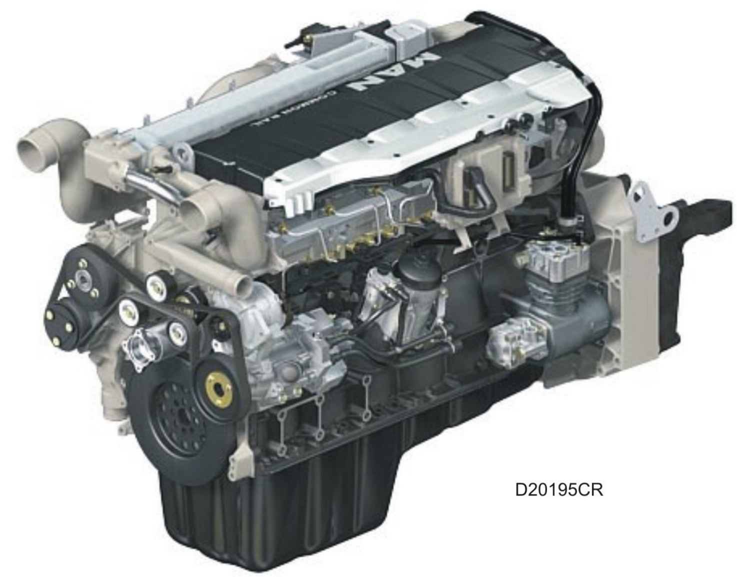
Engine Training Course

D 2066 LF..
with
EDC 7
Common Rail



Compiled by
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MAN Service Akademie
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This document is to be used only for training and is not included in the regular updating service.

CONTENTS

DESCRIPTION OF D 2066 CR ENGINE

GENERAL INFORMATION

The Series D2066 LF series of inline engines was a new development for the heavy Trucknology Generation (TGA) series of MAN trucks:

- New, higher power-output and torque ratings and steeper torque curves.
- Increased peak effective pressure in the engine and the new combustion principle with common-rail (CR) fuel supply have distinctly improved engine efficiency and lowered fuel consumption over large area of the operating range.
- The system used to bolt down the individual cylinder heads, the cylinder head gaskets, the cylinder liners and the crankcase have all been redeveloped to withstand the higher ignition pressures.
- Adoption of the second-generation Bosch Common Rail fuel injection system (1600 bar).
- Engine management by EDC7 and communication with FFR via the CAN bus.
- Depending on operating conditions and the quality of the fuel and oil, oil-change intervals of up to 120.000 m can be achieved, so that the customer’s operating costs are lower.
- The new D2066LF 10.5-litre engine concept is designed to achieve even higher reliability.
- The engine braking effect has been increased in conjunction with a developed version of the pressure-controlled exhaust valve brake (EVB) which is available as an optional extra.
- A further increase in engine braking power has been achieved by the introduction of the completely new, innovative crankshaft-driven primary brake system (the Pri-Tarder water-filled retarder).

New features compared with the previous D28.. EURO 3 engines

Engine:

- Crankcase
- Crankshaft
- Conrods
- Pistons
- Cylinder liners
- One-piece cylinder head
- Overhead camshaft
- Cylinder head gasket
- Gear drive, forward/reverse
- Exhaust manifold gasket
- Oil pump
- Oil circuit
- Oil filter module with crankcase breather

Maintenance work:

Renewing oil and fuel filters and adjusting valve clearances every 120.000 km

Water pump:

MAN Pri-Tarder as separate unit

Cooling fan mount

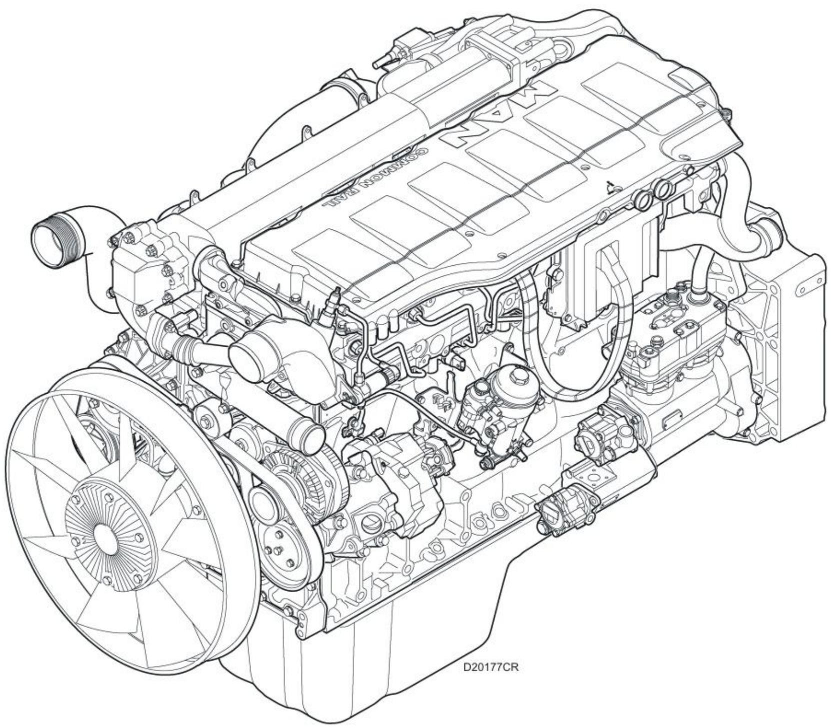
Eaton viscous–drive fan

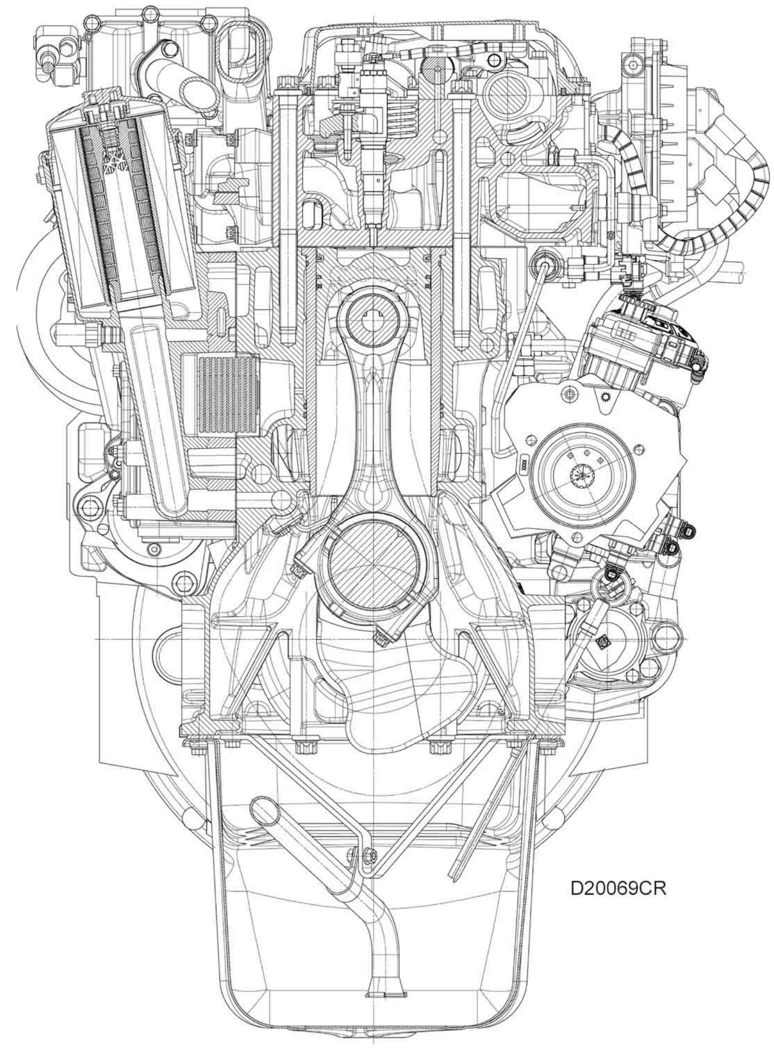
EGR with overheat shutoff

Common Rail fuel injection system:

- EDC 7
- Injectors (7-hole)
- CP3.4 high-pressure pump with rail distribution
- new plug-in fuel system
- new fuel service center

D20.. EURO 3/4 COMMON RAIL





RANGE OF ENGINES

Engine	Series	Nominal power output (ISO 1585-88195 EEC)	Chassis number beginning with:
D 2066 LF 04 .... Euro 3	TGA	310 HP / 228 KW	WMAH..
D 2066 LF 03 .... Euro 3	TGA	350 HP / 257 KW	WMAH..
D 2066 LF 02 .... Euro 3	TGA	390 HP / 287 KW	WMAH..
D 2066 LF 01 .... Euro 3	TGA	430 HP / 316 KW	WMAH..

KEY TO TYPE DESIGNATIONS

Example: TGA 26.430

T Trucknology

G Generation

A Trucks over 18t gross vehicle weight

26 Gross weight in metric tons

430 Horsepower, not specified according to Euronorm

EXHAUST EMISSIONS

Commercial vehicles with a gross weight of more than 3.5 t are subject in Europe to the **13-stage test according to ECE R49**.

Exhaust emissions from the engine to be tested are measured in 13 predetermined stationary operating conditions.

After this a mean emission value is calculated.

Exhaust emissions in g/KW/h	**1993**	**1996**	**2000**
Pollutant	**EURO 1**	**EURO 2**	**EURO 3**
CO (carbon monoxide)	**5**	**4**	**2,1**
HC (hydrocarbons)	**1,25**	**1,1**	**0,66**
NOx (oxides of nitrogen)	**9**	**7**	**5**
Particulate	**0,4**	**0,15**	**0,1**

ADDITIONAL EQUIPMENT

At the customer’s special request and depending on the vehicle’s intended use, the following additional equipment can be fitted:

- 1- or 2-cylinder air compressor with or without power take-off for 2nd steering pump, hydraulic pumps or 2x winter-service pumps.
- MAN version of Pri-Tarder with internal piston-ring pack and Simrax external sealing pack
- Exhaust brake with EVB, pressure-regulated
- Trial of water pump with plastic impeller
- Installation of large-head alternator

KEY TO ENGINE TYPE PLATE

ENGINE TYPE PLATE

MAN - Werk Nürnberg

Typ D2066 LF 01

Motor-Nr. / Engine No. **N I / N II**

505 0404 094 B 2 F 1 P1

N I / N II panel

I Dimensional deviation of 0,10 mm

II Dimensional deviation of 0,25 mm

P Big eng bearing journals

H Main bearing journals

Engine type code

D2066 LF 01

D .... Type of fuel (diesel)

20 .... + 100 = cylinder bore, e.g. 120 mm ∅

6 .... 6 x 10 + 100 marks app. stroke = 155 mm

6 .... No. of cylinders 6 = 6-cylinder, 0 = 10-cylinder
2 = 12-cylinder

L .... Type of forced aspiration (turbocharger with charge-air intercooler)

F .... Installed position of engine:

- F Forward control truck with vertical engine
- OH Rear-engined bus, vertical engine
- UH Rear-engined bus, horizontal engine

01 Engine version; particularly important for spare parts supply, technical data and adjustment values,

ENGINE IDENTIFICATION NUMBER

Example:

505	0404	094	B	2	F	1
↓	↓	↓	↓	↓	↓	↓
A	B	C	D	E	F	G

D20032CR

A .... **505** .... Engine type code

B .... **0404** .... Day of assembly

C .... **094** .... Assembly sequence (stage reached on day of assembly)

D .... **B** .... Overview of flywheel

E .... **2** .... Overview of injection pump/regulating system

F .... **F** .... Overview of air compressor

G .... **1** .... Special equipment (e.g. engine-speed power take-off)

TORQUE – BASIC PRINCIPLES

A TORQUE

As engine speed increases, so do the power output and the torque. After overcoming friction losses and the more severe heat losses at low speeds, the engine reaches its peak torque if optimum cylinder filling is assured. At even higher engine speeds the torque drops again because of increased flow resistance and shorter valve opening times.

B POWER OUTPUT

Power output is the product of engine speed and torque. Since torque drops more slowly than engine speed goes up, engine power output rises further initially. Between the maximum torque and the maximum power output is the “flexibility” area of engine operation. Within this area, power output is kept constant by the increasing torque as the engine speed drops.

C SPECIFIC FUEL CONSUMPTION

The explanation of the full-load fuel consumption curve on the graph is as follows: at low engine speeds, the fuel particles do not mix with air so effectively under pressure (14,5:1) and therefore fuel consumption is poor. At high engine speeds, combustion is incomplete because of the very short time available, and fuel consumption therefore goes up.

D20078CR

D20077CR

TECHNICAL DATA

D 2066 LF 03 EURO 3

Type .... **R6 TI-EDC (4 V)**

Layout of cylinders..**6 inline, vertical**

Max. power output .... **257 KW (350 HP)**

- at engine speed **1900 1/min**

Max. torque ....**1750 Nm**

- in engine-speed range..............................**1000 - 1400 1/min**

Displacement ....**10518 cc**

Bore / stroke ....**120 / 155**

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

Cylinder 1 position.....................................**at cooling-fan end**

Injector pattern **7-hole**

Compression ratio...**18**

Idle speed **600 1/min**

Valve clearances, engine cold ....**Inlet 0,50 mm**

- exhaust / with EVB ....**0,60 mm / 0,40 mm**

Compression pressure..**> 30 bar**

Permissible pressure difference between cylinders.**max. 4 bar**

Coolant ....**litres**

Oil content.. **min 36 / max. 42 litres**

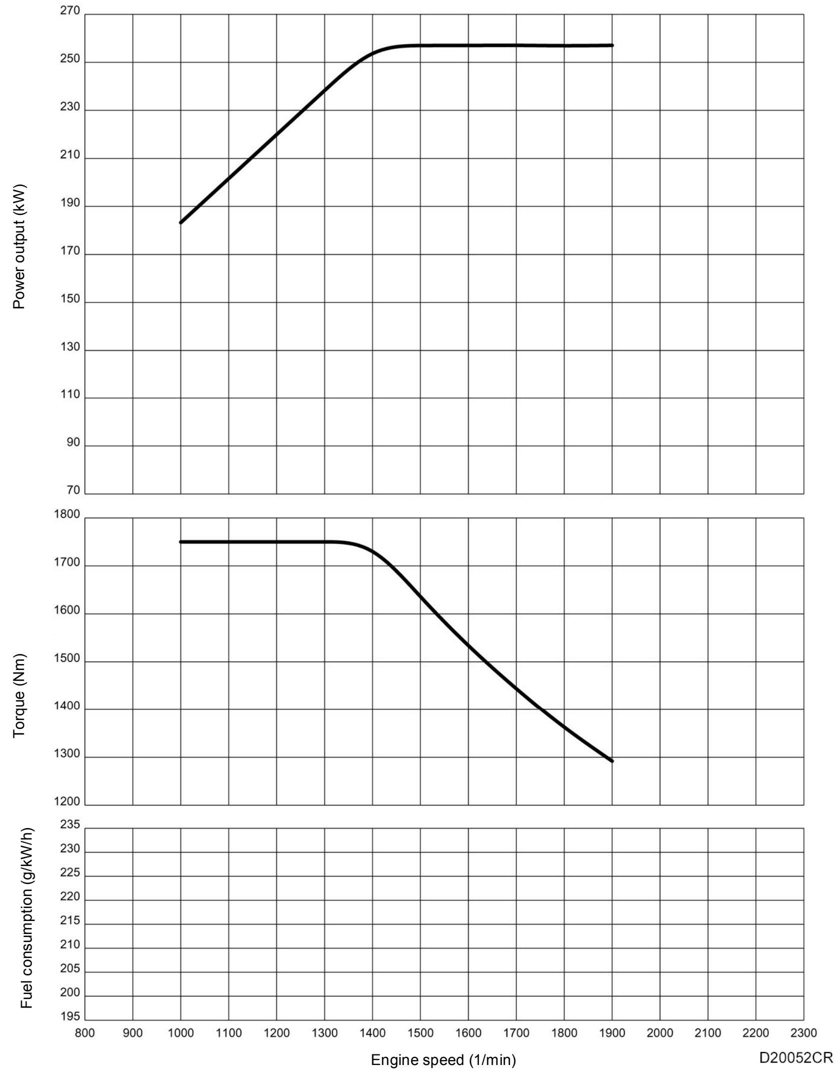
Fuel supply system ....**Bosch EDC 7**

Fan coupling ....**hydraulic / electric**

Dry weight ....**967 kg**

K value .... **1,2 m^{-1}**

Length of engine incl. fan.. **1499 mm**


Power output (kW)
270
250
230
210
190
170
150
130
110
90
70
Torque (Nm)
1800
1700
1600
1500
1400
1300
1200
Fuel consumption (g/kW/h)
235
230
225
220
215
210
205
200
195
800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
Engine speed (1/min)
D20052CR

D 2066 LF 01 EURO 3

Type.. **R6 TI-EDC (4 V)**

Layout of cylinders...**6 inline, vertical**

Max. power output .... **316 KW (430 HP)**

- at engine speed.. **1900 1/min**

Max. torque...**2100 Nm**

- in engine-speed range..............................**1000 - 1400 1/min**

Displacement...**10518 cc**

Bore / stroke ....**120 / 155**

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

Cylinder 1 position.....................................**at cooling-fan end**

Injector pattern...**7-hole**

Compression ratio...**18**

Idle speed **600 1/min**

Valve clearances, engine cold ....**Inlet 0,50 mm**

- exhaust / with EVB ....**0,60 mm / 0,40 mm**

Compression pressure ....**> 30 bar**

Permissible pressure difference between cylinders.**max. 4 bar**

Coolant ....**litres**

Oil content.. **min 36 / max. 42 litres**

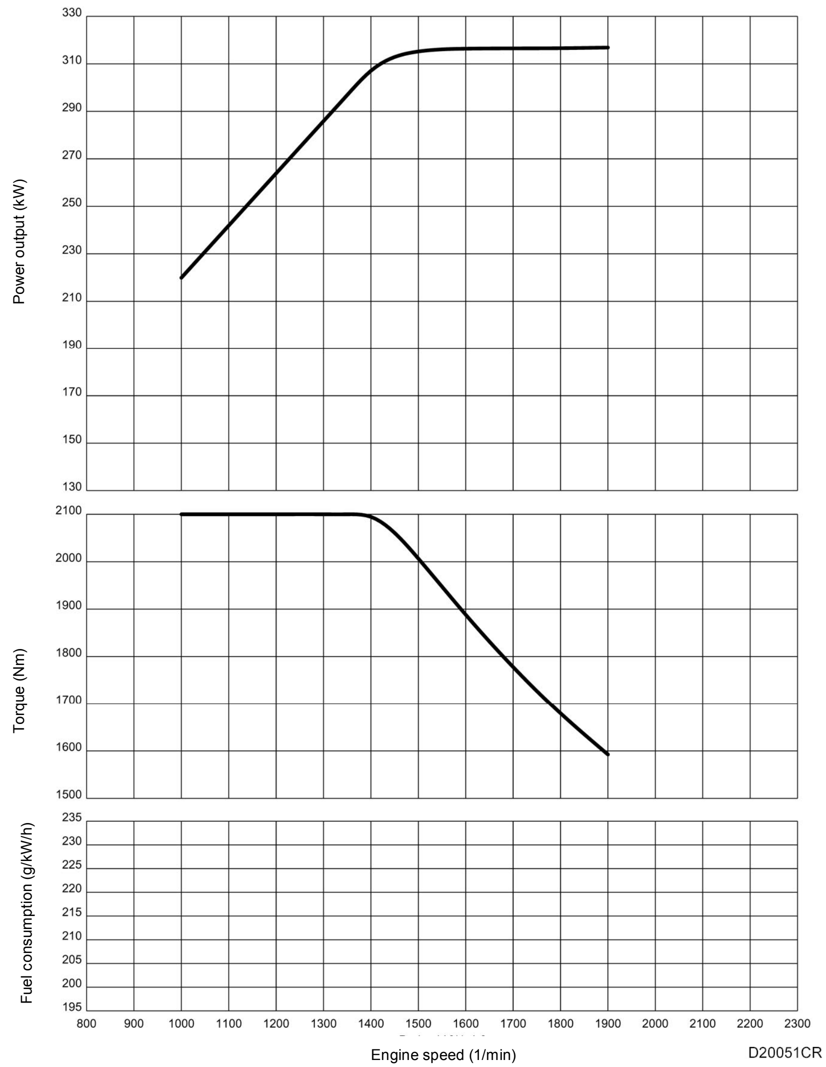
Fuel supply system ....**Bosch EDC 7**

Fan coupling ....**hydraulic / electric**

Dry weight...**967 kg**

K value .... **1,2 m^{-1}**

Length of engine incl. fan.. **1499 mm**


Power output (kW)
330
310
290
270
250
230
210
190
170
150
130
Torque (Nm)
2100
2000
1900
1800
1700
1600
1500
Fuel consumption (g/kW/h)
235
230
225
220
215
210
205
200
195
800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300
Engine speed (1/min)
D20051CR

ENGINE BLOCK AND CRANKCASE

The crankcase is cast in one piece with the cylinder block from special-grade GJV-250 iron. The wet cylinder liners are highly wear-resistant special centrifugal castings in GJL-250, and are replaceable. They are sealed at the bottom by **two** elastomer O-rings (Viton rings).

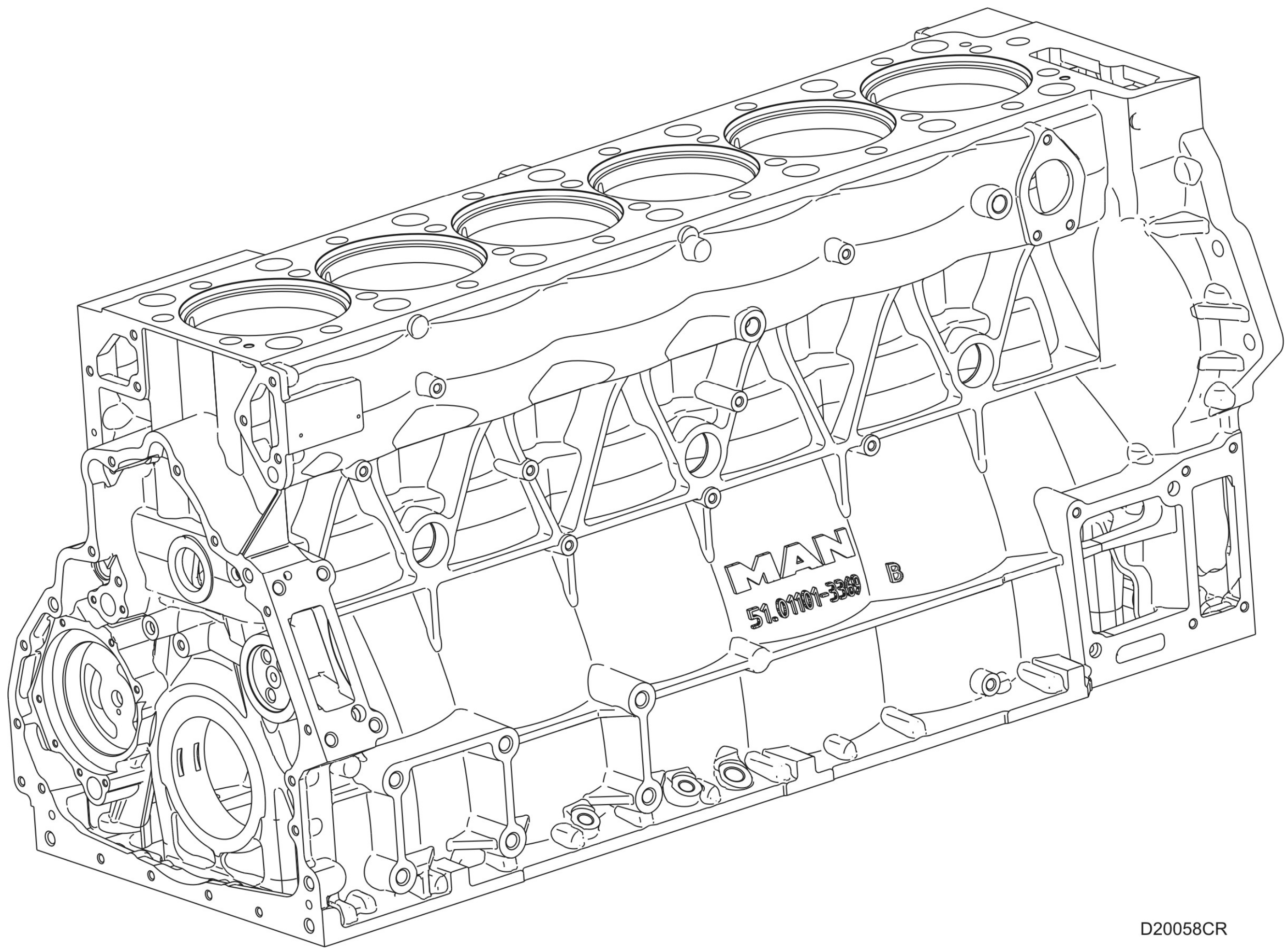
The dividing walls in the crankcase have been reinforced to cope with the higher ignition pressures (over **200** bar).

The crankcase emissions will be vented through the oil separator to the suction side of the turbocharger.

The crankcase has been modified externally to provide a compact mounting for the new assemblies (EDC 7 control unit, rail and camshaft sensor).

The crankcase is closed at the rear by the flywheel and timing gear housing, which is a GJS-450 spheroidal graphite casting and contains the rear crankshaft sealing ring.

- Acoustically optimised, symmetrical crankcase cast from GJV-450
- Cracked main bearing caps
- Integral breather chamber



D20058CR

CYLINDER LINERS

The wet, replaceable cylinder liners are special centrifugal castings.

The lower O-rings (**1**) are coated with a thin layer of engine oil, and also the transition to the cylindrical section of the liner.

WARNING:

DO NOT USE A BRUSH TO APPLY THE OIL.

NOTE:

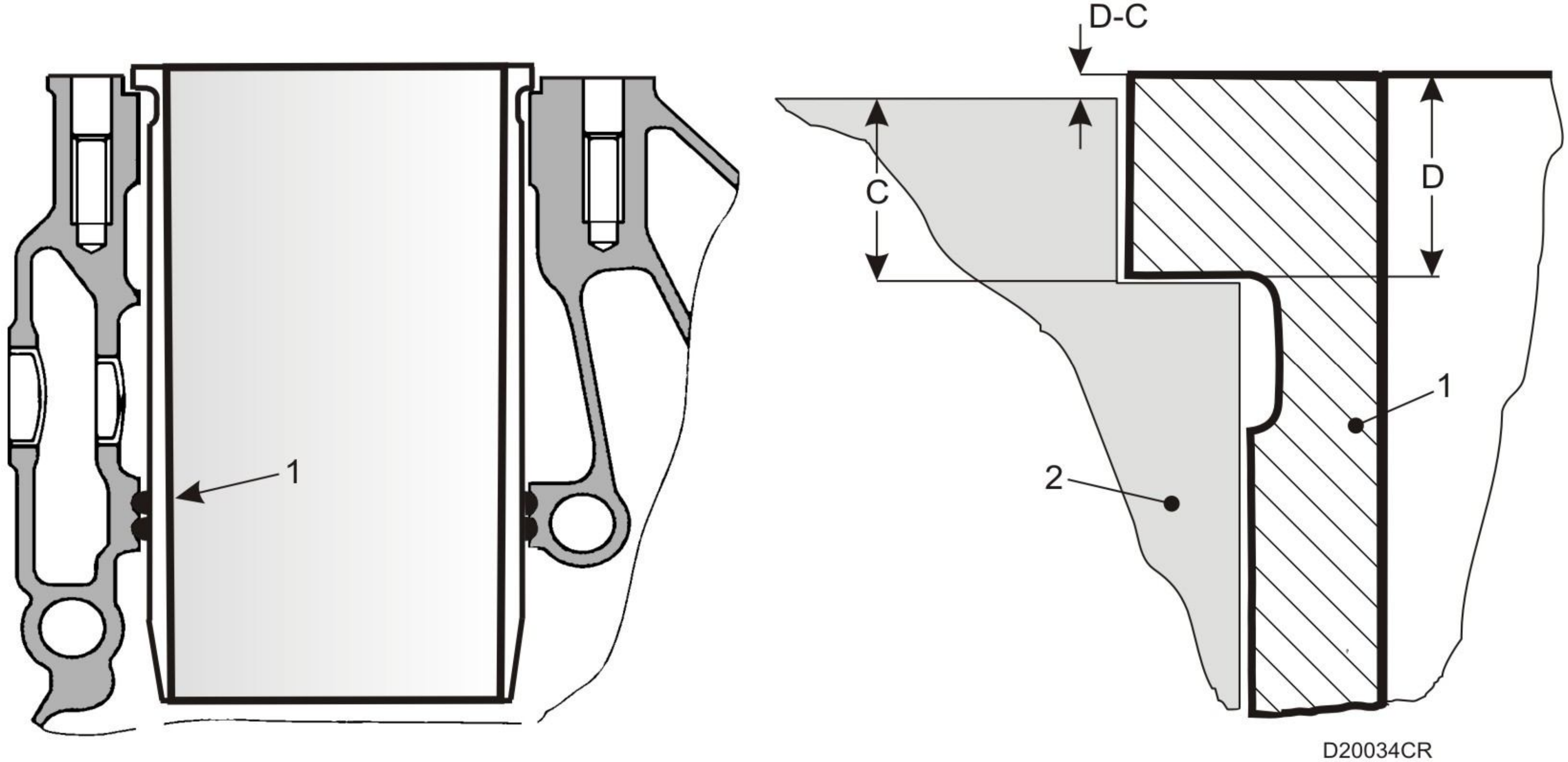
Do not use any kind of grease or sealant.

Measure liner top projection by the approved test method (measure without the sealing ring). Insert the cylinder liner into the crankcase without the O-rings.

Attach the measuring pressure plate and tighten to **40 Nm**. After this, measure with the dial gauge at not less than 4 points.

1	Cylinder liner
2	Crankcase (**C**) shoulder recess
D	Height of shoulder on cylinder liner
D - C	Measured projection of cylinder liner from crankcase

- **Cylinder liner projection:** **min 0,03 max. 0,085 mm**
  (measure by means of measuring device without O-ring)
- Depth of shoulder recess **"C"** **7,985 – 8,015 mm**
- Height of cylinder liner shoulder "**D"** **8,05 – 8,07 mm**


1
D-C
C
D
1
2
D20034CR

PISTON CLEARANCE IN CYLINDER LINER

Determining piston clearance:

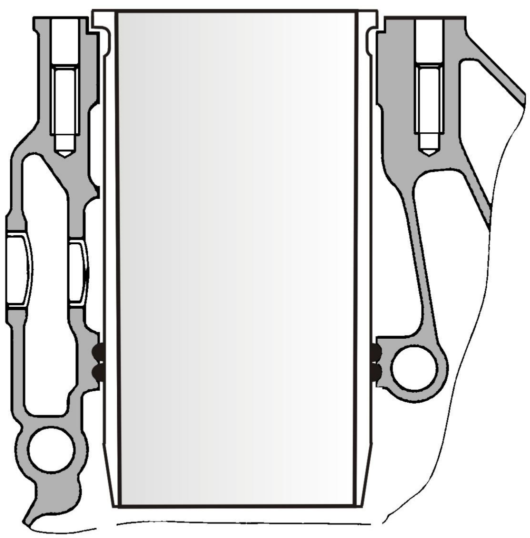
Using the internal measuring gauge, measure the internal diameter of the cylinder liner on **three** measuring levels from top to bottom at equal 45-degree spacings. Read off the piston diameter from the crown of the new piston. If the piston has already been run, use an outside micrometer to measure from the underside of the piston at a right angle to the piston axis and deduct the piston diameter from the largest cylinder liner diameter previously measured. The value calculated in this way is the piston clearance.

Example for piston clearance on D 20..LF

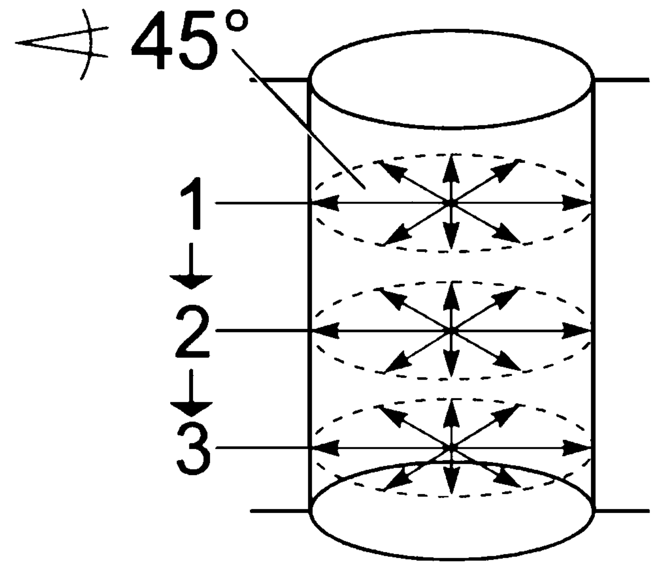
Internal cylinder ∅ .... **119,99 – 120,01 mm**

Piston ∅ A.. **119,87- 119,88 mm**

1 / 2 / 3 Heights for measuring cylinder diameter



D20035CR



TM 016

CRANKSHAFT

The crankshaft is resistant to torsion and flexing, and has eight forged-on **balance weights to balance out the inertial forces; it runs in seven main bearings in the crankcase. The main and big-end bearing journals and the locating bearing shoulders are induction-hardened and ground.**

Axial location is by means of thrust washers recessed into the crankcase at the central bearing pedestal.

Warning: the lubricating grooves on thrust washers **A** must face the crankshaft webs.

Warning: Never use a hammer or lever to detach the vibration damper. It will malfunction if dented even slightly, and this could lead to clutch damage or a broken crankshaft.

A **Crankshaft thrust bearing**................ **0,200 – 0,401 mm**

B **Main bearing bolts**.................................... **300 Nm+ 90°**

E **Designation H and P** – tolerance value **N** or **N1** for big-end or main bearings. **N1 = 0,1 mm** size variation

Variation in bearing shells "F":

- Measure **"C"**
- Measure **"D"**
- Variation = **"C" minus "D"**
- The variation must be **111,2 mm** to **112,4 mm** (**0,3 – 1,2 mm**).
- **Important: "C"** must be larger than **"D"**

Main bearing journal diameter: ....**N 103,98 – 104,00 mm**

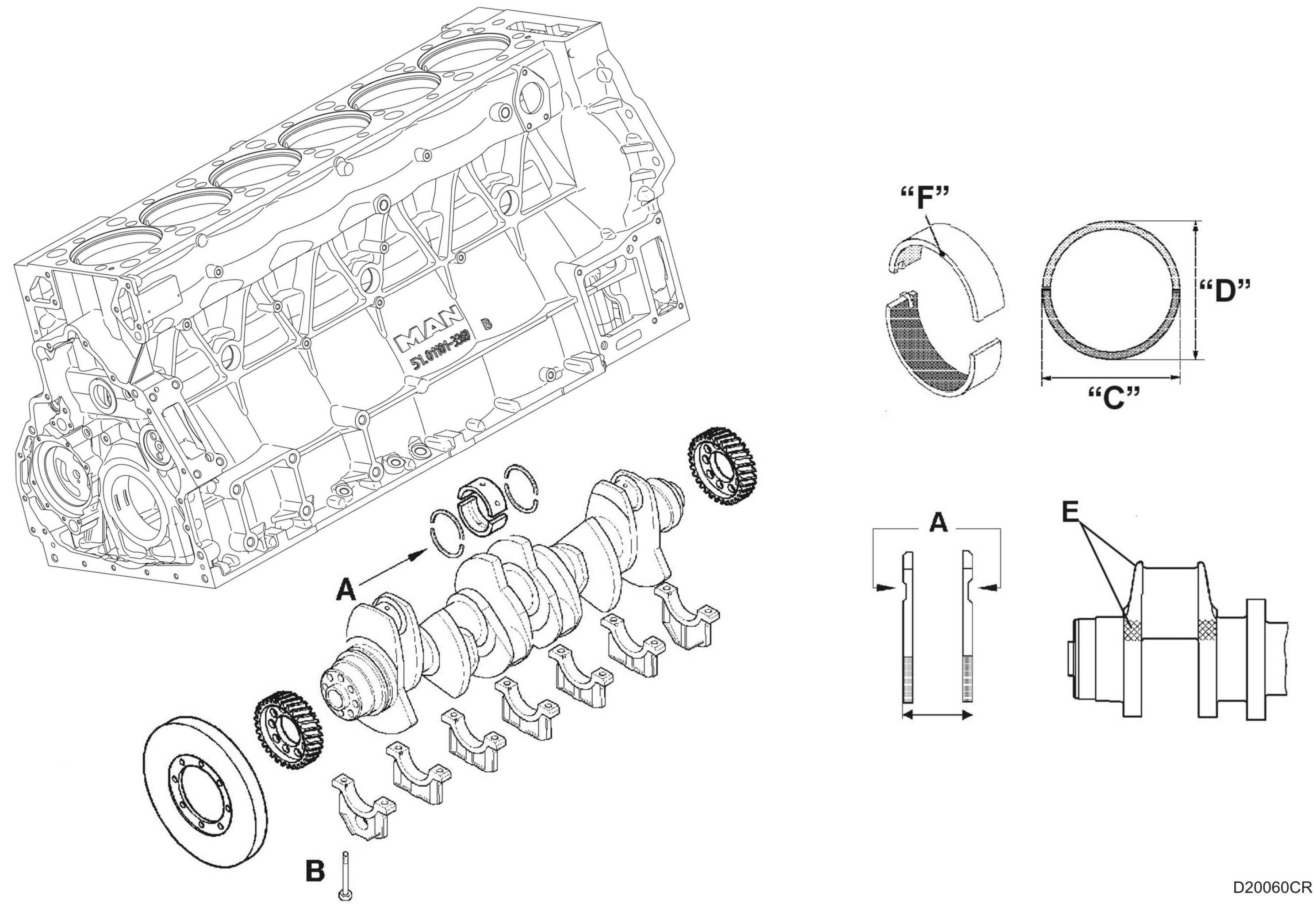
Max. main bearing play: ....**N 0,060 – 0,116 mm**

Further undersizes: ....**0,25 – 0,50 mm, 0,75 – 1,00 mm**

Note:

- all main bearing caps are produced by ***cracking***
- the upper main bearing shell **has** an oil hole
- the lower main bearing shell **has no** oil hole

Tighten vibration damper bolts to **150** Nm+**10** Nm torque and **90°+10°** of angle



A
B
"F"
"D"
"C"
A
E
D20060CR

FRONT AND REAR CRANKSHAFT SEALS

Radial shaft sealing rings made from polytetrafluoroethylene (PTFE, trade name Teflon) are always used for the front and rear crankshaft seals.

