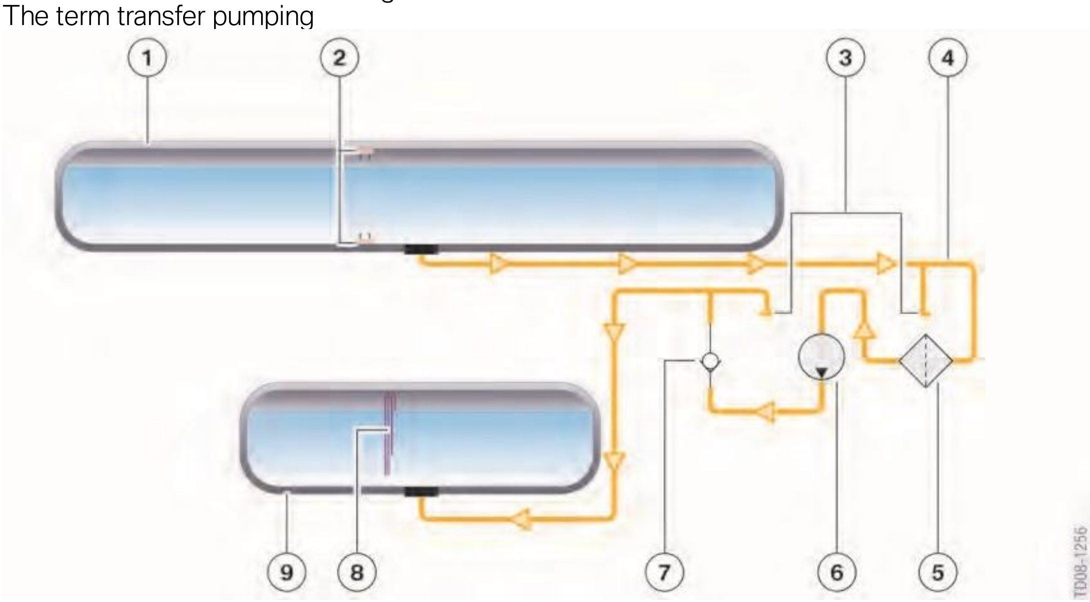
The delay time that is initiated by the temperature in the active reservoir is approx. 18 minutes while the delay time initiated by the ambient temperature is 25 minutes. Since the delay time initiated by the ambient temperature is longer, this will give rise to a longer delay.

Now another condition comes into play. Only the end of the delay caused by the temperature in the active reservoir can enable metering. This means:

- The delay time initiated by the temperaturein the active reservoir will have elapsed after 18 minutes. No enable is yet provided by the second delay caused by the ambient temperature. A second cycle of 18 minutes now begins.
- The delay time initiated by the ambienttemperature will elapse after 25 minutes and will send its enable signal. However, this delay cannot enable metering.
- The second cycle of the delay time causedby the temperature in the active reservoir will have elapsed after 36 minutes. Since the enable from the delay caused by the ambient temperature is now applied, metering will be enabled.

Transfer pumping

So-called transfer pumping is required since two reservoirs are used for storing the ureawater solution. The term transfer pumping relates to pumping the urea-water solution from the passive reservoir into the active reservoir.



47 - Transfer pumping

Index	Explanation	Index	Explanation
1	Passive reservoir	6	Pump
2	Level sensors	7	Non-return valve
3	Extractor connections	8	Level sensor
4	Transfer line	9	Active reservoir
5	Filter		

The following conditions must be met for transfer pumping:

- Thereisaurea-watersolutioninthepassivereservoir
- The ambient temperature is above aminimum value of -5 °C for at least 10 minutes
- A defined quantity (300 ml) was used up inthe active reservoir or the reserve level in the active reservoir was reached.

The solution is then pumped for a certain time in order to refill the active reservoir. The transfer pumping procedure is terminated if the "full" level is reached before the time has elapsed.

If the passive reservoir was refilled, transfer pumping will only take place after a quantity of approx. 3 l has been used up in the active reservoir. The entire quantity is then pumped over. The system then waits again until a quantity of approx. 3 l has been used up in the active reservoir before again pumping the entire quantity while simultaneously starting the incorrect refilling detection function. This function determines whether the system has been filled with the wrong medium as it is present in high concentration in the active reservoir.

Transfer pumping does not take place in the event of a fault in the level sensor system.

Delivery

The urea-water solution is delivered from the active reservoir to the metering module. This

is performed by a pump that is integrated in the delivery unit. The delivery unit additionally contains:

• Heater

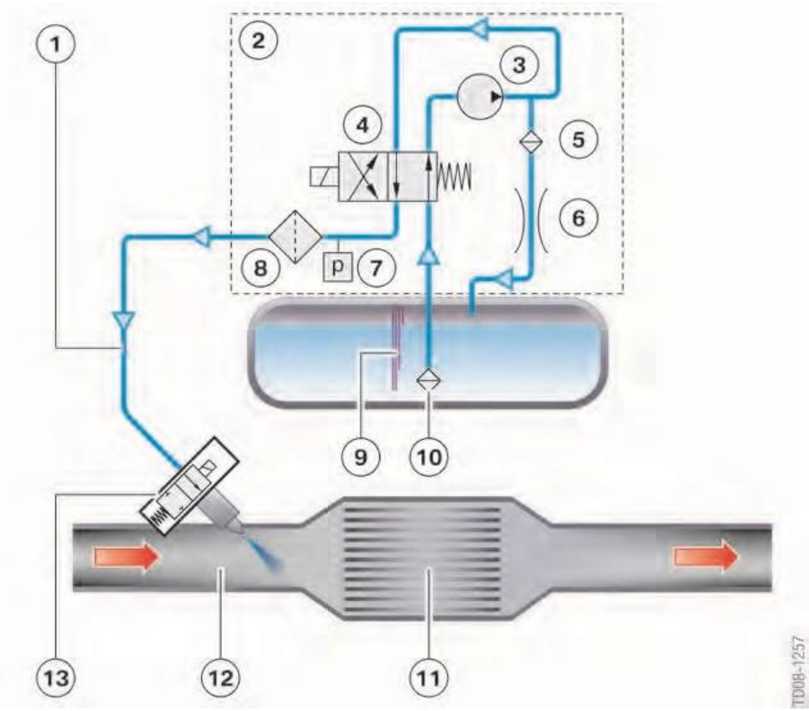
• Pressure sensor

• Filtertask

• Return throttle

• Reversing valve.

provides a speed



48 - Delivery

Index	Explanation	Index	Explanation
1	Metering line	8	Filter
2	Delivery module	9	Level sensor
3	Pump	10	Filter
4	Reversing valve	11	SCR catalytic converter
5	Filter	12	Exhaust system
6	Restrictor	13	Metering module
7	Pressure sensor		

The pump is actuated by a pulse-width modulated signal (PWM signal) from the DDE. The PWM signal

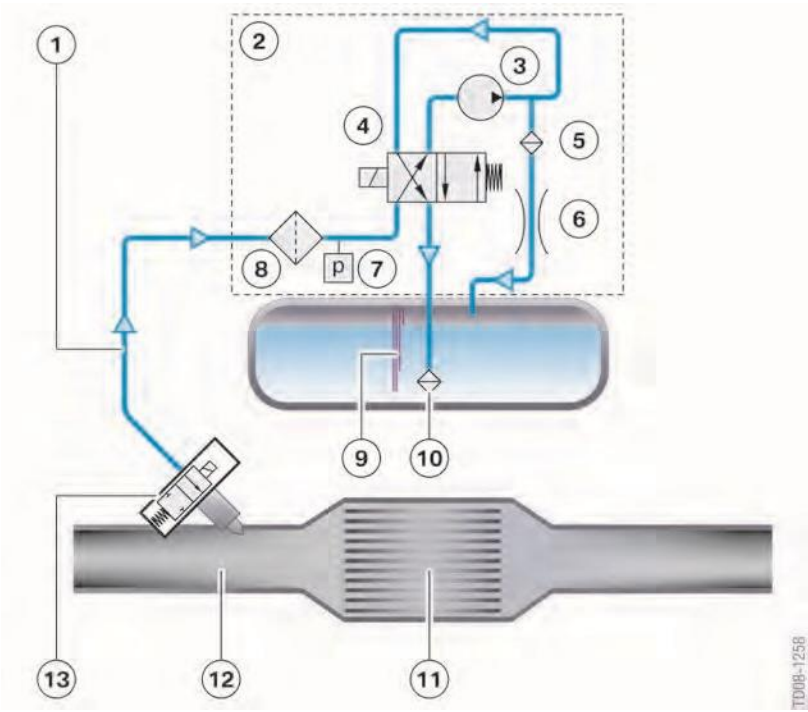
specification for the purpose of establishing

the system pressure. The value for the speed specification is calculated by the DDE based on the signal from the pressure sensor.
When the system starts up, the pump is actuated with a defined PWM signal and the line to the metering module is filled. This is followed by pressure build-up. Only then does pressure control take place.

When the metering line is filled, the opened metering valve allows a small quantity of the urea-water solution to be injected into the exhaust system.

During pressure control, i.e. during normal operation with metering, the pump is actuated in such a way that a pressure of 5 bar is applied
in the metering line. Only a small part of the urea-water solution delivered by the pump is actuallyinjected.Themajorityofthesolutionis transferred via a throttle back into the active reservoir. This means, the delivery pressure is determined by the pump speed together with the throttle cross section.

The solution is injected four times per second. The quantity is determined by the opening time and stroke of the metering valve.
However, the quantity is so low that there is no noticeable drop in pressure in the metering line.



Evacuating

Afterturningofftheengine,thereversingvalve switches to reverse the delivery direction of the pump, thus evacuating the metering line and metering module.

