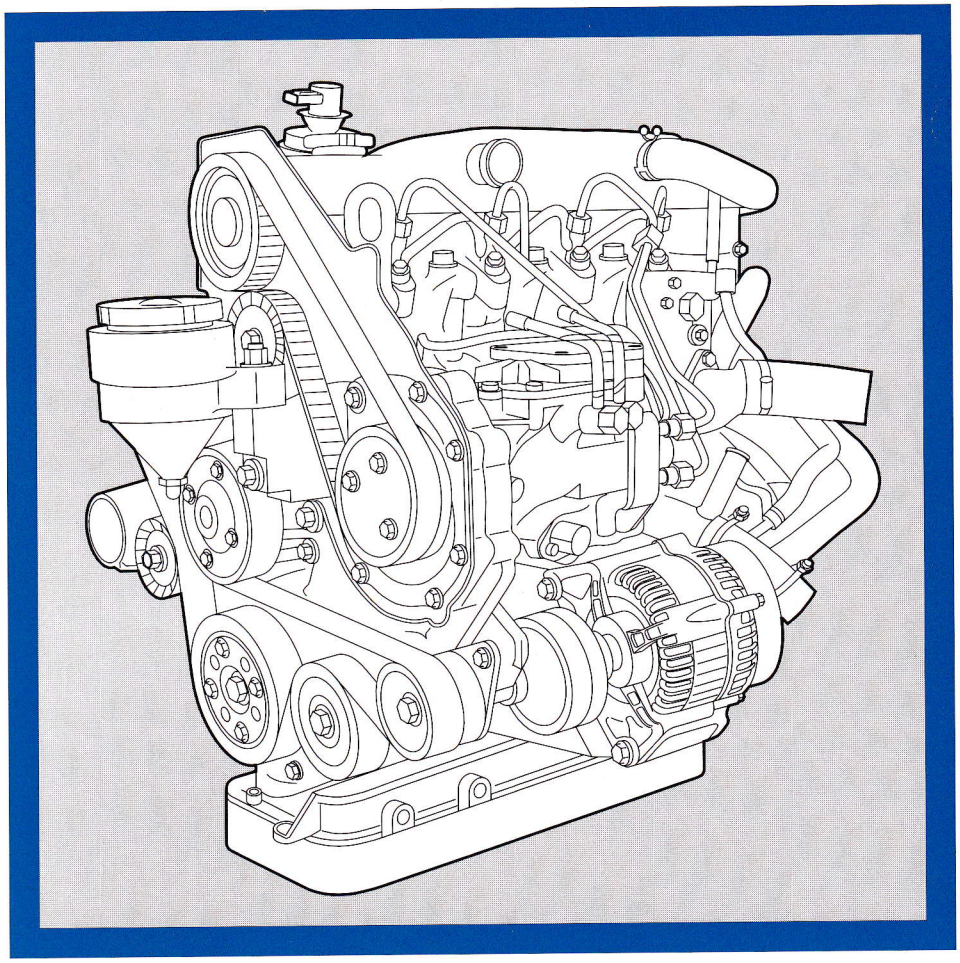
T3

Technical Service Training

Focus

New Product Introduction 00/271

1.8L Endura-DI Turbocharged Intercooled Diesel Engine



Student Information

CG 7747/S en 6/98

With the 1999 model year the Escort is superseded by a new generation vehicle, the "FOCUS". This new innovative medium-sized vehicle incorporates the latest technical developments and modified components and systems from existing Ford vehicles.
The object of the "FOCUS" course is to present the vehicle and familiarise you with the vehicle components and systems. To this end, the training literature has been split into the following publications based on the main areas:

- New Product Introduction 00/269 "Focus", CG 7745/S
- New Product Introduction 00/270 "Focus – Body", CG 7746/S
- **New Product Introduction 00/271 "Focus – 1.8L Endura-DI Turbocharged Intercooled Diesel Engine", CG 7747/S**
- New Product Introduction 00/272 "Focus – 4F27E Automatic Transmission", CG 7748/S
- New Product Introduction 00/273 "Focus – Overview", CG 7749/S

This New Product Introduction is an overview of the new 1.8L Endura-**DI direct injection** turbocharged intercooled diesel engine.

This new 1.8L Endura-DI turbo diesel engine is based on the proven 1.8L Endura-DE swirl chamber engine.

The drive for the camshaft and for the fuel injection pump has been completely redesigned. The camshaft is now driven by means of its own toothed belt and the fuel injection pump by means of a twin chain.

A fully electronic Bosch fuel injection pump is used to handle the direct injection process and ensure compliance with the latest exhaust emission standards.

The electronic diesel control engine management system used until now is superseded by the EEC V engine management system. Diagnosis and testing are carried out with the FDS 2000 through the data link connector (DLC).

Please remember that our training literature has been prepared solely for FORD TRAINING PURPOSES.
Repair and adjustment operations **MUST** always be carried out according to the instructions and specifications in the workshop literature.
Please make extensive use of the training courses offered by Ford Technical Training Centres to gain extensive knowledge in both theory and practice.

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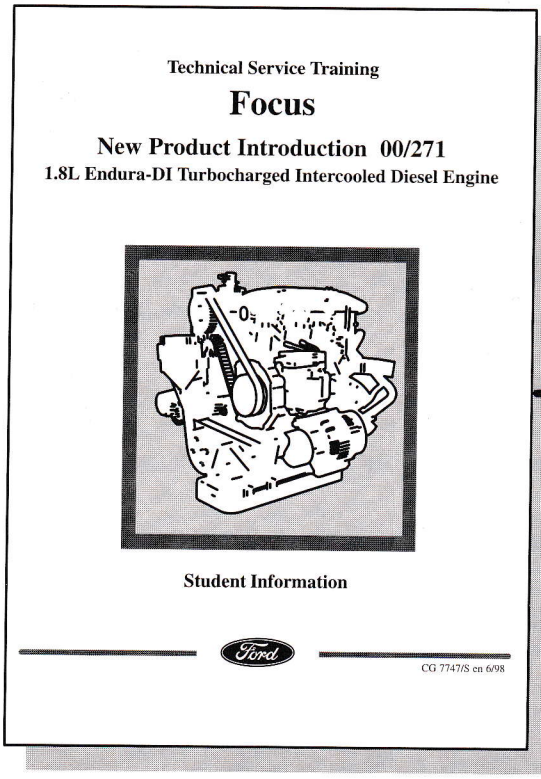


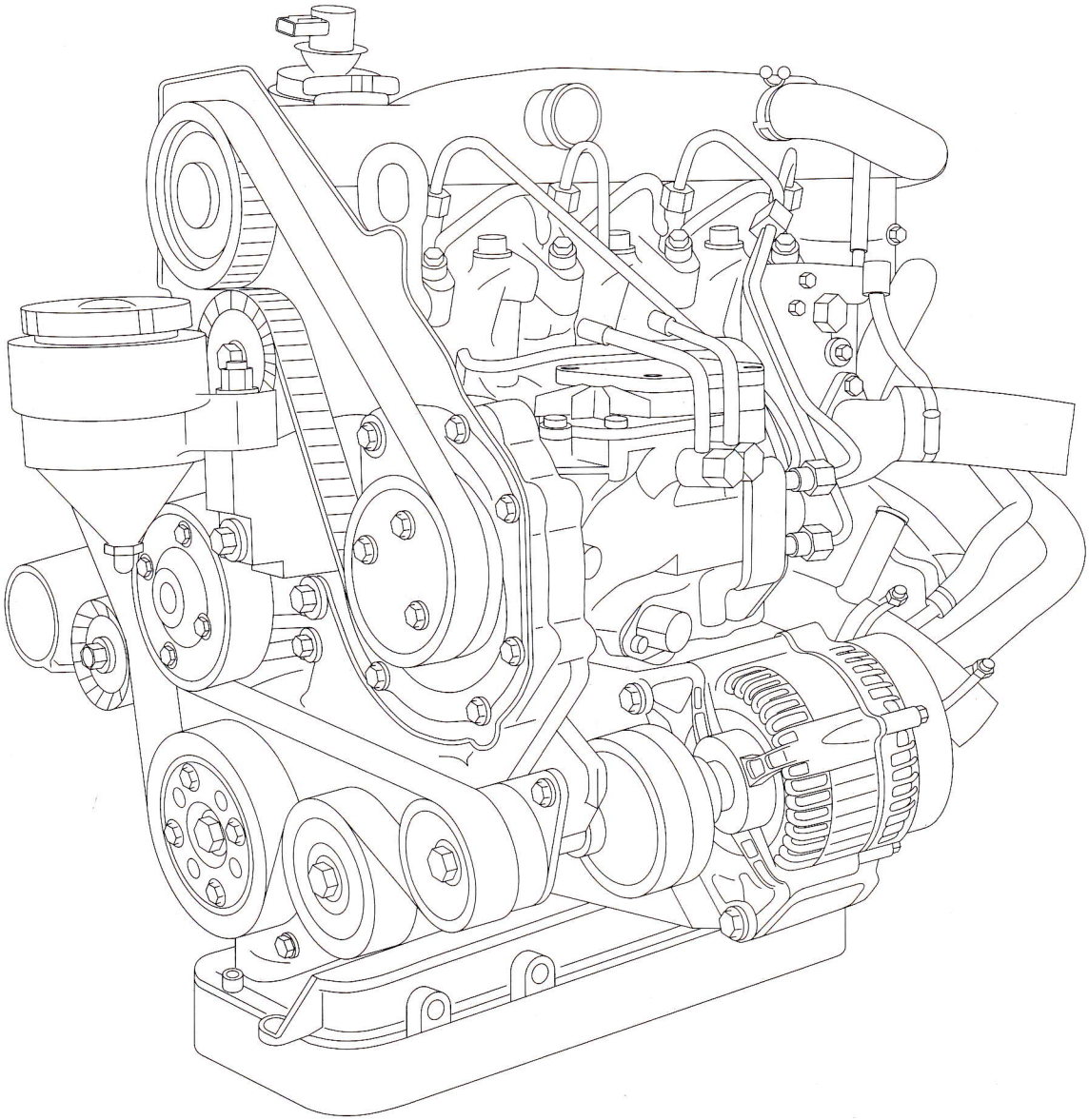
New Product Introduction 00/269
"Focus", CG 7745/S

New Product Introduction 00/270
"Focus – Body", CG 7746/S

New Product Introduction 00/272
"Focus – 4F27E Automatic Transmission", CG 7748/S

New Product Introduction 00/273
"Focus – Overview", CG 7749/S

Video
"Focus", CG 7751/V



Engine

- Transversely installed 1.8L 4-cylinder direct injection turbocharged diesel engine
- Garrett GT15 turbocharger with intercooler
- Camshaft driven by a toothed belt from the fuel injection pump
- Fuel injection pump driven by a gemini chain from the crankshaft
- Fully electronic Bosch VP 30 distributor-type fuel injection pump
- 5-hole fuel injectors with two-spring nozzle holder
- G-rotor oil pump mounted on the crankshaft

Engine management

- EEC V electronic engine management (fuelling, fuel injection timing, exhaust gas recirculation)
- PCM with 104 pins and integral passive anti-theft system (PATS)
- New cylinder head temperature (CHT) sensor
- Controlled battery charging (smart charging)

Emission control

- D3 exhaust emission standard
- Electronically controlled exhaust gas recirculation (EGR)
- Oxidation catalyst

Diagnosis and testing

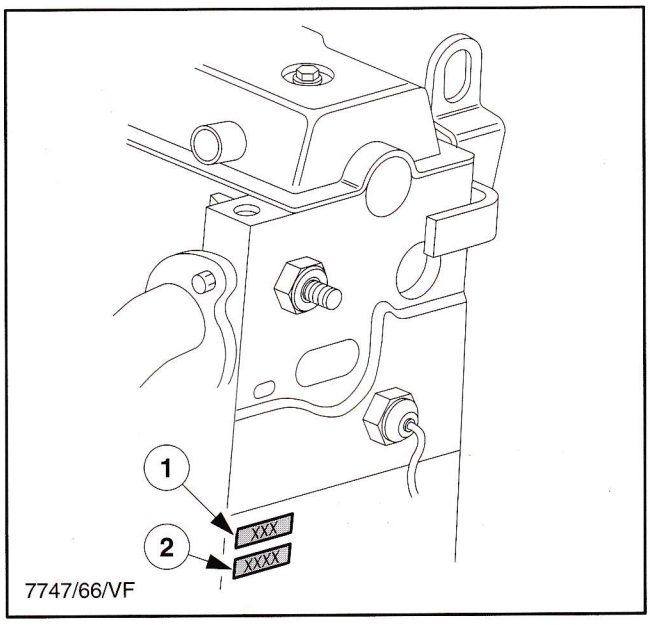
- Data link connector (DLC) for FDS 2000

Development of the 1.8L Endura-DI turbocharged intercooled diesel engine

- The 1.8L Endura-DI (direct injection) engine is based on the existing 1.8L Endura-DE turbocharged diesel engine.
- The cylinder block and cylinder head of the Endura-DE were redesigned for the direct fuel injection and modified in many details for the Endura-DI.
- The toothed belt drive used until now was superseded by a combination of a toothed belt for the camshaft and a chain for the fuel injection pump.
- The maximum power output is 66 kW, as for the Endura-DE. The torque has been increased from 180 Nm (for the Endura-DE in the Mondeo '97) to 200 Nm for the Endura-DI in the Focus.
- The fuel is injected by a fully electronic Bosch distributor-type fuel injection pump.
- The engine is controlled by the EEC V engine management system which has an integral electronic passive anti-theft system (PATS).
- The Endura-DI offers outstandingly low fuel consumption and smooth running.
- Its exhaust emissions lie well below the current European limits due to the EGR cooler and various other measures.
- Diagnostic checks can be run on the engine management system using FDS 2000 through the data link connector (DLC).

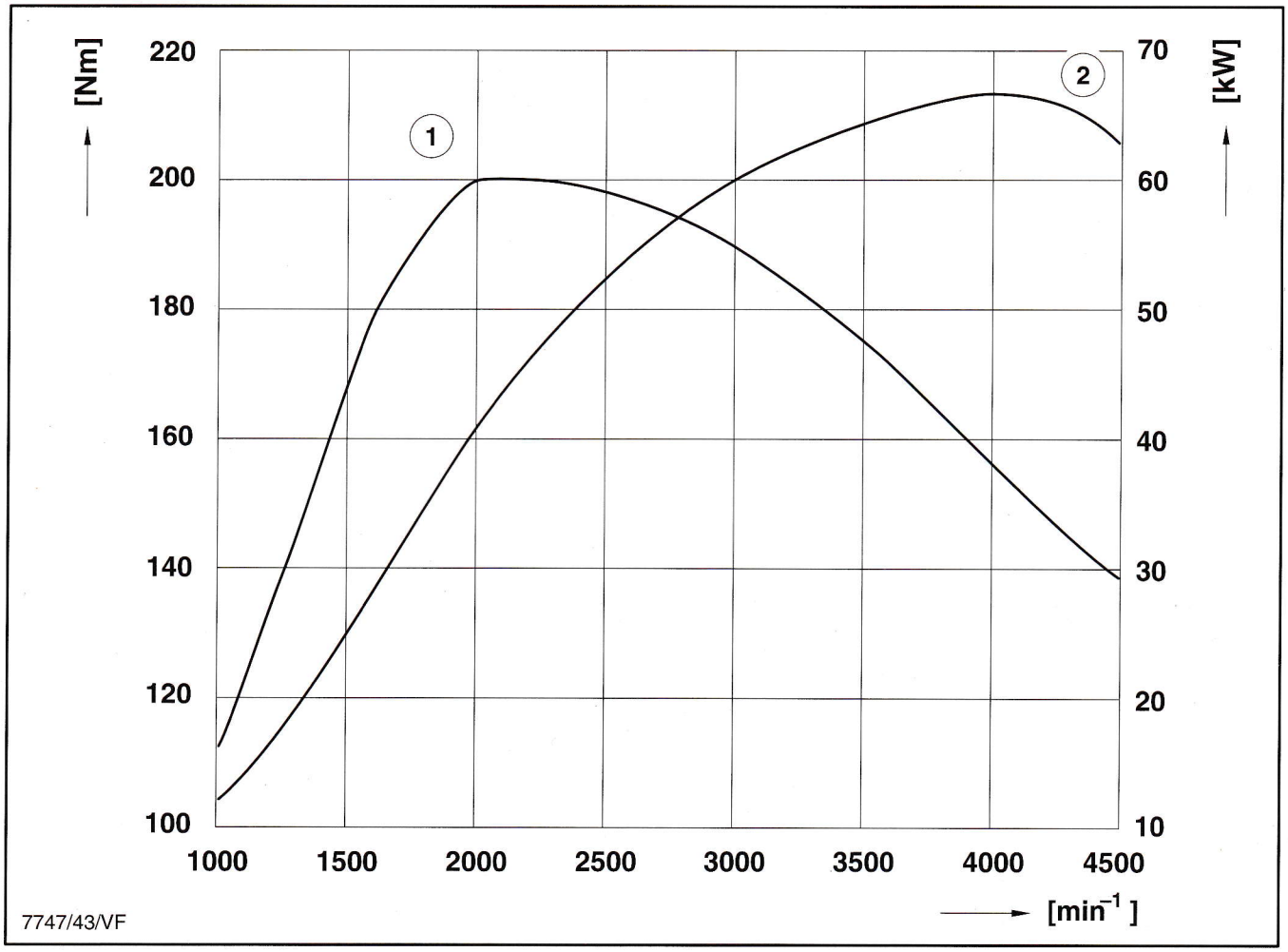
Serial number/engine code

- Motor code and serial number are placed above the transmission on the engine block.