Relatively high internal tension causes sealing lip **(A)** to curve inwards. The PTFE sealing ring is therefore supplied on a transit sleeve **(B)** and must remain on it until it is installed. This is in any case desirable because the sealing lip is easily damaged and can leak even if the damage is only slight. Do **not** coat the sealing lip and flywheel contact ring with oil or any other lubricant.

Note:

New engines do not have the contact ring.

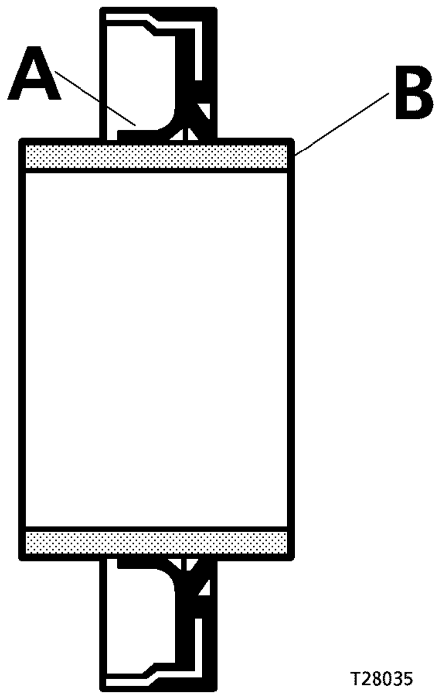
If you change the front radial seal ring on the crankshaft, you have to replace the front crankshaft gear.

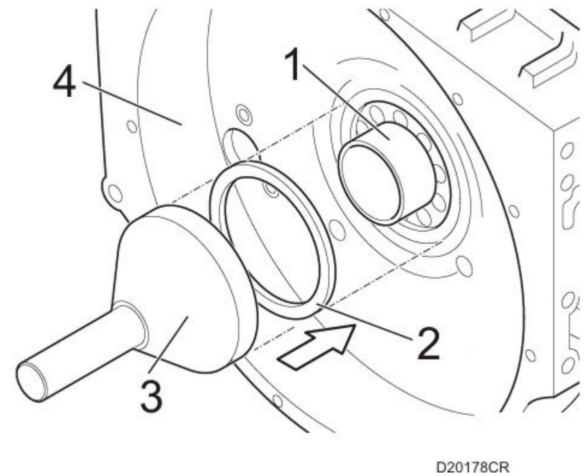
Assembly instructions:

The PTFE sealing ring must be absolutely free from oil or grease when installed. The slightest trace of oil or grease on the contact ring or sealing ring will cause leakage.

Before installing, clean the contact ring and the insertion tool to remove all traces of oil, grease and corrosion inhibitor. Any commercially available cleaning agent can be used.

Do not keep PTFE sealing rings in store unless they are mounted on the transit sleeve supplied. After as short a period as 20 minutes they will lose their built-in tension if stored without their sleeves, and may then cause leakage.


A
B
T28035


1
2
3
4
D20178CR

Extracting the radial shaft sealing ring

Loosen the sealing ring by striking it lightly.

To remove it, use a suitable puller.

Push the four puller hooks flat under the sealing lip and turn through **90 degrees**, so that they grip the sealing ring behind the lip. Turn the spindle to extract the radial shaft sealing ring.

Installing the radial shaft sealing ring

Bolt the adapter to the crankshaft.

Clean the adapter and the contact ring. Note that the radial shaft sealing ring must be installed **dry and must not be coated with oil or any other lubricant**.

Offer up the radial shaft sealing ring with transit sleeve to the adapter and push it on.

Remove the transit sleeve.

Push the fitting sleeve on to the adapter.

Screw the spindle into the adapter.

Pull the radial shaft sealing ring fully in until the insertion sleeve strikes the end cover.

1 **PTFE** crankshaft seal

2 Retaining screw

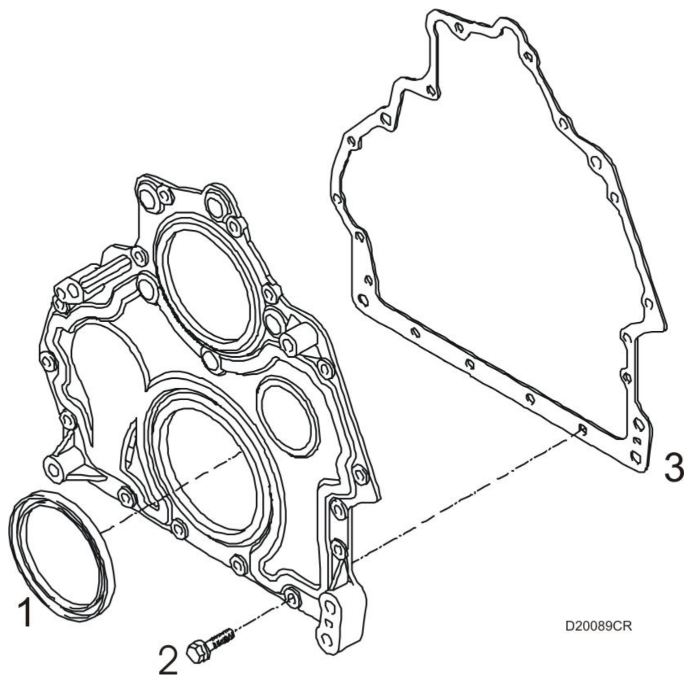
3 Seal (*Metaloseal)* for timing case at fan end

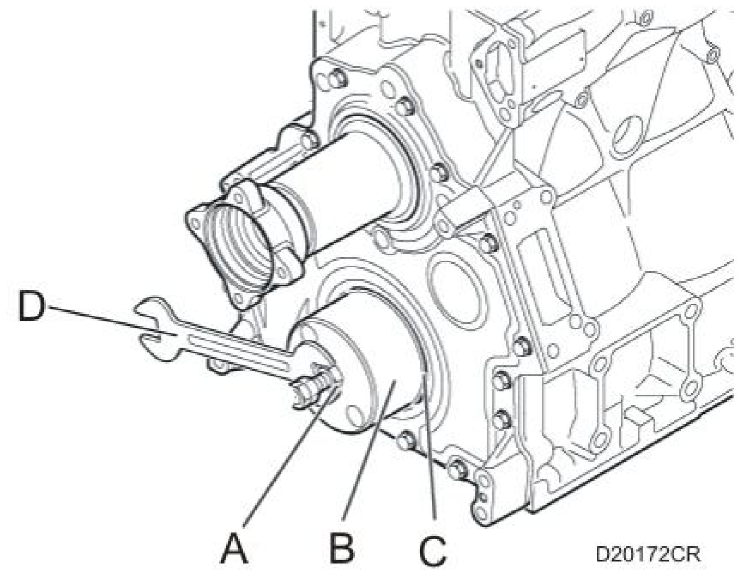
A hexagon nut

B fitting sleeve

C intermediate cover

D open ring spanner


1
2
3
D20089CR


D
A
B
C
D20172CR

FLYWHEEL

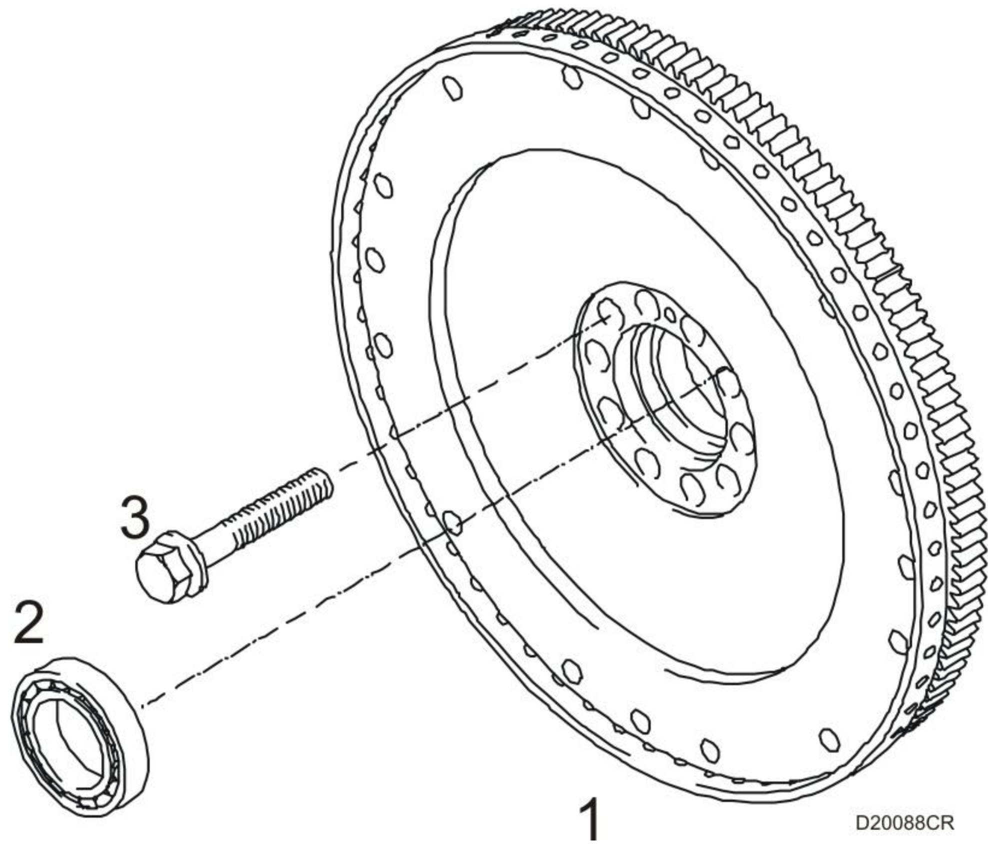
The flywheel is centred by a locating pin in relation to the crankshaft, and secured with 10 bolts which are tightened to a specified angle.

TIGHTENING PROCEDURE FOR FLYWHEEL BOLTS:

- Hex bolts **3**: initial tightening to **140 Nm** M14x1.5 (10.9)
- Final tightening: turn through a further **90°**
- The bolts are **NOT** to be re-used.

1 Flywheel

2 Input shaft bearing


3
2
1
D20088CR

Machining the flywheel:

If severe score-marks have occurred, max. 1,4 – 1,5 mm of metal can be removed from the flywheel surface for the clutch pressure plate.

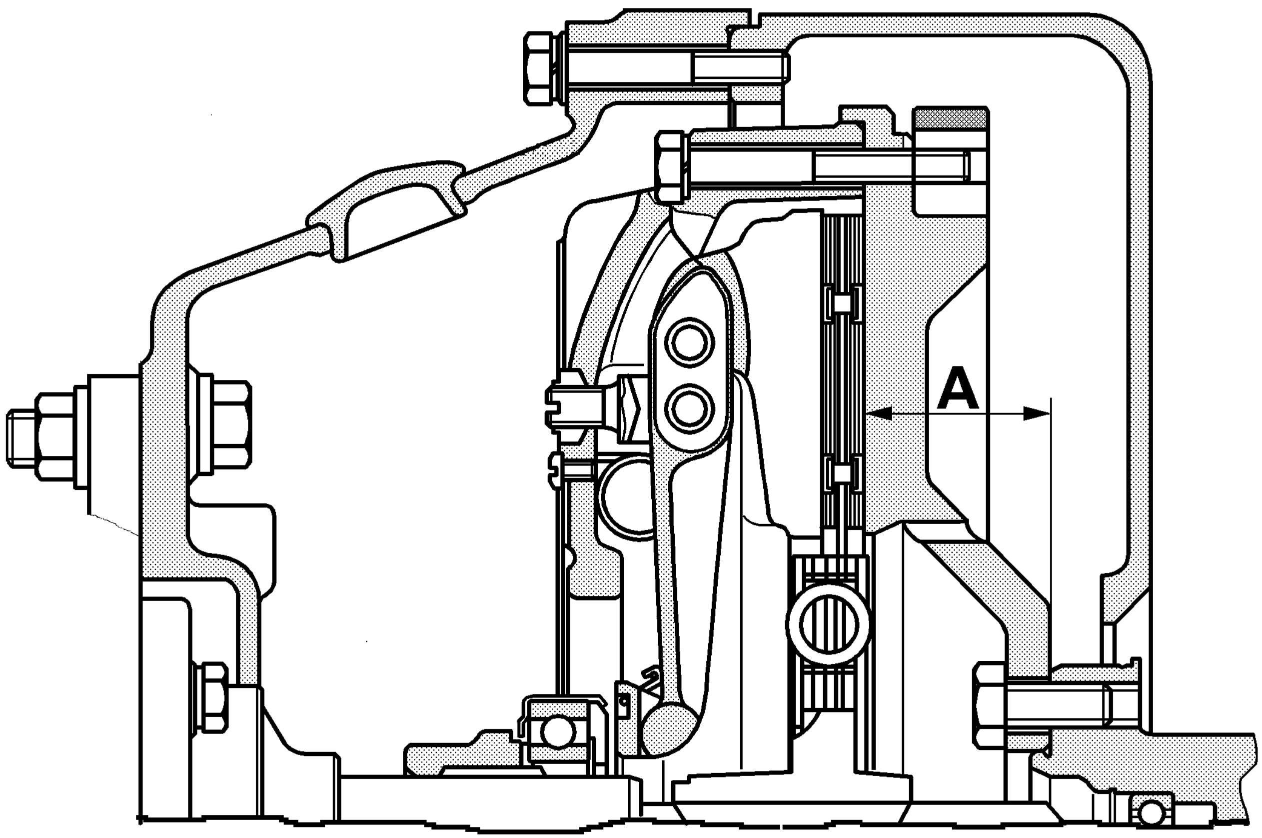
Minimum dimension **A**: **61,3 mm**

Standard dimension **A**: **62,8 ± 0,1 mm**

Maximum runout of starter gear ring **0,5 mm**

External diameter of flywheel **488,0 – 487,8 mm**

To install the starter gear ring, heat it to **200 - 230°C**.


A
T28014

CONRODS

The conrods are precision drop-forged from “C38mod” heat-treatable steel and shot blasted. The inclined bearing caps are formed by ***cracking***. The inclined bearing caps make it possible to extract the conrods easily upwards, through the cylinders, during overhaul or repair work. The upper bearing shell is of highly wear-resistant sputtered bearing material.

Measuring the big-end bearings:

The bearing holes of the big-end bearing shells are measured while installed in directions 1, 2 and 3 and at levels **a** and **b** with the measuring device.

Bearing shells with holes within the tolerance limits can be re-used. The bearings must be renewed if the dimensions are outside the tolerance limits.

Weight difference per set **max. 50 g**

- upper big-end bearing (GLYO 188)
- lower big-end bearing (GLYO 81)

NOTE:

- the upper bearing shell is marked **TOP** or has a red paint spot on the side (hardened support shell).

Big-end bearing journals (regular ∅): .... **89,98 – 90,00 mm**

Big-end bearing variation **C** (Miba) ....**95,5 (+ 2,5 + 0,5) mm**

Bore spacing .... **256 ± 0,02 mm**

Small-end bearing (internal ∅) .... **52,000 – 0,008 mm**

Big-end bolt tightening torque:

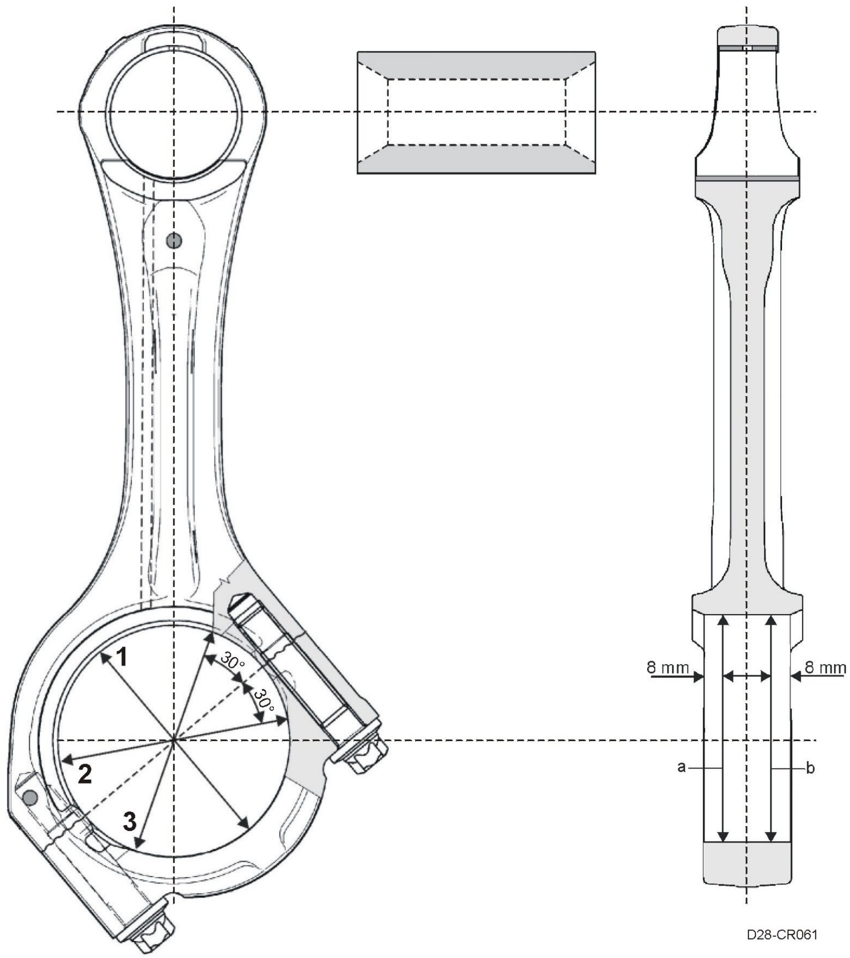
Tightening torque ....100 Nm $^{+10}$ plus 90° $^{+10°}$

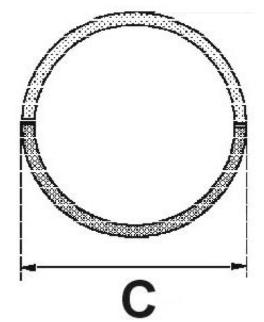
These bolts must not be re-used.

The conrod and matching big-end bearing cap are marked identically at the side, next to the crack line.

Warning:

Do not stand the conrod or big-end bearing cap on the cracked surface. If the crack pattern is damaged or otherwise changed, the conrod and cap will not fit together correctly and may be damaged beyond repair.


1
30°
30°
2
3
8 mm
8 mm
a
b
D28-CR061


C
D28-CR083

PISTONS

Three-ring pistons made from a special aluminium alloy are used. They have a cast-in ring carrier for the uppermost piston ring. The combustion chamber recess is stepped and has an “omega” shape. Pockets are provided for the inlet and exhaust valve heads. To prevent overheating the pistons have a cast-in cooling duct (430/390 HP engines) and are cooled by a jet of oil from a spray nozzle.

The pistons have been matched to the **higher ignition pressures** by stepped support on the conrods and in the combustion chamber.

- The pistons for the **430/390 HP** engine are cooled by oil spray from a cooling passage. To ensure that piston cooling takes place correctly even at low engine speeds, the **pressure regulating valve** in the oil spray nozzles has been **deleted**.
- Pistons for the **350/310 HP** engine are cooled by the well-proven direct spray method.

Piston rings:

The compression rings are a double-sided trapezoidal ring and a micro-chamfer ring. A penthouse-pattern oil scraper ring with tubular spring is used.

Piston recess/projection at crankcase:

Minus 0,03 mm to plus 0,30 mm

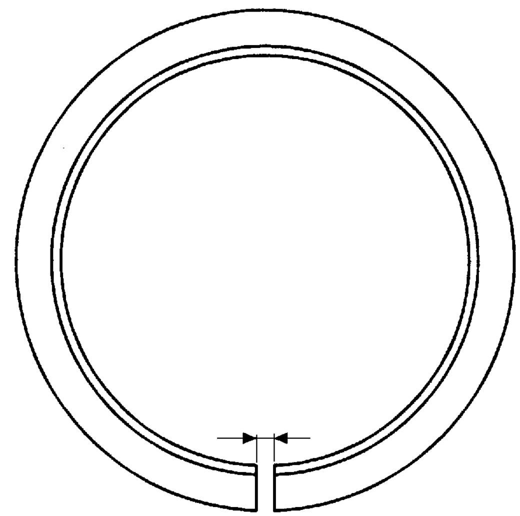
Piston ring end gaps (wear limit):

I Trapezoidal compression ring wear limit .... **1,5 mm**

II Micro-chamfer compression ring wear limit .... **1,5 mm**

III Oil scraper wear limit .... **1,5 mm**

D20094CR



TM 017

Piston (technical data from Alcan)

1 Piston diameter at right angle to small-end eye:

Measure the piston 22 mm above its bottom edge.

2 Piston diameter ....119,87 to 119,89 mm

3 Compression height:

Normal: D2066LF ....**76,80 to 0,05 mm**

4 Center of piston pin eye to piston head

A Piston recess into/projection from top of crankcase:

- 0,03 to + 0,30 mm

Piston ring groove heights

(5) Compression ring groove 1 ....**3,115 to +- 0,015 mm**

(6) Compression ring groove 2 ....**3,04 to 3,06 mm**

(7) Oil scraper ring groove...............................**4,05 to 4,02 mm**

Piston ring heights

Compression ring (double-sided trapezoidal ring) with chrome-ceramic surface layer

Piston ring height... **3,50 mm**

End gap ....**0,40 to 0,55 mm**

Compression ring (micro-chamfer)...................**3,00 to -0,03 mm**

End gap ....**0,47 to 0,7 mm**

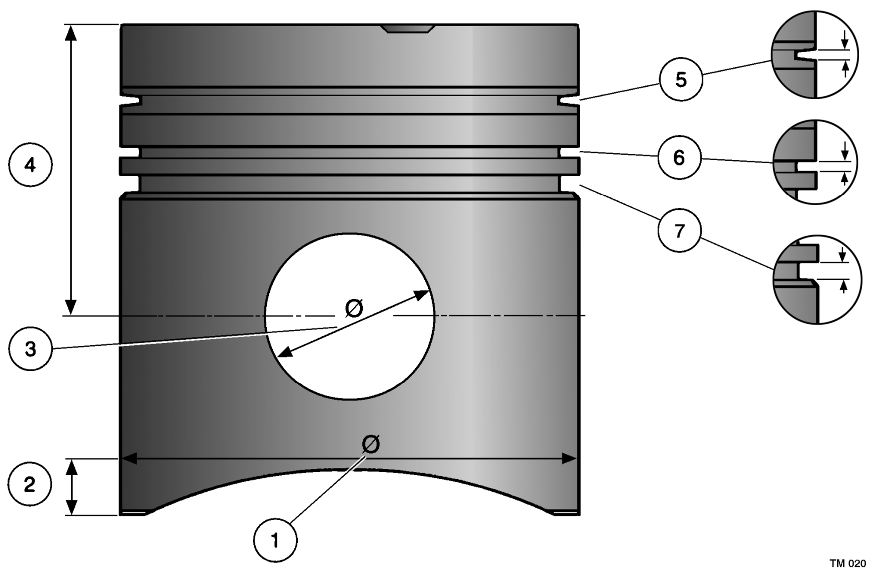
Oil scraper ring

Piston ring height.......................................**3,99 to 3,97 mm**

End gap ....**0,25 to 0,55 mm**

Difference in piston weight per set for any engine ..... **max. 60 g**

- **Install with arrow pointing forwards**
- **The small recess inside the piston body is to clear the oil spray nozzle**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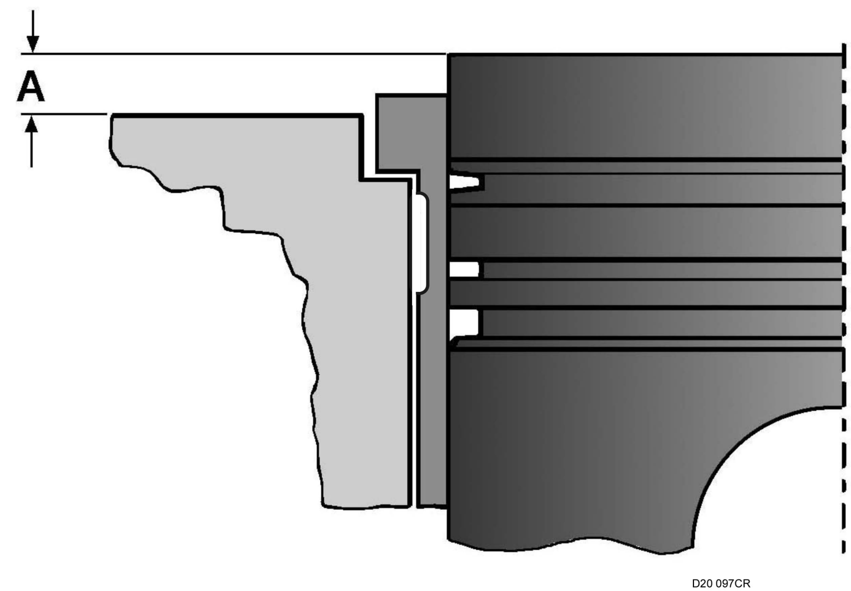

A
D20 097CR

ENGINE TIMING GEAR

Adjusting engine timing

The mark on the crankshaft gearwheel **6** must be aligned with the mark on intermediate gearwheel **5**.

The mark on camshaft gearwheel **1** must be aligned with the edge of the housing on the cylinder head **10**.

A **Gearwheels at flywheel end**

1 Camshaft gearwheel (*36 teeth*)

2 Intermediate gearwheel in cylinder head (*38 teeth*)

3 Intermediate gearwheel in crankcase (*40 teeth*)

4/5 Large intermediate gearwheel (*74/36 teeth*)

6 Crankshaft gearwheel (*37 teeth*)

7 Air-compressor intermediate gearwheel, *split* (*36 teeth*)

8 Air compressor drive gearwheel (*29 teeth*)

9 Power take-off (*30 teeth*)

10 Mark for camshaft on cylinder head

11 Mark on crankshaft intermediate gearwheel
(timing case sealant is Loctite **5900**)

B **Auxiliary drive gearwheels at fan end**

A Crankshaft gearwheel (*45 teeth*)

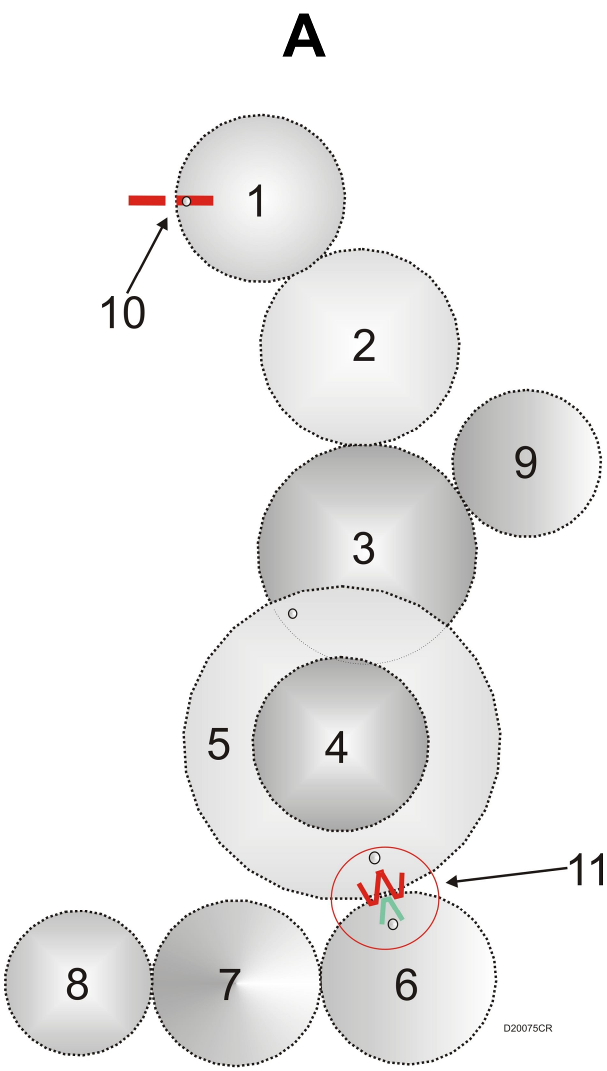
B Oil pump inner rotor

C Oil pump outer rotor (*34 teeth*)

D Fan drive gearwheel (*36/41 teeth) i = 41 teeth for 1:1,*
i =36 teeth for 1:1.25

E High-pressure pump (*27 teeth*)

F Intermediate gearwheel (*44 teeth*)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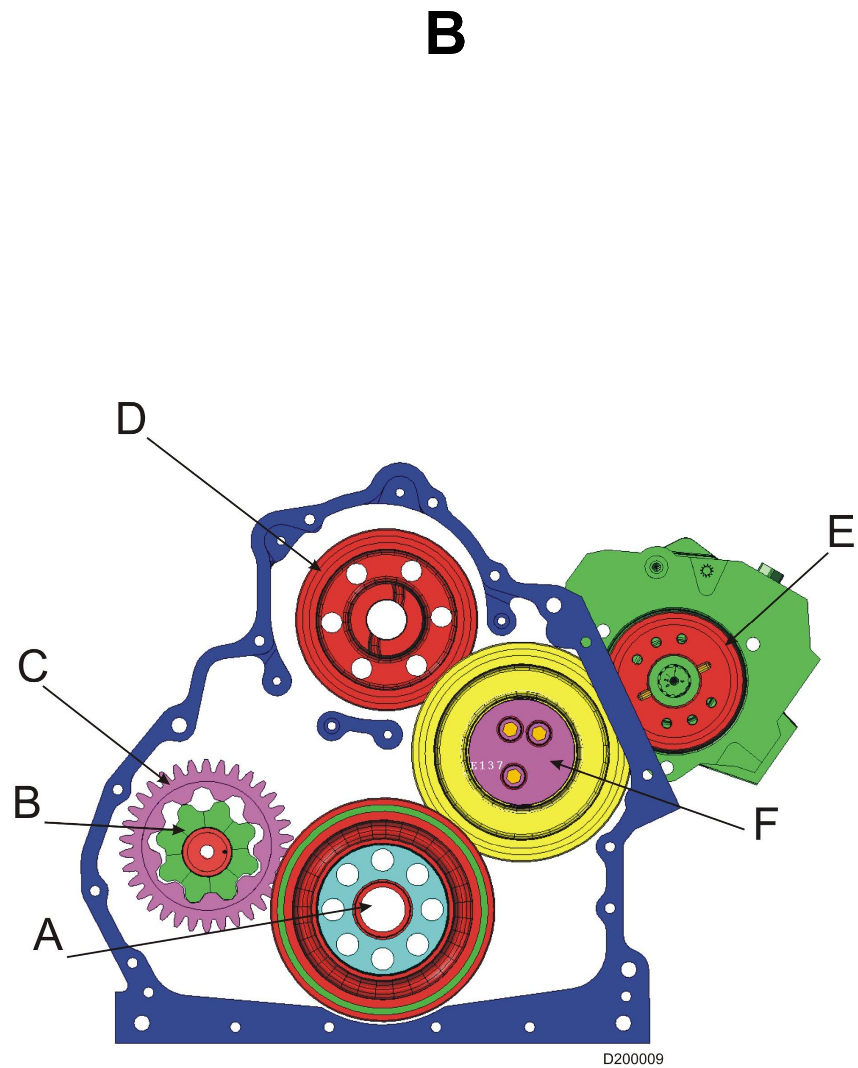
D20075CR


B
D
E
C
B
F
A
D200009

CHECKING VALVE TIMING

Valve timing must always be checked at precisely the specified valve clearances.

D2066 LF01/03 valve clearances: **inlet 0,50 mm/ exhaust 0,60 mm/ with EVB 0,40 mm**

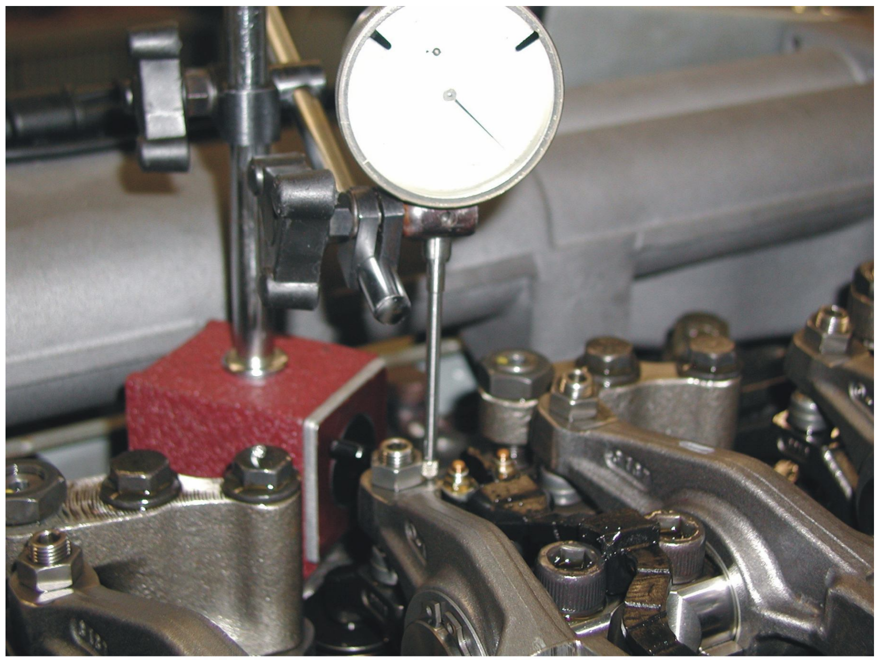
Inlet valve lift **10,00 mm**

D2066 LF01/03 valve clearances: **inlet 0,50 mm / exhaust 0,60 mm / with EVB 0,40 mm**

Exhaust valve lift **12,00 mm**

Proceed as follows:

– Attach the device for turning over the engine to the clutch housing
– Take off the valve cover
– Adjust inlet/exhaust valve clearances correctly
– Set flywheel to **OT (TDC)** (**cylinder 6 valve overlap**)
– Place dial gauge with **app. 10 mm preload** on the head of the inlet valve for cylinder 3, then set to **"O"**
– Turn the engine over in the direction of normal rotation ***(anti-clockwise)*** until the dial gauge pointer no longer moves
– **Valve timing settings must be within the following tolerance ranges as shown on the dial gauge (7,9 – 8,5mm)**
– **Take the valve lifting reading at the dial gauge.**



D20083CR

Valve timing

VALVE TIMING FOR D2066 LF01/03

Inlet opens	**24**° before TDC
Inlet closes	**12**° after BDC
Exhaust opens	**60**° before BDC
Exhaust closes	**30**° after TDC

TIMING CHART

Values in degrees refer to crankshaft rotation.

