Aftersales Training - Product information. Engine N53.

BMW Service

All the information contained in the product information constitutes a solid and fundamental tool of the Aftersales Training literature.

Modifications and supplements to the technical data must be taken from the corresponding updated information from BMW Service.

Information updated: November 2006

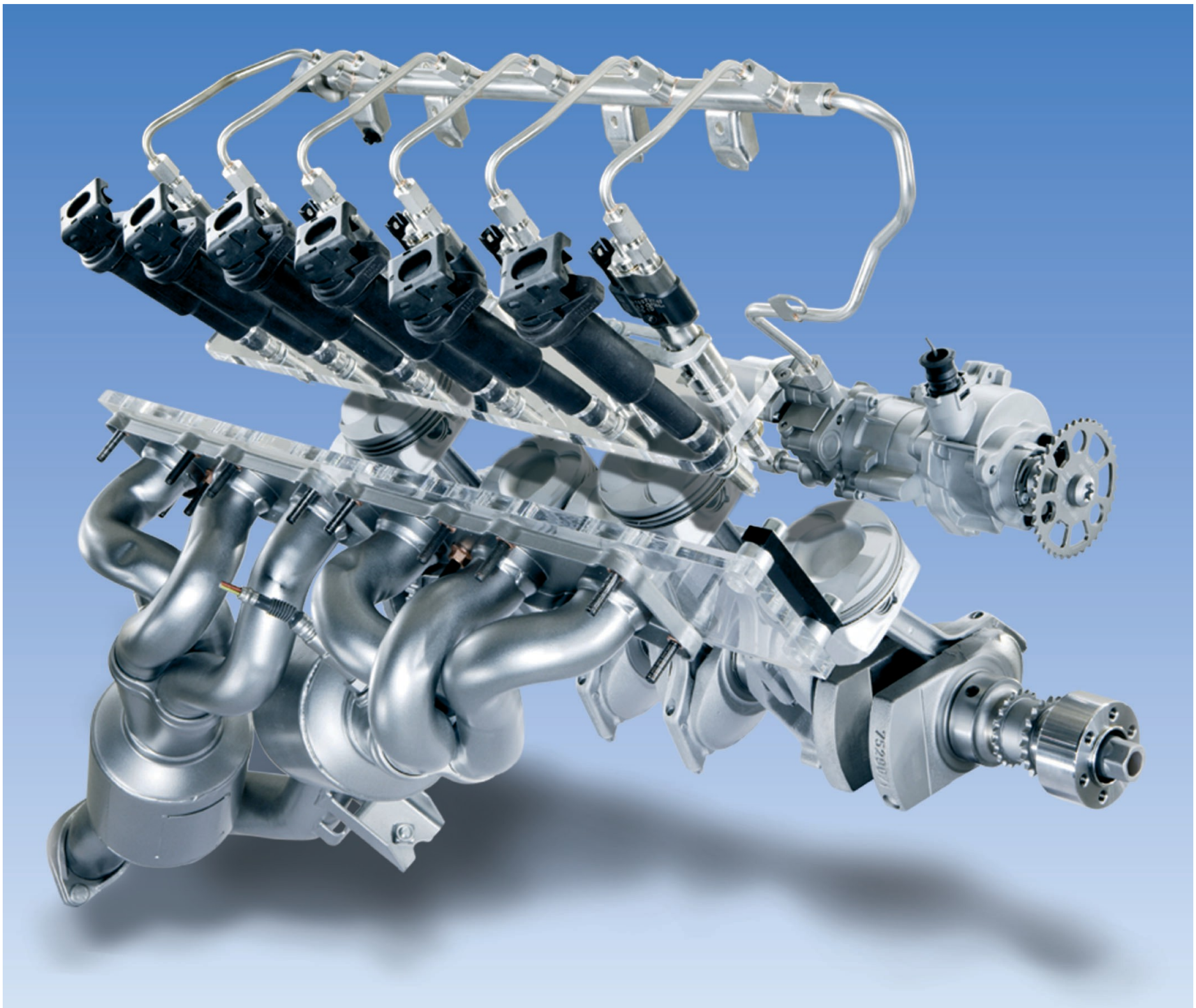
Contact: conceptinfo@bmw.de

VS-12 Aftersales Training

Product information. Motor N53.

Direct injection gasoline engine

Qualitative load control of gasoline engines



Notes on this product information

Symbols used

For ease of understanding and to highlight important information, the following symbols are used in this product information:

3 Contains information that allows to better convey a concept in relation to the described systems and their operation.

1 Identifies the end of a prompt.

News and national variants

BMW vehicles meet the highest demands in terms of safety and quality. Modifications to improve aspects of environmental protection, customer benefits, design or construction lead to continuous development of systems and components. For this reason there may be some differences between this product information and the vehicles available for the course.

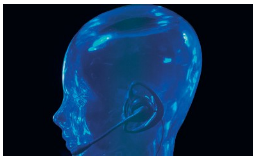
This documentation describes only left-hand drive vehicles of European models. In right-hand drive vehicles, some control elements or components are partially differently arranged than shown in the graphics of this product information. Market- or country-specific equipment variants may also result in deviations from the product information.

Additional sources of information

More information on each of the topics can be found at:

- Instruction manual
- BMW Diagnostic System
- Documentation of workshop systems
- BMW After Sales Service Technique.

Index.
Engine N53.



Objectives.
N53 engine.

Training supplement, reference book for practical use

This product information should provide you with an understanding of the structure, functions and technical relationships of the N53 motor.

The product information is designed as reference documentation and completes the seminar content preset by BMW Aftersales Training. This information is also suitable for individual study.

In preparation for technical training, this product information provides an overview of the technical relationships of the N53 engine. Together with the practical exercises of the N53 engine, this product information provides an overview of the technical relationships of the N53 engine.

training course, the product information should enable the participants to carry out service work on this engine.

The technical and practical knowledge of the current BMW models facilitates the understanding of the systems presented here and their functions.

Recommended instructional and information programs (SIPs) for understanding:

- Engine N52
- Engine N73.

TE04-5832

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S
Information) on this subject.
Basic knowledge provides security in theory and practice.

Introduction.
N53 engine.

6-cylinder in-line engine, direct injection, in stratified-load operation

High performance and low consumption are not at odds with each other

With the N53 engine the new generation of the BMW inline 6-cylinder engine family is extended with a very notable member. This engine continues in some ways the development path of the N52 engine. It offers high dynamics with very low harmful emissions and low fuel consumption. In the development of this direct-injection engine, which over a wide range of its range of use operates in stratified charging mode, the main objective was to reduce CO_2 emissions and thus also achieve lower fuel consumption.

The N53 engine meets all emission standards currently in force in Europe and much of the world.

With the N53, engineers have succeeded in creating a powerful and extremely economical engine.

With this engine, driving enjoyment is assured, especially under environmentally friendly conditions.

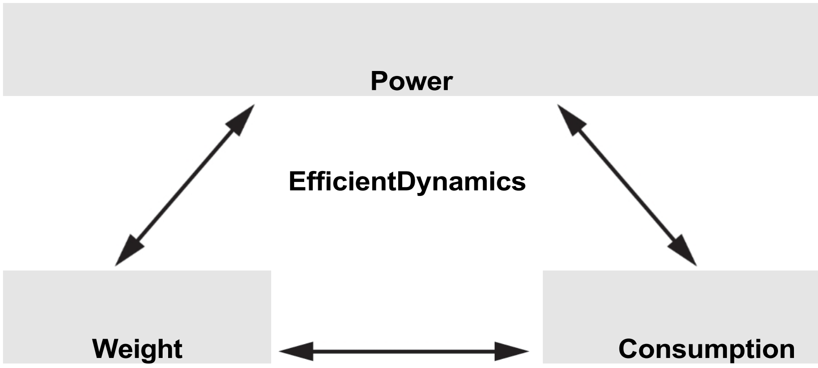
This product information will help you to understand the technology of this engine and help the customer to enjoy the driving pleasure.

EfficientDynamics

Reduction of emissions and consumption with an increase in power output

While the legal specifications provide the framework, customer wishes determine the orientation of the objectives. The central impetus for new innovations is provided by BMW's own brand awareness, the company's technological capabilities and the resulting demands on the products. The driving pleasure suggested in the slogan "Do you like to drive?" is not only a motive for customer expectations, but also forms the basis for the challenges set by the company's own engineers.

In any case, driving pleasure is not achieved simply through great dynamics, but increasingly thanks to the greater efficiency achieved. The conscious pleasure of such driving also contributes to the certainty of not being forced to achieve such improved dynamics at the cost of excessive fuel consumption. BMW has therefore defined the overall objective of developing efficient dynamics with clear specifications. Each new engine generation satisfies the condition of even better driving performance. In addition, each new powertrain offers greater cost-effectiveness.



With the new N53 engine, BMW is thus exploring new potentials in engine technology.

The direct injection process with HPI (High Precision Injection) is an ideal solution for reducing fuel consumption. The extremely efficient way of increasing power output is primarily due to the new gasoline direct injection system. HPI enables clear advantages in fuel consumption without having to limit the dynamic qualities of the engine. This advance has been achieved thanks to the central location of the piezo injector between the valves and next to the spark plug. In this position, the outwardly open injector, which is inserted into the N54, can project the fuel in the form of a particularly regular cone into the combustion chamber. This not only results not only in a more precise metering of the mixture, but also in a cooling effect, which allows higher compression and a increased efficiency of the combustion process.

The N53 motor, driven to λ 0.9 to 2.5, achieves its full performance potential with very low fuel requirement, and consequently with reduced emission of gases harmful to man and his environment.

With the N53 engine, efficient dynamics reach new levels.

This powerful and economical engine has been developed on the basis of the previous N52 and also has the proven advantages that are:

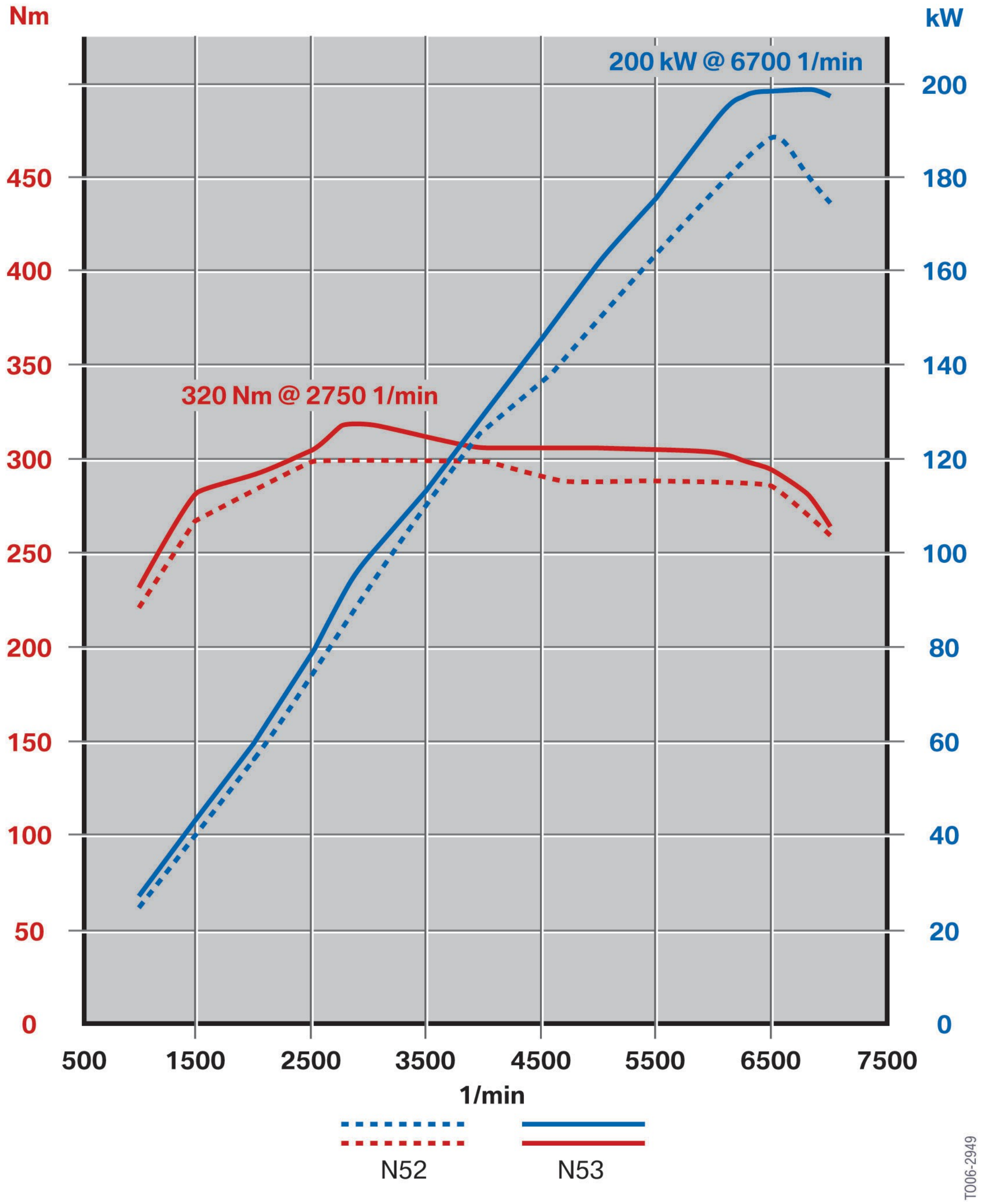
- Weight-saving magnesium crankshaft housing
- Electric coolant pump, activated as required
- Flow-regulated oil pump, which on this engine has been extended with an electric control.

Technical Data

Synoptic table with the main characteristics of the N54 engine

Designation	Value
Type of construction	6-cylinder in-line engine
Displacement [cm]^3	2996
Bore/stroke [mm]	85/88
Distance between cylinders [mm].	91
Ignition order	1-5-3-6-2-4
Power [kW]	200
per speed [r.p.m.].	6700
Torque [Nm]	320
per speed [r.p.m.].	2750
Flow limitation speed [r.p.m.].	7000
Power-to-weight ratio [kg/kW].	0,84
Power referred to displacement [kW/l].	66,8
Compression ratio	12,0
Valves/cylinders	4
Suction valve ∅ [mm].	32,4
Exhaust valve ∅ [mm].	29
Admission angle adjustment VANOS [°crank].	45
Exhaust angle adjustment VANOS [°crank].	45
Weight of motor [kg] (group 11 to 13)	168
Fuel octane rating [ROZ].	98
Fuel [ROZ].	91-98
Engine oil	Longlife-04 SAE 5W-30
Regulation against pitting	Yes
Digital engine electronics	MSD80
EU exhaust gas standard	EURO4
U.S. Exhaust Gas Standard	ULEV2
Consumption according to EU standard (NEFZ) [l/100 km].	8,1

Full load diagram



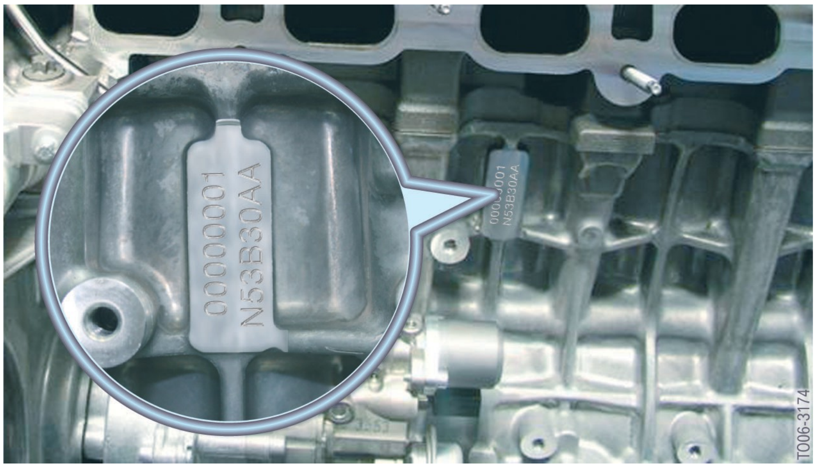
1 - Power diagram/torque diagram

Two variants

The N53 engine is produced with two different power ratings. This product information is based on the N53B30O0 variant.

Engine identification

The engine number is stamped on the high pressure pump, on the crankcase.



2 - Engine number

The engines have an identification on the crankcase for correct identification and classification. This engine identification is also required for government authorization. The seven

The first numbers are the important ones. In the graphic above the engine number you can see where this engine identification is located.

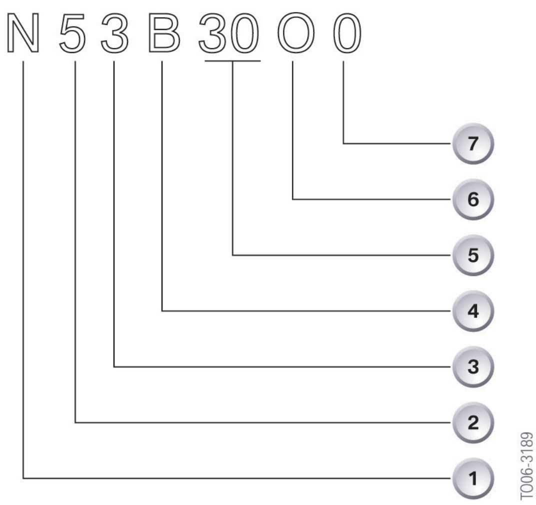
Engine designation

1	2	3	4	5	6	7
Developer and engine generation	Engine type	Technique of engines	Operation nto or fuel	Cilindrad a in 1/10 liter	Category of power (LK)	Improvements important for review
A =Motorcycle M =BMW Group Old = 4 in line N =BMW Group line Generation P =BMW Motorsport Tritec, Toyota, PSA S =BMW M GmbH W = Other motors e.g.	Motors for combustion: Generation1 New4 = 4 in 5 = 6 in line 6 = V8 7 = V12 8 = V10	0-9	B = Gasoline D = Diesel H = Hydrogen	01-99	T = TOP LK O = upper LK (standard) revision M = mean LK U = lower LK K = minimum LK	0 = New development 1-9 = (e.g. TU)

* Inconsistent motor technique:
1 = SULEV or PZEV engine for U.S. (e.g. N51)
2 = VALVETRONIC (e.g. N12, N52, N62, exception N46)
3 = Direct gasoline injection (e.g. N73)
5 = Dual VANOS without VALVETRONIC (e.g. N45, S65, S85)
4 = gasoline direct injection with turbocharging (e.g. N14, N54) 7 = diesel direct injection with turbocharging (e.g. M47, M57, M67)

The difference between the engine designation and the engine identification is in the last two characters, which are the additional information about the power category and the technical revision level.

In the technical documentation, the engine designation is used for clear identification. The following figure shows the interpretation of the motor designation based on the N53 motor. In the technical documentation you will also find abbreviated forms of the engine designation, which in its shortest form has only three characters and only allows the classification of the engine type.



3 - Engine designation

HPI in stratified load operation

Economical and powerful

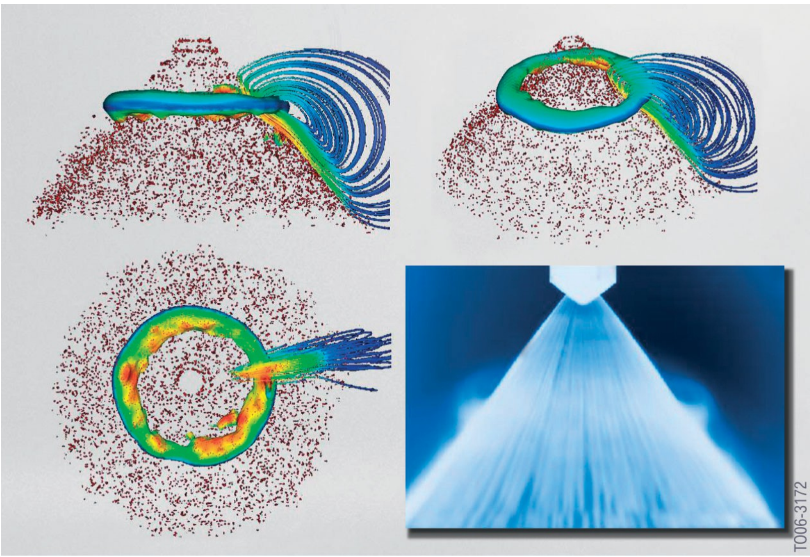
Direct gasoline injection with a clear fuel consumption advantage

When used in the N54 high-performance engine, direct gasoline injection provides a significant increase in power output without increasing fuel consumption.

But High Precision Injection can do more. In the N53 engine, a highly economical operation has been achieved, in which the proportion of gasoline in the fuel-air mixture is metered very sparingly. This means that only the exact amount of gasoline required at any one time is added to the intake air. The resulting mixture is of high quality.

In this lean-burn operation, different layers of air-fuel mixture are formed in the combustion chamber.
The greater the distance to the spark plug, the lower the proportion of gasoline in the mixture. Only right next to the spark plug is there a particularly rich and better ignition layer. As soon as it is ignited, the lower, poorer mixture layers further away from the spark plug also burn cleanly and evenly.

Thanks to High Precision Injection, it has been achieved for the first time that the directed-jet combustion process remains stable with a lean mixture over a particularly wide characteristic range. This results in improved vehicle economy and reduced exhaust emissions.



1 - Fuel injection into the combustion chamber

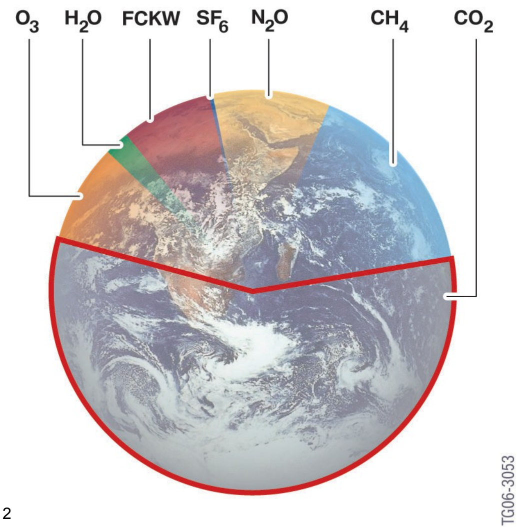
CO2 reduction

Greenhouse effect - global warming

Greenhouse gases

Carbon dioxide CO_2 is a natural and harmless component of the earth's atmosphere. It is exhaled by humans and animals. It is created by the combustion of any fossil fuel such as wood, coal or oil, and therefore also by gasoline. What is problematic is that increasing industrialization emits too large quantities of CO_2 into the atmosphere, causing global warming along with other greenhouse gases.

