# Reference Manual

# ENGINE TECHNOLOGY

## Technical Training

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Reference Manual

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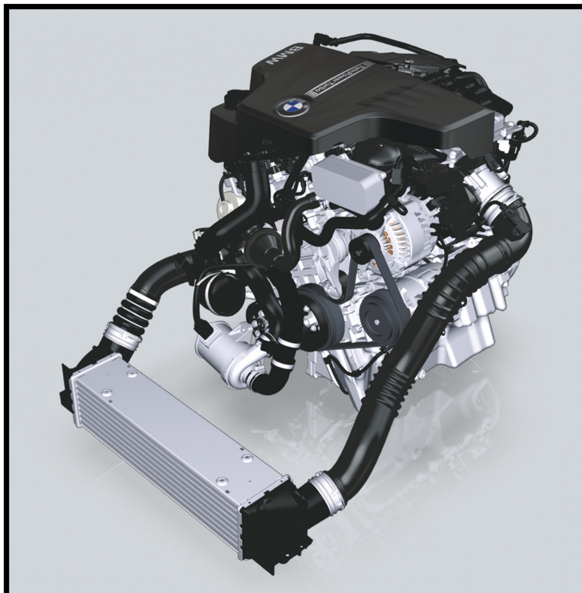
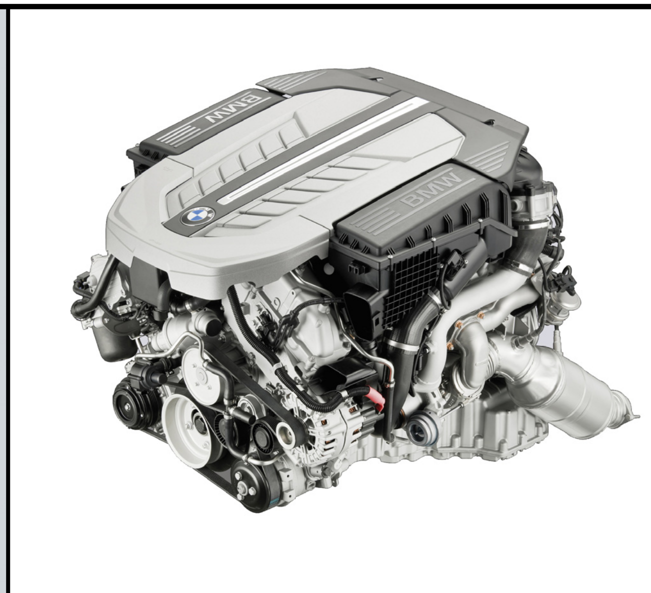
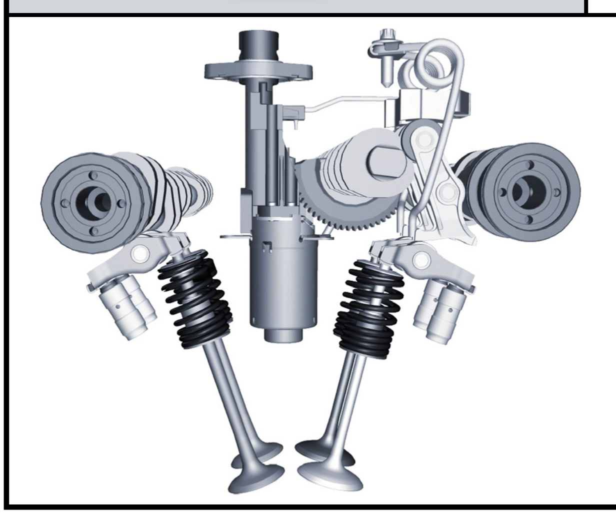
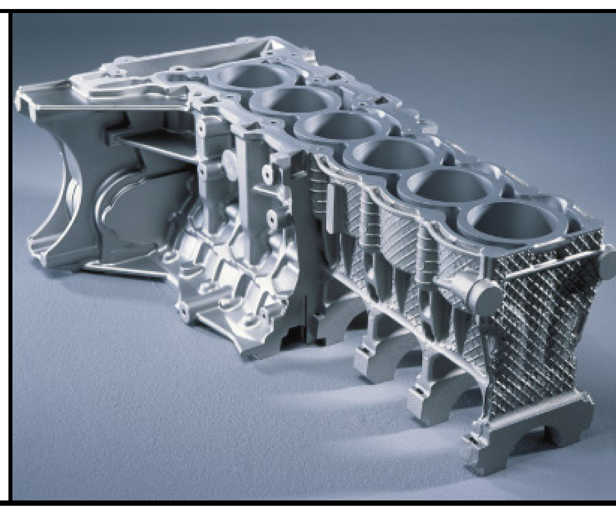
# BMW
## Technical Training

# Engine Technology









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## Basic Measuring Techniques

**Subject** **Page**



Initial Print Date: 03/05 Revision Date: 03/15

# Basic Measuring Techniques

## Model: All

# OBJECTIVES

After completion of this module you will be able to:

- Use basic measuring tools
- Perform basic engine measurements
- Understand metric measurements

## Basic Engine Measurements

During the course of engine repairs some basic engine measurements are required to verify engine diagnosis as well as to complete proper repairs. These measurements are made by precision measuring tools such as micrometers, Vernier calipers, cylinder bore gauges and dial indicators.

**N52 engine cut-away**

Also, a working knowledge of the metric system is also a vital skill that is needed by the technician. All BMW engine measurements consist of metric specifications. Some of the routine engine measurements performed include:

- Valve Guide Wear (Tilt Angle K)
- Cylinder Bore Measurements (Taper and Out-of-Round)
- Cylinder Head Warpage and Thickness
- Axial and Radial Endplay Measurements (Crankshaft/Camshaft etc)

Among all of the skills possessed by a modern technician, basic measuring techniques are perhaps the most overlooked and least used. This is why it is important to review these skills from time to time as a refresher.

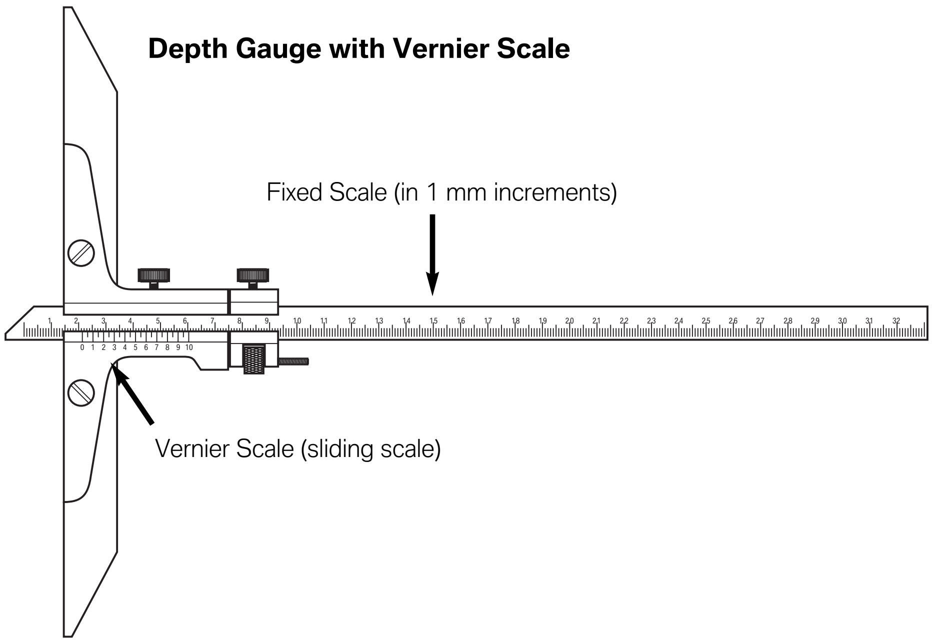
Also, it is necessary to access technical data to obtain the proper specifications for these measurements. This course is designed to review measuring techniques to assist in engine diagnosis.

## Vernier Measurement

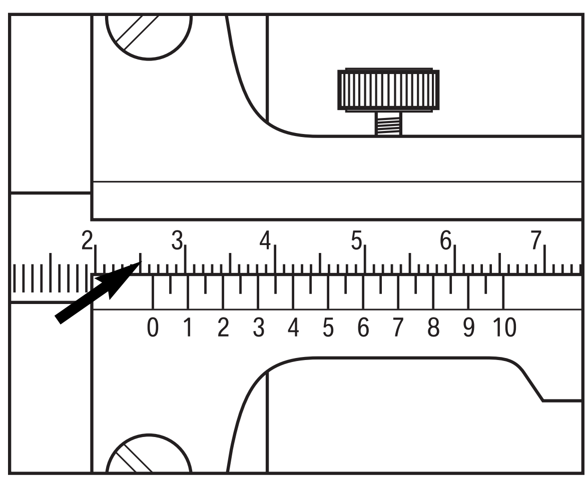
The Vernier scale is used on various measuring tools such as the Vernier caliper and the Depth Gauge. The Vernier scale can be used with Fractional (US) and Metric systems. For the purposes of this training module we will always refer to the Metric Vernier scale.

The Vernier scale consists of a fixed scale and a sliding scale. The fixed scale is divided with graduations in 1 millimeter increments. The sliding scale has 10 graduations in increments of 0.5.

**Depth Gauge with Vernier Scale**




In order to read a measurement, use the zero mark on the left end of the vernier scale to use as a guide to read a measurement on the fixed scale.




In the example shown at the right, the zero mark is resting between 26 and 27 mm. Therefore the base measurement is 26 mm.

Next, the decimal measurement must be taken. For this, find a line on the Vernier that most closely matches any line on the fixed scale.

Using the example drawing, the “4” on the Vernier scale is lining up directly with a line on the fixed scale.

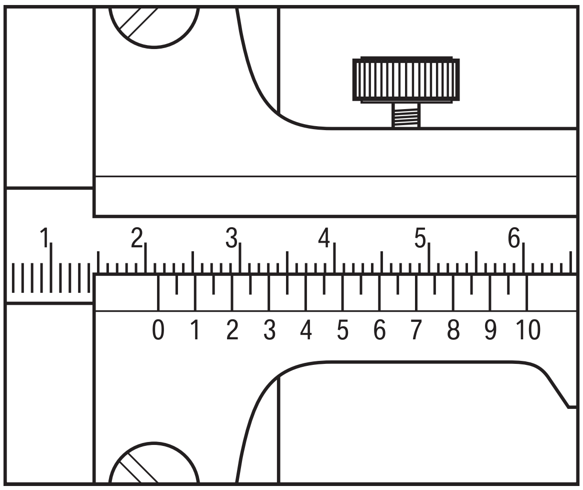
Combining the previous reading with this reading, the result would be 26.4 mm.

The designations on the Vernier scale are in increments of 0.5. For example, if a reading on the Vernier scale falls on the 0.5 (i.e. 2.5, 3.5 etc) designation this would indicate 5/100th’s of a millimeter.

## Classroom Exercise - Vernier Readings

Fill in the correct Vernier scale readings in the spaces provided below.

**Vernier 1**




**Vernier Reading 1:**

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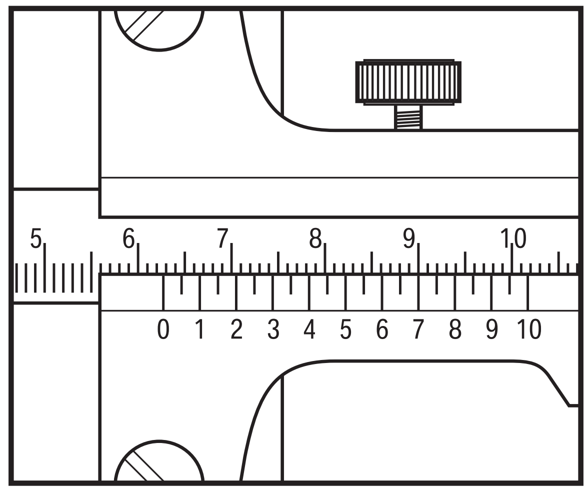
**Vernier 2**




**Vernier Reading 2:**

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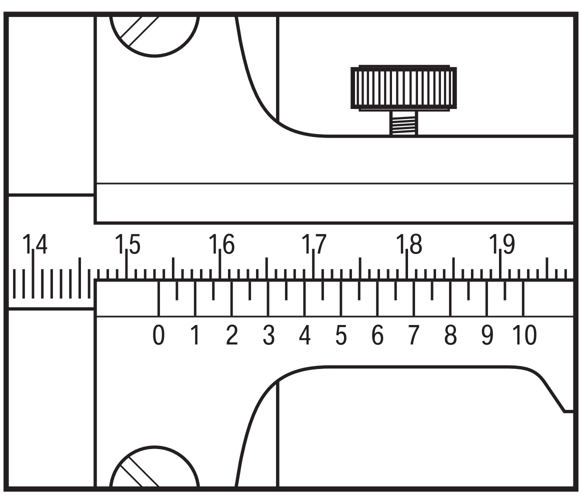
**Vernier 3**




**Vernier Reading 3:**

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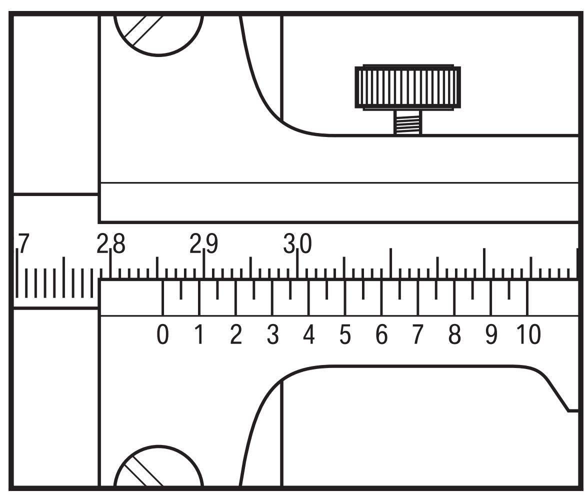
**Vernier 4**




**Vernier Reading 4:**

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## Micrometer Measurements

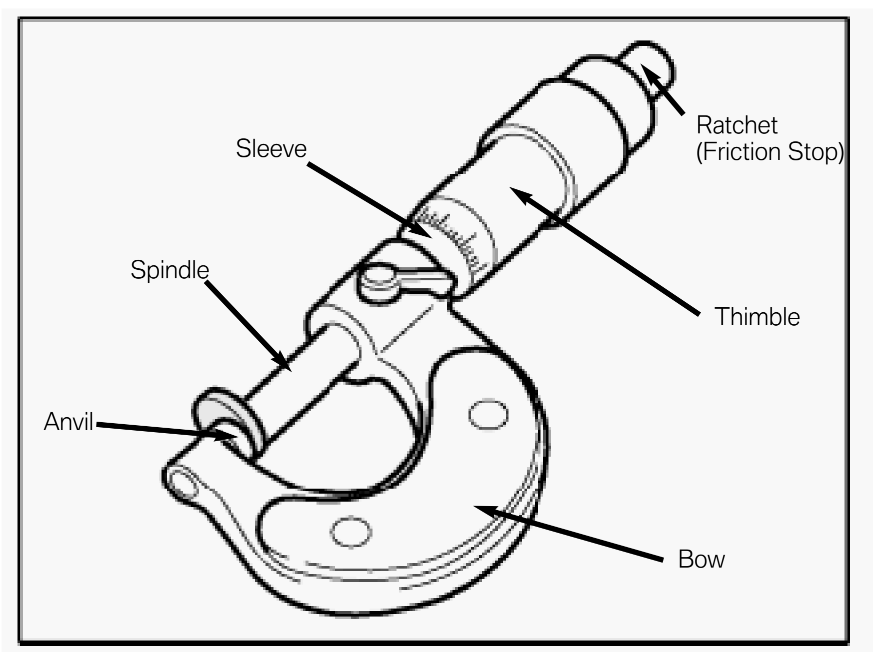
Another valuable measuring tool is the micrometer, which can be used for measurements such as bearing journal diameter, cylinder head thickness, valve shim thickness and brake rotor thickness etc. Micrometers also come in configurations for inside measurements as well.

The micrometer scale comes in both fractional and metric varieties. We will cover only the metric micrometer scale in this course.

First you must familiarize yourself with the construction of the micrometer in order to understand how measurements are made.

### Metric Micrometer Construction

The micrometer is constructed of a few basic parts. The actual item to be measured is placed between the anvil and the spindle. The micrometer can be adjusted to the approximate size using the thimble. The thimble should only be used for the coarse adjustment. In order to make the actual measurement, the micrometer should only be turned using the ratchet (a.k.a. the friction stop). Do not attempt to make a measurement using the thimble. This will give an inaccurate measurement and ultimately damage the micrometer.

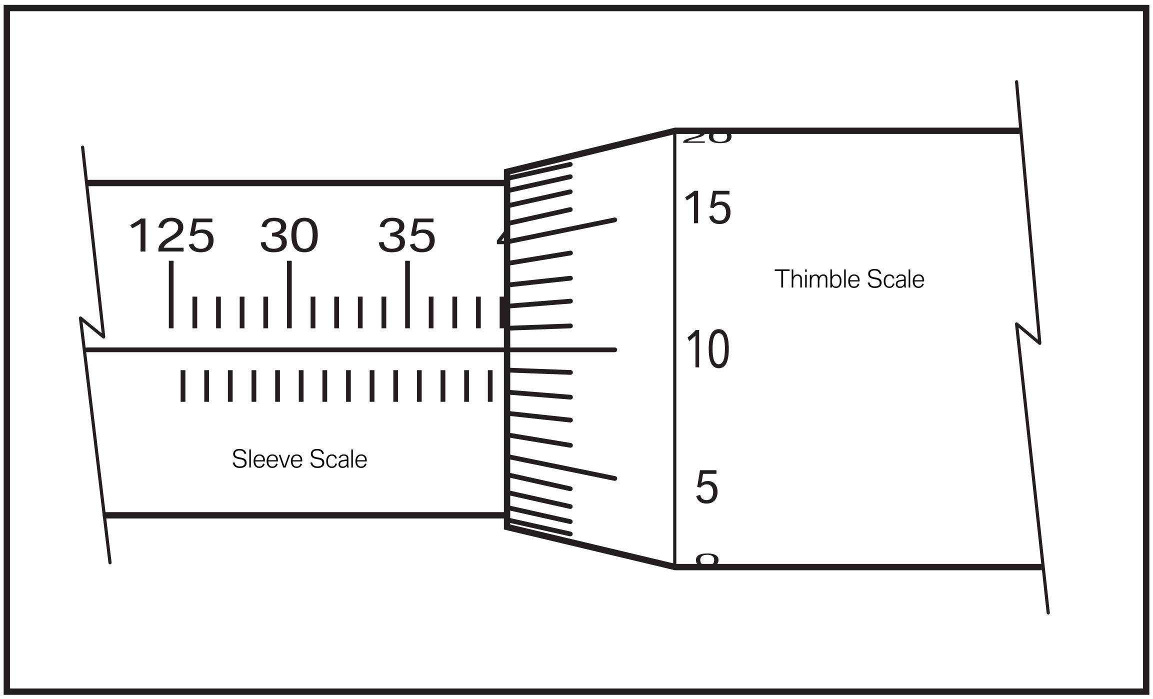



Micrometers are available in various sizes for outside as well as inside measurements. The more common variation is the outside micrometer. They are usually available in 25 millimeter increments such as 0-25 mm, 25-50 mm, 50-75 mm etc.

The metric micrometer can measure in increments of one hundredth of a millimeter (0.01mm). One hundredth of a millimeter is equal to 0.0003937 inch which is less than one thousandth of an inch.

The measurement area of the micrometer consists of the sleeve scale and the thimble scale. The sleeve scale is used to read whole and half millimeters. The thimble scale (which rotates) reads in hundredths (0.01) of a millimeter from zero to fifty. Two complete revolutions of the thimble equals one millimeter.

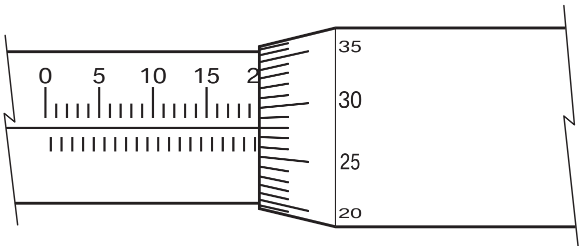
On the sleeve scale, each scale mark above the center line indicates whole millimeters. Below the center line, half of a millimeter (or 0.5mm) increments are indicated.

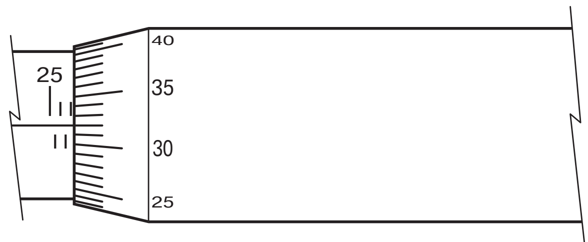



Using the example shown above, the micrometer is a 125-150mm micrometer. To read this micrometer, first take the basic reading from the sleeve scale. The thimble is past the 139 mm mark. Therefore the reading is a least 139 mm. Next, look at the thimble scale and note the reading on the centerline. The “10” on the thimble scale is lined up with the centerline. This indicates a reading of 0.10 mm. If you add the two readings; 139 + .10 = 139.10 mm.

## Classroom Exercise - Micrometer Measurements

Fill in the correct micrometer readings in the spaces provided below.




**Micrometer Reading 1:**

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**Micrometer Reading 2:**

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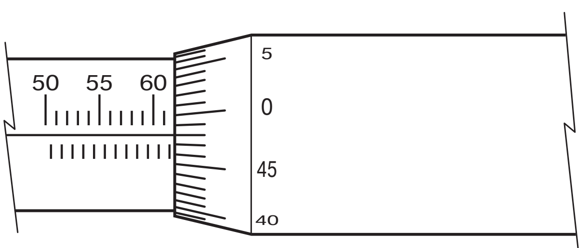


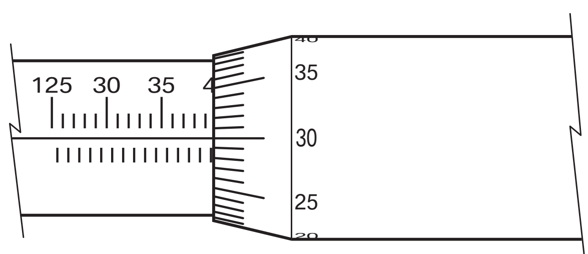


**Micrometer Reading 3:**

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**Micrometer Reading 4:**

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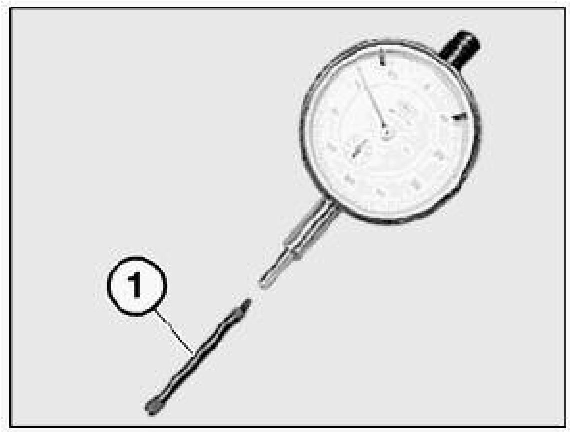
## Dial Indicator Measurements

The dial indicator is used to measure the travel or movement of a specific item. It can also be used to measure axial and radial runout. In engine measurement applications, the dial indicator can be used to measure valve guide wear, axial movement of the crankshaft (thrust), and runout of flywheels and harmonic balancers.

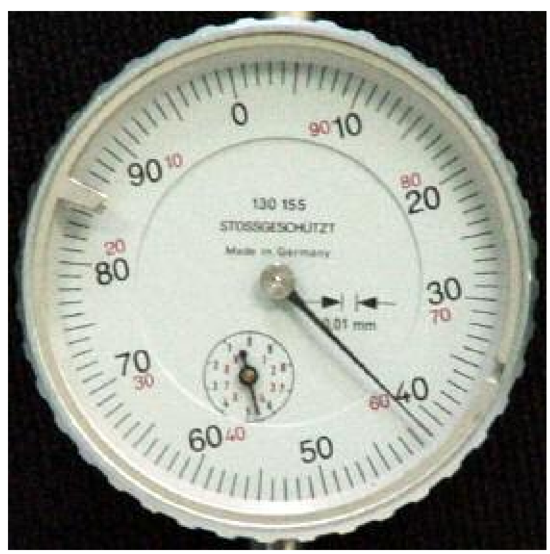
First, it is important to familiarize yourself with Dial Indicator construction. The face of the dial indicator consists of a moveable bezel which is also attached to the large measuring scale. This allows the tool be brought to the “zero point” when needed.

The main measuring device is the contact point. The contact point (1) is placed against the object to be measured. Usually, the contact point is rounded or has a ball bearing. This allows for a more accurate measurement.




The measuring face of the dial indicator consists of 2 scales. The smaller scale is for the ‘coarse” measurement which is in graduations of 1 millimeter. One revolution of the small scale is 10 millimeters.

The large scale is in graduations of 0.01 millimeter and the scale goes from zero to one hundred. Therefore, one revolution of the large scale is one millimeter.

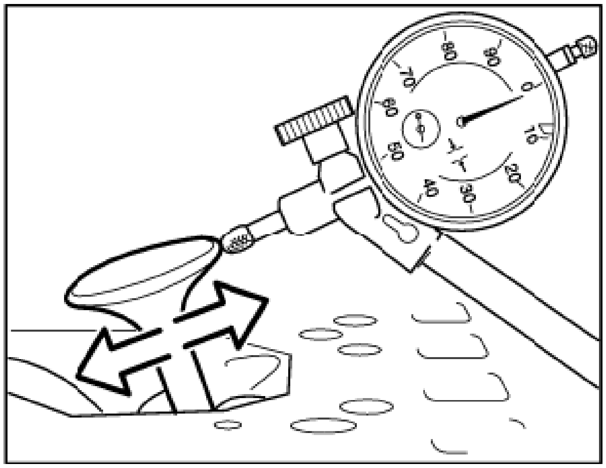



The dial indicator also needs to be held in place when taking a measurement. This requires a stand or base. Depending upon the application, these stands can be a clamp type, magnetic or a threaded base.

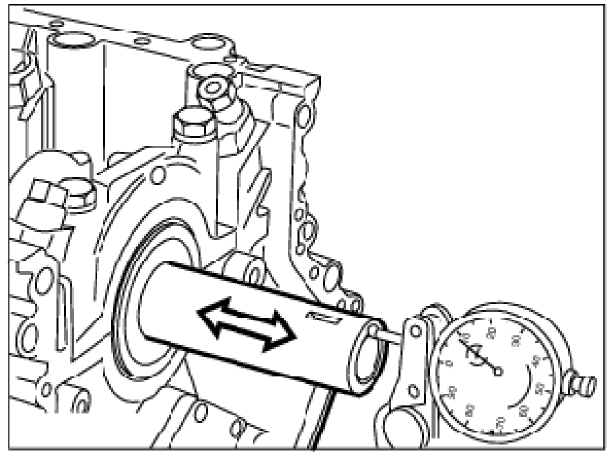
When taking a measurement, place the contact point on the object to be measured. The dial indicator must be pre-loaded slightly to prevent the measurement from bottoming out.

When reading the scale, be sure to “zero” the dial indicator first. If the readings to be taken are less than 1 millimeter, you do not need to use the small scale. If the readings are larger than 1 millimeter, be sure to factor the small scale into your measurement.

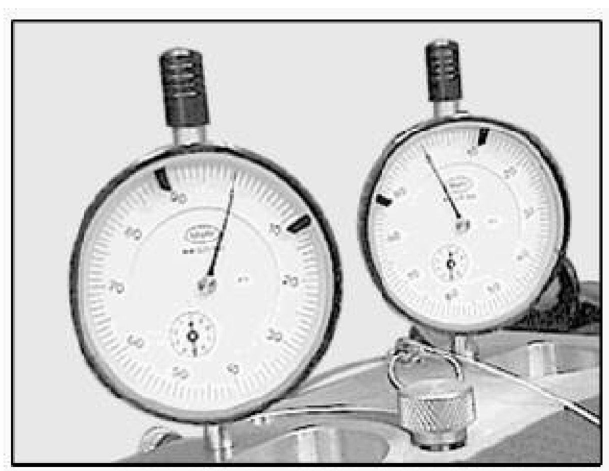
## Examples of Dial Indicator Measurements



Valve Guide Wear - Tilt Angle “K”



Crankshaft Endplay - Axial

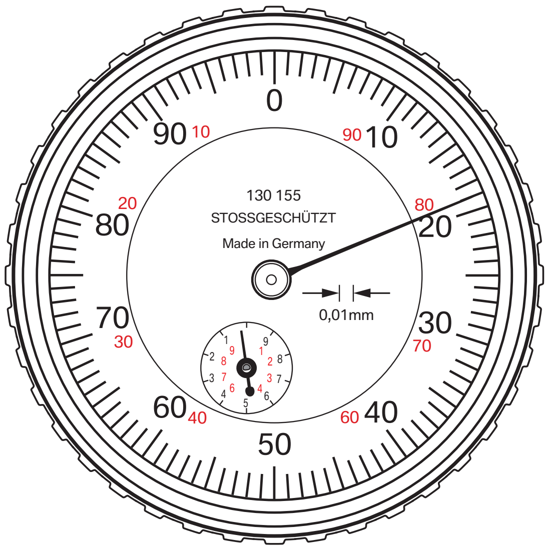


S62 Engine - Basic Throttle Setting

## Classroom Exercise - Dial Indicator Measurements

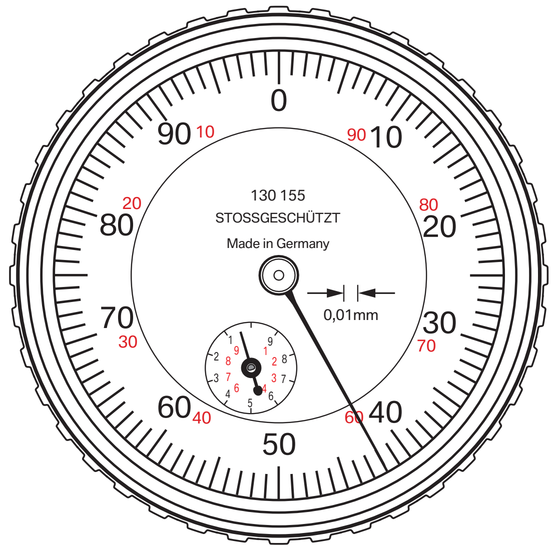
**Compare the dial indicator readings, and determine the total travel. Record your results below in the spaces provided.**

**Dial indicator A**



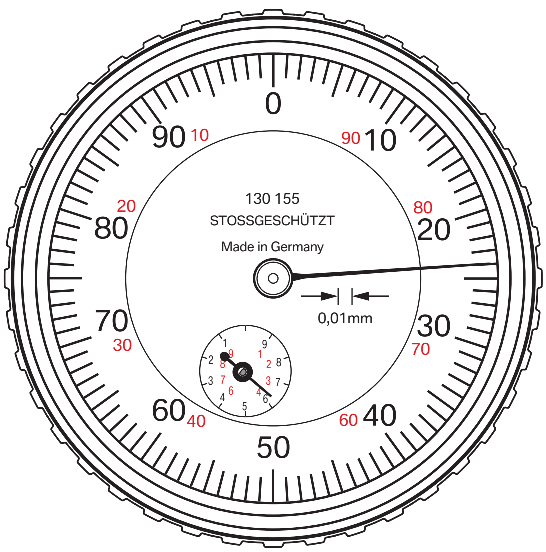

Reading: ______________

**Dial indicator B**



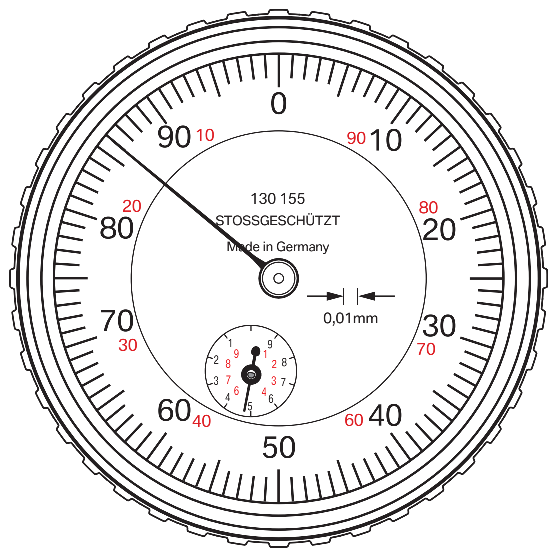

Reading: ______________

**Dial indicator C**




Reading: ______________

**Dial indicator D**




Reading: ______________

# Additional Engine Measurements

During engine repair procedures it is sometimes necessary to assess engine wear to make determinations on parts replacement. Also, some engine measurements are needed to verify a previous diagnosis.

For example, a cylinder leakdown test could indicate a cylinder sealing concern. Once the engine is disassembled, it would be necessary to verify this condition by checking the piston and piston ring condition. If OK, the next step would be to determine the condition of the cylinder bore. At this point, the cylinders should be checked for taper (conicity) and for out-of-round. The correct measurements could mean the difference between just replacing the rings and/or pistons or replacing the engine block. This is why it is necessary to make accurate measurements when needed.

Some of the other routine engine measurements include:

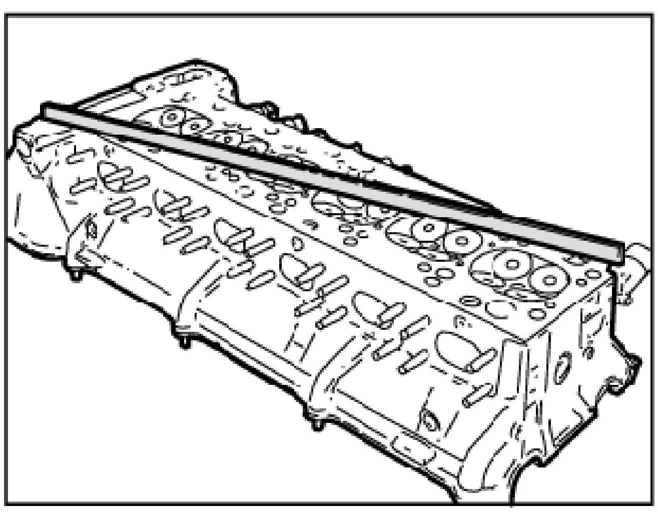
- Cylinder head warpage
- Cylinder head thickness (on some applications)
- Piston rings - end gap and axial clearance

* Cylinder bore - including out-of-round and taper

## Cylinder Head Measurement

If a repair requires removal of the cylinder head, a few basic measurements can be performed to save time and unnecessary machine shop costs. If an engine has been overheated or has an internal or external fluid leakage (coolant/oil), it is a good idea to check the cylinder head for warpage.

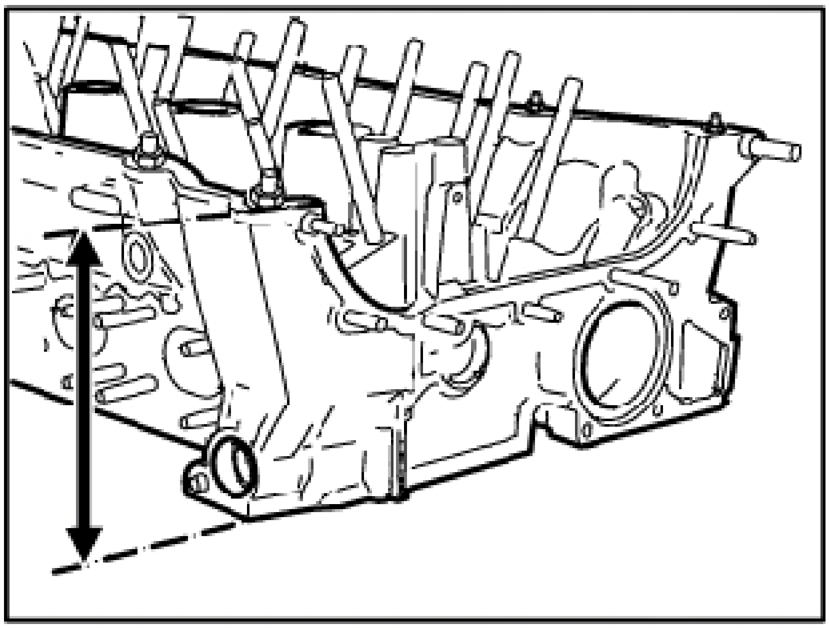
This can be done by using a commercially available machinists straight edge and a feeler gauge. By sliding the feeler gauge under the straight edge in various locations, it can determine if there are any low spots or warpage. The specifications for warpage are found in ISTA under Technical Data. Usually, the specification is about 0.05 mm.



Also, check to see if the cylinder head has a specification for machining limit. If so, it may be possible to have the cylinder head re-surfaced. Depending on the amount of material removed during the machining process, it may be necessary to install a thicker head gasket. There are some “service” head gaskets available through the parts department.

The cylinder head can be checked for minimum thickness. This is done using a micrometer or a vernier caliper. This is not possible on all engines, the example shown below is a 6-cylinder (M52TU/M54).

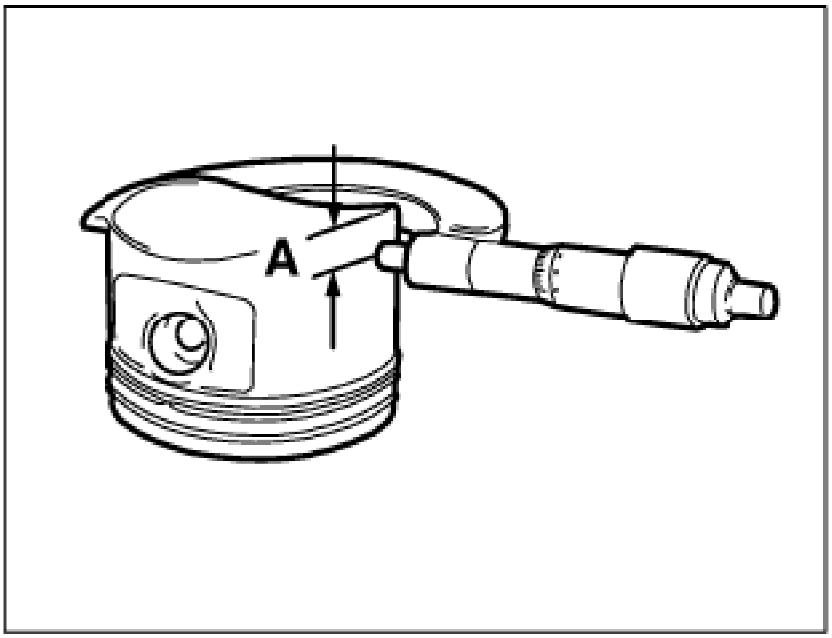
If the minimum thickness is not met, the head will need to be replaced.



## Piston Measurements

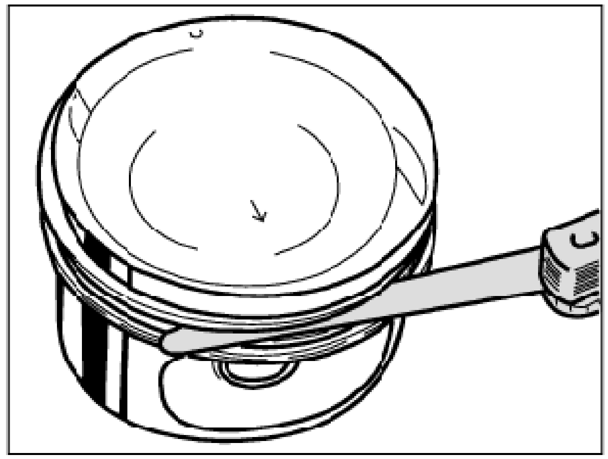
When replacing pistons and/or piston rings, there are some basic measurements that need to be made. When fitting a piston to a cylinder bore, the piston diameter should be checked to ensure a proper fit.

The piston diameter is measured using a micrometer. The measurement is taken at a specified point (A) which is 90° from the piston pin axis. Each engine has a specific location to measure piston diameter. For example, the illustration below shows measuring Point A. The specification for this engine (N55) is 12 mm. So the piston diameter is measured 12 mm from the bottom of the piston skirt.




The piston diameter, when subtracted from the cylinder bore equals the cylinder wall to piston clearance. If the clearance measurement obtained is not correct, re-check your readings.

## Piston Ring Measurements

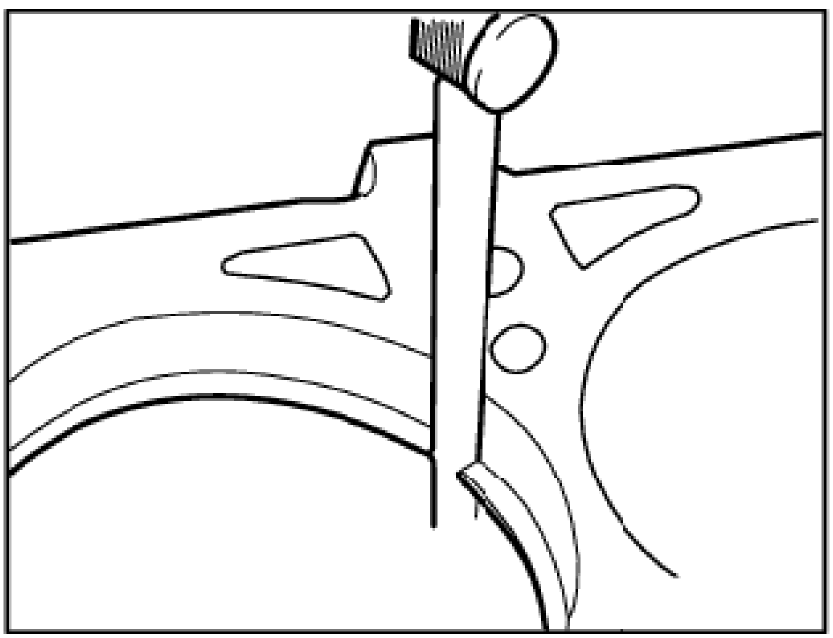


There are some important specifications to check when installing piston rings. One of the measurements in axial clearance. Axial clearance is the distance between the piston ring and ring land. This prevents the rings from binding in the ring land at operating temperature. Axial clearance is measured using a feeler gauge.

Also the piston ring end gap has to be checked. This measurement is checked using a feeler gauge.

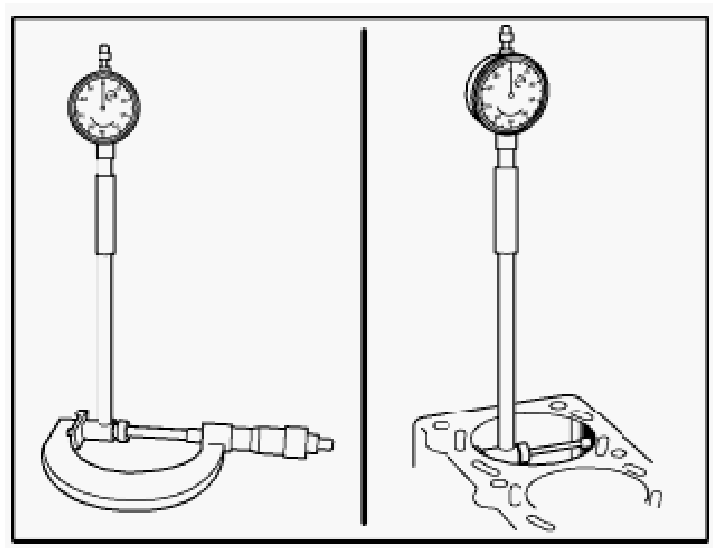
This clearance is critical in order to prevent the end gaps from contacting each other when the engine is at operating temp.

When installing the piston rings, always stagger the end gaps as per the repair instructions.



## Cylinder Bore

In order for the cylinder bore to be considered acceptable, it must not be excessively tapered or out-of-round. Once the cylinder has been checked for obvious damage and the surface finish is OK, the integrity of the bores must be verified. If cylinder wear is suspected, it must be checked using the proper cylinder bore gauge.



Each cylinder must be checked at three position in the bore - top, middle and bottom. Also there must be two opposing dimensions that should be checked. The difference between the top and bottom measurements will indicate the taper of the bore. The opposing dimensions will indicate the out-of-round specification.

If these measurements are out of specification, the cylinder bore must be re-finished or overbored. New pistons and rings must be fitted as well.

A dial bore gauge is a special purpose dial indicator for checking bores. The most accurate dial bore gauges have an accuracy of 0.0001 in. , or 1/10,000 in.

The dial bore gauge consists of a dial indicator at one end of a long stalk and a tripod arrangement positioned 90° to the stalk at the other end. The tripod is made up of a single interchangeable post that goes against one side of the bore being checked and two hardened buttons at the other end that automatically center the plunger in the bore. The gauge plunger is between the two buttons, directly opposite the post. To allow for different bore sizes, the post is interchangeable. This allows you to measure the big end of a connecting rod or the diameter of a cylinder bore.

### Reading Technique

To achieve a reading, the gauge is first zeroed. This is done by measuring across the gauge with an outside mike set to the specified bore size and rotating the dial face until 0 aligns with the needle.

The gauge is then inserted into the bore to the desired depth and rocked back and forth until the lowest reading is achieved. When the gauge is square to the bore and the indicator needle reverses direction, the lowest reading is read. This may be on the plus or minus side of the zero, indicating an oversize or undersize bore. Because it's so fast and accurate, the dial bore gauge is most helpful while honing bores for fitting pistons.

## How to Use a Dial Bore Gauge

Dial-bore gauges (DB) or dial indicators, when used in conjunction with a micrometer, can give very accurate and precise inside measurements. Used for holes of at least two inches in diameter, they consist of a base that houses an interchangeable anvil that sets the range of the measurement and a small sliding stud that when compressed will give a reading on the gauge or dial portion of the tool. The dial will have a rotating bezel that is rotated to "zero' the gauge at the target measurement, which is set by a separate micrometer. Dial-bore gauges are useful in checking for taper or out-of-round conditions in a cylinder bore as well as many other inside machinists measurements.

Things you'll need:

- Dial bore indicator set
- Micrometer (of the desired range)
- Machinist's rule

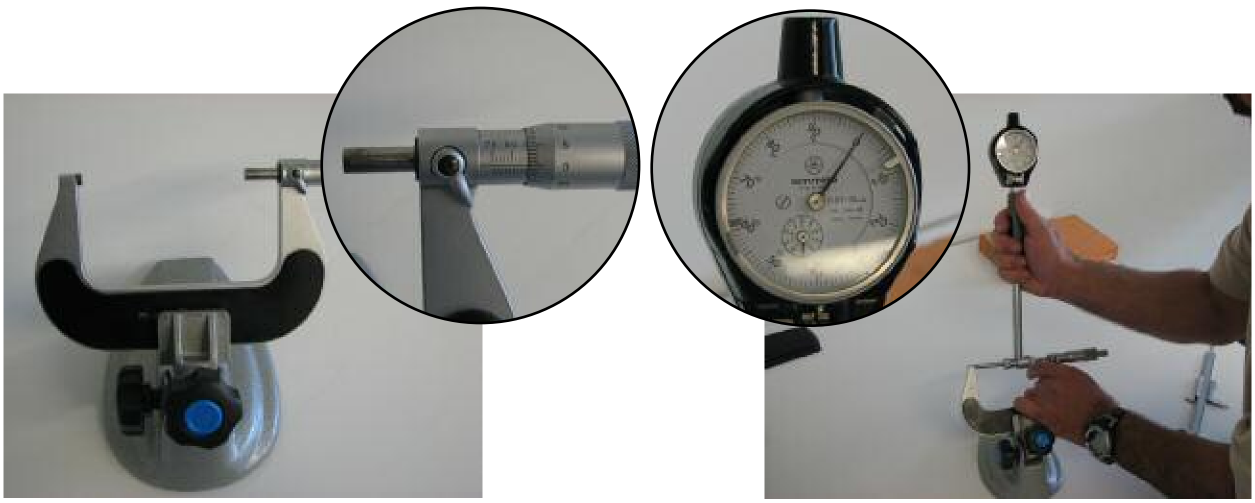
1. Measure the cylinder bore diameter with a caliper or steel machinist rule to determine the pin (measuring adapter) size.

2. Select the appropriate pin size closest to the cylinder bore diameter (avoid using shims if possible).

**For example: If the rough measurement is = 84mm select 85mm pin (without shim)**

3. Install the pin onto the bore gauge tool and snug the retaining nut finger tight. The pin should be long enough to contact the side of the bore and slightly compress the stud when inserted into the bore. Do not use an oversized pin and try to force the indicator, as this will likely destroy the accuracy of the tool.

4) Install the bore gauge tool and pin in a fixed outside micrometer that is set to the nominal bore specification measurement and zero the dial indicator. [Remember that zero = your preset measurement (e.g. 84mm)].



5. Insert the gauge into the bore to the desired depth and rock it back and forth until the lowest reading is achieved. When the gauge is square to the bore and the indicator needle reverses direction, the lowest reading is read. This may be on the plus or minus side of the zero, indicating an oversize or undersize bore.

6. You must take 6 measurements for each cylinder bore:
   a. Position the tool in the cylinder bore longitudinally (in-line with the crankshaft) and make three measurements, at the top, middle and bottom of the cylinder.
   b. Then position the tool across the bore (at 90° from the previous measurement) and make three more measurements of the top, middle and bottom of the cylinder.



7. Record your in-line and crosswise measurements and compare the top, middle and bottom readings to the engine's specifications to determine if the cylinder is out of round or conical.



8. Add or subtract the positive or negative number, respectively, from your target or arbitrary number. This final adjusted number is the actual measurement of the bore.

**Tips & Warnings**

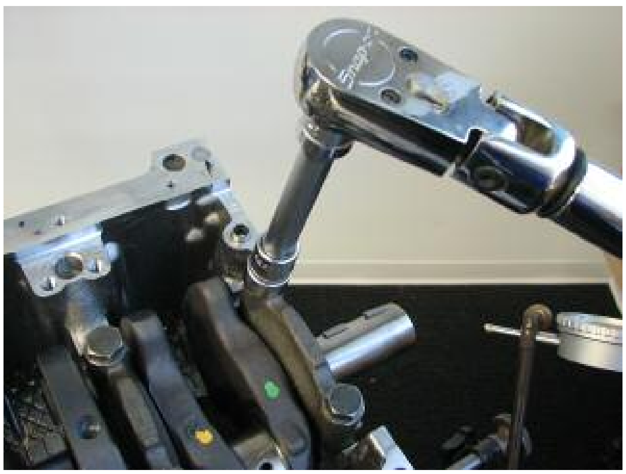
- Clean the bore to be measured and ensure that it is free of oil, grease or particles before introducing a precision measuring tool into the hole.
- Never force precision measuring tools.

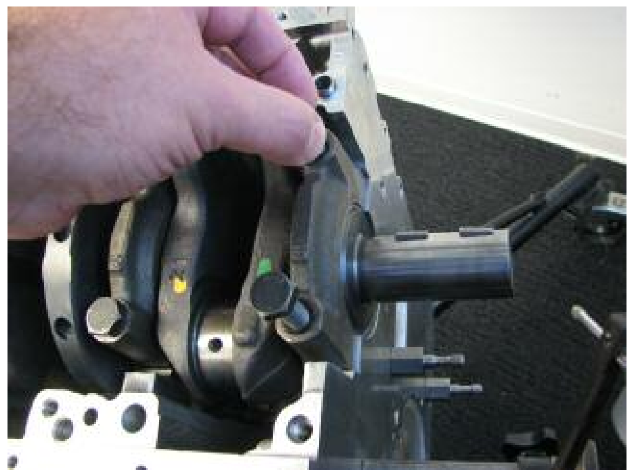
## Plastigage

Plastigage is used to measure oil clearances on crankshaft main, connecting rod and camshaft journals.

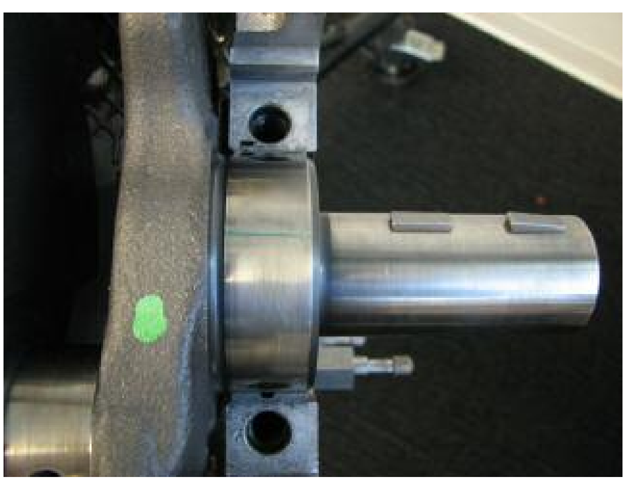
All parts should be free from grease and oil in order to get an accurate measurement. The first step is to assemble the journal and cap with new bearing inserts installed. Make sure all bearing caps are installed properly based on the factory makings.

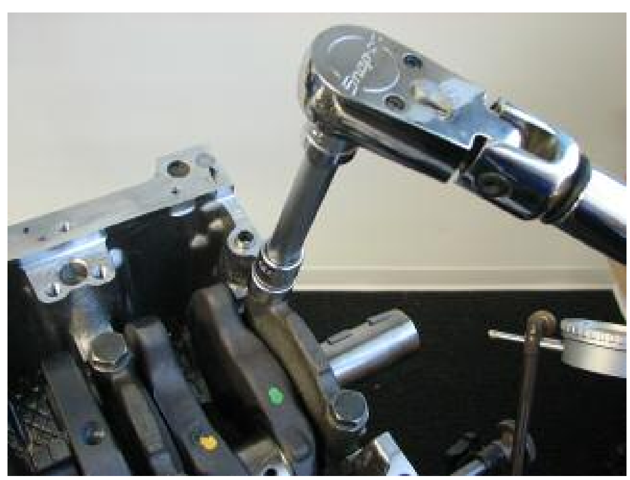
The next step is to torque all cap bolts to specification. Then loosen the bolts of the bearing cap that you want to check clearance on and remove the cap.



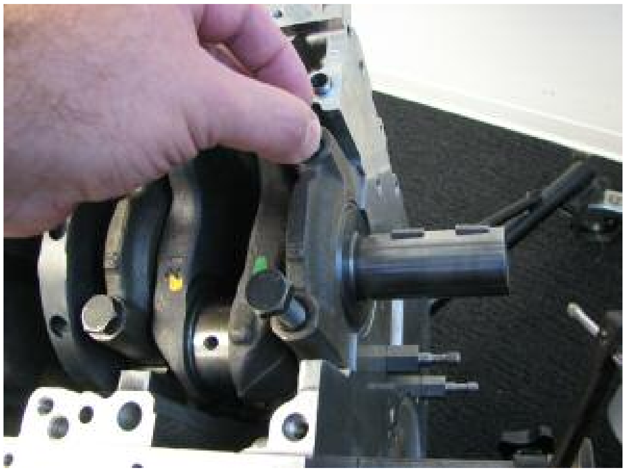


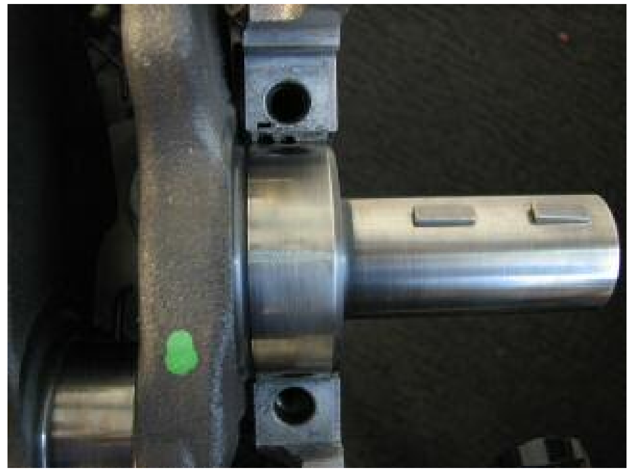
Using a clean, lint free shop cloth wipe any oil off of the surfaces you want to clearance. Cut a piece of Plastigage and remove it from the package. Place the Plastigage across the surface of the journal (in line with the shaft). Install the bearing cap over the Plastigage and torque the cap bolts to factory specification.



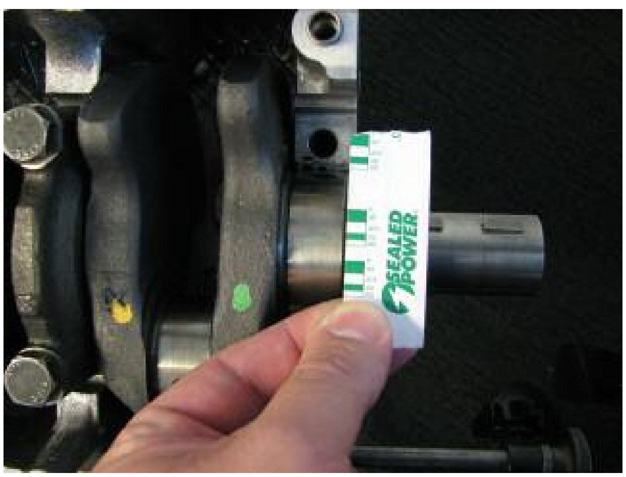


Remove the bolts and the bearing cap once again. You will see the crushed Plastigage on the surface of the journal and bearing insert. Using the scale printed on the side of the wrapper measure the crushed Plastigage imprint.





Compare your measurement to the oil clearance specification; if it is within range proceed with assembly. If the measurement falls between two sizes then you can estimate what the size in between is.




NOTES PAGE

# Units of Measure

## Metric System

All BMW specifications are metric.  Therefore, a thorough knowledge of those areas on the metric system which apply to BMW vehicles is vital to a BMW Service Technician.

The unit of length, and the basis for all other metric units of measurement is the meter. The meter (1 meter), as a point of reference, is slightly longer that a yard (39.37 inches).

The divisions of a meter are hundredths and thousandths.  One hundredth of a meter is called a centimeter, and is equal to 0.3937 inch or about half the diameter of a nickel.

One thousandth of a meter is called a millimeter.  The small marks between the centimeter increments are each one millimeter, or one tenth of a centimeter.  And as a point of reference, a standard paper clip is about one millimeter thick.

## Metric System Denominations

Throughout the metric system, common to all units of measurement, are prefixes which designate multiples or fractions of the unit.

For automotive applications, the most common prefixes are centi; designating one-hundredth; milli; for one thousandth and kilo- for one thousand.

There are letters uniformly used throughout the system to label the divisions or multiples of each unit of measurement.  The letter “m” represents milli, “c’ is for centi and “k” is for kilo.  These are then combined with the letter representing the unit of measurement.

For example, mm is millimeter, cm is centimeter and km is kilometer.  The same applies to liter which is the unit of volume and gram which is the unit of weight.

One kilogram is equal to one thousand grams which is equal to 2.2 pounds.

All metric measurements are directly related.  For example, one thousand cubic centimeters, or 10cm x 10cm x 10cm of water weighs one kilogram.  The volume of those one thousand cc’s is one liter.

## Metric Reference Chart

| Weight | | | |
|---|---|---|---|
| **1 kilogram** | = 1 kg | = 1000 grams | = 1000 g |
| **1 hectogram** | = 1 hg | = 100 grams | = 100 g |
| **1 dekagram** | = 1 dag | = 10 grams | = 10 g |
| **1 gram** | = 1g | | |
| **1 decigram** | = 1dg | = 0.1 gram | = 0.1 g |
| **1 centigram** | = 1 cg | = 0.01 gram | = 0.01 g |
| **1 milligram** | = 1 mg | = 0.001 gram | = 0.001 g |
| **Length** | | | |
| **1 kilometer** | = 1 km | = 1000 meters | = 1000 m |
| **1 hectometer** | = 1 hm | = 100 meters | = 100 m |
| **1 dekameter** | = 1 dam | = 10 meters | = 10 m |
| **1 meter** | = 1m | | |
| **1 decimeter** | = 1dm | = 0.1 meter | = 0.1 m |
| **1 centimeter** | = 1 cm | = 0.01 meter | = 0.01 m |
| **1 millimeter** | = 1 mm | = 0.001 meter | = 0.001 m |
| **Volume** | | | |
| **1 kiloliter** | = 1 kl | = 1000 liters | = 1000 l |
| **1 hectoliter** | = 1 hl | = 100 liters | = 100 l |
| **1 dekaliter** | = 1 dal | = 10 liters | = 10 l |
| **1 liter** | = 1l | | |
| **1 deciliter** | = 1dl | = 0.1 liter | = 0.1 l |
| **1 centiliter** | = 1 cl | = 0.01 liter | = 0.01 l |
| **1 milliliter** | = 1 ml | = 0.001 liter | = 0.001 l |

## Metric System Conversion Charts

| Linear Measure to Metric | Linear Measure (Metric) to English |
| --- | --- |
| 1 inch = 2.54 cm | 1 mm = 0.03937 inch |
| 12 inches = 1 foot = 30.48 cm | 1 cm = 0.39 inch |
| 3 feet = 1 yard = 0.91 m | 1 m = 39.37 inch |
| 5.5 yards = 1 rod = 5.03 m | 1 km = 0.62 miles |
| 5280 feet = 1 mile = 1.61 km | |
| **Square Measure to Metric** | **Square Measure (Metric) to English** |
| 1 $in^2$ = 6.45 $cm^2$ | 1 $mm^2$ = 0.002 $in^2$ |
| 144 $in^2$ = 1 $ft^2$ = 0.09 $m^2$ | 1 $cm^2$ = 0.16 $in^2$ |
| 9 $ft^2$ = 1 $yd^2$ = 0.84 $m^2$ | 1 $m^2$ = 1549 $in^2$ |
| 640 acres = 1$mi^2$ = 2.59 $km^2$ | 1 $km^2$ = 0.39 $mi^2$ = 247.10 acres |
| **Cubic Measure to Metric** | **Cubic Measure (Metric) to English** |
| 1 $in^3$ = 16.39 $cm^3$ | 1 $mm^3$ = 0.000061 $in^3$ |
| 1728 $in^3$ = 1 $yd^3$ = 0.76 $m^3$ | 1 $cm^3$ = 0.061 $in^3$ |
| 27$ft^3$ = 1 $yd^3$ = 0.76 $m^3$ | 1 $m^3$ = 35.32 $ft^3$ |
| | 1 $km^3$ = 0.24 $mi^3$ |
| **Liquid Measure to Metric** | **Liquid Measure (Metric) to English** |
| 1.81 $in^3$ = 1 fluid oz. = 30 ml | 1 ml = 0.03 fluid oz = 0.061 $in^3$ |
| 1 pint = 0.47 l | 1000 $cm^3$ = 1 l = 61.02 $in^3$ = 1.06 qt |
| 57.75 $in^3$ = 1 quart = 0.95 l | 1 $ft^3$ water = 62.5 lb |
| 231 $in^3$ = 1 gal = 3.79 l = 0.0038 $m^3$ | |
| 1 $ft^3$ = 7.48 gal = 28.35 l | |
| **Weights to Metric** | **Weight (Metric) to English** |
| 1 0z = 28.35 g | 1 g = 0.035 oz |
| 1 lb = 453.59 g | 1 kg = 2.20 lb |
| 1 lb = 0.45 kg | 1 metric ton = 1000 kg = 1.102 tons = 2205 lb |
| 1 ton = 0.91 metric ton | |
| **Temperature to Metric** | **Temperature to Fahrenheit** |
| F = 9/5C +32 | C = 5/9 (F-32) |

## Pressure Conversion Chart

| Bar | kPa | psi | in.Hg. |
|---|---|---|---|
| 6.0 | 600 | 87.0 | |
| 5.9 | 590 | 85.5 | |
| 5.8 | 580 | 84.0 | |
| 5.7 | 570 | 82.5 | |
| 5.6 | 560 | 81.0 | |
| 5.5 | 550 | 79.0 | |
| 5.4 | 540 | 78.5 | |
| 5.3 | 530 | 77.0 | |
| 5.2 | 520 | 75.5 | |
| 5.1 | 510 | 73.5 | |
| 5.0 | 500 | 72.5 | |
| 4.9 | 490 | 71.0 | |
| 4.8 | 480 | 69.5 | |
| 4.7 | 470 | 68.0 | |
| 4.6 | 460 | 66.5 | |
| 4.5 | 450 | 65.5 | |
| 4.4 | 440 | 64.0 | |
| 4.3 | 430 | 62.5 | |
| 4.2 | 420 | 61.0 | |
| 4.1 | 410 | 59.5 | |
| 4.0 | 400 | 58.0 | |
| 3.9 | 390 | 56.5 | |
| 3.8 | 380 | 55.0 | |
| 3.7 | 370 | 53.5 | |
| 3.6 | 360 | 52.0 | |
| 3.5 | 350 | 51.0 | |
| 3.4 | 340 | 49.5 | |
| 3.3 | 330 | 48.0 | |
| 3.2 | 320 | 46.5 | |
| 3.1 | 310 | 45.0 | |

## Pressure Conversion Chart (cont.)

| Bar | kPa | psi | in.Hg. |
|---|---|---|---|
| 3.0 | 300 | 43.5 | |
| 2.9 | 290 | 42.0 | |
| 2.8 | 280 | 40.5 | |
| 2.7 | 270 | 39.0 | |
| 2.6 | 260 | 37.5 | |
| 2.5 | 250 | 36.5 | |
| 2.4 | 240 | 35.0 | |
| 2.3 | 230 | 33.5 | |
| 2.2 | 220 | 32.0 | |
| 2.1 | 210 | 30.5 | |
| 2.0 | 200 | 29.0 | |
| 1.9 | 190 | 27.5 | |
| 1.8 | 180 | 26.0 | |
| 1.7 | 170 | 24.5 | |
| 1.6 | 160 | 23.0 | |
| 1.5 | 150 | 22.0 | |
| 1.4 | 140 | 20.5 | |
| 1.3 | 130 | 19.0 | |
| 1.2 | 120 | 17.5 | 35.90 |
| 1.1 | 110 | 16.0 | 32.91 |
| 1.0 | 100 | 14.5 | 29.92 |
| 0.9 | 90 | 13.0 | 26.93 |
| 0.8 | 80 | 11.5 | 23.94 |
| 0.7 | 70 | 10.0 | 20.94 |
| 0.6 | 60 | 9.0 | 17.95 |
| 0.5 | 50 | 7.5 | 14.96 |
| 0.4 | 40 | 6.0 | 11.97 |
| 0.3 | 30 | 4.5 | 8.98 |
| 0.2 | 20 | 3.0 | 5.98 |
| 0.1 | 10 | 1.5 | 2.99 |
| 0.0 | 0 | 0.0 | 0.0 |

## Review Questions - Basic Measuring Techniques

1. When using a micrometer, why is it important to only turn the thimble using the ratchet (friction stop) when making a measurement?

2. What are the increments on the thimble scale of a micrometer?

3. How should the diameter of a piston be measured?

4. One rotation of the large scale on a metric dial indicator is equal to_______.

5. What are some of the measurement that a dial indicator can be used for?

6. What are some of the measurements that can be performed on a cylinder head?

7. Explain taper and out-of-round on a cylinder bore:

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# Table of Contents

## Engine Diagnosis



Initial Print Date: 03/05 Revision Date: 03/15

# Engine Diagnosis

## Model: All

## Production:  All

# OBJECTIVES

After completion of this module you will be able to:

- Understand the Operation of New Generation Engines
- Utilize BMW Diagnostic Equipment to Diagnose Engine Related Complaints
- Understand Engine Diagnosis Using Basic Hand Tools

# Engine Diagnosis

When attempting to diagnose driveability complaints, always consider the basics. Regardless of the level of technology employed on an engine, it still needs a few basic things to occur in order to run properly. Whether the engine employs the latest technology or not, always refer to the basic principles first.

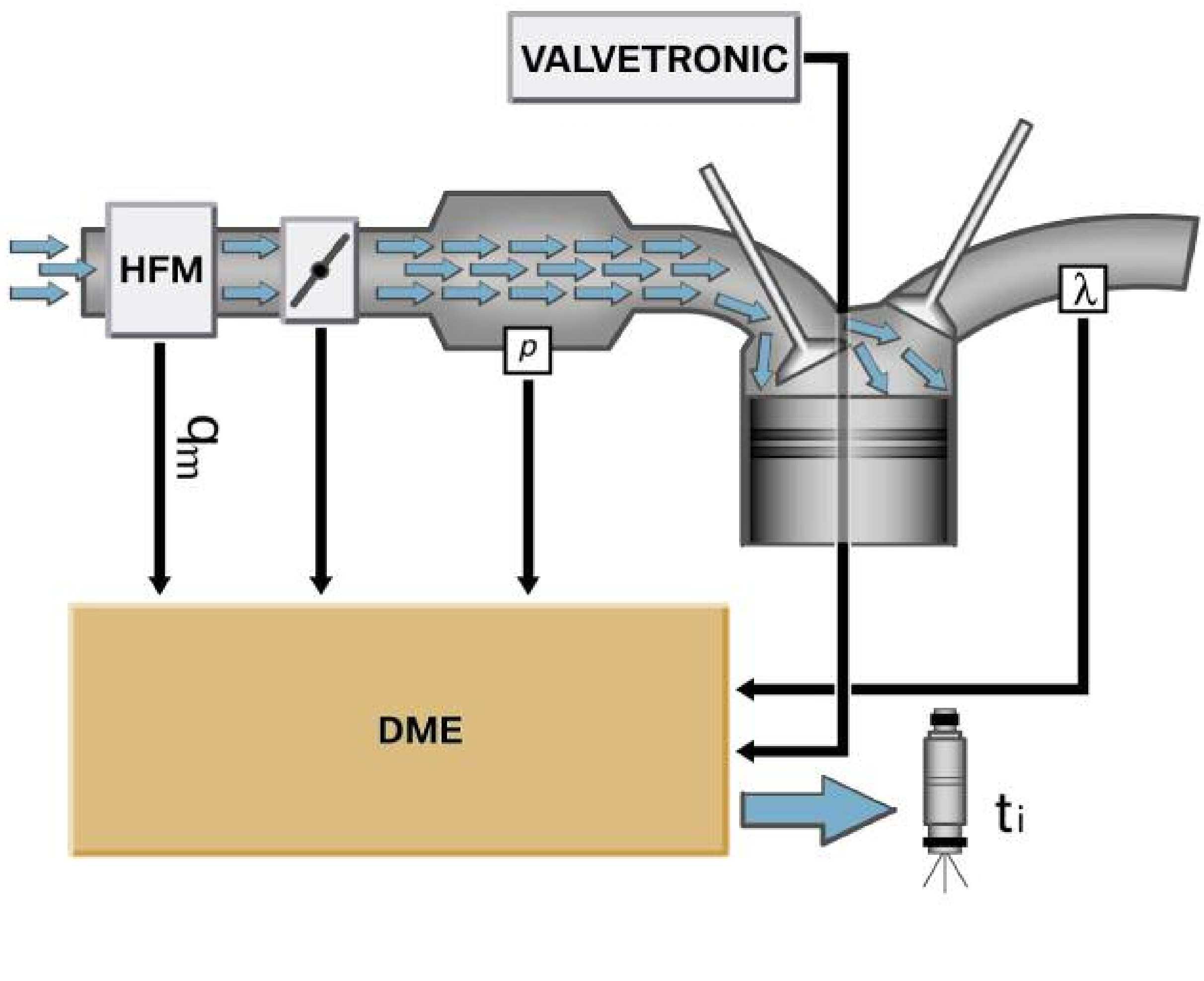
Any engine using **four-cycle spark-ignition** (Otto cycle) principles must meet the same fundamental conditions to run properly. Most engine related driveability problems fall into a few basic categories:

- No Start/No Crank
- Extending cranking before engine start
- Rough Running Cold Idle
- Rough Running Warm Idle
- Rough Running Under Load
- Lack of Power
- Check Engine Light (MIL)

**N63 engine cut-away**

When referring to engine basics, all engines need fuel, air and spark to run.  However, in order for a spark-ignition engine to run properly, a few things must be taken into consideration.  The fuel, air, spark principle can be broken down further into the following categories:

- Sufficient engine compression with a leak-free combustion chamber.
- Sufficient amount of ignition voltage (spark) at the correct time.
- Proper fuel pressure and volume.
- Properly functioning fuel injection system (Engine management).
- Properly functioning air management system (Electronic throttle systems).
- Correct valve timing (VVT and VANOS).



## Compression Testing

In order for an engine to run smoothly and efficiently, the combustion chamber must be free of leakage. An engine with low compression in one or more cylinders is inefficient and will run rough or lack in performance. Low compression may or may not cause the MIL to illuminate.

Low compression can be caused by the following:

- Leaking valves caused by burned valves or seats. The valve guide can also be worn causing the valve not to seat properly. Valves can also be bent from piston contact (from over-rev).
- Piston Rings which can be worn from high mileage or poor maintenance. Also, the rings can be damaged from foreign material or improper installation.
- Cracks in cylinder head or engine block. Cracks can be caused by overheating resulting in misfires or rough running.
- Defective cylinder head gasket. The cylinder head gasket can fail due to overheating which can cause cylinder leakage resulting in misfire, low compression and rough running.
- Bent connecting rod. A connecting rod can be bent from a defective fuel injector or water ingress into the combustion chamber causing hydrostatic lock.

Compression testing can be performed using a conventional compression gauge. There are some preliminary tasks and safety precautions that must be carried out before starting the compression test:

- Remove the fuel pump fuse and or relay, start the vehicle and allow vehicle to stall out on residual fuel.
- Disable ignition by unplugging all ignition coils and remove **ALL** sparkplugs.
- Connect battery charger to vehicle.
- Ensure that the throttle is wide open during cranking (see special note for VALVETRONIC equipped vehicles).
- Crank engine until compression gauge stops increasing. Be sure to crank engine equally between cylinders.
- Continue compression test on ALL cylinders so comparisons can be done.

* Record readings

- If necessary, re-check cylinders with suspect readings.
- If some cylinder readings come up low, add a few drops of oil and re-check.
  This can differentiate between valves/rings.

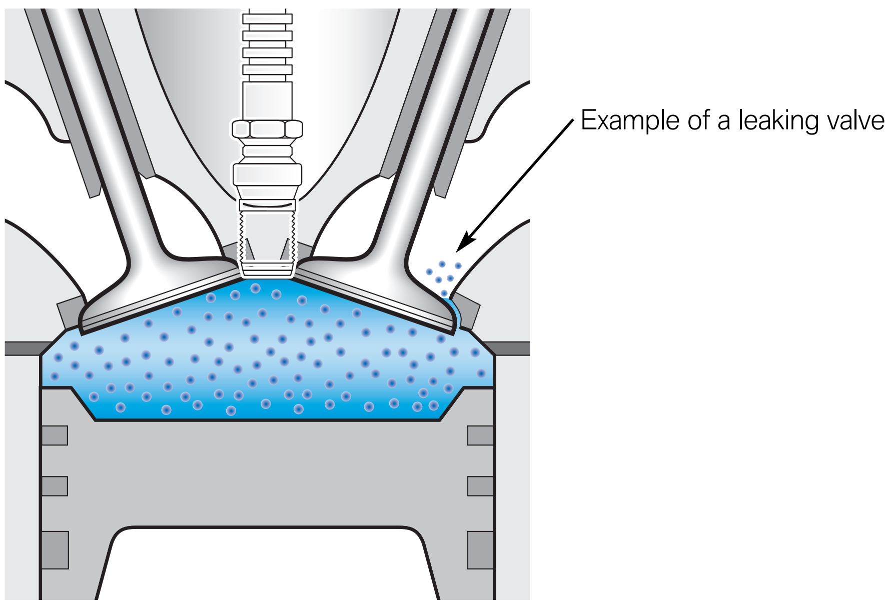
## Cylinder Leakage Testing

Once a problem cylinder is detected via a compression test or by other means, a cylinder leakage test is used to pinpoint the problem area.

The leakage test uses an air pressure gauge and compressed air to indicate the percentage of air loss. By listening and observing at key points, the problem can be narrowed down before the engine is disassembled.

The first step is to bring the piston to TDC (compression stroke). Then compressed air is introduced into the cylinder using the cylinder leakage tester. Be sure the engine does NOT rotate, if the engine rotates, the engine was not at true TDC.

Check the gauge on the tester, it should read in percentage of leakage. Check the engine specification for permissible leakdown. A general rule of thumb is 15% or less for a good cylinder. However, some engines have a tighter tolerance.
**Note: Most BMW engines should be at 8% or less.**



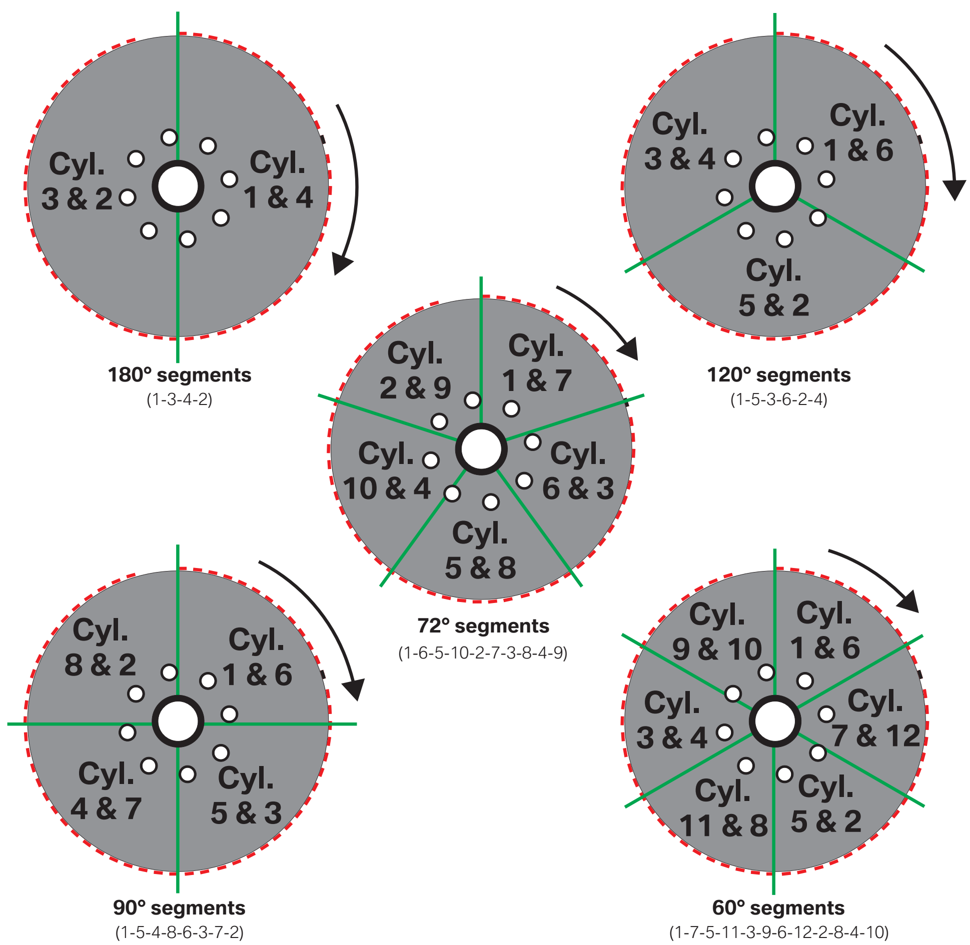

If any cylinder shows excessive leakdown, check for leakage by listening or observing the following points:

- Listen for air (hissing) at the tailpipe. This would indicate leakage at the exhaust valves on that cylinder.
- Listen for air (hissing) at the throttle. This would indicate leakage at the intake valves on that cylinder. (Be sure throttle is wide open and listen at throttle opening)
- Open the oil cap and listen for air. This would indicate air leakage into the crankcase. This would be piston rings or cylinder bore concerns.
- Observe the coolant reservoir and or remove the radiator cap. Bubbles in the coolant would most likely indicate head gasket leakage or cracked block/head.

## Hints on Cylinder Leakage Testing

When performing cylinder leakage tests, the following tips might be helpful:

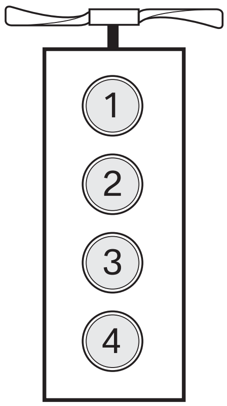
- Remove all spark plugs to allow easier rotation of the engine. (If this test is done after a compression test, the plugs should already be out).
- Perform the leakage test on all cylinders, not just the problem cylinder. This would indicate any other problems which can be rectified. This eliminates any repeat repairs and wasted diagnostic time.
- Perform the leakage test in cylinder firing order starting with cylinder #1. It takes two revolutions of the engine to complete the leakage test.
- Start at cylinder #1 and rotate the engine to the next cylinder in the firing order. Divide the number of cylinders into 720, the result is the number of degrees that each cylinder fires. For example, if you divide a 6 cylinder into 720, this equals 120 degrees. If you start at cylinder 1 and rotate the engine 120 degrees in the direction of rotation, you can check the next cylinder in the firing order.
- This process eliminates the need to rotate the engine an excessive amount.




View from Crank Pulley

## Cylinder Arrangement and Firing Order

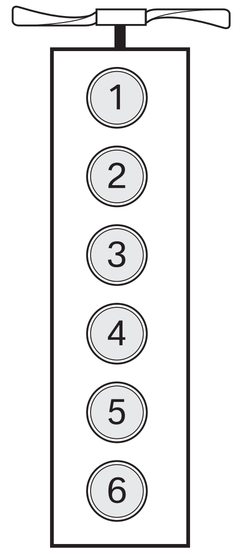
### 4-Cylinder




**M10, M42, M44, S14, N20**

**Firing Order 1-3-4-2**

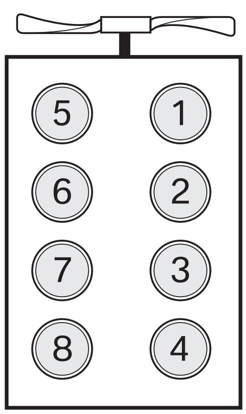
### 6-Cylinder




**M20, M30, M50 (TU), M52 (TU), M54, N52, N52KP, N51, N54, N55, S38, S52, S54**

**Firing Order 1-5-3-6-2-4**

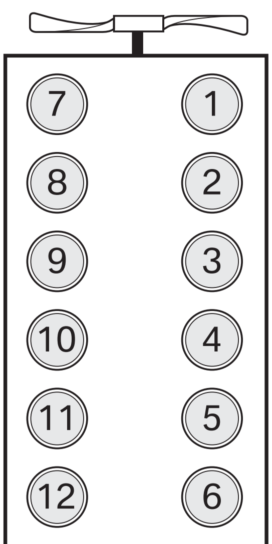
### 8-Cylinder




**M60, M62, M62TU, N62, N62TU, N63, S63**

**Firing Order 1-5-4-8-6-3-7-2**

### 12-Cylinder




**M70, M73, M73TU, N73, S70, N74**

**Firing Order 1-7-5-11-3-9-6-12-2-8-4-10**

**Note: The S65 uses a 1-5-4-8-7-2-6-3 firing order instead of 1-5-4-8-6-3-7-2 commonly employed in BMW V8's.**

# Table of Contents

## BMW Engines Introduction



Initial Print Date: 09/06 Revision Date: 03/15

| Subject | Page |
| --- | --- |

## BMW Engines Introduction

## Model: All

## Production: Start of Production

# OBJECTIVES

After completion of this module you will be able to:

- Identify the most current BMW Engines
- Describe the additions to the NG6 engine family
- Understand the new engine designations

# 4 Cylinder Engines

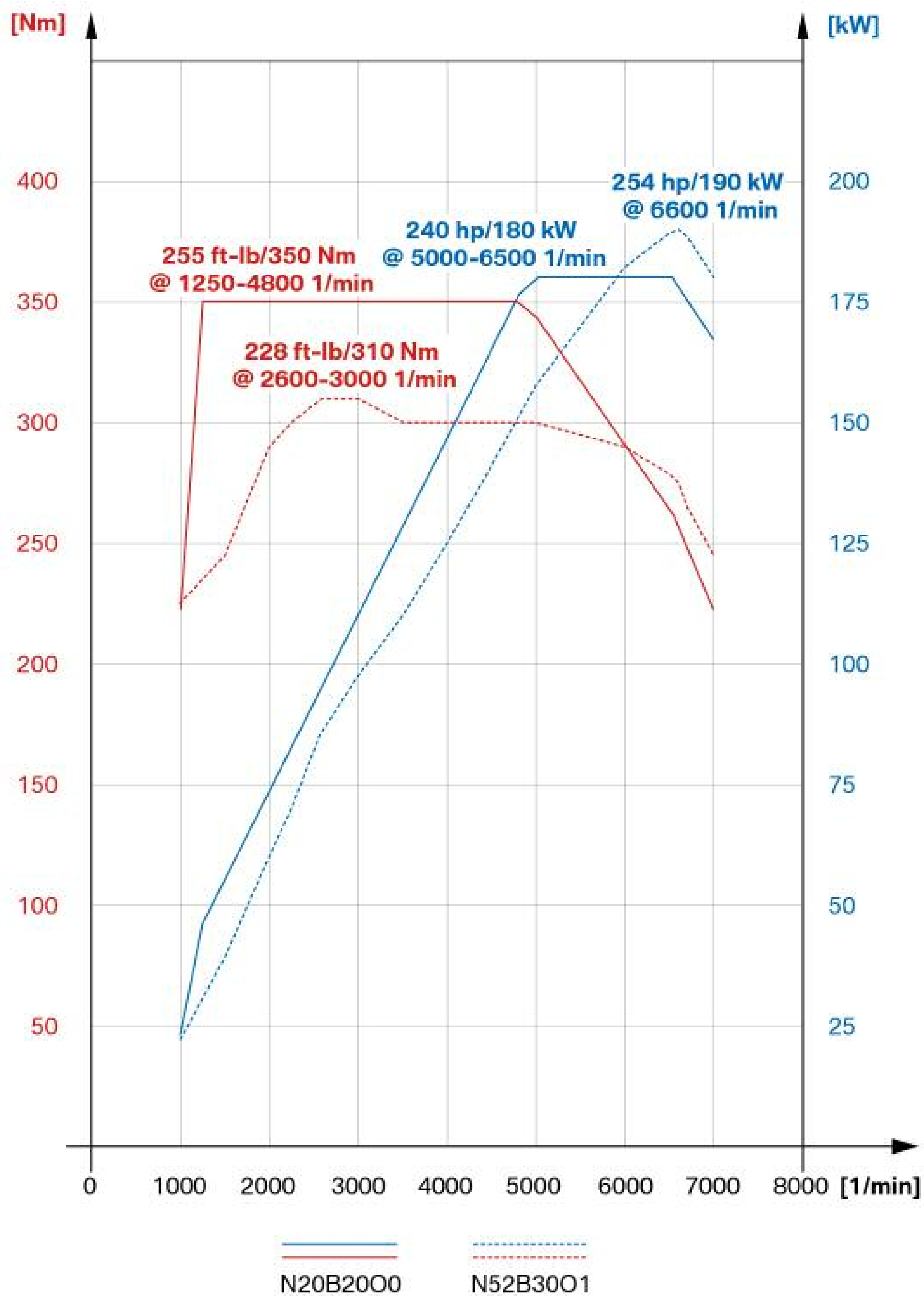
## N20 Engine

BMW has decided to bring back the 4–cylinder engine to the US market. The last BMW 4–cylinder engine in the US was the M44, this lasted until 1999 and was installed in the E36 318is/318ti/Z3.

Since then BMW in the US has not had a 4–cylinder engine. The N20 engine represents the new generation of BMW 4-cylinder gasoline engines. It will gradually be phased in on a number of BMW  models starting in September 2011. The N20 will replace the N52 6-cylinder naturally aspirated  engines. The N20 engine is equipped with the latest technology, such as TVDI (Turbocharged  Valvetronic Direct Injection) in conjunction with a TwinScroll exhaust turbocharger. As a whole, it is closely related to the N55 engine.

## Full Load Diagram

**Full load diagram for the N20B20O0 engine compared with N52B30O1 engine**



# N20 Engine Features

## Engine Components/Systems Overview

### Engine mechanical components

- Aluminum crankcase with coated cylinder bore
- Optimized cooling jackets
- Use of the TVDI technology
- TwinScroll exhaust turbocharger
- 3rd generation Valvetronic with new intermediate levers
- New generation VANOS with central valves
- Assembled camshafts
- Two mode crankcase ventilation
- Forged crankshaft
- Positive crankshaft offset
- Piston with negative pin offset
- Chain drive for counterbalance shafts with chain tensioner
- Counterbalance shafts arranged on top of one another.

### Oil supply

- Map-controlled oil pump
- New pendulum-slide oil pump design
- Unfiltered oil cooling
- New combined oil pressure and temperature sensor.

### Cooling

- Electric coolant pump
- Map controlled thermostat.

### Air intake and exhaust emission systems

- TwinScroll exhaust turbocharger
- Hot-film air mass meter
- Enhanced crankcase ventilation.

## Vacuum system

- Two-stage vacuum pump
- Vacuum reservoir for the wastegate valve is built into the engine cover.

## Fuel preparation

- High-pressure injection (as N55)
- Solenoid valve injectors
- Bosch high-pressure pump
- High-pressure lines to the injectors are soldered to the rail
- No fuel low-pressure sensor.

## Engine electrical system

- Bosch MEVD17.2.4 engine control unit.

## Engine Designation

The N20 engine is described in the following version: N20B20O0.

The technical documentation also features the short form of engine designation N20, which only allows assignment of the engine type.

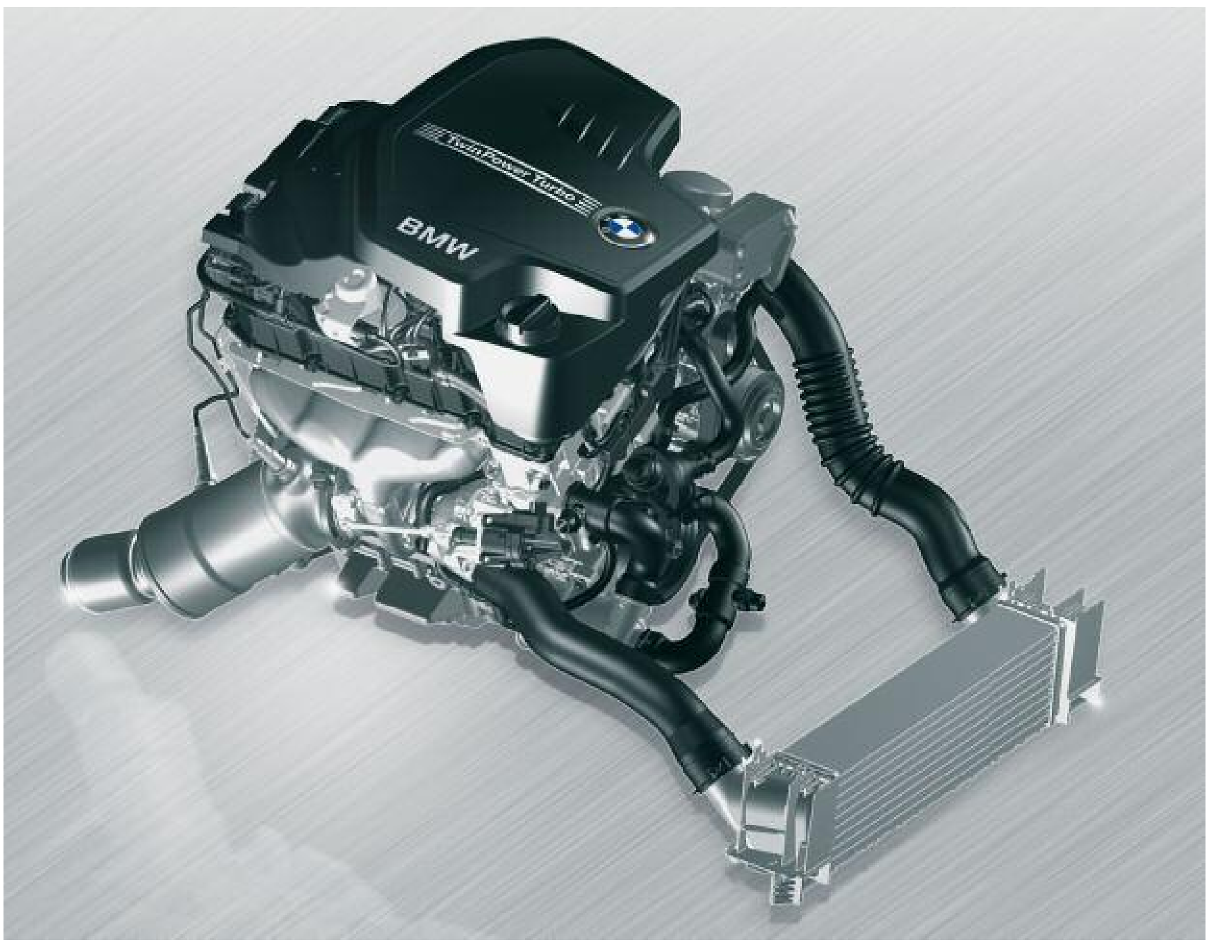
**Breakdown of N20 engine designation**

| Index | Explanation |
|---|---|
| N | BMW Group "New generation" |
| 2 | 4-cylinder engine |
| 0 | Engine with exhaust turbocharger, Valvetronic and direct fuel injection (TVDI) |
| B | Gasoline engine, longitudinally installed |
| 20 | 2.0 liters displacement |
| O | Upper performance class |
| 0 | New development |

## N26 Engine

The N26 engine is the third generation of the BMW SULEV engines used in the US market. The N26 shares many technical features with the current N20 engine. This engine is currently available in the F30 328i as of 3/2012. The new N26 engine is the first turbocharged SULEV gasoline engine worldwide that requires no secondary air system.

This not only means that the BMW Group is complying with the requirements of the world's most stringent exhaust emission legislation, but also underlines the fact that the term "premium" is being defined by the many facets of substantiality to an ever increasing extent. Twin Power Turbo technology enables dynamic performance and achievement of low fuel consumption while adhering to the most stringent exhaust emission limits.



## N26 Engine Features

The N26 engine also shares many features with the N20 engine, such as the cylinder head, valvetrain, engine block, crankshaft, pistons. Over 95% of the N26 engine is carried over from the N20.

By using the latest technology TVDI (Turbocharged Valvetronic Direct Injection) in conjunction with a TwinScroll exhaust turbocharger, it is now possible to decrease emissions substantially, while at the same time maintaining the same power output as the N20.

### Engine Components/Systems Overview

The following provides an overview of the features the N26 engine has in common with the N20:

- Engine block
- Crankshaft
- Valve train
- Camshaft
- Belt drive
- Oil supply
- Crankcase ventilation
- Cooling system
- Evaporative system

The N26 engine uses the same crankcase ventilation principle as N20 engine. The main difference is that the pressure regulating valve is now welded to the cylinder head cover. This is now considered hydrocarbon emissions tight.

- Air intake and exhaust system

The air intake and exhaust systems differ slightly on the N26.engine. There is an additional HC filter located in the air filter box to capture hydrocarbon emissions. The exhaust turbocharger is identical to the N20 but now incorporates an electric wastegate valve actuator.

**Note: As from 07/2012 all N20 engines have electric wastegates.**

- Secondary air system is NOT required
- Vacuum system reservoir no longer integrated into engine cover
- Fuel system

Bosch HDEV5.2 solenoid valve injector is an inward-opening multi-hole valve. These injectors are identical to the N55 and N20 from a technical point of view. The N26 injectors are refered to as "sorted", which means that they are less prone to leakage. The leakage is <0.5mm³/min @20MPa (200bar)

- Engine electrical system

Engine management MEVD17.2.9 is used with the N26 engine with new internal programming. Adaption algorithm for continuous injector individual measurement of the opening and closing time (flight phase of the injector needle) by characteristics of the current signal.

Higher precision of the injected fuel quantity, especially required for 'double" injection for heating-up of catalytic converter.

Engine wire harness modification, due to electric wastegate.

**Note: All N20 engines will receive MEVD17.2.9 starting with 07/12 production.**

## Engine Designation

In the technical documentation, the engine designation is used to ensure the clear identification of engines.

The N26 engine is available in the following version: **N26B20O0**

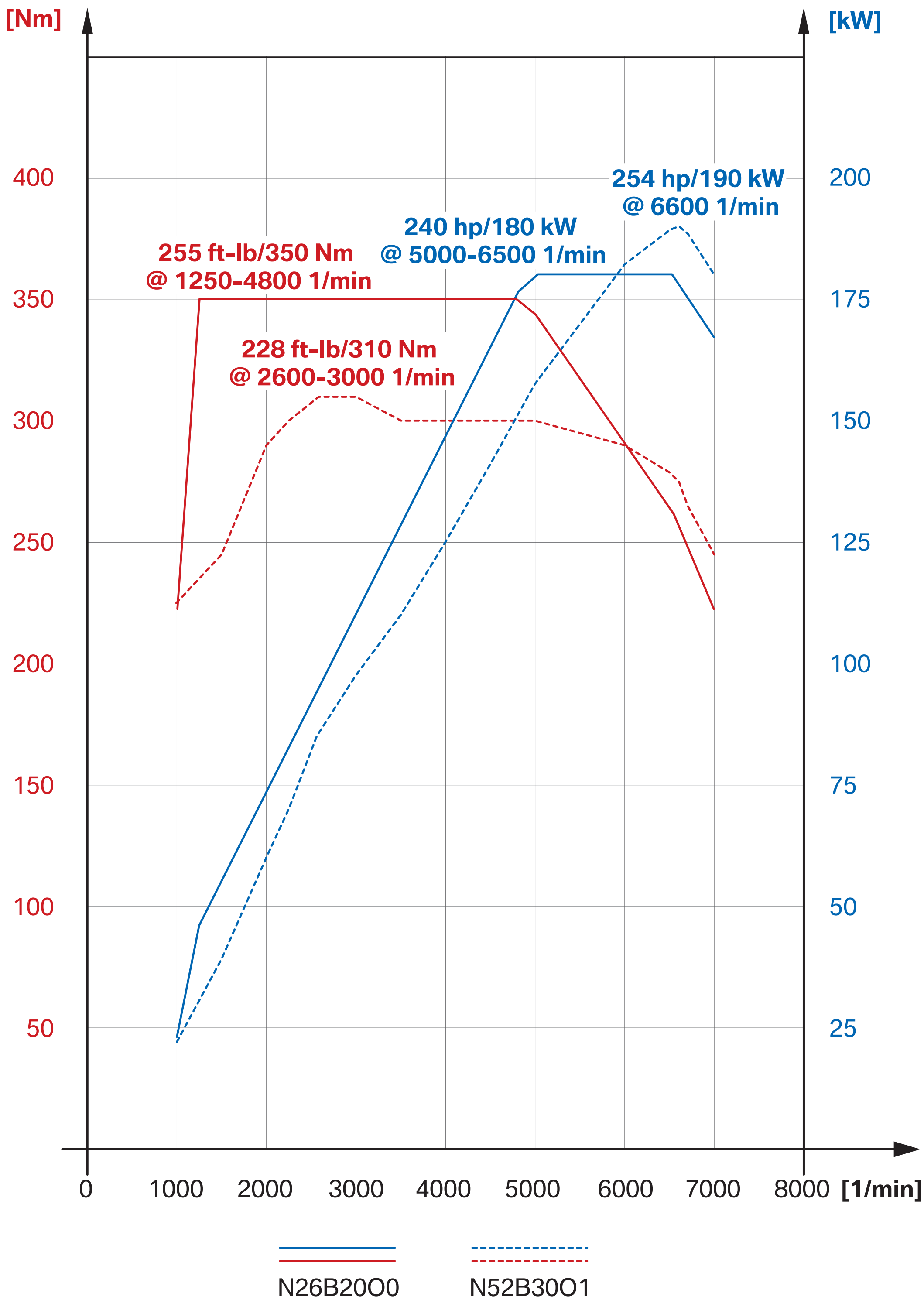
In the technical documentation, you will also find the short form of the engine designation N26 which only permits identification of the engine type.

**Breakdown of N26 engine designation**

| Index | Explanation |
|---|---|
| **N** | BMW Group "New generation" |
| **2** | 4-cylinder engine |
| **6** | Engine with exhaust turbocharger, Valvetronic and direct fuel injection (TVDI) |
| **B** | Gasoline engine, longitudinally installed |
| **20** | 2.0 liters displacement |
| **O** | Upper performance class |
| **0** | New development |

## Full Load Diagram

**Full load diagram for the N26B20 engine, compared with the N55B30 engine**



## Technical Data (N26 vs. N20)

| | | N26B20O0 | N20B20O0 |
|---|---|---|---|
| Engine type | - | 4 cylinder | 4 cylinder |
| Displacement | [cm³] | 1997 | 1997 |
| Stroke/bore | (mm) | 84/90 | 84/90 |
| Firing order | - | 1-3-4-2 | 1-3-4-2 |
| Power output | (kw/bhp) @ RPM | 180/240<br>5000 - 6500 | 180/240<br>5000 - 6500 |
| Torque | (Nm) @RPM | 350/258<br>1250 - 4800 | 350/258<br>1250 - 4800 |
| Power output per liter | [kw/l] | 90.14 | 90.14 |
| Cutoff speed | (rpm) | 7000 | 7000 |
| Compression ratio | - | 10.0 : 1 | 10.0 : 1 |
| Valves per cylinder | - | 4 | 4 |
| Diameter of intake valve | (mm) | 32 | 32 |
| Diameter of exhaust valve | (mm) | 28 | 28 |
| Diameter of connecting rod bearing inside diameter | (mm) | 144.35 | 144.35 |
| Engine management | | MEVD 17.2.9 | MEVD 17.2.4 up to 07/12<br>MEVD 17.2.9 from 07/12 |
| Emission standard (US) | | SULEV | ULEV II |

# 6 Cylinder Engines

Previously in 2005, BMW introduced the beginning of a new generation (NG) of six cylinder engines with the N52. Since then, BMW has introduced 3 new variations of the NG6 engine family.


N55 Engine

The first of the new engines is the N54, which made its debut in the new 3-series coupe in September 2006. The **N54** is **turbocharged** and uses the second generation of direct injection (DI 2). This engine was introduced in the 335i coupe in the fall of 2006.

The N52 was eventually replaced by the **N52KP**. The N52KP engine is an improved and cost optimized version of the N52. The N52KP was introduced in the 328i and 328xi coupe from September 2006 and replaced the N52 in various models.

The **N51** (which is a **SULEV II** compatible engine) was phased into selected production models from 9/06. The N51 features many of the same features of the previous SULEV engine (M56) including a “Zero Evap” system.

Finally, the **N55** engine is the successor to the N54 and was introduced to the US market with the launch of the F07 535i Gran Turismo in the Spring of 2010. Re-engineering and modifications have made it possible to now use only one exhaust turbocharger. Against the backdrop of reduced costs and improved quality, the technical data has remained virtually the same.

## New Generation Engine Designations

A new engine numbering system was introduced to enable fast and distinct identification.

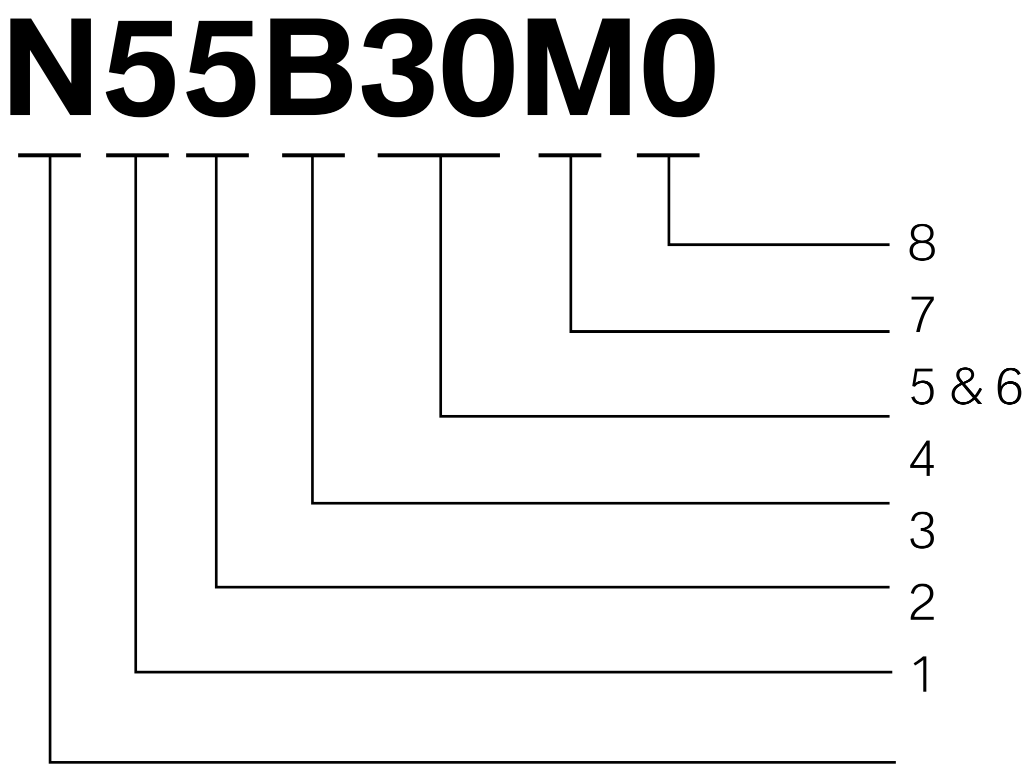
The “TU” designation was dropped together with the associated version number which is now replaced by a simple count number at the end of the engine designation.

The codes T through K are also new for the various power stages instead of the previous “OL” or “UL” designations.

For example, the new N52KP engine which is a variant of the original N52 engine will now be known as the N52B30O1. This would be instead of the traditional “TU” suffix as in - N52B30TU.

The block stamping (above) is located in the same place as the previous N52 engine.

The chart on the opposing page shows the breakdown of the new engine designations.



## Engine Numbering System

In order to organize and classify the engines developed by BMW, a numbering system has been developed.

**N 5 5 B 30 M 0**

**Digit 1** is the engine developer and/or generation:

- A = Motorcycle
- M = BMW Group (Old Generation)
- N = BMW Group (New Generation)
- G H K L T = BMW Group (Future Generation)
- P = BMW Motorsport
- S = BMW M GmbH

**Digit 2** is the engine type:

| Combustion Engines | Electric Motors |
|---|---|
| 4 = in-line 4 | A = Asynchronous |
| 5 = in-line 6 | P = Permanent Magnet |
| 6 = V8 | R = Switched Reluctance |
| 7 = V12 | S = Synchronous |
| 8 = V10 | T = Transversal flow |

**Digit 3** is the engine technology:

**Digit 4** is working procedure and/or fuel:

- B = Gasoline
- D = Diesel
- E = Electric
- G = Natural Gas
- H = Hydrogen
- M = Methanol
- X = Electronic - Diesel
- Y = Electronic - Gasoline

**Digits 5 & 6** are the displacement value:

**Digit 7** is the performance class:

- S = Super performance
- T = Top performance class
- O = Upper performance class (standard)
- M = Intermediate performance class
- U = Lower one performance class
- K = Smallest one performance class

**Digit 8** is release relevant information:

- 0 = New Development
- 1-9 = Revision (such as technical update or cost project)

# N52KP Engine Overview

The enhanced and improved version of the original **N52** is referred to as the N52KP or more accurately the **N52B30O1**. This engine includes cost saving measures as well as various technical improvements. The N52KP will eventually replace the N52 in all vehicle applications. One of the first vehicles to use the N52KP was the 328i coupe (E92).

The technical highlights of the N52KP include:

- New engine management (MSV80)
- New HFM (digital)
- New throttle - EGAS8 with magnetoresistive position feedback
- Plastic valve cover with integrated crankcase vent valve and oil separation
- Stronger connecting rods
- Exhaust valve stem increased to 6mm
- New electric water pump (2nd generation)
- Lightweight camshafts (hydroformed)

The N52KP will be available in three versions as follows:

- N52B30O1 - High Output version with 260hp
- N52B30M1 - Medium Output version with 230hp
- N52B30U1 - Possible future application with 215hp

Each of the above engines will have a different specific output for installation into various models. For example, the E83 LCI (X3 3.0si) will receive the “O” version which has a power output of 260 horsepower at 6600 rpm.

## Technical Data (N52B30M1)

| Description | Value |
|---|---|
| Engine type | Inline 6 cylinder |
| Displacement ($cm^3$) | 2996 |
| Stroke/bore (mm) | 88/85 |
| Cylinder spacing (mm) | 91 |
| Firing order | 1-5-3-6-2-4 |
| Power output(kw/bhp) @ RPM | 172/230 @ 6250 RPM |
| Torque (Nm) @RPM | 270 @ 3000 |
| Maximum engine speed | 7000 |
| Compression ratio | 10.7 |
| Valves/ | 4 |
| Knock control | Yes |
| Engine management | MSV80 |
| Emission compliancy (US) | ULEV 2 |
| Injection system type | Manifold injection |

## N51 Overview

In order to comply with **SULEV** requirements, the **N51** is another variant of the N52 engine. There are various measures to meet the EPA/CARB standards, some of which are familiar from the previous SULEV (M56) engine.

Some of the SULEV measures for the N51 include:

- Near engine catalyst with additional underbody catalyst
- Secondary air system
- Optimized combustion chamber geometry in cylinder head
- Modified piston crown for lower compression
- Plastic valve cover with integrated crankcase vent valve and separator (from N52KP)
- Stainless steel fuel lines with threaded connections
- Radiator with “Prem-air” coating
- Throttle system - EGAS08 carried over from N52KP
- Airbox with Activated carbon filter for EVAP control
- Purge system pipes are made from “optimized” plastic

## N54 Engine Overview

The first new member of the **NG6** family was the **N54** which was initially available in the E92 335i. The N54 continues the tradition of “efficient dynamics” by meeting the customer demand for high performance and the necessary requirements of low fuel consumption and emissions.

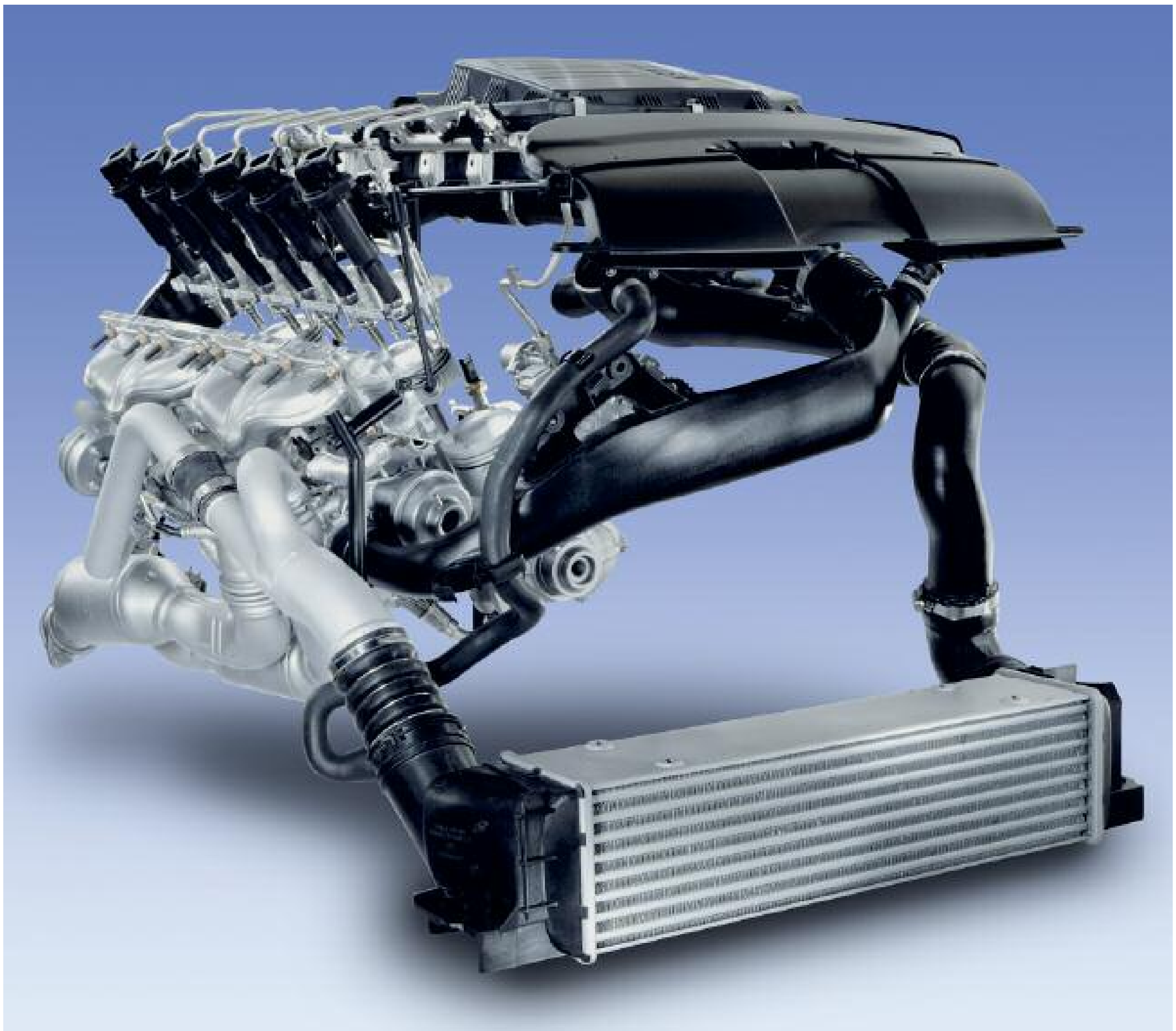
The N54 is available as a **3.0 liter** engine and features the following:

- Exhaust driven turbochargers (Bi-turbo)
- Air to air Intercooler
- 2nd Generation Direct Injection (HPI) with piezo injectors
- New engine management (MSD80)
- Bi-VANOS
- All aluminum crankcase with iron cylinder liners (similar dimensions to N52)
- External oil cooler
- New high output electric water pump (400 W)
- Aluminum cylinder head with plastic valve cover
- Steel crankshaft

As per the new engine designations, the N54 will be officially referred to as the N54B30O0. The "O" designates the "upper" output range and the "0' indicates the first generation in this series.

The N54 features the new HPI injection system which is capable of pressures of to 200 bar. This system features the new "piezo" injector technology with "outward" opening injectors.

Also, the N54 benefits from **parallel bi-turbocharging** with air to air intercoolers.

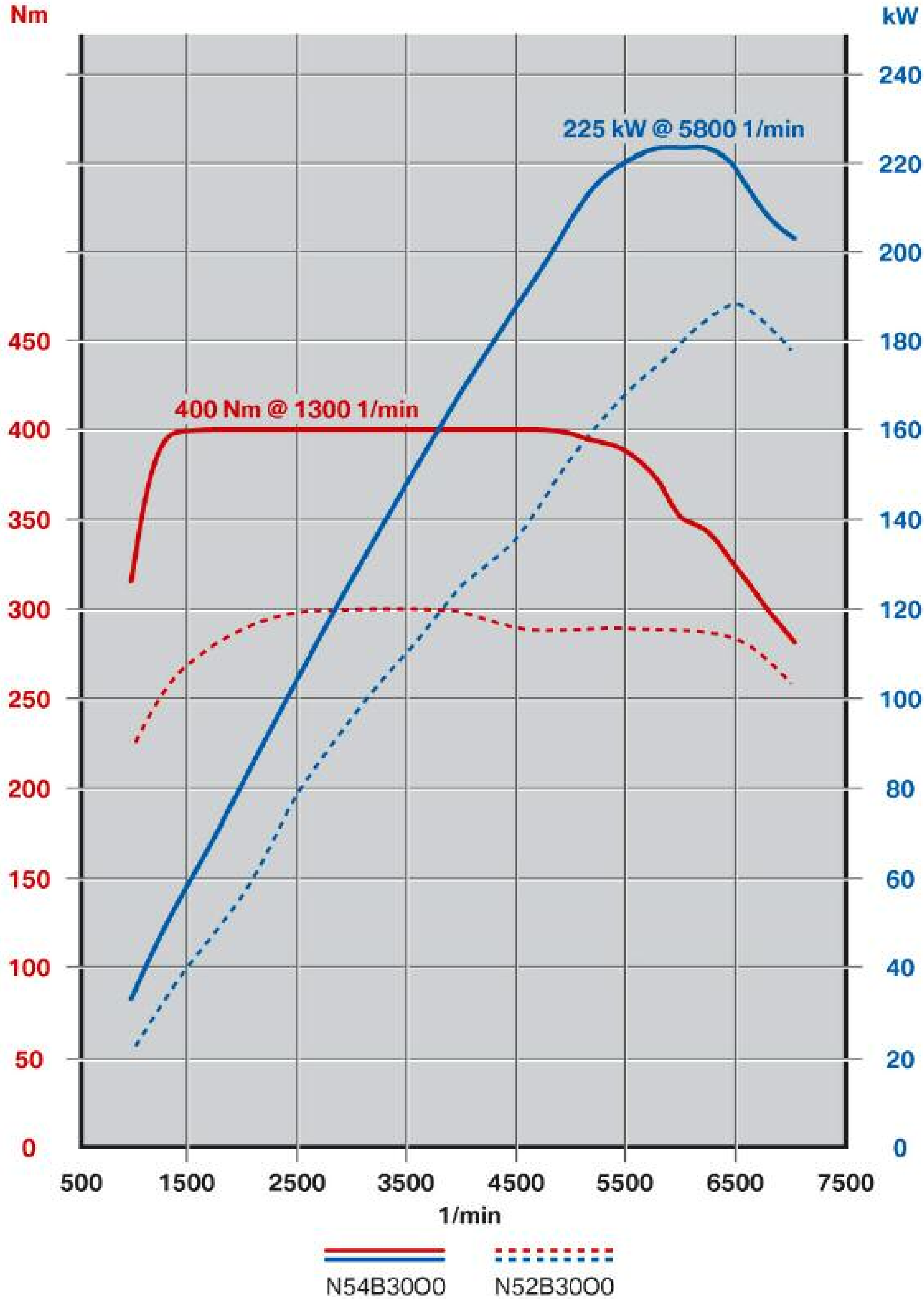


Overall, the N54 provides the driver with uncompromising response and high torque output in a package that is up to 150 pounds lighter than a V-8 engine. The new technology used in the N54, allows for maximum efficiency and the required low tailpipe emission figures to meet ULEV II guidelines.

## Technical Data (N54)

| Description | Value |
|---|---|
| Engine type | Inline 6 cylinder |
| Displacement ($cm^3$) | 2979 |
| Stroke/bore (mm) | 84/89.6 |
| Cylinder spacing (mm) | 91 |
| Crankshaft main bearing diameter (mm) | 65 |
| Crankshaft rod journal diameter (mm) | 50 |
| Firing order | 1-5-3-6-2-4 |
| Power output(kw/bhp) @ RPM | 225/300 @ 5800 RPM |
| Torque (Nm) @RPM | 400 @ 1300 - 5000 |
| Maximum engine speed | 7000 |
| Power to weight ratio (kg/kW) | 0.83 |
| Power output per liter (kW/l) | 75.5 |
| Compression ratio | 10.2 |
| Valves/cyl | 4 |
| Inlet valve diameter (mm) | 31.44 |
| Exhaust valve diameter (mm) | 28 |
| Engine weight (kg) | 187 |
| Knock control | Yes |
| Engine management | MSD80 |
| Emission compliancy (US) | ULEV 2 |
| Injection system type | HPI (DI 2) |

## Power Output Comparison (N52 to N54)



## N55 Engine Overview

The N55 engine is the successor to the N54 engine and was introduced to the US market with the launch of the F07 535i Gran Turismo in the Spring of 2010. Technical updates and modifications make it possible to use only one exhaust turbocharger. The technical data has remained virtually the same - with reduced costs and improved quality.

Innovations on the N55 engine:

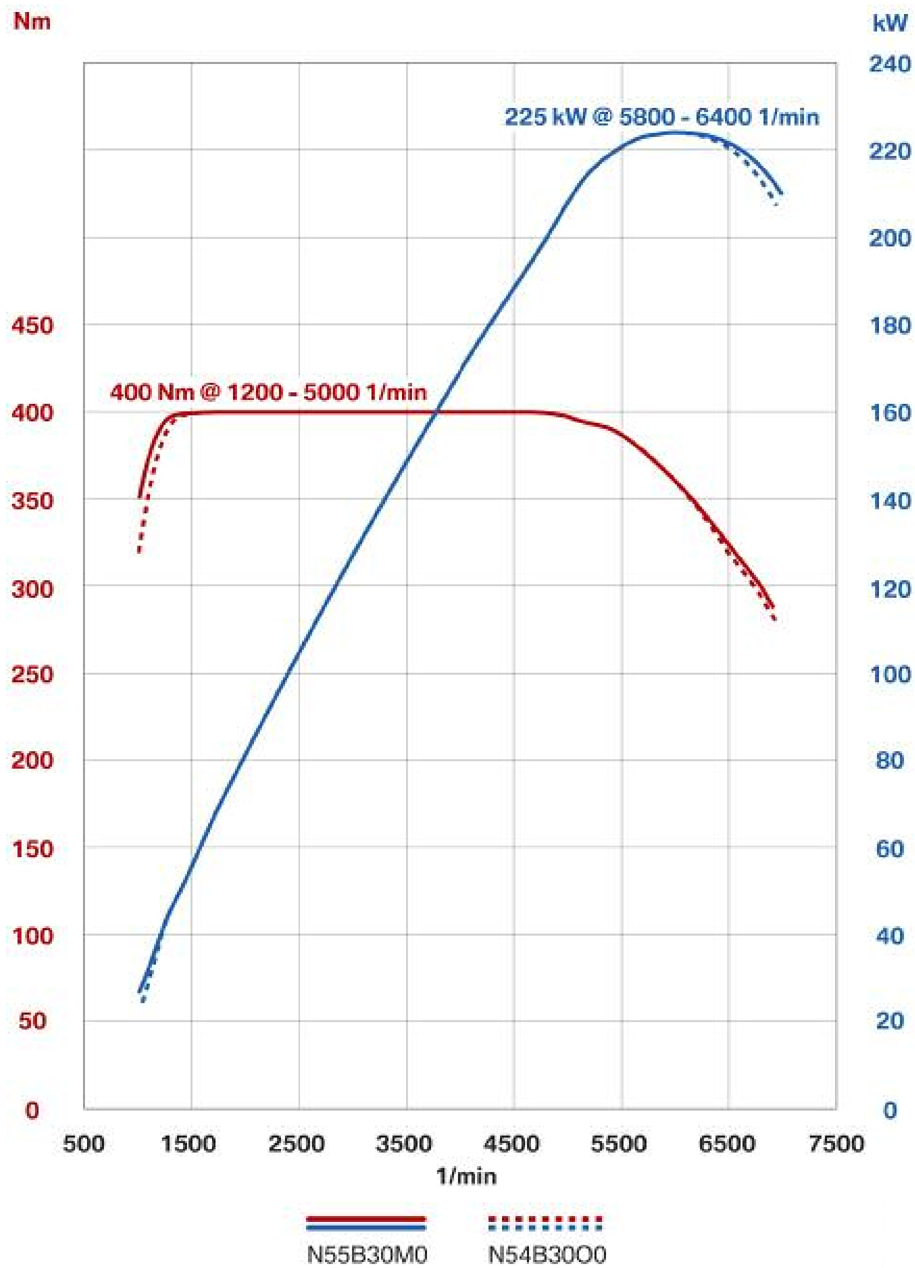
- Single exhaust turbocharger (twin scroll type)
- Air-gap-insulated exhaust manifold six into two
- Catalytic converter is located closer to engine
- Direct fuel injection with central injector location, (uses solenoid valve injectors)
- 3rd generation VALVETRONIC
- Engine mounted Digital Engine Electronics (MEVD17.2 Bosch), integrated into intake system, FlexRay capability
- Lightweight-construction crankshaft
- Characteristic-map-regulated oil pump
- Uniform single-belt drive across all model series

## Technical Data (N54 vs. N55)

| | Unit | N54B30O0 (E71/X6 xDrive35i) | N55B30M0 (F07/535i) |
|---|---|---|---|
| Configuration | | 6 inline | 6 inline |
| Cylinder capacity | [cm³] | 2979 | 2979 |
| Bore/stroke | [mm] | 84.0/89.6 | 84.0/89.6 |
| Power output at engine speed | [kW/bhp] [rpm] | 225/306 5800 - 6250 | 225/306 5800 - 6400 |
| Power output per liter | [kW/l] | 75.53 | 75.53 |
| Torque at engine speed | [Nm] [rpm] | 400 1300 - 5000 | 400 1200 - 5000 |
| Compression ratio | [ε] | 10.2 | 10.2 |
| Valves/cylinder | | 4 | 4 |
| Fuel consumption, EU combined | [l/100 km] | 10.9 | 8.9 |
| CO2 emission | g/km | 262 | 209 |
| Digital Motor Electronics | | MSD81 | MEVD17.2 |
| Exhaust emission legislation, US | | ULEV | ULEV II |
| Engine oil specification | | BMW Longlife-01 BMW Longlife-01 FE BMW Longlife-04 | - |
| Top speed | [km/h] | 240 | 250 |
| Acceleration 0 - 100 | [s] | 6.7 | 6.3 |
| Vehicle curb weight DIN/EU | [kg] | 2070/2145 | 1940/2015 |
| * = Electronically governed | | | |

## Full Load Diagram

Compared to its predecessor, the N55 engine is characterized by lower fuel consumption with the same power output and torque data.




**Full load diagram E90 335i with N54B30O0 engine compared to the F07 535i with N55B30M0 engine**

## Models

### N54B30O0 engine variants

| Model | Version | Series | Displace-ment in cm³ | Stroke/ bore in mm | Power output in kW/bhp at rpm | Torque in Nm at rpm |
|---|---|---|---|---|---|---|
| 135i** | US | E82, E88 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| 335i** | US | E90, E92, E93 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| 335i xDrive** | US | E90, E92 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| 335is | US | E92, E93 | 2979 | 89.6/84.0 | 320 SAE hp 5800 - 6250 | 450 (332 ft-lbs) *1400 - 5000 |
| Z4 sDrive35i** | US | E89 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| Z4 sDrive35is | US | E89 | 2979 | 89.6/84.0 | 335 SAE hp 5800 - 6250 | 450 (332/369 ft-lbs) *1400 - 5000 |
| 535i** | US | E60 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| 535i xDrive** | US | E60, E61 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| X6 xDrive35i** | US | E71 | 2979 | 89.6/84.0 | 300 SAE hp 5800 - 6250 | 407 (300 ft-lbs) 1400 - 5000 |
| 740i | US | F01, F02 | 2979 | 89.6/84.0 | 315 SAE hp 5800 - 6250 | 450 (330 ft-lbs) 1600 - 4500 |

* **The enhanced engine management system of the BMW Z4 sDrive35is and the 335is include an electronically controlled overboost function to briefly increase torque under full load by another 37 ft-lbs. This temporary torque peak of 369 ft-lbs gives the car a significant increase in acceleration for approximately 5 seconds.**

**** As of MY 2011 the N55 replaced the N54 in these models.**

## Engine Designation and Engine Identification

### Engine designation

This training material describes the N55B30M0 in detail.

In the technical documentation, the engine designation is used for unique identification of the engine. In the technical documentation you will also find the abbreviated engine designation, i.e. N55, that only indicates the engine type.

| Item | Meaning | Index / explanation |
|---|---|---|
| 1 | Engine developer | M, N = BMW Group<br>P = BMW Motorsport<br>S = BMW M mbH<br>W = Non-BMW engines |
| 2 | Engine type | 1 = R4 (e.g. N12)<br>4 = R4 (e.g. N43)<br>5 = R6 (e.g. N55)<br>6 = V8 (e.g. N63)<br>7 = V12 (e.g. N73)<br>8 = V10 (e.g. S85) |
| 3 | Change to the basic engine concept | 0 = basic engine<br>1 – 9 = changes, e.g. combustion process |
| 4 | Working method or fuel type and possibly installation position | B = Gasoline, longitudinal installation<br>D = Diesel, longitudinal installation<br>H = Hydrogen |
| 5 | Displacement in liters | 1 = 1 liter (whole number of liters) |
| 6 | Displacement in 1/10 liter | 8 = 0.8 liter (tenth of liter) |
| 7 | Performance class | K = Smallest<br>U = Lower<br>M = Middle<br>O = Upper (standard)<br>T = Top<br>S = Super |
| 8 | Revision relevant to approval | 0 = New development<br>1 – 9 = Revision |

## Breakdown of N55 Engine Designation

| Index | Explanation |
|---|---|
| N | BMW Group Development |
| 5 | Straight 6 engine |
| 5 | Engine with direct injection, VALVETRONIC and exhaust turbocharger |
| B | Gasoline engine, longitudinal |
| 30 | 3.0-liter capacity |
| M | Medium performance class |
| 0 | New development |

### Engine identification

The engines are marked on the crankcase with an engine identification code for unique identification.  This engine identifier is also required for approval by the authorities. The N55 engine further develops this identification system and the code has been reduced from previously eight to seven characters. The engine serial number can be found under the engine identifier on the engine. Together with the engine identifier, this consecutive number enables unique identification of each individual engine.

| Item | Meaning | Index / explanation |
|---|---|---|
| 1 | Engine developer | M, N = BMW Group<br>P = BMW Motorsport<br>S = BMW M GmbH<br>W = Non-BMW engines |
| 2 | Engine type | 1 = R4 (e.g. N12)<br>4 = R4 (e.g. N43)<br>5 = R6 (e.g. N55)<br>6 = V8 (e.g. N63)<br>7 = V12 (e.g. N73)<br>8 = V10 (e.g. S85) |
| 3 | Change to the basic engine concept | 0 = basic engine<br>1 – 9 = changes, e.g. combustion process |
| 4 | Working method or fuel type and possibly installation position | B = Gasoline, longitudinal installation<br>D = diesel, longitudinal installation<br>H = hydrogen |
| 5 | Displacement in liters | 1 = 1 liter (whole number of liters) |
| 6 | Displacement in 1/10 liter | 8 = 0.8 liter (tenth of liter) |
| 7 | Type test concerns (changes that require a new type test) | A = Standard<br>B – Z = Depending on requirement, e.g. RON 87 |

### N55 engine, engine identification and engine serial number

| Index | Explanation |
|---|---|
| 08027053 | Individual consecutive engine serial number |
| N | Engine developer, BMW Group |
| 5 | Engine type, straight 6 |
| 5 | Change to basic engine concept, turbocharging, VALVETRONIC, direct fuel injection |
| B | Operating principle or fuel supply and installation position, petrol engine longitudinal |
| 30 | Displacement in 1/10 liter, 3 liter |
| A | Type approval requirements, standard |

NOTES PAGE

# 8 Cylinder Engines

## N63B44O0 Engine

The N63 engine was introduced with the launched of the E71 xDrive50i in 2008. The new 4.4 liter, 400 hp, 450 lb-ft torque V8 engine combines direct injection with twin turbochargers (neatly tucked into the engine valley).

As the successor to the N62 engine, the N63B44O0 was developed based on the principles of "Efficient Dynamics". Efficient Dynamics combines driving enjoyment with efficiency which, in a new engine, is expressed in increased power output together with reduced fuel consumption.


One of the ways of achieving this objective is through downsizing. This means the same power output is achieved with reduced engine displacement or higher power output at the same engine displacement.

Both objectives apply to the N63 engine. Compared to the N62 engine, the power output has been boosted while decreasing the engine displacement.

In comparison, the N62TU has a displacement of 4.8 liters, while the new N63 engine displaces only 4.4 liters.

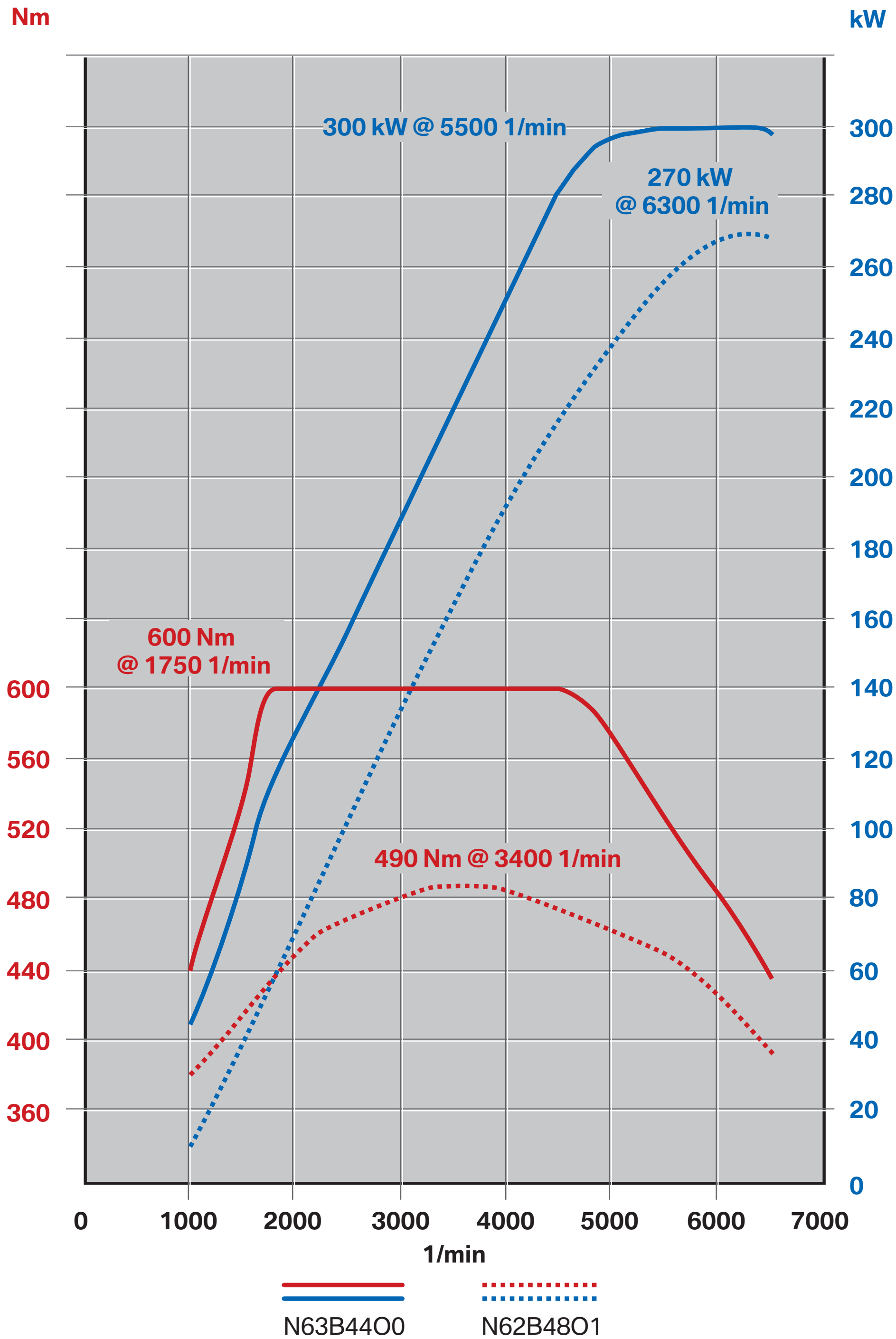
This is primarily achieved by technologies that already gave the N54 engine its legendary dynamics and outstanding efficiency: Bi-turbocharging in connection with high precision injection.

The N63 is the first engine world-wide to feature an optimized package, involving the integration of the turbocharger and the main near-engine catalytic converters in the “v-space”.

The N63 was installed in several BMW models from the E71, E72, E70 LCI to F01, F02, F04, F07, F10 and F12.

### Full Load Diagram

Compared to it's predecessor, the N62TU, the new N63 engine is characterized by distinctly higher output. It has an impressive torque curve which not only peaks earlier (at 1750 RPM), but is also very "flat" which is a characteristic of BMW turbocharged engines.



## Engine Technical Data (N62TU vs. N63)

| Description | Units | N62B48O1 | N63B44O0 |
|---|---|---|---|
| Engine type | | V-8 | V-8 |
| Displacement | (cm3) | 4799 | 4395 |
| Firing order | | 1-5-4-8-6-3-7-2 | 1-5-4-8-6-3-7-2 |
| Stroke | mm | 88.3 | 88.3 |
| Bore | mm | 93 | 89 |
| Power output @ rpm | hp @ rpm | 360 @ 6300 | 400 @ 5500 to 6400 |
| Torque @ rpm | Nm @ rpm | 490 @ 3400 | 600 @ 1750 - 4500 |
| Maximum engine speed | rpm | 6500 | 6500 |
| Power output per liter | kw (hp) | 56.26 (75) | 68.26 (90) |
| Compression ratio | | 10.5 : 1 | 10.0 : 1 |
| Cylinder spacing | mm | 98 | 98 |
| Valves/cylinder | | 4 | 4 |
| Intake valve | mm | 35.0 | 33.0 |
| Exhaust valve | mm | 29.0 | 29.0 |
| Main bearing journal diam-eter | mm | 70 | 65 |
| Connecting rod journal diameter | mm | 54 | 54 |
| Fuel specification (Octane) | (RON) | 98 | 98 |
| Engine management | | ME 9.2.2 | MSD85 |
| Emission standard | | ULEV II | ULEV II |

## Engine Overview

The latest generation of BMW V-8 engines differs from past designs in several areas. Although all of these engines have been derived from the M60 engine from 1993, the N63 engine design is a departure from the original design.