1 = Direction of engine rotation

2 = Inlet valve opens

3 = Inlet valve closes

4 = Inlet valve opening period

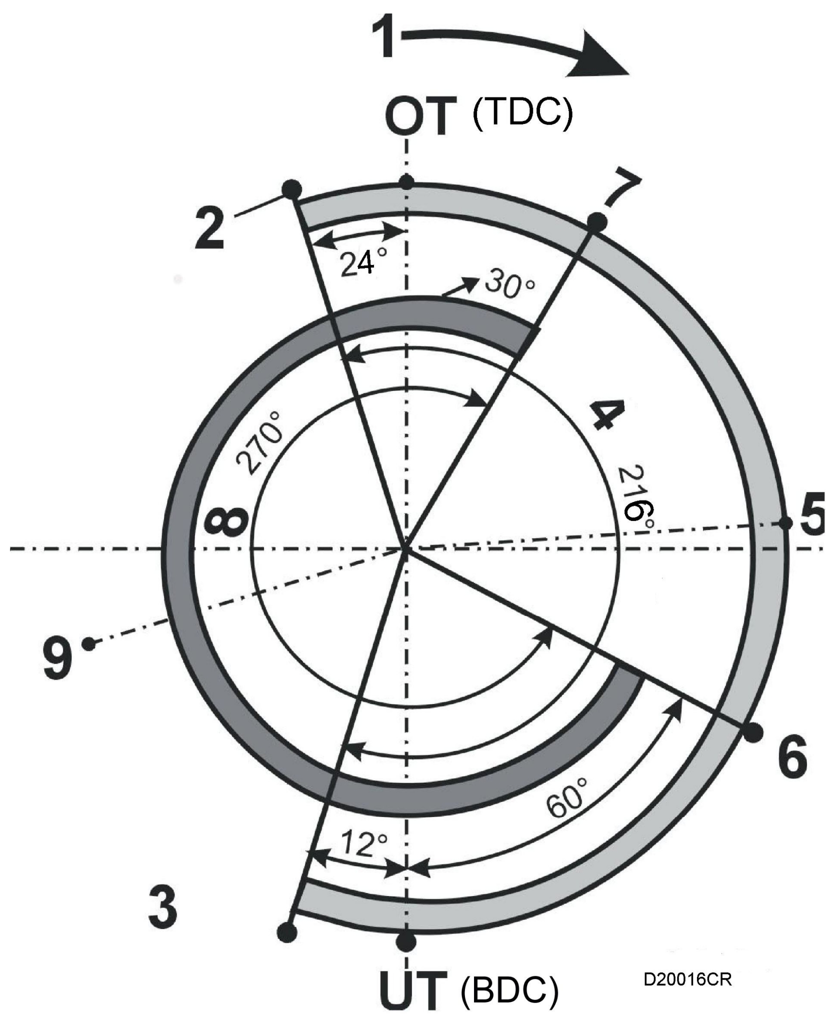
5 = Centre of inlet cam

6 = Exhaust valve opens

7 = Exhaust valve closes

8 = Exhaust valve opening period

9 = Centre of exhaust cam


1
OT (TDC)
2
24°
30°
7
270°
4
216°
5
8
9
6
60°
12°
3
UT (BDC)
D20016CR

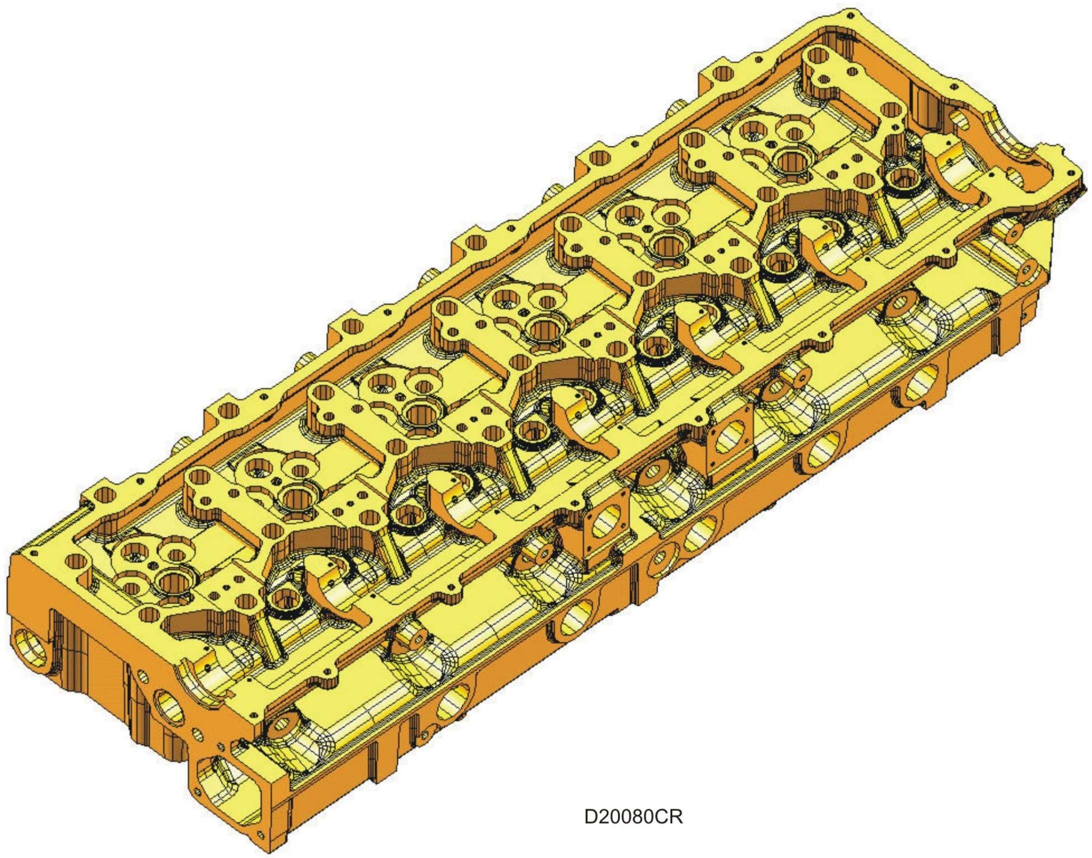
CYLINDER HEAD

These engines have a one-piece cylinder head covering all cylinders and cast from GJL-250 iron. The swirl-pattern inlet ports and the exhaust ports are cast in with shrink-fit inlet and exhaust valve seat rings and pressed-in, replaceable valve guides.

Note:

The cylinder head is designed with a separate coolant flow that is not connected to the water jackets in the engine block.

- Cylinder head gasket without coolant passages
- Cast-on air distribution pipe
- Critical liquid transition points are avoided
- Max. deviation (gap dimension 0,1 mm) from cylinder 1 to cylinder 2
- Cylinder head must not be skimmed at a later date
- Max. 0,4 mm over entire cylinder head



D20080CR

CYLINDER HEAD ATTACHMENT

The complete one-piece cylinder head is attached to the engine block with **26** Torx **E 24** (10.9) bolts that are tightened to a specified wrench angle.
The cylinder head bolts (∅**18 x 2** mm) have crosswise splines.

A Flywheel end

Torx-head bolts for tightening to a specific wrench angle

1) Place the cylinder head in position, align it and insert all bolts in the specified numerical order (first apply Optimol WhiteT to the bolt heads and oil the bolt threads). Tighten the bolts initially to **10 Nm**.

2) Next tightening stage **80 Nm** torque

3) Next tightening stage **300 Nm** torque

4) Next tightening stage **90° + 10°** degrees of angle

5) Final tightening stage **90° + 10°** degrees of angle

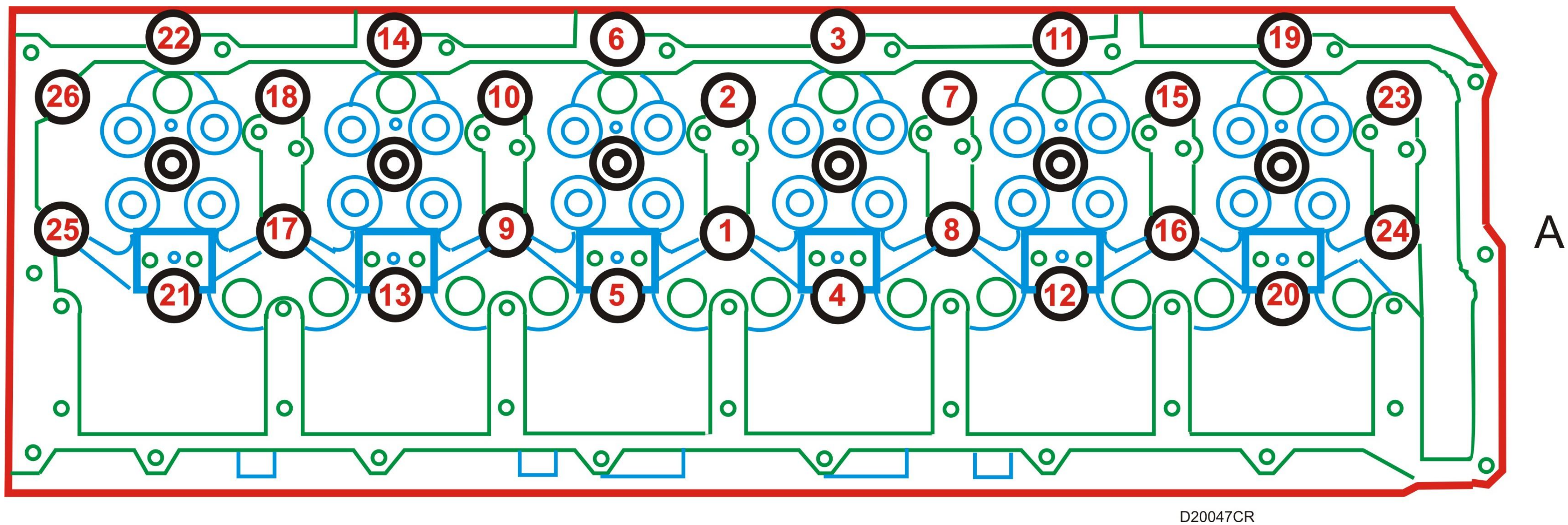
6) Final tightening stage **90° + 10°** degrees of angle

Note:

There is now no need for any slack to be taken up subsequently at the cylinder head bolts.

Note correct tightening sequence (picture 1...2...3...)

Cylinder head bolts must never be re-used.


22
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17
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1
8
16
24
21
13
5
4
12
20
A
D20047CR

Single-piece 4-valve cylinder head, inlet and exhaust valve sides

The inlet and exhaust valves have positive clamping at the 3 grooves in the stem and the wedge-shaped keys. All valves are provided with **valve stem seals** to keep oil consumption to a minimum.

Inlet valve identification:

Spherical recess **"A"** with **big** ∅ in valve head for outlet valve

Spherical recess **"B"** with **small** ∅ in valve head for inlet valve

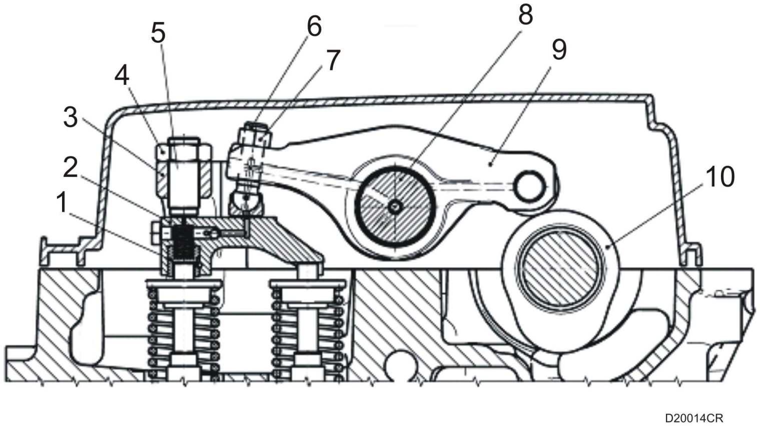
- Inlet valve diameter **40,0 +- 0,1 mm**
- Exhaust valve diameter **38,0 +- 0,1 mm**
- Inlet valve recess in cylinder head **0,60 – 0,80 mm**
- Exhaust valve recess in cylinder head **0,60 – 0,80 mm**

The EVB mechanism is built into exhaust valve bridge “2”. The rocker arms and the EVB are supplied with oil from the rocker arm pivot bearing housing. The EVB counter-holder is located separately.

1 Plunger
2 Valve bridge
3 Counter-holder
4 Locknut (**45 Nm** tightening torque)
5 EVB adjusting screw (**0,40 mm**)
6 Ball-ended adjusting screw (**0,60 mm**)
7 Locknut (**45 Nm** tightening torque)
8 Rocker arm shaft
9 Rocker arm
10 Camshaft
11 Inlet valve adjusting screw
12 Inlet valves
13 Exhaust valves
14 Roller-bearing rocker arms
15 Camshaft

Inlet valve seat angle **120°**

Exhaust valve seat angle **90°**



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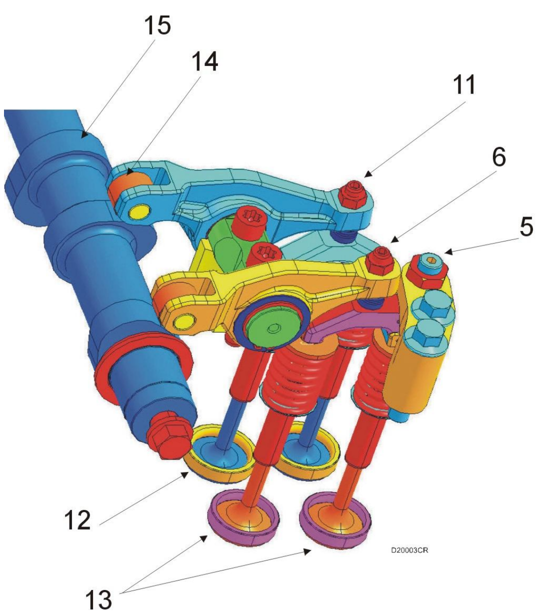
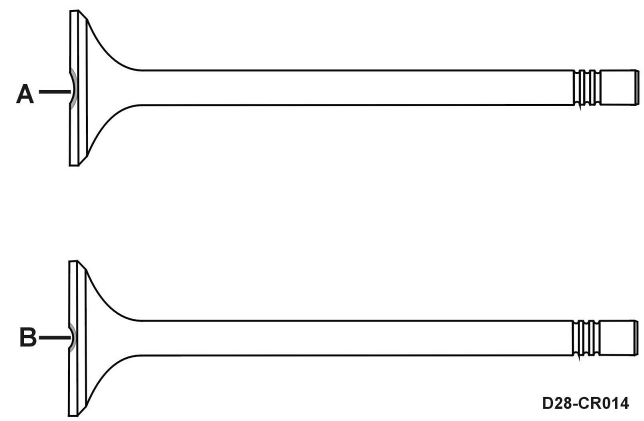
D20014CR



15
14
11
6
5
12
13



A
B
D28-CR014

REMOVING AND INSTALLING INJECTORS

Removing the injector

1. Detach the injector pipe and plug its opening.
2. Remove pressure nut **8** from the pressure stub pipe **4**.
3. Take out pressure stub pipe **4** using the special tool.
4. Remove pressure-flange bolt **6** and clamp **5**.
5. Pull out the injector with the special tool and **keep it in a special safety box**.

NOTE:
Pressure stub pipe **4** must **not** be re-used; always renew the O-ring **3** and the copper washer **2** as well.
After mounting the injector it is recommended to perform a leakage test (explanation on page 93)

Installing the injector

Only remove the transit caps immediately for installation on the engine.

A) Initial tightening of injector with machine screw (**6**): **1 to 2 Nm**

B) Install the thinner end of pressure stub pipe (**4**) towards the injector. Initial tightening of pressure nut: **10 Nm**

C) Final tightening, injector machine screw (**6**): **25** Nm + **90°**

D) Final tightening, pressure stub pipe (**4**): **20** Nm + **60°**

E) Connecting high-pressure lines from and to rail:

- Screw up the rail retaining screws hand-tight only (3x M8 x 50 – 10.9)
- **1st step:** Tighten all injector pipes firmly at both ends to **10 Nm** torque.
  2nd step: Tighten rail to **35** Nm torque.
- Final tightening of all injector pipes **10 Nm + 60°**.

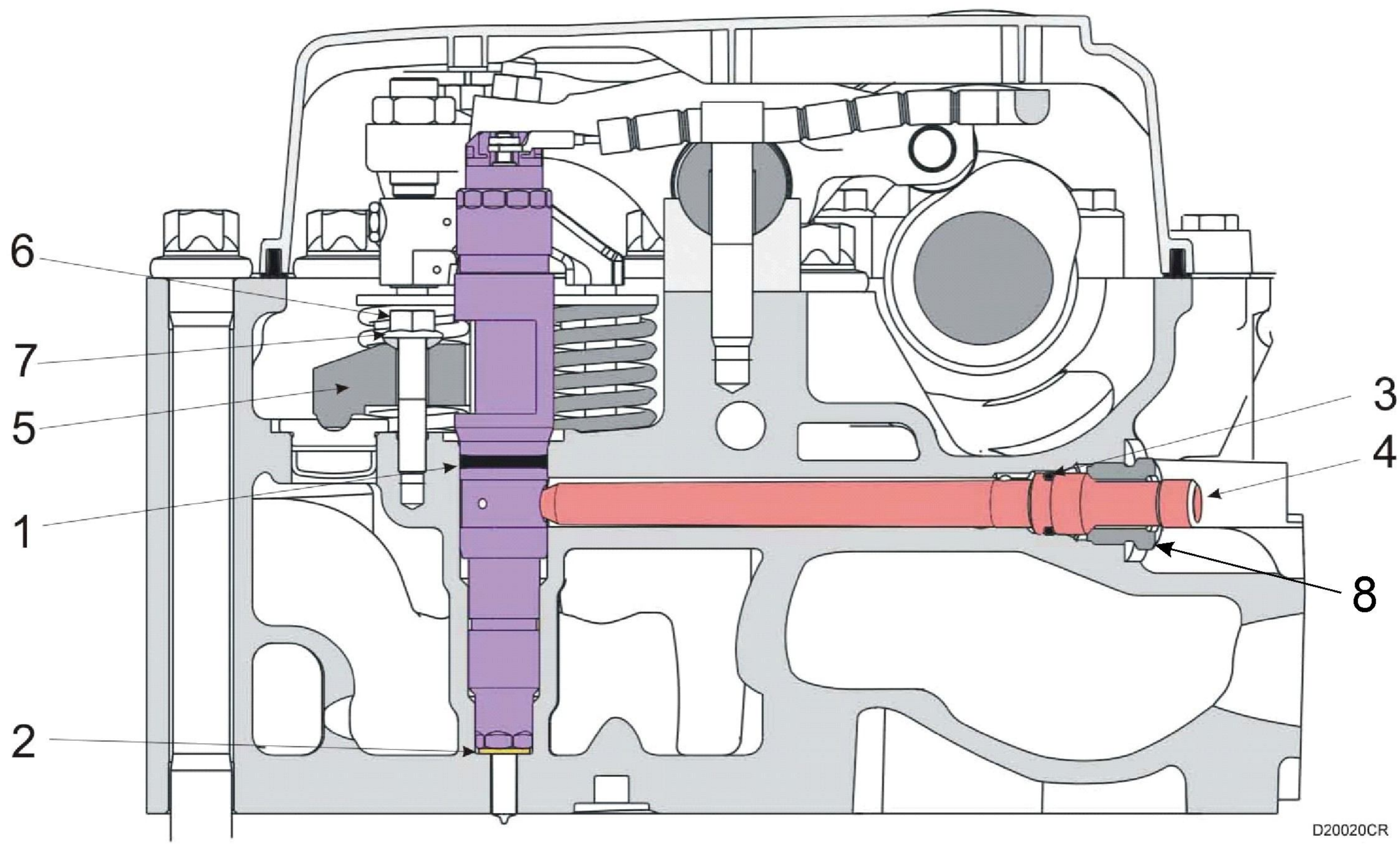
F) Tightening torque for M4 – **1,5 Nm**

Key

1 O-ring (grease before installing)
2 Copper shim
3 O ring
4 Pressure stub pipe
5 Clamp
6 Pressure-flange bolt
7 Conical washer
8 pressure pipe nut

Note:

High-pressure lines must be installed free from trapped stresses, and with no risk of abrasion.


6
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D20020CR

ROCKER ARM PIVOTS

To dismantle the rocker arms, the Seeger circlips **D** are first removed from the pivot shaft **C** and the shaft then removed.

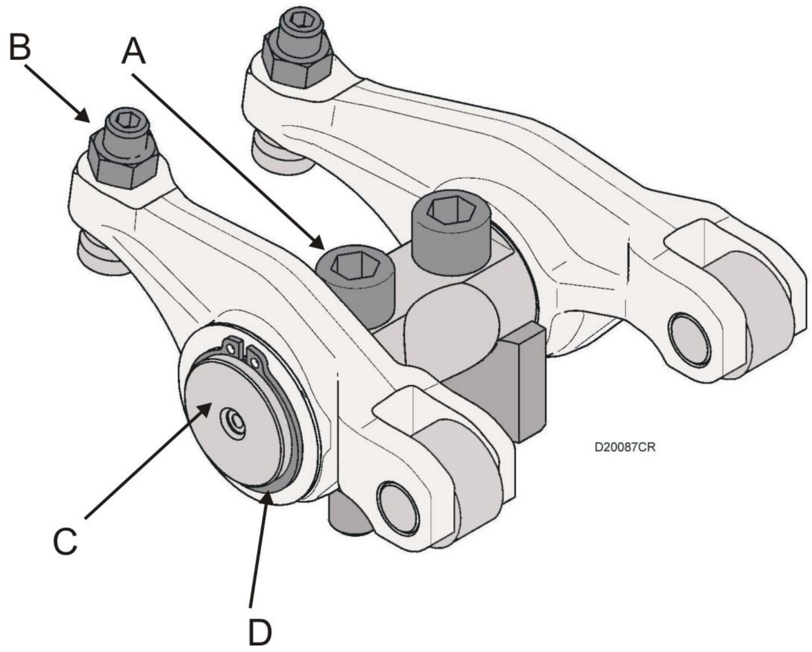
Tighten retaining screw **A** to **105** Nm torque (M12x10,9).

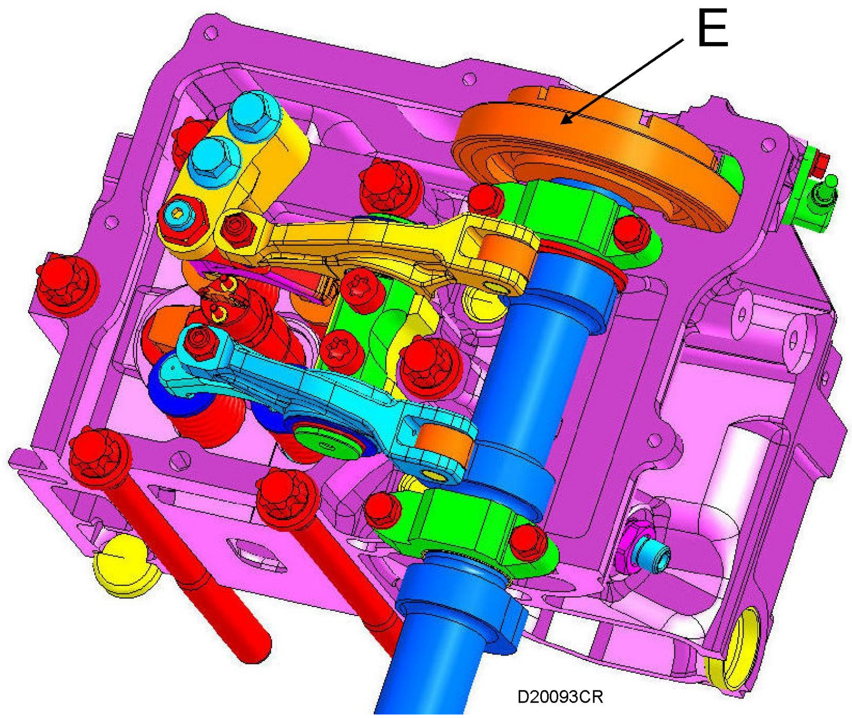
Tighten locknut **B** to **40** Nm torque.

Tighten camshaft gearwheel screw **E** to **150** Nm + **90**° of angle.

New:

The camshaft gearwheel is secured by three screws.


B
A
C
D
D20087CR


E
D20093CR

ADJUSTING VALVE CLEARANCES

Each cylinder has two inlet and two exhaust valves. The valves are opened by the camshaft by way of forged rocker arms with roller tappets.
The rocker arm transmits its movement to the valve by way of an adjusting screw with ball end and a forged valve bridge that is located only by the ends of the valve stems.

The rockers arms pivot on wear-resistant shafts that are pressed into a rocker arm bearing housing and bolted down together with the cylinder head. The EVB mechanism is built into the exhaust valve bridge. Oil is supplied to the rocker arm bearings and the EVB from the rocker arm bearing housing.

Tighten the valve cover sealing screws working from the inside outwards.

.

Valve operating layout

I Valves on overlap

II Cylinders to be adjusted

Checking valve clearances

Adjust valve clearances when the engine is cold **< 50°C**.

Inlet valve clearance = **0,50 mm**

Exhaust valve clearance **without EVB** = **0,60 mm**

Exhaust valve clearance **with EVB = 0,60 mm / 0,40 mm**

Cylinder sequence

1 Fan end

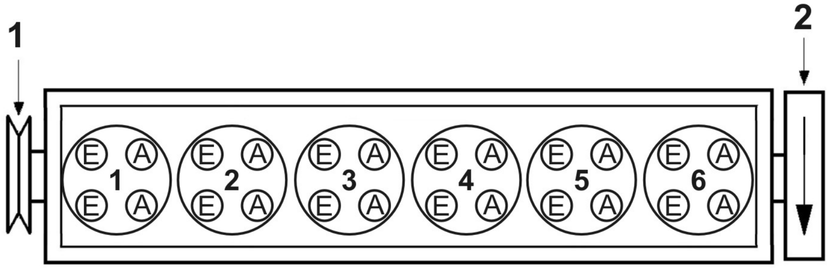
2 Flywheel end

E Inlet valve side

A Exhaust valve side

Firing order – D 2066

1 - 5 - 3 - 6 - 2 - 4



I	6	2	4	1	5	3
II	1	5	3	6	2	4

D20061CR

Valves

6. Zyl. auf Überschneidung

Ventile

1.Zylinder		2. Zylinder		3. Zylinder		4. Zylinder		5. Zylinder		6. Zylinder	
Ein	Aus	Ein	Aus	Ein	Aus	Ein	Aus	Ein	Aus	Ein	Aus
50	60	50	X	X	60	50	X	X	60	X	X

EVB

1.Zylinder	2. Zylinder	3. Zylinder	4. Zylinder	5. Zylinder	6. Zylinder
40	X	40	X	40	X

Turning engine over (360 degrees

Ventile

1.Zylinder		2. Zylinder		3. Zylinder		4. Zylinder		5. Zylinder		6. Zylinder	
Ein	Aus	Ein	Aus	Ein	Aus	Ein	Aus	Ein	Aus	Ein	Aus
X	X	X	60	50	X	X	60	50	X	50	60

EVB

1.Zylinder	2. Zylinder	3. Zylinder	4. Zylinder	5. Zylinder	6. Zylinder
X	40	X	40	X	40

D28-CR027

EXHAUST VALVE BRAKE - EVB;

All D 2066LF engines for TGA trucks are equipped with EVB. The braking effect is about 60 % greater than with a conventional exhaust brake system.

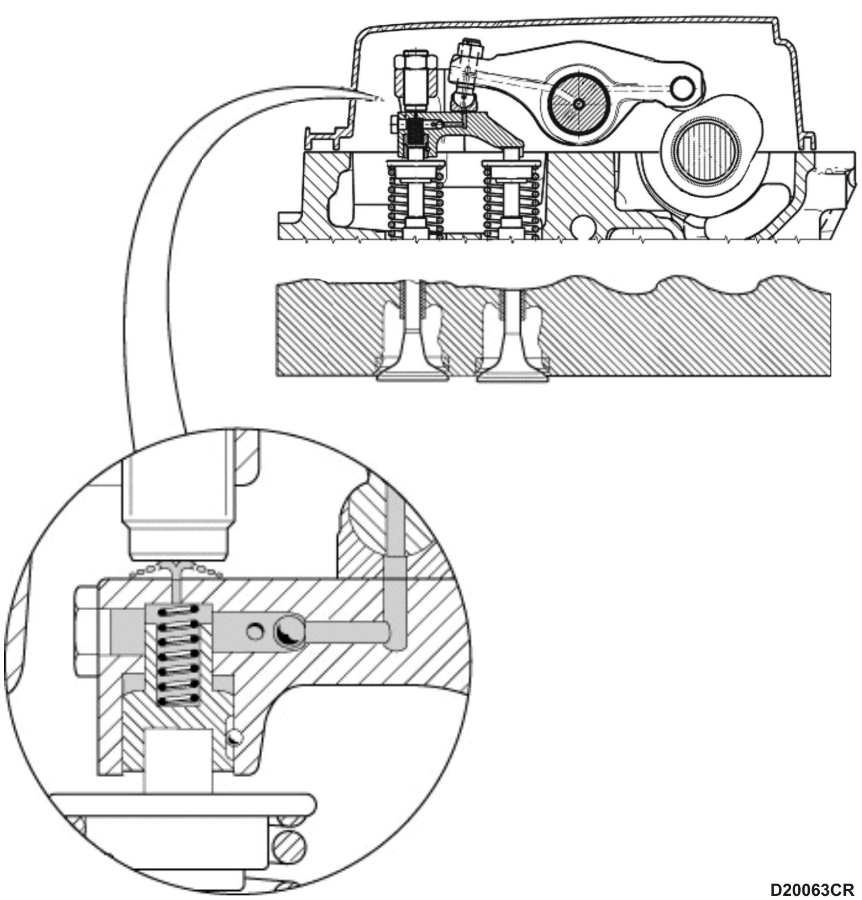
There is a hydraulic plunger pressurised with engine oil in the exhaust valve bridge. The oil pressure is able to escape through a relief hole. Above the valve bridge is the counter-holder, the adjusting screw of which seals the relief hole when the exhaust valve is closed.

When the camshaft opens the valve, the relief hole is exposed and oil pressure from the plunger can escape.

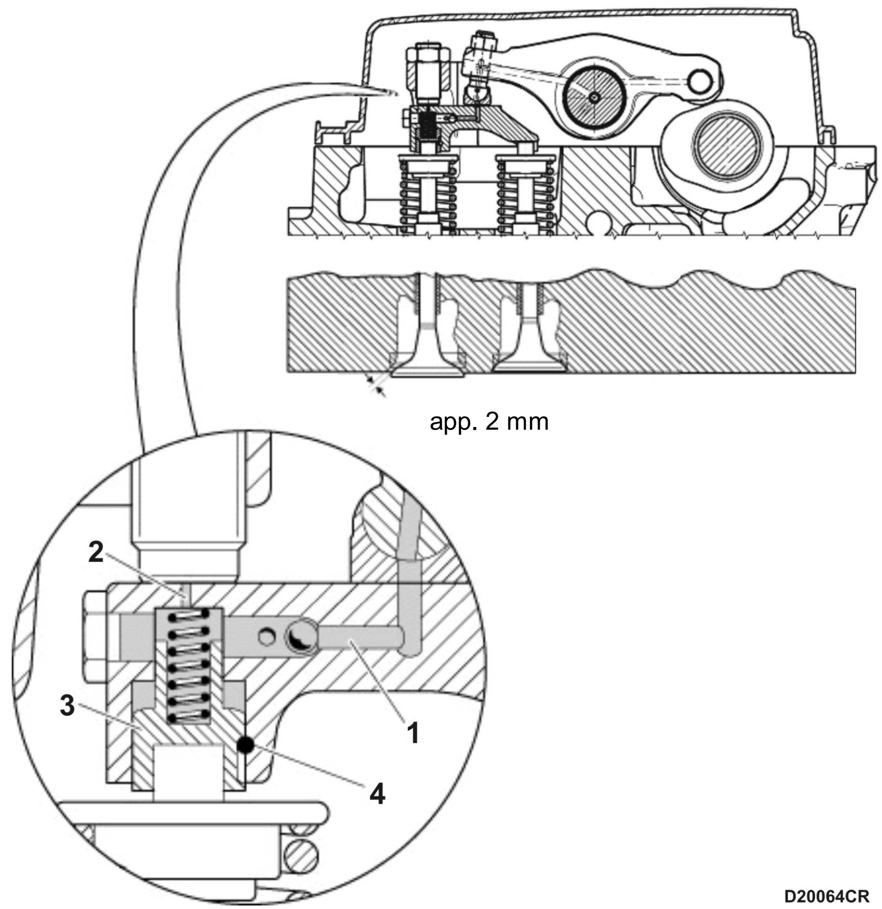
If the exhaust brake flap valve is closed, pressure waves build up in the exhaust manifold and cause the exhaust valves to open briefly, in other words each time the exhaust valve closes it is re-opened for a brief period.

Since the plunger is exposed to oil pressure, it moves after the valve as this opens briefly, but cannot return because the counter-holder has closed the relief hole and the non-return valve the oil feed hole.

The exhaust valve therefore remains slightly open during the compression stroke and the subsequent expansion stroke. This prevents the compression action of the piston from having any effect, so that the crankshaft is not driven and the engine’s braking effect increases.



D20063CR



D20064CR

EVB AND VALVE CLEARANCE ADJUSTMENT

Valve clearances are to be checked in accordance with the specified service intervals and adjusted if necessary. The inlet valve values are the same for engines with or without EVB.

Adjusting exhaust valve clearances:

Turn the piston in the cylinder for which the valves are to be adjusted to top dead centre on the ignition stroke.

Slacken off adjusting screw in the counter-holder as far as possible **without using force**.

NOTE:

Press down on the valve bridge with a screwdriver to expel engine oil from the plunger.

Slacken off adjusting screw until feeler gauge **D (0,60 mm)** can be slid in between the rocker arm **F** and the valve bridge **G**.

Tighten adjusting screw until the feeler gauge can no longer be moved (This will also force the plunger back).

Slacken off adjusting screw again, but only until the feeler gauge can be pulled out with moderate resistance to its movement.

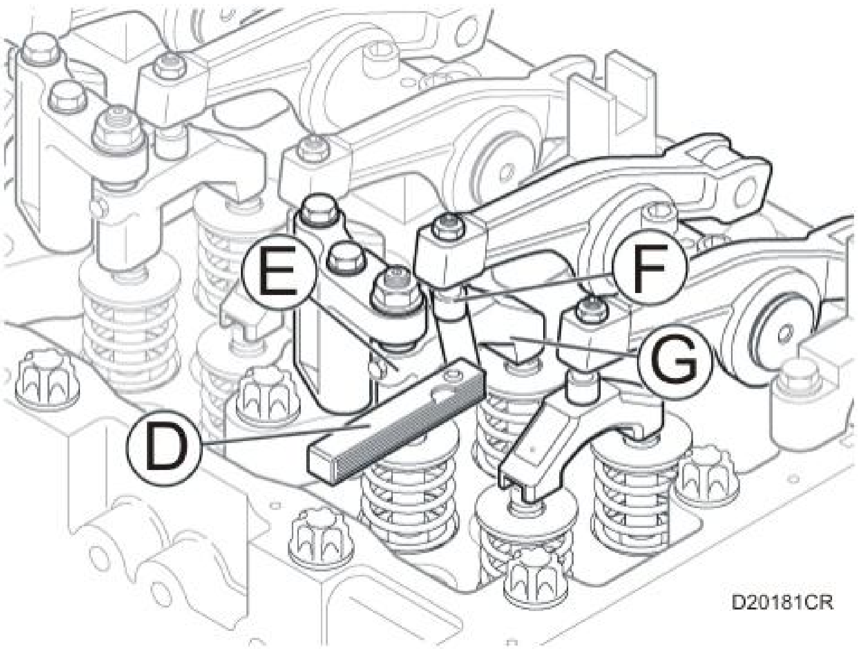
Tighten locknut to **40 Nm** torque.

Slide the feeler gauge **H 0,40** mm between the valve bridge **J** and screws **I**.

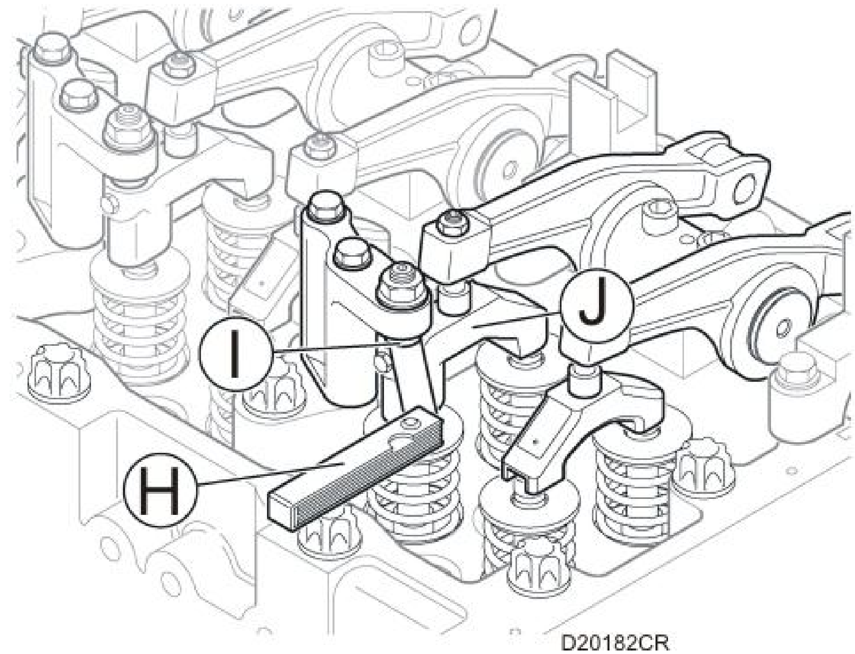
Hold the plunger down and tighten adjusting screw until the feeler gauge cannot be moved.

Slacken off adjusting screw again, but only until the feeler gauge can be pulled out with moderate resistance to its movement.

Tighten locknut to **40 Nm** torque.



E
F
G
D
D20181CR



J
I
H
D20182CR

ENGINE (EXHAUST) BRAKE – PRESSURE-REGULATED EVB

The **pressure-regulated EVB** has been developed to limit excessive scatter in braking performance and to permit integration into the brake management system. The aim was to regulate engine braking performance indirectly by varying exhaust back-pressure. By varying the pressure in the exhaust system, the braking power can be continuously varied and performance fluctuations caused by tolerances avoided.

In order to obtain the necessary exhaust back-pressure with the pressure-regulated EVB system, the pressure applied to the exhaust flap valve actuating cylinder is varied as necessary, There is no torsion spring on this flap valve. The applied pressure is varied by a proportional-action valve that is actuated by the vehicle management computer (FFR) with a pulse-width modulated (PWM) electrical signal. The exhaust back pressure is regulated by measuring its value with a pressure sensor and transmitting this information to the FFR.

The regulating unit integrated into the FFR uses the input values supplied to it (exhaust back-pressure, engine speed, desired braking performance, voltage of vehicle’s electrical system, compressed air supply etc.) to calculate the pulse width of the output signal.

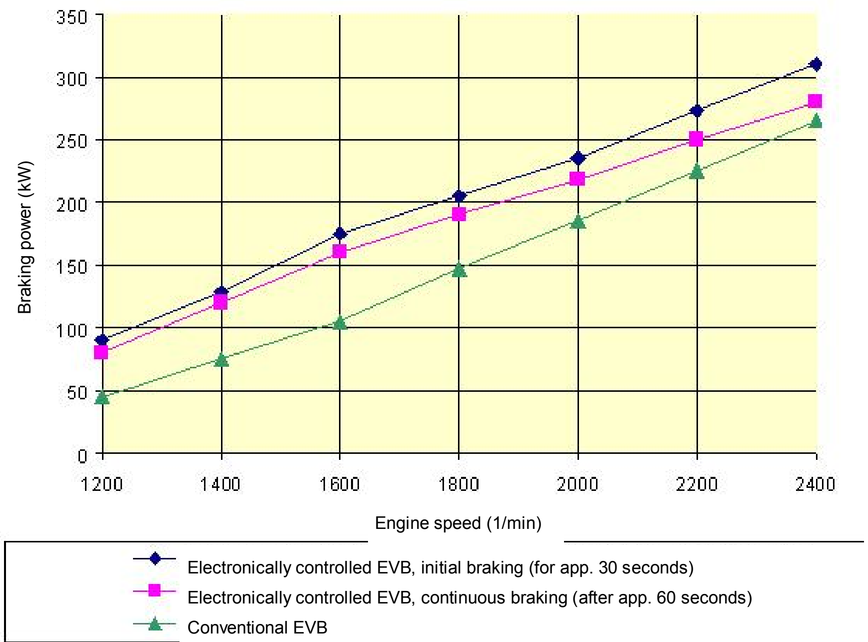
The proportional-action valve, the sensor and the rigid brake flap are incorporated into a single assembly.

In order to reduce the thermal load on components during lengthy brake applications, an engine-speed and time-dependent strategy is used to reduce maximum braking torque slightly.