Global warming is due to the fact that part of the solar radiation that reaches the earth's surface does not leave the earth when it is reflected, but returns to the earth reflected by its outer layer. This is a process
The climate is a natural and important physical phenomenon, which raises the average temperature of the Earth, creating a habitable climate for humans. But in recent years, the climate has already changed.



2

Carbon dioxide (CO_2) is the most common greenhouse gas with 56.8 %. It is followed in smaller proportions by methane (CH_4 , 16.2 %), nitrous dioxide (N_2 O, 9.4 %), ozone (O_3 , 8.0 %), chlorofluorinated hydrocarbon (HCFC, 7.3 %), water vapor (H_2O, 2.0 %) and sulfur hexafluoride (SF_6, 0.3 %).

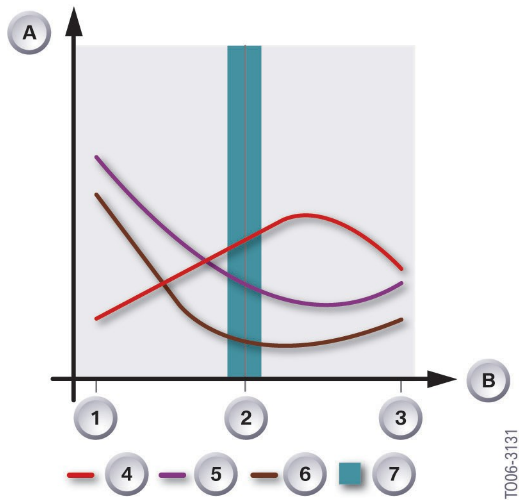
Contaminants

Fossil fuel combustion also produces other toxic pollutants such as carbon monoxide (CO), unburned hydrocarbons (CH) and nitrous oxides (NOx). But unlike CO_2 they are directly harmful to humans; they are toxic.

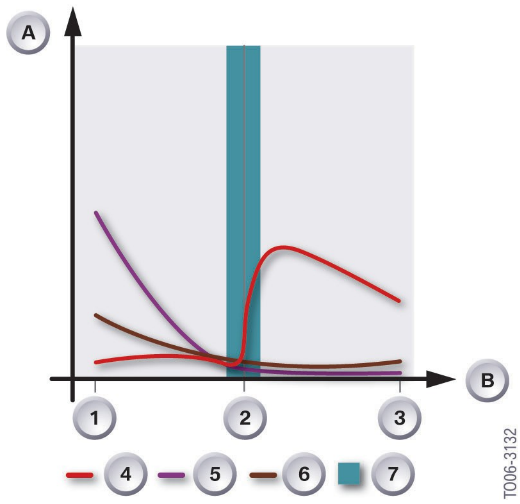
In the combustion of a fuel-air mixture in an engine, lower fuel consumption automatically means lower CO emissions .$_2$

Therefore, the efforts of engine engineers are naturally going in that direction.

However, a reduction of CO_2 leads to an increased production of nitrous oxide in the exhaust. For this reason, expensive exhaust gas treatment with a NOx storage catalyst is required. How the N53 engine reacts to this problem is explained in the sections on the exhaust system and on fuel.



3 - Raw emissions before entering the 3-way catalytic



converter4 - Emissions after passing through the 3-way catalytic converter

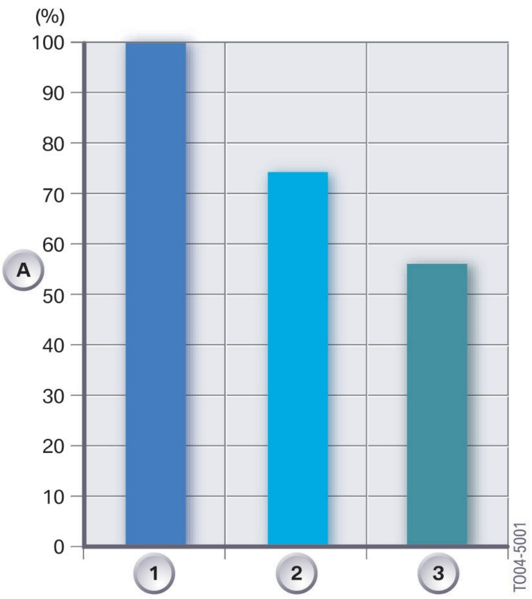
Index	Explanation	Index	Explanation
A	Concentration	4	Nitric oxides NOx
B	Air-air mixture ratio fuel λ	5	Hydrocarbons CH
1	Rich λ < 1	6	Carbon monoxide CO
2	Stoichiometric λ = 1	7	Control range at λ = 1
3	Poor λ > 1		

Engine mechanics

Magnesium as a material in engine construction

Magnesium and aluminum crankshaft crankcase

The potential for weight reduction with a crankcase made of cast aluminum was practically exhausted, so it was necessary to start investigating magnesium. BMW had done this for the first time with the N52 engine. This material, which is already establishing itself in the medium term, is now present in the N53 engine.



1 - Evolution of crankcase weight in in-line engines

Index	Explanation
A	Crankshaft crankcase weight (in %)
1	Grey cast iron - sand casting
2	Integration of Alusil function for low-pressure melting P>55 kW/l
	for combined casting P>55 kW/l

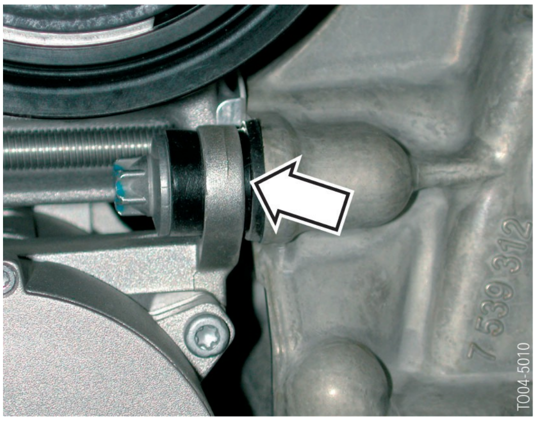
The exceptional property of magnesium and its alloys is the low density of approx. 1.8 g/cm3.

The excellent functional properties of certain magnesium alloys enable the manufacture of complex, large-area die castings with a very good external finish. Due to the low melting temperature, low melting energy and heating capacity relative to the volume of magnesium in the casting, up to 50% higher casting rate is possible compared to aluminum die casting.

Despite the high precision of the cast parts, in many cases a tight chip-cutting finish of the function surfaces is practically unavoidable. Another characteristic of magnesium is its excellent machinability.

However, in contrast to these good properties, there are also some problematic points of view in the use of magnesium and its alloys. The former major problem of corrosion has been solved to a large extent by the development of alloys with significantly higher corrosion resistance. The AJ62 alloy used in the N52 engine is now also used in the N53.

There is still a clear risk of corrosion if the material-specific bases described below are not observed. The installation of unauthorized materials that come into contact with magnesium is not permitted. In other words, only original BMW spare parts may be used. The material of the assembled units must be AJ62-compatible or the part must be hermetically sealed in a magnesium housing.

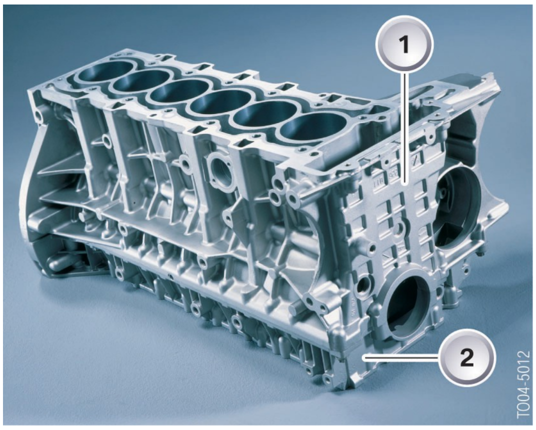


2 - Electric coolant pump insulation

3 When carrying out installation work on the crankcase of the N53 engine, the instructions in the repair manual must be strictly adhered to. 1

Use of magnesium in construction

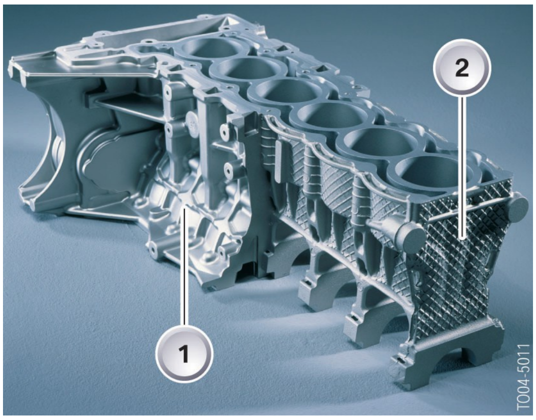
Magnesium cannot be used at certain points, e.g. on the cylinder sliding surface, which is why the crankcase is manufactured in mixed form.



3 - Mixed magnesium and aluminum crankshaft crankcase

Index	Explanation
1	Upper part of crankcase
2	Bedplate

The crankcase consists of a silicon-aluminum insert inseparably cast in a magnesium alloy. The magnesium alloy AJ62 has been specially developed by BMW for this purpose.



4 - Cutting pattern of an aluminum-magnesium composite crankcase

Index	Explanation
1	Mixed magnesium and aluminum crankshaft crankcase
2	Aluminum and silicon insertion

Both the bolted connections to the gearbox, cylinder head and crankshaft housing and the cooling channels are located in the aluminum-silicon insert so that the magnesium does not come into contact with the coolant and the water it contains. Planning of the crankcase is possible.

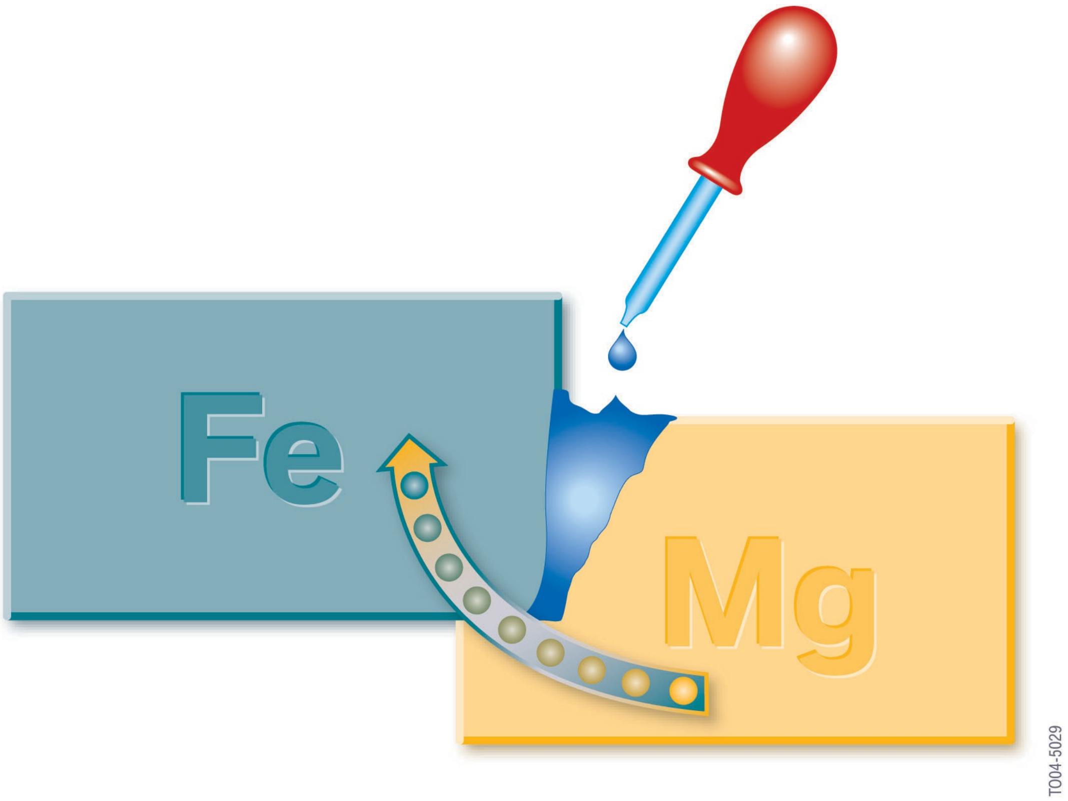
Electrochemical properties of magnesium

Metals are classified as noble or non-noble. Thus, for example, gold is a noble metal and sodium is a very non-noble metal. All other metals are in between. If two metals that are in contact with each other, such as iron and magnesium, are placed in an electrically conductive liquid, e.g. a salt solution, the non-noble metal is diluted and flows into the solution. At the same time the electric current flows from the noble metal to the non-noble metal. On

Under certain circumstances, the non-noble metal is deposited on the noble metal. Magnesium is a non-noble metal. Because of this, other materials easily corrode its surface.

However, the alloy used in the N53 engine is something quite different:

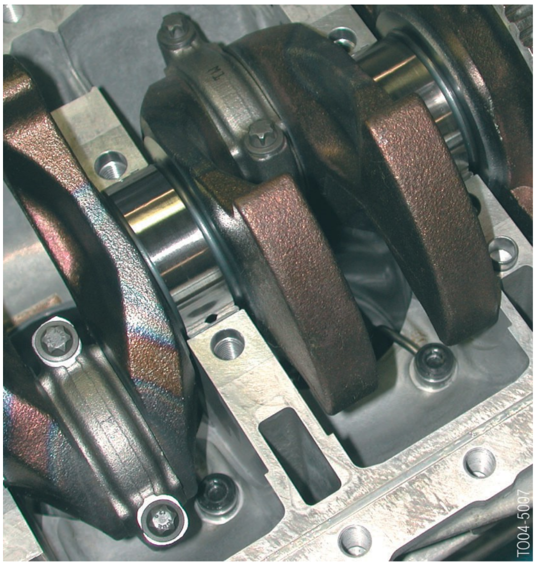
- By adding other metals, the negative properties of the pure metal are largely eliminated so that the requirements placed on the material can be met.



5 - Electrochemical corrosion

An electrical voltage is created between the two metals immersed in electrolyte. All metals can be classified according to this voltage. Iron has an intermediate position in the series of electrical voltages, while aluminum and especially magnesium are not noble. The electrochemical corrosion processes will be faster the greater the voltage difference between the two metals. The laboratory situation described above also occurs in the engine when two metals are in direct contact with each other and the contact surface is wetted, e.g. with water coming from the engine.

of splashes. So-called contact corrosion occurs. It is promoted when the contact surface has a groove in which moisture remains. Contact corrosion can be prevented by keeping the contact surface dry or by spraying it with electrically non-conductive motor oil. For this reason, all internal motor contact surfaces made of magnesium, aluminum and steel are problem-free.



6 - Crankshaft crankcase open from below

Physical properties of materials

Magnesium and aluminum have almost equal expandability factors, which are about twice that of steel:

- Magnesium: 0,0026 % per °C
- Aluminum: 0.0023 % per °C
- Steel: 0.0011 % per °C

The melting temperature of magnesium is very similar to that of aluminum. The melting temperature of steel, on the other hand, is significantly higher:

- Magnesium: 650 °C
- Aluminum: 660 °C
- Steel: 1,750 °C.

The electrical conductivity of aluminum and magnesium is significantly better than that of steel. For this reason, these materials are particularly suitable for shielding electromagnetic anomalies (e.g. from ignition sparks). The same expansibility factor of aluminum and magnesium allows a trouble-free connection of both materials. Because the expansibility factor of steel is only half that of aluminum, steel screws cannot be used in the N53 motor. When the engine heats up, a steel bolt expands only half as much as the crankcase. On the other hand, when the engine cools down, there is a risk that a steel bolt connection will loosen. For this reason, aluminum bolts are used at important points.

Safety at work

Treatment of magnesium chips

In principle, the work most frequently carried out in the after-sales service with this material does not present any problems. The small amount of chips, e.g. when cutting threads, does not require special suction. However, if major work is to be carried out on a magnesium crankcase, it must be ensured that hydrogen is not also collected in the chip collection tank, as it is susceptible to explosion, and that moisture can escape from it. Moisture here refers to water and water-containing compounds.

The following instructions must be observed during chip removal treatment:

While magnesium alloys offer a good starting position with regard to chip removal properties for dry processing, the current development of the technique is wet processing. In this respect, cutting oil or emulsion is used. The greatest risk potential in chip-cutting manufacturing is to be found in the chips themselves. Wet chips are particularly hazardous and, in contrast, oil-wetted chips ignite with great difficulty, which is why direct ignition of the chips in wet processing is not common. Magnesium and water can react to form magnesium hydroxide and hydrogen. For this reason, there is a risk of hydrogen explosion in emulsion treatment if the hydrogen that is constantly being released can be stored somewhere and reaches a critical concentration. It is therefore necessary to be able to remove the moisture from the swarf collector. The chips must also be removed quickly from the emulsion, otherwise saponification or hardening of the emulsion will occur and the emulsion will become unusable. The cutting material palette known from aluminum processing, i.e. high-speed steel, hard metal and polycrystalline diamond (PKD), can be used for magnesium processing.

Polishing requires special attention

The question of wet treatment in polishing is to check from other points of view than the normal treatment procedures that produce shavings. This is because, in polishing, the finest chips (polishing dust) are produced which, above a certain proportion in the air, after possible ignition (e.g. smoking residues, sparks from electric saw work, welding) burn explosively. The concentration above which magnesium particles with a diameter of
approx. 50 µm is 15-30 g/m3. If wet polishing is not possible, or it is too
In this case, the dust produced must be directly vacuumed and deposited with water in a separator.

For this reason, please note:

Work with magnesium in which dust is produced cannot in principle be carried out without a suitable extraction device.

A fundamental criterion for the hazardousness of magnesium is the specific surface area of each product, i.e. the ratio of surface area to volume. From the technical safety point of view, the massive components present no problems. It is practically impossible to ignite them even with a significant source of heat. On the other hand, chips and dust have a much higher reaction capacity. The critical temperature above which the ignition of
dry fine chips is 450-500 °C. Incorrect cutting geometry or
In dry processing, blunt tools can cause this type of heating. The production of sparks due to tool collision or steel processing is another source of risk.

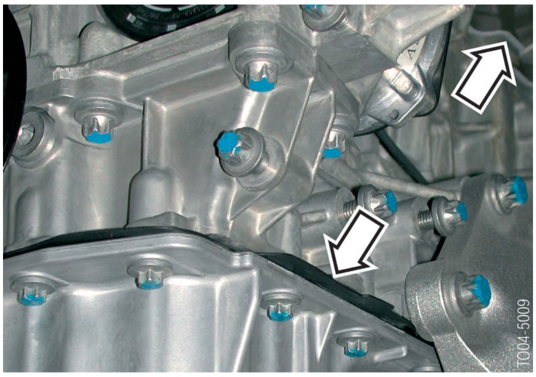
If, despite all precautions, magnesium burns, under no circumstances should water or extinguishers containing water be used (generation of hydrogen, explosion of detonating gas). ABC powder, carbon dioxide or nitrogen extinguishers are not suitable either. It is therefore essential to have extinguishers suitable for metal fires at hand.

In Germany, the rules of the professional union, in this case BGR 204 "Magnesium handling", apply. Companies can request information and The München occupational safety department recommends that at least these safety measures be complied with for the processing of magnesium crankcases. For the processing of magnesium crankcases, the Munich Department for Occupational Safety and Health recommends that these safety measures should be complied with as a minimum. The specific national regulations must also be observed and complied with.

Welding technology

Joints

Contact corrosion can be avoided by placing a non-conductive gasket between the metals. This is the case in the oil pan gasket and the cylinder head gasket, which separate the aluminum oil pan and cylinder head from the magnesium crankcase.



7 - Board overhang

The situation of the cylinder head gasket is similar. However, it should be noted that the cylinder head gasket of the N53 engine, unlike those used so far, has a sealing lip. This prevents dirt and water spray from easily penetrating the gasket and bringing the metals into contact with each other again.

8 - Head gasket sealing lip

Protruding seals must not be damaged, e.g. during the assembly of a part. In the event of damage to a gasket, contact corrosion between the aluminum of the cylinder head and the magnesium of the crankcase would occur within a short time. In the event of significant damage to the sealing lip, even the steel of the gasket core could be affected.

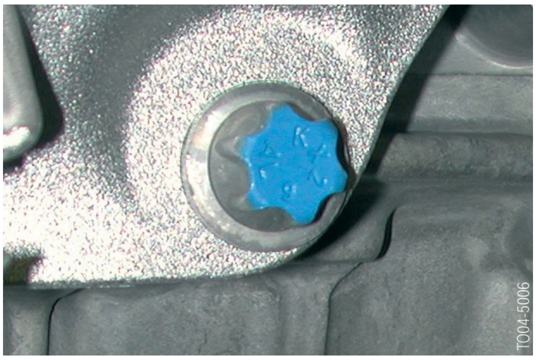
3 Damaged gaskets must be replaced, since if a gasket is damaged, contact corrosion between the aluminum of the cylinder head and the magnesium of the crankcase will occur within a short time. 1

Bolted joints

Engine bolted joints require special attention. When they are opened, the threaded holes must be immediately blown dry to prevent corrosion due to coolant.

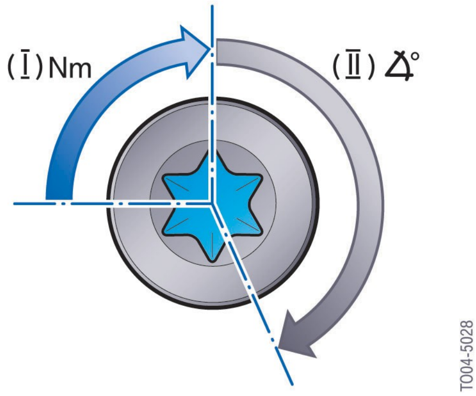
9 - Dry drying of threaded holes

The threaded holes must also be absolutely dry before insertion of the
screw so that it does not occur later on.
contact corrosion between the crankcase material and the bolt. Due to the different expansion coefficients of the materials, the N53 engine has aluminum bolts in all bolted joints that are inserted in magnesium, instead of steel ones. Also the cylinder head cover (magnesium) is attached to the aluminum cylinder head by aluminum screws.



10 - Aluminum screws have a blue head

Due to the low tensile strength of aluminum compared to steel, aluminum bolts must be tightened according to a precisely determined procedure.