49 - Evacuating

Index	Explanation	Index	Explanation
1	Metering line	8	Filter
2	Delivery module	9	Level sensor
3	Pump	10	Filter
4	Reversing valve	11	SCR catalytic converter
5	Filter	12	Exhaust system
6	Throttle	13	Metering module
7	Pressure sensor		

Evacuation also takes place if the system has to be shut down due to a fault or if the minimum temperature in the active reservoir can no longer be maintained.

This is necessary to ensure no urea-water solution remains in the metering line or metering module as it can freeze.

The metering valve is opened during evacuation.

Level measurement

There are level sensors both in the active as well as in the passive reservoir. However, these sensors are not continuous sensors as in the fuel system for example. They can determine only a specific point, to which a defined quantity of urea-water solution in the reservoir is assigned.

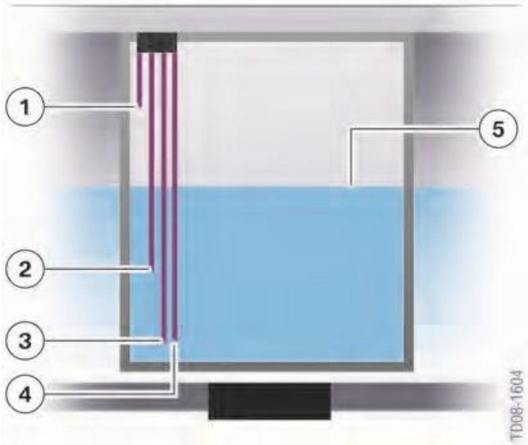
Two separate level sensors are fitted in the passive reservoir, one for "full" and one for "empty". The signals from the level sensors are not sent directly to the DDE but rather to an evaluator.

The active reservoir contains one level sensor that has various measuring points:

- Full
- Warning
- Empty.

Also in this case, there is an evaluator installed between the sensors and the DDE, which fulfils the same tasks as for the passive reservoir.

This evaluator sends a plausible level signal to the DDE. It recognizes changes in the fill level caused, for example, by driving uphill/downhill or sloshing of the liquid as opposed to an actual change in the liquid level in the reservoir.Lowlevelisthereforesignalledwhen thecorrespondingsensorisnolongercovered by the urea-water solution for a defined period of time. Once the level drops below this value, it can no longer be reached during normal operation. This means, the liquid sloshing on the sensor or driving uphill/downhill is no longer interpreted as a higher liquid level.



50 - Example: Level signal OK

Index	Explanation
1	Measuring point "Full"
2	Measuring point "Warning"
3	Measuring point "Empty"

Level of urea-water solution	Level signal
Level > Full	Full
Full > Level > Warning	OK
Warning > Level > Empty	Warning
Empty > Level	Empty

4	Reference
5	Level

The level measurement system must also recognize when the active and passive reservoirs are refilled. This is achieved by comparing the current level with the value last stored.

The level sensor signal after refilling corresponds to the signal while driving uphill. To avoid possible confusion, the refilling recognition function is limited to a certain period of time after starting the engine and driving off - as it can be assumed that refilling will only take place while the vehicle is stationary.

A certain vehicle speed must be exceeded to ensure that sloshing occurs, thus providing a clear indication that the system has been refilled.

Refilling the system while the engine is running can also be detected but with modified logic. The signals sent by the sensors while the vehicle is stationary are also used for this purpose. The vehicle must be stationary for a defined minimum period in order to make the filling plausible.

When the urea-water solution is frozen, a level sensor will show the same value as when it is not wetted/covered by the solution. A frozen reservoir is therefore shown as empty. For this reason, the following sensor signals are used for measuring the level:

- Ambient temperature• Temperature in active reservoir
- Heater enable.

Level calculation

This function calculates the quantity of ureawater solution remaining in the active reservoir. The calculation is calibrated together with the level measurement.

Every time the level drops below a level sensor the corresponding amount of urea-water solution in the reservoir is stored. The amount of urea-water solution actually injected is then subtracted from this value while the pumped quantity is added.

This makes it possible to determine the level more precisely than that would be possible by simple measurement. In addition, the level can still be determined in the event of one of the level sensors failing.

Since it is possible that refilling is not recognized, the calculation is continued only until the level ought to drop below the next lower sensor.

Example:

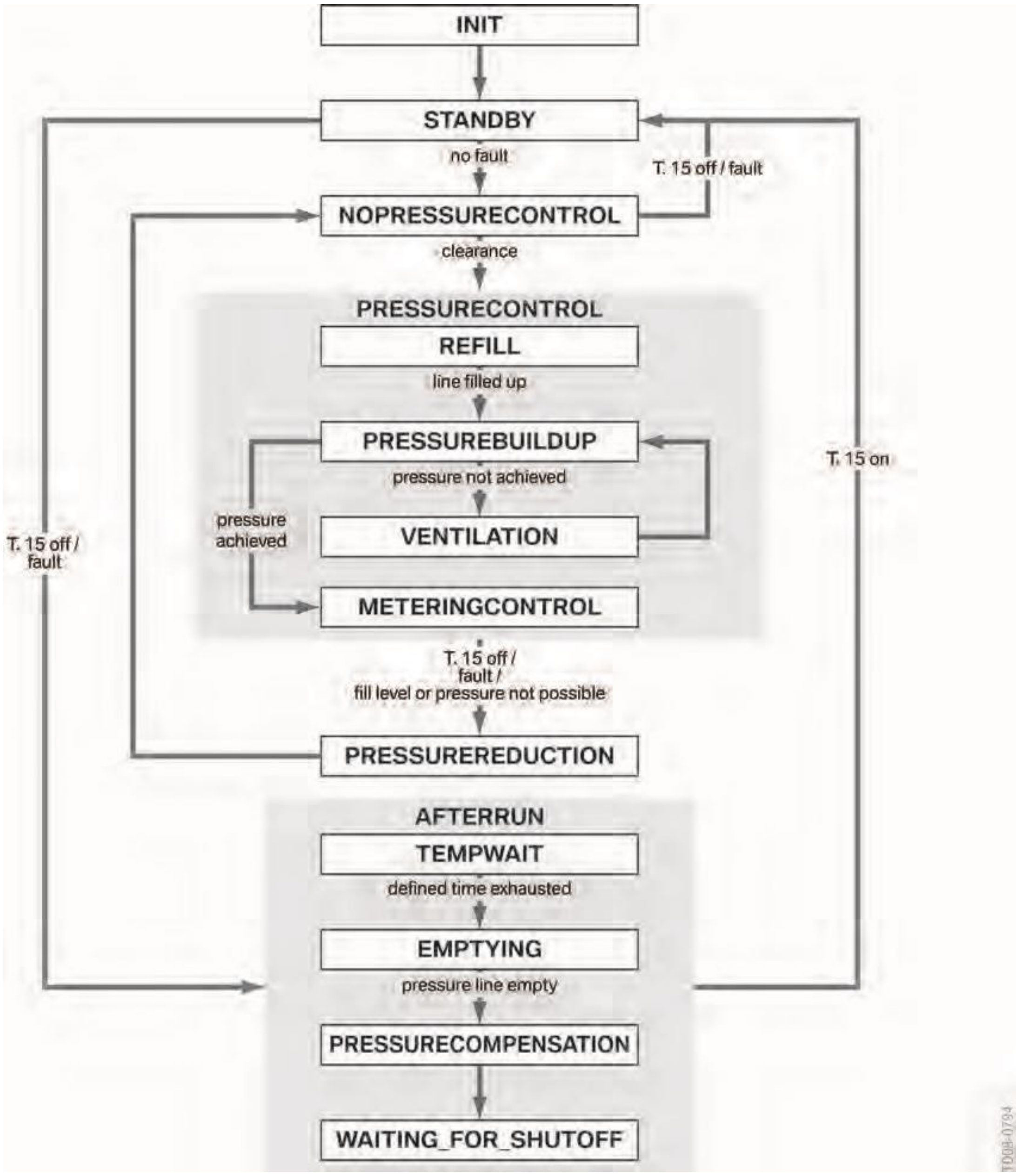
Once the level drops below the "full" level sensor, for example, from now on the quantity of used and repumped urea-water solution is taken into account and the actual level below "full" calculated. Normally, the level then drops below the next lower level sensor at the same time as determined by the level calculation. An adjustment takes place at this point and the calculation is restarted.

If, however, a quantity of urea-water solution is refilled without it being detected, the actual level will be higher than the calculated level. The level calculation is stopped if it calculates that the level ought to have dropped below the next level sensor but the level sensor is still wetted/covered.

By way of exception, a defective level sensor can cause the calculation to continue until the reservoir is empty.

SCR system modes

When the ignition is switched on, the SCR control undergoes a logical sequence of modes in the DDE. There are conditions that initiate the change from one mode to the other. The following graphic shows the sequence of modes which are subsequently described.



51 - Sequence of modes in SCR control

INIT (SCR initialization)

The control unit is switched on (terminal 15 ON) and the SCR system is initialized.

STANDBY (SCR not active)

STANDBY mode is assumed either after initialization or in the case of fault.

AFTERRUN mode is assumed if terminal 15 is switched off in this state or a fault occurs.

NOPRESSURECONTROL (waiting for enable for pressure control)

NOPRESSURECONTROL mode is assumed when no faults occur in the system. In this mode, the system is waiting for the pressure control enable that is provided by the following sensor signals:

- Temperature in catalytic converter
- Temperature in active reservoir• Ambient temperature
- Engine status (engine running).

The system also remains in NOPRESSURECONTROL mode for a minimum period of time so that a plausibility check of the pressure sensor can be performed.

PRESSURECONTROL mode is assumed once the enable is finally given.

STANDBY mode is assumed if terminal 15 is switched off or a fault occurs in NOPRESSURECONTROL mode.