The following chart will point out some of the differences where the N63 is unique and distinct. The information found below outlines the new engine technology as compared to previously known systems. The features are organized by engine system and are divided into the following categories:

- New Development - this is a system or component which has never been used previously on a BMW engine.
- New Design - this is a system or component which has been specifically developed for the N63 engine, but does not represent a technical innovation.
- Technology carried over from N54 - This represents technology already known from the N54 engine and adapted to the N63.

| Component/System | New Development | New Design | Technology carried over from N54 | Remarks |
|---|---|---|---|---|
| Engine casing components | | X | | Engine casing components include the cylinder head, cylinder head cover, crankcase, oil pan. |
| Crankshaft drive system | | X | | Crankshaft drive system includes the crankshaft which has reduced weight, while maintaining sufficient strength. |
| Valve gear | | X | | The N63 engine uses VANOS, which is carried over from N52. (No VALVETRONIC is used) |
| Timing gear | X | | | A new tooth-roller chain is used in the timing gear. |

| Component/System | New Development | New Design | Technology carried over from N54 | Remarks |
|---|---|---|---|---|
| Belt drive | X | | | The belt drive uses the ELAST drive belt, but is characterized by a new tensioning system for the AC compressor. |
| Oil supply | | X | | A volumetrically controlled oil pump is used for the N63 engine. |
| Cooling system | X | | | In addition to a conventional coolant pump, the N63 engine uses an auxiliary electric cooling pump for cooling of the turbochargers. There is also an additional cooling circuit for the water-cooled intercoolers with it’s own electric coolant pump and heat exchangers. |
| Air intake and exhaust systems | | X | | Due to the arrangement if the turbochargers in the “v-space” and the indirect charge air cooling, the intake and exhaust systems are completely re-configured. |
| Turbocharging | | | X | A bi-turbocharging system has been carried over from the N54 engine. |
| Vacuum system | | X | | A two-stage vacuum pump similar to that used on the N62TU engine. |
| Fuel system | | | X | The HPI injection system from the N54 engine has been adapted to the V-8 (N63). |
| Engine electrical system | | X | | The engine management system features a new ECM and there are new oxygen sensors (LSU ADP). |

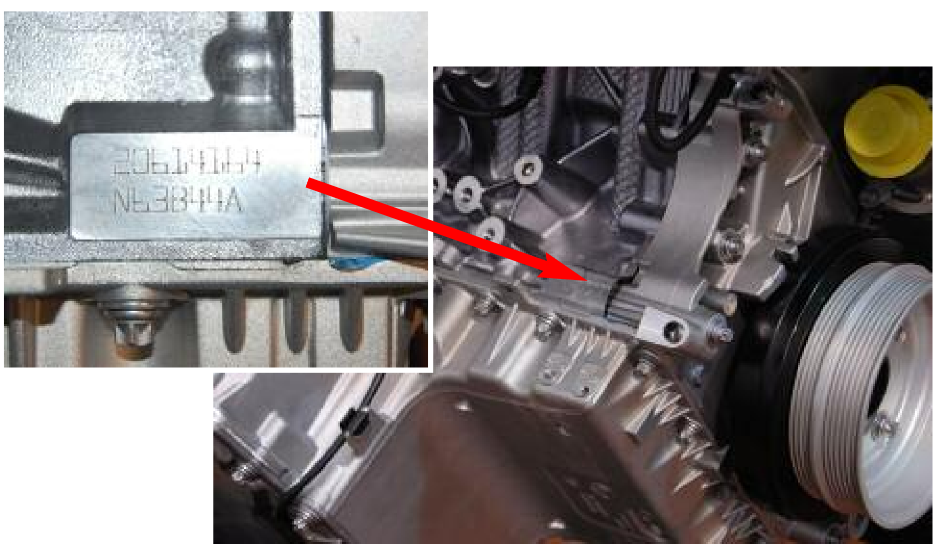
## Engine Designations

Officially, the engine designation for the new BMW N63 engine is N63B44O0.
The designation is broken down in the following:

| Index | Explanation |
|---|---|
| N | BMW Group “New Generation” engine |
| 6 | 8-cylinder engine |
| 3 | Gasoline, direct-injection |
| B | Gasoline engine |
| 44 | 4.4 liter displacement |
| O | Upper output stage |
| 0 | New development |

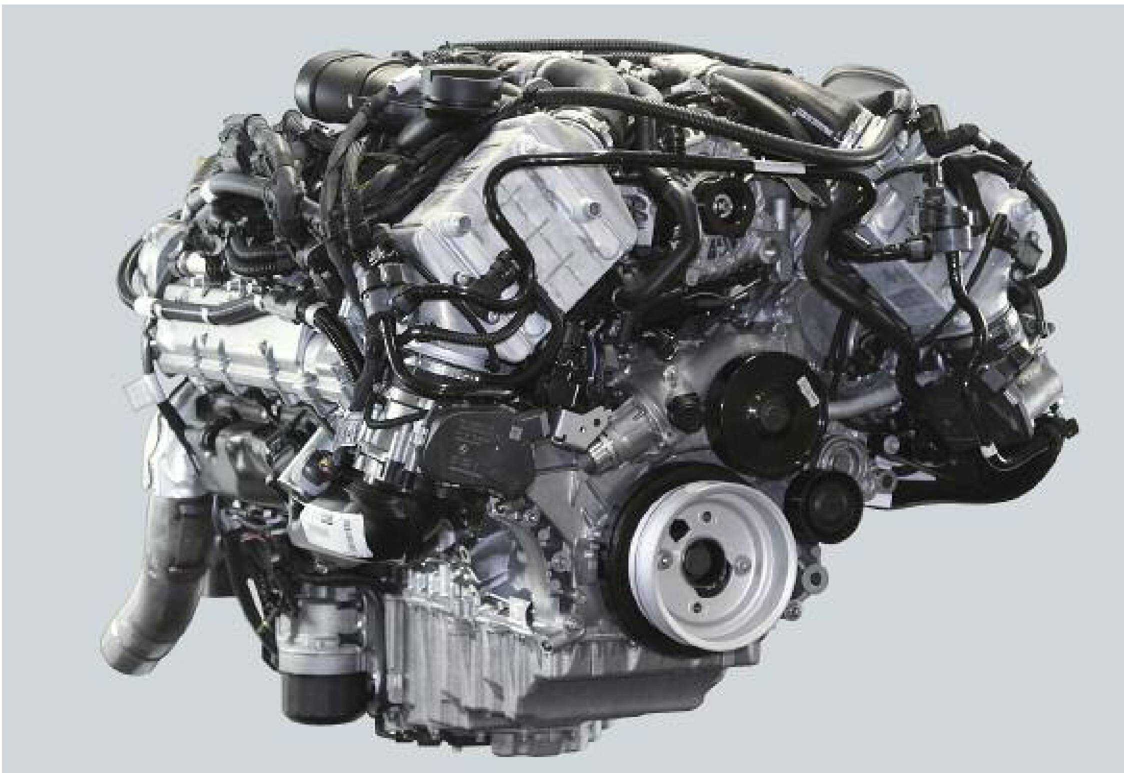
### Engine identification and serial number

The engine ID and sequential serial number are located on the passenger side of the engine behind the AC compressor mounting at the front of the crankcase.



## N63TU Engine

The N63TU engine is the predecessor to the N63. The further developed N63TU engine is the latest fuel-mixture generation technology Turbo-Valvetronic Direct Injection TVDI. There are strong similar ties here to the N20 or N55 engines. The new engine boasts better performance data at reduced fuel consumption and CO2 emissions.



This training material describes the differences to the N63 engine.

**Series Introduction**

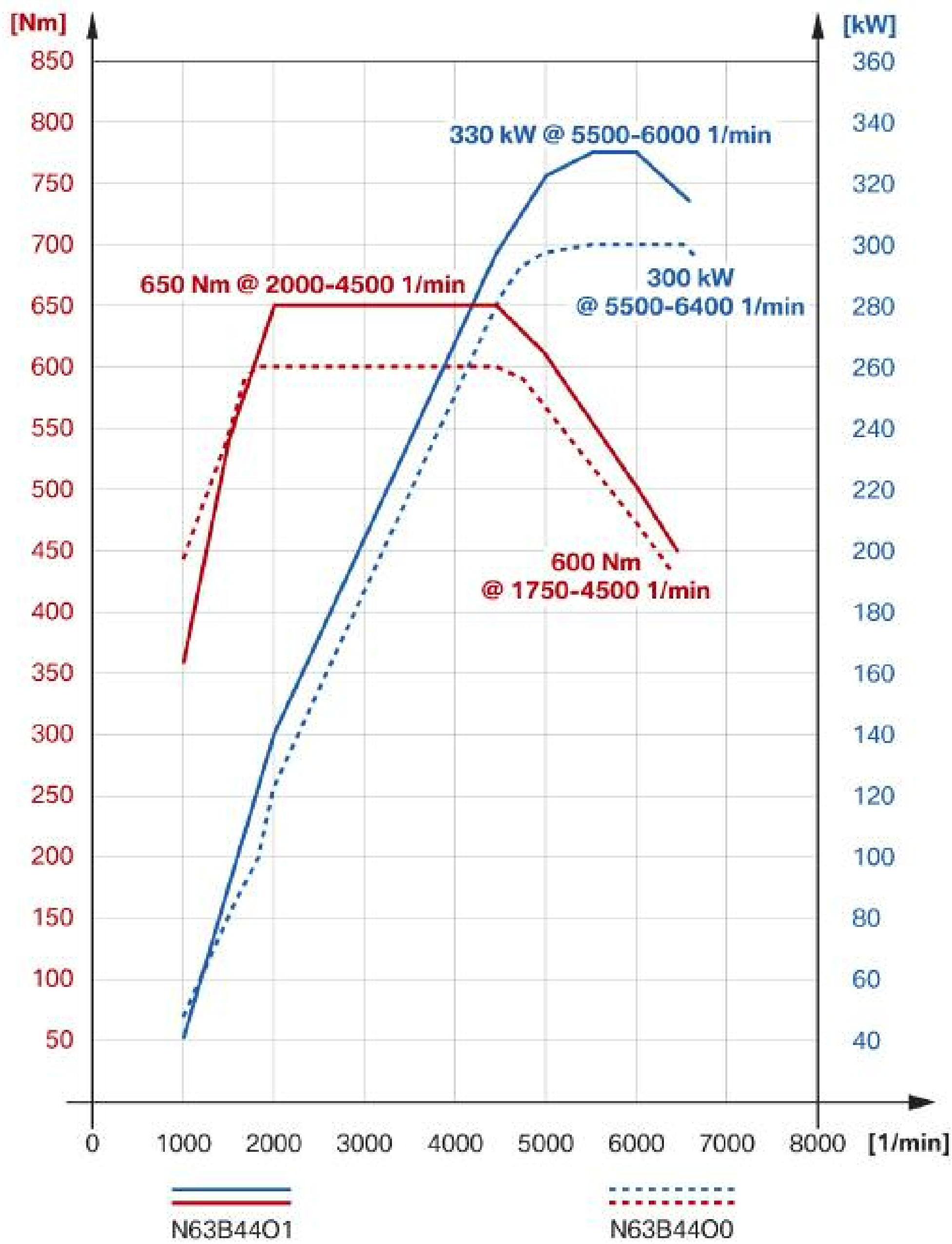
| Series | N63B44O1 | Series Introduction |
|---|---|---|
| F01 | BMW 750i<br>BMW 750i xDrive | 07/2012 |
| F02 | BMW 750Li<br>BMW 750Li xDrive | 07/2012 |
| F06 | BMW 650i<br>BMW 650i xDrive | 07/2012 |
| F07 | BMW 550i<br>BMW 550i xDrive | 07/2012 |
| F12 | BMW 650i<br>BMW 650i xDrive | 07/2012 |
| F13 | BMW 650i<br>BMW 650i xDrive | 07/2012 |

## Technical Data (N63TU)

| Description | Units | N63B44O0 | N63B44O1 |
|---|---|---|---|
| Engine type | | V-8 | V-8 |
| Displacement | (cm3) | 4395 | 4395 |
| Firing order | | 1-5-4-8-6-3-7-2 | 1-5-4-8-6-3-7-2 |
| Stroke | mm | 88.3 | 88.3 |
| Bore | mm | 89 | 89 |
| Power output @ rpm | hp @ rpm | 400 @ 5500 to 6400 | 445 @ 5500 to 6400 |
| Torque @ rpm | Nm @ rpm | 600 @ 1750 - 4500 | 650 @ 1750 - 4500 |
| Maximum engine speed | rpm | 6500 | 6500 |
| Power output per liter | kw (hp) | 68.26 (90) | 75.1 (102) |
| Compression ratio | | 10.0 : 1 | 10.0 : 1 |
| Cylinder spacing | mm | 98 | 98 |
| Valves/cylinder | | 4 | 4 |
| Intake valve | mm | 33.0 | 33.0 |
| Exhaust valve | mm | 29.0 | 29.0 |
| Main bearing journal diameter | mm | 65 | 65 |
| Connecting rod journal diameter | mm | 54 | 54 |
| Fuel specification (Octane) | (RON) | 98 | 98 |
| Engine management | | MSD85 | MEVD17.2.8 |
| Emission standard | | ULEV II | ULEV II |

## Full Load Diagram

**Full load diagram comparing N63B44O0 engine with N63B44O1**



## New features/Changes

### Engine Mechanical

- New cylinder head due to use of the Turbo Valvetronic Direct Injection (TVDI) procedure
- 3rd generation Valvetronic
- New valvetrain with modified timing
- Adoption of VANOS from the N55 engine
- New cylinder head cover with adapted crankcase ventilation
- Pistons with modified piston crown geometry
- New connecting rod with even pitch and adaptation of the crankcase due to modified connecting rod shape
- Adapted crankshaft
- Chain drive with modified guide rails and an extruded chain with 142 elements.

### Oil supply

- Pendulum slide cell pump with small overall width
- Eight individual oil spray nozzles for piston crown cooling.

### Cooling

- Integration of the two engine control units in the low-temperature circuit and cooling over the back panel with cooling pipe
- Expansion tank under the left side wall with separate filling hopper.

### Intake and exhaust emission systems

- Adaptation of the manifold for the air intake duct due to new geometry of the cylinder head cover
- Use of the hot film air mass meter 7
- Adoption of the charge air temperature and intake-manifold pressure sensor from the N20 engine
- Exhaust turbocharger with new compressor and modified wastegate valves
- Discontinuation of the blow-off valves.

### Vacuum system

- Two-stage vacuum pump with new arrangement of the bolt connection
- Vacuum reservoir for the wastegate valves in the V-area of the engine.

### Fuel preparation

- Use of the known high-pressure injection with injectors and high pressure pump HDP5
- Discontinuation of fuel low-pressure sensor.

### Engine management system

- New dual control unit concept with one control unit per bank
- Oil level sensor with an additional temperature sensor in the main oil duct behind the starter motor.

## Engine Designation

The version N63B44O1 of the N63TU engine is described in this document.

The engine designation in the technical documentation, is used to ensure clear identification of the engine.

| Index | Explanation |
|---|---|
| N | BMW Group "New Generation" engine |
| 6 | 8-cylinder engine |
| 3 | Engine with exhaust turbocharger, Valvetronic, and direct fuel injection (TVDI) |
| B | Gasoline engine |
| 44 | 4.4 liter displacement |
| O | Upper output stage |
| 1 | First revision |

NOTES PAGE

# 12 Cylinder Engine

## N74B60U0 Engine

The N74 engine was introduced to the US market with the launch of the F01/F02 760i/760Li in the September 2009.

The N74 engine is the successor to the N73 engine, but shares many technical features with the N63 engine. Thus the N74 engine also has high precision injection featuring outward-opening piezo injectors located centrally in the combustion chamber and twin turbochargers with indirect charge air cooling. On the N74 engine, however, the exhaust turbochargers are located on the outside of the engine.


**N74B60U0 engine**

## N74 Engine Features

The N74 engine also shares many other common features with the N63 engine, such as a volumetric-flow-controlled oil pump and a camshaft drive with tooth-roller type chains.

By using the latest technology, it has been possible to increase power output substantially, while at the same time reducing fuel consumption – Efficient Dynamics in fact.


| Index | Explanation |
|---|---|
| 1 | Camshaft drive with toot-roller type chain |
| 2 | High pressure pump for high precision injection |
| 3 | Charge air cooling for indirect charge air cooling |
| 4 | Outward-opening piezo injector |
| 5 | Volumetric-flow-controlled oil pump |
| 6 | Exhaust turbocharger |
| 7 | Charging pressure control by means of wastegate valves |

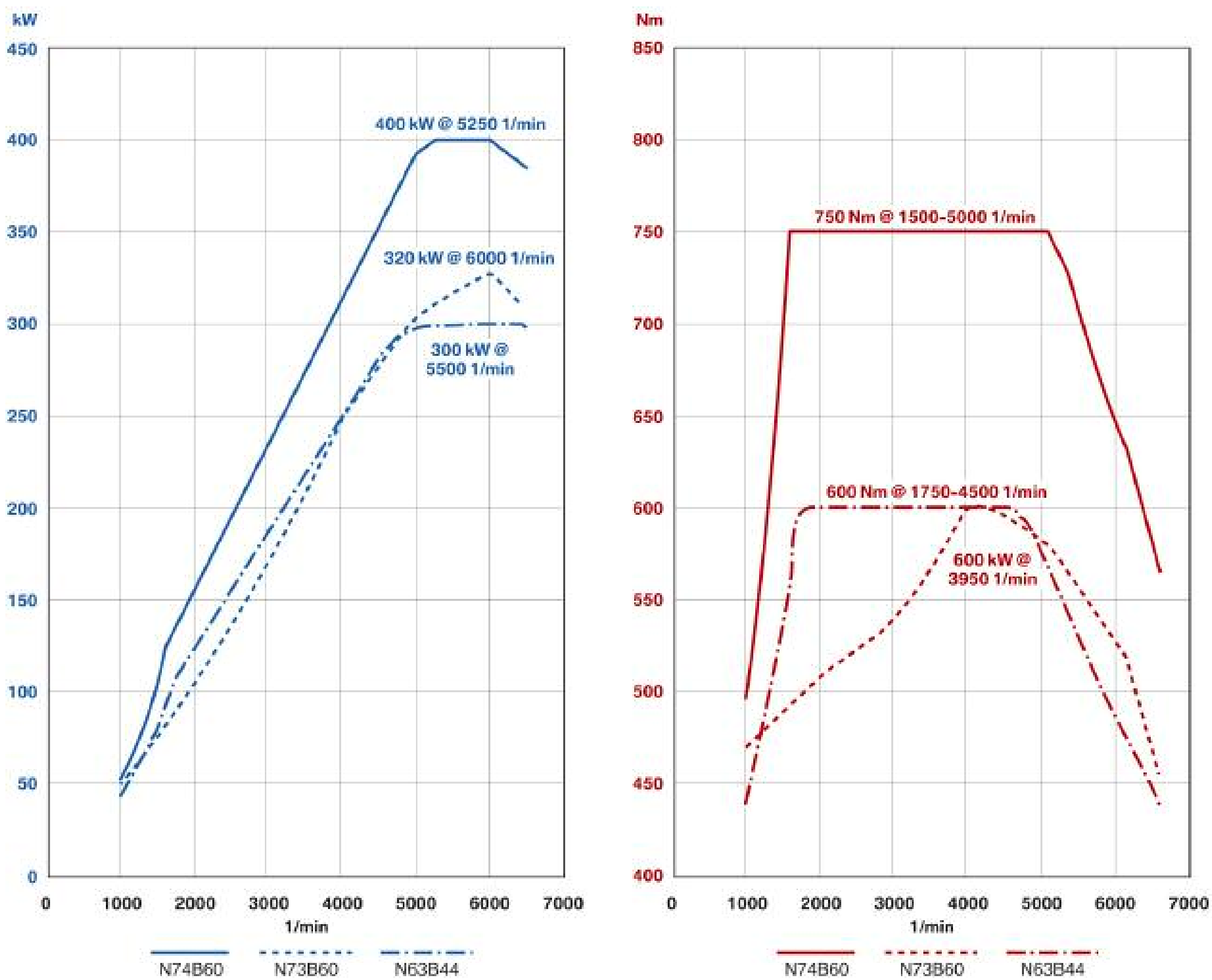
## Technical Data (N73 vs. N74)

| Description | Units of Measure | N73B60O1 | N74B60U0 |
|---|---|---|---|
| Engine type | | V12 60° | V12 60° |
| Firing order | | 1-7-5-11-3-9-<br>6-12-2-8-4-10 | 1-7-5-11-3-9-<br>6-12-2-8-4-10 |
| Displacement | [cm³] | 5972 | 5972 |
| Bore / stroke | [mm] | 89/80 | 89/80 |
| Power output at engine speed | [kW/bhp]<br>[rpm] | 320/435<br>6000 | 400/535<br>5250-6000 |
| Torque at engine speed | [Nm/lb-ft]<br>[rpm] | 600/400<br>3950 | 750/550<br>1500-5000 |
| Power output per liter | [kw/l] | 53.58 | 66.98 |
| Cutoff speed | [rpm] | 6500 | 6500 |
| Compression ratio | | 11.5 | 10.0 |
| Maximum Boost | bar | NA (Naturally Aspirated) | 0.7 |
| Distance between cylinders | [mm] | 98 | 98 |
| Valves per cylinder | | 4 | 4 |
| Diameter of intake valve | [mm] | 35.0 | 33.2 |
| Diameter of exhaust valve | [mm] | 29 | 29 |
| Diameter of main bearing journals of the crankshaft | [mm] | 70 | 65 |

| Description | Units of Measure | N73B60O1 | N74B60U0 |
|---|---|---|---|
| Diameter of connecting rod bearing journals of the crankshaft | [mm] | 54 | 54 |
| Fuel specification | [RON] | 98 | 95 |
| Fuel | [RON] | 91-98 | 91-98 |
| Engine control system | | 2 x MED 9.2.1<br>1 x VALVETRONIC control unit<br>2 high-pressure fuel injection valve control units (HPFI) | 2 x MSD87-12 |
| Exhaust emission standard US | | LEVII | ULEV II |

## Full Load Diagram

**Full load diagram for the N74B60 engine, compared with the N73B60 and N63B44 engines**



## Engine Overview

The following provides an overview of the features of the N74 engine:

- **Engine block**

  The main components of the engine block have been re-designed, although most features are already used on other BMW engines.

- **Crankshaft**

  Although the Pistons and connecting rods have been borrowed from the N63 engine, the crankshaft is a new design.

- **Valve train**

  The VANOS units from the N63 engine are used and the camshafts are manufactured in the same way. The N74 does not use a VALVETRONIC system.

- **Camshaft**

  The tooth-roller type chain of the N63 engine is used. Only the chain length and the layout of the timing gears have been adapted to suit the twelve-cylinder engine.

- **Belt drive**

  The structure of the belt drive includes a “revolver” tensioning system and is identical to that on the N63 engine.

- **Oil supply**

  Though the oil supply system has been designed for the N74 engine, in principle, it's the same as that on the N63 engine. Consequently a volumetric-flow-controlled oil pump is also used here.

- **Crankcase ventilation**

  The engine uses the same crankcase ventilation principle as N63 engine with a new feature called register ventilation. With this feature, the oil separators now have four cyclones per cylinder bank and in naturally-aspirated operation, ventilation only occurs via cylinder bank 2.

- **Cooling system**

  Two separate cooling circuits are used as on N63, one to cool the engine and turbocharger bearings and one for charge air cooling, this latter circuit also provides cooling for the two engine control units.

- **Air intake and exhaust system**

  The air intake and exhaust systems are the same as that on the N63 engine. This means there are two conventional exhaust turbochargers with wastegate and blow-off valves. In contrast to the N63 engine, however, the exhaust turbochargers are located on the outside.

- **Secondary air system**

  As with N73 engine, the N74 is equipped with a secondary air system. One new feature, however, are the two pressure sensors that monitor system operation.

- **Vacuum system**

  The N74 engine has a two-stage vacuum pump as on the N63. The vacuum system only differs in that it has two vacuum reservoirs.

- **Fuel system**

  The N74 engine uses “injection guided” (HPI) high precision injection in homogeneous operation at all times, as on the N54 and N63 engines. The structure of the system is the same as that on the N63 engine. Consequently, the same injectors are used and the high pressure pumps are also very similar.

- **Engine electrical system**

  A total of five control units were used on the N73 for engine control purposes. The N74 now has two engine control units, one of which has the role of the master (primary), the other the secondary. The two MSD87-12 control units are located to the left and right of the engine compartment and are cooled by the low temperature cooling circuit of the engine intercoolers.

The N74 engine uses the most current BMW systems. Although the N74 engine has been designed from scratch, from a technology point of view it is, the same as the N63 engine and has also borrowed many individual components from this engine.

## Engine Identification

### Engine designation
In the technical documentation, the engine designation is used to ensure the clear identification of engines.

The N74 engine is available in the following version: **N74B60U0**

In the technical documentation, you will also find the short form of the engine designation N74 which only permits identification of the engine type.

The following chart explains the meaning of each component of the engine designation.

| Index | Explanation |
|---|---|
| N | BMW Group "New generation" |
| 7 | 12-cylinder engine |
| 4 | Engine with high precision injection and turbocharging |
| B | Gasoline engine |
| 60 | 6.0 liters displacement |
| U | Lower power stage |
| 0 | New development |

### Engine identification and number
To ensure clear identification and classification, the engines have an identification mark on the crankcase. This engine identification is also necessary for approval by the authorities.

Decisive here are the first seven positions. The N74 engine has an engine identification that complies with the new standard, in which the first six positions are the same as the engine designation. The seventh position is a consecutive letter that can be used for various distinctions, e.g. power stage or exhaust emission standard. A general assignment is not possible, but an "A" usually means the basic model.

The engine number is a consecutive number that permits unmistakable identification of each individual engine. The engine designation and number are on the crankcase behind the bracket for the air conditioning compressor.

# Table of Contents

## Engine Technology

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# Engine Technology

## Model: All

## Production: from 9/2006

# OBJECTIVES

After completion of this module you will be able to:

- Understand the basic mechanical features of the N52KP and N54
- Understand the mechanical differences between the current BMW engines
- Describe the operation of VALVETRONIC II, double VANOS, and volume controlled oil pumps

# Engine Construction

## Innovative Solutions

The **N52** engine concept allowed for a substantial weight savings of 10Kg (22 lbs.) over its predecessor the M54. The primary contributors to the total weight savings are the use of an innovative composite magnesium-aluminum crankcase and a lightweight exhaust manifold. The magnesium bedplate and cylinder head cover also played a significant role in overall weight reduction.

The overall lightweight engine package allows for and improved power to weight ratio as well as an improvement in fuel consumption.

## Crankcase

Since magnesium cannot be used in all areas of engine construction, the N52 crankcase is a composite design. The crankcase consists of an aluminum/silicon insert which is cast inseparably in a magnesium alloy.

The crankcase is a two piece design with a separate bedplate also cast from magnesium. An additional design change from previous designs is the timing cover which is now cast as an integral part of the engine block.

The aluminum silicon insert provides the threaded connections for the transmission mounting, cylinder head and crankshaft main bolts. The insert provides the coolant passages as well. This is to prevent coolant contact with the magnesium portion of the engine block.

## Magnesium - New Material in Engine Construction

Until now, magnesium has not been explored as an option for a material for engine construction. Recently, the realization is that the weight savings potential of aluminum has been exploited to its fullest. This is one of the primary factors in the decision to use magnesium as engine building material. The light weight and low density of magnesium make it an outstanding option to aluminum.

Magnesium, which has very good casting properties, makes it possible to manufacture large components with high surface quality. Despite the high accuracy of the cast parts, subsequent machining of function areas is, however, in the majority of cases unavoidable.

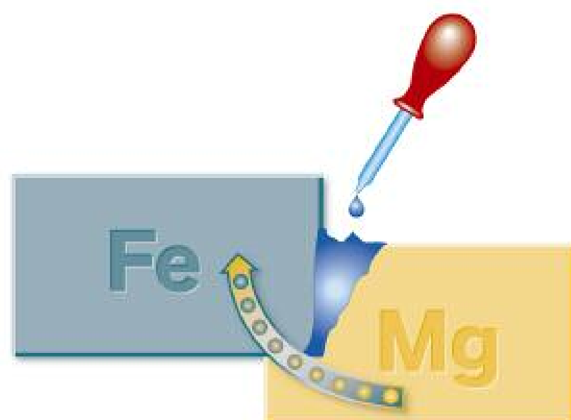
These excellent properties are, however, offset by several problematic aspects in the use of magnesium and its alloys. The former serious problem of corrosion has in the meantime been substantially alleviated by the development of distinctly more corrosion resistant alloys. The alloy used for the N52 is designated AJ62.

Nevertheless, a distinct corrosion risk still exists if the material-specific fundamentals described in the following are disregarded. Non-approved materials that come in contact with magnesium must not be installed.

This means only genuine BMW spare parts must be installed. The materials of the add-on parts must either be compatible with AJ62 or shielded by a seal/gasket from the magnesium casing. For these reasons, it is important to strictly adhere to the corresponding information provided in the repair instructions.

### Electrochemical Properties of Magnesium

Metals are divided into noble (precious) and base metals. Gold, for example, is a noble metal and sodium a very base metal. The other metals are distributed over this division. When two metals such as iron and magnesium get in contact with each other and are placed in an electrically conductive liquid, e.g. a salt solution, the base metal will break down or dissolve and go into solution.



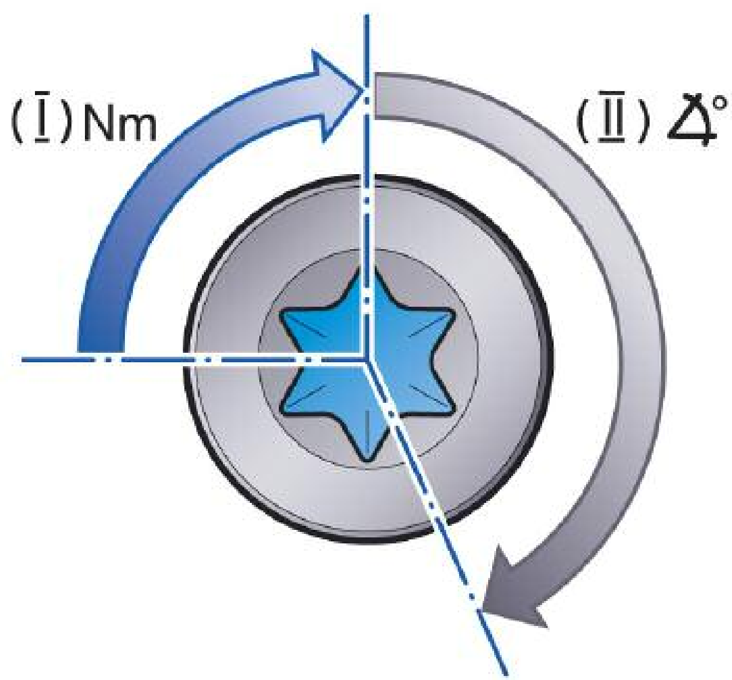

At the same time, electric current flows from the noble metal to the base metal. Under certain conditions, the base metal will deposit itself on the noble metal.

## Bolts

As with the **N52**, the **N54** continues to use the aluminum bolts for most fastening duties. Even though the N54 is an all aluminum crankcase, the aluminum bolts are used to reduce any confusion. This decreases the possibility of any incorrectly installed bolts of the wrong material (steel vs. aluminum). Of course, the **N52KP** and **N51** still retains the use of aluminum bolts as well.

The same rules apply to the handling and installation of aluminum bolts as in the past. Strict adherence to repair instructions is required to ensure proper connections.

**Be sure to use the proper torque/tightening angle sequence as indicated in the "tightening torques" section of TIS.**



The use of magnesium is a new concept for production passenger vehicles.  BMW has developed special processes for the development of the N52 crankcase.  A special magnesium alloy (AJ62) is used which has excellent properties which reduce the possibility of corrosion and allow favorable machining characteristics.

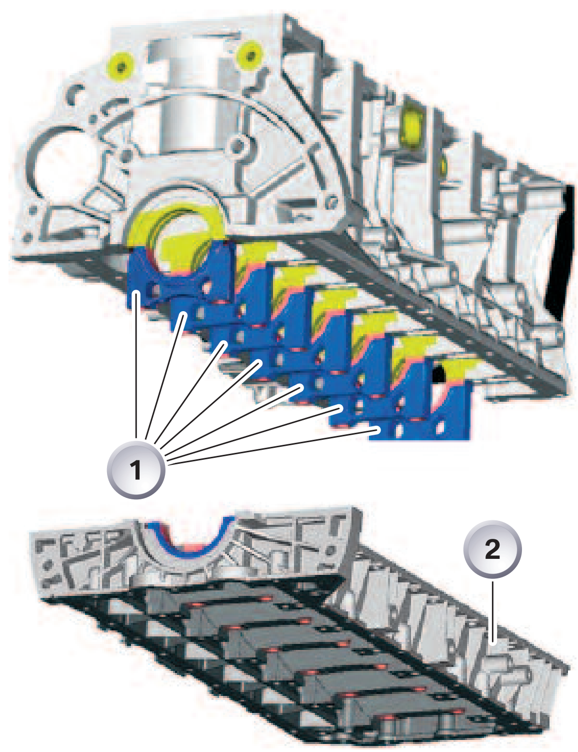
The cylinder bore consists of an Alusil structure, there are no iron cylinder liners as with previous 6 cylinder designs.  The cylinder bores cannot be machined, however this design still allows for planing of the deck surface if needed.

## Bedplate

The **N52** engine uses a split crankcase, the upper section is made from a **composite magnesium/aluminum** structure.  The lower portion, which is used to increase rigidity, is designed as a bedplate structure made from magnesium.

There are sintered steel inlays (arrow) for the main bearings to take up forces which would not be suitable for magnesium alone.

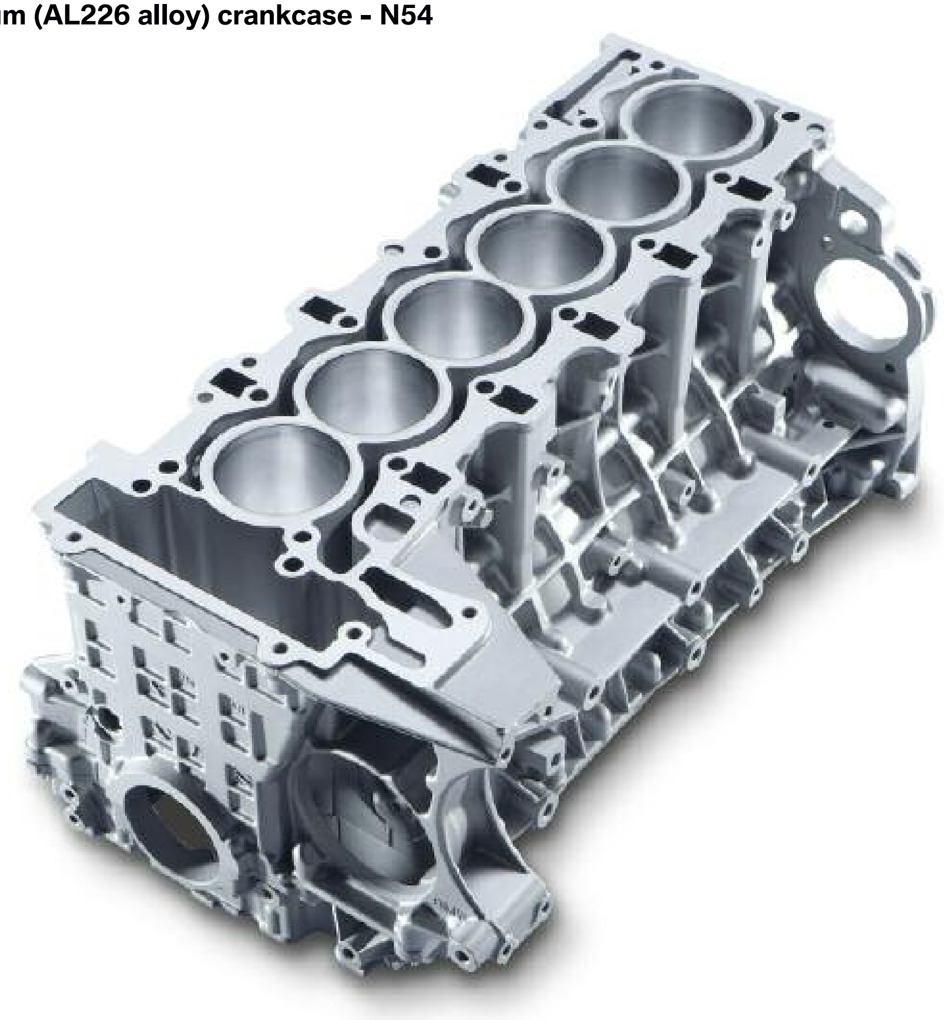
Between the bedplate and crankcase, a liquid sealer is injected under high pressure into a machined groove.  This process is critical in service applications.




| Index | Explanation |
|---|---|
| 1 | Bedplate inlays |
| 2 | Bedplate |

Of the three new 6-cylinder engines introduced in 2007, the **N54** has the most changes in comparison with the N52. Beginning with the crankcase, the N54 engine uses an **all aluminum** alloy block with cast cylinder liners. The aluminum crankcase is pressure cast and differs from the “insert” design of the N52. This design is in contrast to the previous composite magnesium/aluminum crankcase on the N52. The construction of the N54 crankcase is to accommodate the increased torque output of the turbocharged N54.

**All aluminum (AL226 alloy) crankcase - N54**



Dimensionally, the N54 crankcase is the same as the N52 and continues to use the 2-piece crankcase with bedplate. There are some slight differences regarding the bolt pattern for the transmission mounting. This requires a new engine mounting bracket when installing on to the engine stand.

## Gaskets and Seals

The gasket design on the new engines is mostly similar to the N52. The N54 uses a specific head gasket for use with the turbocharged application. The head gasket is a multi-layered design which does not have the protruding lip as on the N52. This lip is not needed due to the fact that the cylinder head is aluminum and contact corrosion is not an issue.

The split crankcase still uses the injected sealant carried over from the N52.

## Piston and Connecting Rods

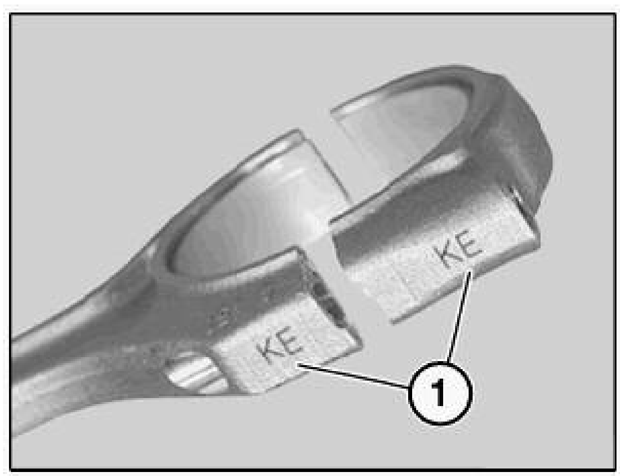
As with the cylinder head, the piston designs differ between engines. Special pistons are used for compatibility with the direct injection system. The piston crown is modified to meet the mixture formation and higher compression requirements.

As in the past, the underside of the pistons are cooled with oil spray jets.

The **N51** engine uses a lower compression ratio and accordingly uses a different piston design. The N52KP uses the same design as the N52 engine.

The connecting rods on all of the NG engines have been stiffened with a thicker beam on the rod. This design has also been in production since the N52 (6/06).

The connecting rods are weight optimized by tapering the “small end” of the rod. This method reduces weight without reducing strength.




The “**big end**” of the connecting rod is “**cracked**” to create to proper centering of the bearing cap without the use of dowel pins. This further contributes to the overall weight reduction. Each connecting rod uses pairing codes (1) to allow the correct rod cap to be matched to the connecting rod.

The connecting rods are divided into weight categories and can only be replaced as a set.

## Crankshafts

While a cast iron crankshaft is used in the N52KP, N51 and N55. The **N54**, **N63** and **N74** all use a **forged steel crankshaft**.

To reduce weight, the main bearings diameter of the crankshaft have been reduced and contain an integrated sprocket for the oil pump. See the specific engine training material for further details.

## Differential Intake Air Control (DISA) N52

The torque developed in an engine greatly depends on the quality of the fresh gas charge during the induction stroke.

Oscillations are induced in the intake air mass during the induction strokes of the individual cylinders, i.e. by the downward movement of the pistons. These oscillations are in turn superimposed by oscillations that arise from pressure peaks as soon as the moved air mass of an intake cylinder comes up against the closing intake valves.

When two oscillations are superimposed, the resulting oscillation is known as the resonance oscillation or sympathetic vibration. The resonance can be an amplification or an attenuation of the initial oscillation or vibration.

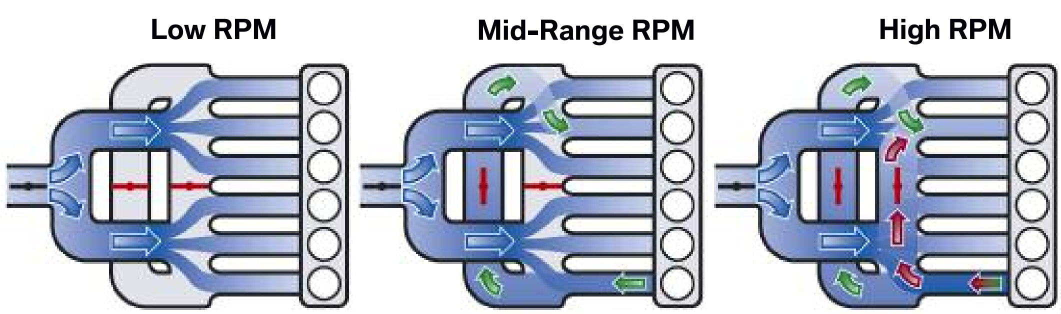
Whether a pressure peak or a pressure hole is applied before the intake valves at the cylinder at the start of the induction stroke depends on the path the superimposed oscillations have covered in the intake area and on the engine speed, i.e. the gas speed.

The desire for high torque over a broad engine speed range necessitates an increasingly diverse range of air intake systems for internal combustion engines. The geometry and control of the intake manifold therefore have a considerable influence on the quality of the charge cycle. An intake manifold with a fixed length would provide an optimum cylinder charge only at a certain engine speed.

The options of boosting torque over a defined engine speed window are limited. Since the N52 reaches a maximum engine speed of 7,000 rpm, the previous 2-stage DISA in the M54 would produce a torque lag in the mid engine speed range. The N52 is thus equipped with a 3-stage DISA in order to provide high torque also in the medium engine speed range.

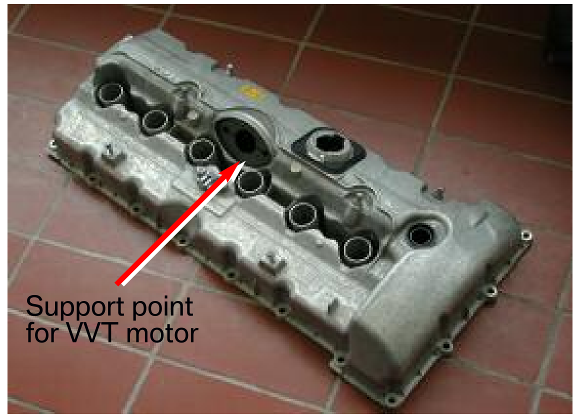
The result of these three stages is illustrated in the diagram below. The switched stages of the DISA achieve a high torque over the entire engine speed range. This principle is realized by means of an intake manifold changeover facility with two DISA actuators and an overflow pipe in the intake area.

**In contrast to the previous system that was controlled with vacuum, the two DISA actuators are now operated by electric motors.**



## Cylinder Head Cover

The cylinder head cover of the **N52** is cast from **magnesium alloy**. The cylinder head cover provides an important mounting point for the VVT motor. All of the bolts which attach the cylinder head cover to the cylinder head are made from aluminum.




**N52 Cylinder head cover**

When performing repairs which involve the removal of the cylinder head cover be sure to replace the bolts and use the proper torque/angle procedure as outlined in the repair instructions.

While the N52 uses a magnesium cylinder head cover, most newer engines 6 cylinder engines use a plastic cover. The N52KP and N51 use the same basic design to accommodate the VVT motor and new crankcase ventilation system.
In comparison, the N54 uses a completely different design. This is due to the lack of VALVETRONIC and the modified crankcase ventilation system.

**N54 Cylinder head cover**

The cylinder head cover of the N55 is a new development. The accumulator for the vacuum system, all crankcase ventilation components and the blow-by channels are integrated into the cylinder head cover.

**N55 Cylinder head cover**

## Cylinder Head

As far as cylinder head designs are concerned, all four of the 6-cylinder engines use a different cylinder head. While all of the heads are made from aluminum, they differ due to the design requirements. For example, the N54 does not use VALVETRONIC and requires accommodation for the fuel injectors for direct injection. The N52KP engine uses a cylinder head which is mostly identical to the N52. The N51, which is a SULEV II design, uses a lower compression ratio and therefore a different cylinder head with a modified combustion chamber. Finally, the N55 uses VALVETRONIC III instead of VVT II with HDE injection.

**Cross-section of N54 Cylinder Head**

The N54 cylinder head features the injector and spark plugs arranged in the center of the combustion chamber surrounded by the intake and exhaust valves. This arrangement is typical of a direct injection engine and has been implemented into most current BMW engines cylinder head designs. The following engines use this design are the N54, N55, N63, S63 and N74.

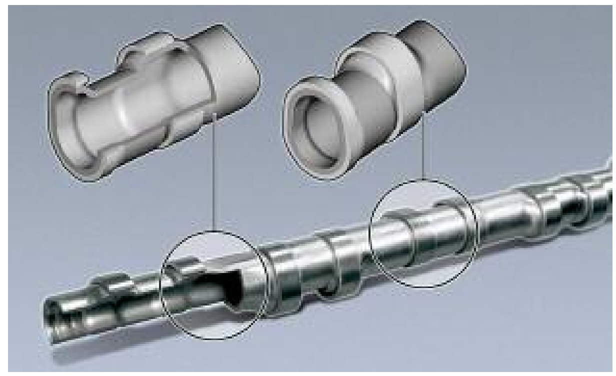
**Please refer to the individual engine training information or repair instructions for further information.**

## Valvetrain

With regard to the valvetrain changes, the intake valves still use the 5mm stem from the N52. However, the exhaust valves have been upgraded to a 6mm valve stem for increased durability. The 6mm exhaust stem has also been in production on the current N52 since 3/06.

Although most current BMW engines have solid construction valves the N55 exhaust valve stems are hollow, filled with sodium and are 6mm in diameter. In addition, the valve seat of the exhaust valves are reinforced.

**Lightweight hydroformed camshaft**



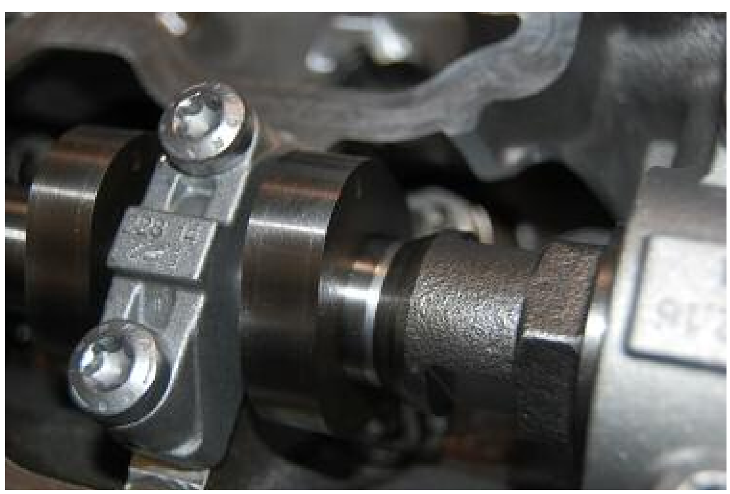
## Camshafts

Recent advancements in engine technology have brought about new camshaft designs. Most engine variants take advantage of the lightweight, hydroformed camshafts from the N52. The lightweight camshafts are manufactured in an internal high pressure forming process called hydroforming.

Only **lightweight hydroformed** camshafts are used on the **N55** engine. The exhaust camshaft features bearing races and is encapsulated in a camshaft housing.
The camshaft housing reduces oil foaming during operation.

The **N63** and **N74** engines have assembled camshafts, of the type as used on the M73 engine. These camshafts are assembled from individual components rather than machined from a solid cast iron blank. All components are shrink-fitted on to the shaft. This technology not only provides a reduction in manufacturing costs, but also a considerable weight savings.

**Note: For supply and production reasons, it is possible that lightweight hydroformed camshafts as well as cast camshafts or a mixture of both were installed in N51, N52 and N54 engines.**



## VANOS

All current BMW engines use the **infinitely variable double VANOS** system which was first introduced on the M52B20TU engine. The design is similar to that of two-setting intake VANOS; the main difference is that in addition to the timing of the intake camshaft, the timing of the exhaust camshaft can also be varied. The system allows for infinite variation of timing of both camshafts according to the control commands from the engine management ECU.

The advantages of infinitely variable double VANOS are:

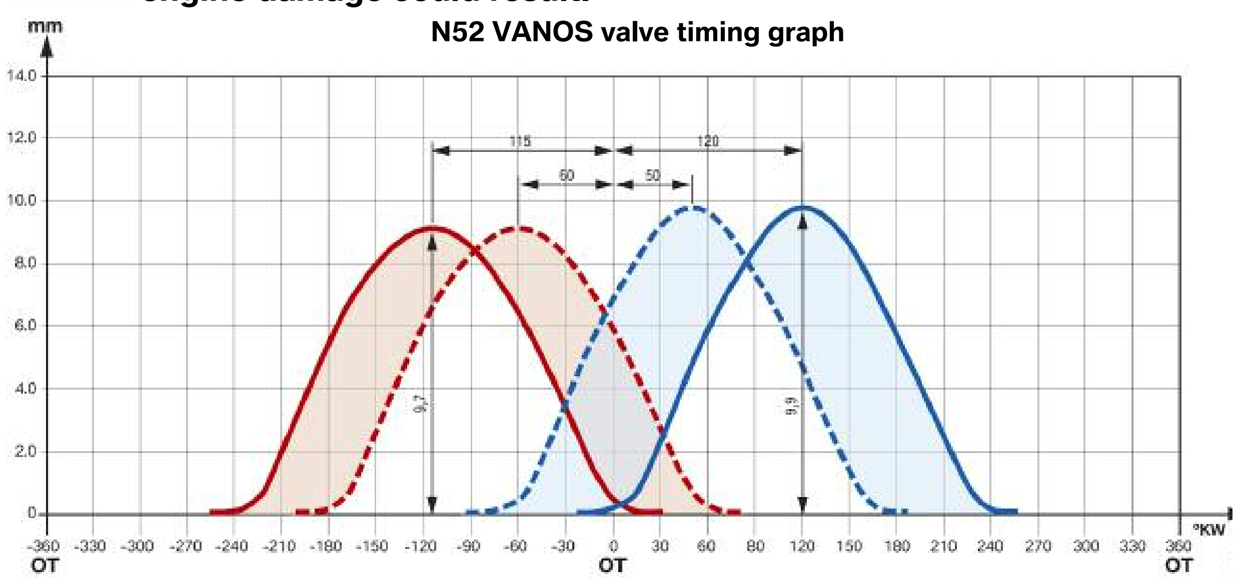
- Higher torque at low and medium engine speeds.
- Smaller quantity of residual exhaust when idling due to smaller valve overlap resulting in improved idling.
- Internal exhaust recirculation in the medium power band in order to reduce nitrogen oxide emissions.
- Faster warm-up of catalytic converters and lower raw emission levels after a cold start.
- Reduction of fuel consumption.

The possible adjustment range of the double VANOS system is clearly identifiable by the blue/red shaded areas.

The infinitely variable double VANOS system is used on all current engines. The main, and sometimes only, change to the system is that each engine uses different spread ranges (check engine specifications for the individual cam spread).

**As with the previous systems, the VANOS units should not be mixed up as the spread ranges for the intake and exhaust are different and engine damage could result.**

**N52 VANOS valve timing graph**



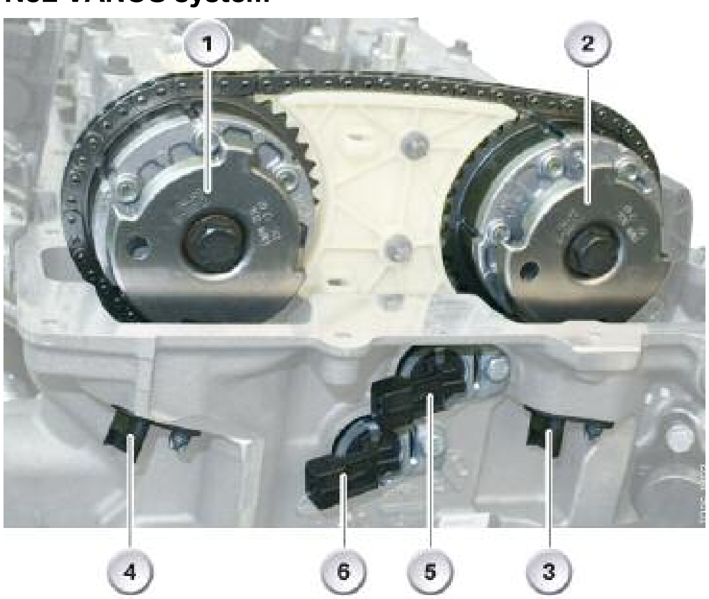
The infinitely variable double VANOS system uses hydraulic oscillating motor type VANOS units for the intake and the exhaust cams. Although they have identical function, the oscillating motor VANOS units are a further development of the variable vane type motor VANOS units used on previous systems. They are designed as an integrated component in the chain drive and are mounted with a central bolt on the respective camshaft. When de-pressurized, a coil spring holds the VANOS unit in the base position.

**N52 Hydraulic oscillating motor/VANOS unit**


| Index | Explanation |
|---|---|
| 1 | Front plate |
| 2 | Locking pin |
| 3 | Oil channel |
| 4 | Casing with ring gear |
| 5 | Pressure chamber for advancing |
| 6 | Oscillating rotor |
| 7 | Pressure chamber for retarding |
| 8 | Oil channel |

The VANOS units are controlled by oil pressure from the 4/3 proportional solenoid valves. The valves are located in the front of the cylinder head and are controlled by the ECM. The ECM regulates the VANOS based on factors such as engine RPM, load and coolant temperature.

**N52 VANOS system**

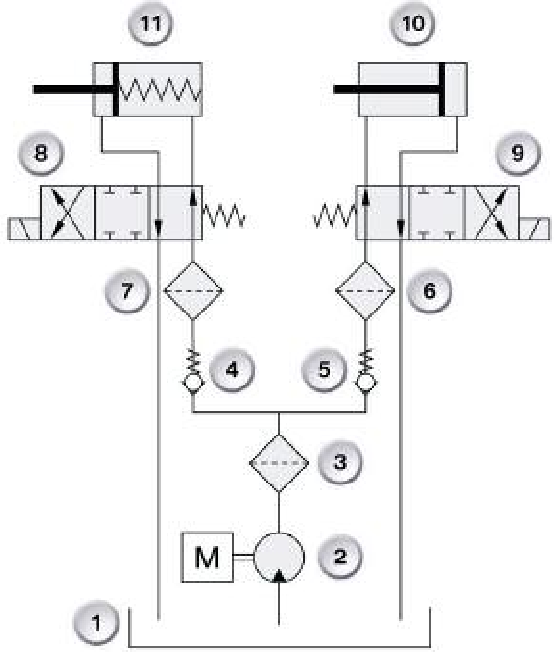



| Index | Explanation |
|---|---|
| 1 | VANOS unit, Exhaust |
| 2 | VANOS unit, intake |
| 3 | Intake camshaft sensor |
| 4 | Exhaust camshaft sensor |
| 5 | VANOS solenoid valve |
| 6 | VANOS solenoid valve |

## Hydraulic Circuit Diagram

The oil circulation for the VANOS system passes from the sump (1) to the oil pump (2) into the oil filter (3) and from there separately for the intake and exhaust camshafts through a non-return valve (5) fitted between the cylinder head and the crankcase, into a fine filter (6) on the solenoid valve, and into the solenoid valve (9). The solenoid valves direct the flow of oil so as to apply pressure to either one side or other of the pressure chamber in relevant hydraulic vane motor (10 or 11).

**N52 VANOS system hydraulic circuit**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Sump | 7 | Filter |
| 2 | Oil pump | 8 | Solenoid valve |
| 3 | Oil filter | 9 | Solenoid valve |
| 4 | Non-return valve | 10 | Hydraulic vane motor |
| 5 | Non-return valve | 11 | Hydraulic vane motor |
| 6 | Filter | | |

The position of the intake and exhaust camshafts is adjusted by a hydraulic vane motor on each camshaft.

The two seals between camshaft and camshaft bearing are required to ensure a reliable supply of oil. The solenoid valves are attached to the cylinder head by mounting brackets. The mounting brackets must not be bent; observe repair instructions. The adjustment time for 60° of crankshaft rotation is approx. **300 ms**.

That figure is true of all VANOS systems with hydraulic vane motor or oscillating motor.

## Volume Controlled Oil Pump

The high oil volume demands of the VANOS system creates a need for an oil pump that can deliver a high volume of oil when needed. Also, the pump needs to be able to cut back on the oil delivery volume when the requirements are not as great.

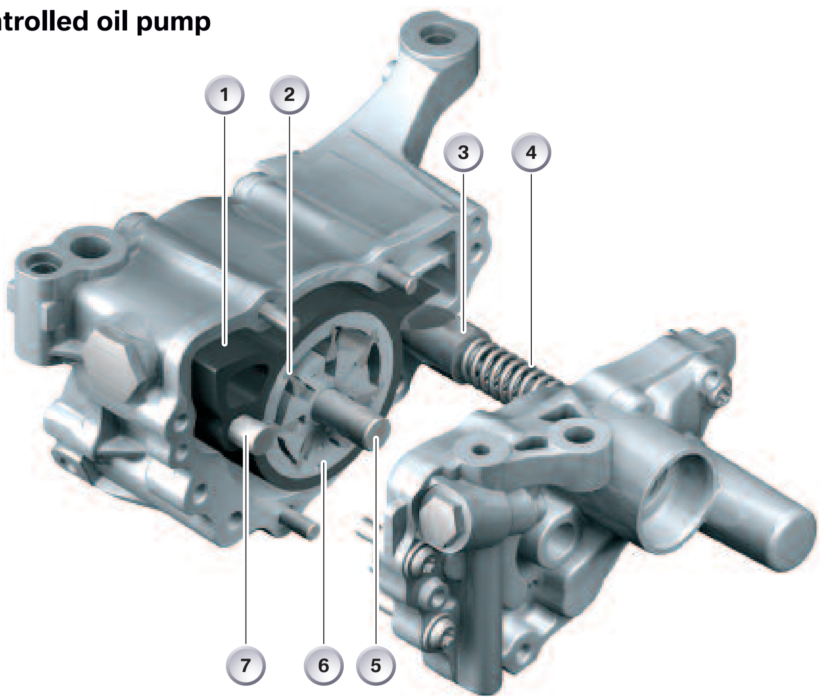
This occurs when the VANOS is not as active, for instance during cruise situations.

This oil pump is a “volume controlled” design which not only meets the oiling requirements, but also contributes to improved fuel economy and emissions.

The advantages of a volumetric-flow controlled oil pump:

- Favorable space/efficiency ratio
- Provides sufficient hydraulic pressure and volume for valve control systems
- Reduced volumetric flow fluctuations
- Hydraulic energy not converted into thermal loss
- Reduction of premature oil aggiing
- Reduced sound emissions

**N52 volume controlled oil pump**

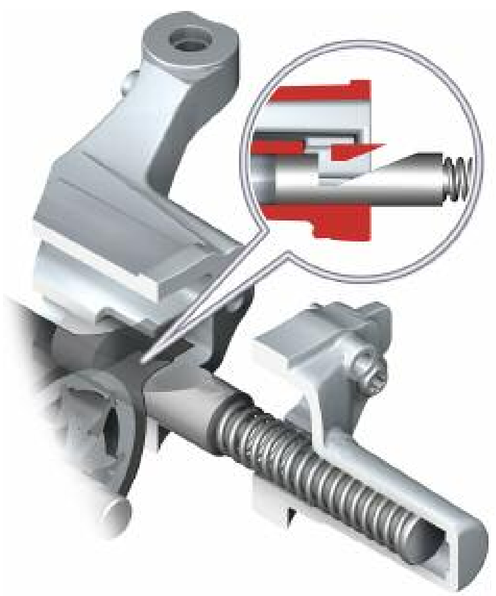


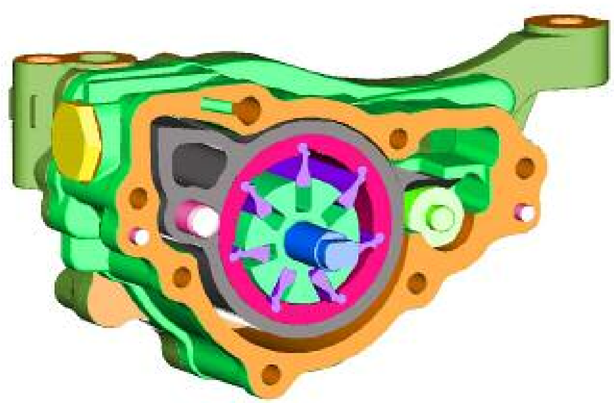

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Vane | 5 | Pump Shaft |
| 2 | Slide Valve | 6 | Rotor |
| 3 | Control Piston with Pendulum Support | 7 | Pivot |
| 4 | Compression Spring | | |

The N52 engine was the first to be equipped with a volumetric-flow controlled oil pump. This type of pump delivers only as much oil as is necessary under the respective engine operating conditions. The pump minimizes the oil flow delivered in low load operating ranges. This reduces the fuel consumption of the engine and slows down the oil wear rate.

The pump is designed as a slide valve-type vane pump. In delivery mode, the pump shaft is positioned off-center in the housing and the vanes are displaced radially during rotation. As a result, the vanes form chambers of differing volume. The oil is drawn in as the volume increases and, conversely, expelled into the oil channels as the volume decreases.

**Control Piston with Pendulum Support**





## Oil Pump Operation

The crankshaft drives the oil pump with a chain. The applied oil pressure acts on the control piston/pendulum support against the force of a compression spring. The pendulum support varies the position of the slide valve according to the applied oil pressure. When the pump shaft is positioned towards the center of the slide valve the changes in volume are small and the delivered volume is low. When the pump shaft is located off center, the changes in volume and the delivered quantity are greater. If the oil required by the engine increases, for example during VANOS control intervention, the pressure in the lubricating system drops therefore it is also reduced at the control spool. In response, the pump increases the delivery volume and re-establishes the pressure conditions. When the oil required by the engine decreases, the pump correspondingly reduces the delivery quantity towards the zero-delivery direction.

The oil pump used in the N55 engine is a further development of the shuttle slide valve volume control oil pump. The activation of the oil pump is adapted by the engine management and controlled through an oil pressure control valve. See the N55 engine training material for more information.

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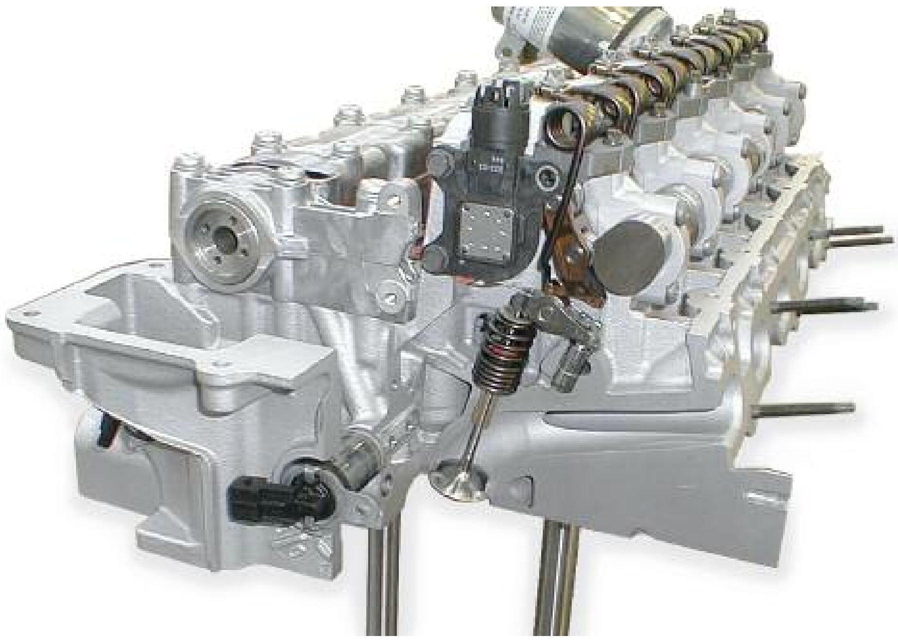
## VALVETRONIC II

The VALVETRONIC I system that was used on the 8 and 12-cylinder engines already had achieved a substantial increase in efficiency. BMW further developed this concept with the VALVETRONIC II and was first introduced in a 6-cylinder engine with the N52.



The results of this further development are in the following ares:

- Increased engine dynamics
- Increased efficiency
- Improved emission values

These results underscore BMW-specific standards and features the following enhancements:

- The top engine speed increased to 7,000 rpm.
- The specific power output increased to 63.4 kW/l (85 hp/liter).
- The specific engine torque is 100 Nm/l over a broad engine speed range.
- Distinctly increased valve acceleration values and friction-optimized transmission elements result in an even more responsive engine.
- Reduced CO2 emissions.
- Compliance with the world's most stringent exhaust emission regulations.

## Design/Function

The VALVETRONIC II consists of the fully variable valve lift control combined with the variable camshaft control (double VANOS). The valve lift is controlled only on the intake side while the timing of the camshafts is adjusted on both the intake and exhaust.

The throttle-free load control is implemented by variable valve lift of the intake valve, variable valve opening timing of the intake valve and variable camshaft spread of the intake and exhaust camshaft.

In terms of this load control principle, VALVETRONIC II corresponds to the VALVETRONIC I introduced on the N62 engine. (See the N52 training material for more information)

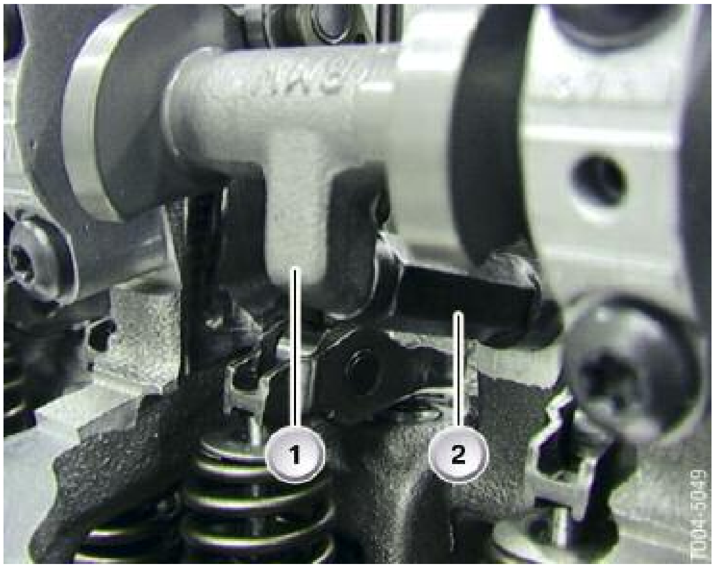
System optimization includes modification of the valve gear kinematics, a modified actuator motor and the adapted spread range of the VANOS units.

The main differences are:

- The plain bearing on the intermediate lever to the eccentric shaft has been replaced by a roller bearing, thus reducing the friction in the valve timing gear.
- Guidance of the intermediate lever is more precise. Only one spring is now required to guide and hold the intermediate lever.
- The moved mass of the valve timing gear has been reduced by 13%.
- The lift range of the intake valves has been improved. The **maximum** lift has been increased to **9.9 mm** but more importantly the **minimum** lift has been further reduced to **0.18 mm**.

The overall result is supported by further improvements in the intake manifold and exhaust dynamics.

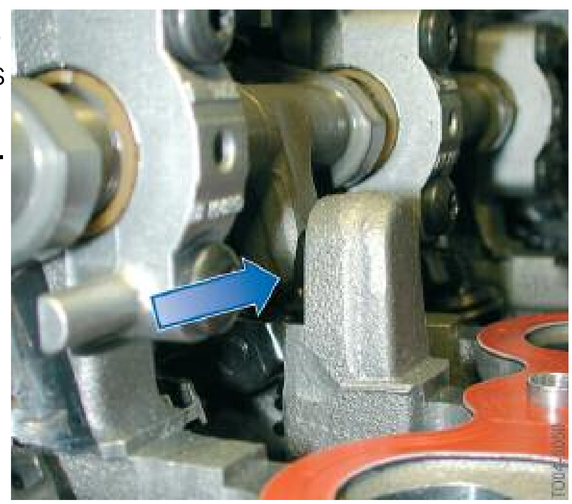

In the minimum valve lift position, the eccentric-shaft stop (1) is in contact with the cylinder-head stop (2) which is screwed into the cylinder head. That way, the minimum valve lift is mechanically limited.




| Index | Explanation |
|---|---|
| 1 | Eccentric-shaft stop |
| 2 | Cylinder-head stop |

The maximum valve lift is also limited by a mechanical stop as can be seen from the following illustration.

A stop routine can be implemented between the mechanical stops in order to detect the positions of the mechanical stops. For this purpose, the eccentric shaft is adjusted from zero lift to full lift. The stop routine is executed only when the motor electronics determines implausible values during the engine start procedure. The stop routine can also be initiated by the diagnosis systems.



**VALVETRONIC II is used on N52 and N51.**

**VALVETRONIC III was introduced with the N55 where it is combined with double VANOS, Direct Injection and Turbocharging (TVDI).**

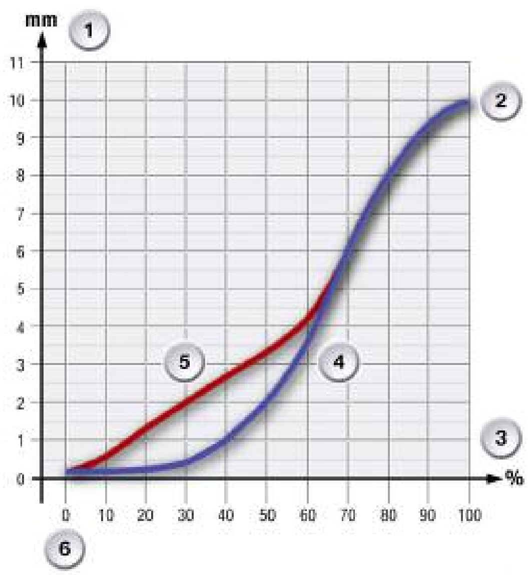
**Refer to the N55 training material for more information.**

**Phasing**

Because VALVETRONIC II, is a very fast and precise torque control system a "Phasing" procedure is implemented to assist adjustment in the lower valve lift range. Both of the intake valves of a cylinder open together up to a lift of 0.2 mm.  Past that point Valve 1 begins to lead (advance) Valve 2 which opens with a slight delay relative to Valve 1. Valve 2 catches up to Valve 1 again at a lift of approx. 6 mm. From there on, they open together again. The phasing is made possible by a slight variation in the profiles of the two cams on the eccentric shaft of a cylinder.

This opening characteristic has a favorable effect on the inflow of gasses into the cylinder. By keeping the opening cross section of the intake valves small a distinctly higher flow rate at a constant intake volume is achieved. In connection with the geometry in the upper area of the combustion chamber, this higher flow rate is used to mix the air/fuel mixture more effectively.

**Intake valve lift curve**




| Index | Explanation |
|---|---|
| 1 | Valve lift (in mm) |
| 2 | Maximum valve lift at full power |
| 3 | Output (in %) |
| 4 | Inlet valve 2 |
| 5 | Inlet valve 1 |
| 6 | Minimum valve lift when idling |

The N52KP and N51 retain the already proven VALVETRONIC system with an optimized VVT motor as of 2007.

Initially turbocharged engines did NOT use VALVETRONIC, as is the case of N54, N63 and N74.  This is due to the fact that the VALVETRONIC system is designed to reduce pumping losses.  It improves volumetric efficiency by optimizing the air charge. A turbocharger system is also designed to increase volumetric efficiency by reducing pumping losses.  Therefore, there was no need for both of these systems to be employed on the same engine.  However with the introduction of the N55 engine turbocharging, direct injection and double VANOS were combined for the first time with the third generation VALVETRONIC system (TVDI) to enhance even further the efficiency of the engine without sacrificing performance.

**See the N55 training material or the Engine Technology section for more information.**

## Vacuum Pump

As with the N62 engine, the N52 has little vacuum available in the intake manifold to operate certain components due in part to the use of the VALVETRONIC system.

The vacuum pump supplies vacuum to the brake booster and the exhaust flap damper and wastegate valve (on turbocharged engines). Thanks to the vacuum pump the exhaust flap damper system no longer requires a vacuum storage reservoir because its operation is no longer affected by variations in intake manifold vacuum.

Although the vacuum pump of N52/N51 is single stage, the vacuum pump used on later engines (N54, N55, N63 and N74) is designed as a **two-stage** pump and therefore has two connections. The first stage is for the brake booster and the second for the secondary loads.

The N51, N52, N54 and N55 engines use a vacuum pump driven by the timing chain drive.The N63 drives the vacuum pump via the rear of the intake cam while the N74 drives it via the front of the exhaust cam.

**N63 Vacuum pump location**

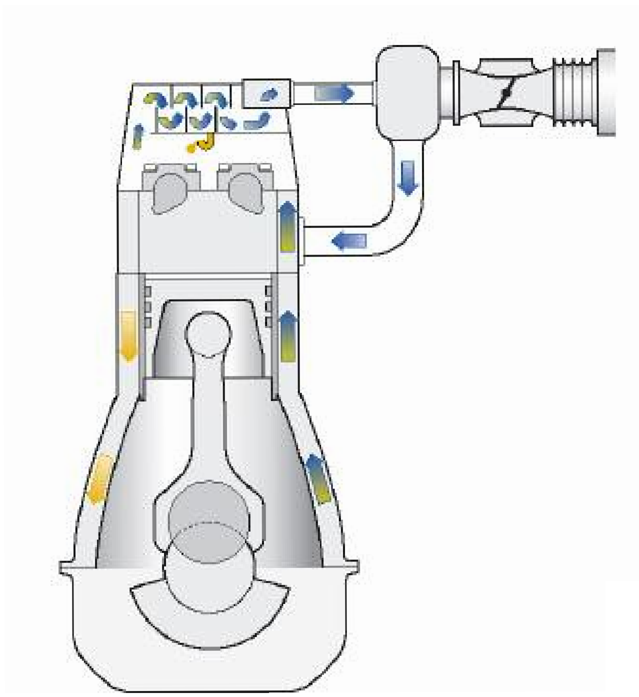
**N52 Vacuum pump location**

**N54/N55 Vacuum pump location**

## Crankcase Ventilation

There are two basic methods for ventilating the crankcase which have been in used by BMW engines.  One of the methods uses a crankcase ventilation valve and the other does not.  In either case, the crankcase vapors must be metered into the intake and the oil must be separated from the vapors.

The basic crankcase ventilation system is shown below.  It features the “labyrinth” method of oil separation which uses a maze of channels to divide the crankcase vapor from the liquid oil.  The vapors can enter the engine through a “calibrated” orifice, while to liquid oil returns back into the engine or oil sump.



The N52KP and N51 engines use a crankcase ventilation valve and the “labyrinth” method of oil separation.

The N54 engine does not use a crankcase ventilation valve and oil is separated using the “cyclonic method” of the cyclone separators.

The crankcase ventilation systems on turbocharged engines operate in two modes.  One mode is for turbocharged operation (Boost mode) and the other is for “naturally aspirated mode” (under low load and deceleration).

The N63 and N74 engine crankcase ventilation operate in accordance with the same principle as on the N54 engine with some differences. In the case of the N63 engine, each cylinder bank has its own crankcase breather.

The N55 uses a different design principle from all previous engines. The operation is described in detail in the N55 training material.

## N54 Crankcase Ventilation

The crankcase ventilation system of the N54 engine is unique due to the fact that this is a turbocharged engine. This means the intake manifold pressure will be higher than that of a naturally aspirated engine. This presents new challenges regarding the design of the crankcase ventilation system.

The basic description of the system is as follows:

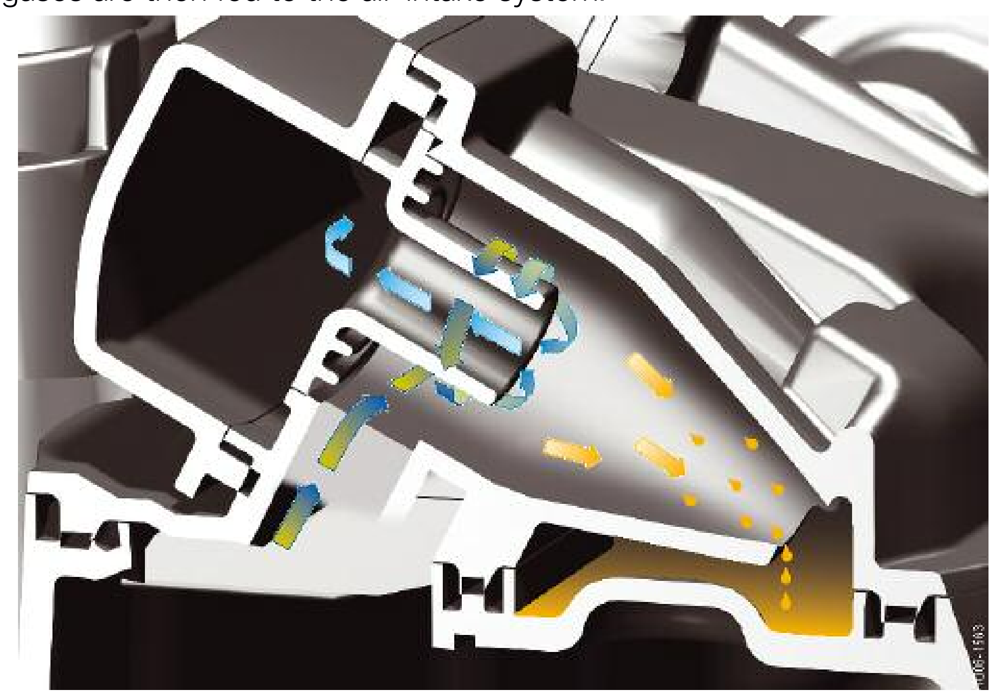
- The system uses a calibrated orifice to meter crankcase vapors into the engine.
- Liquid oil is separated from the crankcase vapors is done by “cyclonic” action.
- There are 2 channels for crankcase vapors depending upon the manifold pressure.
- Most of the system components are integrated into the cylinder head cover.

One of the most important features is the fact that most of the system components are integrated into the plastic cylinder head cover. This allows engine heat to warm the crankcase vapors which prevents any potential freezing of any water vapor trapped in the system. In contrast to the N52, there is only one heating element located at the intake manifold inlet.

### Cyclone Separator

A cyclone oil separator is used in the N54 engine. Here, four of the described cyclones are integrated into the oil-separator housing. The oil mist drawn in from the crankcase is set into a spinning motion in the cyclone. As a result of the centrifugal forces, the heavier oil settles on the cyclone walls and from there drips into the oil drain.

The lighter blow-by gases are sucked out from the middle of the cyclone. The purified blow-by gases are then fed to the air-intake system.



## Crankcase Ventilation System Function

The crankcase ventilation system of the N54 must be capable of venting the crankcase during two different modes of engine operation. When the engine is in deceleration, the intake manifold pressure is low (high vacuum). During acceleration or idling, the intake manifold pressure is higher (low vacuum). Therefore the system operates differently in these modes. This is what is unique about the crankcase venting system on the N54.

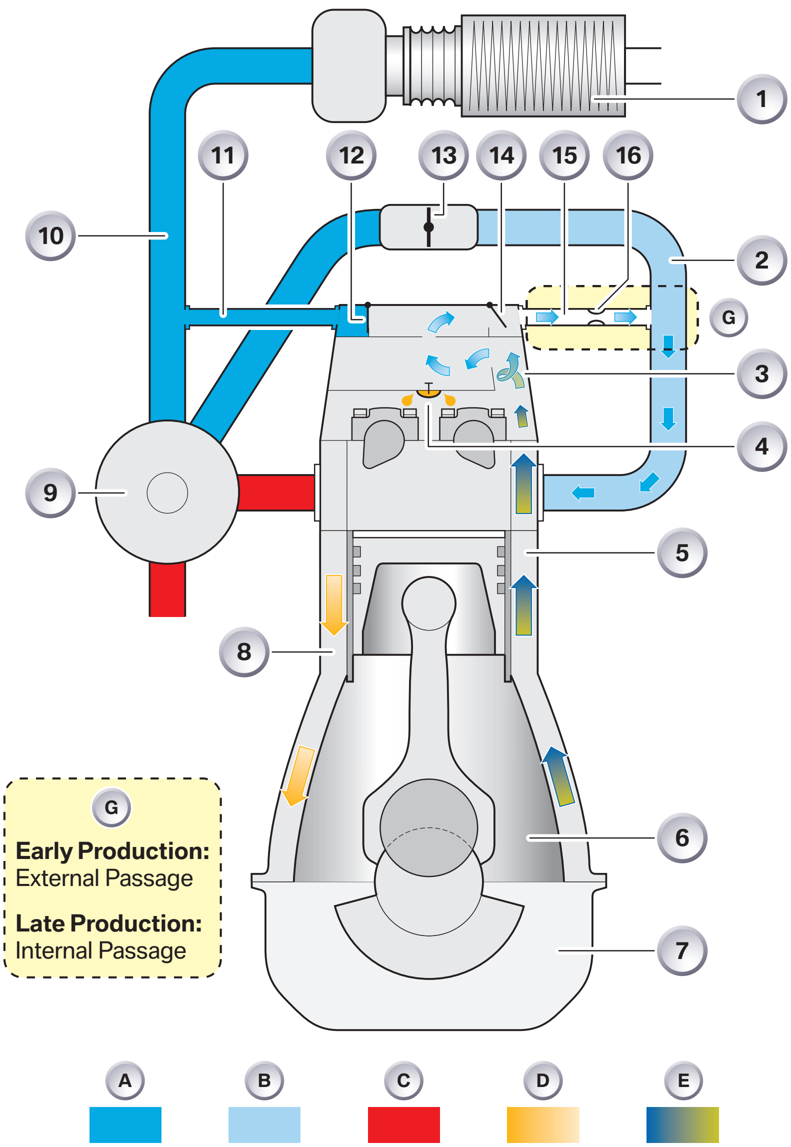

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Check valve, charge air suction line | 3 | Check valve, manifold and pressure restrictor |
| 2 | Ventilation, turbocharged operation | 4 | Ventilation, naturally aspirated mode (decel) |

### Operation with Low Manifold Pressure

When the engine has low manifold pressure such as in decel, the crankcase vapors are routed through a channel (15) between the cylinder head cover and intake manifold. The liquid oil is separated before the channel in the cyclonic separators (3) in the cylinder head cover. The liquid oil returns to the engine via the oil discharge valve (4).

The channel contains a pressure restrictor (16) which regulates the flow of crankcase vapors. During deceleration, the crankcase vapors (E) are directed via a check valve (14) which is located in the cylinder head cover. The check valve is opened when low pressure is present in the intake manifold (throttle closed).

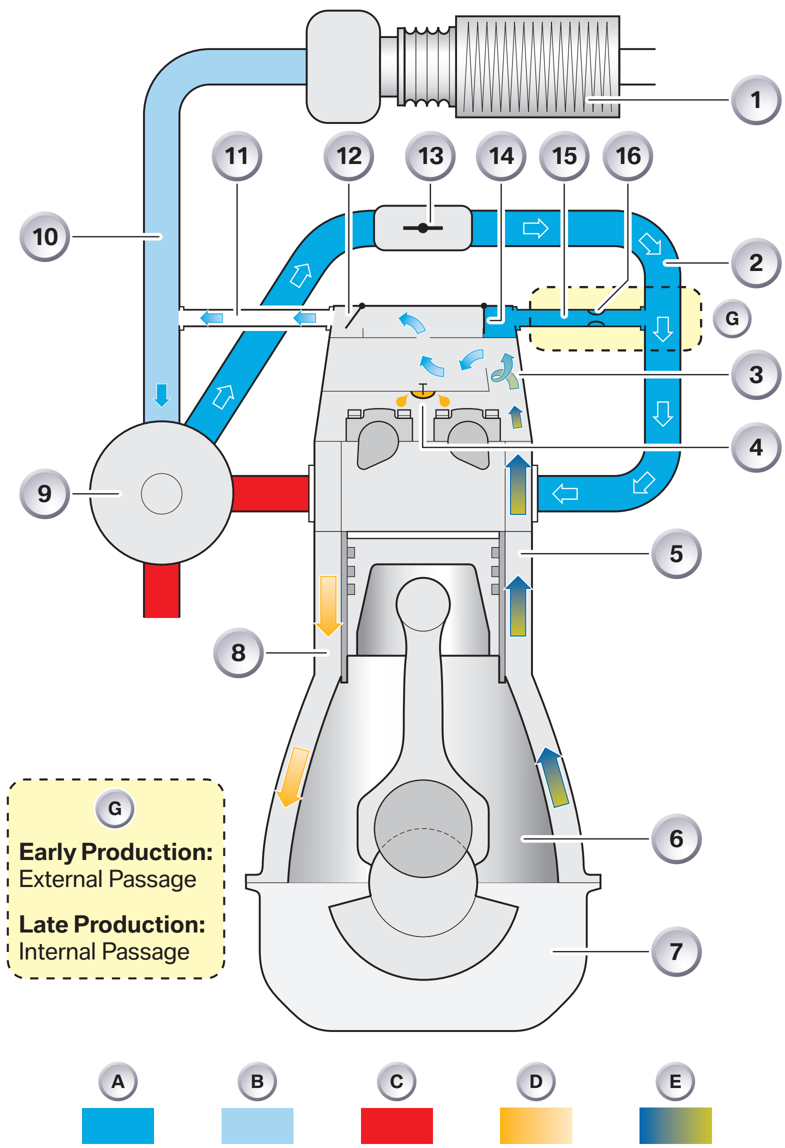
Also, a PTC heater has been integrated into the intake manifold inlet. The inlet pipe is connected to the channel (15) and prevent any moisture from freezing at the inlet.




| Index | Explanation |
|---|---|
| A | Overpressure |
| B | Low Pressure (Vacuum) |
| C | Exhaust gas |
| D | Liquid oil |
| E | Blow-by gases (Crankcase vapors) |
| 1 | Air cleaner |
| 2 | Intake manifold |
| 3 | Cyclone separators |
| 4 | Oil discharge valve |
| 5 | Venting channel |
| 6 | Crankshaft cavity |
| 7 | Oil sump |
| 8 | Oil return channel |
| 9 | Turbocharger |
| 10 | Clean air pipe |
| 11 | Line to clean air pipe |
| 12 | Check valve (non-return) to intake |
| 13 | Throttle valve |
| 14 | Check valve to clean air pipe |
| 15 | Channel to intake manifold |
| 16 | Pressure restrictor |

## Operation with High Manifold Pressure

When in turbocharged mode, the pressure in the intake manifold increases and then closes the check valve (14). Now, a low pressure is present in the charge air suction line (10). This causes a low pressure in the hose (11) leading to the manifold check valve (12). The crankcase vapors (after separation) are directed through the check valve (12) into the charge air suction line (10) and ultimately back into the engine. The check valve (12) also prevent boost pressure from entering the crankcase when the intake manifold pressure is high.




| Index | Explanation |
|---|---|
| A | Overpressure |
| B | Low Pressure (Vacuum) |
| C | Exhaust gas |
| D | Liquid oil |
| E | Blow-by gases (Crankcase vapors) |
| 1 | Air cleaner |
| 2 | Intake manifold |
| 3 | Cyclone separators |
| 4 | Oil discharge valve |
| 5 | Venting channel |
| 6 | Crankshaft cavity |
| 7 | Oil sump |
| 8 | Oil return channel |
| 9 | Turbocharger |
| 10 | Clean air pipe |
| 11 | Line to clean air pipe |
| 12 | Check valve (non-return) to intake |
| 13 | Throttle valve |
| 14 | Check valve to clean air pipe |
| 15 | Channel to intake manifold |
| 16 | Pressure restrictor |

**Be aware that any check valve failure could cause excessive oil consumption possibly accompanied by blue smoke from the exhaust. This should not be mistaken for a failed turbocharger. Always perform a complete diagnosis of the crankcase ventilation system, before replacing any turbocharger or associated components.**

### Crankcase Ventilation N52KP and N51

The crankcase ventilation system on the N52KP and N51 uses a crankcase ventilation valve which is incorporated into the cylinder head cover. Oil is separated via an internal labyrinth which is also incorporated into the cylinder head cover.

This system, like the N54, also benefits from the integral components. This design allows engine heat to warm the crankcase vapors which decreases the likelihood of any moisture freezing in the system during conditions of low ambient temperature.

**Note: For further information regarding the crankcase ventilation system of a specific engine please refer to the appropriate training information (on ICP) or repair instruction (in ISTA).**

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# Cooling System

The engine cooling system undertakes the classic task of carrying heat away from the engine and maintaining a defined operating temperature as constant as possible. The addition of turbocharging also requires cooling of the turbo/turbos.

The cooling system of the N54 engine consists of a radiator circuit and an isolated oil cooling circuit. The fact that there is an isolated oil-cooling circuit ensures that heat is not introduced via the engine oil into the engine's coolant system.

The use of an **Electric Water Pump (EWP)** allows the engine and turbo to be cooled even when the engine is off (N52, N51, N54 and N55). See the N54 system on the next page.

The N63 and N74 engines feature conventional coolant pumps that are driven by the belt drive. This pump cannot be used to continue cooling the turbochargers after the engine has been shut down. In this case an auxiliary pump is used.

## N54 Cooling System Overview

The structure of the coolant circuit of the N54 is the same as that of the N52 engine. The engine is flushed through with coolant in accordance with the cross-flow concept. Cooling output can be influenced as a function of load by activating the following components:

- Electric fan
- Electric coolant pump
- Map thermostat

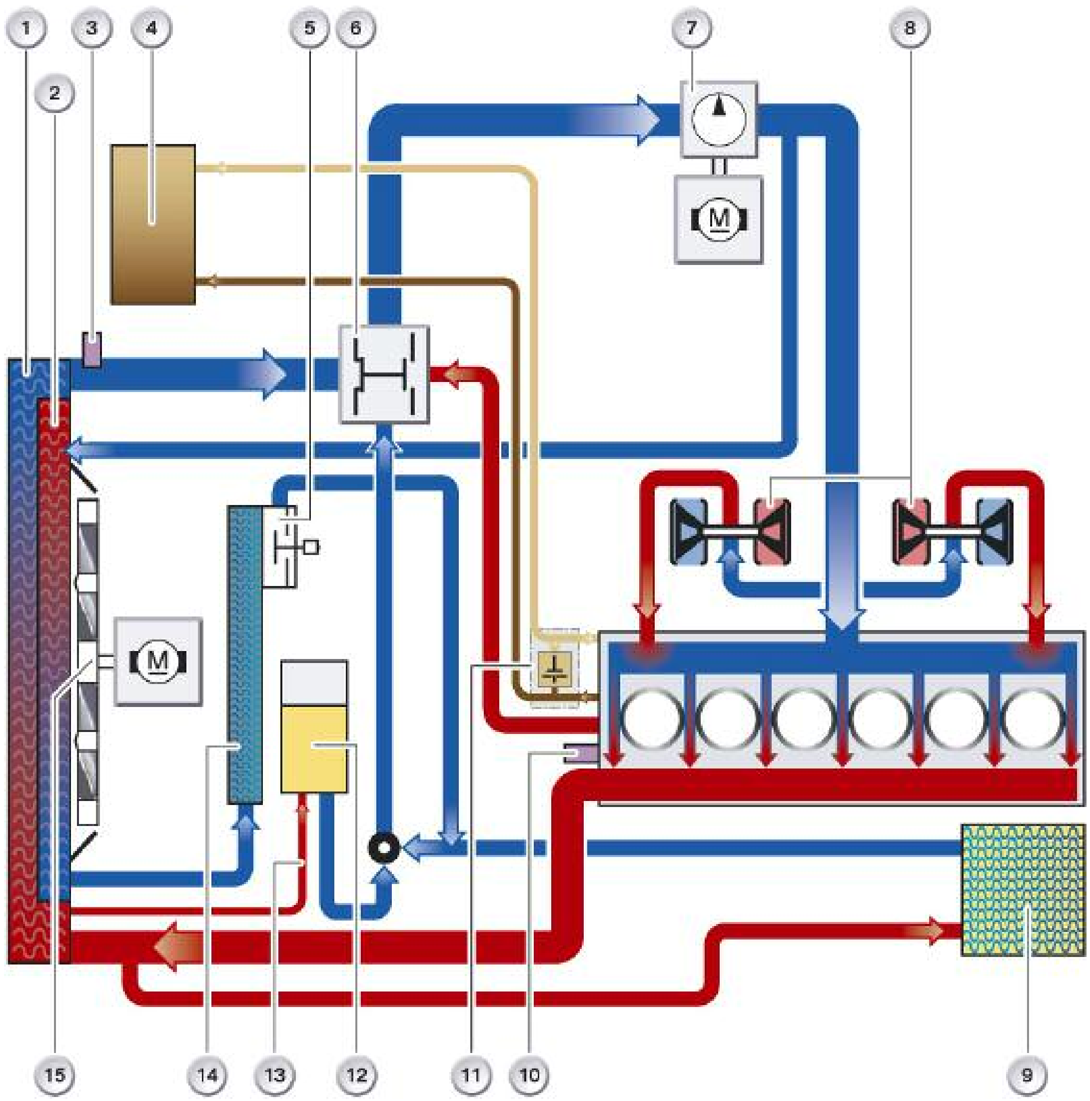
It is also possible in an N54 engine in conjunction with an automatic gearbox to utilize the lower area of the radiator to cool the gearbox by means of the gearbox-oil cooler. This is achieved as in the N52 engine with control sleeves, which are introduced into the radiator tank.

### Radiator

Design measures have been used to increase the performance of the radiator itself. The performance of a radiator is dependent on its radiation surface. However, the intercooler still had to be installed underneath the radiator, and this meant that is was necessary to compensate for the smaller flow area available.

Compared with the N52 engine, the radiator used in the N54 engine has a block depth which has been increased to 32 mm. In addition, the water pipes are situated closer together than in previously used radiators. The upshot of this is an increase in the utilizable radiation surface.

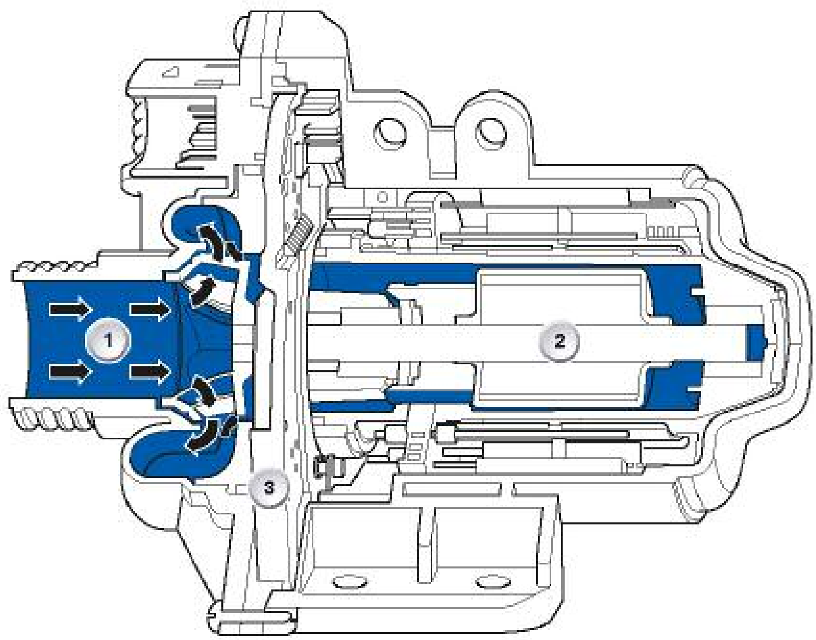
## N54 Electric Water Pump Diagram




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Radiator | 9 | Heat exchanger |
| 2 | Gear-box oil cooler | 10 | Outlet temperature sensor, cylinder head |
| 3 | Outlet temperature sensor | 11 | Thermostat, engine oil cooler |
| 4 | Engine oil cooler | 12 | Coolant expansion tank |
| 5 | Thermostat for gearbox oil cooler | 13 | Vent line |
| 6 | Map thermostat | 14 | Gearbox oil cooler |
| 7 | Electric coolant pump | 15 | Fan |
| 8 | Exhaust turbocharger | | |

## Electric Coolant Pump

The coolant pump of the N54 engine is an electrically driven centrifugal pump with a power output of 400W and a maximum flow rate of 9000 l/h. This represents a significant increase in power of the electric coolant pump used in the N52 engine, which has a power output of 200 W and a maximum flow rate of 7000 l/h.




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Pump | 3 | Electronics for coolant pump |
| 2 | Motor | | |

The power of the electric wet-rotor motor is electronically controlled by the electronic module (3) in the pump. The electronic module is connected via the bit-serial data interface (BSD) to the MSD80 engine control unit.

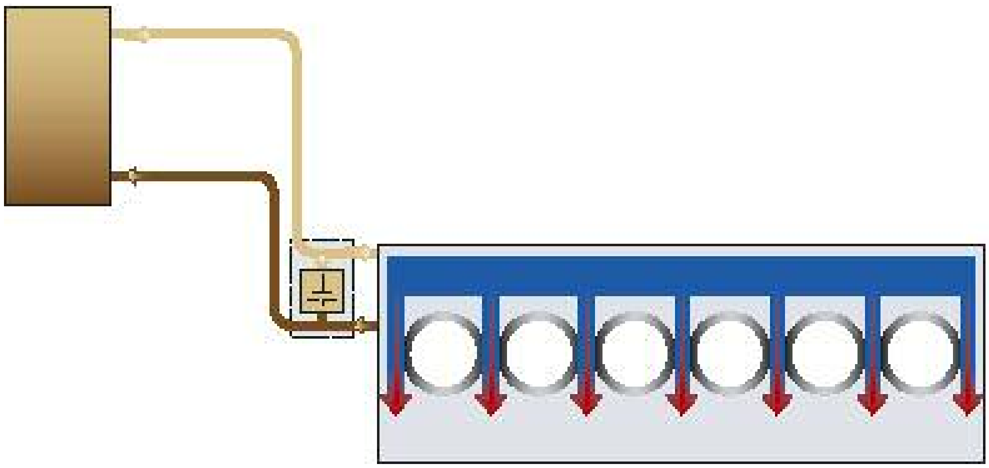
The engine control unit uses the engine load, the operating mode and the data from the temperature sensors to calculate the required cooling output. Based on this data, the engine control unit issues the corresponding command to the electric coolant pump.

The electric coolant pump regulates its speed in accordance with this command. The system coolant flows through the motor of the coolant pump, thus cooling both the motor as well as the electronic module.  The coolant lubricates the bearings of the electric coolant pump.

**The pump must be filled with coolant when removed for service to prevent any corrosion.  The pump impeller must be turned by hand before installation to ensure the pump is not seized.**

## Engine-oil Cooling

The N54 engine is equipped with a high performance engine-oil cooler. The pendulum-slide pump delivers the oil from the oil sump to the oil filter. A thermostat flanged to the oil-filter housing admits the oil to the engine-oil cooler. The engine-oil cooler is located in the right wheel arch in the E92. The thermostat can reduce the resistance opposing the oil by opening the bypass line between the feed and return lines of the engine-oil cooler. This ensures that the engine warms up safely and quickly.



**If a separate oil to air cooler is not installed, an auxiliary radiator in conjuction with an oil to coolant heat exchanger is used to cool the engine oil.**

The auxiliary radiator is connected to the radiator by means of parallel coolant lines, thus increasing the cooling surface area. This system is combined with an oil-to-coolant heat exchanger mounted on the oil filter housing. (See component “C” in the previous graphic.)

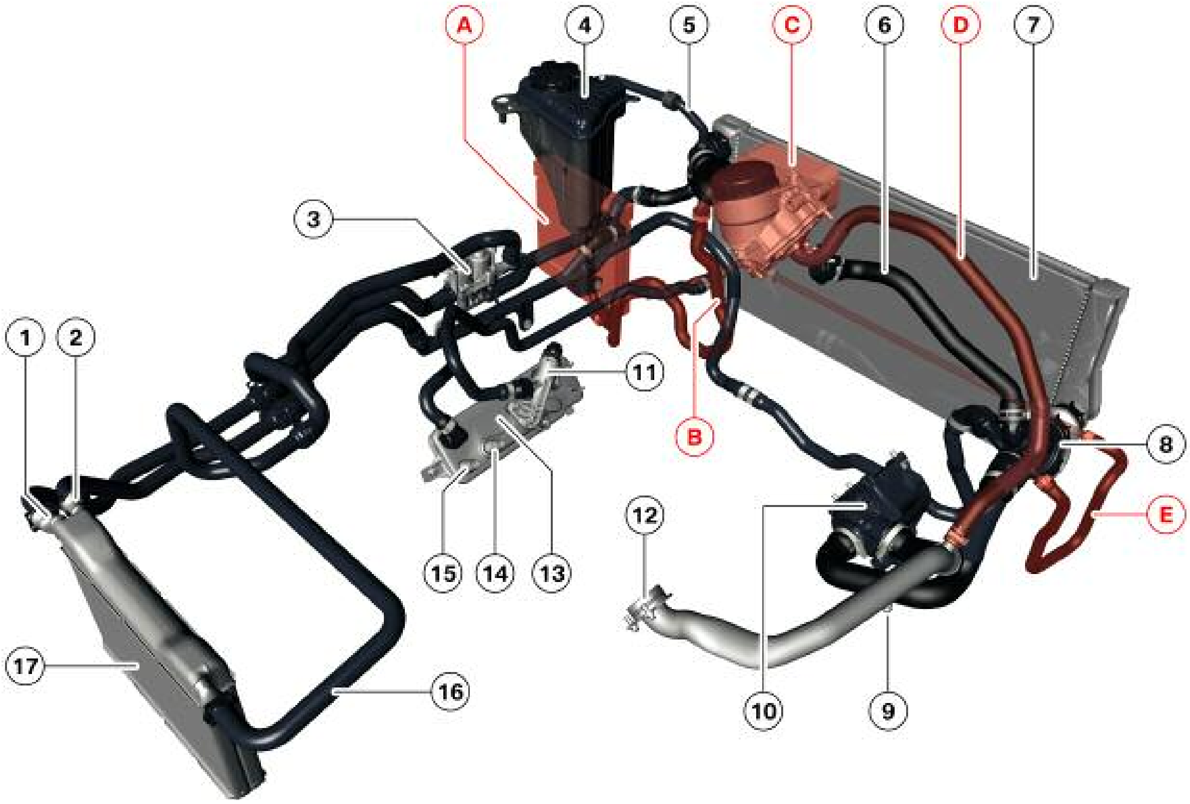
**Auxiliary coolant pump for turbocharger cooling**

Turbo engines that use conventional (mechanical) water pumps (N63, N74) are equipped with an additional electrically operated coolant pump with an output of 20 W. Although it is used during normal engine operation to assist turbocharger cooling this pump’s main function is to carry away the heat build-up from the turbochargers after the engine has been shut down.

The heat input into the engine is calculated based on the injected fuel quantity. This function is similar to the heat management function on 6-cylinder engines explained in the following pages.

The after-running period of the auxiliary electric coolant pump can extend up to 30 minutes. The electric fan also cuts in to improve the cooling effect. As in previous systems, the electric fan runs for a maximum of 11 minutes, however, it now operates more frequently.

### F10 N55 cooling circuit




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Auxiliary radiator | 7 | Bypass line for small cooling circuit |
| B | Coolant feed line to auxiliary radiator | 8 | Thermostat |
| C | Oil-to-coolant heat exchanger | 9 | Electric coolant pump |
| D | Coolant feed line to oil-to-coolant heat exchanger | 10 | Exhaust turbocharger supply line |
| E | Coolant return line from auxiliary radiator | 11 | Thermostat for transmission oil cooling |
| 1 | Zone 1 feed line, heating heat exchanger | 12 | Coolant feed line to engine block |
| 2 | Zone 2 feed line, heating heat exchanger | 14 | Transmission oil-to-coolant heat exchanger |
| 3 | Coolant valve | 15 | Connection, transmission oil line |
| 4 | Expansion tank | 16 | Connection, transmission oil line |
| 5 | Equalization line | 17 | Return, heating heat exchanger |
| 6 | Radiator | | |

**Please refer to the individual engine training information or repair instructions for further information.**

## Heat Management

The engine control unit of the N54 engine controls the coolant pump according to requirements:

- Low output in connection with low cooling requirements and low outside temperatures.
- High output in connection with high cooling requirements and high outside temperatures.

The coolant pump may also be completely switched off under certain circumstances, e.g. to allow the coolant to heat up rapidly during the warm-up phase. However, this only occurs when no heating is required and the outside temperature is within the permitted range.

The coolant pump also operates differently than conventional pumps when controlling the engine temperature. To date, only the currently applied temperature could be controlled by the thermostat.

The software in the engine control unit now features a calculation model that can take into account the development of the cylinder head temperature based on load.
In addition to the characteristic map control of the thermostat, the heat management system makes it possible to use various maps for the purpose of controlling the coolant pump. For instance, the engine control unit can adapt the engine temperature to match the current operating situation.

This means that four different temperature ranges can be implemented:

- 108 °C ECO mode
- 104 °C Normal mode
- 95 °C High mode
- 90 °C High + map-thermostat mode

The control system aims to set a higher cylinder-head temperature (108°C) if the engine control unit determines ECO (economy) mode based on the engine performance.
The engine is operated with relatively low fuel consumption in this temperature range as the internal friction is reduced.

An increase in temperature therefore favors slower fuel consumption in the low load range. In HIGH and map-thermostat mode, the driver wishes to utilize the optimum power development of the engine. The cylinder-head temperature is reduced to 90°C for this purpose. This results in improved volumetric efficiency, thus increasing the engine torque. The engine control unit can now set a certain temperature mode adapted to the respective operating situation. Consequently, it is possible to influence fuel consumption and power output by means of the cooling system.

The temperatures specified only ever represent a target value, the attainment of which is dependent on many factors.  These temperatures are first and foremost not attained precisely.

The consumption-reducing and power increasing effects arise in each case in a temperature spectrum. The function of the cooling system is to provide the optimal cooling output according to the boundary conditions under which the engine is being operated.

**Intelligent Heat Management Options**

The previous section dealt with the various temperature ranges in which heat management is effected.  However, an electrically driven coolant pump makes available even further options.  For instance, it is now possible to warm up the engine without recirculating the coolant or to allow the pump to continue to operate after turning off the engine to facilitate heat dissipation.  The advantages offered by this type of pump are listed in the following table:

| | |
|---|---|
| **Consumption** | • Faster warm-up as coolant is not recirculated until needed<br>• Increased compression ratio due to greater cooling output all full load as compared to similar engines without this option |
| **Emissions** | • Faster engine warm-up by drastically reduced pump speed and the lower volumetric flow of coolant<br>• Reduced friction<br>• Reduced fuel consumption<br>• Reduced exhaust emissions |
| **Power Output** | • Component cooling independent of engine speed<br>• Requirement controlled coolant pump output<br>• Avoidance of power loss |
| **Comfort** | • Optimum volumetric flow<br>- Heating capacity reduced as required<br>- Residual heat with engine stationary |
| **Component Protection** | • After-running of electric coolant pump = improved heat dissipation from engine switch off point.  Allows protection of turbochargers by reduced oil “coking” during heat soak. |

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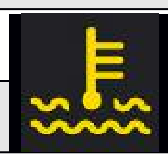
## System Protection

In the event of the coolant or engine oil being subject to excessive temperatures while the engine is running, certain functions in the vehicle are influenced so that more energy is made available to the engine-cooling system, i.e. temperature-increasing loads are avoided.

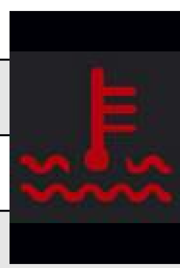
These measures are divided into two operating modes:

- Component protection
- Emergency

### Measures and displays for engine oil temperature

| Engine oil temp (T-oil C) | Operating mode | Display in Cluster | Power output reduction, Air conditioning | Power output reduction, Engine | Torque converter clutch lockup |
|---|---|---|---|---|---|
| 148 | | | Start 0 % | Start 0 % | |
| 149 | | | – | | |
| 150 | Component Protection | | – | | |
| 151 | Component Protection | | – | From here = clear reduction | |
| 152 | Component Protection | | End - 100 % | | |
| 153 | Component Protection | | | | |
| 154 | Component Protection | | | | |
| 155 | Component Protection | | | | |
| 156 | Component Protection |  | | | |
| 157 | Component Protection | | | End @ 90 % | |
| 158 | Emergency | | | | Active |
| 159 | Emergency | | | | Active |
| 160 | Emergency | | | | Active |
| 161 | Emergency |  | | | Active |
| 162 | Emergency | | | | Active |
| 163 | Emergency | | | | Active |

## Measures and displays for coolant temperature

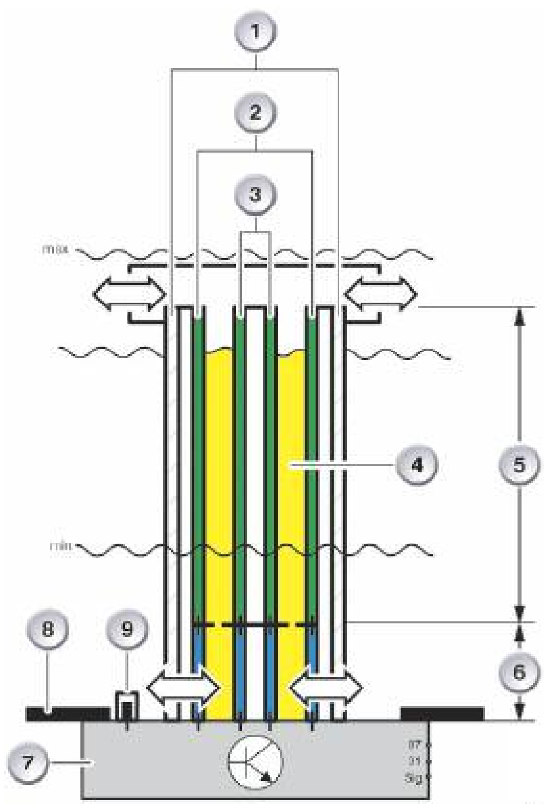
| Coolant (T-Coolant) | Operating mode | Display in Cluster | Power output reduction, Air conditioning | Power output reduction, Engine | Torque converter clutch lockup |
|---|---|---|---|---|---|
| 115 | | | | | |
| 116 | | | | | |
| 117 | Component Protection | | Start 0 % | Start 0 % | |
| 118 | Component Protection | | – | From here = clear reduction | |
| 119 | Component Protection | | – | – | |
| 120 | Component Protection |  | End - 100 % | – | |
| 121 | Component Protection | | | – | |
| 122 | Component Protection | | | – | Active |
| 123 | Component Protection | | | – | Active |
| 124 | Component Protection | | | End @ 90 % | Active |
| 125 | Emergency |  | | | Active |
| 126 | Emergency | | | | Active |
| 127 | Emergency | | | | Active |
| 128 | Emergency | | | | Active |
| 129 | Emergency | | | | Active |

## Electronic Oil Condition Monitoring

There is no dipstick including the guide tube on the N52 engine. This represents a convenience function for the customer while enabling more accurate recording of the engine oil level.

The engine oil level is measured by an oil condition sensor (OZS) and indicated in the central information display (CID). The engine oil temperature and the oil condition are also registered or calculated by the oil condition sensor. The signal from the oil condition sensor is evaluated in the ECM. The evaluated signal is then routed via the PT-CAN, SGM and the K-CAN to the instrument cluster and to the CID.

Registering the engine oil level in this way ensures the engine oil level in the engine does not reach critically low levels thus protecting the engine from the associated damage. By registering the oil condition, it is also possible to determine when the next engine oil change is due. Over filling the engine with oil can cause leaks - a corresponding warning is therefore given.




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Housing | 6 | Oil Condition Sensor |
| 2 | Outer Metal Tube | 7 | Sensor Electronics |
| 3 | Inner Metal Tube | 8 | Oil Pan |
| 4 | Engine Oil | 9 | Temperature Sensor |
| 5 | Oil Level Sensor | | |

## Function of the Oil Condition Sensor

The sensor consists of two cylindrical capacitors arranged one above the other. The oil condition is determined by the lower, smaller capacitor (6). Two metal tubes (2 + 3), arranged one in the other, serve as the capacitor electrodes. The dielectric is the engine oil (4) between the electrodes. The electrical property of the engine oil changes as the wear or aggiing increases and the fuel additives break down.

The capacitance of the capacitor (oil condition sensor) changes in line with the change in the electrical material properties of the engine oil (dielectric). This means that this capacitance value is processed in the evaluation electronics (7) integrated in the sensor to form a digital signal.

The digital sensor signal is transferred to the DME as an indication of the status of the engine oil. This actual value is used in the DME to calculate the next oil change service due.

The engine oil level is determined in the upper part of the sensor (5). This part of the sensor is located at the same level as the oil in the oil pan. As the oil level drops (dielectric), the capacitance of the capacitor changes accordingly. The electronic circuitry in the sensor processes this capacitance value to form a digital signal and transfers the signal to the DME.

A platinum temperature sensor (9) is installed at the base of the oil condition sensor for the purpose of measuring the engine oil temperature.

The engine oil level, engine oil temperature and engine oil condition are registered continuously as long as voltage is applied at terminal 15. The oil condition sensor is powered via terminal 87.

## Faults/Evaluation

The electronic circuitry in the oil condition sensor features a self-diagnosis function. A corresponding error message is sent to the DME in the event of a fault in the oil condition sensor.

## Electronic Oil Level Indicator

The oil level is measured in two stages:

- Static oil level measurement while the vehicle is stationary
- Dynamic oil level measurement during vehicle operation

**Static oil level measurement at engine OFF**

This is only a reference measurement as the oil condition sensor (OZS) is flooded when the engine is turned off and can only detect the minimum oil level. The oil level is measured correctly only when the engine is running (see Dynamic oil level measurement).

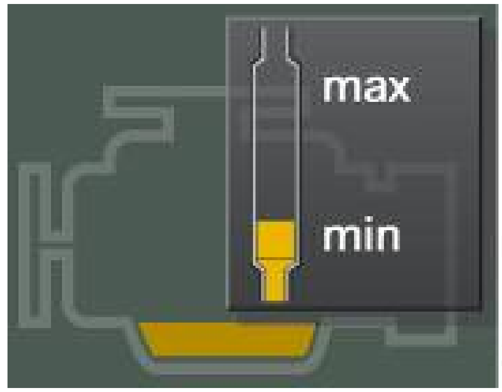
After switching on the ignition, the static oil level measurement provides the driver with the opportunity of checking whether there is sufficient engine oil for safely and reliably starting the engine.

1. It is important that the vehicle is parked horizontally otherwise the oil level measurement may be incorrect.
2. Select on-board computer function "Service" -> "Oil level".

If there is sufficient engine oil for safe and reliable engine start, a graphic appears in the CID in the form of an engine with a green oil sump.

If the oil level is close to minimum, the graphic appears with a yellow oil sump and an oil dipstick that represents the low oil level in yellow.

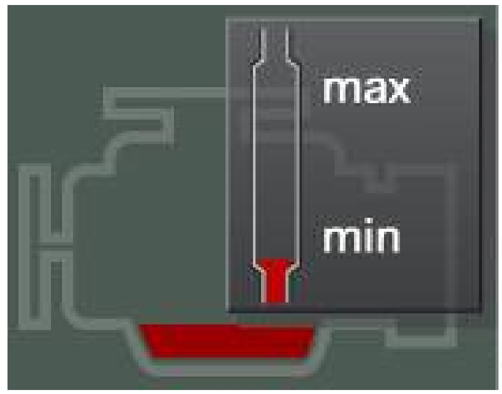
A top-up request +1 liter additionally appears as a text message.  The display will not change if less than 1 liter of oil is topped up. MAX is indicated only after topping up a quantity of 1 liter.




If the oil level drops below minimum, the graphic appears with a red oil sump and an oil dipstick that represents the low oil level in red.

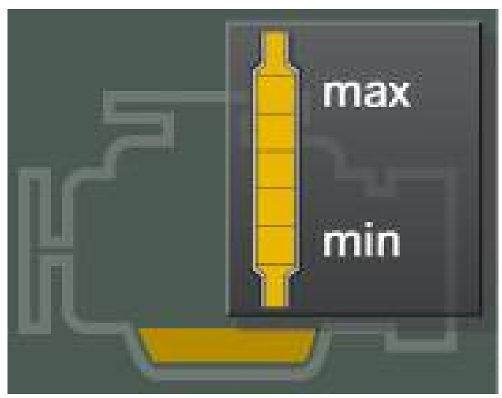
A top-up request +1 liter will additionally appear as a text message.

The display will not change if less than 1 liter of oil is topped up.  MAX is indicated only after topping up a quantity of 1 liter.




If the oil level is above maximum, the graphic appears with a yellow oil sump and an oil dipstick that represents the high oil level in yellow.

A text message is also displayed for the driver.

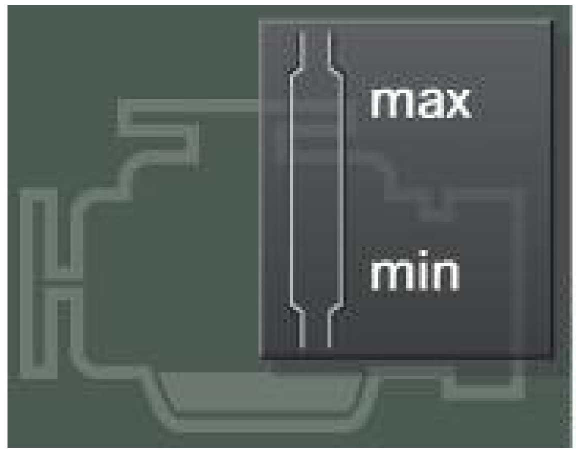


**Dynamic oil level measurement during vehicle operation**

Always perform the dynamic oil level measurement (approximately 5 minutes driving time) after an oil change. The oil level could be misinterpreted as the oil level last stored is initially displayed after an oil change.

No oil level is initially stored after replacing or reprogramming the engine control unit. "Oil level below min" is therefore displayed. The correct oil level is indicated after running the engine for approximately 5 minutes.

1. Start engine.
2. Select on-board computer function - “Check oil level".
3. The oil level is measured. A clock symbol may appear while the level measurement is running. The clock symbol appears for up to 50 seconds after starting the engine when there is no measured value or the long-term value last stored is not within the tolerance range of the currently measured oil level.



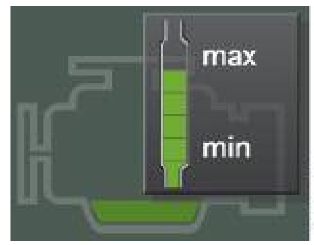
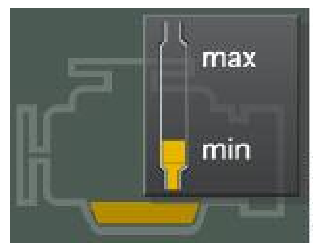
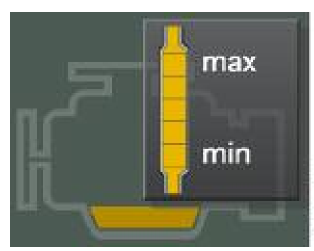

Dynamic oil level measurement begins when the following values are reached:

- Engine temperature > 60°C
- Engine speed > 1000 rpm
- Transverse and longitudinal acceleration < 4-5 m/s2

  The transverse acceleration signal is supplied by the DSC. The longitudinal acceleration is calculated from the speed and time factors.
- Change in inclination of the vehicle < 5% after covering a distance of approximately 200 m. The inclination value is detected by the ambient pressure sensor in the DME.

On reaching this value, the oil level indicator is updated approximately 5 minutes after starting vehicle operation. The oil level is then continuously measured. The indicator is updated at 20 minute intervals. The "Check oil level" menu in connection with the dynamic oil level measurement is exited while driving (vehicle speed > 0) approximately 15 seconds after the oil level is displayed.

## Display Options

| Significance | Remark | Display |
|---|---|---|
| Oil OK with engine stationary | The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range. |  |
| Oil level OK at idle speed | The oil level appears in the CID in the form of a graphic together with the "OK" message, indicating that the oil level is in the safe operating range.<br><br>A further graphic showing a dipstick appears above the displayed graphic. It shows the oil level in green. |  |
| Oil level too low | The oil level appears in the CID in the form of a graphic together with the request to top up with 1 liter of oil.<br>If the oil is not topped up, this request is repeatedly indicated until the minimum oil level is exceeded. |  |
| Oil level too high | The oil level appears in the CID in the form of a graphic together with the indication that the maximum oil level has been exceeded. The excess engine oil must be extracted in the workshop down to the maximum limit.<br><br>If no oil is extracted, this request will be repeated until the oil level drops below the maximum limit. This represents an advantage that extends beyond the user friendliness of the monitoring system. Over filling of the engine that can cause leaks is indicated as a warning in the instrument cluster. |  |
| Service | There is a problem with the measurement system if SERVICE appears in the display. In this case, the oil level is forecast from the oil consumption last measured and shown in the display. It is not necessary to immediately visit a workshop. The remaining kilometers are shown in the service menu. In the event of the instrument cluster failing, the oil level can also be read out with the diagnosis tester. | |

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# Turbocharging

In 2005, the first of the new generation 6-cylinder engines was introduced as the N52. The engine featured such innovations as a composite magnesium/aluminum engine block, electric coolant pump and VALVETRONIC for the first time on a 6-cylinder.

To further increase the power and efficiency of this design, three new engines where introduced for the 2007 model year. These engines are the N52 K, the N51 SULEV II and the N54.

The N52K (N52KP) engine is the naturally aspirated version of the new 6-cylinder engines. The "K" designation indicates that there are various efficiency and cost optimization measures. This engine can also be referred to as the "KP" engine.

The N54 engine was the first turbocharged powerplant in the US market. In addition to turbocharging, the N54 featured second generation direct injection and double VANOS.

This engine ushered in a new philosophy with regard to BMW engines. It is in part driven by the ever tightening emission mandates and the endless quest for high performance and efficiency which is the core of the BMW Efficient Dynamics model.

The N63 twin turbo V8 was launched with the introduction of the E71 xDrive50i in 2008 and was based on the N54. It features double VANOS, direct injection and two turbochargers.

The N74 V12 was introduced in 9/2009 as the successor of N73, with the launch of the F01/F02 760i/760Li. This engine was based on N73 and N63 technology.

The N55 engine is the successor to the N54 and was introduced to the US market with the launch of the F07 535i Gran Turismo in the Spring of 2010. Technical updates and modifications make it possible to use only one exhaust turbocharger. The technical data have remained virtually the same - with reduced costs and improved quality.

The N55 combined (for the first time) VALVETRONIC III with double VANOS, direct injection and turbocharging and is referred to as TVDI.

Turbocharging had not been in widespread use at BMW, as far as gasoline engines are concerned. In fact, the last turbocharged BMW production vehicle before the BMW E90 335i was the E23 (745), which was not officially imported into the US. The previous "turbo" model before that was the legendary 2002 tii turbo in the early 1970's. This 2002 tii turbo was also not officially imported into the US.


Until then BMW had built a reputation for building naturally aspirated high performance engines. Therefore much research has gone into the development of an efficient engine design which meets not only the expectations of the customer, but complies with all of the current emissions legislation.

Currently, the global focus has been centered more and more around the use of alternative fuels and various hybrid designs. While BMW recognizes these concerns, there is still much development to be done on the internal combustion engine. Therefore, at least for the time being, BMW will continue to build the some of best internal combustion engines in the world.

## Turbocharging Terminology

An engine which does not use any form of "forced induction" is referred to as a "naturally aspirated" engine. This means that the air which is entering the engine is at atmospheric pressure. Atmospheric air enters the engine due to the low pressure created by the pistons during the intake stroke.

An engine which uses "forced induction" is referred to as supercharged. This means that the air entering the engine is under pressure (above atmospheric). As far as terminology is concerned, supercharging is the broad term for this type of technology.

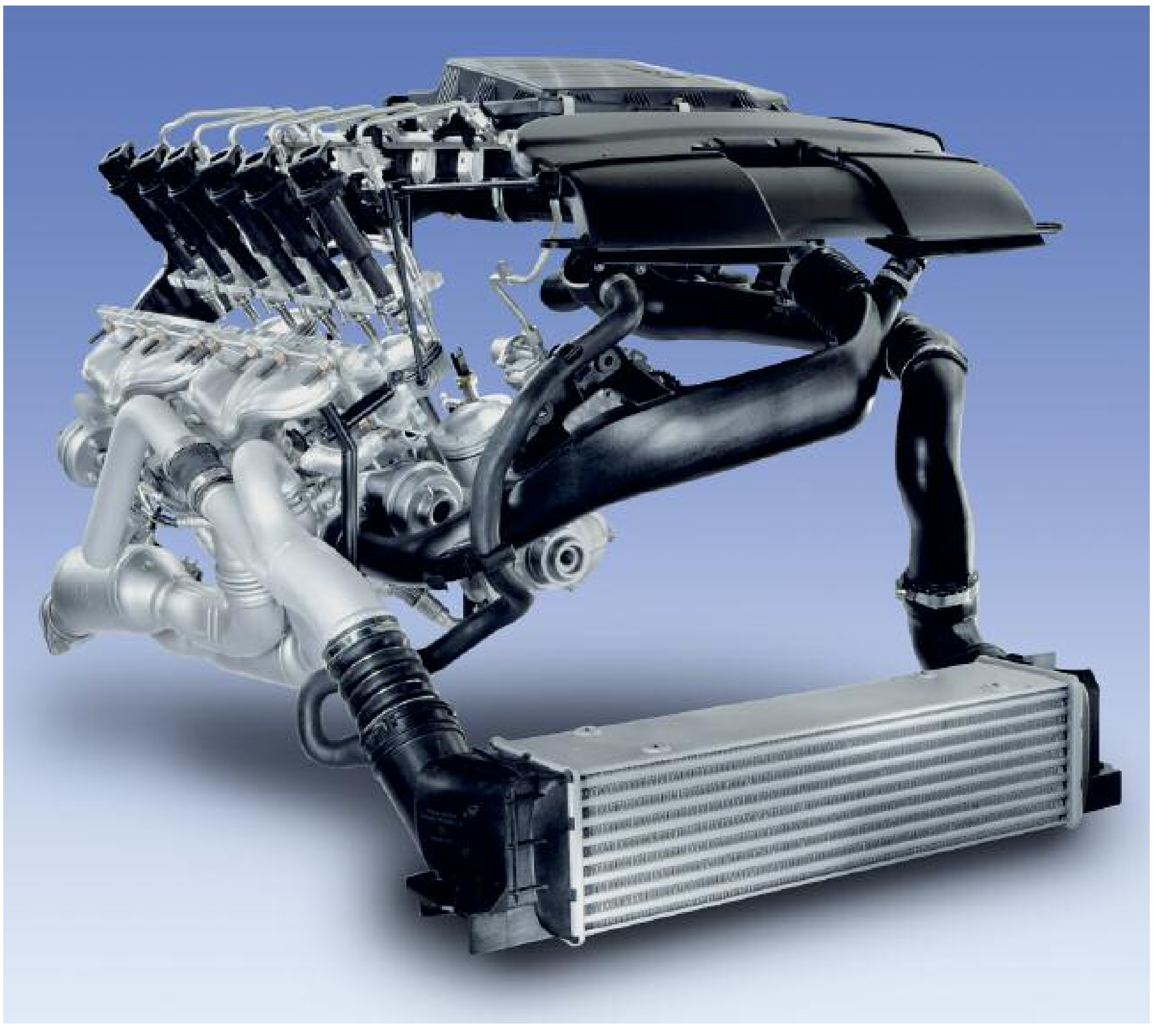
Supercharging can be broken down into two categories, those engines which use a mechanical supercharger and those which use an exhaust driven turbocharger. BMW engines (to date) only use turbochargers.

## Basic Principles of Turbocharging

An adequate supply of air and fuel is necessary on the intake stroke in order to enhance engine efficiency. This mixture can then be compressed and ignited to create the desired engine power output. A normally aspirated engine relies on the basic principle of gas exchange without the use of forced induction.

The volumetric efficiency refers to the ratio between the theoretical cylinder volume and the actual amount of air (and fuel) filling the cylinder during the intake stroke. A naturally aspirated engine has a volumetric efficiency of between 0.6 and 0.9 (60-90%). With the turbocharged engine, volumetric efficiency can peak at over 100%.

A turbocharger uses exhaust gasses to drive a compressor which forces air into the engine above atmospheric pressure. This increase pressure allows for an air charge with a greater density. The result is increased torque and horsepower and enhanced volumetric efficiency.



The turbocharger consists of a turbine and compressor assembly (1) on a common shaft inside of the turbocharger housing. The turbine wheel is driven by exhaust gases and in turn drives the compressor wheel.

The compressor forces air into the intake manifold of the engine. The air entering the engine from the compressor is above atmospheric pressure. The increased atmospheric pressure allows for an air-charge that is more dense and therefore contains more oxygen.

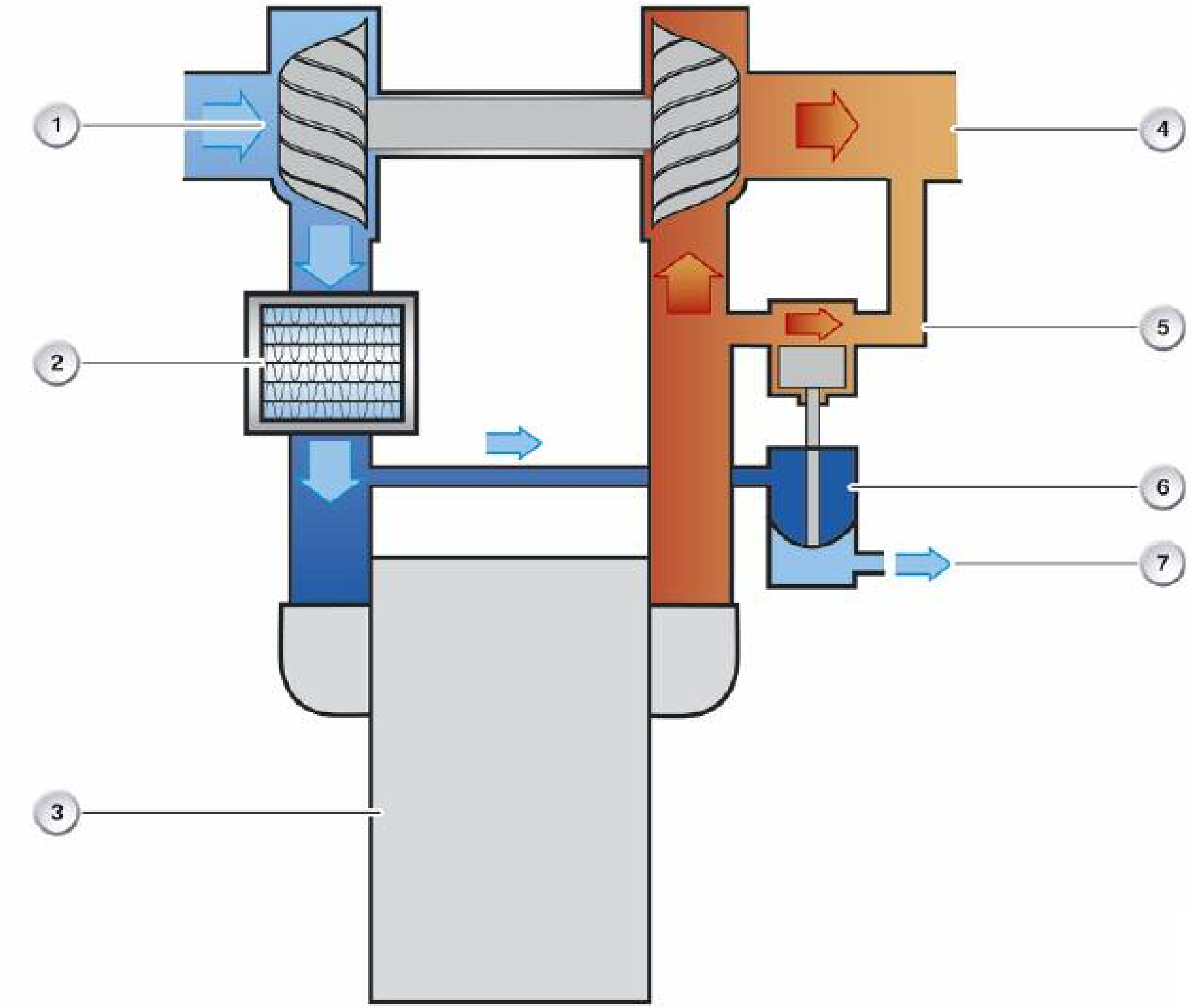
This increased density during the intake stroke ultimately adds up to the creation of more engine output torque. Of course, this increased density must be accompanied by additional fuel to create the desired power. This is accomplished by engine management system programming to increase injector "on-time" and enhanced associated maps.

To prevent the turbocharger from providing too much boost, a "wastegate" (6) is added to allow exhaust to bypass the turbine. This provides a means of control for the turbocharger system. The wastegate is usually actuated by a vacuum diaphragm (6) which is controlled via vacuum fed from solenoids. These solenoids are typically controlled by the engine management system.

Once the intake air is compressed, it is also heated which is not desirable for maximum efficiency. To counter this situation a heat exchanger (2) is added between the compressor and the engine intake. This heat exchanger is commonly referred to as an intercooler. The intercooler is usually an air-to-air heat exchanger which is installed in the air stream ahead of the radiator (direct charge air cooling) or air to coolant heat exchanger (indirect charge air cooling). Regardless of the type, the intercooler lowers the intake air charge to achieve the maximum density possible.

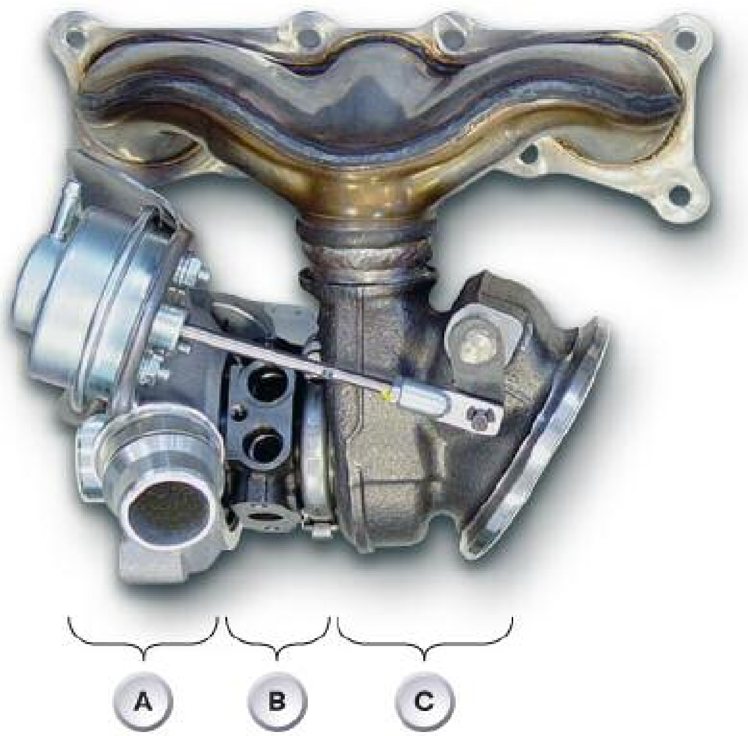
The use of an exhaust driven turbocharger is used to create more engine power through increased efficiency. In the case of the most current BMW engines, the turbocharger is used in conjunction with direct fuel injection. This provides the best combination of efficiency and power with no compromise.

## Turbocharging principles




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Compressor and turbine wheel (on common shaft) | 5 | Exhaust bypass from wastegate |
| 2 | Charge air cooler (intercooler) | 6 | Wastegate (and diaphragm) |
| 3 | Engine | 7 | Vacuum control for wastegate diaphragm |
| 4 | Exhaust outlet from turbine housing | | |

## N54 Turbocharger




| Index | Explanation |
|---|---|
| A | Compressor |
| B | Cooling/lubrication |
| C | Turbine |

# Bi-turbocharging

The induction air is precompressed in such a way that a higher air mass is admitted into the engine's combustion chamber. In this way, it is possible to inject and combust a greater quantity of fuel, which increases the engine's power output and torque.

The turbine and the compressor can rotate at speeds of up to 200,000 rpm.
The exhaust inlet temperature can reach a maximum of 1050°C. Because of these high temperatures, turbochargers are not only connected with the engine-oil system but also integrated in the engine-coolant circuit.