11 - Tightening procedure of an aluminum screw

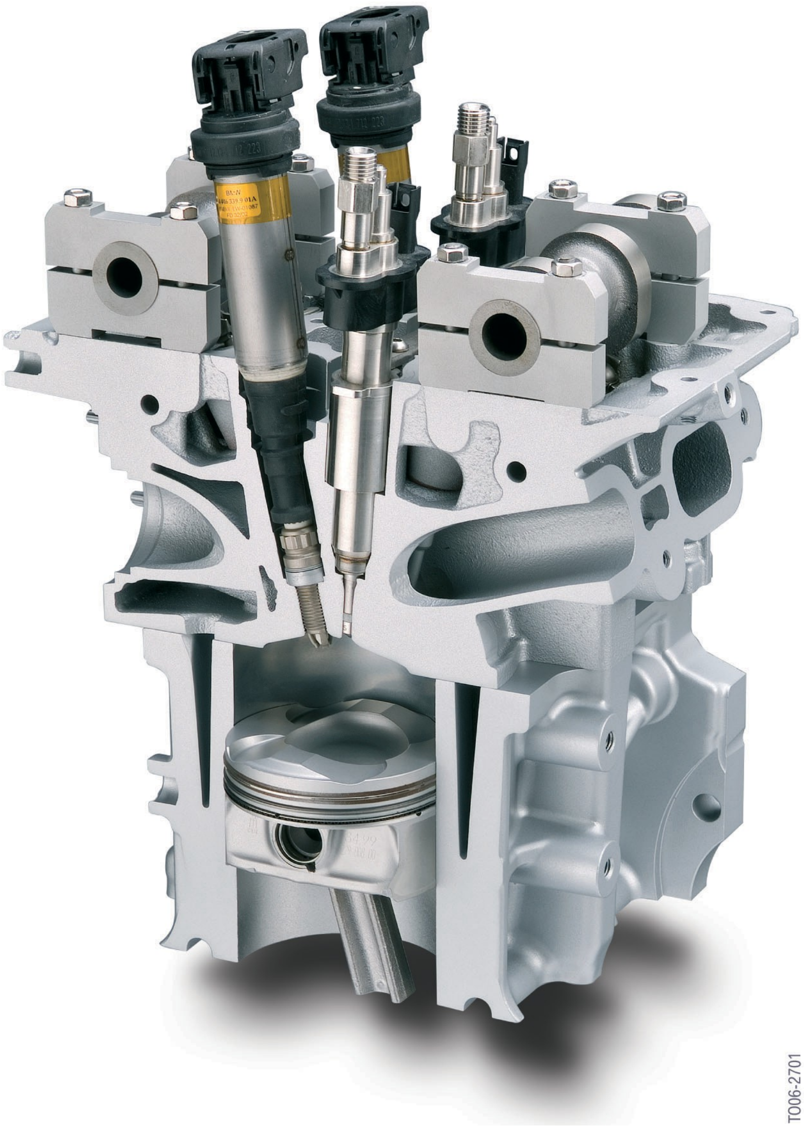
Index	Explanation
I	Torque
	IIAngle of rotation

First the bolt is tightened to a defined torque (I). This is selected in such a way that the parts to be tightened have no play while the bolt is under minimum tension. The screw is then turned to a defined angle (I).
(II). In doing so, the required screw tension is reached.

3 The aluminum screws can only be used once and must always be replaced after unscrewing. 1

Stock

In the N53 engine, the central arrangement of the piezoelectric injectors and spark plugs in the cylinder head is also very important, since that this is the only way to achieve the right position for direct jetting.



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12 - Cylinder section

The combustion heat energy is evacuated from the cylinder head by means of a crosscurrent cooling system.

In the corresponding sections of this product information you can find the following information

For detailed information on the following topics, please refer to the following topics:

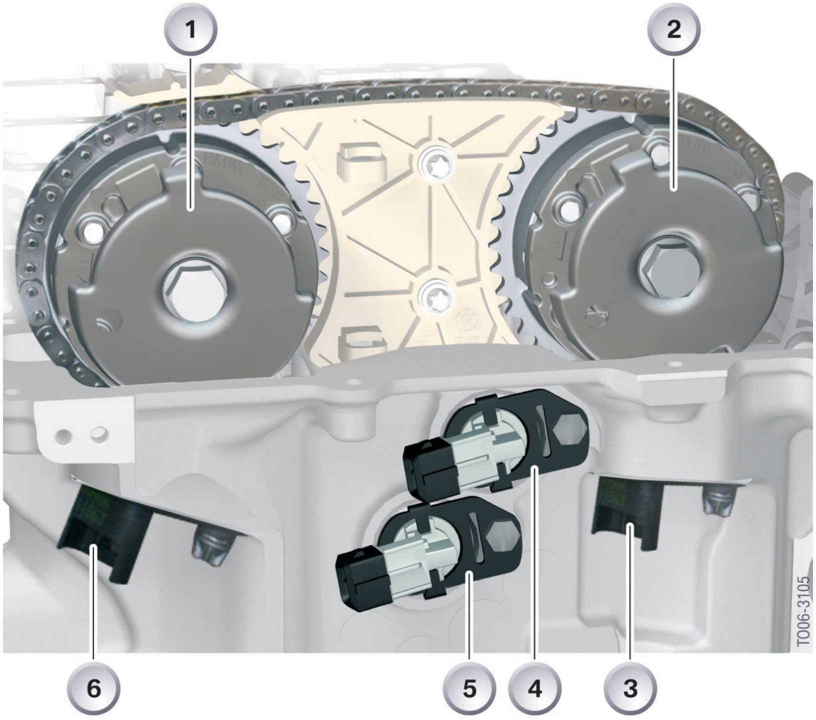
- HPI high pressure injection
- Cooling system
- VANOS.

VANOS

VANOS double progressive

The supercharging of the N53 engine is performed by 4 valves per cylinder, driven by two overhead camshafts. The engine timing can be influenced in a number of ways. variable by the progressive VANOS units. The VANOS units used here have the following setting angle:

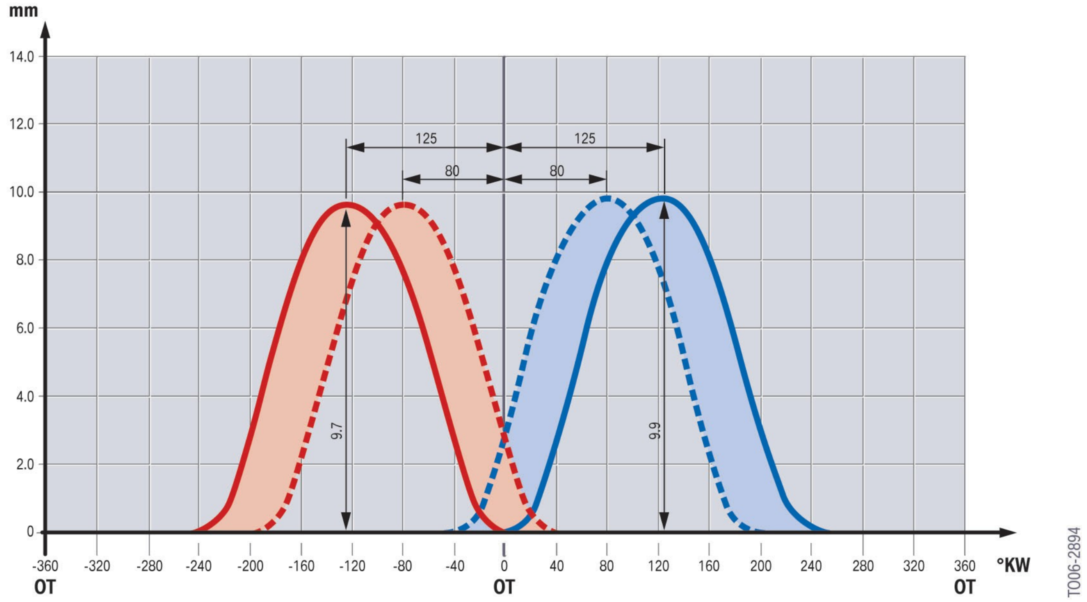
- Intake VANOS unit - 45° crankshaft
- Exhaust VANOS unit - 45° crankshaft.



13 - N53 engine VANOS units

Index	Explanation	Index	Explanation
1	Exhaust VANOS unit	4	Electromagnetic valve Inlet VANOS
2	Intake VANOS unit	5	Solenoid valve VANOS exhaust valve
3	Intake camshaft sensor	6	Exhaust camshaft sensor

The following diagram clearly shows the valve setting areas and valve travels of the camshafts of Intake and exhaust with blue and red fields respectively.



14 - N53 Motor Control Timing Diagram

The advantages of VANOS double progressive:

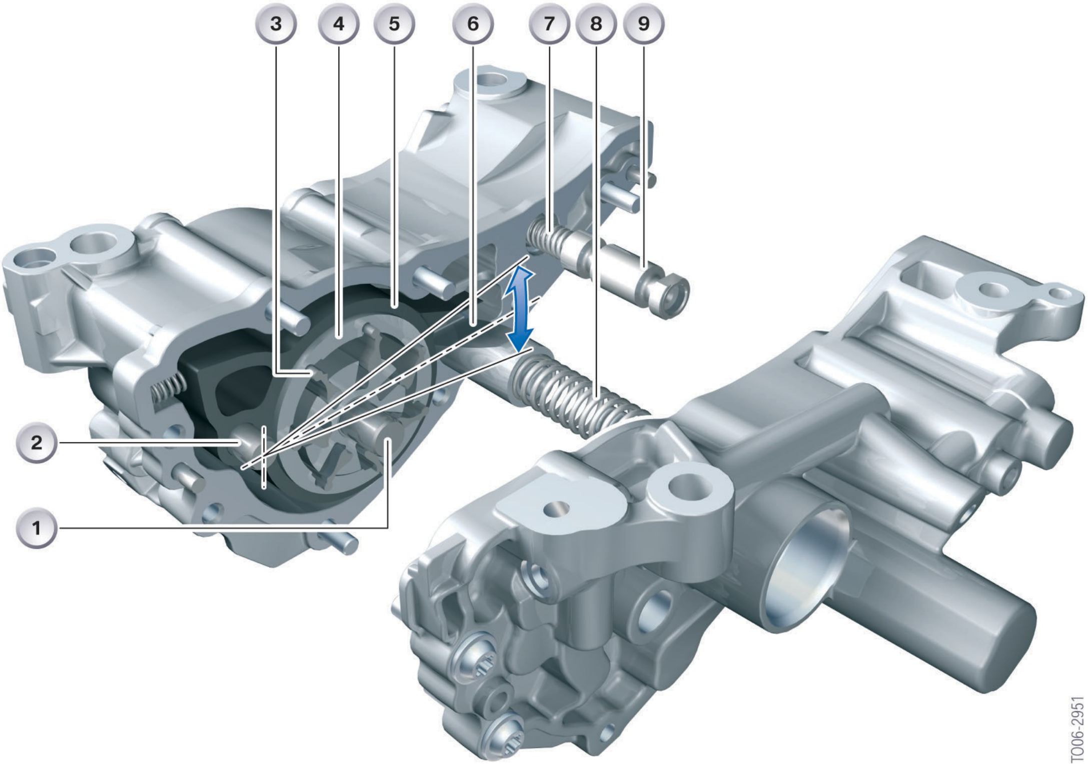
- Increased torque at low and medium speeds
- Less gas remaining at idle due to less valve overlap, resulting in improved idle speed
- Internal exhaust gas recirculation in the partial load range for nitric oxide reduction
- Faster catalyst warm-up and lower raw emissions after cold start-up
- Reduced fuel consumption.

The internal exhaust gas recirculation of the N53 engine is of particular importance. With this gas recirculation, the fresh air and thus the oxygen responsible for the formation of nitric oxides is reduced. This is necessary because in lean-burn operation, the amount of hydrocarbon gases is not sufficient to reduce the nitric oxides produced during combustion. In the section on the exhaust system, the relationships and reciprocal effects of the exhaust gas components are explained in detail.

Oil supply

Electrically controlled oil pump with volumetric flow regulation

Like the N52 and N54 engines, the N53 also has an oil pump with volumetric flow regulation. This type of pump only supplies the oil required depending on the operating range of the engine. In areas with lower load, no superfluous oil is delivered. This reduces the pump's efficiency and thus the engine's fuel consumption, while at the same time reducing oil wear. The unit used is a multicellular oscillating pin pump. The pump shaft is placed on the conveying side, eccentrically in the casing and the vanes move radially during rotation. In this way, the vanes form chambers of different volumes. As the volume increases, the oil is sucked inwards and as the volume decreases, it is expelled into the oil channels.



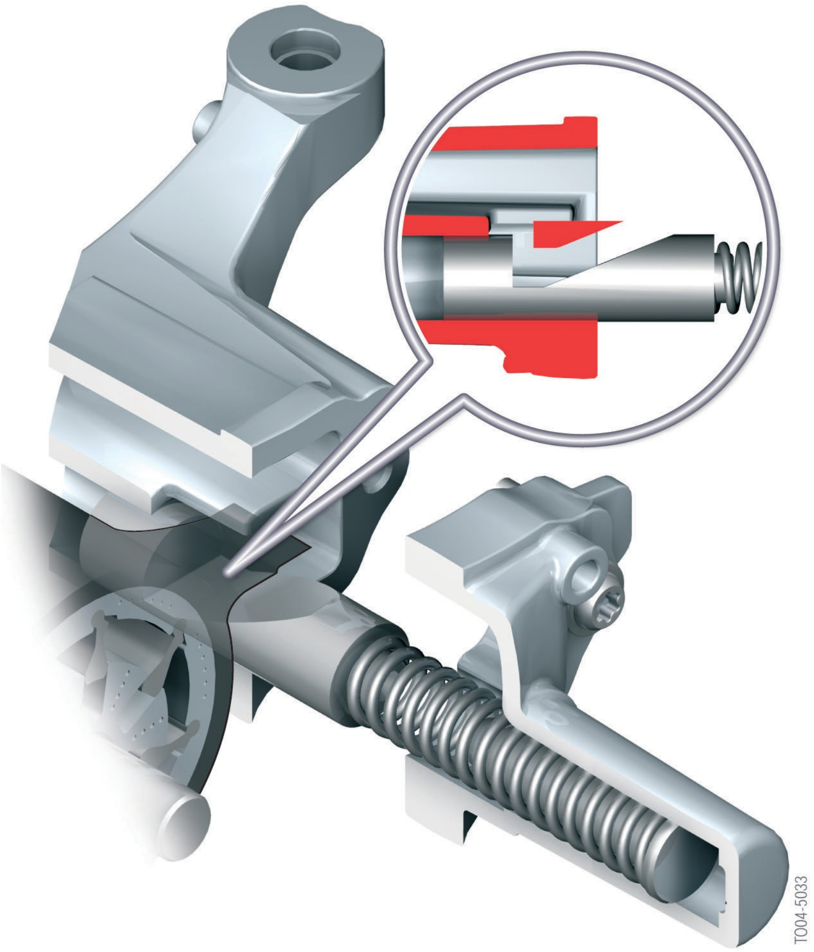
15 - Oil pump

Index	Explanation	Index	Explanation
1	Pump shaft	6	Regulating piston of the pendulum reaction arm
2	Rotating shaft	7	Regulating spring
3	Fins	8	Pressure spring
4	Rotor	9	Regulating plunger
5	Pivot pin		

Function of the oil pump with volumetric flow regulation

The pump is driven by a chain from the crankshaft. The oil pressure acts on the regulating piston with oblique stop surface (pendulum reaction arm) (6) against the force of a spring (8). The pendulum reaction arm varies the position of the pivot pin. If the pump shaft is positioned towards the center on the pivot pin, the volume variations are small and the feed rate small. If the pump shaft is positioned eccentrically, the volume variations and the flow rate are small.

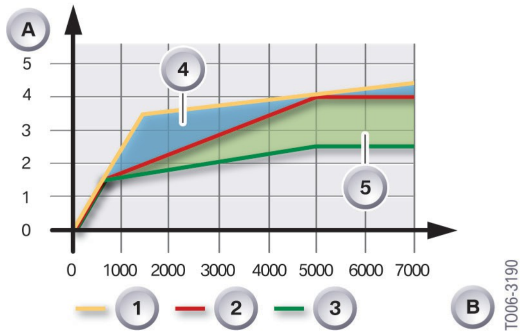
The oil supply system pressures are higher. When the oil requirement of the engine increases, e.g. due to an adjustment of the VANOS, the pressure in the lubrication system drops and thus also in the control piston. The pump increases the delivery volume and resumes the previous pressure behavior. When the oil requirement of the engine is reduced, the pump regulates the supply flow in the direction of reduction.



16 - Regulating piston of the pendulum reaction arm on motor N52

The oil pump used on the N53 engine is an upgrade of the pendulum gate pump introduced on the N52 engine, whereby the pump control can be adjusted through the engine control.

The oil pressure is used to regulate the volume of oil conveyed according to requirements. The changes compared to the familiar pump are in the way the pump is controlled. The oil pressure produced no longer acts directly on the control piston of the pendulum reaction arm (6). A control unit in the oil pump (7 + 9) is controlled from the motor control, which then transmits the pressure.
This has the great advantage that other oil pump performance losses are avoided.

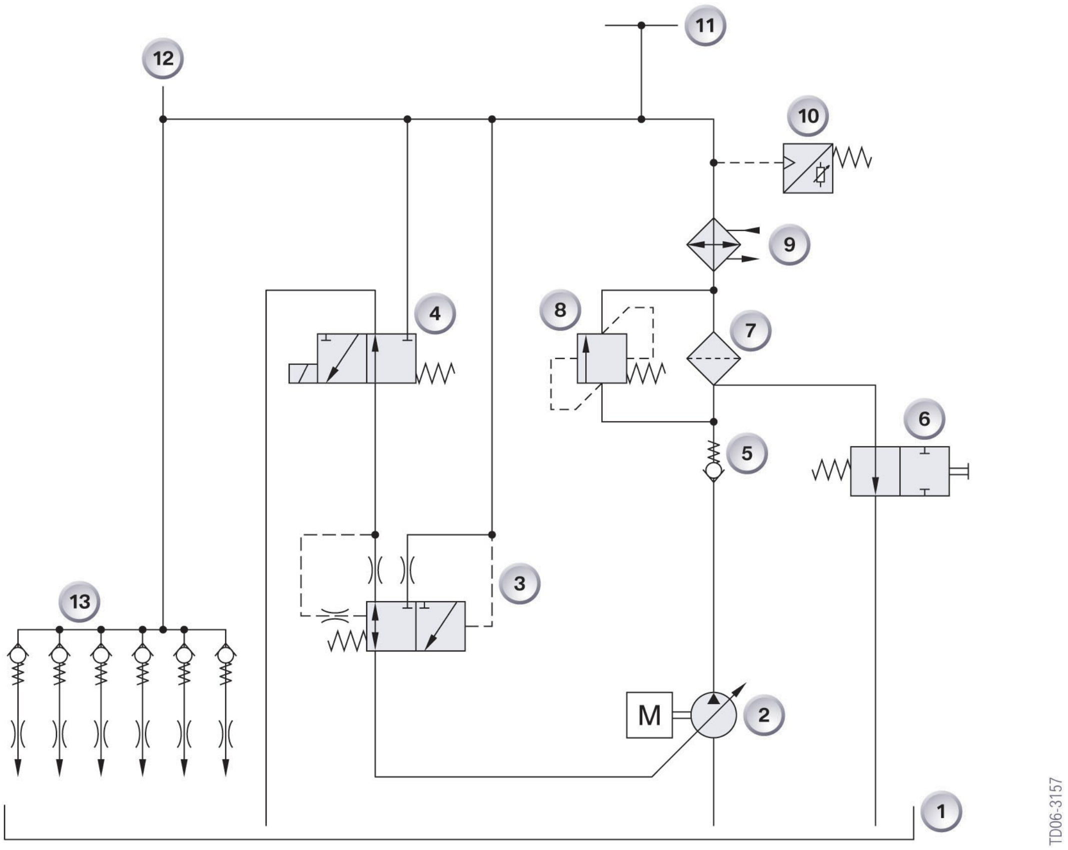


17 - Oil pressure regulated by characteristic field

Index	Explanation
A	Oil pressure (bar)
B	Engine speed (r.p.m.)
1	Hydraulic/mechanical oil pressure regulation
2	Oil pressure regulated by characteristic field at full load
3	Oil pressure regulated by characteristic field without load
4	Savings potential at full load
5	No-load savings potential

18 - Electro-hydraulic pressure regulating valve

The control of the regulating unit in the oil pump is carried out depending on the characteristic range by means of an electrohydraulic pressure regulating valve, which is screwed laterally to the crankcase.



19 - Hydraulic diagram of the oil circuit

Index	Explanation	Index	Explanation
1	Oil sump	8	Filter bypass valve
2	Oil pump with volume flow regulation	9	Oil and coolant heat exchanger
3	Pressure regulating valve	10	Oil pressure sensor
4	Electro-hydraulic pressure regulating valve	11	Cylinder head lubrication points
5	Check valve	12	Engine block lubrication points
6	Bleed valve on oil filter	13	Piston bottom oil injectors
7	Oil filter		

The oil pressure generated by the pump (2) is conveyed to the lubrication points and hydraulic adjusters in the engine. The pressure generated is also used to regulate the operating pressures. For this purpose, the oil pressure is connected downstream of the filter (7) and the oil-coolant heat exchanger (9) via the pressure regulating valve (4) with characteristic field control over the pressure regulating valve (3).

In case of failure of the electrical pump control, the oil pressure is directed directly to the regulating piston of the pendulum reaction arm and thus the well-known hydromechanical control of the pendulum gate oil pump is used.

The oil pressure actually produced is read by the oil pressure sensor (10) and sent to the engine control.

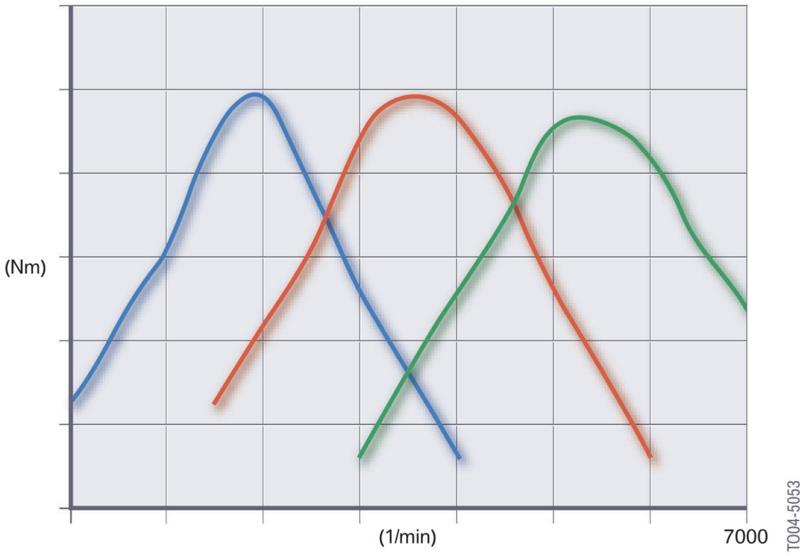
Suction air system

Differentiated Intake System (DISA)

20 - Intake air manifold with throttle valve on engine N53

The N53 engine, like the N52 model, is equipped with a differentiated intake system (DISA). This resonance load ensures an optimized torque curve for the engine. The functionality of such a resonance load is described in the training documentation for the N52 engine.