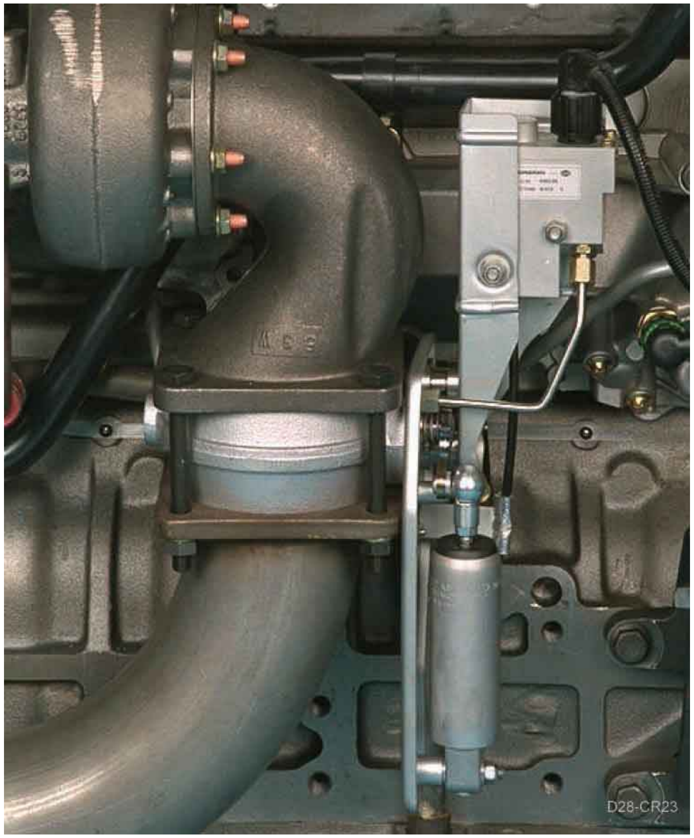
When the system is actuated, the highest permissible exhaust back pressure is used for a short period ***(INITIAL BRAKING).***

After about 30 seconds, the exhaust back-pressure is gradually reduced to the continuous braking value.

This regulating process is complete after about 1 minute, after which the exhaust back-pressure remains at the permissible level for continuous braking.



350
300
250
200
150
100
50
0
Braking power (kW)
1200
1400
1600
1800
2000
2200
2400
Engine speed (1/min)
Electronically controlled EVB, initial braking (for app. 30 seconds)
Electronically controlled EVB, continuous braking (after app. 60 seconds)
Conventional EVB


D28-CR23

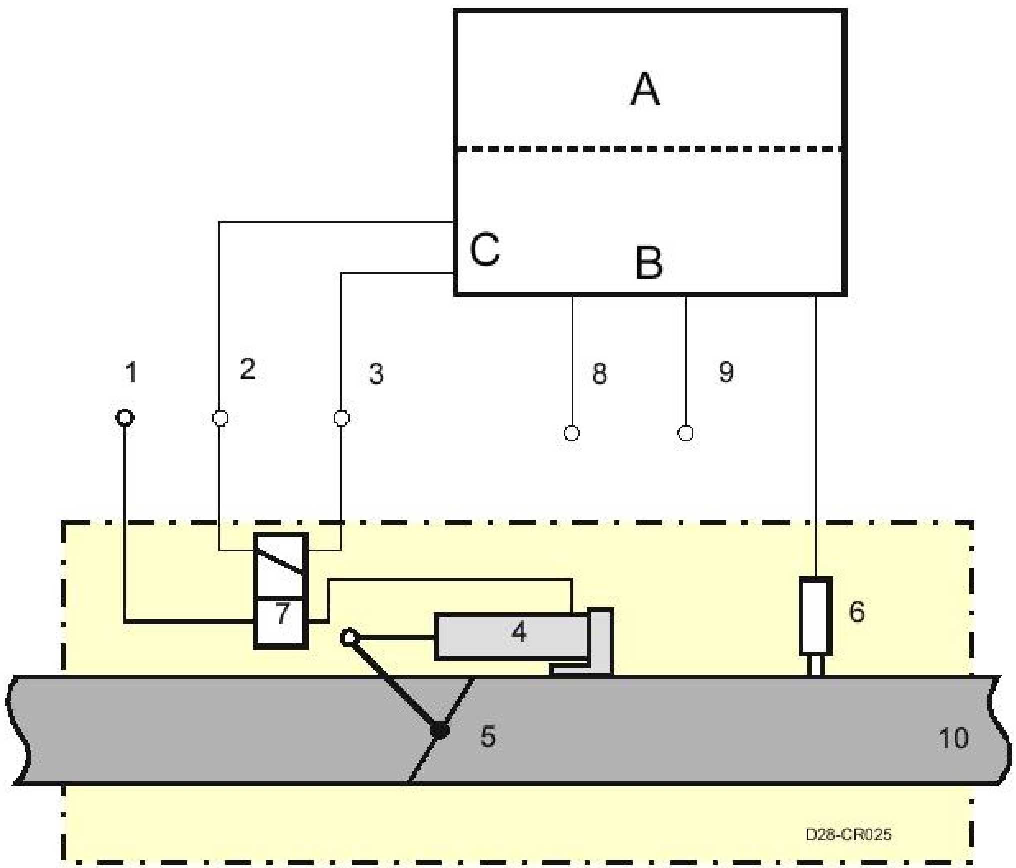
Advantages compared with previous non-pressure regulated EVB:

- Engine braking moment can be continuously varied.
- The regulated exhaust brake can be set to the maximum possible or permissible engine braking torque over the entire engine-speed range. This makes distinctly higher braking power available at low engine speeds in particular.
- The pressure-regulated EVB is used to reduce the thermal load on critical assemblies. After a limited period of braking at full exhaust back pressure, the system is reduced to the predetermined speed-dependent continuous braking power.
- The pressure-dependent EVB greatly reduces the strong hysteresis effect of the torsion-spring flap (different braking power according to whether engine speed is falling or rising).
- There is no torsion spring in the brake flap valve, since it is less affected by external influences.
- Provision for diagnosis makes it much easier to check the functioning of the exhaust brake.

Functional diagram of electronically regulated exhaust valve flap

- **1** Compressed air connection
- **2** Pulse-width modulated actuator signal + plug 4/14
- **3** Pulse-width modulated actuator signal – plug 1/3
- **4** Actuating cylinder
- **5** Brake flap
- **6** Exhaust back-pressure sensor analog signal plug 3/4
- **7** Proportional-action valve
- **8** Road speed signal
- **9** Engine speed
- **10** Exhaust back-pressure

- **A** Vehicle management computer (FFR)
- **B** Input signals 8/9
- **C** Output signals 2/3


A
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D28-CR025

BOOST PRESSURE - INTERCOOLER

Minimum boost pressure at full load

When determining the boost pressure, please note that the measurement must be taken after the charge-air intercooler and at constant full load.

Minimum boost pressures

Engine type: D 20..

⇒ D2066 LF 01	min	2000 mbar
⇒ D2066 LF 03	min	1600 mbar

The purpose of the charge-air intercooler is to reduce the temperature of the charge air after it has been increased by compression in the turbocharger.

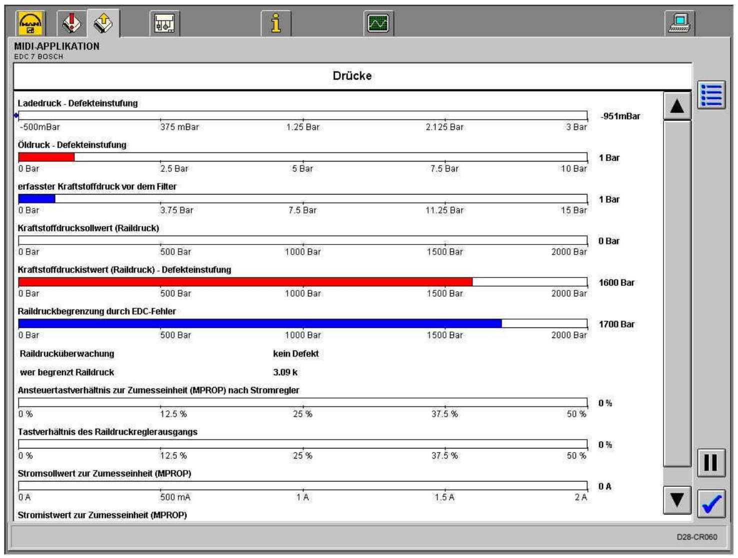
As a result, the combustion air entering the engine is at a lower temperature.

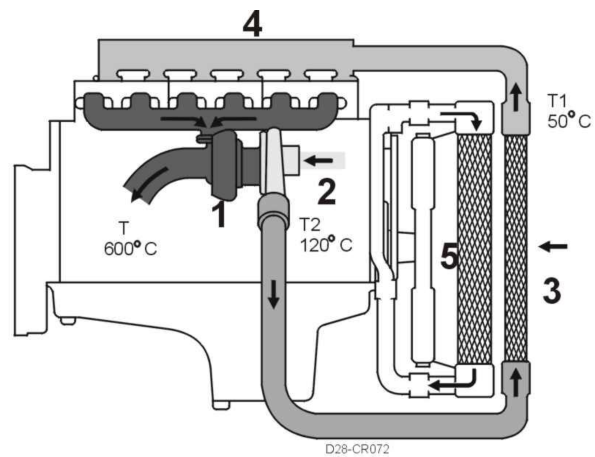
Compressing the charge air yields higher power output and reduces fuel consumption; if the temperature of the charge air is also lowered, the thermal loads on the engine are minimised and the exhaust gas temperature – and therefore emissions of oxides of nitrogen (NOx) – are reduced.

Checking boost pressure

The engine must be at its regular operating temperature.

The boost pressure stated for various engine speeds is obtained at full load after the engine speed has remained constant for about 3 minutes.


MIDI-APPLIKATION
EDC 7 BOSCH
Drücke
Ladedruck - Defekteinstufung
-500mBar 375 mBar 1.25 Bar 2.125 Bar 3 Bar
-951mBar
Öldruck - Defekteinstufung
0 Bar 2.5 Bar 5 Bar 7.5 Bar 10 Bar
1 Bar
erfasster Kraftstoffdruck vor dem Filter
0 Bar 3.75 Bar 7.5 Bar 11.25 Bar 15 Bar
1 Bar
Kraftstoffdrucksollwert (Raildruck)
0 Bar 500 Bar 1000 Bar 1500 Bar 2000 Bar
0 Bar
Kraftstoffdruckistwert (Raildruck) - Defekteinstufung
0 Bar 500 Bar 1000 Bar 1500 Bar 2000 Bar
1600 Bar
Raildruckbegrenzung durch EDC-Fehler
0 Bar 500 Bar 1000 Bar 1500 Bar 2000 Bar
1700 Bar
Raildrucküberwachung kein Defekt
wer begrenzt Raildruck 3.09 k
Ansteuertastverhältnis zur Zumesseinheit (MPROP) nach Stromregler
0 % 12.5 % 25 % 37.5 % 50 %
0 %
Tastverhältnis des Raildruckreglerausgangs
0 % 12.5 % 25 % 37.5 % 50 %
0 %
Stromsollwert zur Zumesseinheit (MPROP)
0 A 500 mA 1 A 1.5 A 2 A
0 A
Stromistwert zur Zumesseinheit (MPROP)
D28-CR060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50° C
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D28-CR072

TURBOCHARGER

Before renewing the turbocharger, perform the following checks:

IF OIL CONSUMPTION IS TOO HIGH:

- Check that the air cleaner is not blocked
- Check for a reduction in the air intake cross-section (e.g. damage, partial blockage with dirt)
- Both these faults can increase oil consumption by creating manifold depression (partial vacuum).

IF ENGINE POWER OUTPUT IS TOO LOW:

Before satisfactory engine performance can be obtained, the

- valve clearances must be correct
- exhaust brake must be fully open.

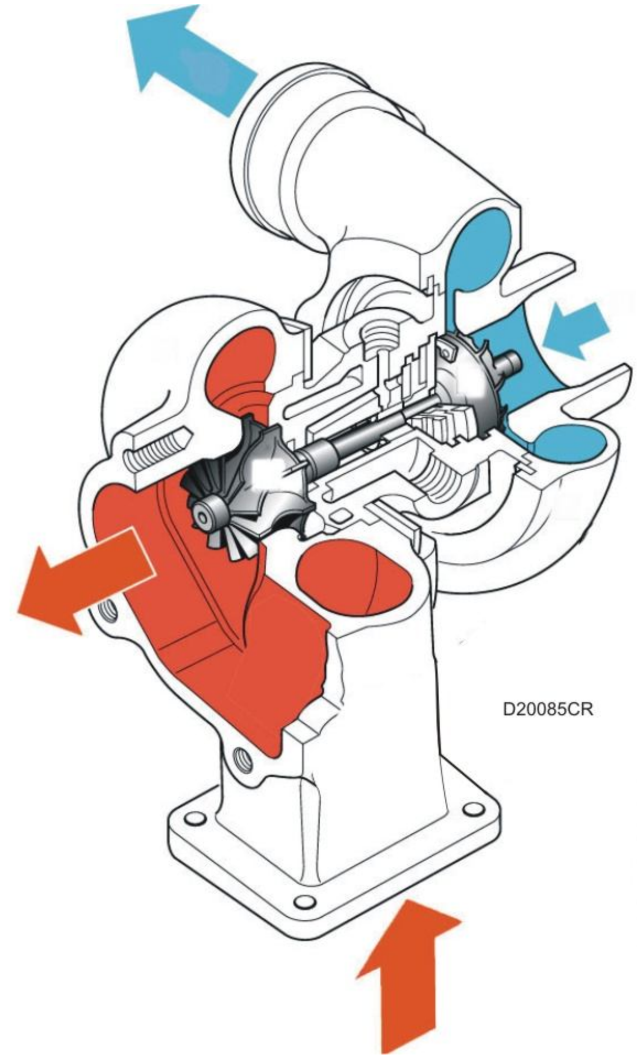
IN ADDITION, CHECK

- boost pressure
- compression pressure
- dirt blocking the air cleaner
- reduction in intake air path cross-section or air leaks
- damage to the exhaust system.

If none of these fault are detected, check the turbocharger for

- carbonisation in the turbine area which could impede free rotation (this fault can also be rectified by axial movement)
- severe dirt blockage in the compressor area
- damage by foreign bodies
- turbine rotor scraping against housing.

If very dirty, clean the compressor side of the turbocharger and check bearing play.


D20085CR

EXHAUST GAS RECIRCULATION (EGR)

In order to obtain good economy, high energy utilisation and low consumption from the **Euro 3** engines as well, the D2066LF01/02/03... engines are equipped with an externally regulated exhaust gas recirculation system.

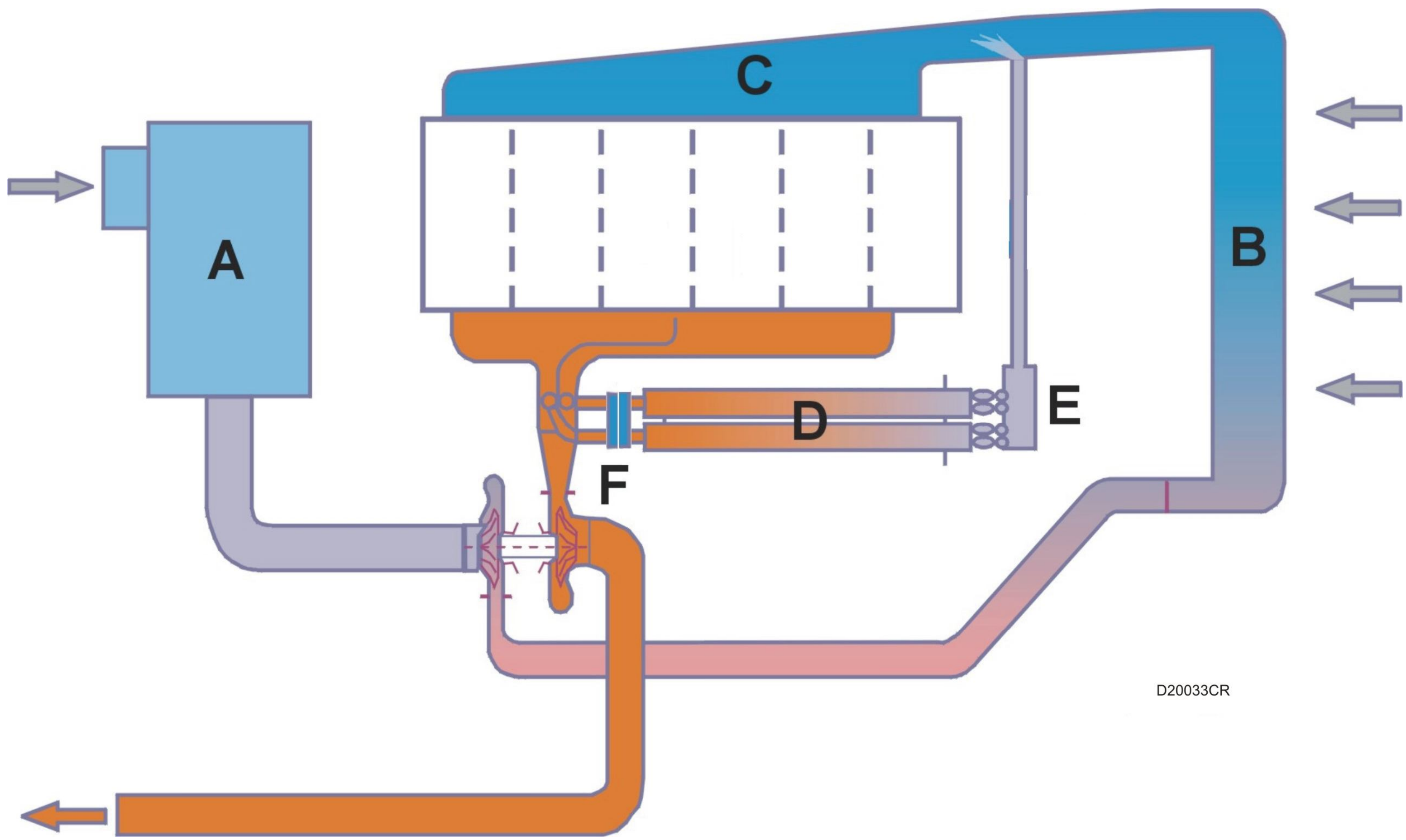
The EGR diverts part of the exhaust gas from the combustion process (about 10 %) back to the cylinders. This lowers the combustion temperature and therefore reduces NO_x emissions. By suitably modifying the start of fuel injection, fuel consumption can also be lowered in this way.
EGR draws gas from both flows through the exhaust manifold.

A shutoff flap valve is provided to close the EGR system in certain engine operating situations (for example when the exhaust brake is in use). This flap is actuated by a compressed-air cylinder, into which the solenoid valve and a limit-of-travel sensor are integrated.

The hot exhaust gas is supplied to the EGR module via corrugated-tube compensators. In the module, it first flows in two streams through a stainless steel multi-tube heat exchanger. It is cooled from approximately 700 °C to below 200 °C by means of engine coolant passing through the EGR cooler.

Further downstream there is a peak pressure valve in each exhaust gas flow; these valves allow the gas to pass but prevent any return flow. This is essential because of the positive scavenging effect at high engine loads. The two gas flows are then combined. The cooled gas then passes as a single stream through a corrugated-tube compensator and is injected into the intake airflow in the air distributor pipe.

A Air cleaner
B Charge-air intercooler
C Engine intake manifold
D EGR cooler
E Peak pressure valves
F Electro pneumatic shutoff flap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EGR actuating flap remains closed

The exhaust gas recirculation is shut down if ...	This is to prevent ...
- charge-air temperature is below **10°C**	condensation from causing sulphurous acid deposits in the cold intake air.
- charge-air temperature is above **70°C**	the charge air from being heated up too much by the recirculated exhaust gas.
- coolant temperature is above **95°C**	the engine from overheating.
- the engine is running in a dynamic mode.	the engine from suffering a drop in power output and the exhaust brake's performance being reduced.
- and the exhaust brake is active.	

Adjusting the EGR compressed-air cylinder

Adjust the ball end **E** of the compressed-air cylinder, so that it can be attached with about **4 mm** of preload when the shutoff flap is closed (max. stroke 30 mm)

A Input, cylinders 1 to 3

B Input, cylinders 4 to 6

C EGR flap

D Peak pressure valves

Exhaust pipes (stainless steel)

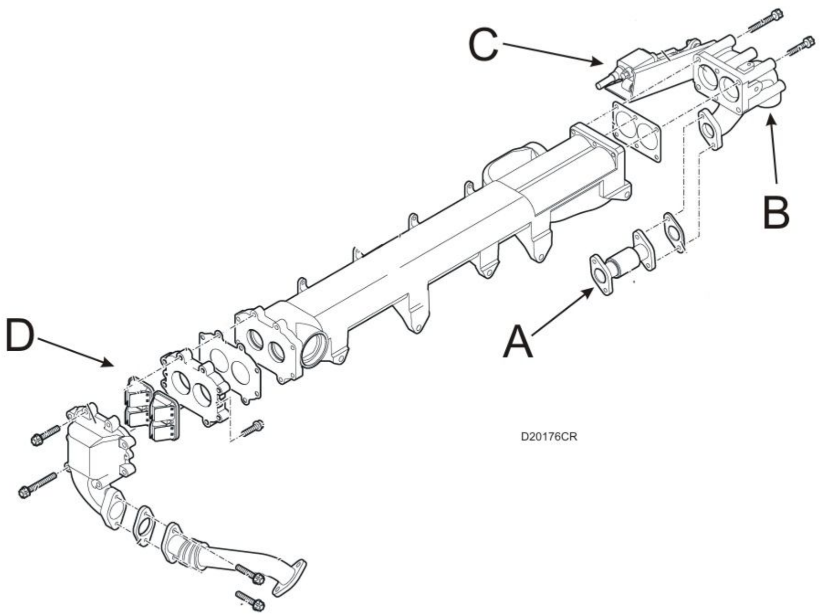
- Compressed-air actuating cylinder for shutoff flap
- Solenoid valve for cylinder actuation
- Reed contact for feedback of piston rod position to EDC control unit

F compressed-air supply

G electrical connection

- Pin 1 (3100) – pin 2 (60367) < 1 Ω

- Pin 3 (60031) – pin 4 (60153) **34 – 47** Ω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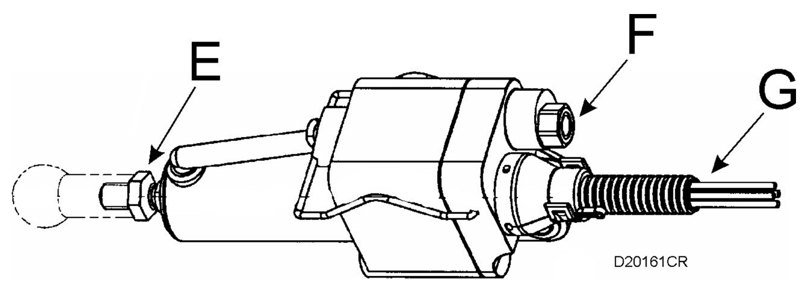
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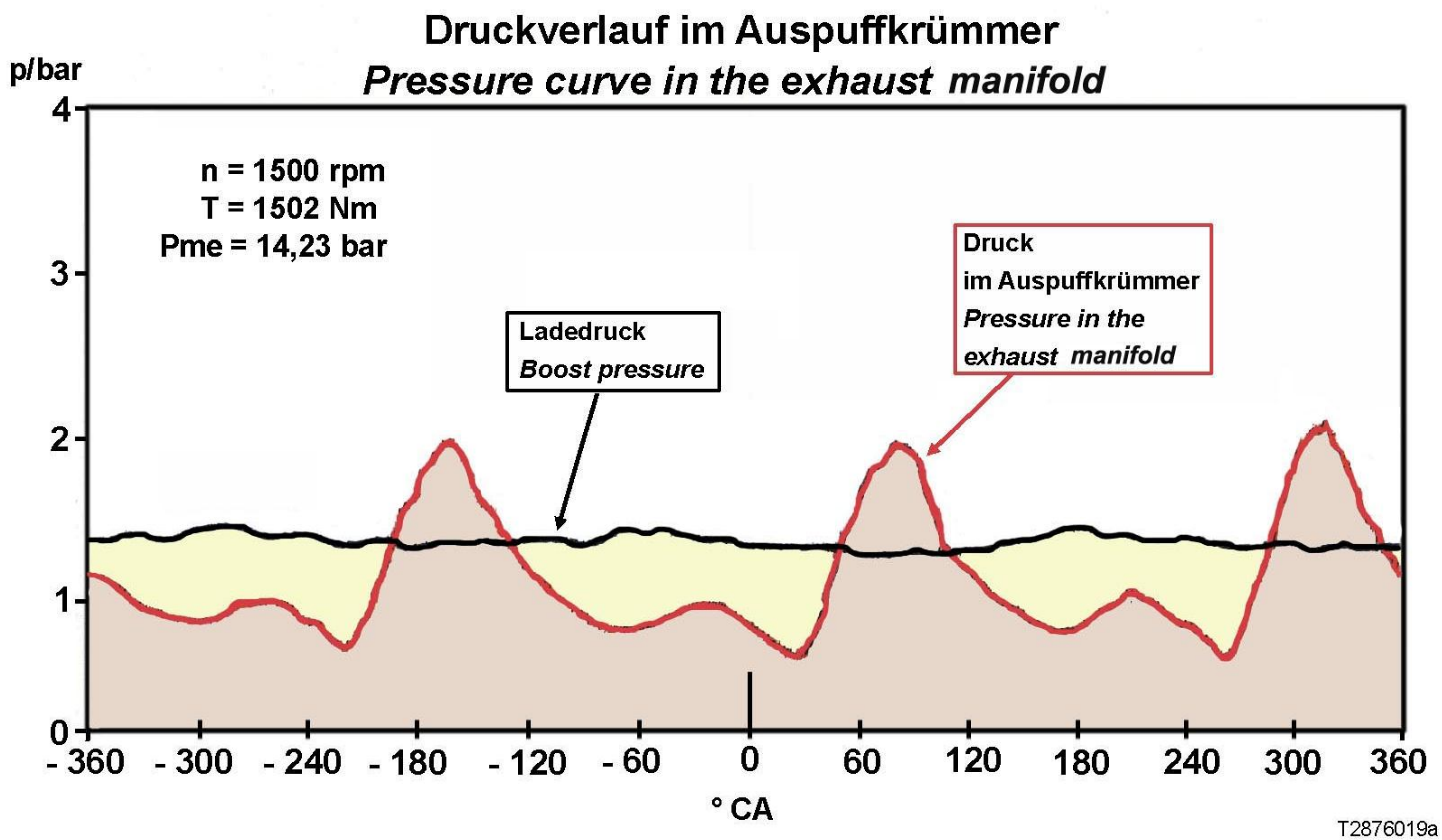
Pressure patterns in the exhaust manifold

Pressure peaks occur in the exhaust manifold.

It is only these pressure peaks that can be recirculated to the combustion chambers.

The pressure peaks used for this purpose are higher than the maximum turbocharger boost pressure.



Druckverlauf im Auspuffkrümmer
Pressure curve in the exhaust manifold
p/bar
4
3
2
1
0
n = 1500 rpm
T = 1502 Nm
Pme = 14,23 bar
Ladedruck
Boost pressure
Druck
im Auspuffkrümmer
Pressure in the
exhaust manifold
- 360
- 300
- 240
- 180
- 120
- 60
0
60
120
180
240
300
360
° CA
T2876019a

V-BELT DRIVES

V-BELTS

A ribbed V-belt (Poly-V belt) is used.

Detaching and installing **Poly –V** belts

Loosen the tensioner pulley screw.

A Air conditioning compressor

B Vibration damper

C Belt drive

D Flange for cooling fan

E Belt tensioner

F Idler pulley

G Alternator pulley

H Pulley

I Coolant pump

J Poly –V belt

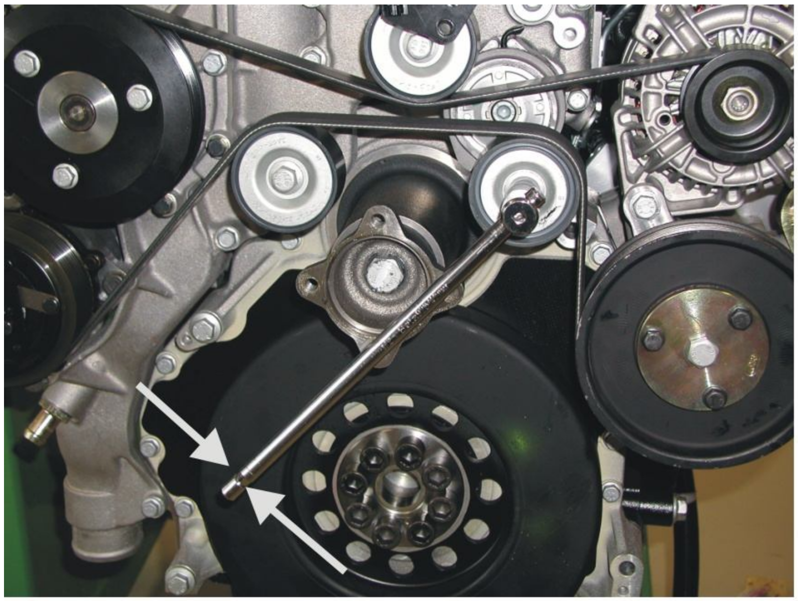
V-BELT TENSIONER

The automatic belt tensioner uses a sprung pulley.

NOTE:

Dismantling

Turn the central screw in the tensioner pulley with a ring wrench.



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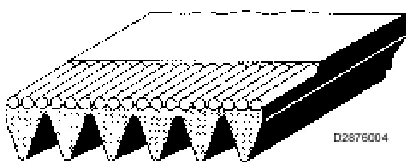
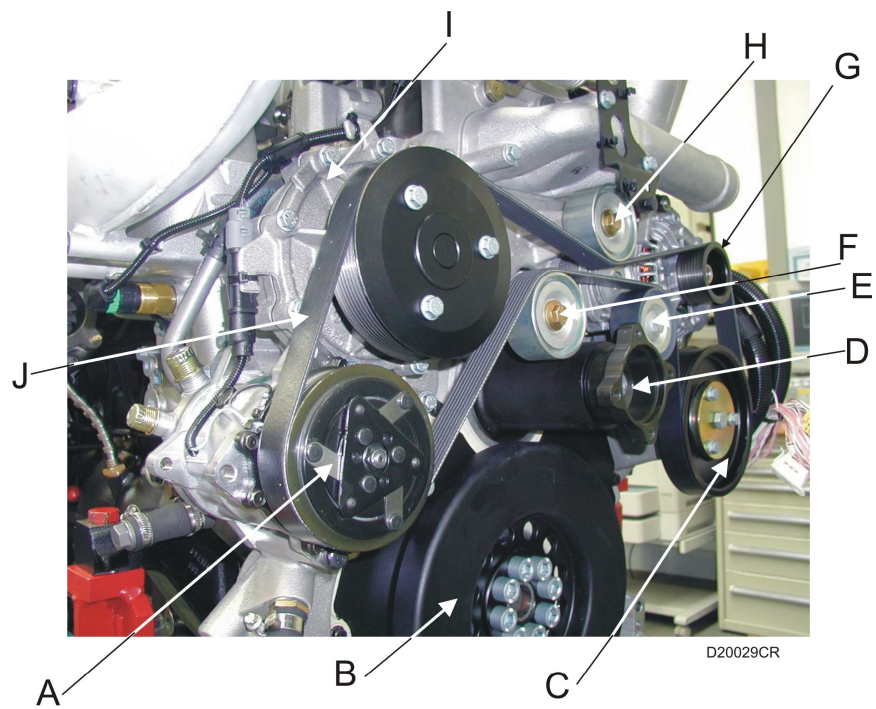




FAN MOUNT

1 Drive gear

2 Roller bearing

3 Loctite 5900 sealant

4 Ball thrust bearing

5 Shaft sealing ring, pressed in flush

6 Fan hub

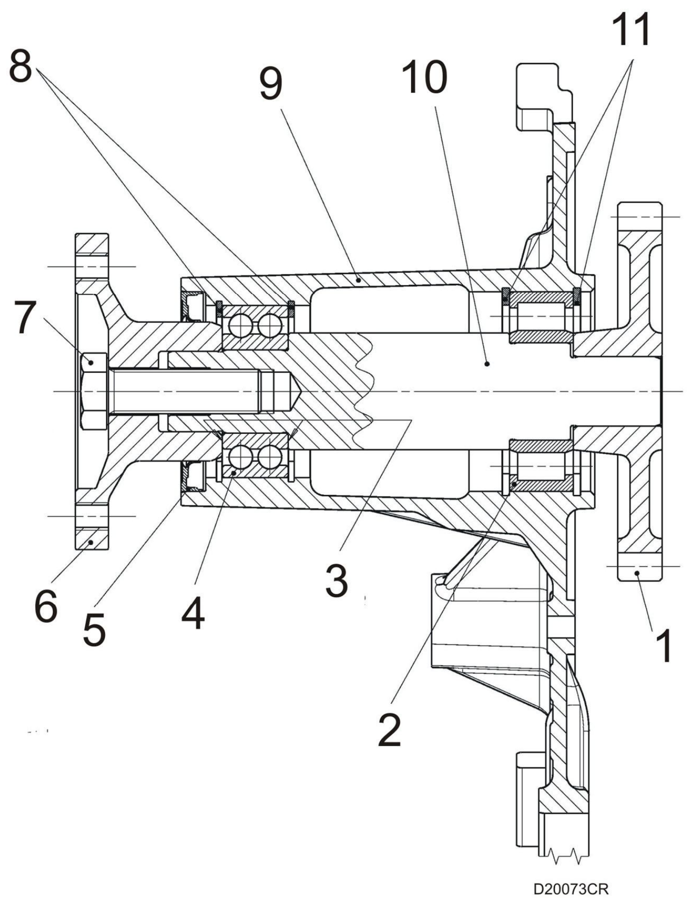
7 Screw, tightening torque **100** Nm +**90°** **LEFT-HAND THREAD!**

8 2 circlips

9 Housing cover

10 Fan bearing shaft

11 2 circlips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D20073CR

ELECTRICALLY CONTROLLED FAN COUPLING

Fan with viscous coupling

The shrouded cooling fan is driven by gearwheels through an electrically controlled viscous coupling.

The truck's management computer supplies an electrical signal to energise the solenoid valve in the fan. The fan coupling's solenoid valve is controlled by the truck management computer (FFR).

Fan speed depends on

⇒ coolant temperature

⇒ outside temperature

⇒ charge-air temperature

⇒ information from the secondary retarder

TECHNICAL DATA

Control signal voltage .... 24 V, from FFR

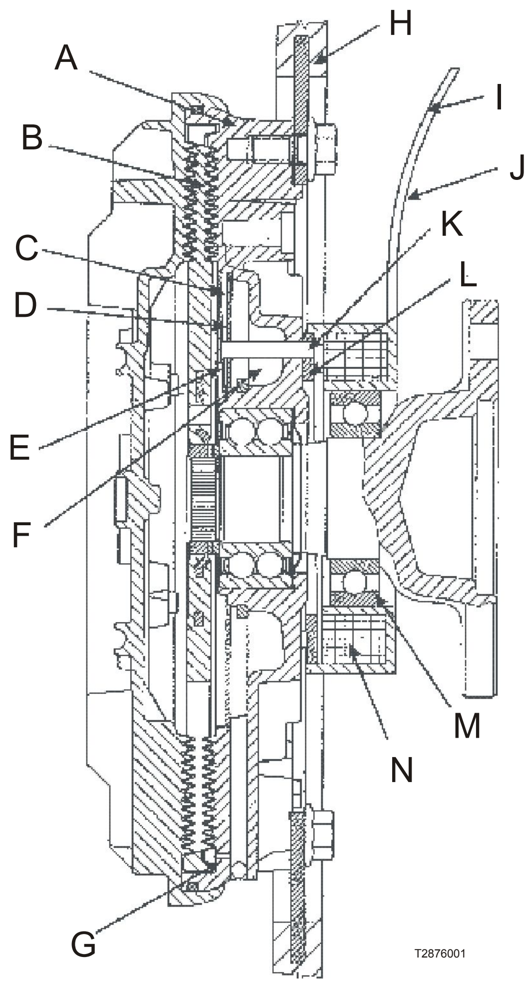
Drive speed n^1 (fan shaft) .... Engine speed

.... +26% (i=1,25)

Switched fan speed... app. 88% of n^1

Fan idle speed at

governed engine speed 500-1000 1/min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CHECKING THE FAN COUPLING:

Static test:

This test only checks the function of the electromagnet.

- Disconnect and reconnect solenoid (**A**): a metallic **click** will be heard from the armature plate (or test with MAN-Cats II).

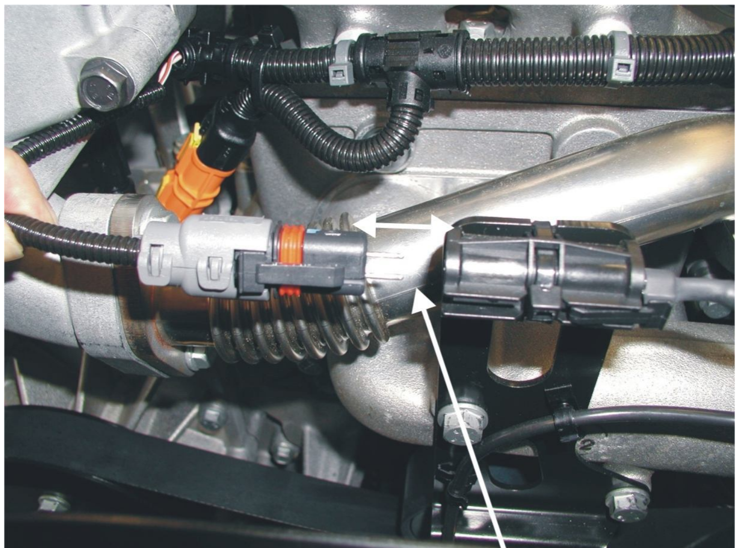
Dynamic test:

- Select the governed speed.
- Detach the plug (line 61304 to the magnetic clutch).
- Maximum fan speed should be reached after 2 minutes (engine speed x fan step-up ratio i = 1,26 less approx. 12 % slip); the fan coupling has engaged.
- Reconnect the plug.
- Within 1 minute the fan speed should have dropped to 500-1000 U/min (idle speed. The fan coupling has disengaged.