1 Engine code (C9DC)
2 Serial number

Engine power output and torque



1 Torque curve

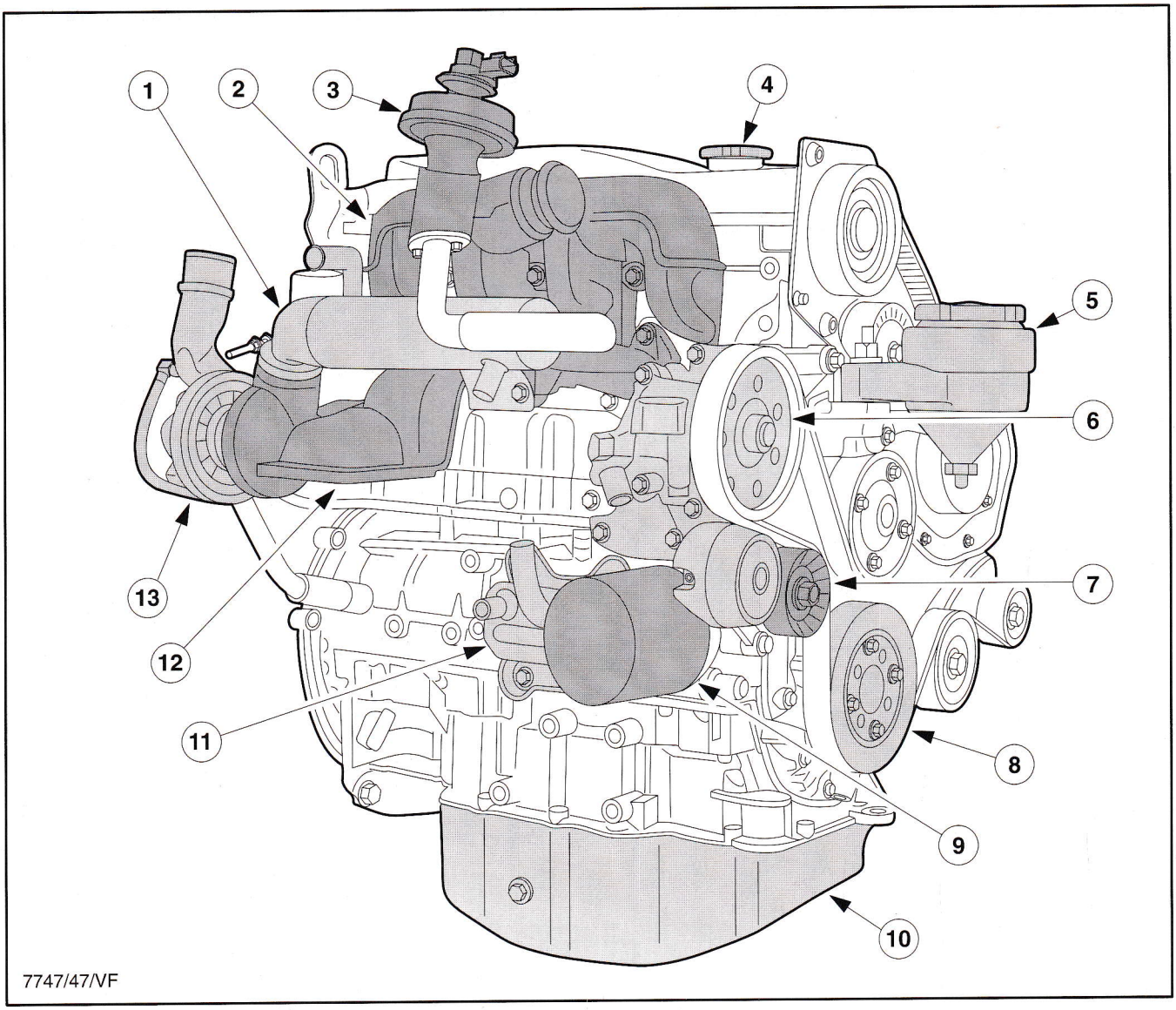
2 Power curve

Technical data

Engine data	Dimensions
Cubic capacity	1753 cc
Stroke	82 mm
Bore	82.5 mm
Stroke/bore ratio	0.994
Maximum power output (DIN/EEC)	66 kW at 4000 rpm
Maximum torque (DIN/EEC)	200 Nm between 2000 and 2400 rpm
Compression ratio	19.4 : 1

Front/exhaust side

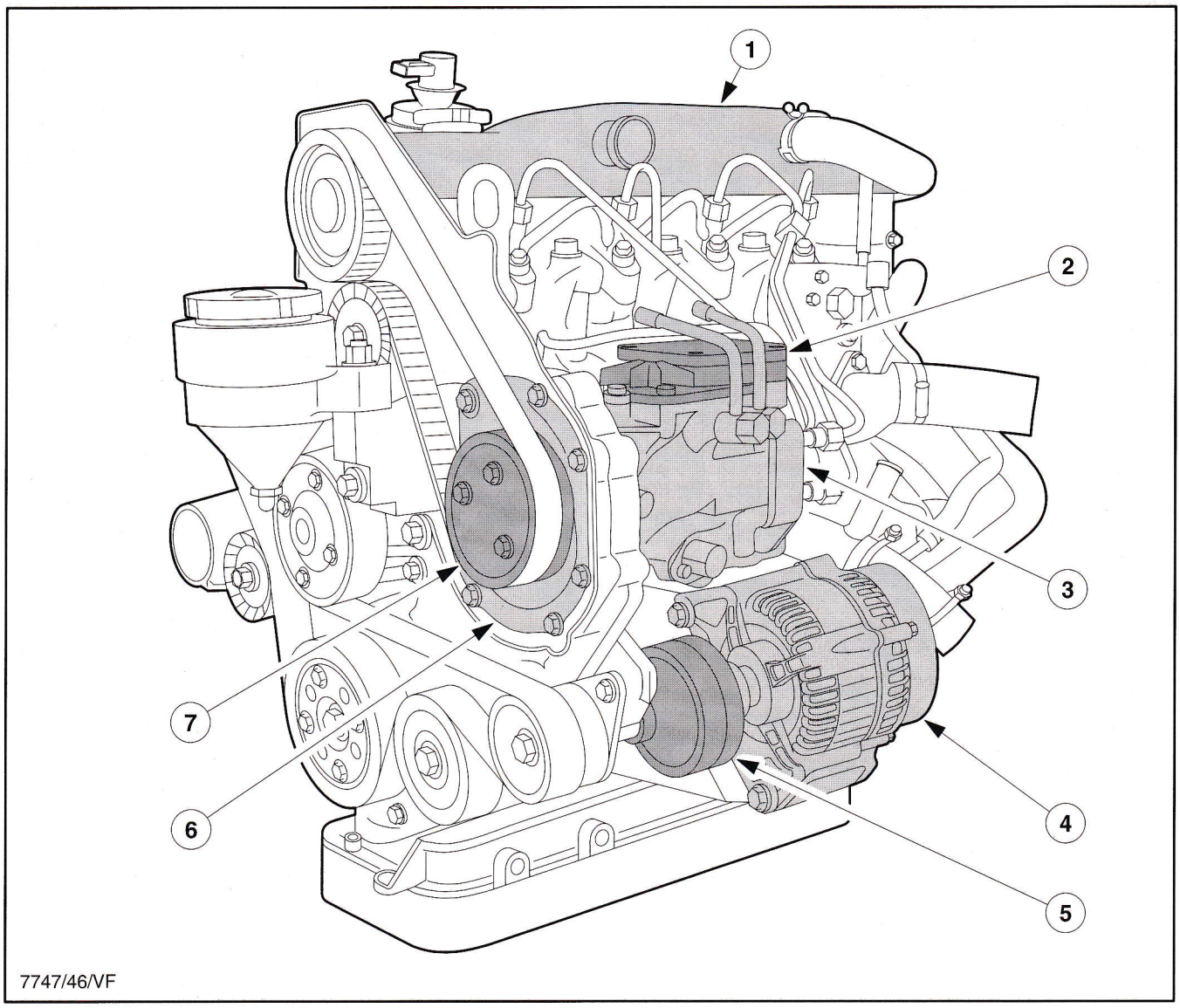
- The engine is shown without the timing belt cover.



1 EGR cooler
2 Intake manifold
3 EGR valve
4 Oil filler cap
5 Engine mounting
6 Power steering pump pulley
7 Belt tensioner
8 Crankshaft pulley/vibration damper
9 Oil filter
10 Oil pan
11 Oil cooler
12 Exhaust manifold
13 Turbocharger

Front/fuel injection pump side

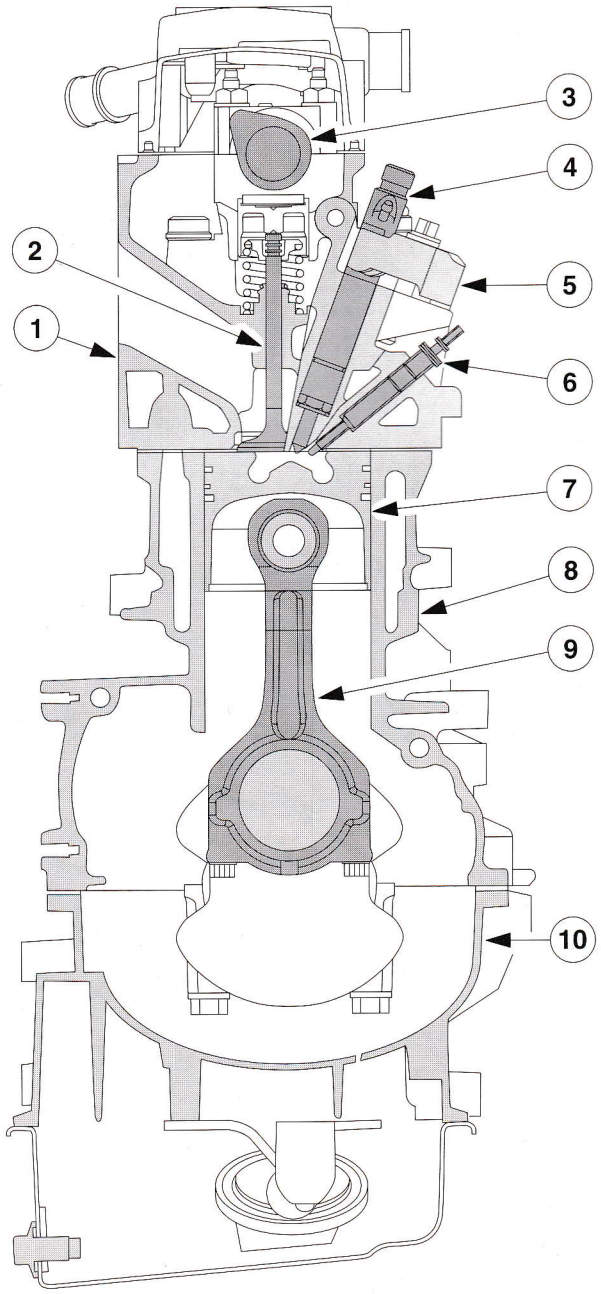
- The engine is shown without the timing belt cover.



7747/46/VF

1 Valve cover
2 Pump control unit (PCU)
3 Bosch VP 30 distributor-type fuel injection pump
4 Generator
5 Clutch
6 Fuel injection pump oil seal housing
7 Injection pump pulley

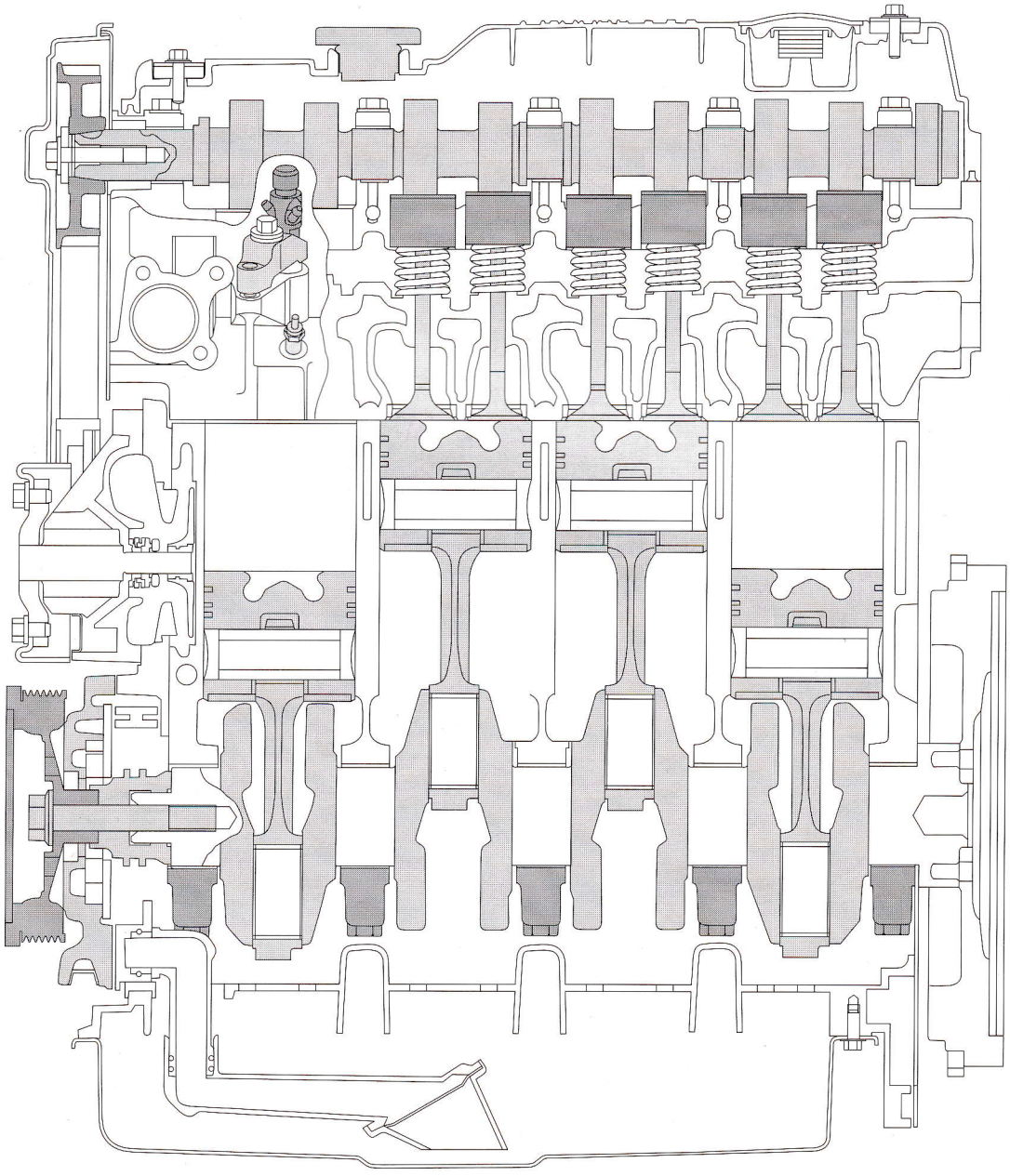
Longitudinal section



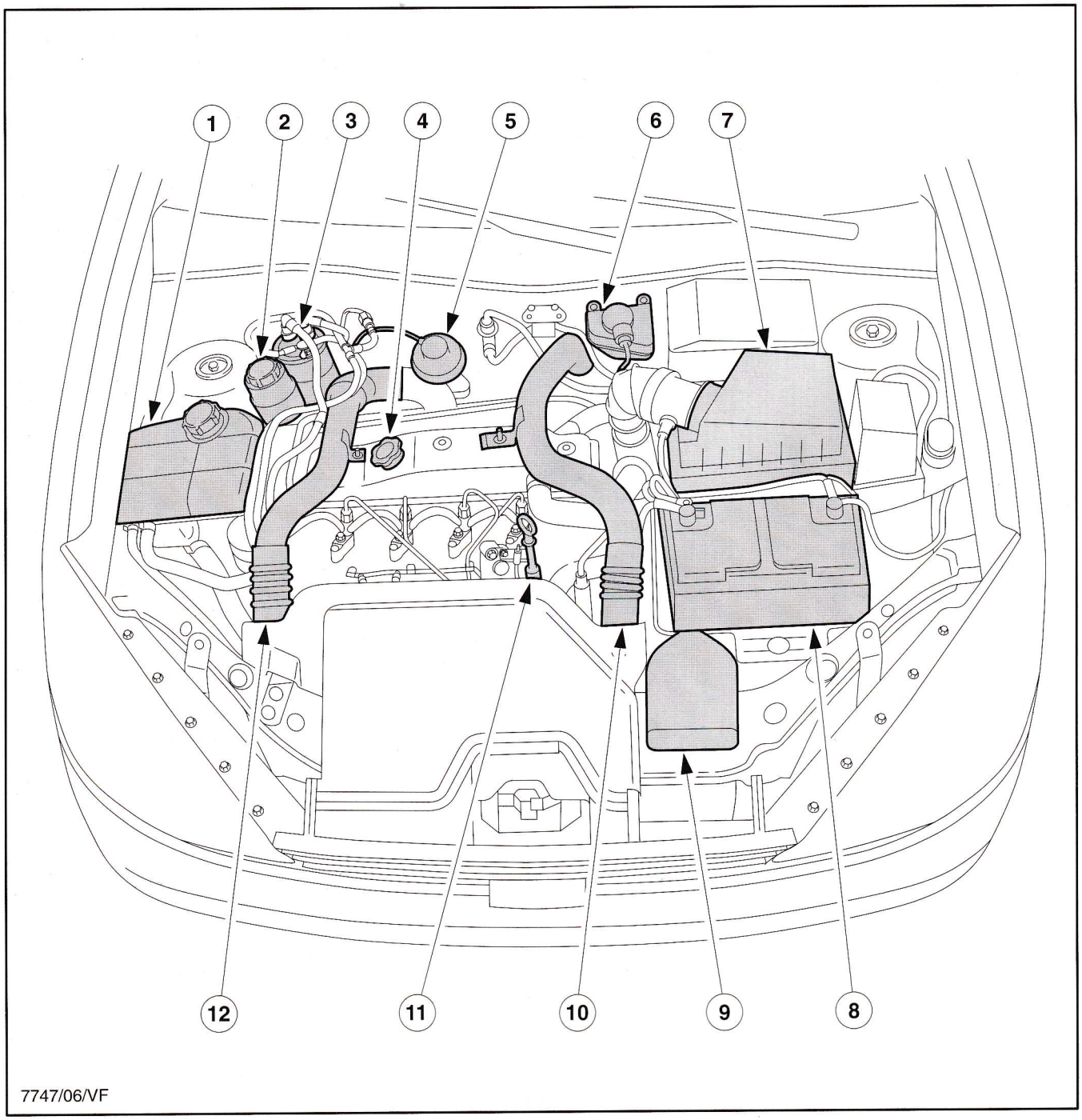
7747/64/VF

1 Cylinder head
2 Intake valve
3 Camshaft
4 Fuel injector
5 Retainer for fuel injector
6 Pencil-type glow plug
7 Piston
8 Cylinder block
9 Connecting rod
10 Intermediate housing

Cross-section



7747/65/VF

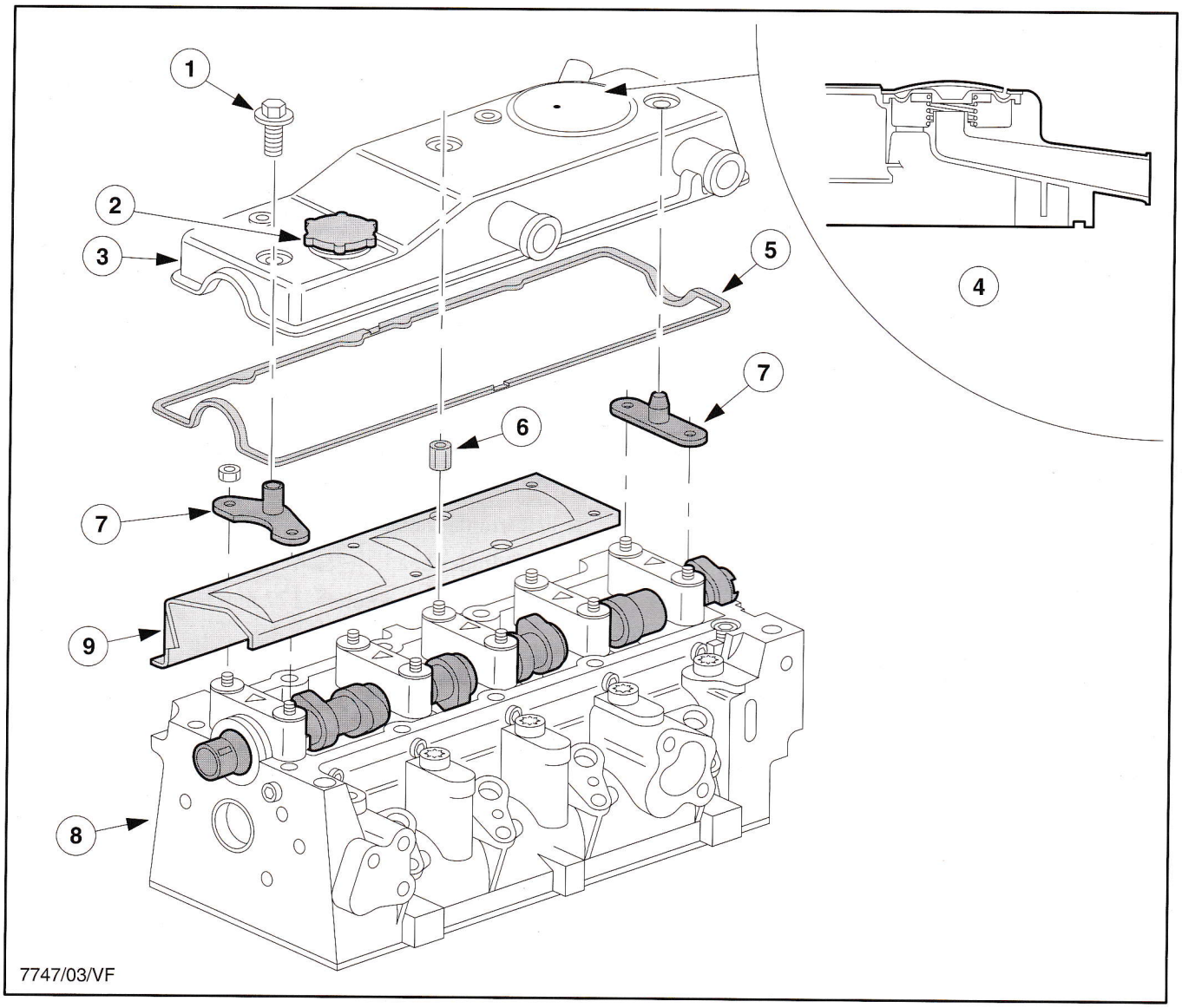


1 Coolant expansion tank
2 Power steering fluid reservoir
3 Fuel filter
4 Oil filler cap
5 EGR valve
6 Brake fluid reservoir
7 Air cleaner
8 Battery
9 Air intake
10 Air ducting from turbocharger to intercooler
11 Oil dipstick
12 Air ducting from intercooler to intake manifold

Cylinder head and valve cover

- The cylinder head is based on the head of the Endura-DE. The main changes have come about due to the new coolant bores and the positions of the fuel injectors and glow plugs.
- The valve cover has two front connections and one rear connection plus an additional valve for the crankcase ventilation system.