In engine variant N53B30O0 the engine is equipped with a three-stage DISA.



21 - Torque curve with a step-switched DISA

With a staggered DISA, the different resonance stages are released with an electrically operated DISA adjuster.

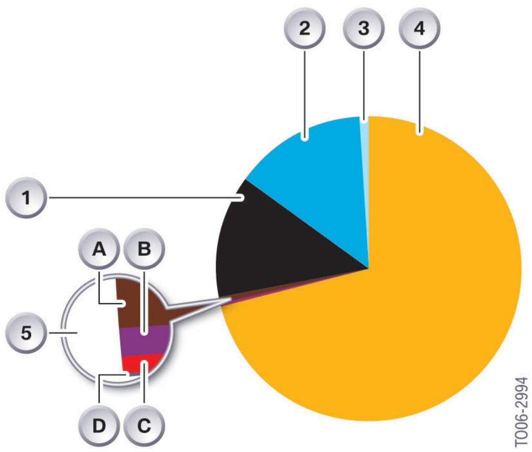
DISA Variants

Engine	DISA	DISA gates
N53B30O0	three stages	two
N53B30U0	one stage	none
N53B25U0	two stages	a

22 - DISA Regulator

Gasoline engine exhaust emissions

The exhaust gas from a conventional gasoline engine, driven with a mixture of 14.7 parts air to 1 part fuel (λ =1) is composed of the elements following:



23 - Gasoline engine exhaust gas composition λ =1

Index	Explanation
1	Carbon dioxide CO_2 (13.7 %)
3	Others; noble gases, hydrogen H and oxygen O_2 (0.7 %)
	4Nitrogen N_2 (71,5 %)
5	Contaminants (1 %)
	AM Carbon monoxide CO (0.7%)
B	Hydrocarbons CH (0.2 %)
C	Nitric oxides NOX (0.1 %)
D	Solid waste (0.005 %)

Concentrations may differ from the data given, as they depend on engine operating conditions and environmental conditions, such as fuel quality and relative air humidity.

A large part of the world's energy needs are obtained through combustion processes. The combustion of fossil fuels such as gasoline has consequences for the environment. Therefore, over the past decades, great efforts have been made to improve the combustion processes of fossil fuels.

combustion with respect to its environmental tolerance and efficiency.

One of the most challenging goals for research and technology has been to reduce the formation of toxic substances through primary and secondary measures.

The following is a brief presentation of what the exhaust gases of a gasoline engine are composed of and what is to be considered as a harmful substance. It will serve to better understand the peculiarities of the N53 engine in its emissions behavior.

Exhaust gas composition

A complete combustion of gasoline and sufficient oxygen would result in an exhaust that, after the chemical reaction of $H2O$ and $CO2$, would be composed of:

CH + $O2$ -> H2O + $CO2$

Main components of the exhaust gas:

- N_2 Nitrogen

  Nitrogen accounts for 78% of the air we breathe. It does not participate in combustion, i.e. in the reaction of the hydrocarbon CH with oxygen O_2 .

  Its proportion in the exhaust gases is 71.5%.

- CO_2 Carbon dioxide

  Carbon, as a chemical compound contained in the fuel, forms carbon dioxide when burned as a whole.

  The amount of carbon dioxide expelled is directly proportional to the fuel consumption of an engine and can be reduced only by the amount of fuel burned in the engine. Carbon dioxide is a natural component of air. It is, for example, what we exhale when we breathe. The proportion of natural carbon dioxide in the air has been stable for millennia, at a level harmless to life, but since industrialization it has been increasing. The culprit is the aforementioned energy transformation using fossil fuels.

The increasing proportion of carbon dioxide in the atmosphere is considered to be co-responsible for the so-called greenhouse effect. By this we mean global warming. The earth's atmosphere is warming because only a part of the solar thermal radiation can be returned, as part of this radiation bounces off the inner side of our atmosphere and gradually warms the earth.

- H_2O Water

The chemically combined hydrogen in the fuel is converted into water vapor, which condenses to a large extent upon cooling.

But since the combustion conditions and the fuel compositions required for this are never ideal, there is no such combustion in the cylinders of an engine.
As a result, in addition to the main components H_2O, CO_2 and N_2, there are several other components in the gases. These other components are to a greater or lesser extent harmful to humans and the environment and must be treated in some way or avoided in exhaust systems.

Secondary/noxious exhaust gas components

The less complete the combustion, the higher the emission of pollutants. The term pollutants refers to all exhaust components that are harmful to humans.

- CO Carbon monoxide

  Carbon monoxide is the consequence of incomplete combustion of a rich mixture. It is a colorless gas that reduces the oxygen absorption capacity of human blood, making it toxic.

- CH Hydrocarbons

  Hydrocarbons also appear mainly as a result of incomplete combustion due to the absence of air, i.e. a rich mixture. Certain hydrocarbons are considered carcinogenic in case of constant contact.

- $_{NOX}$ Nitric oxides

  Nitric oxide encompasses various types of nitrogen-oxygen combinations. As a result, they are formed by secondary reactions in all combustion processes with nitrogen-containing air. Nitrogen does not, in fact, participate in the combustion of carbon. Due to the high temperatures and pressure in the combustion chamber, oxidation processes take place with the oxygen in the air. Nitrogen monoxide NO and nitrogen dioxide NO_2 and, to a lesser extent, nitrous oxide (laughing gas) N_2 O are produced.

  The higher the temperatures and the more air in the combustion mixture, the greater the amount of nitric oxides produced. This is why engines operating with lean mixtures must be equipped with exhaust gas treatment systems.

  Nitric oxides are to blame for acid rain and, in combination with hydrocarbons, for the formation of smog.

  – NO Nitrogen monoxide

    Nitrogen monoxide is a colorless, odorless gas that is slowly transformed in air into NO_2 .

    It is a very toxic gas.

  – NO_2 Nitrogen dioxide

    Nitrogen dioxide is a reddish-brown gas with a chlorine-like odor and is very toxic.

- Solid waste

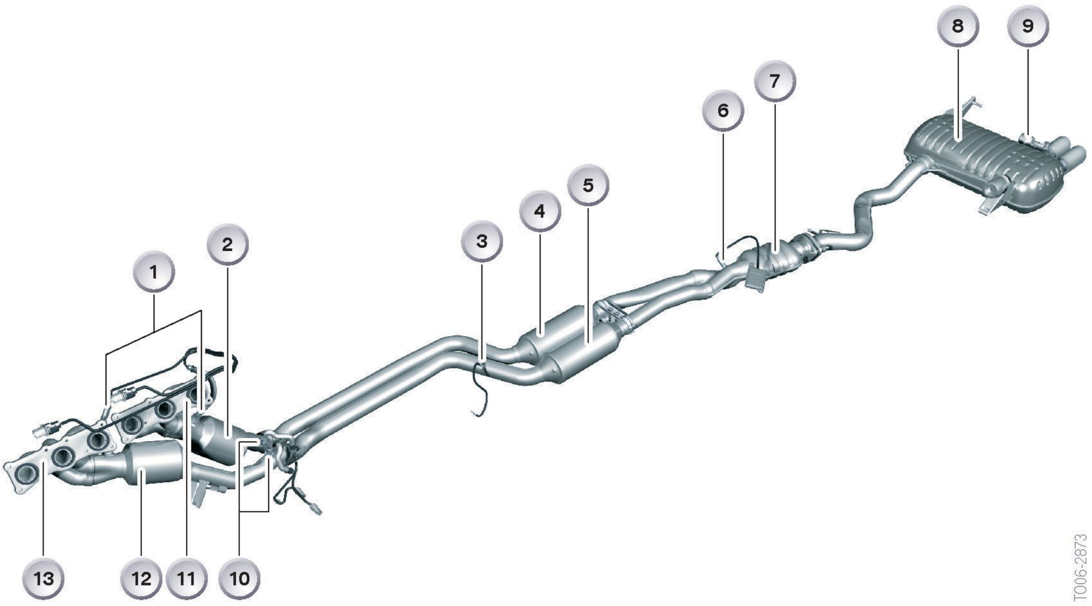
  Solid substances, i.e. the particles emitted, are present in very small quantities in gasoline engines.

- SO_2 Sulfur dioxide

  Due to the sulfur content of fuels, sulfur compounds can occur in the exhaust gas. In the distribution area of the N53 engine, the proportions of sulfur in the fuels have been greatly reduced by legal provisions. Therefore, sulfur dioxide emissions in the exhaust gas of the N53 can be neglected provided that the right fuel is used. The consequences of using a high-sulfur fuel in an N53 engine are described in the chapter on the NOX accumulator catalyst.

Structure of the exhaust system of the N53 engine on E93

Exhaust gases from the N53 engine are routed in dual flow through a 3-in-1 exhaust manifold in each flow, through the three-way catalysts and through the NOX accumulation catalysts. The exhaust stream is collected then in front of the center muffler and is taken to the end muffler. The system consists of two end pipes, and the right one is where the exhaust flap known from other vehicles is used.



24 - N53 engine exhaust system

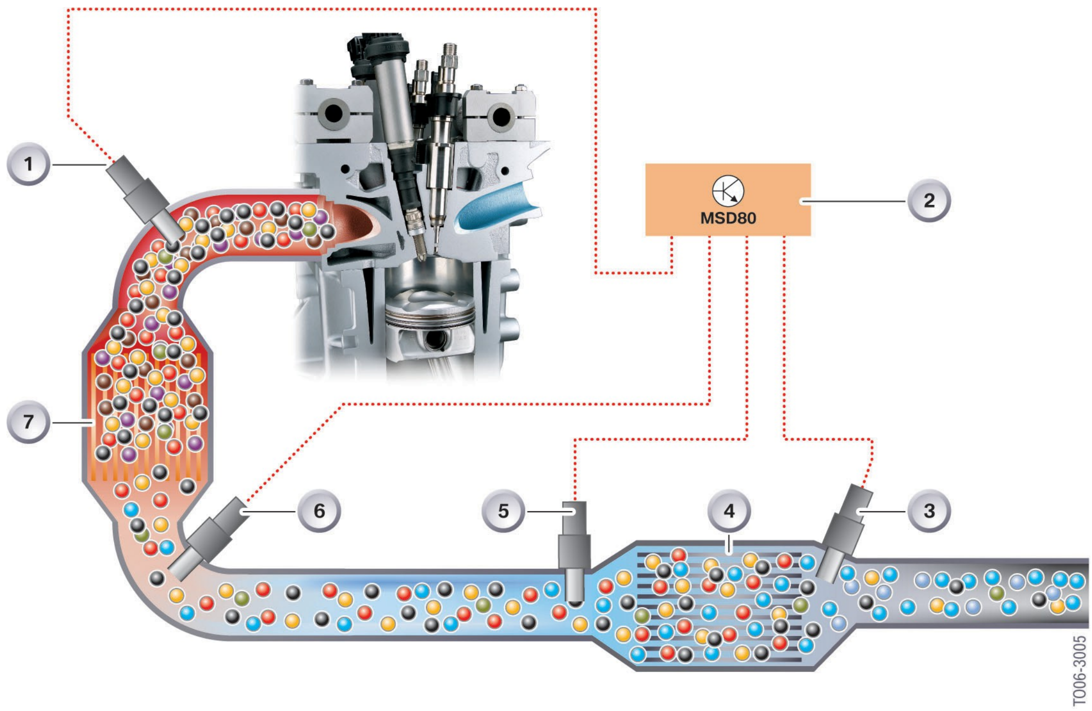
Index	Explanation	Index	Explanation
1	Lambda sensors (control sensors with constant characteristic line)	8	End silencer
2	Catalytic converter 3-way bed 2	9	Exhaust gas flap
3	Temperature sensor	10	Lambda sensors (control sensors with dashed characteristic line)
4	NOX accumulator catalyzer bed 2	11	Exhaust manifold 3-in-1 bed 2
5	NOX accumulator catalyzer bank 1	12	3-way catalytic converter bed 1
6	Nitric oxide sensor	13	3-in-1 exhaust manifold bench 1
7	Central silencer		

The exhaust system has, on the one hand, the function of safely transferring the substances produced during combustion to the rear of the car and dampening the sound it produces.

But it also has other active functions:

- In the exhaust system, the various components of the gas are treated so that they do not cause too much harm to people and the environment.
- The composition of the exhaust gas is monitored by probes. The results of this control are passed on to the engine control to optimize the combustion processes. In this way, the exhaust gases are reduced to the minimum necessary for each driving situation.

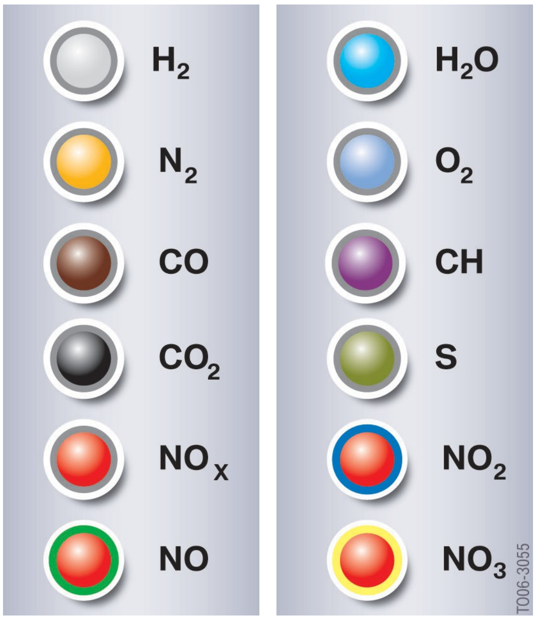
Post-treatment of emissions



25 - Post-treatment of N53 emissions

Index	Explanation	Index	Explanation
1	Control probe with constant characteristic line	5	Exhaust gas temperature sensor
2	Motor control device	6	Control probe with discontinuous characteristic line
3	Nitric oxide sensor	7	3-way catalytic converter
4	NO_X accumulator catalyst		

The following graphic symbols are used to further clarify the functions of emission post-processing.



26 - Symbols for exhaust gas components

The exhaust gas treatment of the N53 engine takes place in two areas of function.

- Homogeneous (λ = 1)
  For homogeneous operation (λ = 1) a 3-way catalyst (7) is used with a lambda regulation (1 + 6), as we already know from other gasoline engines, where it is installed as standard.
- Poor (λ > 1)
  Due to increased oxide production
  nitric in lean operation (λ > 1) it is necessary to reduce this harmful component with a device
  additional, the NO_X accumulator catalyst (4) with temperature sensor (5) and temperature sensor (5) with temperature sensor (5) and temperature sensor (6).
  of nitric oxide (3).

Functional description of exhaust gas treatment

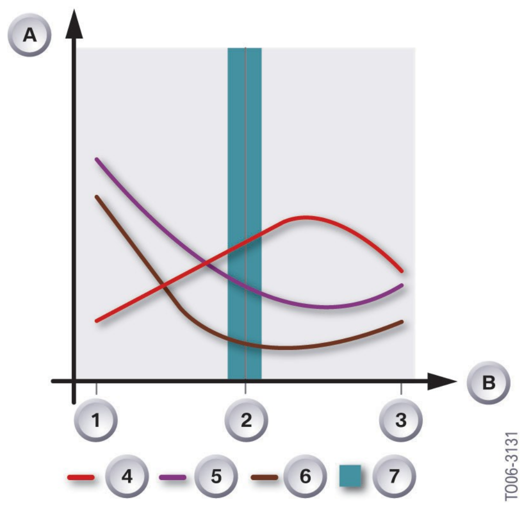
Three-way catalytic converter with lambda regulation

The raw emissions from the combustion pass through an exhaust manifold to the three-way catalytic converters (7). Here the remaining oxygen content of the gas is measured with constant characteristic line lambda probes (1). With the result of this measurement, the quality of the combustion process is evaluated and regulated by the engine control.

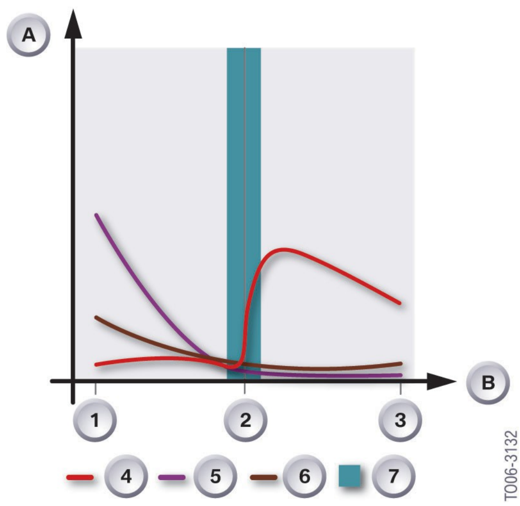
The three harmful substances contained in the exhaust gas, CH, CO and NO_X, are transformed into the harmless components H_2O, CO_2 and N_2 in the three-way catalytic converter. The catalyst is a material that initiates a chemical reaction without directly participating in it.
Carbon-containing components are transformed by oxidation. Oxygen

The oxygen required for this is taken from the same residual oxygen contained in the exhaust and from the oxygen contained in the nitric oxide. The nitric oxide is reduced in this process to harmless molecular nitrogen. But this is only possible with a relatively small proportion of nitric oxides, such as occurs in homogeneous operation.

This functionality of the 3-way catalytic converter is monitored by a lambda sensor located behind the catalytic converter with a dashed characteristic line (6). Through this lambda sensor, the engine control unit (2) recognizes whether sufficient oxygen has been extracted from the exhaust and whether it has been used for the transformation of harmful components.



27 - Raw emissions before entering the 3-way catalytic



converter28 - Emissions after passing through the 3-way catalytic converter

Index	Explanation	Index	Explanation
A	Concentration	4	Nitric oxides NO_X
B	Air-air mixture ratio fuel λ	5	Hydrocarbons CH
1	Rich λ < 1	6	Carbon monoxide CO
2	Stoichiometric λ = 1	7	Control range at λ = 1
3	Poor λ > 1		

The following chemical reactions take place in the 3-way catalyst:

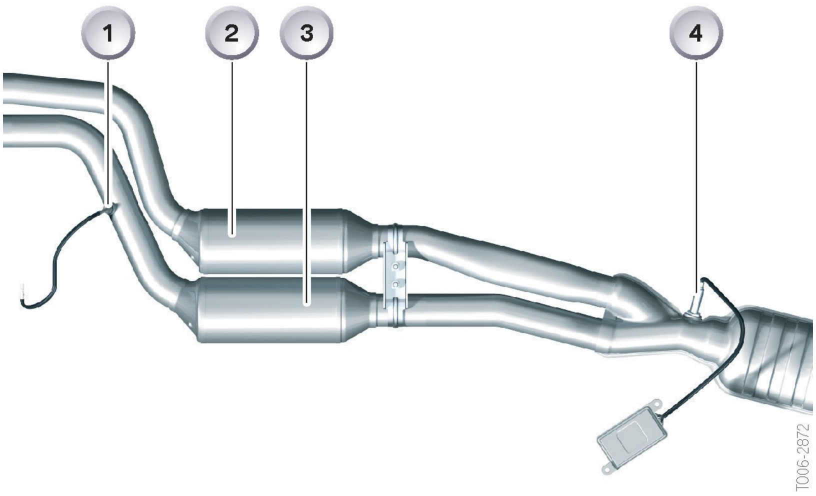
- $2CO + OR_2 \rightarrow 2CO_2$
- $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
- $2NO + 2CO \rightarrow N_2 + 2CO_2$
- $2NO_2 + CO \rightarrow N_2 + 2CO_2$

In this way, more than 99% of the pollutants are converted in homogeneous operation.

NOX accumulator catalyst

When the N53 engine runs lean, the exhaust emissions change and the carbon ratios drop significantly. The increase in oxygen content and the lack of carbon means that the reduction of nitric oxides cannot take place in the 3-way catalytic converter. In addition, the proportion of nitric oxides first rises sharply at lambda values above 1 before falling back to further impoverish the mixture. The maximum in nitric oxide emissions is found with a slight excess of air in the range of λ = 1.05 to 1.1. In order to slow down this increase in emissions and recover the regeneration capacity of the 3-way catalytic converters, an additional function is required to treat the exhaust gases in the N53 engine.

A NOX storage catalyst is added to the 3-way catalytic converters of the N53 engine. Here, the nitric oxides contained in the exhaust gas are temporarily stored and converted into harmless substances.



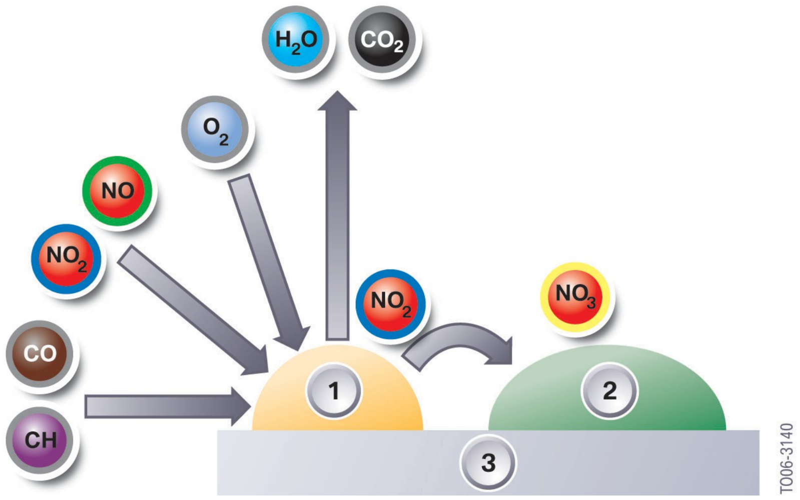
29 - Catalysts NOX accumulators of the E93 with N53 engine

Index	Explanation	Index	Explanation
1	Exhaust gas temperature sensor	3	NOX accumulator catalyzer bed 2
2	NOX accumulator catalyzer bed 1	4	Nitric oxide sensor

NOX (2 + 3) storage catalysts have a structure similar to that of 3-way catalysts. In a carrier layer (wash coat) there is a noble metal with catalytic effect on one side and a material for the intermediate storage of the accumulated nitric oxides on the other side. These NOX storage catalysts work in the following ways in a temperature range from 220 °C to 450 °C, i.e. in this temperature range it is possible to both accumulate and to transform the nitric oxides. Desulfurization requires temperatures greater than 600 °C - 650 °C. These temperatures are monitored by a temperature sensor (1) in the exhaust system. The control and monitoring of the nitric oxide regeneration is based on a calculation model stored in the engine control and the data measured by the nitric oxide sensor (4).