Note

Fan coupling de-energised ™ engaged

Electric power present at fan coupling ™ disengaged.



D20066CR

A

ACCIDENT PREVENTION – CLEANLINESS FOR CR SYSTEM

Warning:

Risk of injury!
The fuel jets are strong enough to damage the skin.
Atomised fuel represents a fire risk.

When the engine is running, never slacken off the threaded unions on the high-pressure side of the common rail fuel supply system (injection pipe from high-pressure pump to rail, on the rail or on the cylinder head leading to the injector).
Do not remain too close to the engine when it is running.

Caution:

Risk of injury!
When the engine is running, the fuel lines are always at a pressure of up to 1.600 bar.

Before slackening off the threaded unions, wait for at least a minute so that pressure can drop.
If necessary use MAN-Cats to check the pressure drop in the rail.

Warning:

Risk of injury!
Persons with a hart pacemaker must not come closer than 20 centimetres to the engine when it is running.

Never touch any live parts on the electrical wiring to the injectors when the engine is running.

Cleanliness

Modern diesel fuel injection systems contain high-precision parts that are exposed to extremely severe loads. In view of this technical precision, extreme cleanliness is essential during all work on the fuel system.

Even dirt particles only **0,2 mm** in size can lead to failure of the affected components.

COMMON RAIL STORAGE-TYPE FUEL INJECTION SYSTEM

Common Rail system with EDC 7 engine management

The CR fuel injection system consists of a volume-regulated high-pressure pump that supplies a volumetric reservoir known as the “rail” with fuel at very high pressure (max. 1600 bar). The rail supplies fuel at this pressure to the injectors, where it is finely atomised and injected into the combustion chambers.

The principal feature of the CR system is that it decouples the pressure-build-up from the injection of fuel from the rail. This is a time-controlled principle that overcomes the typical limitations of conventional cam-controlled systems. The increased mean injection pressure and the injection timing can be chosen freely within broad limits, independently of the engine operating point.

The CR system used on the D28 engine can reach injection pressures of up to 1600 bar.

The CP3.4 volume-controlled high-pressure pump, which is supplied with fuel from a flanged-on pre-delivery pump, supplies fuel to the rail until the desired fuel pressure has been reached. The rail acts as a pressure reservoir and is connected by hydraulic lines to the solenoid-actuated injectors, which deliver a pre-determined volume of the stored fuel to the engine’s combustion chambers.

This is the basis for a combustion process that is capable of achieving the best possible exhaust-emission and acoustic values. The injection system’s hydraulic components are monitored by the control unit which has sensors that supply a continuous flow of data on engine and vehicle operation. The rail pressure sensor, control unit and volume-controlled high-pressure pump, for example, form a control loop that results in the desired rail pressure. Further sensors, for instance for the engine coolant temperature, charge-air temperature or atmospheric pressure, enable the engine to adapt effectively to changing ambient operating conditions.

The EDC7 control unit is flexibly decoupled and bolted to a support beam on the left of the engine in an easily accessible position. The control unit’s electric wiring passes directly to the cable duct and the CR injectors.

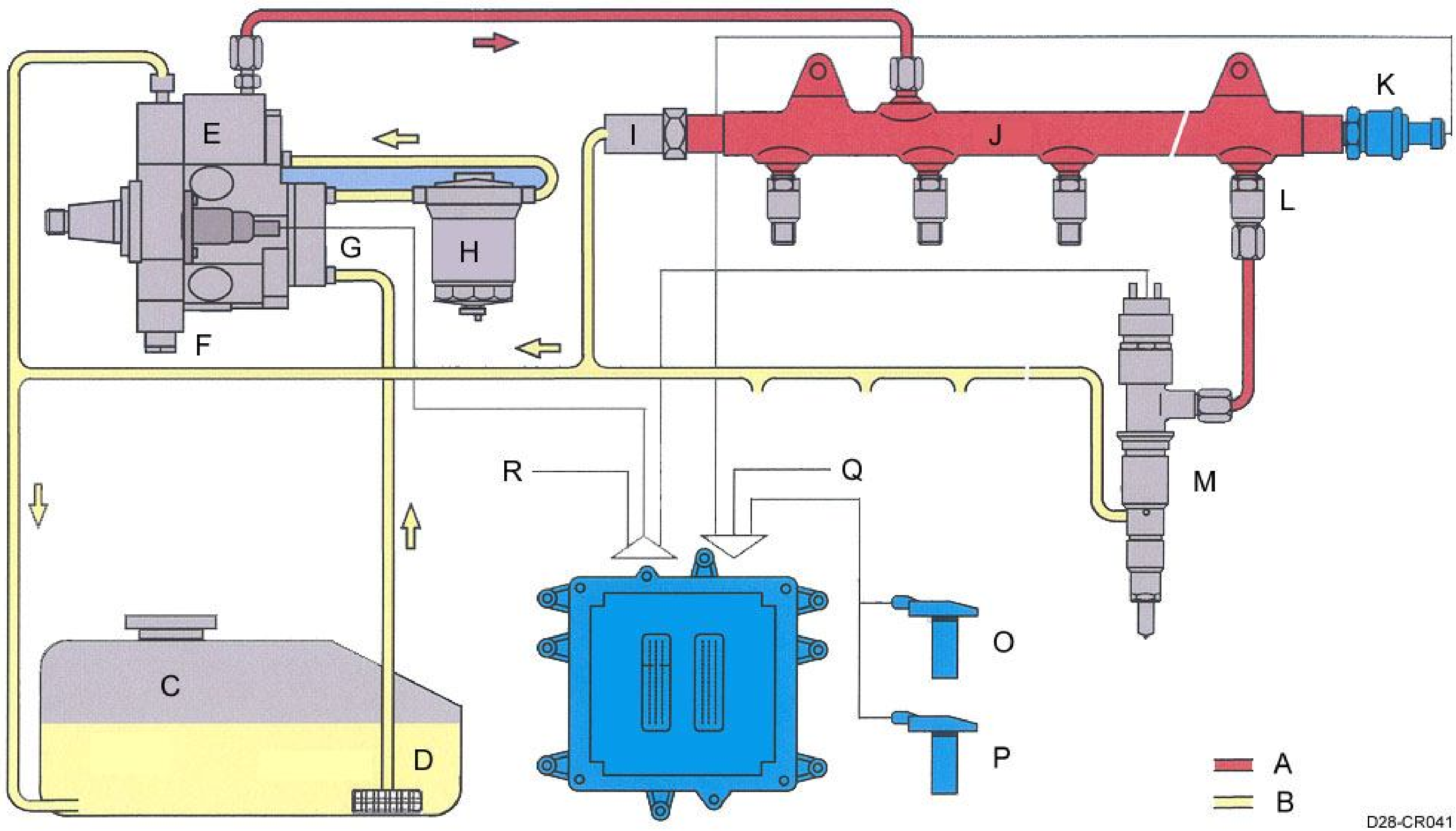
A High pressure **B** Low-pressure area **C** Fuel tank
D Suction line **E** High-pressure pump **F** Pressure line

G Pre-delivery pump **H** KSC **I** Pressure limiting valve
J Rail **K** Rail pressure sensor **L** High-pressure line

M Injector **O** Camshaft sensor **P** Crankshaft sensor
Q Input signals **R** Output signals

Warning:

Common rail (CR) engines must not be run on RME fuel (“biodiesel”).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D28-CR041

a) Injection lines

Injection lines **A** have an external diameter of 8 millimetres and, in view of the high pressures in them, are hydraulically pre-loaded, of carefully determined length and secured to the engine in a manner that prevents vibration.

b) Fuel line to CR injector

Fuel passes from the injector line to the CR injector along a pressurised tube secured by a clamp. A rod-type filter is integrated into this pressure tube, which is located at the side in the cylinder head. This position has been chosen to avoid having to open the fuel system when servicing the valve gear. Outside the pressure pipe, fuel leakage from the CR injectors is conveyed to a collector pipe.

c) Fuel Service Center (KSC)

The fuel service centre (KSC) for CR engines has been revised in design and is mounted on the air distributor pipe. It combines in a single module the functions of hand pump **B**, fuel pre-filter, main filter, continuous bleed and filter heating. The KSC is designed and rated for long periods of continuous operation.

The KSC is easily accessible from above for maintenance. When the filter element is changed, the fuel runs back automatically from the filter to the tank in order to prevent fuel contamination.

Fully recyclable, environmentally acceptable filter elements are used. Their quality has been matched to the requirements of the CR fuel injection system.

Important:

The same cleanliness requirements as for CR apply when renewing the filter element. Do not remove residual dirt deposits in the KSC. This represents an acute risk of dirt reaching the clean side of the system (riser pipe).

All fuel lines attached to the engine can be re-used and consist of reliable PA pipe with easily assembled plug connections (Raymond).

d) CR injectors and nozzles

The CR injectors are located vertically in the cylinder head and secured from the top with a clamp possessing high elasticity when tightened. The injectors have 7-hole blind nozzles with an opening pressure of 300 bar. The seal between the CR injector and the combustion chamber is formed by a copper ring against the cylinder head.

A High-pressure line

B Manual fuel supply pump

C CP3 high-pressure pump (**clockwise rotation**)

D Drive flange for high-pressure pump gearwheel

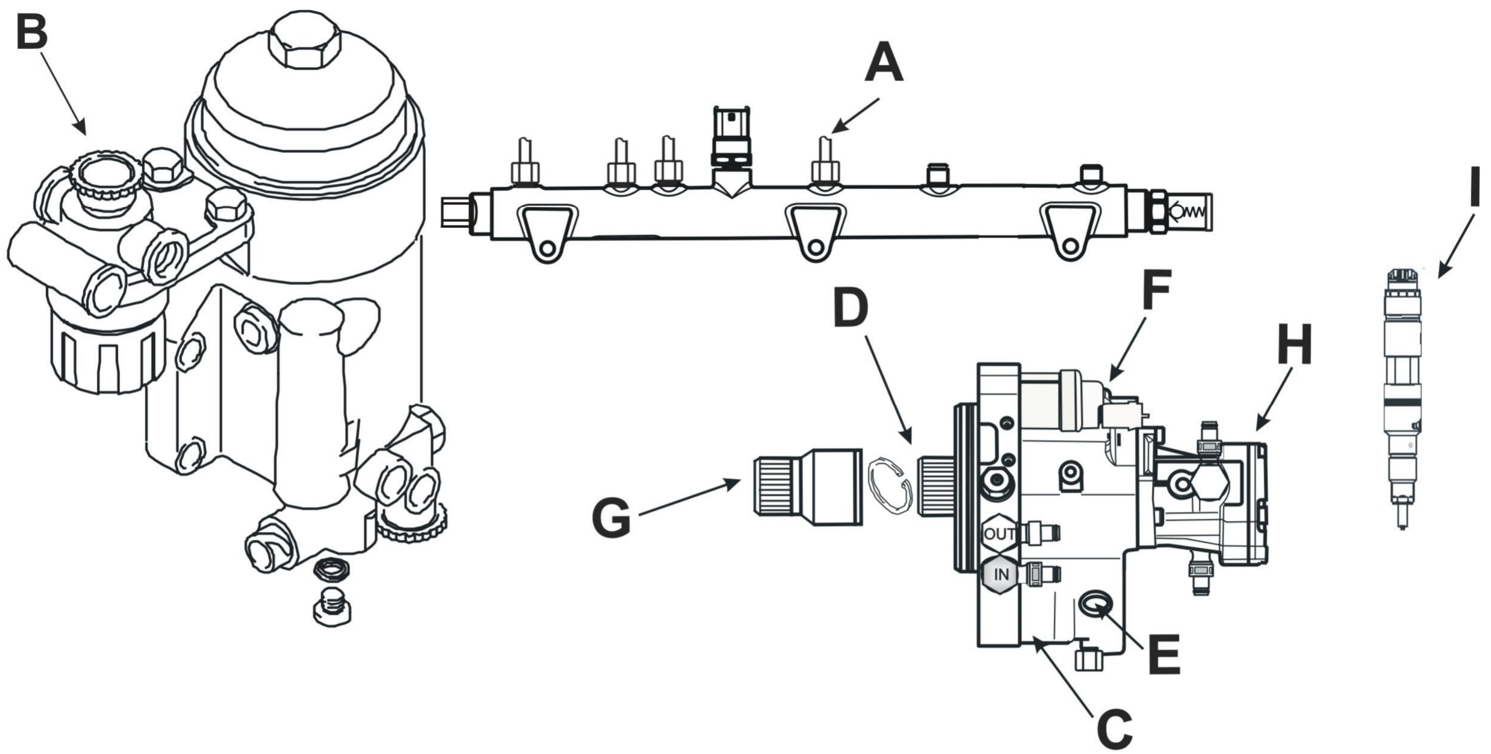
E Engine oil filler

F Proportional-volume valve

G Intermediate adapter

H Fuel delivery pump

I Injector



D20040CR

CR engines are equipped with a revised Fuel Service Centre (KSC).

The KSC is a single unit containing the fuel pre-filter, manual supply pump, main filter, continuous bleed and heating element. The filter area is about 90% larger than with conventional fuel filters. The filter element contains no metal parts and can be recycled in an environmentally acceptable manner. The pre-filter can be washed through to clean Filter elements are fully recyclable.

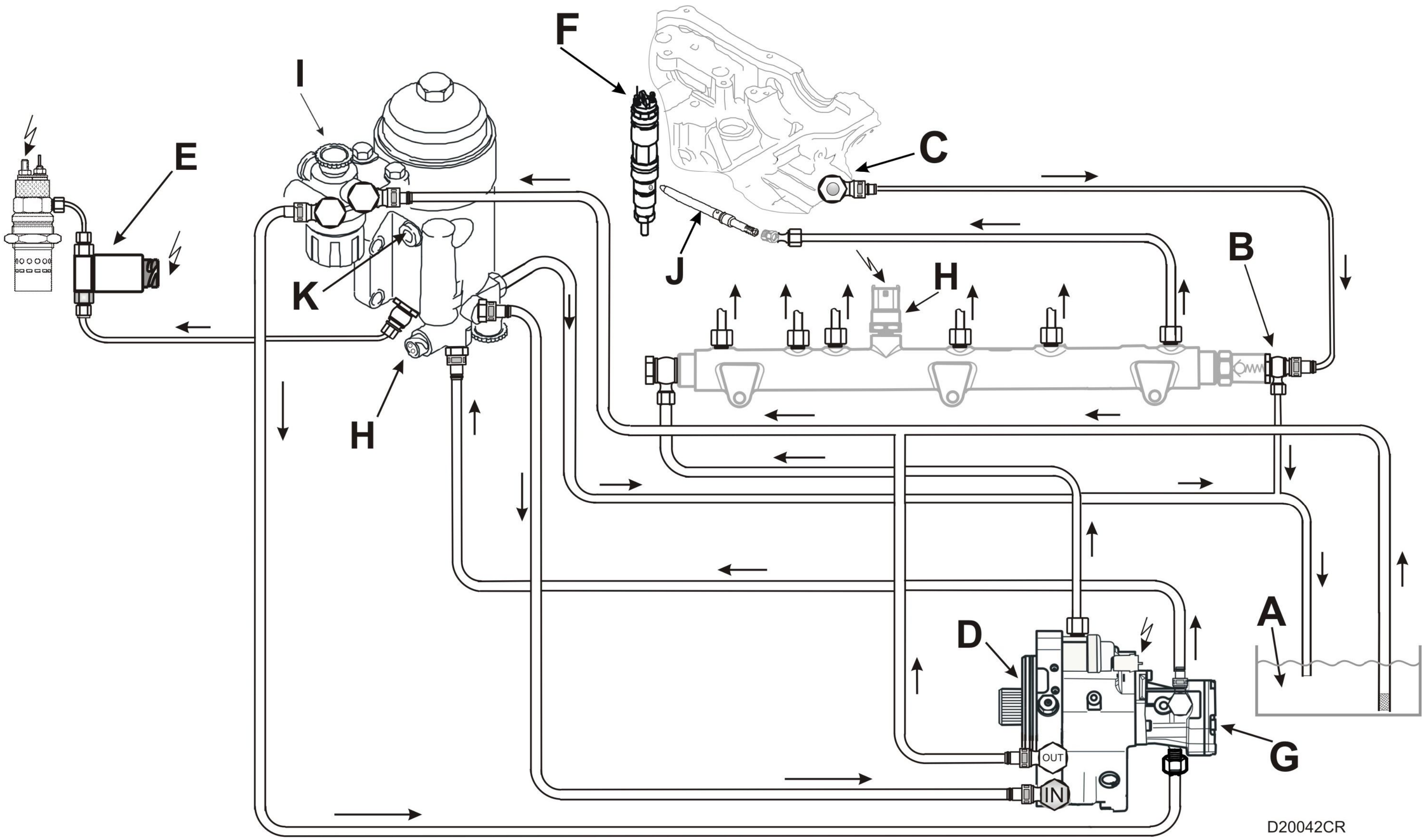
Caution:

Dirt deposits that occur during filter renewal must be discharged at the drain plug.

Modification

The fuel return line no longer passes to the fuel tank but terminates at the KSC pre-filter.

A	Suction filter in fuel tank, 300µm
B	Pressure limiting valve (DBV), two-stage, opening pressure app. 1800 bar
C	Flow relief valve (1,2 –1,3 bar)
D	CP 3 high-pressure pump
E	Solenoid valve for flame starting system
F	Injector
G	Fuel delivery pump (4,5 –7,5 bar)
H	Connection for fuel filter heating
I	Manual fuel delivery pump with pre-filter
J	Pressure tube socket with rod-type filter
K	Connection for fuel pressure sensor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LOW-PRESSURE AREA

Components

- Fuel tank
- Gear-type pre-delivery pump
- Fuel filter and low-pressure lines

The gear-type pre-delivery pump draws fuel out of the tank and delivers in through the KSC to the high-pressure pump. All fuel lines attached to the engine are made from PA tube with easily assembled plug connectors (drain plug valves are installed).

LEAK OIL TEST

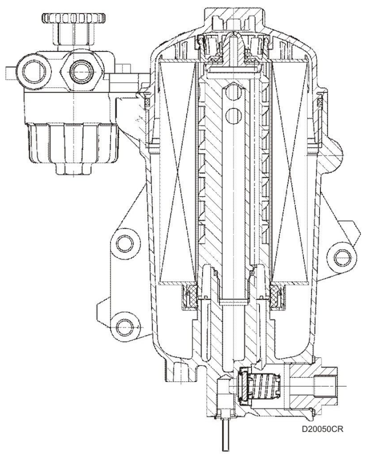
- **Disconnect the return line from the cylinder head to the rail**
- **Connect a manometer with a shutoff cock instead of the hollow screw (connector C page 93)**
- **Duration of test: 3 min with max. 4,0 bar $^{+0,5}$ bar filtered compressed air**
- **Max. allowed pressure loss 0,2 bar**

Note:

Measuring instruments are not to be connected to the Common Rail (CR) fuel system unless the engine is stopped and pressure in the rail has been allowed to drop.

FUEL SERVICE CENTER

A From fuel delivery pump
B Installed position of filter heating
C Optional feed to flame starting system
D Water drain plug (unscrew during filter renewal)
E to fuel tank
F from fuel tank
G Hand pump
H to fuel pre-delivery pump
I Pre-filter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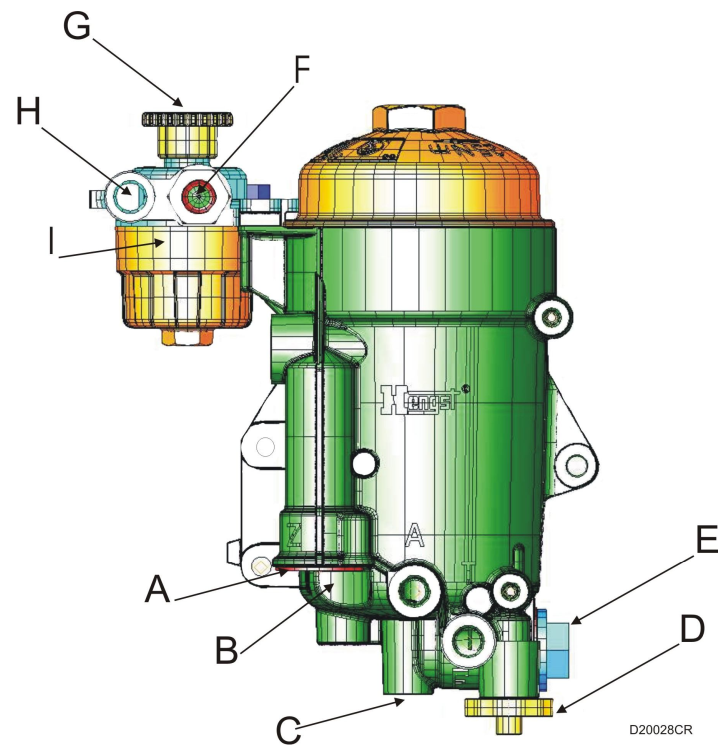
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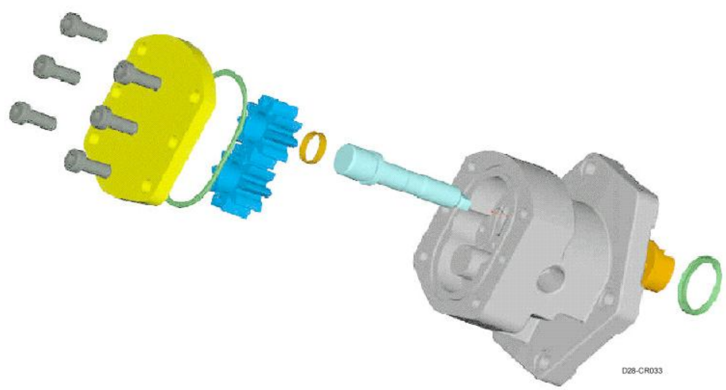

D28-CR033

HIGH-PRESSURE AREA

The task of the high-pressure area is to build up the pressure needed for fuel injection and to make a sufficient quantity of fuel available in all operating conditions. The high-pressure pump is driven by the engine and has oil lubrication. Fuel comes from pre-delivery pump **(3)** and is delivered by line to the KSC and to the suction chamber of the high-pressure pump. The pre-delivery pump is flanged to the high-pressure pump. The metering unit (ZME) **(1)** M-prop. is attached to the suction side of the high-pressure pump. The ZME is an actuator for fuel pressure regulation in the rail's high-pressure reservoir.

A CP 3 high-pressure pump

Input (measure if start problems occur)

Nominal pressure with n = LL **.....** to **.....** bar

Return pressure below **.....** bar

If the pump is renewed or a new high-pressure pump **(2)** installed, fill it with **0,04 l** of engine oil and tighten oil filler plug to a torque of 18 Nm.

When installing the drive gearwheel, remove grease from the teeth with test petrol or spirit.

Tighten the drive gear **(4)** to **110 Nm (free from grease)**.

Clockwise rotation (when looking at the pump drive).

M10 flange bolts **45 Nm** tightening torque.

B ZME metering unit (proportional-volume valve)

CP 3.4 proportional volume valve for fuel

The metering unit (ZME) M-prop. is bolted to the suction side of the high-pressure pump housing. The ZME is an actuator that regulates fuel pressure in the high-pressure reservoir (the rail).

The ZME metering unit is regulated by a PWM (pulse width modulated) signal.

Sensing ratio 100%: zero delivery

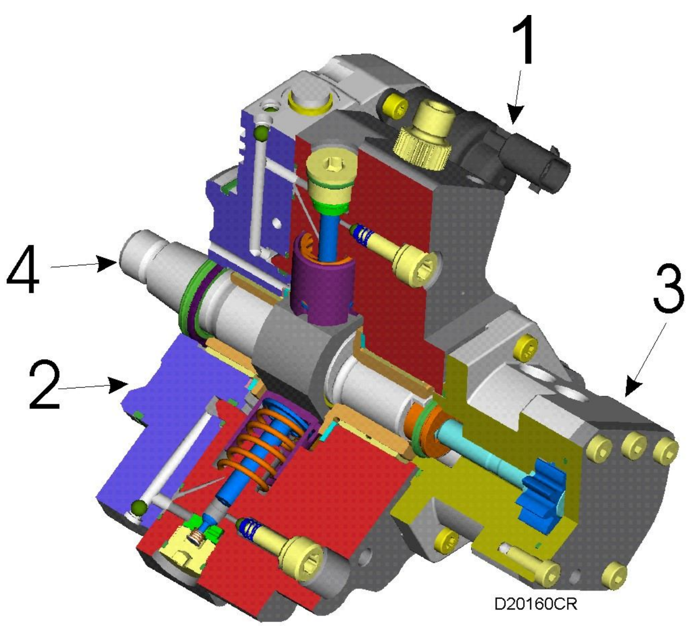
Sensing ratio 0%: maximum delivery

C Max. fuel volume

D Min. fuel volume

E trapezoidal groove

A



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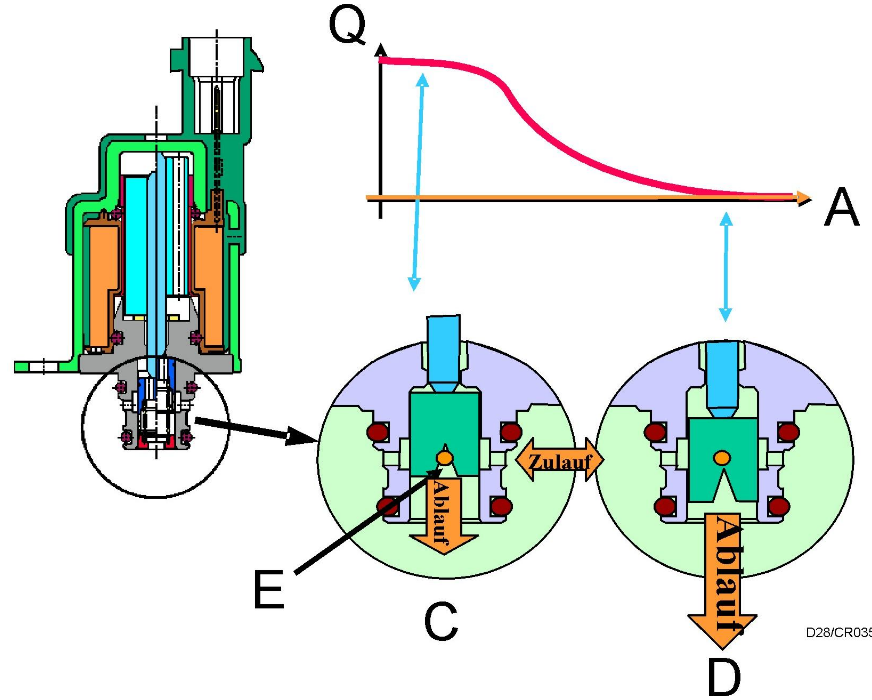


CR HIGH-PRESSURE PUMP

- Unlike the conventional diesel engine, installation of the CR high-pressure pump does not require any adjustment work.

- The CR pump (27-tooth gearwheel) is driven via intermediate gearwheel (44 teeth) and the crankshaft gearwheel (45 teeth) at the fan end.

- When the engine is started the signals from the speed sensor at the camshaft drive gearwheel and the flywheel speed sensor are compared.

- After a few revolutions the CR high-pressure pump receives a signal and the engine fires and runs.

A High-pressure area

B Low-pressure area

C Engine oil filler

1 Fuel supply from fuel filter

2 to rail

3 to tank

4 to filter

5 Return to tank

6 from filter

7 to rail

8 Proportional-volume valve

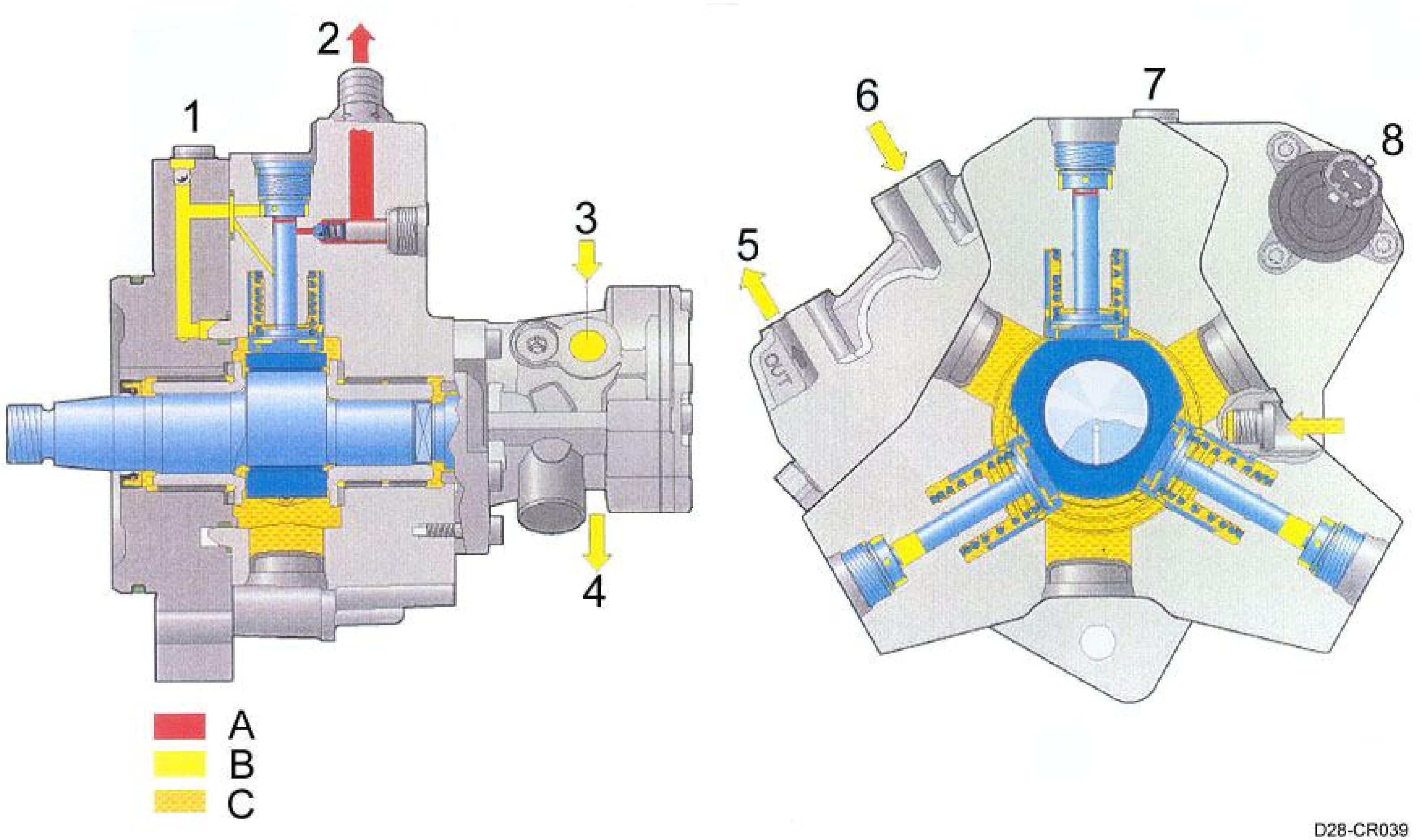
Note:

The ECU monitors the rail pressure via a pressure sensor.

In case of a fault, a pressure limiting valve guarantees a limp-home operation of the engine with app. **800 bar** rail pressure.

Gear ratio:

Crankshaft – high pressure pump 1:1,67



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REMOVIN AND INSTALLING THE HIGH-PRESSURE PUMP

Removing the high-pressure pump

Detach the fuel lines and seal all open connections including those on the high-pressure pump with plastic plugs. Attach special tool 80.99601-6021 to the high-pressure pump. Take out the retaining screws and drive out the pump with the striker tool. Take off the adapter flange with special tool 80.99602-0174.

High-pressure pump power take-off

1 Drive housing
2 M8x25 10.9 machine screw
3 High-pressure pump drive gear
4 Shaft sealing ring (**PTFE**)
5 V-belt pulley
6 Pulley for CP3 drive shaft
7 Sealant
8 M8x25 10.9 bolt
9 M8x18 10.9 bolt
10 Drive shaft

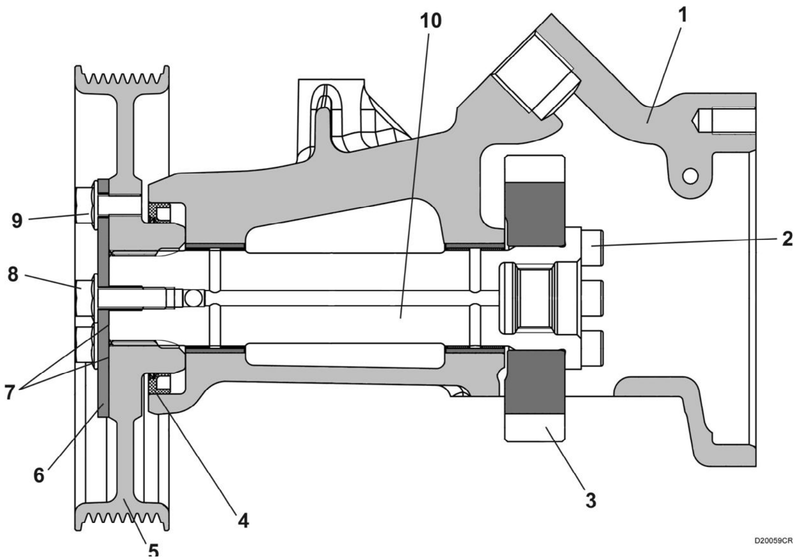
Installing the high-pressure pump

Using guide screws 80.99617-0205, install the adapter flange with a new O-ring and tighten the four bolts to **45 Nm** torque. Screw guide pin 80.99601-6021 into the adapter flange and attach the high-pressure pump with the new O-rings (one for the lubricating oil feed hole, one to seal the housing), using 3 bolts tightened to **45 Nm** torque.

Important:

Add **app. 0,04 l** of **engine oil** to the new high-pressure pump.

A O-ring to seal housing
B O-ring to seal oil supply
C CP3 high-pressure pump (**clockwise rotation**)
D Drive flange for high-pressure pump gearwheel
E Engine oil filler
F Proportional volume valve
G Adapter flange
H Fuel pump



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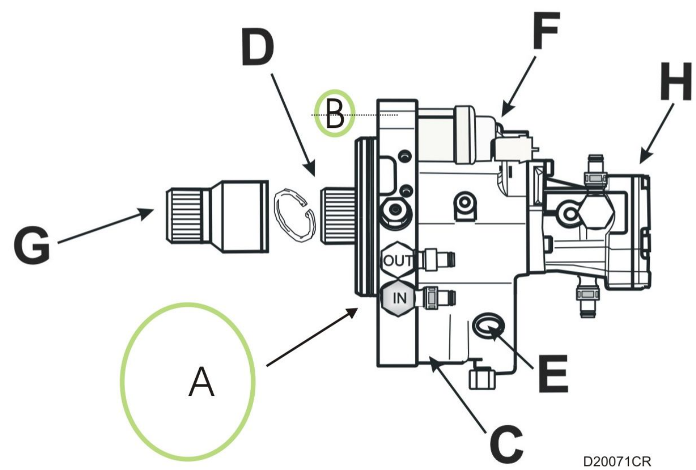

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RAIL

The high-pressure reservoir (the rail) has the task of retaining sufficient fuel at high pressure and thus suppressing pressure fluctuations caused by pump delivery and the injection process. Pressure in the rail is kept almost constant even when fairly large volumes of fuel are drawn off. This ensures constant injection pressure when the injector is opened.

A Two-stage pressure limiting valve

The two-stage pressure-limiting valve (DBV) is mounted on the rail and acts as a pressure relief and pressure-limiting valve.
A drain opens if pressure rises too far.
In normal operating conditions a spring presses a plunger firmly into its seat on the valve, so that the rail remains closed. If the maximum system pressure is exceeded, the plunger is forced open against the spring by the pressure in the rail.

If rail pressure is too high (1800 bar) the first plunger moves and opens a partial cross-section permanently. Rail pressure is then held constant at app. 700- 800 bar.

The two-stage pressure-limiting valve does not close until the engine is shut down. Once the DBV has opened, the second stage remains open for as long as the engine is running.

If the DBV fails to open quickly enough when rail pressure is too high, it is forced open.
To force the DBV open, the fuel metering unit is opened and fuel delivery at the injectors is shut down.
Rail pressure rises steeply until the DBV opening pressure is reached. If forcing the valve open does not have the desired result, for instance if the DBV has seized or jammed, the engine is shut down.

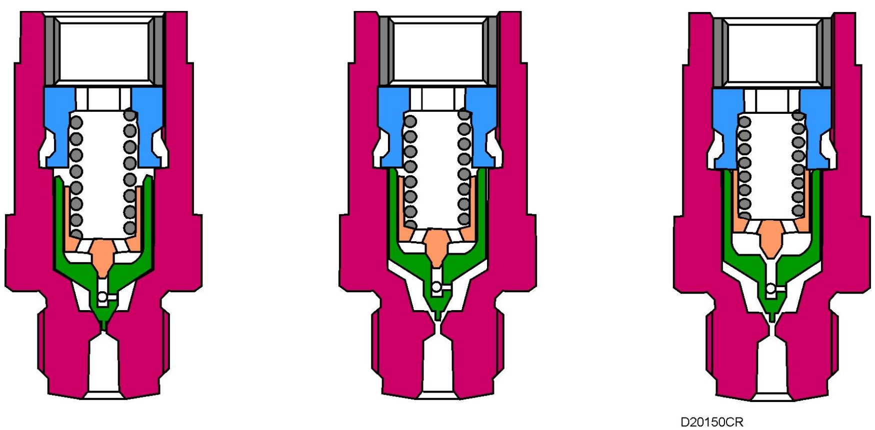
B Rail pressure sensor B487

- Pin 1 (60160) –A 61 rail pressure earth (ground)
- Pin 2 (60162) –A 80 rail pressure input (1,01-1,60 Volt)
- Pin 3 (60161) –A 43 rail pressure (4,75-5,25 Volt)

The rail can make a fuel quantity of approximately **30 cc** available.