NOTE: The ventilation bore in the valve must always be clear. If the bore were blocked, the ventilation valve would be opened continuously. This would result in gases being induced from the cylinder block and burnt all the time the engine was running, producing black smoke.



1 Retaining bolt with silicone rubber seal
2 Oil filler cap
3 Valve cover
4 Crankcase ventilation valve
5 Valve cover gasket
6 Spacer sleeve
7 Spacer
8 Cylinder head
9 Oil baffle

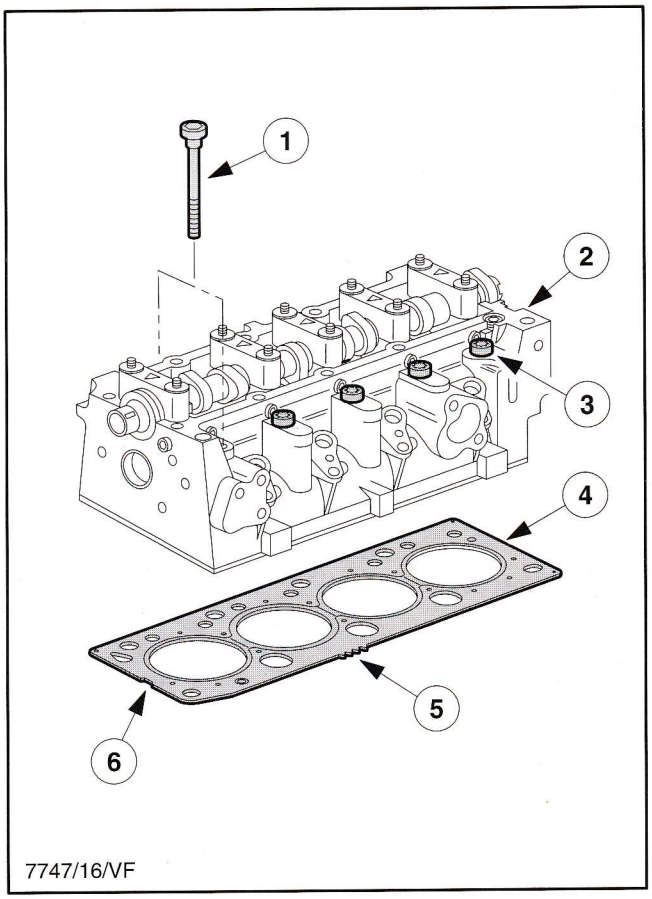
Cylinder head gasket and bolts

- The cylinder head gasket is a multilayer steel gasket. It consists of three steel strips coated with rubber. The rubber coating increases service life.

NOTE: The rubber coating of the cylinder head gasket is sensitive to scoring, therefore the mating faces of the cylinder head and block must be cleaned carefully without using any sharp implements.

- The position of the cylinder head gasket is fixed by two locating sleeves. In addition, the cutout must face the front of the engine.
- The thickness of the gasket is marked with two to seven teeth. When the gasket is changed, a gasket with the same marking must be fitted.
- The cylinder head bolts are of different lengths. The two front cylinder head bolts (1) are 137 mm long, the others are 177 mm long.

NOTE: When the cylinder head is installed, new cylinder head bolts must always be used. Refer to the current service literature for the tightening sequence.

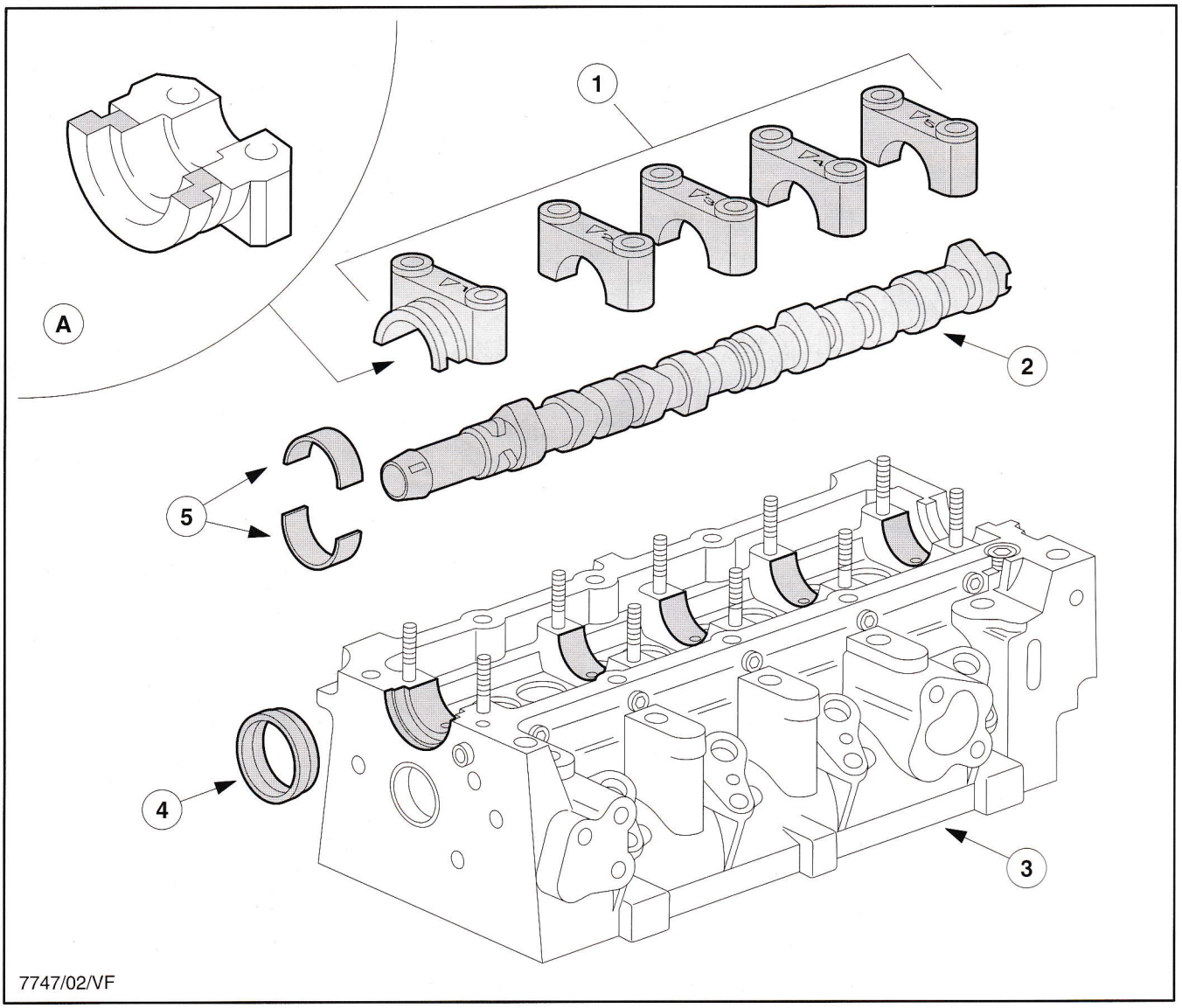


1 Cylinder head bolts – 137 mm long
2 Cylinder head
3 Cylinder head bolts – 177 mm long
4 Cylinder head gasket
5 Cylinder head gasket thickness marking
6 Position marking

Camshaft and bearings

- The eight valves are operated by a single overhead camshaft. The cam profile is different to that on the Endura-DE.
- The bearing caps are numbered and marked with an arrow which must point towards the camshaft pulley when they are in place.
- The front bearing cap accommodates the oil seal for the camshaft. A special tool must be used to install the oil seal. Sealer must be applied to bearing cap No. 1 in area (A).

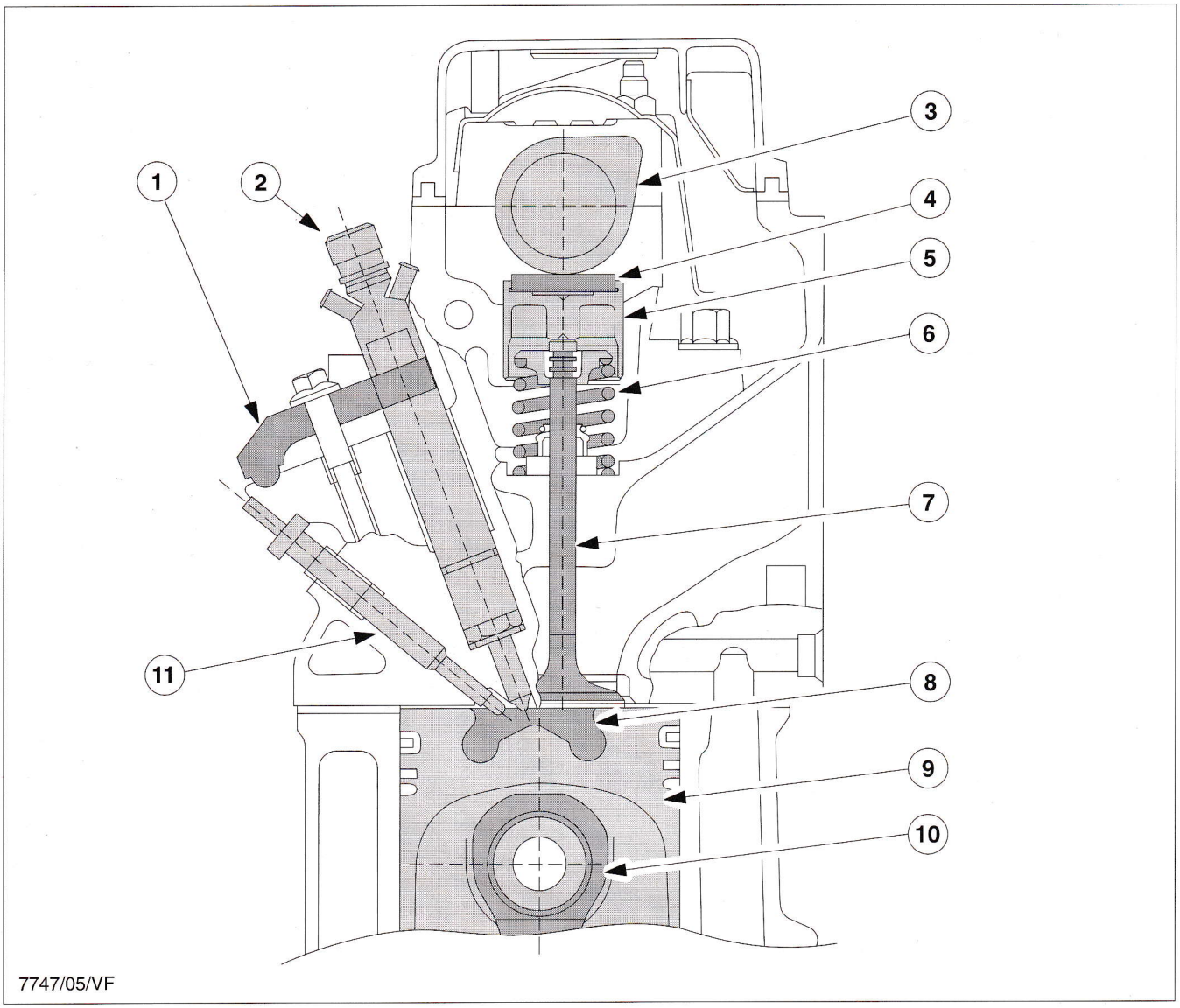
NOTE: Refer to the current service literature for the retaining bolt tightening sequence and torque.



A Sealer
1 Bearing caps (1 – 5)
2 Camshaft
3 Cylinder head
4 Camshaft oil seal
5 Bearing shells

Valve gear

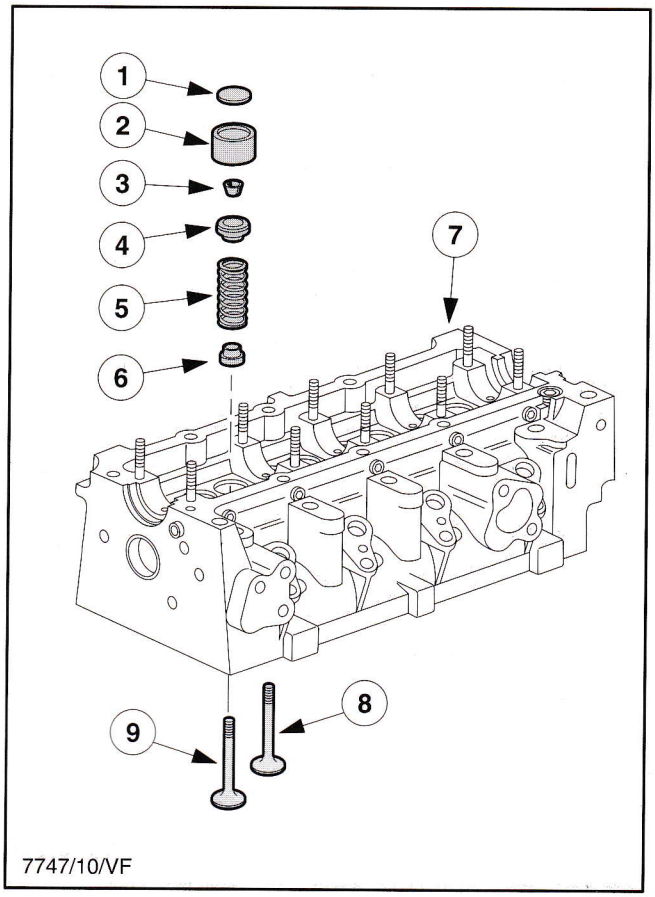
- The cylinder head is made of cast iron and based on the head of the Endura-DE. It accommodates the pencil-type glow plugs, fuel injectors and valve gear.
- The glow plugs and fuel injectors have been moved due to the recess in the piston crown.
- The fuel injectors are a push fit and are held in position by a retainer.



1 Retainer for fuel injector
2 5-hole fuel injector
3 Camshaft
4 Shim
5 Bucket tappet
6 Valve spring
7 Valve
8 Piston recess
9 Piston
10 Connecting rod
11 Pencil-type glow plug

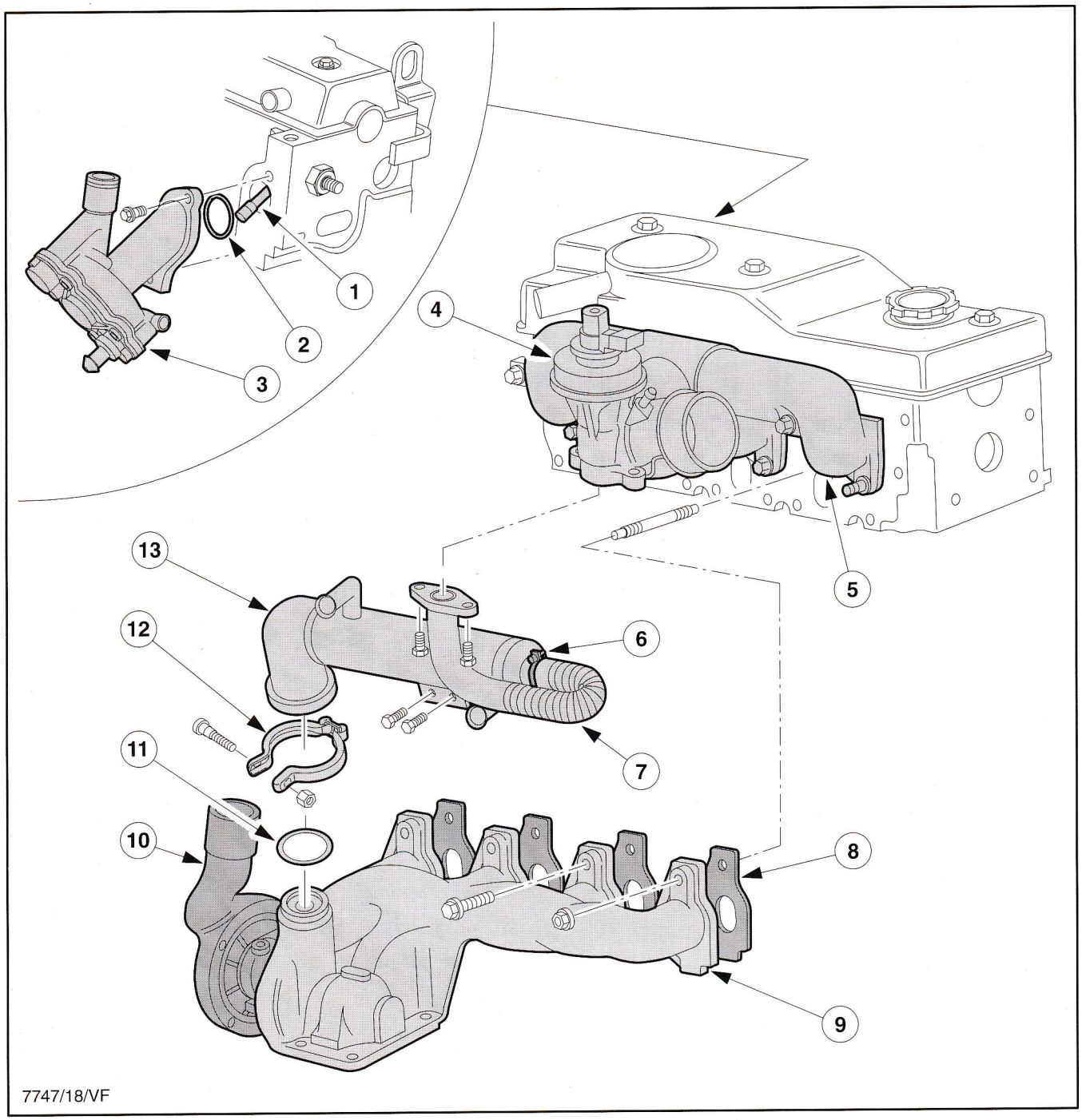
Valves

- Each cylinder has one intake and one exhaust valve. The valves are operated from the camshaft through shims and bucket tappets.
- The valves are new with minor dimensional changes from the Endura-DE.
- The valve clearances are the same as on the Endura-DE.
- The valve clearances are adjusted by changing the shims.
- The procedure for measuring and changing the shims is as for the Endura-DE using two special tools.