PRESSURECONTROL (SCR system running)

PRESSURECONTROL mode is the normal operating status of the SCR system and has four submodes.

PRESSURECONTROL mode is maintained until terminal 15 is switched off. A change to PRESSUREREDUCTION mode then takes place.

A change to PRESSUREREDUCTION mode also takes place if a fault occurs in the system.

The four submodes of PRESSURECONTROL are described in the following:

- REFILL

  The delivery module, metering line and the metering module are filled when REFILL mode is assumed. The pump is actuated and the metering valve opened by a defined value. The fill level is calculated.

  The mode changes to PRESSUREBUILDUP when the required fill level is reached or a defined pressure increase is detected.

  PRESSUREREDUCTION mode is assumed if terminal 15 is switched off or a fault occurs in the system.

- PRESSUREBUILDUP

  In this mode, the pressure is built up to a certain value. For this purpose, the pump is actuated while the metering valve is closed.

  If the pressure is built up within a certain time, the system switches to the next mode of METERINGCONTROL. If the required pressure built-up is not achieved after the defined period of time has elapsed, a status loopisinitiated,andVENTILATIONmodeis assumed.

  If the pressure cannot be built up after a defined number of attempts, the system signals a fault and assumes PRESSUREREDUCTION mode.

  PRESSUREREDUCTION mode is also assumed when terminal 15 is switched off or another fault occurs in the system.

- VENTILATION

  If the pressure could not be increased beyond a certain value in PRESSUREBUILDUP mode, it is assumed that there is still air in the pressure line.

  The metering valve is opened for a defined period of time to allow this air to escape. This status is exited after this time has elapsed and the system returns to PRESSUREBUILDUP mode. The loop between PRESSUREBUILDUP and VENTILATION varies corresponding to the conditionofthereducingagent.Thereason for this is that a different level is established after REFILL depending on the ambient conditions. Repeating the ventilation function will ensure that the pressure line is completely filled with reducing agent.

  PRESSUREREDUCTION mode is assumed if terminal 15 is switched off or a fault occurs in the system.

- METERINGCONTROL

The system can enable metering in METERINGCONTROL mode. This is the actual status during normal operation. The urea-water solution is injected in this mode.

In this mode, the pump is actuated in such awaythatadefinedpressureisestablished. This pressure is monitored. If the pressure progression overshoots or undershoots defined parameters, a fault is detected and the system assumes PRESSUREREDUCTION mode. These faults are reset on return to METERINGCONTROL mode.

PRESSUREREDUCTION mode is also assumed if terminal 15 is switched off or another fault occurs in the system.

PRESSUREREDUCTION

Metering enable is cancelled on entering PRESSUREREDUCTION mode.

This status reduces the pressure in the delivery module, metering line and the metering module after PRESSURECONTROL mode. For this purpose,thereversingvalveisopenedandthe pump actuated at a certain value, the metering valve is closed.

PRESSUREREDUCTION mode ends when the pressure drops below a certain value. The system assumes NOPRESSURECONTROL mode if the pressure threshold is reached (undershot) within a defined time.

The system signals a fault if the pressure does not drop below the threshold after a defined time has elapsed. In this case or also in the case of another fault, the system assumes NOPRESSURECONTROL mode.

NOPRESSURECONTROL mode is also assumed when terminal 15 is switched on.

AFTERRUN

The system is shut down in AFTERRUN mode.

If terminal 15 is switched on again before afterrun has been completed, afterrun is cancelled and STANDBY mode is assumed. If this is not the case the system goes through the submodes of AFTERRUN.

- TEMPWAIT (catalytic converter cooling phase)

  In AFTERRUN mode, TEMPWAIT submode is initially assumed if the system is filled. This is intended to prevent excessively hot exhaust gasses being drawn into the SCR system.

  The duration of the cooling phase is determined by the exhaust gas temperature. EMPTYING submode is assumed after this time, in which the exhaust system cools down, has elapsed.

  EMPTYING submode is also assumed if a fault occurs in the system.

  If terminal 15 is switched on in this status, STANDBY mode is assumed.

- EMPTYING

  The system assumes AFTERRUN_EMPTYING submode after the cooling phase. The pressure line and the delivery module are emptied in this submode. The urea-water solution is drawn back into the active reservoir by opening the reversing valve, actuating the pump and opening the metering valve. This is intended to prevent the urea-water solution freezing in the metering line or the metering module.

Thelevelinthemeteringlineiscalculatedin this mode.

PRESSURECOMPENSATION mode is assumed if the metering line is empty. PRESSURECOMPENSATION mode is also assumed if a fault occurs in the system. If terminal 15 is switched on, STANDBY mode is assumed.

- PRESSURECOMPENSATION (intake line - ambient pressure)

  After the system has been completely emptied, PRESSURECOMPENSATION submode is assumed. In this status the pump is switched off, the reversing valve is then closed followed by the metering valve after a delay. The time interval between switching off the pump and closing the valve prevents a vacuum forming in the intake line; pressure compensation between the intake line and ambient pressure takes place.

  After executing the steps correctly the system assumes WAITING_FOR_SHUTOFF submode.

  WAITING_FOR_SHUTOFF is also assumed if a fault occurs in the system.

  If terminal 15 is switched on, STANDBY mode is assumed.

- WAITING_FOR_SHUTOFF (shutting down SCR)

  The control unit is shut down and switched off.

Warning and shut-down scenario

The SCR system is relevant to the vehicle complying with the exhaust emission regulations - it is a prerequisite for approval/ homologation! If the system fails, the approval will be invalidated and the vehicle must no longer be operated. A very plausible case leading to the system failure is that the ureawater solution runs out.

Vehicle operation is no longer permitted without the urea-water solution, therefore, the engine will no longer start.

To ensure the driver is not caught out, a warning and shut-down scenario is provided that begins at a sufficiently long time before the vehicle actually shuts down so that the driver can either conveniently top up the ureawater solution himself or have it topped up.

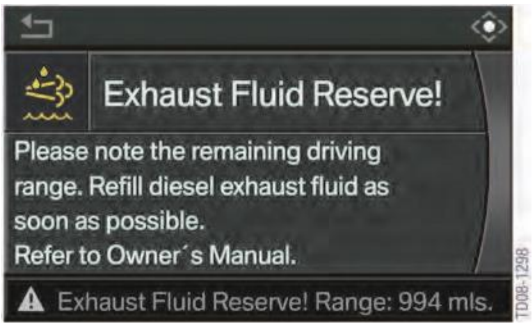
Warning scenario

The warning scenario begins when the level drops below the "Warning" level sensor in the active reservoir. At this point, the active reservoir is still approximately 50 % full with urea-water solution. The level is then determined as a defined volume (depending on type of vehicle). From this point on, the actual consumption of the urea-water solution is subtracted from this value. The mileage is recorded when the amount of 2500 ml is reached.

A countdown from 1000 mls now takes place - irrespective of the actual consumption of the urea-water solution. The driver receives a priority 2 (yellow) check control message showing the remaining range.

52 - CC message in instrumentcluster, range < 1000 mls

If the vehicle is equipped with an on-board computer (CID - Central Information Display), instruction will also be displayed.

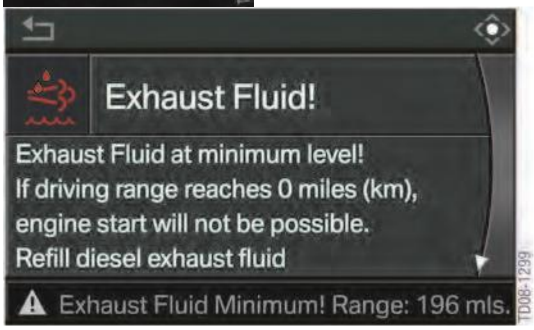


53 - CC message in CID, range < 1000 mls

The driver receives a priority 1 (red) check control message as from 200 mls.

54 - CC message in instrumentcluster, range < 200 mls

In this case the following message is shown in the CID:



55 - CC message in CID, range < 200 mls

Shut-down scenario

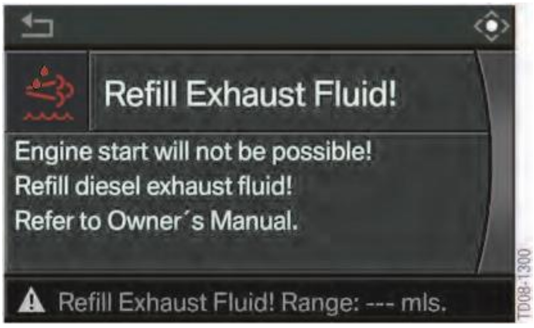
If the range reaches 0 mls, similar as to in the fuel gauge, three dashes are shown instead of the range.

Exhaust fluid incorrect

Ifthesystemisfilledwithanincorrectmedium, this will become apparent after several hundred miles (kilometres) later by elevated

56 - CC message in instrument cluster, range = 0 mls

The check control message in the CID changes and shows that the engine can no longer be started.



57 -CC message in CID, range=0mls

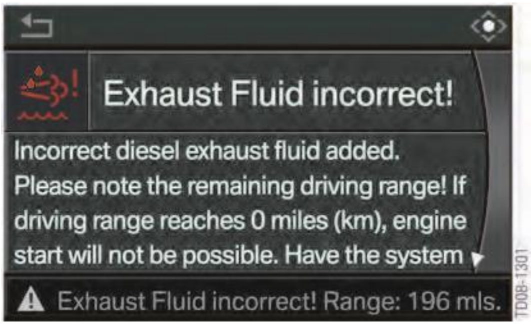
Inthiscase,itwillnolongerbepossibletostart theengineifithasbeenshutdownforlonger than three minutes. This is intended to allow thedrivertomoveoutofahazardoussituation if necessary.