C Connecting the high-pressure pump

A



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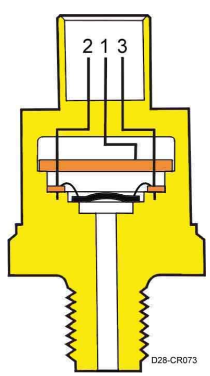
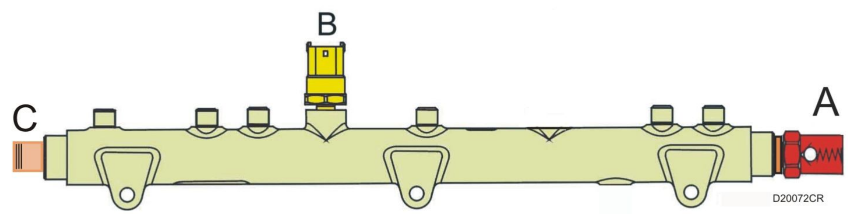




INJECTORS

The CR injectors are located vertically in the combustion chambers and secured in position from above by a clamp and screw with a highly resilient action. 7-hole blind injector nozzles with an opening pressure of 300 bar are installed. A copper sealing ring is used at the cylinder head to make a seal between the CR injector and the combustion chamber.

The EDC 7 control unit determines the length of the injection period by energising the injector winding for the main and possibly for a follow-up injection phase. It also determines the injection pressure and energises the exceptionally quick-acting solenoid valves in the injectors.
The drain restrictor in the control chamber is opened or closed by the solenoid valve armature.

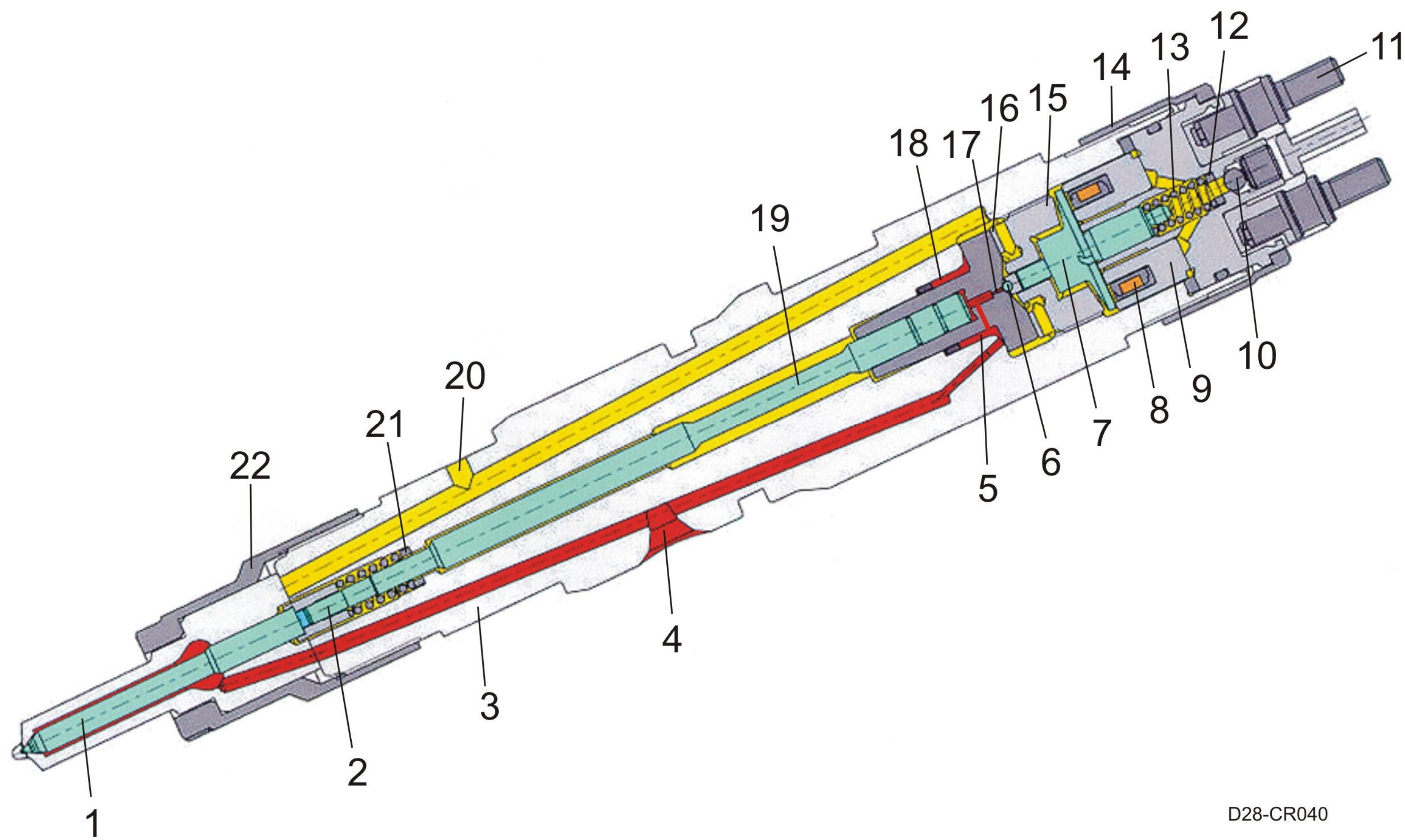
- When the drain restrictor is open, pressure in the control chamber drops and the jet needle opens.
- When the drain restrictor is closed, pressure rises in the control chamber and the jet needle closes.

In other words, the jet needle opening pattern (opening and closing speed) is determined by the feed restrictor in the injector control chamber.
A return line for fuel leak-off leads via the drain restrictor and jet needle to the fuel tank.

The precise amount of fuel injected is determined by the outlet cross-section of the nozzle, the solenoid valve opening period and the reservoir pressure in the common rail system.

Components

1	Jet needle	**2**	Pressure block
3	Injector body	**4**	High-pressure union
5	Valve assembly	**6**	Valve ball
7	Armature	**8**	Solenoid coil
9	Solenoid core	**10**	Sealing ball
11	Electrical connection	**12**	Adjusting washer
13	Valve spring	**14**	Solenoid clamp nut
15	Clamp screw	**16**	Washer
17	Drain restrictor	**18**	High-pressure sealing ring
19	Valve plunger	**20**	Fuel return
21	Adjusting washer	**22**	Nozzle clamping nut



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D28-CR040

INJECTOR OPERATING PRINCIPLE

Signal forms

A Input signal

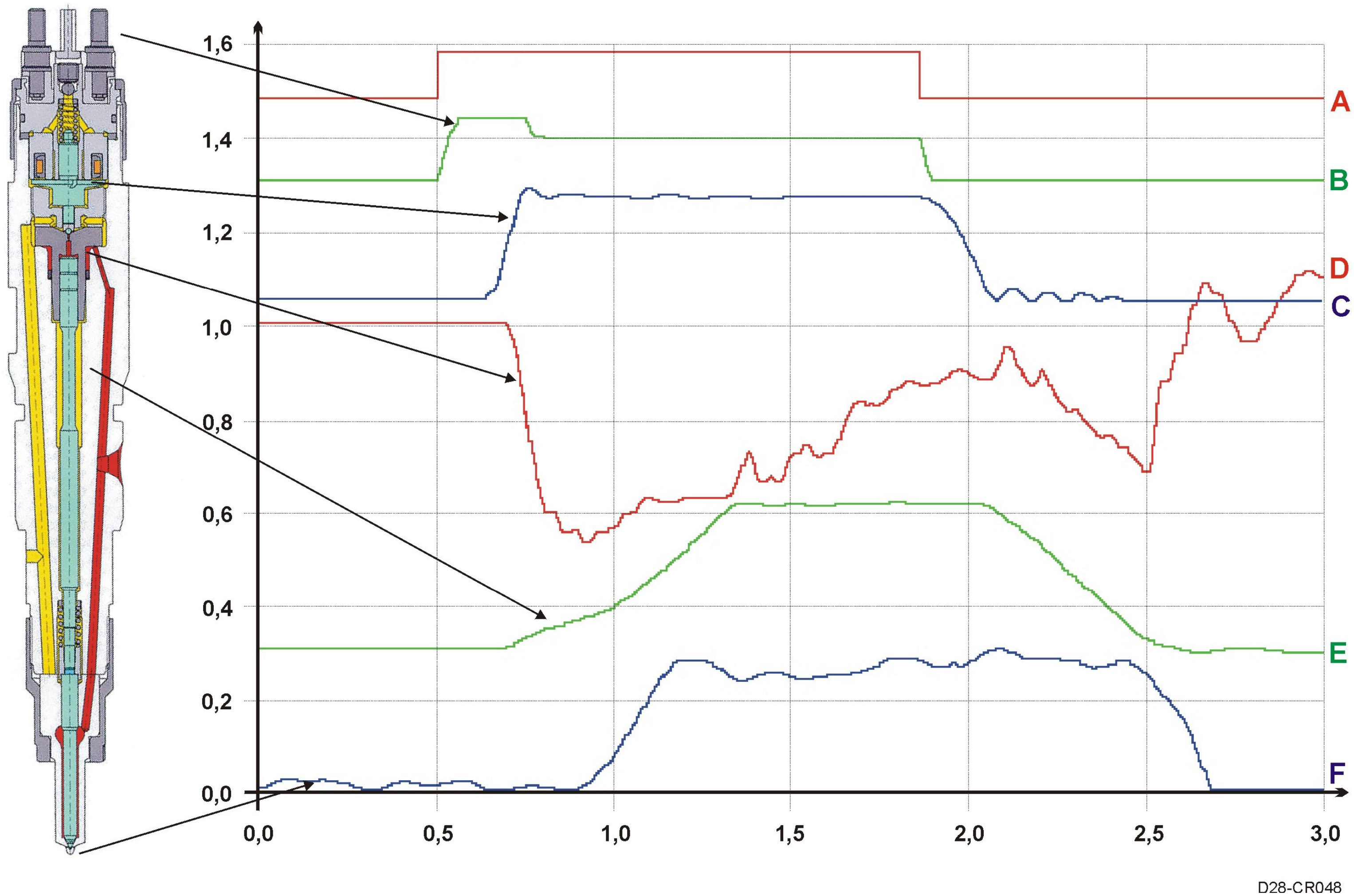
B Solenoid valve current

C Armature stroke

D Control chamber pressure

E Jet needle stroke

F Injection rate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D28-CR048

INJECTION TIMING

A Current

B Stroke

C Pressure

D Injection rate

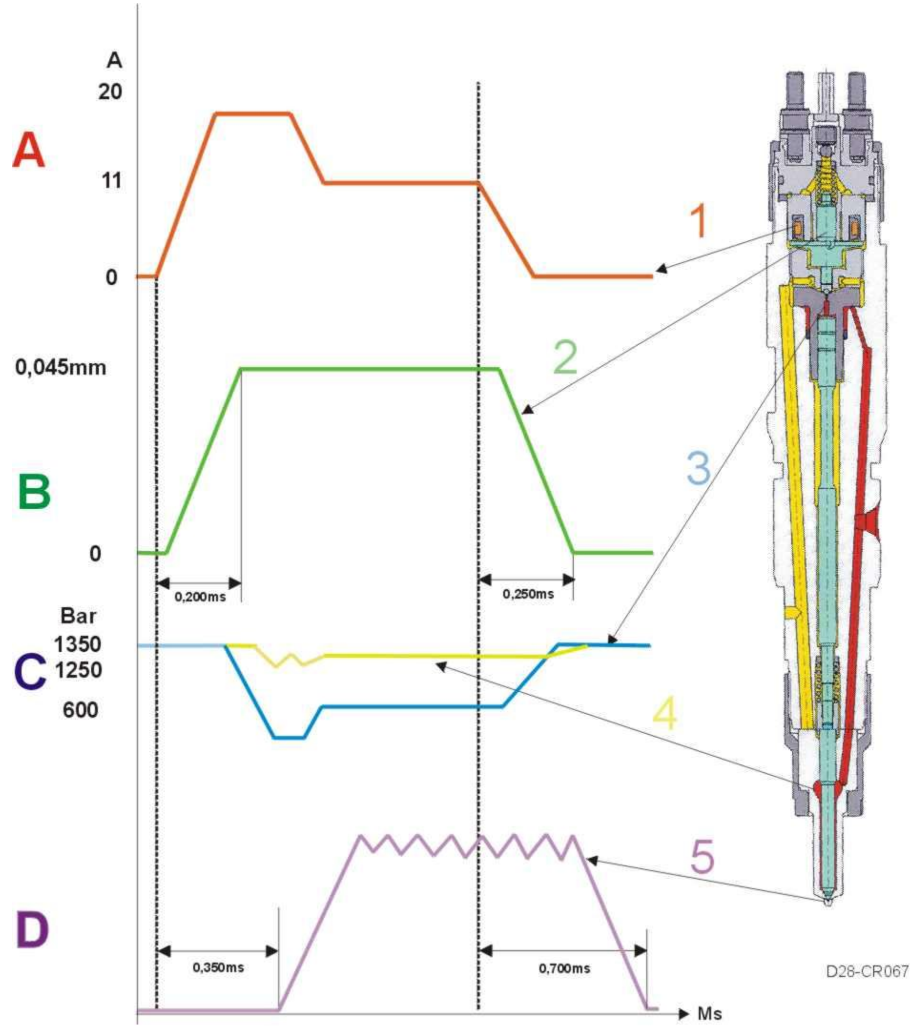
1 Current

2 Armature stroke

3 Pressure in control space

4 Pressure in chamber

5 Injection


A
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1350
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D28-CR067

COMBUSTION PRESSURE PATTERN

Combustion pressure pattern with and without pilot injection

A Pilot injection

B Main injection

C Combustion pressure pattern **without** pilot injection

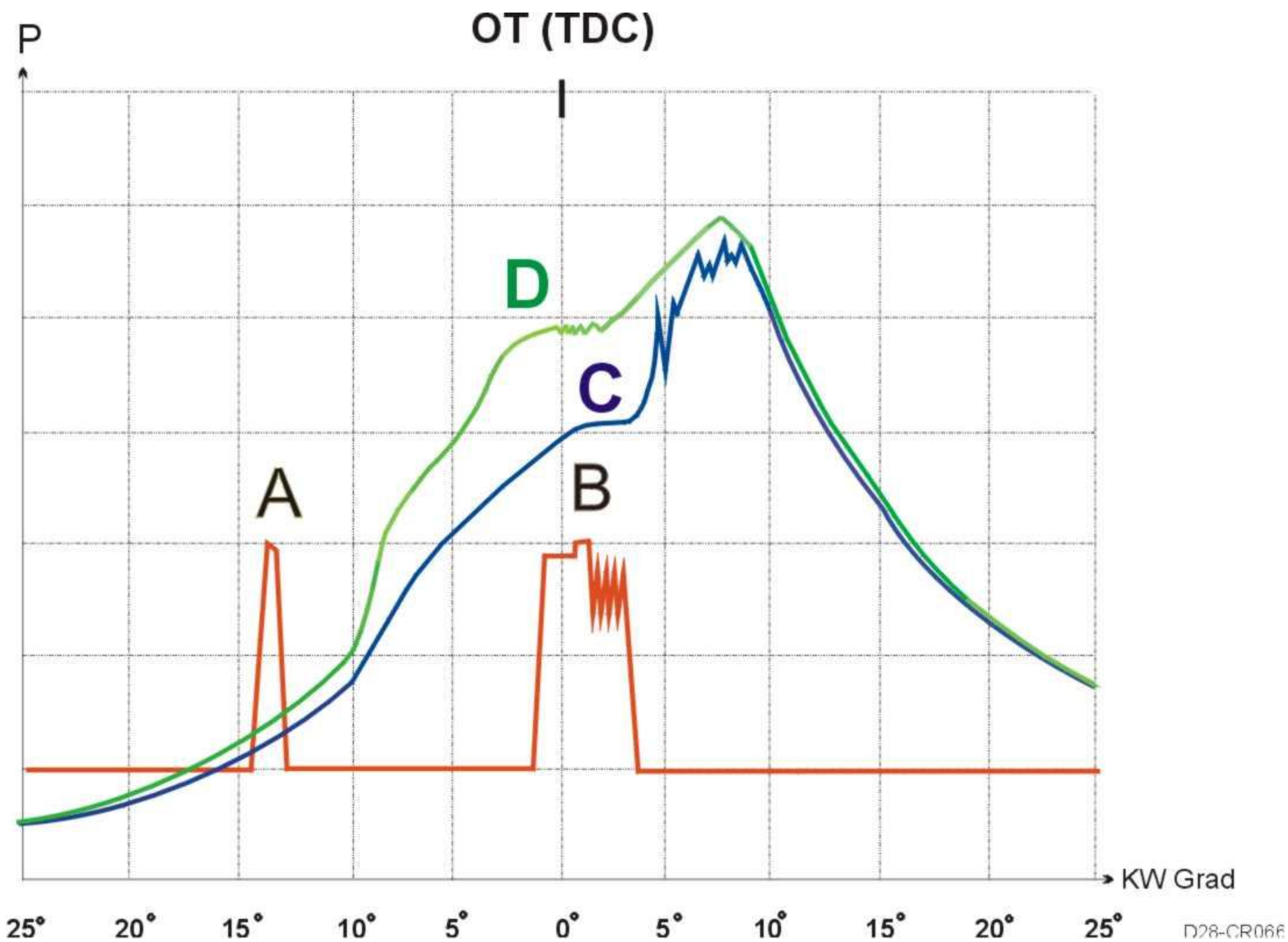
D Combustion pressure pattern **with** pilot injection

Advantages of pilot injection

Pressure builds up uniformly, so that combustion noise is reduced and the engine runs more smoothly.

Note:

Pilot injection **A** only takes place when the engine is ***idling*** and running at ***part-load.***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D28-CR066

SPEED SENSORS

Crankshaft speed sensor 3 B488

Sensor **3** calculates the angle of crankshaft rotation and is therefore responsible for starting fuel injection into the individual cylinders at the correct times.

Sensor wheel **A** on the flywheel has **60** minus **2** teeth (**4**), at intervals of 6 degrees of angle.

The gap (**4**) is intended to indicate the 360-degree crankshaft position and is in a fixed relationship to cylinder 1.

Camshaft speed sensor 2 B499

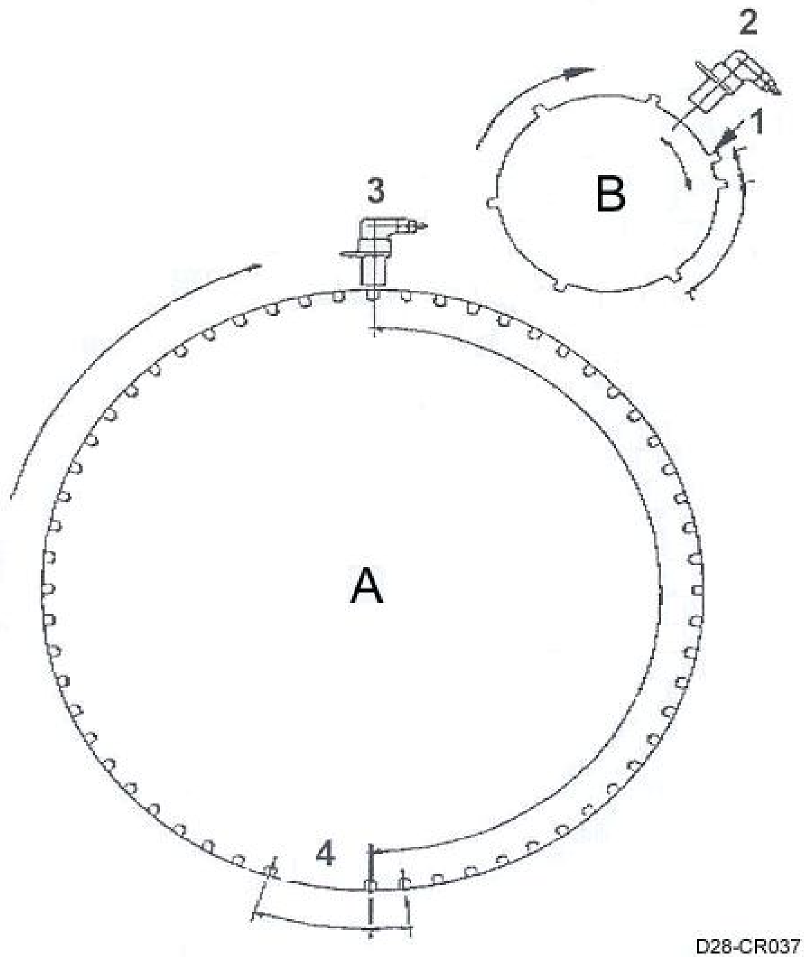
The camshaft rotates at half crankshaft speed. Its position indicates whether a piston is on the compression or the exhaust stroke in its cylinder. The segment wheel **B** on the camshaft is referred to as a “phase wheel”. It has one phase mark for each cylinder (**6** marks and also a synchronising mark **1**).

The phase marks are spaced at equal intervals round the segment wheel.

The synchronising mark (**1**) is additional, and is located close behind one of the phase marks. It is used for determination of the engine’s angle of rotation within its complete operating cycle of 720 degrees.

C Speed sensor signal from flywheel

D Speed sensor signal from camshaft speed sensor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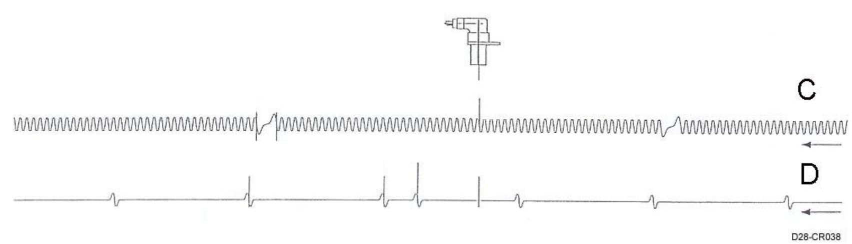
D28-CR037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D28-CR038

Water trap and fuel filter

The Separ 2000 is installed in the suction line at an easily accessible point. All other filters normally used in the suction line must be removed, but the pre-filter and the fine and micro-filters remain in the fuel system.

- **Draining off moisture condensate and impurities** (weekly, but may be necessary more often in certain climates, ambient and operating conditions)

Note: The fuel tank must be at least half full before the moisture condensate can be drained off. Do this, including impurities if present, before they reach the lower edge of the centrifuge (visible in sight glass).

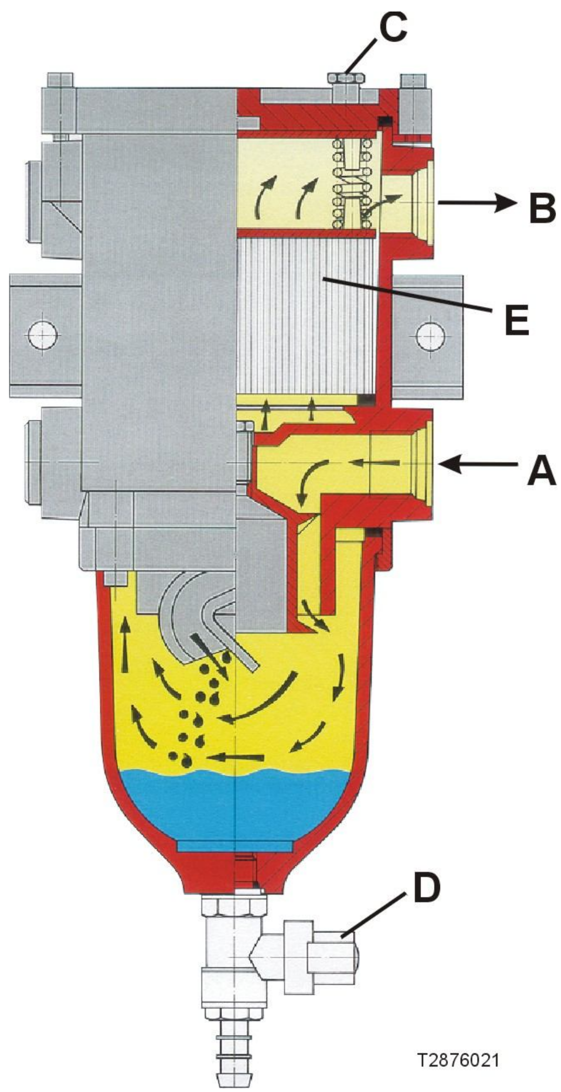
- Park the vehicle and stop the engine.
- Attach the hose with clip (MAN No. 81.12540-6004) to the spigot of the drain tap

Assembly hint: Tighten the clip to some extent, but so that the hose can still be slid into position

- Place a vessel in position to trap escaping liquid.
- After each drainage procedure, renew the bleed screw sealing ring.
- Open the bleed screw by one to two turns.
- Open the drain tap.
- Allow the moisture condensate and impurities to drain out and dispose of them according to legal requirements.
- Close the drain tap.
- Retighten the bleed screw.
- Pull off the hose.

Bleed screw tightening torque ....8 - 10 Nm

A	**Fuel inlet**
B	**Fuel return**
C	**Bleed screw**
D	**Moisture drain tap**
E	**Micro-filter (30 µ)**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GENERAL NOTES ON OPERATING FLUIDS

Engine oil

High-performance diesel-engine oil

(**S**uper **H**igh **P**erformance **D**iesel **O**il - **SHPD**)
according to MAN Directive M3277

These oils have much higher potential performance than engine oils according to Works Standards MAN **270** and **271**.

In forced-aspiration (e.g. turbocharged) diesel engines in particular, SHPD oils have numerous advantages in terms of avoiding piston carbonisation, minimising wear and releasing performance reserves.

In the interests of longer operating life we therefore recommend the use of these oils for turbocharged engines; they are of course also suitable for naturally aspirated engines.

Engine oils – additives

For CR the only permissible oils are those that have been tested for compliance with Works Standard **M 3277**.

The formulations used for these oils ensure that they will always satisfy normal driving requirements if the specified oil-change intervals are adhered to.

Please note that using any kind of additive in the engine oil will change its characteristics in an **unpredictable manner.**

Since the use of such additives could have an adverse effect on performance, the degree of maintenance required and the engine’s operating life, it is important to note that MAN Nutzfahrzeuge AG will be obliged to reject all warranty claims if this precaution is disregarded.

Engine oils

Even if of the specified intervals are not reached, the engine oil should be changed at least once a year.

__Sulphur content of diesel oil__

If the sulphur content exceeds 1.0%, the engine oil change intervals must be halved.

Viscosity classes

Engine oil viscosity is quoted according to the SAE classification system.

The SAE figures indicate the viscosity at low and at high temperatures.

At low temperatures the viscosity is important because it influences cold starting; at high temperatures it is important for the lubricating effect to be sufficient at high engine speeds and loads.

The viscosity of the engine oil thus depends on operating conditions.

Exception to general practice

If engine oils approved by MAN are not available in certain countries, use only engine oils for which the manufacturer or supplier is prepared to issue a written guarantee that the quality is at least equivalent to the MIL-L-2104D, API- CD/SF, CE/SF, CE/SG or CCMC-D4 or D5 specifications.

1 Oil filter

A single oil filter attached directly to the crankcase and angled forwards is installed; it uses replaceable and fully recyclable filter elements and is provided with a filter bypass valve and an oil return check valve. The seal between the oil filter body and the crankcase is formed by a moulded elastomer seal inserted into the flange of the oil cooler.
When the filter element is renewed, oil drains out of the filter body into the crankcase through a drain valve that opens automatically.

2 Oil sump

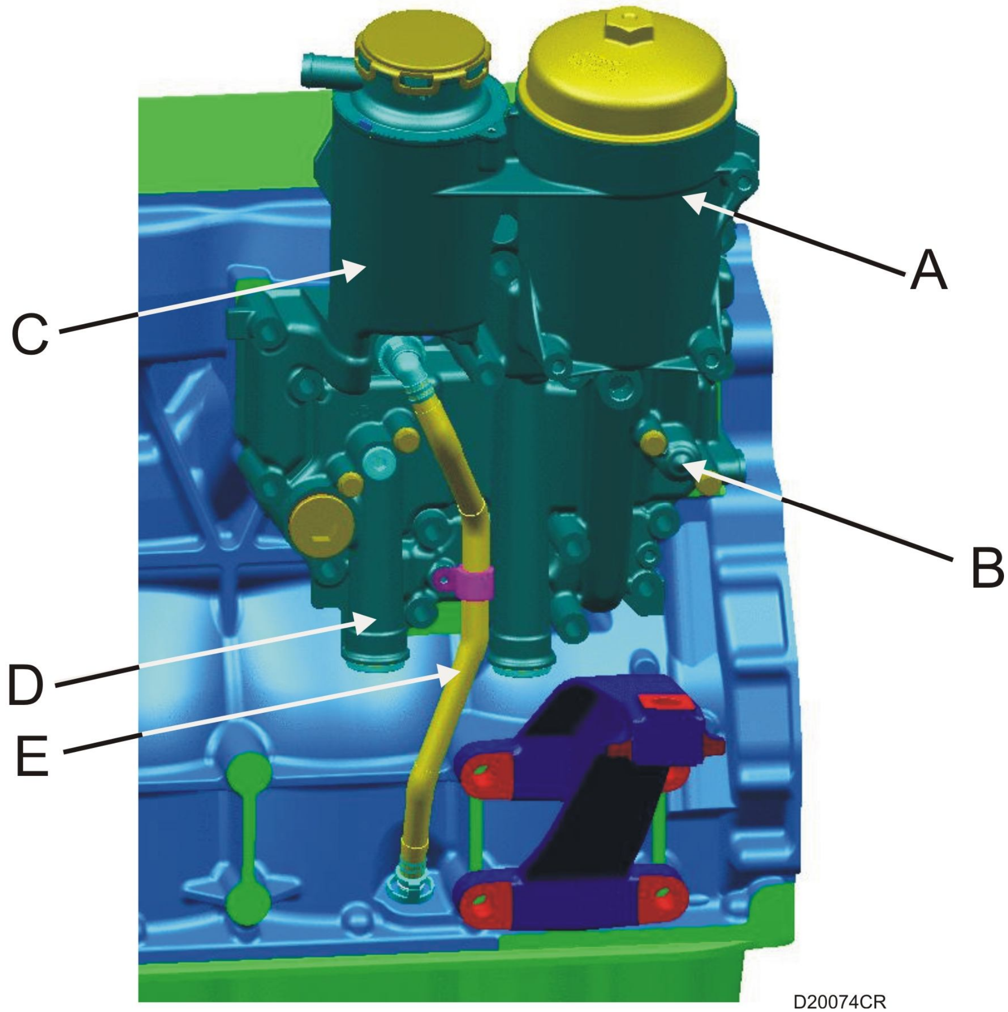
The oil sump is a deep drawn sheet-metal sandwich element designed to reduce noise emissions; it is decoupled by a moulded elastomer gasket to prevent noise transmission.

The engine oil content for **D2066LF**.. engines if the truck is used on the public highway is (min./max.) **6 l.**
Engines are filled initially at the factory with high-performance engine oil according to Works Standard **M 3291.** This oil is suitable for oil change intervals of up to **120.000** km in long-distance transport. The oil change after running in can then be omitted.

3 Oil cooler

The oil cooler is fabricated by brazing from flat stainless steel tube and integrated into the oil cooler housing/crankcase on the right side of the engine.

A Replaceable-element oil filter easily accessible for maintenance
B Oil return check valve
C Crankcase breather with centrifugal dirt trap
D Shutdown valve
E Centrifuge up to oil level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D20074CR

ENGINE OIL CIRCUIT

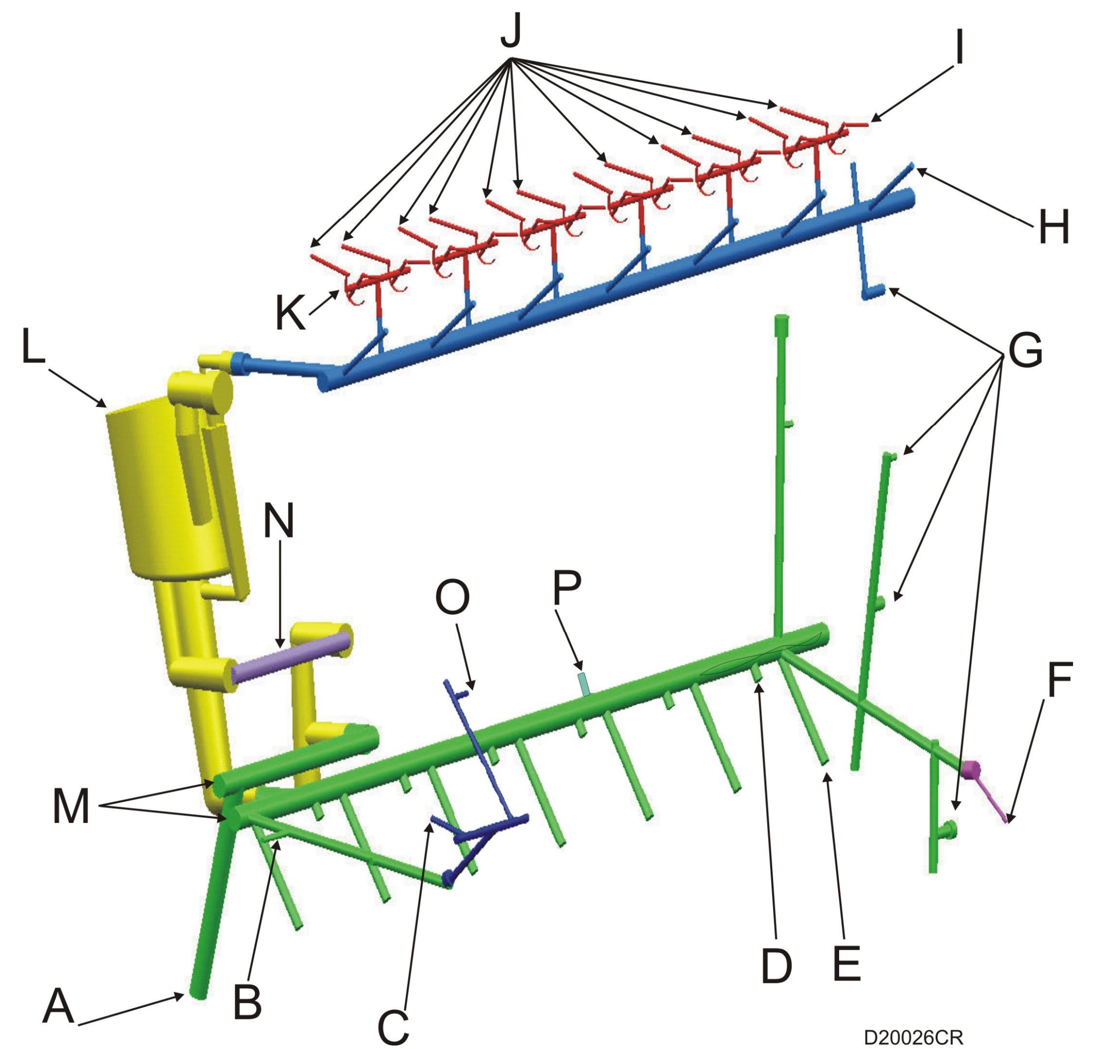
Pressurised oil is used to lubricate the main, big-end and camshaft bearings and the turbocharger, valve gear, high-pressure pump and air compressor. A new, enlarged gear-type oil pump is used. Pump output and the cross-section of the oil suction line have been modified to match the engine's increased oil demand

OIL CIRCUIT DIAGRAM

A Engine oil under pressure, from oil pump
B Oil supply to fan bearings
C Oil supply to drive housing
D Oil spray jets (6)
E Oil supply to main bearings (7)
F Oil supply to air compressor
G Oil supply to intermediate gearwheel bearings
H Camshaft bearings (7)
I Oil supply to cams and rollers
J Inlet and exhaust valve rockers (12)
K Rocker arm bearings (12)
L Oil filter
M Main oil passage
N Oil cooler
O Oilway to high-pressure pump
P Oilway to turbocharger

Note:

The oil filter is installed on the pressure side.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D20026CR

Oil pump

Delivery volume n = nom. speed min^{-1} app. **136** litres

A Retaining bolt, M6x20 (10.9)

B Machine screw, M10x35 (10.9)

C Oil pump pinion shaft

D O-ring seal 22x2

E Oil pump pinion (30 mm, sintered)

F Ring gear for oil pump (renewable)

Engine oil pressure

550 1/min..................... ***1,0 bar minimum oil pressure***

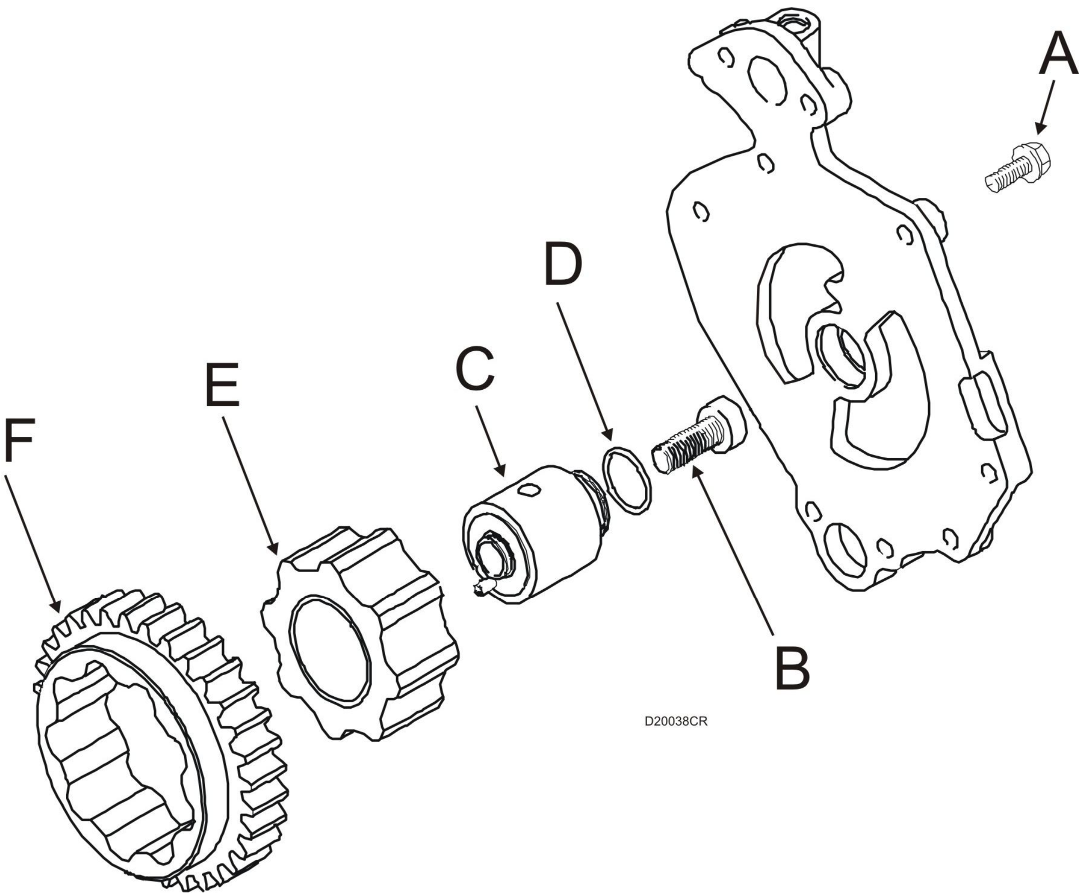
1200 1/min.................. ***3,5 bar minimum oil pressure***

1900 1/min.................. ***4,8 bar minimum oil pressure***

Measure oil pressure with the engine warmed up to its regular operating temperature.