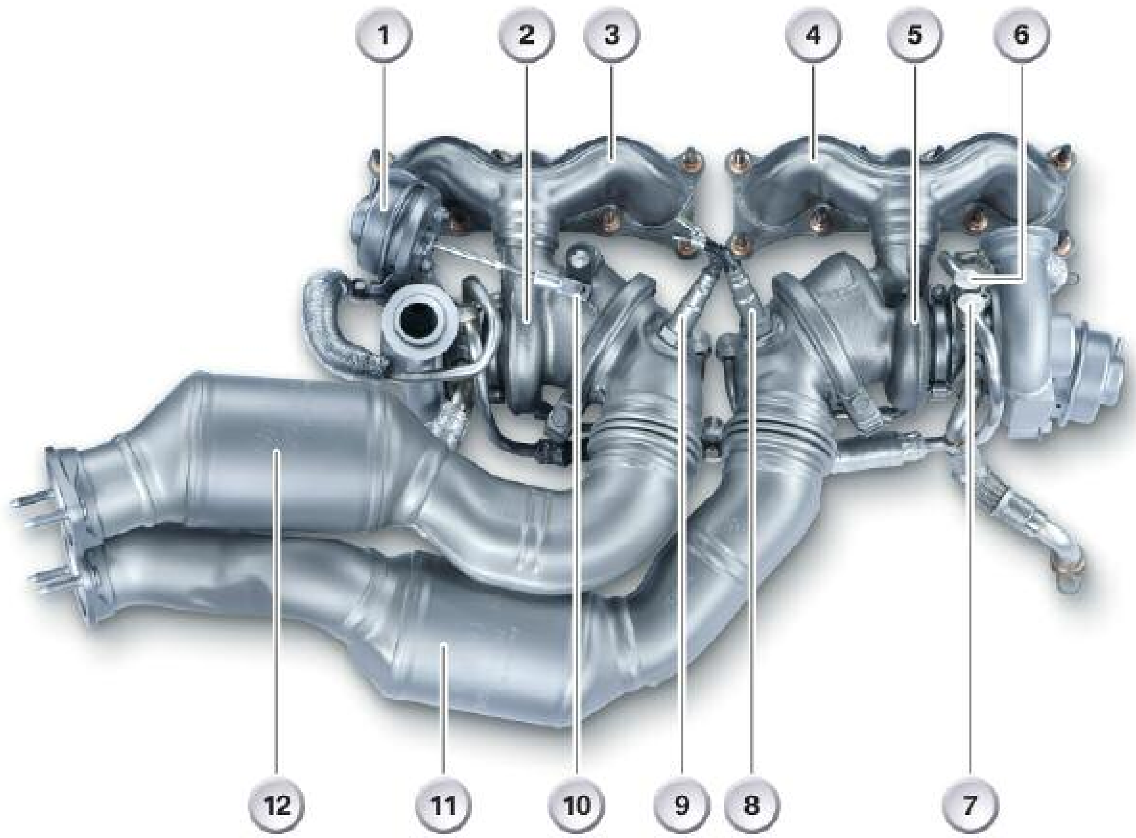
By operating an electric coolant pump even after the engine has been switched off it is possible to dissipate the residual heat from the turbochargers and thus prevent the oil in the bearing housing from overheating.

Utmost importance is attached to turbochargers response characteristics.  A delayed response to the driver's command, i.e. the accelerator-pedal position, is not acceptable. The driver therefore must not experience any so-called "turbo lag".

This requirement was met (in the N54 engine) with two small turbochargers, which are connected in parallel.  Cylinders 1, 2 and 3 (bank 1) drive the first turbocharger (5) while cylinders 4, 5 and 6 (bank 2) drive the second (2).

The advantage of a small turbocharger lies in the fact that, as the turbocharger runs up to speed, the lower mass of the turbine allows it to accelerate quicker, and thus the compressor attains a higher boost pressure in a shorter amount of time.

**N54 exhaust manifolds, turbos and related components**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Wastegate actuator, bank 2 | 7 | Coolant supply |
| 2 | Turbocharger, bank 2 | 8 | Planar broad-band oxygen sensor, bank 1 |
| 3 | Exhaust manifold, bank 2 | 9 | Planar broad-band oxygen sensor, bank 2 |
| 4 | Exhaust manifold, bank 1 | 10 | Wastegate actuating lever |
| 5 | Turbocharger, bank 1 | 11 | Catalytic converter, bank 1 |
| 6 | Coolant return | 12 | Catalytic converter, bank 2 |

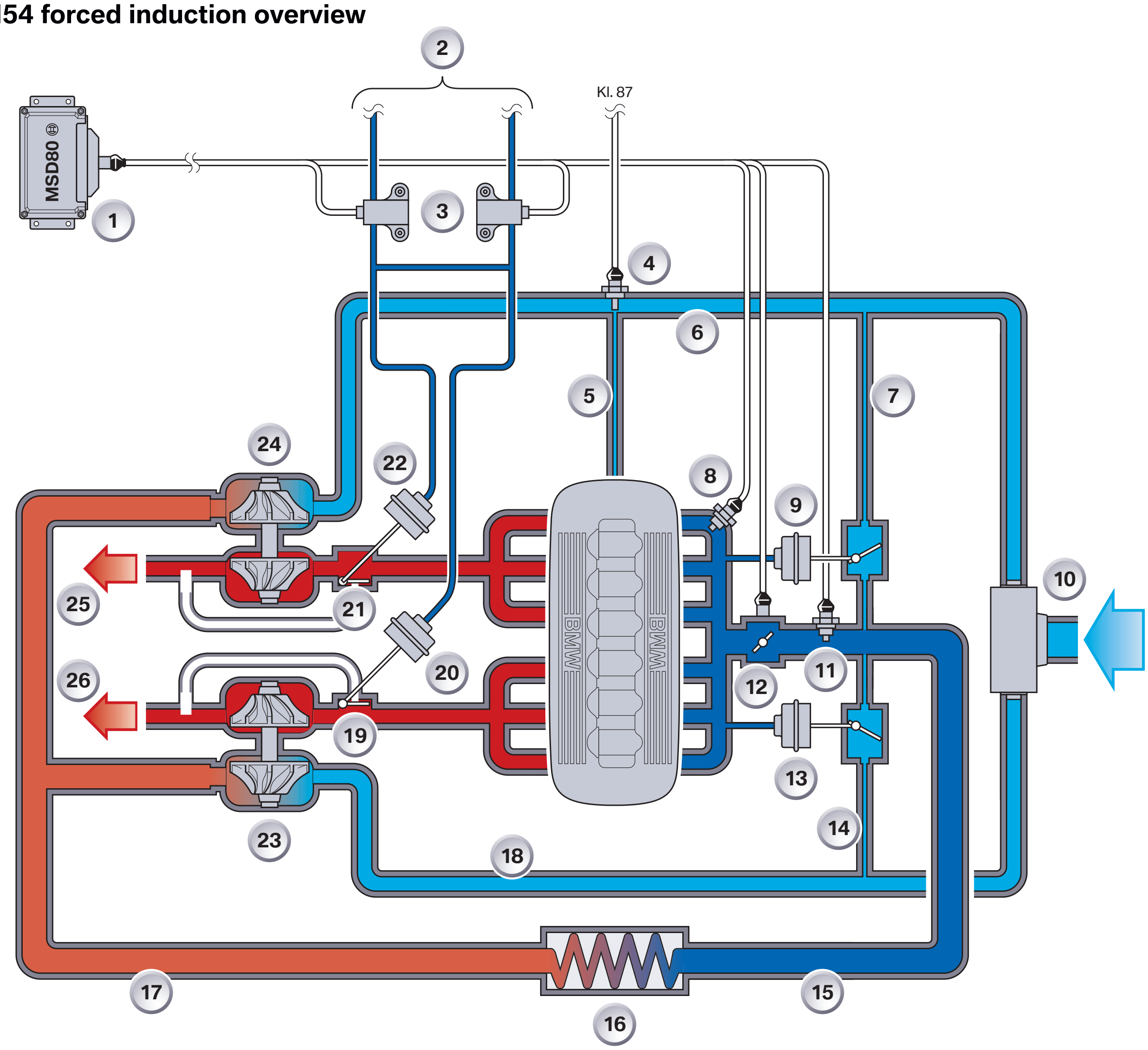
## Air Ducting Overview

The fresh air is drawn in via the air cleaner (10) and the charge-air suction lines (6 + 18) by the compressors of turbochargers (23 + 24) and compressed.

Because the turbochargers can get very hot during operation, they are connected with the engine's coolant and engine-oil circuits. The charge air is greatly heated when compressed in the turbocharger, making it necessary for the air to be cooled again in an intercooler (16).

The compressed and cooled charge air is routed from the intercooler via the throttle valve (12) into the intake manifold. The system is equipped with several sensors and actuators in order to ensure that the load of fresh air is optimally adapted to the engine's respective operating conditions.

**N54 forced induction overview**



## N54 forced induction overview legend

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | MSD80 Engine control module | 14 | Recirculated-air line, bank 1 |
| 2 | Lines to vacuum pump | 15 | Charge air pressure line |
| 3 | Electro-pneumatic pressure transducer | 16 | Intercooler |
| 4 | heater, blow-by gases | 17 | Charge air manifold |
| 5 | Blow-by line turbocharged operation mode | 18 | Charge air suction line, bank 1 |
| 6 | Charge air suction line, bank 2 | 19 | Wastegate flap, bank 1 |
| 7 | Recirculated-air line, bank 2 | 20 | Wastegate actuator, bank 1 |
| 8 | Intake manifold pressure sensor | 21 | Wastegate flap, bank 2 |
| 9 | Blow-off valve, bank 2 | 22 | Wastegate actuator, bank 2 |
| 10 | Air cleaner | 23 | Turbocharger, bank 1 |
| 11 | Charge air pressure and temperature sensor | 24 | Turbocharger, bank 2 |
| 12 | Throttle valve | 25 | To catalytic converter, bank 2 |
| 13 | Blow-off valve, bank 1 | 26 | To catalytic converter, bank 1 |

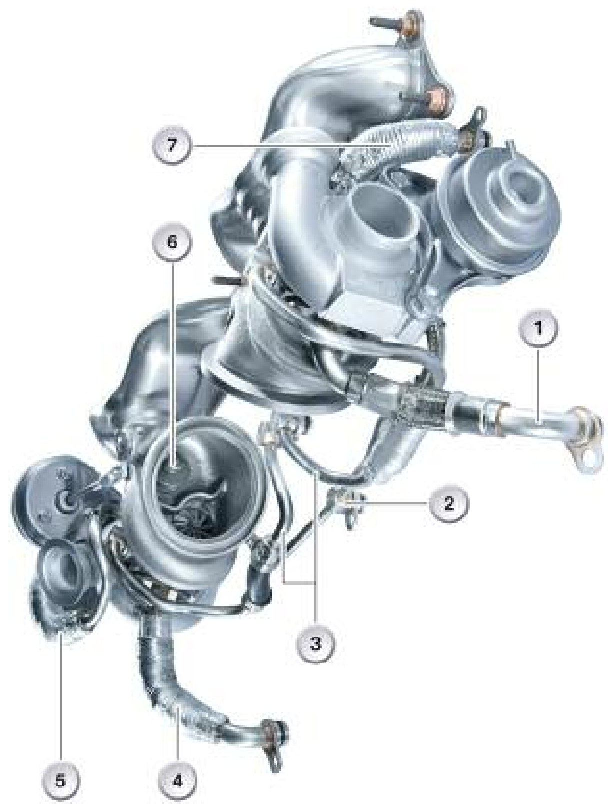
## Boost-pressure Control (Wastegate)

The boost pressure of the turbochargers is directly dependent on the flow of exhaust gas which reaches the turbocharger turbines. Both the velocity and the mass of the exhaust-gas flow are directly dependent on engine speed and engine load.

The engine-management system uses **wastegate valves** to control the boost pressure. These valves are operated by vacuum-pressure actuators, which are controlled via electropneumatic pressure transducers by the engine-management system.

The vacuum pressure is generated by the permanently driven vacuum pump and stored in a pressure accumulator. The system is designed to ensure that these loads and consumers do not have a negative influence on the brake-booster function.

The exhaust-gas flow can be completely or partially directed to the turbine wheel with the wastegate valves. When the boost pressure has reached its desired level, the wastegate valve begins to open and direct part of the exhaust-gas flow past the turbine wheel. This prevents the turbine from further increasing the speed of the compressor.
This control option allows the system to respond to various operating situations.




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Oil return, bank 1 | 5 | Coolant return, bank 2 |
| 2 | Oil supply | 6 | Wastegate valve |
| 3 | Coolant supply | 7 | Coolant return, bank 1 |
| 4 | Oil return, bank 2 | | |

In the idle phase, the wastegate valves of both turbochargers are closed. This enables the full exhaust-gas flow available to be utilized to speed up the compressor already at these low engine speeds.

When power is then demanded from the engine, the compressor can deliver the required boost pressure without any noticeable time lag. In the full-load situation, the boost pressure is maintained at a consistently high level when the maximum permissible torque is reached by a partial opening of the wastegate valves. In this way, the compressors are only ever induced to rotate at a speed which is called for by the operating situation.

The process of the wastegate valves opening removes drive energy from the turbine such that no further increase in boost pressure occurs, which in turn improves overall fuel consumption.

At full-load the N54 engine operates at an overpressure of up to **0.8 bar** in the intake manifold.

**Note: N26 engine was the first engine to use an electric wastegate actuator. This is required to assist in the rapid heating of the catalytic converter to meet SULEV emission requirements. The vacuum waste gate has been replaced in favor of the electric wastegate actuator in many BMW engines for this reason.**

**Blow-off Control (Diverter Valves)**

The blow-off valves in the N54 engine reduce unwanted peaks in boost pressure which can occur when the throttle valve closes quickly. They therefore have an important function with regard to engine acoustics and help to protect the turbocharger components.

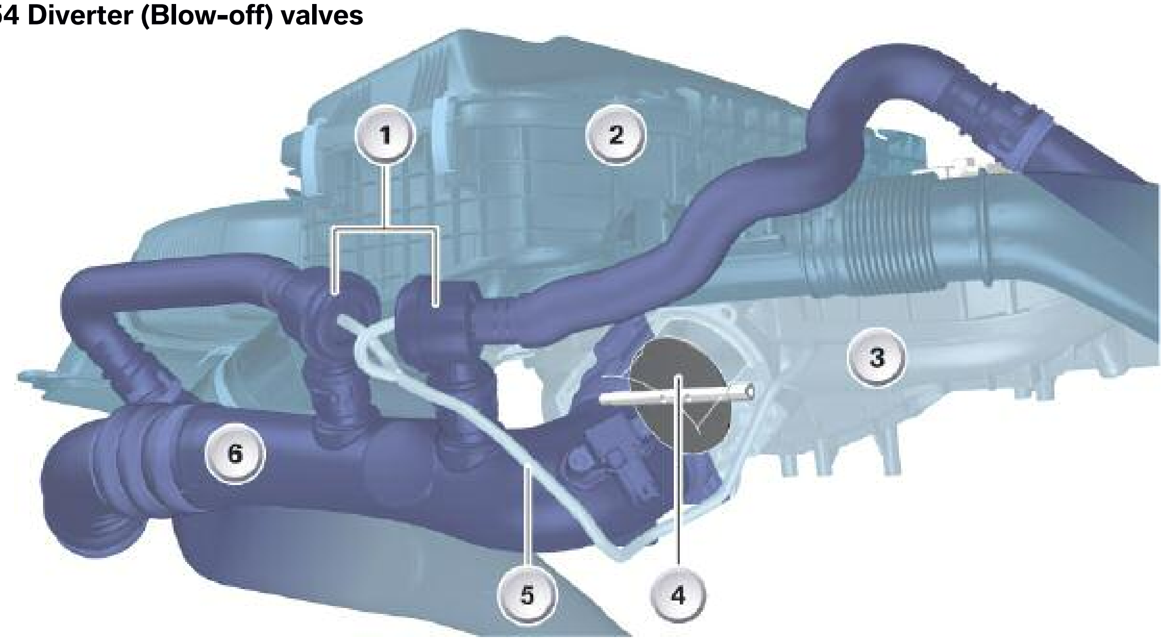
A vacuum pressure is generated in the intake manifold when the throttle valve is closed at high engine speeds. This leads to a build-up of high dynamic pressure after the compressor which cannot escape because the route to the intake manifold is blocked.

This leads to a "pumping up" of the turbocharger which means that:

- a clearly noticeable, disruptive pumping noise can be heard,
- and this pumping noise is accompanied by a component-damaging load being exerted on the turbocharger, since high-frequency pressure waves exert axial load on the turbocharger bearings.

**Note: In comparison to previous turbocharged BMW engines the N63TU does not use a blow-off valve. The use of Valvetronic and special tuning and turbo upgrades rendered it unnecessary. See the N63TU training material for more information.**

**N54 Diverter (Blow-off) valves**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Blow-off valves | 4 | Throttle valve |
| 2 | Air cleaner (ambient pressure) | 5 | Control line, blow-off valves |
| 3 | Intake manifold | 6 | Charge air pressure line |

The blow-off valves are mechanically actuated spring-loaded diaphragm valves which are activated by the intake-manifold pressure as follows:

In the event of a pressure differential before and after the throttle valve, the blow-off valves are opened by the intake-manifold pressure and the boost pressure is diverted to the intake side of the compressor. The blow-off valves open starting from a differential pressure of **0.3 bar**. This process prevents the disruptive and component-damaging pumping effect from occurring.

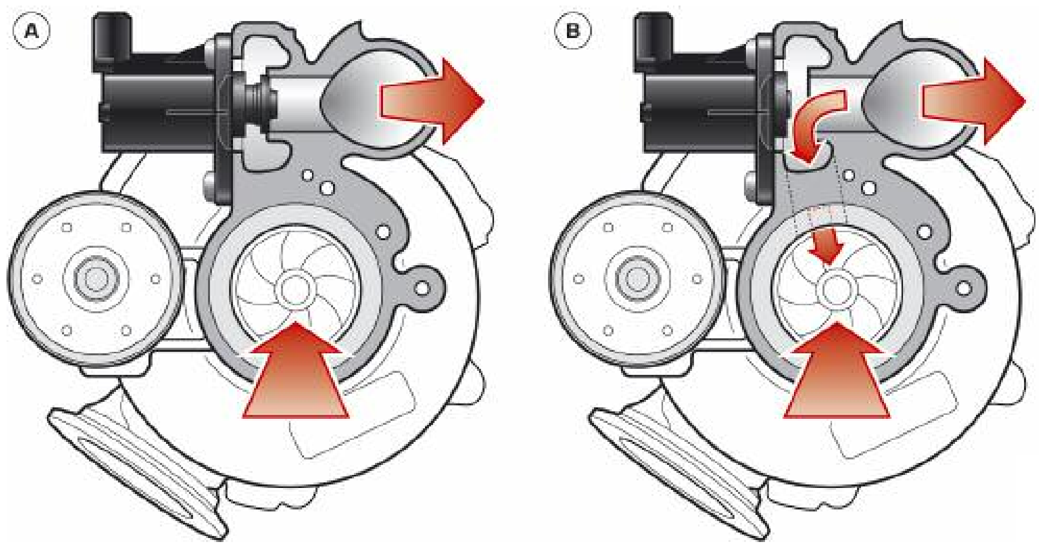
The system design dictates that the blow-off valves are also opened during operating close to idle (pressure differential Pcharger/Psuction = 0.3 bar). However, this has no further effects on the turbocharging system.

The turbocharger is pressurized with the full exhaust-gas flow at these low speeds and already builds up a certain level of induction-air precharging in the range close to idle. If the throttle valve is opened at this point, the full boost pressure required is very quickly made available to the engine.

One of the major advantages of the vacuum pressure-actuated wastegate valves is that they can be partially opened in the mid-range in order not to allow excessive induction-air precharging to the detriment of fuel consumption. In the upper load range, they assume the required control position corresponding to the necessary boost pressure.

The diverter valves in the **N63** engine also reduce unwanted peaks in boost pressure which can occur when the throttle valve closes quickly. They therefore have an important function with regard to engine acoustics and help to protect the turbocharger components. As with the N54 a vacuum is generated in the intake manifold when the throttle valve is closed at high engine speeds. This leads to a build-up of high dynamic pressure after the compressor which cannot escape because the route to the intake manifold is blocked.

**N63 Diverter valve operation**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Diverter valve, closed | B | Diverter valve, open |

This leads to a "pumping up" of the turbocharger.

In contrast with the N54, the diverter valves on the N63 engine are electrically operated valves. When the throttle valve closes, the boost pressure (upstream of the throttle valve) and its increase are compared with stored target values.

The diverter valves are opened if the actual values exceed the target by a certain value. As a result, the boost pressure is diverted to the intake side of the compressor.

This procedure prevents the disruptive and component-damaging pumping effect from occurring.

**On N55 and N74 the diverter valve is located on the compressor housing. See twin-scroll turbo section for more information.**

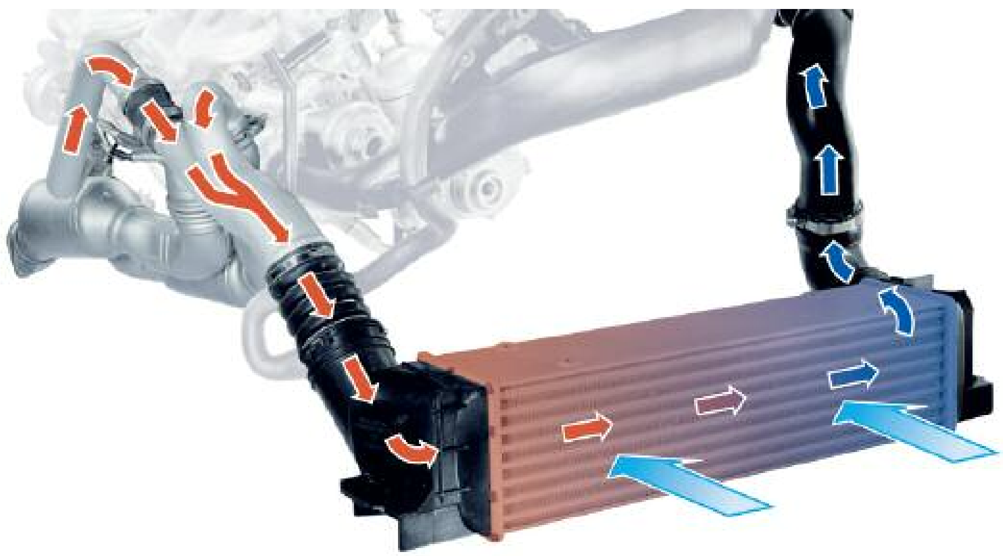
**Diverter valve on the N63**

## Charge Air Cooling

### Direct Charge Air Cooling
Cooling the charge air in the N54 engine serves to increase power output as well as reduce fuel consumption. The charge air heated in the turbocharger by its component temperature and by compression is cooled in the intercooler by up to 80°C.

This increases the density of the charge air and improves the charge in the combustion chamber. This translates in lower boost pressure required which in turn reduces the risk of knock which improves engine efficiency.

**N54 Direct charge air cooling (air to air)**



**The N55 uses Direct Charge Air Cooling (air to air) as on the N54.**

### Indirect Charge Air Cooling
Indirect charge air cooling was used for the first time on the N63 engine.

The charge air is cooled by means of an air-to-coolant heat exchanger. Therefore, the N63 engine features a separate self contained low-temperature coolant circuit.

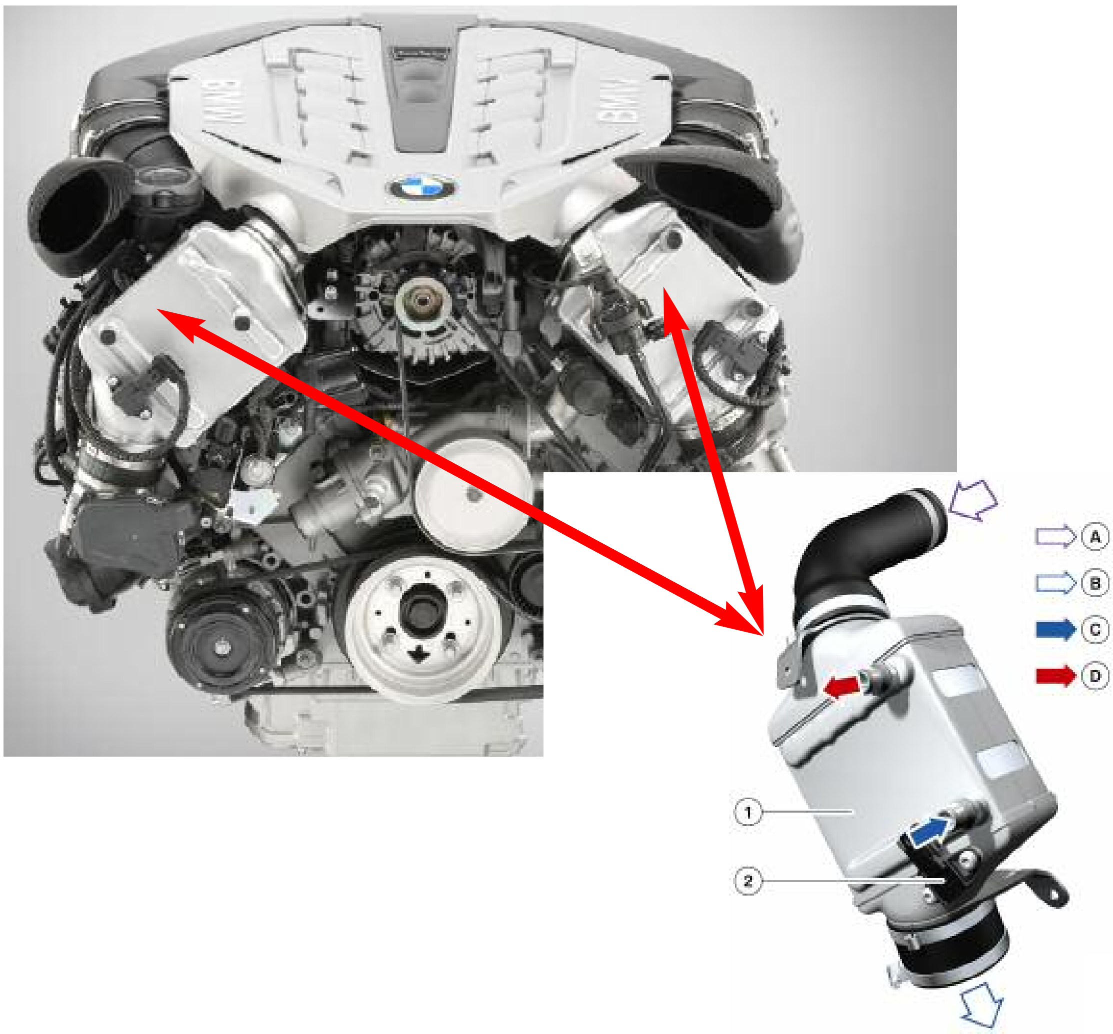
The charge air heated in the turbocharger by its component temperature and by compression is cooled in the intercooler by up to 80°C. This results in increased power output and reduced fuel consumption.

As with direct charge air cooling, the increased density of the charge air improves the charge in the combustion chamber and results in lower boost pressure required which reduces the risk of knock improves engine efficiency.

Indirect charge air cooling has the advantage of requiring little space as the system can be mounted directly on the engine. Due to the near-engine installation position, the distinctly shorter pipe length required for charge air routing also have a positive effect.

In this way, pressure loss has been substantially reduced, thus improving power yield and engine response.

**N63 Indirect charge air cooling (air to coolant)**



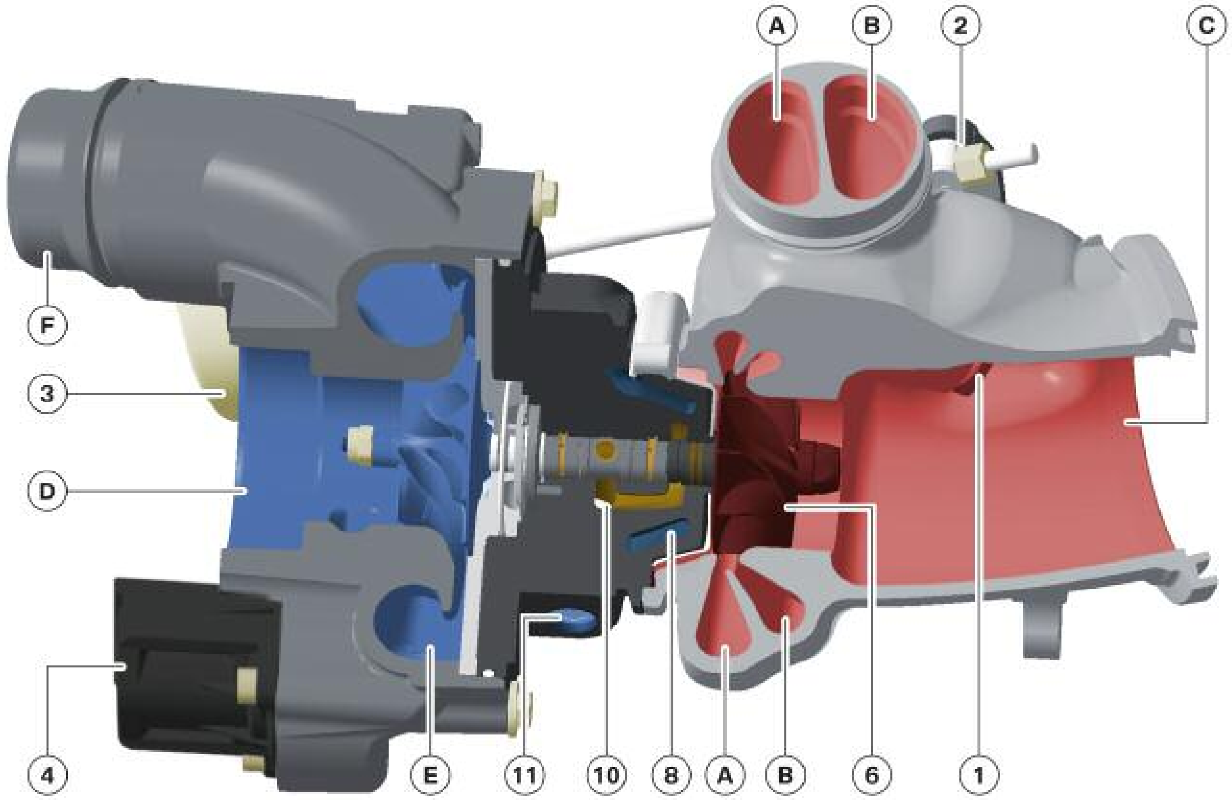

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Hot charge air | D | Hot coolant |
| B | Cooled charge air | 1 | Intercooler |
| C | Cooled coolant | 2 | Charge air pressure/temperature sensor |

**The N74 uses Indirect Charge Air Cooling (air to coolant) as on the N63.**

## Twin Scroll Turbocharger

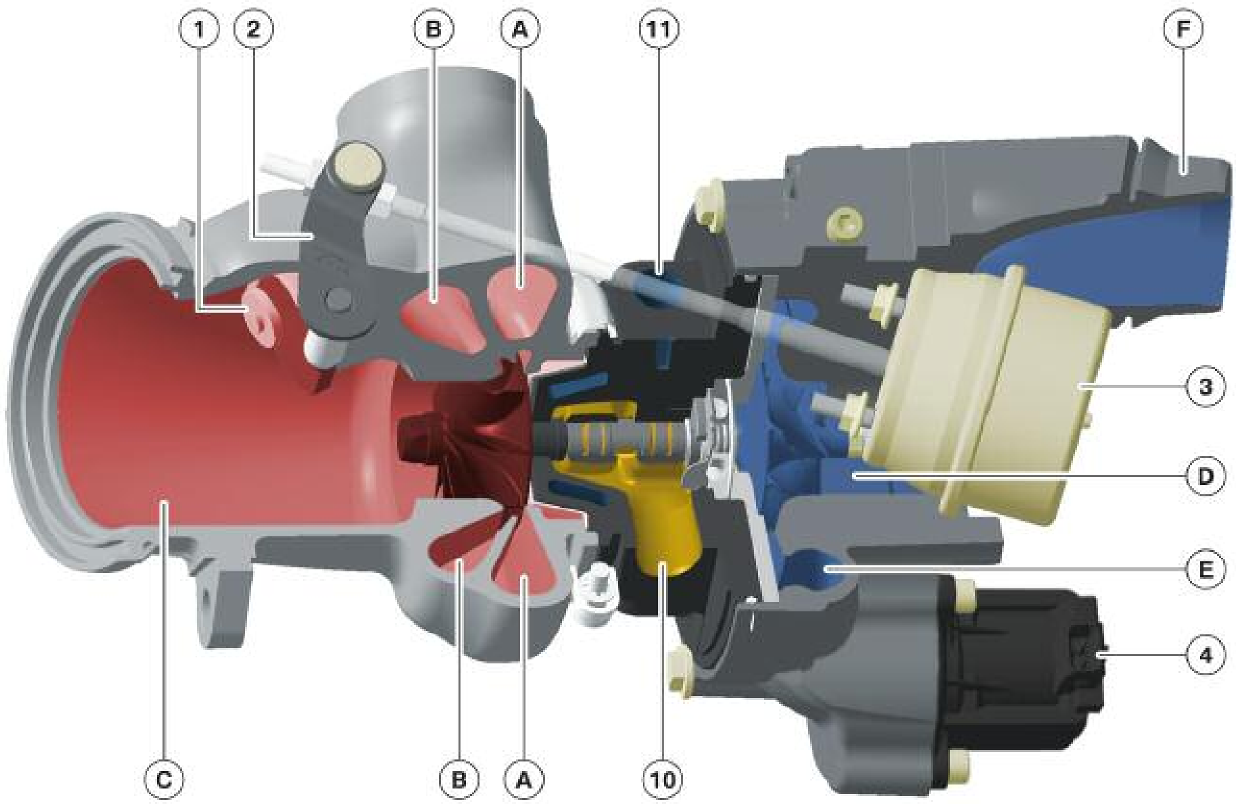
The N55 is equipped with a single twin scroll turbocharger instead of two separate small turbochargers as on the N54 engine. The following graphics show the operating principle of the twin scroll turbocharger.

**Twin scroll turbocharger rear view**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Exhaust duct 1 (cylinders 1 - 3) | 2 | Lever arm, wastegate valve |
| B | Exhaust duct 2 (cylinders 4 - 6) | 3 | Vacuum unit for wastegate valve |
| C | Connection to catalytic converter | 4 | Diverter valve |
| D | Inlet from intake silencer | 6 | Turbine wheel |
| E | Ring channel | 8 | Cooling duct |
| F | Outlet to intercooler | 10 | Oil return |
| 1 | Wastegate valve | 11 | Coolant return |

## Twin scroll turbocharger front view




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Exhaust duct 1 (cylinders 1 - 3) | 1 | Wastegate valve |
| B | Exhaust duct 2 (cylinders 4 - 6) | 2 | Lever arm, wastegate valve |
| C | Connection to catalytic converter | 3 | Vacuum unit for wastegate valve |
| D | Inlet from intake silencer | 4 | Diverter valve |
| E | Ring channel | 10 | Oil return |
| F | Outlet to intercooler | 11 | Coolant return |

### Function of the Twin Scroll Turbocharger

The system is designed so that constant exhaust gas pressure is rearly applied to the turbocharger. At low engine speeds, the exhaust reaches the turbine in tuned pulsed form. Due to this pulsation, a higher pressure ratio is temporarily reached in the turbine. Since the efficiency increases as the pressure rises, the pulsation improves the boost pressure progression and thus the torque progression of the engine. This is the case particularly at low engine speeds.

The response characteristics of the twin scroll turbocharger are enhanced when compared to a single scroll setup. The turbocharger turbines are fed through two separate channels within the turbine housing (highlighted red in the graphic above). Each of these channels or “scrolls” is always fed by the exhaust pulses from the same two cylinders.

To limit the back pressure and ensure that the individual cylinders do not mutually influence each other during the cylinder charging process, cylinders 1 - 3 (bank 1) and cylinders 4 - 6 (bank 2) are combined to form two exhaust channels. The exhaust gas pulses in the exhaust channels (1 and 2) are directed into two scrolls (spirals) within the turbocharger to drive the turbine wheel. This design layout makes it possible to optimally use the exhaust pulsations for generating boost pressure based on the firing order of the engine. This improves engine efficiency by enhancing throttle response and limiting unwanted turbo lag.

The wastegate valve is used for the purpose of limiting the boost pressure and is already known from previous BMW turbo engines. It is vacuum operated and electronically controlled through a vacuum control solenoid by the DME (ECM).

#### Diverter valve

The basic function of the diverter valve remains the same. The difference compared to the N54 engine is that the diverter valve is not operated pneumatically. The diverter valve on the N55 engine is an electric actuator that is controlled directly by the DME.
As with N74 the number of components has been greatly reduced by positioning the diverter valve on the turbocharger compressor housing.

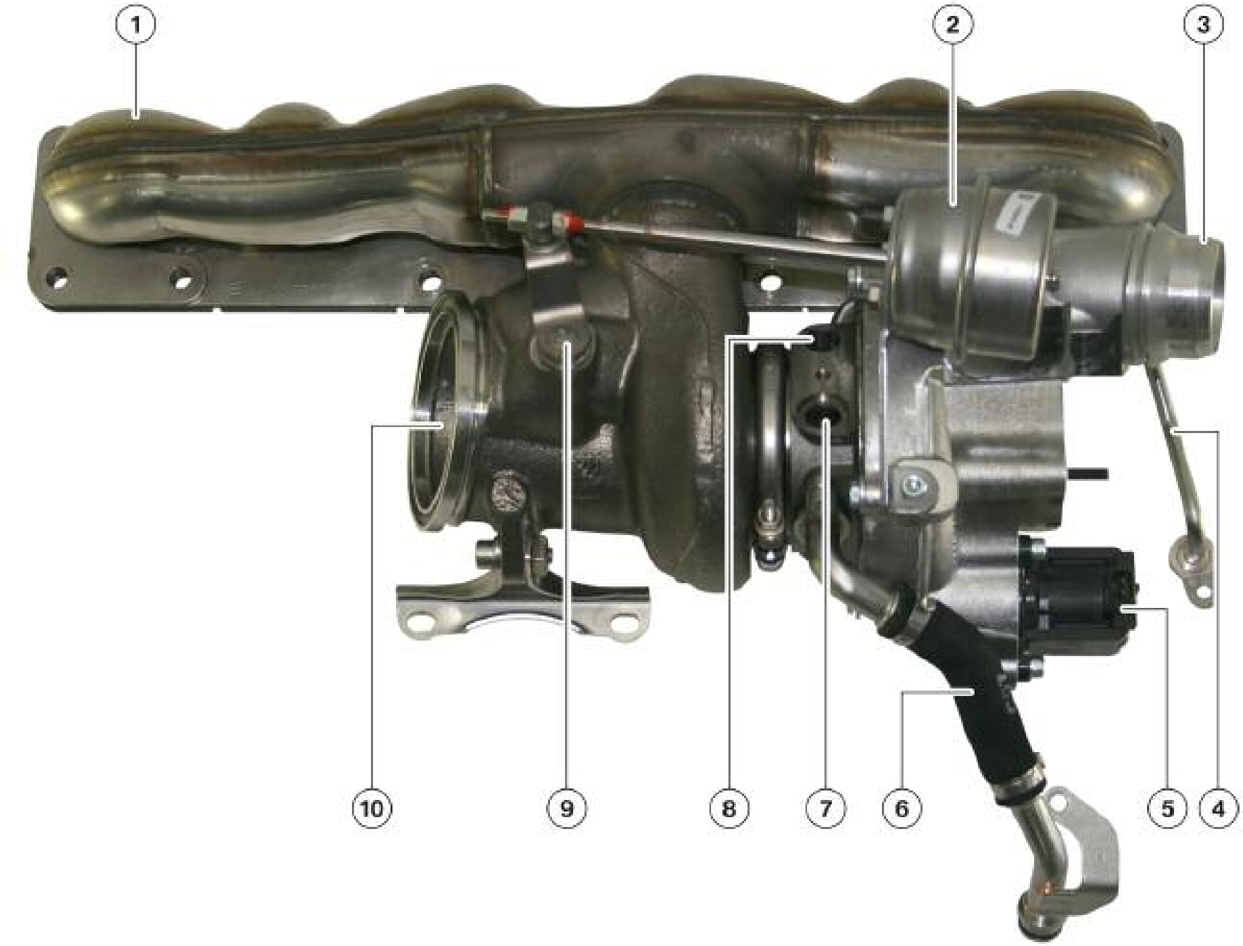
The diverter valve is designed to release unwanted pressure in the intake by connecting the pressure side of the induction system to the inlet side under deceleration. The undesirable peaks in the boost pressure that can occur when the throttle valve is quickly closed are reduced. This means the diverter valve plays an important role in terms of the engine acoustics while protecting the components of the turbocharger.

**For further information regarding the N55 engine refer to the N55 training material available on TIS and ICP.**

## Tuned Pulsed Exhaust Manifold

The exhaust manifold is air-gap insulated and designed as a six ports into two chamber manifold. Dividing six exhaust ports into two exhaust chambers is necessary in order to ensure optimum flow to the twin scroll turbocharger. The exhaust pulses from the first three cylinders (1-3) feed one scroll (duct 1) of the turbo, while the last three (4-6) feed the second scroll (duct 2). The exhaust manifold and turbocharger are welded together to form one component.

**N55, attachment of exhaust manifold and turbocharger to engine block**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Exhaust manifold | 6 | Oil return line |
| 2 | Vacuum unit | 7 | Coolant infeed |
| 3 | Connection to intercooler | 8 | Coolant return |
| 4 | Oil feed line | 9 | Shaft, wastegate valve |
| 5 | Diverter valve | 10 | Connection to exhaust system |

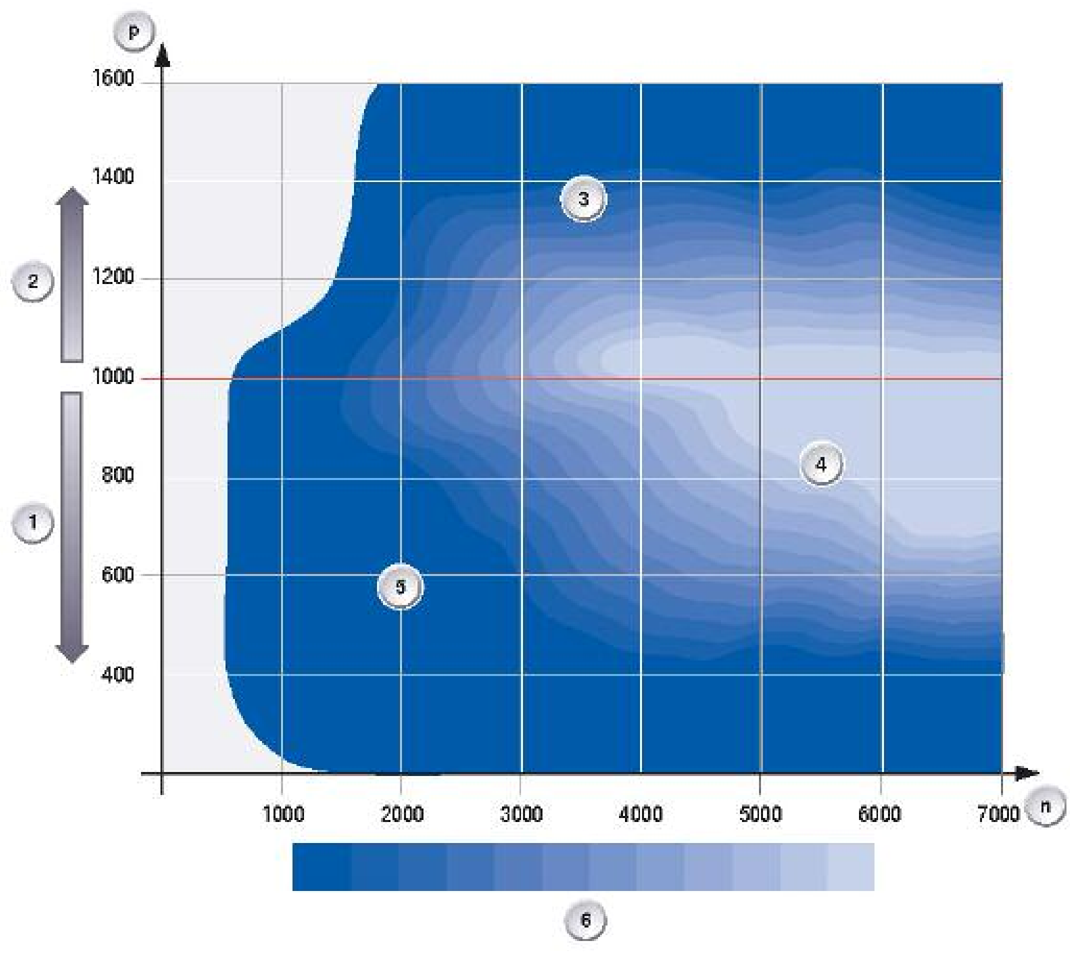
## Load Control

Load control is effected by means of the throttle valve and the waste gate valves.

The throttle valve is the primary component in this process. The wastegate valves are actuated to bring about a fine tuning of the boost pressure. At full load the throttle valve is completely open and load control is undertaken by the wastegate valves.

The load-control graphic shows that the wastegate valves are integrated in load control in all operating situations of the N54 engine on the basis of map control.

**Load Control Overview**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| n | Engine speed in RPM | 3 | Wastegate controlled as a function of boost pressure |
| p | Absolute pressure in the intake in millibar | 4 | Wastegate partially opened |
| 1 | Naturally aspirated engine operation | 5 | Wastegate closed |
| 2 | Turbocharged operation | 6 | Dark = Wastegate fully closed<br>Light = Wastegate fully open |

## Controlled Variables

The following variables, among others, influence control of the engine's boost pressure:

- Intake-air temperature
- Engine speed
- Throttle-valve position
- Ambient pressure
- Intake-manifold pressure
- Pressure before the throttle valve (reference variable)

The electropneumatic pressure transducers are activated by the engine control unit on the basis of these variables. The result of this activation can be checked from the boost pressure achieved, which is measured before the throttle valve.

There follows a comparison of the boost pressure achieved with the setpoint data from the program map, which can if necessary give rise to an activation correction. The system therefore controls and monitors itself during operation.

## Limp-home Mode

In the event during operation of malfunctions, implausible values or failure of any of the sensors involved in turbocharger control, activation of the wastegate valves is shut down and the valve flaps are thus fully opened. Turbocharging ceases at this point.

The list below sets out those components or functional groups in which a failure, a malfunction or implausible values result in boost-pressure control being deactivated. The driver is alerted to a fault of this type via an EML indication.

- High-pressure fuel system
- Inlet VANOS
- Exhaust VANOS
- Crankshaft sensor
- Camshaft sensor
- Boost-pressure sensor
- Knock sensors
- Intake-air temperature sensor

One principle of vehicle repair is particularly important in this respect:

**It is important to focus on the causes rather than the effects.**

With regard to the diagnosis and subsequent repair of turbocharging components, it is important to ensure that they are also actually identified as defective components with the diagnostic technology available.

It is always vital to ensure that the cause of the fault is determined and rectified and that if necessary work is not carried out on symptoms of fault consequences.
Thus, for instance, a leaking flange on the intercooler can have far-reaching consequences.

When diagnosing a turbo complaint always follow the three golden rules of procedure:

1. Do not rashly trace loss of power and engine malfunctions back to the turbocharger. To avoid the replacement of turbochargers which are in perfect working order, the following should be observed:

   When blue smoke emerges from the exhaust system, check whether the air cleaner is contaminated or the engine is consuming too much oil because of wear. Or, if the crankcase ventilation system is faulty. Only then resort to checking the turbocharger. If the turbocharger is running too loud, inspect all the connections on the turbocharger pressure side. If black smoke or a loss of power is detected, in this case too check the engine and the connecting pipes first.

2. Main causes of turbocharger damage:

   - Insufficient lubrication and consequently bearing failure. Compressor and turbine wheels will grind in the housings, the seals will be damaged and the shaft may also shear off.
   - Foreign bodies damage the turbine and impeller. The resulting imbalance will reduce efficiency and may cause rotor damage.
   - Contaminated oil causes scoring on shaft journals and bearings. Oilways and seals will become clogged and cause oil leakage. Elements entering the turbocharger system from the outside such as sand, dirt, screws and the like will be trapped by a filter before the compressor.

     Service the filters at regular intervals (service intervals). Make sure to keep the clean-air area of the air cleaner and the air ducting to the compressors clean and free from all types of debris.

3. Do not make any alterations to the turbocharger: Never attempt to alter the boost-pressure control linkage. The turbocharger has been optimally configured at the factory. If the turbocharger operates at higher boost pressures than permitted by the engine manufacturer, the engine may run hot and pistons, cylinder heads or engine bearings may fail, or the safety function of the engine electronics may respond and activate the engine's limp-home program.

# Direct Injection

The term “direct injection” refers to a fuel injection system which injects fuel directly into the combustion chamber rather than into the intake manifold. This technology has been around since the 1930’s, but has not been in widespread use until the late 20th century.

The early development of this type of injection system took place in Germany in 1937 on an aircraft engine. The first passenger car to run on direct engine was a car called the “Gutbrod” in the early 50’s.

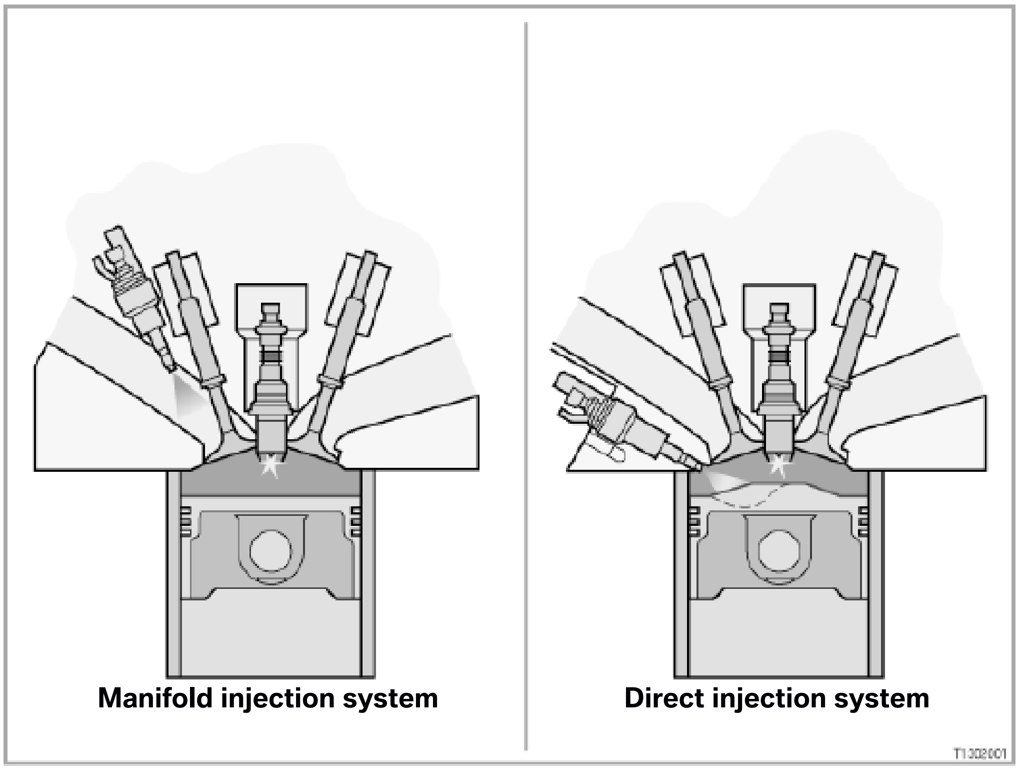
Due to the complexity and cost of the direct injection system, the technology did not take hold. Later, the development of more cost efficient components and the need for a more efficient internal combustion engine, the DI engine made a comeback in the late 1990’s.

The first application of this technology on a BMW was in 2003 on the 760Li. The new N73 V-12 engine utilized direct injection with the combination of VALVETRONIC and the latest direct injection technology.

For the 2007 model year, BMW introduced the N54 engine with direct fuel injection. It combined (for the first time) turbocharging with the second generation of direct injection (DI 2), referred to as High Precision Injection (HPI).

## Direct Injection Principles

As the name suggest, the direct injection (DI) system uses a fuel injector which sprays fuel directly into the combustion chamber. The fuel injection pressure (N73) is from 80 to 120 bar. The A/F mixture in a DI engine is formed inside of the combustion chamber. In comparison, a manifold injection system sprays fuel into the intake manifold or into the intake port near the intake valve. In this case, the A/F mixture is formed outside of the combustion chamber. The injection pressure on most manifold injection systems is between 3 and 5 bar.




The DI system allows for increased engine efficiency and has several distinct advantages over manifold injection systems:

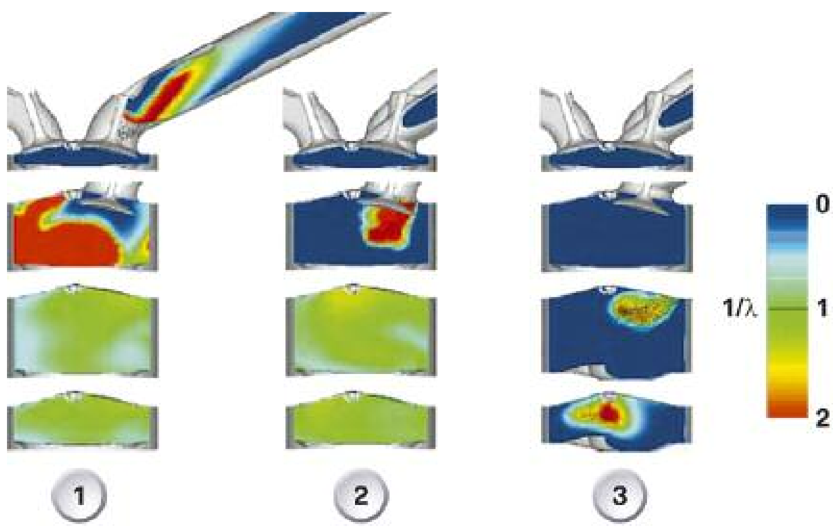
- The fuel is evaporated and atomized in the combustion chamber, which provides a "cooling effect" on combustion. A cooler combustion chamber allows an increase in air density, which allows for more available oxygen. In addition, cooler combustion allows for an increase in compression ratio which equates to improved efficiency and engine power.
- By injecting the fuel directly into the combustion chamber, there is less possibility for fuel to condense or accumulate on the manifold walls or the back of the intake valve. This results in less fuel needed to achieve the desired A/F ratio.
- The increased injection pressure causes the fuel droplet size to be reduced. This allows for improved atomization and therefore improved mixture formation.

## Mixture Formation

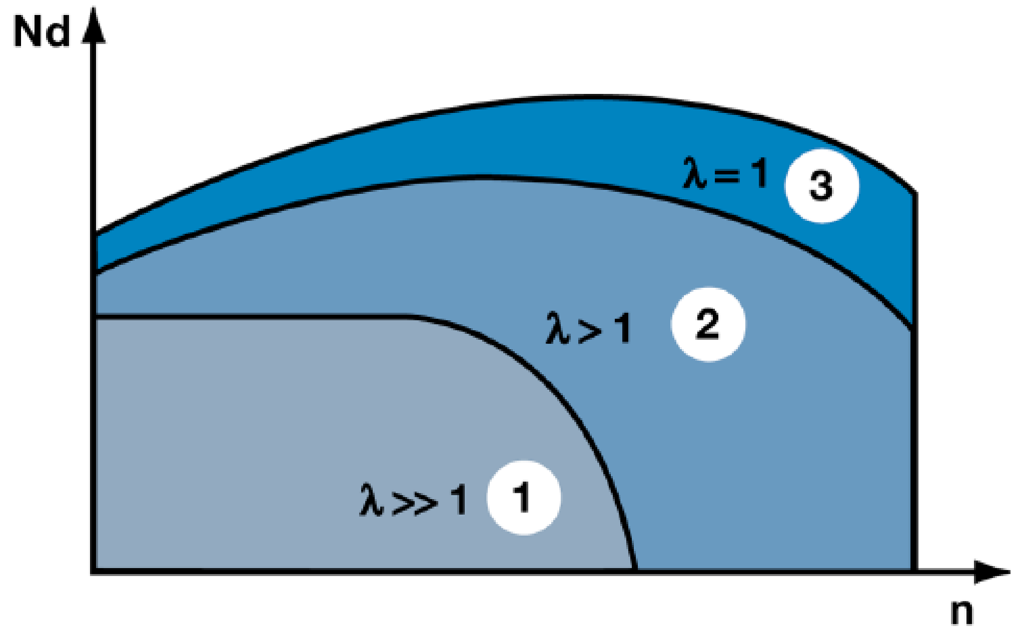
In a conventional (manifold injection) engine, the air fuel mixture is formed outside of the combustion chamber. In contrast, the mixture must be formed inside the combustion chamber in a DI engine.

A DI fuel system has two basic operating concepts:

- **Homogeneous Mixture Formation** - A homogeneous mixture means that the A/F ratio is stoichiometrically controlled much in the same way as a manifold injection system. This means that the A/F mixture is evenly spread throughout the combustion chamber. One of the primary advantages of this arrangement is that a conventional three-way catalytic converter can be used. Also, the sulfur content of the fuel is not a factor which allows the engine to be used in all global markets. Currently, BMW only uses engines which operate in this mode (mostly at Lambda = 1).
- **Stratified Mixture Formation** - In the stratified injection method, a homogeneous mixture is only created around the area of the spark plug. A lean (inhomogeneous) mixture exists in the rest on the combustion chamber. Therefore the overall A/F mixture in the combustion chamber is lean (lambda > 1). This results in increased combustion chamber temperature, and subsequently increased NOx emissions. The increased NOx requires the use of a DeNOx catalyst which is not effective when sulfur is present in the fuel. Therefore, sulfur free fuel must be used which is not readily available in all markets. For the time being, BMW does not have any engines which operate in “stratified charge” in the US market.




| Index | Explanation |
|---|---|
| 1 | Manifold injection |
| 2 | Homogeneous direct injection |
| 3 | Stratified direct injection |




| Index | Explanation |
|---|---|
| 1 | Lean, charge stratification |
| 2 | Lean, homogeneous |
| 3 | Homogeneous |
| Nd | Engine torque |
| n | Engine speed |

As the above chart shows, the use of load stratification (1) is only possible in a limited load and speed range. Over and above this load and speed range, the engines can only be operated in homogeneous mode (2-3).

Through the deployment of VALVETRONIC, the N73 engine in the middle torque/speed range (1) demonstrates the same consumption advantages as engines of other manufacturers with charge stratification.

Because large-capacity engines are mainly operated in the lower to middle load and speed range, it is only advisable to use load stratification in these engines.

Smaller-sized engines are mainly operated in the high load and speed range and thus in homogeneous mode.

Current BMW engines operate mostly in the homogeneous mode with a lambda value of 1. In the US market, BMW does not use a “stratified charge” engine due to the fact that these engines emit high NOx levels.

## High Precision Injection

The BMW High Precision Injection (HPI) is the second generation of direct injection (DI 2) for BMW. The first generation was on the N73 engine in 2003. The HPI system was introduced in the N54 and is currently also used on N63, S63 and the N74 V12 engine.

The term “high precision” refers to the precise metering and directional control of the atomized fuel. Also, the injection process now allows for multiple injection events due to the use of piezo injectors. The HPI system represents a key function in the concept for the most economical use of fuel without compromising performance.

High precision injection allows for a more precise metering of the fuel injection process and therefore permits a higher compression ratio of 10.2 to 1. This compression ratio is quite high considering the N54 is turbocharged. However, the “spray guided” injection process cools the air charge and decreases the possibility of unwanted engine knock. The operating pressure of the HPI system is up to 200 bar.

High-precision injection represents the key function in the concept of using the less fuel as possible. The new generation of gasoline direct injection satisfies the expectations placed on it with regard to economic efficiency without compromising the engine's dynamic qualities (Efficient Dynamics).

High-precision injection provides for a more precise metering of mixture and higher compression - ideal preconditions for increasing efficiency and significantly reducing consumption.

This is made possible by locating the piezo injector centrally between the valves. In this position, the new injector (which opens in an outward direction) distributes a particularly uniform amount of fuel into the combustion chamber in a tapered shaped spray pattern.

The new direct injection of BMW HPI spark ignition engines operate according to the spray-guided process.

**HPI Function**

The fuel is delivered from the fuel tank by the electric fuel pump via the feed line (5) at an “feed” pressure of 5 bar to the high pressure pump. The feed pressure is monitored by the low-pressure sensor (6). The fuel is delivered by the electric fuel pump in line with demand.

If this sensor fails, the electric fuel pump continues to run at 100% delivery with terminal 15 ON.

On N54 and N55 The high pressure pump is driven “in-tandem” with the vacuum pump which is driven by the oil pump chain drive assembly.(See HDE for more information)

The fuel is compressed in the permanently driven three-plunger high-pressure pump (8) and delivery through the high-pressure line (9) to the rail (3). The fuel accumulated under pressure in the rail in this way is distributed via the high-pressure lines (1) to the piezo injectors (2).

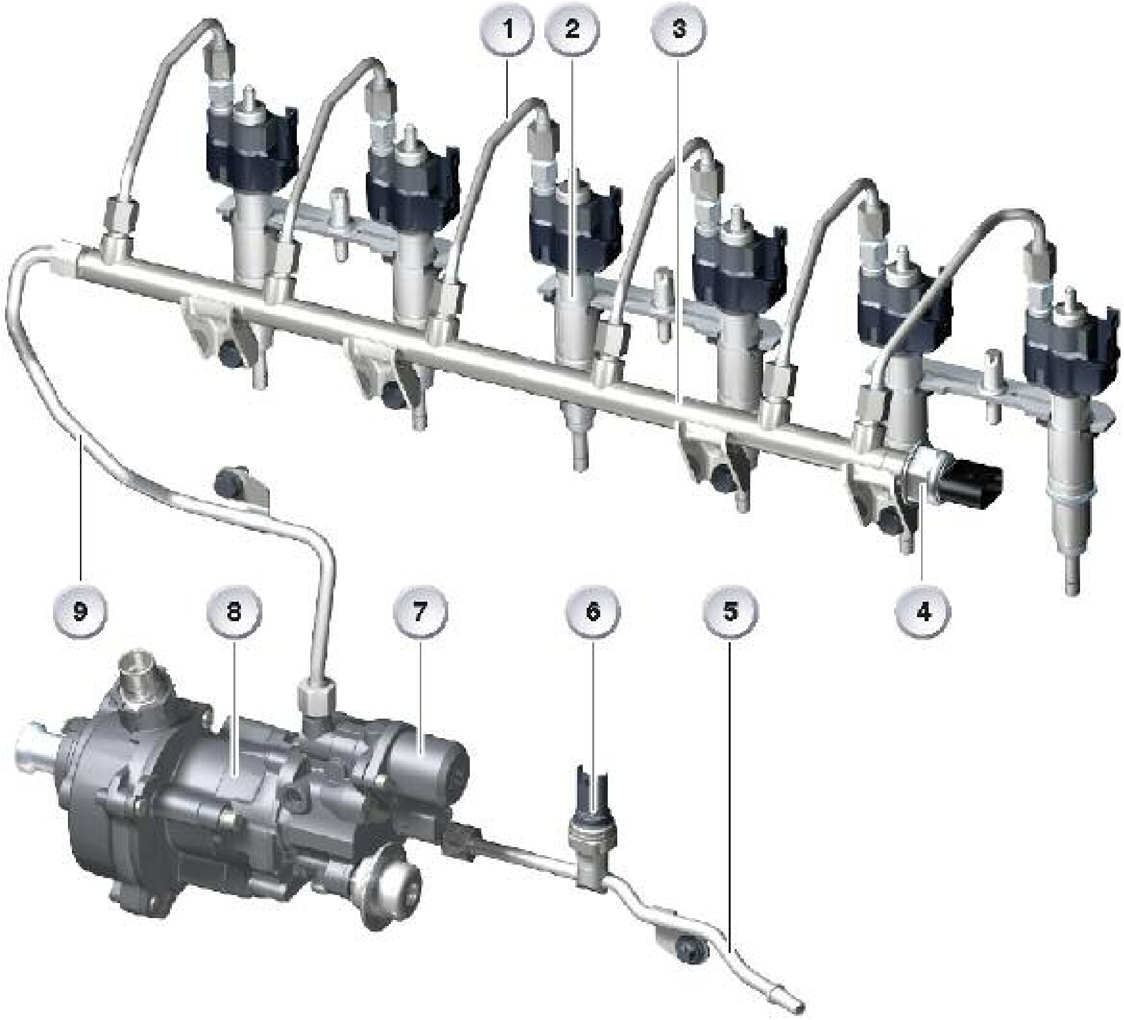
**The high pressure injection pump on the N63 and N74 is of a more compact design. It is mounted on the cam cover and driven by a triple cam on the exhaust cam on the N63 and by the intake cam on the N74. Please refer to the appropriate training information or repair instructions for more details.**

**N63 high pressure pump**

The required fuel delivery pressure is determined by the engine-management system as a function of engine load and engine speed. The pressure level reached is recorded by the high-pressure sensor (4) and communicated to the engine control unit.

Control is effected by the fuel-supply control valve (7) by way of a setpoint/actual-value adjustment of the rail pressure. Configuration of the pressure is geared towards best possible consumption and smooth running of the engine. 200 bar is required only at high load and low engine speed.

**N54 HPI direct injection components**

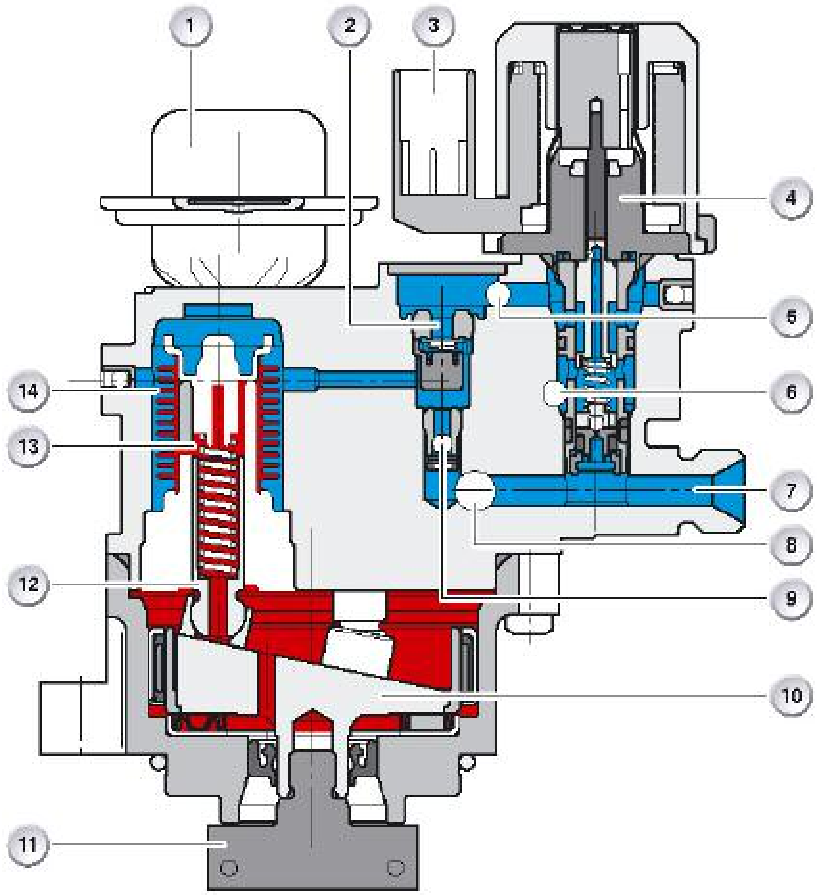



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | High-pressure line to injector (6) | 6 | Low-pressure sensor |
| 2 | Piezo injector | 7 | Fuel supply control valve |
| 3 | Fuel rail | 8 | Three plunger high pressure pump |
| 4 | High pressure sensor | 9 | High pressure line (pump to rail) |
| 5 | Feed line from in-tank pump | | |

## High Pressure Pump Function and Design

The fuel is delivered via the supply passage (6) at the admission pressure generated by the electric fuel pump to the high-pressure pump. From there, the fuel is directed via the fuel supply control valve (4) and the low-pressure non-return valve (2) into the fuel chamber (14) of the plunger-and-barrel assembly. The fuel is placed under pressure in this plunger-and-barrel assembly and delivered via the high pressure non-return valve (9) to the high pressure port (7).

**N54 HPI high pressure pump**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Thermal compensator | 8 | Supply passage, pressure limiting valve |
| 2 | Low pressure non-return valve (check valve) | 9 | High pressure non-return valve (x 3) |
| 3 | Connection to engine management | 10 | Pendulum disc |
| 4 | Fuel supply control valve | 11 | Drive flange, high pressure pump |
| 5 | Return, pressure limiting valve | 12 | Plunger ( x 3) |
| 6 | Supply from electric fuel pump (in-tank) | 13 | Oil filling, high pressure pump |
| 7 | High pressure port to fuel rail | 14 | Fuel chamber ( x 3) |

The high-pressure pump is connected with the vacuum pump via the drive flange (11) and is thus also driven by the chain drive, i.e. as soon as the engine is running, the three plungers (12) are permanently set into up-and-down motion via the pendulum disc (10).

Fuel therefore continues to be pressurized for as long as new fuel is supplied to the high-pressure pump via the fuel-supply control valve (4). The fuel-supply control valve is activated by means of the engine management connection (3) and thereby admits the quantity of fuel required.

Pressure control is effected via the fuel-supply control valve by opening and closing of the fuel supply channel. The maximum pressure in the high-pressure area is limited to 245 bar. If excessive pressure is encountered, the high-pressure circuit is relieved by a pressure-limiting valve via the ports (8 and 5) leading to the low-pressure area.

This is possible without any problems because of the incompressibility of the fuel, i.e. the fuel does not change in volume in response to a change in pressure. The pressure peak created is compensated for by the liquid volume in the low-pressure area.

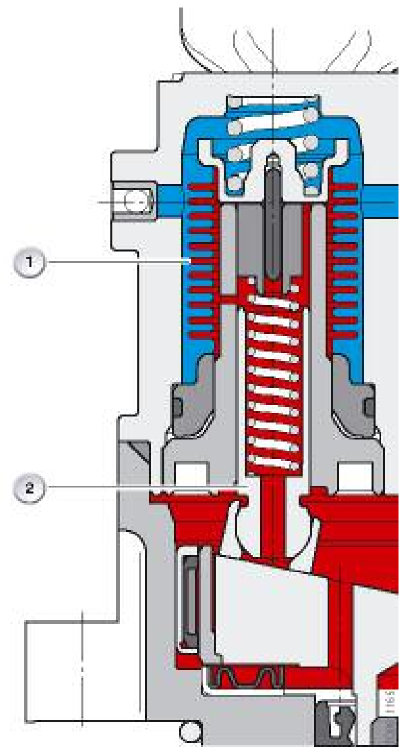
Volume changes caused by temperature changes are compensated for by the thermal compensator (1), which is connected with the pump oil filling.

**Pressure Generation in High-pressure Pump**

The plunger (2) driven by the pendulum disc presses oil (red) into the metal diaphragm (1) on its upward travel. The change in volume of the metal diaphragm thereby reduces the available space in the fuel chamber. The fuel thereby placed under pressure (blue) is forced into the rail.

The fuel-supply control valve controls the fuel pressure in the rail. It is activated by the engine management system via a pulsewidth modulated (PWM) signal.

Depending on the activation signal, a restrictor cross-section of varying size is opened and the fuel-mass flow required for the respective load point is set. There is also the possibility of reducing the pressure in the rail.




| Index | Explanation |
|---|---|
| Red | Oil filling |
| Blue | Fuel |
| 1 | Metal diaphragm |
| 2 | Plunger |

## Limp-home Mode

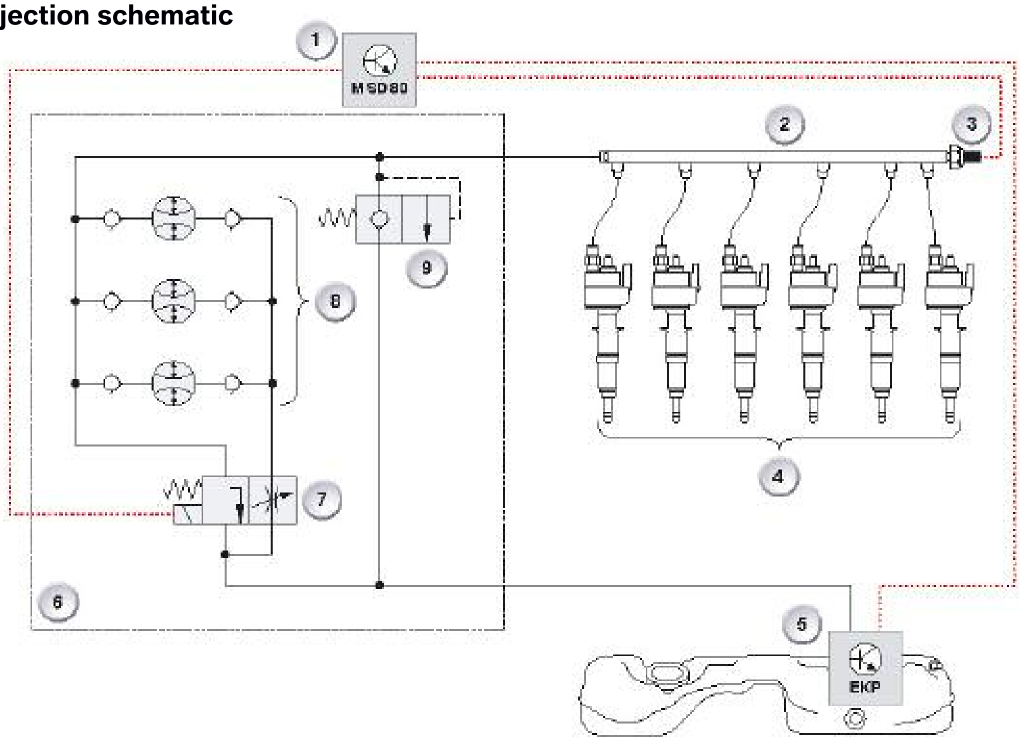
If a fault is diagnosed in the system, such as e.g. failure of the high-pressure sensor, the fuel-supply control valve is de-energized; the fuel then flows via a so-called bypass into the rail.

In the event of HPI limp-home mode, turbocharging is deactivated by an opening of the wastegate valves.

Causes of HPI limp-home mode can be:

- Implausible high-pressure sensor values
- Failure of the fuel-supply control valve
- Leakage in the high-pressure system
- Failure of the high-pressure pump
- Failure of the high-pressure sensor

**N54 HPI injection schematic**

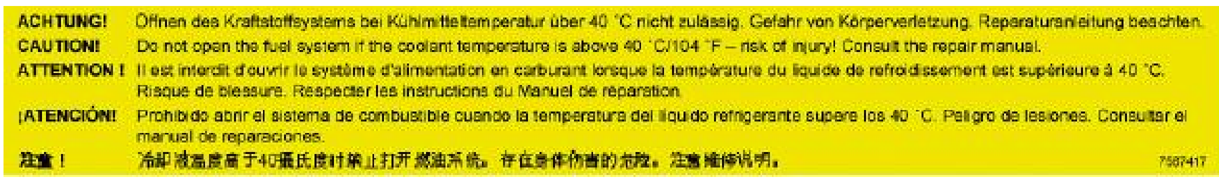



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Engine control module (MSD80) | 6 | High-pressure pump |
| 2 | Fuel rail | 7 | Fuel supply control valve |
| 3 | High pressure sensor | 8 | High pressure pump with non-return valves |
| 4 | Piezo injectors | 9 | Pressure liming valve with bypass |
| 5 | Electric fuel pump | | |

## Fuel System Safety

Working on this fuel system is only permitted after the engine has cooled down. The coolant temperature must not exceed 40 °C. This must be observed without fail because otherwise there is a danger of fuel sprayback on account of the residual pressure in the high-pressure system.

When working on the high-pressure fuel system, take particular care to ensure conditions of absolute cleanliness and follow the work sequences described in the repair instructions. Even the tiniest contaminants and damage to the screw connections on the high-pressure lines can cause leaks.




Do not attempt to open any fuel lines or connections on the HPI injection system until the coolant temperature is below 40 degrees Celsius (approximately 104 degrees Fahrenheit)

## Piezo Fuel Injectors

The outward-opening piezo-injector makes it possible to spray direct injection on to the top of the cylinder. This component ensures that the injected fuel spray cone remains stable, even under the prevailing influences of pressure and temperature in the combustion chamber.

The extremely quick opening of the nozzle needle of the piezo-injector permits injection pressures of up to 200 bar. Thus it is possible to inject fuel into the combustion chamber under the extreme conditions of the power cycles limited by the valve opening times.

The piezo-injector is located in the center of the cylinder head, next to the spark plug, between the intake and exhaust valves. This installation position prevents the cylinder walls or the piston crown from being wet with injected fuel. A uniform formation of the homogeneous air/fuel mixture is obtained with the aid of the gas movement in the combustion chamber and a stable fuel spray cone.

The gas movement is influenced on the one hand by the geometry of the intake passages and on the other hand by the shape of the piston crown. The injected fuel is swirled in the combustion chamber with the boost air until a homogeneous mixture is available throughout the compression space at the point of ignition.

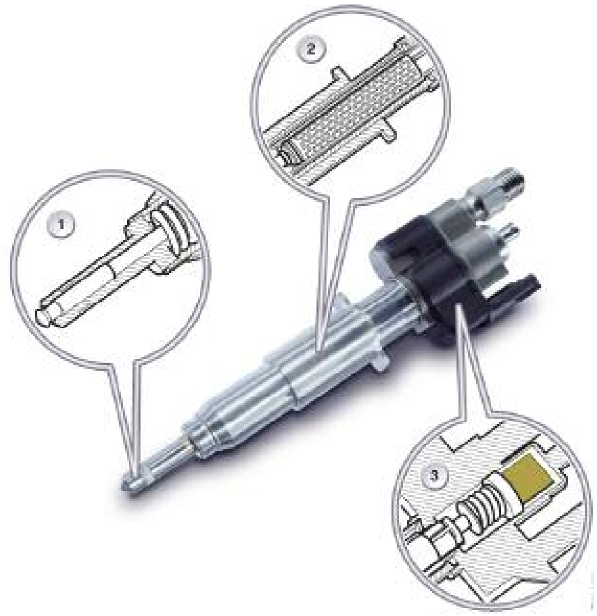
**Note: When working on the fuel system, it is important to ensure that the ignition coils are not saturated with fuel. The resistance of the silicone material is significantly reduced when wet with fuel. This can cause arcing at the spark-plug and lead to misfires.**

- Before making modifications to the fuel system, remove the ignition coils and protect the spark-plug holes against spilled fuel with a shop rag.
- Before refitting the piezo-injector, remove the ignition coils and ensure absolute cleanliness.
- Ignition coils that have been heavily saturated with fuel must be replaced.

**HPI uses piezo injectors and HDE uses solenoid type injectors. See N55 training material.**

## Injector Design and Function

The piezo-injector essentially consists of three sub-assemblies. The expansion of the energized piezo-element lifts the nozzle needle outwards from its valve seat. To be able to counter the different operating temperatures with comparable valve lifts, the injector has a thermal compensating element.



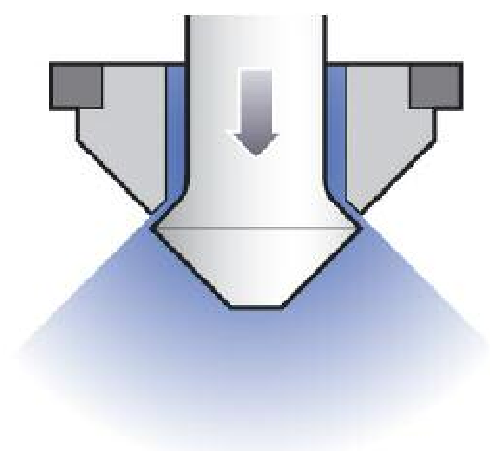

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Outward opening nozzle needle | 3 | Thermal compensator |
| 2 | Piezo-element | | |

The nozzle needle is pressed outwards from its tapered valve seat. This opens up an annular orifice. The pressurized fuel flows through this annular orifice and forms a hollow cone, the spray angle of which is not dependent on the backpressure in the combustion chamber.

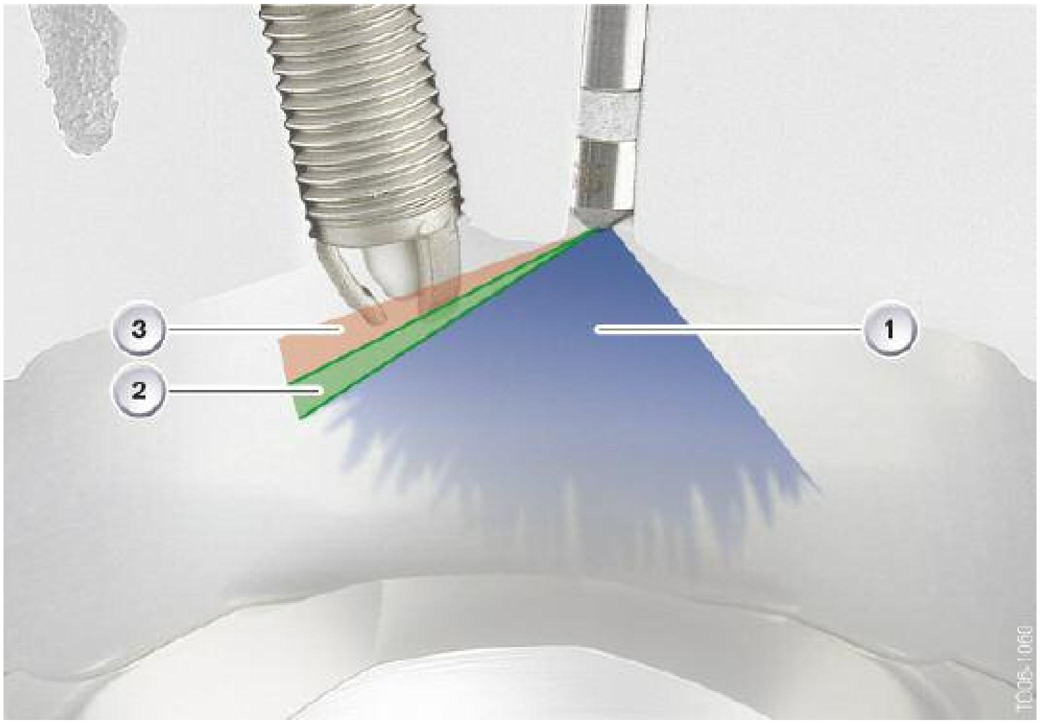
**Do not attempt to clean the injectors in any way. This may result in damage which can effect the spray pattern.**

**Any divergence in the spray pattern can cause damage to the spark plug or the engine itself.**

**Outward opening injector nozzle needle**



The spray cone (1) of a piezo-injector can diverge during operation (2). Due to the formation of soot inside the engine, such divergence is perfectly normal and acceptable to a certain extent. If, however, spray divergence reaches the stage where it begins to spray the spark plug wet, the spark plug may incur damage.




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Ideal “spray” cone | 3 | Non-permitted divergence of spray cone |
| 2 | Permitted divergence of spray cone | | |

**Replace the Teflon sealing ring when fitting and removing the piezo-injector. This also applies when an injector that has just been fitted has to be removed again after an engine start.**

**A piezo-injector provided with a new Teflon sealing ring should be fitted as quickly as possible because the Teflon sealing ring could swell up. Please observe the repair instructions and follow without fail.**

**When fitting, make sure that the piezo injector is correctly seated. The hold-down element for securing the piezo-injectors must rest on both injector tabs, otherwise the necessary force is not applied to the piezo-injector. Do not clean the nozzle-needle tip of the piezo-injector.**

## Injection Strategy

Injection of the fuel mass required for the operating situation can take place in up to three individual injections. Which option is used in the relevant operating situation is dependent on engine load and speed. Here, the actual time resulting from the engine speed available for metering the fuel is an important framework quantity.

A special situation during the operation of any engine is the range in which a high load occurs at low engine speed, so-called "Low End Torque" operation. In this operating situation, the required fuel mass is metered to the engine in three individual injections.

This results in a highly effective mixture formation which in the final analysis has the effect of both increasing power output and saving fuel.

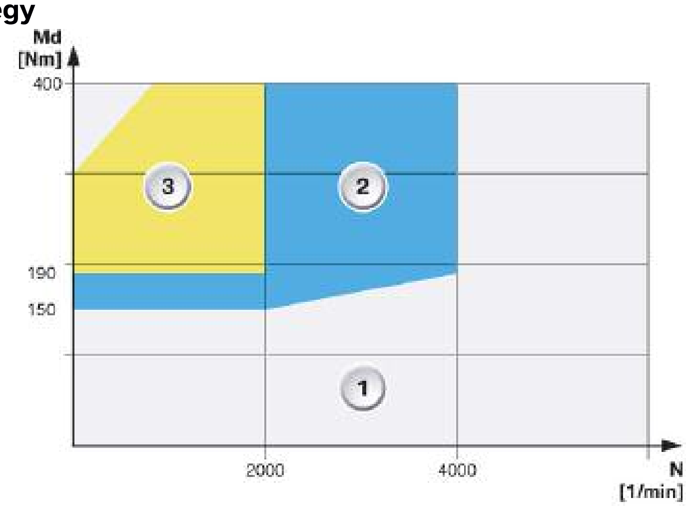
In order to bring the catalytic converters up to operating temperature as quickly as possible, the system has a catalyst-heating mode for when the engine is started from cold. In this mode, combustion heat is intentionally introduced into the exhaust train and not used first and foremost to develop power output.

The point of ignition is moved to 30° (crankshaft degrees) after TDC. The main quantity of the required fuel is injected before TDC and mixed with the boost air. The piston is situated after TDC in its downward travel such that the air/fuel mixture is already expanding again, which reduces the ignitability of the mixture at the spark plug.

In order to ignite the mixture reliably, a small residual quantity of fuel is injected 25° after TDC and this guarantees an ignitable mixture at the spark plug. This small fuel quantity therefore provides for ignition of the residual charge in the combustion chamber.

This operating mode is set by the engine-management system after a maximum period of 60 seconds from engine starting but is terminated if the catalytic-converter response temperature is reached earlier.

**N54 injection strategy**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Single injection event | 3 | Triple injection event |
| 2 | Double injection event | | |

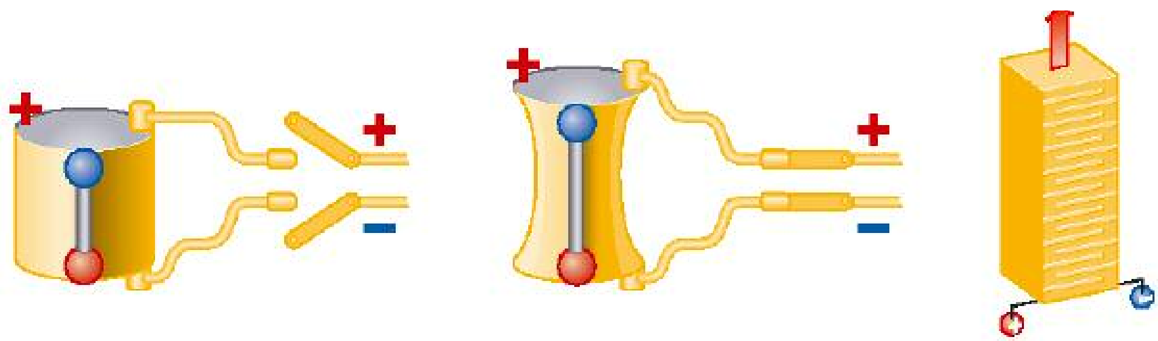
## Piezo Element

The movement of the nozzle needle in the injector is generated by a piezo-element.

A piezo-element is an electromechanical converter, i.e. it consists of a ceramic material which converts electrical energy directly into mechanical energy (force/travel). A familiar application is the piezo cigarette lighter - when a piezo-crystal is pressed, voltage is generated until a spark flashes and ignites the gas.

In the case of the piezo-actuator, voltage is generated so that the crystal expands. In order to achieve greater travel, it is possible to design a piezo-element in several layers.

The actuator module consists of layers of the piezo-ceramic material connected mechanically in series and electrically in parallel. The deflection of a piezo-crystal is dependent on the applied voltage up to a maximum deflection; the higher the voltage, the greater the travel.



1 2 3

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Piezo crystal - not energized | 3 | Piezo element in layers (stacked) |
| 2 | Piezo crystal - energized | | |

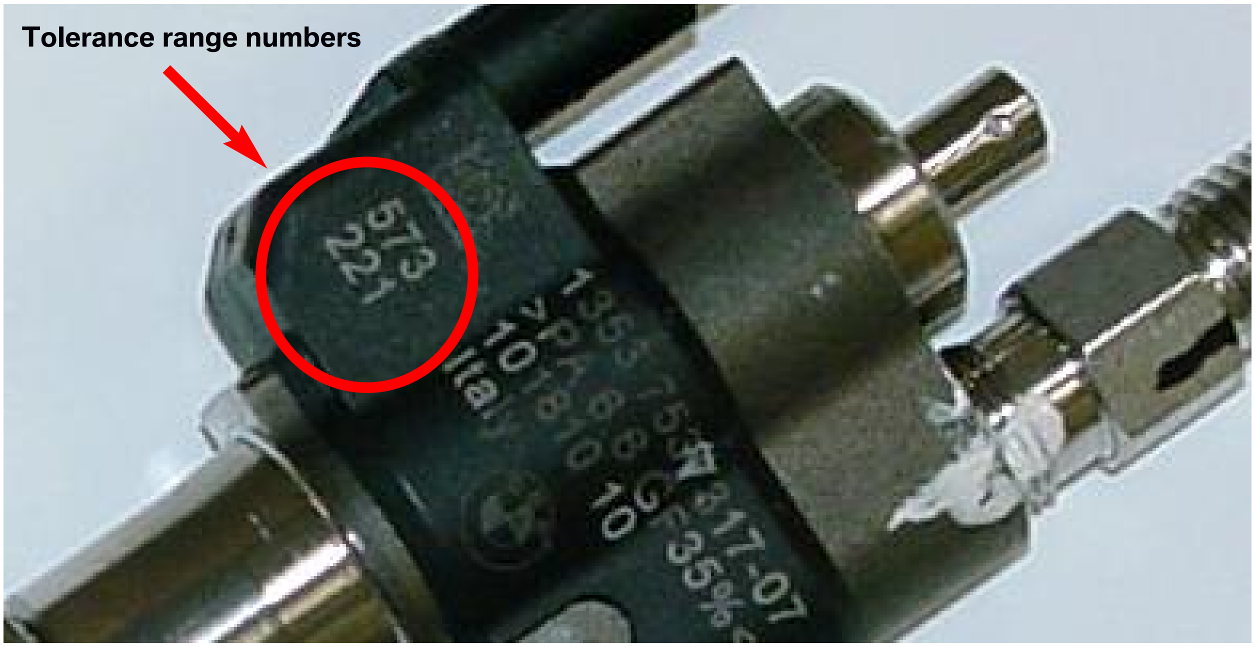
### Injector Adjustment

When the injectors are manufactured, a multitude of measurement data is recorded at specific points in the factory. In this way, the tolerance ranges for injector-quantity adjustment are determined and specified in a six-digit number combination.

Information on the lift performance of the injector is also added for injector voltage adjustment. Injector adjustment is required because of the individual voltage demand of each piezo actuator. An allocation is made to a voltage demand category, which is included in the number combination on the injector.

These data items are transmitted to the ECM. During engine operation, these values are used to compensate for deviations in the metering and switching performance.

**When replacing an injector, it is absolutely essentially to carry out an injector adjustment.**




## Injector Control and Adaptation

The fuel mass required for the operating situation is injected by the piezo-injector into the combustion chamber. This mass can be influenced by three correcting variables:

- the rail pressure
- the injector opening time
- the injector opening lift

The injector opening time and the injector opening lift are activated directly at the piezo injector. The opening time is controlled via the ti signal and the opening lift via the energy quantity in the activation of the piezo-injector.

## Injector Adaptation

The fuel masses and injection cycles determined from the load/speed map are included in a pilot-control program map. Here, while further framework parameters are taken into consideration, the energy quantities and injector opening times required to activate the injectors are determined.

The N54 engine can be safely and reliably operated with these program-map values.

## Optimization

For optimization of:

- Emission values
- Smooth running
- Fuel consumption
- Power output

the controlled variables of energy quantities and injector opening times are continuously monitored. This occurs on a bank-selective basis by way of lambda closed-loop control.

The residual oxygen in the exhaust gas is measured in each case for cylinder bank 1 and cylinder bank 2. This measurement result is compared with the values expected from the set correcting variables. The result of a deviation is that the injector opening signal is adapted. This adaptation is stored in the control unit and is therefore available for subsequent engine operation. However, these stored values are lost when the system is flashed and must be relearned. A further adaptation of the injector activation takes place depending on time and use. This cylinder-selective adaptation involves a check of the residual-oxygen content with a conclusion as to the cylinder causing the situation. To this end, it is necessary for part of the exhaust-gas flow not to be swirled in the turbocharger. For this reason, the flap of the wastegate valve must be fully opened, i.e. swung out of the exhaust-gas flow. This wastegate-flap position extends beyond its normal opening position in engine operation. Based on the result of this cylinder-selective monitoring, the energy quantity is adapted if necessary to activate the injectors.

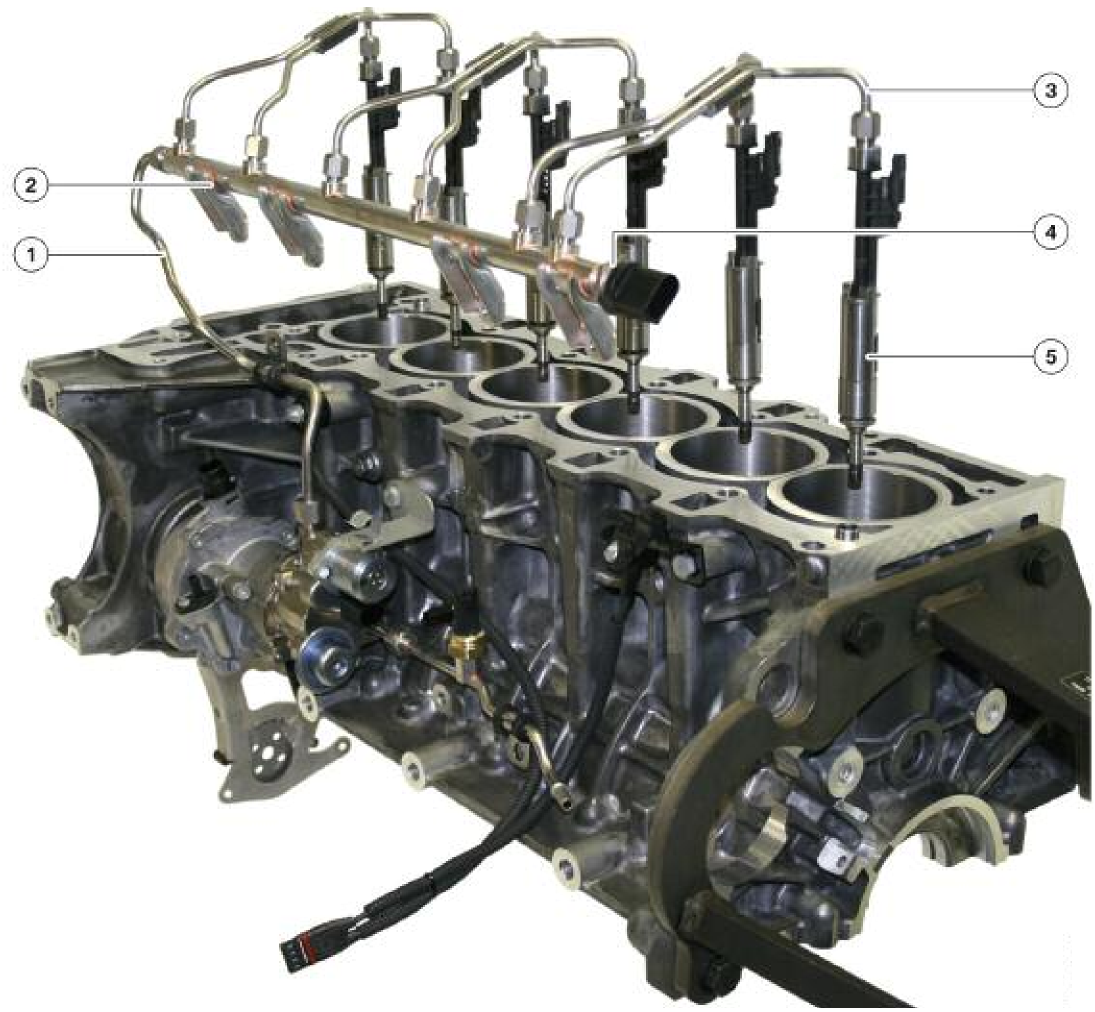
Furthermore, the cylinder-selective adaptation includes if necessary an adaptation of the injector opening signal based on smooth running monitoring of the N54 engine. Overall adaptation of the injectors is limited to a 15% additional quantity.

## HDE Fuel Injection

The high pressure fuel injection system (HDE) is used on the N55 engine. In contrast to high precision injection (HPI), HDE uses solenoid fuel injectors with multi-hole nozzles.

The following overview shows the complete fuel injection system. The system is similar to the N54 fuel injection. Although the same high pressure pump, pressure sensor, and fuel rail are used, the high pressure fuel injection valves are new. The HDE system uses Bosch high pressure solenoid type fuel injection valves with the designation HDEV5.2.

**N55, overview of high pressure fuel injection system**




| Index | Explanation |
|---|---|
| 1 | High pressure line |
| 2 | Rail |
| 3 | High pressure line |
| 4 | Fuel rail pressure sensor |
| 5 | Solenoid valve fuel injector |

# VALVETRONIC III

The main differences between VALVETRONIC III and VALVETRONIC II are in the arrangement of the VALVETRONIC servomotor and the VALVETRONIC sensor. As in VALVETRONIC II, the turbulence level is increased at the end of the compression cycle for the purpose of optimizing the mixture formation with the use of phasing and masking measures. This movement of the cylinder charge improves the combustion during partial load operation and in catalytic converter heating mode. The quench areas also contribute to mixture formation.

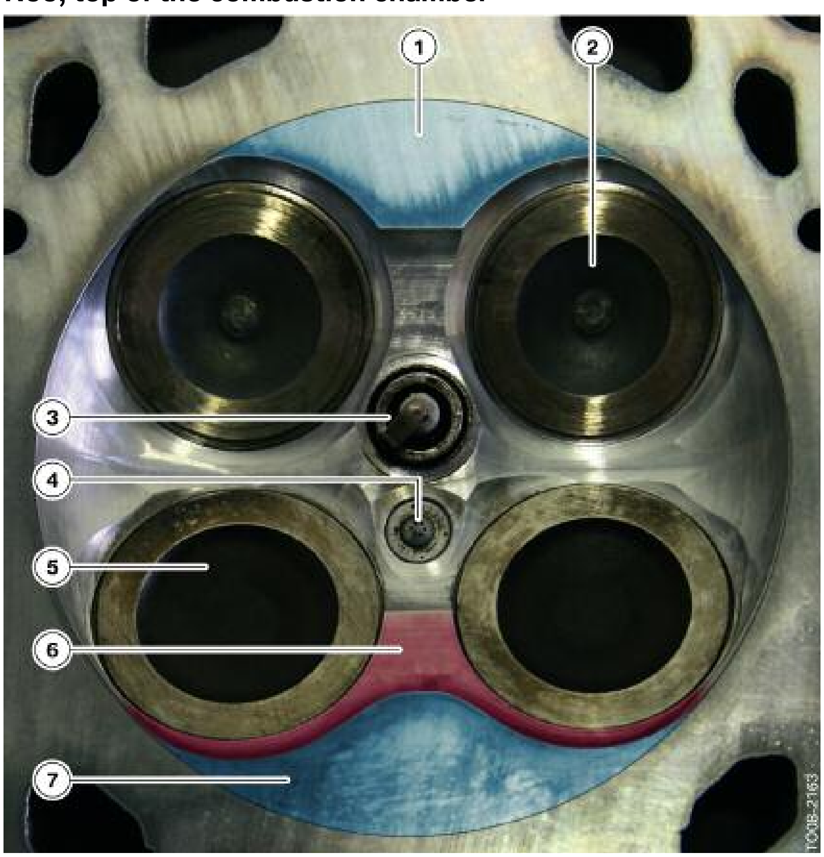
## Phasing

Phasing results in a lift difference between both intake valves of up to 1.8 mm in the lower partial load range. Consequently, the flow of fresh air is distributed asymmetrically.

## Masking

Masking refers to the design of the valve seats. This machining ensures that the incoming fresh air is aligned in such a way as to give rise to the required cylinder charge movement. The advantage of this measure is that the combustion retardation is reduced by approximately 10° of crankshaft rotation. The combustion process takes place faster and a larger valve overlap can be achieved, thus considerably reducing NOx emissions.

**N55, top of the combustion chamber**

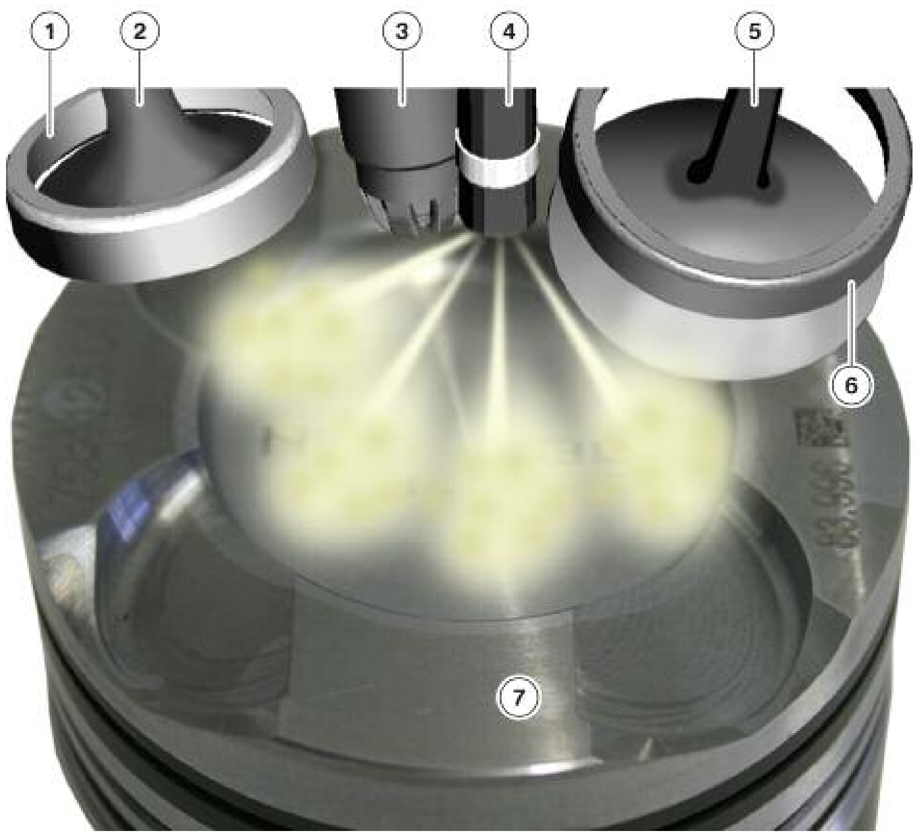



| Index | Explanation |
|---|---|
| 1 | Quench area |
| 2 | Exhaust valves |
| 3 | Spark plug |
| 4 | Fuel injector |
| 5 | Intake valve |
| 6 | Masking |
| 7 | Quench area |

## Combustion Chamber Geometry

The following graphic shows the arrangement of the individual components in the combustion chamber. It can be seen that the BMW (spray-guided) high precision injection (HPI) system is not used but rather a Bosch solenoid valve fuel injector with multi-hole nozzle. The fuel injection is specially adapted to the combination of VALVETRONIC III and turbocharging. For better illustration, a set of valves has been removed in the graphic.

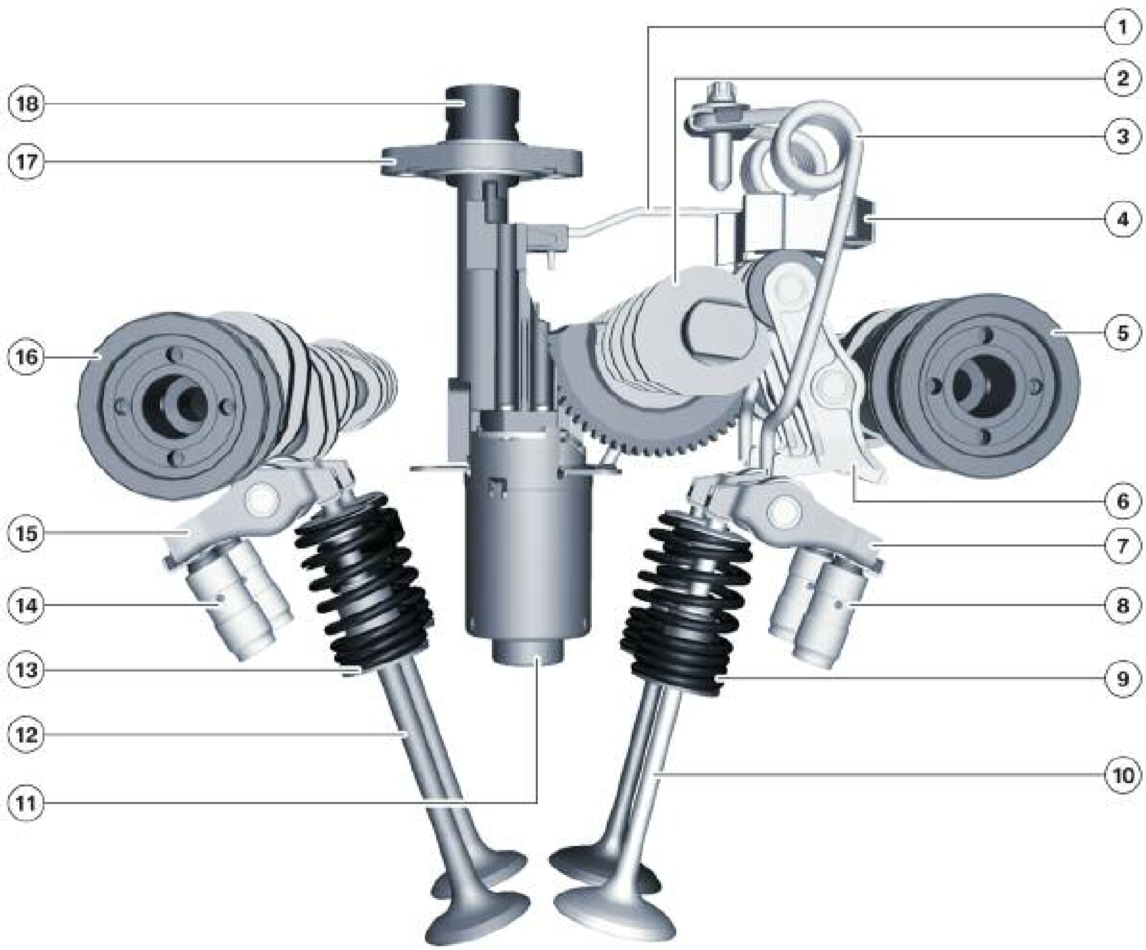
**N55, combustion chamber with components**




| Index | Explanation |
|---|---|
| 1 | Valve seat, exhaust valve |
| 2 | Exhaust valve |
| 3 | Spark plug |
| 4 | Fuel injector |
| 5 | Intake valve |
| 6 | Valve seat, intake valve |
| 7 | Piston |

The VALVETRONIC III servomotor contains a sensor for determining the position of the motor and the eccentric shaft. The servomotor is lubricated with engine oil by means of an oil spray nozzle (1) aimed directly at the worm drive and the eccentric shaft mechanism.

**N55, design of valve lift adjustment**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Oil spray nozzle | 10 | Intake valve |
| 2 | Eccentric shaft | 11 | VALVETRONIC servomotor |
| 3 | Return spring | 12 | Exhaust valve |
| 4 | Gate block | 13 | Valve spring |
| 5 | Inlet camshaft | 14 | Hydraulic valve lash adjustment |
| 6 | Intermediate lever | 15 | Roller cam follower, exhaust |
| 7 | Roller cam follower, intake | 16 | Exhaust camshaft |
| 8 | Hydraulic valve lash adjustment | 17 | Sealing sleeve |
| 9 | Valve spring | 18 | Socket |

### VALVETRONIC Servomotor

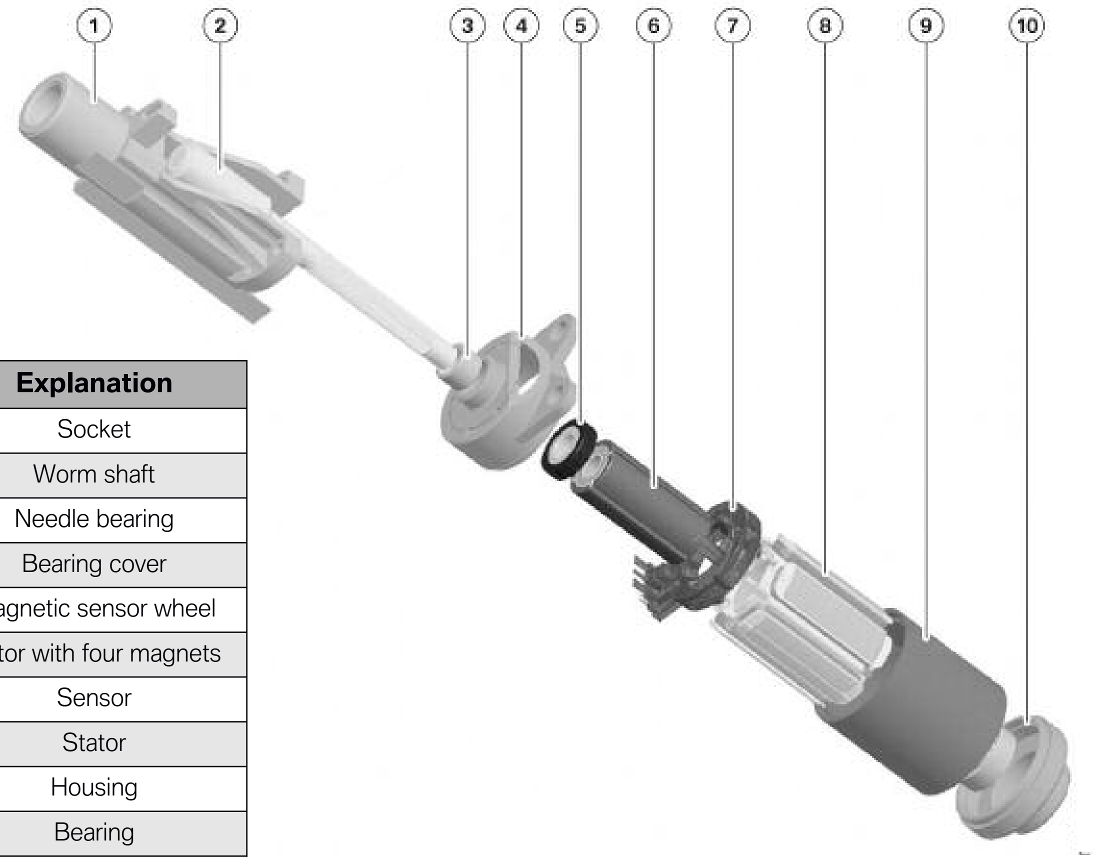
A brushless direct current motor (BLDC motor) is used. The BLDC motor is maintenance-free and very powerful, due to the contactless energy transfer system. The use of integrated electronic modules ensures precision control.

The VALVETRONIC servomotor has the following special features:

- Open concept (engine oil is directly supplied to the motor).
- The eccentric shaft angle is determined by angle increments from the integrated sensor system.
- Power consumption is reduced by about 50%.
- Higher actuating dynamics (e.g. cylinder-selective adjustment, idle speed control, etc.).
- Lightweight design is approximately 600 grams.

### Function

Actuation of the VALVETRONIC servomotor is limited to a maximum of 40 amps. A maximum of 20 amps are available over a period of > 200 milliseconds. The VALVETRONIC servomotor is actuated by a pulse width modulated signal. The duty cycle is between 5% and 98%.




| Index | Explanation |
|---|---|
| 1 | Socket |
| 2 | Worm shaft |
| 3 | Needle bearing |
| 4 | Bearing cover |
| 5 | Magnetic sensor wheel |
| 6 | Rotor with four magnets |
| 7 | Sensor |
| 8 | Stator |
| 9 | Housing |
| 10 | Bearing |

# Table of Contents

## N55 Engine



Initial Print Date: 02/10 Revision Date: 03/15

| Subject | Page |
|---|---|

Subject | Page

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# N55 Engine

## Model: All with N55

## Production: From Start of Production

# OBJECTIVES

After completion of this module you will be able to:

- Describe the features of the N55B30M0 engine
- Describe the specifications of the N55 engine
- Identify the internal and external components of the N55 engine
- Understand the function of the crankcase ventilation on the N55 engine
- Understand the function of the electronic volume control oil pump

# Introduction

The N55 engine is the successor to the N54. Re-engineering and modifications have made it possible to now use only one exhaust turbocharger. Against the backdrop of reduced costs and improved quality, the technical data have remained virtually the same.

**N55 Engine**

# Engine Designation and Engine Identification

## Engine Designation

This training material describes the N55B30M0 in detail.

In the technical documentation, the engine designation is used for unique identification of the engine. In the technical documentation you will also find the abbreviated engine designation, i.e. N55, that only indicates the engine type.

| Item | Meaning | Index / explanation |
|---|---|---|
| 1 | Engine developer | M, N = BMW Group<br>P = BMW Motorsport<br>S = BMW M mbH<br>W = Non-BMW engines |
| 2 | Engine type | 1 = R4 (e.g. N12)<br>4 = R4 (e.g. N43)<br>5 = R6 (e.g. N55)<br>6 = V8 (e.g. N63)<br>7 = V12 (e.g. N73)<br>8 = V10 (e.g. S85) |
| 3 | Change to the basic engine concept | 0 = basic engine<br>1 – 9 = changes, e.g. combustion process |
| 4 | Working method or fuel type and possibly installation position | B = Gasoline, longitudinal installation<br>D = Diesel, longitudinal installation<br>H = Hydrogen |
| 5 | Displacement in liters | 1 = 1 liter (whole number of liters) |
| 6 | Displacement in 1/10 liter | 8 = 0.8 liter (tenth of liter) |
| 7 | Performance class | K = Smallest<br>U = Lower<br>M = Middle<br>O = Upper (standard)<br>T = Top<br>S = Super |
| 8 | Revision relevant to approval | 0 = New development<br>1 – 9 = Revision |

## Breakdown of N55 Engine Designation

| Index | Explanation |
|---|---|
| N | BMW Group Development |
| 5 | Straight 6 engine |
| 5 | Engine with direct injection, VALVETRONIC and exhaust turbocharger |
| B | Gasoline engine, longitudinal |
| 30 | 3.0-liter capacity |
| M | Medium performance class |
| 0 | New development |

## Engine Identification

The engines are marked on the crankcase with an engine identification code for unique identification. This engine identifier is also required for approval by the authorities. The N55 engine further develops this identification system and the code has been reduced from previously eight to seven characters. The engine serial number can be found under the engine identifier on the engine. Together with the engine identifier, this consecutive number enables unique identification of each individual engine.

| Item | Meaning | Index / explanation |
|---|---|---|
| 1 | Engine developer | M, N = BMW Group<br>P = BMW Motorsport<br>S = BMW M GmbH<br>W = Non-BMW engines |
| 2 | Engine type | 1 = R4 (e.g. N12)<br>4 = R4 (e.g. N43)<br>5 = R6 (e.g. N55)<br>6 = V8 (e.g. N63)<br>7 = V12 (e.g. N73)<br>8 = V10 (e.g. S85) |
| 3 | Change to the basic engine concept | 0 = basic engine<br>1 – 9 = changes, e.g. combustion process |
| 4 | Working method or fuel type and possibly installation position | B = Gasoline, longitudinal installation<br>D = diesel, longitudinal installation<br>H = hydrogen |
| 5 | Displacement in liters | 1 = 1 liter (whole number of liters) |
| 6 | Displacement in 1/10 liter | 8 = 0.8 liter (tenth of liter) |
| 7 | Type test concerns (changes that require a new type test) | A = Standard<br>B – Z = Depending on requirement, e.g. RON 87 |

## N55 engine, engine identification and engine serial number

| Index | Explanation |
|---|---|
| 08027053 | Individual consecutive engine serial number |
| N | Engine developer, BMW Group |
| 5 | Engine type, straight 6 |
| 5 | Change to basic engine concept, turbocharging, VALVETRONIC, direct fuel injection |
| B | Operating principle or fuel supply and installation position, petrol engine longitudinal |
| 30 | Displacement in 1/10 liter, 3 liter |
| A | Type approval requirements, standard |

# Engine Mechanical

## Engine Housing

The engine housing consists of the engine block (crankcase and bedplate), cylinder head, cylinder head cover, oil pan and gaskets.

**Engine Block**
The engine block is made from an aluminum die-casting and consists of the crankcase with bedplate.

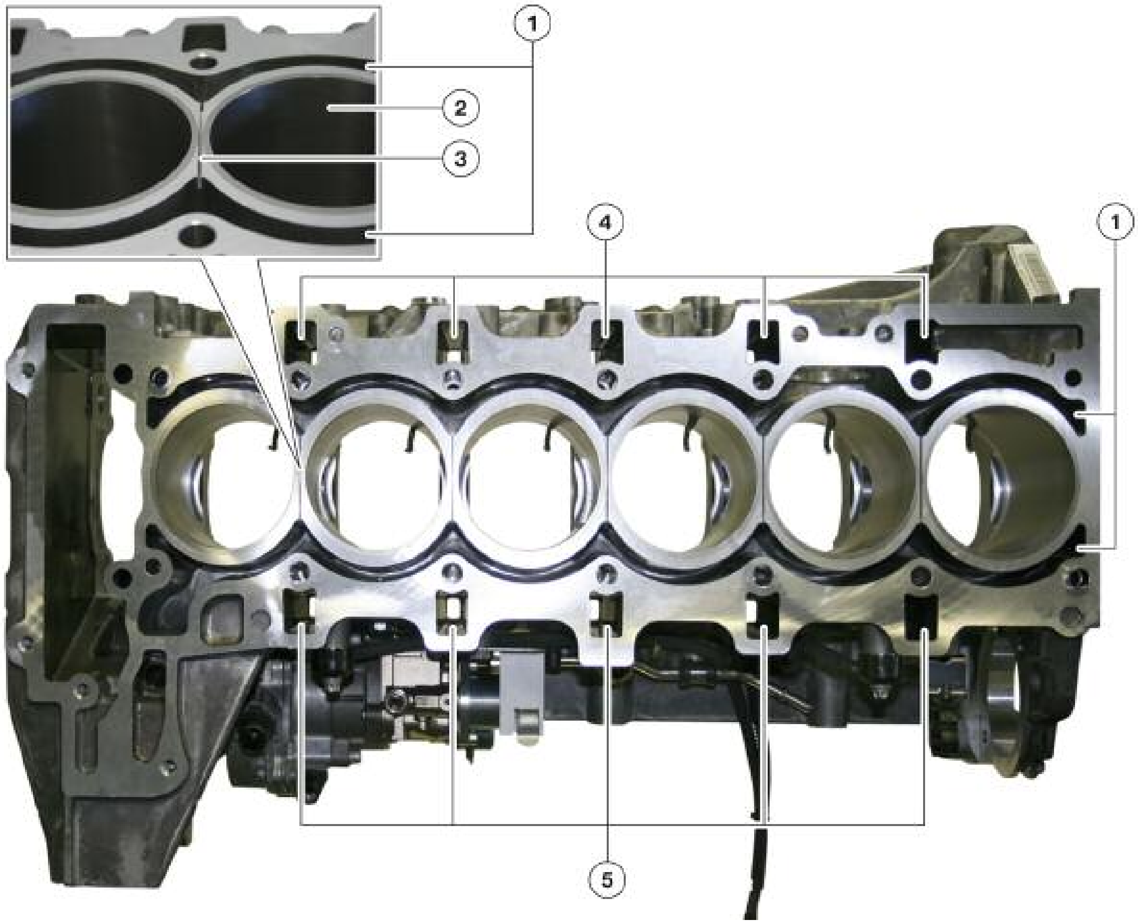
**Crankcase and Bedplate**
The crankcase features cast iron cylinder liners (2). A new feature is that the webs between two cylinders on the deck of the block now have a grooved cooling passage (3). Coolant can flow along these grooves from one side of the crankcase to the other, thus enhancing cooling of this area.

Five oil return ducts on the exhaust side (4) now permit oil to return from the cylinder head into the oil pan. These oil return channels extend into the bedplate up to below the oil deflector. They help reduce churning losses as the returning engine oil can no longer reach the crankshaft even at high transverse acceleration.

Five oil return channels on the intake side (5) also ensure that the blow-by gasses can flow unobstructed from the crankshaft area into the cylinder head and to the crankcase breather in the cylinder head cover.

The cooling duct (1) in the engine block is split and coolant flows directly through it.

## N55, crankcase with web cooling

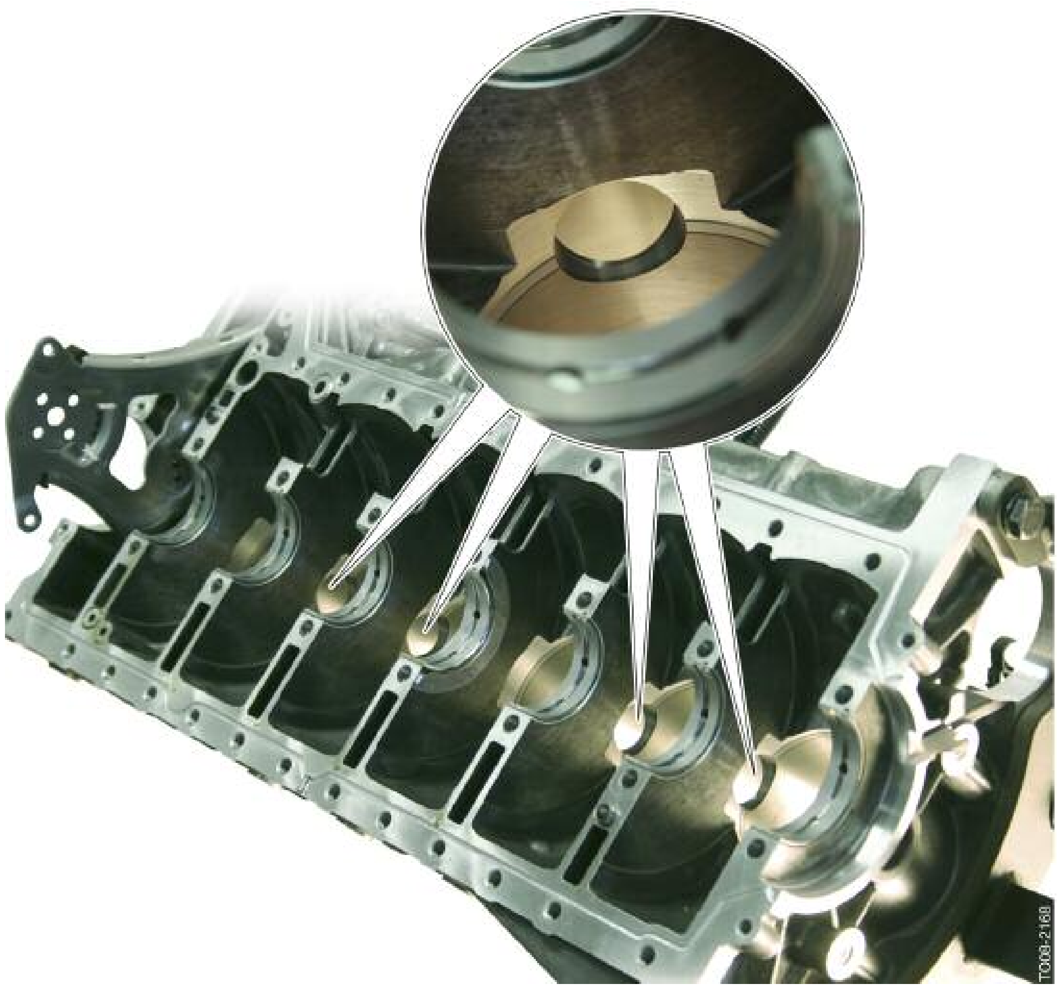



| Index | Explanation |
| --- | --- |
| 1 | Cooling duct |
| 2 | Cylinder liner |
| 3 | Grooved cooling passage |
| 4 | Oil return ducts, exhaust side |
| 5 | Oil return ducts, intake side |

The crankcase has large longitudinal ventilation holes bored between the lower chambers of the cylinders. The longitudinal ventilation holes improve the pressure equalization, between the oscillating air columns that are created in the crankcase, by the up and down movement of the pistons.

This enhances power by relieving the unwanted pressure that acts against the downward movement of the pistons. It also enhances crankcase ventilation and adds to oil service life by promoting the movement of blow-by gasses within the engine.

**N55, ventilation holes in crankcase**

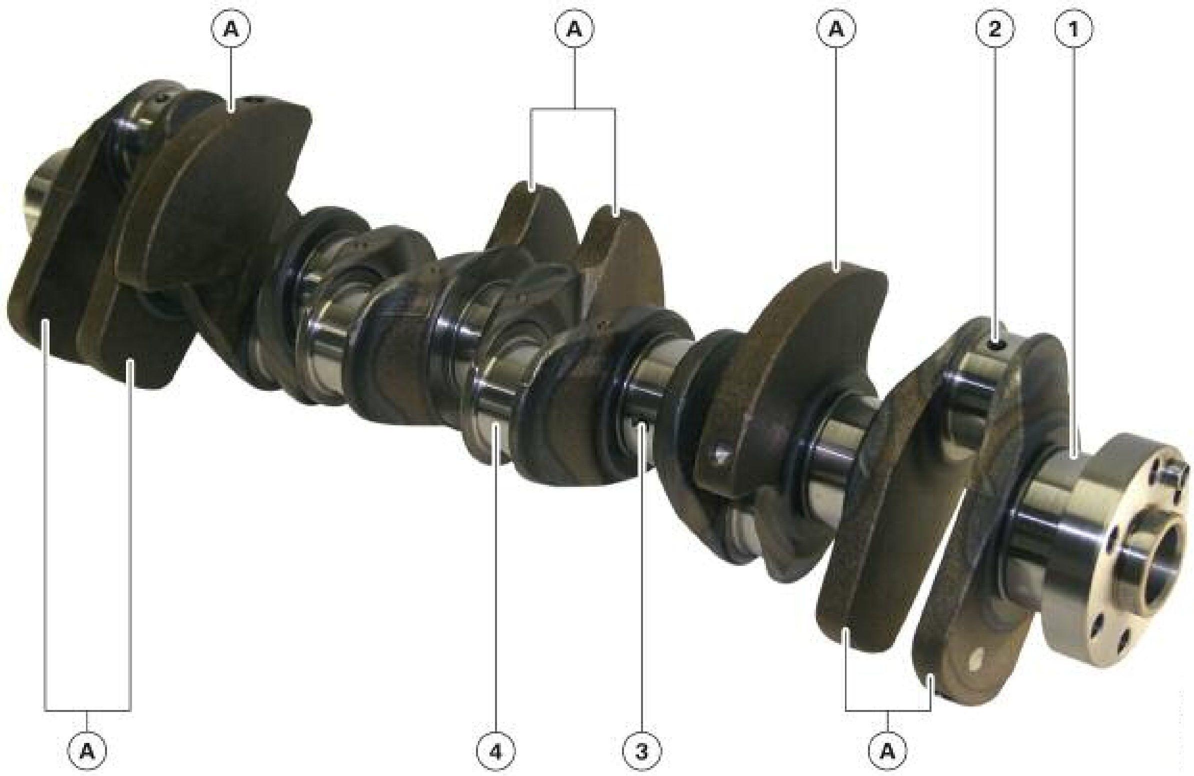


## Crankshaft

The crankshaft of the N55 is of lightweight design, at 20.3 kg it's approximately 3 kg lighter than the crankshaft in the N54 engine.

The crankshaft is made from cast iron (GGG70). The counterweights are arranged asymmetrically. There is no incremental wheel installed on the crankshaft. The timing chains are mounted by means of an M18 central bolt.

**N55 Crankshaft**




| Index | Explanation |
|---|---|
| A | Counterweights |
| 1 | Main bearing journal 7 |
| 2 | Oil hole from big-end bearing to main bearing |
| 3 | Oil hole from main bearing to big-end bearing |
| 4 | Big-end bearing journal, cylinder 4 |

### Crankshaft Main Bearings

As on the N54 engine, the main bearings on the crankshaft are designed as two component bearings free of lead. The thrust bearing is mounted at the fourth bearing position.

## Pistons and Rings

A full slipper skirt type piston with a diameter of 82.5 mm is used. The first piston ring is a plain rectangular compression ring with a chrome-ceramic coating on the contact surface. The second piston ring is a tapered faced Napier type ring. The oil scrape ring is designed as a steel band ring with spring that is also known as VF system.

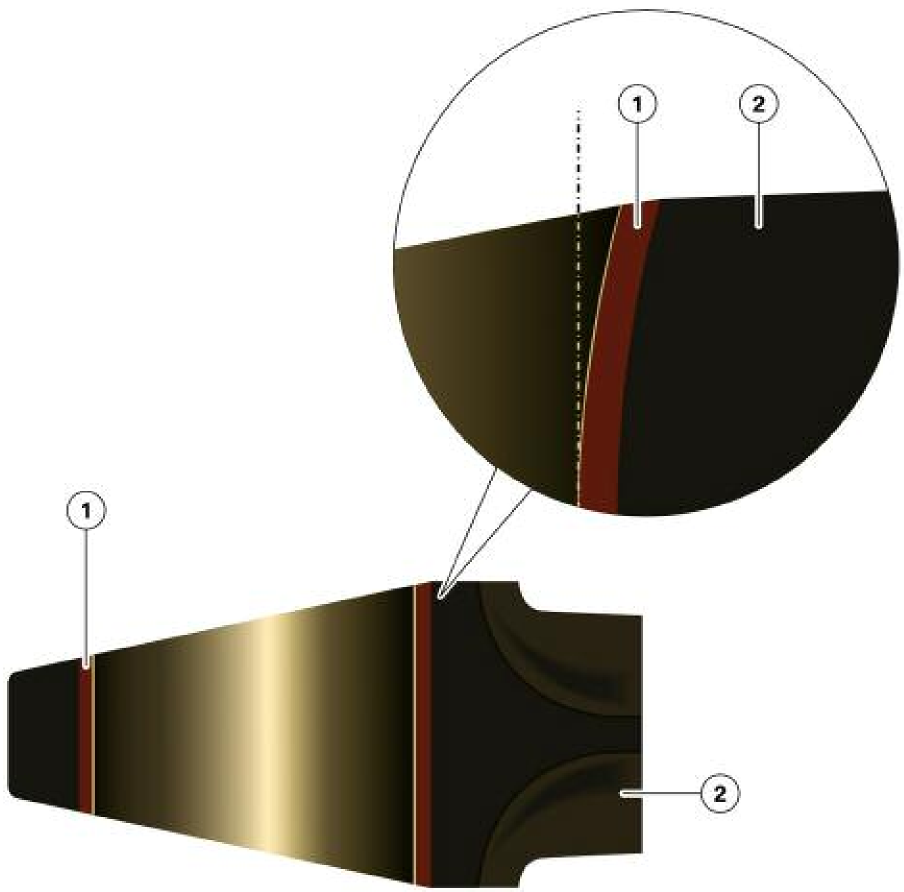
**N55 piston with piston rings**


| Index | Explanation |
|---|---|
| 1 | Plain rectangular compression ring |
| 2 | Tapered faced Napier ring |
| 3 | VF system ring |
| 4 | Steel inlay for first piston ring |
| 5 | Groove for first piston ring |
| 6 | Groove for second piston ring |
| 7 | Groove for oil scraper ring |
| 8 | Hole for lubricating oil drain |
| 9 | Graphite coating |

## Connecting Rod and Bearings

The size of the connecting rod of the N55 engine is 144.35 mm. A new feature is the specially formed hole in the small end of the connecting rod.  This formed hole is machined wider on the lower edges of the wrist pin bushing/bore.  This design evenly distributes the force acting on the wrist pin over the entire surface of the rod bushing and reduces the load at the edges, as the piston is forced downward on the power stroke.

**N55, small end of the connecting rod**

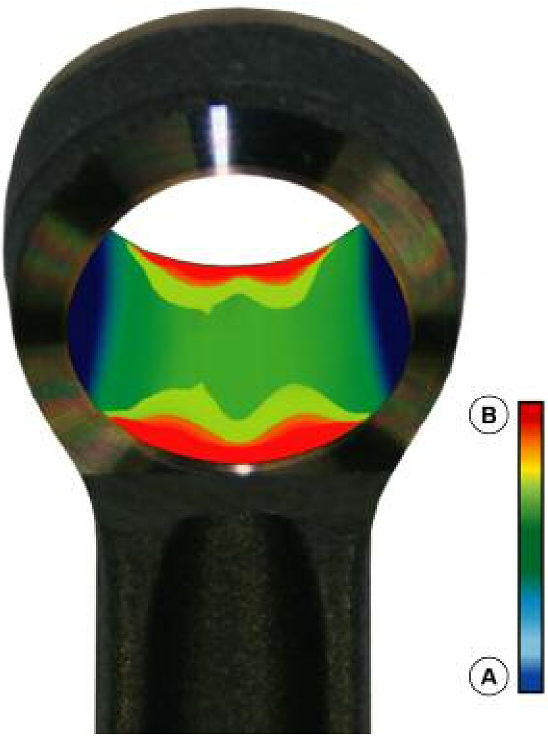



| Index | Explanation |
|---|---|
| 1 | Bushing |
| 2 | Connecting rod |

NOTES PAGE

The following graphic shows the surface load on a standard connecting rod without the formed hole. Due to combustion pressure, the force exerted by the piston via the wrist pin is mainly transmitted to the edges of the rod bushing.

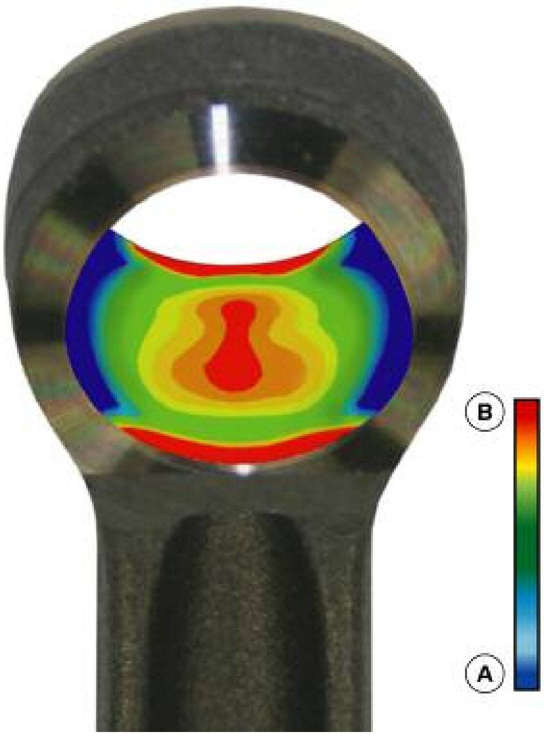
**N54, connecting rod small end without formed hole**




| Index | Explanation |
|---|---|
| A | Low surface load |
| B | High surface load |

The graphic below illustrates the small end of the connecting rod with a formed hole. The force is more evenly distributed over a larger area and the load on the edges of the rod bushing is reduced considerably.

**N55, connecting rod small with formed hole**




| Index | Explanation |
|---|---|
| A | Low surface load |
| B | High surface load |

Lead-free bearing shells are used on the large connecting rod end. The material G-488 is used on the connecting rod side and the material G-444 on the bearing cap side.