1 Shim
2 Bucket tappet
3 Valve collets
4 Spring retainer
5 Valve spring
6 Valve stem oil seal
7 Cylinder head
8 Exhaust valve
9 Intake valve

Cylinder head accessories



1 Tappet
2 O-ring
3 Vacuum pump
4 EGR valve
5 Intake manifold
6 Connecting pipe clamp
7 Connecting pipe
8 Exhaust manifold gasket
9 Exhaust manifold
10 Turbocharger
11 Gasket EGR cooler
12 EGR cooler clamp
13 EGR cooler

Intake manifold and EGR valve

- The intake manifold is made of aluminium. It forms a unit with the EGR valve.

NOTE: The intake manifold gasket must not be reused.

Exhaust manifold

- A plastic sleeve on the upper right-hand stud provides the required scope for thermal expansion.

NOTE: When the exhaust manifold is removed, a new plastic sleeve must be installed since it melts when the engine is used for the first time.

EGR cooler

- An EGR cooler which is cooled by the engine coolant circuit, is installed to optimize exhaust emissions.
- Cooling the recirculated exhaust gas lowers the combustion temperature and reduces the formation of NO_x (oxides of nitrogen).

NOTE: The EGR cooler clamp cannot be reused. It must be fitted so that the bolts of the catalyst remain accessible. In addition the steel gasket on turbo charger side of the EGR-cooler has to be renewed.

Turbocharger

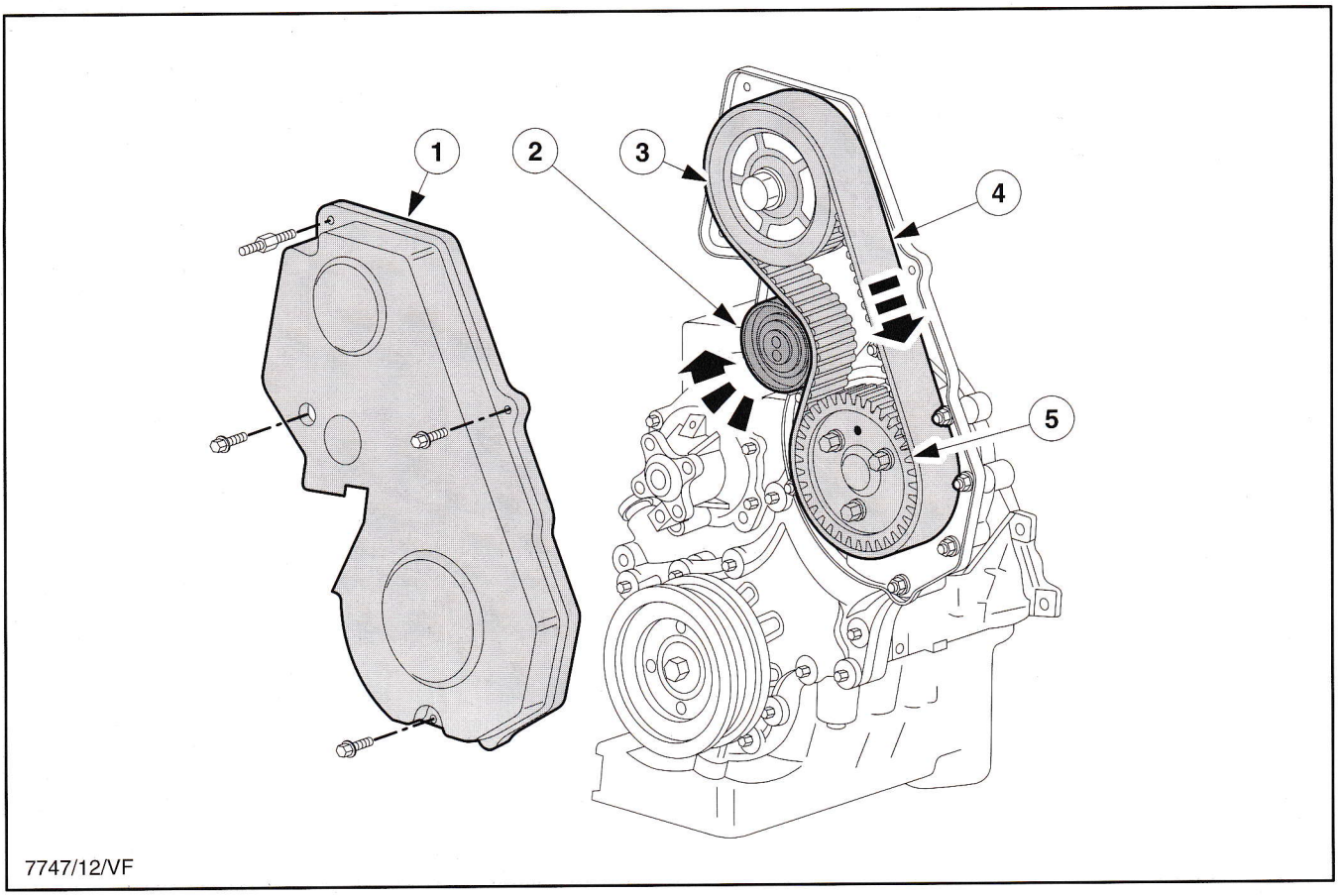
- The Garrett GT15 turbocharger forms a unit with the exhaust manifold. On the GT15 the turbine and compressor share a common housing.

Vacuum pump

- The vacuum pump is driven by a tappet which is operated by an additional cam on the camshaft. It produces the required vacuum for the brake booster and the vacuum-controlled actuators.
- The tappet has helical grooves which cause it to rotate, and supplies the components of the vacuum pump with oil.
- Surplus oil is passed back through a return to the oil pan.

Camshaft drive

- The camshaft drive has been completely redesigned on the Endura-DI. The camshaft is driven by means of a toothed belt from the fuel injection pump.
- The toothed belt must be fitted the right way round with the arrow pointing in the normal direction of rotation of the engine.
- The camshaft pulley is secured on the camshaft with a tapered seat. A special tool is used to remove the pulley.



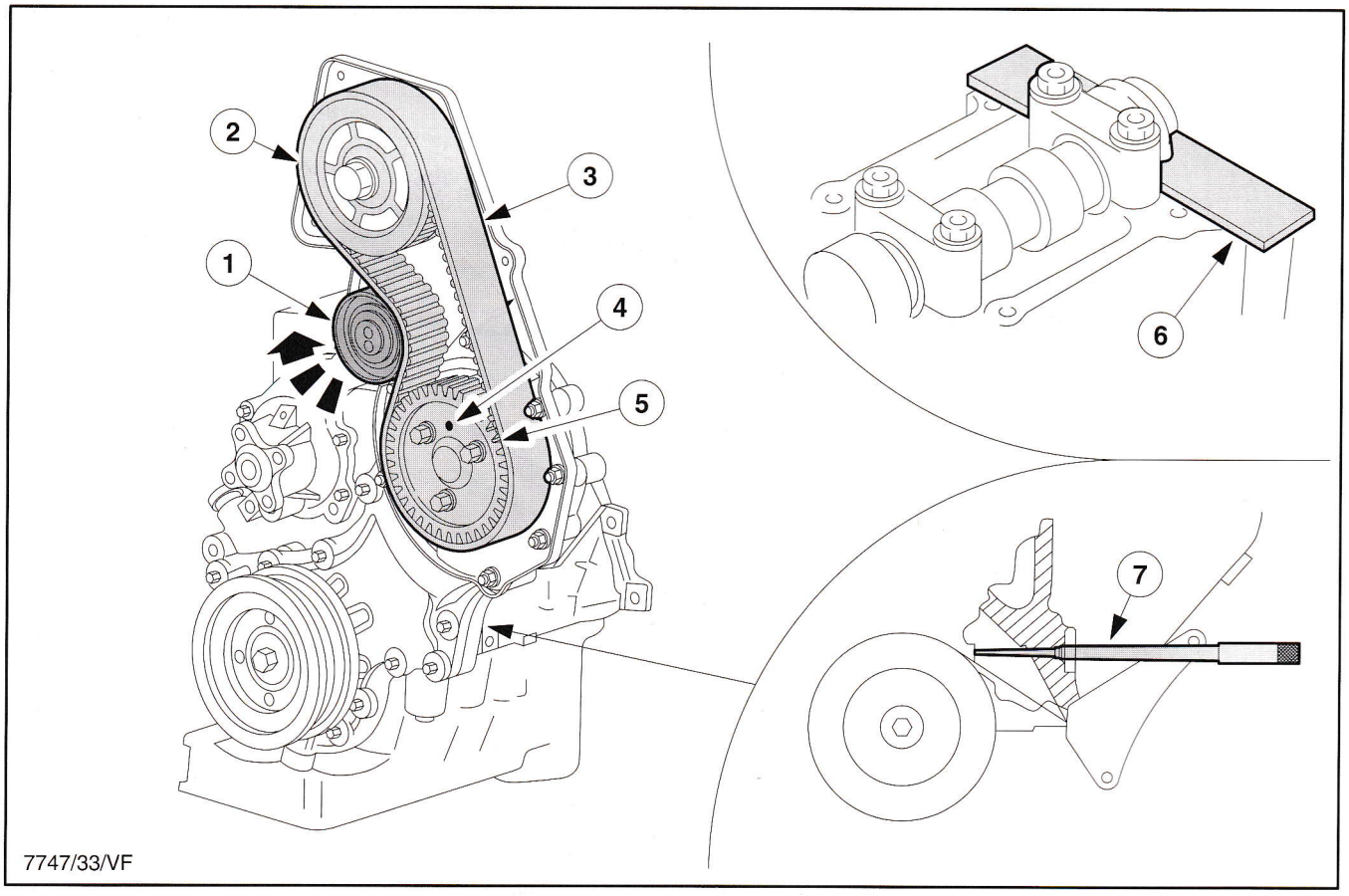
1 Timing belt cover
2 Timing belt tensioner
3 Camshaft pulley
4 Timing belt
5 Fuel injection pump pulley

Camshaft drive timing

- The procedure for adjusting the timing has changed due to the changed timing belt drive.
- Two special tools are required to set the camshaft in relation to the crankshaft.
- The camshaft setting tool is still inserted in the off-center slot in the camshaft as previously.
- After removing a threaded blanking plug, the TDC setting pin is screwed into the side of the cylinder block above the generator. Then the crankshaft is turned carefully until it comes up against the setting pin.
- At TDC the mark on the fuel injection pump pulley (4) has to be in 12 o' clock position.
- The timing belt is tensioned with the timing belt tensioner.

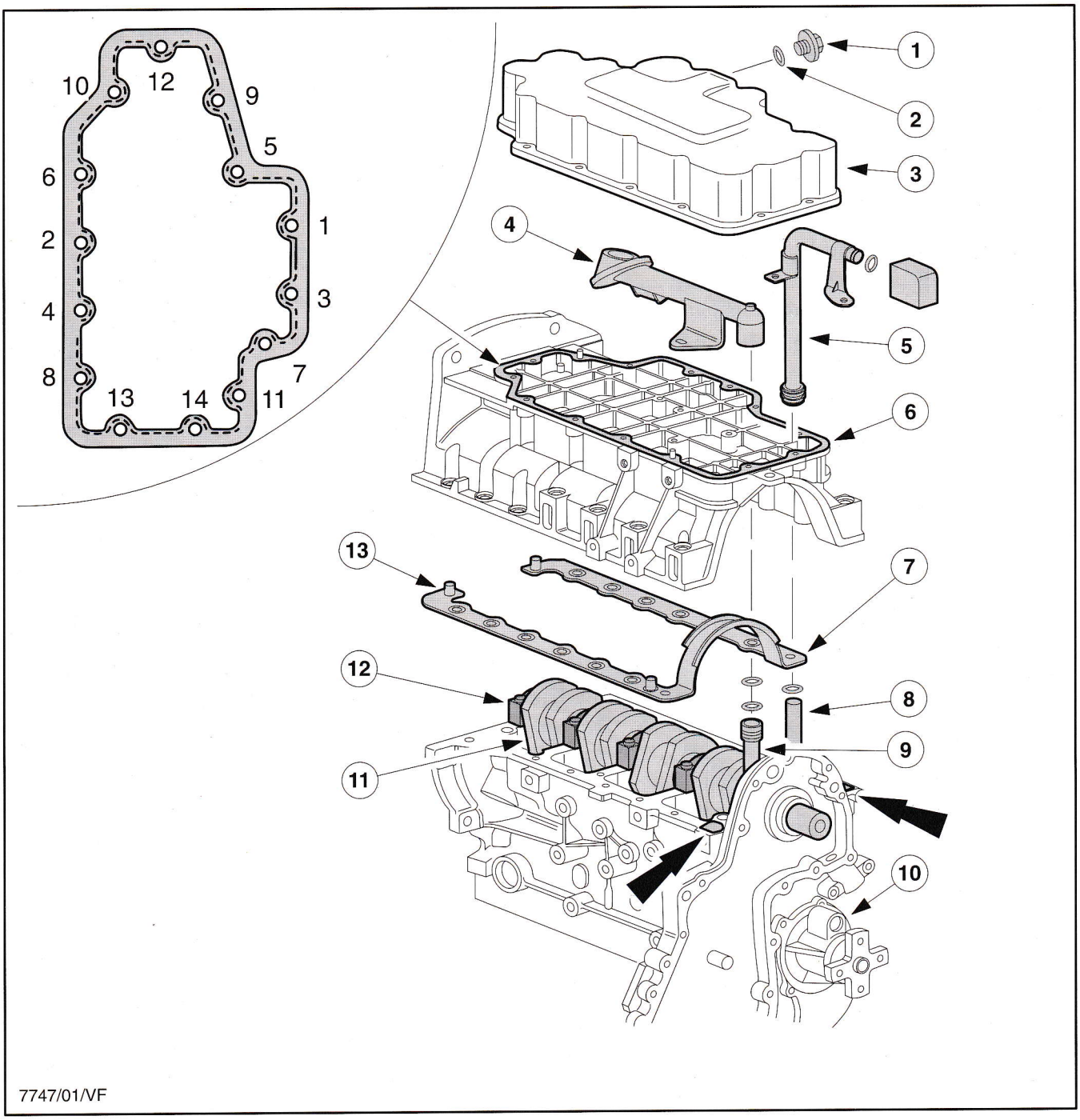
NOTE: If the timing belt is removed, it must not be reused. A timing belt which has already run must not be retensioned.

NOTE: Refer to the current service literature for the interval for changing the timing belt and the precise procedure for adjusting it.



1 Timing belt tensioner
2 Camshaft pulley
3 Timing belt
4 TDC mark
5 Fuel injection pump pulley
6 Camshaft setting tool
7 TDC setting pin

Cylinder block accessories



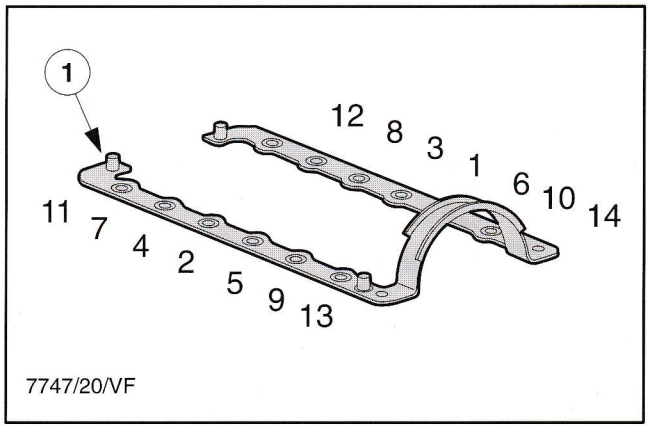
A Oil pan bolt tightening sequence
1 Oil drain plug
2 O-ring
3 Oil pan
4 Oil pick up pipe
5 Connecting pipe
6 Intermediate housing
7 Intermediate housing gasket
8 Oil outlet
9 Oil pump inlet
10 Cylinder block
11 Crankshaft
12 Crankshaft bearing cap
13 Rubber guide

Intermediate housing

- The intermediate housing takes the place of the aluminium oil pan used on the Endura-DE. It serves to stiffen the cylinder block and reduce NVH.
- It is sealed with a rubber gasket which has to be positioned in the intermediate housing with four rubber guides.

NOTE: In addition a sealing compound has to be applied on the T-joints indicated by the arrows.

NOTE: The intermediate housing, like the oil pan, must be secured by tightening the bolts in a predetermined sequence. Refer to the current service literature for the tightening sequence and torque.



Intermediate housing bolt tightening sequence
1 Rubber guide

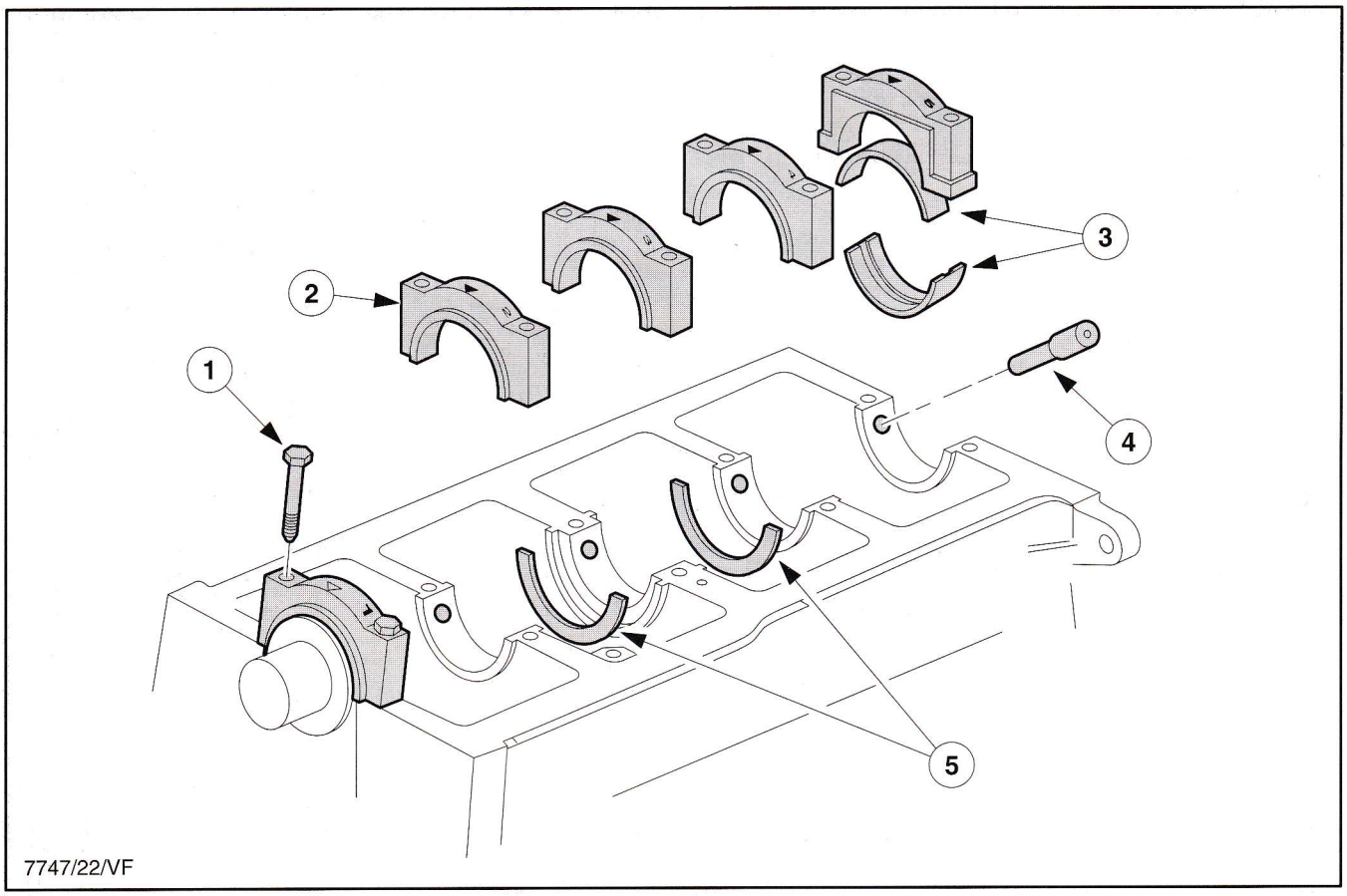
Oil pan and oil drain plug

- The oil pan is made of steel. It is sealed with a liquid sealer. The sealer must be applied on the inside (along the broken line in the inset).