3 Outside the active temperature window of the NOX accumulator catalyst, the engine operates with homogeneous mixture. 1

NOX accumulation



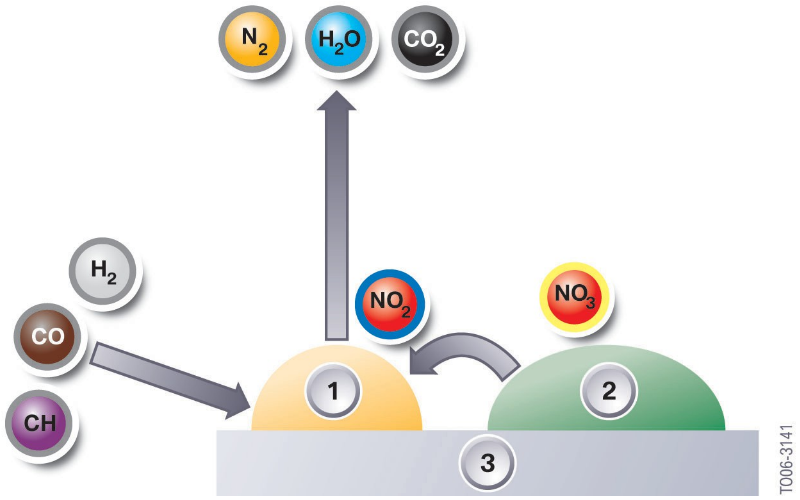
30 - NOX accumulation

Index	Explanation	Index	Explanation
1	Platinum as a catalytic component	3	Supporting element (Wash-Coat)
2	Barium oxide BaO as accumulator element		

The graph shows the storage process of the nitric oxides contained in the exhaust gas. In the catalytic component (1) the well-known 3-way catalyst transformation of the carbon-containing components CH and CO with the high oxygen remainder in the gases into H_2O and CO_2 takes place. The oxides nitric oxides accumulate in the accumulator component (2) both highly oxidized and as NO_2 . Barium oxide BaO combines with nitrogen dioxide NO_2 and oxygen O_2 transforming into barium nitrate Ba(NO)32 .

- BaO + NO_2 + O_2 -> $Ba(NO_3)_2$

NOX destocking and reduction (conversion)



31 - NOX reduction and destocking

Index	Explanation	Index	Explanation
1	Platinum as a catalytic component	3	Supporting element (Wash-Coat)
2	Barium oxide BaO as accumulator element		

In order to remove the stored nitric oxides from the accumulator element and convert them, the motor is switched to a richer mixture operation with $\lambda = 0.9$. In this operating mode produce more CO, CH and H_2 .

Destocking

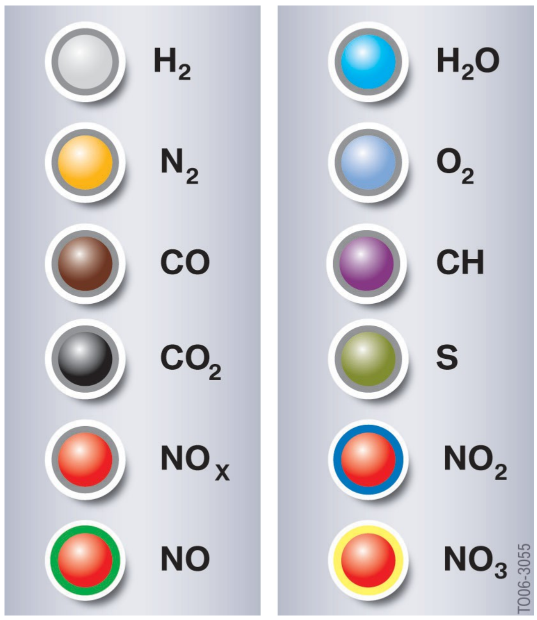
The CO reacts with the accumulator component, barium nitrate (3), and the barium oxide is retransformed, releasing carbon dioxide and nitrogen monoxide.

- $Ba(NO_3)_2 + 3CO \rightarrow 3CO_2 + BaO + 2NO$.

Conversion

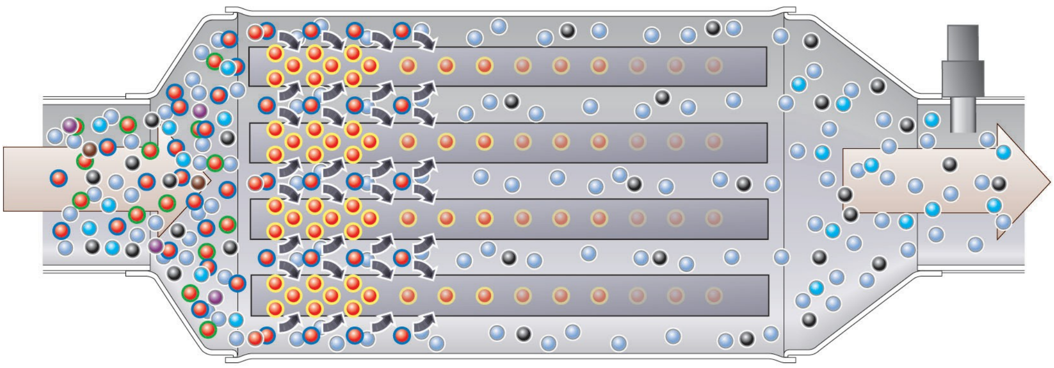
In the catalytic component, the released nitrogen monoxide reacts with carbon monoxide to create molecular nitrogen and carbon dioxide.

- $2NO + 2CO \rightarrow N_2 + 2CO_2$.



32 - Symbols for exhaust gas components

NO_X accumulation on the NO_X accumulator catalyst



33 - NO_X accumulation

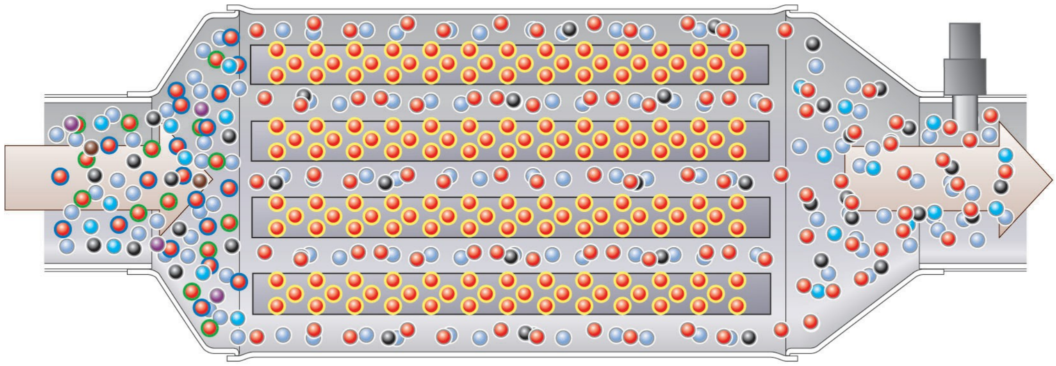
Lean-burn exhaust gas is characterized by a low proportion of CH and CO, as well as a high proportion of O_2 .

For the conversion of the gases in the 3-way catalytic converter, the consequence is that the nitric oxides cannot be reduced to the required extent. For the oxidation of the carbon-containing components, only the remaining oxygen is used and not the oxygen that is combined in the nitric oxides. This

This is very annoying, especially in lean-burn operation, with λ =1.1 for the entire gas emission of the
engine, as the proportion of nitric oxides in the engine's is the maximum.

Therefore, the gases rich in nitric oxides are the raw emission for the NO_X accumulator catalyst. They are stored in the accumulator component on the carrier element so that they can be converted in a downstream process.

NOX accumulator catalyst saturation



34 - Saturation

The storage capacity of nitric oxide in the accumulator material is limited. When the accumulation material has been completely transformed into barium nitrate, no more nitric oxide can be stored.

This saturation state is very important for the motor control. The control detects this saturation in two different ways.

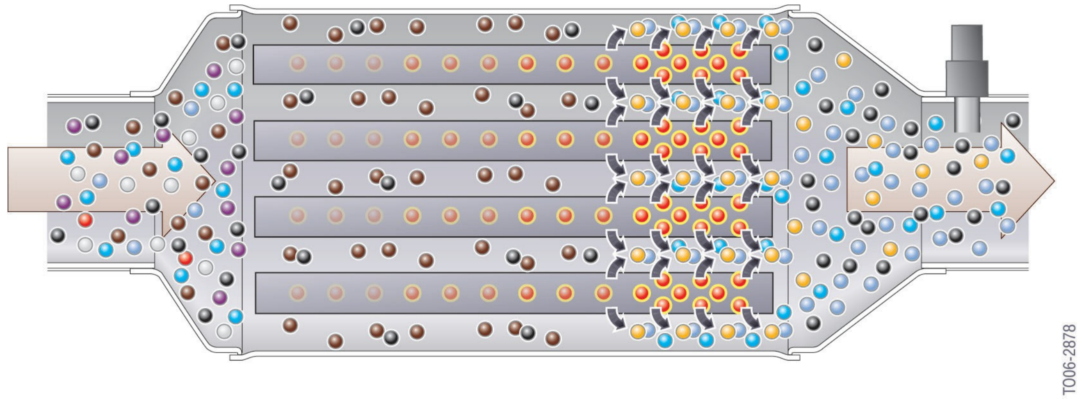
- Using a model-based procedure and considering the catalyst temperature, the elapsed driving profile and the stored value for thermal aging of the accumulator catalyst, the accumulated NOX amount is calculated.
- The nitric oxide sensor located in the accumulator catalytic converters detects the nitric oxides in the gases and sends the values to the engine control. It then sends the values to the engine control.

  The operation of this sensor is explained. Since the sensor can only react above a certain measurable amount of nitric oxide, monitoring is affected by a certain low NOX range.

The results of this monitoring are stored in the engine control system in order to take into account the state of aging and the degree of sulfurization of the NOX accumulator catalyst.

3 When an N53 engine control unit is replaced, the NOX accumulator catalyst aging and sulfurization states must be transferred. 1 3 When an accumulator catalytic converter is to be renewed, the sulfuration and catalyst aging values in the engine control unit must be initialized again. 1

Destocking and conversion of nitric oxides



35 - Destocking and conversion

When saturation of the accumulation catalyst is detected, the engine control initiates the destocking of the nitric oxides. For this purpose, the engine operation N53 transitions to a richer mixing phase of λ = 0,9. De-storage occurs as follows described above, through the transformation of barium nitrate. In the catalytic component of the accumulator catalyst, the conversion of the nitric oxides then takes place.

At the end of the conversion there is another important moment of engine operation, as the engine control must know when this rich mixture phase can end.

For this purpose, a calculation model and the nitric oxide sensor are used again. The sensor measures the oxygen concentration in the exhaust gas and displays a voltage jump from "lean" to "rich" when destocking is complete.

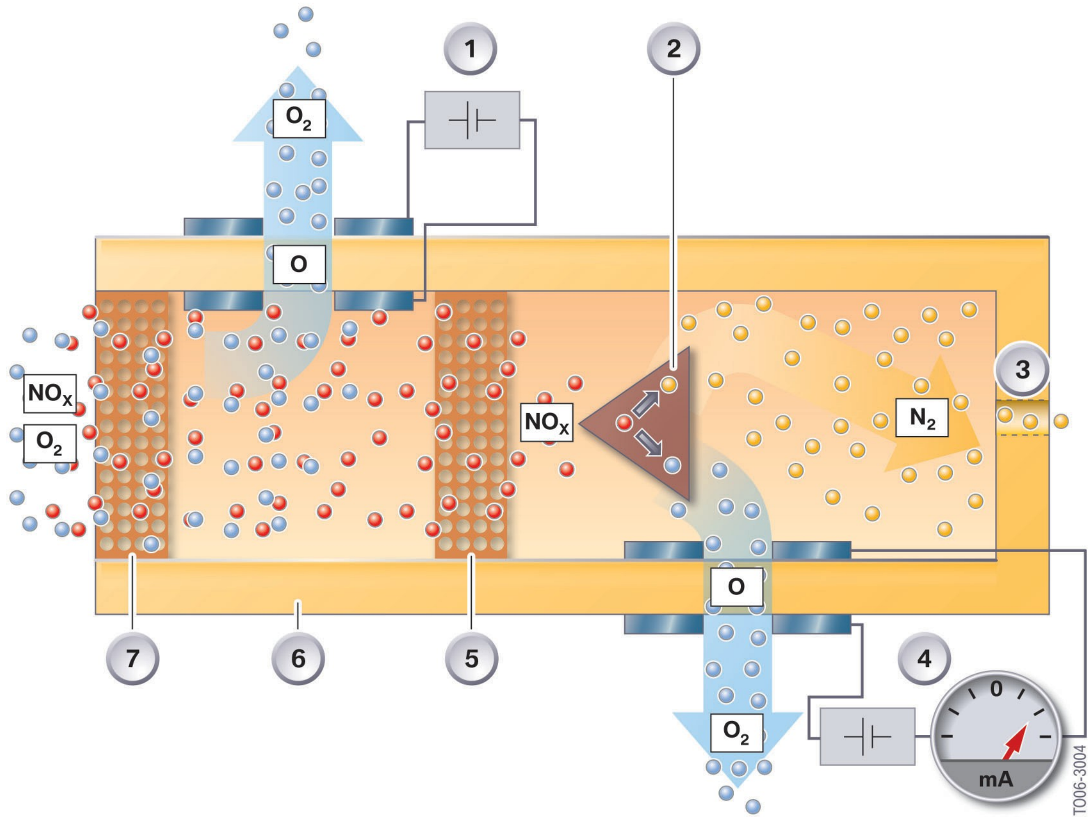
Nitric oxide sensor

36 - Nitric oxide sensor

The nitric oxide sensor consists of a measuring probe and a control unit. The control unit communicates with the motor control unit via LoCAN.

The nitric oxide sensor is similar in function to a broadband lambda sensor. The measuring principle is based on the idea of referring the nitric oxide measurement to an oxygen measurement.

The graph below shows how this measuring principle works.



37 - Schematic diagram of nitric oxide sensor operation

Index	Explanation	Index	Explanation
1	Pumped flow rate chamber 1	5	Barrier 2
2	Catalytic element	6	Zirconium dioxide fixed electrolyte (ZrO)2
3	Nitric oxide output	7	Barrier 1
4	Pumped flow rate chamber 2		

The oxide-oxygen mixture enters the nitric oxide sensor after the NOX accumulator catalyst. In the first chamber, the oxygen contained in this mixture is ionized with the aid of the first pump cell and bypassed with the fixed electrolyte. A lambda signal can be detected via the pump flow rate of the first chamber. The remaining nitric oxide then passes through the second barrier and enters the second sensor chamber. The nitric oxide disintegrates in a catalytic element into oxygen and nitrogen. The oxygen thus released is ionized again and can pass the fixed electrolyte. The pumping flow rate that then appears makes it possible to deduce, through the amount of oxygen it contains, the amount of nitric oxide.

Accumulation and regeneration cycle

There is no fixed time or path dependence with respect to the accumulation and regeneration of nitric oxides.

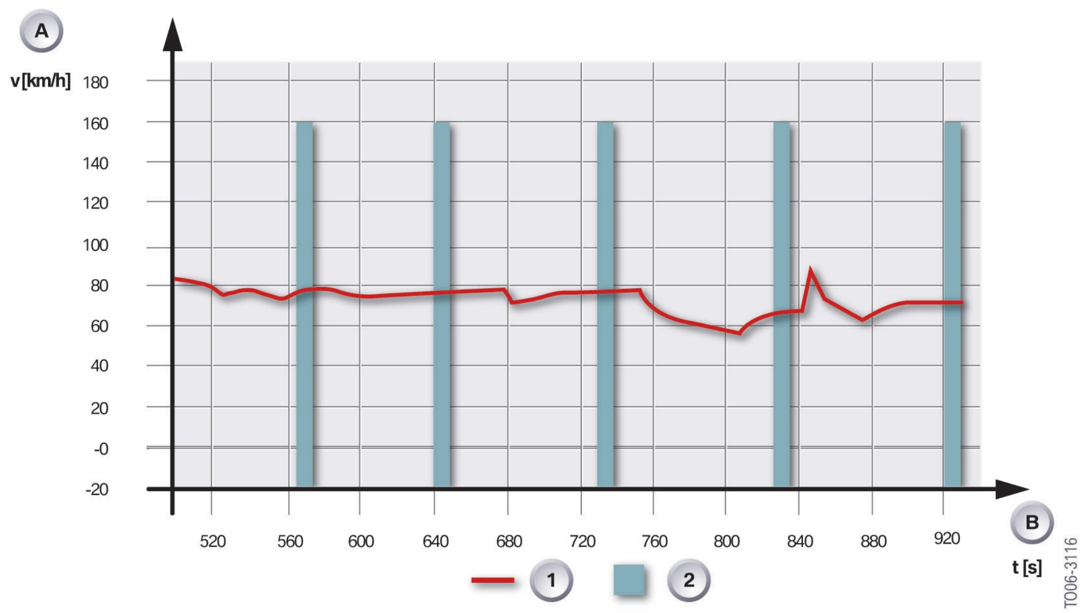
The magnitudes that have an influence here are:

- The capacity of the $_{NOX}$ accumulator catalytic converter
- Driving profile
- Fuel quality.

Running the engine with a richer mixture, which is necessary for the destocking and regeneration of nitric oxides, results in a barely perceptible increase in fuel consumption. To ensure that this does not have a negative impact on the overall fuel consumption and thus on the emission of nitrogen dioxide, it is necessary to use a richer fuel mixture.

In the case of the N53 engine, the engine control tries to perform the regeneration phases at times of operation when the engine normally runs with a homogeneous mixture. In other words, it tries to perform regeneration during acceleration or high load phases.

The two NOX accumulator catalysts of the N53 engine are not regenerated at the same time, but one after the other. In this way, only the cylinders of one bank will operate with homogeneous mixture, thus keeping the amount of fuel required for regeneration limited (bank 1 = cyl. 1, 2, 3; bank 2 = cyl. 4, 5, 6). This regeneration takes place at neutral load and has no effect on the running quality of the N53 engine.



38 - Accumulation and regeneration cycle

Index	Explanation	Index	Explanation
A	Speed	1	Weather
B	Driving cycle	2	Nitric oxide regeneration

The graph shows a driving cycle (1) as an example, from which it can be seen that the accumulation and regeneration (2) is a constant process, which can be influenced by several different parameters.

Accumulation capacity

The accumulation capacity of these NOX catalysts is mainly influenced by two magnitudes:

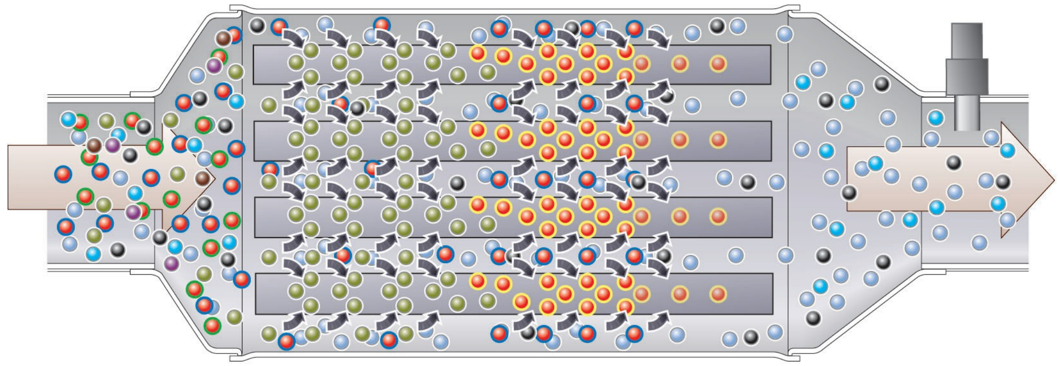
- thermal aging
- sulfidation.

Thermal aging

Thermal aging is a reduction of the accumulation capacity of the catalyst that depends on the temperatures at which the catalyst must operate. We are already familiar with this phenomenon in 3-way catalysts. Above a certain temperature, the components applied to the catalytic converter will on the wash coat, i.e. the catalyst carrier material, begin to sinter. Their active surface area is reduced and the storage capacity and the catalyst effect decreases.

Since the critical temperatures of the NOX accumulator catalytic converter are lower than those of the 3-way catalytic converters, these accumulator catalytic converters are no longer so close to the engine, but are located underneath the car. In the lining of the underside of the E93 there are vent holes that serve to cool the accumulator catalysts.

NOX accumulator catalyst sulfurization



39 - Sulfurization

When a vehicle with an N53 engine loads high sulfur fuel, there is a reduction in the storage capacity of the NOX accumulator catalysts. The sulfur contained in the fuel combines chemically with the catalyst accumulator material. The barium is transformed with the sulfur into barium sulfate and is no longer able to combine with the nitric oxides.

This may result in the loss of the entire storage capacity. The engine will recognize such sulfidation when an initiated reduction phase does not produce the expected effective reduction of nitric oxides.