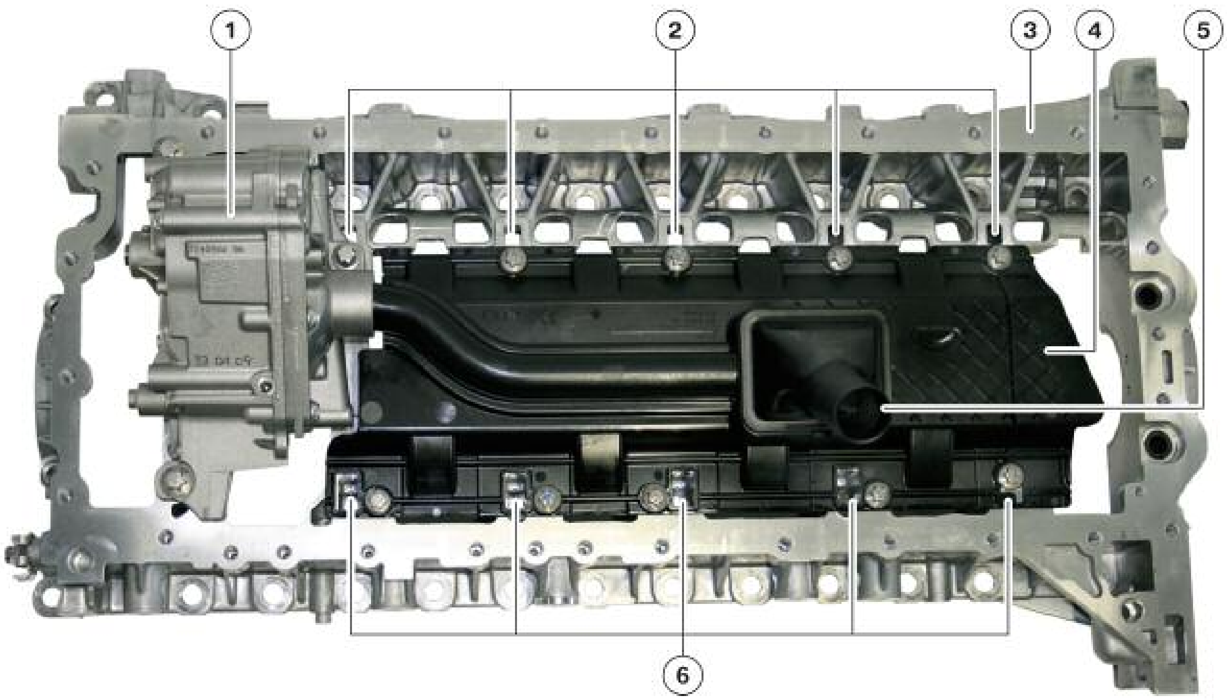
The size M9 x 47 connecting rod bolts are the same on the N55 and N54 connecting rod.

## Oil Pan

The oil pan is made from an aluminum casting. The oil deflector and the intake pipe to the oil pump are designed as one component. To facilitate attachment to the bedplate, the oil return ducts are designed so that they extend over the oil deflector. Consequently, the oil return ducts end in the oil sump.

Ducts are provided for the oil supply to the vacuum pump as it is now lubricated by filtered oil and not by unfiltered oil as on the N54 engine.

**N55, bedplate with oil pump and oil deflector**




| Index | Explanation |
|---|---|
| 1 | Oil pump |
| 2 | Oil return ducts, intake side |
| 3 | Bedplate |
| 4 | Oil deflector |
| 5 | Intake manifold with oil screen filter |
| 6 | Oil return ducts, exhaust side |

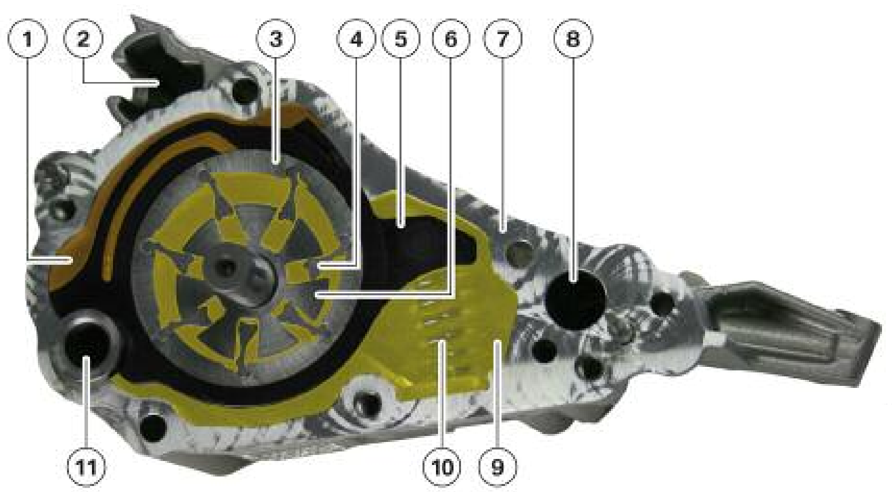
# Electrionic Volume-controlled Oil Pump

A modified version of the volume control oil pump of the N54 engine is used. For the first time a Duroplast reciprocating slide valve is installed. The volumetric flow control system operating principle of the oil pump is described in the E71 X6 training material under the ”N63 Engine” available on TIS and ICP.

This type of pump delivers only as much oil as is necessary under the respective engine operating conditions. No surplus quantities of oil are delivered in low-load operating ranges. This operating mode reduces the pump work and therefore the fuel consumption of the engine while also slowing down the oil aging process. The pump is designed as a slide valve-type vane pump. In delivery mode, the pump shaft is positioned off-center in the housing and the vanes are displaced radially during rotation. As a result, the vanes form chambers of differing volume. The oil is drawn in as the volume increases and expelled into the oil galleries as the volume decreases.

The oil pressure in the system (downstream of the oil filter) acts on the slide against the force of a compression springs in the control oil chamber. The slide element rotates about a pivot axis.

**N55, oil pump**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Control oil chamber | 7 | Housing |
| 2 | Pressure limiting valve | 8 | Hole for pressure control valve |
| 3 | Rotor | 9 | Damping oil chamber |
| 4 | Vane | 10 | Compression spring (2x) |
| 5 | Duroplast slide valve | 11 | Pivot axis of rotation |
| 6 | Inner rotor | | |

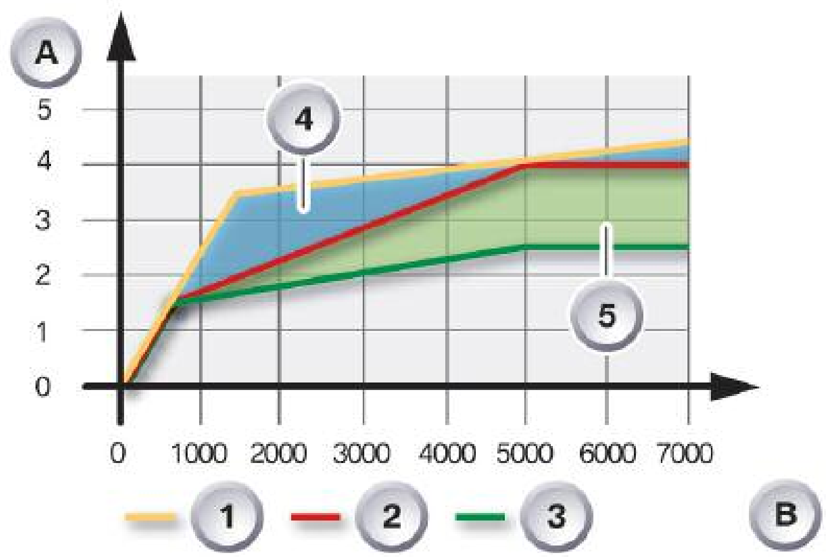
## Oil Pump and Pressure Control

The oil pump has been redesigned with regard to the functionality and durability of the Duroplast reciprocating slide valve. The oil pump used in the N55 engine is a further development of the shuttle slide valve volume control oil pump. The activation of the oil pump is adapted by the engine management and controlled through an oil pressure control valve.

The delivered oil volume is controlled by means of the oil pressure, based on specific requirements. The modifications, compared to previous pumps, are primarily in the pump activation system. The oil pressure no longer acts directly on the control piston but rather directly on the slide valve. The engine management activates the electrohydraulic pressure control valve, which affects the oil pressure at the slide valve control mechanism within the oil pump, altering the pump output. This has the advantage of avoiding power losses by running the oil pump only when needed.

The electrohydraulic pressure control valve controls the pump output and is bolted to the front of the engine block. It is operated based on a characteristic map within the DME (ECM) which in turn is based on feedback from the oil pressure sensor. The N55 uses a special oil pressure sensor for this purpose which functions in the similar way as the HPI fuel pressure sensor.

**Characteristic map-controlled oil pressure**



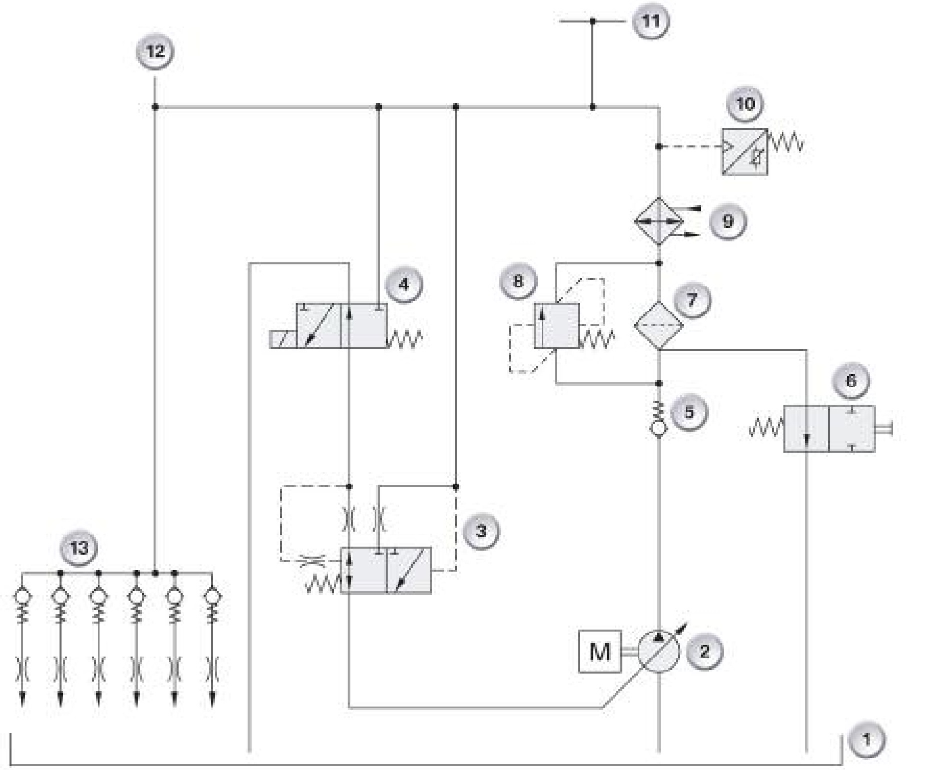

| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Oil pressure (bar) | 3 | Characteristic map-controlled oil pressure, no load |
| B | Engine speed (rpm) | 4 | Saving potential, full load |
| 1 | Oil pressure control, hydraulic/ mechanical | 5 | Saving potential, no load |
| 2 | Characteristic map-controlled oil pressure, full load | | |

The oil pressure generated by the oil pump (2) is delivered to the engine's lubricating points and hydraulic actuators. This system uses oil pressure feed back to control the desired operating oil pressure. For this purpose, the oil pressure downstream of the oil filter (7) and engine oil-to-coolant heat exchanger (9) is adjusted by the DME (map-controlled) via the pressure control valve (4) to the pressure control valve (3).

The actual generated oil pressure is registered by the oil pressure sensor (10) and recognized by the engine management.

In the event of an electrical malfunction, the oil pressure is set to the default control setting. The pump compression springs are allowed to expand, moving the slide valve to its maximum oil pressure position.

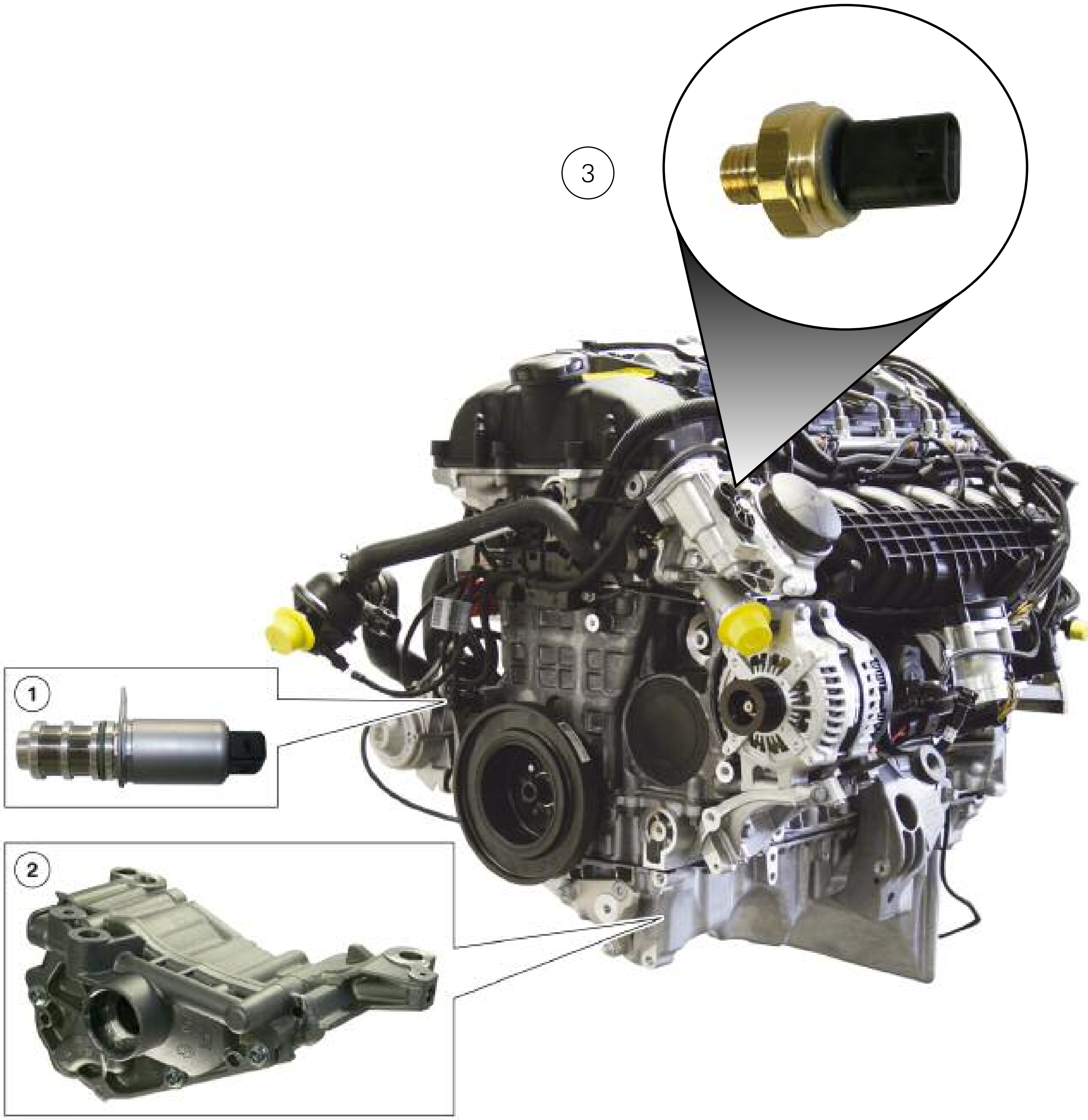
**Hydraulic diagram of the N53 engine oil circuit with electronic pressure control**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Oil Pan | 8 | Filter By-pass valve |
| 2 | Volume controlled oil pump | 9 | Engine oil to coolant heat exchanger |
| 3 | Pressure regulating valve | 10 | Oil Pressure sensor |
| 4 | Electro-hydraulic pressure regulating valve | 11 | Lubricating points, cylinder head |
| 5 | Non-return valve | 12 | Lubricating points, engine block |
| 6 | Outlet valve at the filter | 13 | Oil spray nozzles, piston crowns |
| 7 | Oil filter | | |

**Note: The N53 hydraulic circuit diagram shown is for explanation of the oil pressure control only, and does not apply directly to the N55 engine.**

**N55, oil pump and pressure control valve**

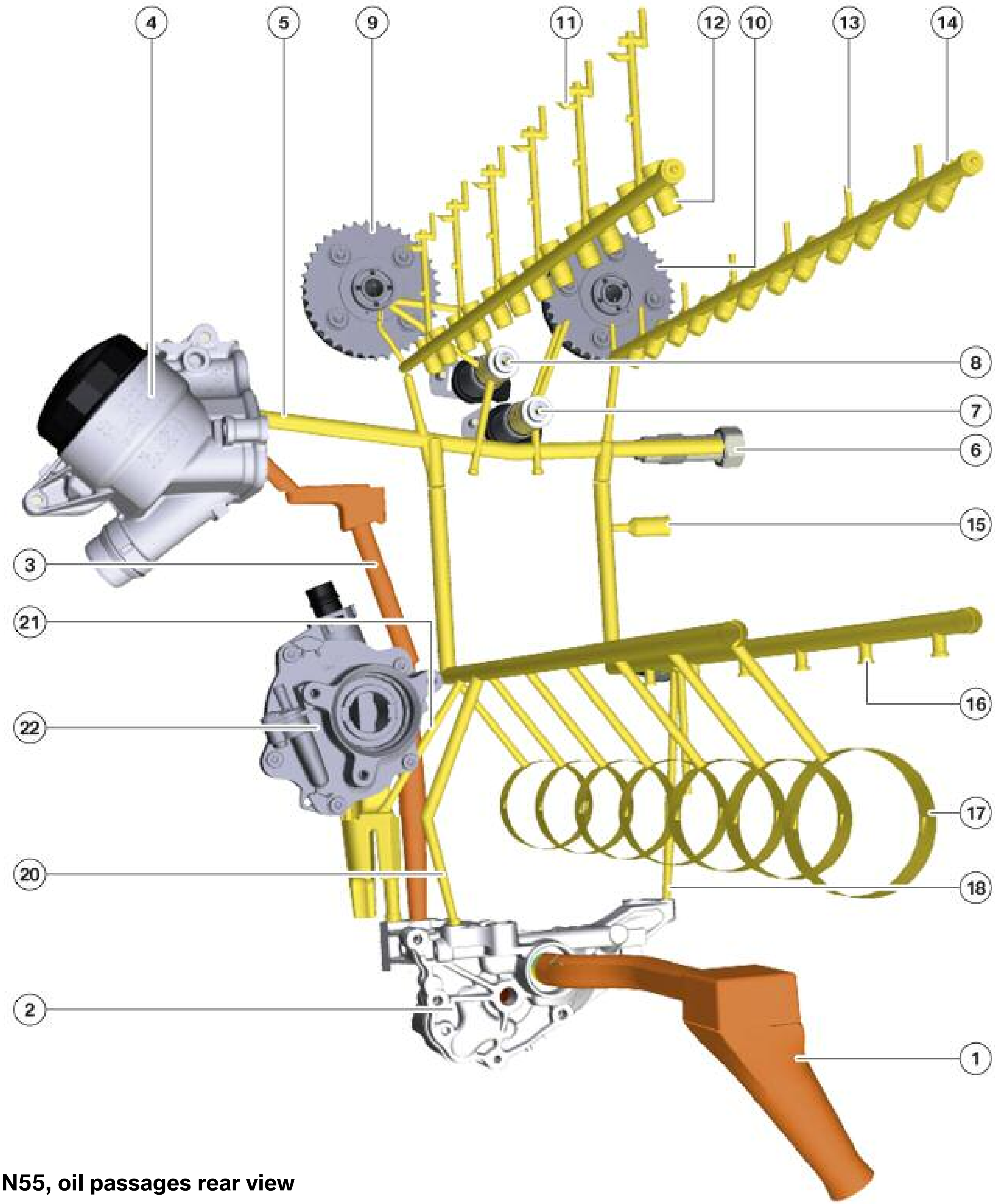



| Index | Explanation |
|---|---|
| 1 | Oil pressure control valve |
| 2 | Oil pump |
| 3 | Oil pressure sensor |

NOTES PAGE

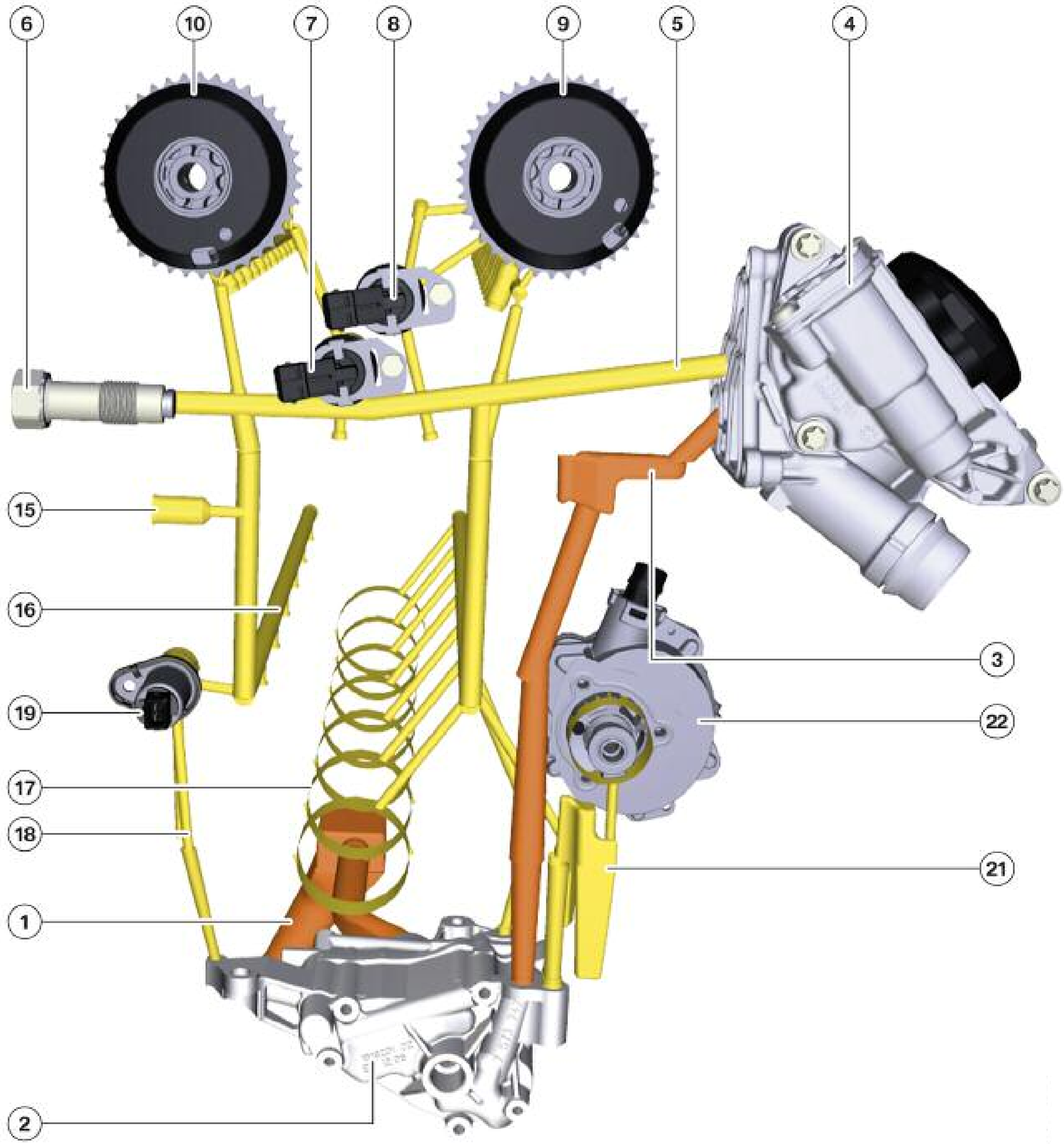
## Oil Supply

The following graphics show an overview of the oil circuit of the N55. Compared to the N54 engine, there are considerably fewer oil ducts in the cylinder head. This is mainly due to the use of the new VANOS solenoid valves.




**N55, oil passages rear view**

| Index | Explanation |
|---|---|
| 1 | Intake pipe |
| 2 | Oil pump |
| 3 | Unfiltered oil duct |
| 4 | Oil filter |
| 5 | Main oil duct (filtered oil duct) |
| 6 | Chain tensioner |
| 7 | VANOS solenoid valve, exhaust side |
| 8 | VANOS solenoid valve, intake side |
| 9 | VANOS adjustment unit, intake side |
| 10 | VANOS adjustment unit, exhaust side |
| 11 | Oil duct for intake camshaft and eccentric shaft lubrication |
| 12 | Hydraulic valve lash adjustment |
| 13 | Oil duct for exhaust camshaft lubrication |
| 14 | Hydraulic valve lash adjustment |
| 15 | Connection to exhaust turbocharger lubrication |
| 16 | Connection for oil spray nozzles |
| 17 | Crankshaft bearing |
| 18 | Oil duct for oil pressure control |
| 20 | Oil duct for oil pressure control |
| 21 | Oil duct for vacuum pump lubrication |
| 22 | Vacuum pump |




**N55, oil passages front view**

| Index | Explanation |
| --- | --- |
| 1 | Intake pipe |
| 2 | Oil pump |
| 3 | Unfiltered oil duct |
| 4 | Oil filter |
| 5 | Main oil duct (filtered oil duct) |
| 6 | Chain tensioner |
| 7 | VANOS solenoid valve, exhaust side |
| 8 | VANOS solenoid valve, intake side |
| 9 | VANOS adjustment unit, intake side |
| 10 | VANOS adjustment unit, exhaust side |
| 15 | Connection to exhaust turbocharger lubrication |
| 16 | Connection for oil spray nozzles |
| 17 | Crankshaft bearing |
| 18 | Oil duct for oil pressure control |
| 19 | Oil pressure control valve |
| 21 | Oil duct for vacuum pump lubrication |
| 22 | Vacuum pump |

## Oil Filtration and Oil Cooling

The oil filter housing is made from Duroplast. Based on the application, two types of engine oil coolers may be used. Depending on the oil temperature, a thermostat on the oil filter housing controls the oil flow through the oil cooler.

## Oil Spray Nozzles

The N55 engine is equipped with oil spray nozzles for the purpose of cooling the piston crown. A special tool is required for positioning the oil spray nozzles.

## Oil Pressure

Since the N55 engine has an oil pump with electronic volumetric flow control, it is necessary to measure the oil pressure precisely. For this reason, a new oil pressure sensor is installed.

Advantages of the new oil pressure sensor:

- It now measures absolute pressure (previous measured relative pressure).
- It is characteristic map control in all speed ranges.

## Oil Level

The oil quality sensor is used for measuring the oil level as on previous BMW engines.

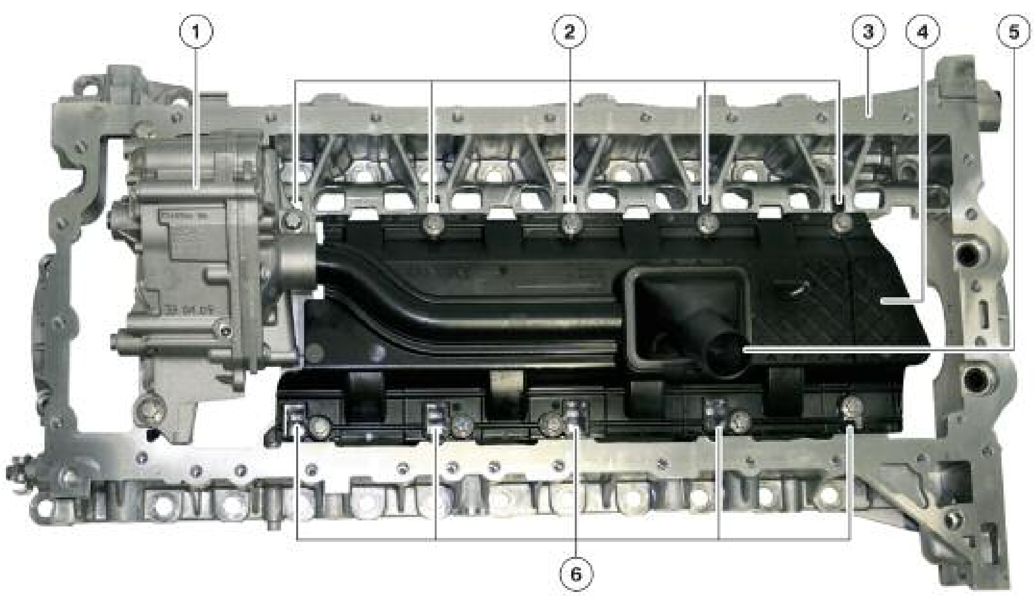
## Oil Return

The following graphics show the integrated oil deflector. It combines the following components:

- Oil deflector (4)
- Intake snorkel (5)

The oil sump (1) and crankshaft are separated by the integrated oil deflector. Oil scraper edges are installed on the bedplate to direct the spray oil from the crankshaft.

Depending on the model, the oil pan can be adapted to different installation configurations by simply changing the intake snorkel. The oil, flowing back from the cylinder head (2, 6) is directed under the oil deflector. In this way, even under high transverse acceleration conditions, no returning oil can reach the crankshaft and cause churning losses.



## Cylinder Head

Direct fuel injection, turbocharging and VALVETRONIC systems are combined for the first time on a BMW 6-cylinder engine. The cylinder head of the N55 engine is a new development. It features a very compact design and is equipped with third generation VALVETRONIC.

The combination is referred to as Turbo-VALVETRONIC-Direct-Injection (TVDI).

This system reduces CO2 emission and fuel consumption by 3 - 6%.

There are now no connections for the VANOS non-return valves as they have been integrated in the solenoid valves. The cylinder head also features cooling passages near the fuel injectors; providing indirect cooling.

**N55, cylinder head**

## Cylinder Head Cover

The cylinder head cover is a new development. The accumulator for the vacuum system is built into the cylinder head cover.

All components for crankcase ventilation and the blow-by channels are also integrated into the cylinder head cover. The non-return valves ensure that the blow-by gasses are reliably added to the intake air in both engine modes (NA and Boost).

The N55 engine is equipped with a vacuum-controlled crankcase ventilation system; therefore, a regulated negative pressure of approximately 38 mbar is maintained.

**N55, cylinder head cover with crankcase ventilation**


| Index | Explanation |
|---|---|
| 1 | Connection, blow-by gas to clean air pipe |
| 2 | Connection, vacuum line to vacuum pump |
| 3 | Reserve, vacuum connection |
| 4 | Vacuum connection to electropneumatic pressure converter EPDW for wastegate valve |
| 5 | Duct for blow-by gas feed into intake system with integrated non-return valve |
| 6 | Blow-by gas duct with settling chamber, impact plate, pressure control valve and non-return valves |
| 7 | Pressure regulating valve |

## Crankcase Ventilation

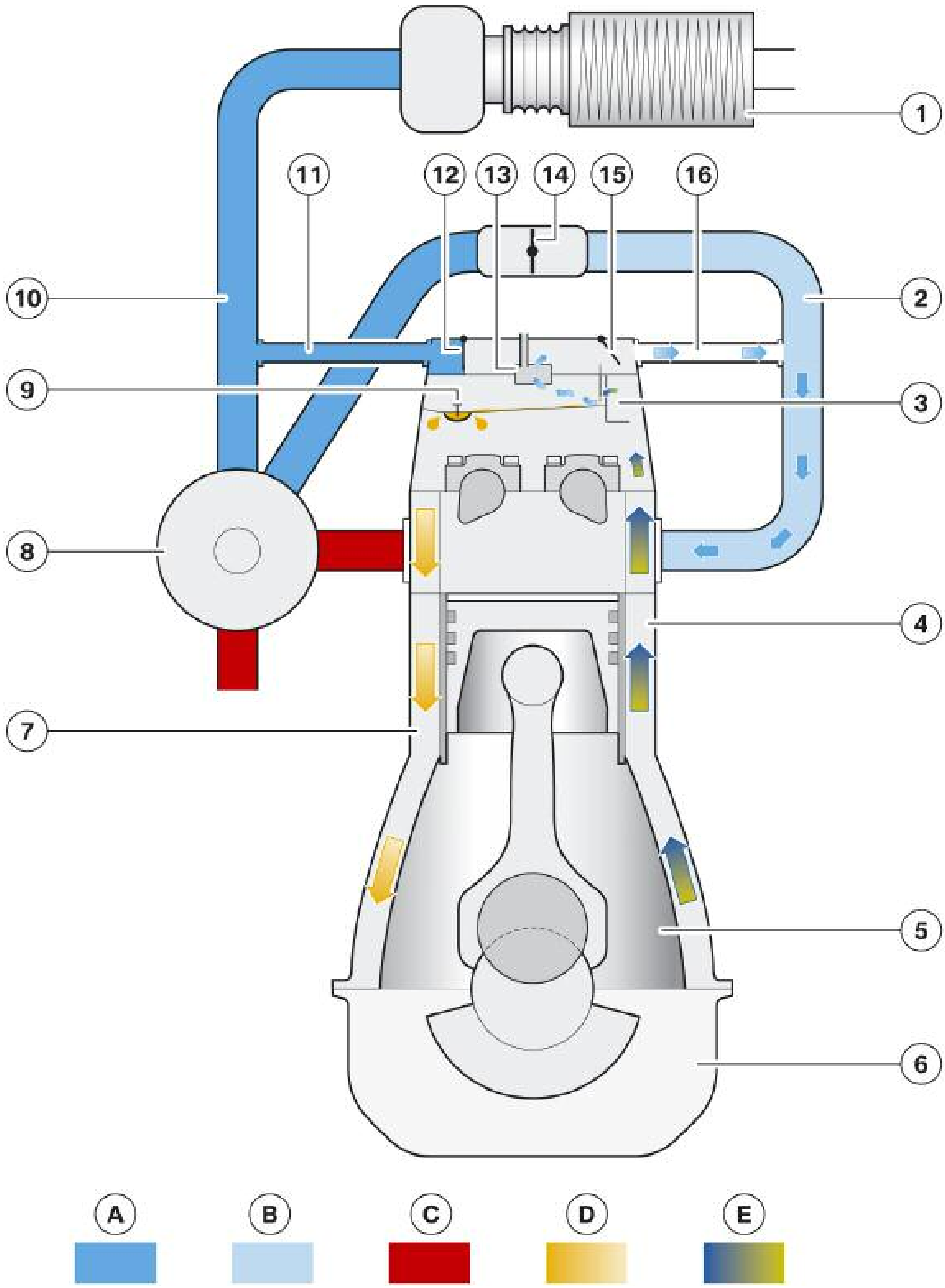
The blow-by gasses flow into the settling chamber of the cylinder head cover through an opening located in the rear of the cover. Here, the blow-by gasses are directed through holes on to an impact plate, against which the oil impacts at high speed, and drains off. The blow-by gasses, cleaned of oil, flow via the pressure control valve (depending on the operating mode) through the non-return valves into the inlet pipe upstream of the turbocharger, or via passages in the cylinder head ahead of the intake valves.
The separated oil is drained via a return flow duct into the oil pan.

**Naturally Aspirated Mode**
The standard function can only be used as long as a vacuum prevails in the intake air manifold, i.e. in naturally-aspirated engine mode.

With the engine operating in naturally-aspirated mode, the vacuum in the intake air manifold opens the non-return valve (15) in the blow-by duct within the cylinder head cover. This draws off blow-by gasses via the pressure control valve. At the same time, the vacuum also closes the second non-return valve (12) in the duct to the charge air intake pipe.

The blow-by gasses flow via a distribution rail integrated in the cylinder head cover, through the intake passages (16) in the cylinder head, which lead directly into the intake ports, ahead of the valves.

N55, crankcase ventilation, naturally-aspirated mode



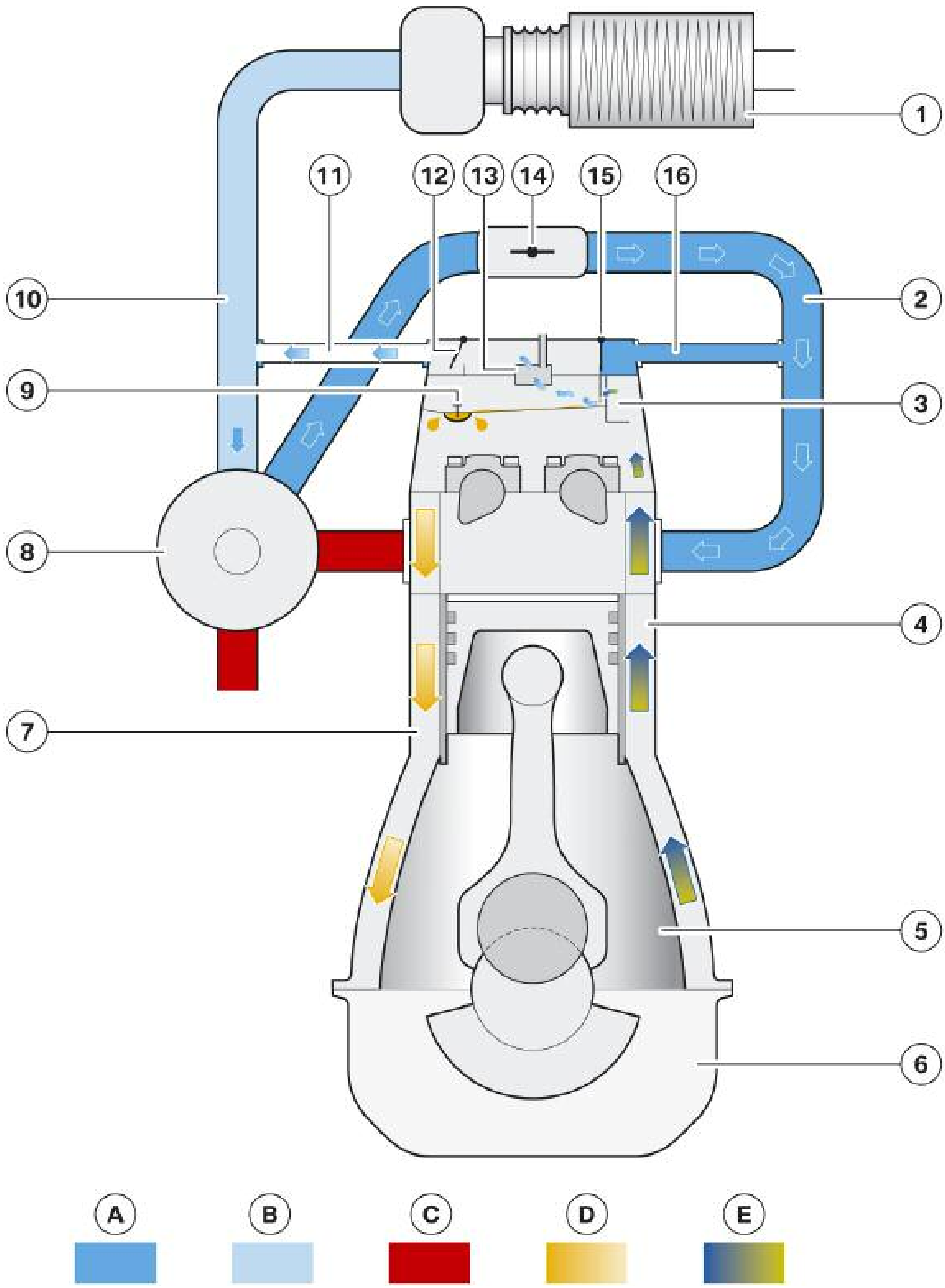
| Index | Explanation |
|---|---|
| A | Ambient pressure |
| B | Vacuum |
| C | Exhaust gas |
| D | Oil |
| E | Blow-by gas |
| 1 | Air cleaner |
| 2 | Intake manifold |
| 3 | Impact plates |
| 4 | Oil return channel |
| 5 | Crankcase |
| 6 | Oil sump |
| 7 | Oil return channel |
| 8 | Exhaust turbocharger |
| 9 | Oil drain valve |
| 10 | Charge air intake line |
| 11 | Hose to charge air intake line |
| 12 | Non-return valve |
| 13 | Pressure regulating valve |
| 14 | Throttle valve |
| 15 | Non-return valve |
| 16 | Passages in cylinder head and cylinder head cover |

**Boost Mode**

As the pressure in the intake air manifold increases in boost mode, blow-by gasses can no longer be introduced via the passages in the cylinder head, otherwise, the boost pressure could enter the crankcase. A non-return valve (15) in the blow-by channel within the cylinder head cover closes the connection (16) to the intake air manifold. This protects the crankcase from excess pressure.

The increased demand for fresh air creates a vacuum in the clean air pipe between the turbocharger and intake silencer. This vacuum is sufficient to open the non-return valve (12) and draw the blow-by gasses via the pressure control valve.

**N55, crankcase ventilation, turbocharged (boost) mode**



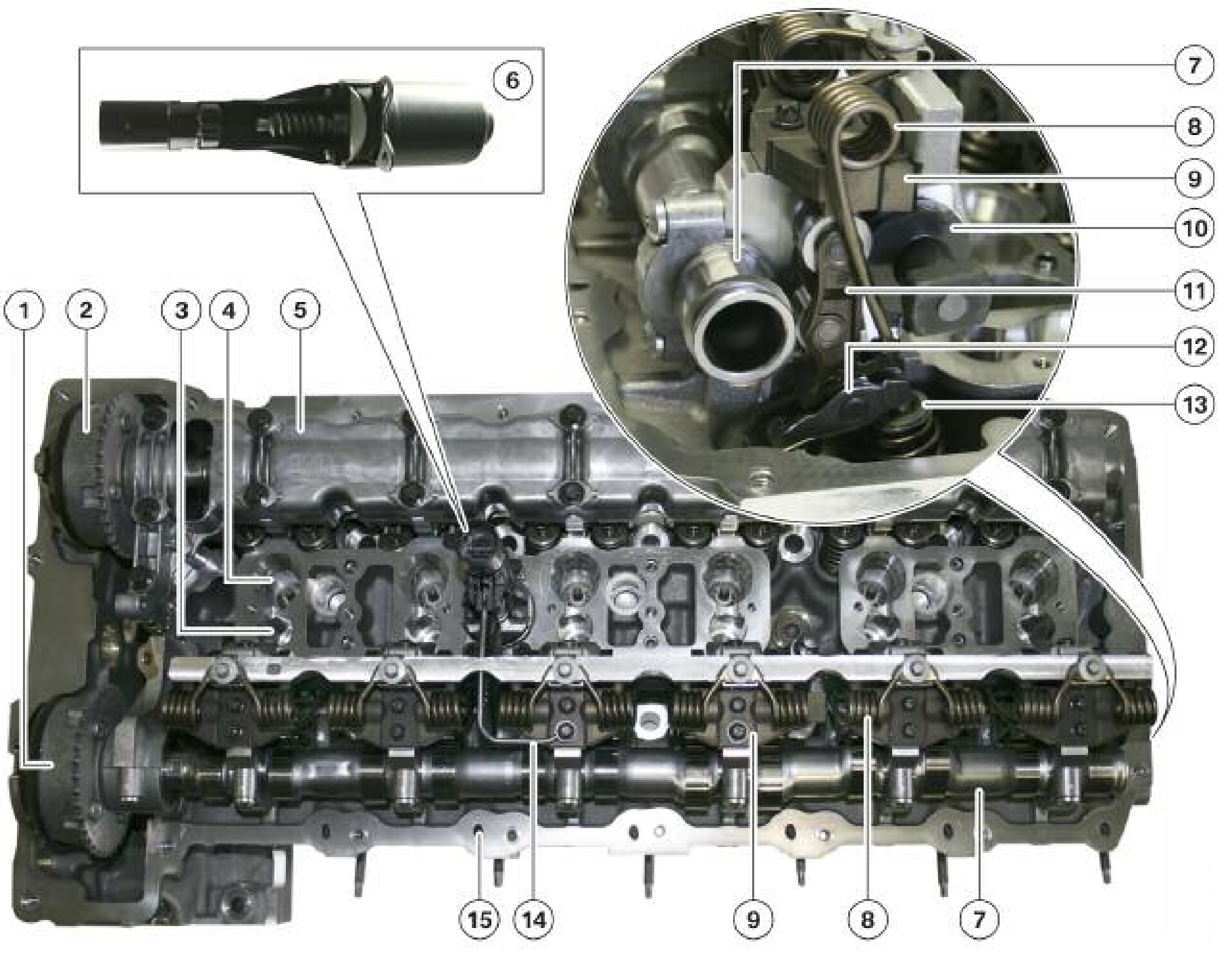
| Index | Explanation |
|---|---|
| A | Excess pressure |
| B | Vacuum |
| C | Exhaust gas |
| D | Oil |
| E | Blow-by gas |
| 1 | Air cleaner |
| 2 | Intake manifold |
| 3 | Impact plates |
| 4 | Oil return channel |
| 5 | Crankcase |
| 6 | Oil sump |
| 7 | Oil return channel |
| 8 | Exhaust turbocharger |
| 9 | Oil drain valve |
| 10 | Charge air intake line |
| 11 | Hose to charge air intake line |
| 12 | Non-return valve |
| 13 | Pressure regulating valve |
| 14 | Throttle valve |
| 15 | Non-return valve |
| 16 | Passages in cylinder head and cylinder head cover |

**If a customer complains about high oil consumption and oil is discovered in the turbocharger, it should not be immediately assumed that the turbocharger is defective. If the oil is present in the fresh air pipe (before the turbocharger) then the entire engine should be checked.**

## Valvetrain

The following graphic shows the design of the cylinder head on the N55 engine with VALVETRONIC III and direct fuel injection.

**N55, overview of valvetrain**




**Notice the hollow, lightweight design of the camshafts (7) and the blow-by passages leading into the intake ports (15).**

| Index | Explanation |
|---|---|
| 1 | VANOS unit, intake camshaft |
| 2 | VANOS unit, exhaust camshaft |
| 3 | Injector well |
| 4 | Spark plug well |
| 5 | Camshaft housing |
| 6 | VALVETRONIC servomotor |
| 7 | Inlet camshaft |
| 8 | Torsion spring |
| 9 | Gate |
| 10 | Eccentric shaft |
| 11 | Intermediate lever |
| 12 | Roller lever tappet |
| 13 | Valve head |
| 14 | Oil spray nozzle |
| 15 | Passages for introducing blow-by gas into the intake ports |

## Intake and Exhaust Valves

The valve stems have a diameter of 5 mm on the intake valve and 6 mm on the exhaust valve. The larger diameter exhaust valve are hollow and filled with sodium. In addition, the valve seat of the exhaust valves are reinforced.

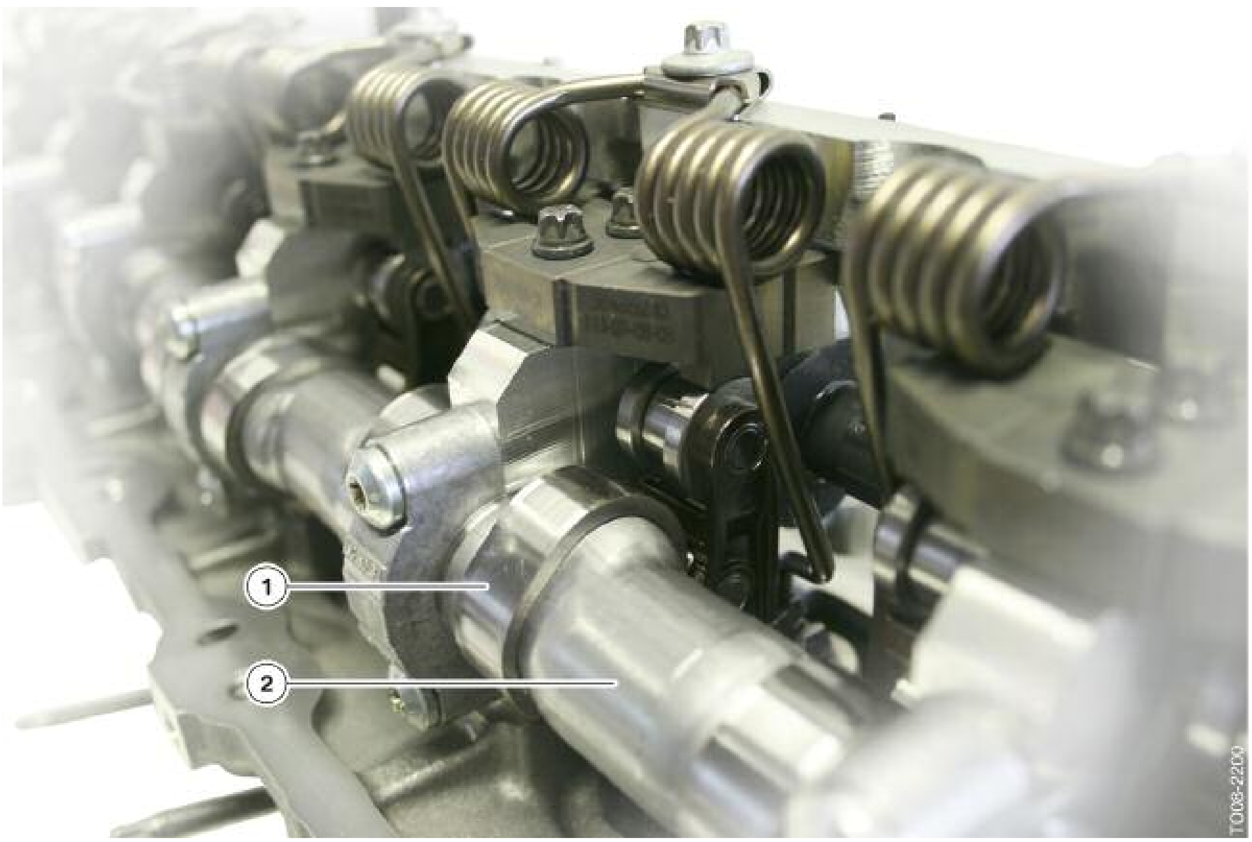
## Valve Springs

The valve springs are different for the intake side and exhaust side.

## Camshafts

Lightweight camshafts as well as cast camshafts or a mixture of both were installed in N54 engines. Only lightweight construction camshafts are used on the N55 engine. The lightweight camshafts for the N55 are manufactured in an internal high pressure forming process called hydroforming. The exhaust camshaft features bearing races and is encapsulated in a camshaft housing. The camshaft housing reduces oil foaming during operation.

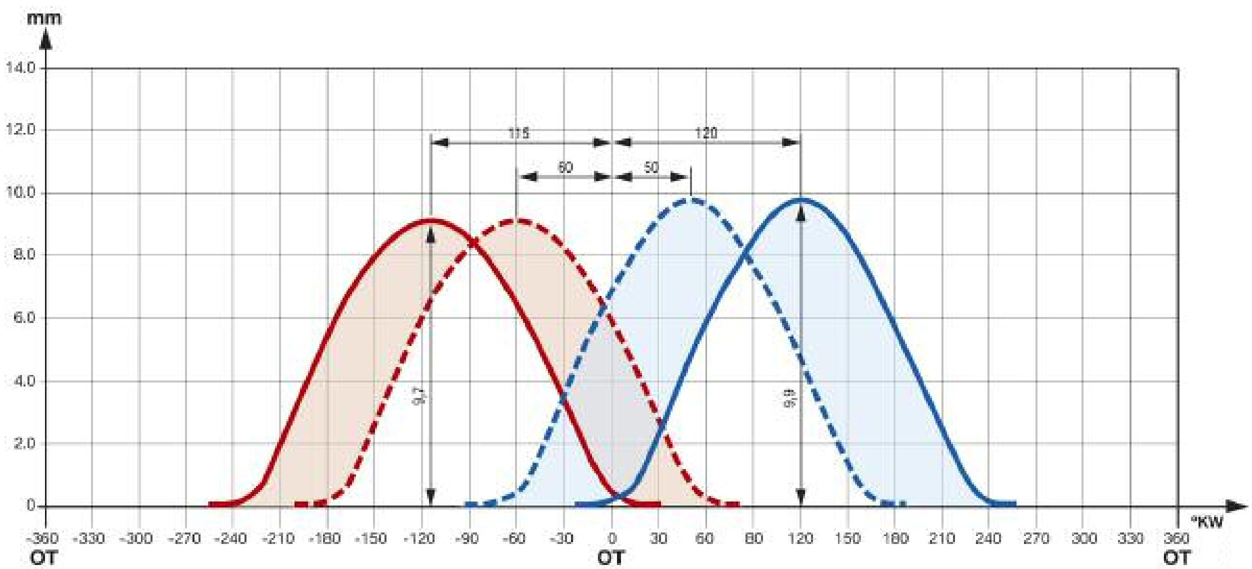
**N55, assembled camshaft**




| Index | Explanation |
|---|---|
| 1 | Shell-shaped cam |
| 2 | Corrugated tube |

## Valve Timing

### N55 valve timing diagram

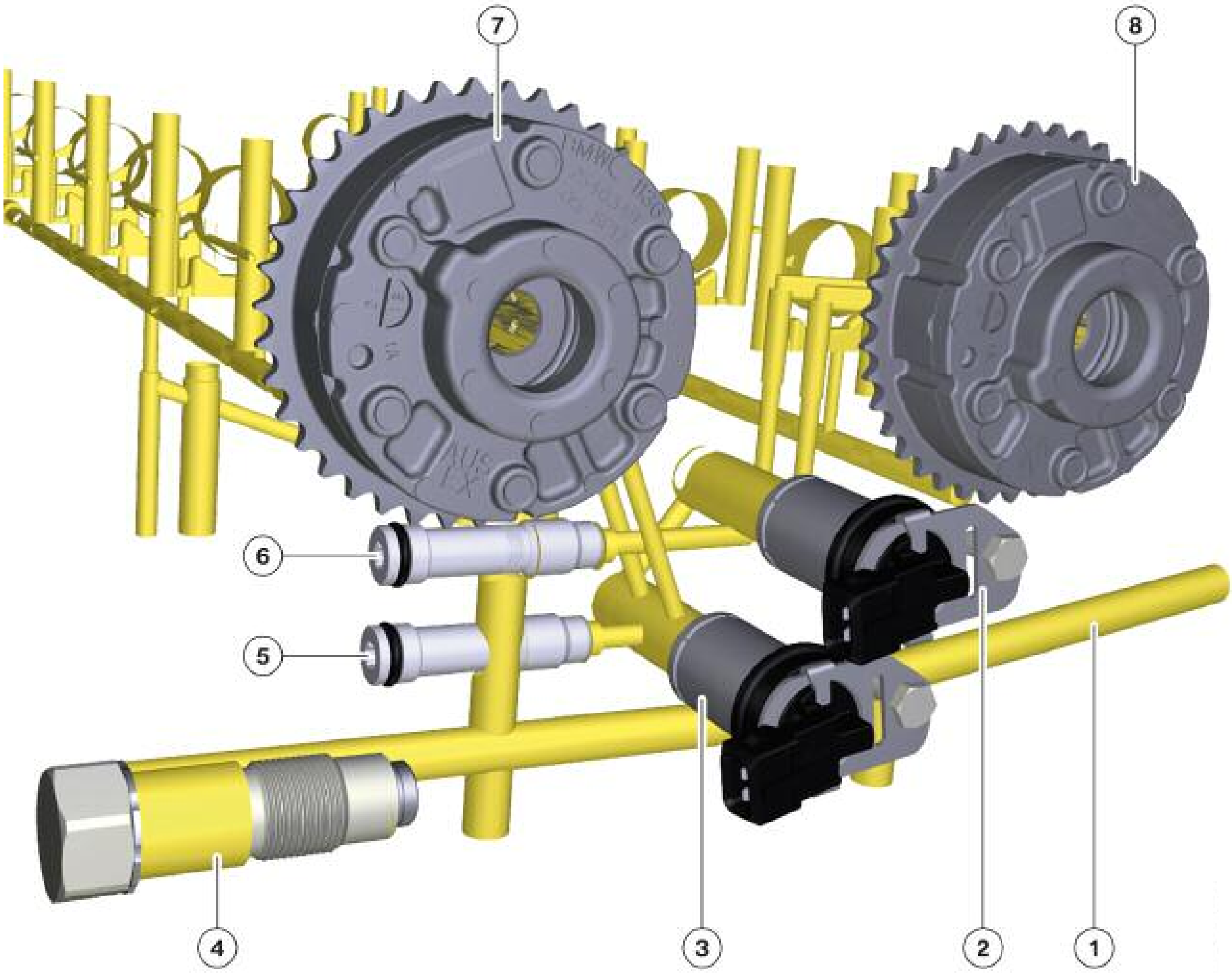



| | | N54B30O0 | N55B30M0 |
|---|---|---|---|
| Intake valve Ø | [mm] | 31.4 | 32 |
| Exhaust valve Ø | [mm] | 28 | 28 |
| Maximum valve lift, intake valve/exhaust valve | [mm] | 9.7/9.7 | 9.9/9.7 |
| Intake camshaft spread (VANOS adjustment range) | [°crankshaft] | 55 | 70 |
| Exhaust camshaft spread (VANOS adjustment range) | [°crankshaft] | 45 | 55 |
| Intake camshaft opening angle (max.-min. spread) | [°crankshaft] | 125 - 70 | 120 - 50 |
| Exhaust camshaft opening angle (max.-min. spread) | [°crankshaft] | 130 - 85 | 115 - 60 |
| Opening period intake camshaft | [°crankshaft] | 245 | 255 |
| Opening period exhaust camshaft | [°crankshaft] | 261 | 261 |

**The N55 has a larger intake and exhaust VANOS adjustment range as well as larger intake valve lift, and cam duration than the N54 engine.**

## VANOS System

### N54, VANOS with oil supply

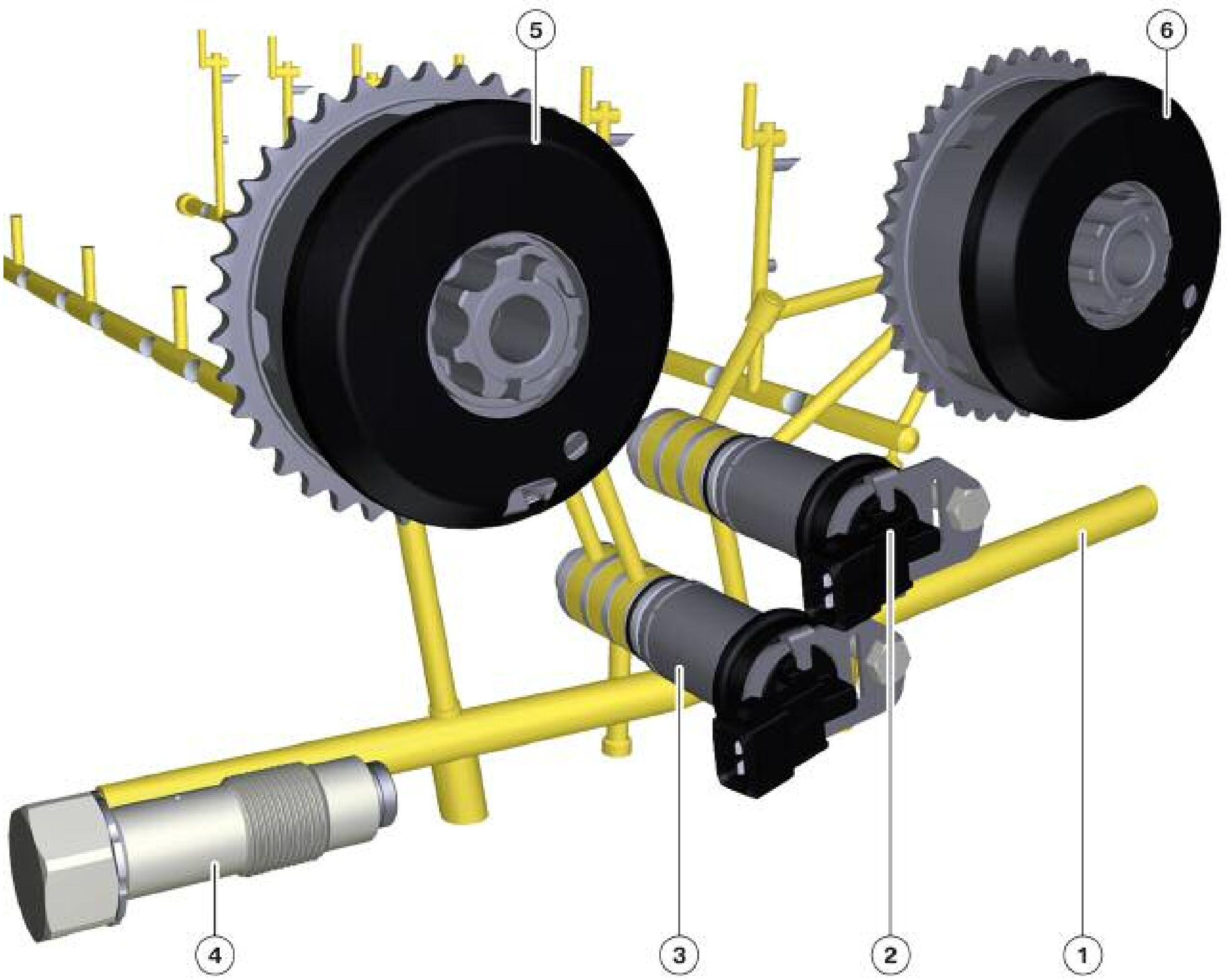



| Index | Explanation |
|---|---|
| 1 | Main oil duct |
| 2 | VANOS solenoid valve, intake side |
| 3 | VANOS solenoid valve, exhaust side |
| 4 | Chain tensioner |
| 5 | Non return valve, exhaust side |
| 6 | Non return valve, intake side |
| 7 | VANOS adjustment unit, exhaust side |
| 8 | VANOS adjustment unit, intake side |

## Overview

The VANOS system has been optimized to provide even faster adjustment speeds of the VANOS units. The aluminum VANOS units are much lighter and are also less susceptible to soiling. It can be seen by comparing the N54 VANOS system with the N55 VANOS that fewer oil passages are required and that the non-return valves are no longer on the cylinder head but rather incorporated into the solenoid valves on N55.

**N55, VANOS with oil supply**




| Index | Explanation |
|---|---|
| 1 | Main oil duct |
| 2 | VANOS solenoid valve, intake side |
| 3 | VANOS solenoid valve, exhaust side |
| 4 | Chain tensioner |
| 5 | VANOS adjustment unit, exhaust side |
| 6 | VANOS adjustment unit, intake side |

## VANOS Solenoid Valves

The non-return valve with screen filter used on the N54 engine have now been integrated in the VANOS solenoid valves on the N55 engine. This measure has made it possible to reduce the number of oil ducts in the cylinder head. The screen filters on the VANOS solenoid valve ensure trouble-free operation and reliably prevent the VANOS solenoid valve from sticking due to dirt particles.

## Cam Sensor Wheels

The sensor wheels are now "deep-drawn" sheet metal components and no longer made from two parts. This design increases production accuracy while reducing manufacturing costs.

**N55, camshaft sensor wheel**


| Index | Explanation |
|---|---|
| A | Rear View |
| B | Front view |

## VALVETRONIC III

The main differences between VALVETRONIC III and VALVETRONIC II are in the arrangement of the VALVETRONIC servomotor and the VALVETRONIC sensor. As in VALVETRONIC II, the turbulence level is increased at the end of the compression cycle for the purpose of optimizing the mixture formation with the use of phasing and masking measures. This movement of the cylinder charge improves the combustion during partial load operation and in catalytic converter heating mode. The quench areas also contribute to mixture formation.

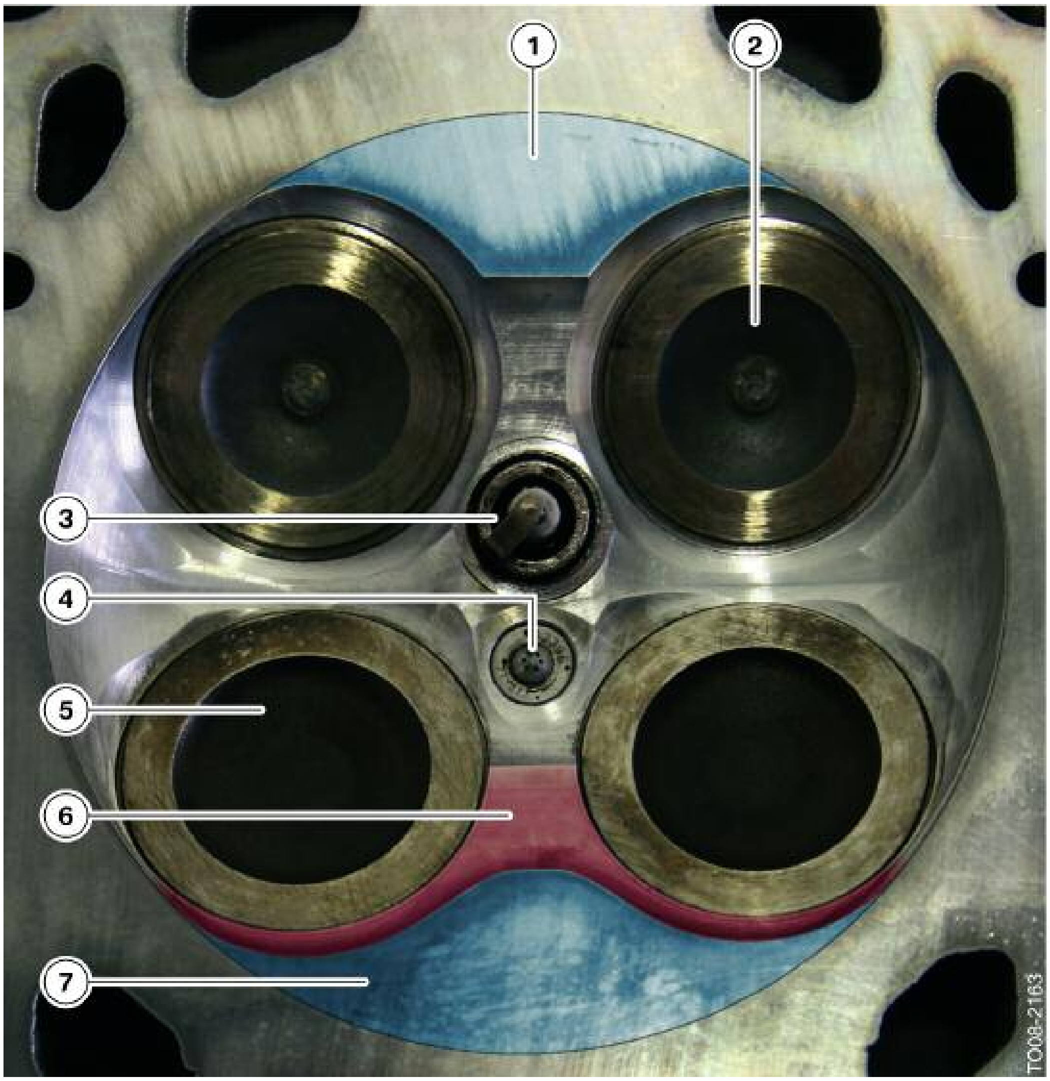
### Phasing

Phasing results in a lift difference between both intake valves of up to 1.8 mm in the lower partial load range. Consequently, the flow of fresh air is distributed asymmetrically.

### Masking

Masking refers to the design of the valve seats. This machining ensures that the incoming fresh air is aligned in such a way as to give rise to the required cylinder charge movement. The advantage of this measure is that the combustion retardation is reduced by approximately 10° of crankshaft rotation. The combustion process takes place faster and a larger valve overlap can be achieved, thus considerably reducing NOx emissions.

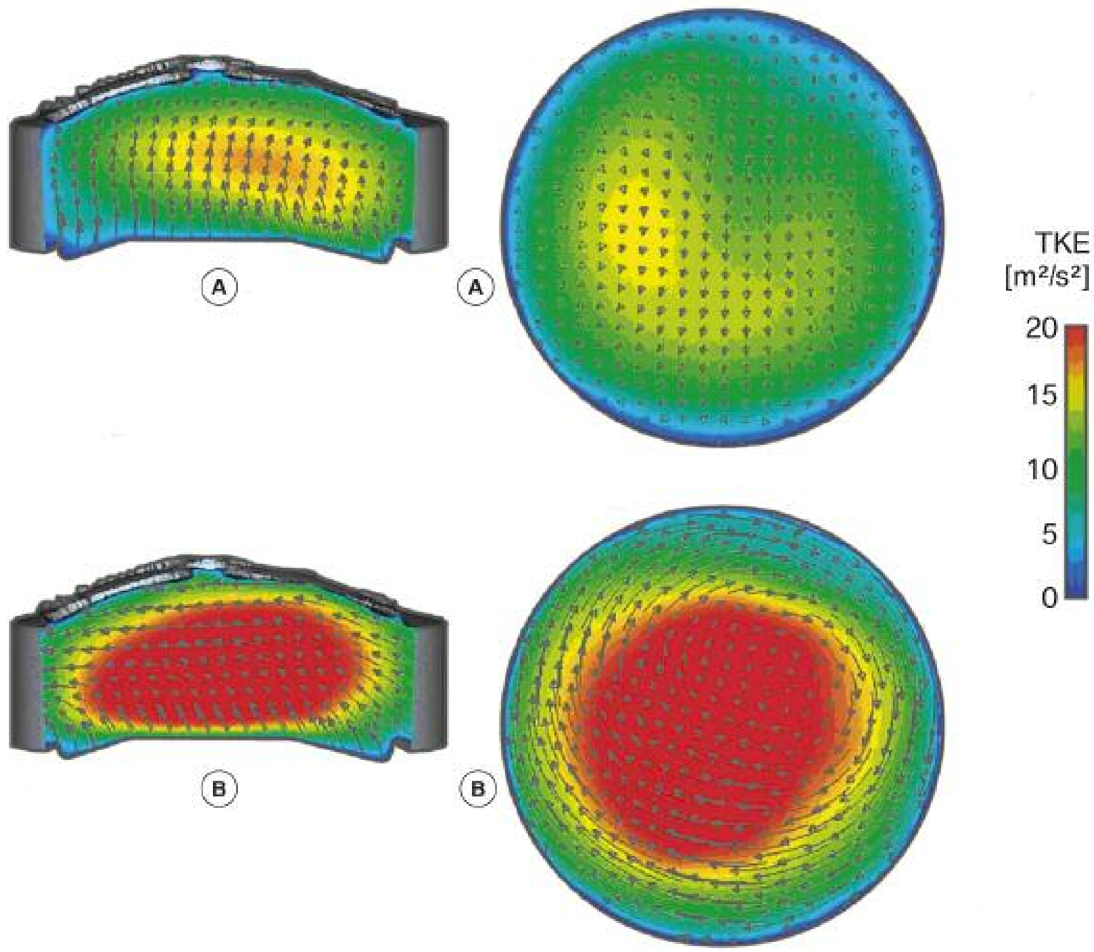
## N55, Top of the combustion chamber




| Index | Explanation |
|---|---|
| 1 | Quench area |
| 2 | Exhaust valves |
| 3 | Spark plug |
| 4 | Fuel injector |
| 5 | Intake valve |
| 6 | Masking |
| 7 | Quench area |

The following graphic shows the effect of the previously described measures. These measures achieve improved and faster combustion in the red area. Technically, this is known as the turbulent kinetic energy.

**Influence of phasing and masking on flow in the combustion chamber**



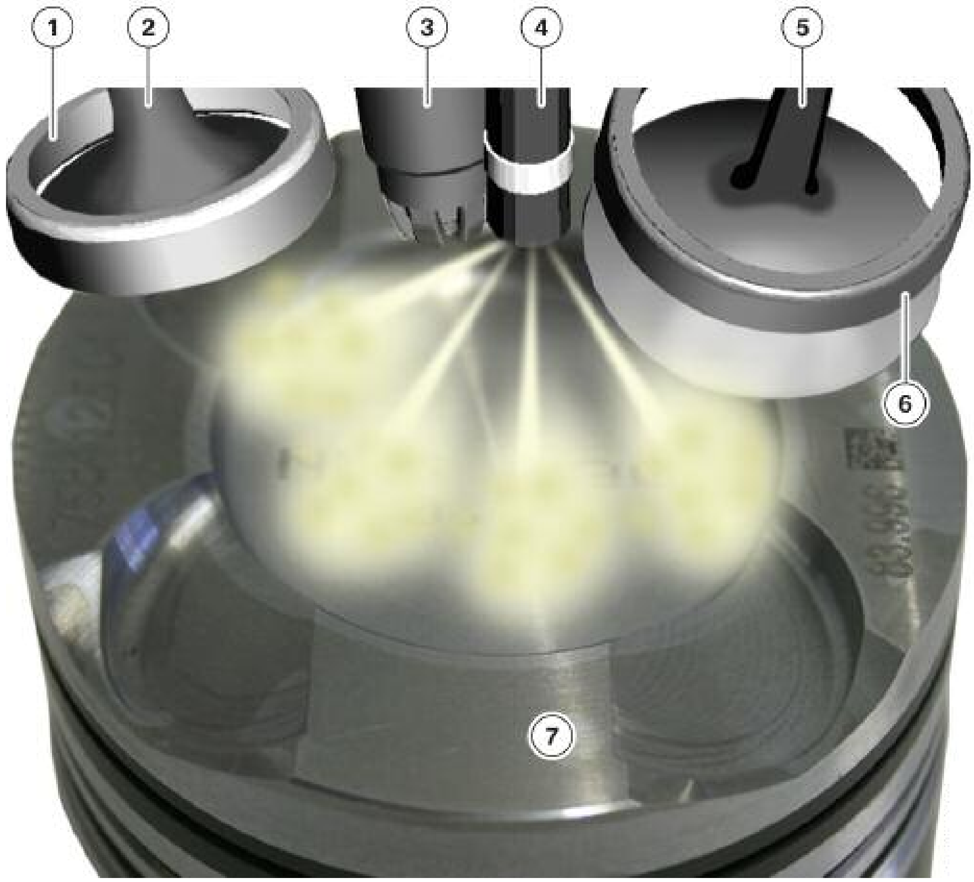

| Index | Explanation |
|---|---|
| A | VALVETRONIC I |
| B | VALVETRONIC II and III with Phasing and masking |
| TKE | Turbulent knitic energy |

Engine response is improved by the combination of VALVETRONIC III, direct injection and turbocharging. The response up to naturally aspirated full load is shortened on a naturally aspirated engine with VALVETRONIC as there is now no need wait for the intake air manifold to be filled. The subsequent torque buildup as the turbocharger starts up can be accelerated with the partial lift setting at low engine speed. This effectively flushes out residual gas, thus resulting in faster torque build-up.

## Combustion Chamber Geometry

The following graphic shows the arrangement of the individual components in the combustion chamber. It can be seen that the BMW (spray-guided) high precision injection (HPI) system is not used but rather a Bosch solenoid valve fuel injector with multi-hole nozzle. The fuel injection is specially adapted to the combination of VALVETRONIC III and turbocharging. For better illustration, a set of valves has been removed in the graphic.

**N55, combustion chamber with components**

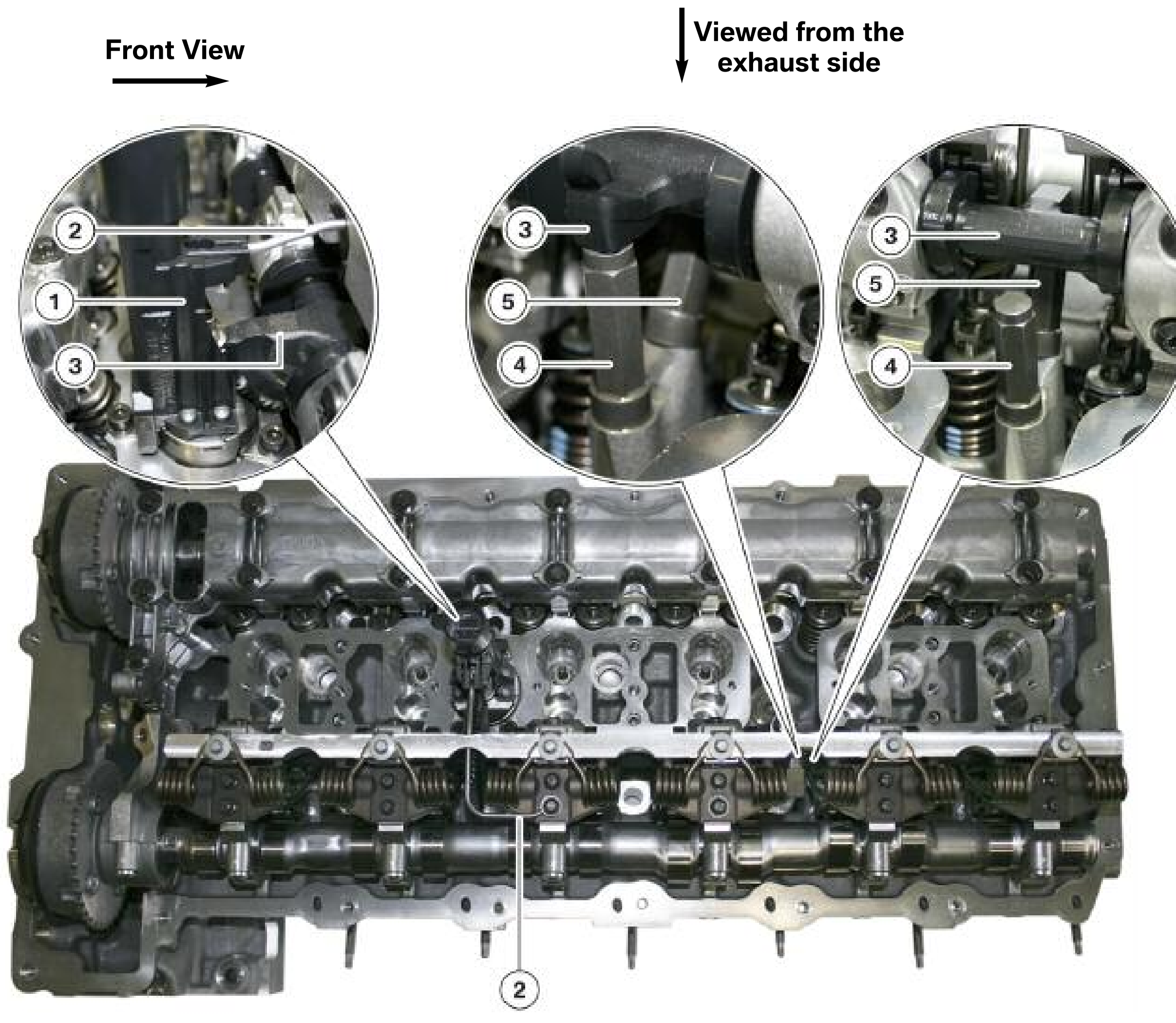



| Index | Explanation |
|---|---|
| 1 | Valve seat, exhaust valve |
| 2 | Exhaust valve |
| 3 | Spark plug |
| 4 | Fuel injector |
| 5 | Intake valve |
| 6 | Valve seat, intake valve |
| 7 | Piston |

### Valve Lift Adjustment Overview

As can be seen from the following graphic, the installation location of the servomotor has changed with VALVETRONIC III. Another new feature is that the eccentric shaft sensor is no longer mounted on the eccentric shaft but has been integrated into the servomotor.

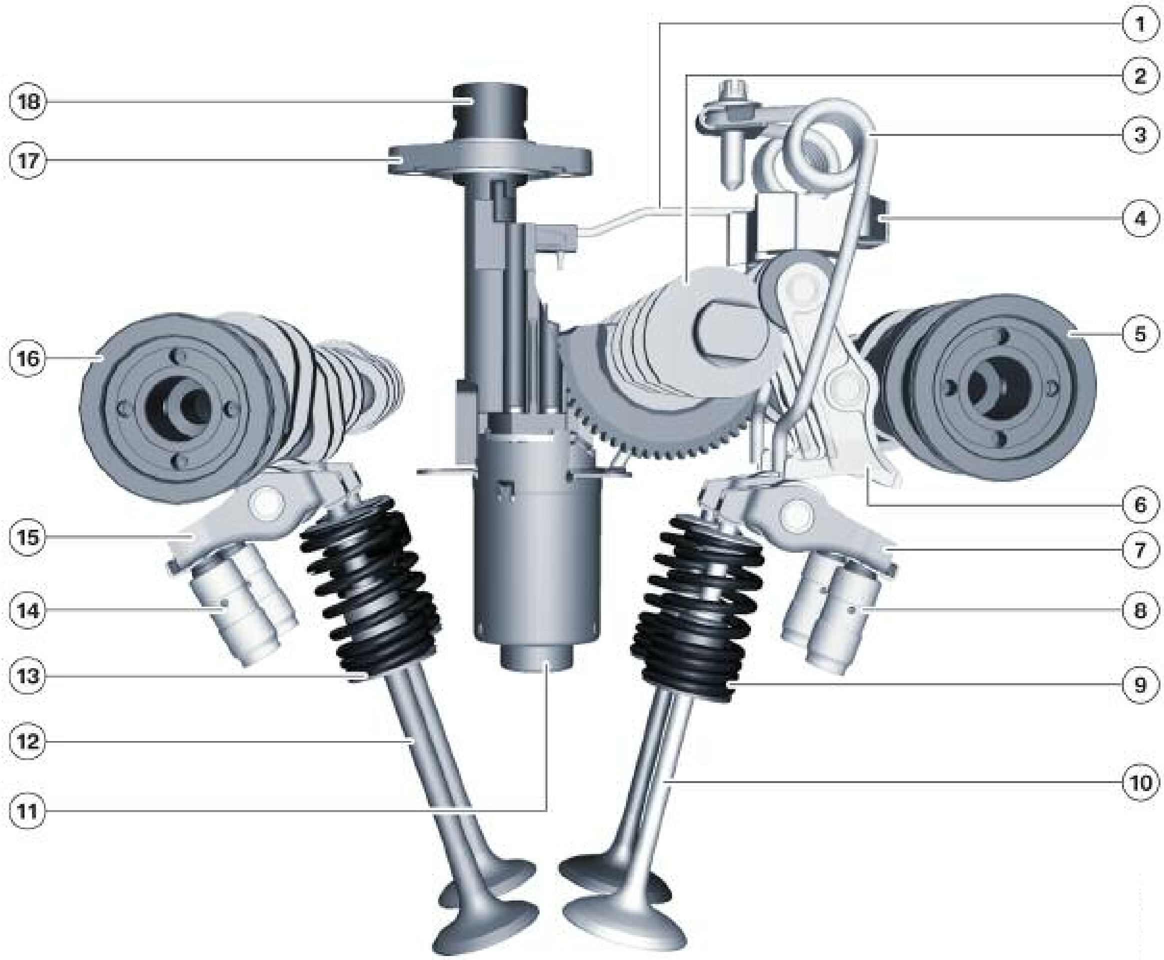
**N55, valve lift adjustment**




| Index | Explanation |
|---|---|
| 1 | VALVETRONIC servomotor |
| 2 | Oil spray nozzle |
| 3 | Eccentric shaft |
| 4 | Eccentric shaft minimum stop |
| 5 | Eccentric shaft maximum stop |

The VALVETRONIC III servomotor contains a sensor for determining the position of the motor and the eccentric shaft. The servomotor is lubricated with engine oil by means of an oil spray nozzle (1) aimed directly at the worm drive and the eccentric shaft mechanism.

**N55, design of valve lift adjustment**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Oil spray nozzle | 10 | Intake valve |
| 2 | Eccentric shaft | 11 | VALVETRONIC servomotor |
| 3 | Return spring | 12 | Exhaust valve |
| 4 | Gate block | 13 | Valve spring |
| 5 | Inlet camshaft | 14 | Hydraulic valve lash adjustment |
| 6 | Intermediate lever | 15 | Roller cam follower, exhaust |
| 7 | Roller cam follower, intake | 16 | Exhaust camshaft |
| 8 | Hydraulic valve lash adjustment | 17 | Sealing sleeve |
| 9 | Valve spring | 18 | Socket |

## VALVETRONIC Servomotor

A brushless direct current motor (BLDC motor) is used. The BLCD motor is maintenance-free and very powerful, due to the contactless energy transfer system. The use of integrated electronic modules ensures precision control.

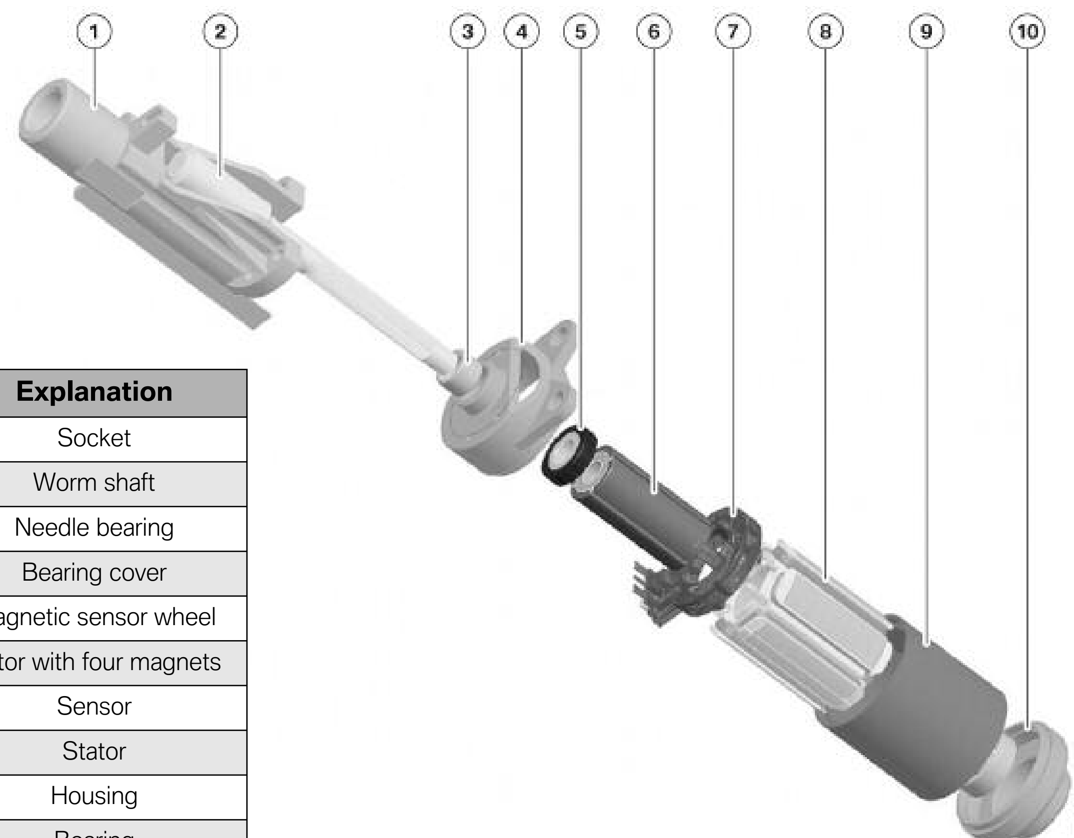
The VALVETRONIC servomotor has the following special features:

- Open concept (engine oil is directly supplied to the motor).
- The eccentric shaft angle is determined by angle increments from the integrated sensor system.
- Power consumption is reduced by about 50%.
- Higher actuating dynamics (e.g. cylinder-selective adjustment, idle speed control, etc.).
- Lightweight design is approximately 600 grams.

## Function

Actuation of the VALVETRONIC servomotor is limited to a maximum of 40 amps. A maximum of 20 amps are available over a period of > 200 milliseconds. The VALVETRONIC servomotor is actuated by a pulse width modulated signal. The duty cycle is between 5% and 98%.

**VALVETRONIC Servomotor**

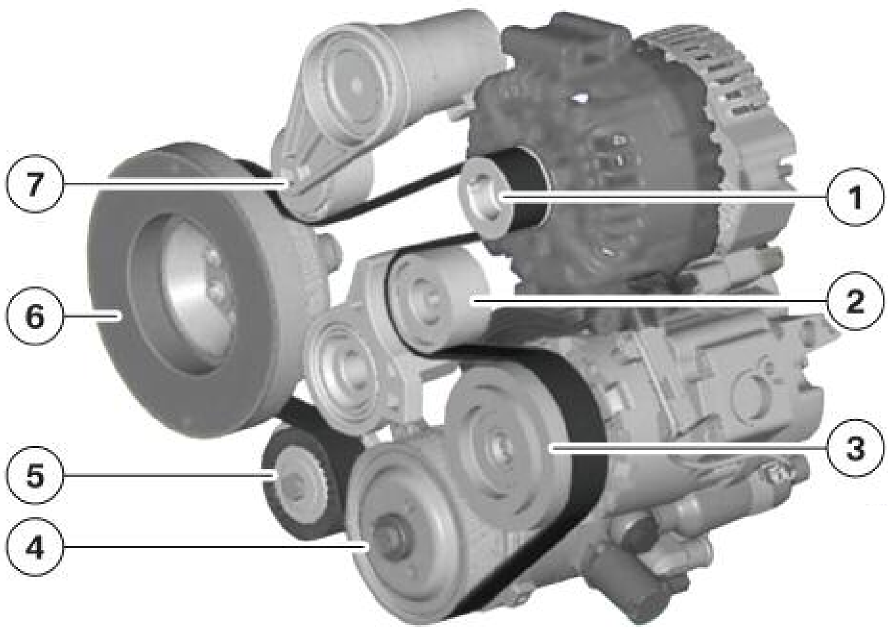



| Index | Explanation |
|---|---|
| 1 | Socket |
| 2 | Worm shaft |
| 3 | Needle bearing |
| 4 | Bearing cover |
| 5 | Magnetic sensor wheel |
| 6 | Rotor with four magnets |
| 7 | Sensor |
| 8 | Stator |
| 9 | Housing |
| 10 | Bearing |

## Belt Drive and Auxiliarly Components

The belt drive has two deflection pulleys and one double ribbed belt.

**N55, Belt drive**

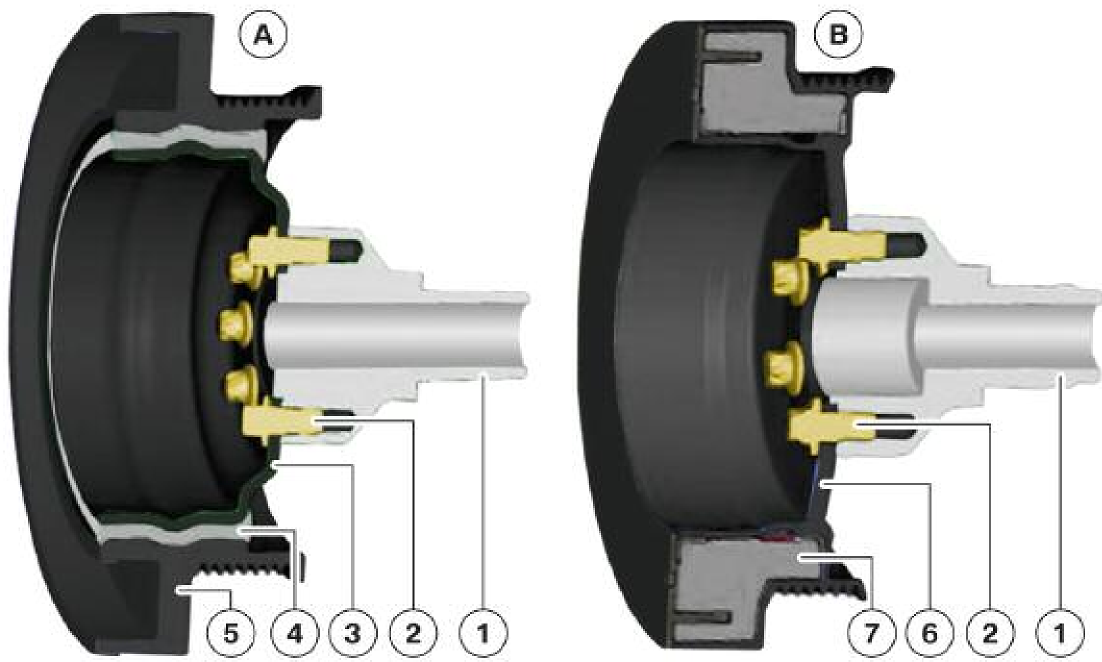



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Belt pulley, alternator | 5 | Deflection pulley |
| 2 | Deflection pulley | 6 | Vibration absorber with belt pulley |
| 3 | Belt pulley, A/C compressor | 7 | Belt tensioner |
| 4 | Belt pulley, power steering pump | | |

## Vibration Damper

A single-mass vibration damper is used on the N55 engine. The belt pulley is mounted on the secondary pulley. Compared to the N54 engine, this design layout additionally reduces the belt load as the vulcanization decouples the belt pulley with flywheel mass from the crankshaft.

**N54, vibration damper**




| Index | Explanation |
|---|---|
| A | Vibration damper, N55 engine |
| B | Vibration damper, N54 engine |
| 1 | Crankshaft |
| 2 | Bolts |
| 3 | Primary pulley |
| 4 | Vulcanization |
| 5 | Secondary belt pulley with flywheel mass |
| 6 | Primary belt pulley |
| 7 | Flywheel mass |

## N55, vibration damper


| Index | Explanation |
|---|---|
| 1 | Secondary belt pulley with flywheel mass |
| 2 | Flange |
| 3 | Vulcanization |

# Air Intake and Exhaust System

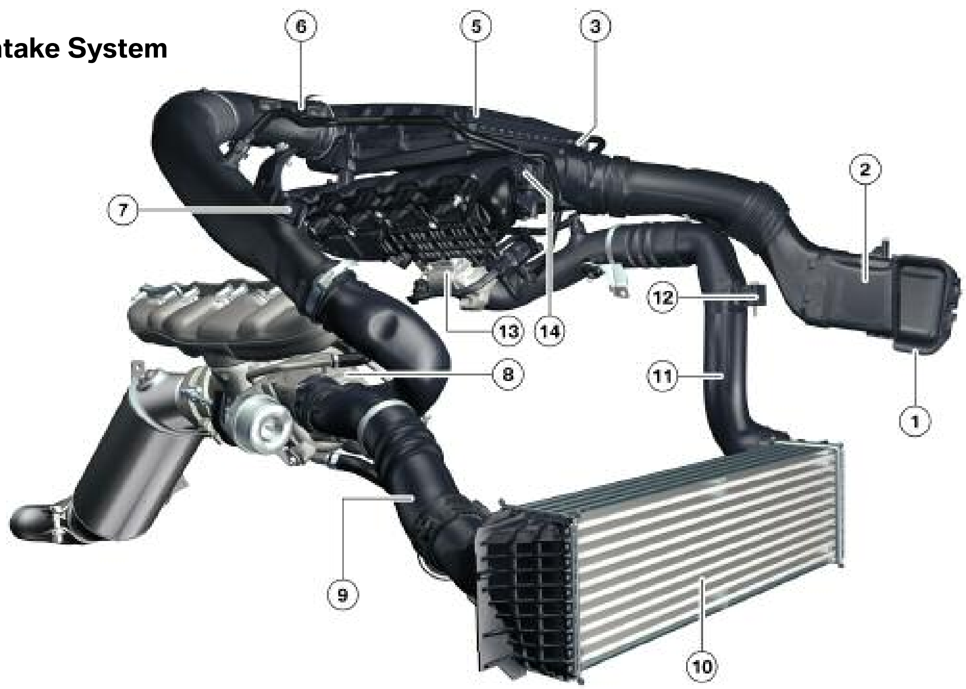
## Air Intake System

Several functions of the air intake system have been optimized for the N55 engine:

- The unfiltered air is routed up to the intake silencer (similar to the N54 engine).
- The filtered air duct is completely new and simplified to accommodate the new turbocharger.
- The crankcase ventilation system has been redesigned.
- The diverter valve has been integrated into the compressor housing of the turbocharger.
- The fuel tank ventilation has been correspondingly adapted.

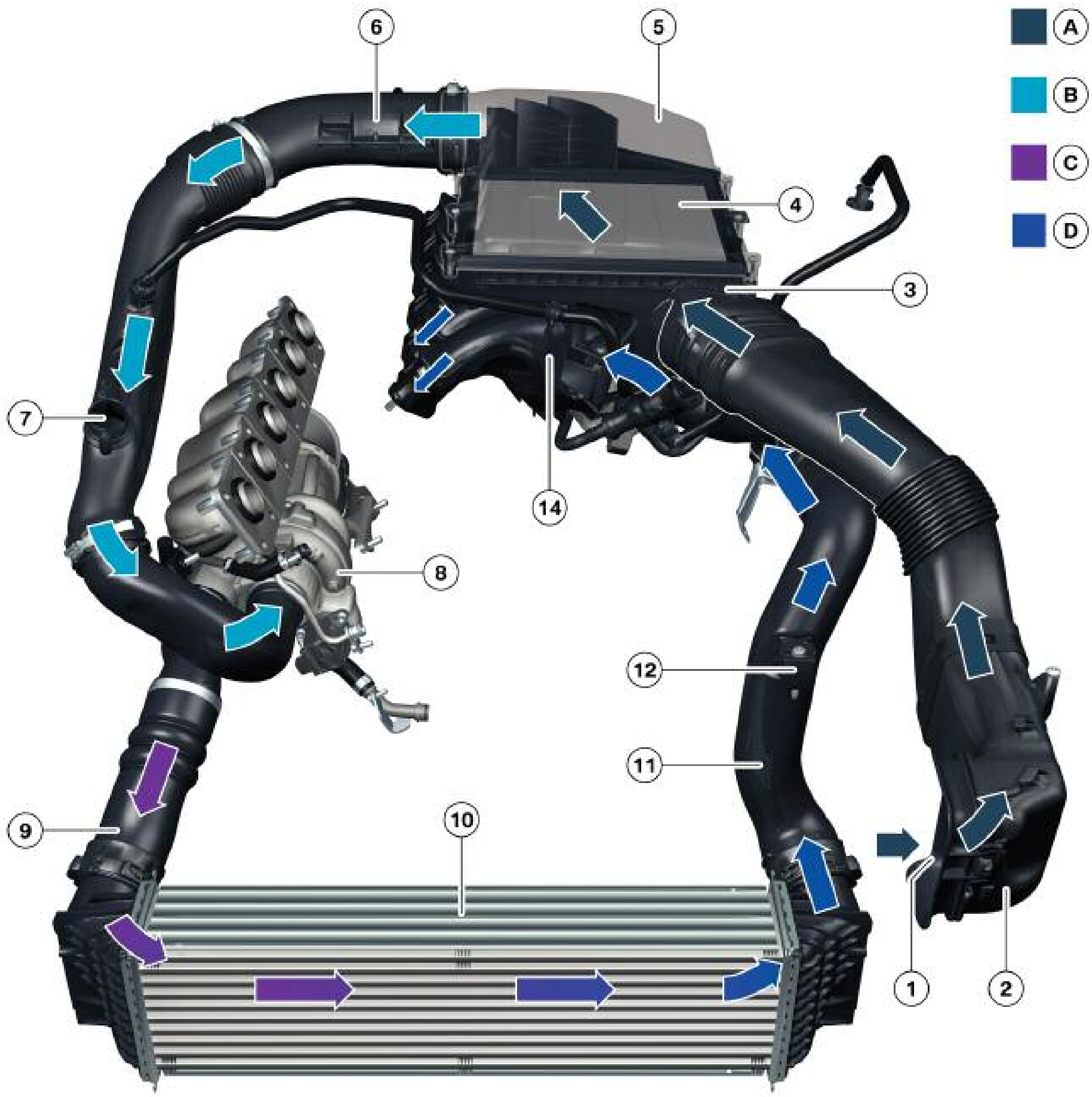
The design layout of the air intake system has been simplified, compared to the dual turbocharger set up of the N54.

**N55, Air Intake System**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Intake snorkel | 9 | Charge-air pipe |
| 2 | Unfiltered air pipe | 10 | Intercooler |
| 3 | Intake silencer | 11 | Charge-air pipe |
| 5 | Air intake silencer cover | 12 | Boost pressure-temperature sensor |
| 6 | Hot-film air mass meter | 13 | Throttle valve |
| 7 | Crankcase ventilation connection | 14 | Intake manifold |
| 8 | Exhaust turbocharger | | |

## N55, Air Intake and Exhaust System



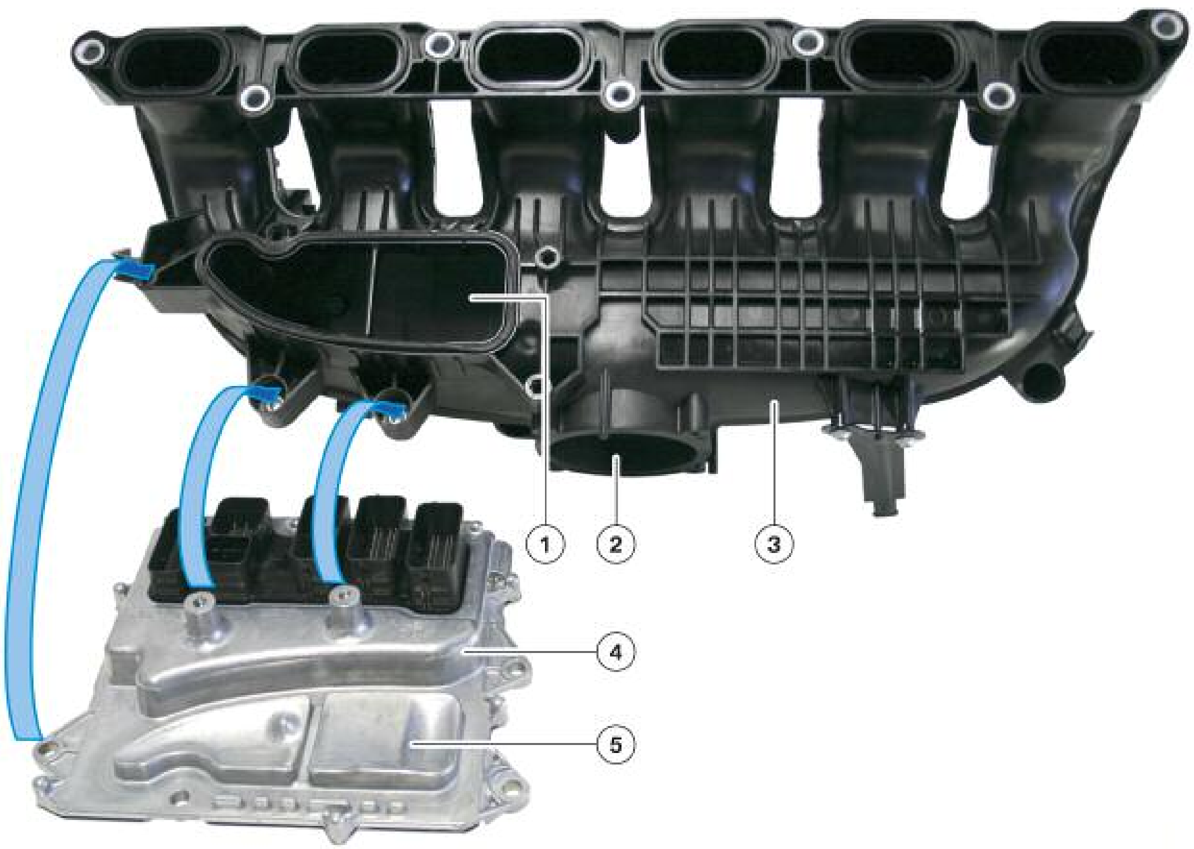
| Index | Explanation |
| --- | --- |
| A | Unfiltered air |
| B | Purified air |
| C | Heated charge air |
| D | Cooled charge air |
| 1 | Intake snorkel |
| 2 | Unfiltered air pipe |
| 3 | Intake silencer |
| 4 | Filter element |
| 5 | Air intake silencer cover |
| 6 | Hot-film air mass meter |
| 7 | Crankcase ventilation connection |
| 8 | Exhaust turbocharger |
| 9 | Charge-air pipe |
| 10 | Intercooler |
| 11 | Charge air pipe |
| 12 | Boost pressure-temperature sensor |
| 14 | Intake air manifold |

## Intake Manifold

The engine control unit is mounted on the intake manifold. The intake air is used to cool the engine control unit.

Thanks to this arrangement, the engine comes down the assembly line completely assembled with the control unit, the sensors, and actuators already connected.

**N55, intake system with DME control unit**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Mounting flange for engine control unit cooling | 4 | Engine control unit |
| 2 | Mounting flange for throttle valve | 5 | Cooling fins |
| 3 | Air intake system | | |

## Fuel Tank Ventilation System

The fuel vapors are stored in a charcoal canister and then fed via the fuel tank vent valve to the combustion process. It was also necessary to adapt this system to all the given conditions related to turbocharging.

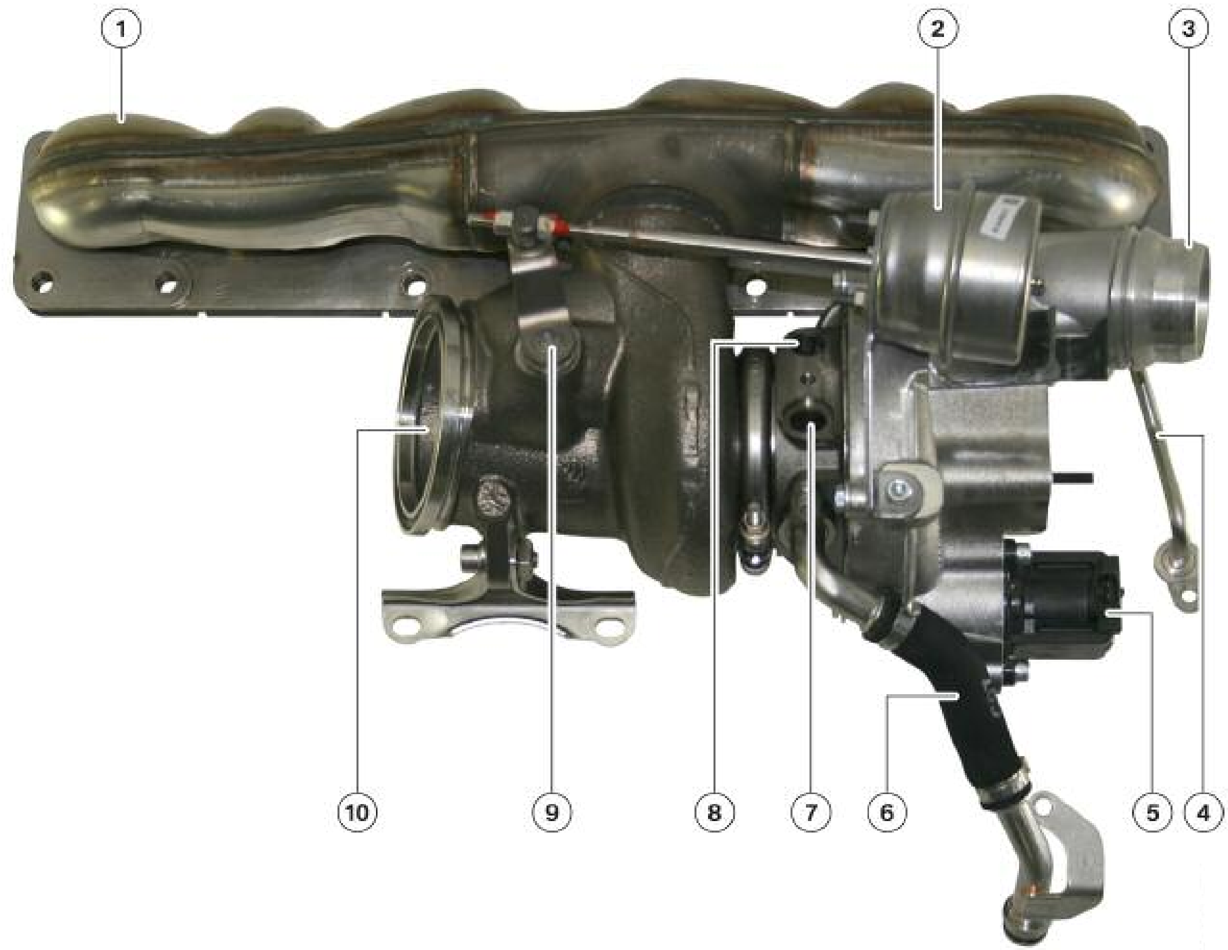
**N55, fuel tank ventilation system**


| Index | Explanation |
|---|---|
| 1 | Connection to ventilation line from charcoal canister |
| 2 | Connection upstream of throttle valve |
| 3 | Fuel tank vent valve |
| 4 | Connection downstream of throttle valve |
| 5 | Connection upstream of turbocharger |

## Exhaust Manifold

The exhaust manifold is air-gap insulated and designed as a six ports into two chamber manifold. Dividing six exhaust ports into two exhaust chambers is necessary in order to ensure optimum flow to the twin scroll turbocharger. The exhaust pulses from the first three cylinders (1-3) feed one scroll (duct 1) of the turbo, while the last three (4-6) feed the second scroll (duct 2). The exhaust manifold and turbocharger are welded together to form one component.

**N55, attachment of exhaust manifold and turbocharger to engine block**

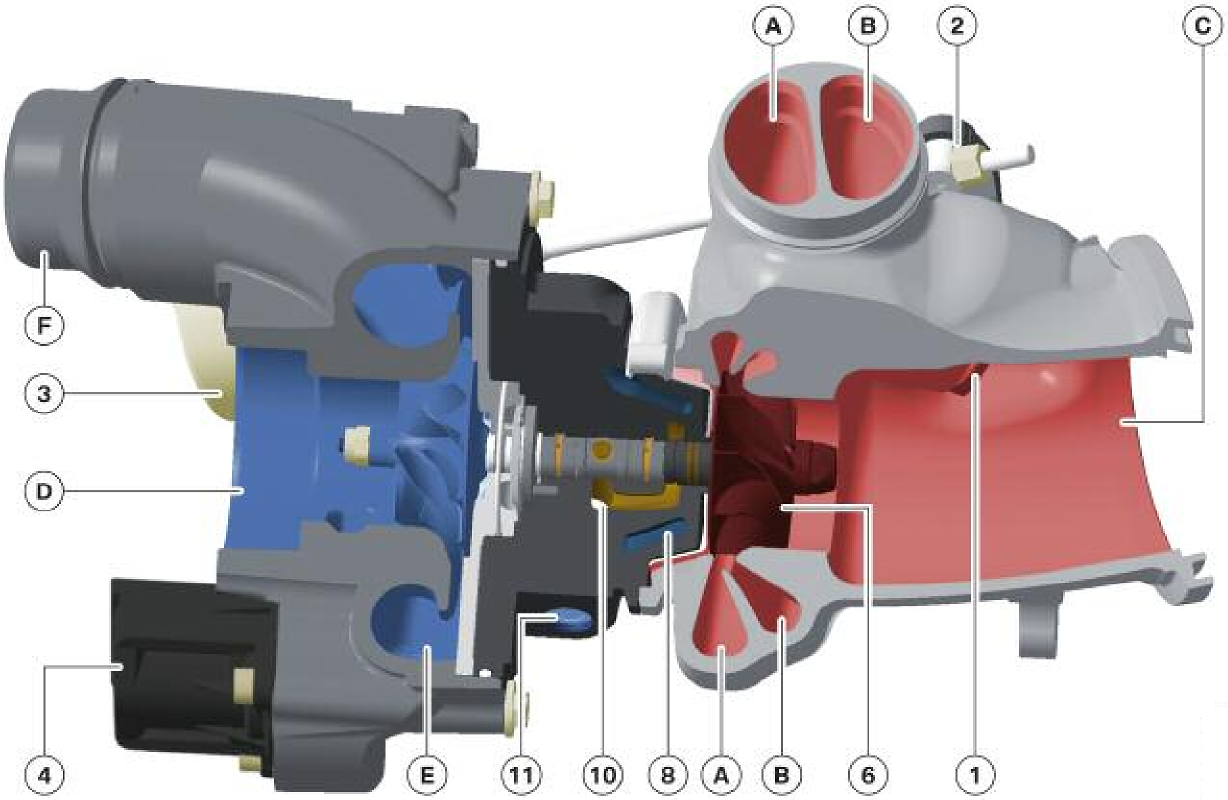



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Exhaust manifold | 6 | Oil return line |
| 2 | Vacuum unit | 7 | Coolant infeed |
| 3 | Connection to intercooler | 8 | Coolant return |
| 4 | Oil feed line | 9 | Shaft, wastegate valve |
| 5 | Diverter valve | 10 | Connection to exhaust system |

## Turbocharger

The N55 is equipped with a single twin scroll turbocharger instead of two separate small turbochargers as on the N54 engine. The following graphics show the operating principle of the twin scroll turbocharger.

**Twin scroll turbocharger rear view**




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Exhaust duct 1 (cylinders 1 - 3) | 2 | Lever arm, wastegate valve |
| B | Exhaust duct 2 (cylinders 4 - 6) | 3 | Vacuum unit for wastegate valve |
| C | Connection to catalytic converter | 4 | Diverter valve |
| D | Inlet from intake silencer | 6 | Turbine wheel |
| E | Ring channel | 8 | Cooling duct |
| F | Outlet to intercooler | 10 | Oil return |
| 1 | Wastegate valve | 11 | Coolant return |

## Function of the Twin Scroll Turbocharger

The system is designed so that constant exhaust gas pressure is rearly applied to the turbocharger. At low engine speeds, the exhaust reaches the turbine in tuned pulsed form. Due to this pulsation, a higher pressure ratio is temporarily reached in the turbine. Since the efficiency increases as the pressure rises, the pulsation improves the boost pressure progression and thus the torque progression of the engine. This is the case particularly at low engine speeds.

To limit the back pressure and ensure that the individual cylinders do not mutually influence each other during the cylinder charging process, cylinders 1 - 3 (bank 1) and cylinders 4 - 6 (bank 2) are combined to form two exhaust channels. The exhaust gas pulses in the exhaust channels (1 and 2) are directed into two scrolls (spirals) within the turbocharger to drive the turbine wheel. This design layout makes it possible to optimally use the exhaust pulsations for generating boost pressure based on the firing order of the engine. This improves engine efficiency by enhancing throttle response and limiting unwanted turbo lag.

The wastegate valve is used for the purpose of limiting the boost pressure and is already known from previous BMW turbo engines. It is vacuum operated and electronically controlled through a vacuum control solenoid by the DME (ECM).

## Diverter Valve

The basic function of the diverter valve remains the same. The difference compared to the N54 engine is that the diverter valve is not operated pneumatically. The diverter valve on the N55 engine is an electric actuator that is controlled directly by the DME.
The number of components has been greatly reduced by positioning the diverter valve on the turbocharger compressor housing.

The diverter valve is designed to release unwanted pressure in the intake by connecting the pressure side of the induction system to the inlet side under deceleration. The undesirable peaks in the boost pressure that can occur when the throttle valve is quickly closed are reduced. This means the diverter valve plays an important role in terms of the engine acoustics while protecting the components of the turbocharger.

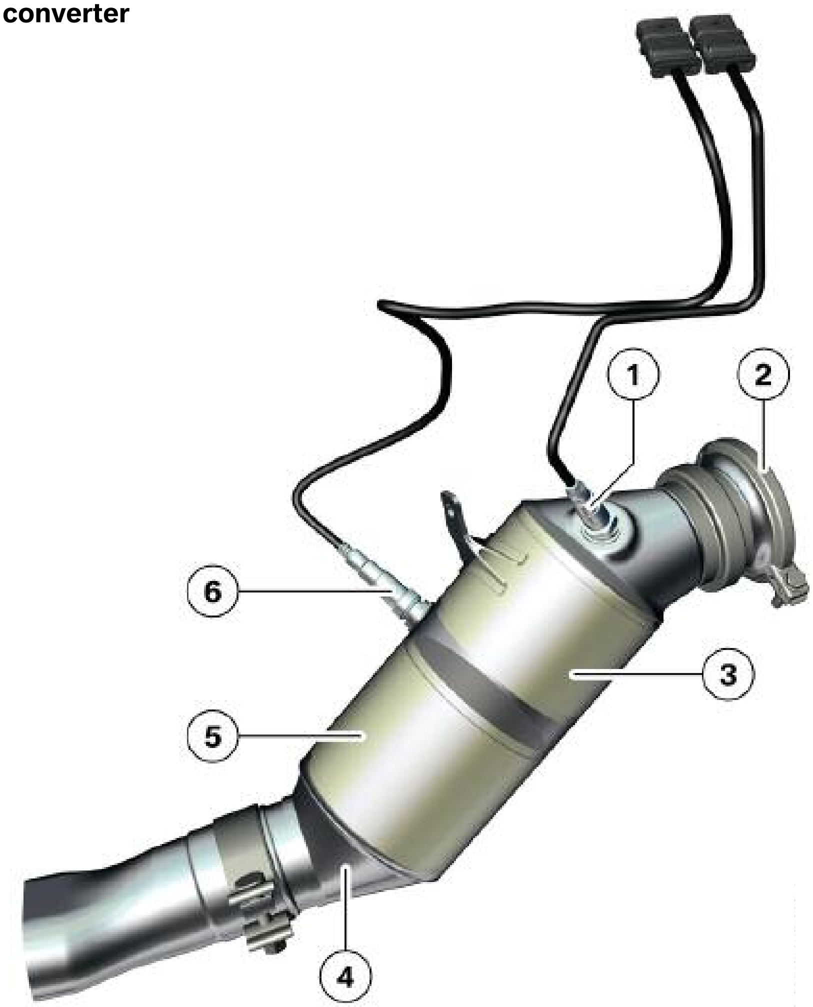
## Catalytic Converter

Two ceramic honeycomb structures are contained in the catalytic converter housing. The catalytic converter has a volume of 2.7 liters. Depending on the type of vehicle the ceramic structures have different coatings.

Ceramic structure 1 has a volume of 1.2 liters, a diameter of 125 mm, and contains 600 cells.

Ceramic structure 2 has a volume of 1.5 liters, a diameter of 125 mm, and contains 400 cells.

**N55, catalytic converter**

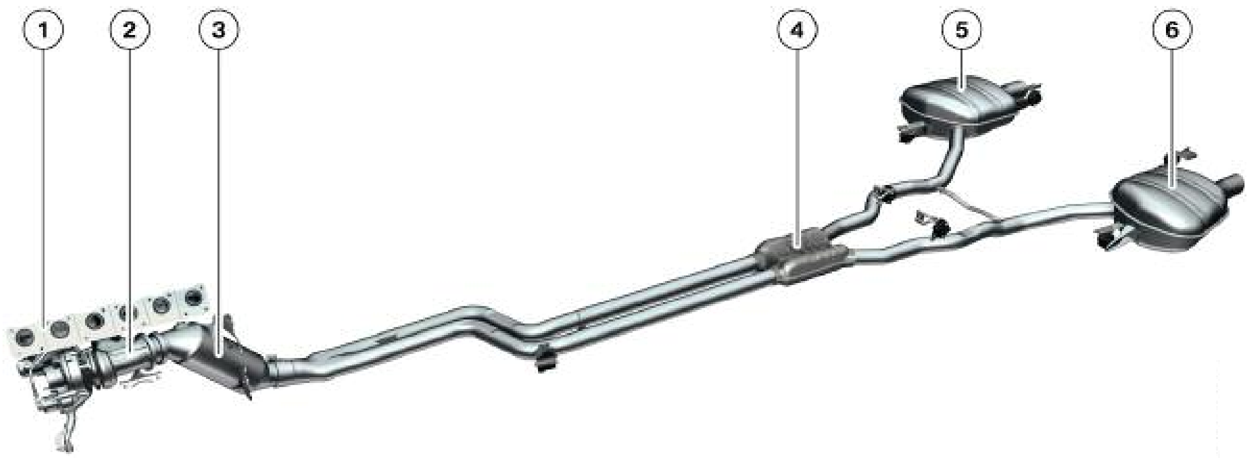



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Oxygen sensor upstream of catalytic converter | 4 | Catalytic converter outlet funnel |
| 2 | Connection to the turbocharger | 5 | Ceramic structure 2 |
| 3 | Ceramic structure 1 | 6 | Oxygen sensor after ceramic structure 1 |

## Exhaust System

With the single twin scroll turbocharger, the design of the exhaust system is less complicated than that of the N54 engine, with two turbochargers. In addition to a "near-engine" catalytic converter design, the exhaust system also features a center silencer and two rear silencers.

**N55, exhaust system F07**



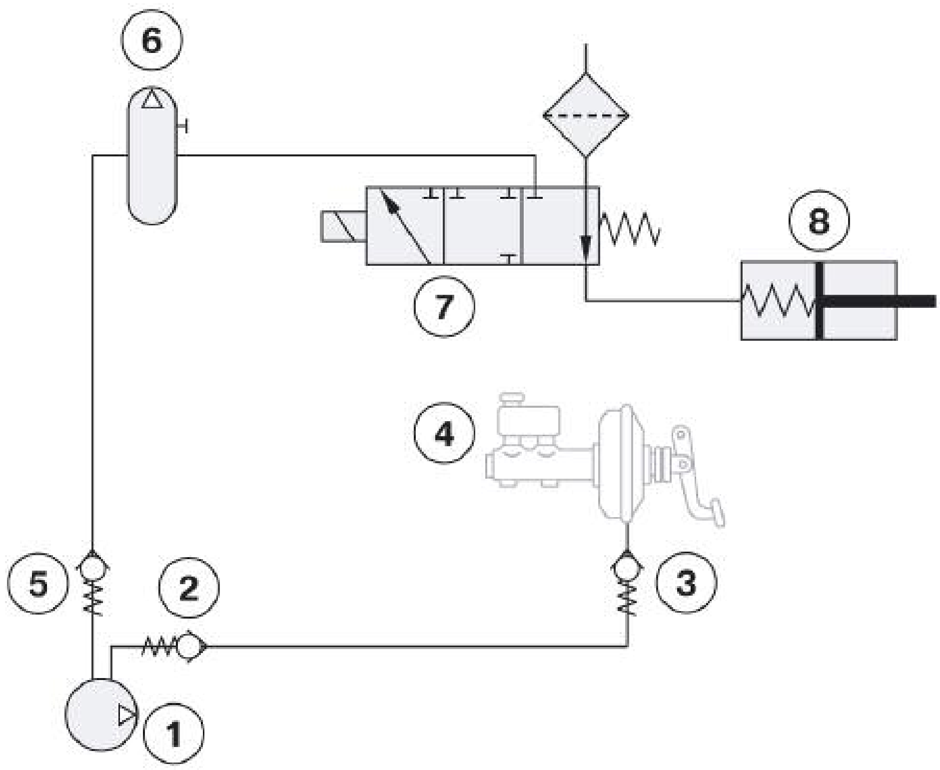

| Index | Explanation |
|---|---|
| 1 | Exhaust manifold |
| 2 | Exhaust turbocharger |
| 3 | Catalytic converter |
| 4 | Center silencer |
| 5 | Rear silencer, right |
| 6 | Rear silencer, left |

**Note: Due to the high efficiency of the "near engine" three way catalytic converter, no additional catalytic converters are necessary.**

## Vacuum System

The N55 engine is equipped with a vacuum pump for generating the vacuum required by the brake booster and the auxiliary consumers (exhaust flaps and wastegate). A vacuum accumulator (built into the cylinder head cover) is used to ensure there is sufficient vacuum for the wastegate valve at all times.

**N55, vacuum system**

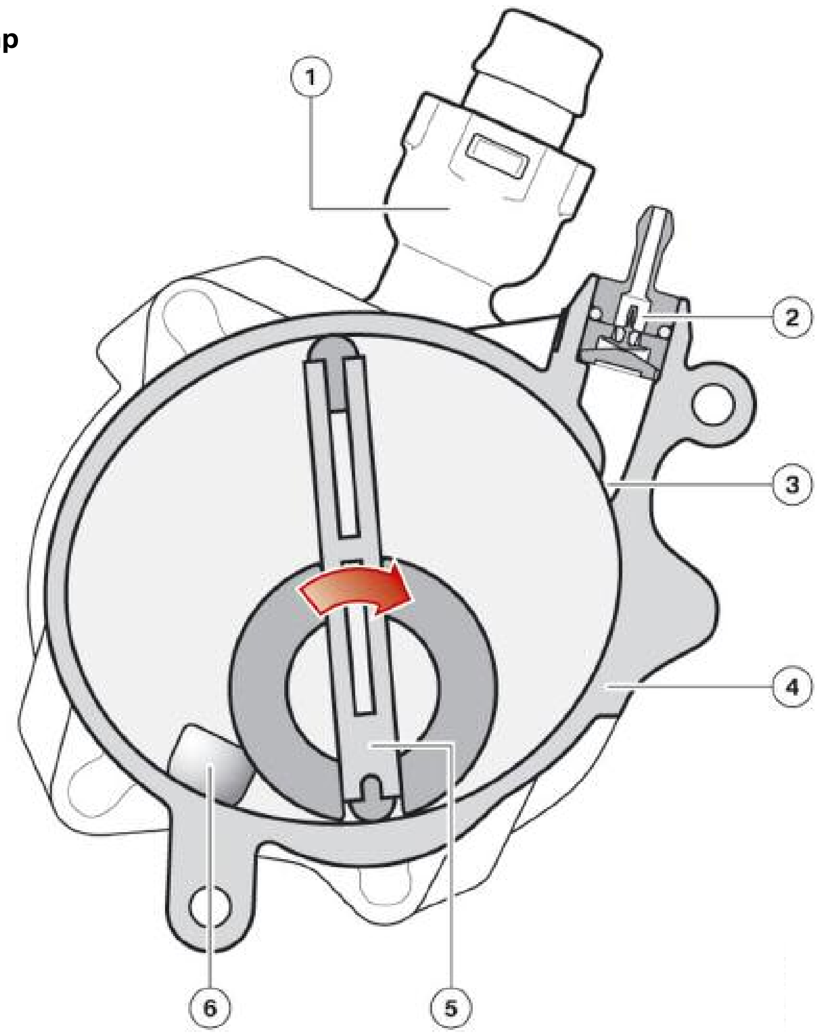



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Vacuum pump | 5 | Non-return valve |
| 2 | Non-return valve | 6 | Vacuum accumulator (Integrated into the cylinder head cover) |
| 3 | Non-return valve | 7 | Electropneumatic pressure converter (Vacuum solenoid) |
| 4 | Brake servo unit | 8 | Vacuum unit, wastegate valve |

## Vacuum Pump

The vacuum pump is similar to that used on the N63 engine. It is a two-stage pump and therefore has two connections. The first stage is for the brake booster and the second for the auxiliary consumers.

**N55, vacuum pump**

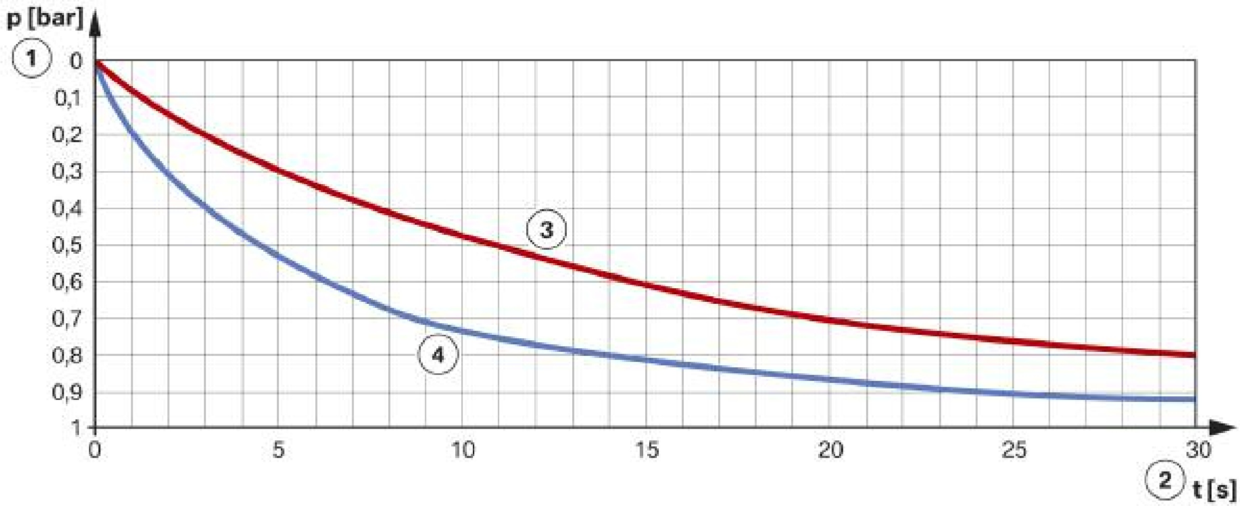



| Index | Explanation |
|---|---|
| 1 | Non-return valve for brake booster |
| 2 | Non-return valve for auxiliary consumer |
| 3 | Connection opening for auxiliary consumers |
| 4 | Vacuum pump housing |
| 5 | Vane |
| 6 | Connection opening for brake booster |

The largest area is used for the first stage, ensuring vacuum is built up at a rapid rate for the brake booster. The last section is the opening stage for the auxiliary consumers. It therefore takes longer to build up the vacuum here, as shown in the following diagram.

This solution takes into account the different requirements for the brake booster and the auxiliary consumers.

**N55, delivery rate of the two-stage vacuum pump**




| Index | Explanation |
|---|---|
| 1 | Vacuum |
| 2 | Time |
| 3 | Delivery rate for auxiliary consumers |
| 4 | Delivery rate for brake booster |

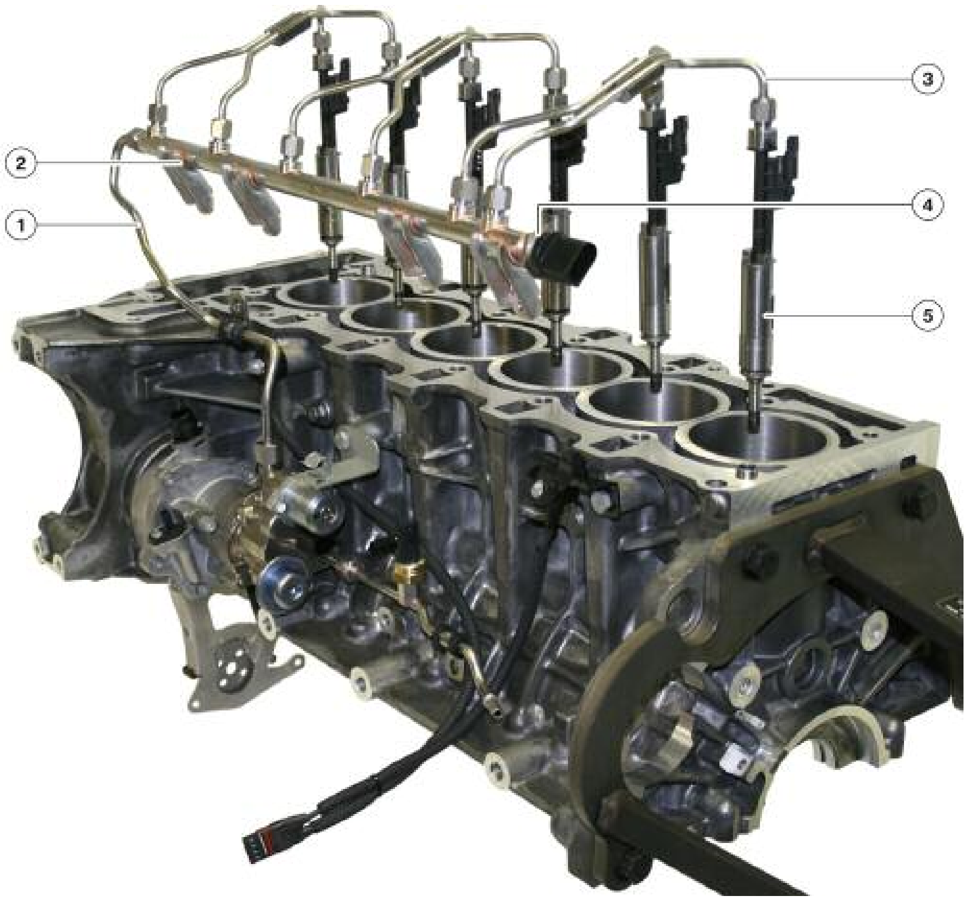
# Fuel System

## Fuel Injection

The high pressure fuel injection system (HDE) is used on the N55 engine. In contrast to high precision injection (HPI), HDE uses solenoid fuel injectors with multi-hole nozzles.

The following overview shows the complete fuel injection system. The system is similar to the N54 fuel injection. Although the same high pressure pump, pressure sensor, and fuel rail are used, the high pressure fuel injection valves are new. The HDE system uses Bosch high pressure solenoid type fuel injection valves with the designation HDEV5.2.

**N55, overview of high pressure fuel injection system**



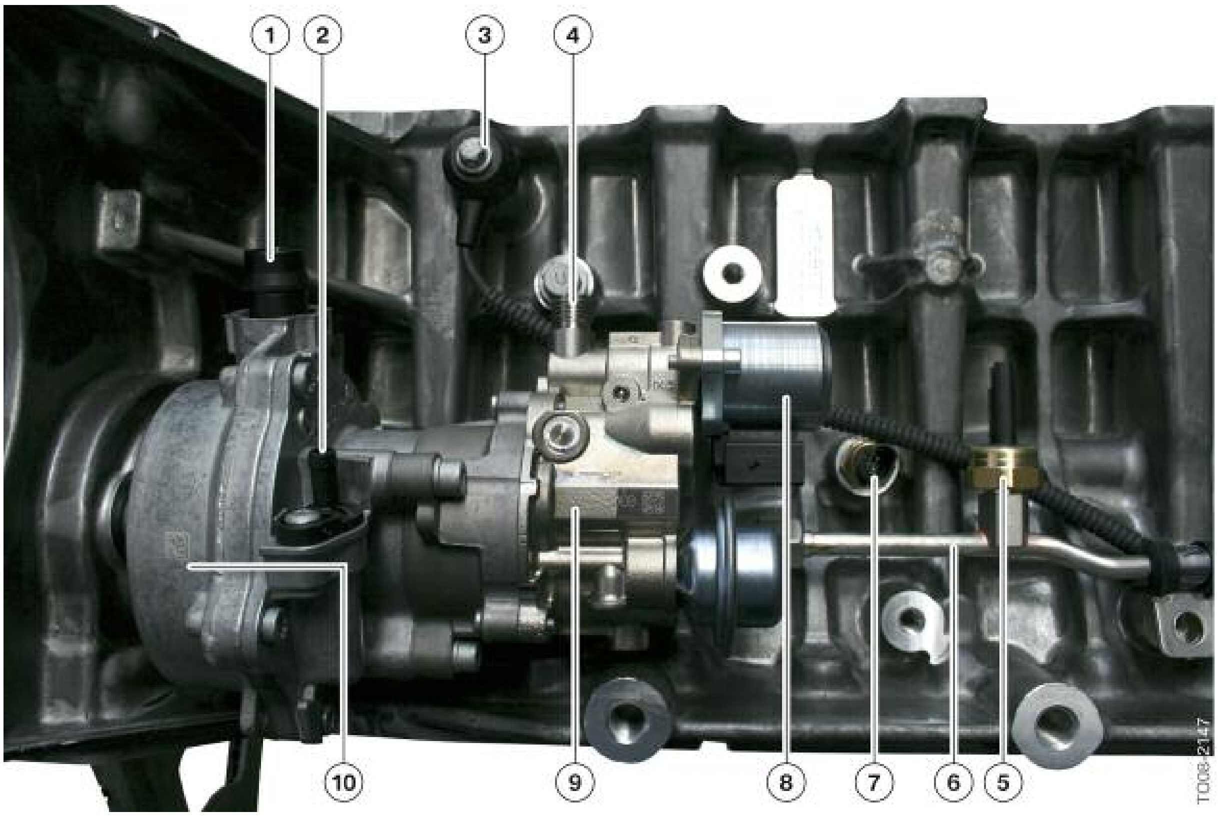

| Index | Explanation |
|---|---|
| 1 | High pressure line |
| 2 | Rail |
| 3 | High pressure line |
| 4 | Fuel rail pressure sensor |
| 5 | Solenoid valve fuel injector |

## Fuel Pressure Sensor

The fuel is supplied at a primary pressure of 5 bar by the electric fuel pump from the fuel tank via the supply line to the high pressure pump. The primary pressure is monitored by the fuel pressure sensor (5). The fuel is delivered by the electric fuel pump corresponding to engine requirements. The fuel pressure sensor known from the N54 and N63 is used.

In the event of the fuel pressure sensor failing, the electric fuel pump continues operation at 100% delivery rate as from terminal 15 ON.

**N55 Engine**

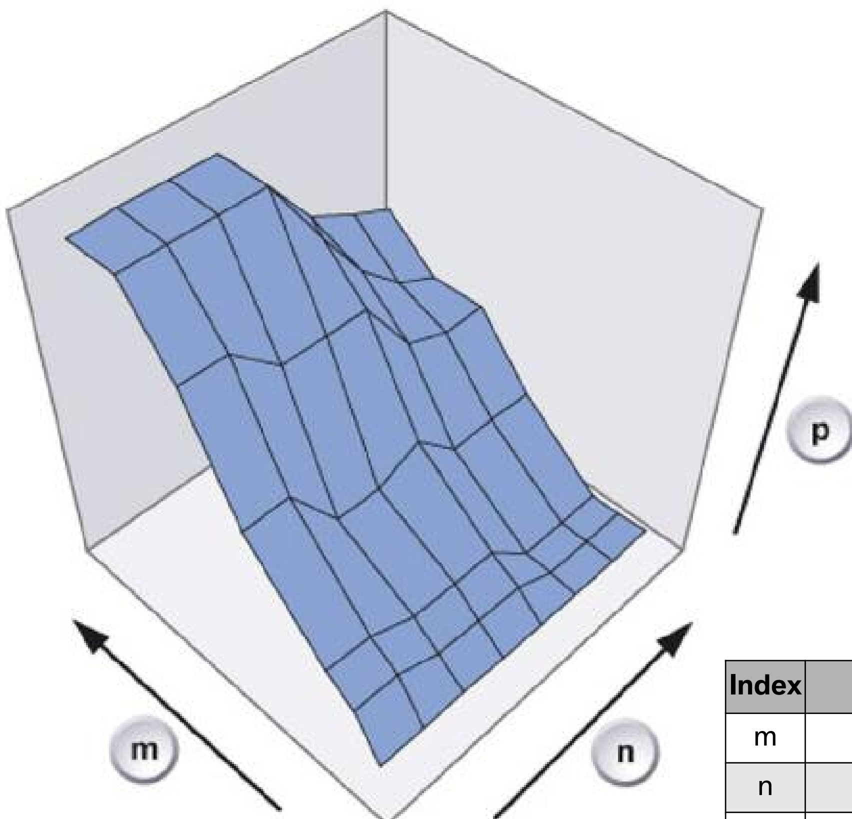



| Index | Explanation | Index | Explanation |
|---|---|---|---|
| 1 | Non-return valve for brake booster | 6 | Fuel supply line |
| 2 | Non-return valve for auxiliary consumers | 7 | Oil pressure sensor |
| 3 | Knock sensor | 8 | Quantity control valve |
| 4 | Connection, high pressure line to fuel rail | 9 | High pressure pump |
| 5 | Fuel pressure sensor | 10 | Vacuum pump |

## High Pressure Fuel Pump

The fuel is pressurized in the permanently driven three-piston high pressure pump and delivered to the fuel rail via the high pressure line. The fuel stored under pressure in the fuel rail is distributed via the high pressure lines to the high pressure fuel injection valves. The required fuel pressure is determined by the engine management as a function of the engine load and engine speed. The pressure level is registered by the rail pressure sensor and sent to the engine control unit. The fuel is regulated by the quantity control valve based on a target/actual value comparison of the rail pressure. The pressure level is configured such to achieve the smoothest running properties with the best possible fuel consumption. A pressure of 200 bar is only required at high load and low engine speed. The high pressure pump is of the same design as the high pressure pump used on the N54 engine.