Note:

- Marks aligning oil pump pinion with cover
- Ring gear endplay 0,030 – 0,090 mm
- Pinion 0,030 – 0,090 mm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D20038CR

Oil module with integral oil cooler

The oil filter element (51.05504-0107) is positioned vertically and has a replaceable paper element; the oil drains out of the filter automatically during filter renewals.

1 Non-return valve .... **0,2 ± 0,05 bar**

2 Maintenance-free oil separator

3 Filter bypass valve, opening pressure............................ **bar**

4 Tightening torque for oil filter cover.............**max. 25 + 5 Nm**

5 Plastic guide for oil filter element

11 O-ring seal

12 Oil filter (surface area 12.500 sq. mm)

8 Pressure relief valve .... **10 ± 1 bar**

Renew sealing rings **6** (51.05504-0107) each time the oil is changed. They are included with the replacement oil filter.

To replace the oil filter, open its cover (**40 Nm** torque) until the upper O-ring is visible.

Wait for about a minute and a half, after which the oil filter cover can be removed without oil overflowing.

A Oil trap (maintenance-free)

B Coolant pre-heating (optional)

C Return from oil trap to sump

D Oil filter (with replaceable filter element)

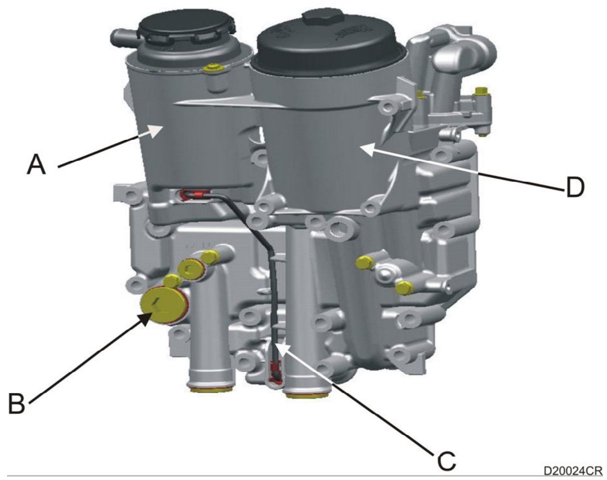
E Flat-pattern oil cooler

F Oil feed from oil pump

G Pressurised oil supply to crankcase

H Oil return from cylinder head

I Pressurised oil supply to cylinder head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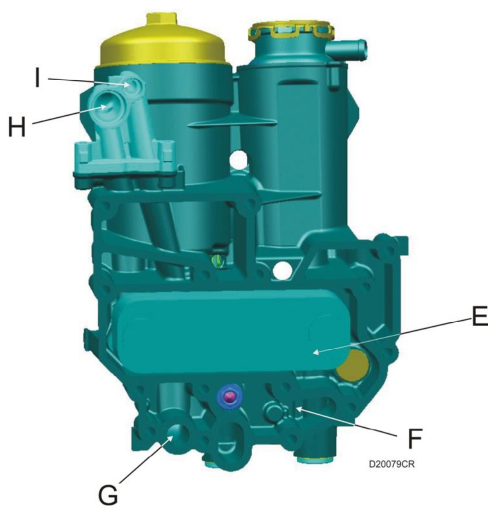
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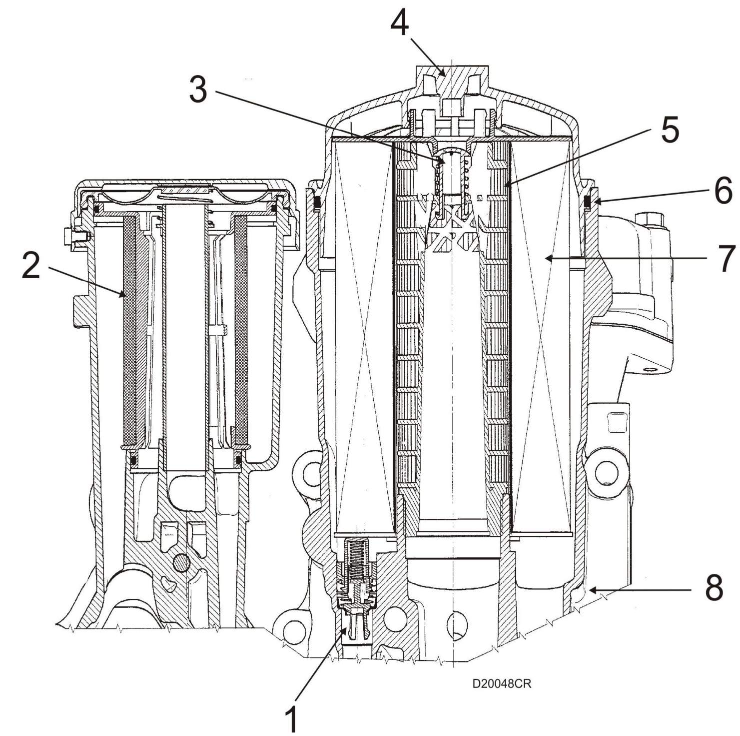
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D20048CR

Oil spray jets for piston crown cooling

On D20-CR engines, oil spray jets with hollow screws and no pressure regulating valves are installed. In view of the high torque available at low engine speeds, the piston crowns (Engine 390/430 PS) must always be cooled.

The oil jet must enter the cooling passage and reach the piston crown without hindrance.

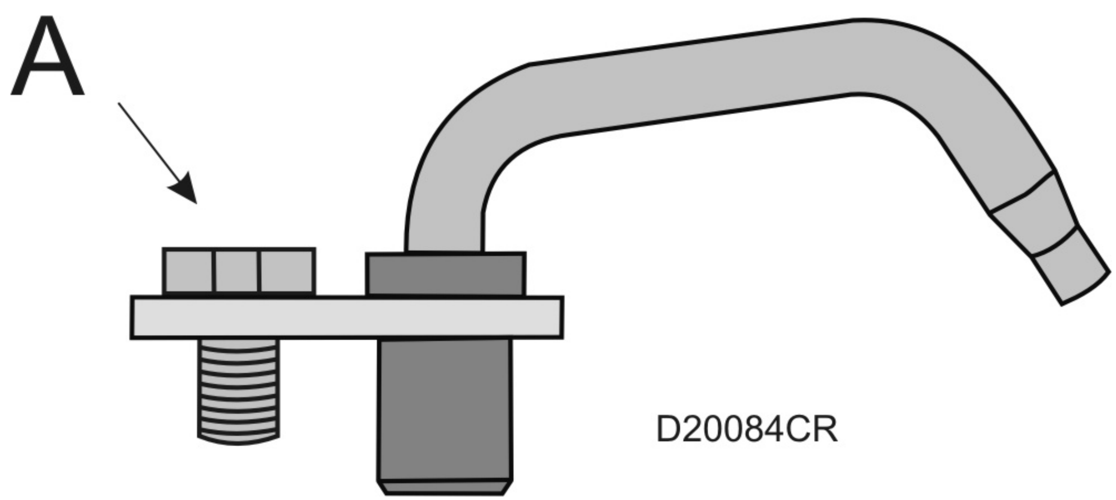
NOTE:

Bent oil spray jets must be replaced, never straightened.

Tightening torque of M 6x12 (10.9) hollow screws **A**: **13 Nm**.

Delivery rate at **3,5** bar app. **5,4** litres

Delivery rate at **5,0** bar app. **6,4** litres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D20084CR

OIL LEVEL SENSOR WITH TEMPERATURE SENSOR

Function of oil level sensor

The oil level probe uses a hot-wire measuring principle. After switching on the truck's electrical system, a 280 mA current is transmitted through the dipstick for 0.8 sec. The voltage drop at the resistance in the dipstick is measured at the beginning and end of the current flow. The difference between the two voltages is evaluated by the control unit (FFR) and displayed as a bar chart on the instrument panel.

Technical data

Resistance, pin 1 - 2................. **5,65 Ω (25°C)**
Time ti....................................... **0,8 sec**
Current Imax............................. **280 mA**

Function of oil temperature sensor

The oil temperature is measured with a PTC (**A**).
Resistance, pin 3 - 4................. **1980-2020 Ω (25°C)**
.... **2055-2105 Ω (30°C)**

With FFR 81.25805-7011 or higher, the warning threshold below a minimum of 30 l and above a maximum of 35 l appears as a display message **"Check oil level"**. If the oil level display is called up and the engine has been overfilled, a solid black bar is displayed; if the engine oil level is too low, no bar is displayed.

NOTE

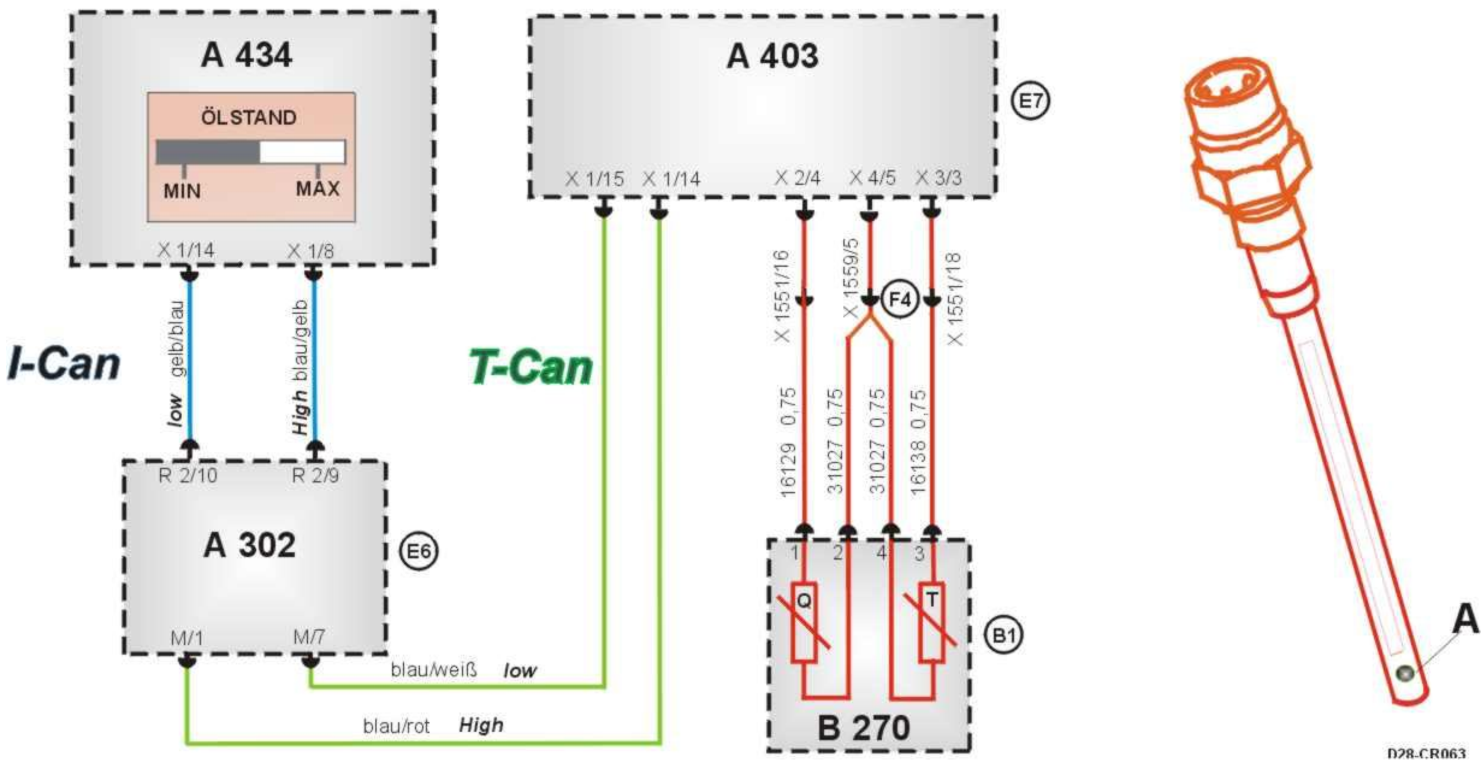
- The oil level probe transmits a value to the FFR control unit, which is also available on the data bus until the electrical system is switched off and on again, whereupon a new value is measured.
- After switching on the truck's electrical system, the oil level is measured every 5 seconds and the value supplied to the data bus. This level-sensing method also indicates the change in level as oil is added.

WARNING: If the engine is started, the cycle of oil level measurements is terminated and the last value supplied to the data bus. The oil level measuring cycle restarts whenever the electrical system is switched off and on again.

B 270	Oil level probe
A 403	Truck management computer
A 302	Central computer
A 434	Instrument cluster
T	Oil temperature measurement
Q	Oil level measurement
I-CAN	Instrument CAN
T-CAN	Driveline CAN
B1/E6/E7/F4	Installed position

OELSTANDSANZEIGE - NEU

OIL LEVEL DISPLAY - NEW



D2066LF... engines are rated to operate at the following coolant temperatures:

- 90°C continuous
- 105°C briefly
- 110°C briefly with retarder in use

Thermostats

Two replaceable wax-element thermostats are installed in the intermediate housing and used to create a bypass circuit as the engine is warming up. This separates the radiator from the coolant circuit until the thermostats start to open at 83 °C, and therefore ensures that the regular engine operating temperature is reached more rapidly.

Renewing the coolant

Important: Renew the filler cap and the cap with operating valve on the equalising tank.

Coolant with antifreeze: MAN 324

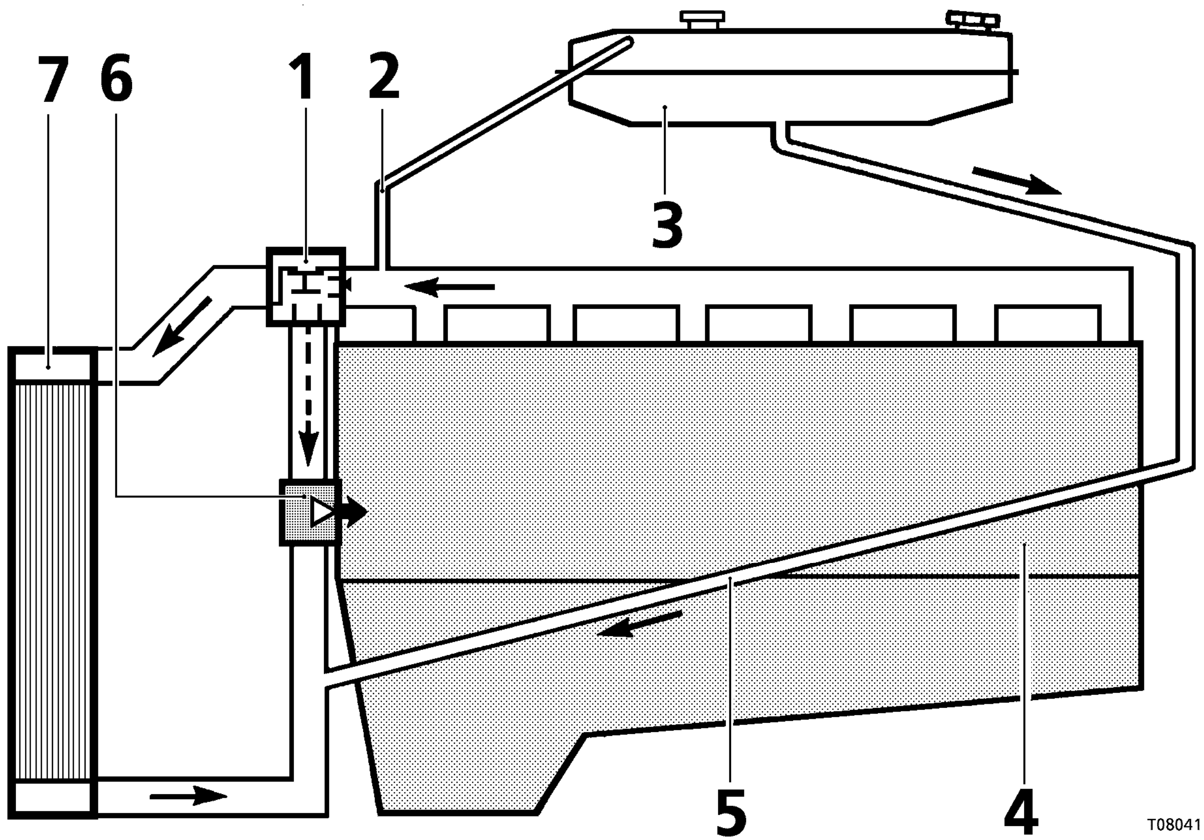
Maintenance group A every **3 years (every 500.000 km at the latest)**

Maintenance group B every **4 years (no distance limit)**

Maintenance group C every **4 years (but not later than every 4.000 hours of operation)**

Coolant with corrosion inhibitor: MAN 248 (without antifreeze) – renew once a year (all maintenance groups).

1 Thermostat
2 Coolant bleed line
3 Equalising tank
4 Engine
5 Filling line
6 Water pump
7 Radiator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Adding coolant

NOTE:

The cooling system must be filled according to the correct procedure in order to avoid damage by cavitation; this occurs primarily at the water pump and cylinder liners. Make sure that all the air trapped in the cooling system can escape. This is best assured by adding the coolant slowly.

- Insert and tighten all drain plugs, close all drain taps and re-attach hoses that were previously removed.
- Make sure that corrosion and cavitation protection are adequate (**antifreeze concentration 50% by volume**).
- Open the heater control lever (heater/ventilation cabinet in buses) by setting it to the red spot.
- Do not open the cap with the operating valve (2) when filling the system.
- Add coolant slowly at the filler pipe (1).
- Run the engine at a fast idle speed for about 5 minutes and top up the coolant level continuously.
- Stop the engine and check the coolant level; add more coolant if necessary.
- Attach the filler cap. Check the system again after driving the vehicle for 1 to 5 hours.

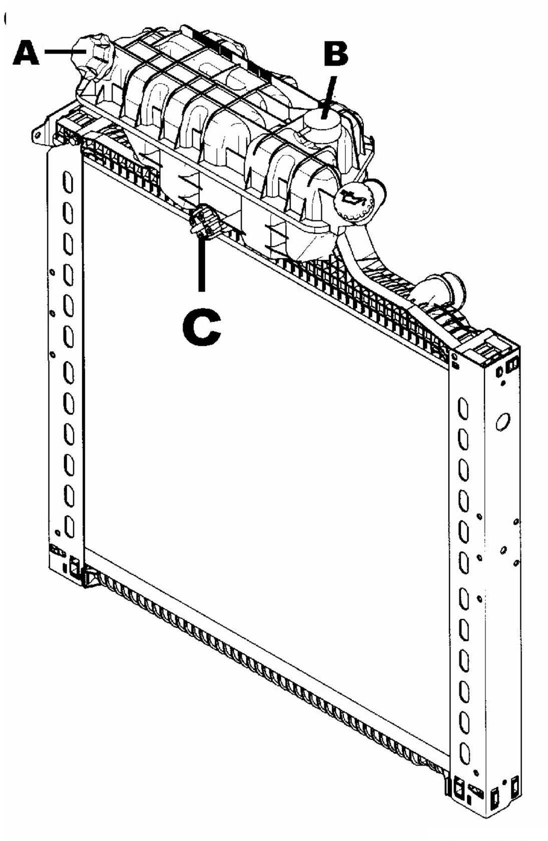
The coolant level must be visible above the rim, or else reliable engine cooling cannot be guaranteed.

% glycol by vol.	Ice flocculation point	Boiling point °C
10	-4	+101
20	-9	+102
30	-17	+104
40	-26	+106
50	-39	+108

A Filler cap **1**

B Cap with operating valve **2**
Pressure relief valve opens at **0,7 + 0,2** bar overpressure
Vacuum valve opens at **0,1** bar underpressure

C Coolant level probe B139
If the coolant level drops below the permitted limit, a warning is transmitted to the display via the I-CAN bus (Reed contact). Electrical connection to ZBR R1/3, wire No. 16113



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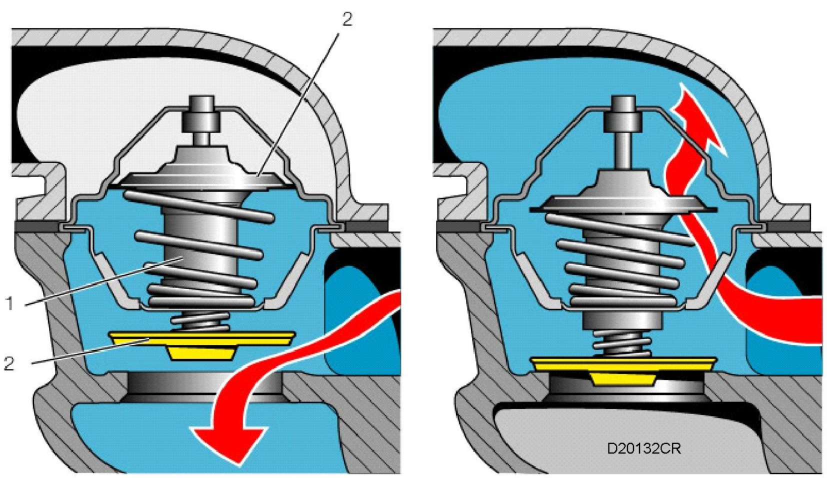


Water pump

The water pump is maintenance-free. It is mounted on the front timing case and driven by the Poly-V belt.

A Hub pressed in flush (+/- 0,1 mm)

B Slipring seal distance from housing (+ 0,8 –0,6 mm)

C Impeller pressed in (+/- 0,1 mm)

D Sealing plug

Water pump circulation

1 Coolant inlet

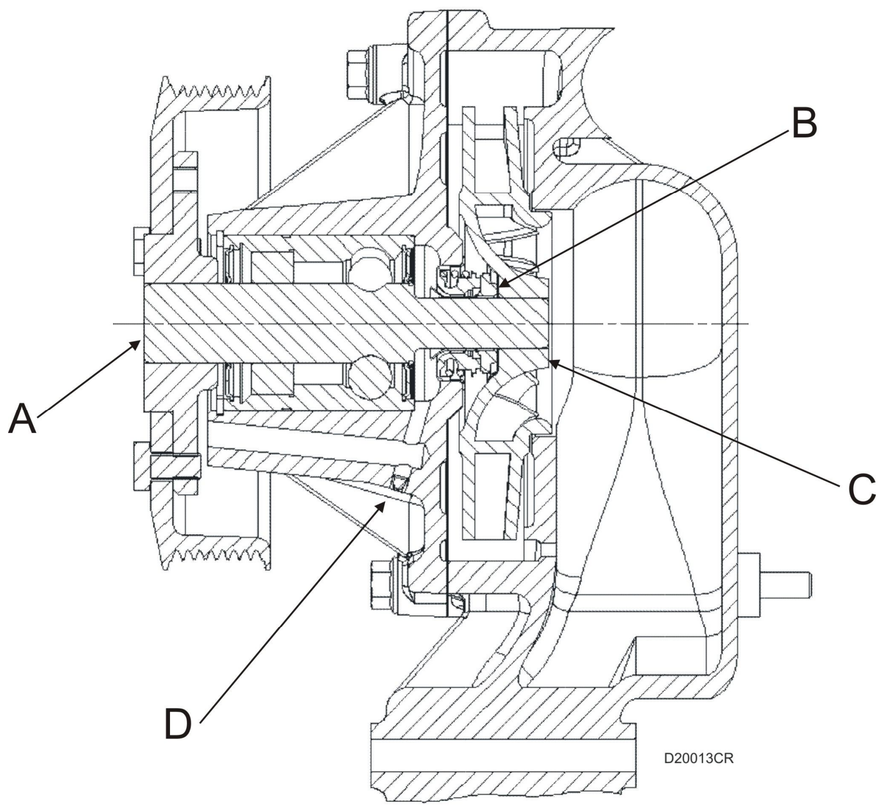
2 Coolant outlet

3 Cylinder 1

4 Cylinder 6

Note:

- Do not handle the SiC rings with bare hands.
- Grey cast iron impeller



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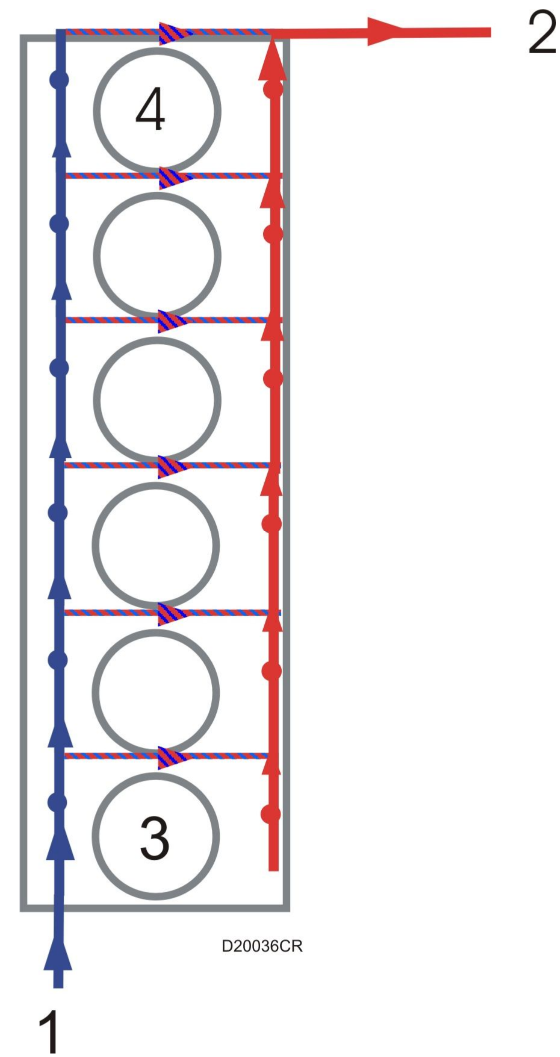

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D20036CR
1

TGA FLAME START SYSTEM

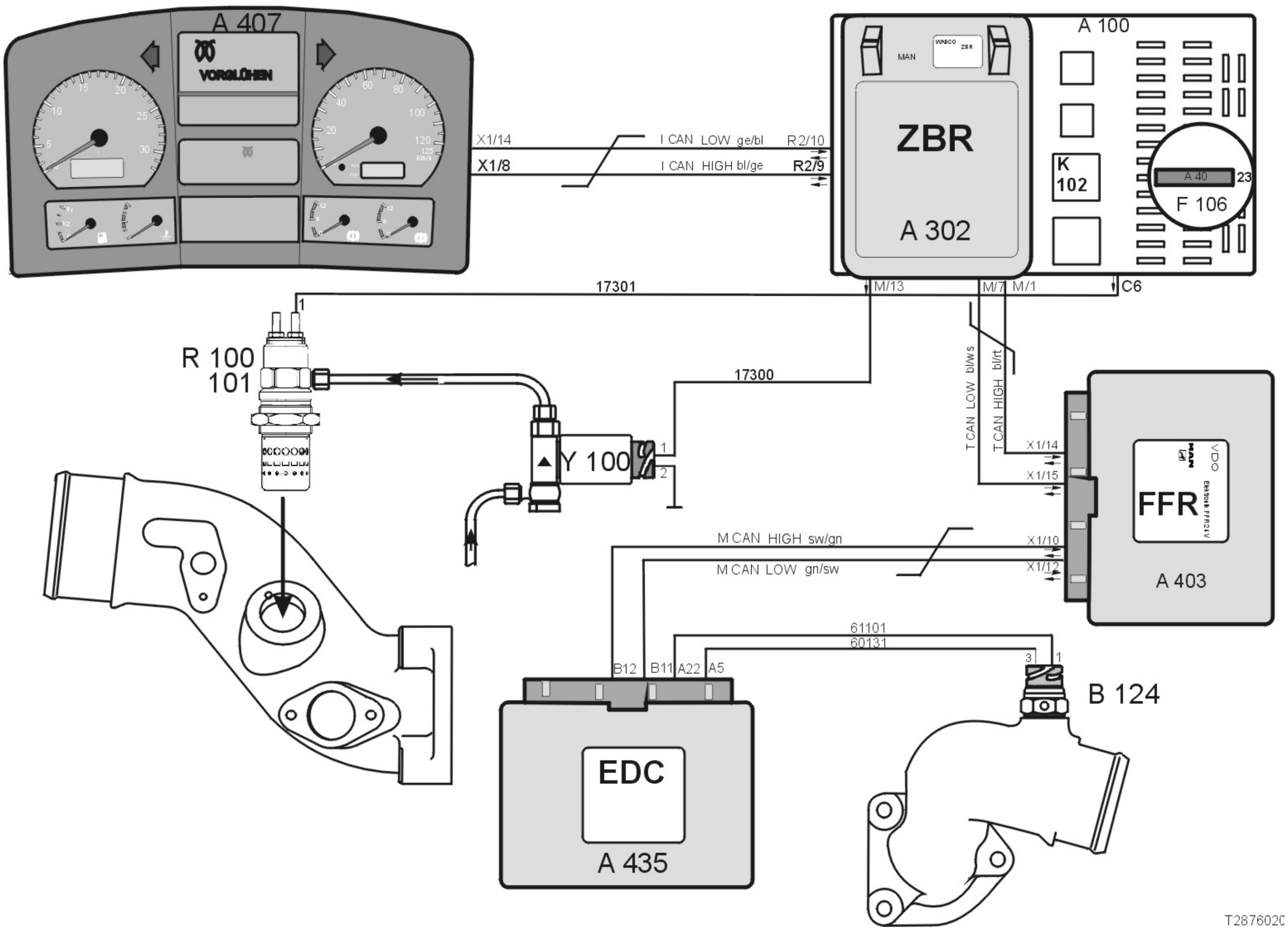
1. The central vehicle computer (ZBR) regulates the flame start system.
2. The flame start system is not activated until coolant temperature drops to below +10 °C).

Pre-heat period

- The telltale LED (pre-heating) is energised continuously via the I-CAN bus.
- The flame start relay K 102 (normally open) is energised intermittently at a voltage of > 24 V. If the voltage is below 24 V, the relay is supplied with current continuously.
- Solenoid valve Y 100 is not energised.
- At a voltage of 22 - 23 V, the pre-heat period is approx. 33 – 35 seconds.
- If the starter switch (terminal 50) (Q101) is operated during the pre-heat period, the flame start telltale light and the flame start relay are shut down.

Readiness to start

- The flame start telltale light flashes according to a signal transmitted via the “Instruments” data bus (I – CAN). The flame start relay is energised intermittently according to the voltage present at terminal 15.
- Solenoid valve Y 100 is not energised.
- If the starter switch (terminal 50) is operated during the period of readiness to start, the flame start relay maintains its intermittent cycle according to the voltage at terminal 15. The flame start telltale light flashes in the same rhythm as the energising of the flame start relay. The flame start solenoid valve is energised. When the starter switch (terminal 50) is released again, the engine will start and run.



A 407
VORGLÜHEN
X1/14
X1/8
I CAN LOW ge/bl
I CAN HIGH bl/ge
R2/10
R2/9
A 100
ZBR
A 302
K
102
A 40
23
F 106
17301
M/13
M/7
M/1
C6
1
R 100
101
17300
T CAN LOW bl/ws
T CAN HIGH bl/rt
Y 100
1
2
X1/14
X1/15
FFR
VDO
A 403
M CAN HIGH sw/gn
M CAN LOW gn/sw
X1/10
X1/12
61101
60131
B12
B11
A22
A5
3
1
B 124
EDC
A 435
T2876020

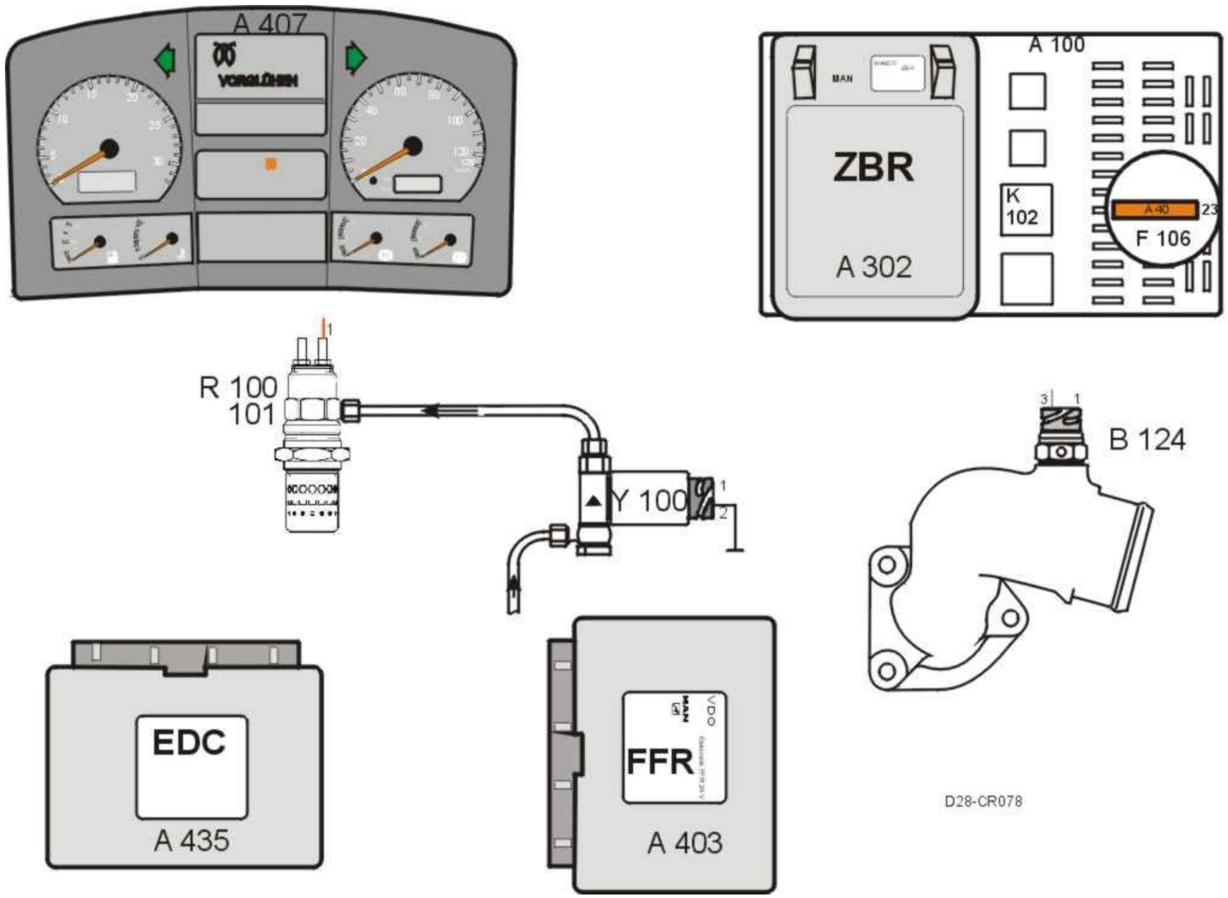
Post-heating period

- The flame start relay is energised in an intermittent cycle that depends on the voltage at terminal 15; the flame start telltale light flashes in the same rhythm as the relay. The flame start solenoid valve is switched on.
- If the engine is not running and the alternator is not detected as running (> 0), the relay and the telltale light are not operational. If the starter switch (terminal 50) is turned on after the safety shut-down period, the relay, telltale light and solenoid valve do not operate.

NOTE: If the coolant temperature sensor fails, the engine oil temperature is used as a substitute input. The flame start system is also active if the engine temperature signal fails; the post-heating period is then limited to 30 seconds.

Inputs

- Starter operated - signal from FFR or T CAN
- Coolant temperature - EDC from T CAN
- Flame start plug current from central electrics ZBR II pin ZE/19
- Terminal 15 from central electrics ZBR II ZE/17
- **R 100** flame heater plug – signal from fuse F 106 (40 A) plug position 23 to relay K 102
- **A 302** Central vehicle computer signal to display A 407 via I-CAN
- **A 403** Vehicle management computer signal from EDC control unit (M-CAN) to central vehicle computer (T-CAN)
- **B 124** Coolant temperature sensor (NTC) signal to EDC control unit.


A 407
VORGLÜHEN
A 100
ZBR
A 302
K 102
F 106
R 100
101
Y 100
B 124
EDC
A 435
FFR
A 403
D28-CR078

Flame heating plug R100 / solenoid valve Y100

Fuel is supplied to the flame heating plug via solenoid valve Y 100 from the Fuel Service Center(KSC).