NOTE: The oil pan is located with two studs (insert A, items 8 and 9) to ensure that it is sealed correctly. The bolts must be tightened in a predetermined tightening sequence.

Crank gear

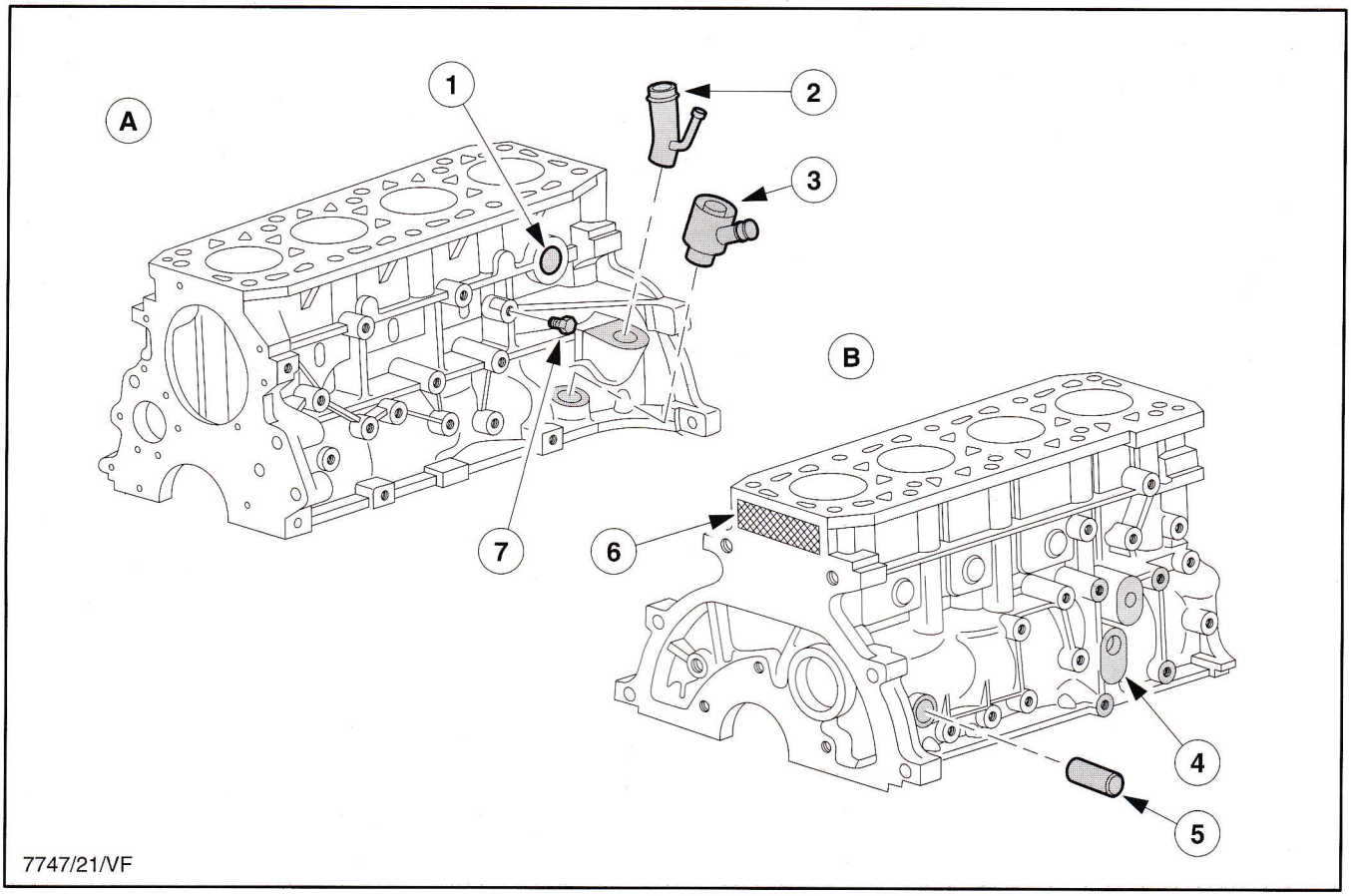
- The crankshaft runs in five bearings. The bearing caps are numbered and marked with an arrow which must point towards the front end when the caps are in place.
- The crankshaft end play is limited by thrust washers on main bearing No. 3. The oil grooves in the thrust washer must point towards the crankshaft.
- The paint marks on the bearing shells are the same as the marks on the Endura-DE.
- The piston cooling oil splash nozzles are located above the main bearings.



1 Bearing cap bolt
2 Main bearing cap
3 Main bearing shells
4 Oil splash nozzle
5 Thrust washers

Cylinder block

- The cylinder block is based on the block of the Endura-DE. It has modified ribs for optimum stiffening. It has no cylinder liners and is 3.5 kg lighter overall.
- The cylinder walls are honed using a new honing method (plateau honing) to reduce oil consumption and so improve emissions.
- Two different bore diameters are used in production to set the play between the cylinders and pistons exactly.
- The different bores are marked by letters (A or B) on the block.
- A coolant drain plug is located in the cylinder block.

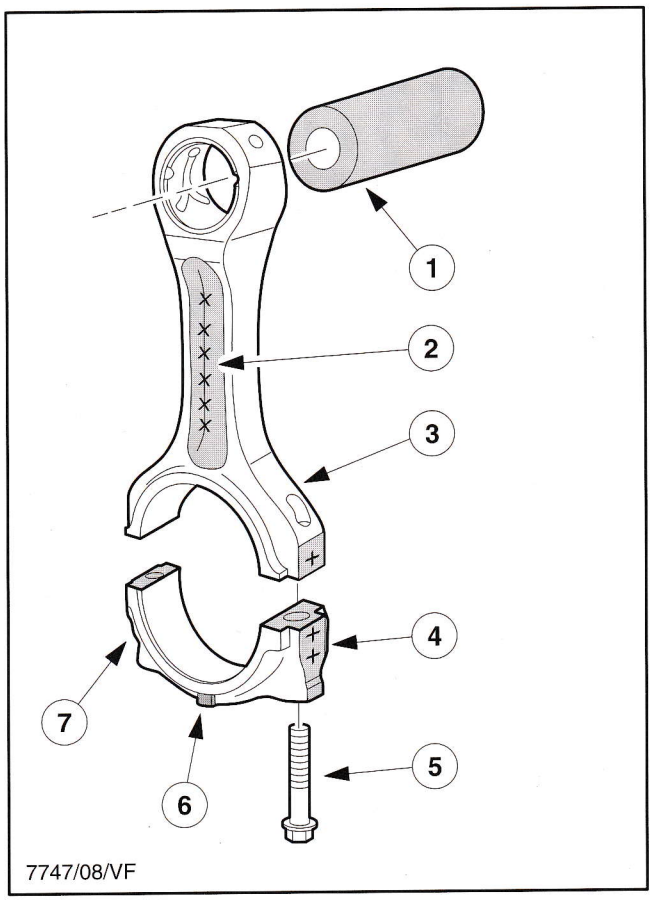


A Front side
B Transmission side
1 Core plug for installation of a block heater
2 Crankcase ventilation connector
3 Oil dipstick guide
4 Oil cooler connector
5 Turbocharger return
6 Engine identification
7 Coolant drain plug

Connecting rods

- The connecting rods and bearing caps are "fracture separated" to ensure a precise fit at the big end and accurate fixture.
- The bearing shells have no retaining lugs.
- The connecting rods are divided into different lengths A to D and weight classes + and – . The markings are located on the side of the connecting rod.
- Only connecting rods of the same length and same weight may be used in an engine.
- The lug on the bearing cap and the part number on the connecting rod must face the front of the engine when they are in place.

NOTE: If slackened, new retaining bolts must be installed.

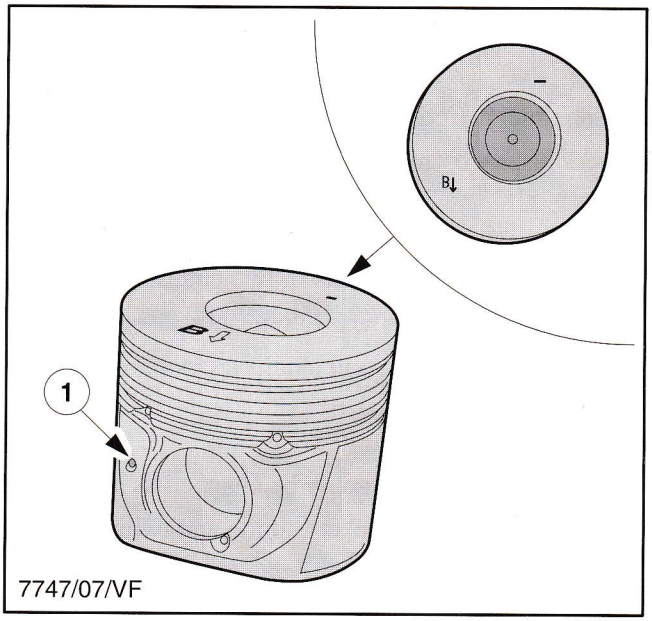


1 Piston pin
2 Part number
3 Connecting rod
4 Connecting rod length marking
5 Connecting rod bearing cap retaining bolt
6 Position marking
7 Weight class marking

Pistons

- In the crown the pistons have an off-center recess with a shape developed for optimum swirl.
- The piston skirt has a molybdenum coating to protect against scoring and ensure improved noise characteristics.
- The position of the piston is determined by an arrow on the crown and a mark on the skirt. The arrow and the mark must face the front side when the piston is in place.
- The pistons are divided into different classes: A and B for the diameter, + and – for the weight.

NOTE: Only pistons with the same wheight may be installed in an engine.



1 Marking

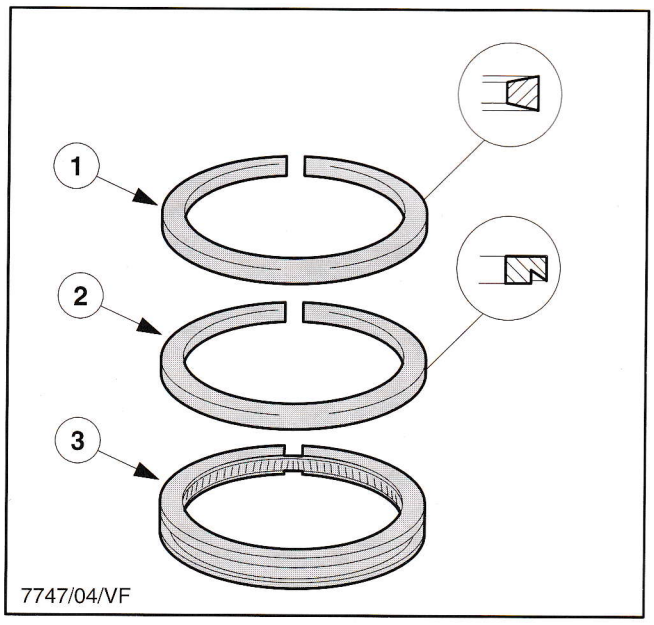
Piston rings

- The upper and lower compression rings are of different design. The ring gaps are color-coded to ensure that the compression rings are fitted in the correct positions.
  - Upper compression ring – orange
  - Lower compression ring – white

NOTE: One paint mark for piston class A, two paint marks for piston class B.

- Install the piston rings with the ring gaps staggered at 120 degrees.

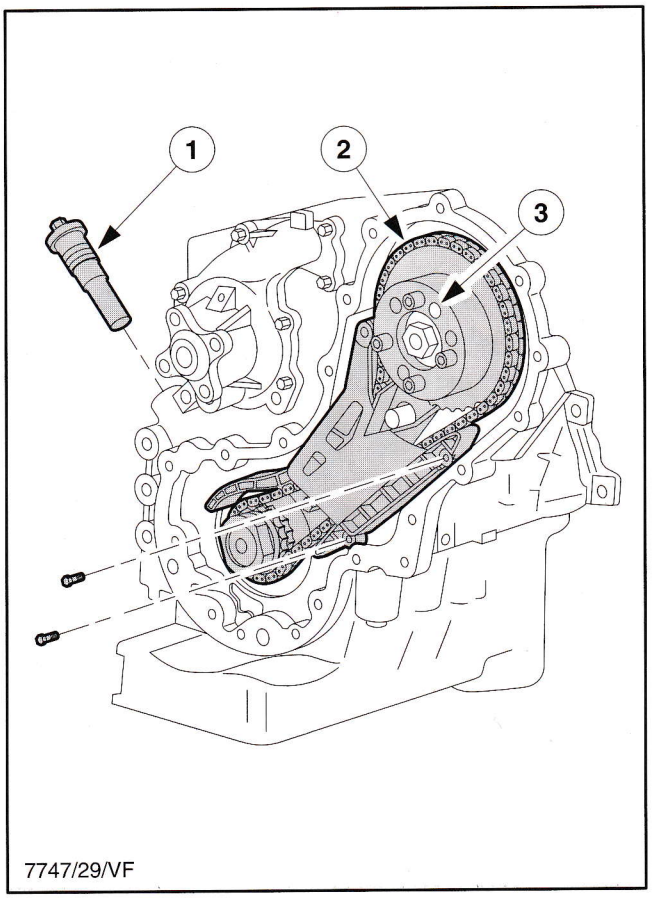
NOTE: When the compression rings are in place, the paint mark must be visible on the ring gap on the right when looking at the piston crown. In the case of the three-piece oil control ring, the gap in the internal spiral must lie opposite the outer ring gaps.



1 Upper compression ring
2 Lower compression ring
3 Oil control ring

Fuel injection pump drive

- The fuel injection pump is driven from the crankshaft by means of a chain drive with a ratio of 2:1.
- The chain drive consists of two chains (gemini chains) which run next to one another offset by half a link. The gemini chains are not connected to one another.
- The chain drive can only be changed as a complete unit (sprockets, guide and twin chain). No provision is made for changing individual components.
- The chain is tensioned by means of a hydraulic chain tensioner which is connected to the engine oil circuit.
- There is a hole in the fuel injection pump sprocket to adjust the timing.

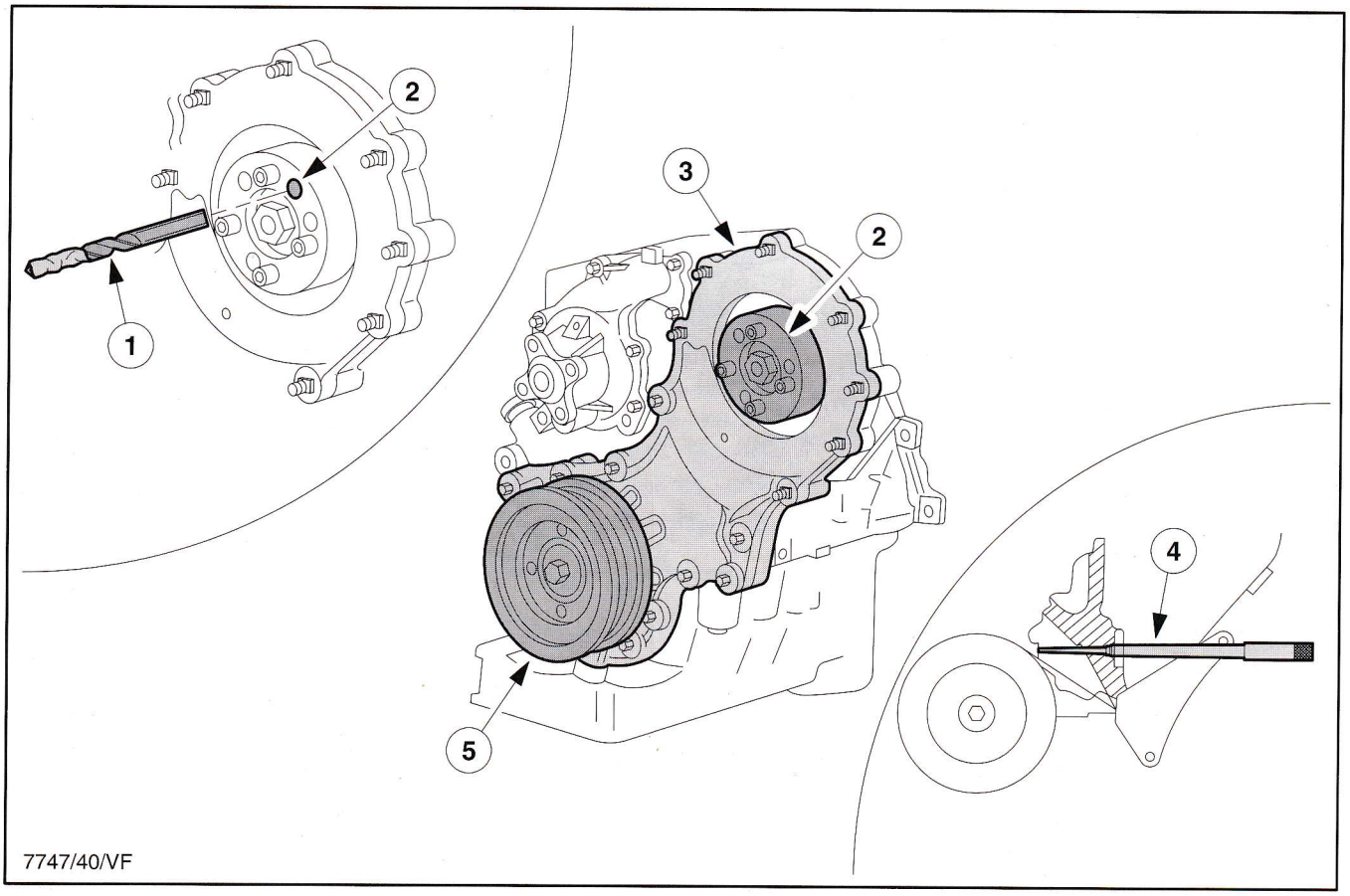


1 Hydraulic chain tensioner
2 Chain drive unit
3 Hole to adjust timing

Fuel injection pump timing

- The TDC setting pin and a 6 mm drill bit are required to set the fuel injection pump to the crankshaft.
- The fuel injection pump is immobilised by its sprocket using a 6 mm drill bit.
- After removal of a blanking plug, the TDC setting pin is screwed into the side of the cylinder block above the generator. Then the crankshaft is turned carefully until it comes up against the setting pin.
- The chain is tensioned automatically with a hydraulic chain tensioner which is connected to the engine oil circuit.