**N55, fuel pressure diagram**




| Index | Explanation |
|---|---|
| m | Engine Load |
| n | Engine Speed |
| p | Pressure |

**Fuel Injectors**
The high pressure fuel injection valve Bosch HDEV5.2 is a solenoid type injector. In contrast to the piezo-electric injectors used on the current BMW engines, the solenoid valve fuel injectors are designed as inward-opening multi-hole valves with highly variable jet angle and form. They operate at a system pressure of up to 200 bar.

**CAUTION!!!** **Do not open the fuel system if the coolant temperature is above 40°C/104°F. The residual pressure in the high pressure fuel system could cause bodily injury.**

It is essential to observe the utmost cleanliness when working on the high pressure fuel system and to follow the proper working procedures described in the repair instructions. Even minute soiling or damage at the thread connections of the high pressure lines could cause leaks.

**Note: Special tool # 13 0 270 must be used to remove the HDEV5.2 high pressure injector valves from the engine. Damage to the injector or the related components may occur otherwise. See the Service Information section in this training material for more information.**

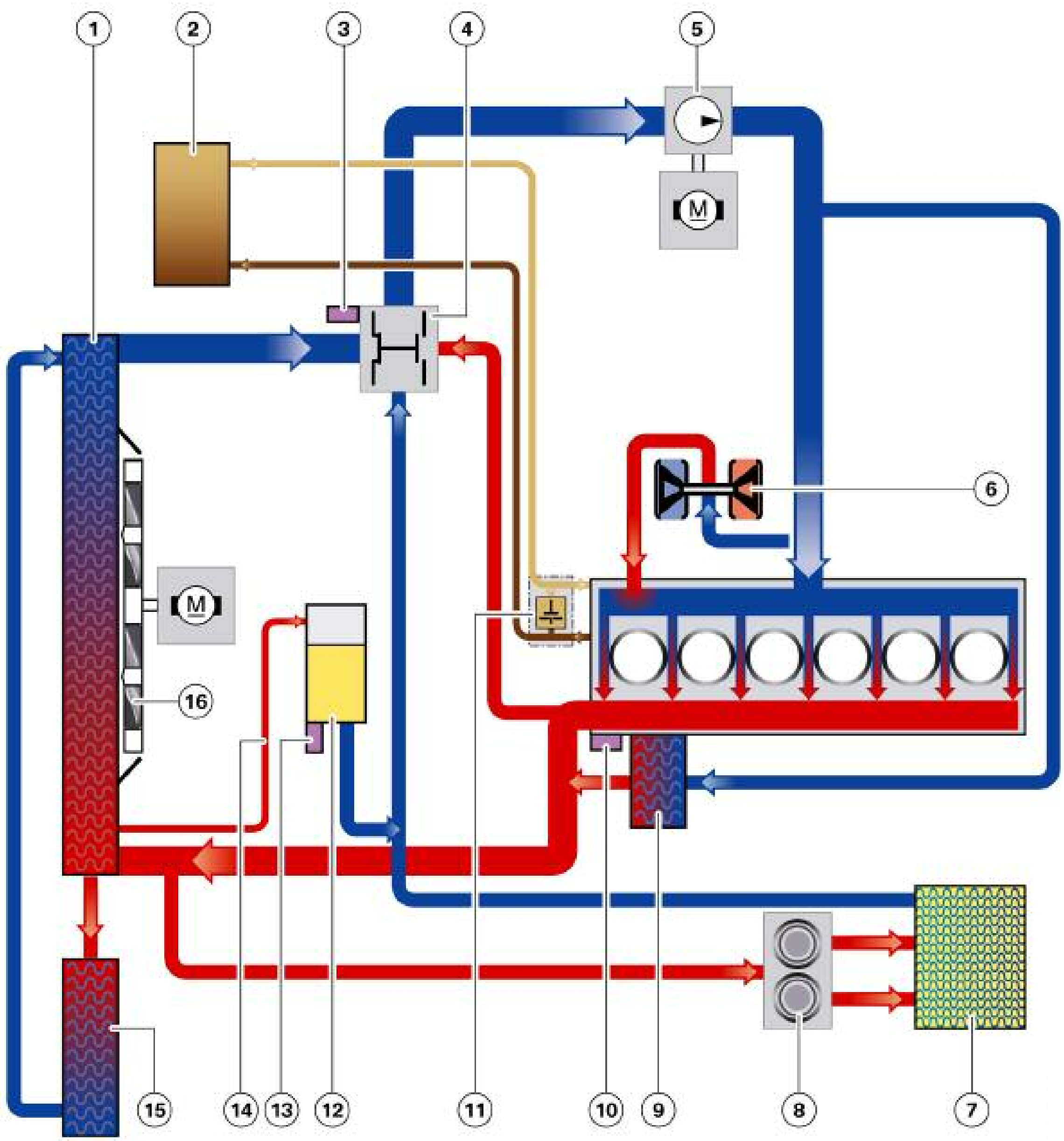
Particular care must be taken when working on the fuel system of the N55 engine to ensure that the ignition coils are not wet with fuel. The resistance of the silicone insulating material of the coils is greatly reduced by the contact with fuel. This could result in arcking at the top of the spark plug and misfiring. See the Service Information section and repair instructions for more information.

# Cooling System

The cooling system of the N55 is enhanced with additional oil cooling.

Two different types of oil cooling systems are used depending on the model and application. In the “hot climate” version, heat transfer from the engine oil to the engine coolant is avoided by separating the oil cooler from the engine coolant circuit. The other version uses an auxiliary radiator in combination with an oil to coolant heat exchanger bolted to the oil filter housing. The auxiliary radiator enhances cooling efficiency by adding surface area to the cooling system.

**N55, cooling system**

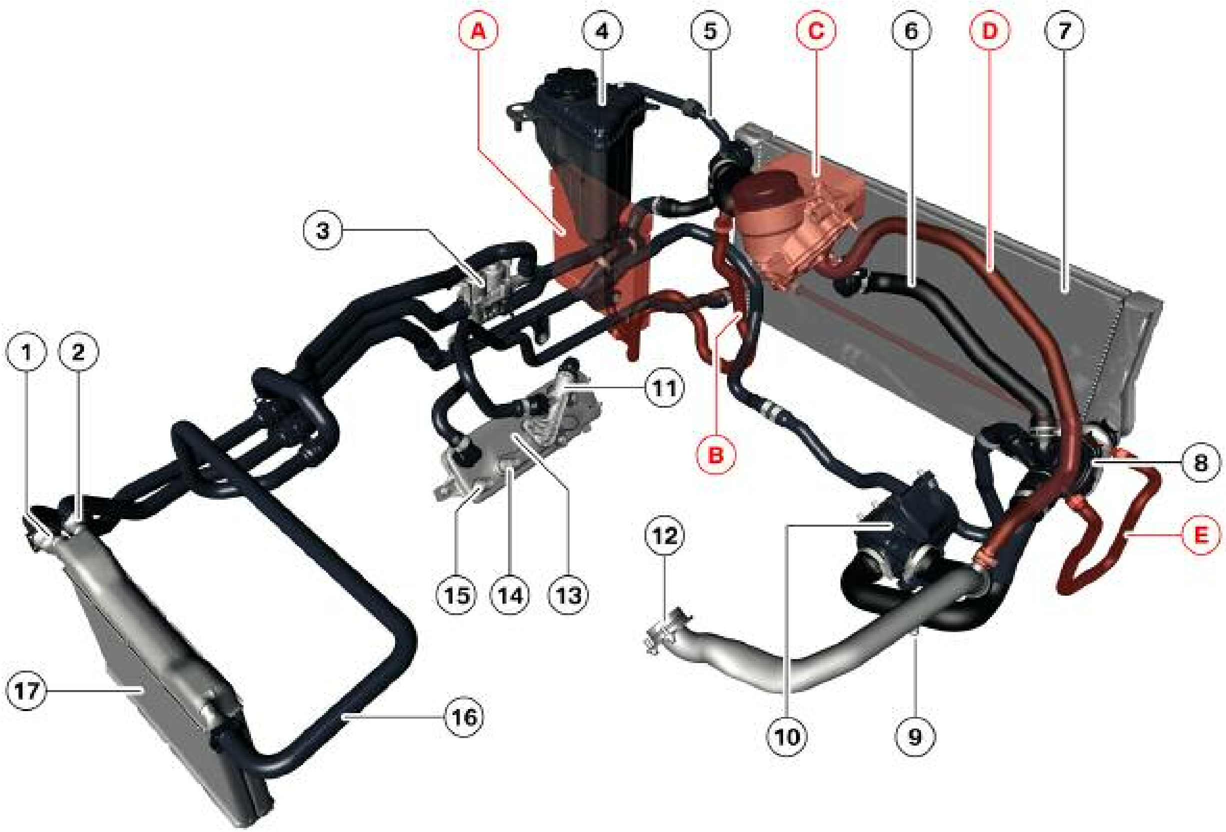


## Legend for N55 cooling system

| Index | Explanation |
|---|---|
| 1 | Radiator |
| 2 | Engine oil to air cooler (hot climate version) |
| 3 | Heater coil |
| 4 | Characteristic map thermostat |
| 5 | Electric coolant pump |
| 6 | Exhaust turbocharger |
| 7 | Heating heat exchanger |
| 8 | Coolant valve |
| 9 | Oil-to-coolant heat exchanger |
| 10 | Coolant temperature sensor |
| 11 | Engine oil thermostat (hot climate version) |
| 12 | Expansion tank |
| 13 | Coolant level switch |
| 14 | Equalization line |
| 15 | Auxiliary radiator |
| 16 | Electric fan |

## Components

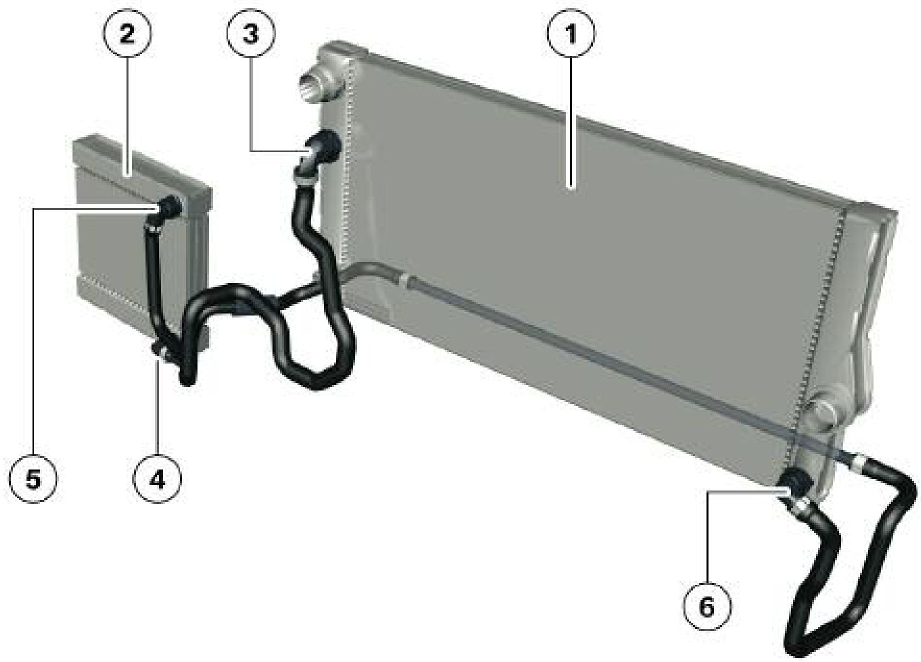
### N55, Cooling System Components




| Index | Explanation | Index | Explanation |
|---|---|---|---|
| A | Auxiliary radiator | 7 | Bypass line for small cooling circuit |
| B | Coolant feed line to auxiliary radiator | 8 | Thermostat |
| C | Oil-to-coolant heat exchanger | 9 | Electric coolant pump |
| D | Coolant feed line to oil-to-coolant heat exchanger | 10 | Exhaust turbocharger supply line |
| E | Coolant return line from auxiliary radiator | 11 | Thermostat for transmission oil cooling |
| 1 | Zone 1 feed line, heating heat exchanger | 12 | Coolant feed line to engine block |
| 2 | Zone 2 feed line, heating heat exchanger | 14 | Transmission oil-to-coolant heat exchanger |
| 3 | Coolant valve | 15 | Connection, transmission oil line |
| 4 | Expansion tank | 16 | Connection, transmission oil line |
| 5 | Equalization line | 17 | Return, heating heat exchanger |
| 6 | Radiator | | |

The following graphic shows the connection of the auxiliary radiator to the cooling system. The auxiliary radiator is connected to the radiator by means of parallel coolant lines, thus increasing the cooling surface area. This system is combined with an oil-to-coolant heat exchanger mounted on the oil filter housing. (See component “C” in the previous graphic.)

**N55, auxiliary radiator**




| Index | Explanation |
|---|---|
| 1 | Radiator |
| 2 | Auxiliary Radiator |
| 3 | Feed connection to the auxiliary radiator |
| 4 | Feed connection at the auxiliary radiator |
| 5 | Return connection to the auxiliary radiator |
| 6 | Return connection from the auxiliary radiator |

**If a separate oil to air cooler is not installed, an auxiliary radiator in conjuction with an oil to coolant heat exchanger is used to cool the engine oil.**

## Oil Cooler

### N55, engine oil cooling, “hot climate”

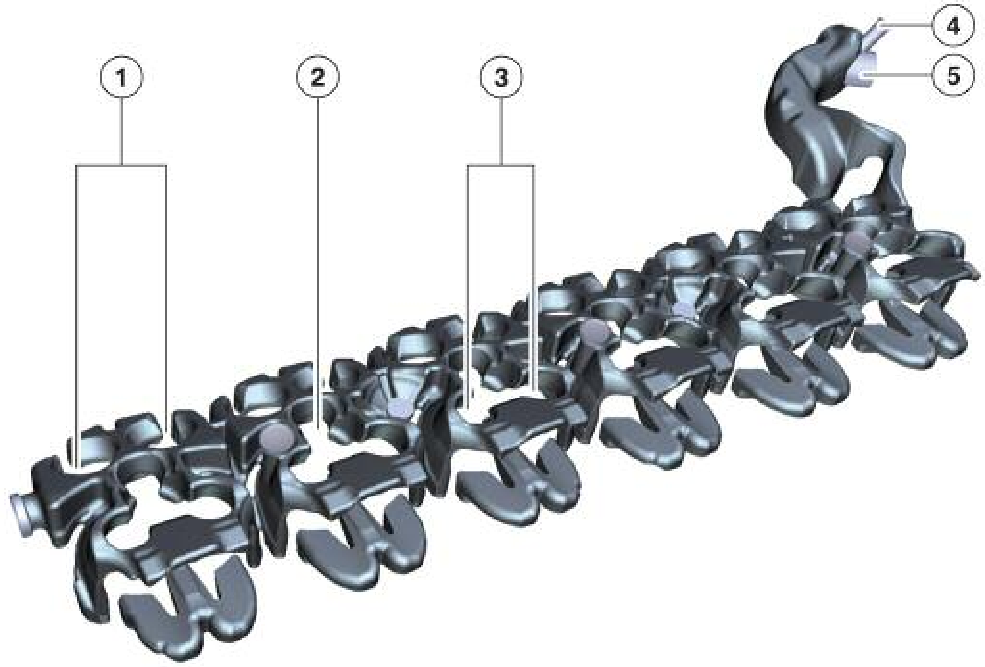

| Index | Explanation |
|---|---|
| 1 | Oil filter module |
| 2 | Thermostat |
| 3 | Oil cooler lines |
| 4 | Engine oil to air heat exchanger (oil cooler) |

**Most current US vehicles use a separate engine oil to air heat exchanger to cool the engine oil (hot climate version).**

## Coolant Passages

The coolant passages in the cylinder head are also used for indirect cooling of the fuel injectors. The following graphic clearly shows that the coolant flows over the valves and the fuel injectors, thus reducing the heat transfer to the components to a minimum.

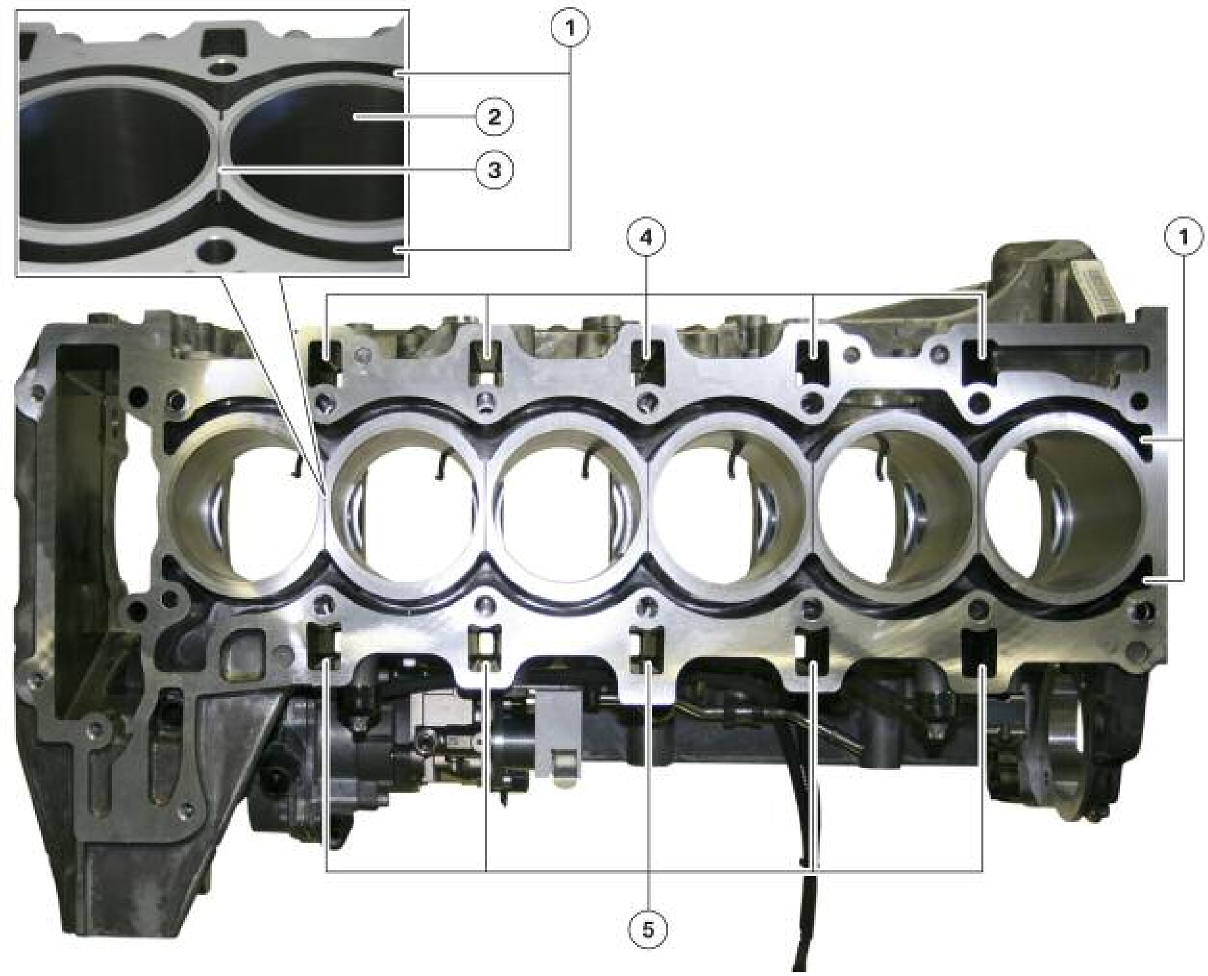
**N55, casting of the coolant passages in cylinder head**




| Index | Explanation |
|---|---|
| 1 | Channel, intake valves |
| 2 | Channel, fuel injectors |
| 3 | Channel, exhaust valves |
| 4 | Connection, coolant hose to thermostat (small cooling circuit) |
| 5 | Connection, coolant hose to radiator (large cooling circuit) |

The cast iron cylinder liners are cast into the aluminum die-casting. The deck area (webs) between the cylinders have grooved coolant passages. Coolant can flow along these grooves from one side of the block to the other, thus cooling the deck area between the cylinders.

**N55, coolant passages and web cooling of the engine block**




| Index | Explanation |
|---|---|
| 1 | Cooling duct |
| 2 | Cylinder liner |
| 3 | Grooved coolant passage |
| 4 | Oil return ducts, exhaust side |
| 5 | Oil return ducts, intake side |

# Service Information

## Cylinder Head

The combination of exhaust turbocharger, VALVETRONIC, and direct fuel injection is referred to as Turbo-VALVETRONIC-Direct-Injection (TVDI).

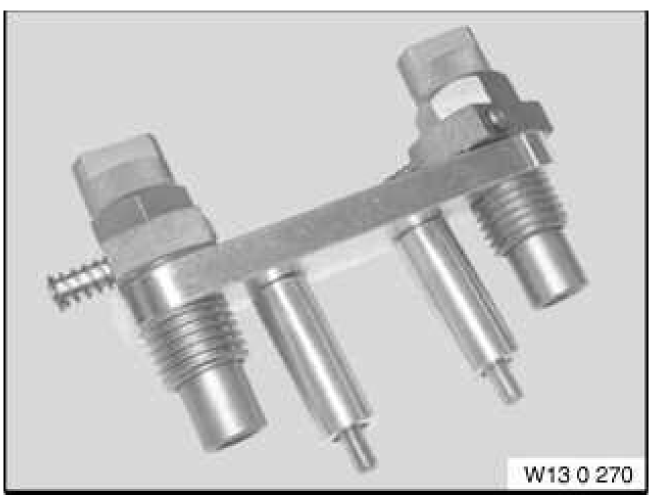
## Cylinder Head Cover

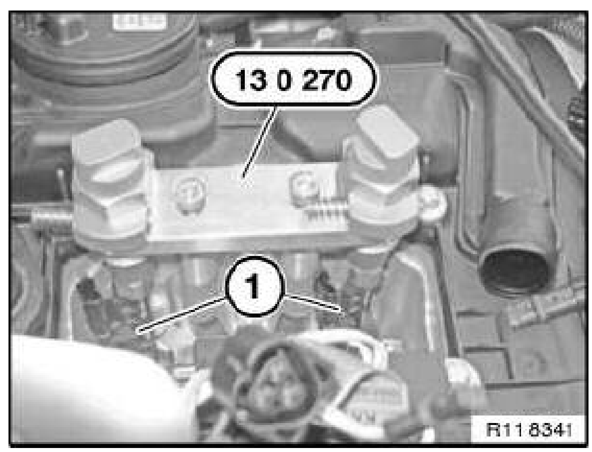
**If a customer complains about high oil consumption and oil is discovered in the turbocharger, it should not be immediately assumed that the turbocharger is defective.**

**If the oil is present in the fresh air pipe after the introduction of the blow-by gasses then the entire engine should be checked for leaks. Defective gaskets or crankshaft seals may be the cause of excessively high blow-by gas output.**

## Fuel Injectors

In order to remove the N55 fuel injectors from the cylinder head, special tool #13 0 270 must be utilized. Failure to use the special tool will result in damage to the injectors.

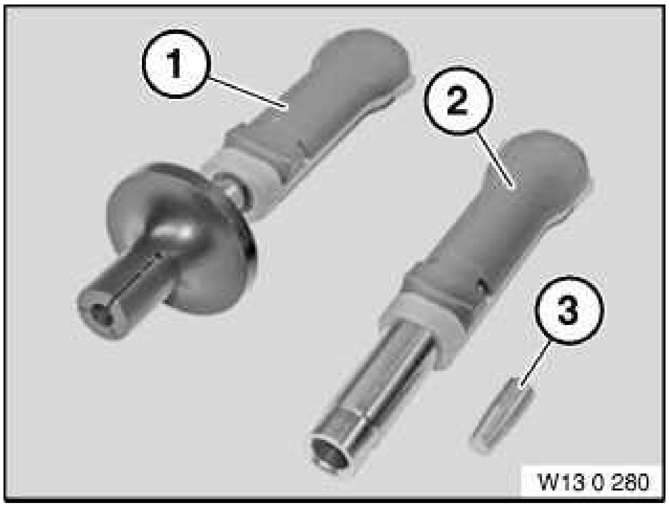


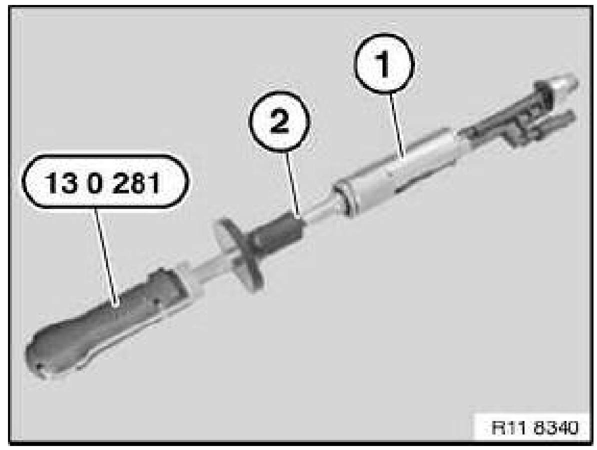




**Do not open the high pressure fuel injection system if the coolant temperature is above 40°C . The residual pressure in the high pressure fuel system could cause bodily injury.**

**It is essential to follow the repair instructions and observe the utmost cleanliness when working on the high pressure fuel system. Even minute soiling or damage at the connections of the high pressure lines and cause leaks.**

There is a new tool # 13 0 280 that must be used when replacing the PTFE seals on the tips of the solenoid valve injectors. As with piezoelectric injectors these seals must be replaced if and when the injectors are being re-installed.



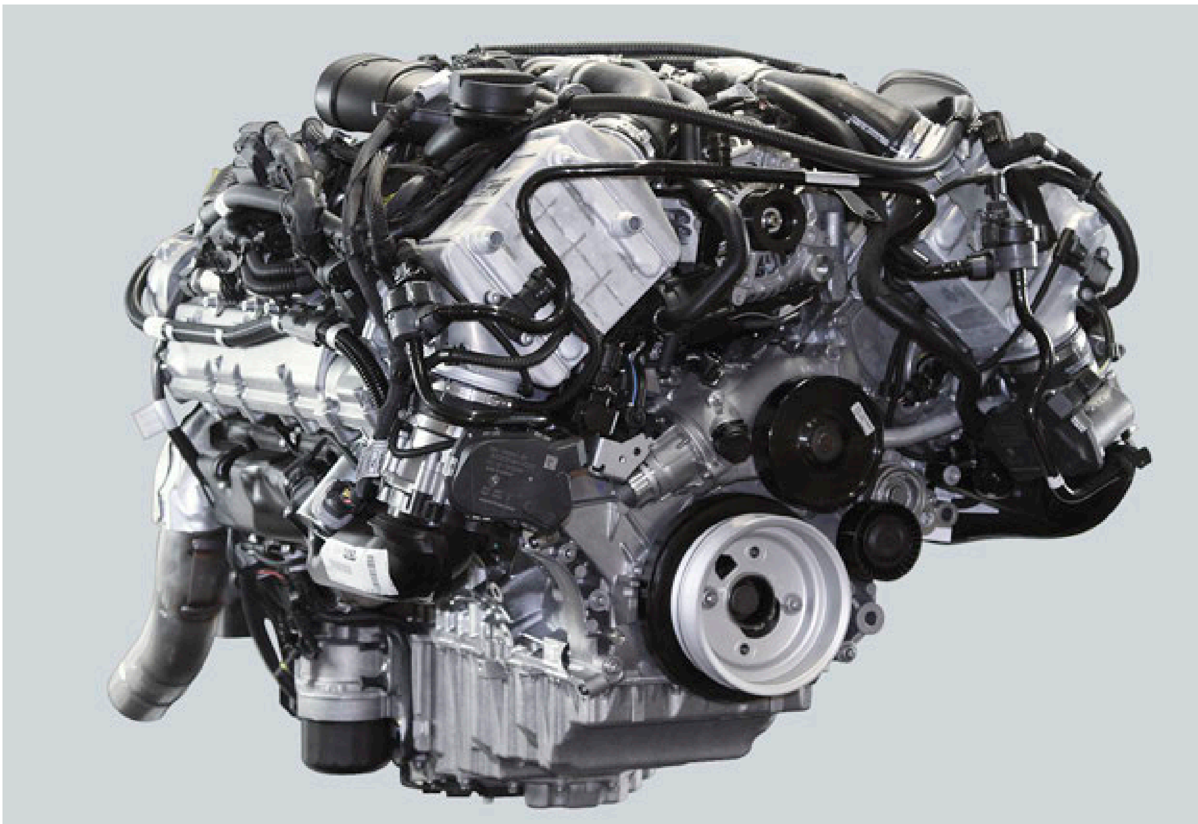

## Ignition Coils

The ignition coils of the N55 have been redesigned for better rigidity and durability. Particular care must be taken when working on the fuel system to ensure that the ignition coils are not wet with fuel. The resistance of the silicone material is greatly reduced by contact with fuel. This could compromise the coils insulation and result in arcking at the top of the spark plug causing a misfire.

- The ignition coils must be removed before working on the fuel system.
- When installing new solenoid valve fuel injectors utmost cleanliness must be observed.
- After removing the ignition coils use a rag to prevent fuel from entering the spark plug well.
- Ignition coils that have been saturated with fuel must be replaced.

# Technical training.
## Product information.

# N63TU Engine



Edited for the U.S. market by:
**BMW Group University**
Technical Training
ST1209 9/1/2012

**BMW Service**

# General notes

### Symbols used

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

⚠

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

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### Information status and national-market versions

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

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

### Additional sources of information

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

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

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The information contained in this document forms an integral element of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the current respective information systems of the BMW Group for any changes/additions to the technical data.

Information status: **April 2012**
**VH-23/International Technical Training**

# N63TU Engine
## Contents

# N63TU Engine
## Contents

# N63TU Engine
# 1. Introduction

The N63TU engine is the predecessor to the N63. The further developed N63TU engine is the latest fuel-mixture generation technology Turbo-Valvetronic Direct Injection TVDI. There are strong similarities here to the N20 or N55 engines. The new engine boasts better performance data at reduced fuel consumption and $CO_2$ emissions.

This training material describes the differences to the N63 engine.

## 1.1. Models

| Development series | N63B44O1 | Series introduction |
|---|---|---|
| F01 | BMW 750i<br>BMW 750i xDrive | 07/2012 |
| F02 | BMW 750Li<br>BMW 750Li xDrive | 07/2012 |
| F06 | BMW 650i<br>BMW 650i xDrive | 07/2012 |
| F07 | BMW 550i<br>BMW 550i xDrive | 07/2012 |
| F12 | BMW 650i<br>BMW 650i xDrive | 07/2012 |
| F13 | BMW 650i<br>BMW 650i xDrive | 07/2012 |

## 1.2. Technical data

| | Unit | N63B44O0 | N63B44O1 |
|---|---|---|---|
| Development series | | F01 | F01 LCI |
| Model designation | | BMW 750i | BMW 750i |
| Design | | V8 | V8 |
| Displacement | [cm³] | 4395 | 4395 |
| Firing order | | 1-5-4-8-6-3-7-2 | 1-5-4-8-6-3-7-2 |
| Bore/Stroke | [mm] | 89/88.3 | 89/88.3 |
| Power output<br>at engine speed | [kW] (HP)<br>[rpm] | 300 (400)<br>5500 - 6400 | 330 (445)<br>5500 - 6000 |
| Cutoff speed | [rpm] | 6500 | 6500 |
| Power output per liter | [kW (HP) x l] | 68.3 (90.9) | 75.1 (102) |
| Torque<br>at engine speed | [Nm] (lb-ft)<br>[rpm] | 600 (400)<br>1750 - 4500 | 650 (480)<br>2000 - 4500 |
| Compression ratio | [ε] | 10.0 | 10.0 |
| Valves per cylinder | | 4 | 4 |
| Fuel rating | [RON] | 95 | 98 |

# N63TU Engine
## 1. Introduction

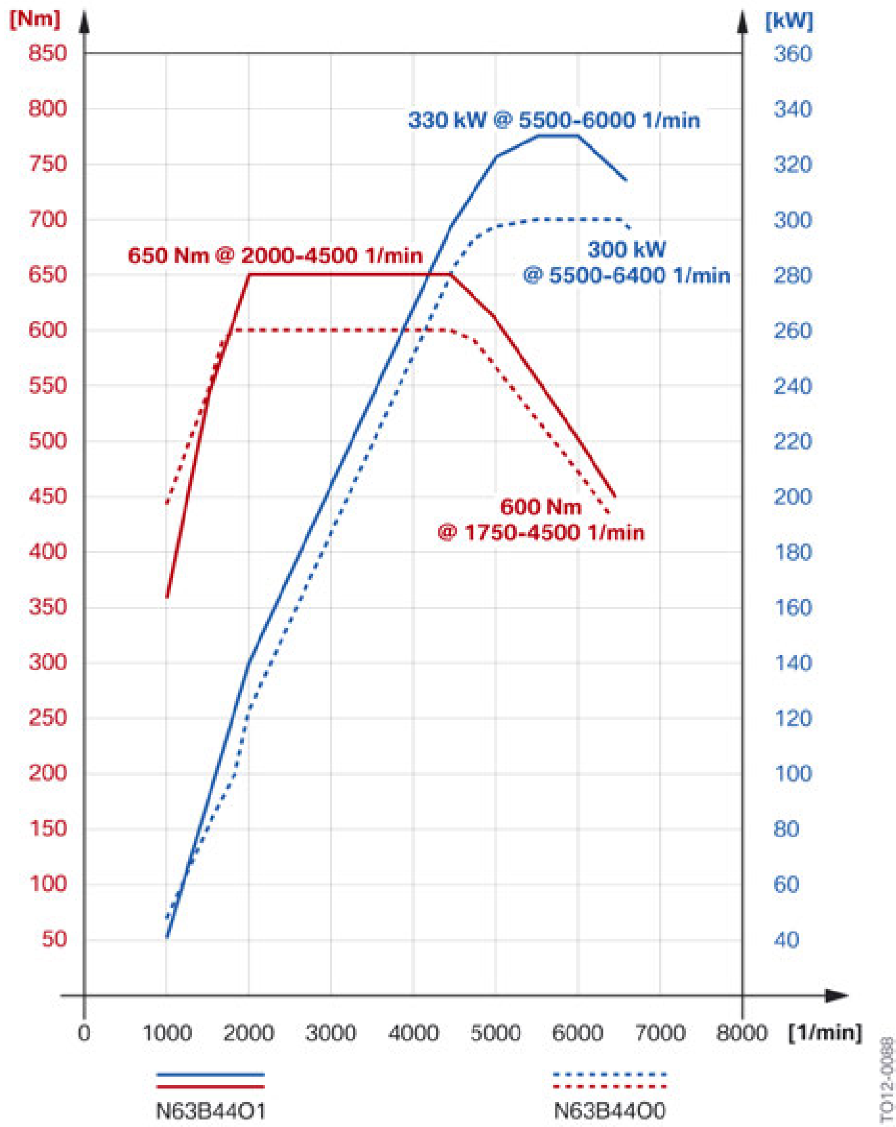
| | Unit | N63B44O0 | N63B44O1 |
|---|---|---|---|
| Fuel | [RON] | 91 - 98 | 91 - 98 |
| Fuel consumption complying with EU | [l/100 km] | 11.4 | 8.6 |
| $CO_2$ emissions | [g/km] | 266 | 199 |
| Digital Engine Electronics (DME) | | MSD85 | MEVD17.2.8 |
| Exhaust emissions legislation | | EURO 5 (ULEV II) | EURO 5 (ULEV II) |
| Maximum speed | [km/h (mph)] | 250 (155) | 250 (155) |
| Acceleration 0–100 km/h/62mph | [s] | 5.2 | 4.8 |
| Vehicle curb weight DIN/EU | [kg] | 1945/2020 | 1940/2015 |

# N63TU Engine

# 1. Introduction

### 1.2.1. Full load diagram

**BMW N63/N63TU in the F01**




Full load diagram comparing N63B44O0 engine with N63B44O1 engine

## 1.3. New features/Changes

The following table provides an overview of the changes to the N63 engine.

# N63TU Engine
## 1. Introduction

| System | Comment |
|---|---|
| Engine mechanical | • New cylinder head due to use of the Turbo Valvetronic Direct Injection (TVDI) procedure<br>• 3rd generation Valvetronic<br>• New valvetrain with modified timing<br>• Adoption of VANOS from the N55 engine<br>• New cylinder head cover with adapted crankcase ventilation<br>• Pistons with modified piston crown geometry<br>• New connecting rod with even pitch and adaptation of the crankcase due to modified connecting rod shape<br>• Adapted crankshaft<br>• Chain drive with modified guide rails and an extruded chain with 142 elements. |
| Oil supply | • Pendulum slide cell pump with small overall width<br>• Eight individual oil spray nozzles for piston crown cooling. |
| Cooling | • Integration of the two engine control units in the low-temperature circuit and cooling over the back panel with cooling pipe<br>• Expansion tank under the left side wall with separate filling hopper. |
| Intake and exhaust emission systems | • Adaptation of the manifold for the air intake duct due to new geometry of the cylinder head cover<br>• Use of the hot film air mass meter 7<br>• Adoption of the charge air temperature and intake-manifold pressure sensor from the N20 engine<br>• Exhaust turbocharger with new compressor and modified wastegate valves<br>• Discontinuation of the blow-off valves. |
| Vacuum system | • Two-stage vacuum pump with new arrangement of the bolt connection<br>• Vacuum reservoir for the wastegate valves in the V-area of the engine. |
| Fuel preparation | • Use of the known high-pressure injection with injectors and high pressure pump HDP5<br>• Discontinuation of fuel low-pressure sensor |
| Engine management system | • New dual control unit concept with one control unit per bank<br>• Oil level sensor with an additional temperature sensor in the main oil duct behind the starter motor. |

# N63TU Engine
# 1. Introduction

## 1.4. Engine identification

### 1.4.1. Engine designation

The version N63B44O1 of the N63TU engine is described in this document.

The engine designation in the technical documentation, is used to ensure clear identification of the engine.

The technical documentation also contains the short form of the engine designation N63TU, which only indicates the engine type.

**Itemization**

| Index | Explanation |
|---|---|
| **N** | BMW Group "New Generation" |
| **6** | V8 engine |
| **3** | Engine with exhaust turbocharger, Valvetronic and direct fuel injection (TVDI) |
| **B** | Gasoline engine, longitudinally installed |
| **44** | 4.4 liters displacement |
| **O** | Upper performance class |
| **1** | First revision |

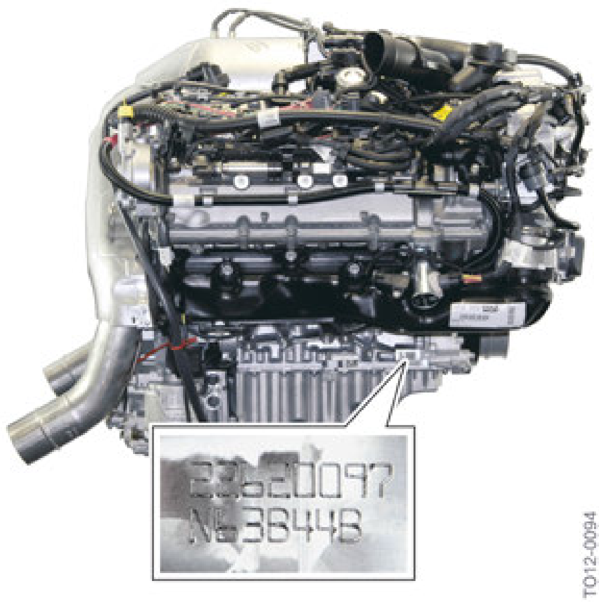
### 1.4.2. Engine identification

The engines have an identification mark on the crankcase to ensure clear identification and classification. This engine identification is necessary for approval by government authorities. The first six digits of the engine identification correspond to the engine designation.

The engine serial number can be found on the engine above the engine identification. This consecutive (serial) number, in conjunction with the engine identification, permits clear identification of each individual engine.

# N63TU Engine

## 1. Introduction




N63TU engine identification and engine number on the right front of the engine

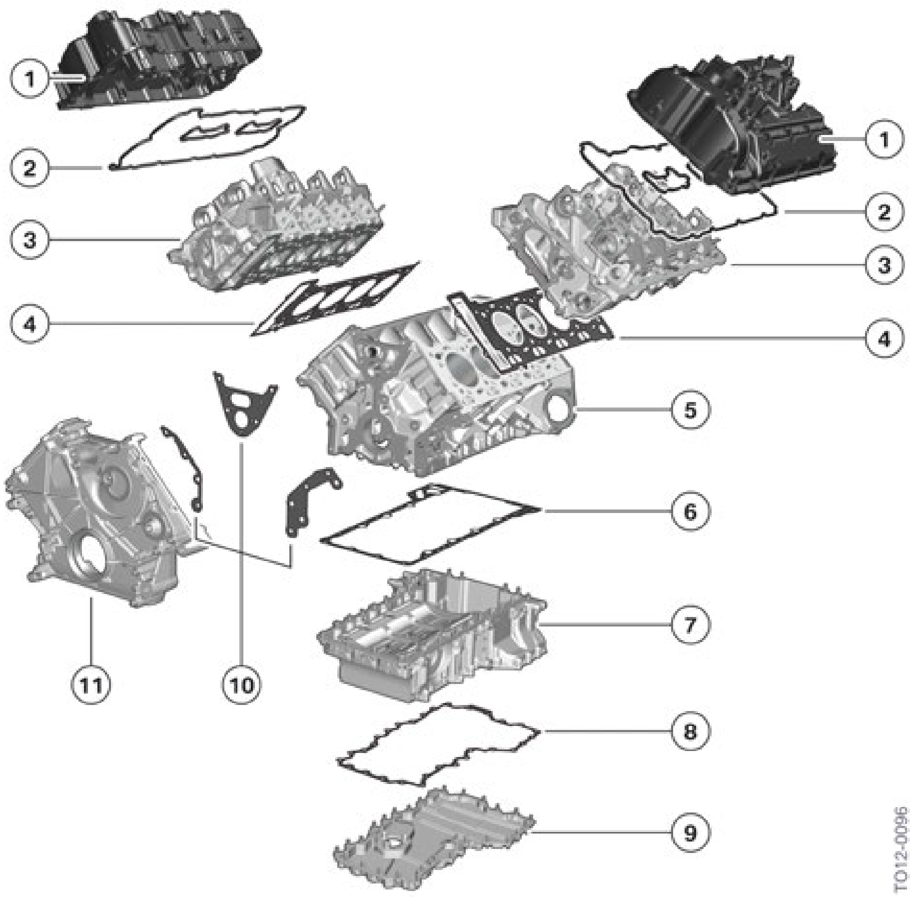
| Index | Explanation |
|---|---|
| 22620097 | Individual consecutive (serial) engine number |
| N | BMW Group "New Generation" |
| 6 | V8 engine |
| 3 | Engine with exhaust turbocharger, Valvetronic and direct fuel injection (TVDI) |
| B | Gasoline engine, longitudinally installed |
| 44 | 4.4 liters displacement |
| B | Type test concerns, standard |

# N63TU Engine

## 2. Engine Components

### 2.1. Engine housing

The engine housing is comprised of the engine block, cylinder heads, cylinder head covers, oil sump and the gaskets.




N63TU engine, structure of engine housing

| Index | Explanation |
| --- | --- |
| 1 | Cylinder head cover |
| 2 | Profile seal |
| 3 | Cylinder head |
| 4 | Cylinder head gasket |
| 5 | Crankcase |
| 6 | Gasket for upper oil sump section |
| 7 | Upper oil sump section |

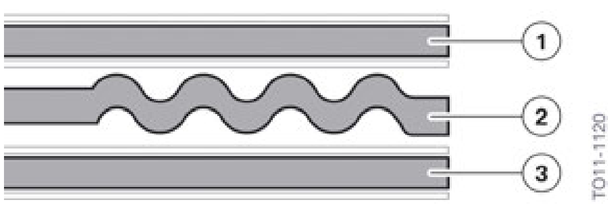
| Index | Explanation |
|---|---|
| 8 | Gasket for oil sump |
| 9 | Oil sump |
| 10 | Gasket |
| 11 | Gear case cover |

### 2.1.1. Crankcase

The crankcase is manufactured from die-cast aluminium GL-AlSi917Cu4MG, as on the N63 engine. The cylinder bores are made from Alusil. The crankcase has been revised as now only connecting rods with an even pitch are used.

### 2.1.2. Cylinder head gasket

A three-layer spring steel gasket is used for the cylinder head gasket. There is a stopper plate (2) in the area of the cylinder bores in order to achieve sufficient contact pressure for sealing. The contact surfaces for the cylinder head and the engine block are layered and have a partial fluorocaoutchouc coating with anti-stick coating.



N63TU engine, cylinder head gasket

| Index | Explanation |
|---|---|
| 1 | Top spring steel layer with anti-stick coating |
| 2 | Stopper layer |
| 3 | Bottom spring steel layer with anti-stick coating |

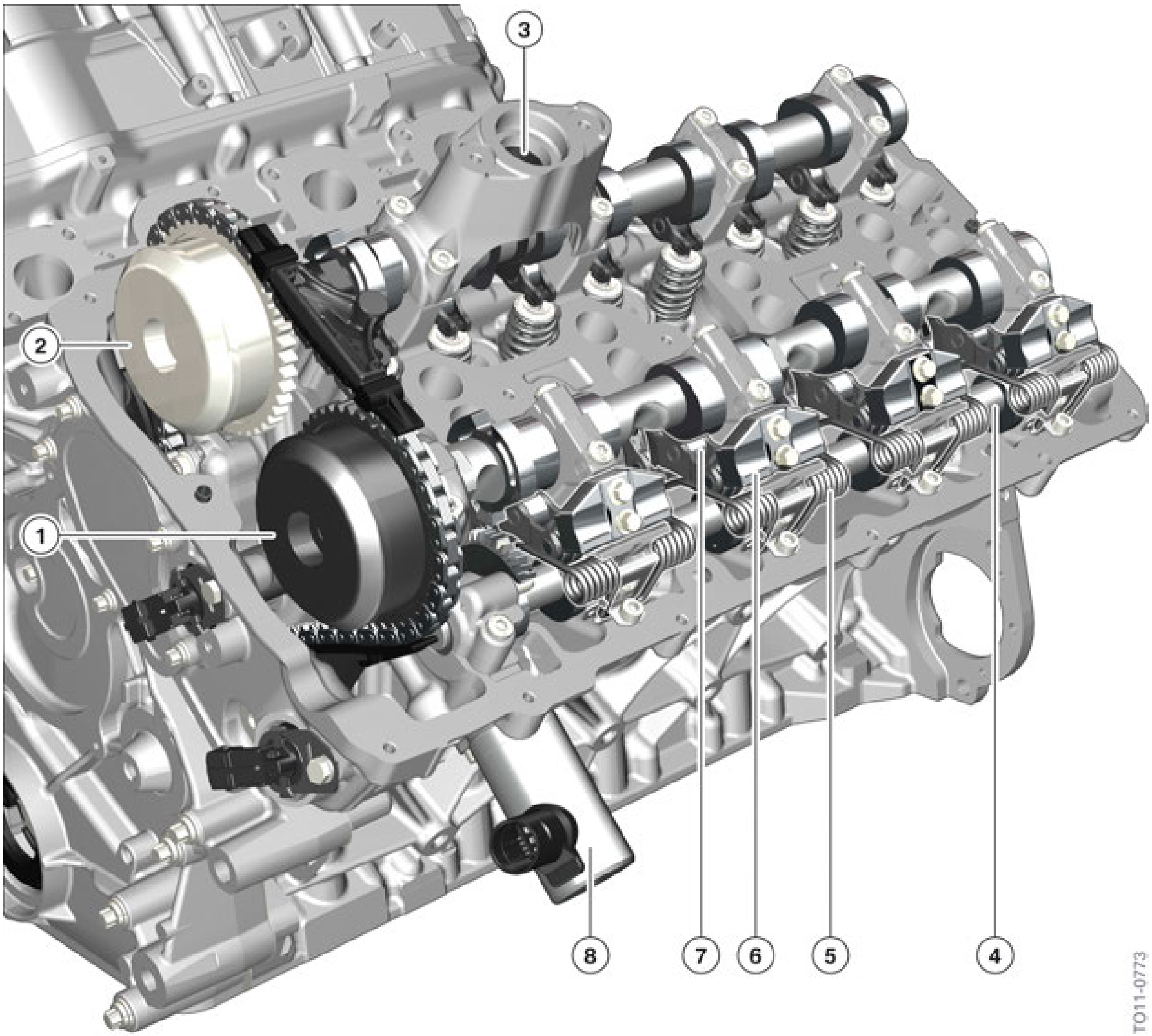
### 2.1.3. Cylinder head

The cylinder head of the N63TU top engine is a new development with integrated air ducts for the crankcase ventilation in the intake area.

3rd generation Valvetronic technology (from the N55 engine) is also used in the N63TU top engine. Although in this case the Valvetronic servomotor is mounted on the outer side at the cylinder head.

The combination of exhaust turbocharger, Valvetronic and direct fuel injection is known as **T**urbo **V**alvetronic **D**irect **I**njection (TVDI).

## 2. Engine Components




N63TU engine, cylinder head with Valvetronic

| Index | Explanation |
|---|---|
| 1 | VANOS, intake side |
| 2 | VANOS, exhaust side |
| 3 | Roller tappet, high pressure pump |
| 4 | Eccentric shaft |
| 5 | Torsion spring |
| 6 | Gate |
| 7 | Intermediate lever |
| 8 | Valvetronic servomotor |

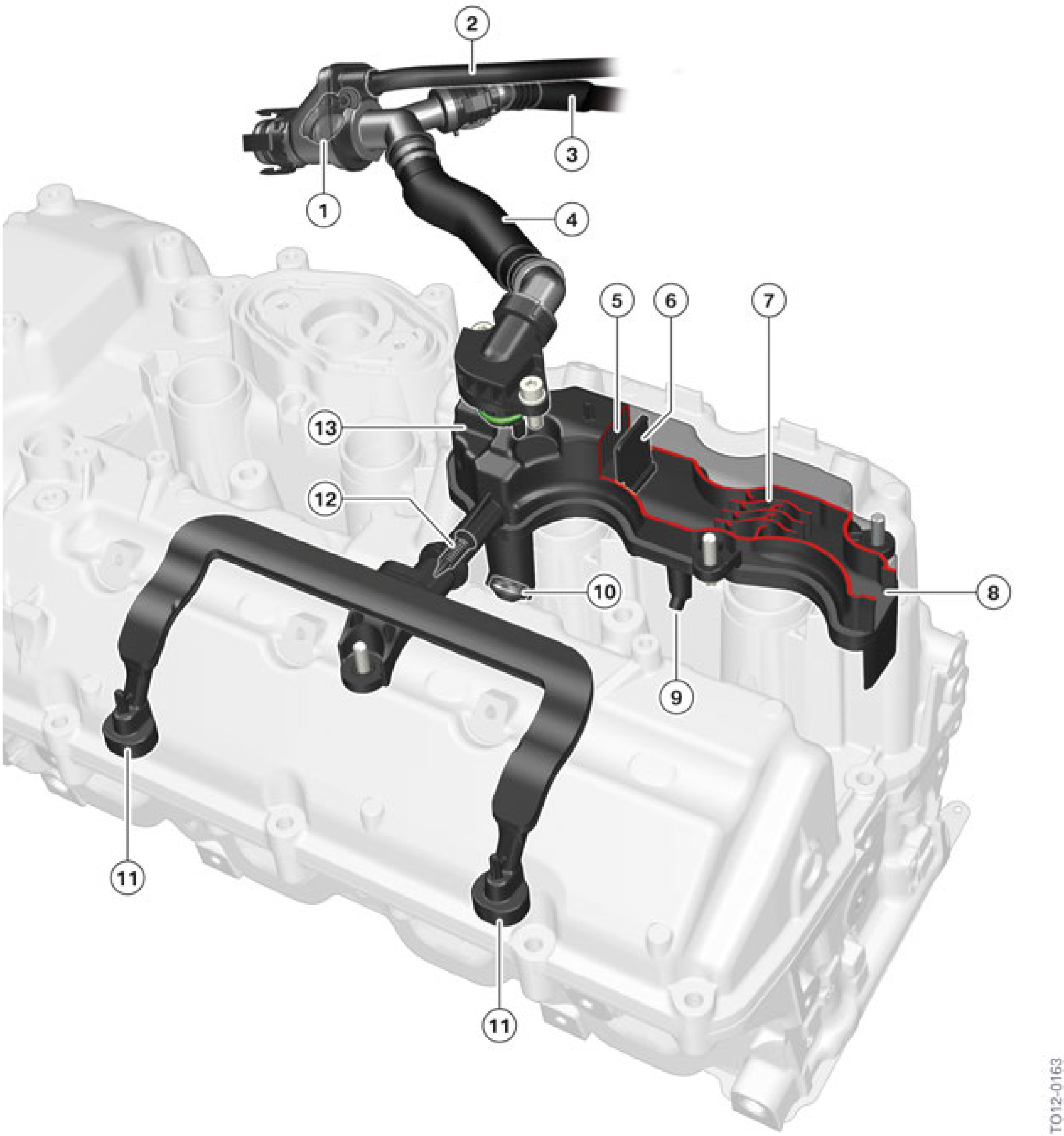
### 2.1.4. Cylinder head cover

#### Design

The cylinder head cover is a new design with adapted crankcase ventilation and line routing. A ventilation register with an additional ventilation line is used. Each bank has its own oil separator. An additional line from the crankcase ventilation to the air intake system is not used as corresponding bore holes for the individual intake ports are integrated in the cylinder head.

The camshaft sensors are positioned on the front of the cylinder head cover.

A labyrinth oil separator is used to separate the oil from the blow-by gas. A pre-separator (7) and a fine separating plate with very small air holes (6) are installed in the flow direction. The oil droplets are separated at these barriers and returned to the cylinder head via the oil return lines (9 and 10). An impact surface (5) with an upstream fine filter mesh ensures further separation of oil particles. The oil return (10) is equipped with a non-return valve in order to prevent direct intake of blow-by gasses without separation. If the oil level increases in this pipe, the non-return valve opens and the oil drops into the cylinder head. Finally the cleaned blow-by gases are fed into the intake system depending on the operating condition of the engine via the non-return valve (1) or via the volume control valves (12 and 3).




N63TU engine, cylinder head cover with crankcase ventilation

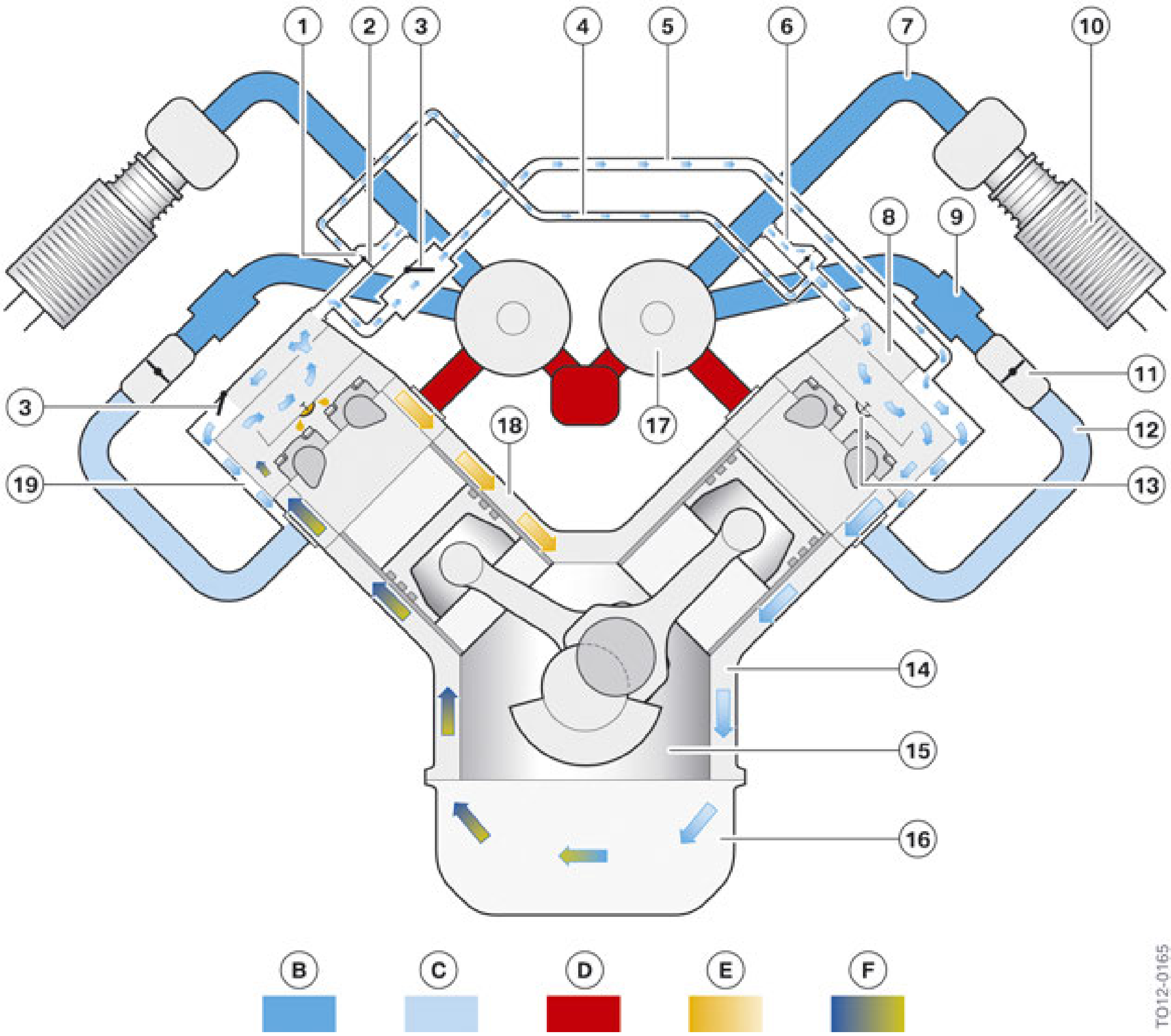
| Index | Explanation |
|---|---|
| 1 | Non-return valve for the clean air pipe with leak hole |
| 2 | Purge air line |
| 3 | Intake pipe with volume control valve |
| 4 | Line to clean air pipe |
| 5 | Impact surface with upstream fine filter mesh |

| Index | Explanation |
|---|---|
| 6 | Fine separating plate with very small air holes |
| 7 | Pre-separator |
| 8 | Inlet for blow-by gases |
| 9 | Oil return |
| 10 | Oil return with non-return valve |
| 11 | Connecting line via blow-by-gas channel for the intake port |
| 12 | Volume control valve for the air intake system with throttle function |
| 13 | Oil separator |

**Crankcase ventilation in naturally aspirated mode**

In the naturally aspirated mode there is vacuum in the air intake system (12). The two volume control valves (3) are opened. The cleaned blow-by gases reach the inlet areas of both banks and thus the air intake system through the left oil separator via the intake pipe (5) and ducts in the cylinder head (19). As there is a risk that oil may be drawn in via the crankcase ventilation in the case of large vacuums, the volume control valve has a throttle function and limits the flow and thus also the pressure level in the crankcase.

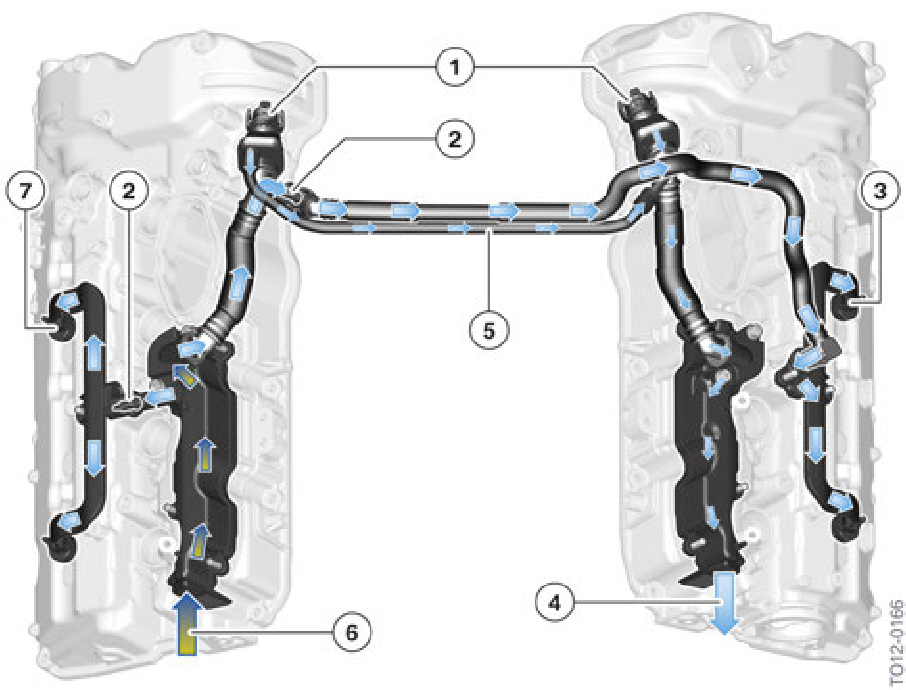
The vacuum in the crankcase ventilation keeps the non-return valves (2 and 6) closed. Fresh air flows from both clean air pipes through the right oil separator into the inside of the engine via the leakage holes. The vacuum in the crankcase ventilation is thus restricted. At the same time the chemical ageing of the lubricating oil and also the water content in the blow-by gases are reduced by flushing the crankcase with fresh air.




N63TU engine, overview of crankcase ventilation in the naturally aspirated engine operation

| Index | Explanation |
|---|---|
| B | Ambient pressure |
| C | Vacuum |
| D | Exhaust gas |
| E | Oil |
| F | Blow-by gases |
| 1 | Leakage hole in the housing of the non-return valve |
| 2 | Non-return valve for the clean air pipe |
| 3 | Volume control valve for the air intake system with throttle function |
| 4 | Purge air line |
| 5 | Intake system from bank 2 to bank 1 |

| Index | Explanation |
|---|---|
| 6 | Line to the clean air pipe with non-return valve and leakage hole |
| 7 | Clean air pipe |
| 8 | Oil separator |
| 9 | Charge air cooler |
| 10 | Intake silencer with hot film air mass meter 7 |
| 11 | Throttle valve |
| 12 | Intake manifold |
| 13 | Oil return |
| 14 | Ventilation duct |
| 15 | Crank chamber |
| 16 | Oil sump |
| 17 | Exhaust turbocharger |
| 18 | Oil return duct |
| 19 | Duct in the cylinder head |

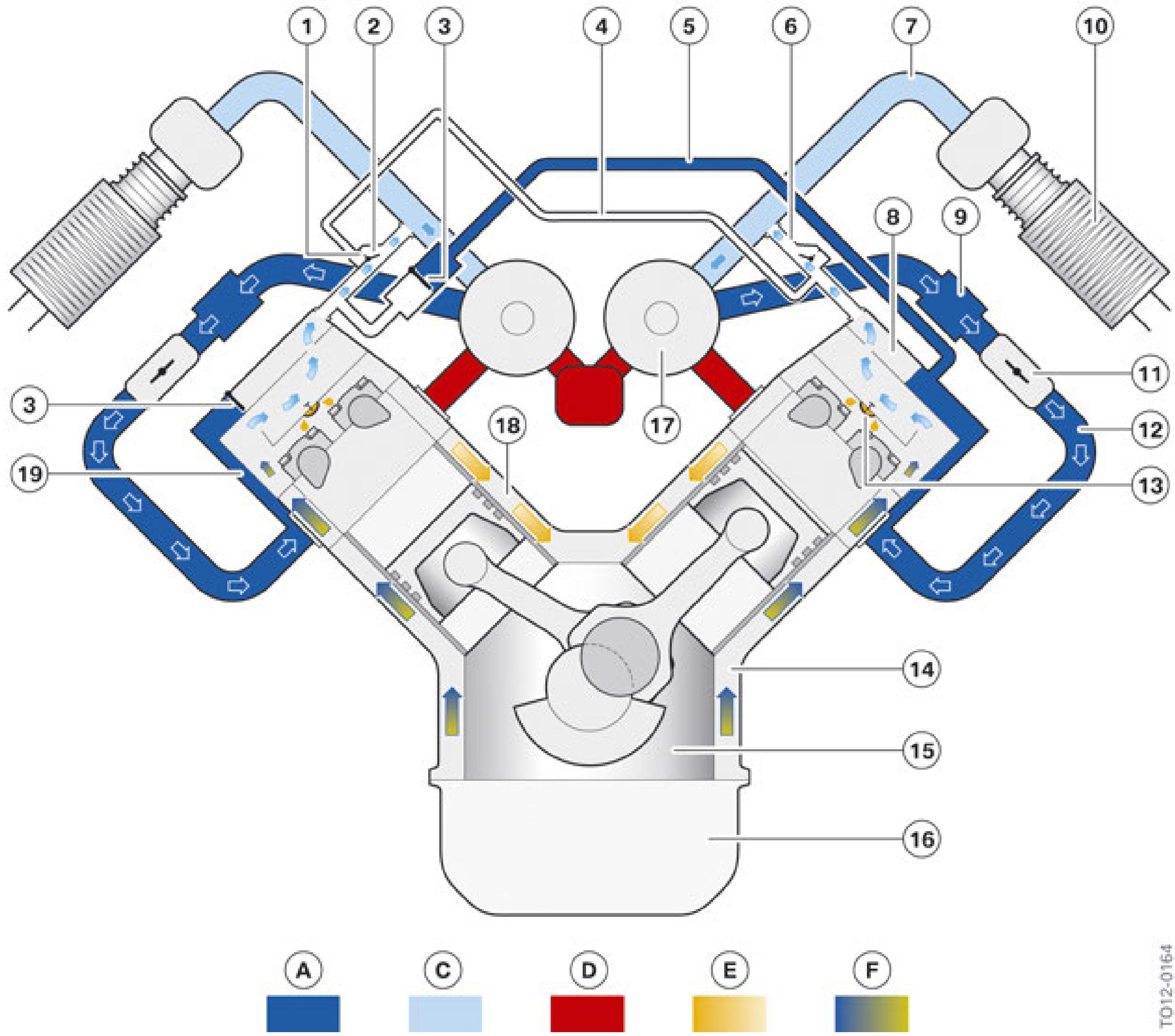



N63TU engine, components of the crankcase ventilation in the naturally aspirated mode

| Index | Explanation |
|---|---|
| 1 | Fresh air supply via leakage holes when non-return valves are closed |
| 2 | Volume control valves open |
| 3 | Inlet of the blow-by gases to the inlet area of the cylinder head |
| 4 | Supply of scavenging air via the oil separator to the crankcase |
| 5 | Purge air line |
| 6 | Intake of blow-by gases to the oil separator |
| 7 | Intake of the cleaned blow-by gases via ducts to the inlet area of the cylinder head |

**Crankcase ventilation in boost mode**

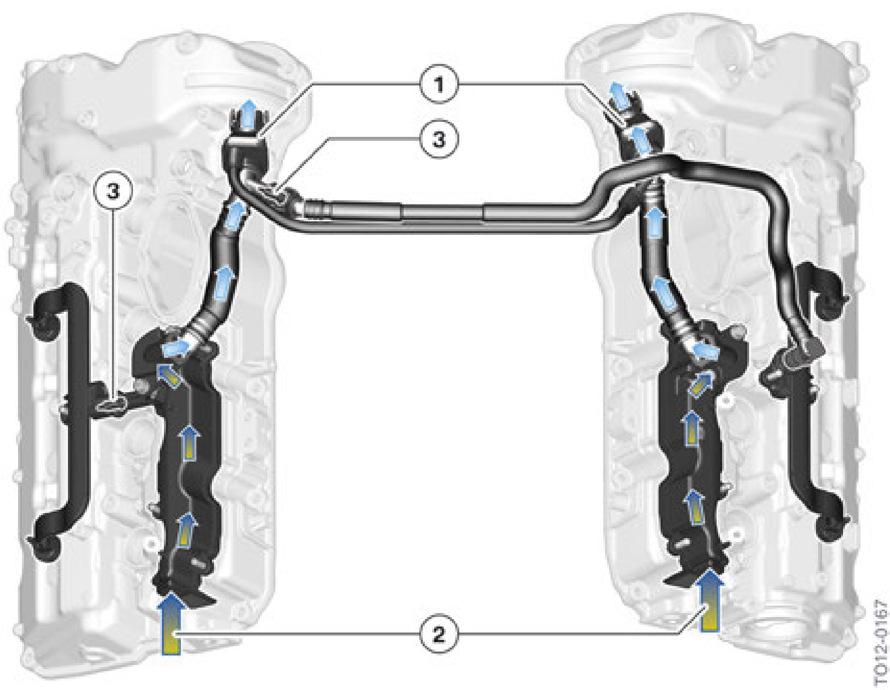
In boost mode the pressure in the intake system (12) increases and thus closes the volume control valves (3). As there is a vacuum in this operating condition in the clean air pipe (7), the non-return valves (2 and 6) for the clean air pipe thus open and the cleaned blow-by gases are sent via the compressor of the turbocharger and the charge air cooler (9) into the air intake system.




N63TU engine, overview of ventilation in boost mode

| Index | Explanation |
|---|---|
| A | Charging pressure |
| C | Vacuum |
| D | Exhaust gas |
| E | Oil |
| F | Blow-by gases |
| 1 | Leakage hole in the housing of the non-return valve |
| 2 | Non-return valve for the clean air pipe open |
| 3 | Volume control valves for the intake system with throttle function, closed |
| 4 | Purge air line |
| 5 | Intake pipe from bank 2 to bank 1 |

| Index | Explanation |
|---|---|
| 6 | Line to the clean air pipe with open non-return valve |
| 7 | Clean air pipe |
| 8 | Oil separator |
| 9 | Charge air cooler |
| 10 | Intake silencer with hot film air mass meter 7 |
| 11 | Throttle valve |
| 12 | Intake system |
| 13 | Oil return |
| 14 | Ventilation duct |
| 15 | Crank chamber |
| 16 | Oil sump |
| 17 | Exhaust turbocharger |
| 18 | Oil return duct |
| 19 | Duct in the cylinder head |



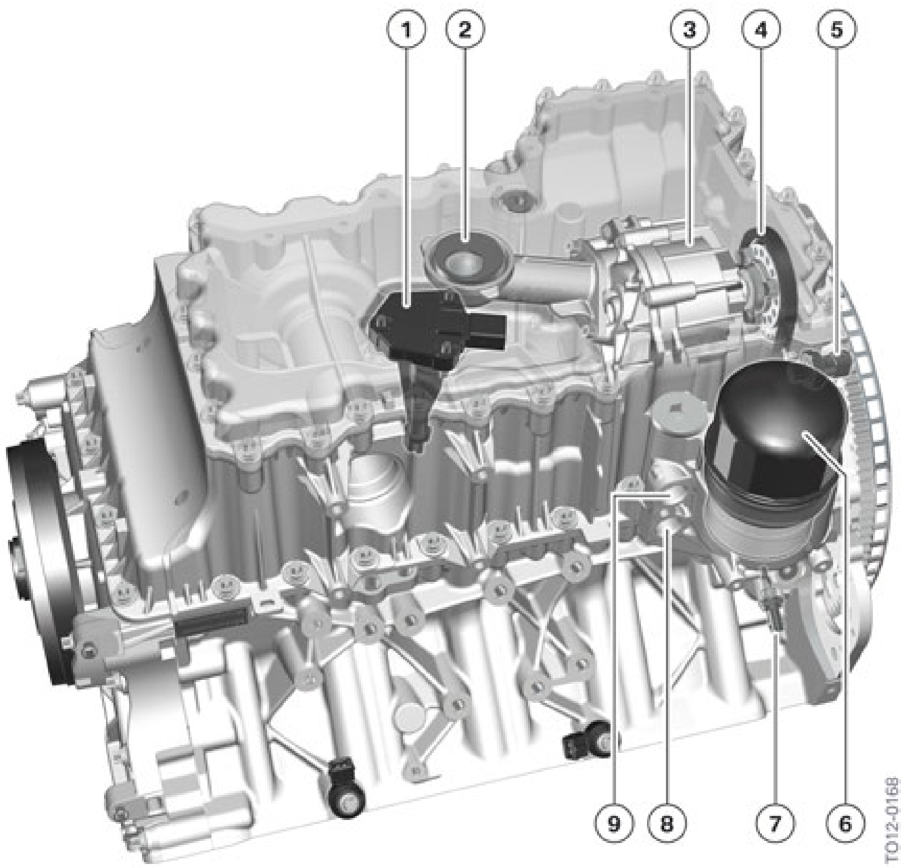

N63TU, components of the crankcase ventilation in boost mode

| Index | Explanation |
|---|---|
| 1 | Non-return valves for the clean air pipe open |
| 2 | Intake of blow-by gases to the oil separator |
| 3 | Volume control valves closed |

### 2.1.5. Oil sump

The oil sump is made from aluminium. It is designed as a one-piece component, known from the N63 engine. The oil filter screen is integrated in the upper oil sump section.

The oil pump is bolted to the upper oil sump section and driven via a chain by the crankshaft. The oil deflector is integrated in the upper oil sump section. The oil drain plug in the oil filter cover is no longer used.

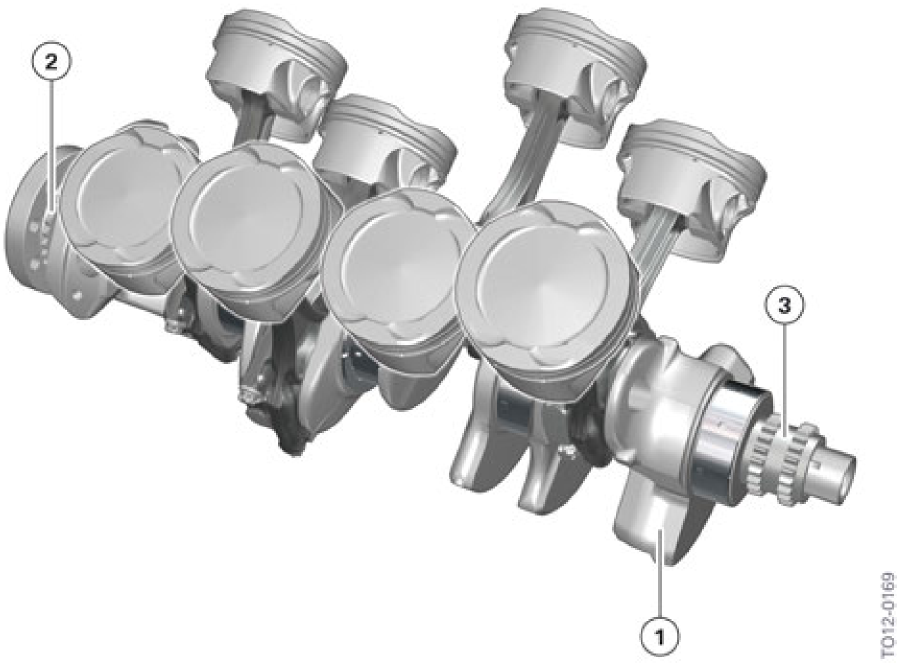



N63TU engine, upper oil sump section with oil pump

| Index | Explanation |
|---|---|
| 1 | Oil level sensor |
| 2 | Intake pipe for the pressure pump |
| 3 | Pendulum slide cell pump |
| 4 | Chain drive of the crankshaft |
| 5 | Oil pressure switch |
| 6 | Oil filter cover without oil drain plug |
| 7 | Oil temperature sensor |
| 8 | Connection from the engine oil cooler |
| 9 | Connection to the engine oil cooler |

## 2.2. Crankshaft drive

The crankshaft with connecting rods and pistons have changed in comparison to the N63 engine. The weight of the crankshaft has been optimized and the connecting rods are no longer diagonal, but have an even pitch. The piston weight was also reduced.




N63TU, crankshaft drive with connecting rod and piston

| Index | Explanation |
|---|---|
| 1 | Crankshaft |
| 2 | Oil pump drive gear |
| 3 | Camshafts drive gear |

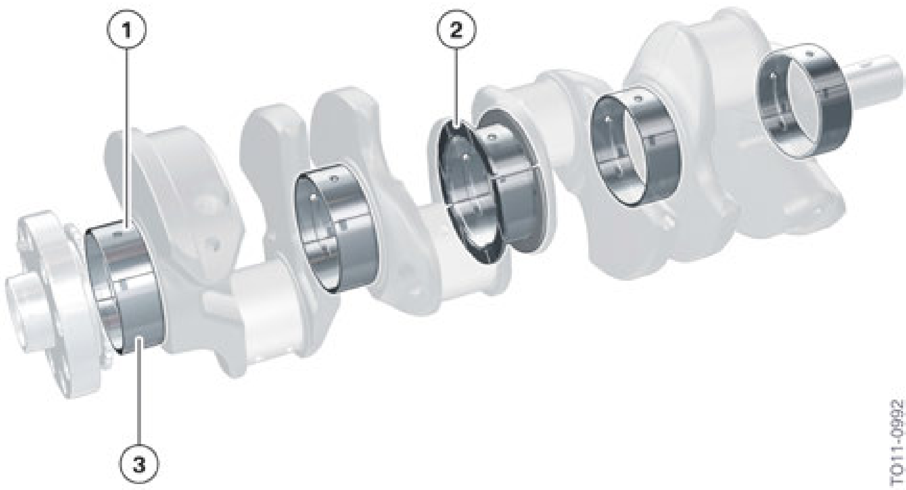
### 2.2.1. Crankshaft with bearings

#### Crankshaft

The crankshaft of the N63TU engine has a stroke of 88.3 mm and is made of the material C38. It is a forged with a hardened surface layer and six balance weights.

#### Crankshaft bearings

The crankshaft is supported by five bearings. The two-material thrust bearing is located in the middle at the third bearing position. Robust lead-free two-material bearings are used.




N63TU, crankshaft bearings

| Index | Explanation |
|---|---|
| 1 | Upper bearing shell with groove and oil hole |
| 2 | Thrust bearing with groove and oil hole |
| 3 | Lower bearing shell without groove |

⚠

The identification markings for the bearings are stamped on the crankcase and on the crankshaft. Please refer to the repair instructions if the crankshaft is to be fitted with new bearings.

### 2.2.2. Connecting rod with bearing

#### Connecting rod

The connecting rod of the N63TU engine has been redesigned. It is a cracked forged connecting rod with even pitch. A shaped bore is fitted in the connecting rod eye. The force acting from the piston via the piston pin is optimally distributed to the bushing surface by this shaped bore and the edge load.

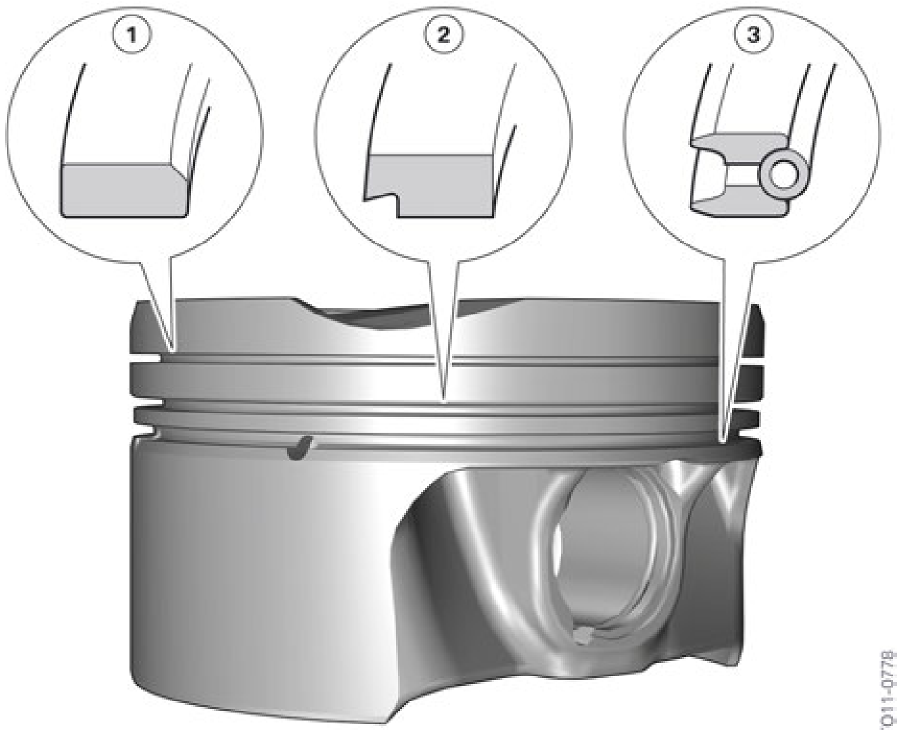

N63TU, cracked connecting rod with even pitch

**Bearings**

The connecting rod bearing shells are lead-free and robust electroplated. The bearing pairs are marked in red/blue. The blue bearing is on the rod side, the red bearing is installed on the cap.

### 2.2.3. Piston with piston rings

Cast pistons with a Mahle piston ring package are used. The piston crown shape is adapted accordingly to the combustion process, the valve positions and the use of the injectors with multiple nozzles. The piston pin was manufactured 3 mm (0.11 in) shorter as a result of the new piston and is now 57 mm (2.24 in) long. The piston weight was reduced by 60 g (2.1 oz) per piston with the new design despite the increased ignition pressure.

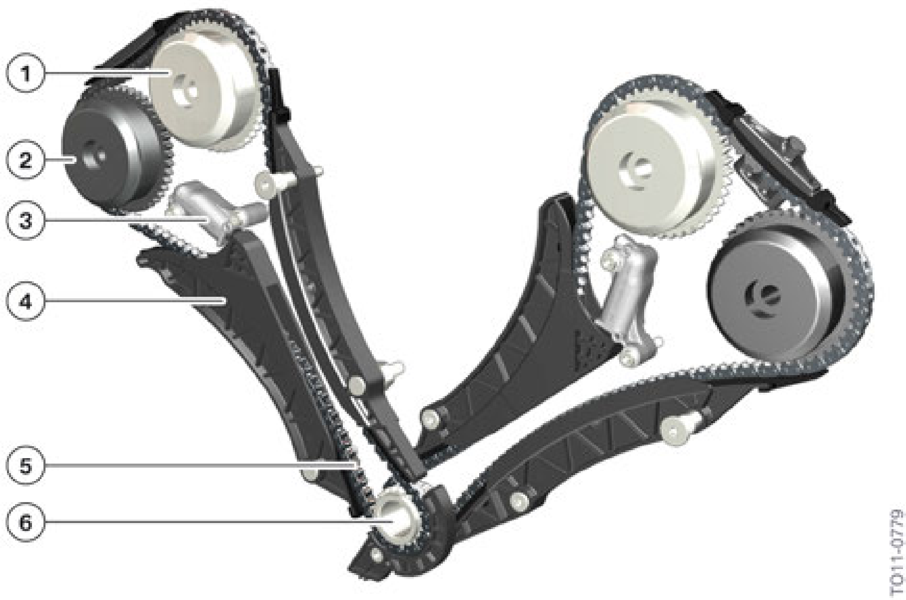



N63TU, cast piston with piston rings

| Index | Explanation |
|---|---|
| 1 | Plain rectangular compression ring with rounded groove (B-ring) |
| 2 | Taper faced piston ring (NM-ring) |
| 3 | Oil scraper ring with spiral expander (DSF-ring) |

### 2.3. Camshaft drive

A toothed roller-type chain with 142 elements is used per bank to drive the camshafts. This is supplied with oil via the oil spray nozzle in the chain tensioner. Tensioning rail, guide and slide rails are now different parts for both banks. The tensioning rail with an integrated thrust piece is made completely from plastic.




N63TU, camshaft drive

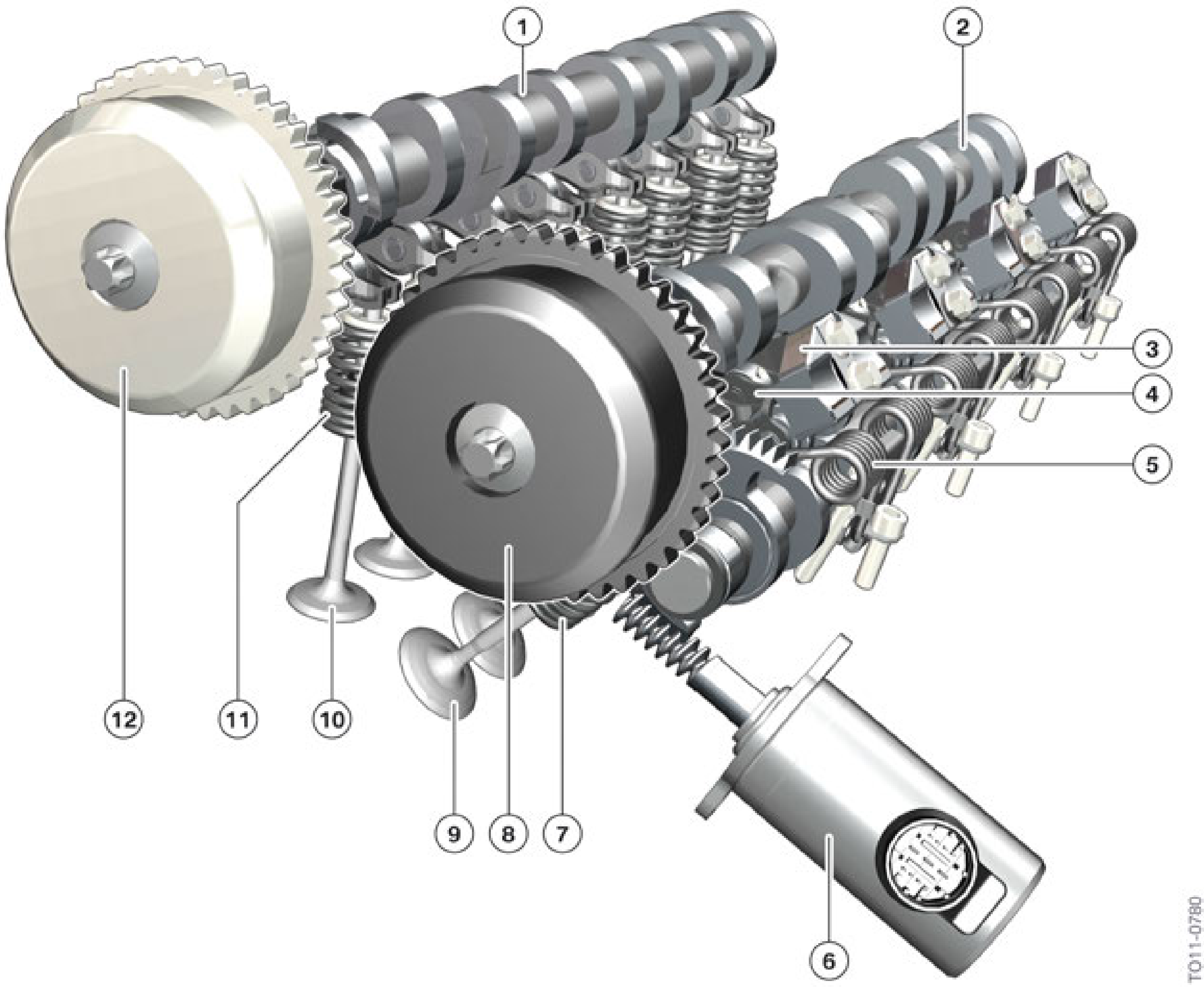
| Index | Explanation |
|---|---|
| 1 | VANOS, exhaust side |
| 2 | VANOS, intake side |
| 3 | Chain tensioner |
| 4 | Tensioning rail |
| 5 | Tooth-type chain |
| 6 | Crankshaft gear |

## 2.4. Valvetrain

### 2.4.1. Design

In the N63TU engine the fully variable valve lift control is also used in addition to double VANOS. The valvetrain itself is comprised of all known components.

# 2. Engine Components

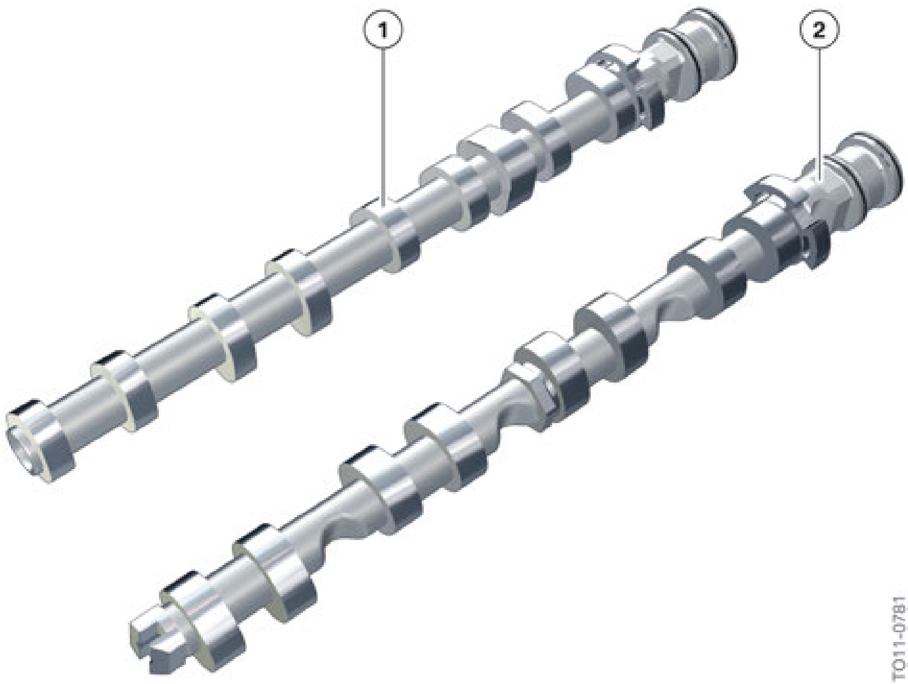



N63TU, valvetrain

| Index | Explanation |
|---|---|
| 1 | Exhaust camshaft |
| 2 | Intake camshaft |
| 3 | Gate |
| 4 | Intermediate lever |
| 5 | Torsion spring |
| 6 | Valvetronic servomotor |
| 7 | Valve spring, intake valve |
| 8 | VANOS, intake side |
| 9 | Intake valve |
| 10 | Exhaust valve |
| 11 | Valve spring, exhaust valve |
| 12 | VANOS, exhaust side |

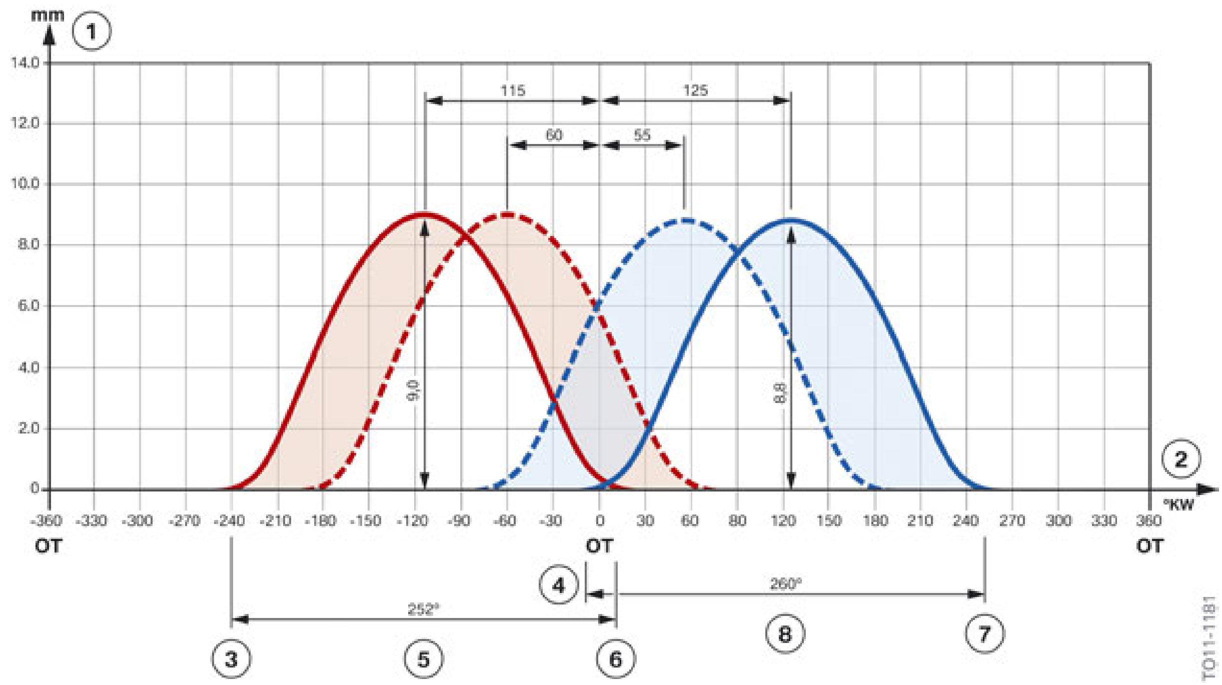
### Camshafts

The N63TU engine uses the same lightweight construction camshafts as N63. These composite camshafts are assembled from individual components (press fitted onto knurled points) rather than machined from an solid blank.




N63TU, assembled camshafts

| Index | Explanation |
|---|---|
| 1 | Exhaust camshaft |
| 2 | Intake camshaft |




N63TU, cam/valve timing diagram

| Index | Explanation |
|---|---|
| 1 | Valve lift [mm] |
| 2 | Crankshaft degrees [°KW] |
| 3 | Exhaust valve open |
| 4 | Intake valve open |
| 5 | Opening period of exhaust valve |
| 6 | Exhaust valve closes |
| 7 | Intake valve closes |
| 8 | Opening period of intake valve |

### Technical data of the valvetrain

| | | N63B44O0 | N63B44O1 |
|---|---|---|---|
| Intake valve diameter / Shaft diameter | [mm] | 33.0/6 | 33.2/6 |
| Exhaust valve diameter / Shaft diameter | [mm] | 29/6 | 29/6 |
| Maximum valve lift, intake / exhaust valve | [mm] | 8.8/9.0 | 8.8/9.0 |
| VANOS adjustment range, intake (camshaft spread) | [crankshaft degrees] | 50 | 70 |
| VANOS adjustment range, exhaust (camshaft spread) | [crankshaft degrees] | 50 | 55 |

| | | | |
|---|---|---|---|
| Intake camshaft opening angle (max.-min. spread) | [crankshaft degrees] | 70 – 120 | 55 – 125 |
| Exhaust camshaft opening angle (max.-min. spread) | [crankshaft degrees] | 64 – 114 (cylinders 2,4,7,8)<br>70 - 120 (cylinders 1,3,5,6) | 60 – 115 |
| Opening period, intake camshaft | [crankshaft degrees] | 231 | 260 |
| Opening period, exhaust camshaft | [crankshaft degrees] | 215 (cylinders 2,4,7,8)<br>231 (cylinders 1,3,5,6) | 252 |

**Intake and exhaust valves**

The intake and exhaust valves both have a shaft diameter of 6 mm. The exhaust valves are hollow and filled with Sodium. This results in improved and quicker heat dissipation.

### 2.4.2. Valvetronic

⚠

The Valvetronic is comprised of fully variable valve lift control and variable camshaft timing control (double VANOS), which makes the closing time of the intake valve freely selectable.

As with pervious Valvetronic engines valve lift control is performed on the intake side, while camshaft control is performed on both the intake and exhaust sides.

Throttle-free load control is only possible if:

- the valve lift of the intake valve and
- the camshaft adjustment of the intake and exhaust camshafts are variably controllable.

Result:

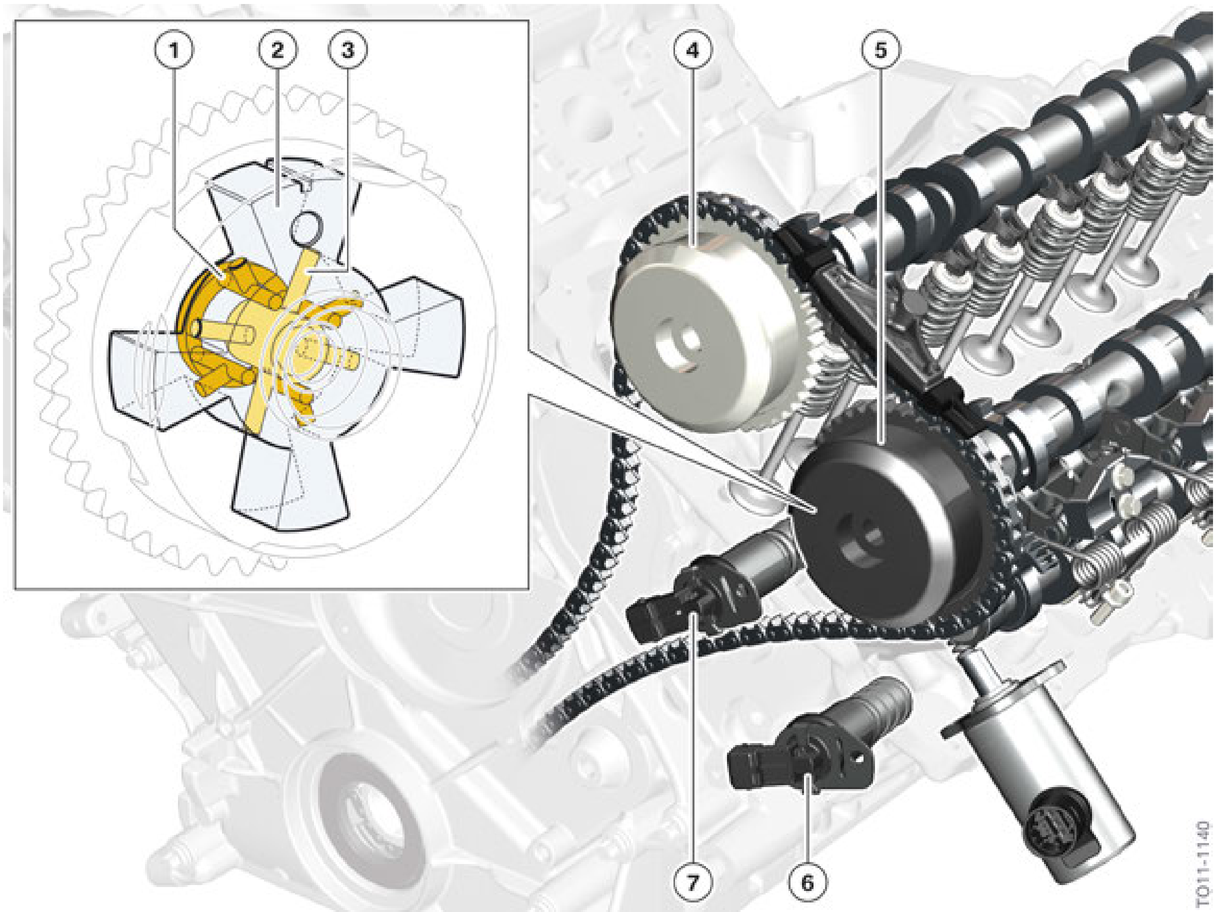
The opening and closing times and thus the opening period and the lift of the intake valve are selectable freely.

**VANOS**

The VANOS (variable camshaft timing control) components known from the N55 engine are used.

In the process:

- The adjustment range of the VANOS was increased from 50° to 70° through the use of four flanks instead of five
- The weight was reduced from 1050 g to 650 g (37 to 22.3 oz) through the use of aluminium instead of steel.




N63TU, VANOS with oil supply

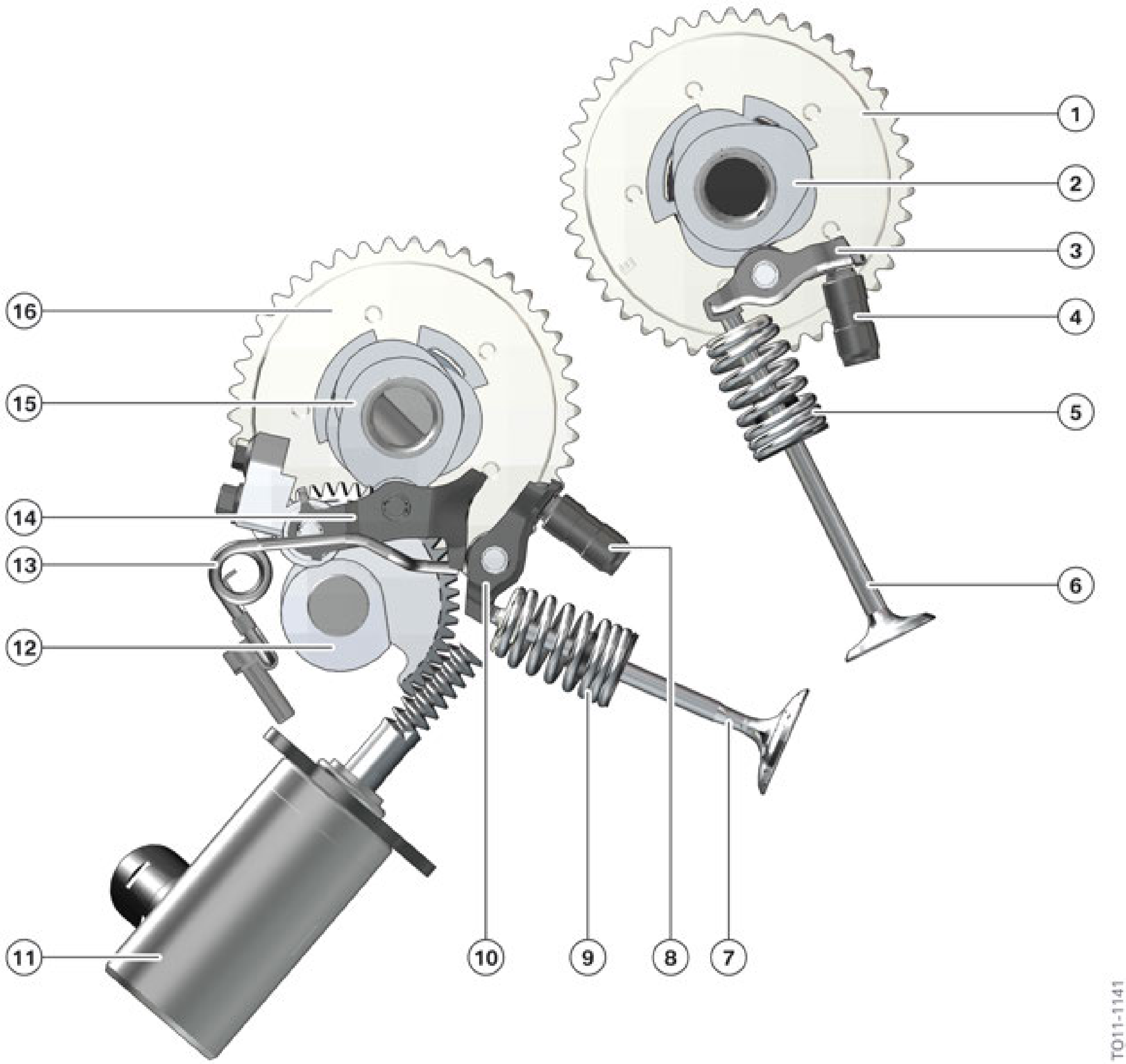
| Index | Explanation |
|---|---|
| 1 | Oil duct for timing advance |
| 2 | Rotor |
| 3 | Oil duct for timing retardation |
| 4 | VANOS, exhaust side |
| 5 | VANOS, intake side |
| 6 | VANOS solenoid valve, intake side |
| 7 | VANOS solenoid valve, exhaust side |

### Valve lift control

As can be seen in the following diagram, the Valvetronic servomotor is attached at the intake side to the cylinder head. The eccentric shaft sensor is integrated into the Valvetronic servomotor.

The system uses Valvetronic III, which was introduced in the N55 engine.

The roller cam follower of the intake side and the intermediate lever are made from sheet metal and divided into various classes. This can be seen on the punched-on numbers.




N63TU, valve lift control

| Index | Explanation |
|---|---|
| 1 | VANOS, exhaust side |
| 2 | Exhaust camshaft |
| 3 | Roller cam follower |
| 4 | Hydraulic valve clearance compensation (HVCC) |
| 5 | Valve spring on exhaust side |
| 6 | Exhaust valve |
| 7 | Intake valve |
| 8 | Hydraulic valve clearance compensation (HVCC) |
| 9 | Valve spring on intake side |

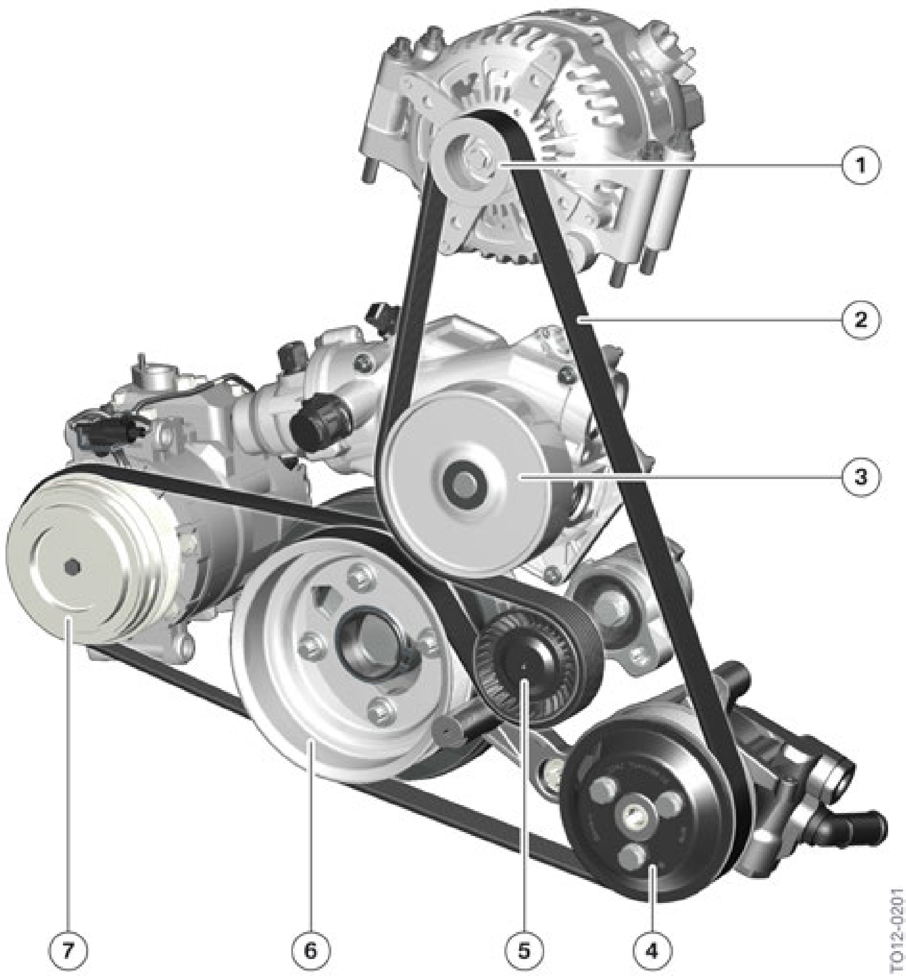
| Index | Explanation |
|---|---|
| 10 | Roller cam follower |
| 11 | Valvetronic servomotor |
| 12 | Eccentric shaft |
| 13 | Spring |
| 14 | Intermediate lever |
| 15 | Intake camshaft |
| 16 | VANOS, intake side |

## 2.5. Belt drive

The belt drive from the N63 engine is used and remains unchanged.

The belt drive includes a main belt drive with an alternator, coolant pump and power steering pump. The main belt drive is operated with a tensioning pulley with torsion spring tensioner.

The secondary belt drive includes the air conditioning compressor and is equipped with an elastic belt. The revolver tensioning system known from the N63 engine is used for replacing the elastic belt.




N63TU, belt drive

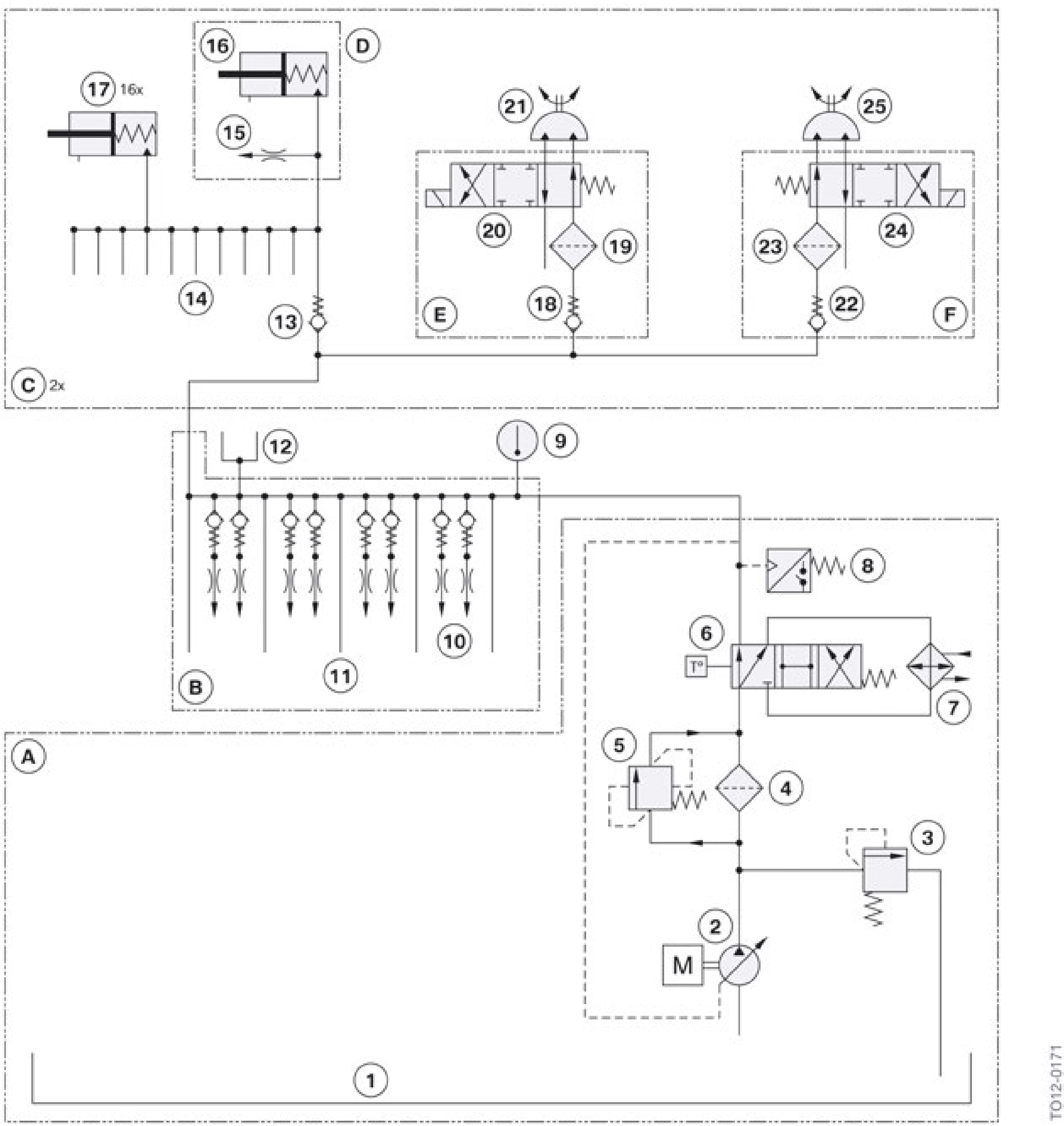
| Index | Explanation |
|---|---|
| 1 | Belt pulley, alternator |
| 2 | Belt |
| 3 | Belt pulley, coolant pump |
| 4 | Belt pulley, power steering pump |
| 5 | Belt tensioner |
| 6 | Belt pulley, crankshaft |
| 7 | Belt pulley, A/C compressor |

# 3. Oil Supply

## 3.1. Overview

The following graphics provide an overview of the oil supply and show the hydraulic circuit diagram and the actual layout of the oil passages in the engine.

### 3.1.1. Hydraulic circuit diagram




N63TU, hydraulic circuit diagram

# N63TU Engine
## 3. Oil Supply

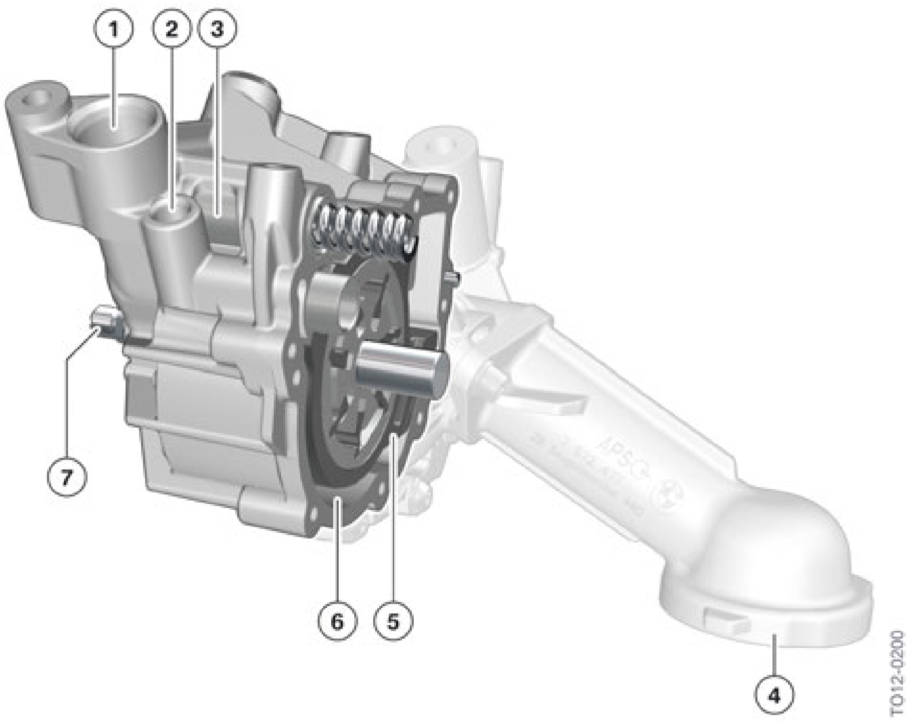
| Index | Explanation |
|---|---|
| A | Oil sump |
| B | Crankcase |
| C | Cylinder head 2 x |
| D | Chain tensioner |
| E | VANOS valve, intake |
| F | VANOS valve, exhaust |
| 1 | Oil sump |
| 2 | Volume-controlled pendulum slide cell pump |
| 3 | Pressure limiting valve |
| 4 | Oil filter |
| 5 | Filter bypass valve |
| 6 | Thermostat |
| 7 | Oil cooler (oil-air heat exchanger) |
| 8 | Oil pressure switch |
| 9 | Oil temperature sensor |
| 10 | Oil spray nozzles for piston crown cooling |
| 11 | Lubrication point on crankshaft main bearing |
| 12 | Lubrication points on exhaust turbocharger |
| 13 | Non-return valve, cylinder head |
| 14 | Lubrication points on camshaft bearing |
| 15 | Oil spray nozzle for timing chain |
| 16 | Chain tensioner |
| 17 | Hydraulic valve clearance compensating elements (16 x) |
| 18 | Non-return valve |
| 19 | Strainer |
| 20 | VANOS solenoid valve |
| 21 | Swivel motor |
| 22 | Non-return valve |
| 23 | Strainer |
| 24 | VANOS solenoid valve |
| 25 | Swivel motor |

## 3.2. Oil pump and pressure regulation

The N63TU engine is equipped with a volume-flow-controlled oil pump. It is driven via a chain by the crankshaft. It is a pendulum slide cell pump whose controller functions similar to the N63 engine. The width of the housing was reduced by 6 mm and only has an overall width of 40 mm. The function is the same as the existing pendulum slide cell pump. The intake snorkel is positioned deep in the rear area of the oil sump to guarantee an adequate oil supply.

Information on the operating principle of a volume-flow-controlled oil pump can be found in the ST501 Engine Technology "N63 Engine" training material available on TIS and ICP.

### 3.2.1. Oil pump

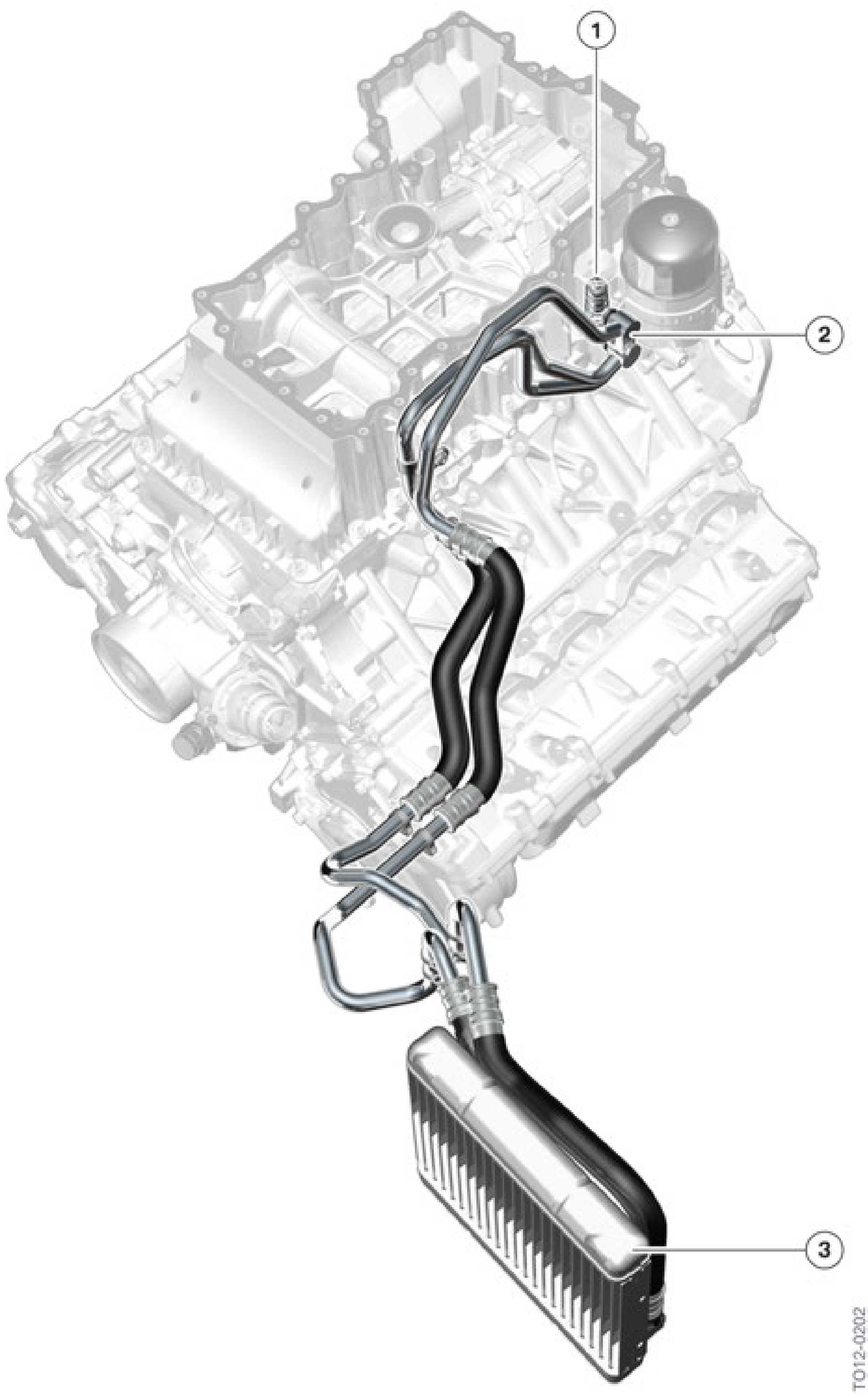



N63TU, oil pump with counterbalance shafts

| Index | Explanation |
|---|---|
| 1 | Oil pump outlet |
| 2 | Oil return to the oil chamber |
| 3 | Pressure limiting valve (maximum 18 bar) |
| 4 | Intake pipe |
| 5 | Pendulum slide with a width of 40 mm |
| 6 | Oil chamber for pendulum slide |
| 7 | Drive for oil pump shaft |

### 3.3. Oil cooling and filtering

The N63TU engine uses the full-flow oil filter familiar from the N63 engine. It is bolted onto the oil sump from below. The oil drain plug is not used in the oil filter cover. A filter bypass valve is integrated into the oil filter housing.




N63TU, oil filter module

| Index | Explanation |
|---|---|
| 1 | Thermostat |
| 2 | Connection for engine oil cooler |
| 3 | Engine oil cooler |

### 3.3.1. Oil cooling

The N63TU engine has an air to coolant heat exchanger for cooling the engine oil which is attached below the cooling module. To ensure quick heating-up of the engine oil, a thermostat is integrated in the oil sump. The thermostat releases the supply to the oil cooler from an engine oil temperature of 100 °C (212 °F).

### 3.3.2. Oil filtering

As with all BMW engines, the N63TU has a filter bypass valve which can open a bypass round the filter if, for example, the engine oil is cold and viscous. This occurs if the pressure difference between before and after the filter exceeds 2.5 bar (36.25 psi). The permissible pressure difference has been increased from 2.0 to 2.5 bar (29 to 36.25 psi) in order to protect the lead-free crankshaft and connecting rod bearings. This ensures that the filter is bypassed much less frequently and any dirt particles are reliably filtered out. The filter bypass valve is integrated into the oil filter housing.

## 3.4. Oil monitoring

### 3.4.1. Oil level

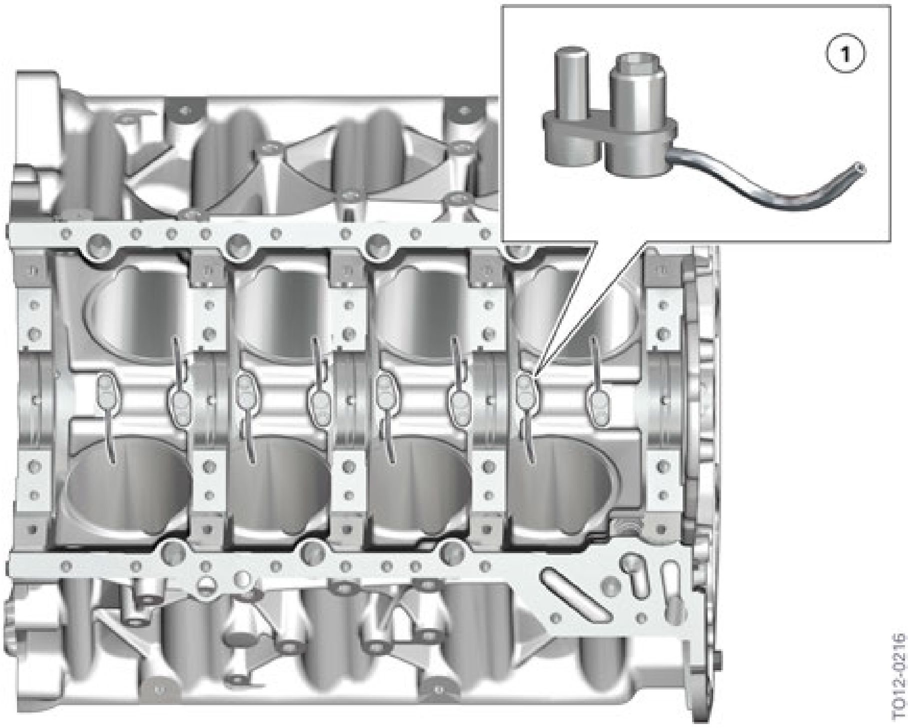
The familiar oil level sensor is used which is already installed in the N20 and N55 engines with BN 2020 vehicle electrical system.

## 3.5. Oil spray nozzles

As with previous engines components which cannot be reached directly by an oil duct are lubricated and/or cooled by oil spray nozzles.

### 3.5.1. Piston crown cooling

The oil spray nozzles for piston crown cooling are similar to the N63 engine in principle. They incorporate a non-return valve to enable them to open and close only from a specific oil pressure. Each cylinder has its own oil spray nozzle, which obtains the correct installation position through its styling. In addition to the piston crown cooling, these are also responsible for the lubrication of the piston wrist pins.




N63TU, oil spray nozzles for the piston crown cooling

| Index | Explanation |
|---|---|
| 1 | Oil spray nozzle |

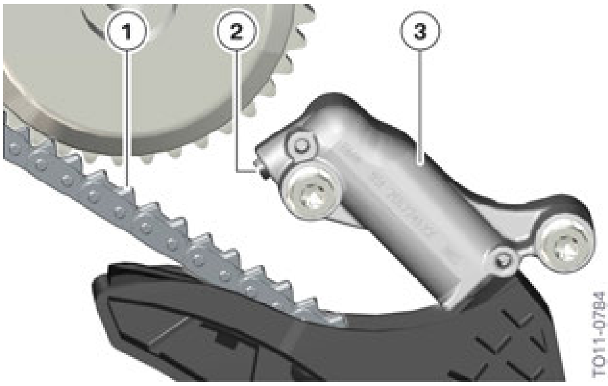
| | |
|---|---|
| Opening pressure | 2.25 - 2.65 bar (32.6 - 38.4 psi) |
| Closing pressure | 2.0 bar (29 psi) |

### 3.5.2. Chain drive

The chain drive in the N63TU engine is divided into an upper section for the camshaft drive and a lower section for the oil pump drive.

#### Camshaft drive

The oil spray nozzles for lubricating the timing chains are integrated into the respective chain tensioner of the banks. They spray the oil directly onto the timing chain. A throttle in the oil spray nozzle limits the emerging oil. The timing chain of the camshaft drive is designed as a toothed roller-type chain.




N63TU, chain tensioner with oil spray nozzle for timing chain

| Index | Explanation |
|---|---|
| 1 | Toothed roller-type chain with 142 elements |
| 2 | Oil spray nozzle |
| 3 | Chain tensioner |

**Oil pump drive**

The oil pump is driven via a roller-type chain by the crankshaft. The roller-type chain is kept tensioned by a tensioning rail. The secondary drive is lubricated via the oil sump.

### 3.5.3. Camshaft

The oil supply of the chain tensioner, the hydraulic valve clearance compensating elements and the bearing positions in the cylinder head is done via a rising pipe from the engine housing in the cylinder head. A non-return valve in the cylinder head in the rising pipe prevents the oil duct idling.

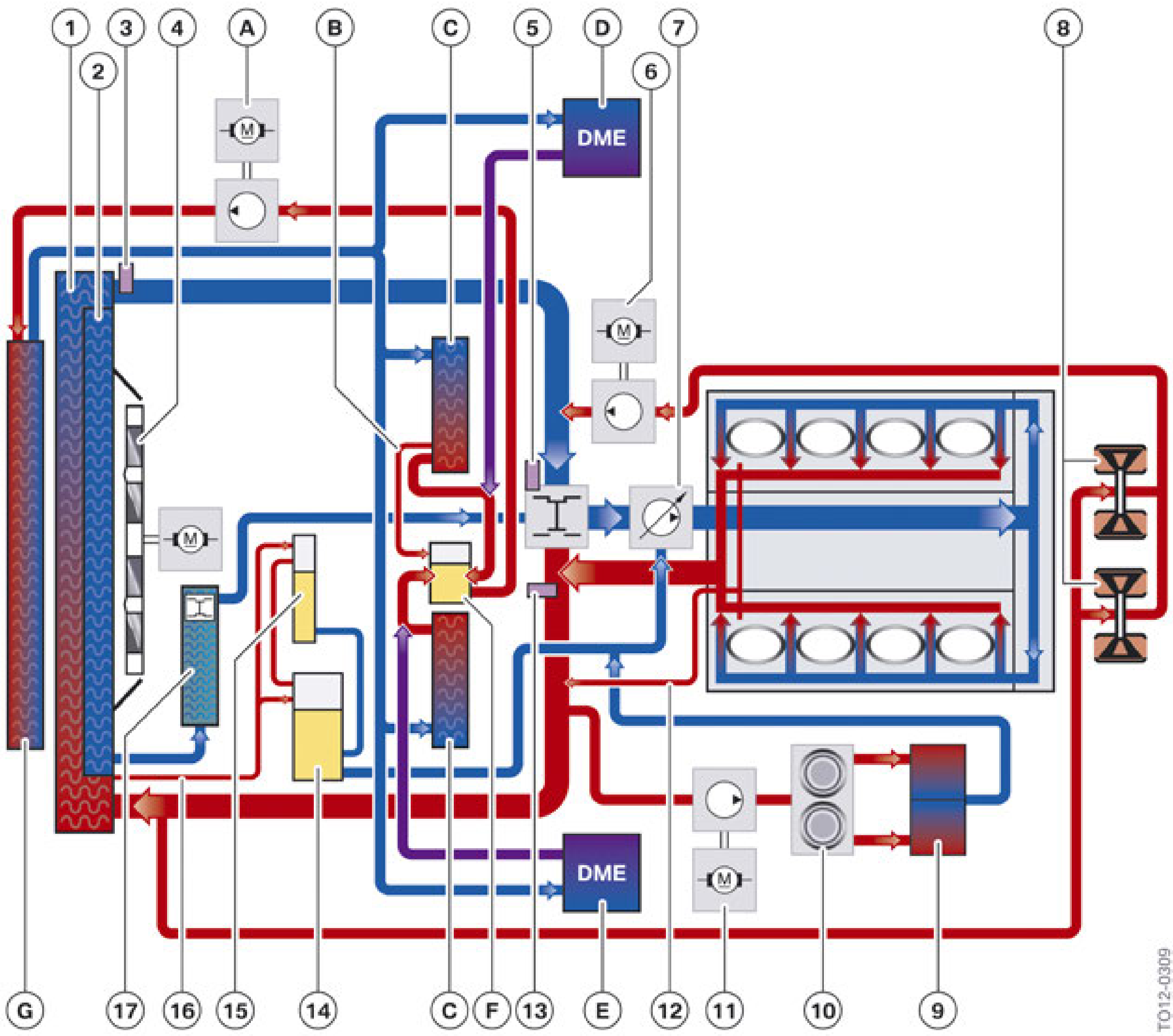
### 3.5.4. Valvetronic servomotor

The worm gear for adjusting the eccentric shaft is lubricated using the oil spray from the camshaft.

# N63TU Engine
## 4. Cooling

The cooling system also shares similarities with the N63 engine. The engine and charge air cooling both have separate cooling systems. The cooling circuit for both Digital Engine Electronics control units was integrated into the charge air cooling system.

### 4.1. System overview




N63TU, complete cooling system

| Index | Explanation |
|---|---|
| A | Electric coolant pump for the cooling circuit of the charge air and DME |
| B | Vent line for charge air cooling |
| C | Charge air cooler |
| D | Digital Engine Electronics (DME 1) |
| E | Digital Engine Electronics (DME 2) |

| Index | Explanation |
|---|---|
| F | Expansion tank |
| G | Cross-flow cooler for the cooling circuit of charge air and DME |
| 1 | Radiator |
| 2 | Radiator for the transmission oil cooling |
| 3 | Coolant temperature sensor at radiator outlet |
| 4 | Electric fan |
| 5 | Map thermostat with heating element |
| 6 | Electric auxiliary water pump for exhaust turbocharger cooling |
| 7 | Temperature-dependent coolant pump |
| 8 | Exhaust turbocharger |
| 9 | Heater core |
| 10 | Duo heater control valve |
| 11 | Electric auxiliary water pump for vehicle heating |
| 12 | Vent line for banks |
| 13 | Coolant temperature sensor at engine outlet |
| 14 | Expansion tank |
| 15 | Coolant filler pipe |
| 16 | Vent line for cooling circuit, engine |
| 17 | Transmission oil-to-coolant heat exchanger |

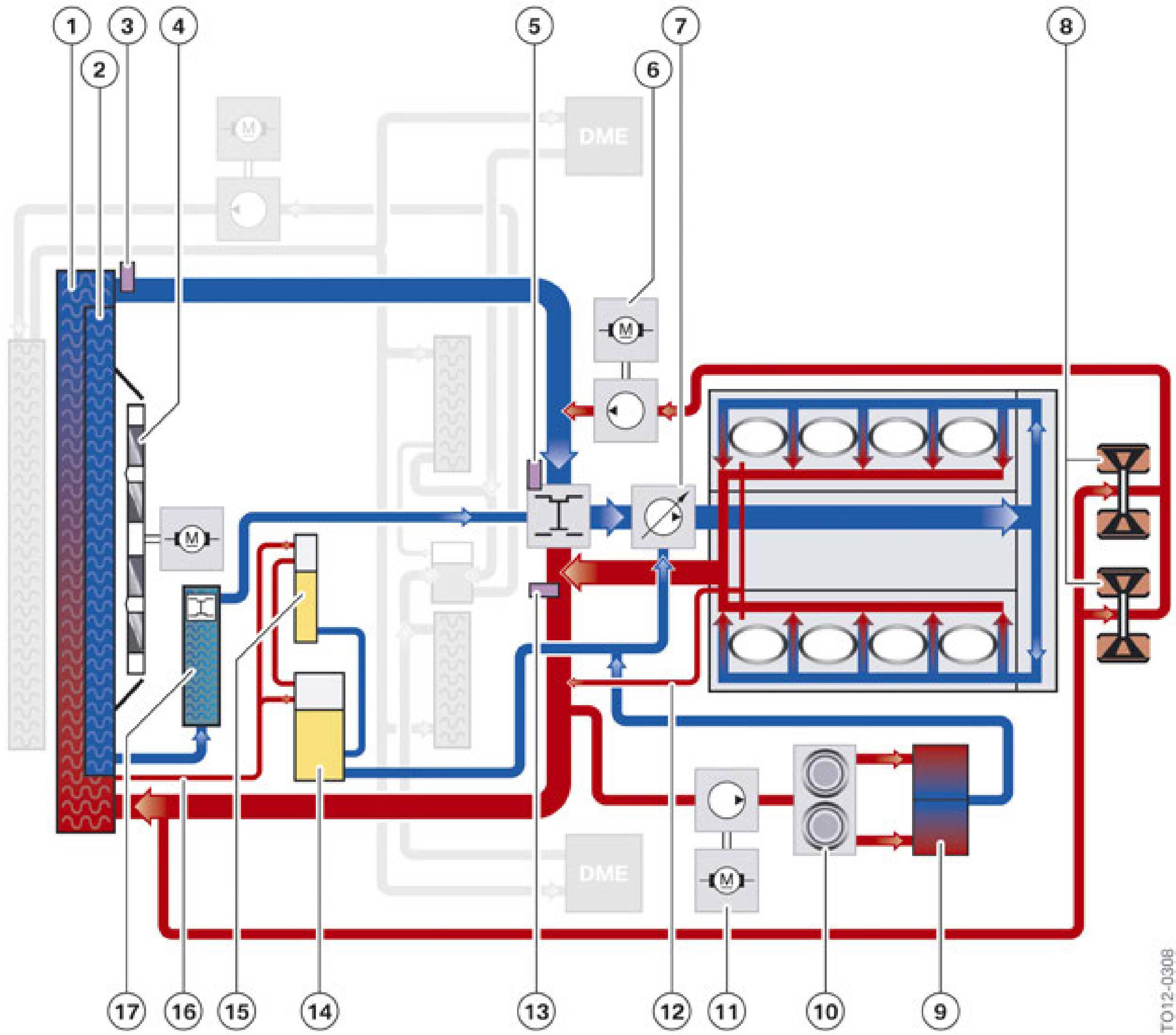
### 4.1.1. Engine cooling circuit

The engine cooling is realized via a conventional coolant pump with a map thermostat. The impeller has a diameter of 70 mm.

An auxiliary radiator is connected to the cooling circuit in the direction of travel on the left. The additional radiator is equipped with a non-return valve with compression spring to prevent a return by the electric auxiliary water pump in the case of a low volumetric flow of the coolant.

The electric fan has a nominal power of 850 W.

The following graphics show the installation locations and layout of the components.