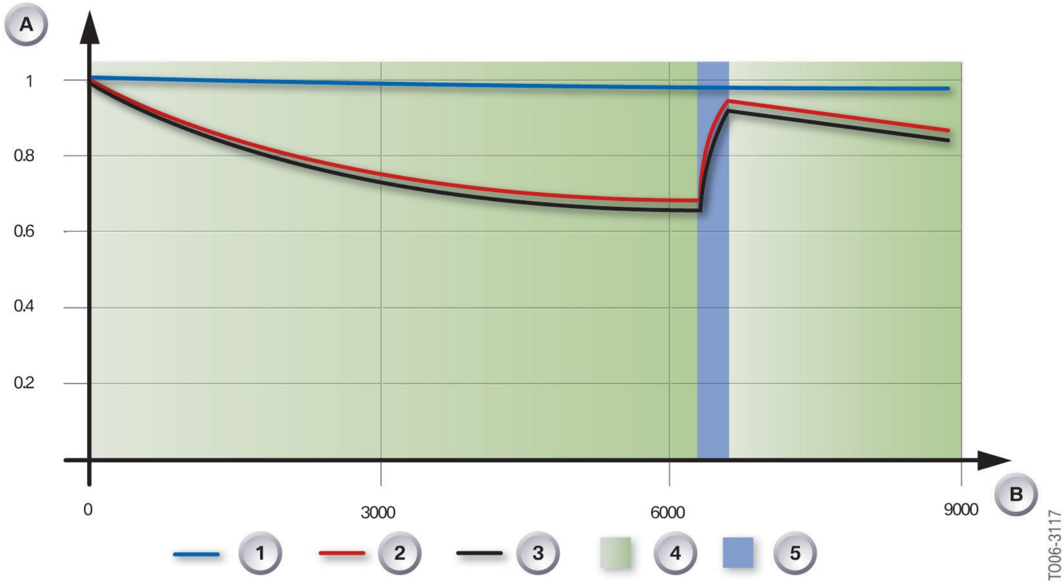
When such sulfidation is recognized, the catalyst must be brought to a temperature of between 600 and 650 °C, so that the sulfate of the catalyst can be removed from the catalyst.
barium oxide back into barium oxide.
barium and sulfur contained in the accumulator can be expelled.

3 Sulfurization of the NOX accumulator catalyst means that the engine can only be operated with a homogeneous mixture, as the nitric oxides cannot be absorbed. This destroys all fuel consumption advantages. of this lean-burn, direct injection engine and higher $CO2$ emissions are produced. 1

3 If the engine is permanently operated with high-sulfur fuel, energy-saving and environmentally friendly operation will be prevented forever. 1

3 Sulfurization of the NOX accumulator catalyst is not a violation of legal emission standards. The N53 engine will continue to operate safely within the limits set by the standard.
EURO 4. 1

3 The sulfidation of the NOX accumulator catalyst is reversible. 1



40 - NOX accumulator catalyst capacity

Index	Explanation	Index	Explanation
A	Accumulation capacity	3	Reduction of total warehouse
B	Mileage (km)	4	Sulfurization
1	Thermal aging	5	Desulfurization
2	Reduction of sulfidation storage		

From the graph it can be seen that the total storage capacity depends on both thermal aging and sulfidation. With the desulfurization process, the storage capacity increases.

3 The absorption capacity of the NOX accumulator catalyst for nitric oxides and, consequently, its aging, depends on:

- Fuel quality with respect to sulfur release
- Catalyst operating temperatures.

Exhaust gas recirculation (AGR)

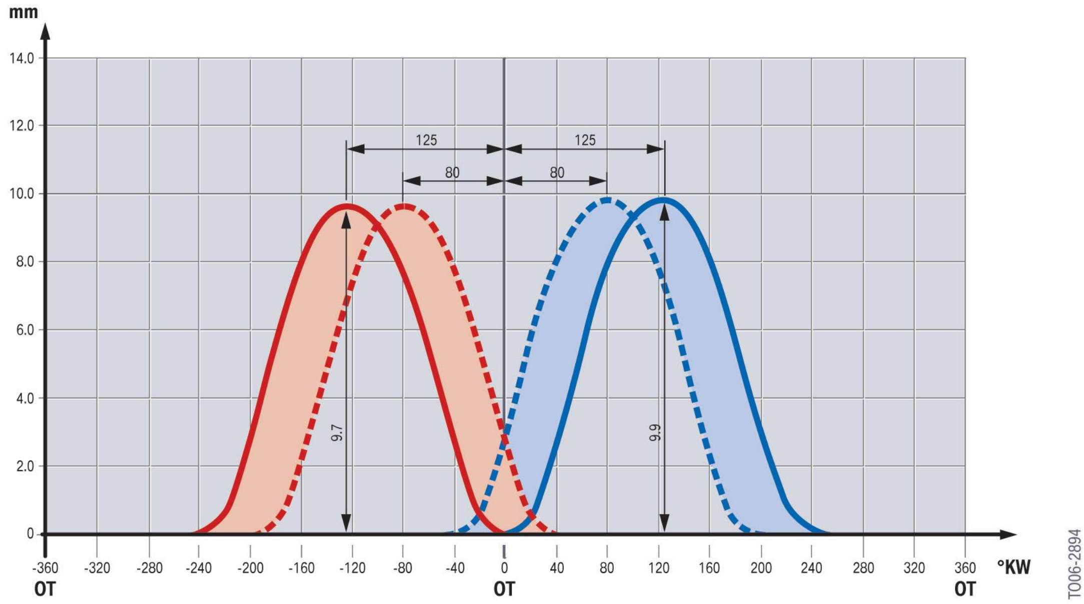
In the medium-load range, the most frequent mode of engine operation, fuel is injected directly into the cylinder just before ignition. It is only incompletely mixed with air, so there is only a real fuel mixture around the spark plug.

But the lambda ratio of fuel and air is on average much poorer (λ > 1, stratified load) than in an engine of conventional gasoline with injection into the intake manifold. The higher the charge, the earlier the fuel is injected into the cylinder's intake stroke, so it has more time to mix with the ambient air and to have a homogeneous mixture with lambda 1 at the moment of ignition. On

Both operating modes of the N53 direct injection engine require very low gross emissions of toxic substances, so that the aftertreatment of the gases in the system can reach the emission limit values or even remain considerably below them.

Gross NO emissions should be kept to a minimum, as 3-way catalytic converters with excessive air in the exhaust gas (with the engine at λ > 1) can practically not convert any NO into nitrogen and oxygen. A suitable measure for the reduction of NO formation is the reduction of combustion temperatures with exhaust gas recirculation.

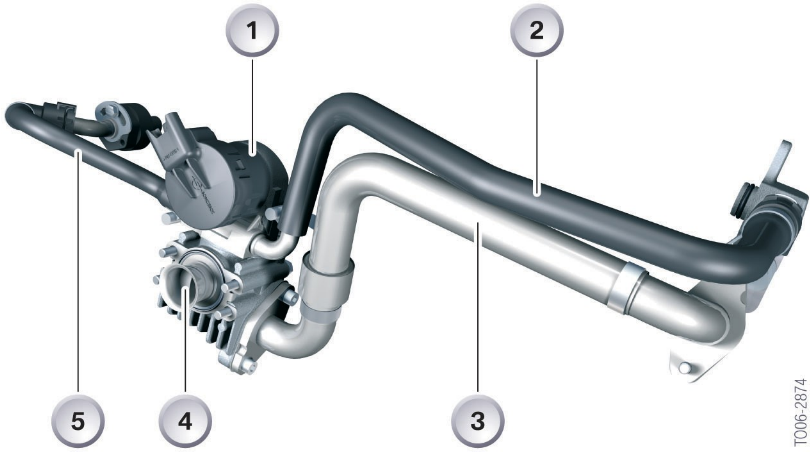
Internal exhaust gas recirculation



41 - VANOS setting ranges on the N53 engine

Due to the valve overlap in the engine, waste gas is returned to the cylinders. This recirculation of exhaust gases can be influenced by the VANOS by adjusting the valve opening and closing times, i.e. changing the valve overlap times.

External exhaust gas recirculation



42 - Engine exhaust gas recirculation system N53

Index	Explanation	Index	Explanation
1	Exhaust gas recirculation valve	4	Suction system connection sleeve
2	Refrigerant inlet	5	Refrigerant return
3	Exhaust pipe		

In the N53 engine, in addition to internal gas recirculation, an external recirculation takes place. Here, larger quantities of exhaust gases are intentionally returned to the intake unit to be mixed with the air before entering the cylinders.

The exhaust gas recirculation valve is located below the DISA and feeds the returned exhaust gases into the intake system at the intake valve height.

External exhaust gas recirculation in lean-burn direct injection gasoline engines has a peculiarity. The exhaust gas, compared to that of a homogeneous mixture engine, is to a large extent enriched with oxygen. This oxygen is partly returned by the gas recirculation to the cylinders. The engine control needs information to be able to adjust the amount of fuel to the mass of oxygen that has been introduced into the combustion chambers.

On the one hand, it has the information provided by the signal from the lambda sensors about the oxygen content in the exhaust system.

In addition, a recirculation valve status message is transmitted to the engine control unit.

This status message can be used to correct the exhaust gas recirculation volume if necessary.

Fuel supply system

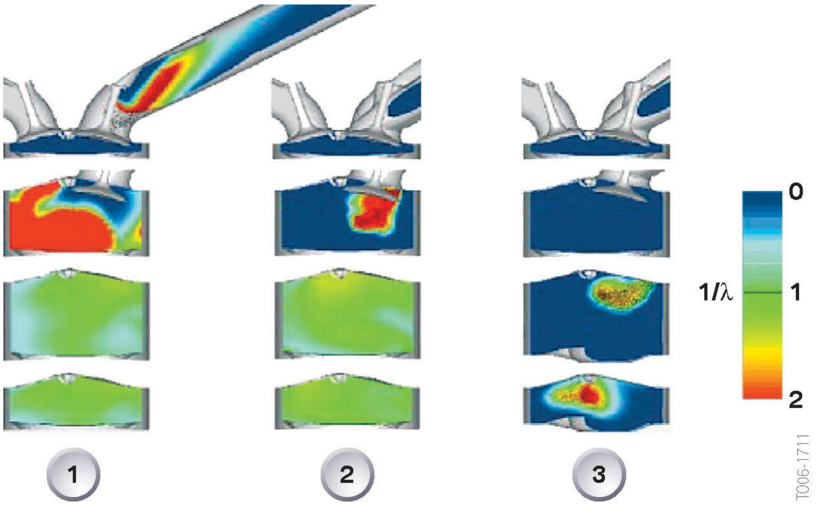
Direct injection is a fundamental module of the N53 engine design. Only in the injection process described below are the potentials for stratified, lean-burn combustion realized. With a power per liter of 66.8 kW/liter and a reduction in fuel consumption of more than 20% compared to a gasoline engine, the N53 engine has a power per liter of 66.8 kW/liter.

conventional, significant advantages are achieved that can be easily experienced by the customer.

With this increase in power and this reduction in consumption, the emissions performance far exceeds the legal requirements.

Fundamentals of direct injection

In direct injection, fuel is injected at high pressure (between 50 and 200 bar) directly into the combustion chamber.
In principle, two direct gasoline injection concepts are possible, either by means of the formation of a homogeneous or stratified mixture, each with its own particularities with respect to fuel consumption and exhaust emissions.



43 - Comparison of mix formations

Index	Explanation	Index	Explanation
1	Injection in the intake manifold	3	Direct injection in stratified operation
2	Homogeneous direct injection		

The differences are due to the different mixture formation procedures. The above graph entitled "Comparison of mixture formations" shows the evolution over time of the mixture formation in the case of a direct homogeneous or stratified type injection compared to an injection into the intake manifold. In this case it should be noted that the lambda values are represented on the color scale as an inverse value (1/ lambda).

The mixture composition is represented as the ratio of air to fuel at four different times. The colors represent the corresponding local air-fuel ratio according to a comparative scale.

Direct injection in stratified operation

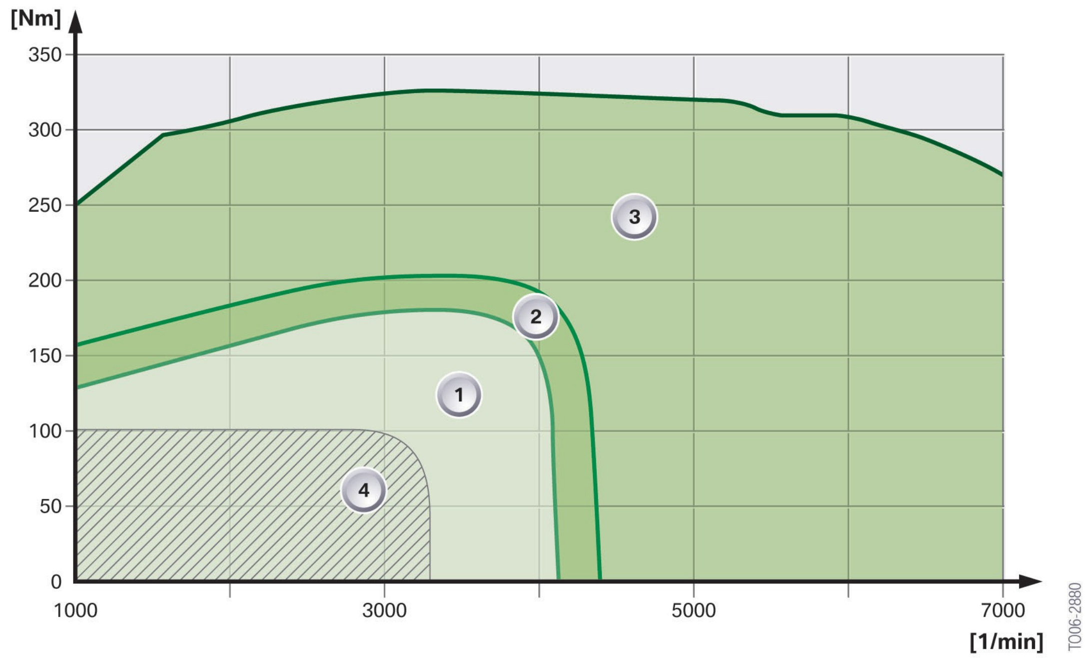
In direct injection, the injector flows directly into the combustion chamber. The combustion air is sucked in almost without throttling (through the intake valve). The fuel is injected later, during the compression stage. This creates a fuel mixture mist only at the spark plug. Most of the combustion chamber is filled with air and exhaust gases.

Due to the excess air, this type of operation produces an exhaust gas whose composition cannot be treated by a conventional 3-way catalytic converter to remove nitric oxides. For this reason, a special system is required to treat these exhaust gases. The structure and function of this system to reduce nitrogen oxides in the exhaust gas is nitric oxides are described in the section on the exhaust system.

Load-stratified operation cannot be applied across the entire operating range of a motor. There are physical limits.

- As the load increases, the amount of fuel must increase and the fuel mixture haze is greater.
- As revolutions increase, the time available for load change and mixture formation is less.

As the graph below shows, BMW's engine developers have achieved with the N53 an engine capable of running at stratified load over a wide rpm spectrum and delivering very remarkable performance.



44 - Characteristic range of the N53 motor operating modes

Index	Explanation	Index	Explanation
1	Extended stratified load operation λ >> 1	3	Classic homogeneous operation λ = 1
2	Area of change λ > 1	4Load	operation engine layering known 1st generation direct injection wall/air guided

Adapted to the running situation of the engine, the N53 engine can be operated in 3 ways in which the cylinders receive different proportions of air-fuel mixture.

In the high-load and high-speed ranges, the engine operates with a homogeneous mixture.

- Lambda = 1

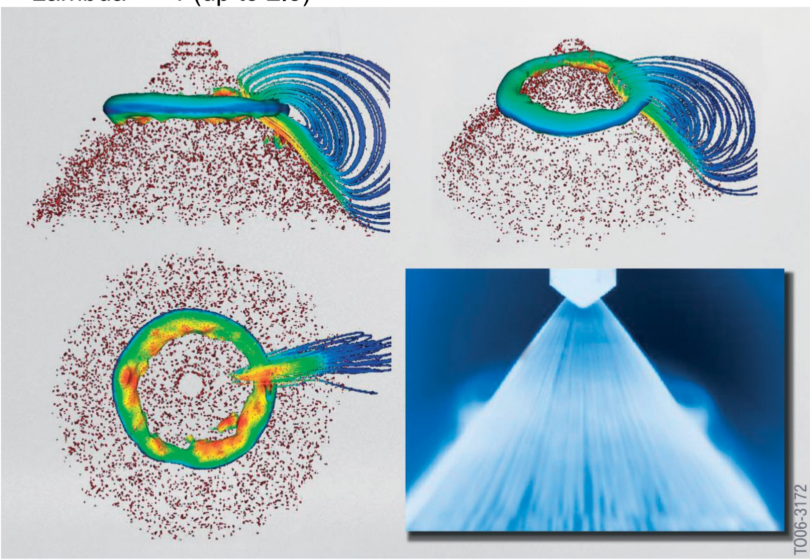
  With a marked characteristic field of up to a speed of more than 4000 r.p.m. and a torque of more than 150 Nm, the engine can run with a very lean mixture.

- Lambda >> 1 (up to 2.5)

  In a range located between these two characteristic fields of the total range, the engine operates with lean mixture.

- Lambda > 1

The shape of the fuel injection in the combustion chamber plays a very important role for the realization of this characteristic field of operating types. With the High Precision Injection (HPI) system described below, it is possible to inject the fuel with a conical geometry, with high speed, high dosing accuracy and over a whole operating spectrum with constant quality.



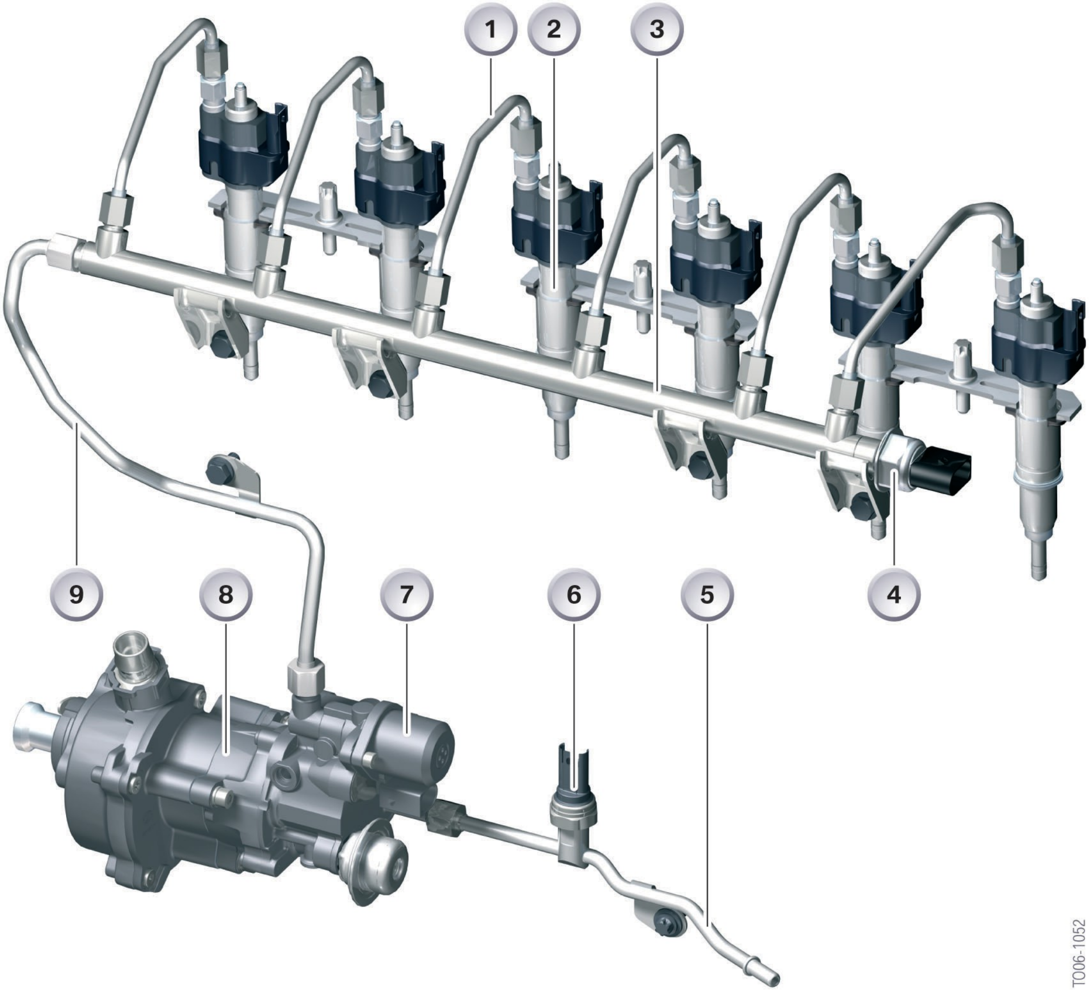
45 - Engine fuel cone N53

In stratified load operation, the N53 direct injection engine achieves a higher degree of efficiency and therefore lower fuel consumption than a conventional engine. gasoline, which operates with λ = 1. This is due to the following effects:

- Since in stratified operation, the intake air enters with the intake valve fully open, the load change work and the resulting losses in efficiency are very low.
- There is less wall heat loss due to lower combustion chamber temperatures
- Due to the different gas composition (excess air, exhaust gas recirculation), the thermodynamic efficiency increases.
- Compression can be increased, as direct injection leads to an internal cooling effect and a reduction in the tendency to pitting. The degree of thermodynamic effectiveness is increased over the entire operating range of the engine.

High Precision Injection (HPI)

Overview and operation



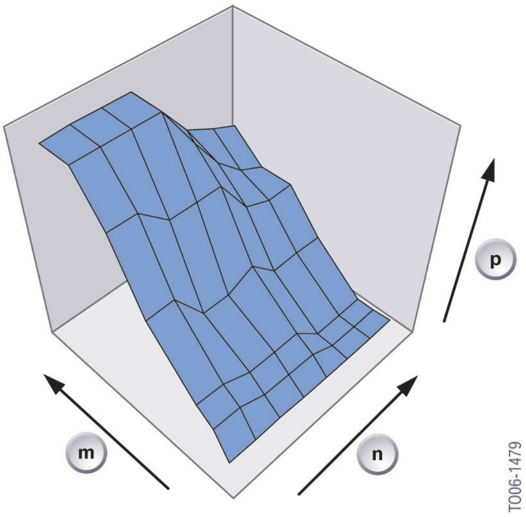
46 - HPI

Index	Explanation	Index	Explanation
1	High pressure line (rail - injector)	6	Low pressure sensor
2	Piezoelectric injector	7	Flow control valve
3	Rail	8	3-piston high pressure pump
4	High pressure sensor	9	High pressure line (pump - rail)
5	Supply line (from electric fuel pump)		

The fuel is pumped in the required quantity from the fuel tank by the electric fuel pump through the supply line (5) with a pre-pressure of 5 bar to the high-pressure pump. The low pressure sensor (6) monitors the pre-pressure. In the event of a failure of this sensor, the fuel electric pump is reactivated with 100 % of the flow rate via terminal 15 ON.