If the system is refilled only after engine start has been disabled, the logic of the refill recognition system is changed in this special case, enabling faster refill.

58 -CC message in instrument cluster in the case of incorrect exhaust fluid

Theexclamationmarkinthesymbolidentifies the fault in the system.

In this case, the message in the CID informs the driver to go to the nearest workshop.



nitrogen oxide values in the exhaust gas despite adequate injection of the supposed urea-water solution. The system recognizes an incorrect medium when certain limits are exceeded. From this point on, a warning and shut-down scenario is also initiated that allows a remaining range of 200 mls.

Refilling

The active and passive reservoirs can be refilled with urea-water solution either by the service workshop or

by the customer himself.

The system can be refilled without any problemswiththevehicleonaninclineofupto

5° in any direction. In this case, 90 % of the maximum possible fill is still achieved.

The volume of the urea-water solution reservoir is designed such that the range is large enough to cover one oil change interval. This means the "normal" refill takes place as part of the servicing work in the workshop. If, however, the supply of urea-water solution should run low prematurely due to extraordinarydrivingprofile,itispossibletotop up a smaller quantity.

Refilling in service workshop

Refilling in the service workshop refers to the routine refill as part of the oil change procedure. This takes place at the latest after:

- 13000 mls on the E90,• 11000 mls on the E70 or
- one year.

In this case, the system must be emptied first in order to remove older urea-water solution.
This takes place via the extractor connections in the transfer line. Although a small residual quantity always remains in the reservoirs, it is negligible.

Topping up

Any required quantity can be topped up if the urea-water solution reserve does not last up to the next oil change. Ideally, this quantity
should only be as much as is required to reach the next oil change, as the system is then emptied.

Components of the selective catalytic reduction system

Urea-water solution

The urea-water solution is the carrier for the ammonia that is used to reduce the nitrogen oxides (NO_x) in the exhaust gas. To protect persons and the environment from the effects of ammonia and to make it more easy to handlefor transportand refuellingprocedures, it is provided in an aqueous urea solution for the SCR process.

The recommended urea-water solution is AdBlue. The VDA (Association of German Automobile Industry) holds the rights to the trademark AdBlue. AdBlue is a high-purity, water-clear, synthetically manufactured 32.5 % urea solution that is standardized in accordance with DIN 70070/AUS32.

The urea-water solution used must correspond to this standard.

Health and safety

The urea-water solution is not toxic. It is an aqueous solution which, according to valid European chemical law, poses no special risks. It is not a hazardous substance and it is not a dangerous medium as defined by transport laws.

If small amounts of the product come in contact with the skin while handling the ureawater solution it is sufficient to simply rinse it off with ample water. In this way, the possibility of any ill effects on human health are ruled out.

Degradability and disposal

The urea-water solution can be broken down by microbes and is therefore easily degradable. The urea-water solution poses a minimum risk to water and soil. In Germany, the urea-water solution is categorized in the lowest water hazard class (WGK 1). In view of its excellent degradability properties, small quantities of spilt urea-water solution can be flushed into the sewage system with ample water.

Materials compatibility

Contact of urea-water solution with copper and zinc as well as their alloys and aluminium must be avoided as this leads to corrosion. No problems whatsoever are encountered with stainless steel and most plastics.

Storage and durability

To avoid adverse effects on quality due to contamination and high testing expenditure, the urea-water solution should only be handled in storage and filling systems specifically designed for this purpose.

In view of the fact that the urea-water solution freezes solid at a temperature of -11 °C and decomposes at an accelerated rate at temperatures above 25 °C, the storage and filling systems should be set up in such a way that a temperature range from 30 °C to -11 °C is ensured.

Provided the recommended storage temperature of maximum 25 °C is maintained, the urea-water solution meets the requirements stipulated by the standard DIN 70070 for at least 12 months after its manufacture. This period of time is shortened if the recommended storage temperature is exceeded. The urea-water solution will become solid if cooled to temperatures below -11 °C. When heated up, the frozen ureawater solution becomes liquid again and can be used without any loss in quality.

Avoid direct UV radiation.

Passive reservoir

The passive reservoir is the larger of the two supply reservoirs.

Vehicle	Volume	Location	Position of filler neck

E70	16.5 l	In underbody, approximately under driver's seat	On the left in engine compartment, under unfiltered air pipe
E90	14.4 l	Under luggage compartment floor instead of multifunction pan	Left side in rear bumper panel

The name passive reservoir refers to the fact • Level sensors (2x) that it is not heated.

• Operating vent (2x on E90)

The following components make up the

Index	Explanation	Index	Explanation
1	Operating vent	5	Fill line connection
2	Filler vent	6	"Empty" level sensor
3	"Full" level sensor	7	Passive reservoir

4	Operating vent

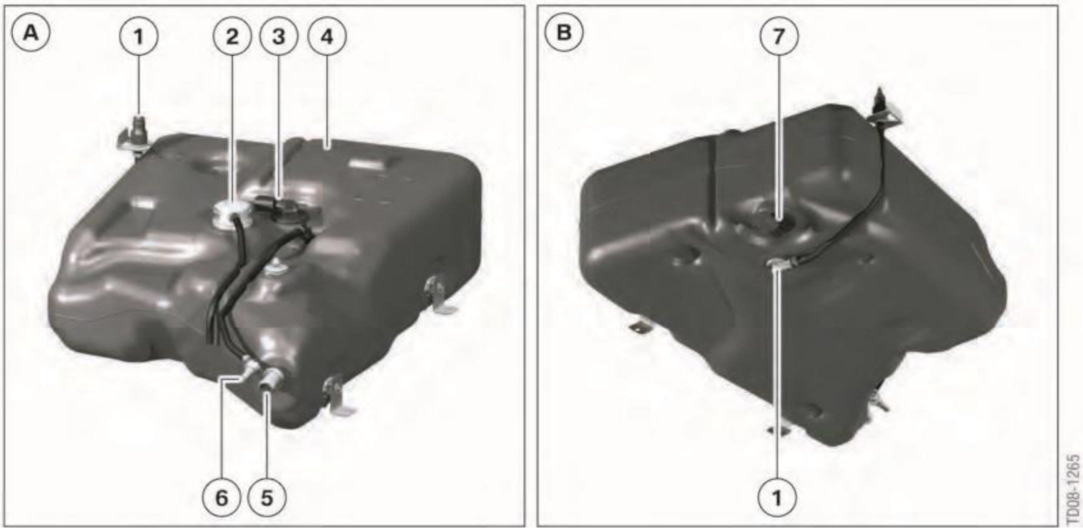
• Filler vent.passive reservoir:

60 - E90 Passive reservoir

The passive reservoir on the E70 is encased in insulation as it is positioned near the front of the exhaust system where the heat transfer to the urea-water solution would be very high.

Index	Explanation	Index	Explanation
1	Connection for transfer line	5	Fill line connection
2	Operating vent	6	Filler vent
3	"Full" level sensor	7	"Empty" level sensor

61 - Insulation of passive reservoir E70



62 - E70 Passive reservoir

Level sensors

There are two level sensors in the passive reservoir. One supplies the "Full" signal and the other the "Empty" signal.

The sensors make use of the conductivity of the urea-water solution. Two contacts project into the reservoir. When these contacts are wetted with urea-water solution the circuit is closed and current can flow, thus enabling a sensor signal.

The two level sensors send their signal to an evaluator. This evaluator filters the signals and recognizes, for example, sloshing of the ureawater solution and transfers a corresponding level signal to the digital diesel electronics.

The "Full" level sensor is located at the top of the passive reservoir. Both contacts are wetted when the passive reservoir is completely filled and the sensor sends the "Full" signal.

The "Empty" level sensor is located at the bottom end of the passive reservoir. The reservoir is considered to be "not empty" for as long as the sensor is covered by urea-water solution. The evaluator detects that the passive reservoir is empty when no sensor signal is received.

63 - Level sensor in passive reservoir

Venting

The passive reservoir is equipped with one operating vent (2 in the E90) and one filler vent.

The operating vent is directed into atmosphere. A so-called sintered tablet ensures that no impurities can enter the reservoir via the operating vent. This sintered tablet consists of a porous material and serves
as a filter that allows particles only up to a certain size to pass through.

The filler vent is directed into the filler pipe and therefore no filter is required.

Transfer unit

The transfer unit pumps the urea-water This pump is designed as a diaphragm pump. solution from the passive reservoir to the It operates in a similar way to a piston pump active reservoir. There is a screen filter in the inlet port of the pump.

64 -Transfer unit

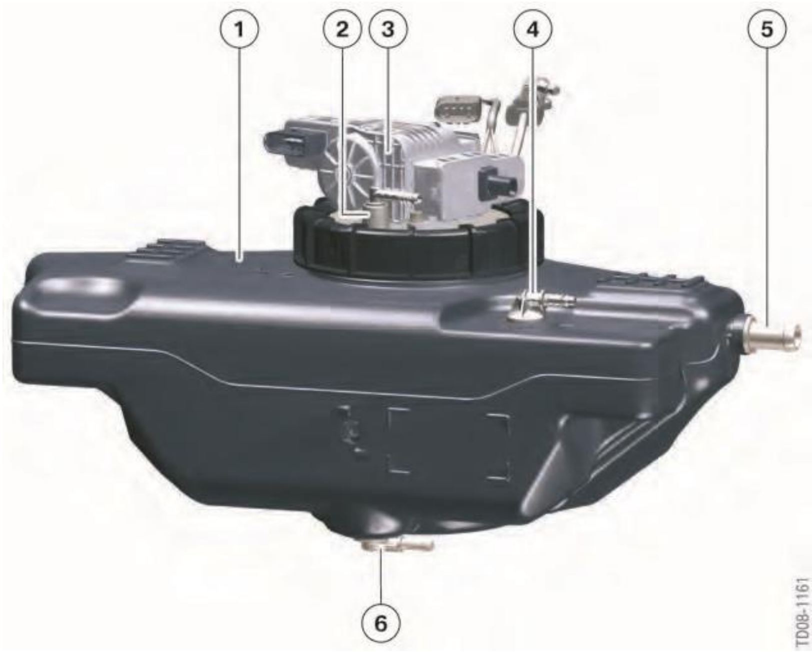
but the pump element is separated from the mediumbyadiaphragm.Thismeansthereare no problems regarding corrosion.