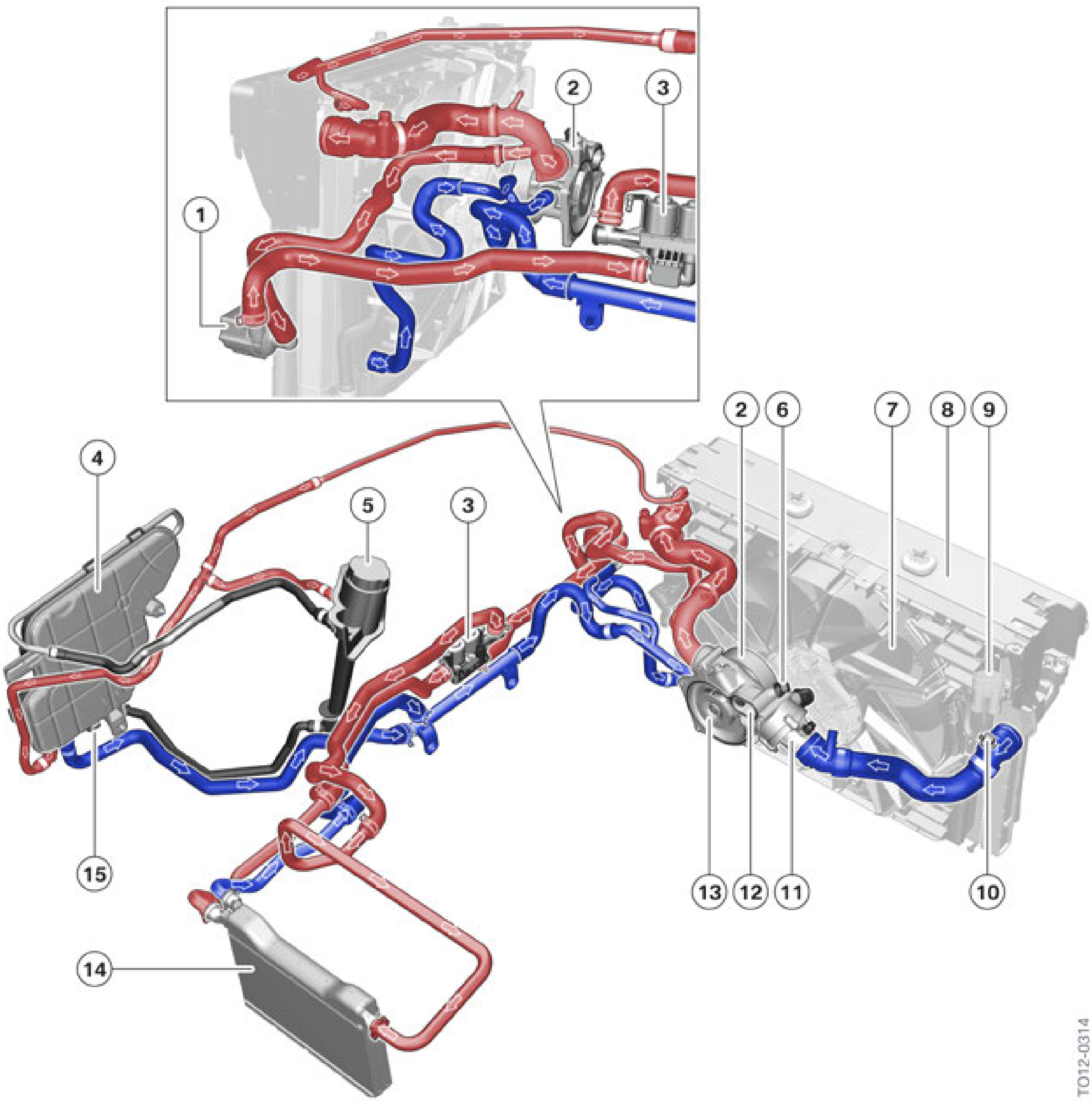



N63TU engine cooling circuit

| Index | Explanation |
|---|---|
| 1 | Radiator |
| 2 | Radiator for the transmission oil cooling |
| 3 | Coolant temperature sensor at radiator outlet |
| 4 | Electric fan |
| 5 | Map thermostat with heating element |
| 6 | Electric auxiliary water pump for exhaust turbocharger cooling |
| 7 | Temperature- and speed-dependent coolant pump |
| 8 | Exhaust turbocharger |
| 9 | Heater core |
| 10 | Duo heater control valve |

| Index | Explanation |
|---|---|
| 11 | Electric auxiliary water pump for vehicle heating |
| 12 | Vent line for banks |
| 13 | Coolant temperature sensor at engine outlet |
| 14 | Expansion tank |
| 15 | Coolant filler pipe |
| 16 | Vent line for cooling circuit, engine |
| 17 | Transmission oil-to-coolant heat exchanger |

### Components of the engine cooling circuit (without the turbocharger cooling circuit shown)




N63TU engine cooling system components shown without turbocharger cooling circuit

| Index | Explanation |
|---|---|
| 1 | Electric auxiliary water pump |
| 2 | Coolant pump |
| 3 | Duo heater control valve |
| 4 | Expansion tank |
| 5 | Filling cup |
| 6 | Coolant temperature sensor at engine outlet |

| Index | Explanation |
|---|---|
| 7 | Electric fan |
| 8 | Radiator |
| 9 | Plug connection for electric fan |
| 10 | Coolant temperature sensor at radiator outlet |
| 11 | Map thermostat |
| 12 | Return of heated coolant from engine housing to coolant pump |
| 13 | Supply of cooled coolant via impeller to the engine housing |
| 14 | Heater core |
| 15 | Coolant level sensor |

**Components of turbocharger cooling circuit**

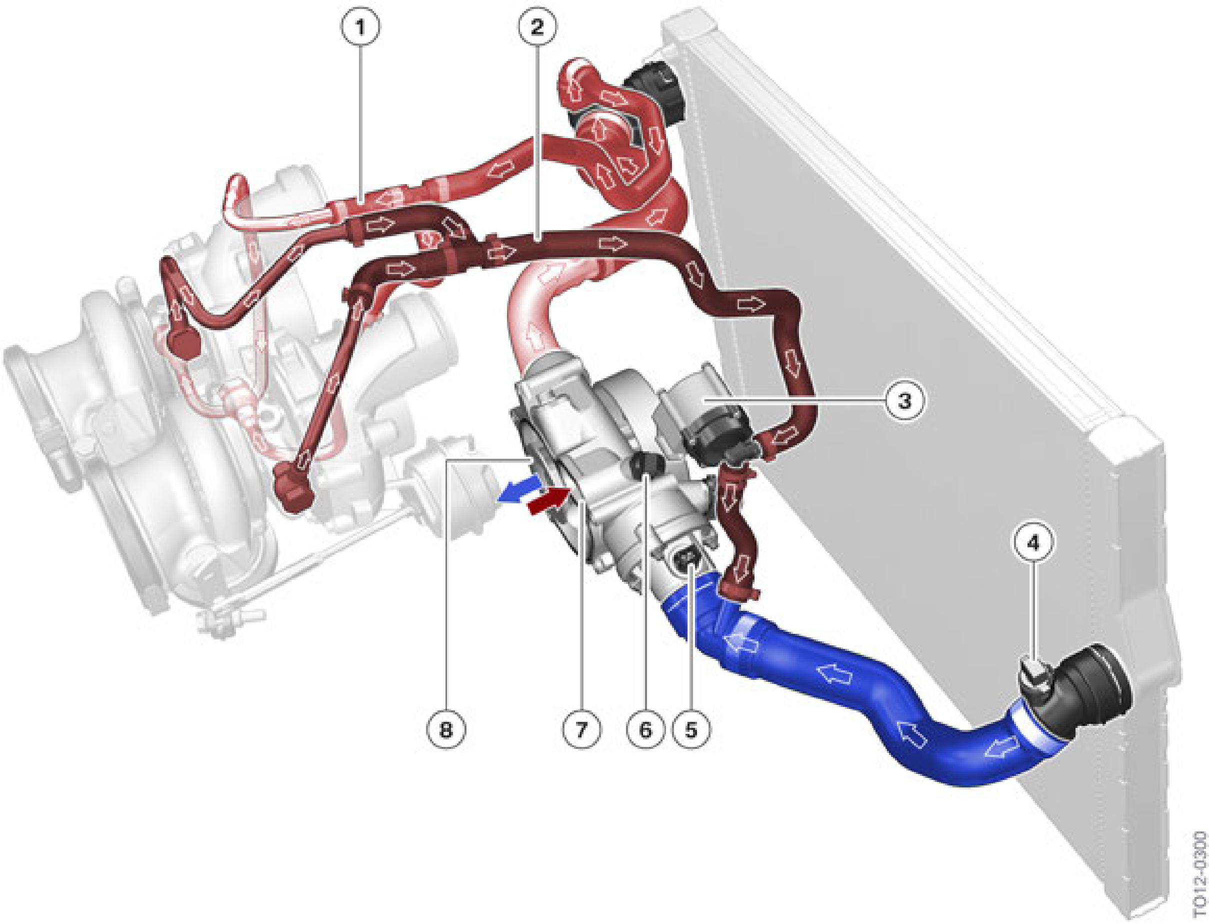
The mechanical coolant pump is driven via a belt and cannot be used for cooling the exhaust turbocharger after the engine has shut down. Therefore there is a 20 W electric coolant pump to feed coolant through this separate cooling circuit. The electric coolant pump is switched on also during engine operation depending on the coolant temperature at the engine outlet.

The after-run of the electric coolant pump can last up to 30 minutes for a stationary engine and when the ignition is turned off.

This is calculated according to the following values:

- Engine oil temperature
- Injected fuel quantity
- Intake air temperature
- Exhaust-gas temperature
- Fuel temperature.

The electric fan can also run for a maximum of 11 minutes after the engine is turned off.

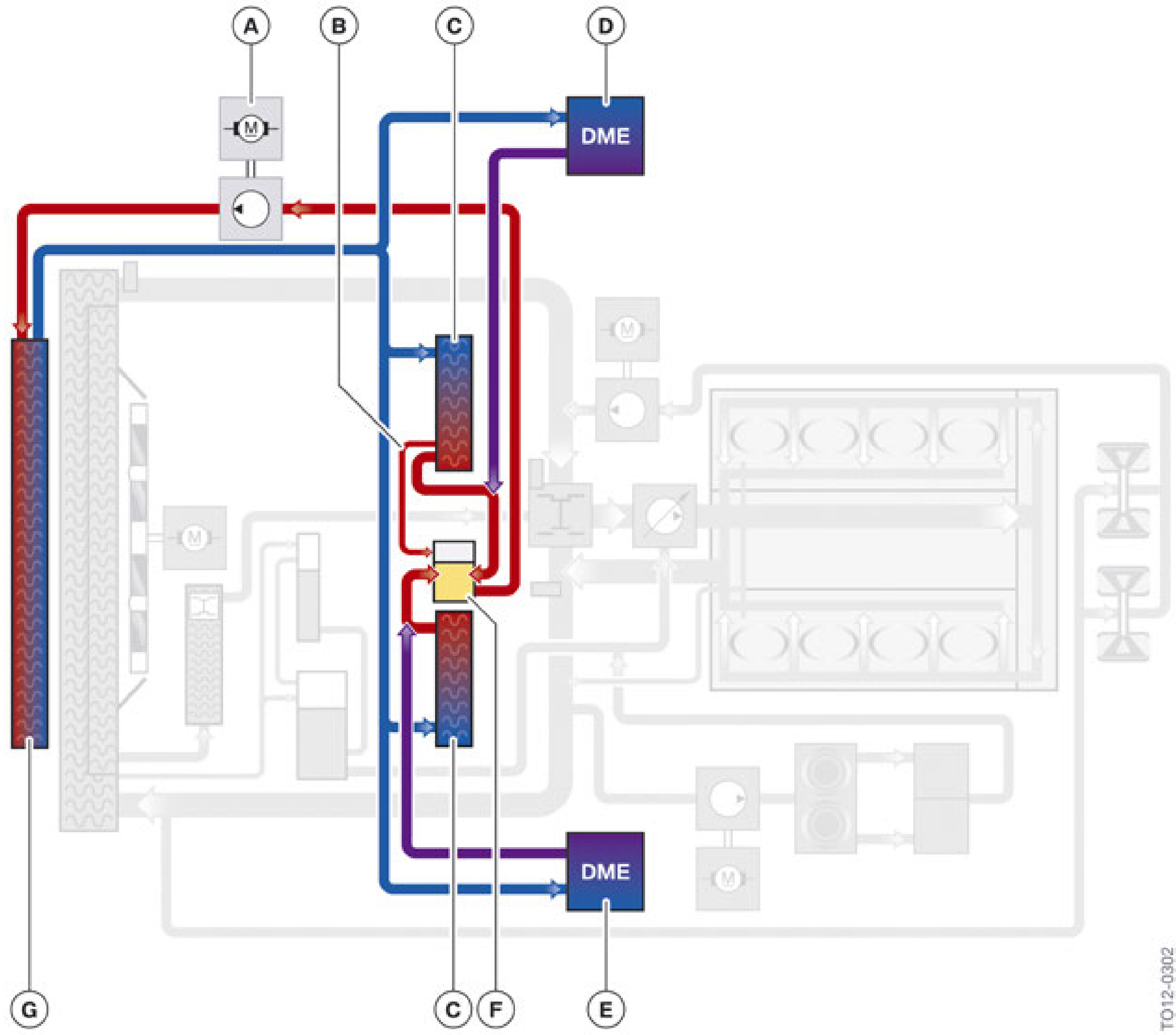



N63TU, turbocharger cooling circuit with electric auxiliary water pump

| Index | Explanation |
|---|---|
| 1 | Supply line to the exhaust turbochargers |
| 2 | Return line from the exhaust turbochargers to the auxiliary water pump |
| 3 | Electric auxiliary water pump |
| 4 | Coolant temperature sensor at radiator outlet |
| 5 | Map thermostat |
| 6 | Coolant temperature sensor at engine outlet |
| 7 | Return of the heated coolant from the engine housing to the coolant pump housing |
| 8 | Supply of the cooled coolant to the engine housing |

### 4.1.2. Charge air coolers and DME cooling circuit

An independent cooling system with an electric coolant pump is used for the cooling circuit of the charge air cooler and DME control units. The cooling circuit for the charge air cooling and the Digital Engine Electronics (DME) contains a cross-flow radiator and two auxiliary radiators.

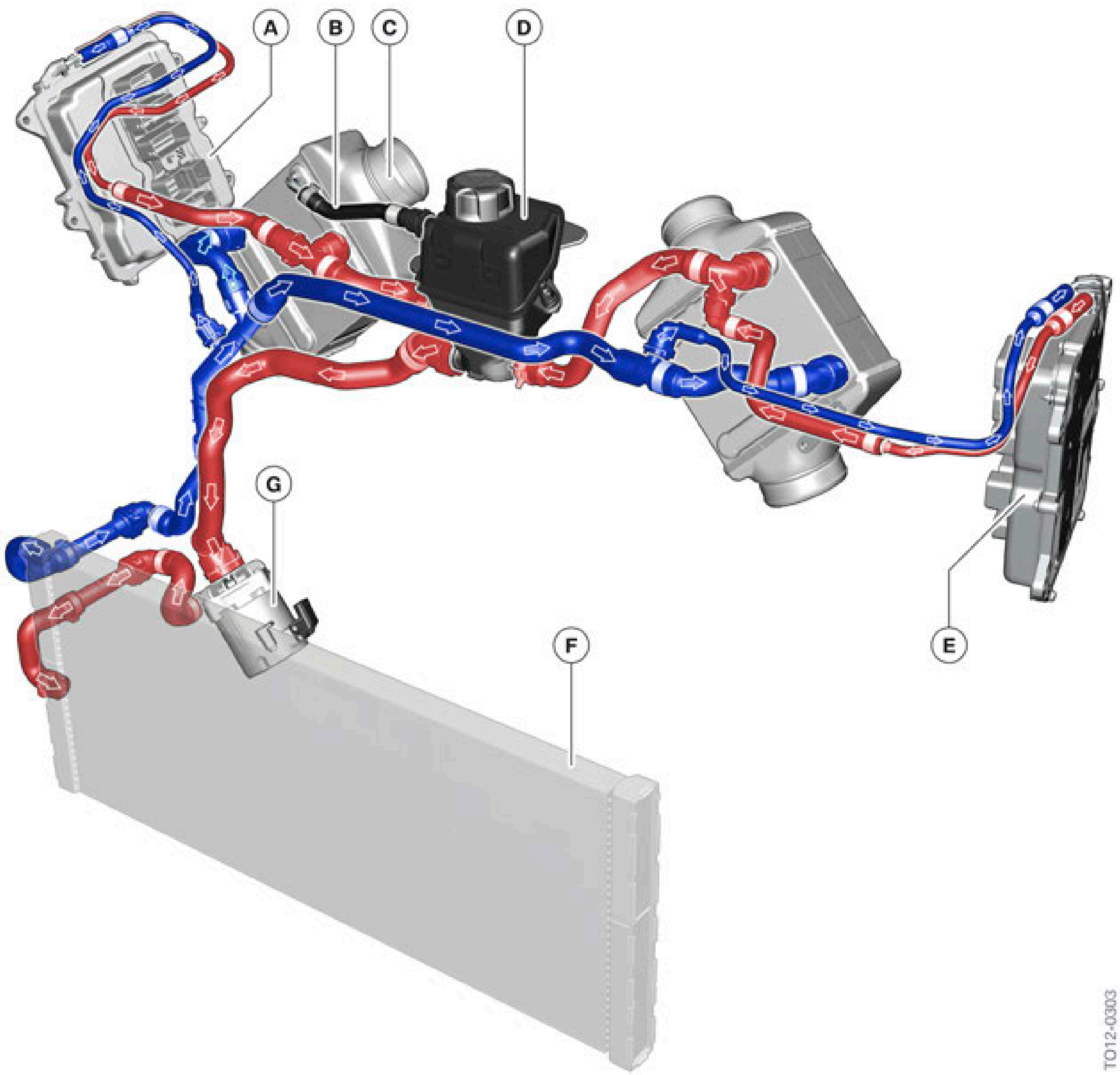



N63TU charge air cooling and DME cooling circuit

| Index | Explanation |
|---|---|
| A | Electric coolant pump for the charge air coolers and DME cooling circuit |
| B | Vent line for charge air cooling |
| C | Charge air coolers |
| D | Digital Engine Electronics (DME 1) |
| E | Digital Engine Electronics (DME 2) |
| F | Expansion tank |
| G | Cross-flow heat exchanger for the charge air coolers and DME cooling circuit |

### Components of the charge air cooling and DME cooling circuit

The 50 W pump has a self-diagnosis and dry-run protection. If the engine speed is increased by 15 minutes over a period, the auxiliary water pumps are switched off and a fault code is stored in the DME. The expansion tank does not have a coolant level sensor and does not automatically detect when the fluid level is too low.




N63TU components of the charge air coolers and DME cooling circuit

| Index | Explanation |
|---|---|
| A | Digital Engine Electronics (DME 1) |
| B | Ventilation line for charge air cooling |
| C | Charge air cooler |
| D | Expansion tank |
| E | Digital Engine Electronics (DME 2) |
| F | Cross-flow heat exchanger for the charge air coolers and DME cooling circuit |
| G | Electric coolant pump for the charge air coolers and DME cooling circuit |

## 4.2. Heat management

The N63TU engine has the same heat management functions in the Digital Engine Electronics (DME) as in the N55 engine. This comprises independent control of the electric cooling components of electric fan, map thermostat and coolant pumps.

### 4.2.1. Auxiliary water pump

The N63TU engine also has three electric auxiliary water pumps in addition to the mechanical coolant pump:

- for heating the interior
- for cooling the exhaust turbocharger
- for cooling the charge air cooler and the two DME control units.

The electric coolant pump for the cooling circuit of the charge air and DMEs has a power of 50 W. The other two pumps have a 20 W power rating.

⚠

If the coolant pump is removed and then to be reused, it is important to ensure that it is set down still filled with coolant. Drying out the pump may cause the bearings to stick in position. This will cause the coolant pump not to start, which in turn may result in engine damage.

Before installing, turn the impeller manually to ensure that it moves freely.

### 4.2.2. Map thermostat

The N63TU engine is fitted with a conventional map thermostat which has the following technical data in non-electrically controlled mode:

- Opening start at 105 °C (221 °F)
- Complete opening at 120 °C (248 °F).

In addition, an electric heater in the map thermostats can be used to make the thermostat open at a lower coolant temperature.

# N63TU Engine

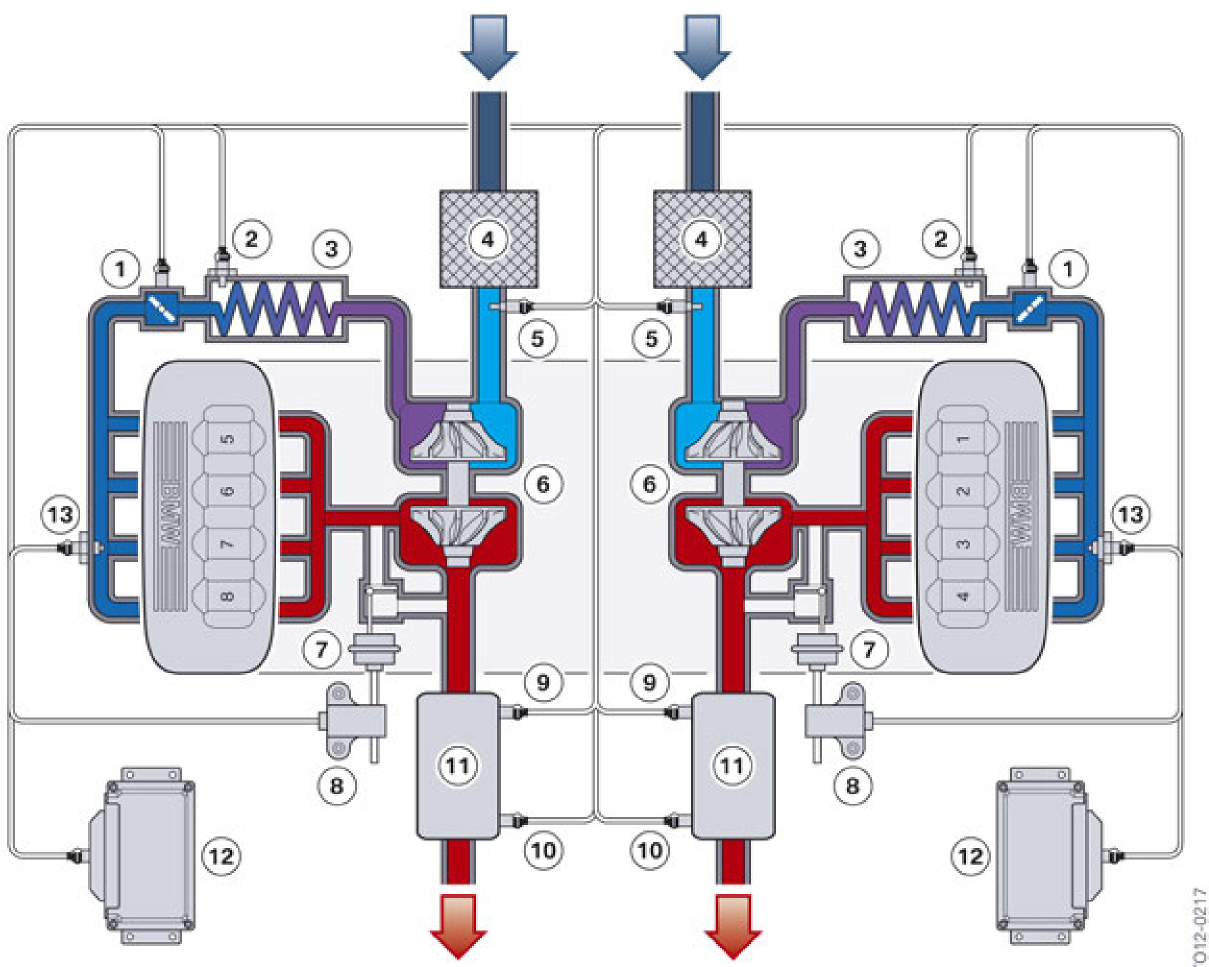
# 5. Intake/Exhaust Emission System

The intake and exhaust emission systems are in principle comparable with those in the N63 engine.

The list below itemizes the most important changes to the intake and exhaust emission systems:

- Flow-optimized air intake duct with adaptation of the manifold to the new cylinder head cover geometry
- Hot film air mass meter 7
- Adaptation of the intake system with regard to the Valvetronic servomotor attached at the side
- Adaptation of the exhaust system by integration of the pipe elbows in the catalytic converter near the engine and discontinuation of the bolt-on flanges.

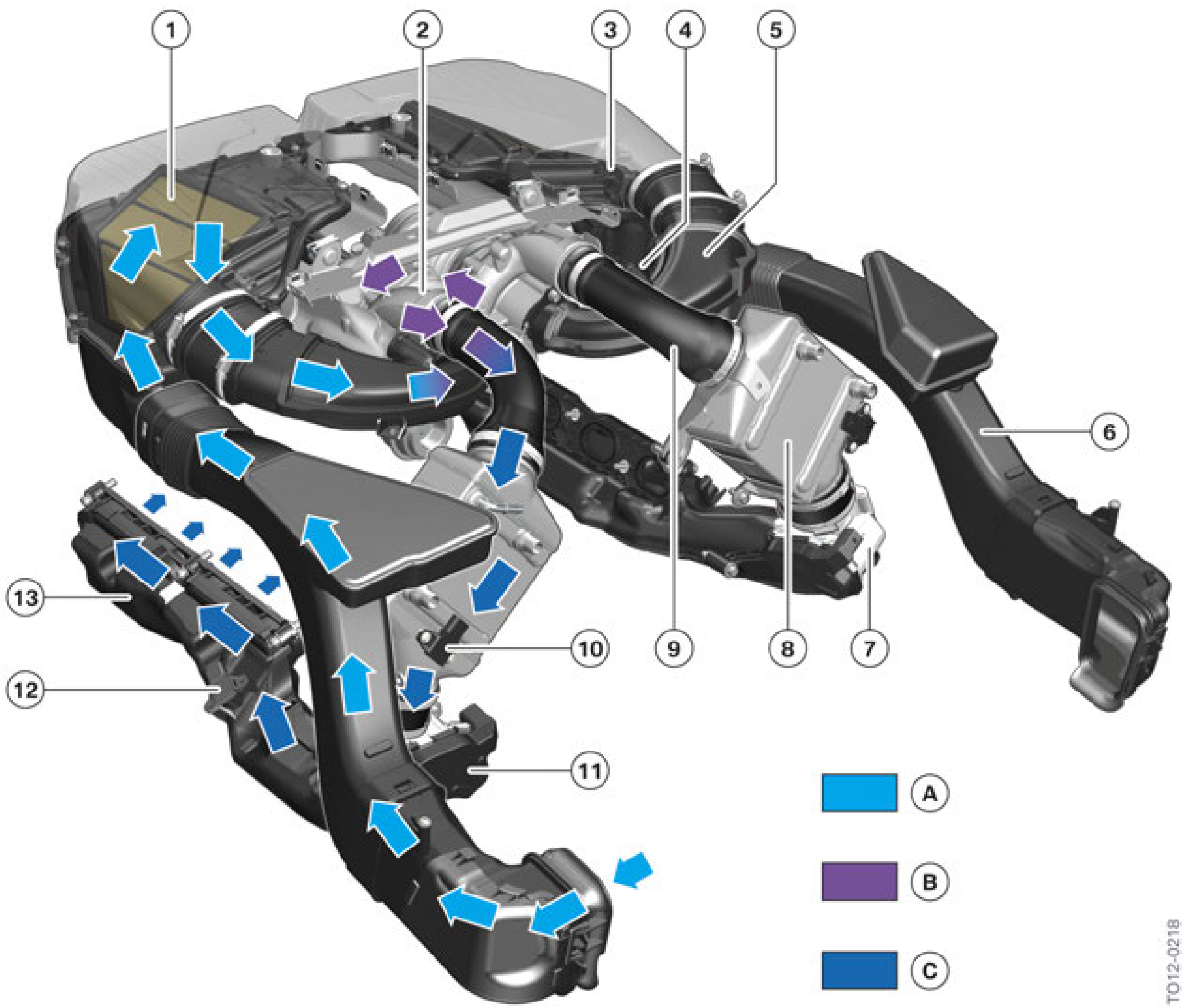
## 5.1. Overview




N63TU, air intake and exhaust emission systems

| Index | Explanation |
|---|---|
| 1 | Throttle valve |
| 2 | Charging pressure sensor |
| 3 | Charge air cooler |
| 4 | Intake silencer |
| 5 | Hot film air mass meter 7 |
| 6 | Exhaust turbocharger |
| 7 | Wastegate valve |
| 8 | Electropneumatic pressure converter |
| 9 | Oxygen sensor before catalytic converter, control sensor LSU ADV |
| 10 | Oxygen sensor after catalytic converter, monitoring sensor LSF4.2 |
| 11 | Catalytic converter |
| 12 | Digital Engine Electronics (DME) |
| 13 | Charge air temperature and intake-manifold pressure sensor |

## 5.2. Intake air system




N63TU, air intake system

| Index | Explanation |
|---|---|
| A | Intake air |
| B | Compressed, heated charge air |
| C | Cooled charge air |
| 1 | Intake silencer |
| 2 | Exhaust turbocharger without blow-off valve |
| 3 | Hot film air mass meter 7 |
| 4 | Connection for crankcase ventilation for clean air pipe |
| 5 | Clean air pipe |
| 6 | Unfiltered air pipe |
| 7 | Connection for tank vent valve |

| Index | Explanation |
|---|---|
| 8 | Charge air cooler |
| 9 | Charge air pipe |
| 10 | Charging pressure sensor |
| 11 | Throttle valve with servomotor |
| 12 | Charge air temperature and intake-manifold pressure sensor |
| 13 | Intake manifold |

### 5.2.1. Intake silencer

The N63TU engine has its own intake silencer for each bank. These are fixed in the vehicle and hold the hot film air mass meters.

### 5.2.2. Hot film air mass meter

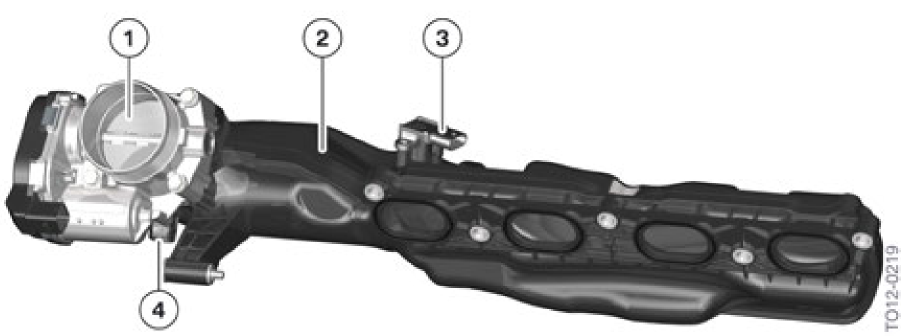
The N63TU engine is equipped with the hot film air mass meter 7 which is familiar from the N20 engine.

⚠

Malfunction or disconnection of the hot film air mass meter does not immediately result in emergency engine operation. However, impaired mixture preparation and therefore poor emission values are possible, which is why the emissions warning lamp lights up.

### 5.2.3. Intake manifold

The volume of the air intake system has been optimized and it has a flow-optimized connection for the throttle body. It also includes the charge air temperature and charging pressure sensor.



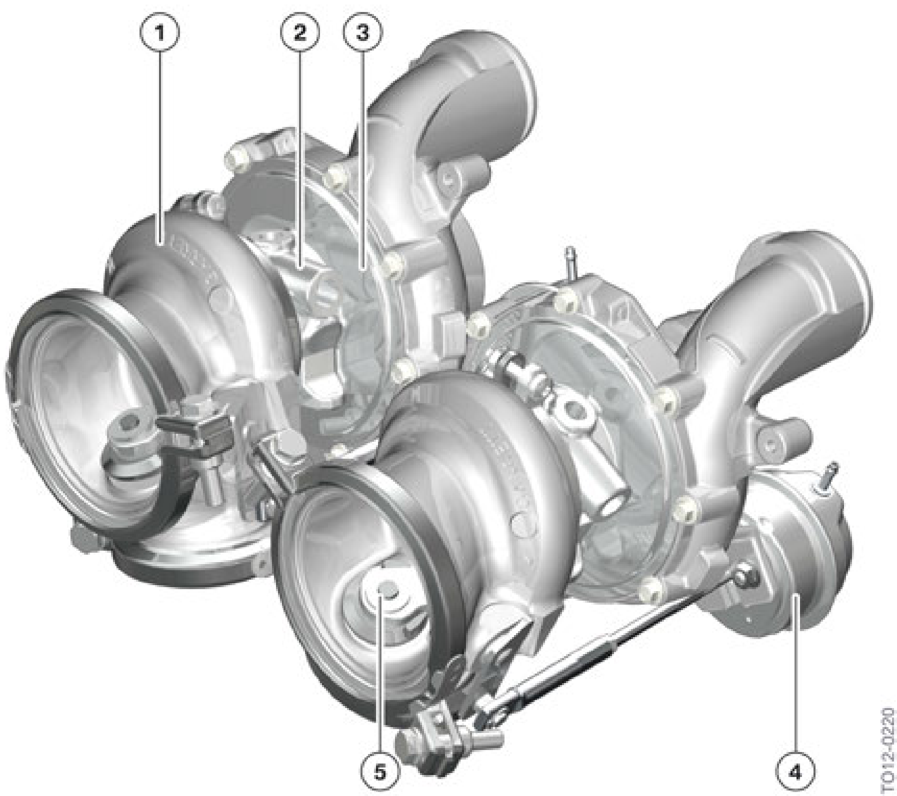

N63TU, intake manifold with throttle valve

| Index | Explanation |
|---|---|
| 1 | Throttle valve |
| 2 | Intake manifold |
| 3 | Charge air temperature and intake-manifold pressure sensor |
| 4 | Connection from tank vent valve |

## 5.3. Exhaust turbocharger

The N63TU engine has two exhaust turbochargers. The compressor was slightly revised and is now equipped with nine blades of the same size. Up to now double blades with five large and five small blades were used. In comparison to previous turbocharged BMW engines the N63TU does not use a blow-off valve. The use of Valvetronic and special tuning and turbo upgrades rendered it unnecessary.

The exhaust turbocharger has the familiar structure with an adapted housing and a wastegate valve.




N63TU, exhaust turbochargers

| Index | Explanation |
|---|---|
| 1 | Turbine |
| 2 | Bearing seat |
| 3 | Compressor |
| 4 | Vacuum unit |
| 5 | Wastegate valve |

⚠

**Precise alignment of the exhaust turbochargers is necessary for assembly. Always follow proper repair instructions.**

### 5.3.1. Function

The blow-off valves at the exhaust turbocharger are discontinued on this engine as their job is effectively replaced by the engine interventions. This is due to the use of an optimized compressor which permits a more stable pump design in comparison to the predecessor compressor.

Reasons for the installation of a blow-off valve to date were:

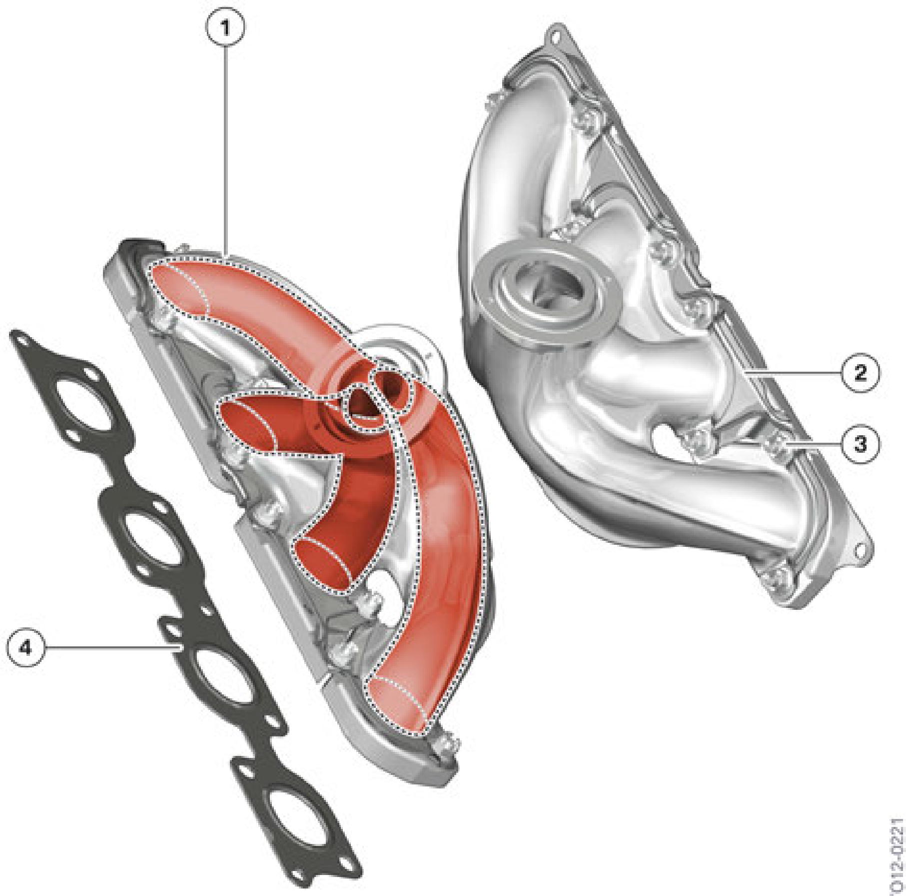
- Prevent compressor surge (transition from traction to coasting/overrun mode)
- Possible pumping causes pulsating, acoustic interference noise
- Arising pressure waves as a result which stress the thrust bearing of the turbocharger.

In the case of load shedding without a blow-off valve the aim is to avoid a compressor pump. A pumping compressor arises if high pressure ratios and low mass flows occur. In contrast the engine measures are that through the engine control the target mass flow is increased until the pump limit can fall below the limit and the charging pressure can dissipate. The necessary mass flow is adjusted by activating the throttle valve and valve lift. Excessive cylinder filling and the resulting high torque is then torque-controlled for example reduced via retarding the ignition timing. The results in neutral driveability.

## 5.4. Exhaust emission system

### 5.4.1. Exhaust manifold

The cast-iron exhaust manifold of the N63TU engine remains unchanged from its predecessor.

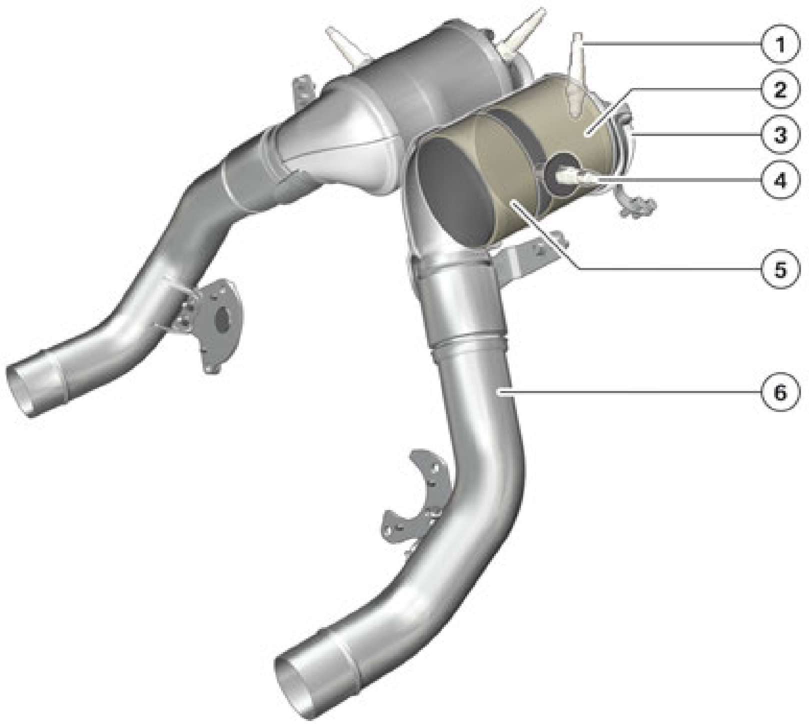



N63TU exhaust manifold

| Index | Explanation |
| --- | --- |
| 1 | Exhaust manifold |
| 2 | Slide rail |
| 3 | Nut |
| 4 | Beaded metal gasket |

### 5.4.2. Catalytic converter

The N63TU engine has one catalytic converter per bank. The outlet hoppers are now single-walled. The catalytic converter near the engine comprises first and second monoliths. The catalytic converters have decoupling elements which are also described as expansion elements.




N63TU, sectional view of the catalytic converter

| Index | Explanation |
|---|---|
| 1 | Control sensor |
| 2 | Ceramic monolith 1 |
| 3 | Connection of the turbine |
| 4 | Monitoring sensor |
| 5 | Ceramic monolith 2 |
| 6 | Exhaust pipe |

**Oxygen sensors**

The typical Bosch oxygen sensors are used:

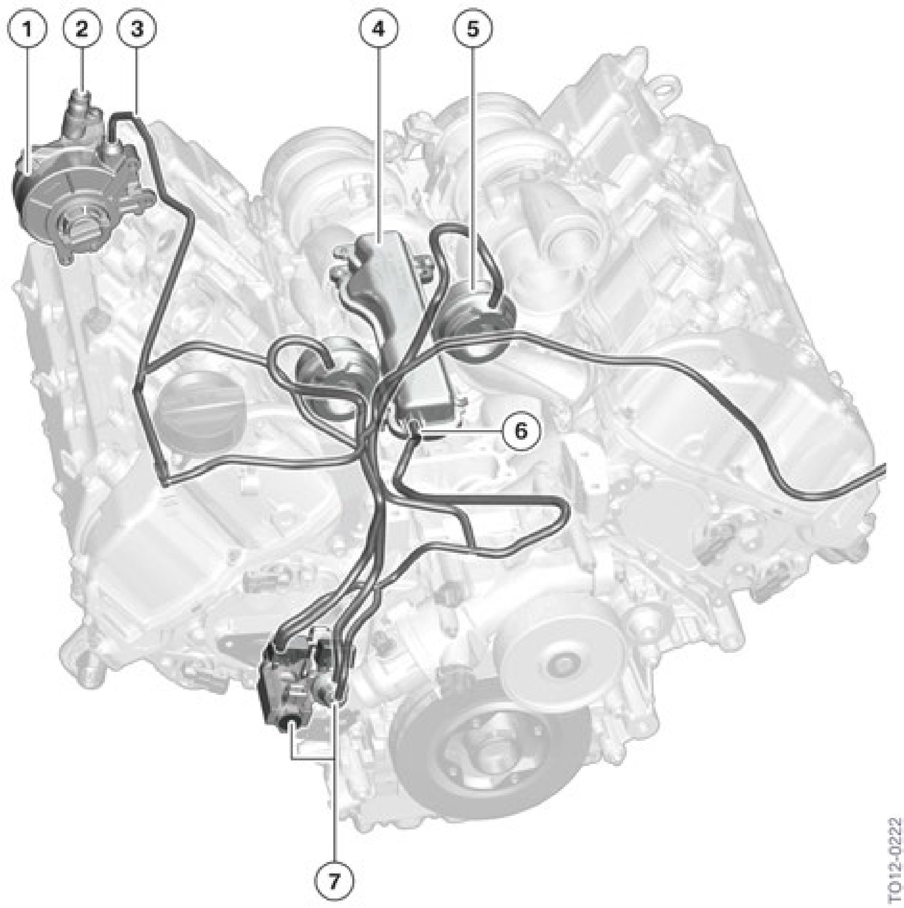
- Control sensor: LSU ADV
- Monitoring sensor: LSF4.2.

The control sensor is located ahead of the primary ceramic monolith, as close as possible to the turbine outlet. Its position has been chosen so that all the cylinders can be recorded separately. The monitoring sensor is positioned between the first and second ceramic monoliths.

# N63TU Engine

## 6. Vacuum System

The vacuum system of the N63TU engine demonstrates some changes with regard to the N63 engine. The vacuum reservoir and the pressure converter are in the familiar locations. The bolting points of the vacuum pump have a new arrangement due to the new cylinder head.




N63TU, vacuum system

| Index | Explanation |
|---|---|
| 1 | Vacuum pump |
| 2 | Connection, brake servo |
| 3 | Connection for secondary consumer |
| 4 | Vacuum reservoir |
| 5 | Vacuum units for wastegate valves |
| 6 | Connection for vacuum line to the electric changeover valve for vacuum units of exhaust flaps |
| 7 | Electropneumatic pressure converter (EPDW) for wastegate valves |

The vacuum pump (as usual) is designed to have two stages so that the majority of the generated vacuum is made available to the brake servo. The vacuum reservoir is positioned in the V-space and is now made out of plastic.

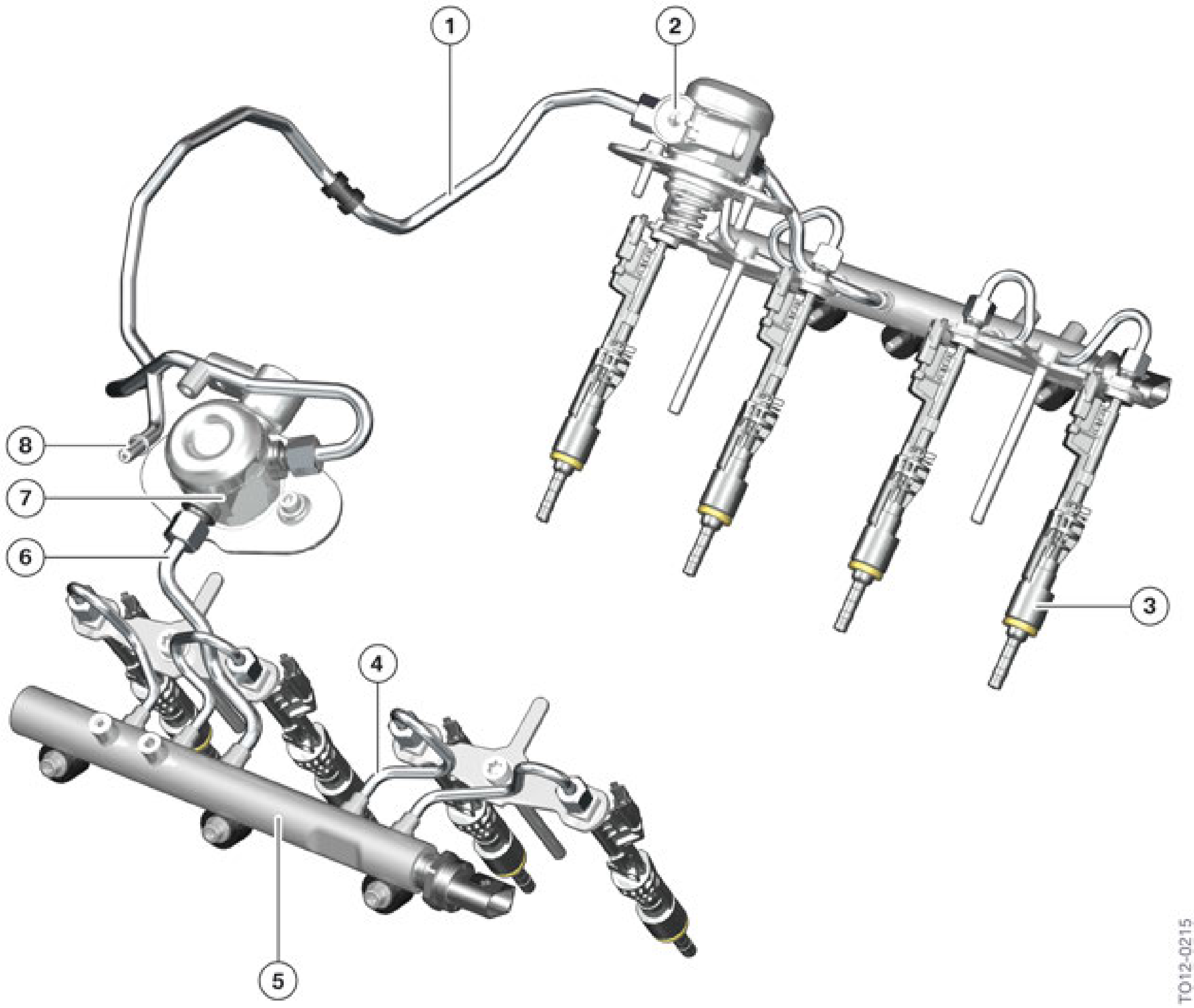
# N63TU Engine

# 7. Fuel Preparation

The N63TU engine makes use of high-pressure injection, which was introduced in the N55 engine. It differs from high-precision injection (HPI) in that it uses solenoid valve type injectors with multi-hole nozzles.

## 7.1. Overview

The following overview shows the fuel preparation system of the N63TU engine. It essentially corresponds to the systems with direct fuel injection familiar in BMW models. Only the guide of the fuel line has been adapted in the area of the alternator.




N63TU, fuel preparation

| Index | Explanation |
| --- | --- |
| 1 | Fuel line |
| 2 | Fuel quantity control valve |
| 3 | Injector |
| 4 | High pressure line, rail - injector |

| Index | Explanation |
|---|---|
| 5 | Rail |
| 6 | High pressure line, high pressure pump to rail |
| 7 | High pressure pump |
| 8 | Fuel supply line |

Bosch high-pressure fuel injection valves with the designation HDEV5.2 are used. The high pressure pump is already known from the 4-, 8- and 12-cylinder engines. An innovation in the N63TU engine is the fact that the high pressure lines from rail to injector are now no longer bolted at the rail end, but welded as on N20.

⚠

**Do not open the fuel system if the coolant temperature is above 40°C/104°F. The residual pressure in the high pressure fuel system could cause bodily injury.**

It is essential to observe the utmost cleanliness when working on the high pressure fuel system and to follow the proper working procedures described in the repair instructions. Even minute soiling or damage at the thread connections of the high pressure lines could cause leaks.

When working on the fuel system of the N63TU engine, it is important to ensure that the ignition coils are not wet with fuel. The resistance of the silicone material is greatly reduced by sustained contact with fuel. This could result in arcing at the top of the spark plug and misfiring.

- Before making any modifications to the fuel system, always remove the ignition coils and protect the spark plug shaft against the ingress of fuel by covering them with a cloth
- Before reinstalling the solenoid valve injectors, remove the ignition coils and ensure that greatest possible cleanliness is maintained.
- Ignition coils heavily saturated with fuel must be replaced.

### 7.2. Fuel pump control

The fuel is delivered from the fuel tank through the electric fuel pump via the feed line at a primary pressure of 5.9 bar (85.57 psi) to the high pressure pump. The on-load speed control is done via the DME. The low-pressure sensor has been eliminated.

### 7.3. High pressure pump

The known Bosch high pressure pump is used. This is a single-plunger pump which is driven from the exhaust camshaft via a triple cam. So that sufficient fuel pressure is guaranteed in each load condition of the engine, a high pressure pump is used in the N63TU engine for each bank.

For further information on the high pressure pump, please refer to the "N74 Engine" training material available on TIS and ICP.

# N63TU Engine

# 7. Fuel Preparation

## 7.4. Injectors

The Bosch HDEV5.2 solenoid valve injector is an inward-opening multi-hole valve – unlike the outward-opening piezo injector used in HPI engines. The HDEV5.2 is also characterized by high variability with regard to spray angle and spray shape, and is configured for a system pressure of up to 200 bar (2900 psi).

These injectors are already used in the N55 and N20 engines.

For further information on injector activation, refer to the Engine Management System section.


N63TU, injector

The stems of the solenoid valve injectors can only withstand a certain tensile force and a certain torque. It is essential when removing and installing the injectors to follow the specific procedure described in the repair instructions, as otherwise the injectors will be damaged.

If an injector or a cylinder was replaced, an injection quantity compensation must be performed. This is performed with help of the adjustment value. The adjustment value is imprinted on the injector body with three figures. The adjustment value must be read before the installation and input in the DME with the use of a test plan in ISTA.

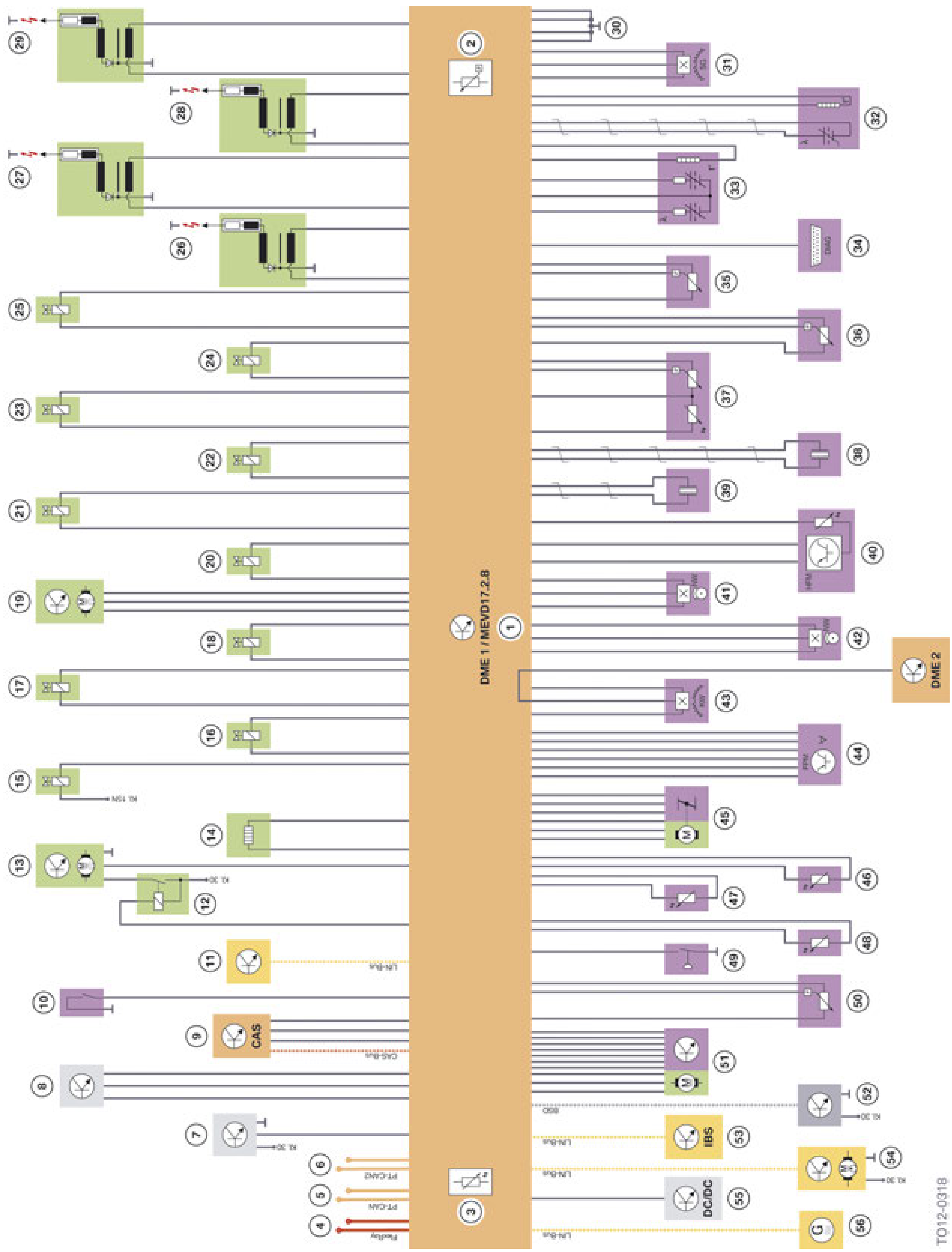
# N63TU Engine
## 8. Fuel Supply

The fuel supply is vehicle-specific. The previously known components are used.

# N63TU Engine

## 9. Engine Management System

### 9.1. Overview

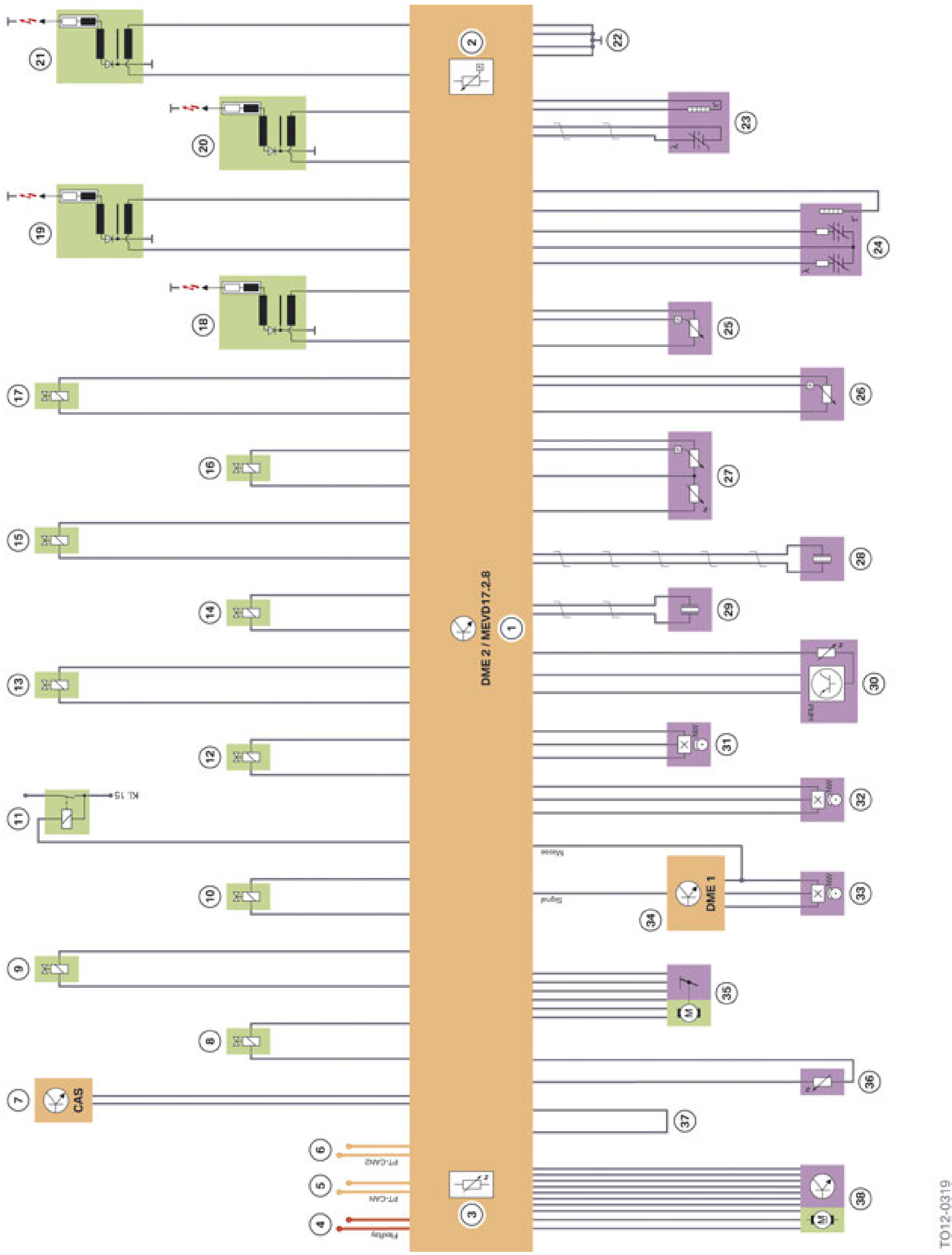



N63TU, DME 1/system wiring diagram MEVD17.2.8

| Index | Explanation |
|---|---|
| 1 | Engine electronics Valvetronic direct fuel injection MEVD17.2.8 DME 1 |
| 2 | Ambient pressure sensor |
| 3 | Temperature sensor |
| 4 | FlexRay |
| 5 | PT-CAN |
| 6 | PT-CAN2 |
| 7 | Tank leak diagnosis, Natural Vacuum Leak Detection NVLD (only US version) |
| 8 | Zero-gear sensor (only with automatic engine start-stop function, manual gearbox) |
| 9 | Car Access System (CAS) |
| 10 | Clutch switch (with manual gearbox only) |
| 11 | Active cowl flap control |
| 12 | Relay for electric fan |
| 13 | Electric fan |
| 14 | Map thermostat |
| 15 | Exhaust flaps (1 valve, 2 flaps) |
| 16 | Tank vent valve |
| 17 | VANOS solenoid valve, intake camshaft |
| 18 | VANOS solenoid valve, exhaust camshaft |
| 19 | Electric coolant pump, exhaust turbocharger |
| 20 | Electropneumatic pressure converter (EPDW) wastegate |
| 21 | Quantity control valve |
| 22–25 | Injectors |
| 26–29 | Ignition coils |
| 30 | Ground |
| 31 | Speed sensor (manual gearbox only) |
| 32 | Oxygen sensor LSF4.2 |
| 33 | Oxygen sensor LSU ADV |
| 34 | Engine speed signal diagnostic connector |
| 35 | Charging pressure sensor before throttle valve |
| 36 | Rail pressure sensor |
| 37 | Charge air temperature and intake-manifold pressure sensor after throttle valve |
| 38 | Knock sensors 1 – 2 |
| 39 | Knock sensors 3 - 4 |
| 40 | Hot film air mass meter (HFM) 7 |

## 9. Engine Management System

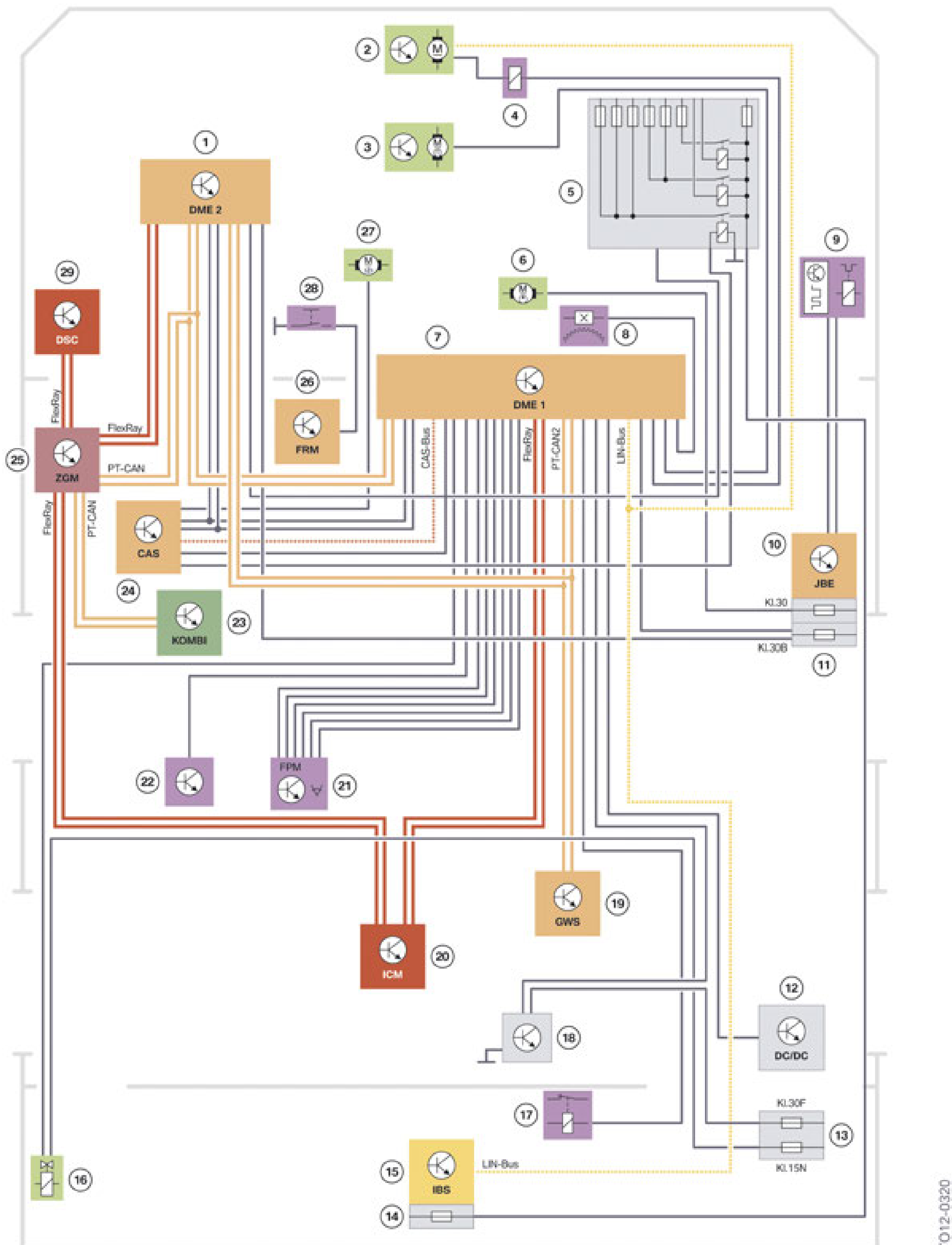
| Index | Explanation |
|---|---|
| 41 | Camshaft sensor, intake camshaft |
| 42 | Camshaft sensor, exhaust camshaft |
| 43 | Crankshaft sensor, signal is looped through to DME slave |
| 44 | Accelerator pedal module |
| 45 | Throttle valve |
| 46 | Engine temperature (sensor at housing of coolant pump) |
| 47 | Coolant temperature at radiator outlet |
| 48 | Oil temperature sensor |
| 49 | Oil pressure switch |
| 50 | Brake vacuum sensor (only with automatic engine start-stop function, manual gearbox) |
| 51 | Valvetronic servomotor |
| 52 | Oil level sensor |
| 53 | Intelligent battery sensor (IBS) |
| 54 | Electric coolant pump, charge air cooler and Digital Engine Electronics (DME) |
| 55 | DC/DC converter (for automatic engine start-stop function) |
| 56 | Alternator |



N63TU, DME 2/system wiring diagram MEVD17.2.8

## 9. Engine Management System

| Index | Explanation |
|---|---|
| 1 | Engine electronics Valvetronic direct fuel injection MEVD17.2.8 DME 2 |
| 2 | Ambient pressure sensor |
| 3 | Temperature sensor |
| 4 | FlexRay |
| 5 | PT-CAN |
| 6 | PT-CAN2 |
| 7 | Car Access System (CAS) |
| 8 | Tank vent valve |
| 9 | VANOS solenoid valve, intake camshaft |
| 10 | VANOS solenoid valve, exhaust camshaft |
| 11 | Relay, transmission oil pump (manual gearbox only) |
| 12 | Pressure converter (EPDW) |
| 13 | Quantity control valve |
| 14–17 | Injector |
| 18–21 | Ignition coil |
| 22 | Ground |
| 23 | Oxygen sensor LSF4.2 |
| 24 | Oxygen sensor LSU ADV |
| 25 | Charging pressure sensor before throttle valve |
| 26 | Rail pressure sensor |
| 27 | Charge air temperature and intake-manifold pressure sensor after throttle valve |
| 28 | Knock sensors 5 - 6 |
| 29 | Knock sensors 7 - 8 |
| 30 | Hot film air mass meter (HFM) 7 |
| 31 | Camshaft sensor, intake camshaft |
| 32 | Camshaft sensor, exhaust camshaft |
| 33 | Crankshaft sensor |
| 34 | Digital Engine Electronics (DME) master |
| 35 | Throttle valve |
| 36 | NTC transmission oil temperature (only with manual gearbox) |
| 37 | DME 1/ DME 2 encoding |
| 38 | Valvetronic servomotor |



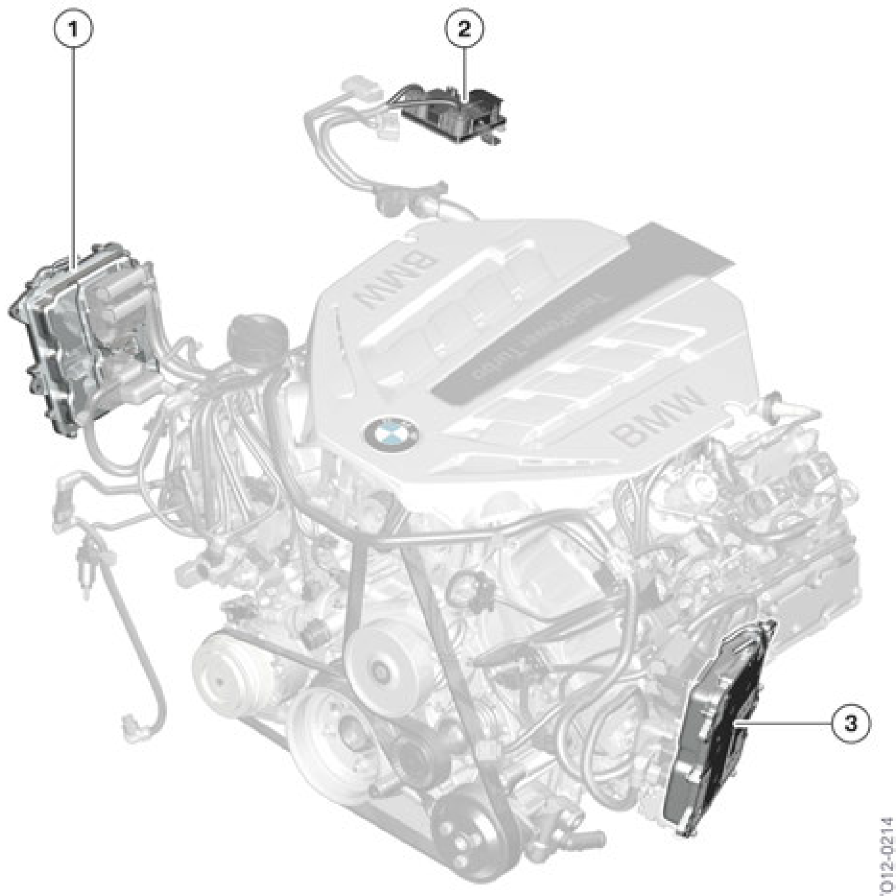

N63TU, vehicle connection module 100 of DME 1 and DME 2

# 9. Engine Management System

| Index | Explanation |
|---|---|
| 1 | Digital Engine Electronics (DME 2) |
| 2 | Automatic air flap control |
| 3 | Electric fan |
| 4 | Solenoid for the automatic air flap control |
| 5 | Power distribution boxes |
| 6 | Electric auxiliary water pump for charge air and DME |
| 7 | Digital Engine Electronics (DME 1) |
| 8 | Transmission speed sensor (manual gearbox only) |
| 9 | A/C compressor |
| 10 | Junction box (JB) |
| 11 | Fuse, terminal 30B |
| 12 | DC/DC converter (for automatic engine start-stop function) |
| 13 | Rear right power distribution box |
| 14 | Fuse, terminal 30 |
| 15 | Intelligent battery sensor (IBS) |
| 16 | Valve, exhaust flap |
| 17 | Relay for electric fan |
| 18 | Tank leak diagnosis (only for US) |
| 19 | Gear selector lever (only automatic) |
| 20 | Integrated Chassis Management (ICM) |
| 21 | Accelerator pedal module |
| 22 | Coupling switch module (manual gearbox only) |
| 23 | Instrument cluster |
| 24 | Car Access System (CAS) |
| 25 | Central gateway module (CGM) |
| 26 | Footwell module (FRM) |
| 27 | Starter motor |
| 28 | Switch reversing light (manual gearbox only) |
| 29 | Dynamic Stability Control DSC |

## 9.2. Engine control unit

The N63TU engine has a Bosch DME with the designation MEVD17.2.8. It is strongly related to the Digital Engine Electronics of the N55 engine. There is a separate water-cooled engine control unit fixed to the engine for every bank. The actuators and sensors of bank one are assigned to the DME 1 control unit, the DME 2 control unit is responsible for the functions of bank two. DME 1 is the master control unit and also assumes all information concerning the entire engine, such as turning on the crankshaft sensor and making it available to the DME 2 control unit directly or via the bus system. Due to the variety of sensors and actuators a distribution to two control units was necessary.




N63TU, Digital Engine Electronics

| Index | Explanation |
|---|---|
| 1 | DME control unit, bank 1 |
| 2 | Power distribution boxes |
| 3 | DME control unit, bank 2 |

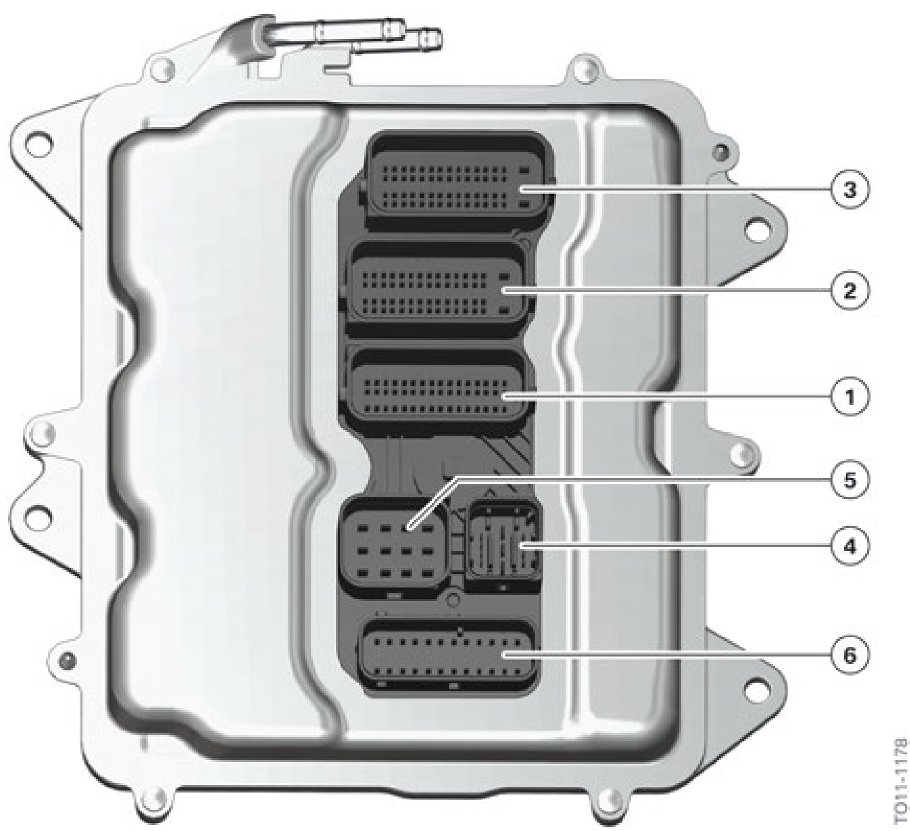
Do not attempt any trial replacement of control units.

Because of the electronic immobilizer, a trial replacement of control units from other vehicles must not be attempted under any circumstances. An immobilizer adjustment cannot be reversed.

The cooling of the two control units of the Digital Engine Electronics is done by connection to the cooling circuit of the charge air cooling. An aluminium cooling loop is integrated in the housing base of the control units for this system.

# 9. Engine Management System

The plug connector concept is identical to the MEVD17.2 in the N55 engine. There is a logical division into six modules.




N63TU, MEVD17.2.8 DME connections

| Index | Explanation |
|---|---|
| 1 | Module 100, vehicle connection, 48 pins |
| 2 | Module 200, sensors and actuators 1, 58 pins |
| 3 | Module 300, sensors and actuators 2, 58 pins |
| 4 | Module 400, Valvetronic servomotor, 11 pins |
| 5 | Module 500, DME supply, 12 pins |
| 6 | Module 600, fuel injection and ignition, 24 pins |

### 9.2.1. Overall function

The Digital Engine Electronics (DME) is the computing and switching center of the engine control system. Sensors on the engine and the vehicle deliver the input signals. The signals for activating the actuators are calculated from the input signals, the set-point values calculated using a computing model in the DME control unit and the stored program maps. The DME control unit activates the actuators directly or via relays.

The DME control unit is woken up via the wake-up line (terminal 15 Wake-up) by the Car Access System (CAS).

## 9. Engine Management System

The after-run starts after terminal 15 OFF. The adaptation values are stored during the after-run. The DME control unit uses a bus signal to signal its readiness to "go to sleep". When all the participating control units have signalled their readiness to "go to sleep", the bus master outputs a bus signal and the control units terminate communication five seconds later.

The board in the DME control unit accommodates two sensors: a temperature sensor and an ambient pressure sensor. The temperature sensor is used to monitor the temperature of the components in the DME control unit. The ambient pressure is required for calculating the air/fuel mixture composition.

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# Technical training.
# Product information.

## N20 Engine

Edited for the U.S. market by:
**BMW Group University**
Technical Training
ST1111 1/1/2013

**BMW Service**

# General information

### Symbols used

The following symbol / sign is used in this document to facilitate better comprehension and to draw attention to particularly important information:

⚠

Contains important safety guidance and information that is necessary for proper system functioning and which it is imperative to follow.

### Information status and national-market versions

The BMW Group produces vehicles to meet the very highest standards of safety and quality. Changes in terms of environmental protection, customer benefits and design make it necessary to develop systems and components on a continuous basis. Consequently, this may result in differences between the content of this document and the vehicles available in the training course.

As a general principle, this document describes left-hand drive vehicles in the European version. Some controls or components are arranged differently in right-hand drive vehicles than those shown on the graphics in this document. Further discrepancies may arise from market-specific or country-specific equipment specifications.

### Additional sources of information

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

- Owner's Handbook
- Integrated Service Technical Application.

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**BV-72/Technical Training**

# N20 Engine
## Contents

# N20 Engine
## Contents

# N20 Engine
# Contents

# N20 Engine
# 1. Introduction

BMW has decided to bring back the 4–cylinder engine to the US market. The last BMW 4–cylinder engine in the US was the M44, this lasted until 1999 and was installed in the E36 318is/318ti/Z3. Since then BMW in the US has not had a 4–cylinder engine. The N20 engine represents the new generation of BMW 4-cylinder gasoline engines. It will gradually be phased in on a number of BMW models starting in September 2011. The N20 will replace the N52 6-cylinder naturally aspirated engines. The N20 engine is equipped with the latest technology, such as TVDI (Turbocharged Valvetronic Direct Injection) in conjunction with a TwinScroll exhaust turbocharger. As a whole, it is closely related to the N55 engine, this is why constant reference is made to the N55 engine in this document.

## 1.1. History

The history of BMW 4-cylinder engines began back in 1927 with the BMW 3/15. From that point on, apart from an interruption stretching from 1936 to 1962, the 4-cylinder gasoline engines have again and again been the precursors to new technologies and have often also been forerunners. Thus, the M31 engine (predecessor of the M10 engine) was the world's first 4-cylinder production engine to feature a TwinScroll exhaust turbocharger and back in 1973 already achieving a power output of 125 kW / 167 bhp from a displacement of 2 liters. In motorsport the crankcase of the M10 with a displacement of 1.5 liters produced the first Formula 1 world champion with a turbocharged engine. In the world of motor racing performance figures of up to 1350 bhp from a displacement of 1.5 liters were achieved, figures which to date have only been achieved by BMW.

### 1.1.1. Historic BMW AG engines

| Designation | Power output in bhp/rpm | Displacement in [cm³] | Year of launch | Model | Series |
|---|---|---|---|---|---|
| DA 1, 2, 4* | 15/3000 | 748 | 1927 | BMW 3/15 | 3/15 |
| DA 3* | 18/3500 | 748 | 1930 | Wartburg | 3/15 |
| M68* | 20/3500 | 782 | 1932 | BMW 3/20 | 3/20 |
| M68* | 22/4000 | 845 | 1934 | BMW 309 | 309 |
| M115** | 75/5700 | 1499 | 1961 | BMW 1500 | 115 |
| M115** Available in the US | 80/5500 | 1499 | 1962 | BMW 1500 | 115 |
| M116** Available in the US | 83/5500 | 1573 | 1964 | BMW 1600 | 116 |
| M116** | 85/5700 | 1573 | 1966 | BMW 1600-2 | 114C |
| M116** | 105/6000 | 1573 | 1967 | BMW 1600ti | 116 |
| M116** | 75/5800 | 1573 | 1975 | BMW 1502 | 114 |
| M118** | 90/5250 | 1773 | 1963 | BMW 1800 | 118 |
| M118** | 110/5800 | 1773 | 1964 | BMW 1800ti | 118 |

# N20 Engine
# 1. Introduction

| Designation | Power output in bhp/rpm | Displacement in [cm³] | Year of launch | Model | Series |
|---|---|---|---|---|---|
| M118** Available in the US | 130/6100 | 1773 | 1965 | BMW 1800ti SA | 118 |
| M118** short-stroke | 90/5250 | 1766 | 1968 | BMW 1800 | 118 |
| M118** short-stroke | 90/5500 | 1766 | 1974 | BMW 518 | E12/4 |
| M05** Available in the US | 100/5500 | 1990 | 1965–1972 | BMW 2000/2002 | 121 |
| M05** | 120/5500 | 1990 | 1965 | BMW 2000ti | 121 |
| M15** Available in the US | 130/5800 | 1990 | 1968 | BMW 2000tii/2002tii | 121 |
| M17** | 115/5800 | 1990 | 1972 | BMW 520 | E12/4 |
| M31** | 170/5800 | 1990 | 1974 | BMW 2002 turbo | E20 |
| M41** | 90/6000 | 1573 | 1975 | BMW 316 | E21 |
| M42** | 98/5800 | 1766 | 1975 | BMW 318 | E12 |
| M42** | 90/5500 | 1766 | 1976 | BMW 518 | E12 |
| M43/1** | 109/5800 | 1990 | 1975 | BMW 320 | E21 |
| M64** | 125/5700 | 1990 | 1975 | BMW 320i | E21 |
| M10 (M92**) | 105/5800 | 1766 | 1980 | BMW 318i | E30 |
| M10 (M99**) | 90/5500 | 1766 | 1980 | BMW 316/518 | E30/E28 |
| M98** | 75/5800 | 1573 | 1981 | BMW 315 | E21 |
| M10 Available in the US | 102/5800 | 1766 | 1984 | BMW 318i Cat | E30 |
| M40B16 | 102/5500 | 1596 | 1988 | BMW 316i | E30 |
| M40B16 | 99/5500 | 1596 | 1988 | BMW 316i Cat | E30 |
| M40B18 | 116/5500 | 1796 | 1987 | BMW 318i | E30 |
| M40B18 | 113/5500 | 1796 | 1987 | BMW 318i Cat BMW 518i Cat | E28/ E30/E34 |
| M42B18O0 Available in the US | 140/6000 | 1796 | 1989 | 318is/318ti | E36 |

# N20 Engine
# 1. Introduction

| Designation | Power output in bhp/rpm | Displacement in [cm³] | Year of launch | Model | Series |
|---|---|---|---|---|---|
| M43B16O0 | 102/5500 | 1596 | 1993 | 316i | E36 |
| M43B16O0 | 87/5500 | 1596 | 1996 | 316g | E36 |
| M43B18O0 | 116/5500 | 1796 | 1993 | 318i/518i/ Z3 1.8 | E34/E36 |
| M43B19U1 | 105/5300 | 1895 | 2000 | 316i | E46 |
| M43B19O1 | 118/5500 | 1895 | 1998 | 318i/Z3 1.8 | E36/E46 |
| M44B19O0 Available in the US | 149/6000 | 1895 | 1995 | 318is/318ti/ Z3 1.9 | E36 |

* denotes engines up to 1933, ** denotes engines from 1957–1980, Cat = catalytic converter from M42/1989 data with and without catalytic converter.

**Note: Not all engines in the chart above were available in the US market. The M44B19O0 was the last 4 cylinder engine available in the US up to the introduction of the N20 in 9/2011.**

### 1.1.2. Historic BMW M engines

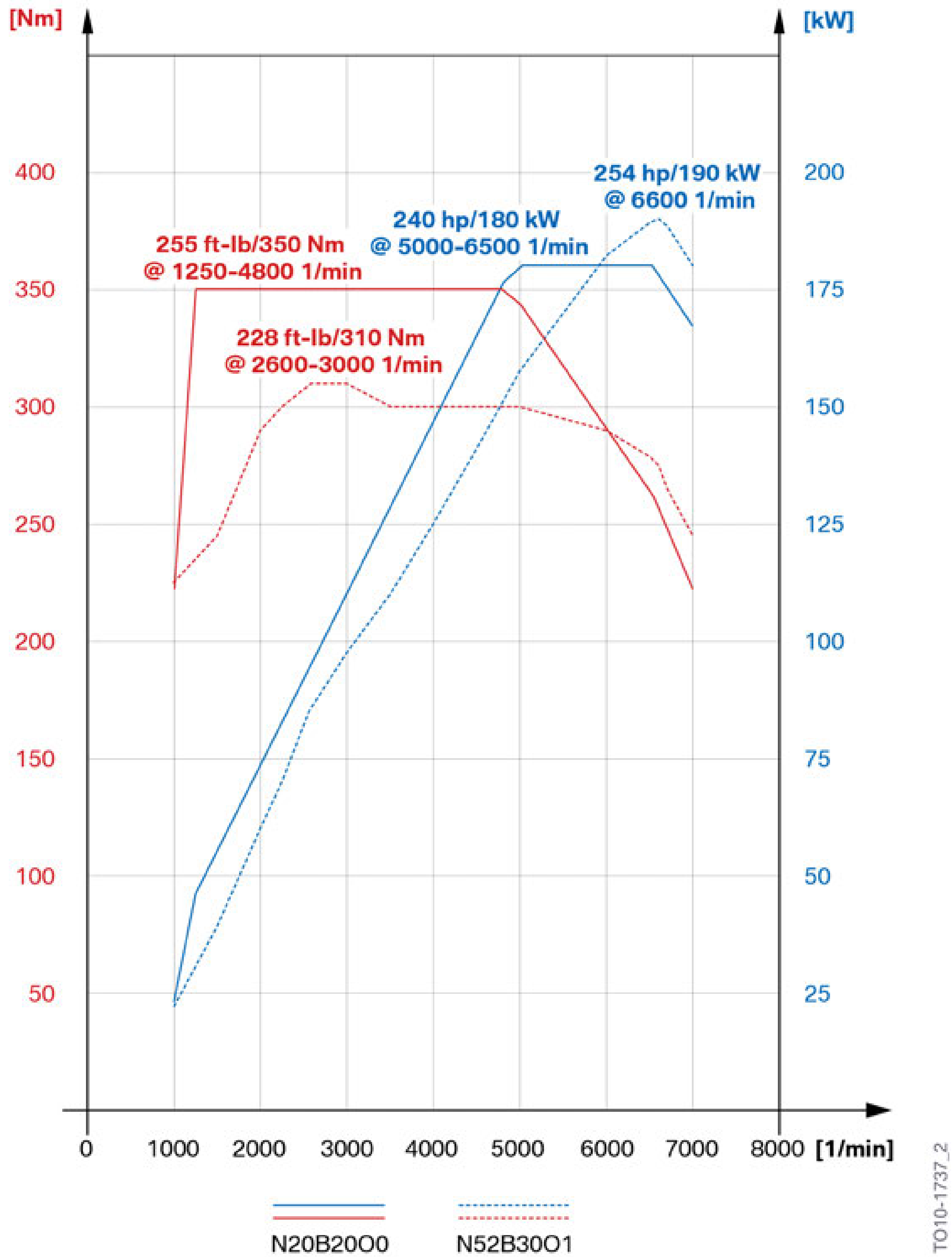
| Designation | Power output in bhp/rpm | Displacement in [cm³] | Year of launch | Model | Series |
|---|---|---|---|---|---|
| S14B23 | 197/6750 | 2302 | 1986 | BMW M3 | E30 |

## 1.2. Technical data

| Model designation | Engine designation | Series introduction |
|---|---|---|
| Various BMW models | N20B20O0 | 2012 Model year |

### 1.2.1. Comparison

**N20B20O0 engine compared with N52B30O1 engine**




Full-load diagram, N20B20O0 engine compared with N52B30O1 engine

# N20 Engine
## 1. Introduction

| | Unit | N52B30O1 | N20B20O0 |
|---|---|---|---|
| **Design** | | Inline 6 | Inline 4 |
| **Displacement** | [cm³] | 2996 | 1997 |
| **Bore/stroke** | [mm] | 85/88 | 84/90.091 |
| **Power output**<br>**at engine speed** | kW/bhp<br>[rpm] | 190/254<br>6600 | 180/240<br>5000 - 6500 |
| **Power output per liter** | [kW/l] | 63.4 | 90.14 |
| **Torque**<br>**at engine speed** | Nm/ft-lbs<br>[rpm] | 310/228<br>2600 - 3000 | 350/255<br>1250 - 4800 |
| **Compression ratio** | [ε] | 10.7 | 10.0 : 1 |
| **Valves per cylinder** | | 4 | 4 |
| **Fuel consumption** | l/100 km | 9.9 | 7,9 |
| **$CO_2$ emissions** | [g/km] | 230 | 183 |
| **Digital Engine Electronics** | | MSV80 | MEVD17.2.4 |
| **Exhaust emissions legislation** | | ULEV II | ULEV II |

## 1.3. New features/changes

### 1.3.1. Overview

| System | Comment |
|---|---|
| Engine mechanical components | • Aluminium crankcase with coated cylinder bore<br>• Optimized cooling jackets<br>• Use of the TVDI technology<br>• TwinScroll exhaust turbocharger<br>• 3rd generation Valvetronic with new intermediate levers<br>• New generation VANOS with central valves<br>• Assembled camshafts<br>• Two mode crankcase ventilation<br>• Forged crankshaft<br>• Positive crankshaft offset<br>• Piston with negative pin offset<br>• Chain drive for counterbalance shafts with chain tensioner<br>• Counterbalance shafts arranged on top of one another. |
| Oil supply | • Map-controlled oil pump<br>• New pendulum-slide oil pump design<br>• Unfiltered oil cooling<br>• New combined oil pressure and temperature sensor. |
| Cooling | • Electric coolant pump<br>• Map controlled thermostat. |
| Air intake and exhaust emission systems | • TwinScroll exhaust turbocharger<br>• Hot-film air mass meter<br>• Enhanced crankcase ventilation. |

| System | Comment |
|---|---|
| Vacuum system | • Two-stage vacuum pump<br>• Vacuum reservoir for the wastegate valve is built into the engine cover. |
| Fuel preparation | • High-pressure injection (as N55)<br>• Solenoid valve injectors<br>• Bosch high-pressure pump<br>• High-pressure lines to the injectors are soldered to the rail<br>• No fuel low-pressure sensor. |
| Engine electrical system | • Bosch MEVD17.2.4 engine control unit. |

### 1.4. Engine identification

#### 1.4.1. Engine designation

The N20 engine is described in the following version: N20B20O0.

The technical documentation also features the short form of the engine designation N20, which only allows assignment of the engine type.

| Item | Meaning | Index / explanation |
|---|---|---|
| **1** | Engine developer | M, N = BMW Group<br>P = BMW Motorsport<br>S = BMW M GmbH<br>W = non-BMW engines |
| **2** | Engine type | 1 = Inline 4 (e.g. N12)<br>2 = Inline 4 (e.g. N20)<br>4 = Inline 4 (e.g. N43)<br>5 = Inline 6 (e.g. N53)<br>6 = V8 (e.g. N63)<br>7 = V12 (e.g. N73)<br>8 = V102 (e.g. S85) |
| **3** | Change to the basic engine concept | 0 = basic engine<br>1 to 9 = changes, e.g. combustion process |
| **4** | Working method or fuel type and possibly installation position | B = gasoline, longitudinal installation<br>D = diesel, longitudinal installation<br>H = hydrogen |
| **5** | Displacement in liters | 1 = 1 liter + |

# N20 Engine
## 1. Introduction

| Item | Meaning | Index / explanation |
|---|---|---|
| **6** | Displacement in 1/10 liter | 8 = 0.8 liters = 1.8 liters |
| **7** | Performance class | K = Smallest<br>U = Lower<br>M = Middle<br>O = Upper (standard)<br>T = Top<br>S = Super |
| **8** | Revision relevant to approval | 0 = New development<br>1 – 9 = Revision |

**Breakdown of N20 engine designation**

| Index | Explanation |
|---|---|
| **N** | BMW Group Development |
| **2** | 4-cylinder in-line engine |
| **0** | Engine with exhaust turbocharger, Valvetronic and direct fuel injection (TVDI) |
| **B** | Gasoline engine, longitudinally installed |
| **20** | 2.0 liters displacement |
| **O** | Upper performance class |
| **0** | New development |

### 1.4.2. Engine identification

The engines have an identification mark on the crankcase to ensure proper identification and classification.

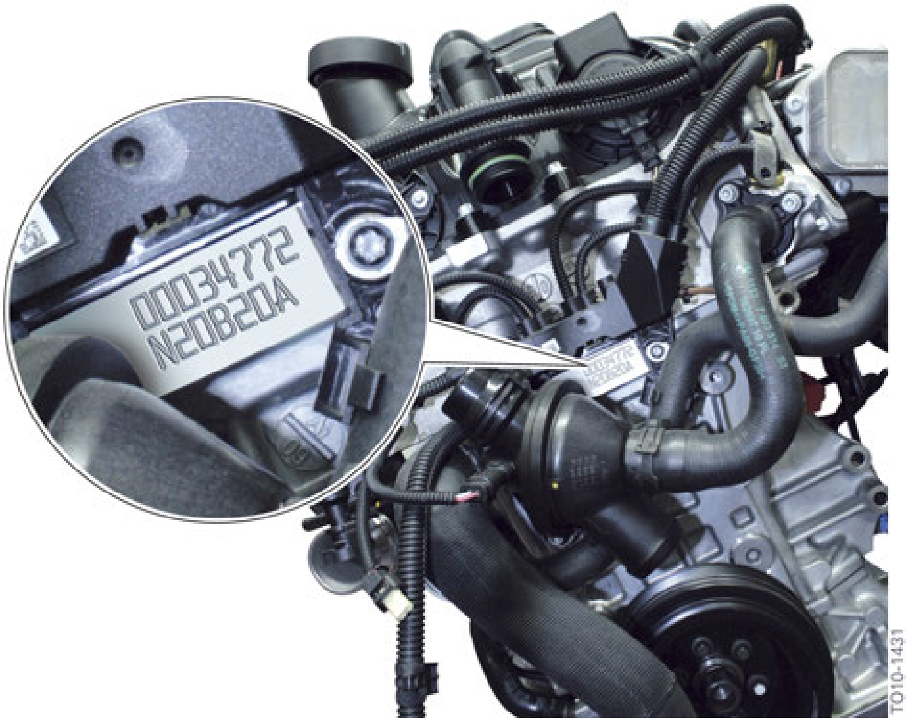
With the N55 engine, this identification was subject to a further development, with the previous eight positions being reduced to seven. The engine number can be found on the engine below the engine identification. This consecutive number, in conjunction with the engine identification, allows proper identification of each individual engine.

# N20 Engine
## 1. Introduction

| Item | Meaning | Index / explanation |
|---|---|---|
| **1** | Engine developer | M, N = BMW Group<br>P = BMW Motorsport<br>S = BMW M GmbH<br>W = non-BMW engines |
| **2** | Engine type | 1 = Inline 4 (e.g. N12)<br>2 = Inline 4 (e.g. N20)<br>4 = Inline 4 (e.g. N43)<br>5 = Inline 6 (e.g. N53)<br>6 = V8 (e.g. N63)<br>7 = V12 (e.g. N73)<br>8 = V102 (e.g. S85) |
| **3** | Change to the basic engine concept | 0 = basic engine<br>1 to 9 = changes, e.g. combustion process |
| **4** | Working method or fuel type and possibly installation position | B = gasoline, longitudinal installation<br>D = diesel, longitudinal installation<br>H = hydrogen |
| **5** | Displacement in liters | 1 = 1 liter + |
| **6** | Displacement in 1/10 liter | 8 = 0.8 liters = 1.8 liters |
| **7** | Type test concerns (changes that require a new type test) | A = Standard<br>B - Z = depending on requirement, e.g. RON 87 |

# N20 Engine

## 1. Introduction



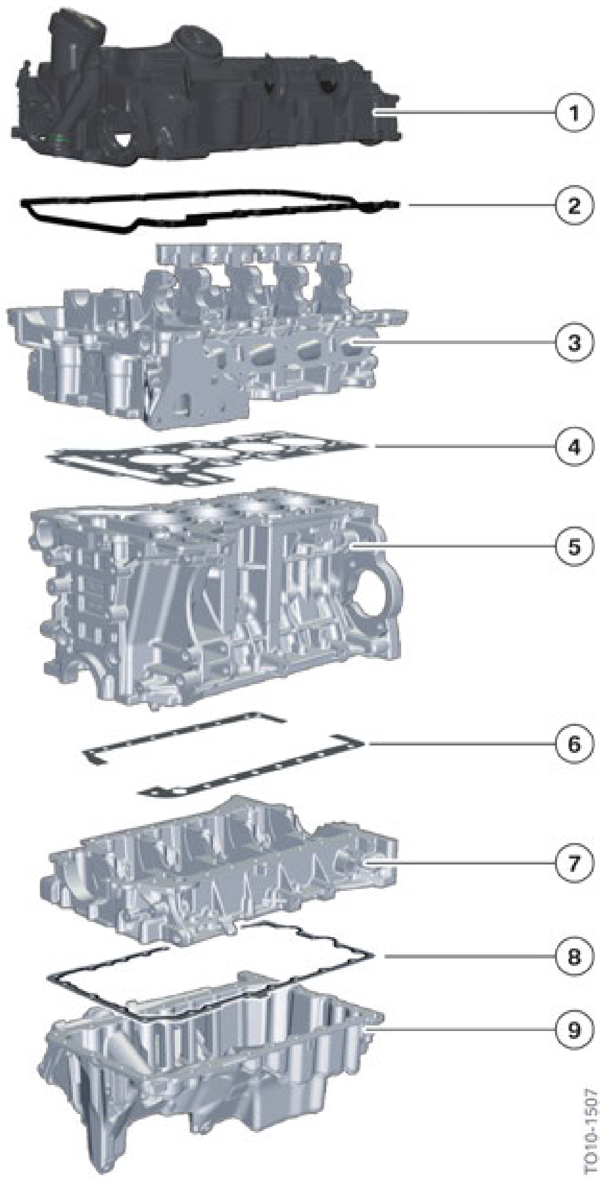

N20 engine number, engine identification and engine number

| Index | Explanation |
|---|---|
| 00034772 | Individual consecutive engine number |
| N | Engine developer, BMW Group |
| 2 | Engine type, Inline 4 |
| 0 | Change to the basic engine concept, Turbocharged Valvetronic Direct Injection |
| B | Operating principle or fuel type and installation position, gasoline longitudinal installation |
| 20 | Displacement in 1/10 liter, 2 liters |
| A | Type test concerns, standard |

# N20 Engine
# 2. Engine Components

## 2.1. Engine housing

The engine housing comprises the engine block (crankcase and bedplate), the cylinder head, the cylinder head cover, the oil sump and the gaskets.




N20 engine, structure of engine housing

| Index | Explanation |
|---|---|
| 1 | Cylinder head cover |
| 2 | Cylinder head cover gasket |
| 3 | Cylinder head |
| 4 | Cylinder head gasket |
| 5 | Crankcase |

| Index | Explanation |
|---|---|
| 6 | Sealant |
| 7 | Bedplate |
| 8 | Oil sump gasket |
| 9 | Oil sump |

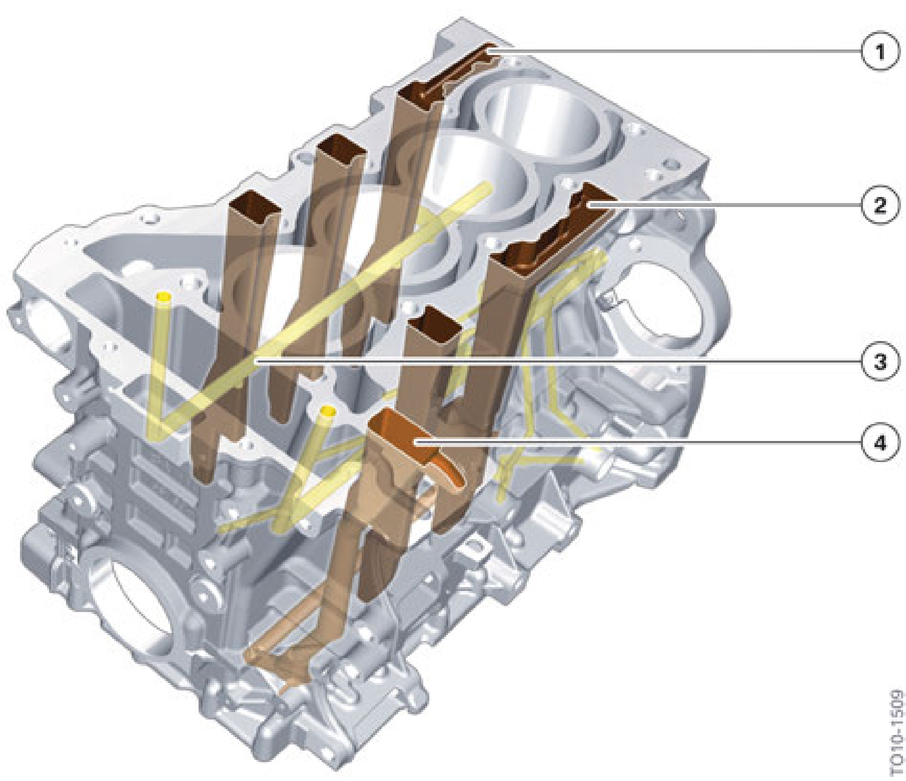
### 2.1.1. Engine block

The engine block is made from diecast aluminium AlSi9Cu3 along with the crankcase and the bedplate. A new coating for the cylinder wall is being used for the first time by BMW. Its referred to as electric arc wire spraying.

The cooling jacket has also been optimized to improve cooling between the cylinders, this is due to the requirements of a turbocharged engine.

#### Oil passages

The graphic below shows the oil passages in the engine block.



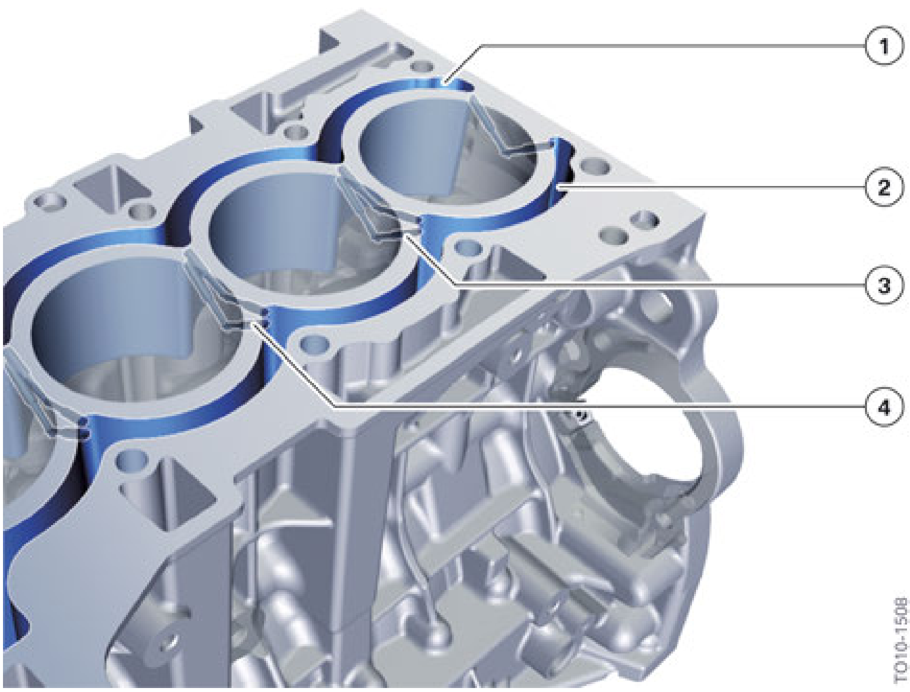

N20 engine, oil passages

# N20 Engine
## 2. Engine Components

| Index | Explanation |
|---|---|
| 1 | Oil return duct |
| 2 | Blow-by duct |
| 3 | Clean oil passages |
| 4 | Unfiltered oil passages |

#### Coolant ducts

The graphic below shows the coolant passages in the engine block.



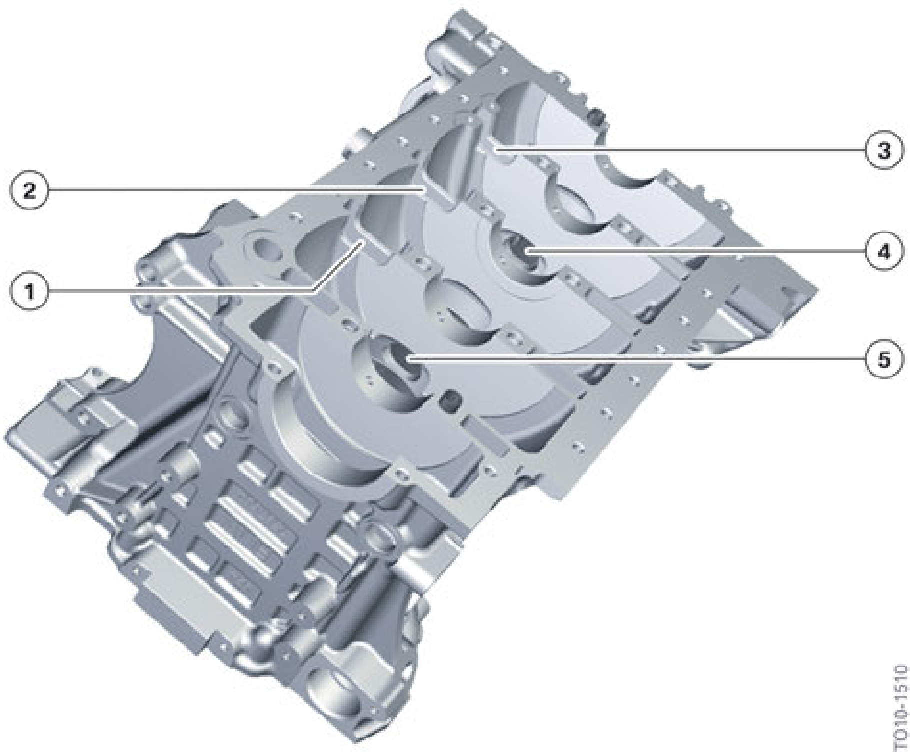

N20 engine, cooling jacket and coolant passages

| Index | Explanation |
|---|---|
| 1 | Cooling jacket, exhaust side |
| 2 | Cooling jacket, intake side |
| 3 + 4 | Coolant passages between the cylinders |

#### Compensation openings

The crankcase features large milled longitudinal ventilation holes. These ventilation holes improve the pressure compensation of the oscillating air columns created by the up and down strokes of the pistons.

Additional openings on the intake side on the bearing seat between the cylinders also improve crankcase pressure.




N20 engine, compensation openings in the bearing seat

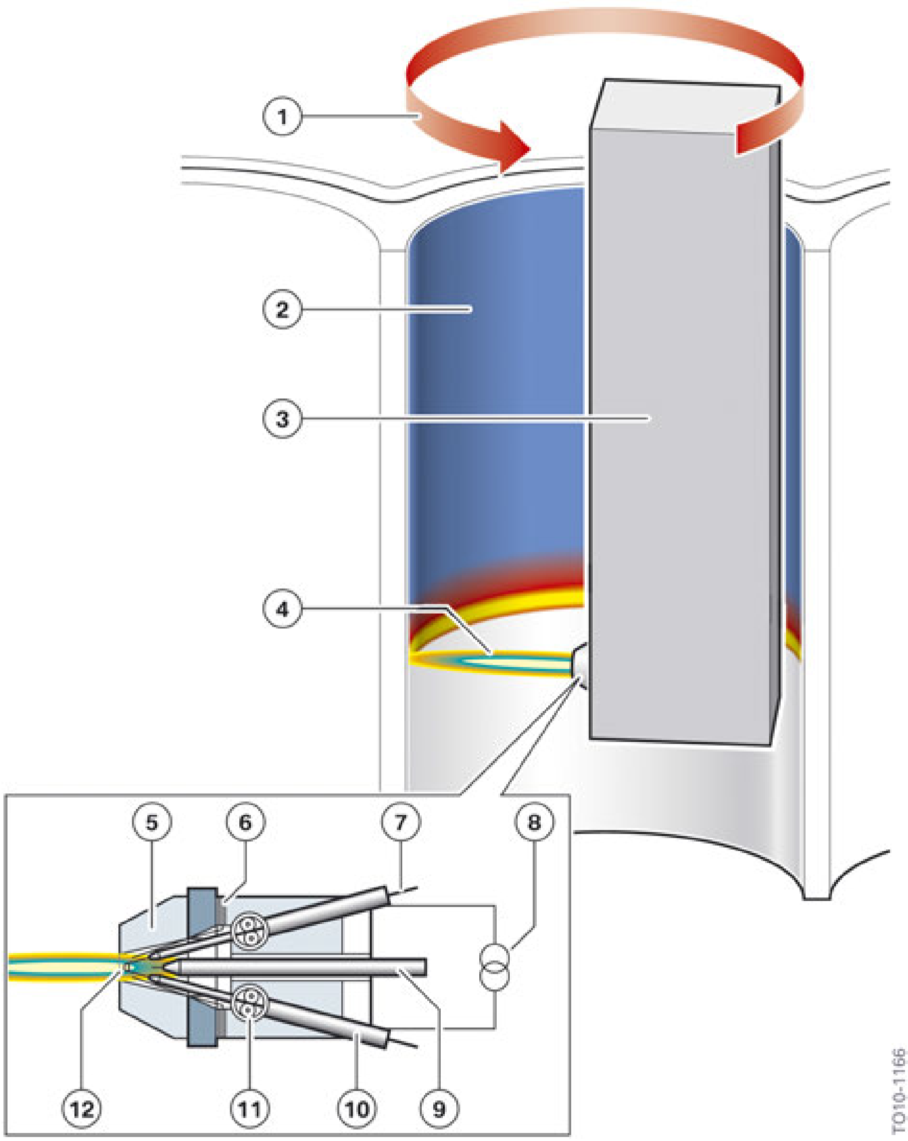
| Index | Explanation |
|---|---|
| 1 + 2 + 3 | Openings |
| 4 + 5 | Ventilation holes |

### Cylinder

An iron wire is used in the electric arc wire spraying process (arc spray process) to coat the aluminium cylinder bores. High voltage is used to ignite an electric arc at both ends of the wire. The temperatures generated in the process are in the region of 3000 °C / 5432 °F. The high temperatures melt the wire, which is continually fed by the wire feed unit. The molten iron is blasted onto the cylinder wall surface at pressure via the central and secondary compressed-air supplies.

The liquid iron adheres to the aluminium surface through:

- Mechanical bonding:
  Molten particles penetrate as a result of high kinetic energy and capillary action into depressions and undercuts, where they solidify to create a very strong coating.




Electric arc spraying

| Index | Explanation |
|---|---|
| 1 | Direction of movement |
| 2 | Coated cylinder surface |
| 3 | EAS unit |
| 4 | Spray jet |
| 5 | Nozzle |
| 6 | Secondary compressed-air supply |
| 7 | Spray wire |
| 8 | Power supply |

| Index | Explanation |
|---|---|
| 9 | Central compressed-air supply |
| 10 | Contact tube |
| 11 | Wire feed unit |
| 12 | Electric arc |

Advantages:

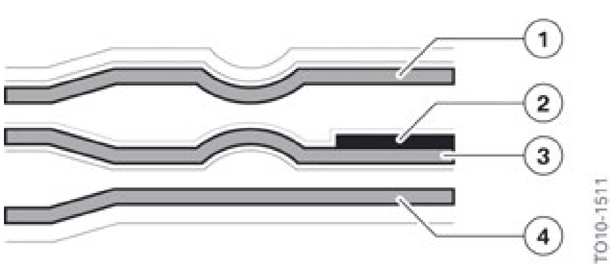
- Spray particles adhere with the base metal
- Ideal for thick coatings or large surfaces
- Greatest application rate per hour of all the thermal spraying processes
- The arc spray coating can barely be distinguished in terms of color from the base metal
- The low-oxide spray coating can be processed during manufacturing like a solid material
- High tensile strength and lower contraction strain
- Micro-porous surface reduces friction
- Coating properties such as coating hardness or surface quality can be determined
- All materials can be added as coatings, such as for example ferrous/nonferrous alloy on cast iron
- Low thermal stress thanks to optimized heat transfer.

The low coating thickness of about 1mm produces optimum heat transfer but does not allow reworking of the cylinder bore surface in service.

If a cylinder is determined out of specification the entire engine block must be replaced.

### 2.1.2. Cylinder head gasket

A three-layer spring steel gasket is used for the cylinder head gasket. A stopper plate (2) is welded on in the area of the cylinder bores in order to achieve sufficient contact pressure for sealing. All the layers of the gasket are coated, the cylinder head and the engine block contact surfaces are coated with a partial fluorocaoutchouc (elastomer) with non-stick coating.




N20 engine, cylinder head gasket

| Index | Explanation |
|---|---|
| 1 | Top spring steel layer with non-stick coating |
| 2 | Welded-on stopper plate |
| 3 | Middle spring steel layer with coating |
| 4 | Bottom spring steel layer with non-stick coating |

### 2.1.3. Cylinder head

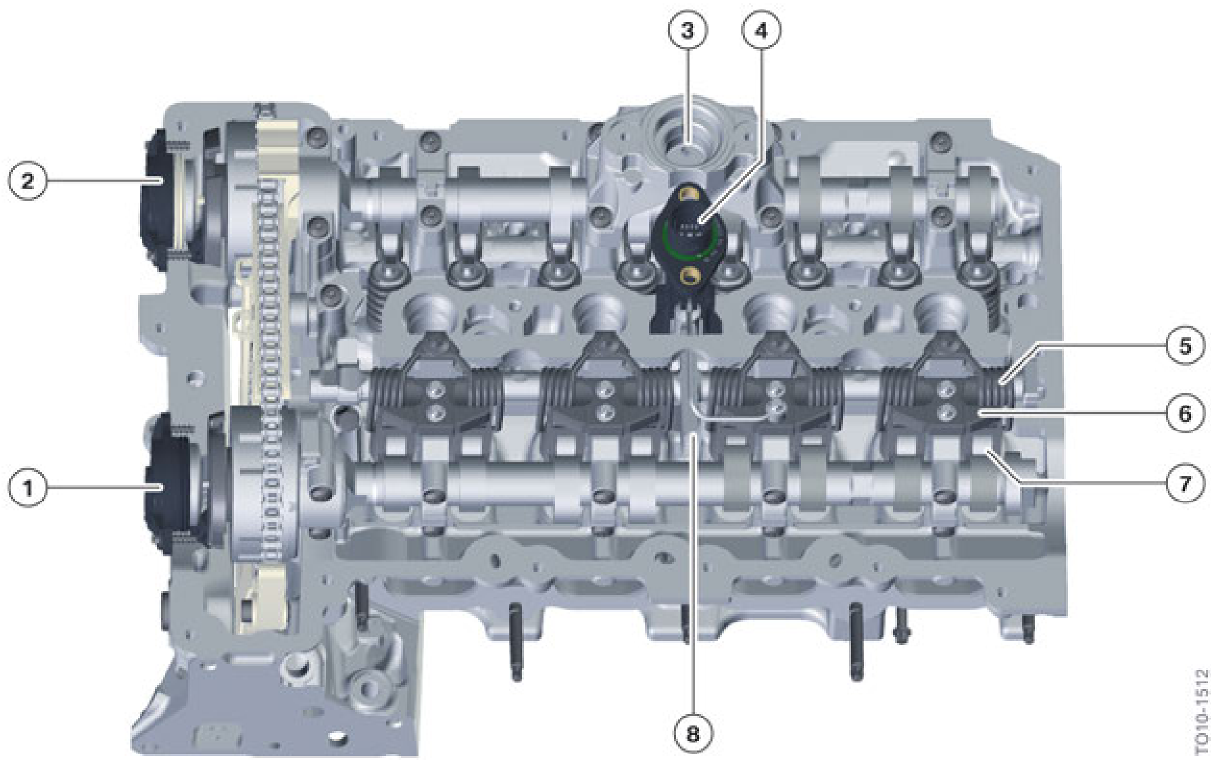
The cylinder head in the N20 engine is similar to the cylinder head in the N55. The 3rd generation Valvetronic system introduced in the N55 is also used in the N20 engine.

The classic VANOS with separate solenoid valve in the N55 engine has been replaced in the N20 engine by a central VANOS with integrated solenoid valve. The benefit of this system is a reduced number of oil passages in the cylinder head.

As in the N55 engine the N20 also uses TVDI technology.

⚠

The combination of exhaust turbocharger, Valvetronic and direct fuel injection is known as **T**urbo **V**alvetronic **D**irect **I**njection (TVDI).




N20 engine, cylinder head

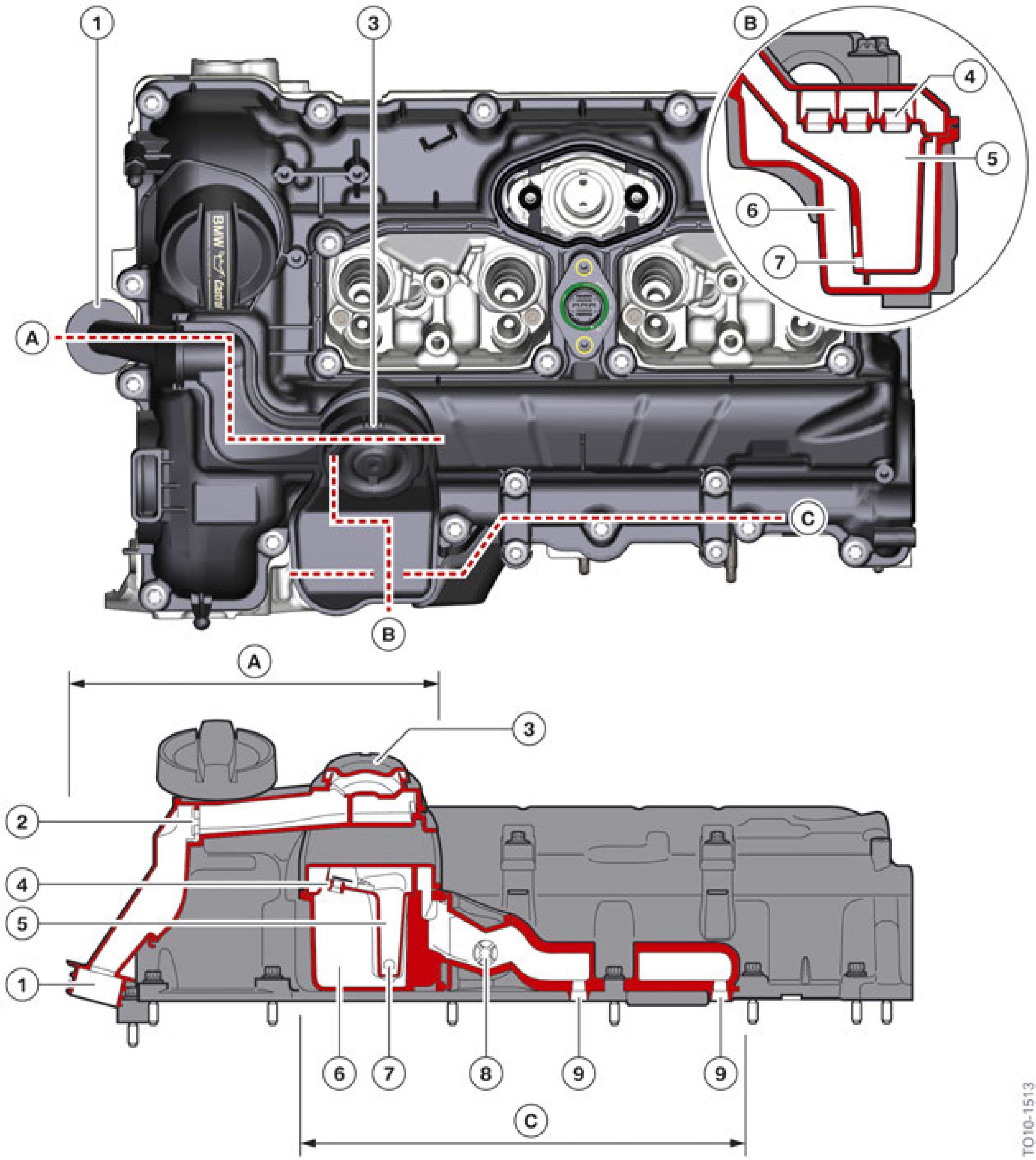
| Index | Explanation |
|---|---|
| 1 | VANOS solenoid actuator, intake |
| 2 | VANOS solenoid actuator, exhaust |
| 3 | Roller tappet, high-pressure pump |
| 4 | Valvetronic servomotor |
| 5 | Spring |
| 6 | Guide block |
| 7 | Intermediate lever |
| 8 | Eccentric shaft |

### 2.1.4. Cylinder head cover

**Design**

The cylinder head cover is a new development. All the components for crankcase ventilation and the blow-by ducts are integrated into the cover. A pressure control valve prevents an excessive vacuum from being generated in the crankcase. Ventilation is performed via different ducts depending on whether the engine is running in turbocharged (Boost) or normally aspirated (NA) mode.

In NA mode, ventilation is performed via the pressure control valve at about 38 mbar.




N20 engine, cylinder head cover with crankcase ventilation

| Index | Explanation |
|---|---|
| A | Section A |
| B | Section B |
| C | Section C |
| 1 | Connection to clean air pipe ahead of exhaust turbocharger |

| Index | Explanation |
|---|---|
| 2 | Non-return valve |
| 3 | Pressure control valve |
| 4 | Spring tab separator |
| 5 | Oil separator |
| 6 | Settling chamber |
| 7 | Non-return valve |
| 8 | Non-return valve |
| 9 | Blow-by duct to the intake ports in the cylinder head |

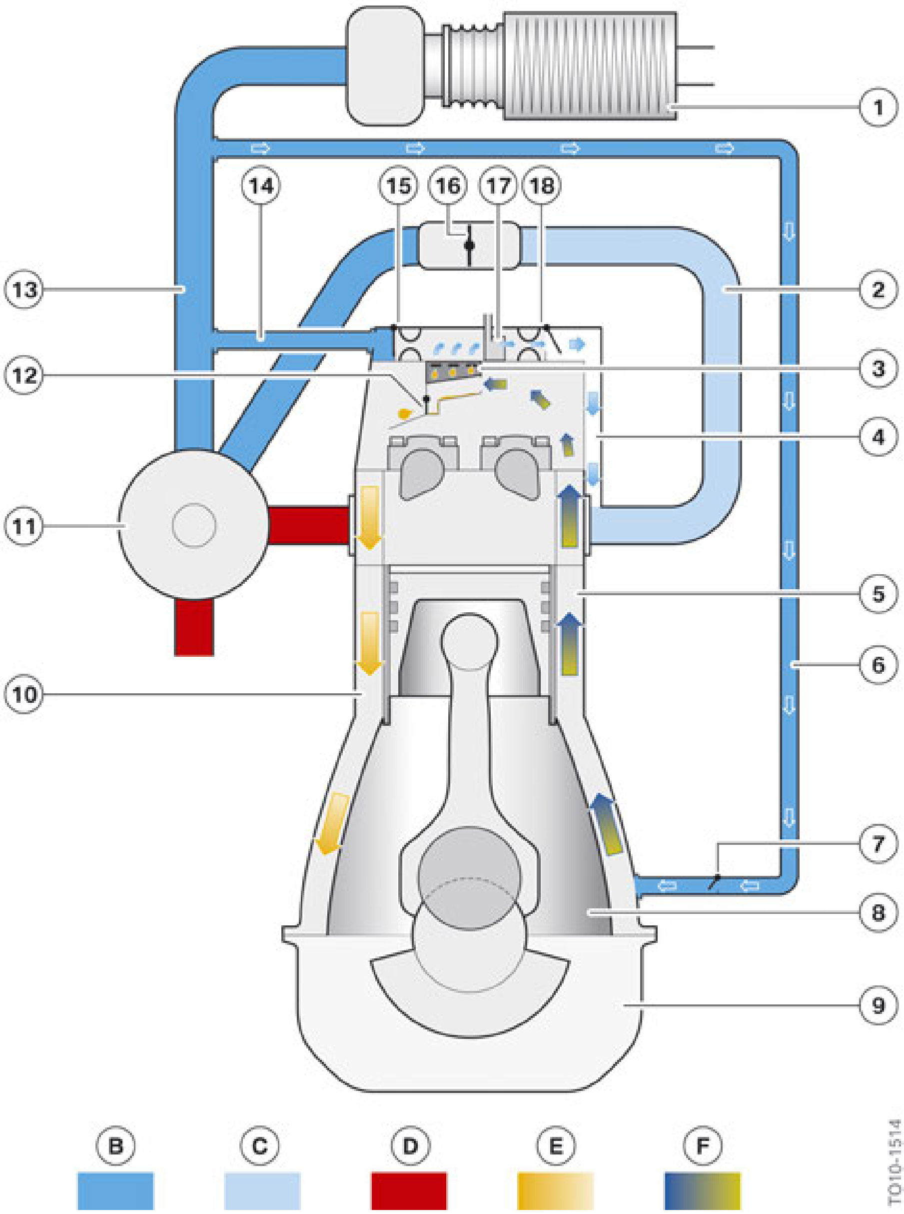
The blow-by gases pass through the opening in the intake side area of cylinder one to the three spring tab separators. The oil in the blow-by gas is separated by the spring tab separators, and flows along the walls down through a non-return valve and back into the cylinder head. The blow-by gas separated from the oil now passes into the air intake system ports or fresh air pipe (depending on the operating mode).

### Function

In naturally aspirated mode, the non-return valve in the blow-by duct of the cylinder head cover is opened by the vacuum pressure in the air intake system and the blow-by gases are drawn off via the pressure control valve. The vacuum pressure simultaneously closes the second non-return valve in the duct to charge-air suction/fresh air line.

The blow-by gases are routed directly into the cylinder head intake ports via the passages integrated in the cylinder head cover .

A purge air line, which is connected to the fresh air pipe ahead of the turbocharger and to the crankcase, routes fresh air via a non-return valve directly into the crankcase. The greater the vacuum in the crankcase, the higher the air mass introduced. This purging prevents the pressure control valve from icing up by reducing moisture in the system.



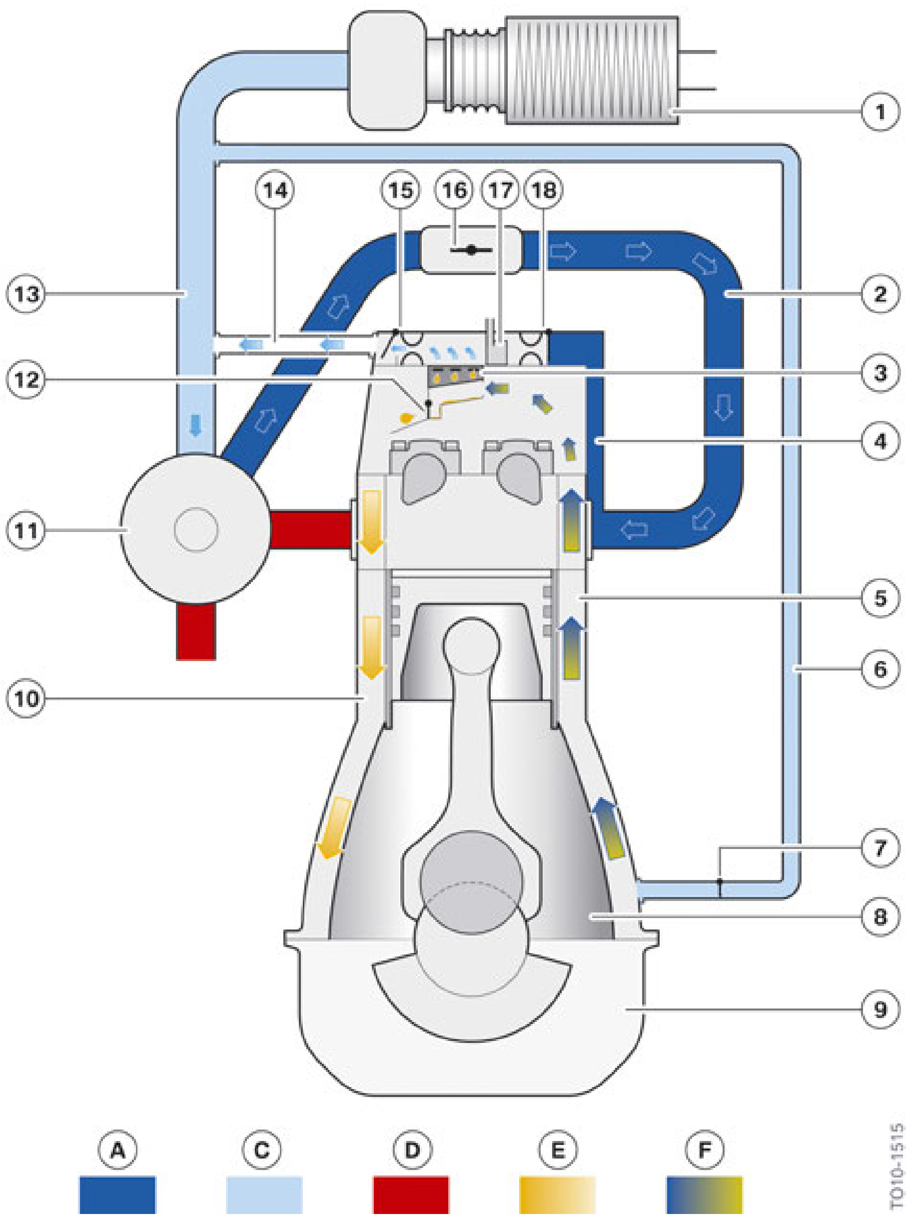

N20 engine, crankcase ventilation, naturally aspirated mode

| Index | Explanation |
|---|---|
| B | Ambient pressure |
| C | Vacuum |
| D | Exhaust gas |
| E | Oil |
| F | Blow-by gas |
| 1 | Air filter |
| 2 | Intake plenum |

| Index | Explanation |
|---|---|
| 3 | Perforated plates |
| 4 | Passages in cylinder head and cylinder head cover |
| 5 | Blow-by gas duct |
| 6 | Purge air line |
| 7 | Non-return valve |
| 8 | Crankcase |
| 9 | Oil sump |
| 10 | Oil return passage |
| 11 | Turbocharger |
| 12 | Non-return valve, oil return |
| 13 | Charge-air suction line/fresh air pipe |
| 14 | Connection to charge-air suction line |
| 15 | Non-return valve with restrictor |
| 16 | Throttle valve |
| 17 | Pressure control valve |
| 18 | Non-return valve with restrictor |

Once in boost mode the pressure in the intake plenum rises thus it is no longer possible for the blow-by gases to be introduced via this route. A non-return valve in the blow-by duct of the cylinder head cover closes the duct to the intake plenum and thereby protects the crankcase against excess pressure.

The now greater fresh-air demand generates a vacuum in the fresh air pipe between the turbocharger and the intake silencer. This vacuum is sufficient to open the non-return valve in the cylinder head cover and draw off the blow-by gases directly without regulation. The pressure control valve (17) is bypassed in this mode, since only a low vacuum is generated which does not have to be limited.




N20 engine, crankcase ventilation, boost mode

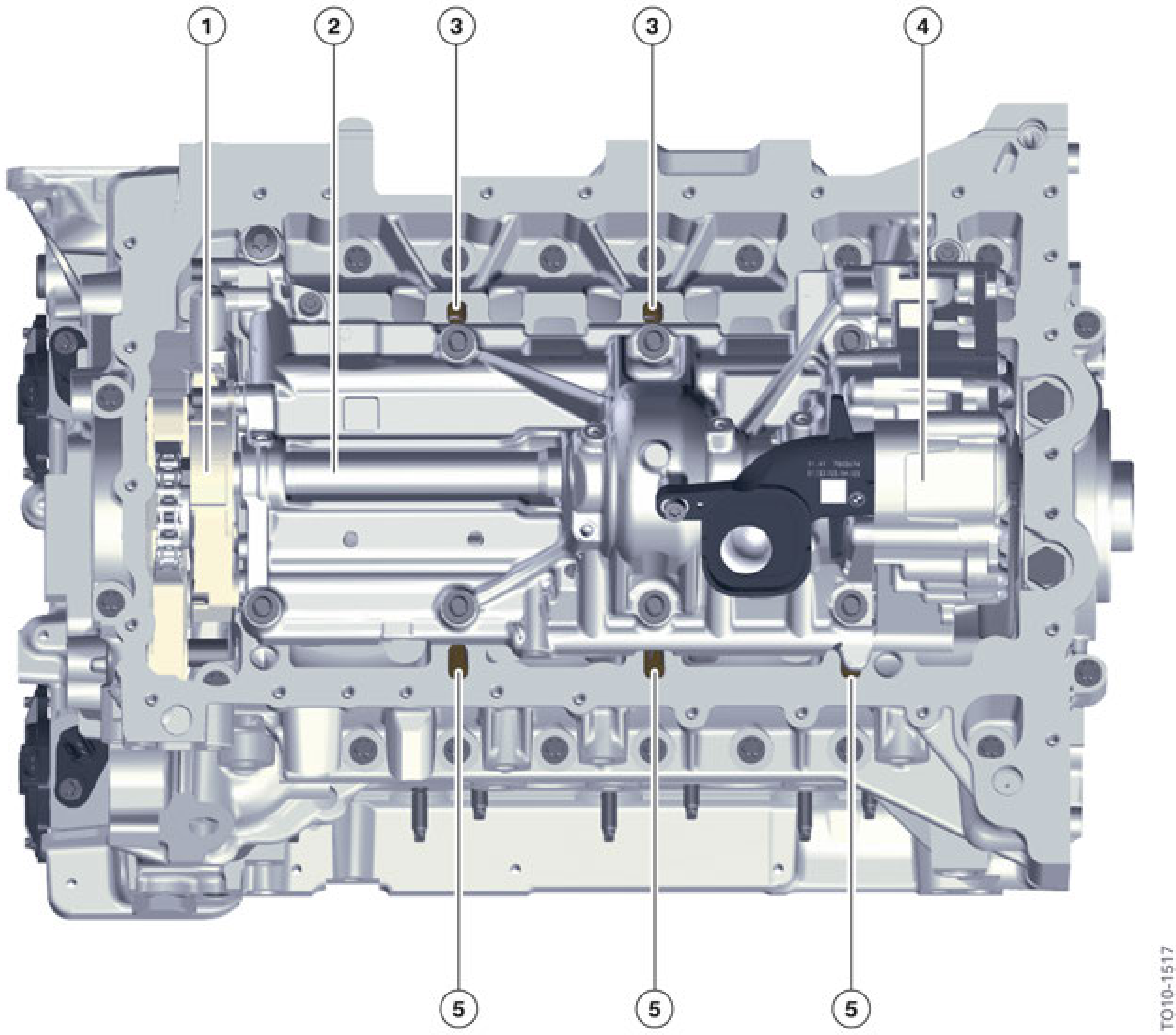
| Index | Explanation |
|---|---|
| A | Charging pressure |
| C | Vacuum |
| D | Exhaust gas |
| E | Oil |
| F | Blow-by gas |
| 1 | Air filter |
| 2 | Intake plenum |

| Index | Explanation |
|---|---|
| 3 | Perforated plates |
| 4 | Passages in cylinder head and cylinder head cover |
| 5 | Blow-by gas duct |
| 6 | Purge air line |
| 7 | Non-return valve |
| 8 | Crank chamber |
| 9 | Oil sump |
| 10 | Oil return passage |
| 11 | Turbocharger |
| 12 | Non-return valve, oil return |
| 13 | Charge-air suction line/clean air pipe |
| 14 | Connection to charge-air suction line |
| 15 | Non-return valve with restrictor |
| 16 | Throttle valve |
| 17 | Pressure control valve |
| 18 | Non-return valve with restrictor |

### 2.1.5. Oil sump

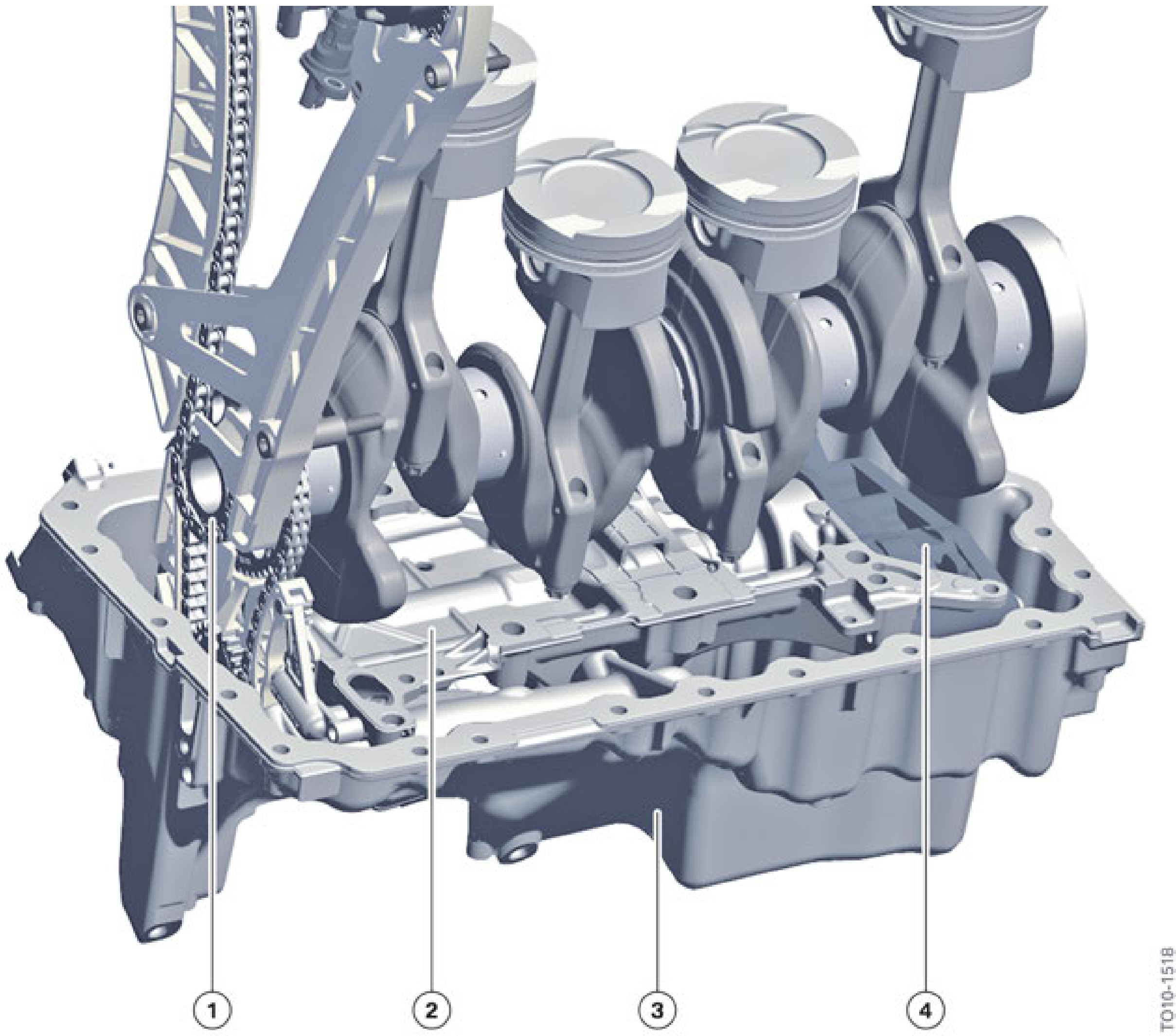
The oil sump is made from plastic for rear wheel drive vehicles and cast aluminium for xDrive models. For xDrive vehicles the oil sump has been modified due to the input shafts and attachment points for the axle drive.