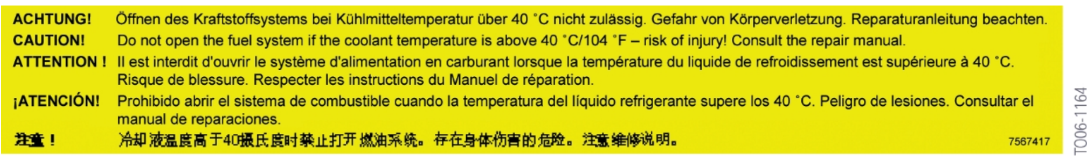
The fuel is compressed in the permanently driven three-piston high-pressure pump (8) and is pumped through the high-pressure line (9) to the rail (3). The fuel stored in the rail distributes the pressure through the high-pressure lines (1) to the piezo injectors (2). The fuel pressure required for injection is determined by the engine control system from the engine load and engine speed. The pressure level reached is registered by the high pressure sensor (4) and transmitted to the motor control unit. Regulation is carried out by the flow control valve (7) after comparing the nominal and actual pressure values in the rail. The pressure sizing is dependent on the type of

The N53 engine is designed to achieve the best fuel consumption and the smoothest operation.



47 - Fuel pressure diagram

Index	Explanation
p	Pressure
m	Motor load
	nNumber of revolutions

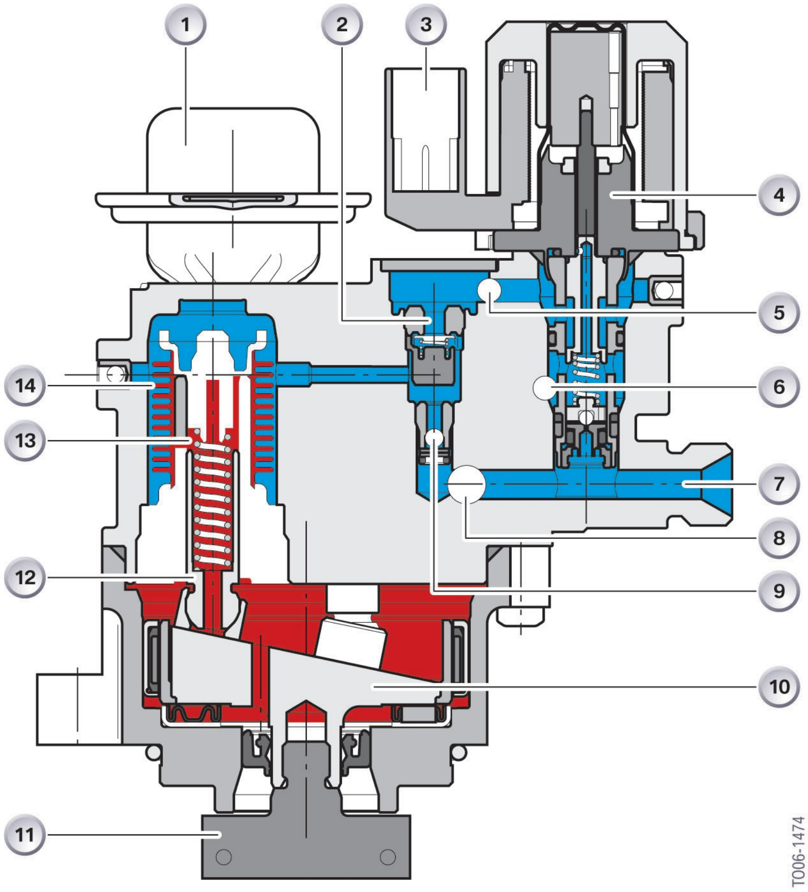


48 - Warning sticker for work on the HPI system

3 Work on this fuel system is only allowed with the engine cooled. The temperature of the
The refrigerant must not exceed 40 °C. It is essential to take into account that, due to the residual pressure in the high-pressure system, there is a danger that pressurized fuel jets will be ejected backwards. 1

3 Work on the high-pressure fuel system must be carried out very cleanly and in accordance with the work sequence described in the repair manual. The presence of small impurities and minor damage to the screw connections of the high-pressure lines can lead to leaks. 1

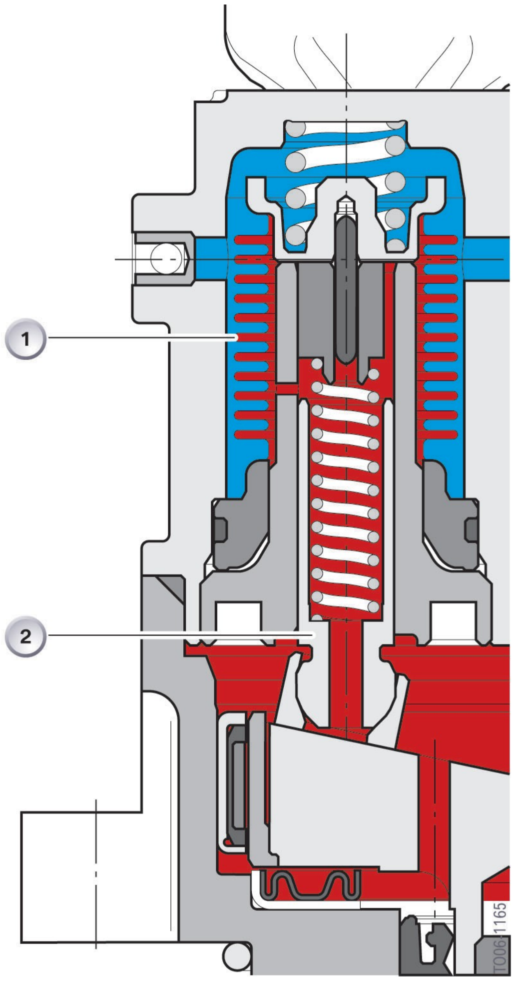
Structure and operation of the high-pressure pump



49 - High pressure pump with flow control valve

Index	Explanation	Index	Explanation
1	Thermal compensator	8	Inlet on pressure limiting valve
2	Low pressure check valve 3x	9	High pressure check valve 3x
3	Connection of the motor control system	10	Oscillating disc
4	Flow control valve	11	High-pressure pump drive flange
5	Pressure limiting valve return	12	Pressure plungers 3x
6	Intake of fuel electric pump	13	High pressure pump oil intake
7	High pressure connection to the rail	14	Fuel chamber 3x

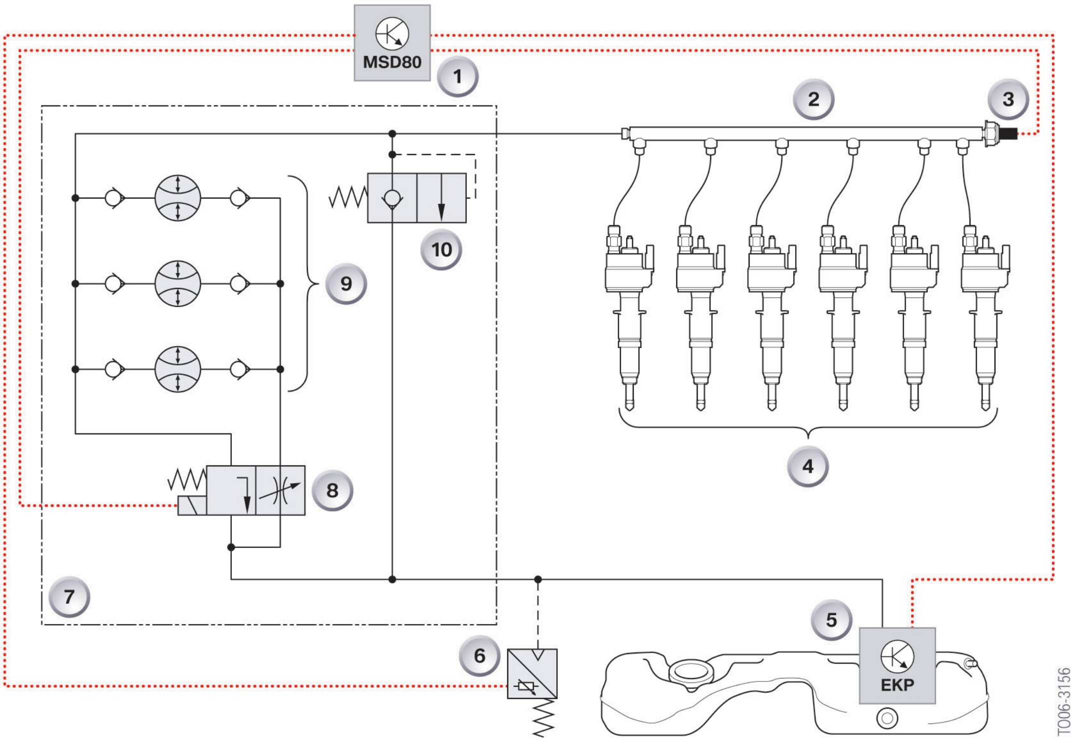
The fuel is pumped through the inlet (6) with the pre-pressure set by the electric fuel pump to the high-pressure pump. From there the fuel is fed through the flow control valve (4) and the low pressure check valve (2) into the fuel chamber (14) of the pumping element. In the pumping element the fuel is pressurized and propelled through the high-pressure check valve (9) to the high-pressure port (7). The high-pressure pump is connected to the low-pressure pump via the drive flange (11) and is thus also driven by the chain drive. This means that as soon as the engine is started, the three pressure-relieving pistons (12) enter into a permanent stroking motion via the oscillating disk (10). In this way the fuel is pressurized as long as more fuel continues to be pumped through the flow control valve (4) to the high-pressure pump. The flow control valve is activated via the connection to the engine control system (3), thus providing the required flow of fuel. The pressure is regulated by the flow control valve by opening or closing the fuel inlet channel. The maximum pressure in the high pressure zone is limited to 245 bar. If this pressure is exceeded, the high-pressure circuit is provided with a pressure limiting valve through the connections (8 and 5) which leads to the low-pressure zone. Due to the incompressible nature of the fuel, this pressure regulation is carried out without any problems. This means that the fuel does not change its volume as the pressure increases. The pressure peaks that occur are compensated by introducing a proportional volume of liquid into the low-pressure zone. The temperature differences make it possible to compensate the volume variations produced in the thermal compensator (1) connected to the oil inlet of the pump.



50 - Pumping element

Index	Explanation
redOil intake	
blue	Fuel
1	Metal membrane
2Pressure plunger	

The pressure piston driven by the oscillating disk (2) compresses oil (red) during its upward movement against the metal diaphragm (1). The increase in volume caused by the metal diaphragm reduces the space available in the fuel chamber. The pressurized fuel (blue) is thus forced into the rail.



51 - Schematic representation of the HPI system

Index	Explanation	Index	Explanation
1	Motor control device	6	Low pressure sensor
2	Rail	7	High pressure pump
3	High pressure sensor	8	Flow control valve
4	Piezoelectric injectors	9	High-pressure pump elements with check valves
5	EKP	10	Pressure relief valve with bypass line

The flow control valve regulates the fuel pressure in the rail. It is activated by a pulse width signal (PWM) from the engine control system. Depending on the activation signal, a variable opening throttle section is left open, thus adjusting the fuel flow rate required for the respective load level. In addition, there is the possibility of reducing the pressure in the rail via piezo injectors.

Emergency operation

There are two levels of emergency operation. With non-plausible exhaust gas values, the engine control does not activate stratified load operation and the injection points move at the rate of the air intake. In such homogeneous operation, the injection pressure is limited to 90 bar in the engine control.

If the engine control system detects a failure of the high-pressure system, e.g. due to a failure of the high-pressure sensor, the flow control valve closes and the flow is prevented; the fuel enters the rail with the pre-pressure created by the electric fuel pump via a bypass. Also in this running situation, the injection points are advanced to the intake rate.

3 With implausible emission values, the engine control unit limits the injection pressure to 90 bar and the N53 engine runs with homogeneous mixture. 1

3 The causes of an emergency operation of the HPI system can be:

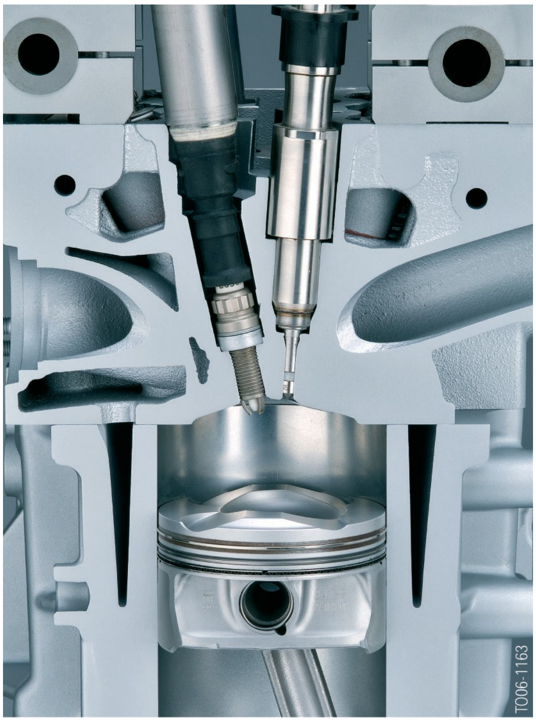
- High pressure sensor values not plausible
- Failure of flow control valve
- Lack of tightness of the high-pressure system
- High pressure pump failure
- High pressure sensor failure.

Piezoelectric injectors with external opening

First of all, the piezoelectric injector with external opening performs the direct injection with directed jet, thus making the general innovations of the N53 engine possible. Only this injector guarantees a stable fuel injection cone, even under the conditions of pressure and temperature prevailing in the combustion chamber. This piezoelectric injector allows injection pressures of up to 200 bar and extremely fast opening of the injector needle. This makes it possible to inject fuel into the combustion chamber independently of the duty cycles limited by the valve opening points. Fuel can be added to the combustion chamber in the appropriate dosage for each operating mode of the N53.

More details are provided in the section on injection strategies.

52 - Piezoelectric injector with external opening



53 - Mounting position of the piezoelectric injector with external opening

The piezo injector is integrated into the cylinder head together with the spark plug in a central position between the intake and exhaust valves. This installation position prevents wetting of the cylinder walls or the bottom of the piston with the injected fuel. A uniform formation of the homogeneous fuel-air mixture is achieved with the help of the gas movement in the combustion chamber and a stable fuel cone. The movement of the gases is influenced on the one hand by the geometry of the inlet channels and on the other by the shape of the piston bottom. The injected fuel enters the combustion chamber turbulently with the charge air until at the ignition point there is a homogeneous mixture in the entire compression chamber.

Injector quantity compensation

Due to the manufacturing tolerances of the injectors, the amount of fuel actually injected varies from the theoretically calculated amount. These tolerances in the quantity injected are determined after production for each injector by measurements carried out by the supplier.

A compensation value is calculated for each injector according to these measurements. When the vehicle is assembled, the compensation values for each installed injector are stored there after installation of the engine control unit.

The compensation values are inserted in the order of installation of each injector in the individual cylinders. With these values, the engine control unit calculates and corrects the fuel quantities to be injected.

With the aid of the service functions, the compensation values of the installed injectors can be stored in the engine control unit.

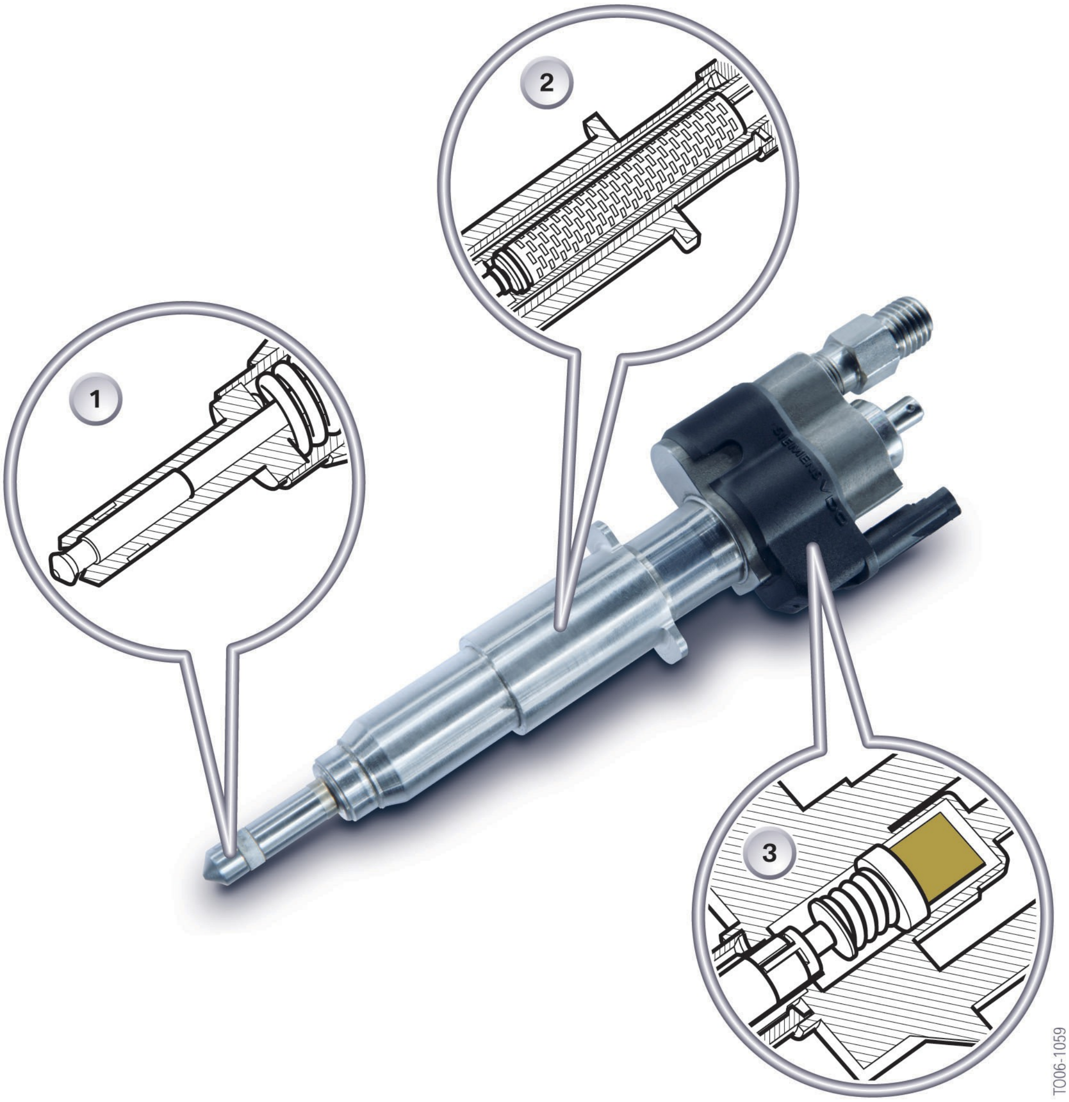
The compensation value is coded and printed on the top of each injector.

3 When the engine control unit or injectors are to be replaced, make sure that the codes printed on each injector are entered for the correct cylinder in the engine control unit. 1

3 When working on the fuel supply system of the N53 engine, it must be ensured that the ignition coils are not contaminated with fuel. The resistance of the silicone material is considerably reduced by the intensive contact with the fuel. This can lead to the spark plug head folding and thus to misfiring.

- Before making any changes to the fuel system, it is imperative to remove the ignition coils and protect the spark plug body with a rag to prevent fuel from entering the interior.
- Before reassembling the piezoelectric injectors, the ignition coils must be disassembled and cleaned as much as possible.
- Ignition coils that are heavily soiled with fuel should be replaced.

Piezoelectric injector structure



54 - Piezoelectric injector components

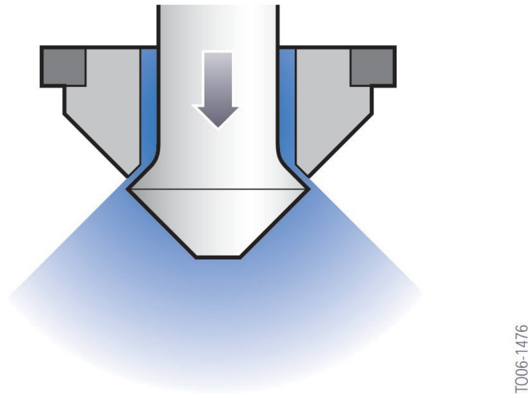
Index	Explanation	Index	Explanation
1	Injector body with 3 outward opening needle		Thermal compensator
2Piezoelectric element			

3 The piezoelectric injector consists essentially of three basic components. The injector needle is lifted out of its seat in the valve by the expansion of the piezo element. In order to be able to tolerate the different operating temperatures with comparable valve opening lifts, the injector is equipped with a thermal compensation element. 1

3 When installing and removing the piezo injector, the Teflon sealing ring must be replaced. This also applies when a newly installed injector is to be disassembled again if the engine has since been started. 1

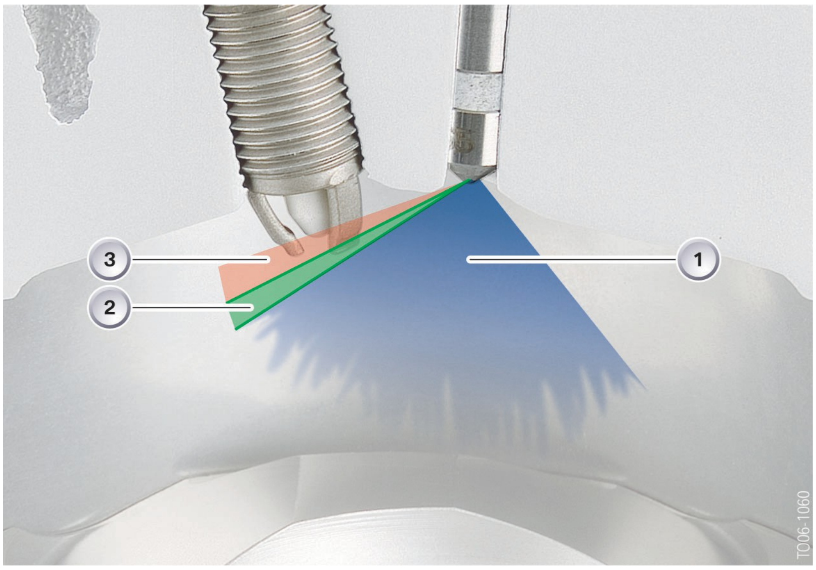
3 A piezo injector fitted with a new Teflon sealing ring should be installed as quickly as possible as the Teflon sealing ring could swell.
The instructions in the Repair Manual must always be observed. 1

3 During assembly, check that the seat of the piezoelectric injector is in perfect condition. 1



55 - Injector needle open to the outside

The injector needle is pushed out of its conical seat in the valve. This frees up an annular passage. The pressurized fuel flows through this annular passage and forms a hollow cone whose jet angle is independent of the back pressure in the combustion chamber.