Index	Explanation
1	Connection for transfer line to passive reservoir (inlet)
2	Pump motor connection
3	Connection for transfer line to active reservoir (outlet)

Active reservoir

The active reservoir is the smaller of the two energy is required to heat the urea-water reservoirs and its name refers to the fact that it solution.
is heated. In view of its small volume, little

Vehicle	Volume	Location	Position of filler neck
E70	6.4 l	On front right in side panel module between bumper panel and wheel arch	On front right in engine compartment at the end of the support carrier cross member
E90	7.4 l	Behind the rear axle differential directly under the passive reservoir	Left side in rear bumper panel



65 - E90

Active reservoir

Index	Explanation	Index	Explanation
1	Active reservoir	4	Filler vent
2	Operating vent	5	Fill line connection
3	Delivery module	6	Connection of transfer line from p

66 - E70 Active reservoir

Index	Explanation
1	Fill line connection, active reservoir
2	Delivery module
3	Metering line
4	Filler vent
5	Connection of transfer line from passive reservoir
6	Active reservoir

Function unit

The so-called function unit is located in the active reservoir. It has the external appearance of a surge chamber and accommodates a heater, filter and a level sensor. The delivery unit is attached to it.

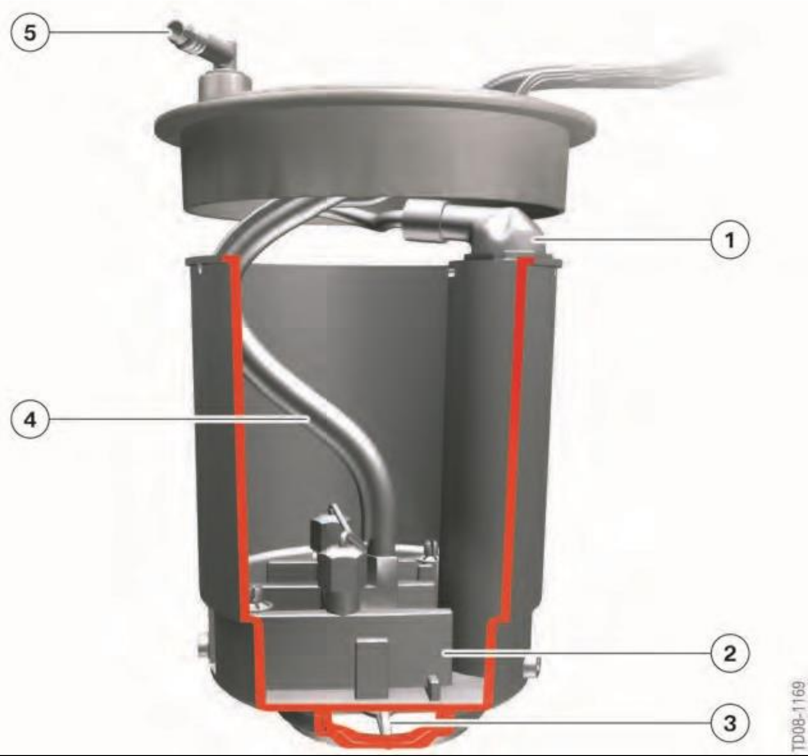
67 - Function unit

Index	Explanation
1	Operating vent
2	Bowl
3	Level sensor

Unlike a surge chamber in the fuel tank, the lower section of the function unit has slots.

This chamber creates a smaller volume in the reservoir that scarcely mixes with the ureawater solution outside the chamber. There is a PTC heating element (positive temperature coefficient) in the base of the chamber that can heat up this smaller volume at a relatively fast rate. The intake line is also heated. In this way, liquid urea-water solution can be made available for vehicle operation even at the lowest temperatures.

The heating element in the chamber is connected to the heater for the intake line to form one heating circuit. A power semiconductor supplies the current for this heating circuit. The power semiconductor is controlled by the DDE. The DDE can determine the current that flows across the heating elements and can therefore monitor their operation.

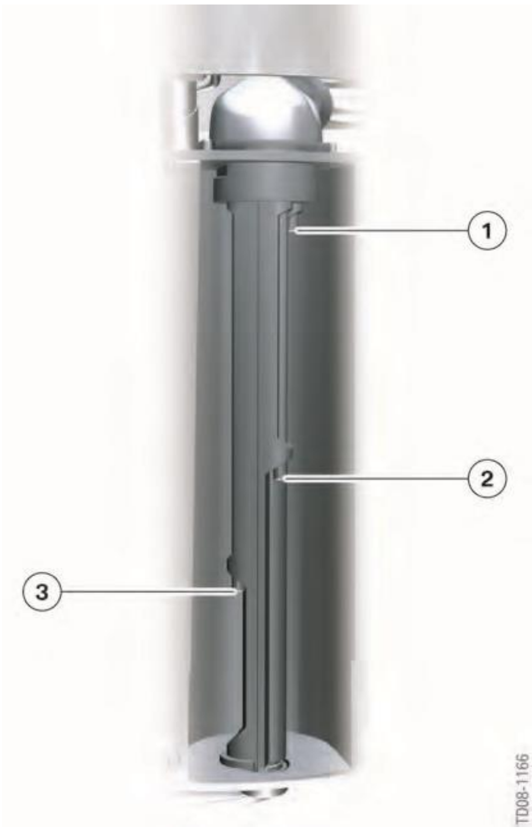


68 - Sectional view of functionunit

Index	Explanation	Index	Explanation
1	Level sensor	4	Intake line with heater
2	Heating element	5	Operating vent
3	Filter		

The temperature sensor provides the signal for the heating control system. It is designed as an NTC sensor (negative temperature coefficient). The temperature sensor is integrated at the bottom end of the level sensor.

Index	Explanation
3	"Empty" contact



69 - Level sensor in active reservoir

The level sensor in the function unit provides the level value for the entire active reservoir.

The level sensor in the active reservoir operates in accordance with the same principle as the level sensors in the passive reservoir. In this case, however, there is only one sensor with several contacts that extend at different levels into the active reservoir.

The sensor makes use of the conductivity of the urea-water solution. A total of four contacts project into the reservoir. When these contacts are wetted with urea-water solution the circuit is closed and current can flow, thus enabling a sensor signal.

Three contacts are responsible for signalling the different levels. The fourth contact is the reference, i.e. the contact via which the electric circuit is closed. This reference contact cannot be seen in the figure as it is located directly behind the "Empty" contact (3).

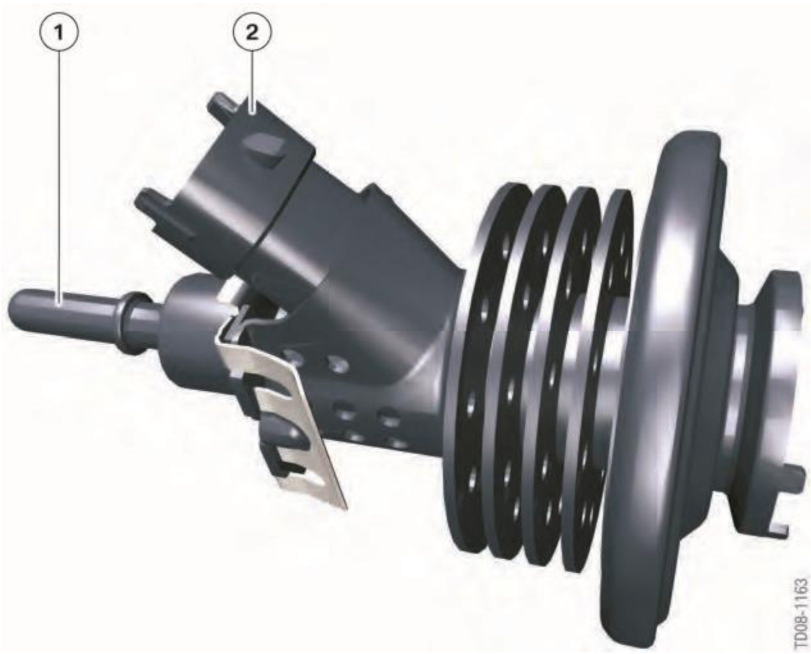
The level sensor sends its signal to an evaluator. This evaluator filters the signal and recognizes, for example, sloshing of the ureawater solution and transfers a corresponding level signal to the digital diesel electronics.

Index	Explanation
1	"Full" contact
2	"Warning" contact

Delivery unit

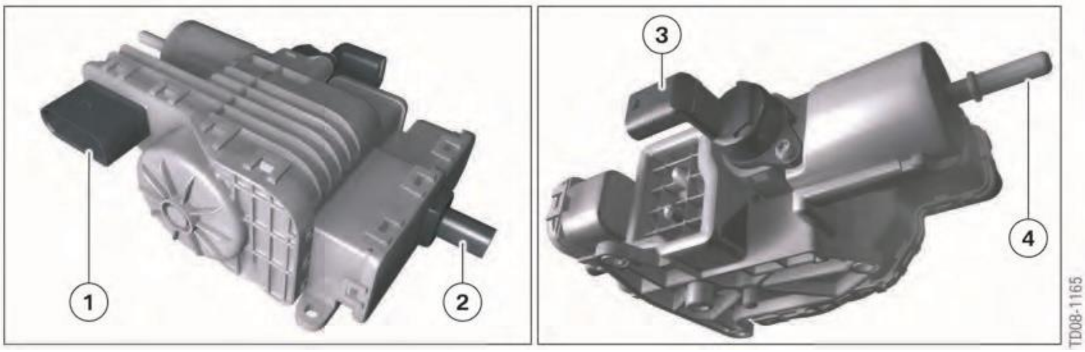
The delivery unit is located on the active reservoir at the top end of the function unit. Among other things, the delivery unit comprises the pump that transfers the ureawater solution from the active reservoir to the metering module. The delivery unit is also heated by a PTC element.