The oil pump with the counterbalance shafts covers the entire oil sump and thereby protects the crankshaft against "oil splashing" by doubling as a windage tray. The oil flowing back through the oil return passages is routed directly into the oil sump and therefore cannot come into contact with the crankshaft.




N20 engine, oil pump with counterbalance shafts

| Index | Explanation |
|---|---|
| 1 | Chain drive |
| 2 | Counterbalance shaft |
| 3 | Oil return ducts, intake side |
| 4 | Oil pump |
| 5 | Oil return ducts, exhaust side |




N20 engine, oil sump with oil pump and counterbalance shafts

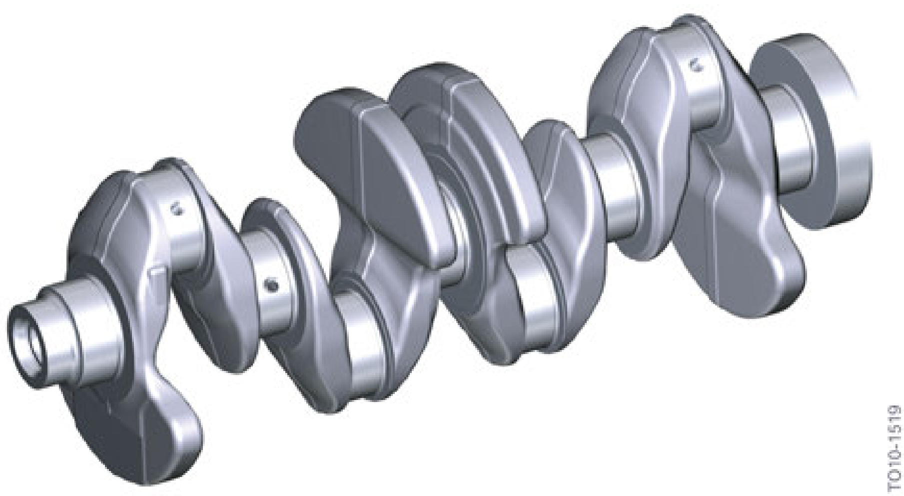
| Index | Explanation |
|---|---|
| 1 | Chain drive |
| 2 | Housing, counterbalance shafts |
| 3 | Oil sump |
| 4 | Oil pump |

## 2.2. Crankshaft drive

### 2.2.1. Crankshaft with bearings

#### Crankshaft

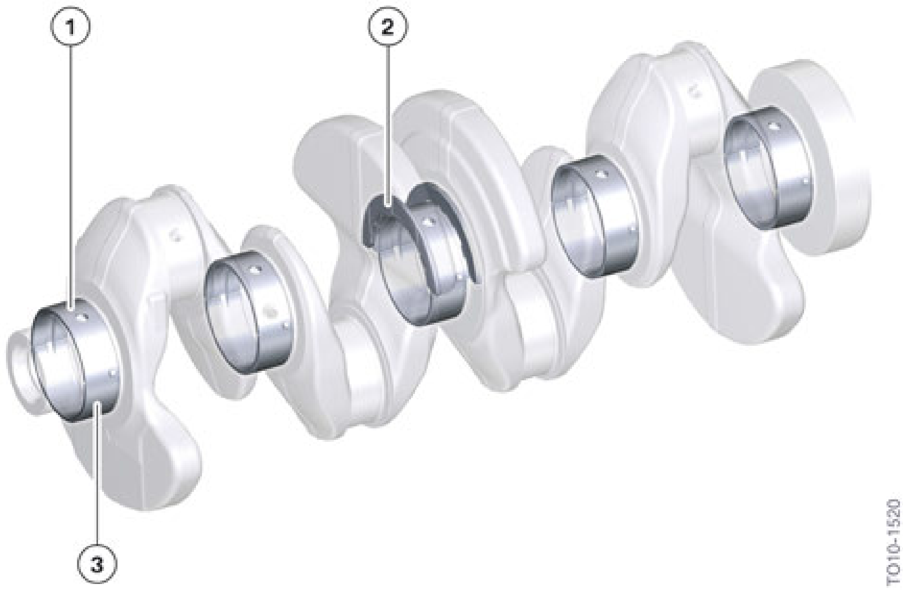
The crankshaft of the N20 engine has a stroke of 89.6 mm and is made of the material C38modBY. It is a forged crankshaft with four balance weights and weighs 13.9 kg/30.6 lbs.




N20 engine, crankshaft

#### Crankshaft bearings and rod bearings

The crankshaft is supported by five (lead-free two component) bearings. The thrust bearing is located in the middle at the third bearing position. The thrust bearing is only designed for 180° and is located in the bearing seat. The bearing in the bearing cap does not provide any axial guidance.



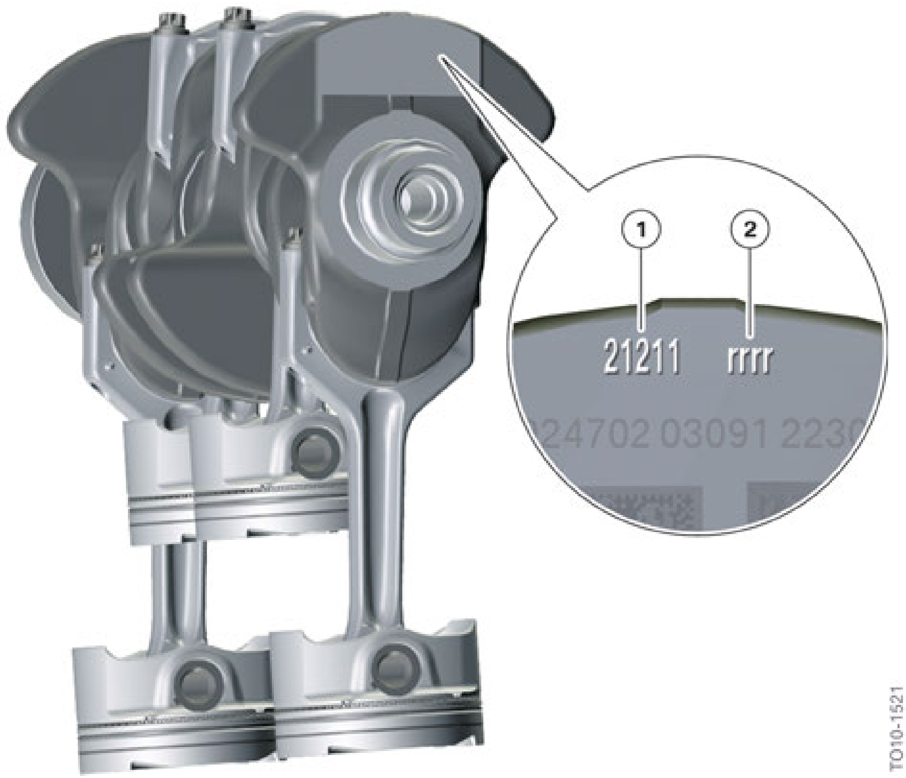

N20 engine, crankshaft bearings

| Index | Explanation |
|---|---|
| 1 | Upper bearing shell with groove and oil hole |
| 2 | Thrust bearing with groove and oil hole |
| 3 | Lower bearing shell without groove |

⚠

The N20 uses the same procedure as with N55 for calculating the correct bearing size by using the crankcase and crankshaft codes.

The identification markings for the upper bearings are found stamped on the crankcase and for the lower bearings on the crankshaft. If the crankshaft is to be fitted with new bearings **refer to the repair instructions** for more information on the procedure to determine the correct bearing size/color.




N20 engine, bearing identification, crankshaft code

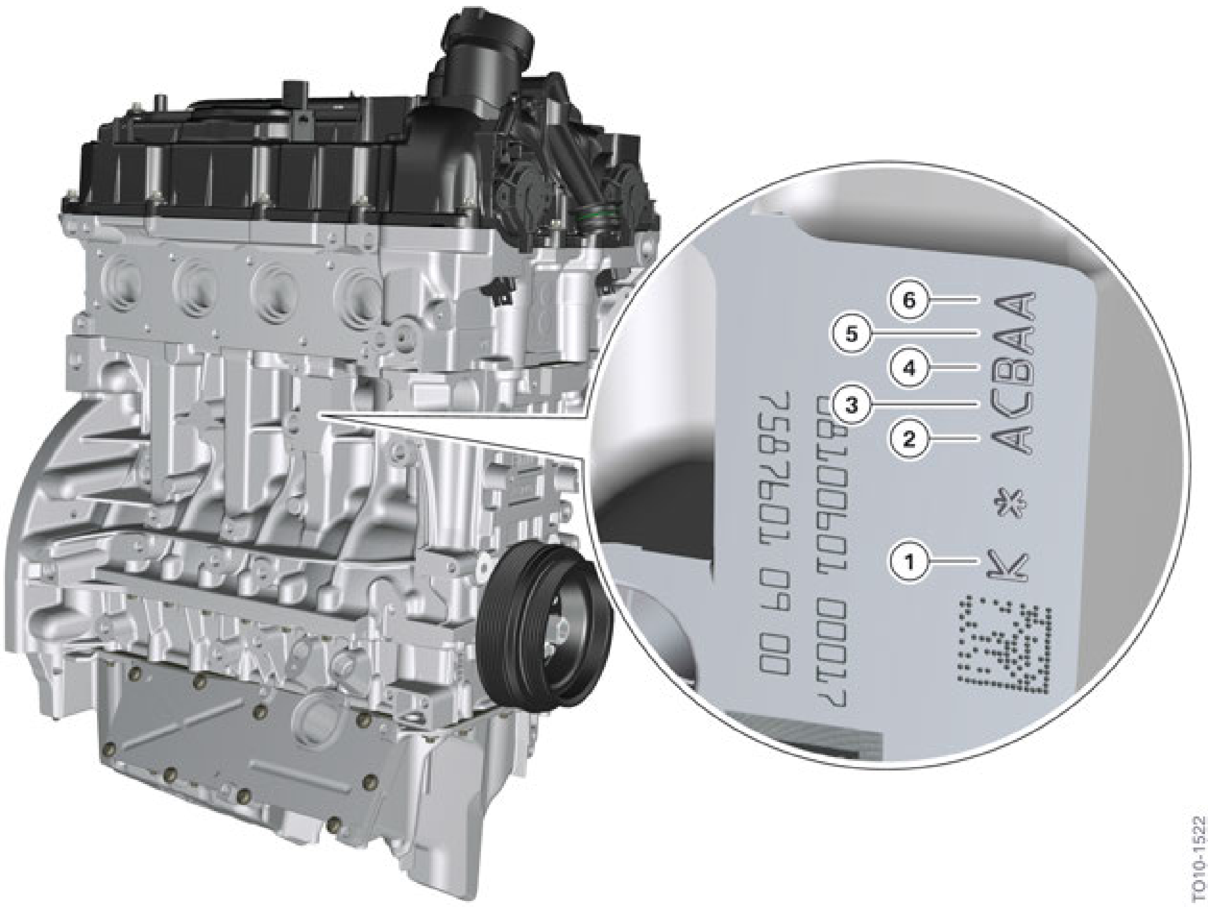
| Index | Explanation |
|---|---|
| 1 | Code digits for crankshaft bearings (21211) |
| 2 | Code letters for connecting rod bearings (rrrr) |

Two bearing categories are used. These bearing categories are “r” and “b”.

The following applies to the bearing position and bearing allocation:

| Bearing category or code letter | Installation location | Bearing color |
|---|---|---|
| b | Rod end | Violet |
| | Bearing cap end | Blue |
| r | Rod end | Yellow |
| | Bearing cap end | Red |

The bearing shells are identical parts to those used in the N54 and N55 engines. A locating groove prevents the wrong bearing shell from being installed.




N20 engine, bearing identification, crankcase

| Index | Explanation |
|---|---|
| 1 | "K" stands for clutch end |
| 2 | Bearing 5 |
| 3 | Bearing 4 |
| 4 | Bearing 3 |
| 5 | Bearing 2 |
| 6 | Bearing 1 |

The "K" designation in position (1) stands for clutch end (German: Kupplungsseite). Thus the first code digit (2) is the ID code for bearing 5 in the crankcase. The second code digit (3) stands for bearing 4, etc.

The following is an example of how to calculate the correct crankshaft main and rod bearings using the stamping codes.

# N20 Engine
## 2. Engine Components


| Bearing position | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Crankcase code | A | A | B | C | A |
| Upper bearing color | Yellow | Yellow | Blue | Red | Yellow |
| Crankshaft code | 2 | 1 | 2 | 1 | 1 |
| Lower bearing (cap) color | Blue | Yellow | Blue | Yellow | Yellow |


| Upper | Lower | Bearing color | Bearing play/thickness | Bearing | Bearing size |
|---|---|---|---|---|---|
| A | 1 | Yellow | Large/Thin | 1<br>2 to 5 | 49.978 – 49.984<br>49.999 – 49.993 |
| B | 2 | Blue | Medium/Medium | 1<br>2 to 5 | 49.972 – 49.977<br>49.987 – 49.992 |
| C | 3 | Red | Small/Thick | 1<br>2 to 5 | 49.965 – 49.971<br>49.980 – 49.986 |

Example of the crankshaft bearing selection procedure.


| Bearing position | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Crankshaft connecting rod code | r | r | r | r |
| Connecting rod side big-end bearing color | Yellow | Yellow | Yellow | Yellow |
| Connecting rod cap side big-end bearing color | Red | Red | Red | Red |

| Bearing class/code | Bearing color | Bearing play/thickness | Bearing size |
|---|---|---|---|
| b | Violet<br>Blue | Large/Thin | 49.9730 – 49.9834 |
| r | Yellow<br>Red | Small/Thick | 49.9835 – 49.9930 |

Example of the connecting rod bearing selection procedure.

**Note: This training material is intended for classroom instruction only. It is not meant to replace currently available repair instructions. Always refer to the most current version of repair instructions, technical data and torque specifications. Refer to the latest version of ISTA.**

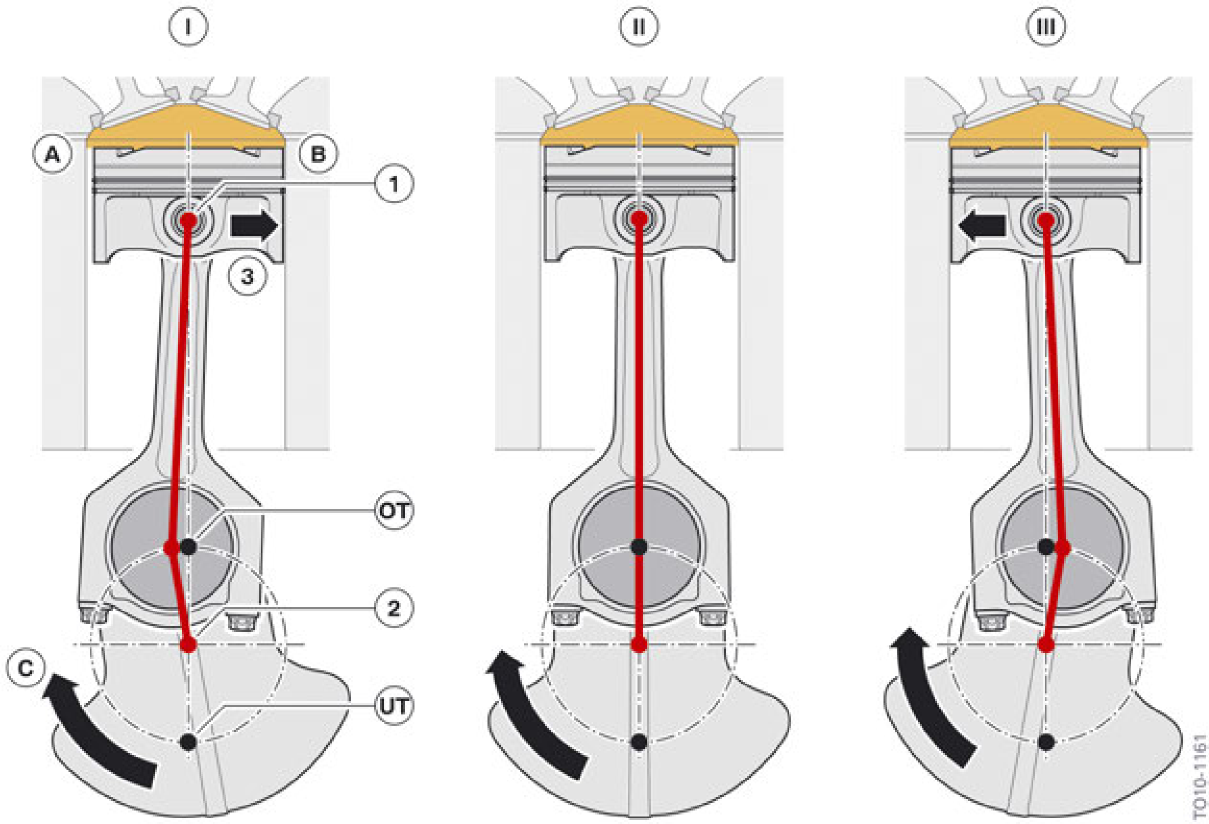
**Pin offset**

Pistons always require a running clearance. The running clearance means that there is always a certain degree of lateral movement (piston slap) as the piston changes direction from up-stroke to down-stroke. The greater the force acting on the piston and the greater the running clearance, the greater the piston slap.

Pin offset involves advancing the time when the piston changes between the compression and power stroke to the lower pressure range before top dead center. This results in a reduction of noise and friction.

Pin offset refers to the displacement of the wrist pin axis from the cylinder center line of the piston. A positive offset indicates offset to the major thrust face, a negative offset denotes offset to the minor thrust face. The major thrust face refers to that side of the piston on which the piston rests in the combustion stroke on its way to bottom dead center (see arrow of III). Minor thrust is the piston's thrust against the opposite cylinder wall during the compression stroke (see arrow of I).

The following graphic shows a conventional crankshaft drive without pin and crankshaft offset.



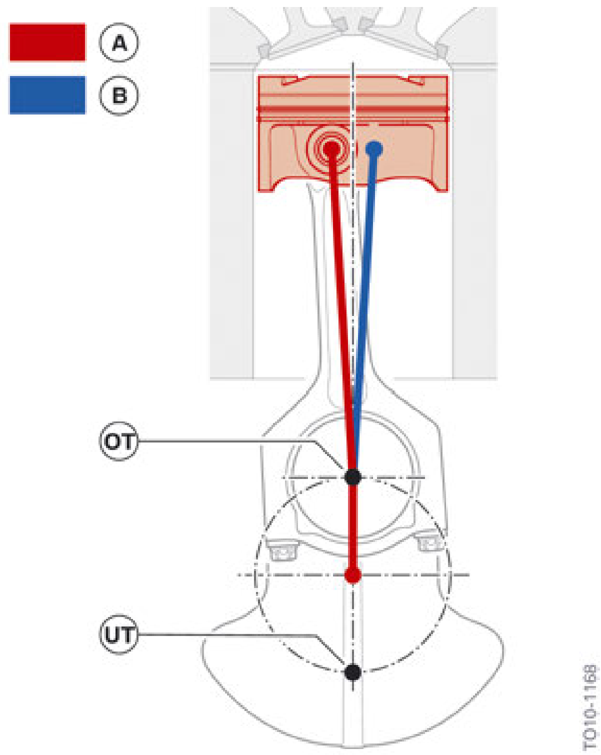

Conventional crankshaft drive

| Index | Explanation |
|---|---|
| I | Piston position and crankshaft position shortly before top dead center (TDC) |
| II | Piston position and crankshaft position at top dead center |
| III | Piston position and crankshaft position after top dead center |
| A | Major thrust face |
| B | Minor thrust face |
| C | Direction of engine rotation |
| 1 | Wrist pin |
| 2 | Center of crankshaft rotation |
| 3 | Thrust force |

As the graphic shows, in a conventional crankshaft drive assembly the wrist pin boss, the connecting rod and the center of crankshaft rotation are in line at top dead center (TDC). Because of this arrangement, the piston is forced against the minor thrust face (B) during the up-stroke. At TDC the forces are compensated because the pressure on the minor thrust face decreases as the crankshaft rotates away from TDC and the piston tilts towards the major thrust face (A). Because there is already high pressure at TDC, this abrupt change of face causes a noise which is referred to as piston slap.

Pin offset can be effected towards the major thrust face (positive) and also towards the minor thrust side (negative). Major-thrust-face pin offset is also referred to as noise offset.

Minor-thrust-face pin offset is also referred to as thermal offset. In this position the sealing effect of the piston rings is improved.

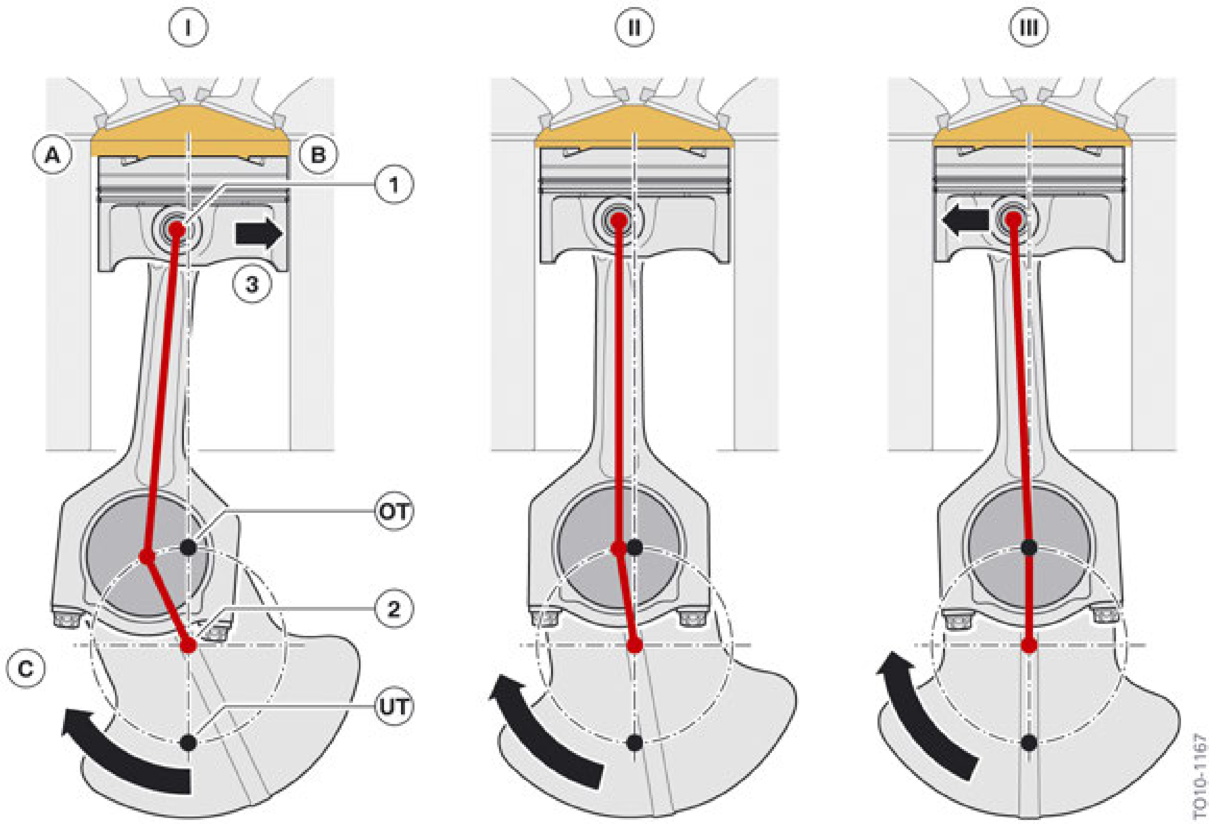



Pin offset

| Index | Explanation |
|---|---|
| A | Major-thrust-face pin offset (positive) |
| B | Minor-thrust face pin offset (negative) |
| OT | Top dead center |
| UT | Bottom dead center |

Because the noise can be heard during the change of faces, technical measures are used to shift this change of faces as far as possible to a range (piston position) in which the acting forces are lower. This is done in current BMW engines by offsetting the wrist pin towards the major thrust face.

The offset is about. 0.3 - 0.8 mm in conventional engines and is therefore virtually imperceptible to the eye. This is also the reason why the pistons have a directional marking at the top. Incorrect installation may result in extreme noise similar to that generated by piston damage.




Piston rocking in an engine with pin offset

| Index | Explanation |
|---|---|
| I | Piston position and crankshaft position before top dead center |
| II | Piston position and crankshaft position shortly before top dead center, with perpendicular connecting rod |
| III | Piston position and crankshaft position at top dead center |
| A | Major thrust face |
| B | Minor thrust face |
| C | Direction of engine rotation |
| 1 | Wrist pin |
| 2 | Center of crankshaft rotation |
| 3 | Thrust force |

The piston rests against the minor thrust face during the up-stroke. A neutral piston position is already achieved before TDC by offsetting the wrist pin. This is the case when the center lines of the cylinder and of the big and small connecting rod eyes are parallel to each other. Already before TDC the piston changes from the minor thrust face to the major thrust face. In this phase the force on the piston is still low. Due to the off-center support of the piston, the force acting on the piston from above has a higher lever arm on the one face than on the other. In this way, the piston is already tilted during the up-stroke, resulting in contact with the major thrust face at the upper edge. In its subsequent movement the piston again travels straight ahead, so that the piston rests completely on the major thrust face. The change of faces is much quieter than in a conventional crankshaft drive.

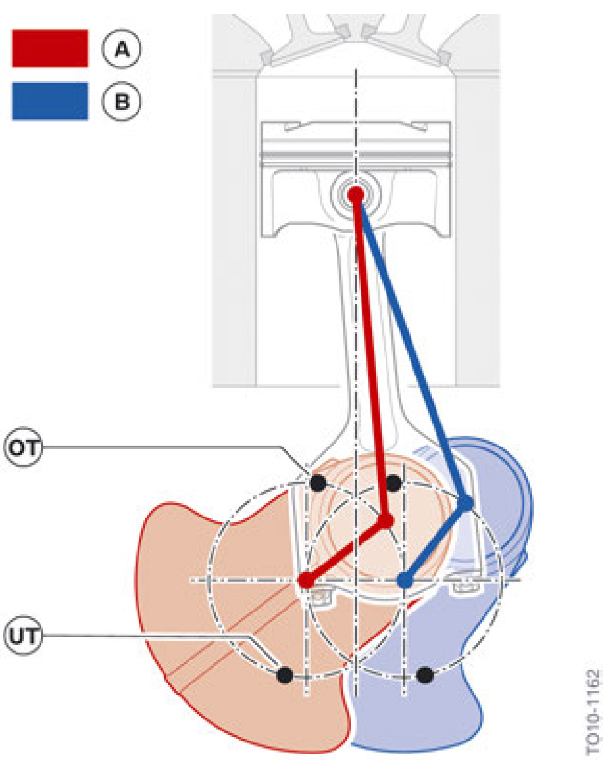
The downside of pin offset is that there is a slight increase in friction on the major thrust face. This minor downside, however, is made up for by the reduced noise.

### Crankshaft offset

A crankcase with crankshaft offset is used for the first time by BMW.

Crankshaft offset denotes the offset of the crankshaft axis from the cylinder center line. This offset can effect on both the major thrust face and the minor thrust face. A positive offset denotes offset to the major thrust face, a negative offset denotes offset to the minor thrust face.

Crankshaft offset can basically be effected in both directions, but up to now only the variation in the positive direction (A) has been used.

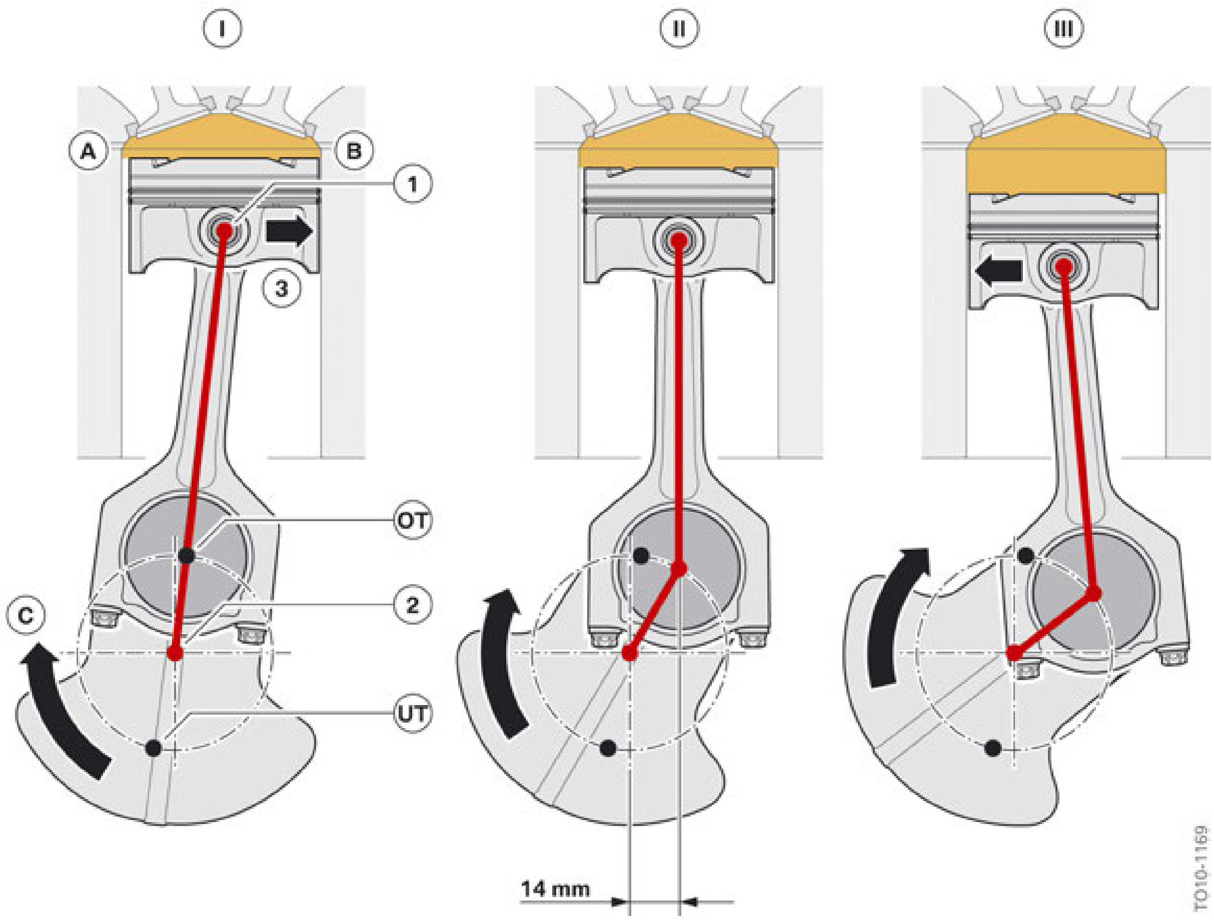



Crankshaft offset

| Index | Explanation |
|---|---|
| A | Positive offset |
| B | Negative offset |
| OT | Top dead center |
| UT | Bottom dead center |

# N20 Engine
## 2. Engine Components

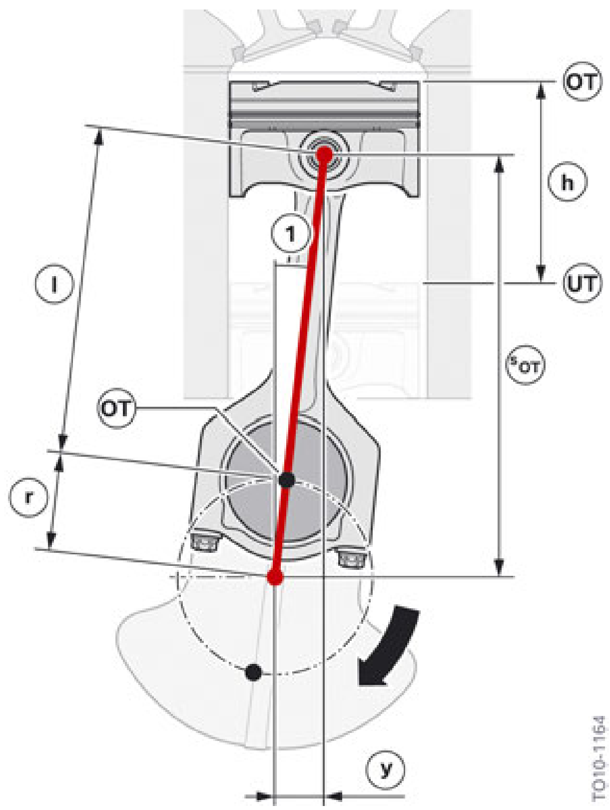
The following graphic clearly shows that positive crankshaft offset, when compared with positive pin offset, has an opposed effect on piston rocking. Thus piston rocking occurs much later and in the range of a high cylinder pressure.




Piston rocking in an engine with crankshaft offset

| Index | Explanation |
|---|---|
| I | Piston position and crankshaft position shortly after top dead center |
| II | Piston position and crankshaft position with perpendicular connecting rod |
| III | Piston position and crankshaft position after piston rocking |
| A | Major thrust face |
| B | Minor thrust face |
| C | Direction of engine rotation |
| 1 | Wrist pin |
| 2 | Crankshaft |
| OT | Top dead center |
| UT | Bottom dead center |

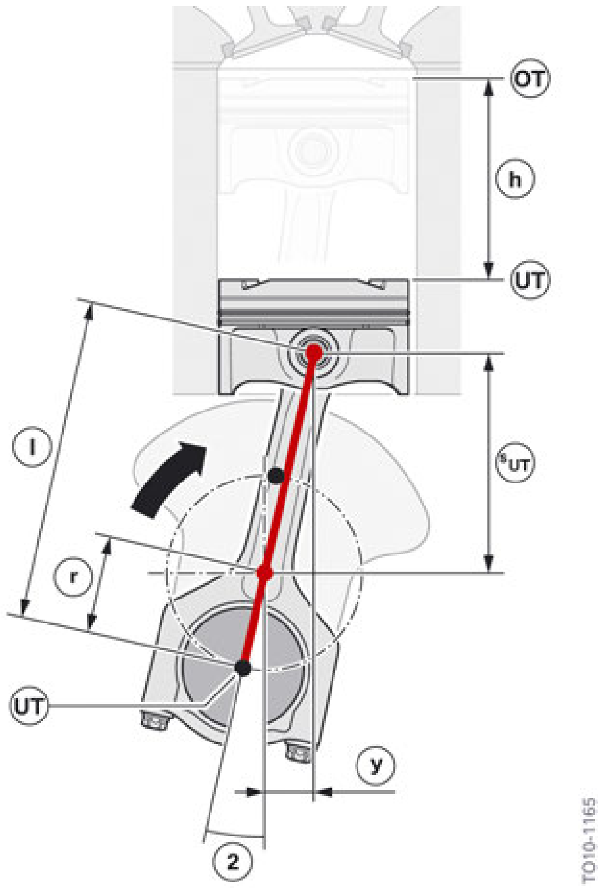
The top and bottom dead centers are also shifted by the crankshaft offset. The top and bottom dead centers are achieved in the extended and overlap positions respectively. The connecting rod and the crankshaft point geometrically in the same direction.




TDC position in an engine with crankshaft offset

| Index | Explanation |
|---|---|
| OT | Top dead center |
| UT | Bottom dead center |
| l | Connecting rod length |
| r | Crank throw |
| y | Crankshaft offset |
| $s_{OT}$ | Distance TDC |
| h | Piston stroke |
| 1 | Angle in TDC position αTDC |

Bottom dead center likewise changes its position and runs to a crank angle of over 180°.

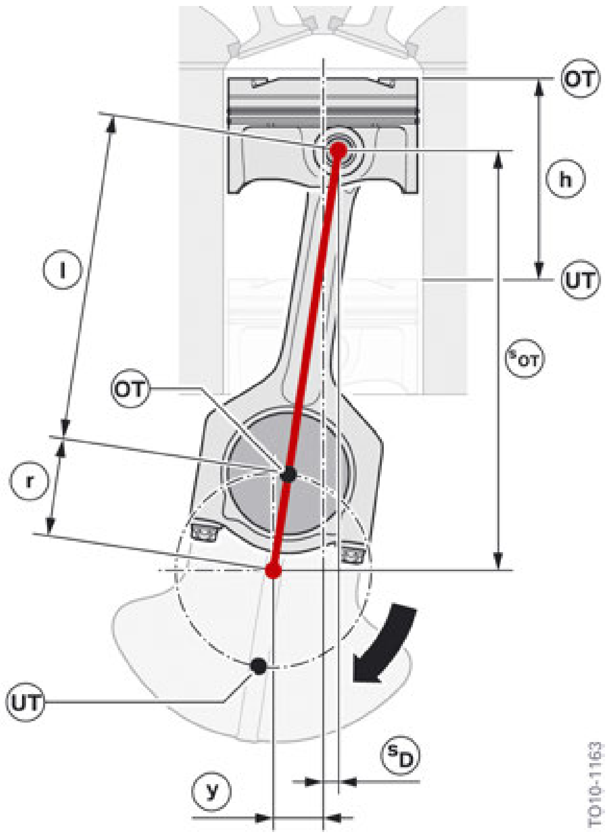



BDC position in an engine with crankshaft offset

| Index | Explanation |
|---|---|
| OT | Top dead center |
| UT | Bottom dead center |
| l | Connecting rod length |
| r | Crank throw |
| y | Crankshaft offset |
| $s_{UT}$ | Distance BDC |
| h | Piston stroke |
| 2 | Angle in BDC position α BDC |

**A combination of positive crankshaft offset and negative pin offset is used in the N20 engine.**

Both negative and positive pin offset affect the piston rocking behavior. In response to the distribution of forces during piston rocking, this occurs later and more quietly.




Combination of crankshaft and pin offset

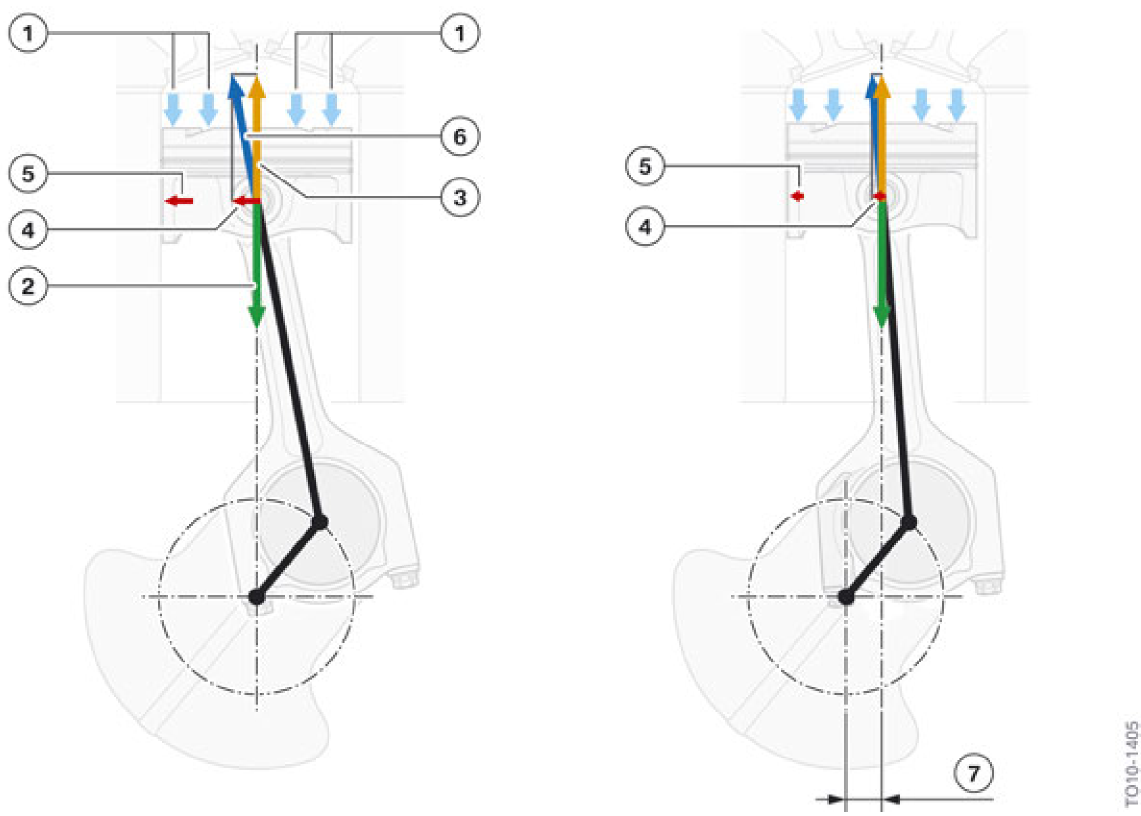
| Index | Explanation |
|---|---|
| OT | Top dead center |
| UT | Bottom dead center |
| l | Connecting rod length |
| r | Crank throw |
| y | Crankshaft offset |
| $s_D$ | Pin offset |
| $s_{OT}$ | Distance TDC |
| h | Piston stroke |

The N20 engine features connecting rods 144.35 mm long, with a crank throw of 44.8 mm. Crankshaft offset is +14 mm, offset of the wrist pin is -0.3 mm.

| Data | Value |
|---|---|
| Stroke | 90.09 mm |
| TDC | + 4.336° |
| BDC | + 188.259° |
| Induction cycle angle and power cycle angle | 183.923° |
| Compression cycle angle and exhaust cycle angle | 176.077° |

### Advantages

In an engine with crankshaft offset, the connecting rod in the power stroke is in a roughly perpendicular position (see the graphic on the right) in contrast to an engine without crankshaft offset (see the graphic on the left). This design significantly reduces the thrust force (5) and the friction of the piston on the cylinder wall which result is increased efficiency. The crankshaft offset in the N20 engine is thus considered one more BMW EfficientDynamics measure.




System diagram of acting forces, left: normal engine, right: engine with crankshaft offset

| Index | Explanation |
|---|---|
| 1 | Pressure force from combustion |
| 2 | Normal piston force |
| 3 | Opposite piston force |
| 4 | Lateral piston force |
| 5 | Thrust force |
| 6 | Resulting force |
| 7 | Crankshaft offset |

### 2.2.2. Connecting rod

**Connecting rod**

The connecting rod of the N20 engine has an inside diameter of 144.35 mm. As with the N55 the N20 uses a specially formed hole in the small end of the connecting rod. This formed hole is machined wider on the lower edges of the wrist pin bushing/bore. This design evenly distributes the force acting on the wrist pin over the entire surface of the rod bushing and reduces the load at the edges, as the piston is forced downward on the power stroke.


N20 engine, connecting rod

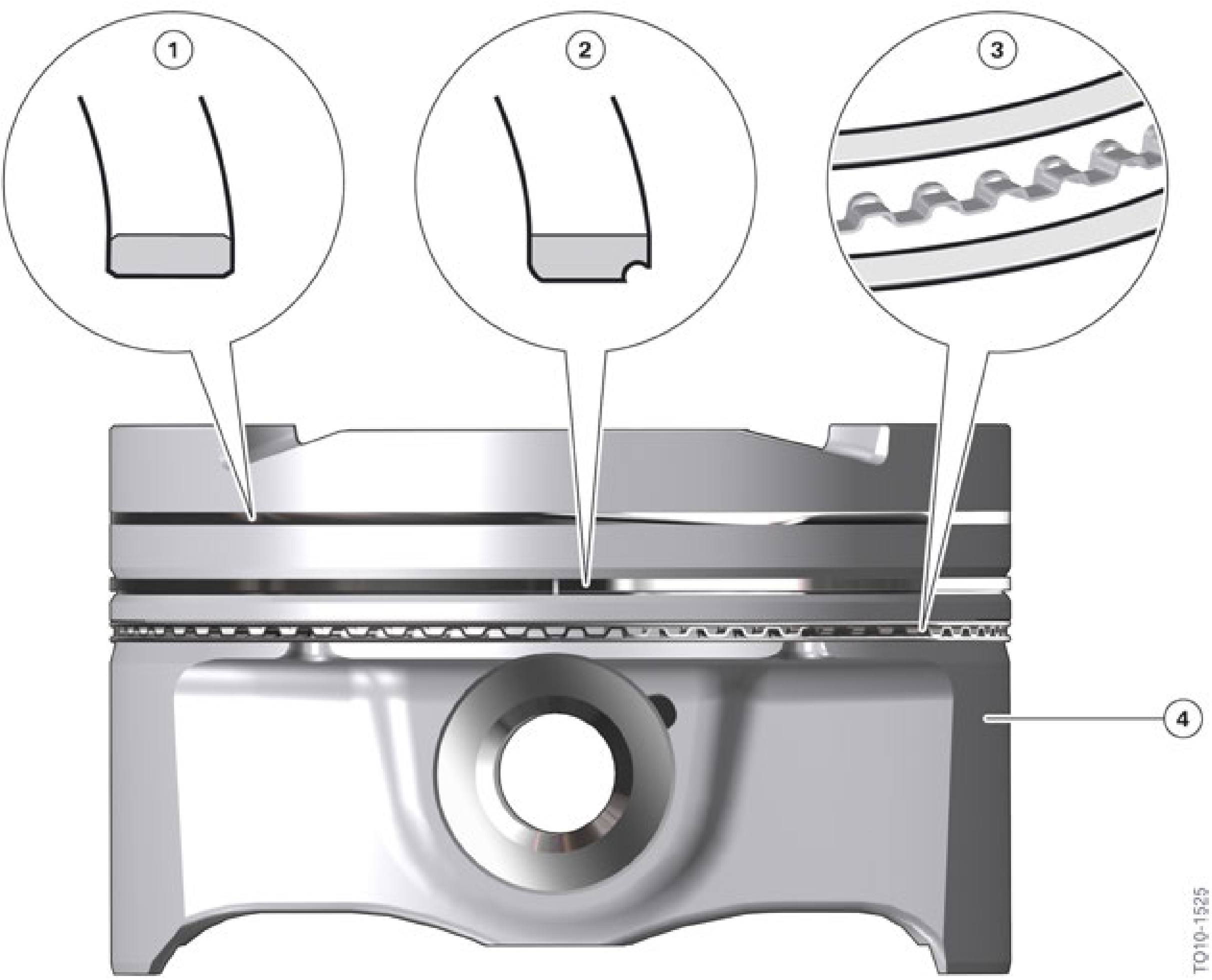
### 2.2.3. Piston with piston rings

A full slipper skirt piston manufactured by the company FM is used. The piston diameter is 84 mm. The first piston ring is a steel-nitrided plain compression ring. The second piston ring is a stepped compression ring. The oil scraper ring is a steel band ring with a spring, which is also known as an MF system ring.

As previously discussed the wrist pin axis has a negative offset to the minor thrust face.

An installation position arrow is stamped on the piston. This arrow always points to the installation of the piston in a longitudinal direction facing the timing chain. It is necessary to install the piston in the correct position, since the asymmetric valve reliefs on the intake and exhaust sides will result in valve and cylinder wall damage.


N20 engine, piston

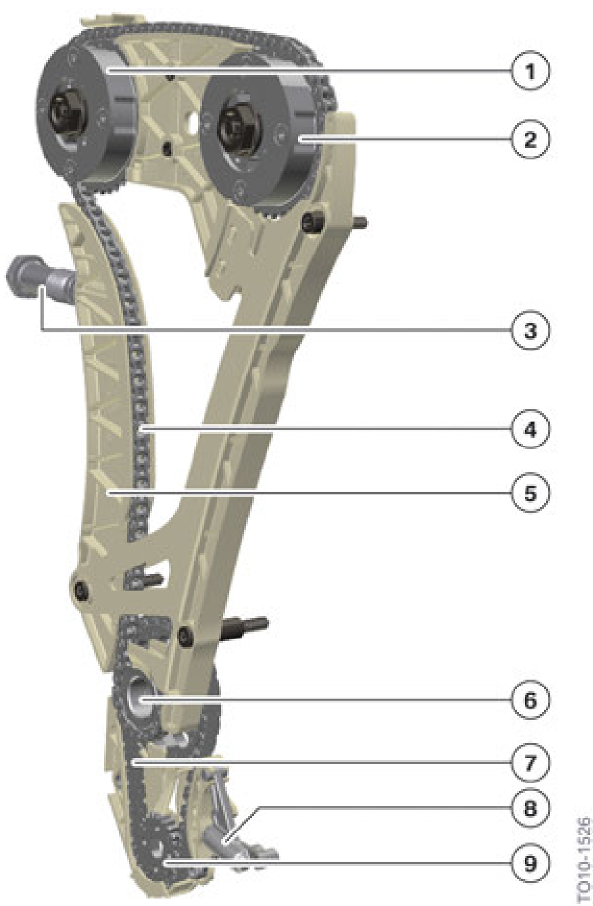



N20 engine, piston rings

| Index | Explanation |
|---|---|
| 1 | Plain compression ring |
| 2 | Stepped compression ring |
| 3 | MF system ring |
| 4 | Piston |

### 2.3. Camshaft drive

The camshaft drive design is similar to previous engines. The oil pump is gear driven via the counterbalance shafts. To ensure that the counterbalance shafts are correctly positioned in relation to the crankshaft, a secondary chain drive is used which is also equipped with a chain tensioner. Both chains have tooth-type design.



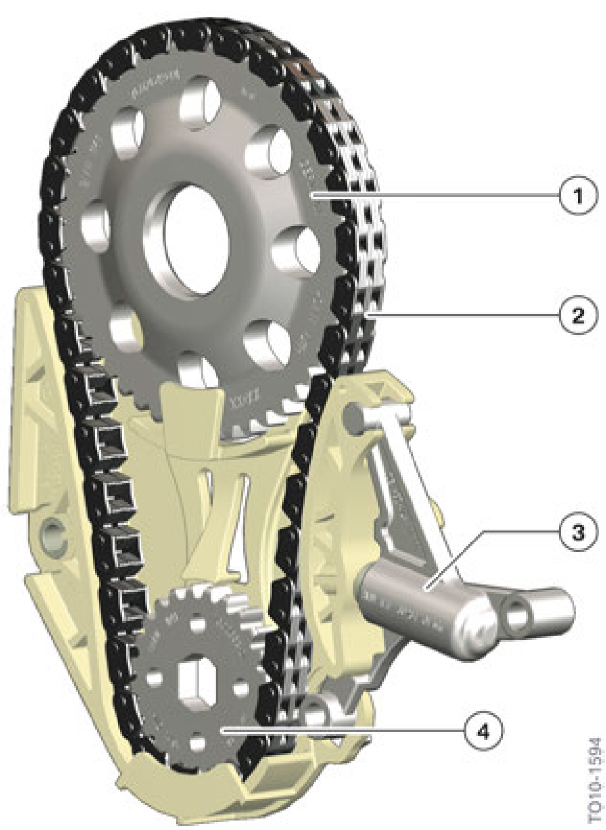

N20 engine, camshaft drive

| Index | Explanation |
|---|---|
| 1 | Exhaust VANOS |
| 2 | Intake VANOS |
| 3 | Chain tensioner |
| 4 | Primary chain |
| 5 | Tensioning rail |
| 6 | Sprocket, driven by crankshaft |
| 7 | Secondary chain (tooth-type chain) |
| 8 | Chain tensioner |
| 9 | Sprocket for counterbalance shaft and oil pump drive |

### 2.4. Counterbalance shafts

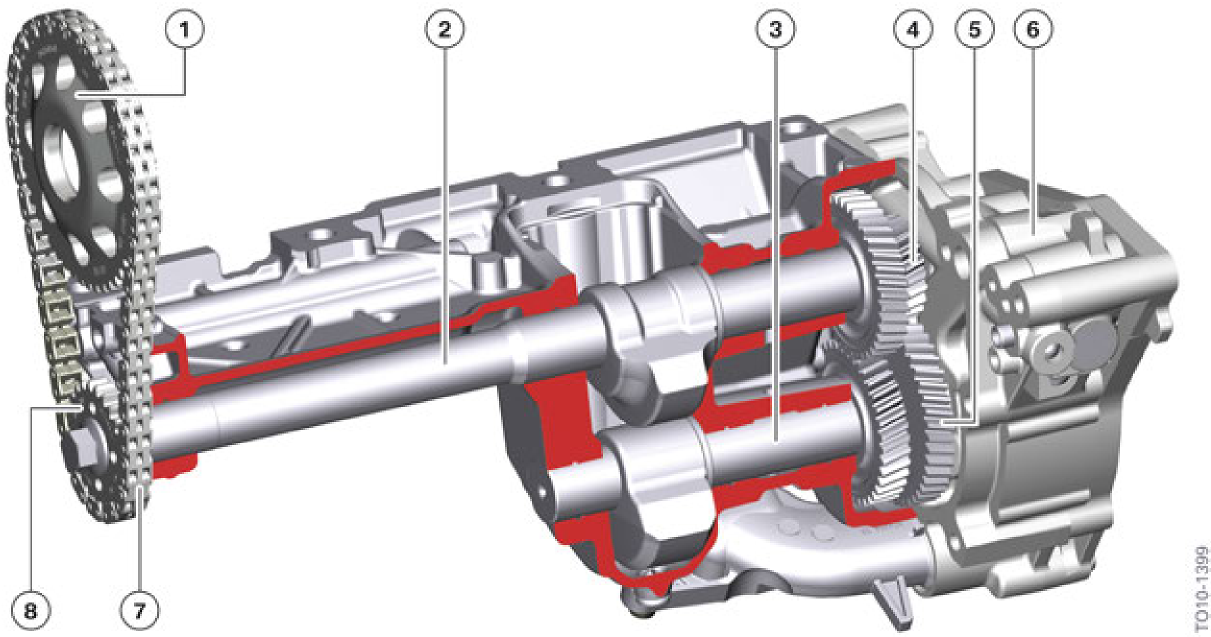
The purpose of the counterbalance shafts is to improve the engine's smooth running and acoustic performance. This is achieved using two counter-rotating shafts which are fitted with balance weights.

The counterbalance shafts are driven by the crankshaft via a tooth-type chain. The tooth-type chain requires the use of special gears on the crankshaft and the counterbalance shafts. The tooth-type chain optimizes the rolling of the drive chain on the sprockets, thereby reducing noise.




N20 engine, counterbalance shaft and oil pump drive

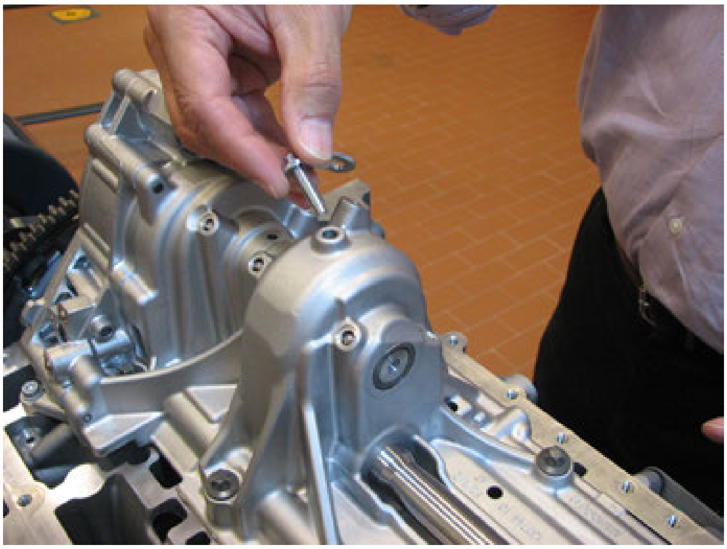
| Index | Explanation |
|---|---|
| 1 | Crankshaft sprocket |
| 2 | Tooth-type chain |
| 3 | Chain tensioner |
| 4 | Counterbalance shaft sprocket |




N20 engine, counterbalance shafts

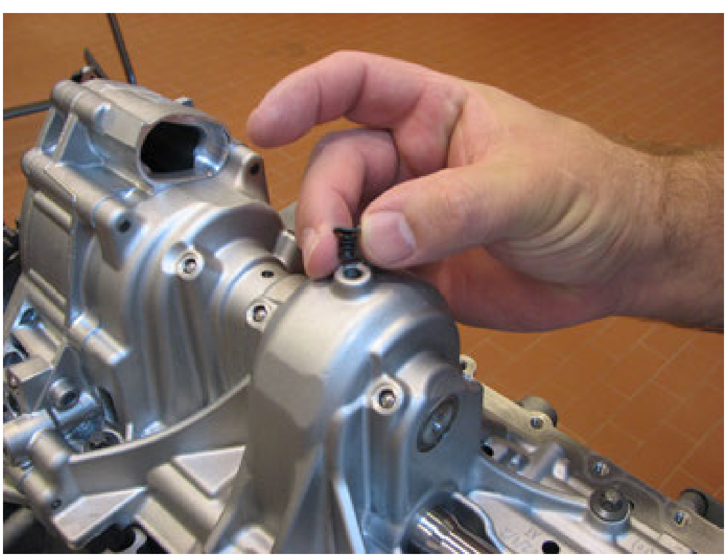
| Index | Explanation |
|---|---|
| 1 | Sprocket on crankshaft |
| 2 | Upper counterbalance shaft |
| 3 | Lower counterbalance shaft |
| 4 | Gear, upper counterbalance shaft |
| 5 | Gear, oil pump |
| 6 | Oil pump |
| 7 | Tooth-type chain, counterbalance shaft and oil pump drive |
| 8 | Counterbalance shaft sprocket |

Before removing and installing the counterbalance drive sprocket the lower counterbalance shaft must be secured with a 4.5 mm thick alignment pin (special tool # 2 212 825) to securely position the counterbalance shafts with the crankshaft.



Counterbalance shaft alignment pin tool 2 212 825

A seal plug which is inserted in the locating hole must be removed for this purpose. This seal plug prevents oil from flowing into the counterbalance shaft chamber during operation, a situation which would cause oil foaming. It is thus imperative that this seal plug be reinstalled during final assembly. The excess oil in the chamber is carried along by the rotation of the balance weights and returned via a discharge opening to the oil sump.



Counterbalance shaft seal plug

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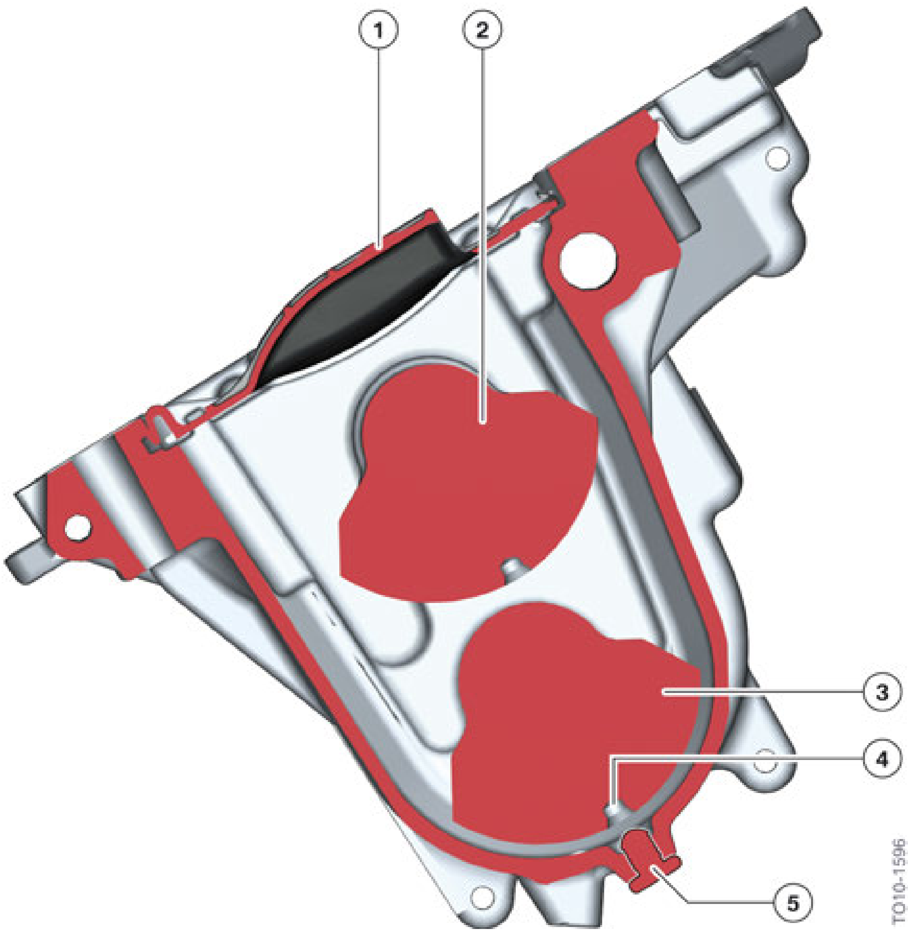
**Positioning of the counterbalance shafts in alignment is necessary to ensure smooth, fault-free engine operation. Please refer to the repair instructions for more information.**



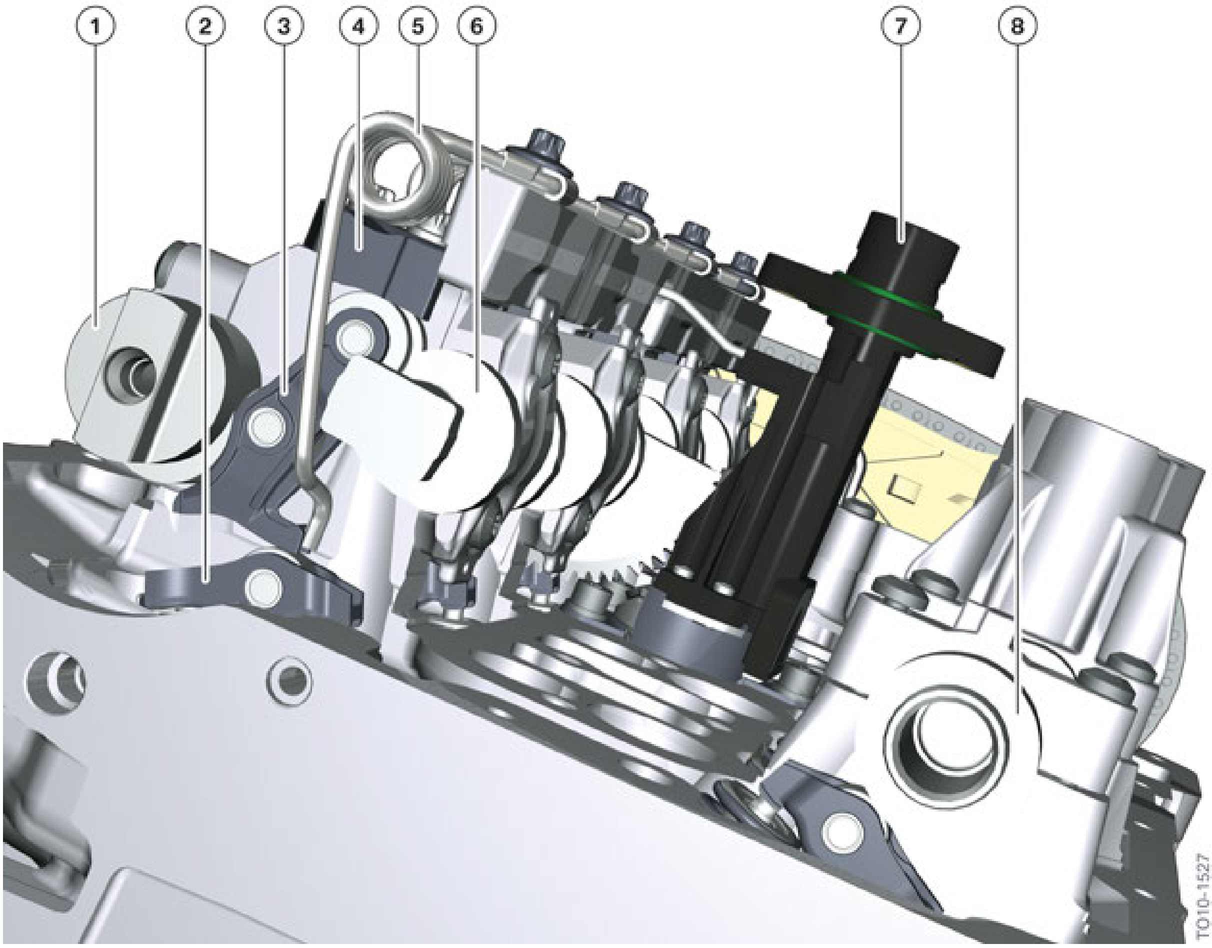

N20 engine, cutaway view of counterbalance shafts

| Index | Explanation |
|---|---|
| 1 | Discharge opening |
| 2 | Upper counterbalance shaft |
| 3 | Lower counterbalance shaft |
| 4 | Alignment pin, lower counterbalance shaft |
| 5 | Seal plug |

# 2. Engine Components

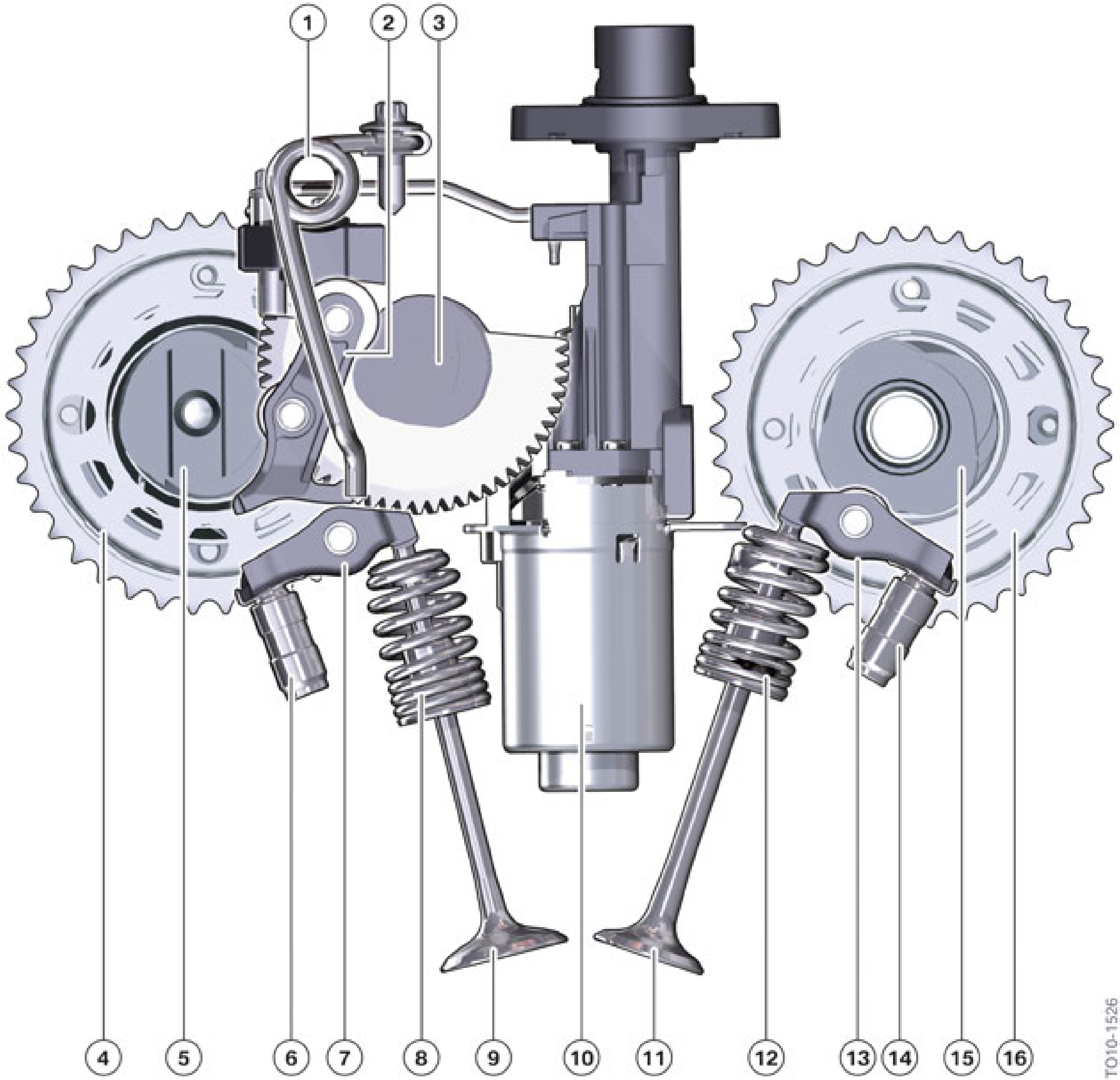
## 2.5. Valve gear

### 2.5.1. Design




N20 engine, valve gear

| Index | Explanation |
|---|---|
| 1 | Intake camshaft |
| 2 | Roller cam follower |
| 3 | Intermediate lever |
| 4 | Guide block |
| 5 | Torsion spring |
| 6 | Eccentric shaft |
| 7 | Valvetronic servomotor |
| 8 | Exhaust camshaft |




N20 engine, valve gear

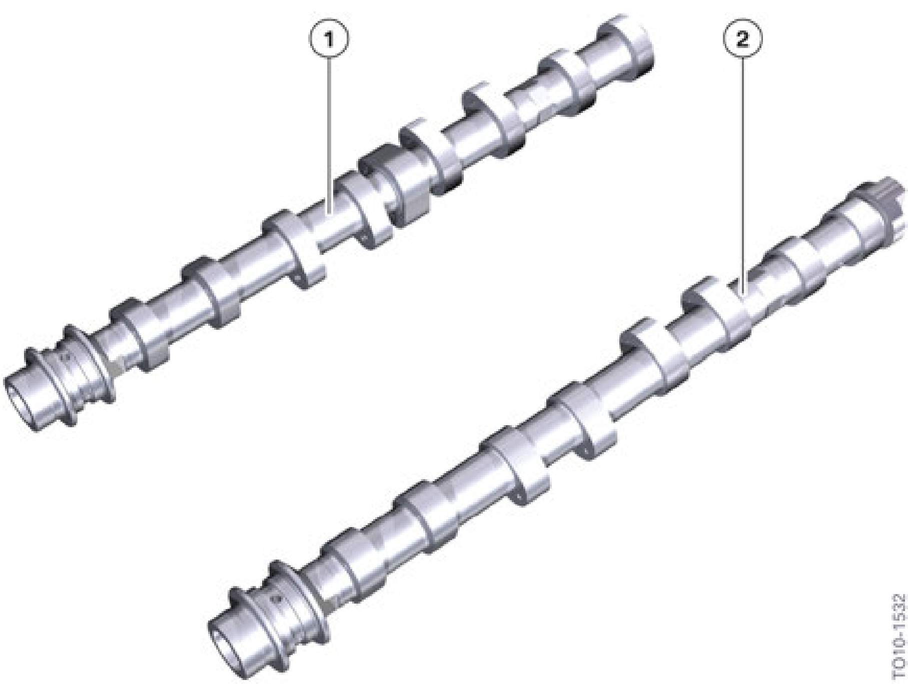
| Index | Explanation |
|---|---|
| 1 | Torsion spring |
| 2 | Intermediate lever |
| 3 | Eccentric shaft |
| 4 | VANOS unit, intake |
| 5 | Intake camshaft |
| 6 | HVCC element, intake |
| 7 | Roller cam follower, intake |
| 8 | Valve spring, intake valve |

| Index | Explanation |
|---|---|
| 9 | Intake valve |
| 10 | Valvetronic servomotor |
| 11 | Exhaust valve |
| 12 | Valve spring, exhaust valve |
| 13 | Roller cam follower, exhaust |
| 14 | HVCC element, exhaust |
| 15 | Exhaust camshaft |
| 16 | VANOS unit, exhaust |

The roller cam followers on the intake side are made from sheet metal and subdivided into five classes, Class “1” to Class “5”. The intermediate levers are now also made from sheet metal and are subdivided into six classes, Class “00” to Class “05”.

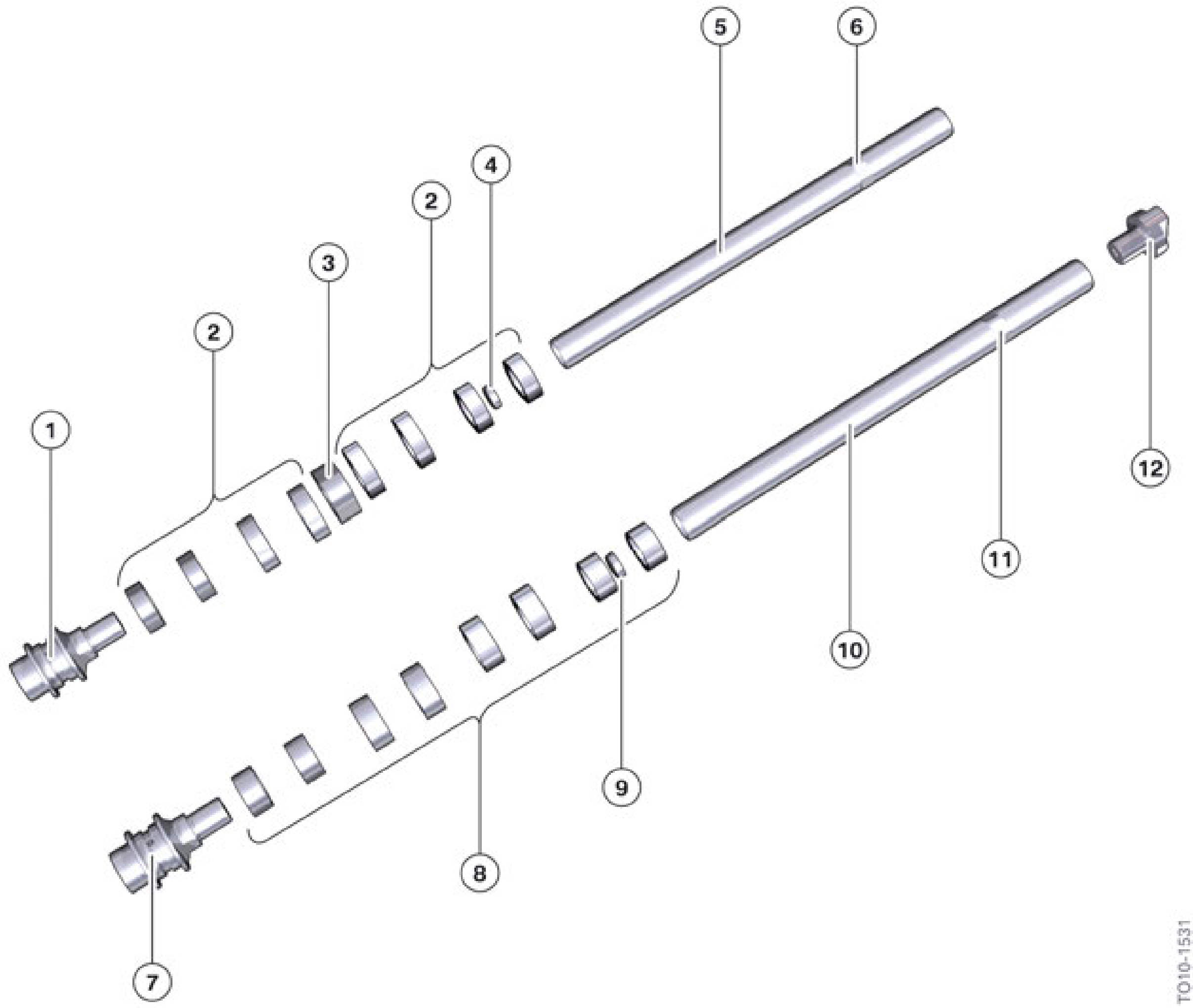
### Camshafts

The N20 engine is fitted with the assembled camshafts already known from the M73 engine. All the components are shrink-fitted onto the shaft. The timing of the camshafts requires new special tool, # 2 212 831. Please refer to the repair instructions for proper timing procedures.




N20 engine, assembled camshafts

| Index | Explanation |
|---|---|
| 1 | Exhaust camshaft |
| 2 | Intake camshaft |

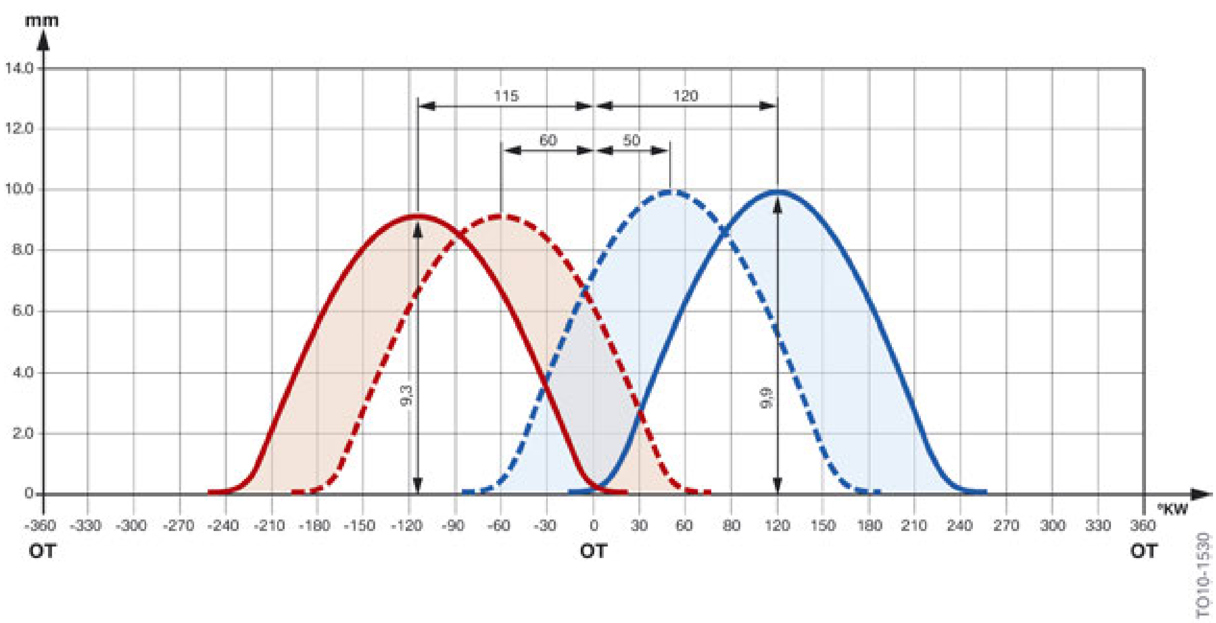



N20 engine, assembled camshafts

| Index | Explanation |
|---|---|
| 1 | Flange for VANOS unit, exhaust |
| 2 | Cam |
| 3 | Cam for high-pressure pump |
| 4 | Sealing cap |
| 5 | Pipe |
| 6 | Hexagon head |
| 7 | Flange for VANOS unit, intake |
| 8 | Cam |

| Index | Explanation |
|---|---|
| 9 | Sealing cap |
| 10 | Pipe |
| 11 | Hexagon head |
| 12 | Vacuum pump drive |

### Valve timing




N20 engine, valve timing diagram

| | | N55B30M0 | N20B20O0 |
|---|---|---|---|
| Intake valve dia./stem dia. | [mm] | 32/5 | 32/5 |
| Exhaust valve dia./stem dia. | [mm] | 28/6 | 28/6 |
| Maximum valve lift, intake/exhaust valve | [mm] | 9.9/9.7 | 9.9/9.3 |
| VANOS adjustment range, intake | [°CA] | 70 | 70 |
| VANOS adjustment range, exhaust | [°CA] | 55 | 55 |
| Spread, intake camshaft | [°CA] | 120 – 50 | 120 – 50 |
| Spread, exhaust camshaft | [°CA] | 115 – 60 | 115 – 60 |
| Opening period, intake camshaft | [°CA] | 258 | 258 |
| Opening period, exhaust camshaft | [°CA] | 261 | 252 |

#### Intake and exhaust valves

The intake and exhaust valves are carryover parts from the N55 engine. The intake valve has a stem diameter of 5 mm. The exhaust valve has a stem diameter of 6 mm, because it is hollow and sodium filled. The exhaust valve seats are made from hardened material and the intake valve seats are induction-hardened.

#### Valve springs

The valve springs used for the intake and exhaust valves are different. The intake valve springs have already been used in the N52, N52TU and N55 engines. The exhaust valve springs are familiar from the N51, N52, N52TU, N54 and N55 engines.

### 2.5.2. Valvetronic

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The Valvetronic comprises fully variable valve lift control and variable camshaft control (double VANOS), which makes the closing time of the intake valve freely adjustable.

Valve lift control is performed on the intake side, while camshaft control is performed on both the intake and exhaust sides.

Throttle-free load control is only possible if:

- the lift of the intake valve
- and camshaft adjustment of the intake and exhaust camshafts are variably controllable.

Result:

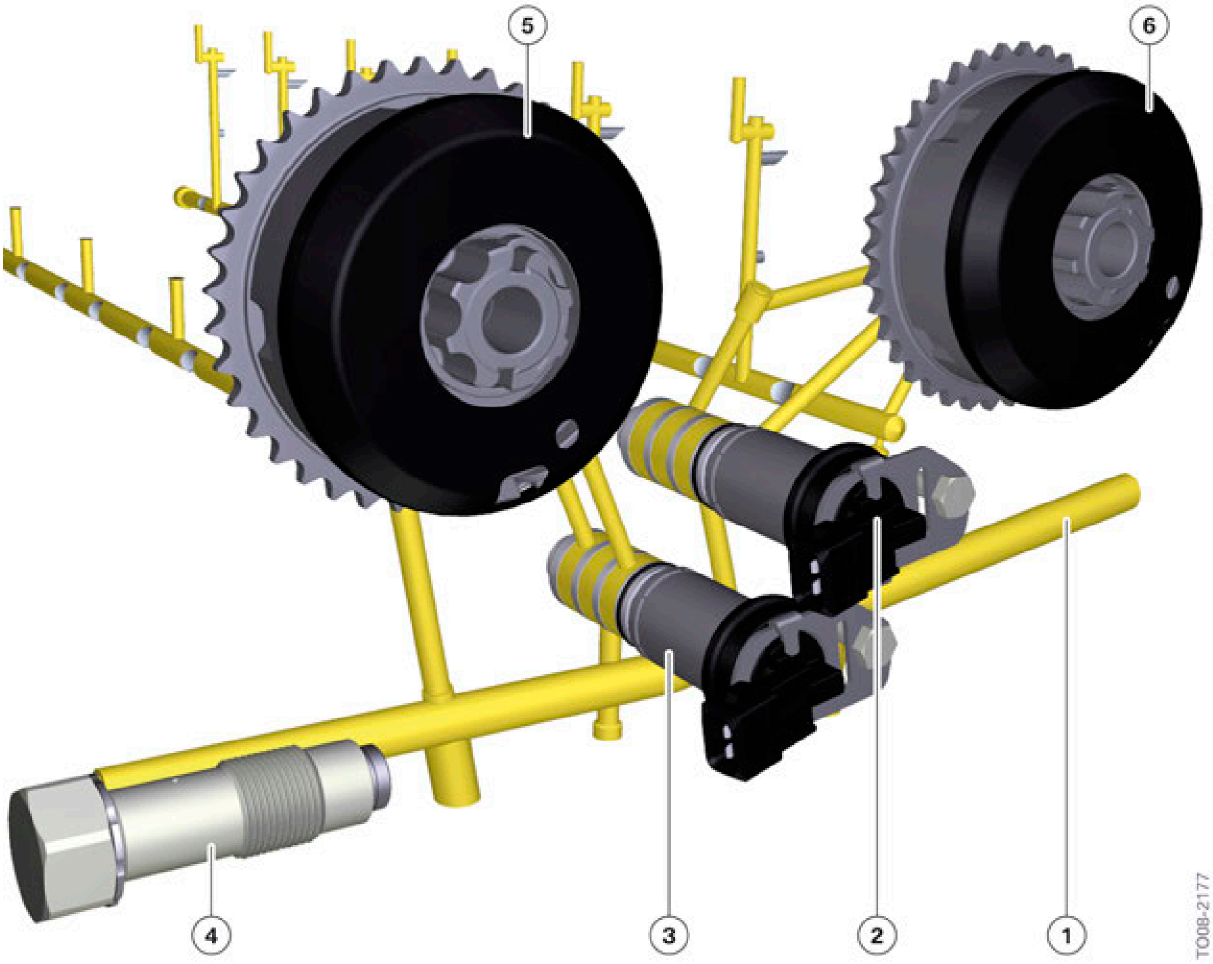
The opening and closing times and thus the opening period and the lift of the intake valve are freely adjustable.

---

#### VANOS

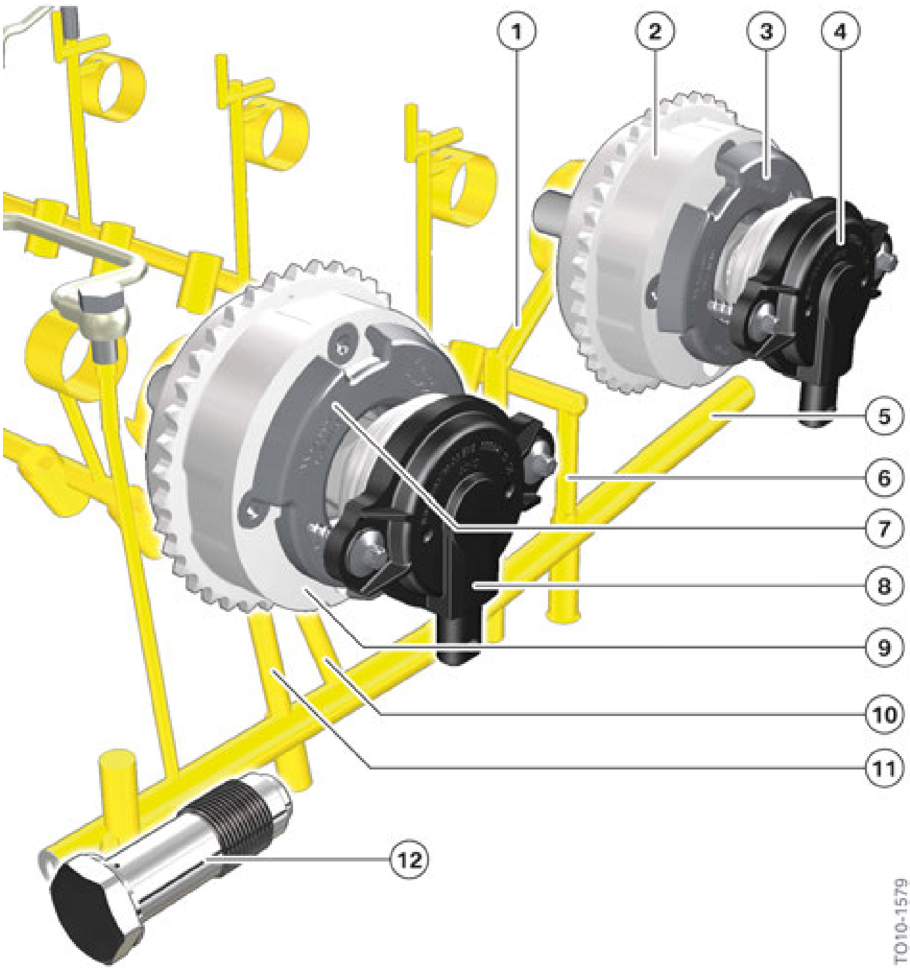
The VANOS system has been modified. This modification now provides for even faster VANOS unit setting speeds. The modification has also further reduced system failure. The following comparison of the VANOS systems of N55 and N20 engines shows that fewer oil passages are necessary.

# N20 Engine
## 2. Engine Components




N55 engine, VANOS with oil supply

| Index | Explanation |
|---|---|
| 1 | Main oil passage |
| 2 | VANOS solenoid valve, intake side |
| 3 | VANOS solenoid valve, exhaust side |
| 4 | Chain tensioner |
| 5 | VANOS unit, exhaust side |
| 6 | VANOS unit, intake side |




N20 engine, VANOS with oil supply

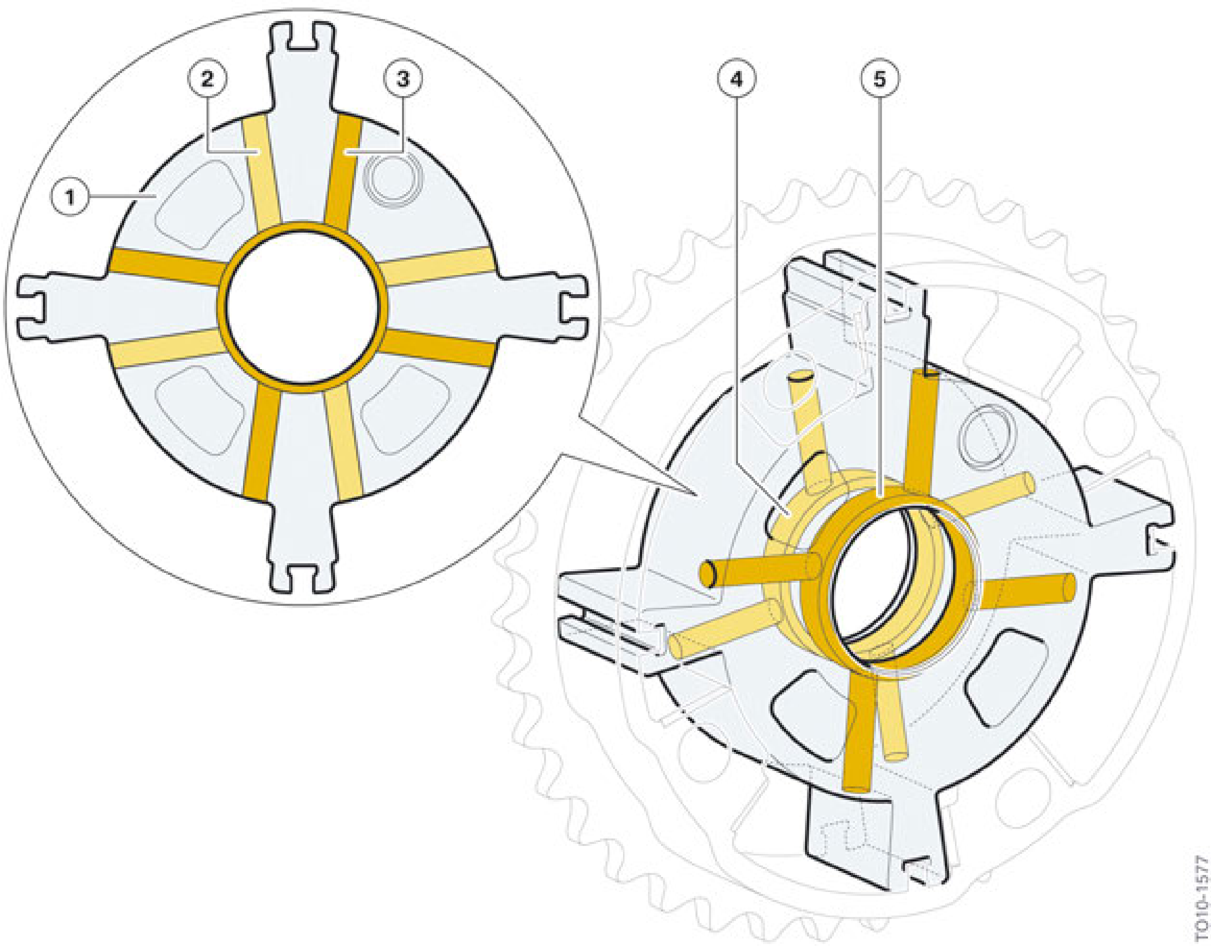
| Index | Explanation |
|---|---|
| 1 | Oil passage to VANOS unit, intake side |
| 2 | VANOS unit, intake side |
| 3 | Camshaft sensor wheel, intake camshaft |
| 4 | VANOS solenoid actuator, intake side |
| 5 | Main oil passage |
| 6 | Oil passage for intake camshaft and HVCC elements |
| 7 | Camshaft sensor wheel, exhaust camshaft |
| 8 | VANOS solenoid actuator, exhaust side |
| 9 | VANOS unit, exhaust side |
| 10 | Oil passage to VANOS unit, intake side |
| 11 | Oil passage for exhaust camshaft and HVCC elements |
| 12 | Chain tensioner |

# N20 Engine

## 2. Engine Components

The following graphic shows the oil passages in the VANOS unit. The intake camshaft can be “advanced” with the passages shaded light yellow; the VANOS unit can be “retarded” with the passages shaded dark yellow.

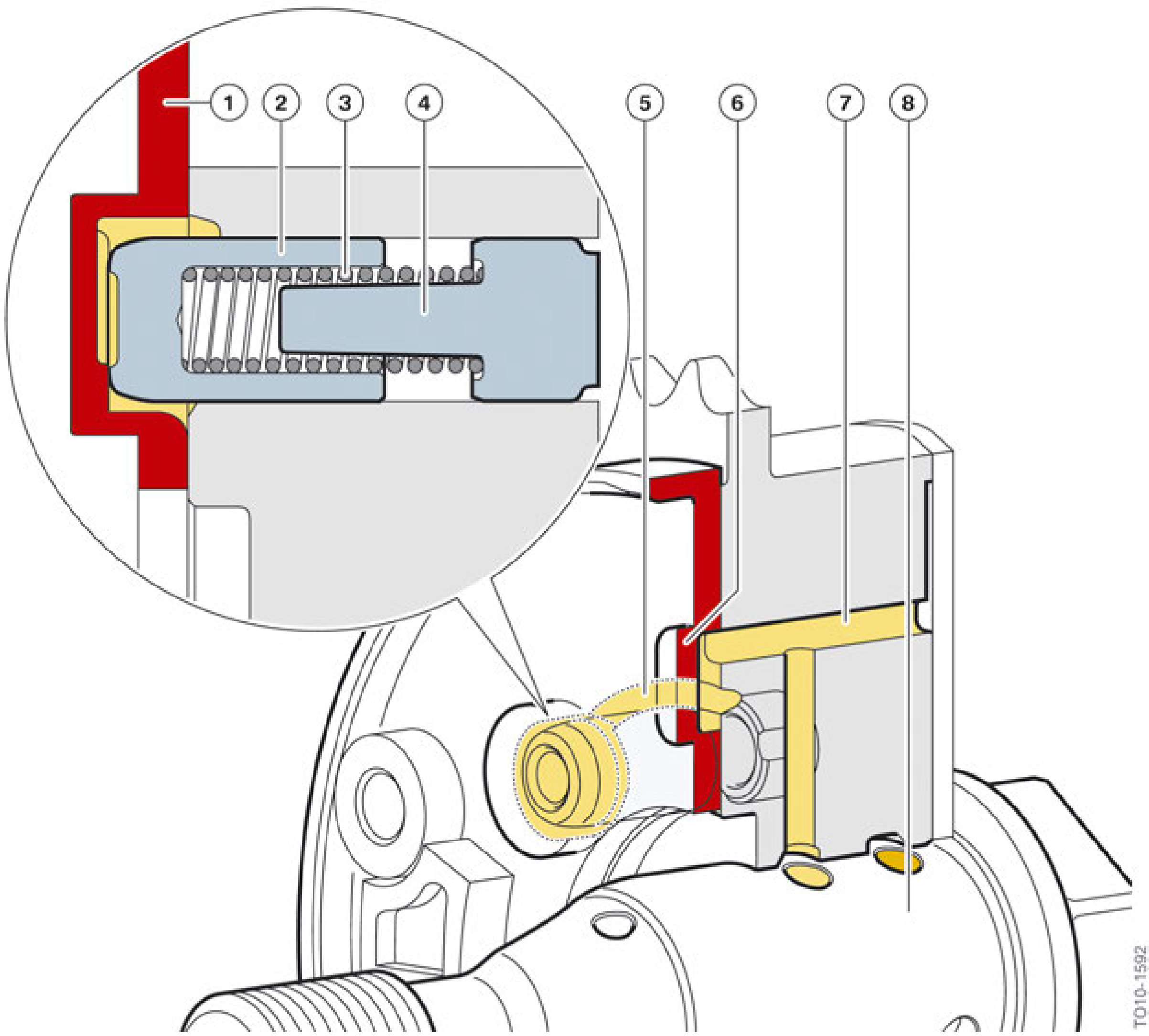
The cam shaft sensor wheels require a new special tool for proper positioning, tool # 2 212 830. Please refer to the repair instructions for more information.




N20 engine, VANOS unit, intake camshaft

| Index | Explanation |
|---|---|
| 1 | Rotor |
| 2 | Oil passage for advancing the timing |
| 3 | Oil passage for retarding the timing |
| 4 | Oil passage for advancing the timing |
| 5 | Oil passage for retarding the timing |

The locking pin ensures that the VANOS unit is locked in a set position when in the depressurized state. The spiral or torsion spring (not shown here) is designed to compensate the middle camshaft friction, because without the spring the VANOS adjusts much faster to “retarded” (with friction) than to “advanced” (against friction). The locking effect is provided by the oil pressure, which when the actuator is nonregistered always forces the VANOS unit into the locking position (where the locking pin engages and blocks the VANOS unit). The timing can be adjusted in this way. This is important when the engine is started to ensure exact timing. The locking pin is simultaneously supplied with the oil pressure available for timing advance via oil passages in the VANOS unit. If the camshaft is to be “advanced”, the locking pin is then forced by the applied oil pressure against the locking spring towards the cartridge and the locking cover is released for VANOS adjustment.



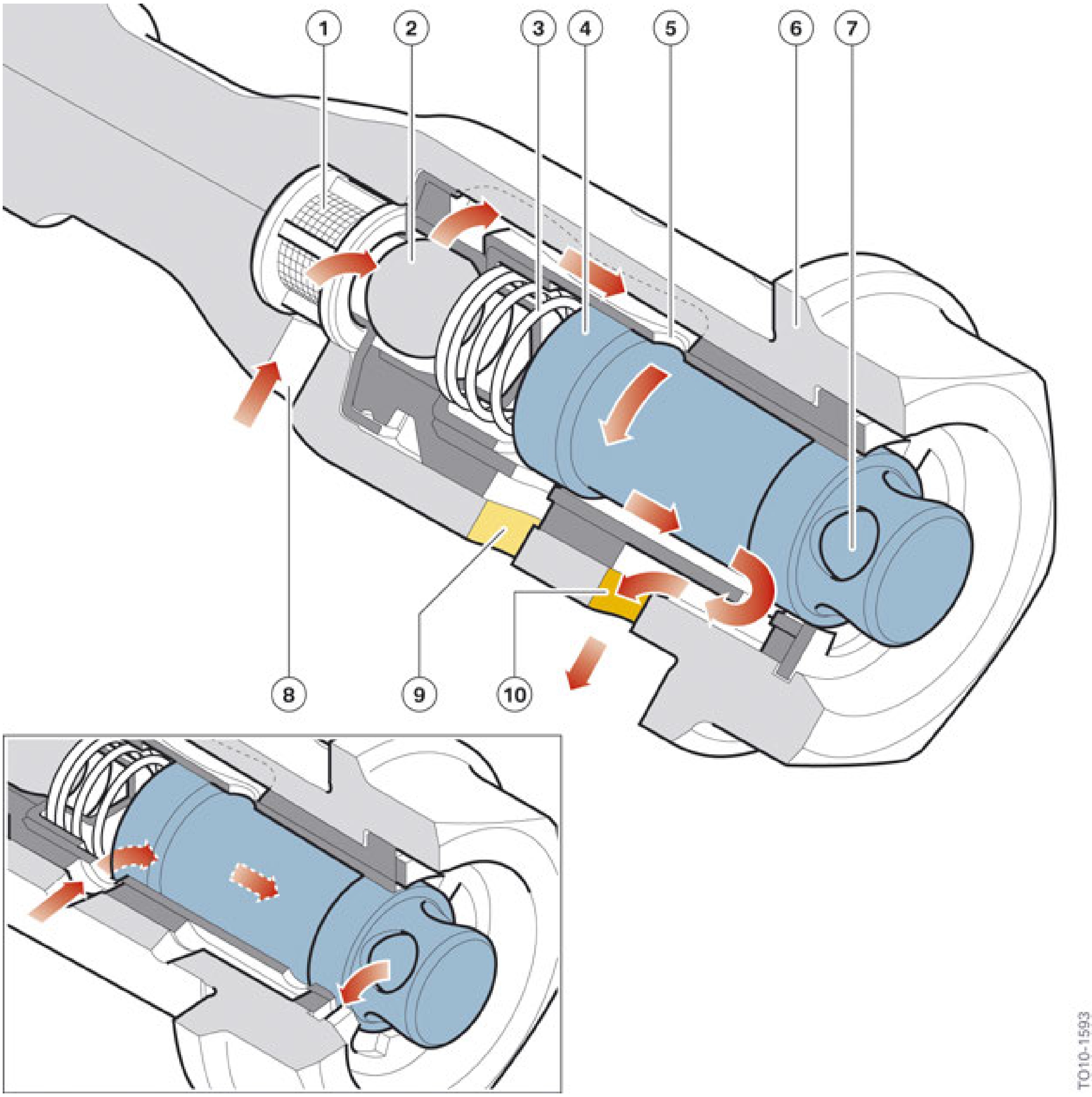

N20 engine, locking pin

| Index | Explanation |
|---|---|
| 1 | Locking cover |
| 2 | Locking pin |
| 3 | Locking spring |
| 4 | Cartridge |

| Index | Explanation |
|---|---|
| 5 | Oil passage |
| 6 | Locking cover |
| 7 | Oil passage |
| 8 | VANOS central valve |

The VANOS unit is secured to the camshaft by the VANOS central valve. The oil flow into the VANOS unit is simultaneously controlled by this VANOS central valve. The system is actuated by a solenoid actuator (which presses against the plunger (4) of the VANOS central valve) thereby switching this valve from advance to the retard position.

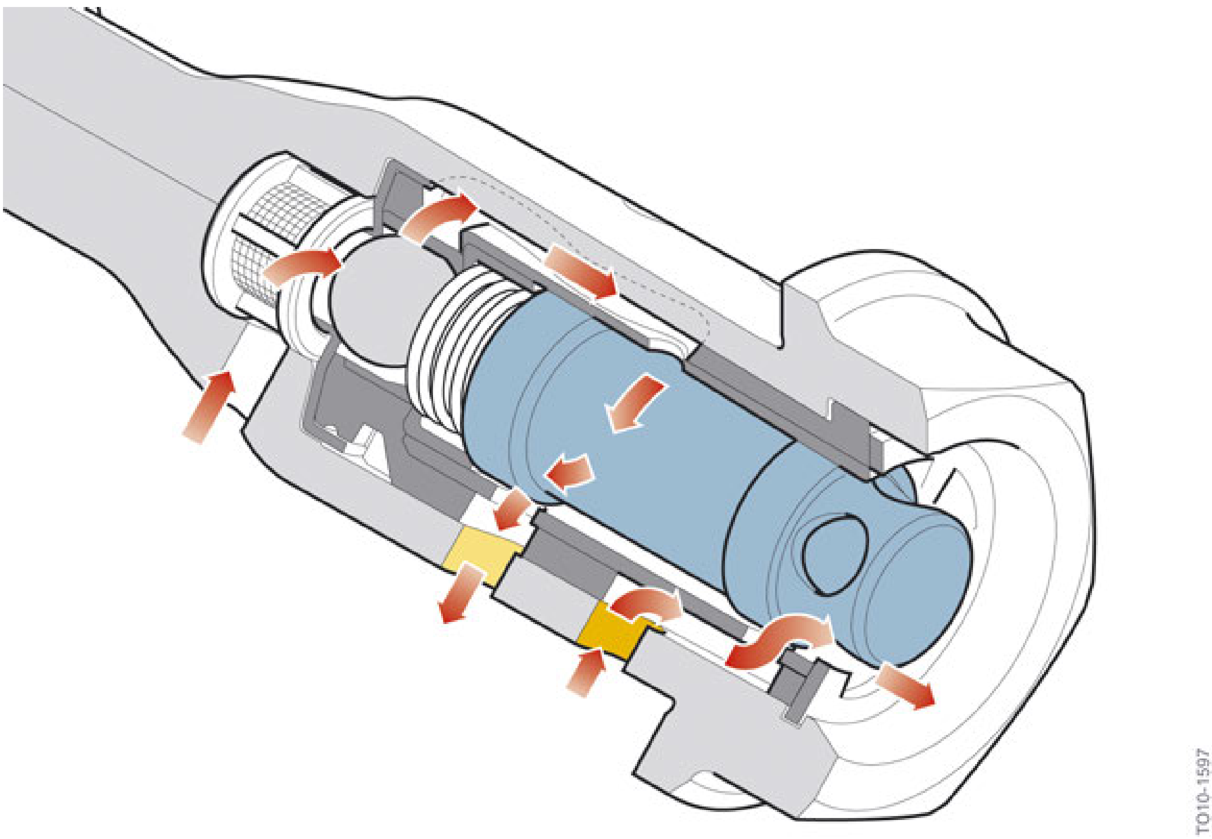
The plunger in the central valve controls the oil flow. In the illustration below the plunger is shown extended. The large graphic shows the flow of oil from the main oil passage into the VANOS unit, while the small graphic shows the flow of oil from the VANOS unit into the cylinder head.




N20 engine, VANOS central valve, intake camshaft

| Index | Explanation |
|---|---|
| 1 | Filter |
| 2 | Ball |
| 3 | Spring |
| 4 | Plunger |
| 5 | Sleeve |
| 6 | Housing |

| Index | Explanation |
|---|---|
| 7 | Opening in plunger |
| 8 | Oil supply from main oil passage |
| 9 | Bore to oil passage in VANOS (timing advance) |
| 10 | Bore to oil passage in VANOS (timing retard) |

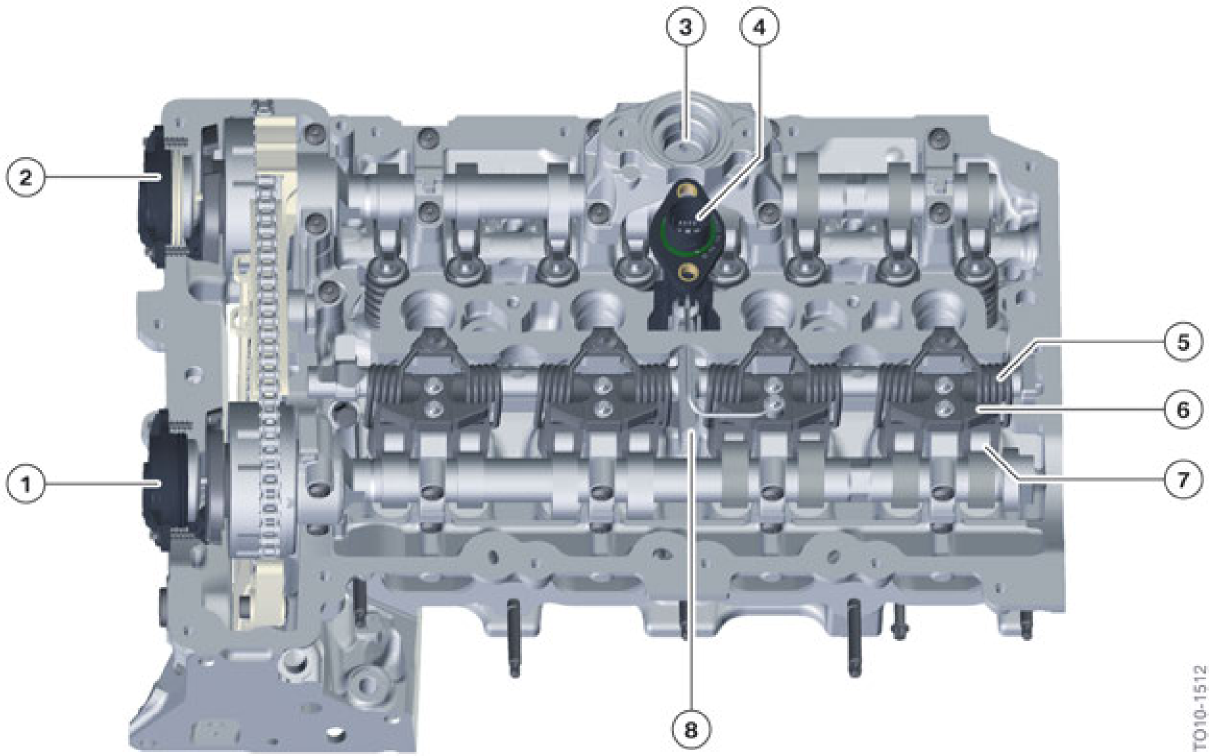



N20 engine, VANOS central valve, intake camshaft

### Valve lift control

As can been seen from the following graphic, valve lift control with the Valvetronic servomotor is identical in terms of design to that of the N55 engine. The eccentric shaft sensor is integrated in the Valvetronic servomotor.

The system uses Valvetronic III, which is already used in the N55 engine.

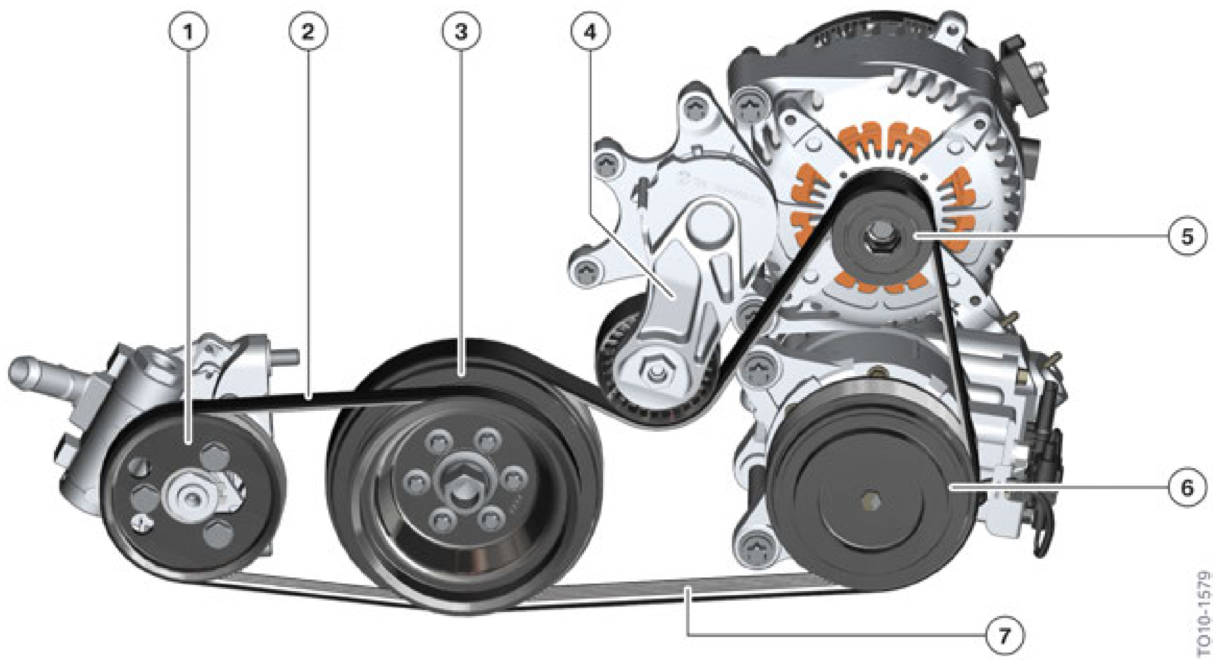



N20 engine, cylinder head

| Index | Explanation |
|---|---|
| 1 | VANOS solenoid actuator, intake |
| 2 | VANOS solenoid actuator, exhaust |
| 3 | Roller tappet, high-pressure pump |
| 4 | Valvetronic servomotor |
| 5 | Spring |
| 6 | Guide block |
| 7 | Intermediate lever |
| 8 | Eccentric shaft |

### 2.6. Belt drive

The belt drive consists of a main belt drive with alternator and A/C compressor and an auxiliary belt drive with the power steering pump. The main belt drive is equipped with a belt tensioner, the auxiliary belt drive is an elasto-belt tensioning system.




N20 engine, belt drive

| Index | Explanation |
|---|---|
| 1 | Belt pulley, power steering pump |
| 2 | Belt, power steering pump |
| 3 | Belt pulleys, crankshaft |
| 4 | Belt tensioner |
| 5 | Belt pulley, alternator |
| 6 | Belt pulley, A/C compressor |
| 7 | Belt |

# N20 Engine

# 3. Oil Supply

The oil supply in the N20 engine is very similar to that in the N55 engine. There are a few changes to the design with some slight differences in operation. Due to the complexity of this system, it is discussed again in greater detail in this training material.

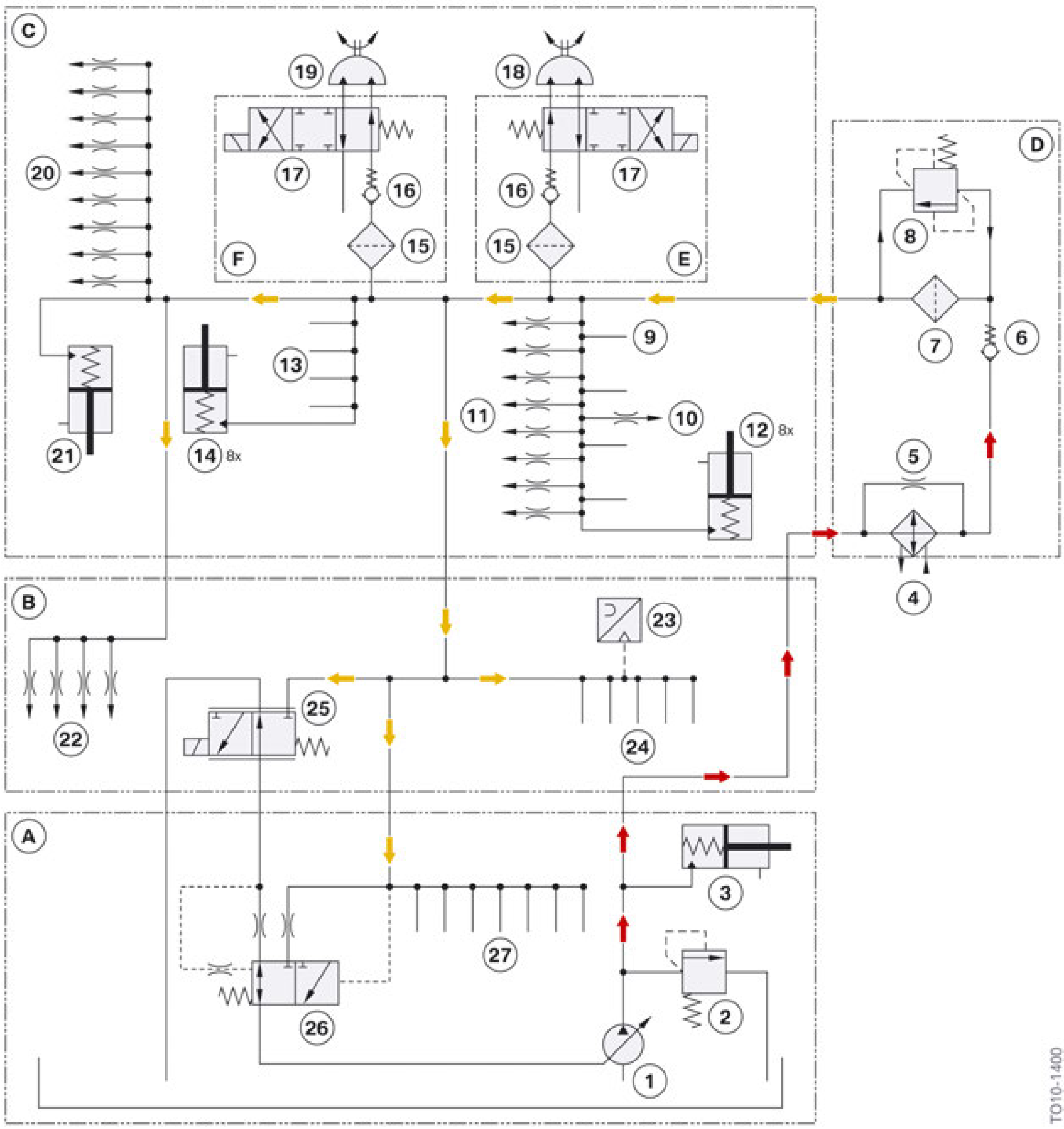
The special features of the oil supply in the N20 engine are:

- Map-controlled oil pump
- New pendulum-slide oil pump design
- New VANOS valves
- Chain tensioner for counterbalance shaft/oil pump drive
- Unfiltered oil cooling
- New combined oil pressure and temperature sensor.

## 3.1. Overview

The following hydraulic circuit diagram and graphics provide an overview of the N20 oil supply and a better understanding of the actual layout of the oil passages in the engine.

### 3.1.1. Hydraulic circuit diagram

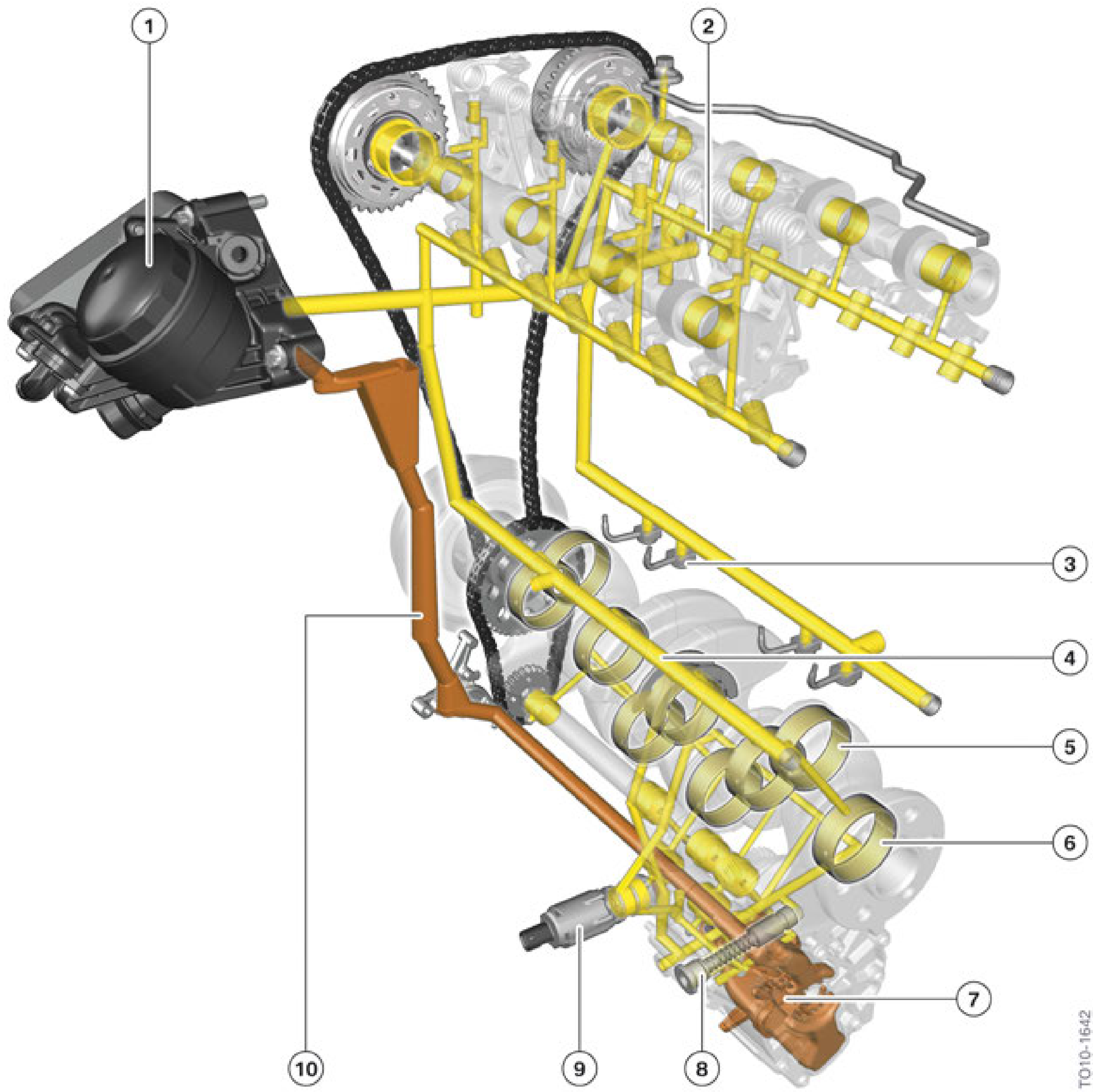



N20 engine, hydraulic circuit diagram

| Index | Explanation |
|---|---|
| A | Oil sump |
| B | Crankcase |
| C | Cylinder head |
| D | Oil filter module |

| Index | Explanation |
|---|---|
| E | VANOS central valve, intake camshaft (also oil supply, lubrication point, camshaft thrust bearing) |
| F | VANOS central valve, exhaust camshaft (also oil supply, lubrication point, camshaft thrust bearing) |
| 1 | Oil pump |
| 2 | Pressure-limiting valve |
| 3 | Chain tensioner, counterbalance shaft and oil pump drive |
| 4 | Engine oil-to-coolant heat exchanger |
| 5 | Permanent bypass |
| 6 | Non-return valve |
| 7 | Oil filter |
| 8 | Filter bypass valve |
| 9 | Lubrication points, intake camshaft bearings (via 4th bearing, supply of vacuum pump) |
| 10 | Oil spray nozzle, gearing, Valvetronic servomotor |
| 11 | Oil spray nozzles, cams, intake camshaft |
| 12 | Hydraulic valve clearance compensation (HVCC), intake side |
| 13 | Lubrication points, bearings, exhaust camshaft |
| 14 | Hydraulic valve clearance compensation (HVCC), exhaust side |
| 15 | Non-return valve |
| 16 | Filter |
| 17 | 4/3-way valve |
| 18 | VANOS unit, intake camshaft |
| 19 | VANOS unit, exhaust camshaft |
| 20 | Oil spray nozzles, cams, exhaust camshaft |
| 21 | Chain tensioner, timing chain |
| 22 | Oil spray nozzles for piston crown cooling |
| 23 | Combined oil pressure and temperature sensor |
| 24 | Lubrication points, crankshaft main bearings |
| 25 | Map control valve |
| 26 | Emergency valve/pressure limiting blow off valve |
| 27 | Lubrication points, bearings, counterbalance shafts |

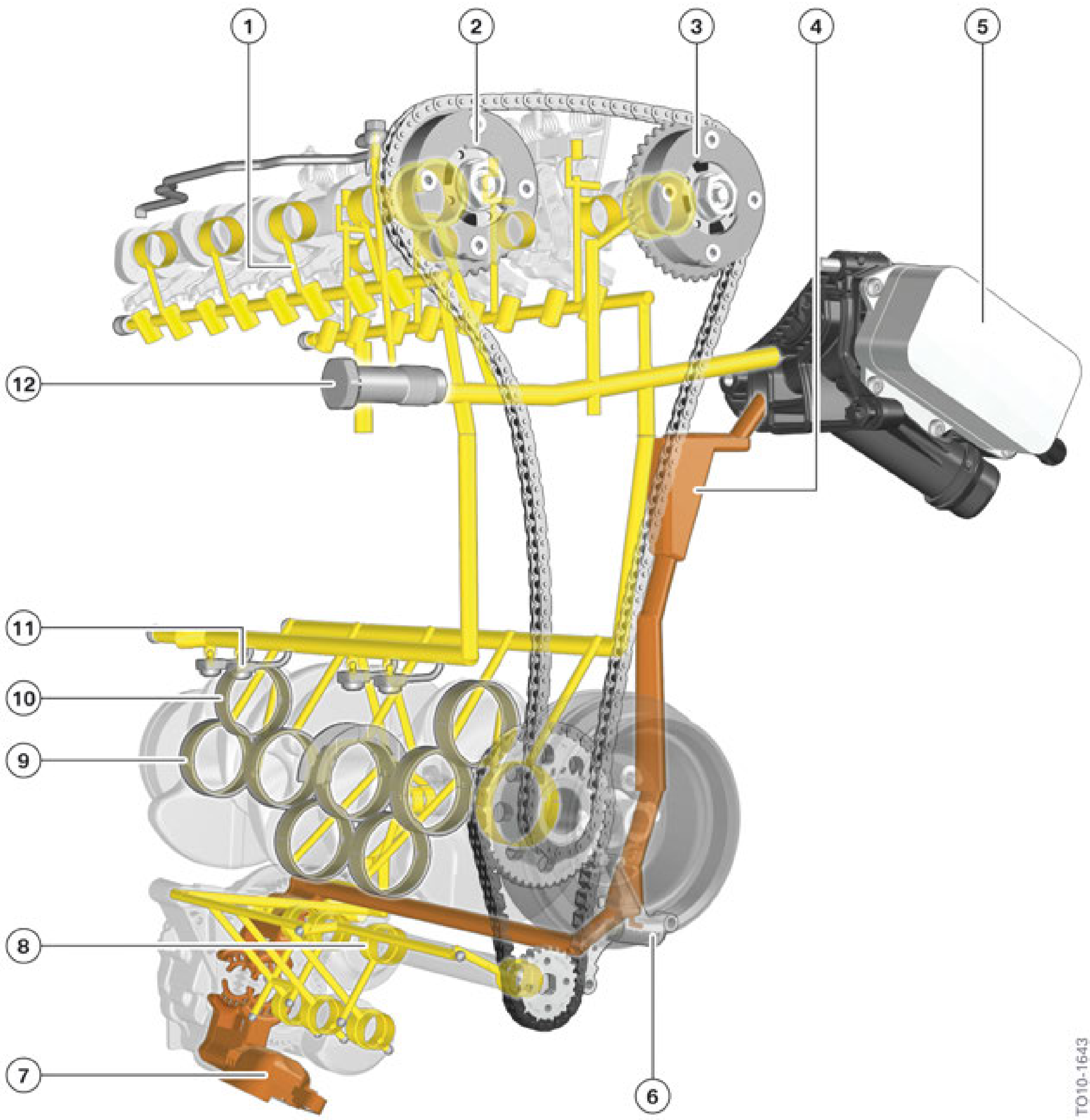
### 3.1.2. Oil passages




N20 engine, oil passages (phantom rear left view)

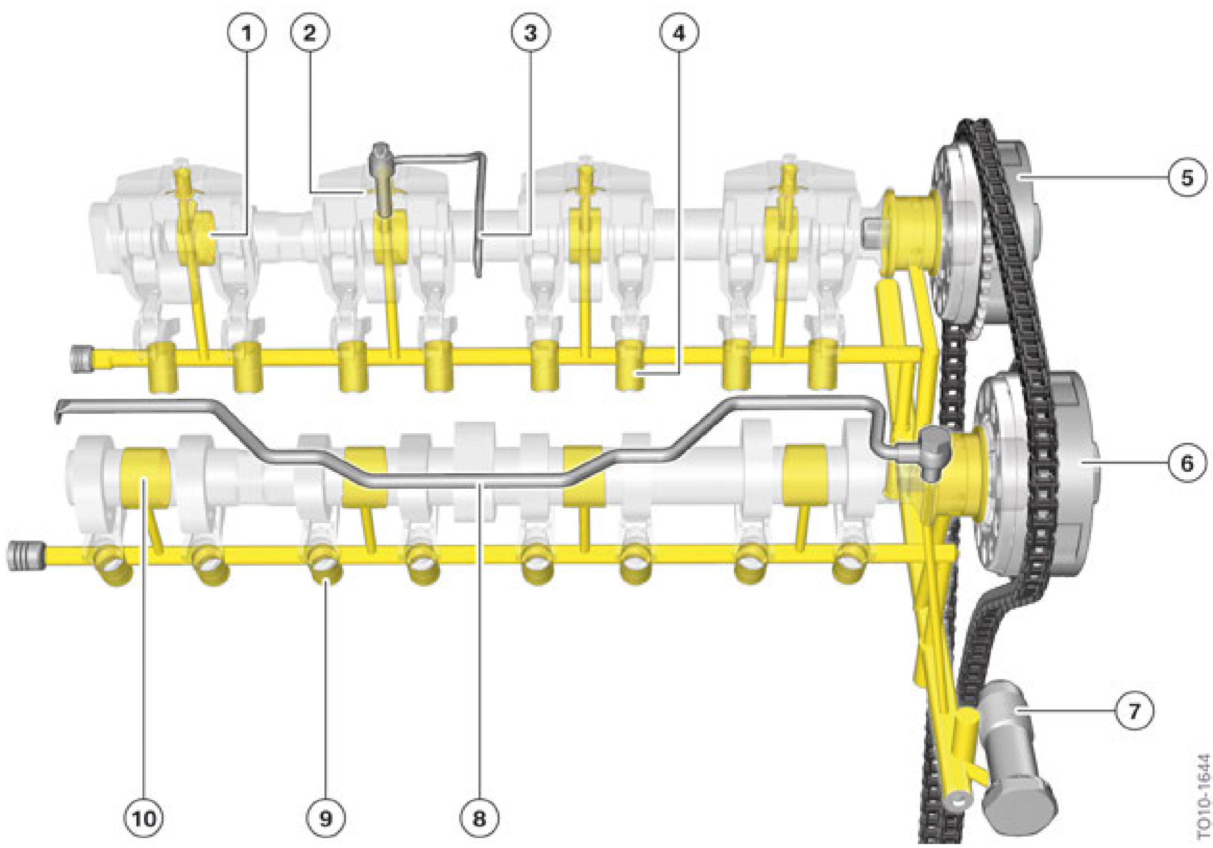
| Index | Explanation |
|---|---|
| 1 | Oil filter |
| 2 | Lubrication points in cylinder head (details, see below) |
| 3 | Oil spray nozzles for piston crown cooling |
| 4 | Main oil passage |
| 5 | Lubrication points, connecting rod bearings |
| 6 | Lubrication points, crankshaft main bearings |

| Index | Explanation |
|---|---|
| 7 | Oil pump |
| 8 | Emergency valve/pressure limiting blow off valve |
| 9 | Map control valve |
| 10 | Unfiltered oil passage |



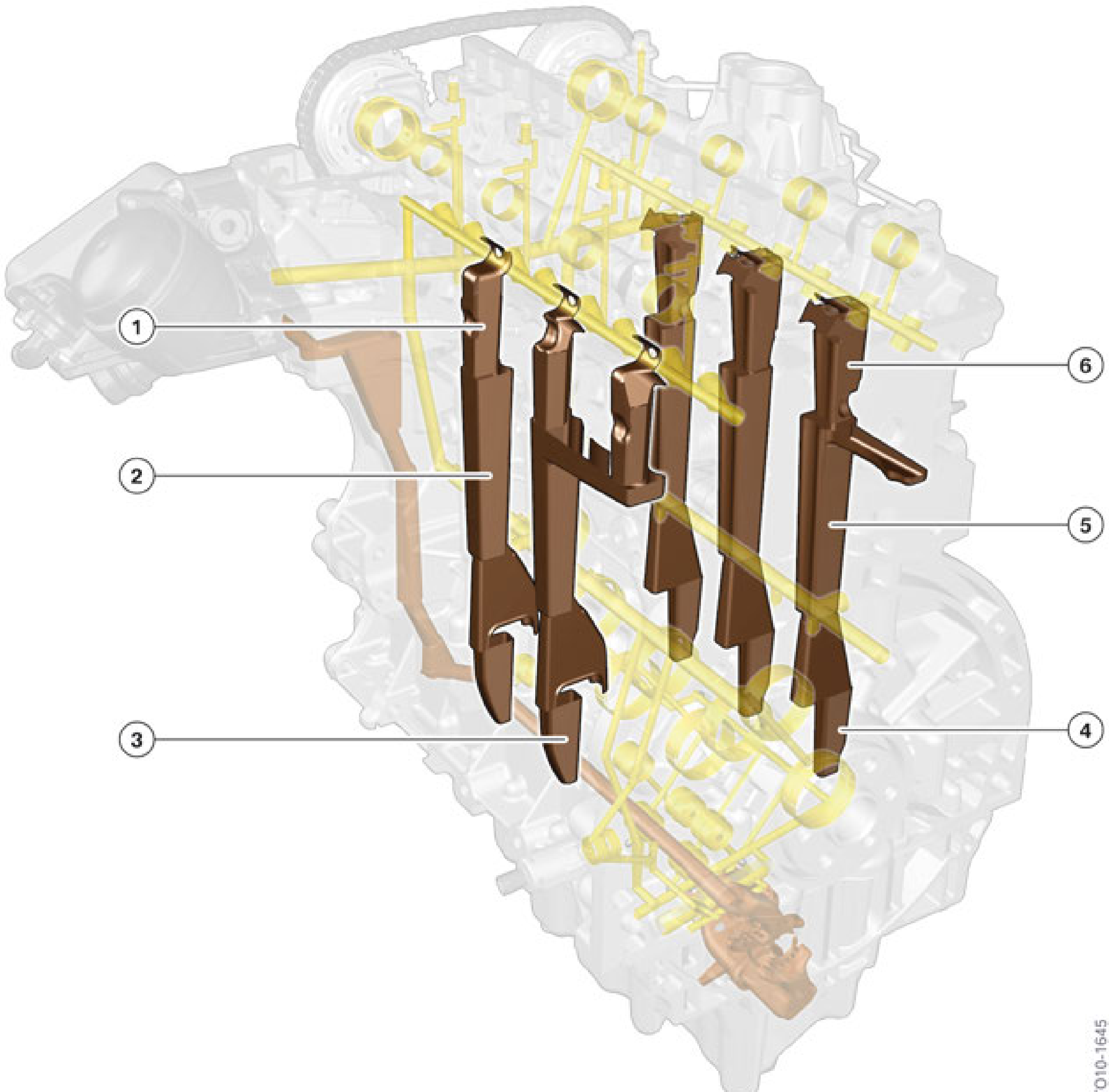

N20 engine, oil passages (phantom right front view)

| Index | Explanation |
|---|---|
| 1 | Lubrication points in cylinder head (details, see below) |
| 2 | VANOS actuator unit, exhaust camshaft |
| 3 | VANOS actuator unit, intake camshaft |
| 4 | Unfiltered oil passage |
| 5 | Engine oil-to-coolant heat exchanger |
| 6 | Chain tensioner, counterbalance shaft and oil pump drive |
| 7 | Oil suction pipe |
| 8 | Lubrication points, counterbalance shaft bearings |
| 9 | Lubrication points, crankshaft main bearings |
| 10 | Lubrication points, connecting rod bearings |
| 11 | Oil spray nozzles for piston crown cooling |
| 12 | Chain tensioner, timing chain |




N20 engine, oil passages in cylinder head (phantom left view)

| Index | Explanation |
| --- | --- |
| 1 | Lubrication points, intake camshaft bearings |
| 2 | Oil spray nozzles in Guide block for intermediate levers and intake cams |
| 3 | Oil spray nozzle, gearing, Valvetronic servomotor |
| 4 | HVCC elements, intake valves |
| 5 | VANOS actuator unit, intake camshaft |
| 6 | VANOS actuator unit, exhaust camshaft |
| 7 | Chain tensioner, timing chain |
| 8 | Oil pipe for oil spray nozzles, exhaust cams |
| 9 | HVCC elements, exhaust valves |
| 10 | Lubrication points, exhaust camshaft bearings |




N20 engine, oil return passages (phantom left rear view)

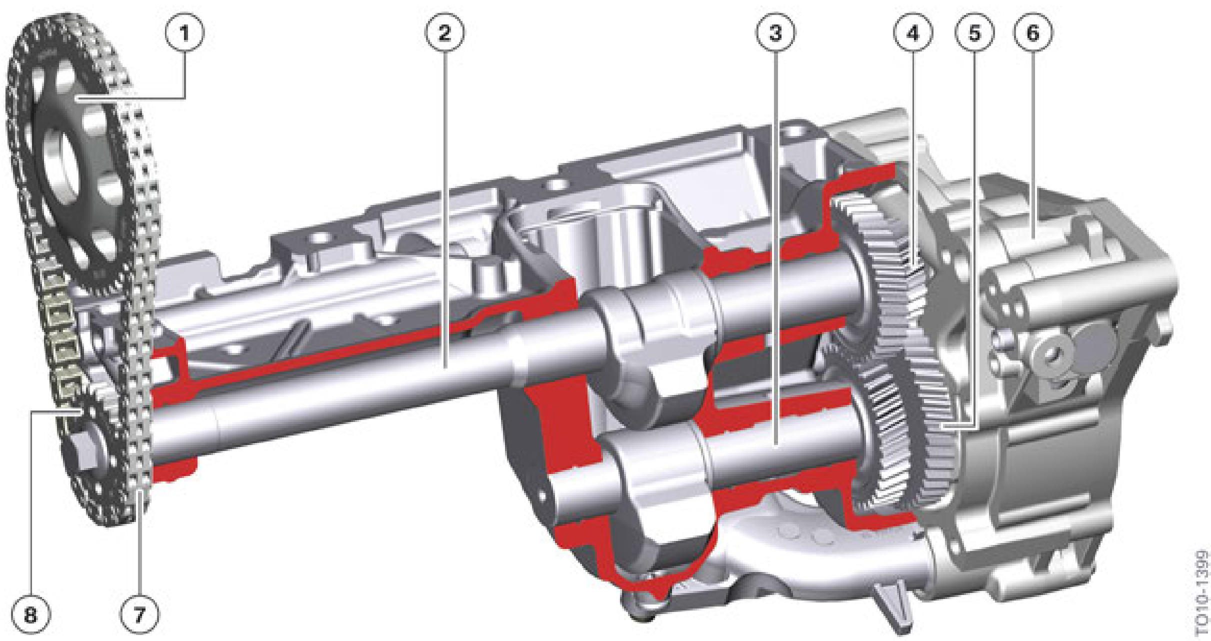
| Index | Explanation |
|---|---|
| 1 | Ventilation passages in cylinder head |
| 2 | Ventilation passages in crankcase |
| 3 | Ventilation passages in bedplate |
| 4 | Oil return passages in bedplate |
| 5 | Oil return passages in crankcase |
| 6 | Oil return passages in cylinder head |

### 3.2. Oil pump and pressure control

A variable-volumetric-flow slide oil pump is used in the N20 engine. Despite its shape being modified, its function is familiar to that of the N63 and N55 engines. Although these two engines share a similar oil pump, they differ in how they are controlled. While the oil pump in the N63 engine is volumetric-flow-controlled, in the N55 and N20 engines its map-controlled.