NOTE: Refer to the current service literature for the precise adjustment procedure.

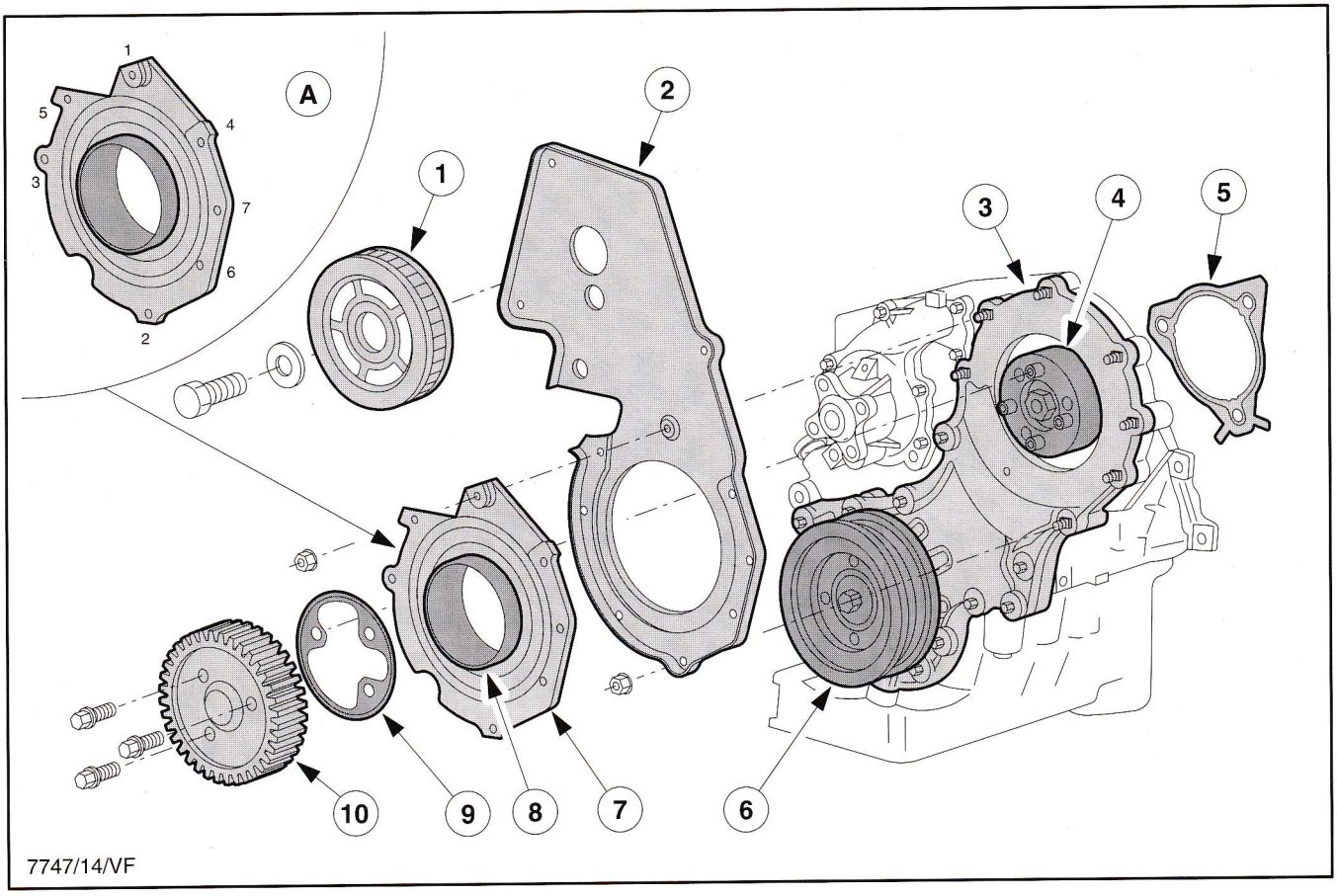


1 Drill bit – 6 mm
2 Fuel injection pump sprocket
3 Oil pump housing
4 TDC setting pin
5 Vibration damper

Fuel injection pump oil seal housing

- The oil seal housing seals the oil pump housing from the fuel injection pump pulley. In service it must be changed complete.
- The fuel injection pump pulley bolts have to be tightened in a specific sequence.
- Both steel gaskets (5 and 9) have to be renewed.

NOTE: The locating sleeve must not be removed until after assembly. During assembly, make sure that the bolts are tightened in the specified sequence (inset A). The oil seal must be installed dry.

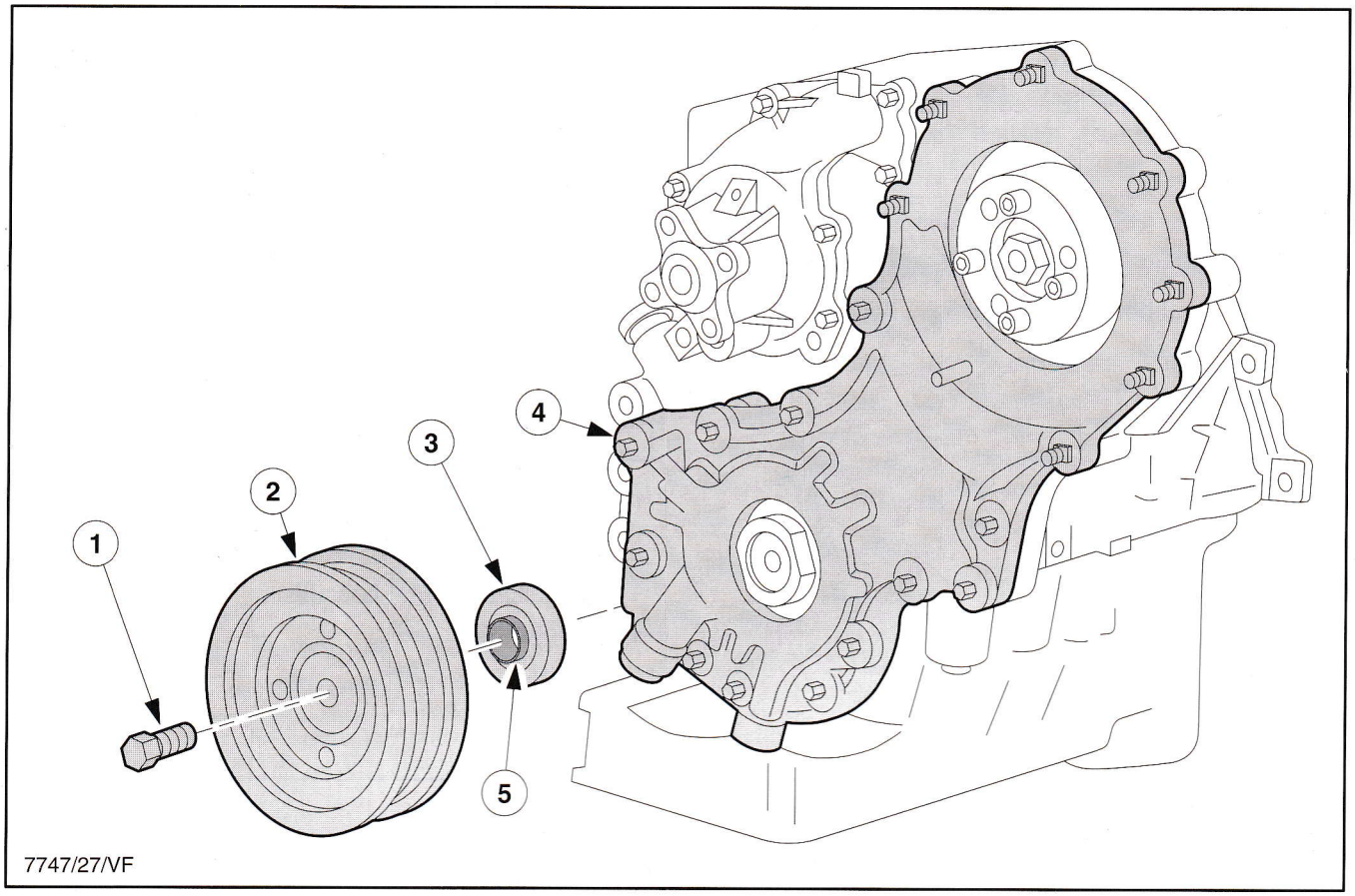


A Tightening sequence for bolts of fuel injection pump oil seal housing
1 Camshaft pulley
2 Timing belt cover backing plate
3 Oil pump housing
4 Fuel injection pump sprocket
5 Fuel injection pump steel gasket
6 Crankshaft pulley/vibration damper
7 Fuel injection pump oil seal housing
8 Memory sleeve
9 Fuel injection pump pulley steel gasket
10 Fuel injection pump pulley

Crankshaft front oil seal

- The front oil seal is made of Teflon. It must be installed and removed using a special tool.

NOTE: The locating sleeve must not be removed until after assembly. The oil seal must be installed dry.

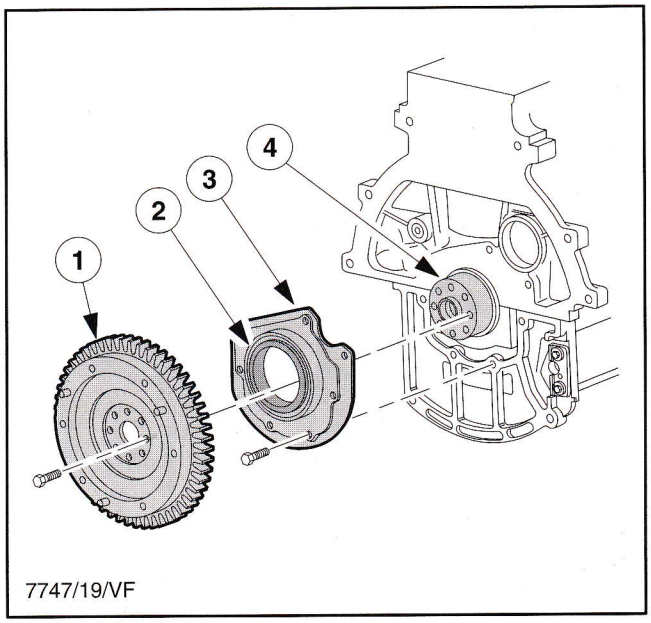


1 Retaining bolt
2 Crankshaft pulley/vibration damper
3 Crankshaft front oil seal
4 Oil pump housing
5 Memory sleeve

Crankshaft rear oil seal housing

- The oil seal housing on the transmission side seals the crankshaft from the cylinder block and intermediate housing.
- In service it must be changed complete.
- A special tool must be used to center the oil seal housing.

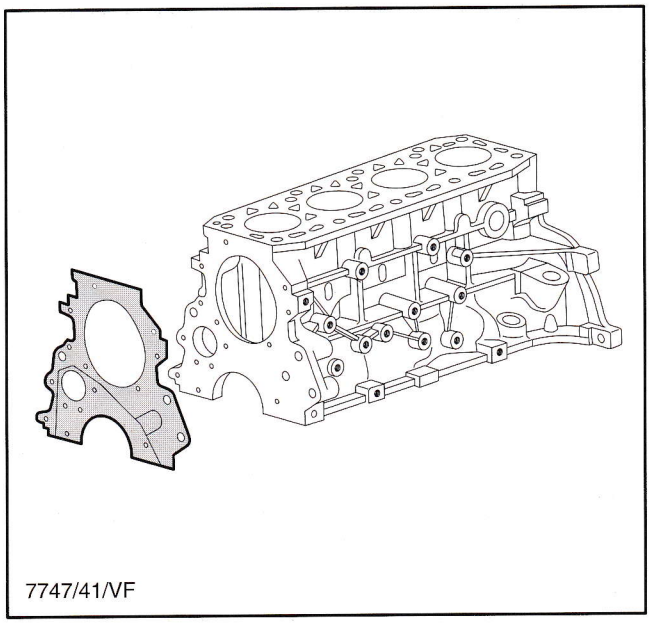
NOTE: The locating sleeve must not be removed until after assembly. The oil seal housing must be installed dry.



1 Flywheel
2 Memory sleeve
3 Crankshaft oil seal housing
4 Crankshaft

Cylinder block front end gasket

- The cylinder block gasket (solid gasket) seals the timing case from the cylinder block.
- The gasket must be located with two studs to ensure that the gasket bears precisely on the cylinder block.
- Then the timing case can be fitted with two bolts and the studs removed again.



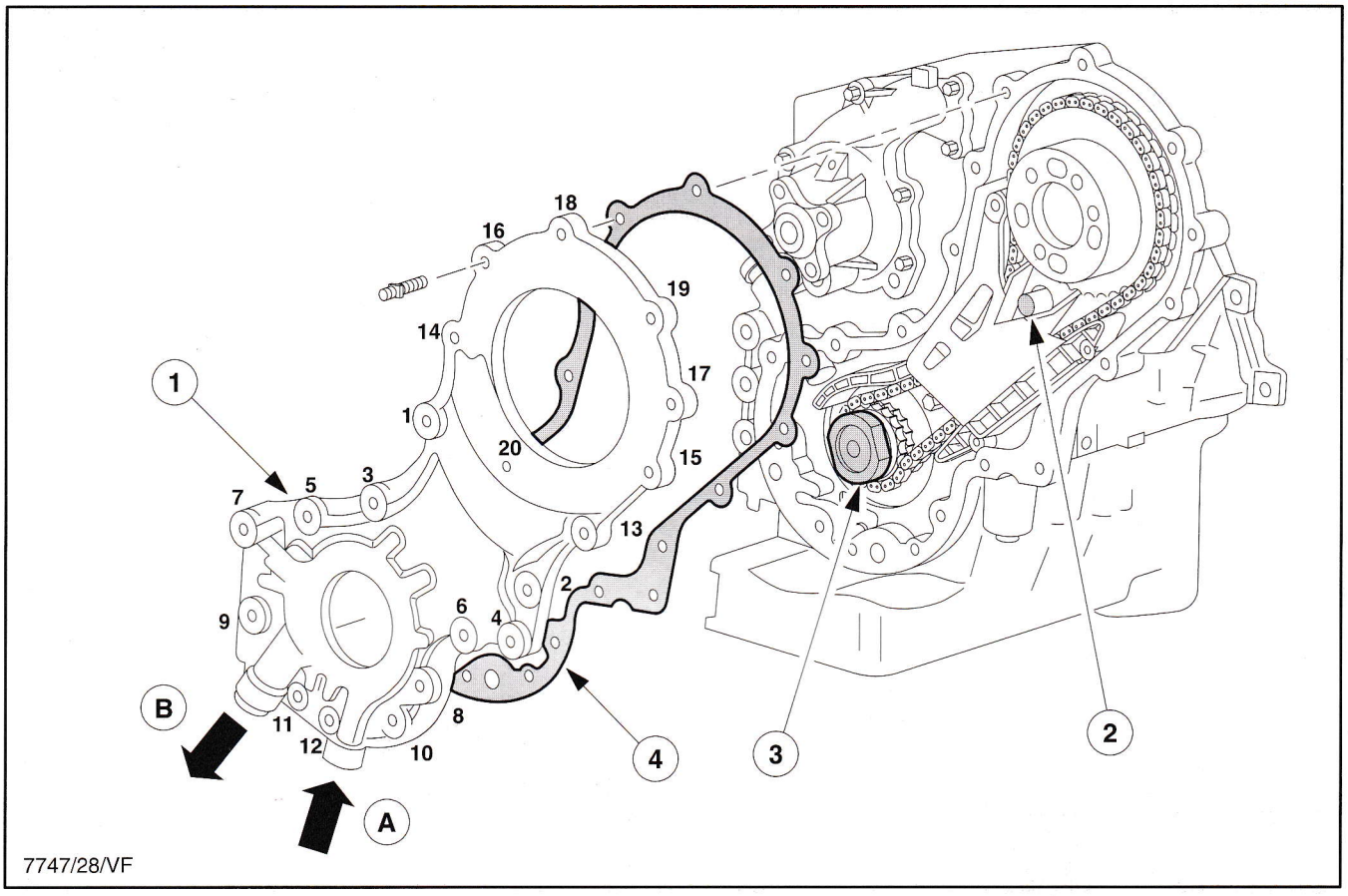
Oil pump

- The oil pump is a G-rotor pump. It is driven directly by the crankshaft.

NOTE: The steel gasket must not be reused. The mating faces of the oil pump must be treated with care to ensure that no scoring occurs.

- A new special tool must be used to center the oil pump during installation.

NOTE: The tool must be inserted prior to assembly and must not be removed until assembly of the oil pump has been completed. Note the tightening sequence for the bolts.

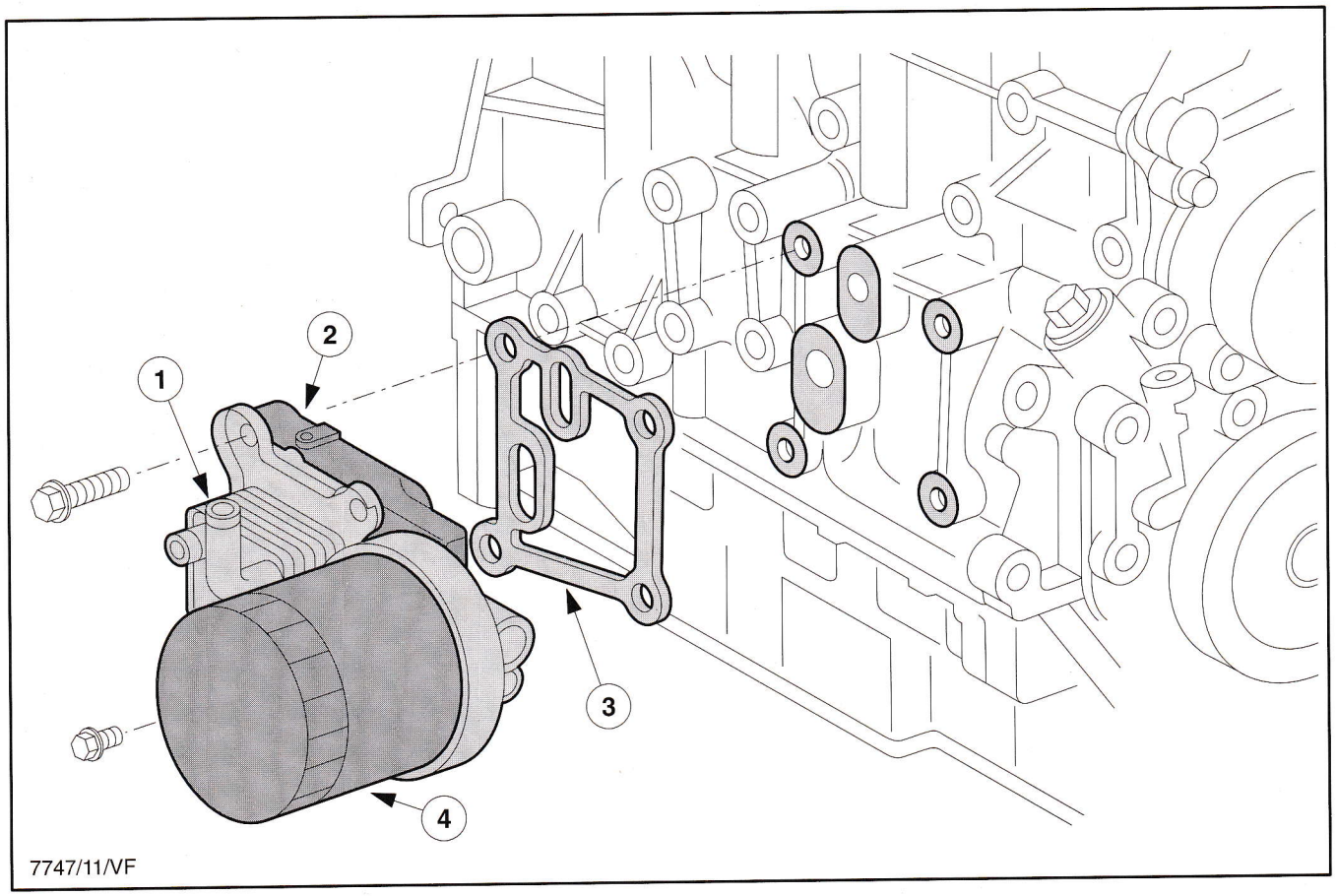


A Suction side
B High pressure side
1 Oil pump
2 Gasket
3 Crankshaft
4 Steel gasket

Oil cooler and filter

- An oil cooler is used in vehicles with a turbocharged engine on thermal grounds. Oil cooler and filter are mounted on an adapter which in turn is mounted on the block.
- It is made of aluminium parts which are brazed together. The steel gasket has to be installed when the oil cooler is removed.
- In addition, the coolant warms the oil cooler at low ambient temperatures so that the oil is brought up to normal operating temperature faster.