Metering module and mixer



71 - Metering module

Index	Explanation	Index	Explanation
1	Metering line connection	2	Metering valve connection



70 - Delivery unit

Index	Explanation	Index	Explanation
1	Pump motor and heater connection	3	Pressure sensor connection
2	Reversing valve connection	4	Metering line connection

The heating element in the delivery unit is connected to the heater for the metering line to form one heating circuit. A power semiconductor supplies the current for this heating circuit. The power semiconductor is controlled by the DDE. The DDE can determine the current that flows across the heating elements and can therefore monitor their operation.

Pump

The pump is a common part with the pump in the transfer unit. While the engine is running, it pumps the urea-water solution from the active reservoir to the metering module. It sucks the meteringlineemptywhentheengineisturned off.

Pressure sensor

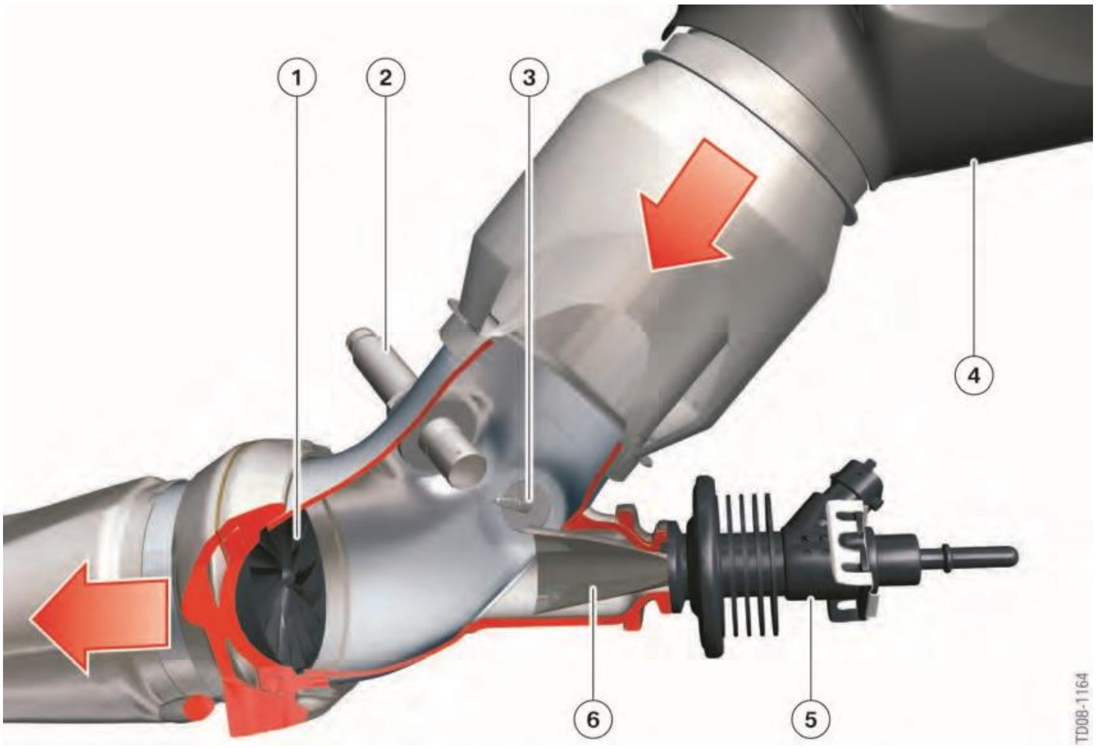
The pressure sensor measures the pressure in the delivery line to the metering module. The value is transferred to the DDE.

Reversing valve

The reversing valve ensures the delivery direction in the metering line can be reversed to empty the metering line while the pump delivers in the same direction. It is designed as a4/2-wayvalveinterchangesthemeteringline and intake line to the pump.

The valve is not actuated in intervals and therefore has only two positions. Since power is permanently applied to the valve when it is actuated, the maximum actuation time is limited in order to avoid overheating.

The metering module is responsible for injecting the urea-water solution into the exhaust pipe. It features a valve that is similar to the fuel injector in a petrol engine with intake manifold injection.



Although the metering module does not have aheater,itisstillheatedbytheexhaustsystem to such an extent that it even requires cooling fins.

The metering module is actuated by a pulsewidth modulated (PWM) signal from the DDE such that the pulse duty factor determines the opening duration of the valve.

72 - Metering module in installed position

Index	Explanation	Index	Explanation
1	Mixer	4	Diesel particulate filter
2	NO_x sensor before SCR catalytic converter	5	Metering module
3	Exhaust gas temperature sensor after diesel particulate filter	6	Insert

The metering module is equipped with a tapered insert (6) that prevents urea-water

Mixer

The mixer mounted in the flange connection
solution residue drying up and clogging the of the exhaust pipe is located directly behind
valve. Its shape creates a flow that prevents
the metering module in the exhaust system.
It urea-water solution from collecting on the swirls the flow of exhaust gas to ensure the walls
of the exhaust system. Urea deposits on urea-water solution is thoroughly mixed with the
insert are burnt off as it is heated to very the exhaust gas. This is necessary to ensure high
temperatures by the flow of exhaust gas. the urea converts completely into ammonia.

Index	Explanation	Index	Explanation
1	Pump flow 1st chamber	5	Barrier 2
2	Catalytic element	6	Solid electrolyte zircon dioxide (ZrO_2)

3	Nitrogen outlet	7	Barrier 1
4	Pump flow 2nd chamber		

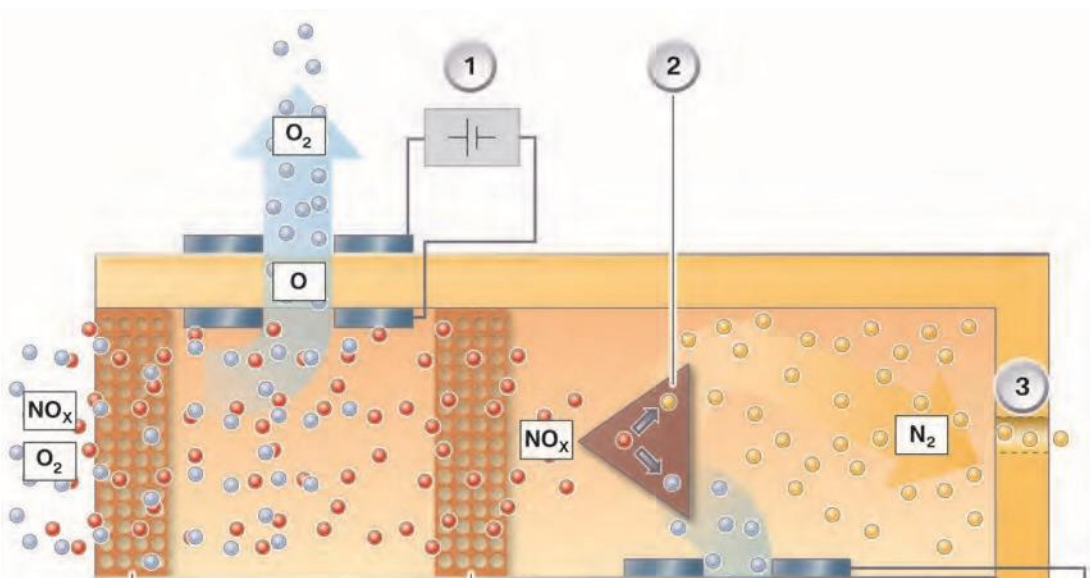
NO_x sensors

73 -NO x sensor

The nitrogen oxide sensor consists of the actual measuring probe and the corresponding control unit. The control unit communicatesviatheLoCANwiththeengine control unit.

Intermsofitsoperatingprinciple,thenitrogen oxide can be compared with a broadband oxygen sensor. The measuring principle is basedontheideaofbasingthenitrogenoxide measurement on oxygen measurement.

The following graphic shows the functional principle of this measuring system.



The exhaust gas flows through the NO_X sensor. Here, only oxygen and nitrogen oxides are of interest. In the first chamber, the oxygen is ionized out of this mixture with the aid of the first pump cell and passed through the solid electrolyte. A lambda signal can be tapped off from the pump current of the first chamber. In this way, the exhaust gas in the NO_X sensor is liberated from free oxygen (not bound to nitrogen).

The remaining nitrogen oxide then passes through the second barrier to reach the second chamber of the sensor. Here, the nitrogen oxide is split by a catalytic element into oxygen and nitrogen. The oxygen released in this way is again ionized and can then pass through the solid electrolyte. The pump current that occurs during this process makes it possible to deduce the quantity of oxygen and the nitrogen level can be concluded from this quantity.

Engine electrical system

In contrast to the ECE version of the M57D30T2 engine, the US version of the engine electrical system features following differences:

- Engine control unit DDE7
- Preheating system with LIN-bus link andceramic heater plugs
- Additional OBD sensors
- Electrically operated swirl flap and EGRvalve
- Additional actuators and sensors forthe lowpressure EGR system.