#### 3.2.1. Oil pump

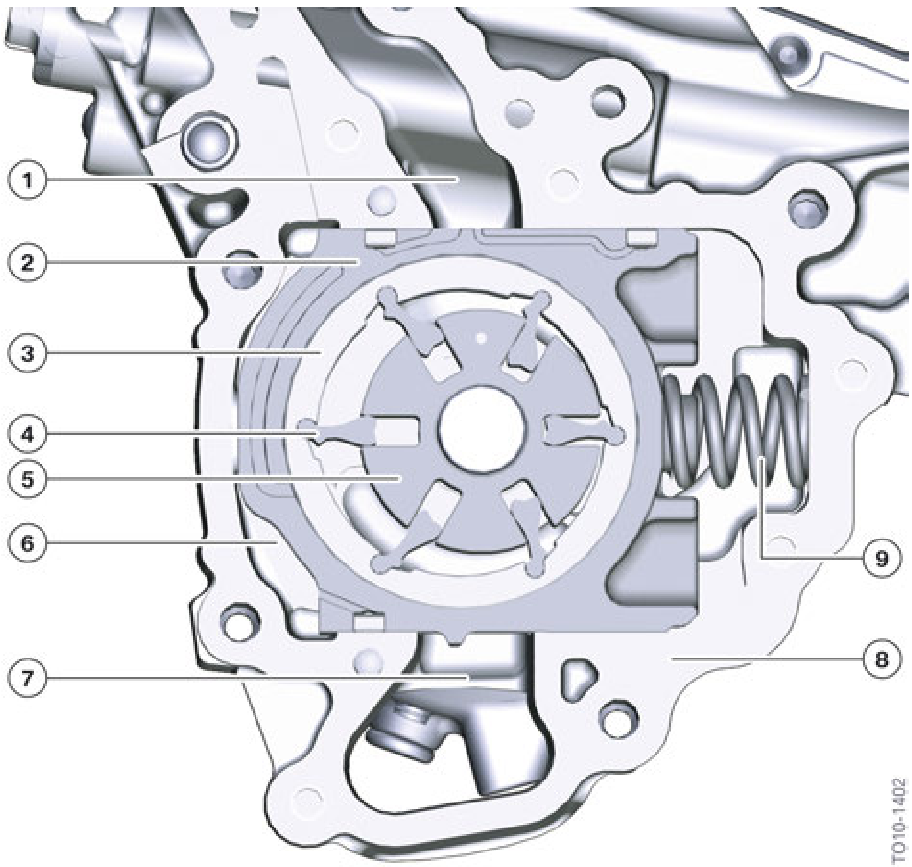
The oil pump is connected to the counterbalance shaft housing. The oil pump is located at the flywheel side of the engine, but is driven at the front of the engine by the crankshaft via a chain. The chain sprocket connects to the oil pump via a long shaft. This shaft forms part of the first counterbalance shaft which rotates in the same direction as the crankshaft. The rotational speed is stepped down from the counterbalance shaft for the oil pump via a pair of gears.




N20 engine, oil pump with counterbalance shafts

| Index | Explanation |
|---|---|
| 1 | Sprocket on crankshaft |
| 2 | Upper counterbalance shaft |
| 3 | Lower counterbalance shaft |
| 4 | Gear, upper counterbalance shaft |
| 5 | Gear, oil pump |
| 6 | Oil pump |
| 7 | Tooth-type chain, counterbalance shaft and oil pump drive |
| 8 | Counterbalance shaft sprocket |

As already mentioned, the function of the slide oil pump has not changed. The main difference is that the slide mechanism no longer pivots on an axis during adjustment, but instead is moved in parallel.




N20 engine, inner workings of oil pump

| Index | Explanation |
|---|---|
| 1 | Pressure side |
| 2 | sliding block |
| 3 | Outer rotor |
| 4 | Pendulum |
| 5 | Inner rotor |
| 6 | Control oil chamber |
| 7 | Suction side |
| 8 | Housing |
| 9 | Main spring |

As in all newer generation slide oil pumps the oil acts directly on the slide mechanism. The higher the pressure here, the more the sliding block is forced against the spring in the direction of the center of the pump, which reduces the volumetric displacement. This reduces the pump delivery rate and limits the pressure in the system. In this way, it is possible to achieve purely hydraulic/mechanical control of the volumetric flow, allowing sufficient operating pressure to be set. This pressure is determined by the strength of the main spring in the oil pump which acts on the sliding block.

As with the N55 the N20 engine features a map control valve which the DME activates to influence the pump delivery rate.

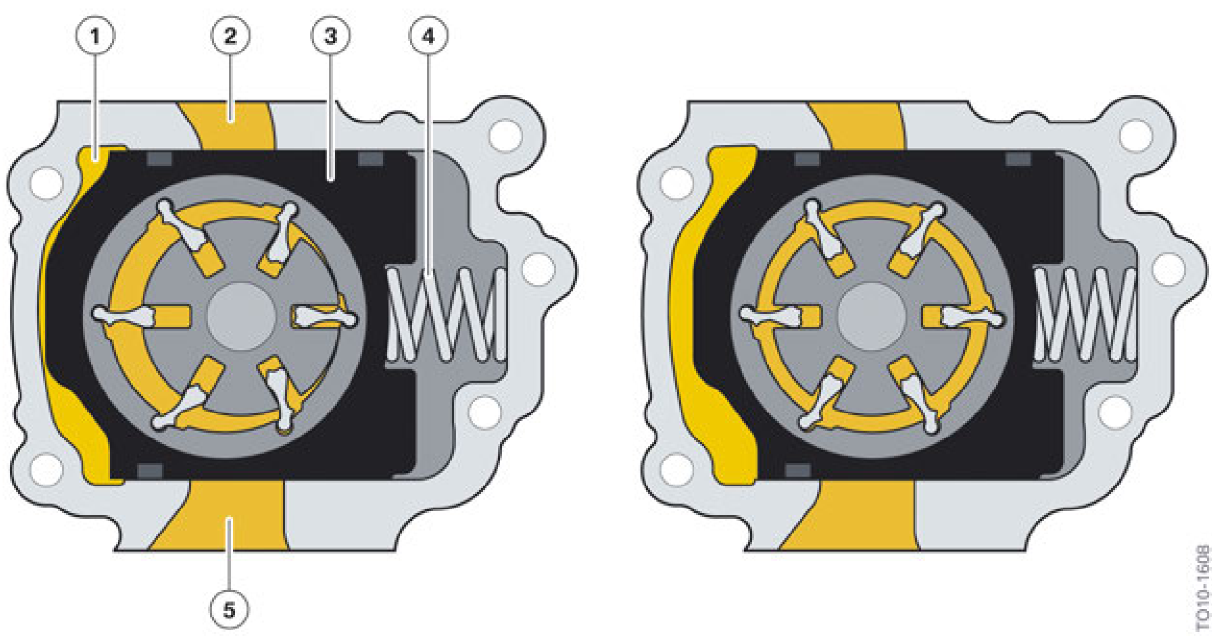
The oil pump cannot be replaced separately. The entire unit including the counterbalance shafts must be replaced if the oil pump fails.

### 3.2.2. Control

Controlling the delivery rate of the oil supply pump is crucial component of the BMW EfficientDynamics strategy. Essentially, engineers attempt to design a pump with regard to its power input as small as possible in order to keep engine losses as low as possible. On the other hand, the pump must also be designed in such a way as to deliver sufficient volume and pressure under all operating conditions. A conventional, non-variable pump would therefore have to be designed in accordance with the second standpoint, i.e. large enough to be able to deliver sufficient amounts of oil at all times. However, this means that the pump may deliver far too much oil volume and pressure over a large portion of its service life and thereby draw more energy than necessary from the powertrain. For this reason, more and more pumps are now variable in design and their control is becoming increasingly more fine-tuned. Thus the conventional pump was followed by volumetric flow control, which was subsequently extended to included map control.

#### Volumetric flow control

The N20 uses a vane type oil pump. The core of this variable-volumetric-flow oil pump is the sliding mechanism. It can be displaced with respect to the pump shaft to vary the pump's delivery rate.




N20 engine, oil pump (left at maximum delivery, right at minimum delivery)

| Index | Explanation |
|---|---|
| 1 | Control oil chamber |
| 2 | Pressure side |
| 3 | Sliding block |
| 4 | Main spring |
| 5 | Suction side |

In the maximum delivery setting the sliding block is positioned off-center with respect to the pump shaft. In this way, an increase in volume occurs on the suction side and correspondingly a decrease in volume occurs on the pressure side. This generates high pump capacity.

When the sliding block is displaced towards the pump shaft, the pump volume is reduced. Therefore, the pump capacity is reduced until finally the minimum delivery is reached.

The position of the sliding block is dependent on the oil pressure in the pump's control oil chamber. This pressure pushes on the sliding block against the force of a spring. When the pressure is low in the control chamber, the sliding block is moved off-center by the force of the spring and the delivery rate is high. When the pressure is high in the control chamber, the sliding block is displaced towards the center of the pump as the spring is compressed and the delivery rate decreases.

With pure volumetric flow control, the pressure in the control oil chamber corresponds to that in the main oil passage. In this way, it is possible to maintain a relatively uniform pressure irrespective of the necessary volumetric flow. One reason for large differences in the necessary volumetric flow in the oil circuit is the VANOS variable camshaft timing control system. In the VANOS units the oil is used not only for lubrication purposes but also for hydraulic actuation of the cam timing. A large oil volume is thus necessary during the adjustment phase, which causes the pressure in the system to drop. The falling pressure causes the sliding block in the oil pump to be displaced in the direction of higher delivery. In this way, a higher volumetric flow is made available and the pressure drop is compensated for.

As already mentioned, the pressure that is set in the oil system is dependent on the force of the spring which counteracts the pressure in the control oil chamber. With a softer spring, the sliding block can be displaced more easily, i.e. with a lower pressure, towards the center. With a harder spring, more pressure is required to reduce the volumetric displacement of the pump. Thus the appropriate spring was calculated and selected to properly operate the N20 oil system.

Map control represents a further fine-tuning of volumetric flow control.

### Map control

Map control is used to influence the pressure in the control oil chamber of the pump. Two valves are involved in this process, a solenoid valve called the map control valve and a hydraulic valve which also acts as a fail-safe. This “fail safe” valve is also referred to as an emergency valve or a second-level mode control valve.

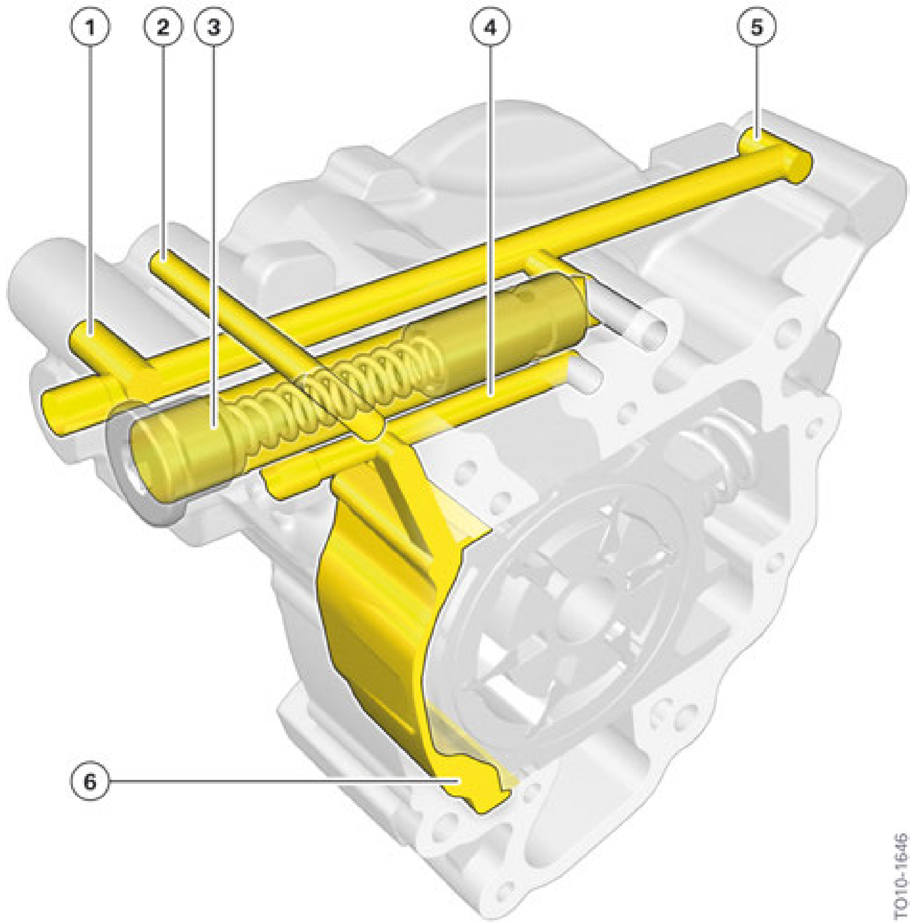
The map control valve is located on the left side of the engine (bolted to bedplate) and channels the oil pressure from the main oil passage to the control oil chamber within the pump. Its purpose is to influence pump volume output by gradually and smoothly reducing the oil pressure in the control oil chamber.


Map control valve

The further it reduces the pressure, the more volume is delivered by the oil pump as the sliding block moves further off center. However, this mode does not produce a positive effect on energy saving. Therefore the main spring in the oil pump which acts on the sliding block is softer than the one used in a purely volumetric-flow-controlled system. In other words, the sliding block can be moved to a centred position very easily, as the pump switches to minimum delivery. In this way, there are lower pressure conditions in the oil system, which in turn translates into less energy spent to drive the oil pump. Where necessary, the pressure in the control oil chamber can now be reduced by the map control valve which also reduces the delivery rate.

The second stage of map control is a hydraulic/emergency valve which is located in the oil pump housing.

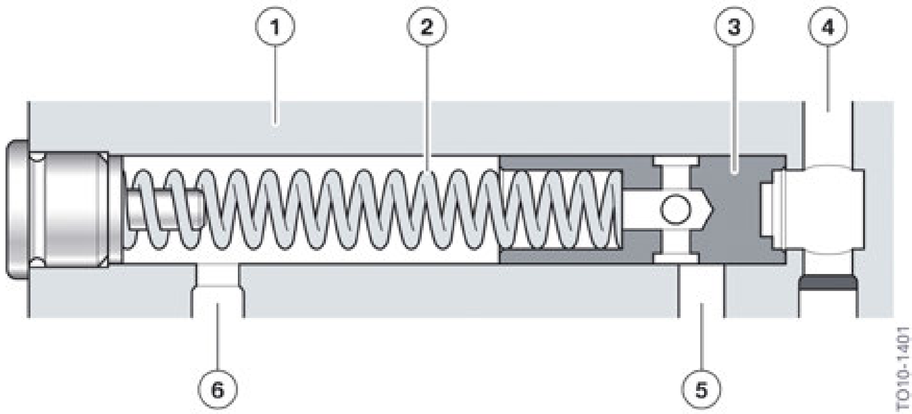
## 3. Oil Supply




N20 engine, oil pump with hydraulic emergency valve

| Index | Explanation |
|---|---|
| 1 | Connection from main oil passage |
| 2 | Connection from map control valve |
| 3 | Hydraulic/Emergency valve |
| 4 | Channel to control oil chamber |
| 5 | Connection to counterbalance shafts |
| 6 | Control oil chamber |

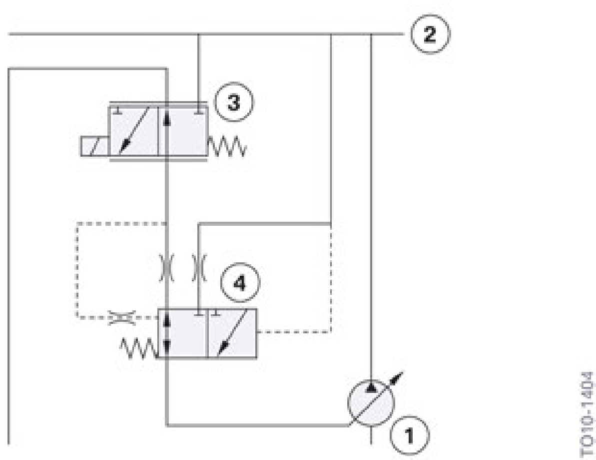
This is 3/2-way valve is used to channel the main oil pressure into the oil pump's control oil chamber. The oil from the main oil passage forces a plunger against a spring until the passage to the oil pump control chamber is opened. The oil pressure from the map control valve acts on the other end of the plunger. The pressure in the map control valve port counter acts the main oil passage pressure to fine tune the oil pressure within the oil pump's volume control chamber which in turn varies the oil delivery rate of the pump.




N20 engine, emergency valve

| Index | Explanation |
|---|---|
| 1 | Oil pump housing |
| 2 | Emergency spring |
| 3 | Plunger |
| 4 | From main oil passage |
| 5 | To control oil chamber in oil pump |
| 6 | From map control valve |

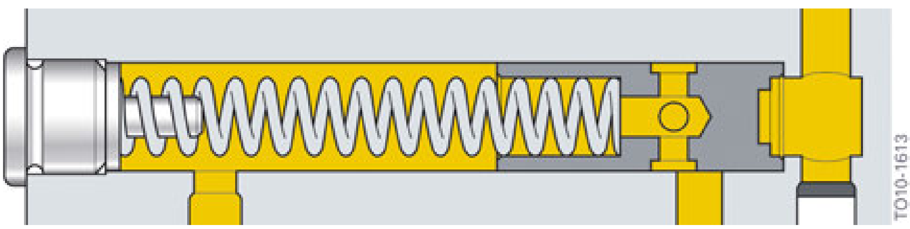
The hydraulic valve is located between the map control valve and the control oil chamber in the oil pump. The following graphic shows this in a simplified oil circuit.




N20 engine, simplified map control oil circuit

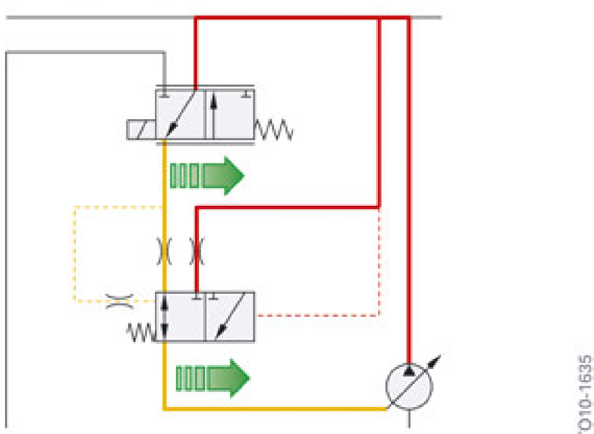
| Index | Explanation |
|---|---|
| 1 | Oil pump |
| 2 | Main oil passage |
| 3 | Map control valve |
| 4 | Emergency valve |

In map control mode oil pressure acts on both ends of the plunger. The oil pressure directly from the main oil passage acts against the emergency valve spring. At the same time the oil pressure released by the map control valve acts on the other end, i.e. along with the emergency valve spring.




N20 engine, hydraulic 3/2-way valve with map control

The plunger remains constantly in its end position during map control. To displace the plunger, there would have to be a pressure of 5.5 bar in the main oil port to counter act the spring. This **never** arises in map control mode, since the maximum set pressure in the system is 4.5 bar in the circuit. In this setting the emergency valve forms a connection between the map control valve and the oil pump's control oil chamber (the valve is **closed** to the main oil duct).



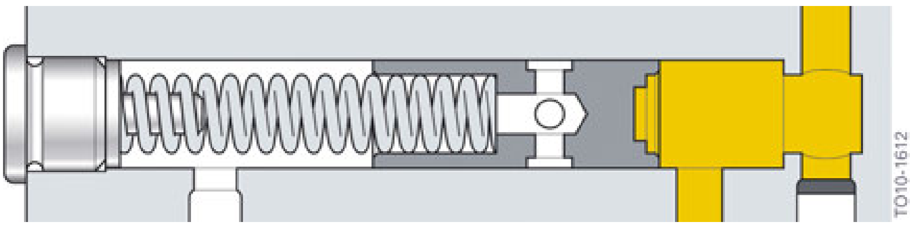

N20 engine, simplified oil circuit with map control

The pump delivery rate is controlled by the pressure in the pump's control oil chamber which in turn is determined directly by the DME via the map control valve.

Map control is the oil system's standard operating mode. It is always engaged when there are no faults in the system and the operating conditions do not exceed or drop below certain values (see below).

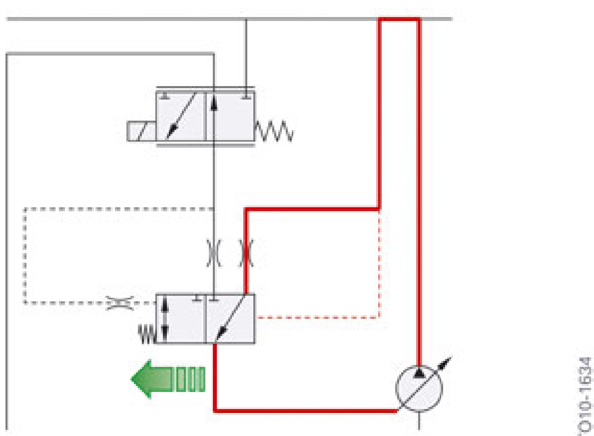
Up to now map control system would manage without the emergency valve. This is however a second stage of map control – a kind of fail safe mode.

If the map control valve is deactivated, the chamber at the end of the spring in the emergency valve is depressurized. Because the plunger is now only being held by the spring the main oil pressure displaces it and makes its way into the pump's control chamber. A pressure difference of 5.5 bar is required to switch the emergency valve into this position.




N20 engine, emergency valve with “second-level control”

In this mode the pressure is channelled from the main oil passage directly into the oil pump's control oil chamber.




N20 engine, simplified oil circuit in emergency mode

There is no map control in emergency mode because the oil pressure is set to 5.5 bar max. and there is no oil admitted into the oil pump's control oil chamber below this level.

The map control valve is closed at zero current. Therefore, should the map control valve fail, the system is automatically in emergency mode, guaranteeing pressure limitation to 5.5 bar. As already mentioned, map control mode is the normal mode of operation. There are, however, several reasons why the DME will switch to emergency mode.

Emergency mode is applied in the following conditions:

- Map control valve faulty
- Oil pressure sensor faulty
- Outside temperature less than - 20 °C/- 4 °F
- High engine oil or coolant temperature
- Driving profile (e.g. high engine revs for a long time)

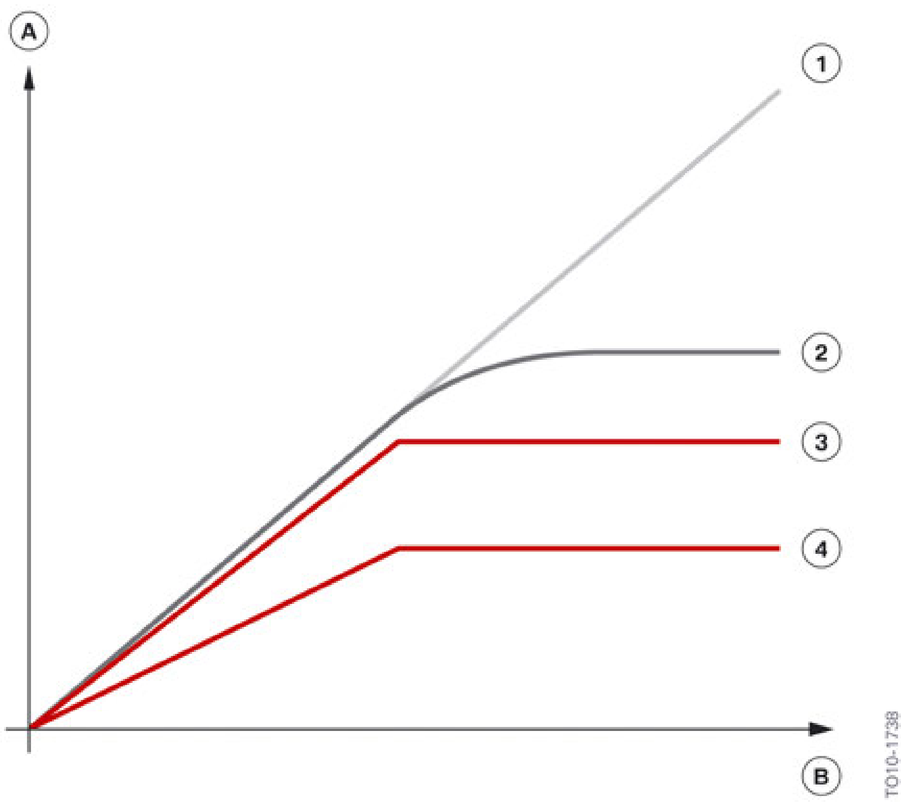
The oil pressure sensor signal allows the DME to identify whether the emergency valve is stuck. If this is the case, the DME attempts to free the emergency valve by applying a varying pressure buildup. If the emergency valve is stuck in the “closed” position, it is possible to continue map control. If, however, the emergency valve is stuck in the “open” position sufficient pressure buildup is no longer possible. The oil pressure indicator light is activated and the engine must be shut down immediately.

### Summary

By applying oil pump map control, it is possible to deliver an oil supply to match demand and to reduce the average pressure level in the oil circuit. This ensures that the oil pump has a lower energy requirement.

The map control valve controls the pressure in the system and in turn allows the delivery rate to be controlled by the DME.

The following diagram shows (in simplified form) the pressure curves plotted against engine speed for different oil pumps.




Simplified pressure curves for different oil pumps

| Index | Explanation |
|---|---|
| A | Oil pressure |
| B | Engine speed |
| 1 | Non-controlled oil pump |
| 2 | Volumetric-flow-controlled oil pump |
| 3 | Map-controlled oil pump at full load |
| 4 | Map-controlled oil pump at partial load |

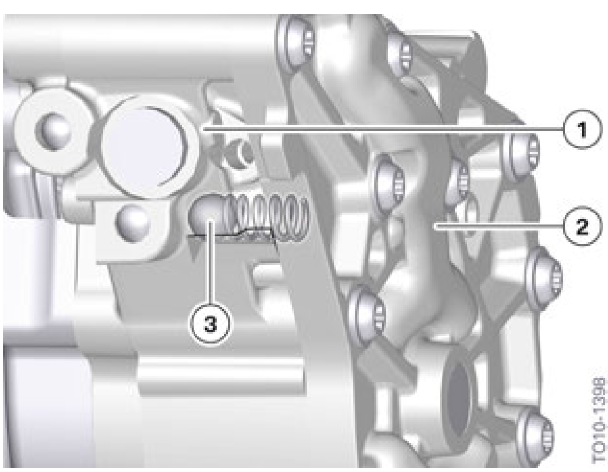
The diagram illustrates the advantage of controlled oil pumps. When a sufficient oil pressure is reached, the delivery rate of the oil pump can be reduced. Lower pressure is synonymous with fuel saving. Thus the map-controlled oil pump offers the greatest advantage here, since it can be controlled regardless of engine speed. At partial load, for example, only lower pressures are required, because the crankshaft main bearings have to bear less load. Accordingly, a lower oil pressure can be set in the partial load range, which illustrates even more clearly the advantage over the volumetric-flow-controlled oil pump.

The oil pressure in map mode ranges between 1.5 and 4.5 bar.

The emergency valve has been integrated in the system as a fail safe and to facilitate a higher pressure in certain conditions. For example if the map control valve fails, it ensures the necessary pressure is built up and the oil pump pressure control of 5.5 bar.

### 3.2.3. Pressure-limiting valve

Additionally available to control the oil pump is a pressure-limiting valve, which is often also known as a cold-start valve.



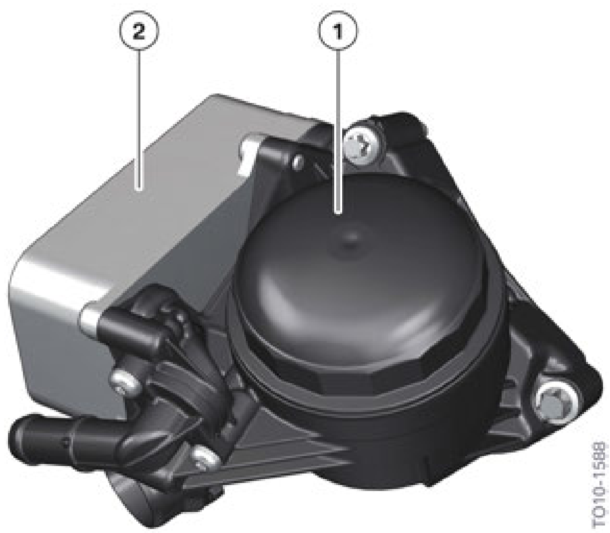

N20 engine, pressure-limiting valve in oil pump

| Index | Explanation |
|---|---|
| 1 | Oil pump housing |
| 2 | Oil pump cover |
| 3 | Pressure-limiting valve |

The pressure-limiting valve is located in the oil pump housing and in the oil circuit as the first component after the pump. It opens at a pressure of roughly 12 to 13 bar and discharges the oil directly into the oil sump. It is necessary at low temperatures and when the oil has a higher viscosity. In these situations the pressure-limiting valve prevents damage to components, in particular to the oil filter module and its seals. This is relevant at temperatures of below -20 °C / -4 °F, since map control is already active above this temperature.

### 3.3. Oil filtering and cooling

The N20 engine has a similar plastic oil filter housing as the N55 engine, to which the engine oil-to-coolant heat exchanger is also directly mounted. This entire unit is known as the oil filter module.




N20 engine, oil filter module

| Index | Explanation |
| --- | --- |
| 1 | Oil filter |
| 2 | Engine oil-to-coolant heat exchanger |

#### 3.3.1. Oil cooling

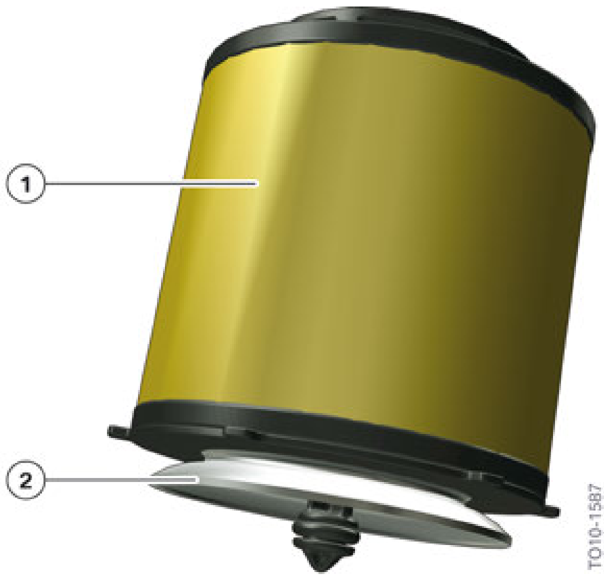
In the N20 engine the engine oil-to-coolant heat exchanger is located in the oil circuit ahead of the oil filter. This is known as raw/unfiltered oil cooling, in contrast to clean oil cooling. This is due to the lead-free crankshaft and connecting rod bearings. Because these components are extremely sensitive to dirt particles, this arrangement brings the oil filter even closer to just before the bearing positions. The importance is even greater should auxiliary engine oil coolers be used in later models, as here there is always the risk of dirt getting into the oil circuit after an accident.

**Permanent bypass**

The N20 engine does not have a heat exchanger bypass valve. Instead, as the N55, it has a permanent bypass. This is a permanently open bypass around the engine oil-to-coolant heat exchanger. The bypass incorporates a flow restrictor to ensure that the majority of the oil flows through the engine oil-to-coolant heat exchanger.

### 3.3.2. Oil filtering

The full-flow oil filter used in the N20 engine. Instead of a non-return valve, a non-return diaphragm is mounted directly on the filter element. The function of this diaphragm is to prevent the oil filter from draining after the engine is shut down.




N20 engine, oil filter

| Index | Explanation |
|---|---|
| 1 | Oil filter |
| 2 | Non-return diaphragm |

The non-return diaphragm is made of rubber and is raised by the oil pressure to admit oil into the filter. When the engine is shut down and the oil pressure drops, the non-return diaphragm uses its shape and elasticity to seal off the oil duct. The engine oil is unable to flow out of the filter. The non-return diaphragm is part of the oil filter and is therefore automatically replaced each time the filter is changed.

The N20 engine has a filter bypass valve which can open a bypass around the filter if, for example, the engine oil is cold and has a higher viscosity. This occurs if the pressure difference between before and after the filter exceeds about. 2.5 bar. The allowable pressure difference has been increased from 2.0 to 2.5 bar in order to protect the lead-free crankshaft and connecting rod bearings. This ensures that the filter is bypassed much less frequently and any dirt particles are reliably filtered out.

## 3.4. Oil monitoring

### 3.4.1. Oil pressure and temperature sensor


N20 engine, oil pressure and temperature sensor

A new combined oil pressure and temperature sensor is used. The pressure signal is required for oil pump map control, the temperature signal for engine heat management.

The sensor is exposed in the main oil passage to the oil pressure prevailing there and the oil temperature. Thus, what is measured is no longer the oil temperature in the oil sump, but instead the actual oil temperature in the engine.

Combined pressure and temperature sensors usually have four connections (power supply, ground, temperature signal, pressure signal). The oil pressure and temperature sensor has only three connections. The temperature and pressure signals are not transmitted on separate wires. Instead, the sensor outputs a pulse-width-modulated (PWM) signal. This PWM signal is split into three fixed cycles. The first cycle is for synchronization and diagnosis, the second transmits the temperature, and the third the pressure. The duration of the “high level” of a respective cycle determines the value.

| Cycle | Function | Duration of cycle | Duration of high level |
|---|---|---|---|
| 1 | Synchronization and diagnosis | 1024 µs | 256 – 640 µs |
| 2 | Temperature | 4096 µs | 128 – 3968 µs |
| 3 | Pressure | 4096 µs | 128 – 3968 µs |

The length of the high level is for the diagnostic signal always a multiple of 128 µs (microsecond = 0.000001 seconds), as is shown in the table below:

| Duration of high signal | Pulse width | Meaning |
|---|---|---|
| 256 µs | 25 % | Diagnosis OK |
| 384 µs | 37.5 % | Pressure measurement failed |
| 512 µs | 50 % | Temperature measurement failed |
| 640 µs | 62.5 % | Hardware fault |

For this purpose the sensor is capable of self-diagnosis and can identify sensor-internal mechanical and electrical faults.

For the temperature signal:

- 128 µs (3.125 % pulse width) = -40 °C/-40 °F
- 3968 µs (96.875 % pulse width) = 160 °C/320 °F

For the pressure signal:

- 128 µs (3.125 % pulse width) = 0.5 bar (absolute)
- 3968 µs (96.875 % pulse width) = 10.5 bar (absolute)

The times indicated are nominal values. Actually the durations of each cycle and of the respective high level are measure and compared with each other. The resulting pulse width produces the respective measured value.

**The actual oil pressure can be measured by installing special tool # 2 212 823. Please refer to the repair instructions.**

### 3.4.2. Oil level monitoring

The established thermal oil level sensor is used to monitor the oil level and the oil temperature.

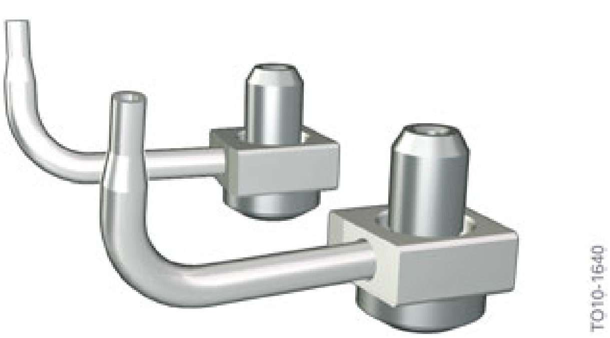
## 3.5. Oil spray nozzles

As with previous BMW engines those components which cannot be reached directly by an oil passage are lubricated and/or cooled by oil spray nozzles.

### 3.5.1. Piston crown cooling

The oil spray nozzles for piston crown cooling are used in the N20 engine. They incorporate a non-return valve to enable them to open and close only from a specific oil pressure.

As well as cooling the piston crowns, they are also responsible for lubricating the wrist pins, which is why it is very important for them to be precisely aligned.




N20 engine, oil spray nozzles for piston crown cooling

| | |
|---|---|
| Opening pressure | 2.5 – 2.9 bar |
| Closing pressure | 2.1 bar |

⚠

The oil spray nozzles for piston crown cooling in the N20 engine must be correctly positioned using a special tool # 2 212 829 after being installed. Refer to the repair instructions.

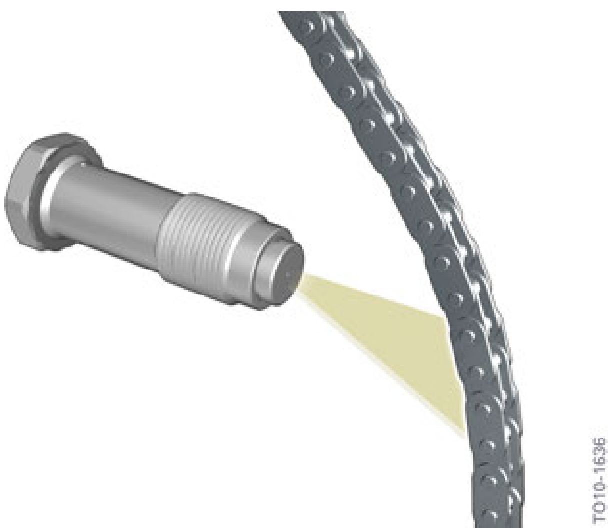
There are two different variants of oil spray nozzle for piston crown cooling for the N20 engine, depending on their arrangement in the engine. One variant for cylinders 1 and 3 and one variant for cylinders 2 and 4.

### 3.5.2. Chain drive

The chain drive in the N20 engine is divided into an upper section (the camshaft drive) and a lower section (the oil pump drive).

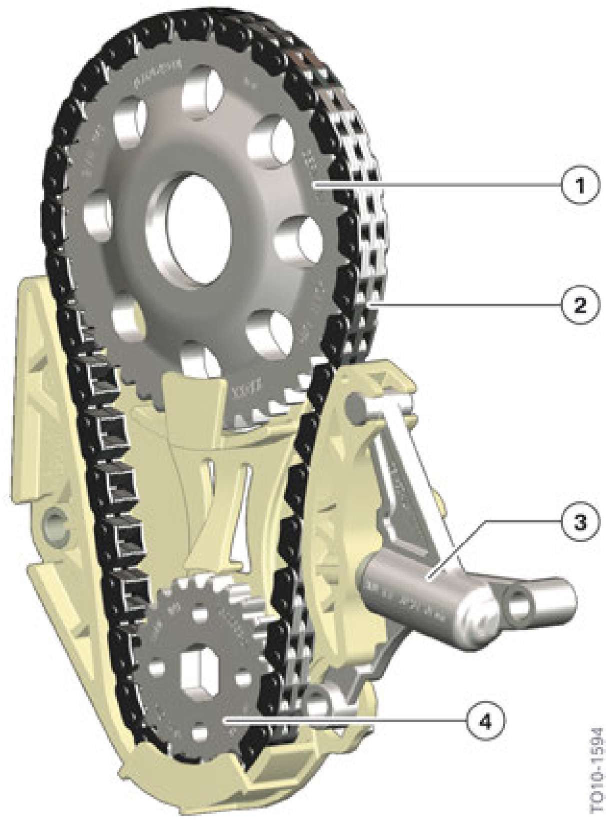
**Camshaft drive**

The timing chain is lubricated by an oil spray nozzle located in the chain tensioner. There is an opening in the tensioning rail through which the oil can be sprayed for this purpose.




N20 engine, chain tensioner with oil spray nozzle for timing chain

**Counterbalance shaft and oil pump drive**




N20 engine, counterbalance shaft and oil pump drive

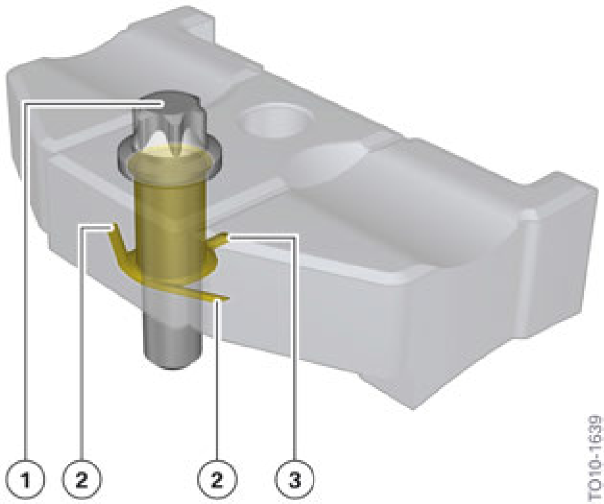
| Index | Explanation |
| --- | --- |
| 1 | Crankshaft sprocket |
| 2 | Chain |
| 3 | Chain tensioner |
| 4 | Counterbalance shaft sprocket |

Oil is sprayed onto the chain through the chain tensioner for the counterbalance shaft and oil pump drive. This is however not necessary for lubrication, since the chain is immersed in the oil sump. In this case, this helps the oil to drain from the chain tensioner.

### 3.5.3. Camshaft

The lobes on the camshaft are also lubricated via oil spray nozzles. For the intake camshaft there are fine grooves in the gates which are supplied with oil from the screw hole.

## 3. Oil Supply

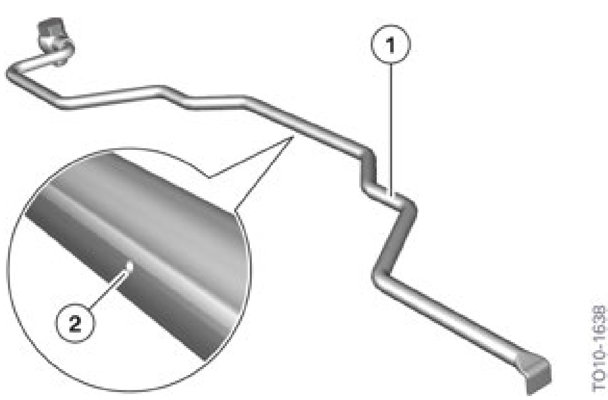



N20 engine, guide block with oil spray nozzles for intake cams

| Index | Explanation |
| --- | --- |
| 1 | Screw connection, gates |
| 2 | Oil spray nozzles for intake cams |
| 3 | Oil supply for oil spray nozzles |

When fitting the guide block it is essential to work in absolutely clean conditions, as any soiling could block the oil spray nozzles. Lubrication of the cam lobes would no longer be guaranteed and could result in damage to the valvetrain.

For the exhaust camshaft, the cylinder head features an oil pipe which sprays oil through small holes directly onto the cam lobes. Accordingly, there are eight holes for lubricating the exhaust valve lobes and an extra hole for lubricating the triple cam which drives the high-pressure fuel pump.




N20 engine, oil pipe with oil spray nozzles for exhaust cam lobes

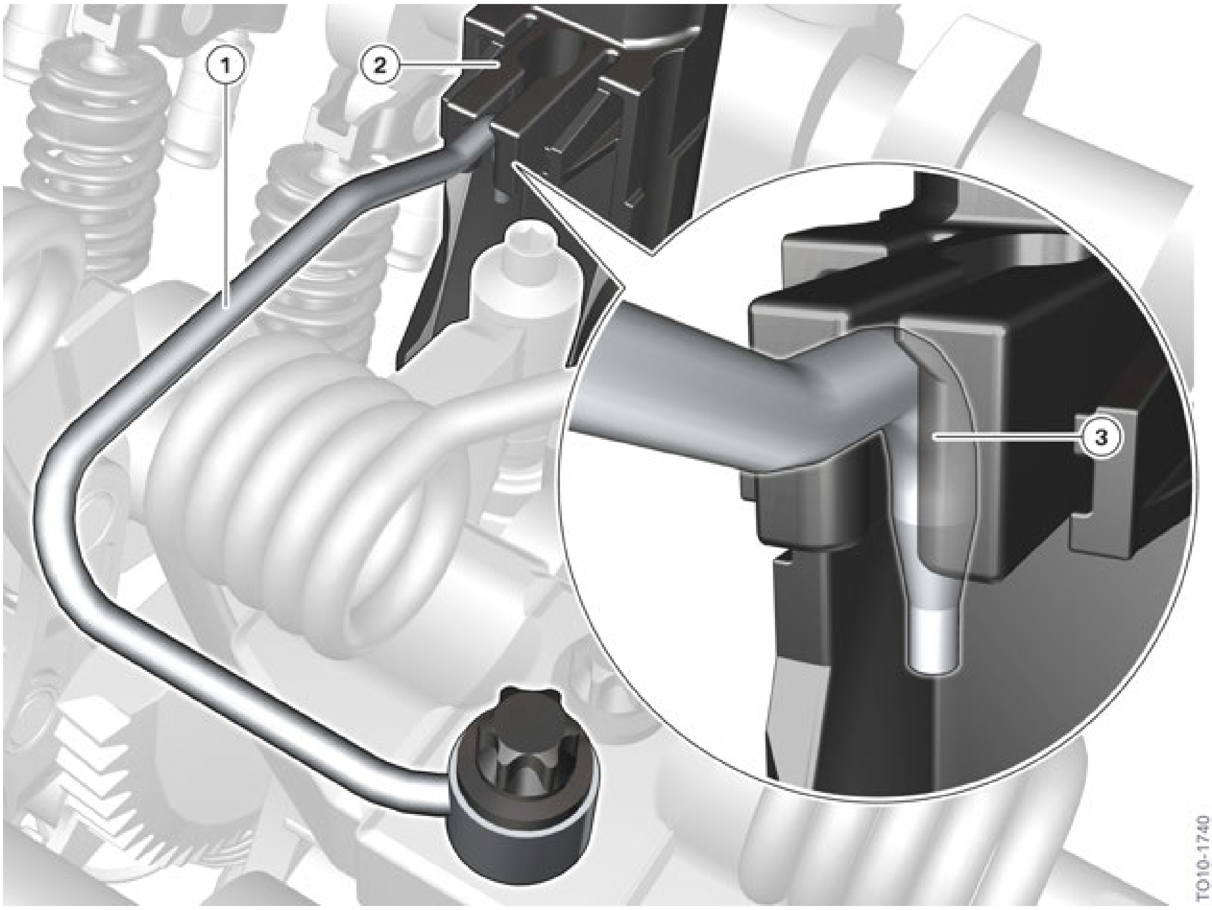
| Index | Explanation |
|---|---|
| 1 | Oil pipe |
| 2 | Hole |

### 3.5.4. Gearing, Valvetronic servomotor


N20 engine, oil spray nozzle for Valvetronic servomotor

The N20 engine features the same Valvetronic servomotor as the N55 engine including the same installation position. The worm gear for adjusting the eccentric shaft is also lubricated by an oil spray nozzle. This nozzle must be correctly aligned when fitted. However, this does not require the use of a special tool. Instead the nozzle has to be carefully and noticeably engaged in the designated guide on the Valvetronic servomotor.

# 3. Oil Supply




N20 engine, engaged oil spray nozzle for Valvetronic servomotor gearing

| Index | Explanation |
|---|---|
| 1 | Oil spray nozzle for Valvetronic servomotor gearing |
| 2 | Valvetronic servomotor |
| 3 | Correctly engaged oil spray nozzle |

⚠

Due to the size of the oil spray nozzle and the fact that the motor can be assembled without the oil spray nozzle, there is the danger of it being forgotten during fitting.

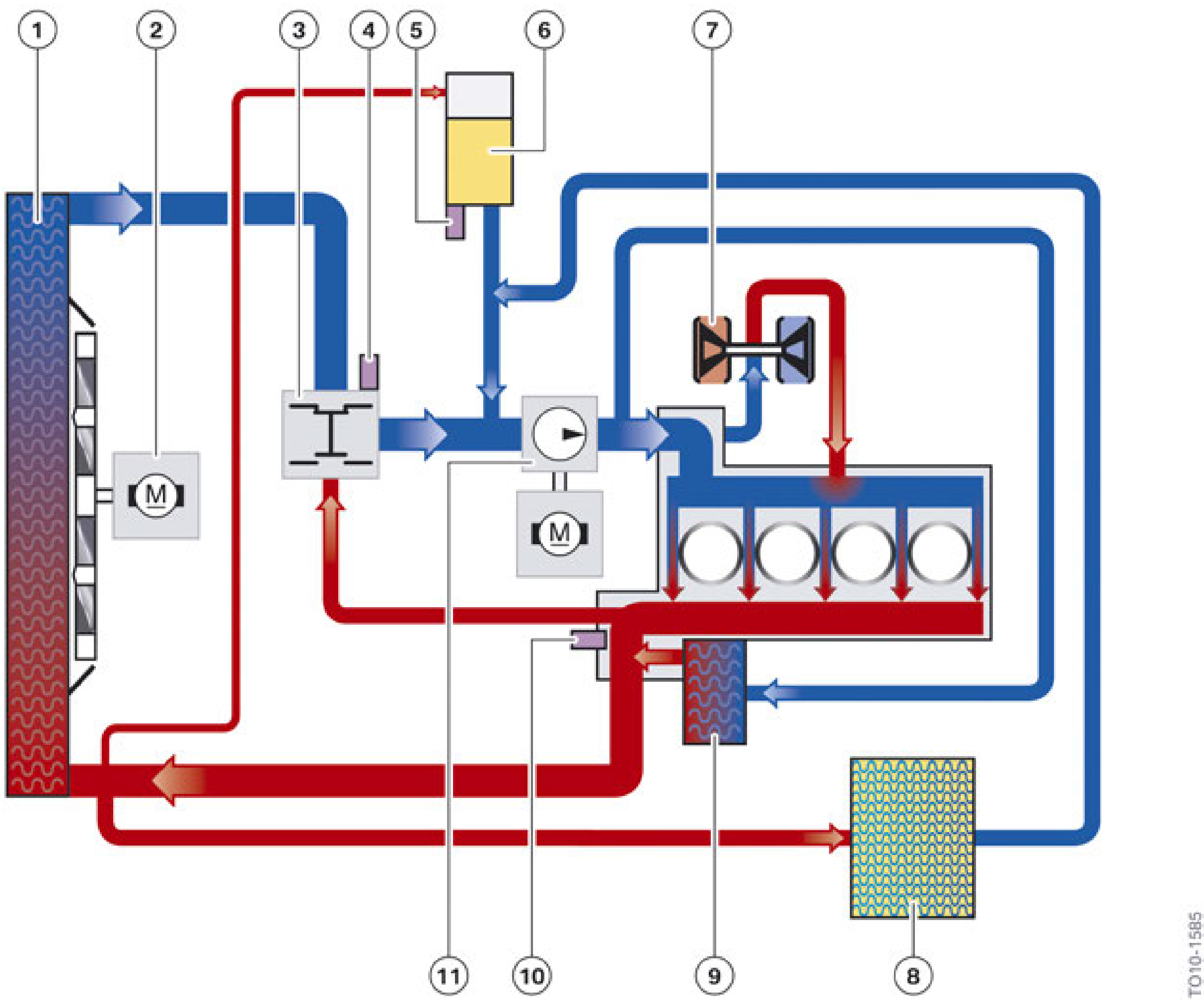
Make sure when fitting the oil spray nozzle that it is correctly positioned and engaged. An incorrectly engaged oil spray nozzle will be subjected to vibrations and may break. Refer to the repair instructions.

# N20 Engine

## 4. Cooling

The cooling system is very similar to the N55 engine. In the N20 engine an engine oil-to-coolant heat exchanger is used to cool the engine oil. The cooling system is controlled (e.g. electric coolant pump, map thermostat and electric fan) by the heat management coordinator in the DME.

### 4.1. Overview




N20 engine, cooling circuit

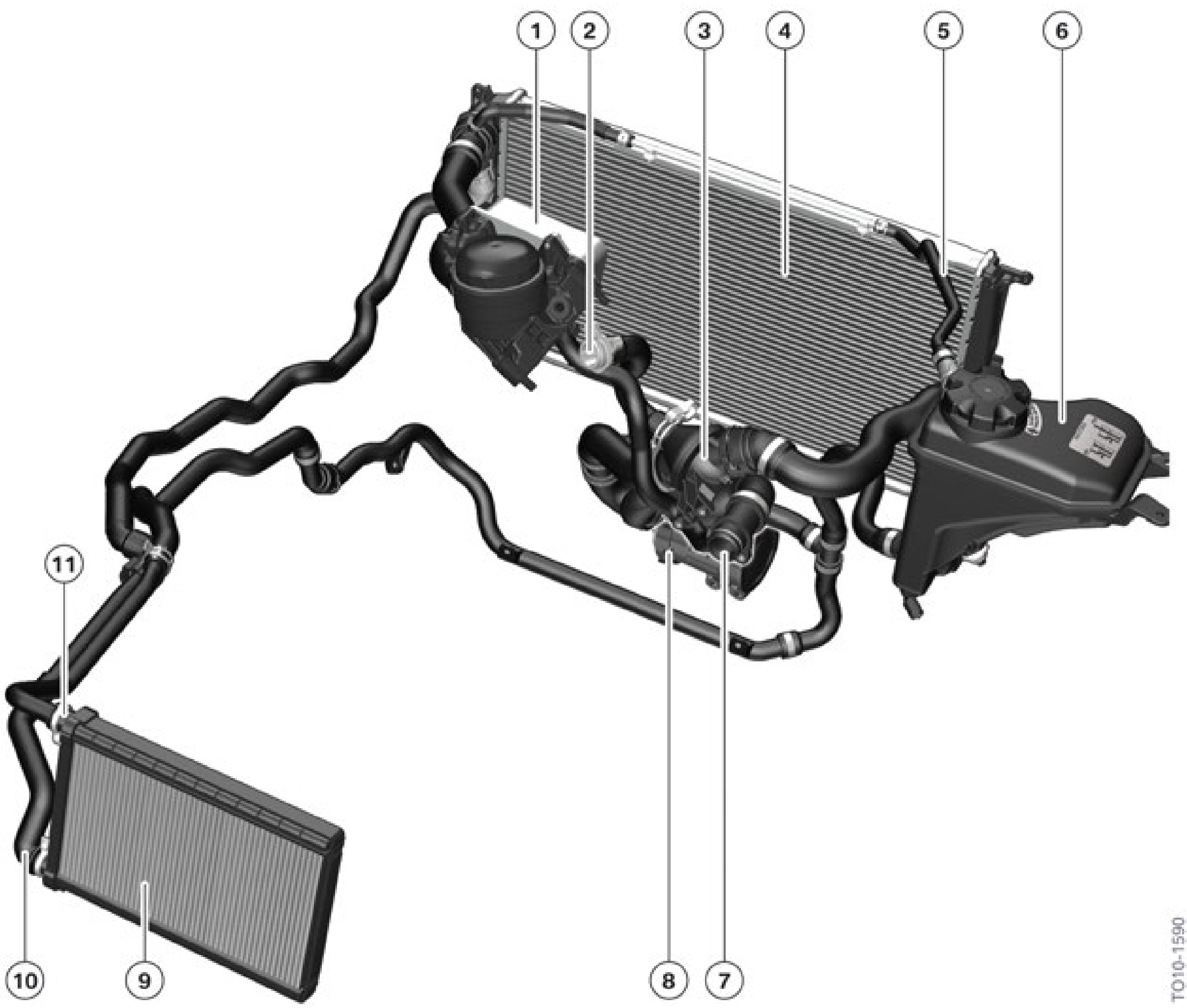
| Index | Explanation |
|---|---|
| 1 | Radiator |
| 2 | Electric fan |
| 3 | Map thermostat |
| 4 | Heater for map thermostat |
| 5 | Fill level sensor in expansion tank |
| 6 | Expansion tank |
| 7 | Exhaust turbocharger |

| Index | Explanation |
|---|---|
| 8 | Heater core |
| 9 | Engine oil-to-coolant heat exchanger |
| 10 | Coolant temperature sensor |
| 11 | Electric coolant pump |

The cooling module itself only comes in one variant. An auxiliary radiator (in the right wheel arch) is used in vehicles used in hot climates markets and in combination with the maximum speed optional equipment.

The electric fan has a nominal power of 600 W.

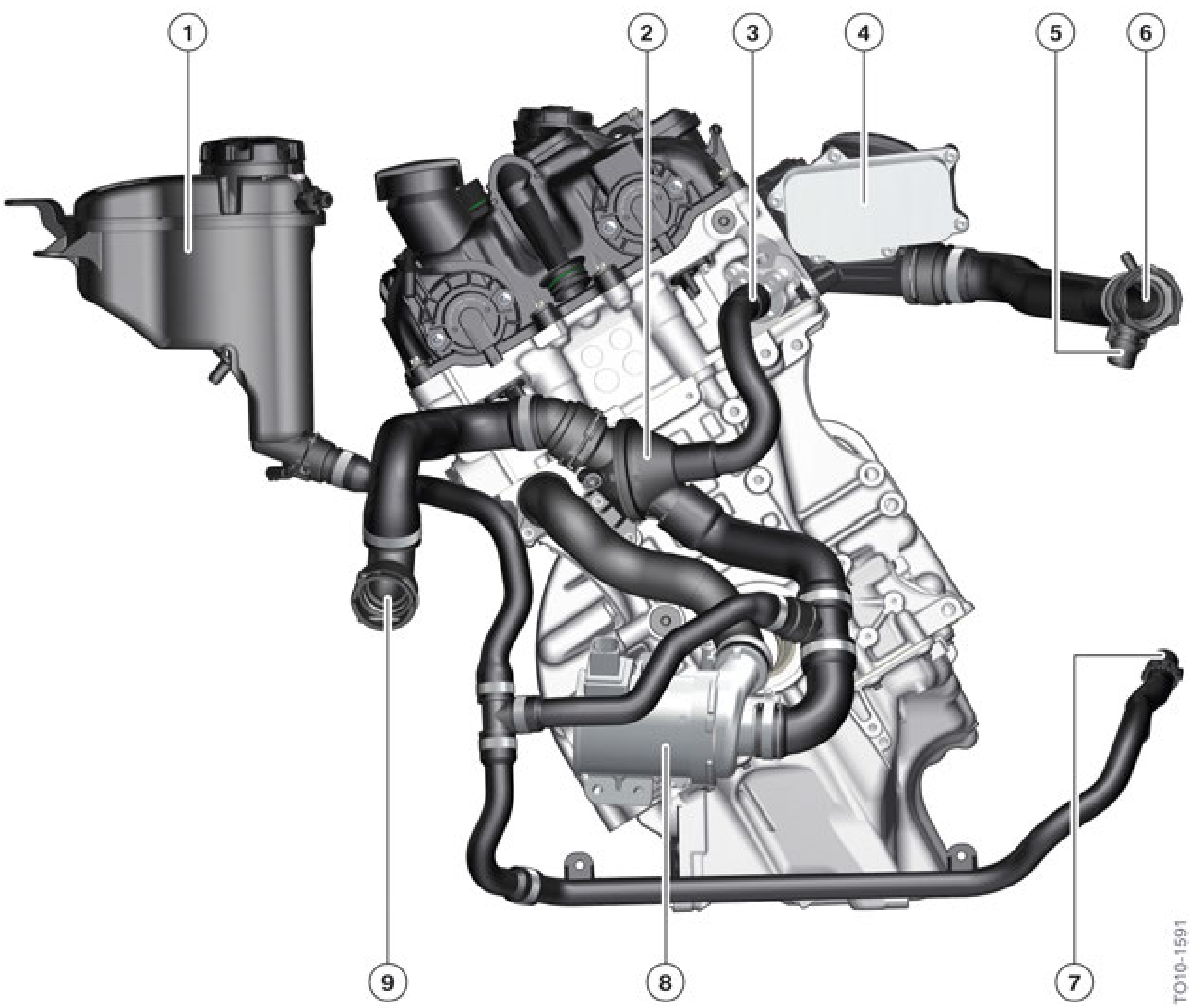
The following graphics show the installation locations and layouts of the components.




N20 engine, cooling system components from rear

# N20 Engine
## 4. Cooling

| Index | Explanation |
|---|---|
| 1 | Engine oil-to-coolant heat exchanger |
| 2 | Engine return, bypass circuit |
| 3 | Map thermostat |
| 4 | Radiator |
| 5 | Ventilation line |
| 6 | Expansion tank |
| 7 | Engine feed |
| 8 | Electric coolant pump |
| 9 | Auxiliary radiator (not installed in all models) |
| 10 | Feed, heater core |
| 11 | Return, heater core |



N20 engine, cooling system components on engine front view

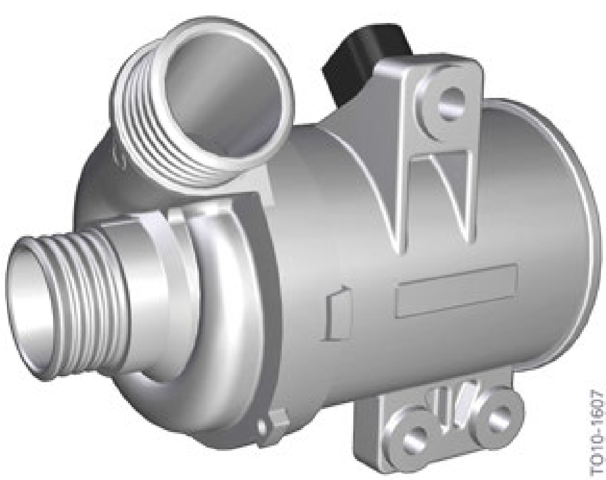
| Index | Explanation |
|---|---|
| 1 | Expansion tank |
| 2 | Map thermostat |
| 3 | Engine return, bypass circuit |
| 4 | Engine oil-to-coolant heat exchanger |
| 5 | Connection, feed, heater core |
| 6 | Feed, radiator |
| 7 | Return, heater core |
| 8 | Electric coolant pump |
| 9 | Return, radiator |

## 4.2. Heat management

The N20 engine has the same heat management functions in the DME as the N55. This allows independent control of the electric cooling components of electric fan, map thermostat and coolant pump.

### 4.2.1. Coolant pump

The N20 engine has an electric coolant pump, as is the case with many BMW engines. Its nominal power consumption is 400 W.




N20 engine, coolant pump

⚠

If the coolant pump is removed but is to be reused, it is important to ensure that it is set down still filled with coolant. Drying out may cause the bearings to stick. Not following this procedure can possibly cause the coolant pump not start, which in turn may result in damage to the engine.

Before installing, turn the pump impeller manually to ensure that it moves freely.

### 4.2.2. Map thermostat

The N20 engine is fitted with a conventional map thermostat which has the following technical data in non-electrically controlled mode:

| Setting of map thermostat | Coolant temperature |
|---|---|
| Starts to open | 97 ±2 °C / 206 ±2 °F |
| Fully open | 109 °C / 228 ±2 °F |

In addition, an electric heater in the map thermostat can be used to make the thermostat open at a lower coolant temperature.

### 4.2.3. Heat management function

The heat management determines the current cooling requirement and controls the cooling system accordingly. Under certain circumstances the coolant pump can even be shut down entirely, for example in order to heat the coolant more quickly in the warm-up phase. The coolant pump continues to deliver when the engine is stopped and very hot to cool the exhaust turbochargers. The cooling output can therefore be requested independently of the engine speed. In addition to the map thermostat the heat management is able to activate the coolant pump using different program maps. The engine management is thus able to adapt the coolant temperature to the driving situation.

The following temperature ranges are adjusted by the engine management:

- 109 °C / 228 ±2 °F= Economy operation
- 106 °C / 222 ±2 °F= Normal operation
- 95 °C / 203 ±2 °F= High operation
- 80 °C / 176 ±2 °F= High operation and current supply to the map thermostat.

If the engine control unit identifies the ”Economy” operating range on the basis of running performance, the engine management adjusts to a higher temperature (109 °C / 228 °F). In this temperature range the engine is to be operated with a relatively low fuel requirement. Internal engine friction is reduced at higher temperature. The temperature increase therefore favors the lower fuel consumption in the low load range. In ”High operation and current supply to the map thermostat” mode the driver would like to utilize the engine's optimum power development. Thus the temperature in the cylinder head is reduced to 80 °C / 176 °F for this purpose. This reduction improves volumetric efficiency, which results in an engine torque increase. The engine control unit can now (adapted to the relevant driving situation) adjust a specific operating range. It is therefore possible to influence consumption and power output via the cooling system.

**System protection**

If the coolant or engine oil is subject to excessive temperatures during engine operation, certain functions in the vehicle are influenced in such a way that more energy is made available for engine cooling.

The measures are split into two operating modes:

- Component protection

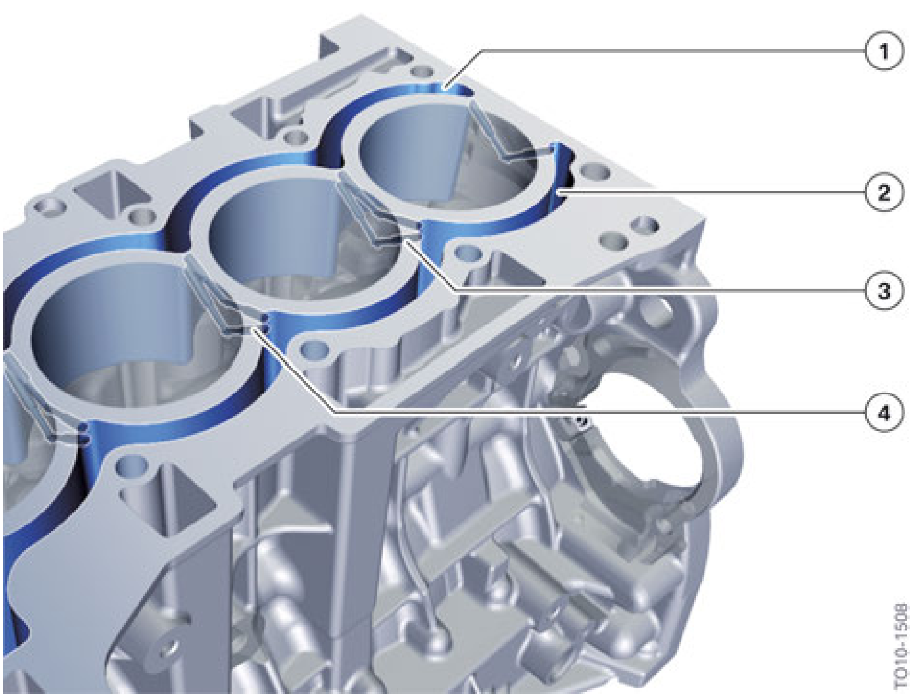
- Coolant temperature from 117 °C/ 242 °F
- Engine oil temperature from 143 °C / 289 °F at the oil pressure and temperature sensor in the main oil passage
- Measure: e.g. power reduction of climate control and of engine

- Emergency
  - Coolant temperature from 122 °C / 251 °F
  - Engine oil temperature from 151 °C / 303 °F at the oil pressure and temperature sensor in the main oil passage
  - Measure: e.g. power reduction of engine (up to about. 90 %)

## 4.3. Internal engine cooling

As in the N55 engine, the coolant passages in the cylinder head also surround the injectors, which are cooled in this way.

Unlike the N55 engine, the N20 engine has no grooves on the block deck between the cylinders. Instead, the N20 engine has bore holes between the cylinders, two on each side, which meet in the middle.




N20 engine, cooling jacket and coolant passages

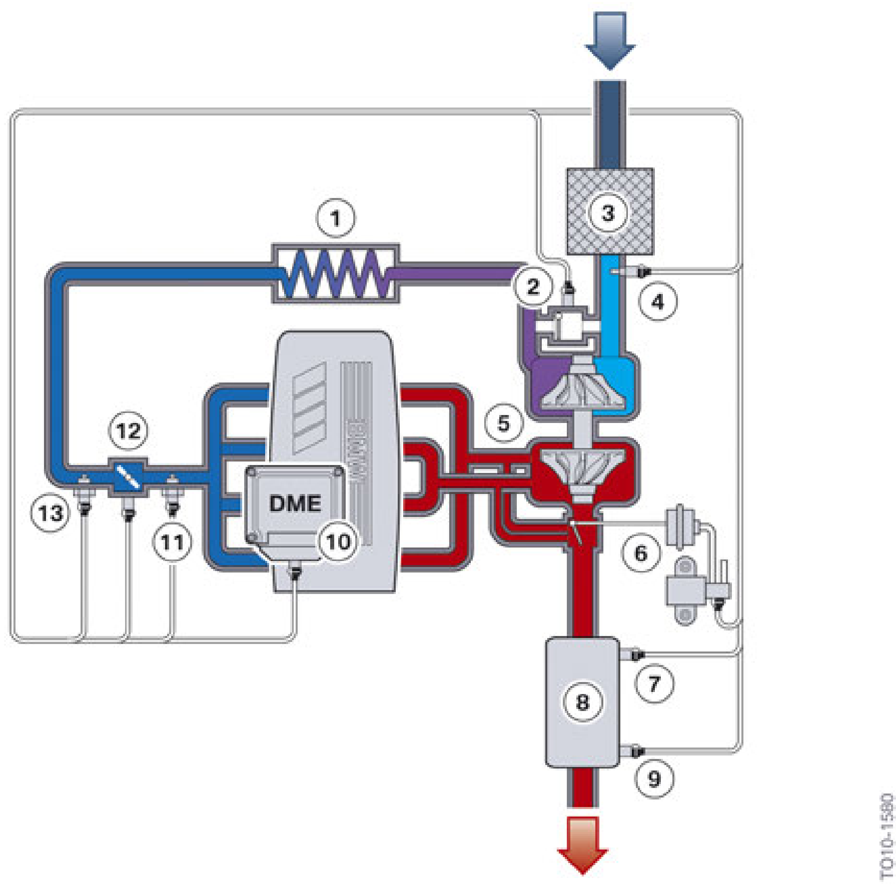
| Index | Explanation |
|---|---|
| 1 | Cooling jacket, exhaust side |
| 2 | Cooling jacket, intake side |
| 3 + 4 | Coolant passages in the lands |

# 5. Air Intake/Exhaust Emission Systems

The air intake and exhaust emission systems are in principle similar to the N55. The list below itemizes the most important features of the air intake and exhaust emission systems:

- Permanently attached intake silencer
- Hot-film air mass meter
- TwinScroll exhaust turbocharger with integrated wastegate and blowoff valves
- Three connections for crankcase ventilation

## 5.1. Overview

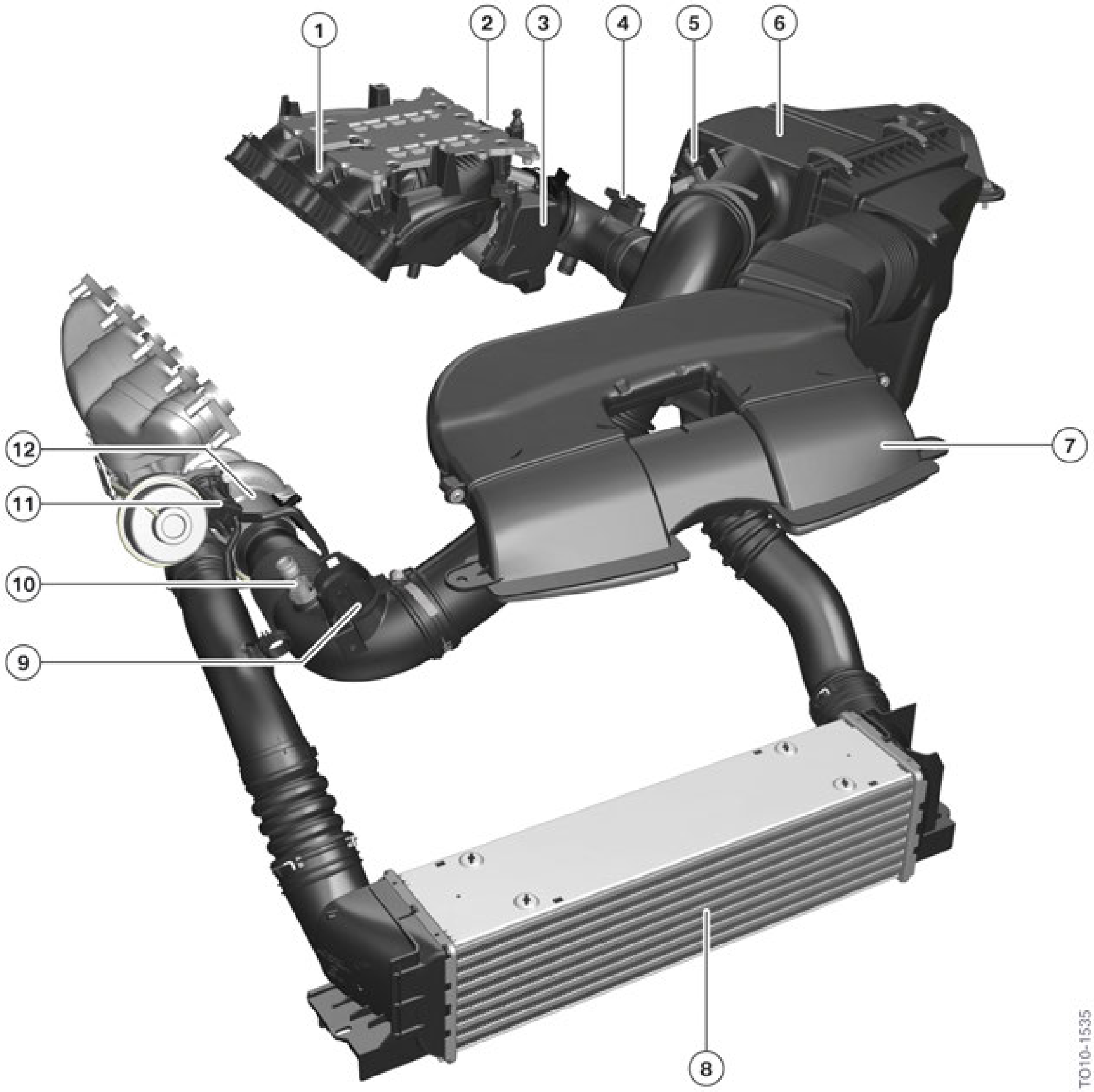



N20 engine, air intake and exhaust emission systems

| Index | Explanation |
|---|---|
| 1 | Charge air cooler |
| 2 | Blowoff valve |
| 3 | Intake silencer |
| 4 | Hot-film air mass meter |
| 5 | Exhaust turbocharger |

| Index | Explanation |
| --- | --- |
| 6 | Wastegate valve |
| 7 | Oxygen sensor before catalytic converter |
| 8 | Catalytic converter |
| 9 | Oxygen sensor after catalytic converter |
| 10 | Digital Engine Electronics (DME) |
| 11 | Intake manifold pressure sensor |
| 12 | Throttle valve |
| 13 | Charge air temperature and pressure sensor |

## 5.2. Intake air system




N20 engine, air intake system

| Index | Explanation |
|---|---|
| 1 | Intake manifold |
| 2 | Intake manifold pressure sensor |
| 3 | Throttle valve |
| 4 | Charge air temperature and pressure sensor |
| 5 | Hot-film air mass meter |
| 6 | Intake silencer |

| Index | Explanation |
|---|---|
| 7 | Unfiltered air intake |
| 8 | Charge air cooler |
| 9 | Connection, crankcase ventilation, turbocharged mode |
| 10 | Connection, purge air line, crankcase ventilation |
| 11 | Blowoff valve |
| 12 | Exhaust turbocharger |

### 5.2.1. Hot-film air mass meter

The N20 engine is equipped with a hot-film air mass meter , which is very similar to that in the N74 engine.

It can generally be said that the quality of air mass determination by measurement using a hot-film air mass meter and by calculation of the substitute value (of intake air temperature, charging pressure, engine speed, etc.) is to be considered as equal in the current state of development. The calculated substitute value is nevertheless used for engine load control. This value is however regularly adjusted with the value of the hot-film air mass meter in order to compensate for tolerances which arise on account of the complex flow conditions in the air intake system. The more sophisticated the mixture preparation method (Valvetronic, High Precision Injection (especially in conjunction with stratified charge mode), TVDI), the more important it is to adjust the substitute value with the hot-film air mass meter. TVDI is currently the most sophisticated mixture preparation method. For this reason, all TVDI engines are also equipped with a hot-film air mass meter.

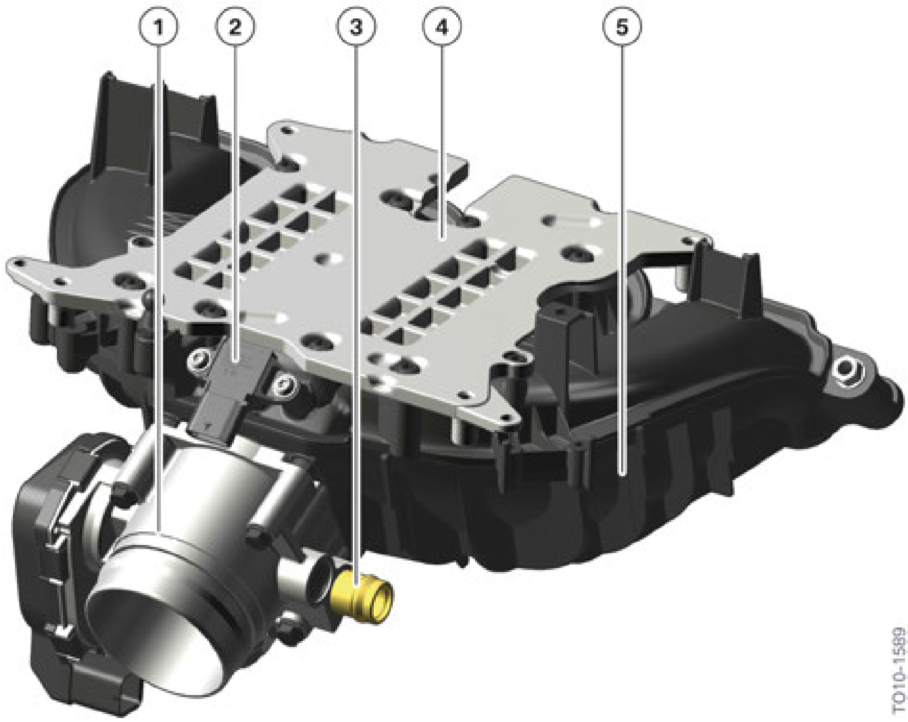
The use of a hot-film air mass meter also offers the opportunity of extended diagnostics, e.g. for tank or crankcase ventilation, as these systems create a deviation in the air mass that can be interpreted and used to diagnose running faults.

⚠

Failure or disconnection of the hot-film air mass meter does not immediately result in emergency engine operation. However, impaired mixture preparation and therefore poorer emission values are possible, which is why the emissions warning lamp (Check Engine Light) lights up.

### 5.2.2. Intake manifold

As in the N55 engine, the Digital Engine Electronics (DME) is mounted on the intake manifold. However, there are differences. First, the DME is located on the intake manifold and not under it. Second, the intake manifold is not open after the DME is removed. Located between the intake manifold and the DME is a metal plate (heat sink) which conducts heat away from the DME this plate is cooled by the air flow of the intake manifold.




N20 engine, intake manifold with throttle valve

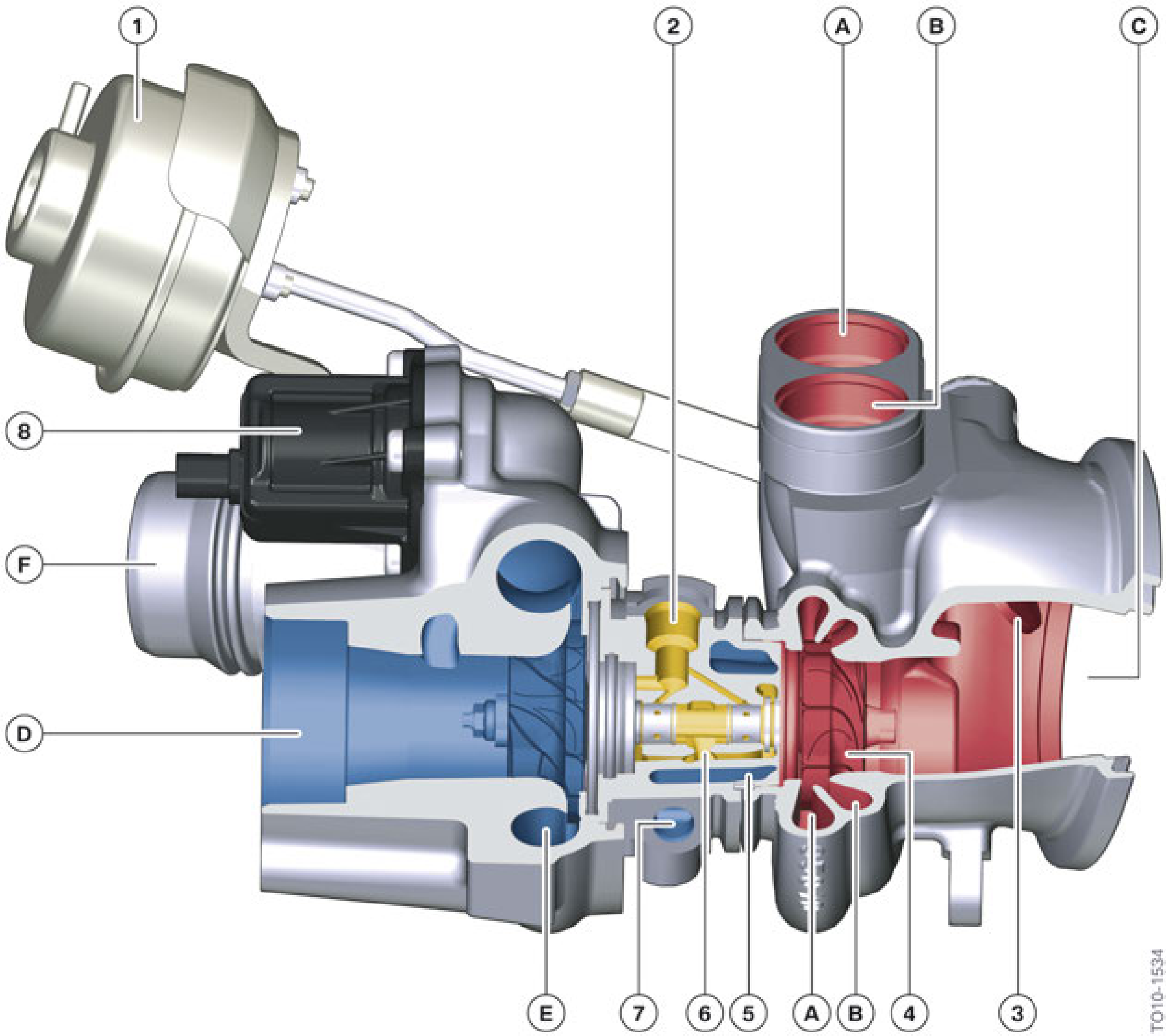
| Index | Explanation |
|---|---|
| 1 | Throttle valve |
| 2 | Intake manifold pressure sensor |
| 3 | Connection from tank vent valve |
| 4 | Metal plate for accommodating the DME |
| 5 | Intake manifold |

**Intake manifold pressure sensor**

Located directly behind the throttle valve, at the entry to the intake manifold, is the intake manifold pressure sensor. On closer inspection, it can be seen to be a combined pressure and temperature sensor. The temperature signal is therefore not read out. The reason for using this sensor lies in the concept of common parts. It is better to use the same sensor which is also used as the charge air temperature and pressure sensor and simply not to read out the temperature signal than to introduce a separate sensor.

### 5.3. Exhaust turbocharger

The N20 engine features an exhaust turbocharger with TwinScroll technology. It includes at the turbine inlet two separate ports in which the exhaust gas is routed from two cylinders to the turbine vanes.




N20 engine, turbocharger

| Index | Explanation |
| --- | --- |
| A | Exhaust port, cylinders 2 and 3 |
| B | Exhaust port, cylinders 1 and 4 |
| C | Outlet to catalytic converter |
| D | Inlet from intake silencer |
| E | Ring port |
| F | Outlet to charge air cooler |
| 1 | Vacuum unit for wastegate valve |
| 2 | Oil supply |
| 3 | Wastegate valve |
| 4 | Turbine wheel |

| Index | Explanation |
|---|---|
| 5 | Cooling passage |
| 6 | Oil passage |
| 7 | Coolant return |
| 8 | Blowoff valve |

The turbocharger has a familiar design with an electric blowoff valve and a vacuum-controlled wastegate valve.

### 5.3.1. Function of TwinScroll exhaust turbocharger

The designation TwinScroll denotes an exhaust turbocharger with a twin-scroll turbine housing. The exhaust gas from two cylinders in each case is routed separately to the turbine. In the N20 engine (as is usual in 4-cylinder engines) cylinders 1 and 4 and cylinders 2 and 3 are brought together to form two ports each feeding one scroll. This results in pulse charging which is used to greater effect.

#### Pressure and pulse charging

Two principles of forced induction are used in engines with exhaust turbochargers – pressure and pulse charging. Pressure charging means that the pressure ahead of the turbine is approximately constant. The energy which drives the exhaust turbocharger is obtained from the pressure difference before and after the turbine.

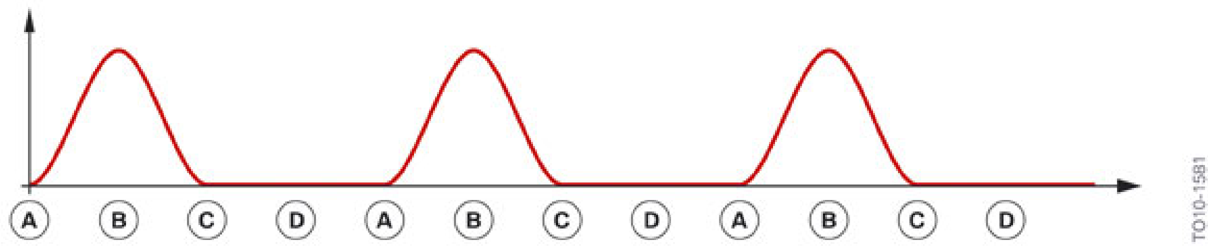
In the case of pulse charging, the pressure before the turbine is high-speed and greatly fluctuating, or pulsating by the discharge of the exhaust gas from the combustion chamber. The pressure increase results in a pressure wave which strikes the turbine. In this case, the kinetic energy of the exhaust gas is used, whereby the pressure waves drive the turbocharger.

Pulse charging provides for a fast response by the turbocharger, especially at low speeds, because pulsation is at its strongest here, whereas in the case of pressure charging the pressure difference between before and after the turbine is still low.

In actual fact, both principles are always used in exhaust turbochargers in passenger car engines. The proportion of pulse charging is higher or lower, depending on the size factors, the exhaust port guides and the number of cylinders.

#### Dependence on the number of cylinders

In a single-cylinder engine there is an exhaust cycle every two revolutions of the crankshaft. Theoretically, exhaust gas is therefore discharged for 180° every 720° crank angle. The graphic below shows **in highly simplified form** the pressure conditions before the exhaust turbocharger in a single-cylinder engine.

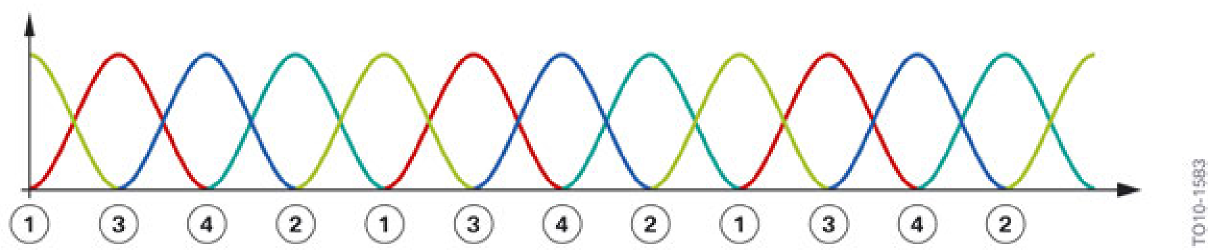


Pressure diagram in exhaust port before the turbocharger in a 1-cylinder engine

| Index | Explanation |
|---|---|
| A | Bottom dead center, exhaust valve opens |
| B | Top dead center, exhaust valve closes, intake valve opens |
| C | Bottom dead center, intake valve closes |
| D | Top dead center, ignition |

As can be seen here, every 720° CA there is a pressure wave which strikes the turbine. This pulse accelerates the turbine.

The next graphic shows the pressure conditions before the turbine in a 4-cylinder engine.

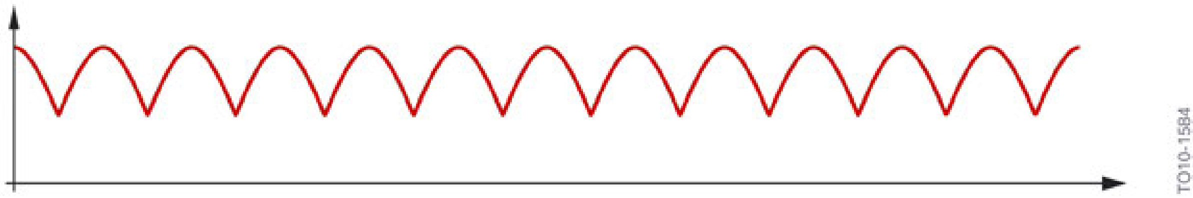


Pressure diagram in exhaust port before exhaust turbocharger in a 4-cylinder engine

| Index | Explanation |
|---|---|
| 1 | Exhaust valve, 1st cylinder, opens |
| 2 | Exhaust valve, 2nd cylinder, opens |
| 3 | Exhaust valve, 3rd cylinder, opens |
| 4 | Exhaust valve, 4th cylinder, opens |

Because each cylinder had its exhaust cycle after two full crankshaft revolutions, there are four pressure waves within the 720° CA. Because of the firing interval, they are distributed evenly at an interval of 180° CA. The pressure waves are superimposed here. While the pressure of one cylinder decreases, the pressure of the next cylinder is already increasing.

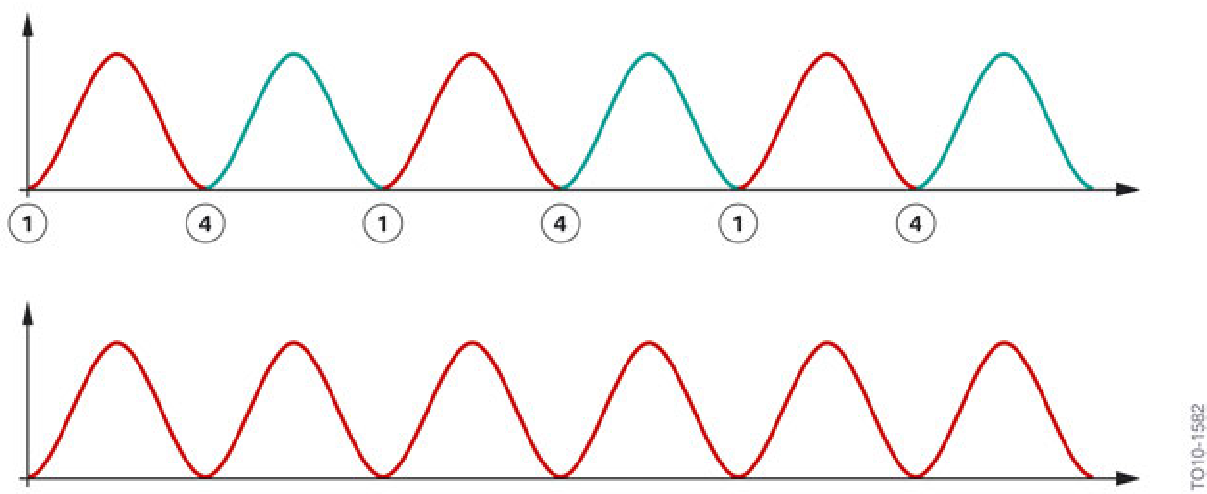
This produces a superimposed pressure before the turbine, as the next graphic shows.




Pressure diagram in exhaust port before the turbocharger in a 4-cylinder engine, superimposed

Because they are superimposed, the pressure difference from minimum to maximum is clearly lower. In this way, the pulse by the pressure wave on the turbine also decreases. In this cases, the proportion of pulse supercharging in the exhaust turbocharger is lower.

One way of preventing this in a 4-cylinder engine is the TwinScroll exhaust turbocharger. By splitting the four cylinders into two ports, the pressure conditions of a 2-cylinder engine are depicted in the two ports in each case, as the following graphic shows.




Pressure diagram in exhaust port before the turbocharger in a 4-cylinder engine, individually and superimposed

| Index | Explanation |
|---|---|
| 1 | Exhaust valve, 1st cylinder, opens |
| 4 | Exhaust valve, 4th cylinder, opens |

Here too the pressures of the two cylinders are superimposed. However, cylinders 1 and 4 and 2 and 3 are combined in the two ports. Because of the firing order of a 4-cylinder engine, there is in each case an interval of 360° CA between the exhaust cycles of a port. Thus there is a large pressure difference and the kinetic energy of the exhaust gas can be better utilized.

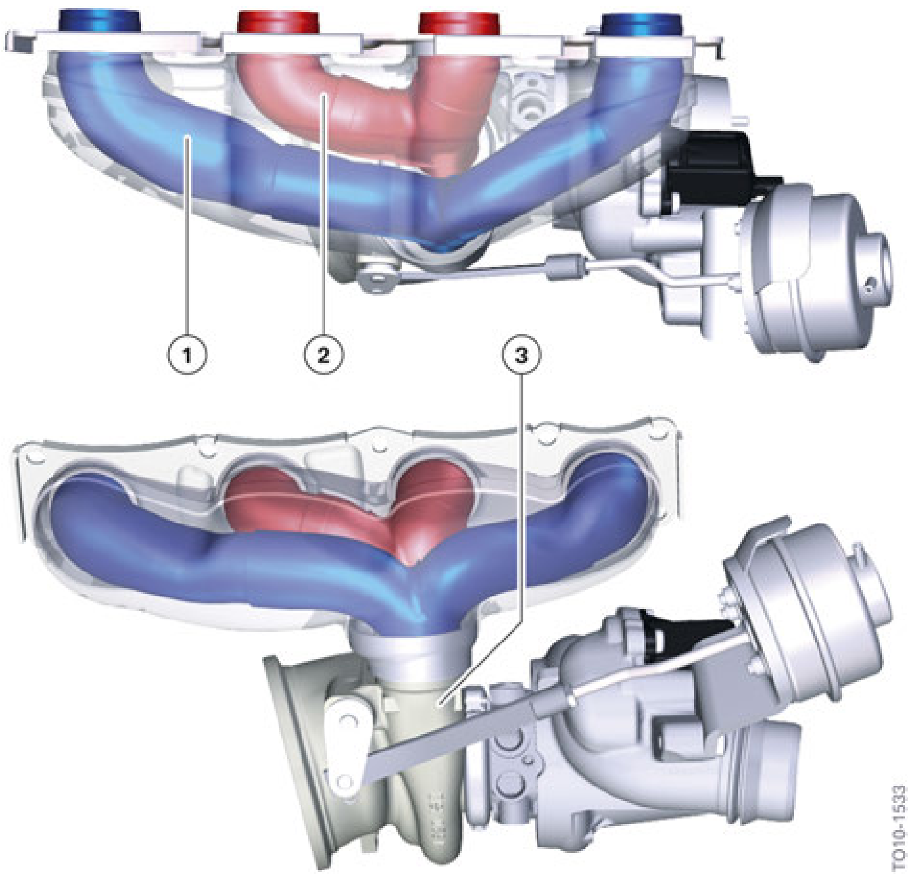
A specially shaped exhaust manifold is used to combine the exhaust pipes from cylinders 1 and 4 and 2 and 3.

In the turbocharger these two ports run separately from each other up to the turbine. The TwinScroll exhaust turbocharger differs from a conventional exhaust turbocharger in that the turbine housing separates in two forming a ring channel around the turbine.

### 5.4. Exhaust emission system

#### 5.4.1. Exhaust manifold

The exhaust manifold is identical in design to that of the N55 engine. It is air-gap-insulated and welded to the turbocharger. The exhaust manifold in the N20 engine is a four-into-two type, which is necessary for the special function of the TwinScroll turbocharger. Here the exhaust outlet pipes of cylinders 1 and 4 and 2 and 3 are combined in each case into one port as previously discussed.

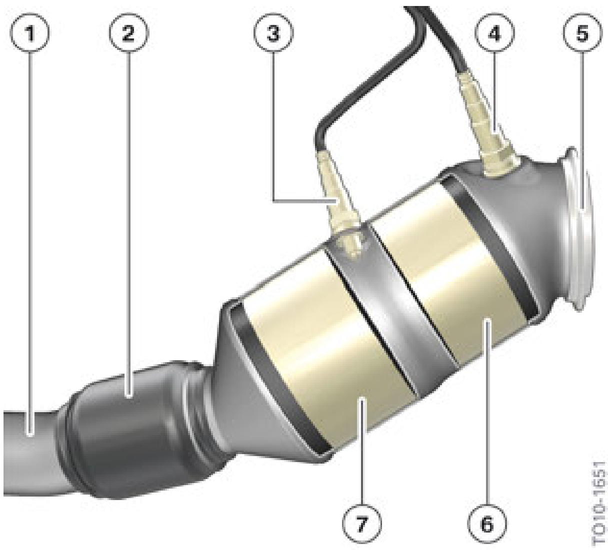



N20 engine, exhaust manifold with exhaust turbocharger

| Index | Explanation |
|---|---|
| 1 | Exhaust ports, cylinders 1 and 4 |
| 2 | Exhaust ports, cylinders 2 and 3 |
| 3 | Exhaust turbocharger |

#### 5.4.2. Catalytic converter

The N20 engine has an upstream catalytic converter with two ceramic monoliths.




Cutaway view of catalytic converter

| Index | Explanation |
|---|---|
| 1 | Connection to exhaust system |
| 2 | De-coupling element |
| 3 | Monitoring sensor |
| 4 | Control sensor |
| 5 | Connection to turbine |
| 6 | Ceramic monolith 1 |
| 7 | Ceramic monolith 2 |

| | Volume | Diameter | Number of cells |
|---|---|---|---|
| Ceramic monolith 1 | 0.75 | 118.4 | 600 |
| Ceramic monolith 2 | 0.99 | 125 | 400 |

### Oxygen sensors

The Bosch oxygen sensors used are familiar from previous engines:

- Pre oxygen sensor: LSU ADV
- Post oxygen sensor: LSF4.2.

The pre oxygen sensor is located ahead of the primary catalytic converter, as close as possible to the turbine outlet. Its position has been chosen so that all the cylinders can be recorded separately. The post oxygen sensor is positioned between the first and second ceramic monoliths.

# N20 Engine
## 6. Vacuum System

The vacuum system of the N20 engine is comparable with that of the N55 engine. As well as supplying the brake servo, it is needed primarily to activate the wastegate valve on the turbocharger. In addition, the exhaust flap is actuated by vacuum in the N20 engine.


N20 engine, vacuum system

| Index | Explanation |
|---|---|
| 1 | Connection, brake servo |
| 2 | Vacuum pump |
| 3 | Connection, exhaust flap |
| 4 | Vacuum reservoir |
| 5 | Electro-pneumatic pressure converter for wastegate valve |
| 6 | Vacuum unit, wastegate valve |

# 6. Vacuum System

The vacuum pump as usual is designed to have two stages so that the majority of the generated vacuum is made available to the brake servo. A vacuum reservoir is used to provide sufficient vacuum for actuating the wastegate valve. This reservoir is built into the engine cover.

⚠

Disconnect the vacuum line before removing the engine cover, as otherwise there is a risk of damage.

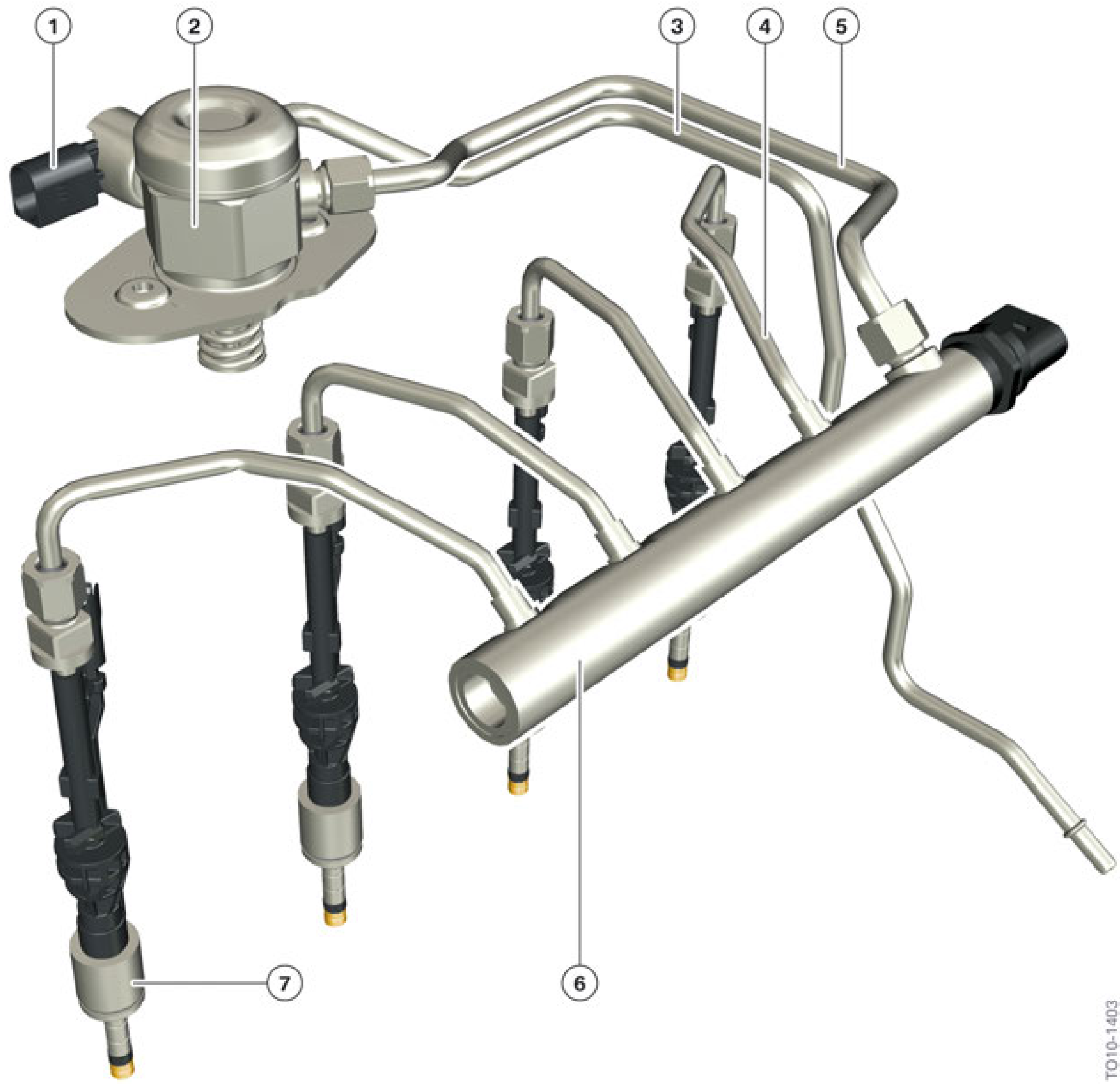
# N20 Engine

## 7. Fuel Preparation

The N20 engine uses high-pressure injection, which was introduced in the N55 engine. It differs from high-precision injection (HPI) in that it uses solenoid valve injectors with multi-hole nozzles instead of the piezoelectric type.

### 7.1. Overview

The following overview shows the fuel preparation system of the N20 engine. It essentially corresponds to the systems with direct fuel injection familiar in BMW models.




N20 engine, fuel preparation

| Index | Explanation |
|---|---|
| 1 | Connection, quantity control valve |
| 2 | High-pressure pump |
| 3 | Low-pressure line |
| 4 | High-pressure line, rail - injector |
| 5 | High-pressure line, high-pressure pump - rail |
| 6 | Rail |
| 7 | Solenoid valve injector |

Bosch high-pressure fuel injectors with the designation HDEV5.2 are used. The high pressure pump is already known from the 8 and 12 cylinder engines. An innovation in the N20 engine is the fact that the high-pressure lines from rail to injector are now no longer screwed at the rail end, but welded. Another feature when compared with established BMW fuel systems is the omission of the fuel low-pressure sensor.

⚠

**Work on the fuel system is only permitted after the engine has cooled down. The coolant temperature must be below 40 °C / 104°F, to avoid risk of injury due to spray back from residual pressure in the high-pressure fuel system.**

**When working on the high-pressure fuel system, it is essential to adhere to conditions of absolute cleanliness and to observe the work sequences described in the repair instructions. Even the slightest contamination and damage to the threaded fittings of the high-pressure lines can cause leaks.**

When working on the fuel system of the N20 engine, it is important to ensure that the ignition coils are not wet with fuel. The resistance of the insulating silicone material is greatly reduced by sustained contact with fuel. This may result in arcing on the spark plug connection and thus in misfires.

- Before making any modifications to the fuel system, remove the ignition coils and protect the spark plugs by covering with a cloth
- Before reinstalling the solenoid valve injectors, remove the ignition coils and ensure that the cleanest possible conditions are maintained.
- Ignition coils heavily saturated by fuel must be replaced.

## 7.2. Fuel pump control

As already mentioned, there is no fuel low-pressure sensor in the N20 engine. The fuel pressure is calculated by monitoring pump speed and load.

## 7.3. High-pressure pump

The Bosch high-pressure pump, familiar from the N63 and N74 is used. This is a single-plunger pump which is driven from the exhaust camshaft via a triple lobe on the cam.

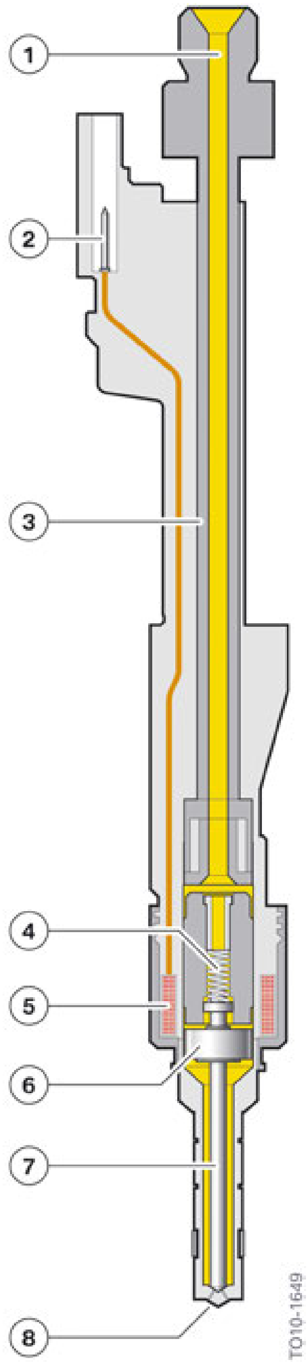
For further information on the high-pressure pump, please refer to the N63 and N74 engine training information available on TIS and ICP.

## 7.4. Injectors

The Bosch HDEV5.2 solenoid valve injector is an inward-opening multi-hole valve unlike the outward-opening piezo injector used in HPI engines. The HDEV5.2 is also characterized by high variability with regard to spray angle and spray pattern, and is configured for a system pressure of up to 200 bar.

These injectors are already used in the N55 engine. However, their operating principle is the same as that of the injectors used in the N73 engines.

**Note: The N73 HDEV control modules contain pulse width modulated final output stages with high performance capacitors to transform the system voltage up to 85 to 100 volts. See ST042 E65 Complete Vehicle /N73 engine training material available on TIS and ICP.**




| Index | Explanation |
|---|---|
| 1 | Fuel line connection |
| 2 | Electrical connection |
| 3 | Stem |
| 4 | Compression spring |
| 5 | Solenoid coil |
| 6 | Armature |
| 7 | Nozzle pintle |
| 8 | 6-hole nozzle |

A magnetic field is generated when the coil is energized. This magnetic field lifts the nozzle pintle against spring pressure off the valve seat and opens the discharge holes of the injector nozzle. The high pressure in the rail forces the fuel through discharge holes at high speed into the cylinder. To terminate injection, current is shut off, the nozzle pintle is forced closed by spring force back onto the valve seat.

The valve opens and closes at very high speed and ensures a constant opening cross-section during the opening period. The injected fuel quantity is dependent on the rail pressure, the back pressure in the combustion chamber and the opening period of the injector.

For further information on injector activation, refer to the section entitled Engine Electrical System of this training material.

Unlike the injectors previously used, the solenoid valve injectors of the N55 and N20 engines have long and relatively sensitive stems made necessary by the shape of the cylinder head. Each stem is made of plastic on the outside but on the inside there is a metal tube serves as a fuel line.

⚠

**The stems of the solenoid valve injectors can only withstand 6Nm of torque which translates to 2000 N of tensile force. It is essential when removing and installing the injectors to follow the specific procedure set out in the repair instructions, along with the use of special tool #0 496 885 for injector removal. If this tool is not used the injectors will be damaged.**

# N20 Engine
# 8. Fuel Supply

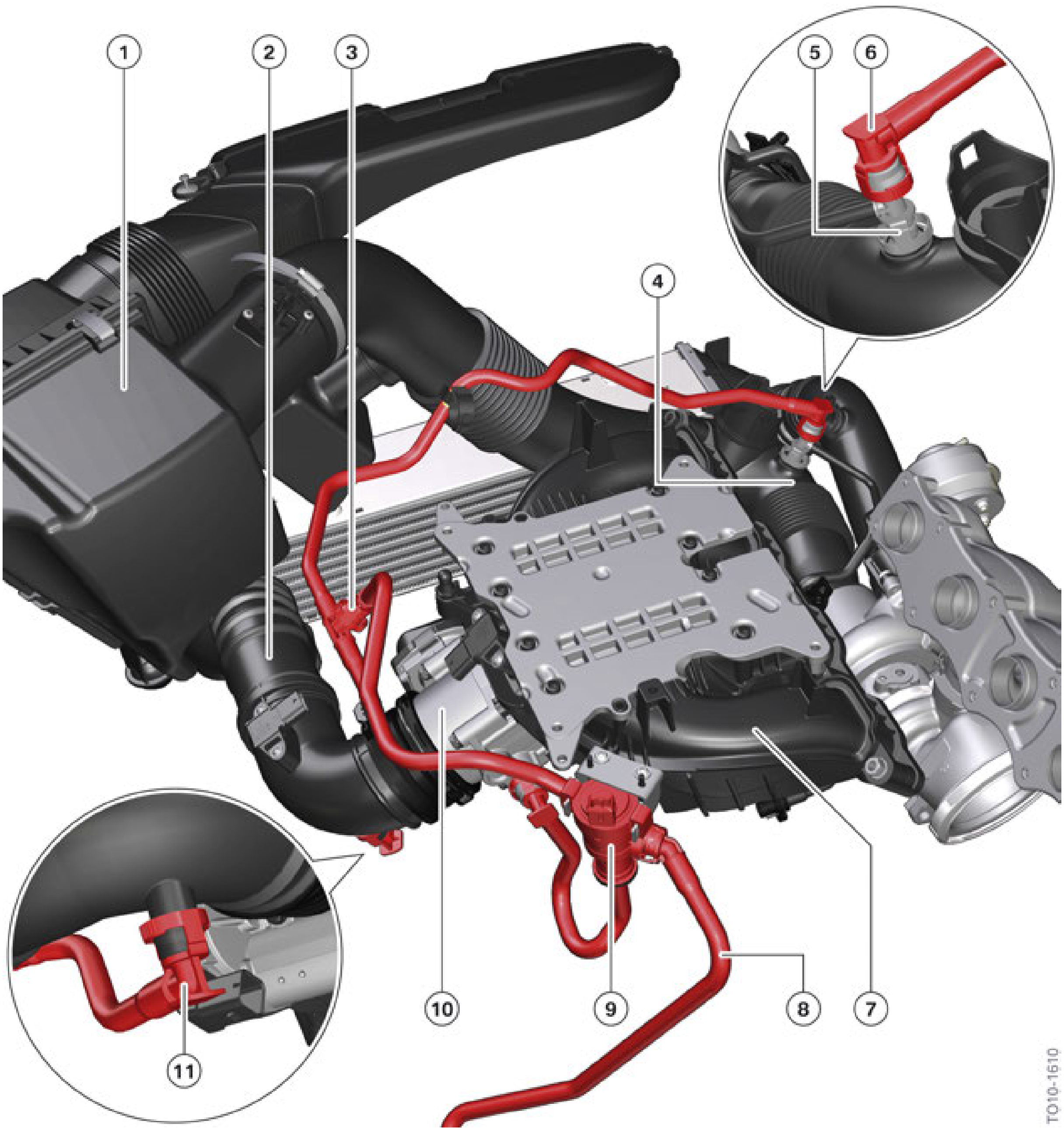
The fuel supply is vehicle-specific. Hardly any changes have been made to the already existing models. Therefore only the tank ventilation system on the engine will be described in greater detail here.

## 8.1. Tank ventilation

Similar to the N55

### 8.1.1. Two-stage tank ventilation

The two-stage tank venting is used on the N20 engine. This sophisticated system is made necessary by the TVDI technology, because in this case sufficient vacuum in the intake manifold is much less common. This was introduced with the N55 engine.

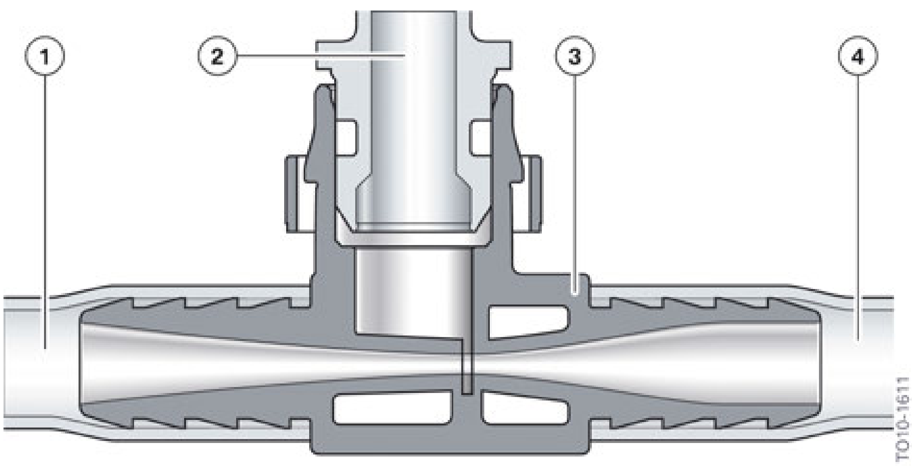



N20 engine, tank ventilation

| Index | Explanation |
|---|---|
| 1 | Intake silencer |
| 2 | Charge air pipe (from charge air cooler to throttle valve) |
| 3 | T-connector with suction jet pump |
| 4 | Clean air pipe (from intake silencer to exhaust turbocharger) |
| 5 | Connection of purge air line, crankcase ventilation |

| Index | Explanation |
|---|---|
| 6 | Connection of tank ventilation to clean air pipe |
| 7 | Intake manifold |
| 8 | Line from carbon canister of tank ventilation system |
| 9 | Tank vent valve with shut off valve |
| 10 | Throttle valve |
| 11 | Connection before throttle valve for driving suction jet pump |

However, a suction jet pump is additionally used in view of the fact that sufficient vacuum cannot always be guaranteed in the clean air pipe. In order to drive this pump, the line to the suction jet pump is connected before the throttle valve. This creates a connection between the charge air pipe and the clean air pipe. In turbocharged mode the pressure in the charge air pipe is always higher than in the clean air pipe, which generates in this line a flow to the clean air pipe.




N20 engine, T-connector with suction jet pump for tank ventilation

| Index | Explanation |
|---|---|
| 1 | Line to clean air pipe |
| 2 | Line from tank vent valve |
| 3 | T-connector with suction jet pump |
| 4 | Line from charge air pipe |

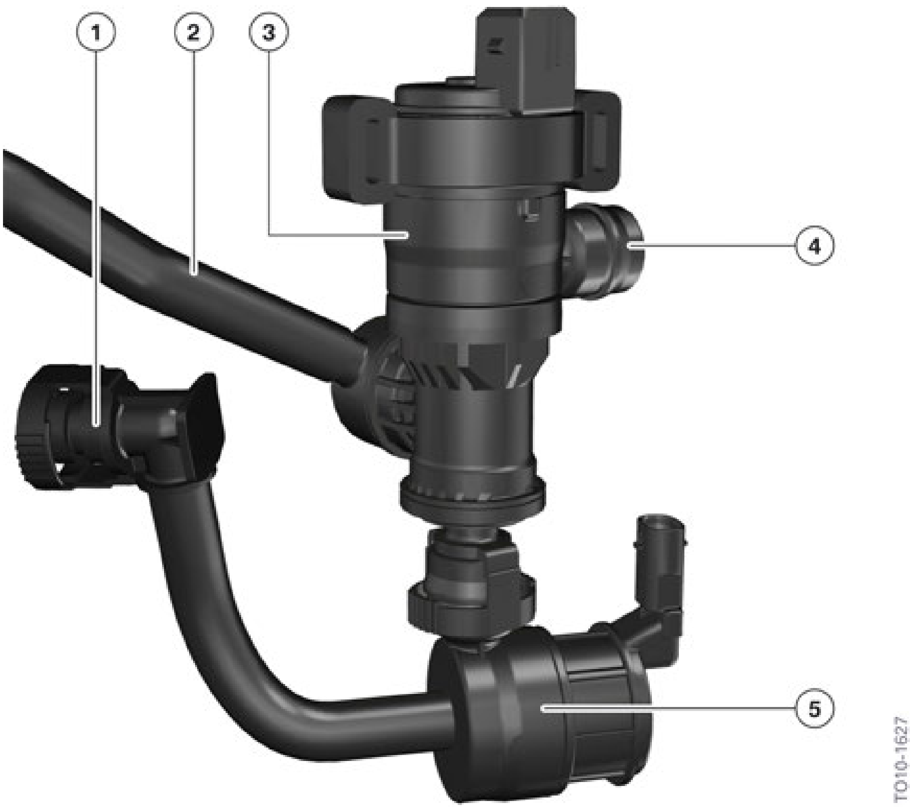
The line from the tank vent valve is connected to this suction jet pump. The venturi effect ensures that the carbon canister is safely purged.

Non-return valves on both lines from the tank vent valve ensure that there is no return flow into the tank vent valve in the event of excess pressure in these lines.

### 8.1.2. Two-stage tank ventilation with shutoff valve

The two stage tank ventilation has a second electrical valve which is very similar in design to the tank vent valve. This is known as a shutoff valve.

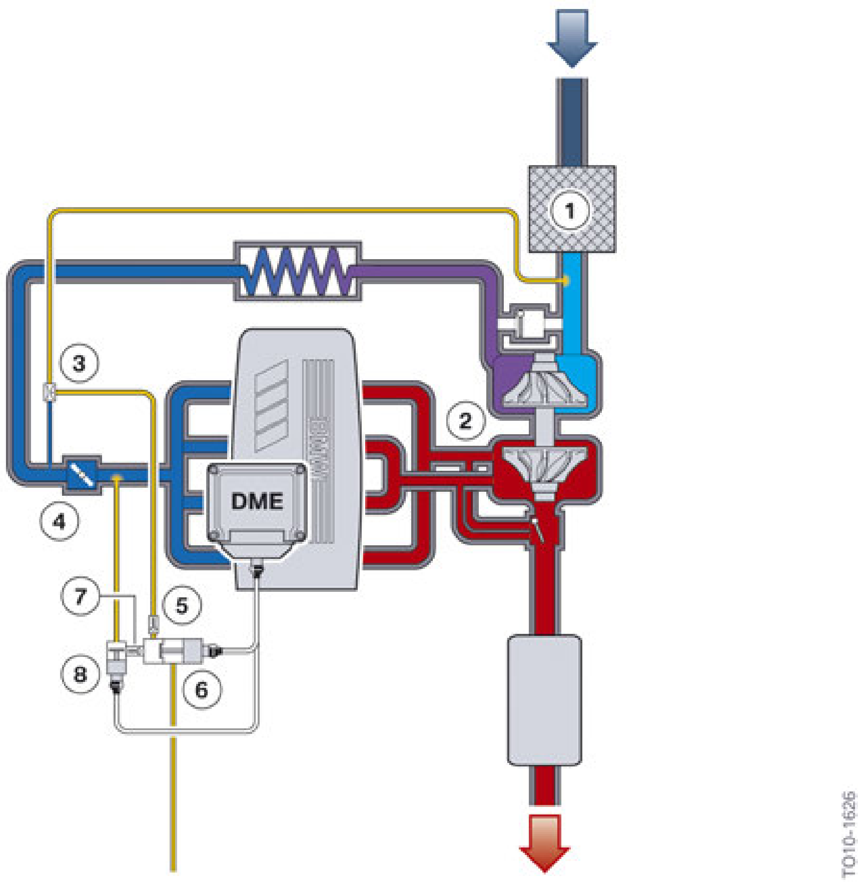
The shutoff valve serves to diagnose the second point of admission and is designed to close off the first admission into the intake manifold under certain conditions.




N20 engine, tank vent valve

| Index | Explanation |
|---|---|
| 1 | Connection after throttle valve |
| 2 | Line for connection to clean air pipe |
| 3 | Tank vent valve |
| 4 | Connection from carbon canister |
| 5 | Shutoff valve |

It is mounted directly below the tank vent valve and is able to seal off the line to the throttle valve.

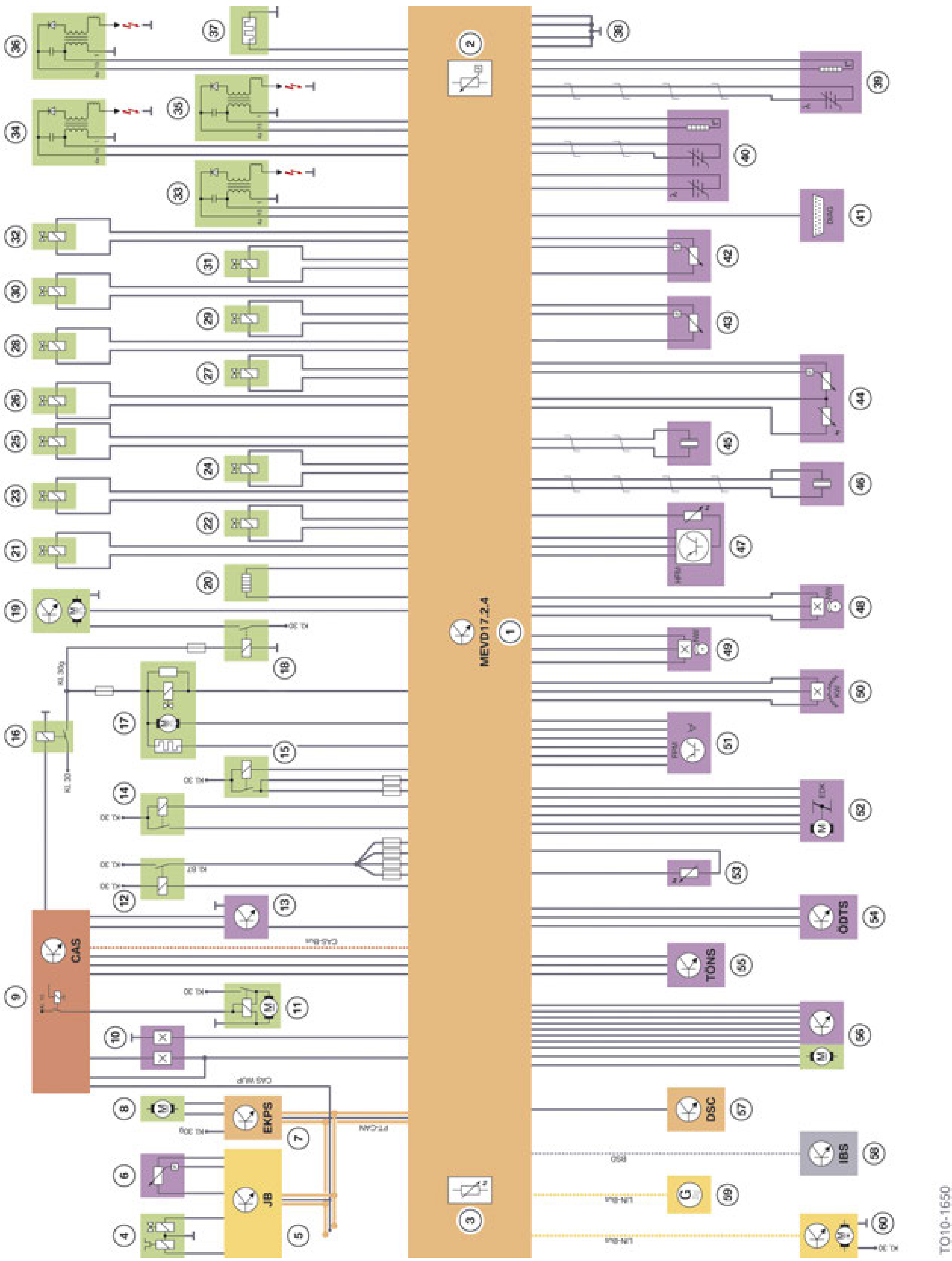



N20 engine, overview, two-stage version of tank ventilation with second valve

| Index | Explanation |
|---|---|
| 1 | Intake silencer |
| 2 | Exhaust turbocharger |
| 3 | T-connector with suction jet pump |
| 4 | Throttle valve |
| 5 | Non-return valve for connection to clean air pipe |
| 6 | Tank vent valve |
| 7 | Non-return valve for connection after throttle valve |
| 8 | Shutoff valve |

The shutoff valve is powered closed and spring loaded open at zero current.

### 9.1. Overview



N20 engine, system wiring diagram MEVD17.2.4

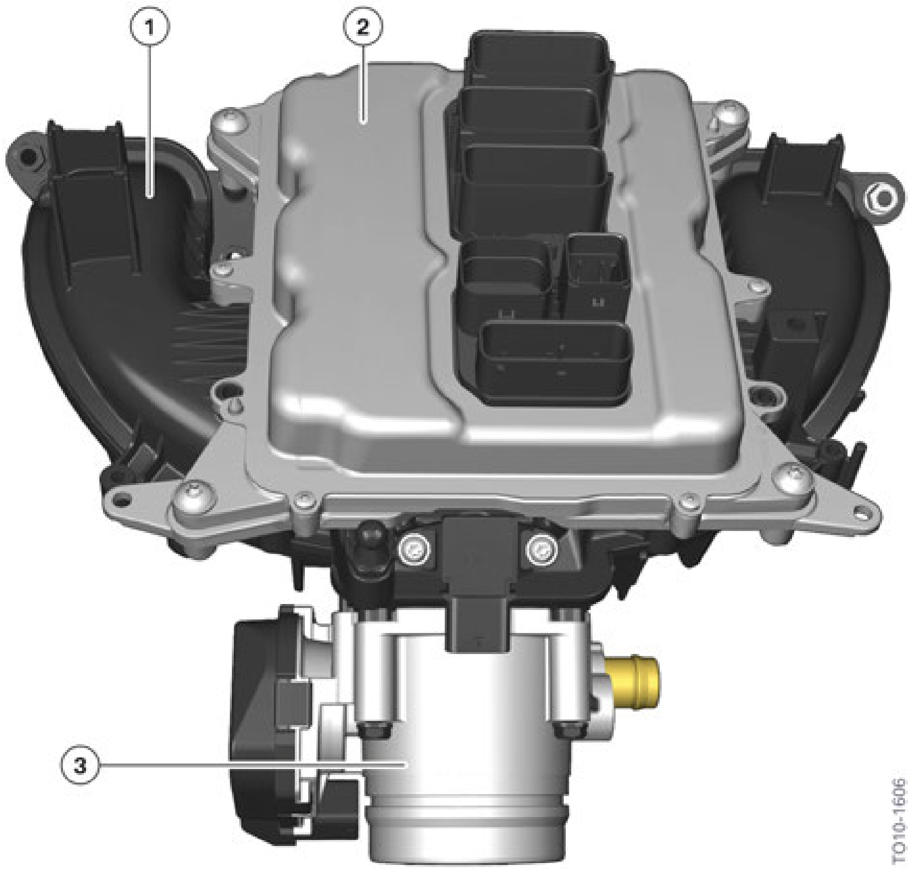
| Index | Explanation |
|---|---|
| 1 | Engine electronics Valvetronic direct fuel injection MEVD17.2.4 |
| 2 | Ambient pressure sensor |
| 3 | Temperature sensor |
| 4 | A/C compressor |
| 5 | Junction box electronics |
| 6 | Refrigerant pressure sensor |
| 7 | Electronic fuel pump control |
| 8 | Electric fuel pump |
| 9 | Car Access System CAS |
| 10 | Brake light switch |
| 11 | Starter motor |
| 12 | DME main relay |
| 13 | Clutch module |
| 14 | Relay, Valvetronic |
| 15 | Relay, ignition and injectors |
| 16 | Relay, terminal 30 switched |
| 17 | Diagnosis module, tank ventilation |
| 18 | Relay for electric fan |
| 19 | Electric fan |
| 20 | Map thermostat |
| 21 | Blowoff valve |
| 22 | Tank vent valve |
| 23 | VANOS solenoid actuator, intake camshaft |
| 24 | VANOS solenoid actuator, exhaust camshaft |
| 25 | Switchable engine sound system |
| 26 | Map control valve |
| 27 | Electro-pneumatic pressure converter for wastegate valve |
| 28 | Quantity control valve |
| 29 – 32 | Injectors |
| 33 – 36 | Ignition coils |
| 37 | Engine ventilation heating |
| 38 | Ground connections |
| 39 | Oxygen sensor after catalytic converter (monitoring sensor) |
| 40 | Oxygen sensor before catalytic converter (control sensor) |
| 41 | Diagnostic socket |

| Index | Explanation |
|---|---|
| 42 | Intake manifold pressure sensor |
| 43 | Rail pressure sensor |
| 44 | Charge air temperature and pressure sensor |
| 45 | Knock sensor 1 – 2 |
| 46 | Knock sensor 3 – 4 |
| 47 | Hot-film air mass meter |
| 48 | Camshaft sensor, intake camshaft |
| 49 | Camshaft sensor, exhaust camshaft |
| 50 | Crankshaft sensor |
| 51 | Accelerator pedal module |
| 52 | Throttle valve |
| 53 | Coolant temperature sensor |
| 54 | Oil pressure and temperature sensor |
| 55 | Thermal oil level sensor |
| 56 | Valvetronic servomotor |
| 57 | Dynamic Stability Control DSC |
| 58 | Intelligent battery sensor IBS |
| 59 | Alternator |
| 60 | Coolant pump |

### 9.2. Engine control unit

The N20 engine features Digital Engine Electronics from Bosch with the designation MEVD17.2.4. It is closely related to the DME of the N55 engine (MEVD17.2) and is also engine-mounted on the intake manifold.

## 9. Engine Electrical System




N20 engine, Digital Engine Electronics

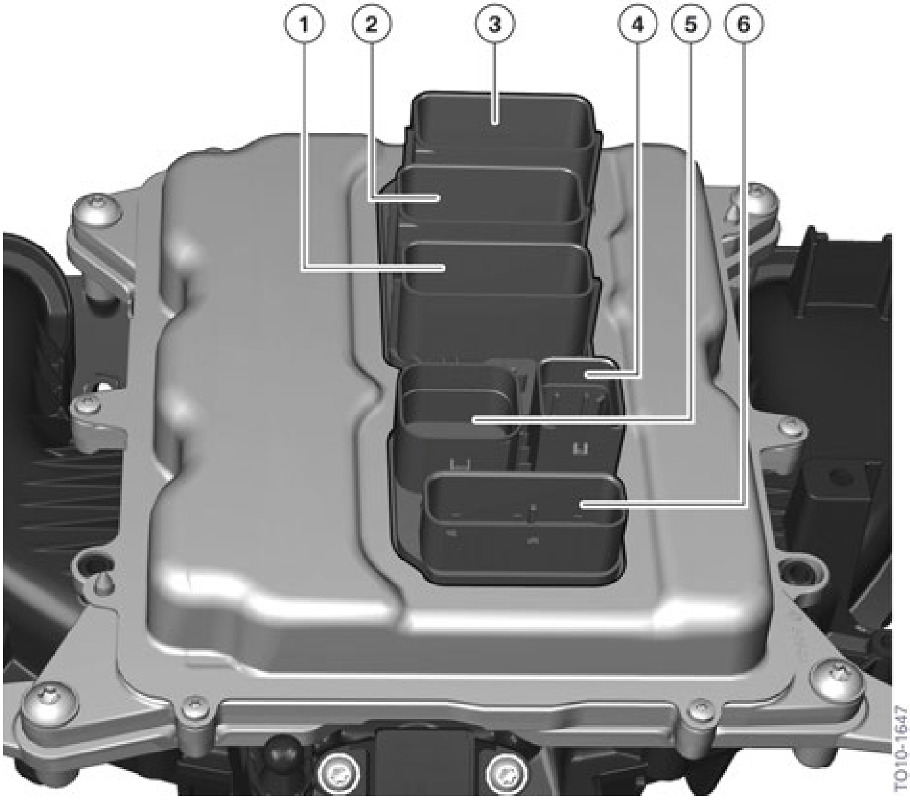
| Index | Explanation |
|---|---|
| 1 | Intake manifold |
| 2 | Digital Engine Electronics |
| 3 | Throttle valve |

**Do not attempt trial and error replacement of control units.**

**Because of the electronic immobilizer, a trial and error replacement of control units from other vehicles must not be attempted under any circumstances. An immobilizer adjustment cannot be reversed.**

The N20 engine DME (MEVD17.2.4) is designed to be mounted on the engine's intake manifold on an aluminium heat sink plate. The DME is cooled through the heat sink plate by the air flowing through the intake manifold. It is important for the DME to be correctly mounted on the heat sink plate (tightening torque, good level contact) so as to ensure heat transfer to the plate and thereby cool the DME.

The connection concept is identical to the MEVD17.2 in the N55 engine. There is a logical division into six modules.



N20 engine, MEVD17.2.4 connections

| Index | Explanation |
|---|---|
| 1 | Module 100, vehicle connection, 48 pins |
| 2 | Module 200, sensors and actuators 1, 58 pins |
| 3 | Module 300, sensors and actuators 2, 58 pins |
| 4 | Module 400, Valvetronic servomotor, 11 pins |
| 5 | Module 500, DME supply, 12 pins |
| 6 | Module 600, fuel injection and ignition, 24 pins |

### 9.2.1. Overall function

The Digital Engine Electronics (DME) is the computing and switching center of the engine management system. Sensors on the engine and the vehicle deliver the input signals. The signals for activating the actuators are calculated from the input signals, the nominal values calculated using a computing model in the DME control unit and the stored program maps. The DME control unit activates the actuators directly or via relays.

The DME control unit is woken up via the wake-up line (terminal 15 Wake up) by the Car Access System (CAS).

The after-run starts after terminal 15 OFF. The adaptation values are stored during the after-run. The DME control unit uses a bus signal to signal its readiness to “go to sleep”. When all the participating control units have signalled their readiness to “go to sleep”, the bus master outputs a bus signal and the control units terminate communication five seconds later.

The printed circuit board in the DME control unit accommodates two sensors: a temperature sensor and an ambient pressure sensor. The temperature sensor is used to monitor the temperature of the components in the DME control unit. The ambient pressure is required for calculating the mixture composition.

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