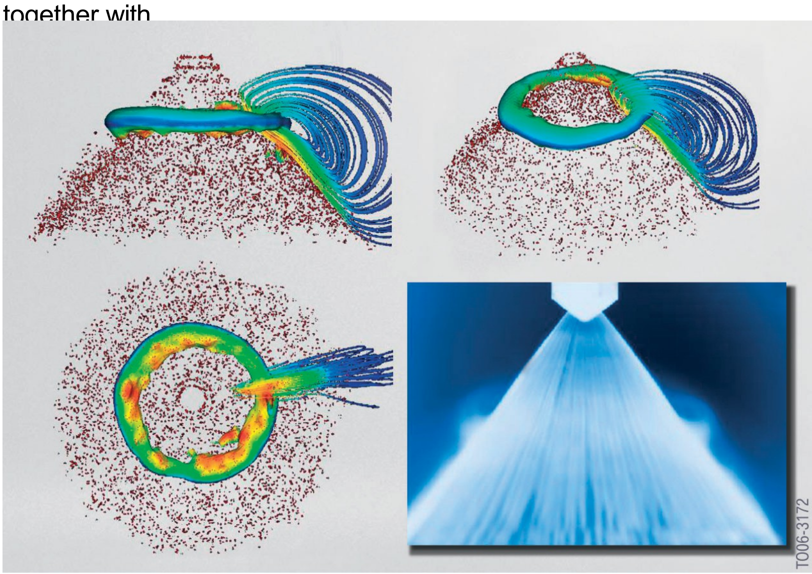
56 - Piezoelectric injector injection cone with outward opening

Index	Explanation	Index	Explanation
1	Ideal pointed cone	3	Unacceptable widening of the injection cone
2	Tolerable injection cone flaring		

The conical jet (1) launched by a piezoelectric injector may widen during operation (2). This is normal and acceptable to a certain degree due to the formation of carbon deposits inside the engine. However, if the spark plug is wetted by the flaring of the jet, the spark plug may be damaged.

Piezoelectric injectors and spark plugs of engine N53

The spark plugs are in a central position in the roof of the combustion chambers together with piezoelectric injectors. They are positioned to ensure that the spark can ignite the fuel mixture in any operating situation.



57 - Engine injection cone N53

The spark plug is always inside the fuel vortex that forms around the injected fuel cone.

In the graph above you can see how in the outer contour of the fuel cone, the injected fuel starts a rotary motion. This causes a fuel concentration that represents the fuel area where the spark should be located.

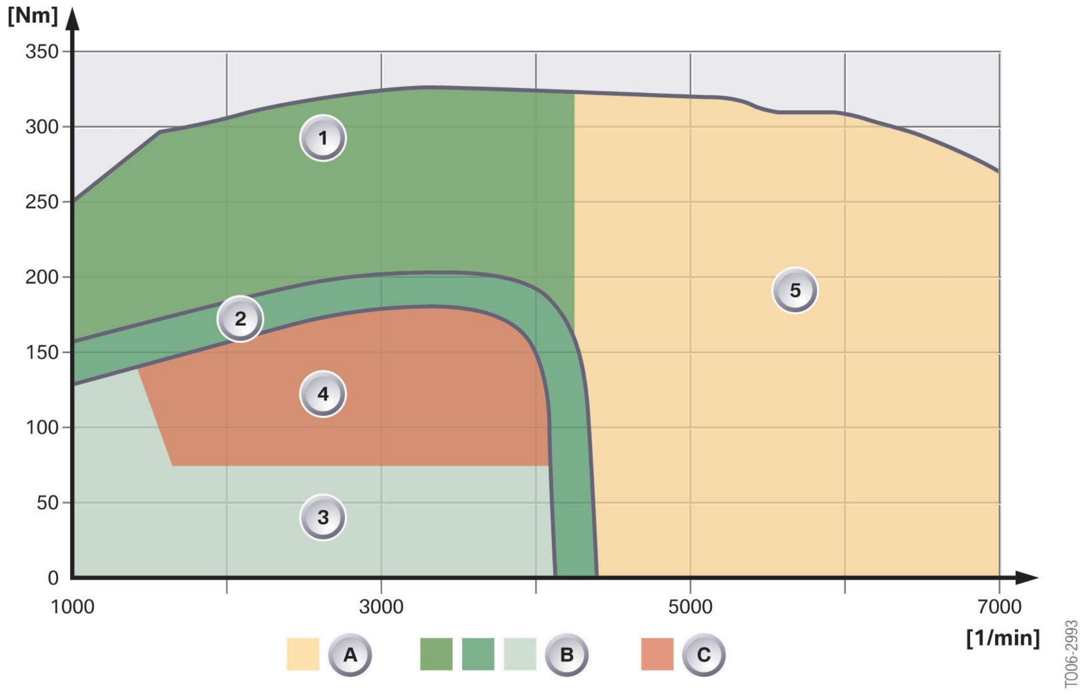
This ensures ignition capability in every operating mode. However, this places a great deal of stress on the spark plug.

In engine operation, typical spark plug structures are formed which, as long as they do not show breaks in the insulator foot, cannot be considered as faults.

58 - N53 engine spark plug in good condition

5[illegible] tion

Injection strategy



60 - Engine injection strategy N53

Index	Explanation	Index	Explanation
A	Simple injection	2	First injection in the intake stroke Second injection just before ignition PMS
B	Double injection	3	Double injection just before ignition PMS
C	Triple injection	4	Triple injection in the second half of the compression stroke
1	First injection in the intake stroke Second injection in the first half of the compression stroke	5	Single injection on the intake stroke

In measuring the amount of fuel required according to the engine speed, the engine control uses several degrees of freedom.

On the one hand, the available time is used and the required quantity is distributed over several injection steps.

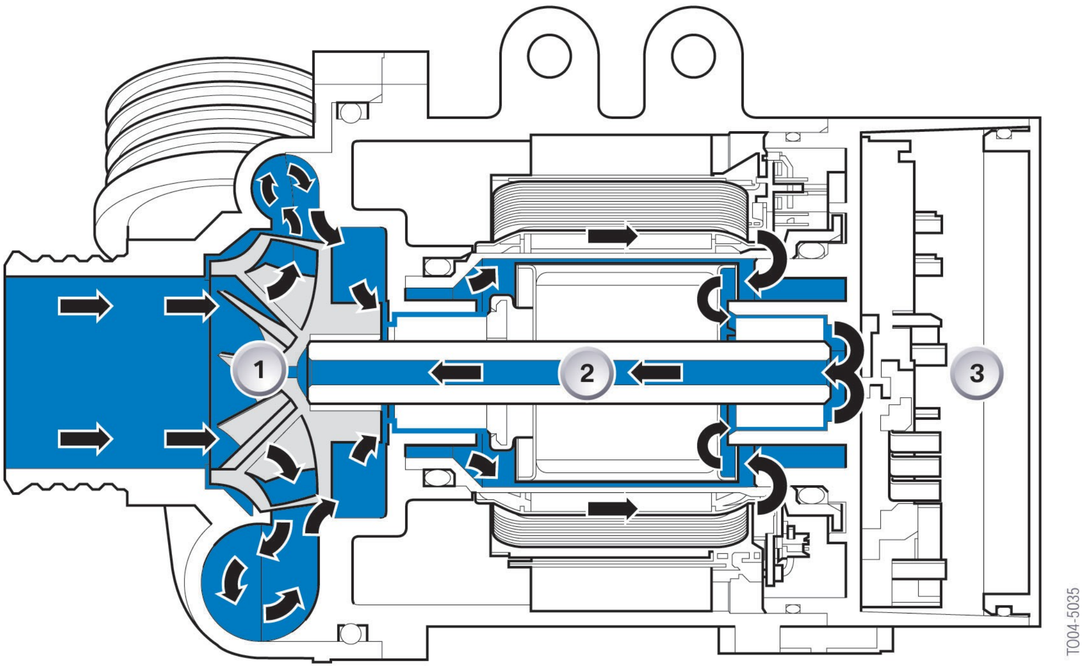
On the other hand, the possibilities offered by the stratified operation of a direct injection engine are also used, such as the cooling of the combustion chamber by liquid fuel injected late, thus achieving a higher degree of thermal efficiency.

Cooling system

The same situation described for the oil circuit is repeated in the coolant circuit. With a conveying adjusted to the needs, performance losses are avoided. In older engines, the volumetric capacity of the coolant pump is calculated according to the maximum cooling requirement of the engine, which in most cases is not necessary. Therefore, the excess coolant circulates in most cases unused through the thermostat in a small circuit. The system has also been optimized on the N53 engine to avoid these performance losses. This type of engine cooling also makes it possible to achieve temperature ranges adapted to the engine load.

The N53 engine also features the thermal management and system protection functions introduced in the N52 and N54.

Electric coolant pump



61 - Electric coolant pump with cooled liquid

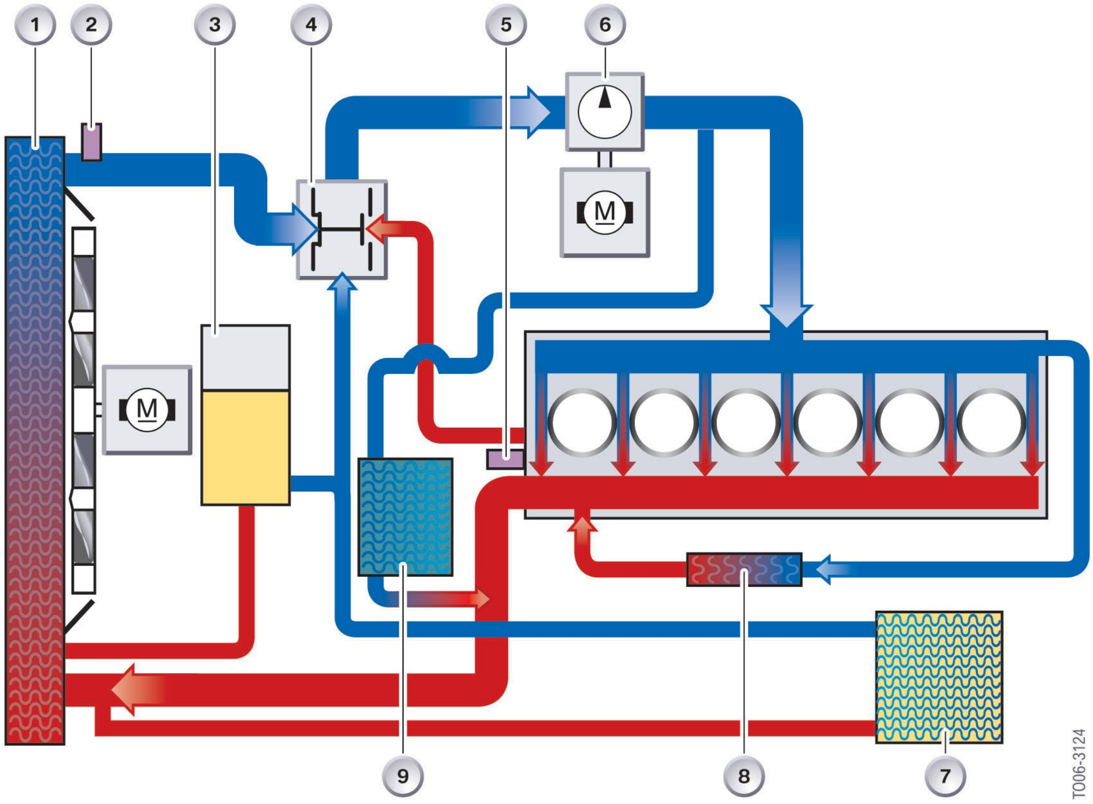
Index	Explanation	Index	Explanation
1	Pump	3	Electronic component (EWPU)
2	Engine		

The coolant pump of the N53 motor consists of an electrically driven centrifugal pump. The power of the electric motor (max. 200 W) with wet type counter is controlled electronically via the electronic component (EWPU) located under the motor closing cover. The EWPU is connected to the DME motor control unit via the serial bit data interface. The motor control unit determines from its The system coolant flows through the coolant pump motor through the coolant pump motor, the load, the operating mode and the temperature sensor data and gives the corresponding command to the EWPU control unit. The system coolant flows through the coolant pump motor. This allows both the motor and the electronics to cool down. The bearings of the electric coolant pump are lubricated by the coolant.

3 During assembly work care must be taken to ensure that the pump does not run dry. When disassembling the pump, it must be stored filled with coolant. The bearing points of the pump can stick together if the pump is not filled with coolant. This could endanger the subsequent start-up of the pump and put the entire thermal regulation system out of operation (if the pump is not started, serious damage to the motor can occur).

If the pump is operated empty, the pump wheel must be turned by hand before completing the installation of the coolant hose. In direct connection with this the system must be filled with coolant. 1

3 During assembly work, it must be ensured that the connector is dry and clean and that the connections are undamaged. 1



62 - Engine cooling system chart N53

Index	Explanation	Index	Explanation
1	Radiator (refrigerant/air heat exchanger)	6	Electric coolant pump
2	Temperature sensor at radiator outlet	7	Heating heat exchanger
3	Expansion tank	8	Exhaust gas recirculation valve
4	Characteristic field thermostat	9	Radiator (coolant/engine oil heat exchanger)
5	Cylinder head outlet temperature sensor		

The cooling performance of the N53 engine can be adapted by means of a freely varying coolant volumetric flow. When the engine is warm, it is possible to stop the coolant pump or also be operated when the engine is stopped. The engine cooling system is installed in the engine cooling system for cooling the recirculation valve housing for its protection.

Engine control system

Motor control device

The MSD80 motor control is also used on the N53 motor. The system is based on the MSV70 motor control unit, which was upgraded in the MSD80 version for installation on the N54 motor.

The engine control was adapted to the peculiarities of the N53 engine.

The MSD80 for the N53 motor differs in the following connections compared to the MSD80 intended for the N54 motor.

- The following connections are missing:
  - Discharge valves
  - Pressure and temperature sensors upstream of the throttle valve (boost pressure)
  - Diagnostic module for tank leakage (DMTL)
  - Oil pressure switch
- The following connections are added
  - DISA adjuster (quantity according to intake air system table)
  - Electrohydraulic pressure regulating valve of the oil pump
  - AGR Valve
  - Exhaust gas temperature sensor
  - NOX sensor
  - Oil pressure sensor.

Engine mechanics

TE06-0645

Magnesium as an engine construction material

Magnesium and aluminum crankshaft crankcase

3 During installation work on the crankcase of the N53 engine, the following must be followed scrupulously follow the instructions in the repair manual. 1

Welding technology

Joints

3 Damaged gaskets must be replaced, since if a gasket is damaged, contact corrosion between the aluminum of the cylinder head and the magnesium of the crankcase will occur within a short time. 1

Bolted joints

3 The aluminum screws can only be used once and must always be replaced after unscrewing. 1

Functional description of exhaust gas treatment

NOX accumulator catalyst

3 Outside the active temperature window of the NOX accumulator catalyst, the engine operates with homogeneous mixture. 1

NOX accumulator catalyst saturation

3 When replacing an N53 motor control unit, you must transfer the aging and sulfuration states of NOX accumulator catalysts. 1 3 When an accumulator catalyst is due for renewal, the catalyst aging and sulfidation values must be reset in the engine control system. 1

Accumulation capacity

NOX accumulator catalyst sulfurization

3 Sulfurization of the NOX accumulator catalyst means that the engine can only be operated with a homogeneous mixture, as the nitric oxides cannot be absorbed. This destroys all fuel consumption advantages. of this lean-burn, direct injection engine and higher CO_2 emissions are produced. 1

3 If the engine is permanently operated with high-sulfur fuel, energy-saving and environmentally friendly operation will be prevented forever. 1

3 Sulfurization of the NOX accumulator catalyst is not a violation of legal emission standards. The N53 engine will continue to operate safely within the limits set by the standard.
EURO 4. 1

3 The sulfidation of the NOX accumulator catalyst is reversible. 1

3 The absorption capacity of the NOX accumulator catalyst for nitric oxides and, consequently, its aging, depends on:

- Fuel quality with respect to sulfur release
- Catalyst operating temperatures.

Fuel supply system

High Precision Injection (HPI)

Overview and operation

3 Work on this fuel system is only permitted when the engine is cooled down. The coolant temperature must not exceed 40 °C. This is fundamental to take into account that, due to the residual pressure in the high-pressure system, there is a danger that pressurized fuel jets will be ejected backwards. 1

3 Work on the high-pressure fuel system must be carried out very cleanly and in accordance with the work sequence described in the repair manual. The presence of small impurities and minor damage to the screw connections of the high-pressure lines can lead to leaks. 1

Emergency operation

3 With implausible emission values, the engine control unit limits the injection pressure to 90 bar and the N53 engine runs with homogeneous mixture. 1

3 The causes of an emergency operation of the HPI system can be:

- High pressure sensor values not plausible
- Failure of flow control valve
- Lack of tightness of the high-pressure system
- High pressure pump failure
- High pressure sensor failure.

Injector quantity compensation

3 When the engine control unit or injectors are to be replaced, make sure that the codes printed on each injector are entered for the correct cylinder in the engine control unit. 1

3 When working on the fuel supply system of the N53 engine it should be noted that the coils

The resistance of the silicone material is considerably reduced by the intensive contact with the fuel. The resistance of the silicone material is considerably reduced by the intensive contact with the fuel. This can lead to the spark plug head folding and thus to misfiring.

- Before making any changes to the fuel system, it is imperative to remove the ignition coils and protect the spark plug body with a rag to prevent fuel from entering the interior.
- Before reassembling the piezoelectric injectors, the ignition coils must be disassembled and cleaned as much as possible.
- Ignition coils that are heavily soiled with fuel should be replaced.

Piezoelectric injector structure

3 The piezoelectric injector consists essentially of three basic components. The injector needle is lifted out of its seat in the valve by the expansion of the piezo element. In order to be able to tolerate the different operating temperatures with comparable valve opening lifts, the injector is equipped with a thermal compensation element. 1

3 When installing and removing the piezo injector, the Teflon sealing ring must be replaced. This also applies when a newly installed injector is to be disassembled again if the engine has since been started. 1

3 A piezo injector fitted with a new Teflon sealing ring should be installed as quickly as possible as the Teflon sealing ring could swell.
The instructions in the Repair Manual must always be observed. 1

3 During assembly, check that the seat of the piezoelectric injector is in perfect condition. 1

Cooling system

The same situation described for the oil circuit is repeated in the coolant circuit. With a conveying adjusted to the needs, performance losses are avoided. In older engines, the volumetric capacity of the coolant pump is calculated on the basis of the maximum cooling requirement of the engine, which in most cases is not necessary. Therefore, the excess coolant circulates in most cases unused through the thermostat in a small circuit. The system has also been optimized on the N53 engine to avoid these performance losses. This type of engine cooling also makes it possible to achieve temperature ranges adapted to the engine load.

The N53 engine also features the thermal management and system protection functions introduced in the N52 and N54.

Electric coolant pump

3 During assembly work, care must be taken to ensure that the pump does not operate at dry. When the pump is disassembled it should be stored full of coolant. The bearing points of the pump may stick together if the pump is not filled with coolant. This could endanger the subsequent start-up of the pump and put the entire thermal regulation system out of operation (if the pump is not started, serious damage to the engine may occur).

If the pump is put into idle operation, the pump wheel must be turned by hand before completing the installation of the coolant hose. In direct connection with this the system must be filled with coolant. 1

3 During assembly work, it must be ensured that the connector is dry and clean and that the connections are undamaged. 1

Test questions. Engine N53.

Catalog of questions

In this section you can test the knowledge acquired. Questions are raised about the N53 engine.

Verification of acquired knowledge

1. What is meant by the term EfficientDynamics?

4The development of engines in which power, fuel consumption and weight are in an optimum ratio.

4 It is a marketing concept for BMW's new inline 6-cylinder engine family.

4 That all measures in the development of an engine are aimed at optimizing the utilization of fuel combustion in a more environmentally friendly way.

2. When disassembling the alternator, you have loosened blue head bolts. What do you need to take into account when reassembling?

4 Nothing

4 Check for proper torque when retightening them

4That it is an aluminum screw to be secured with a screw-locking means

4 The blue head means that it is an aluminum screw that should not be reused.

4 That the new aluminum screws must be tightened according to the prescribed procedure.

3. What is the oil pressure regulated with in the N53 engine?

4 With the control of the oil pump that conveys the volume of oil necessary for the required pressure at any given moment

4With oil pressure switch

4 With engine revolutions.

4. What is the higher exhaust gas ratio of a conventional engine?

4 H_2O

4 N_2

4 CO

4 CO_2.

5. What is the proportion by volume of noxious substances in the exhaust gas of a conventional engine?

4 3%

4 5%

4 10 %

4 1 %.

6. **A special technical device is used in the N53 engine to reduce the nitric oxides produced. Why do engines operating with lambda = 1 not need such an installation?**

4Because in engines with lambda = 1 the limit values are much wider and nitric oxides are accepted in the exhaust gas.

4 Because higher capacity 3-way catalytic converters are used

4Because in engines with lambda = 1, much less nitric oxide is produced.

4Because in homogeneous combustion there are sufficient carbon-containing exhaust gas components to be able to convert the emitted nitric oxides.

7. **What is the great advantage of reducing CO_2 in the exhaust gas?**

4 Reduced odor nuisance when driving in garages

4By reducing CO_2 emissions, fuel consumption is reduced.

4 Increased spark plug life

4The reduction of CO_2 reduces global warming.

8. **What are the consequences of constantly running the N53 engine on high sulfur fuel?**

4 Oil change intervals should be reduced.

4 Sulfur accumulates in the NOx accumulator catalyst and prevents the concentration of nitric oxides.

4The motor can only be operated homogeneously

4Increases fuel consumption.

9. **What types of gas recirculation are used in the N53 engine?**

4 None

4 Internal gas recirculation

4 External gas recirculation

4 Cyclic gas recirculation.

10. **In which working stages can fuel be injected into the N53 engine?**

4 At the work stage

4 In the compression stage

4 At the admission stage

4 At the expulsion stage.

Solutions to questions

1. **What is meant by the term EfficientDynamics?**

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