Engine control unit DDE7.3

The new DDE7 engine control unit that will otherwise be used in the next generation of diesel engines (N47, N57) is used in the US version of the M57D30T2 engine.

The reason for this is that the capacity of the DDE6 is no longer sufficient for the additional functions (especially SCR).

Preheating system

The heating system is responsible for providing reliable cold start properties and smooth operation when the engine is cold.

The DDE control unit sends the temperature requirement of the heater plug to the heating control unit. The heating control unit implements the request and actuates the heater plugs with a pulse-width modulated signal. The heating control unit additionally sends diagnosis and status information via the LIN-bus connection back to the digital diesel electronics.

The LIN-bus is a bi-directional data interface that operates in accordance with the masterslave principle. The DDE control unit is the master.

Each of the six heating circuits can be diagnosed individually.

When the heating control unit is switched on forthefirsttime,theelectricalresistanceofthe heater plugs is evaluated at the start of the heating process. A hot heater plug has a much higherresistancethanacoldplug.Ifhotheater plugs are detected based on their resistance, less power is applied to the heater plugs at the start of the heating cycle. If, on the other hand, cold heater plugs are detected, the maximum powerisappliedtotheheaterplugsatthestart of the heating cycle. This function is known as dynamic repeat heating. This function avoids the situation where too much power is applied to a heater plug, which is already hot, as the result of a second heating cycle following shortly after the first, and therefore overheats.

The DDE control unit determines the necessary heater plug temperature as a function of the following operating values:

- Engine speed
- Intake air temperature
- Injected quantity
- Ambient pressure
- System voltage
- Status signal, starter enable.

The digital diesel electronics sends the required heater plug temperature to the heating control unit to activate heating.

The heating system assumes various operating modes that are explained in the following.

Preheating

Preheating is activated after terminal 15 has been switched on.
The heater system indicator in the instrument cluster is activated at a coolant temperature of ≤ 10 °C.
Preheating is finished when:

- The engine speed threshold of 42 rpm isexceeded (starter is operated) or
- the preheating time has elapsed. Thepreheating time is dependent on the coolant temperature and is defined in a characteristic curve.

Coolant temperature in °C	Preheating time in seconds
< -35	3.5
-25	2.8
-20	2.8
-5	2.1
0	1.6
5	1.1
30	1.1
> 30	0

Start standby heating

Start standby heating is activated when the preheating process is terminated by the preheating time elapsing. Start standby heating is terminated:

- After 10 secondsor
- whentheenginespeedthresholdof42rpmis exceeded.

Start heating

Start heating is activated during every engine start procedure when the coolant temperature is below 75 °C. Start heating begins after the engine speed threshold of 42 rpm has been exceeded. Start heating is terminated:

- After the maximum start heating time of 60seconds has elapsed or
- after the engine start operation has beencompleted or
- when the coolant temperature of 75 °C is exceeded.

Emergency heating

Emergency heating is triggered for 3 minutes in the event of communication between the DDE control unit and heating control unit failing for more than 1 second. The heating control unit then uses safe values so as to prevent damage to the heating system.

Concealed heating

Preheating and start standby heating are activated as so-called concealed heating up to a coolant temperature of 30 °C.

Concealed heating is triggered a maximum of 4 times and is then not enabled again before the engine is restarted.

Concealed heating is triggered by the following signals:

- Driver's seat occupancy
- Driver's seat belt buckle
- Valid key
- Terminal R
- Clutch operated.

Partial load heating

Partial load heating can occur at coolant temperatures below 75 °C after starting the engine. Actuation of the heater plugs depends on the engine speed and load, thus improving the exhaust gas characteristics.

Actuation and fault detection

The power output stages for heater plug actuation are located in the heater control unit. The heater control unit does not have its own fault code memory. Faults in the heating system detected by the heater control unit are signalled via the LIN-bus to the digital diesel electronics. The corresponding fault codes are then stored in the DDE fault code memory.

Toavoiddamage,theheatercontrolunitshuts down all heating activities when the permissible operating temperature of the heater control unit is exceeded.

The ceramic heater plugs are designed for an operating voltage of 7.0 to 10.0 V. A voltage of 10 V can be applied to heat up the plug at a faster rate during the heating process. A PWM signal is applied to the heater plugs for the purpose of maintaining the heater plug temperature. Consequently, an effective voltage is established at the heater plugs that is lower than the system voltage. 3 The ceramic heater plugs are susceptible toimpactandbendingloads.Heaterplugsthat have been dropped may be damaged. 1

3 A maximum voltage of 7 V may be applied to the heater plugs when removed. Higher voltages without cooling air movement can irreparably damage the heater plugs. 1

Sensors and actuators

In the M57D30T2 US engine, the this system. The table below provides an modifications to the sensors and actuators are overview. It shows a comparison between the restricted to the air intake and exhaust system. E70 US and E90 US and the EURO4 version Several new components have been added to of the ECE variant.

Sensors	EURO4	E70 US	E90 US
Outside temperature sensor	7	7	7
Ambient pressure sensor	7	7	7
Hot-film air mass meter (HFM)	7	7	7
Intake air temperature sensor (in HFM)	7	7	7
Charge air temperature sensor	7	7	7
Boost pressure sensor	7	7	7
Exhaust pressure sensor at exhaust manifold		7	7
Oxygen sensor	7	7	7
Exhaust gas temperature sensor before oxidation catalytic converter	7	7	7
Exhaust gas temperature sensor before diesel particulate filter	7	7	7
Exhaust backpressure sensor before diesel particulate filter	7	-	-
Exhaust differential pressure sensor	-	7	7
Temperature sensor after low pressure EGR cooler	-	7	-
Temperature sensor after high pressure EGR cooler	-	7	7
Exhaust gas temperature sensor before SCR catalytic converter	-	7	7
NO_x sensor before SCR catalytic converter	-	7	7
NO_x sensor after SCR catalytic converter	-	7	7
Positional feedback, swirl flaps	-	7	7
Positional feedback high pressure EGR valve	-	7	7
Positional feedback low pressure EGR valve	-	7	-
Blow-by connection	-	7	7

OBD function

The engine management has the additional task of monitoring all exhaust-relevant systems to ensure they are functioning correctly. This task is known as OnBoard Diagnosis (OBD). The malfunction indicator lamp (MIL) is activated if the onboard diagnosis registers a fault.

Actuators	EURO4	E70 US	E90 US
Compressor bypass valve	EUV	EUV	EUV
Turbine control valve	EPDW	EPDW	EPDW
Wastegate	EPDW	EPDW	EPDW
Throttle valve	EL	EL	EL
Swirl flaps	EUV	EL	EL
High pressure EGR valve	EPDW	EL	EL
Low pressure EGR valve	-	EPDW	EPDW
Bypass valve for high pressure EGR cooler	-	EUV	EUV
SCR metering valve	EL	EL	EL

EL = Electrically operated

EUV = Pneumatically operated via electric changeover valve

EPDW = Pneumatically operated via electropneumatic pressure converter

The events specific to US diesel engines that cause the MIL to light up are described in the following.

Oxidation catalytic converter

The oxidation catalytic converter is monitored with regard to its conversion ability which diminishes with ageing. The conversion of hydrocarbons (HC) during cold start is used as the indicator as heat is produced as part of the chemical reaction and it follows a defined temperature progression after the oxidation catalytic converter.

The exhaust gas temperature sensor after the oxidation catalytic converter measures the temperature. The DDE maps the temperature progression during cold start and compares it to calculated models. The result determines how effective the oxidation catalytic converter is operating. A reversible fault is stored if the temperature progression drops below a predetermined value. If this fault is still determined after two successive diesel particulate filter regeneration cycles, an irreversible fault is stored and the MIL is activated.

SCR catalytic converter

The effectiveness of the SCR catalytic converter is monitored by the two NO_X catalytic converters.

The nitrogen mass is measured before and after the SCR catalytic converter and a sum is formed over a defined period of time. The actual reduction is compared with a calculated value that is stored in the DDE.

The following conditions must be met for this purpose:

- NO_X sensors plausible
- Metering active
- Ambient temperature in defined range
- Ambient pressure in defined range
- Regeneration of diesel particulate filter notactive

- SCR catalytic converter temperature indefined range (is calculated by means of exhaust temperature sensor before SCR catalytic converter)
- Flow of exhaust gas in defined range.

Monitoring involves four measuring cycles. A reversible fault is stored if the actual value is lower than the calculated value. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Long-term adaptation is implemented, where the metered quantity of urea-water solution is adapted, to ensure the effectiveness of the SCR catalytic converter over a long period of time. To execute this adaptation procedure, the signal of the NO_X sensor after the SCR catalytic converter is compared with a calculated value. If variations occur, the metered quantity is correspondingly adapted in the short term. The adaptations are evaluated and a correction factor is applied to the metered quantity.

The operating range for the long-term adaptation is the same as that for effectiveness monitoring.

A reversible fault is stored if the correction factor exceeds a defined threshold. If the fault isdeterminedintwosuccessivedrivingcycles, an irreversible fault is stored and the MIL is activated.

Supplying urea-water solution

A supply of a urea-water solution is required to ensure efficient operation of the SCR catalytic converter.

Once the SCR catalytic converter has reached a certain temperature (calculated by the exhaust gas temperature sensor before the SCR catalytic converter), the metering control system attempts to build up pressure in the metering line. For this purpose, the metering module must be closed and the delivery pump actuated at a certain speed for a defined period of time.

If the defined pressure threshold cannot be reached within a certain time, the metering module is opened in order to vent the metering line. This is followed by a new attempt to build up pressure.

A reversible fault is stored if a defined number of pressure build-up attempts remain unsuccessful. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

This monitoring takes place only once per driving cycle before metering begins. Continuous pressure monitoring begins after this monitoring run was successful.