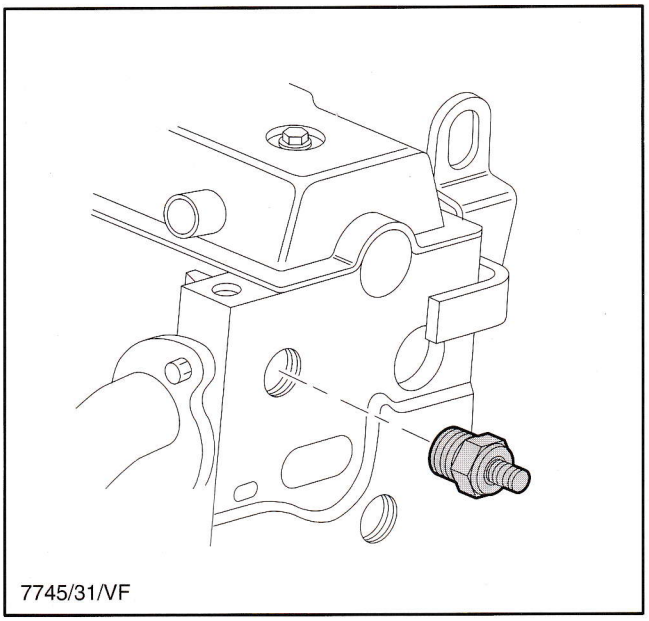
NOTE: Due to the horizontal arrangement of the oil filter, oil may drip as soon as the filter is slackened. Position yourself under the vehicle so that you are clear of dripping oil.



1 Oil cooler
2 Adapter
3 Steel gasket
4 Oil filter

Oil pressure switch

- The oil pressure switch is located on the rear of the cylinder head, as on the Endura-DE.



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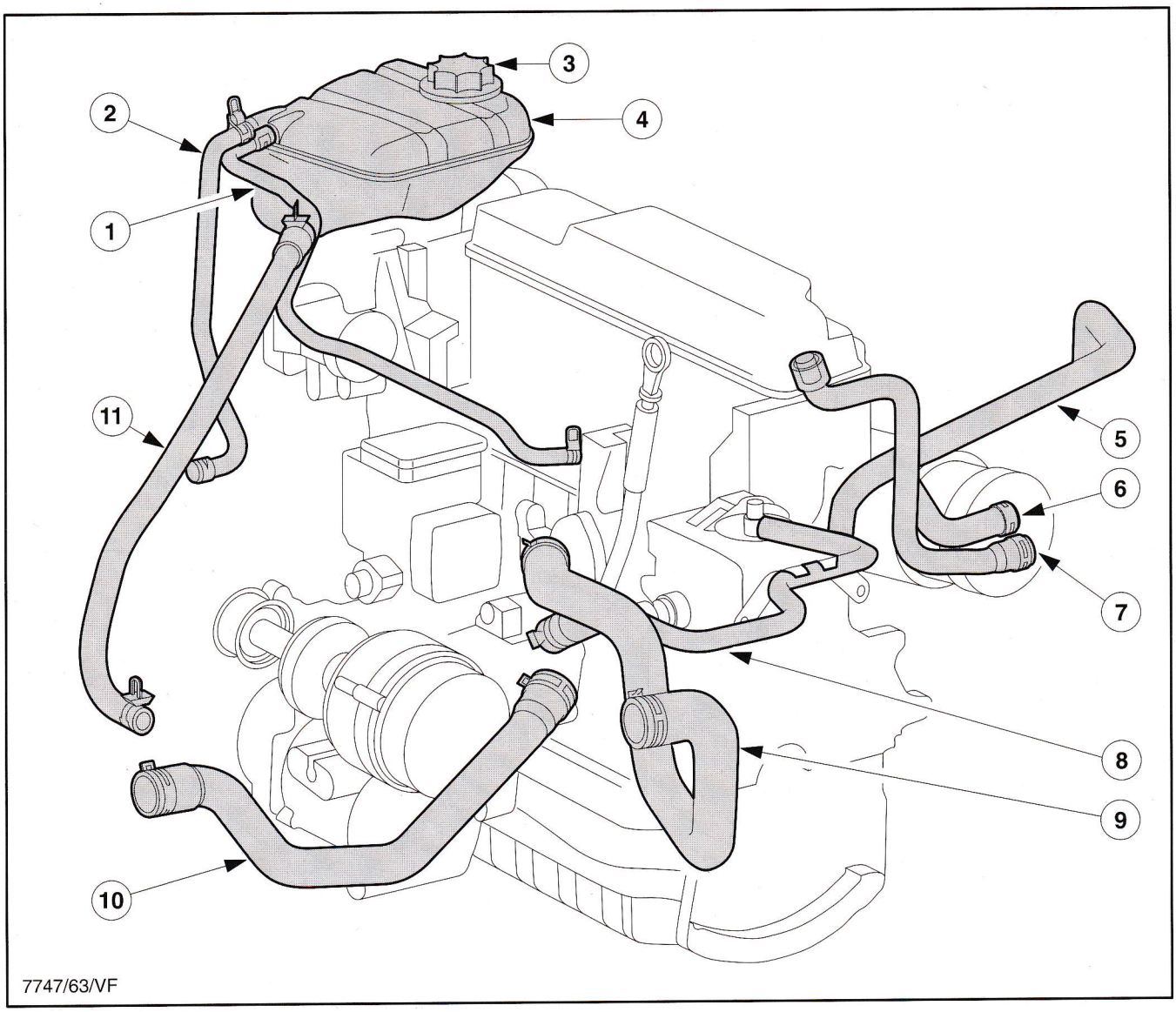
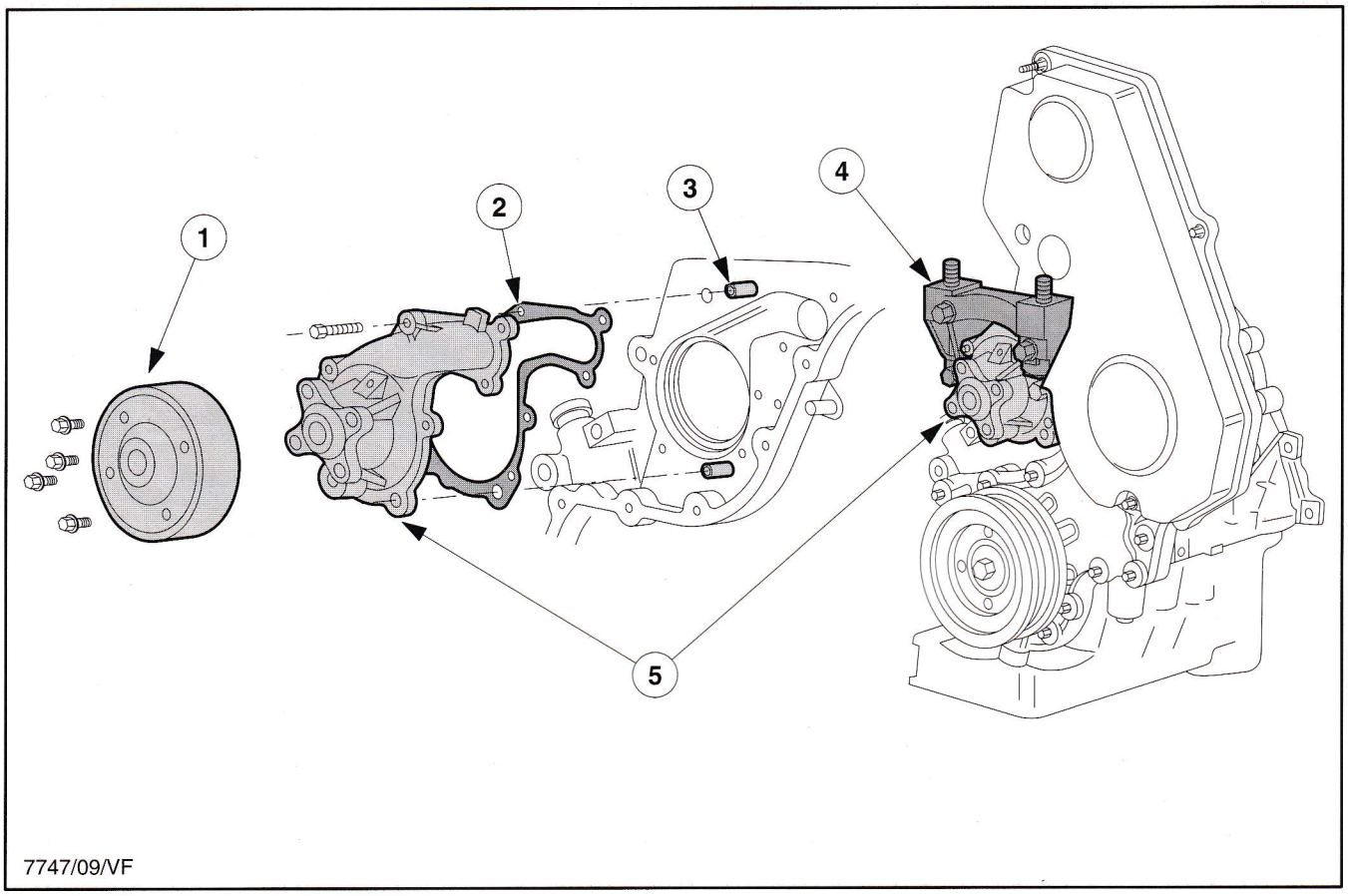
Coolant circuit



1 From engine to coolant expansion tank
2 From radiator to coolant expansion tank
3 Coolant expansion tank cap
4 Coolant expansion tank
5 Booster heater intake
6 Heat exchanger outlet
7 From EGR-cooler to heat exchanger
8 Oil cooler back bleed
9 Radiator upper hose
10 Radiator lower hose
11 Coolant expansion tank outlet

Water pump

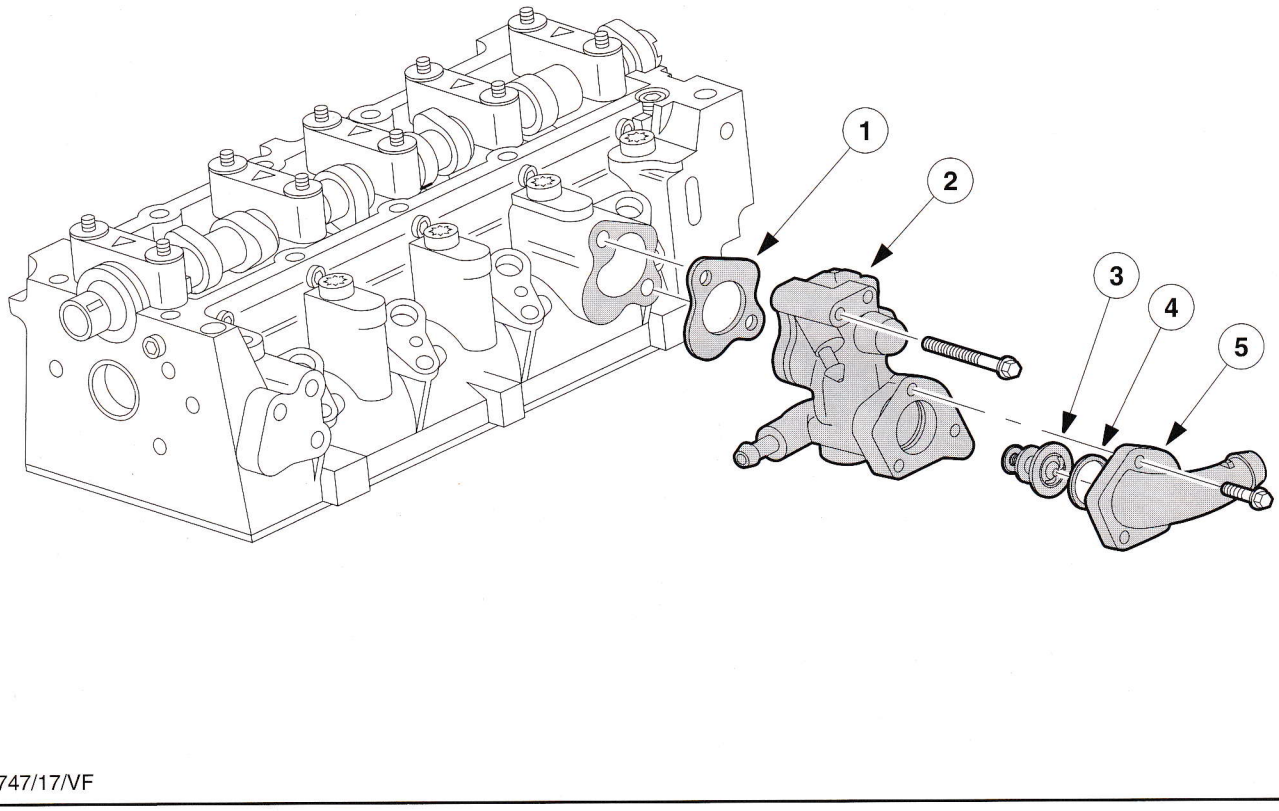
- A vane-type pump made of aluminium is used for the water pump. The pump rotor has six vanes and is made of plastic.
- The pump is mounted directly in the cylinder block under the engine mounting. It is positioned with two locating sleeves and sealed with a steel gasket which must not be reused.
- It is driven by the accessory drive belt.



1 Water pump pulley
2 Steel gasket
3 Locating sleeves
4 Engine mounting
5 Water pump

Thermostat

- The thermostat housing is located on the side of the cylinder head and is sealed with a steel gasket which must not be reused.
- The temperature is sensed by means of the CHT sensor and transmitted to the PCM. The PCM then actuates the cooling fan depending on the engine operating temperature. Therefore, a separate fan switch is eliminated.



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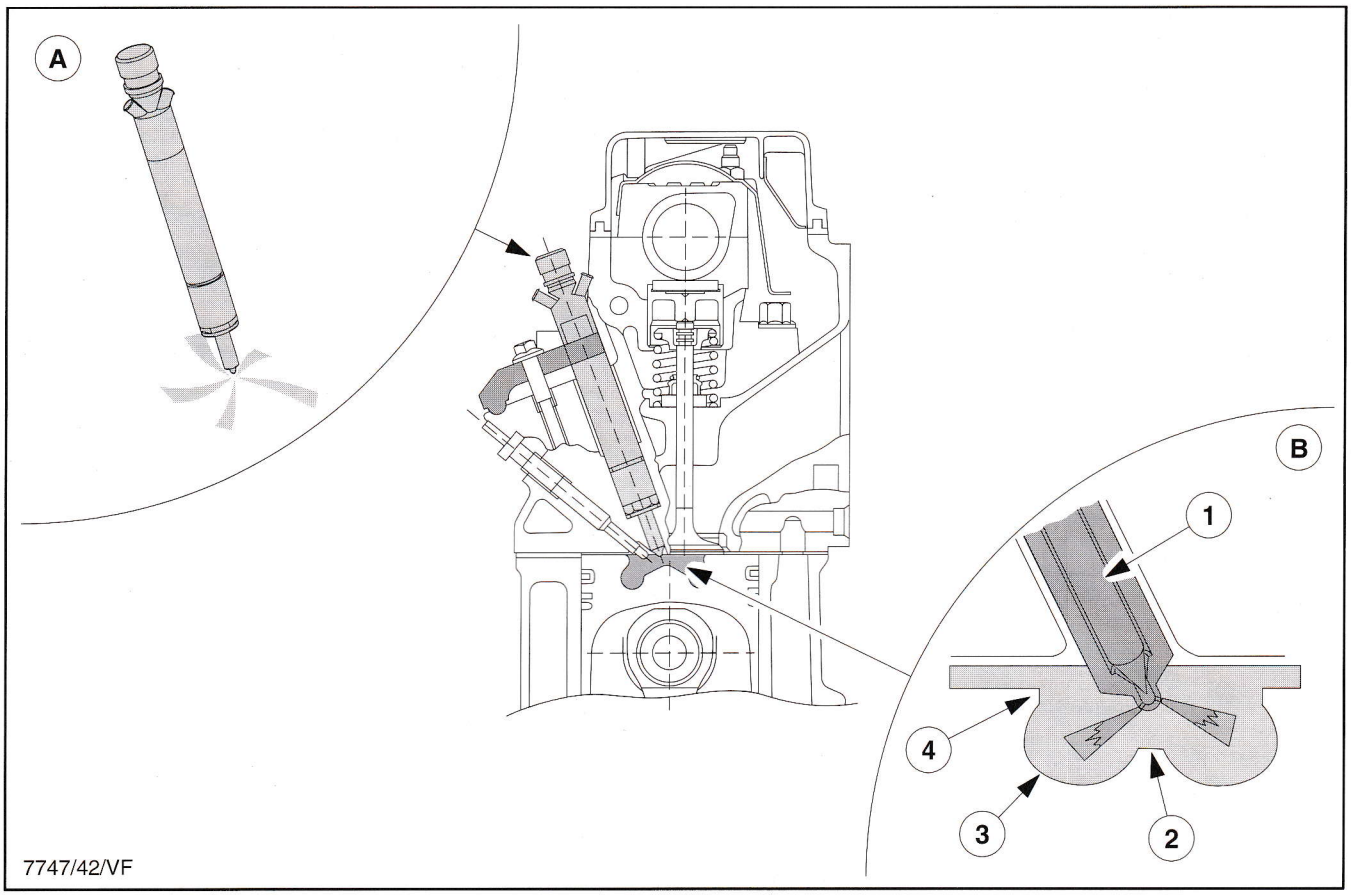
1 Steel gasket
2 Thermostat housing
3 Thermostat
4 Rubber sealing ring
5 Connector for coolant hose

Direct injection

- On the direct injection engine the shape of the combustion chamber is determined by the recess in the piston crown the shape of which has been developed for optimum combustion.
- Five-hole pencil-type fuel injectors located centrally over the piston recess are used for the direct injection process. The positioning of the holes is matched to the piston recess.
- The fuel is injected at a pressure of approximately 1100 bar and ideally atomised. The best possible mixture formation is achieved through the influx of turbulent air and the high fuel injection pressure. The direct injection process reduces fuel consumption by as much as 20%.
- Combustion takes place within a very short time and is therefore harsher than in the swirl chamber engine (knocking).