Electrical values for flame heating plug

- U_{nom} = 24 V
- I_{26} = 28 A ± 2 A after 26 sec
- T 28 = 1090° C after 26 sec

Tightening torques for flame heating plug

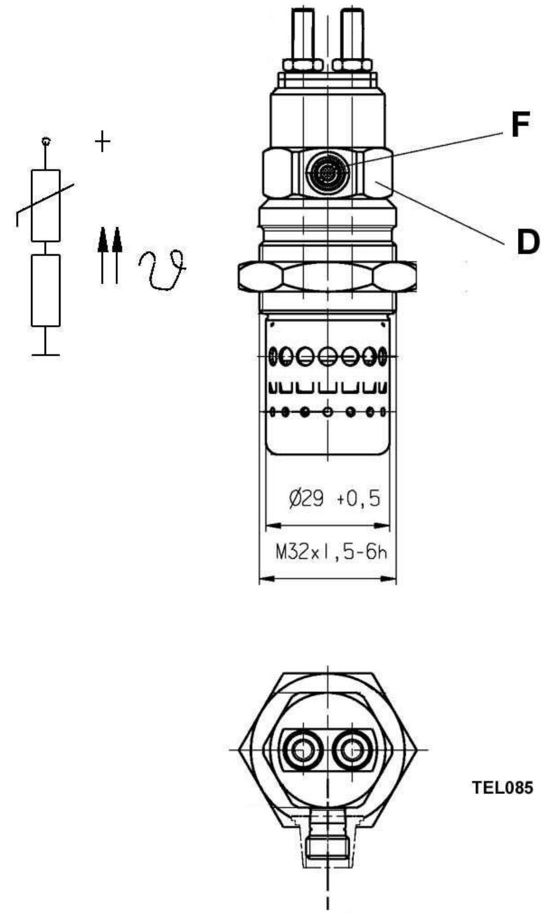
Insertion thread	M 32 x 1,5	max.	**25 Nm**
Oil leak-off union	M 5	max.	**5 Nm**
Fuel union	M 10 x 1		**10 Nm**

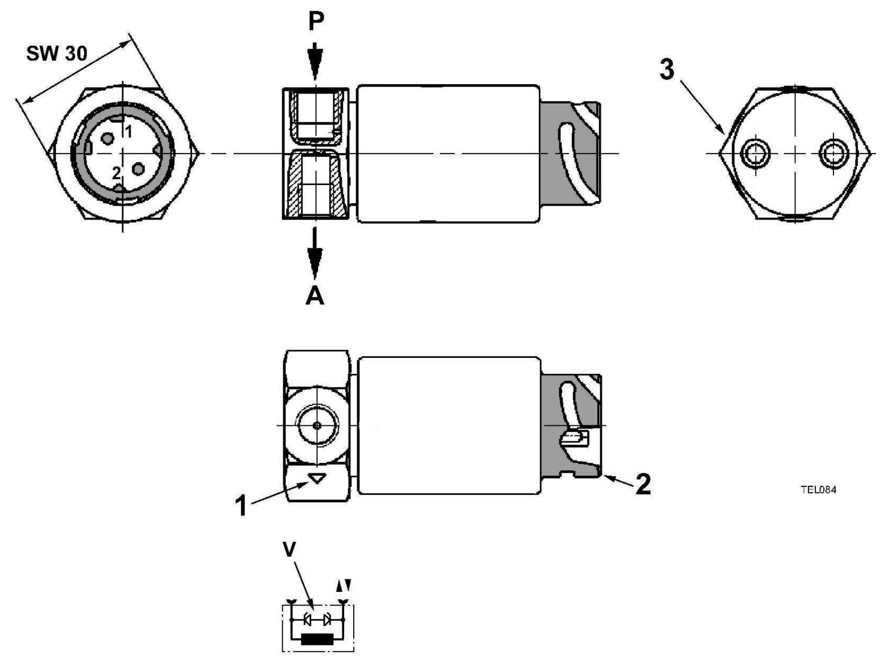
Solenoid valve

- **1** Fuel flow direction arrow
- **2** Plug connector, DIN 72585 A1-2.1-9nK2
- **3** Date of manufacture on hexagon flat
- **A** Connection for flame heating plug
- **P** Connection from KSC
- **V** Diode to extinguish voltage peaks

Technical data

- Valve function - closed when de-energised
- Winding resistance **32 Ω / 20° C**
- Current consumption **0,7 A** at nominal voltage
- Nominal voltage 27 V


F
D
Ø29 +0,5
M32x1,5-6h
TEL085


SW 30
P
A
3
1
2
TEL084
V

AIR COMPRESSOR

A Drive gear

B Bolt (**80** Nm), 18 mm

C Crankshaft (axial play 0,1 – 0,4 mm)

D Oil entry

E Cylinder head bolt (torque **14** Nm)

F Cylinder head bolt (torque **30** Nm)

G Safety valve (torque **90** Nm)

H Attachment for steering pump

Two versions are available: 360 cc and 720 cc

The air compressors are located on the left side of the engine and driven at the *fan end* by the compressor gearwheel (**29 teeth**) and an intermediate gearwheel (**36 teeth**) from the crankshaft gearwheel (**37 teeth**). They are bolted to the crankcase and rated for a usable pressure of 12,5 bar.

The housing is sealed with 04.10160-9029 sealant (Loctite 5900).

Drive is via a divided intermediate gearwheel from the flywheel end.

A heat exchanger (with triple labyrinth) is integrated into the air compressor cylinder head in order to lower the air outlet temperature. A safety valve with a blow-off pressure of 17^{-2} bar is screwed into the cylinder head.

Intermediate gearwheel (split version)

1 Rubberised drive pin

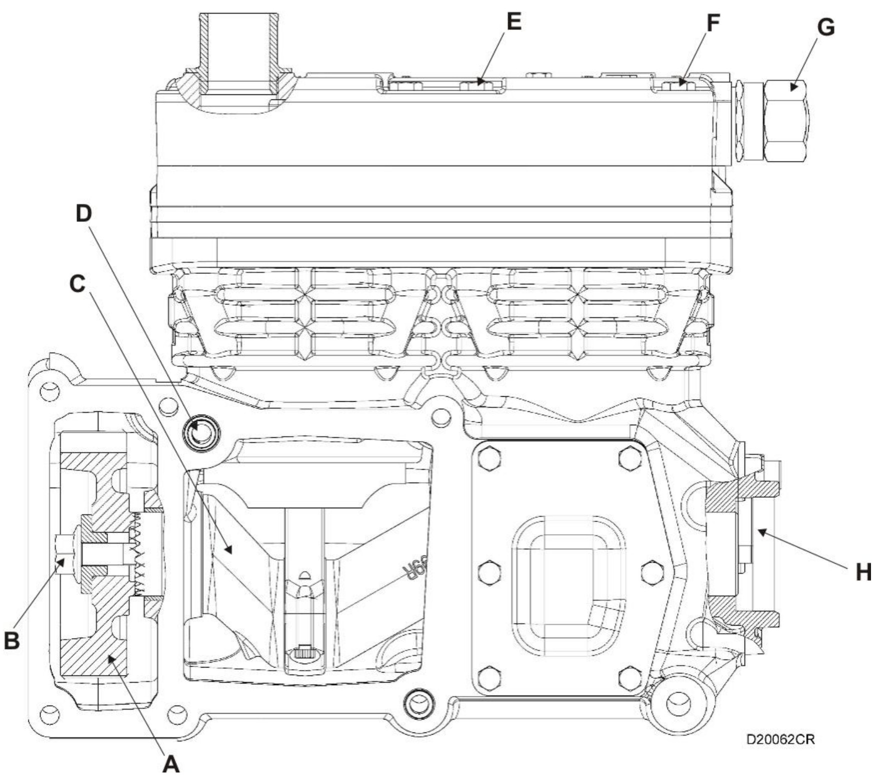
2 Pre-load for both gearwheels

3 Inner gearwheel

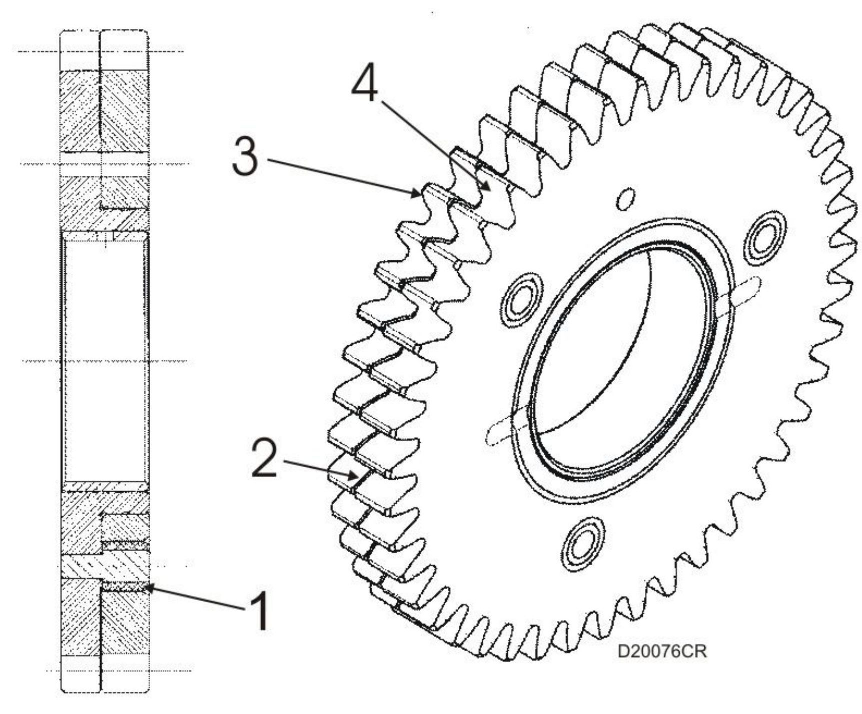
4 Outer gearwheel (36 teeth)

Note:

Before demounting of the intermediate gear, demount the crankshaft gear (**Attention** the thrust washer on the rear gear side can lose and fall into the housing).



E
F
G
D
C
H
B
A
D20062CR



4
3
2
1
D20076CR

Starter motor

D2066LF... engines are equipped for the first time with the Bosch HEF109-M 6,0 kW pre-engaged starter motor, which is a new development and has an integral planetary gear set. For special vehicle duties the starter motor is provided with an acoustic sandwich heat-insulating cover to prevent overheating.

Alternator

110 Ampere Bosch NBC1, 80 A and NBC2 alternators, a new development with higher performance and a low noise level are used; they are mounted on the intermediate housing, and driven by a low-maintenance Poly-V belt from the fan shaft.
The alternators are equipped with a multi-functional voltage regulator. The voltage is varied according to temperature, state of battery charge and current consumption at any given moment. In order to maintain a charge when the engine is idling, the alternator rotates at four times engine speed.

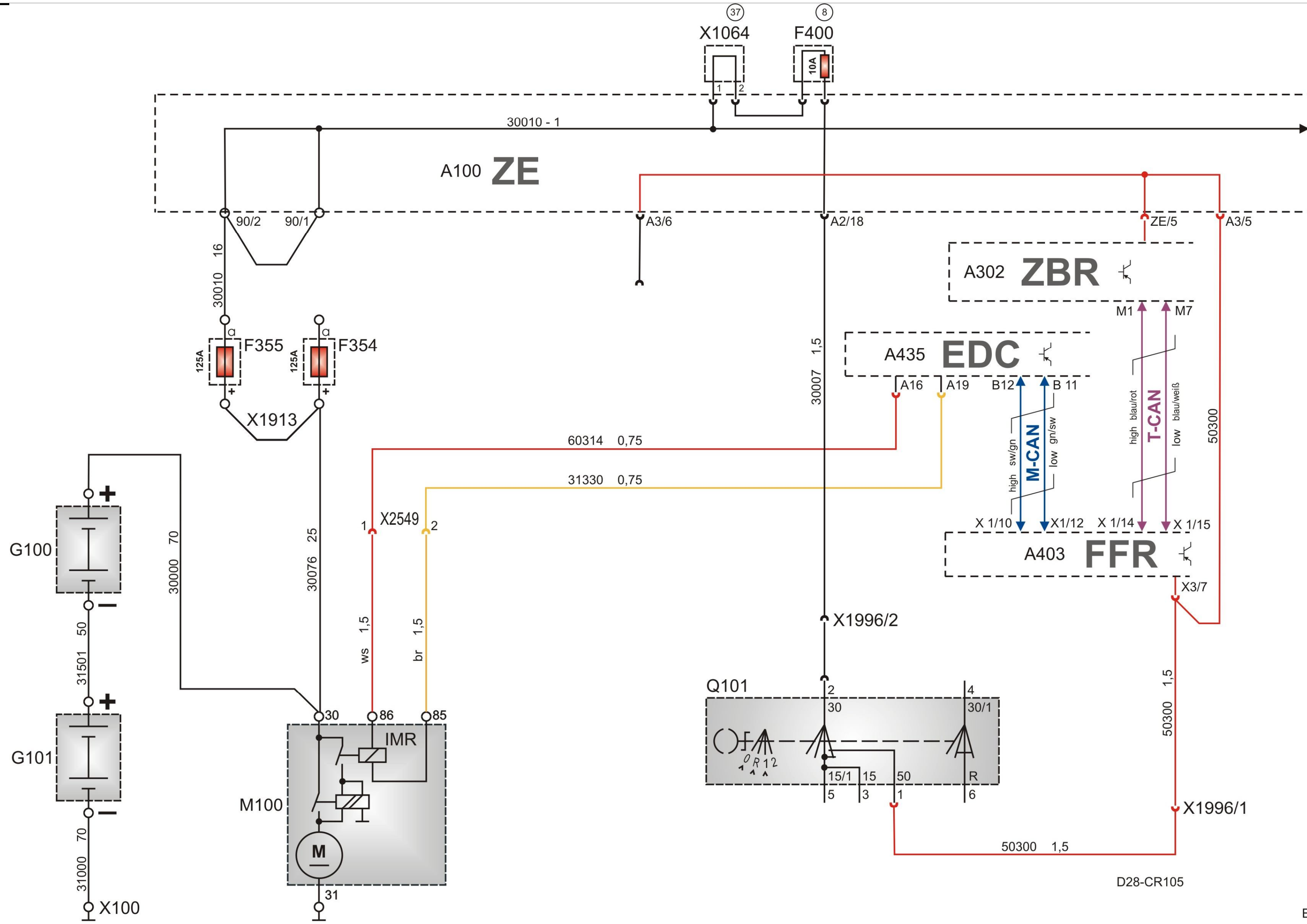
Electrical sensors

Only single temperature sensor is needed on the engine for all FFR temperature management functions (control of flame starting system, cooling fan control, temperature display, EDC, retarder control).

The oil pressure sensor is installed in the oil filter module.
The sensor wiring is led directly to the engine wiring duct.

Starting control

The start signal is transmitted from the key switch to the FFR and then via the engine CAN to the EDC control unit.
After checking the engine start conditions such as engine completely stopped and time lapse for repeat starting, pin 16 of the engine control unit is energised and the IMR activated.
This avoids incorrect switching of the starter motor by the engine control unit (unwanted starting beyond the driver’s control).



X1064
F400
37
8
10A
30010 - 1
A100 ZE
90/2
90/1
A3/6
A2/18
ZE/5
A3/5
A302 ZBR
M1
M7
30010 16
F355
F354
125A
X1913
A435 EDC
A16
A19
B12
B 11
30007 1,5
60314 0,75
31330 0,75
high sw/gn
M-CAN
low gn/sw
high blau/rot
T-CAN
low blau/weiß
50300
X 1/10
X1/12
X 1/14
X 1/15
A403 FFR
X3/7
G100
G101
30000 70
30076 25
X2549
ws 1,5
br 1,5
31501 50
X1996/2
Q101
30
86
85
IMR
M100
M
31
30/1
15/1
15
50
R
50300 1,5
X1996/1
31000 70
X100
D28-CR105
E

Quiet running control

The quiet running control is intended to achieve smooth engine running, particularly during idling.

In six-cylinder engines each cylinder accelerates the engine for 120° in its working stroke and triggers the injectors of the "slow" cylinders for a longer period and those of the "fast" cylinders for a shorter period.

The fuel correction quantity is the difference from the setpoint quantity.

For the evaluation the firing sequence: **1⇒5⇒3⇒6⇒2⇒4** must be observed.

Example of an evaluation:

If the output from cylinder 6 is poor, the correction quantity at injector 6 is increased.

If the engine still does not run smoothly, the quantity for injector 2 will be increased also.

After this, however, the quantity for cylinder 4 will be reduced so that the engine does not turn too fast.

It is therefore possible to see a group in which two injectors receive more fuel (**+**) and one receives less fuel (**-**).

In this **+ +** group the first cylinder is the one with the poor power output.

To obtain an overview of the engine status the **run-up test** as a function of the compression too should be compared in free monitoring in addition to the **cylinder comparison**.

Example of an evaluation:

If the output from cylinder 6 is poor, the correction quantity at injector 6 is increased.

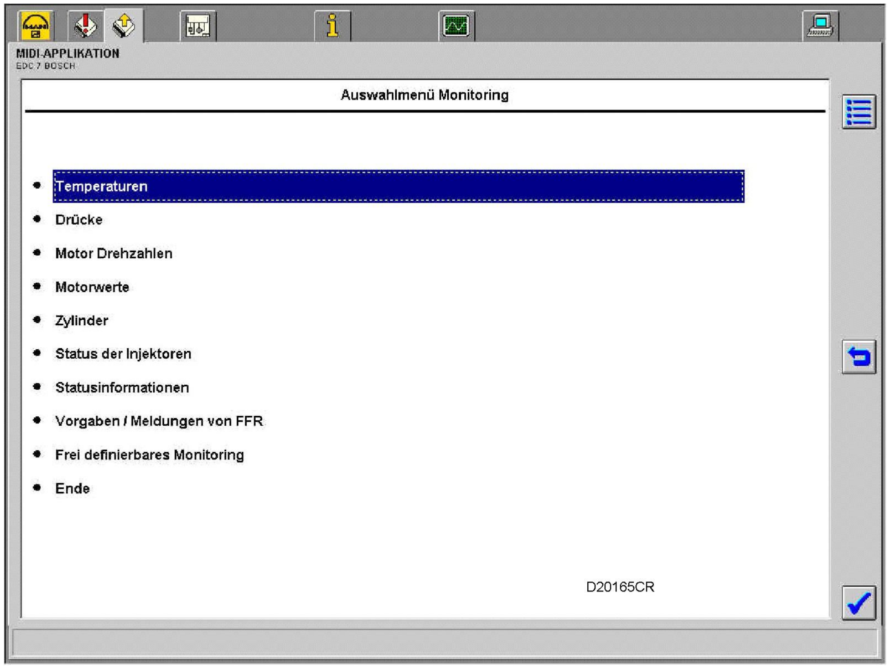
If the engine still does not run smoothly, the quantity for injector 2 will be increased also.

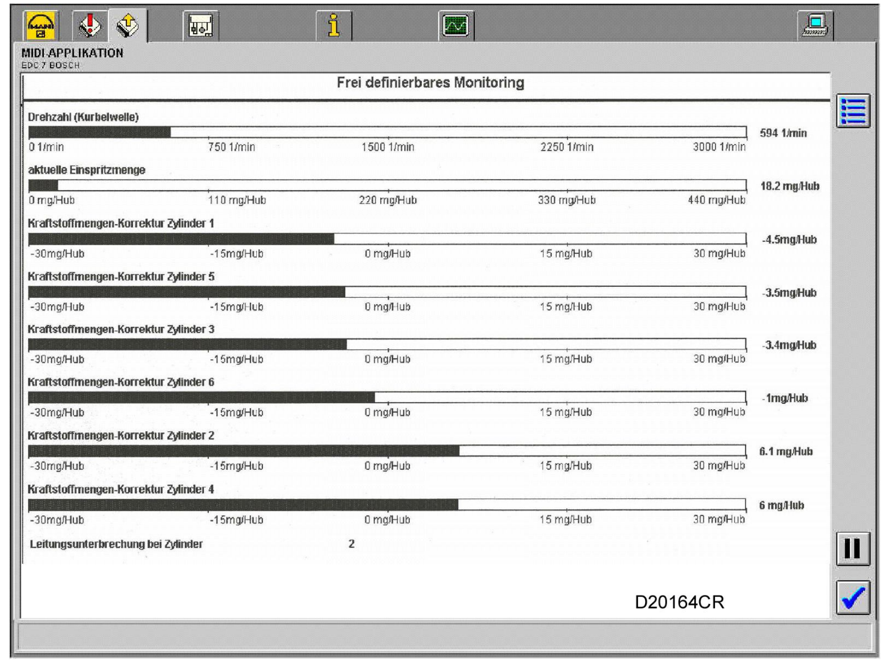
After this, however, the quantity for cylinder 4 will be reduced so that the engine does not turn too fast.

It is therefore possible to see a group in which two injectors receive more fuel (**+**) and one receives less fuel (**-**).

In this **+ +** group the first cylinder is the one with the poor power output.

To obtain an overview of the engine status the **speed** and the **theoretical injection quantity** should be displayed too in free monitoring in addition to the **cylinder comparison**.


MIDI-APPLIKATION
EDC 7 BOSCH
Auswahlmenü Monitoring
Temperaturen
Drücke
Motor Drehzahlen
Motorwerte
Zylinder
Status der Injektoren
Statusinformationen
Vorgaben / Meldungen von FFR
Frei definierbares Monitoring
Ende
D20165CR


MIDI-APPLIKATION
EDC 7 BOSCH
Frei definierbares Monitoring
Drehzahl (Kurbelwelle)
594 1/min
0 1/min
750 1/min
1500 1/min
2250 1/min
3000 1/min
aktuelle Einspritzmenge
18.2 mg/Hub
0 mg/Hub
110 mg/Hub
220 mg/Hub
330 mg/Hub
440 mg/Hub
Kraftstoffmengen-Korrektur Zylinder 1
-4.5mg/Hub
Kraftstoffmengen-Korrektur Zylinder 5
-3.5mg/Hub
Kraftstoffmengen-Korrektur Zylinder 3
-3.4mg/Hub
Kraftstoffmengen-Korrektur Zylinder 6
-1mg/Hub
Kraftstoffmengen-Korrektur Zylinder 2
6.1 mg/Hub
Kraftstoffmengen-Korrektur Zylinder 4
6 mg/Hub
-30mg/Hub
-15mg/Hub
0 mg/Hub
15 mg/Hub
30 mg/Hub
Leitungsunterbrechung bei Zylinder
2
D20164CR

Run-up test

Procedure:

In the run-up test we measure the speed that the engine can achieve with a defined injection quantity in a certain period of time. With this information we can tell whether all injectors are injecting equally.
In the first run-up **all** injectors are triggered and the speed achieved is determined.
In the second run-up the engine is accelerated to a high speed, but this time with injector 1 switched off.
The third run-up is then carried out without injector 2, the fourth to seventh run-ups without injector 3, 4, 5 and 6 respectively.
If the engine now achieves almost the same speed as during the first run-up even though one injector is switched off, the cylinder with the switched-off injector is performing poorly (check the mechanics of the engine).

A Injector switched off
B Speed at start
C Speed achieved
D Acceleration calculated

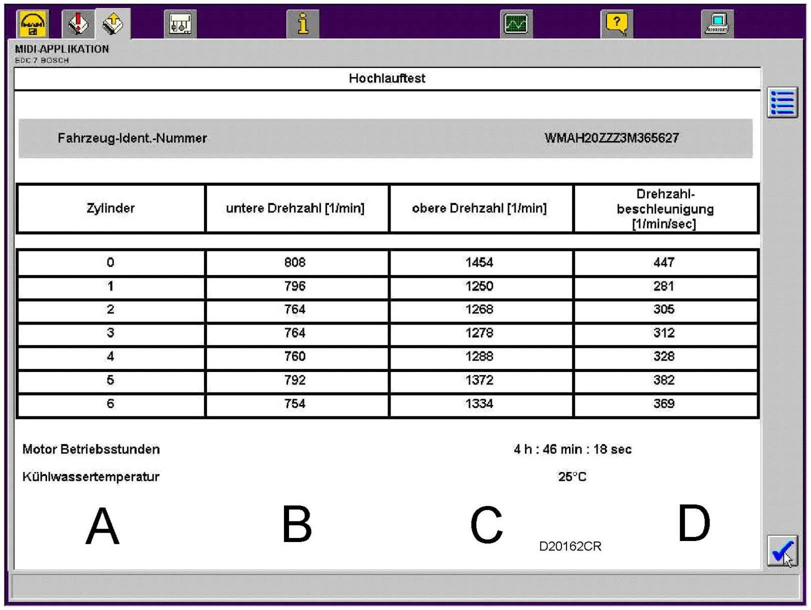
Compression test

Procedure:

In the compression test the engine is turned over by the starter motor.
The control unit suppresses injection and measures for each cylinder how strongly the starter motor is retarded during the compression stroke.
For this the battery must be charged; the starter motor must then be actuated via the ignition key until the control unit has measured the speeds at BDC and shortly before TDC for all cylinders.
Strong retardation, i.e. a low speed before TDC, indicates relatively good compression.

1 Speed before TDC (lower speed in diagram)

2 Speed at BDC (upper speed in diagram)



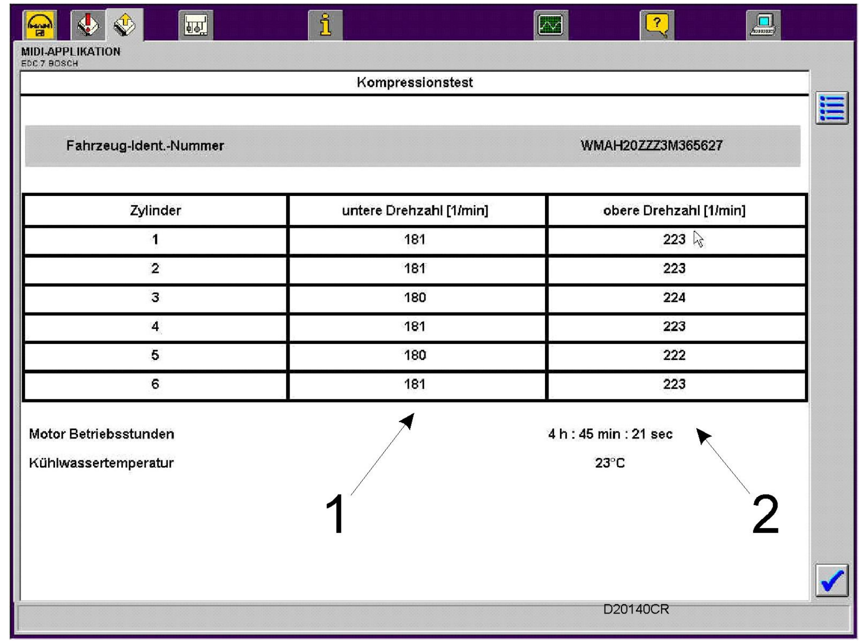
MIDI-APPLIKATION
EDC 7 BOSCH

Hochlauftest

Fahrzeug-Ident.-Nummer WMAH20ZZZ3M365627

Zylinder	untere Drehzahl [1/min]	obere Drehzahl [1/min]	Drehzahl-beschleunigung [1/min/sec]
0	808	1454	447
1	796	1250	281
2	764	1268	305
3	764	1278	312
4	760	1288	328
5	792	1372	382
6	754	1334	369

Motor Betriebsstunden 4 h : 46 min : 18 sec
Kühlwassertemperatur 25°C



MIDI-APPLIKATION
EDC 7 BOSCH

Kompressionstest

Fahrzeug-Ident.-Nummer WMAH20ZZZ3M365627

Zylinder	untere Drehzahl [1/min]	obere Drehzahl [1/min]
1	181	223
2	181	223
3	180	224
4	181	223
5	180	222
6	181	223

Motor Betriebsstunden 4 h : 45 min : 21 sec
Kühlwassertemperatur 23°C

SEALANT, ADHESIVES AND LUBRICANTS

SPARE PART NO.	DESIGNATION	VERSION
04.10160-9029	Sealant	For compressor
04.90300-9009	Adhesive	For EGR coolant manifold bolts
04.10160-9049	Sealant	For crankcase thrust ring/bearing, fan shaft
09.16012-0117	Assembly lubricant	For cylinder head bolt heads
04.10160-9049	Sealant	For crankshaft thrust ring
04.90300-9030	Sealing agent	For oil filler pipe
04.10394-9256	Sealing mastic Terostat 63	For charge air pipe
04.10160-9164	Thread locking agent (green)	Loctite 648

SPARE PART NO.	DESIGNATION	VERSION
04.10160-9131	Adhesive	Loctite 570 – screw, control unit - EDC
04.90300-9030	Sealant	For air compressor connector
04.10394-9256	Sealant	Terostat 63 for power take-off housing
09.15011-0003	Solid lubricant	50 GR
04.10160-9301	Adhesive	Omnivit 200M for air compressor
09.10160-9249	Adhesive	Omnivit FD3041 - compressor intermediate flange
09.10394-9256	Sealing mastic	Terostat T63 – compressor bushing
09.16012-0117	Assembly lubricant	OPTIMOLY WHITE- T / 100 GR
09.16011-0109	Assembly lubricant	Valve stem
04.10160-9208	Sealant	HYLOMAR
04.10194-9102	Sealant	Loctite 518
04.10394-9272	Sealant	Loctite 5900/ 5910 – noise damper cover
04.90300-9024	Sealant	Loctite 648 W
04.10075-0502	Sealant	Loctite 5900 for rear timing case

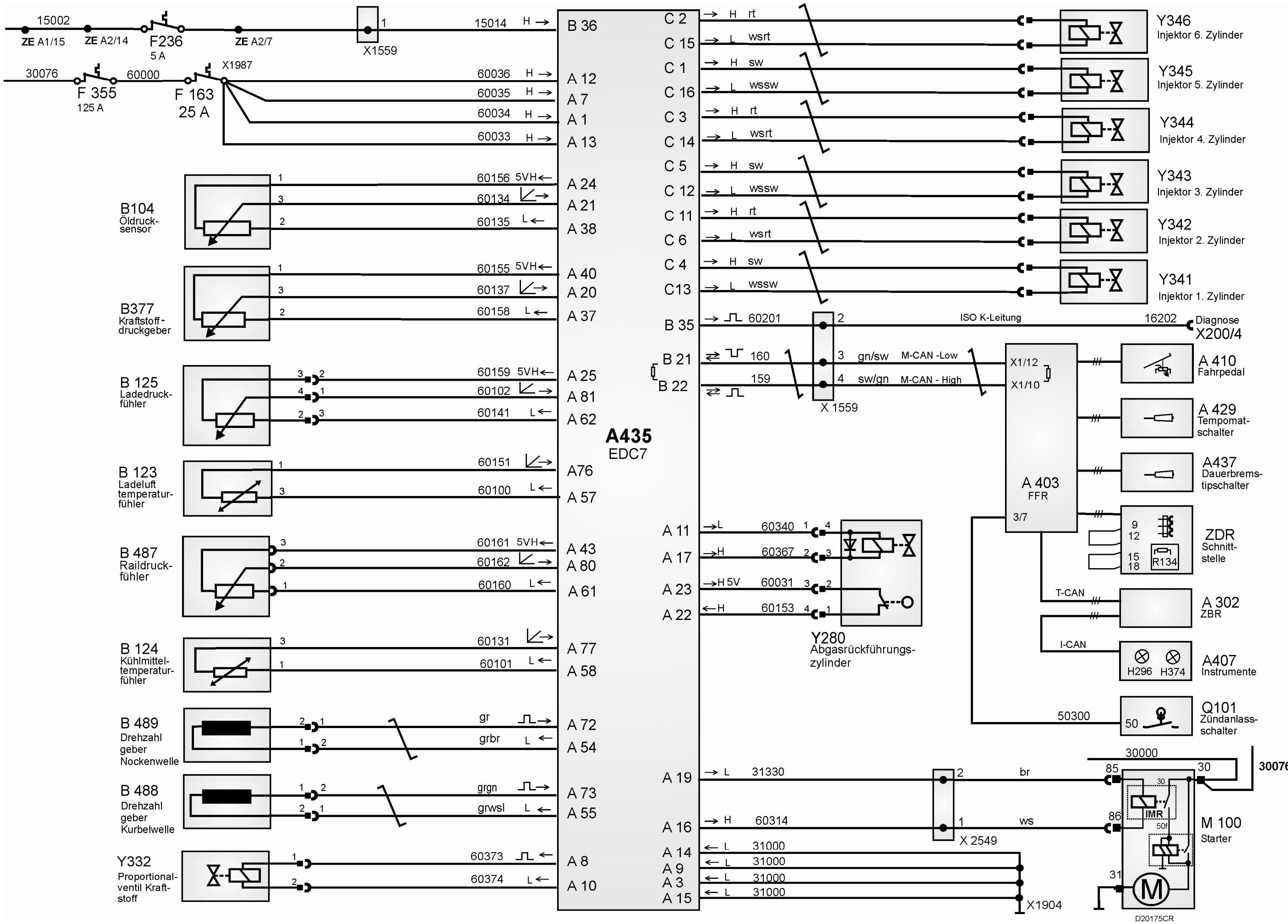
INSTALLED CLEARANCES AND WEAR LIMITS

	Installed dimensions	Wear limit
Main bearing journal diameter – standard size	103,98 – 104,00 mm	
Main bearing play - N	0,06 – 0,116 mm	
Variation between main bearing shells	0,3 – 1,2 mm	
Crankshaft endplay	0,200 – 0,401 mm	max. 1,25 mm
Big end bearing journal diameter – standard size	89,98 - 90,00 mm	
Big end bearing internal diameter – standard size	90,060 – 90,102 mm	
Variation between big end bearings	95,5 – (+2,5/-0,5) mm	
Gudgeon pin internal diameter	52,000 - 0,008 mm	
Cylinder liner projection above engine block	0,030 – 0,085 mm	min. 0,030 mm
Piston projection above top of engine block	-0,03 - + 0,3 mm	
Compression height, standard dimension (undersizes 0,2 – 0,4 – 0,6)	79,25 mm	

	Installed dimensions	Wear limit
1 Compression ring	**0,40 - 0,55 mm**	**1,50 mm**
2 Compression ring	**0,47 - 0,70 mm**	**1,50 mm**
3 Oil scraper ring	**0,25 - 0,55 mm**	**1,50 mm**
Exhaust valve recess	**0,60 - 0,8 mm**	
Inlet valve recess	**0,60 - 0,8 mm**	
Inlet valve clearance	**0,5 mm**	
Exhaust valve clearance	**0,8 mm**	
- with EVB	**0,6 mm**	

D 20-CR TIGHTENING TORQUES

	Item	Thread	Strength class	Tightening torque Nm	Initial tightening Nm	Tightening angle ∡	Remarks
1	Main bearing cap to crankcase	M 18x2	10.9		300+30	90°+10°	Do not re-use screws
2	Large intermediate gearwheel pin	M14	10.9		100+10	90°	
3	Thrust washer at timing case	M8	12.9	40			
4	Camshaft gearwheel to camshaft	M16x1,5	10.9	100	150+10	90°	
5	Flywheel to crankshaft	M14x1,5	10.9		140+10	1X90°+10°	Not to be re-used
6	Big end cap to connecting rod	M12x1,5	11.9		100+10	90°+10°	Not to be re-used
7	Rocker bearing pedestal to cyl. head	M12	10.9		105+10		
8	Locknut at adjusting screw	M10x1	10.9	40			
9	Exhaust manifold to cylinder head	M10			60+5	90°+10°	Torx E 14
10	Flame start pre-heat plug	M32x1,5		max. 25 Nm			
11	Injector lines	M14x1,5			10	60°/30°	Initial fitting 60° Later fitting 30°
12	CR injector wire connection	M4		1,5+0,25			
13	Control unit decoupling	M8	8.8	12+2			Loctite 270
14	High-pressure pump drive gear			105±5			
15	Ribbed V-belt pulley to alternator	M16x1,5		80±5			
16	Vibration damper	M16x1,5	10.9		150 ±10	90°+10°	
17	Cooling fan hub to fan shaft	M16x1,5			100	90°+10°	Left-hand thread
18	Air compressor drive gear	M18x1,5		80+10			
19	Pressure relief valve at compressor	M26x1,5		90+10			
20	Filter cover for oil module			40+10			
21	Cylinder head bolts	M18x2	10.9	10 +80+	300	3x90°+10°	Optimol White T (oil)


15002
ZE A1/15
ZE A2/14
F236
5 A
ZE A2/7
1
X1559
15014
H
B 36
30076
F 355
125 A
60000
X1987
F 163
25 A
60036
60035
60034
60033
A 12
A 7
A 1
A 13
B104
Öldruck-
sensor
60156 5VH
60134
60135 L
A 24
A 21
A 38
B377
Kraftstoff-
druckgeber
60155 5VH
60137
60158 L
A 40
A 20
A 37
B 125
Ladedruck-
fühler
60159 5VH
60102
60141 L
A 25
A 81
A 62
A435
EDC7
B 123
Ladeluft
temperatur-
fühler
60151
60100 L
A76
A 57
B 487
Raildruck-
fühler
60161 5VH
60162
60160 L
A 43
A 80
A 61
B 124
Kühlmittel-
temperatur-
fühler
60131
60101 L
A 77
A 58
B 489
Drehzahl
geber
Nockenwelle
gr
grbr L
A 72
A 54
B 488
Drehzahl
geber
Kurbelwelle
grgn
grwsl L
A 73
A 55
Y332
Proportional-
ventil Kraft-
stoff
60373
60374 L
A 8
A 10
C 2
C 15
C 1
C 16
C 3
C 14
C 5
C 12
C 11
C 6
C 4
C13
H rt
L wsrt
H sw
L wssw
Y346
Injektor 6. Zylinder
Y345
Injektor 5. Zylinder
Y344
Injektor 4. Zylinder
Y343
Injektor 3. Zylinder
Y342
Injektor 2. Zylinder
Y341
Injektor 1. Zylinder
B 35
60201
2
ISO K-Leitung
16202
Diagnose
X200/4
B 21
B 22
160
159
3 gn/sw M-CAN -Low
4 sw/gn M-CAN - High
X 1559
X1/12
X1/10
A 403
FFR
3/7
A 410
Fahrpedal
A 429
Tempomat-
schalter
A437
Dauerbrems-
tipschalter
9
12
15
18
R134
ZDR
Schnitt-
stelle
T-CAN
A 302
ZBR
I-CAN
H296 H374
A407
Instrumente
50300
50
Q101
Zündanlass-
schalter
A 11
A 17
A 23
A 22
60340
60367
H 5V 60031
60153
Y280
Abgasrückführungs-
zylinder
A 19
L 31330
2 br
A 16
H 60314
1 ws
X 2549
30000
85
30
30076
86
IMR
50f
M 100
Starter
31
M
A 14
A 9
A 3
A 15
L 31000
X1904
D20175CR