Aconstantpressureoftheurea-watersolution (5 bar) is required for the selective catalytic reduction process. The actual pressure is measured by the pressure sensor in the delivery module and compared with a minimum and a maximum pressure threshold. A reversible fault is stored if the limits are exceeded for a certain time. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

This monitoring run takes place while metering is active.

Level measurement in active reservoir

A level sensor with three contacts at different heights is used for the active reservoir. The plausibility of the sensor is checked in the evaluator in that it checks whether the signals are logical. For example, it is improbable that the "Full" contact is covered by the solution while the "Empty" contact is not.

In this case, the evaluator sends a plausibility error to the DDE. This takes place at a pulse duty factor of 30 % of the PWM signal. A reversible fault is set. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

This monitoring procedure only takes place if the temperature in the active reservoir is above a defined value.

If the line between the evaluator and at least one contact of the level sensor is interrupted, the fault is signalled to the DDE by a PWM signalwith40 %pulsedutyfactor.Areversible
fault is set. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Suitable urea-water solution

The SCR system is monitored with regard to refilling with an incorrect medium. This monitoring function starts when refilling is detected. Refilling detection is described in the section on the SCR system.

Effectiveness monitoring of the SCR catalytic converter is used for the purpose of determining whether an incorrect medium has been used. An incorrect medium is detected if the effectiveness drops below a certain value within a defined period of time after refilling. A reversible fault is set in this case. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

In addition, the warning scenario with a remaining range of 200 mls is started.

NOx sensors

A dew point must be reached for effective operation and therefore also the monitoring of the NO_X sensor. This ensures that there is no longer any water in the exhaust system that could damage the NO_X sensors.

A reversible fault is set if the following
monitoring functions detect a fault at the NO_X sensor. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

- Detection signal or correction factorincorrect
- Line break or short-circuit betweenmeasuring probe and control unit of NO_X sensor
- Measured value outside the defined rangefor a certain period of time
- Operating temperature is not reached aftera defined heating time
- The distance from the measured value tozero is too great in overrun mode (no nitrogen oxides expected)
- During the transition from load to overrunmode, the signal of the NO_X sensor does not drop fast enough from 80 % to 50 % (only NO_X sensor before SCR catalytic converter)
- If, despite a peak in the signal of the NO_X sensor before the SCR catalytic converter, at least a defined change in the signal of the NO_X sensor after the SCR catalytic converter is not determined this is interpreted as implausible.

Exhaust gas recirculation (EGR)

During normal operation, the exhaust gas recirculation is controlled based on the EGR ratio. During regeneration of the diesel particulate filter, it is conventionally controlled based on the air mass.

The monitoring function also differs in this way: During normal operation a fault is detected when the EGR ratio is above or below defined limits for a certain period of time. This applies to the air mass during regeneration of the diesel particulate filter.

In order to monitor the high pressure EGR cooler, the temperature after the high pressure EGR cooler is measured with the bypass valve open and close with the engine running at idle speed. A fault is detected if the temperature difference is below a certain value.

For the low pressure EGR cooler (only E70), the measured temperature after the low pressure EGR cooler is compared with a calculate temperature for this position. A fault is detected if the difference exceeds a certain value.

Each of these faults is stored reversible. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Diesel particulate filter (DPF)

The diesel particulate filter is monitored by means of the differential pressure sensor. If the filter is defective, the differential pressure before and after the filter will be lower than for a new filter.

Monitoringstartswhentheflowofexhaustgas and the diesel particulate filter temperature exceed certain values. A fault is detected when the differential pressure drops below a defined threshold for a certain period of time.

Conversely, an overloaded/clogged diesel particulate filter is detected when the differential pressure exceeds a defined value for a certain period of time.

When regeneration of the diesel particulate filter is started, the time required until the exhaust temperature before the DPF reaches 250 °C is measured. This time is set to zero if the engine runs for a longer period of time at idle speed or in overrun mode. A fault is detected if a defined time is exceeded before the temperature of 250 °C is reached. In this way, the response characteristics of the increase in exhaust temperature for DPF regeneration are monitored.

The system also monitors whether the exhaust gas temperature before the diesel particulate filter corresponds to the expected valueafteradefinedperiodoftime.Ifthisisnot the case although the control system has reached its limits, a fault is detected.

Also in this case, each of these faults is stored reversible. If the fault is determined in two successive driving cycles, an irreversible fault is stored and the MIL is activated.

Automatic transmission

In view of the high torque developed by the M57D30T2 engine, the GA6HP26TU gearbox is used, which is normally fitted in 8-cylinder petrol engine vehicles.

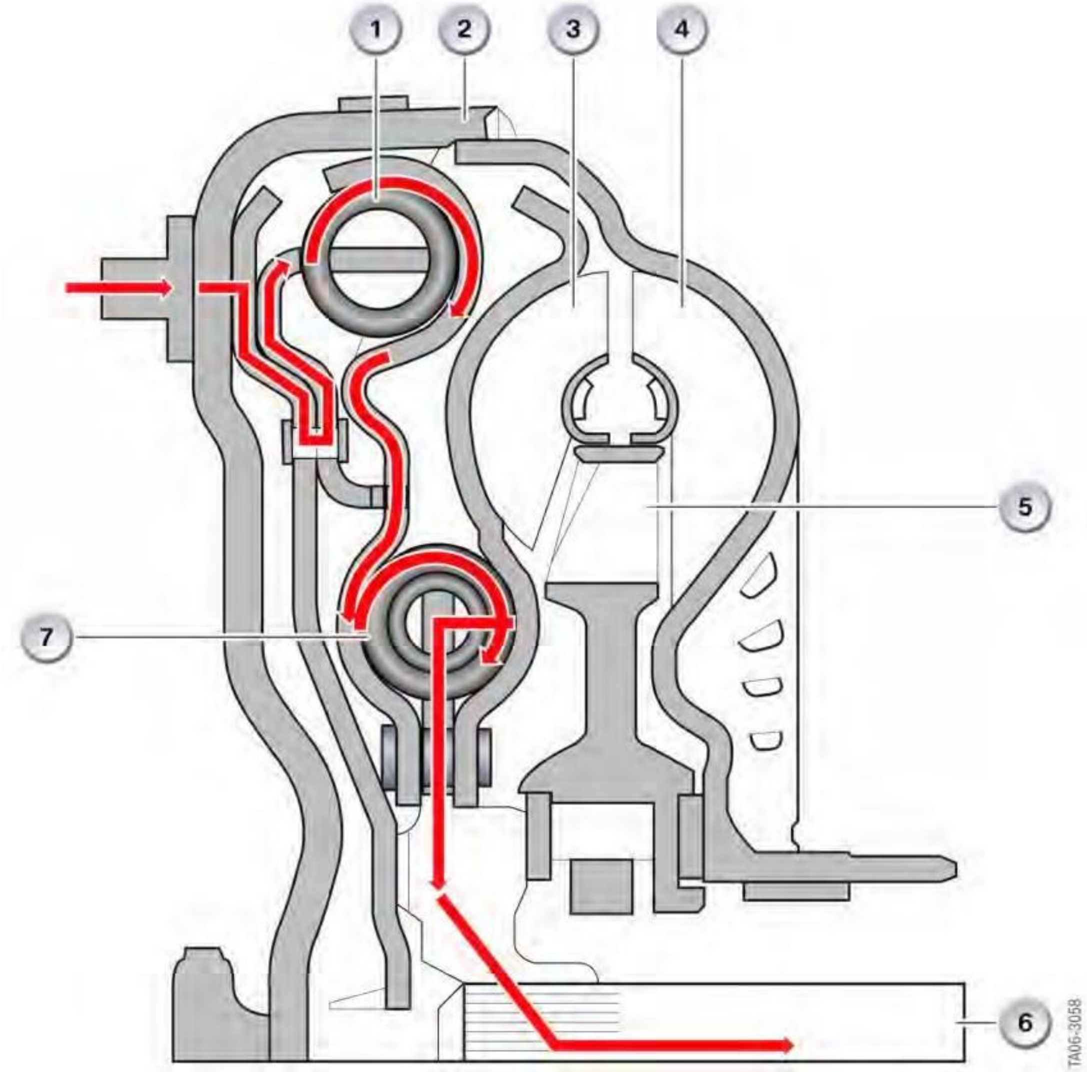
75 -GA6HP26TU gearbox

Twin damper torque converter

The gearbox is identical to that used in the X5 4.8i; only the torque converter is different. A so-called turbine torsional damper (TTD) is used while a twin damper torque converter is used for diesel engines.

In principle, the twin damper torque converter is a turbine torsional damper with a further damper connected upstream.

The primary side of the first damper is connected to the converter lockup clutch while the secondary side is connected to the primary side of the second damper. As in the turbine torsional damper, the secondary side is fixed to the turbine wheel of the torque converter.



76 - Twin damper torque converter

Index	Explanation	Index	Explanation
1	Annular spring	5	Stator
2	Converter housing	6	Transmission input shaft
3	Turbine wheel	7	Annular spring assembly
4	Impeller		

When the converter lockup clutch is open, the power flow is equal to that of the turbine torsional damper. The power is transferred from the turbine wheel via the second damper
(but without damping) to the transmission input shaft.

When the converter lockup clutch is closed, the power is transmitted via the first damper that consists of an annular spring. From here the power is transmitted to the second damper which operationally corresponds to the turbine torsional damper and also consists of two annular springs.

These further improved damping properties effectively adapt the transmission to the operational irregularities of the diesel engine.

Bayerische Motorenwerke Aktiengesellschaft
BMW Group Trainingsakademie
Technisches Training
Röntgenstraße 7
85716 Unterschleißheim
Germany