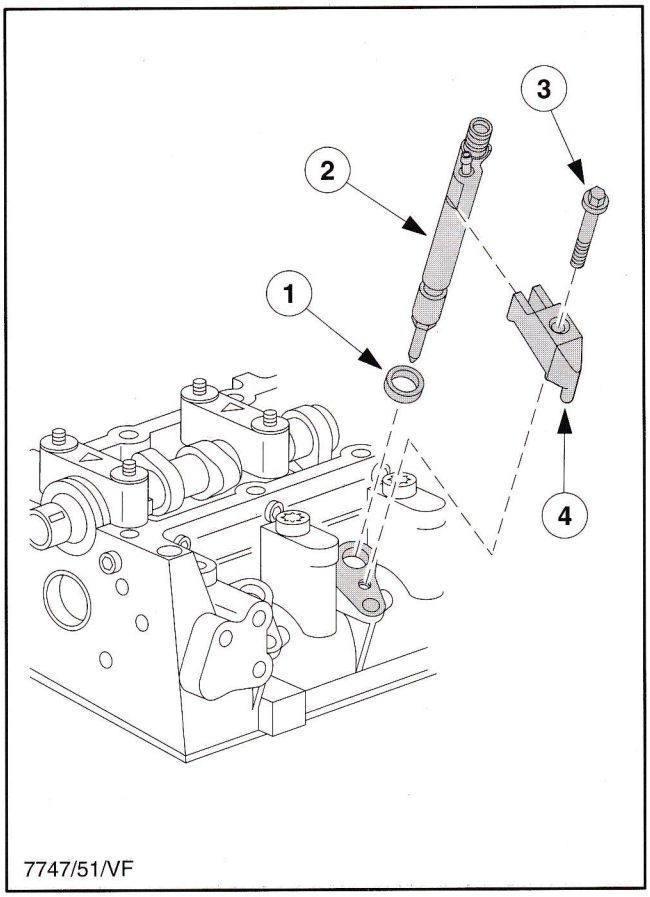


A Injector and spray pattern
B Position of injector relative to piston recess
1 Fuel injector
2 Taper in piston crown
3 Piston recess
4 Turbulence ring

Fuel injectors

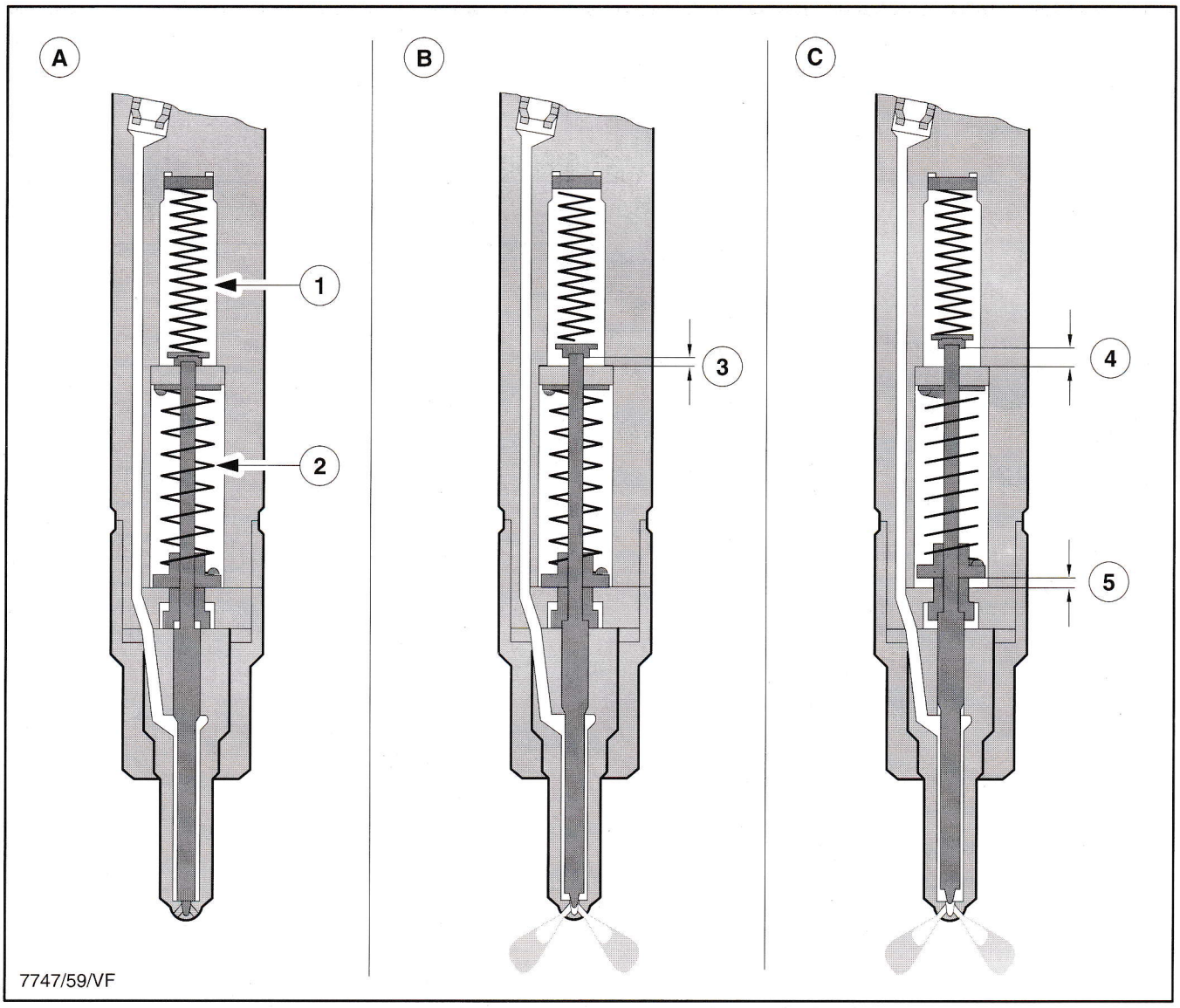
- The five-hole fuel injectors are a push-fit in the cylinder head. A copper sealing ring is used for sealing.
- The installed position of the fuel injectors is determined by a flat recess in the injector. The retainer engages in the flat recess and centors the fuel injector.
- The retainer is located with a ball head spigot and bolted to the cylinder head.

NOTE: The retaining bolts of the retainers must be tightened to the specified torque. The bolts and the copper seals must not be reused, refer to the current service literature.



1 Copper sealing ring
2 Fuel injector
3 Retaining bolt
4 Retainer

- The injector nozzle holder has two springs with different spring rates to produce progressive combustion.
- The first spring is designed so that a small quantity of fuel is pre-injected at low pressure at the start of the fuel injection process.
- This pre-injection ensures a progressive rise in the combustion pressure and creates the ignition conditions for the main fuel charge which is injected at high pressure by the second spring.
- The mechanical load on the crank gear is reduced and combustion is quieter due to the progressive rise in pressure in the combustion chamber.



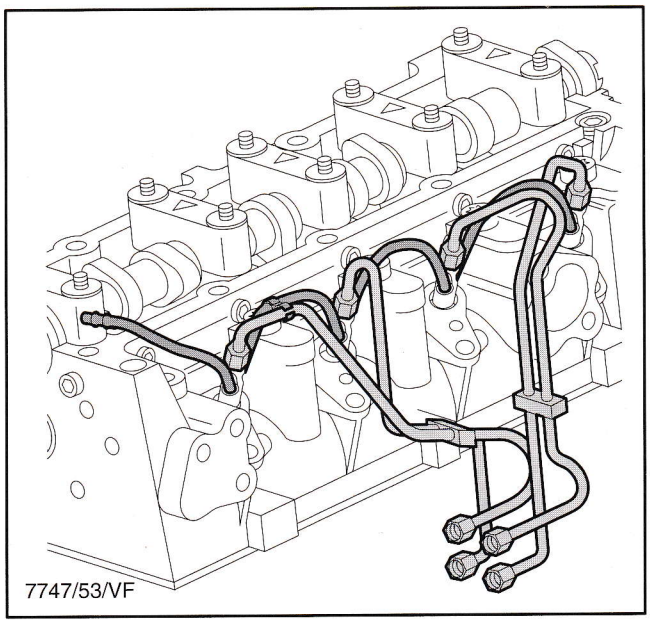
A Fuel injector closed
B Pre-injection
C Main injection

1 Spring 1
2 Spring 2
3 Stroke 1

4 Stroke 1 + stroke 2
5 Stroke 2

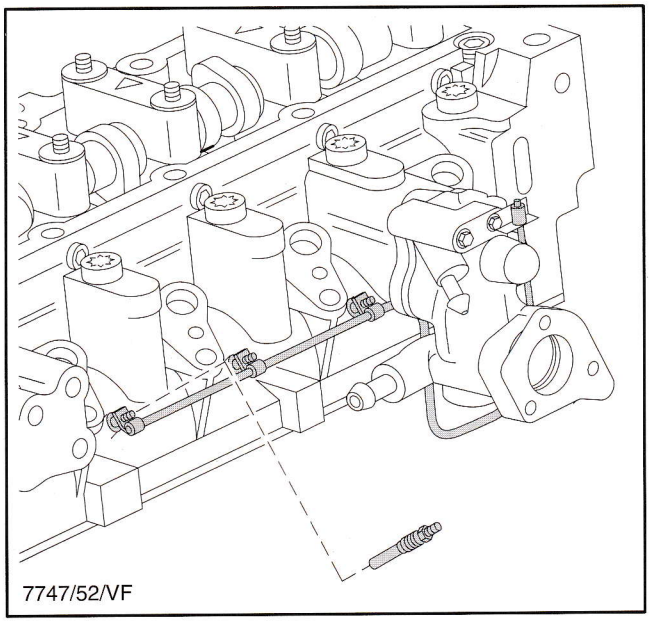
Fuel injection pipes

- The bending radii must not be changed during assembly. The fuel injection pipes must be fitted free of stress.



Pencil-type glow plugs

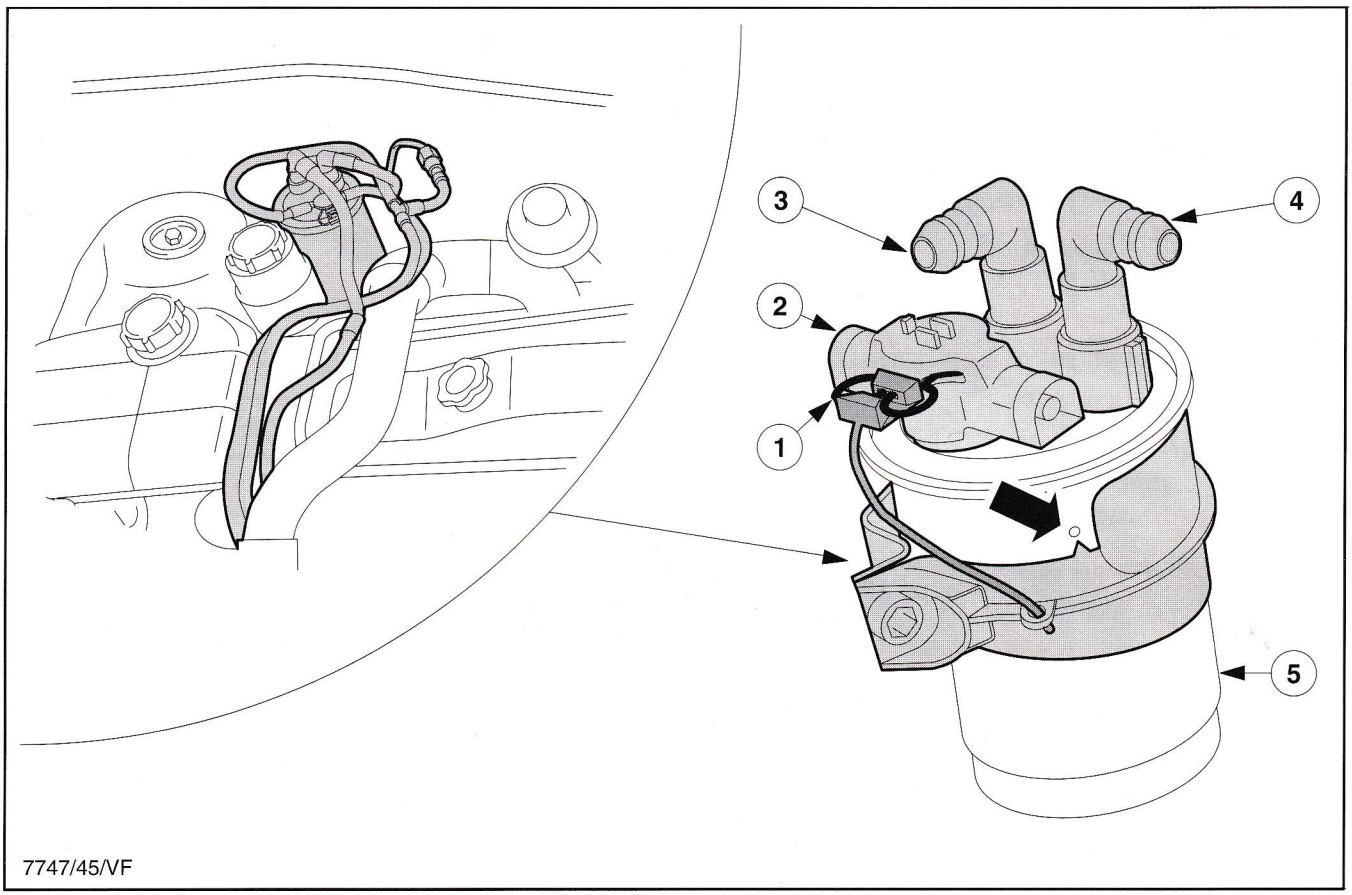
- The glow plugs are seated in the cylinder head parallel with the fuel injectors and heat the combustion chamber when actuated by the PCM.
- The pre-heat time depends on the level of the temperature signal. This is indicated to the driver by a pre-heat indicator in the instrument panel.
- Post-heat reduces engine noise, improves idling and reduces carbon emissions by producing more efficient combustion shortly after starting.



Fuel filter

- A control valve which is used for fuel pre-heating is located on the top of the fuel filter. It is held in the filter housing with a retaining clip.
- The control valve has a bimetal strip. It closes the return to the tank at low temperatures. This allows the warmed fuel from the fuel injection pump to flow back into the fuel filter, warm it and flow to the pump again.
- The fuel pipes are a push-fit and can be detached after unlocking the retainer. They are color-coded and have different diameters:
  - Inlet, white –(⌀ 10 mm)
  - Outlet, black –(⌀ 6 mm)

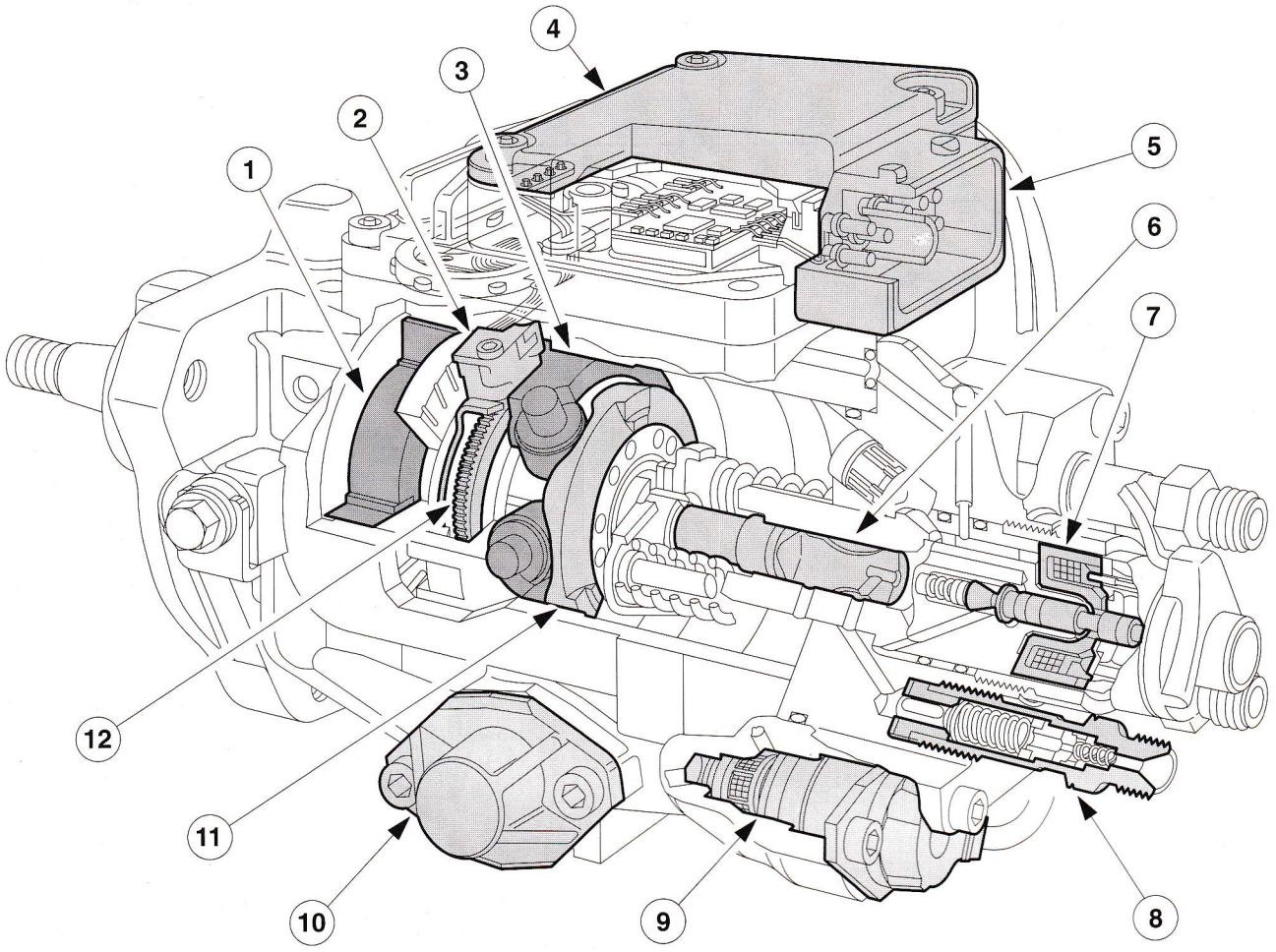
NOTE: When it is installed, the fuel filter must be fitted in the same position (arrow) and prefilled.



1 Retaining clip
2 Control valve
3 Outlet
4 Inlet
5 Fuel filter

Bosch VP-30 distributor-type fuel injection pump

- The VP-30 distributor-type fuel injection pump is based on the pump used on the Transit and Scorpio.
- The VP-30 satisfies the following requirements optimally:
  - low emissions
  - increased economy and improved driveability
  - precision and flexibility as regards as engine adaptation and engine management



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1 Vane pump
2 Rotation angle sensor
3 Roller ring
4 Pump control unit (PCU)
5 Electrical connector
6 Axial piston
7 High-pressure solenoid valve
8 Pressure valve
9 Fuel injection timing solenoid (FITS) valve
10 Fuel injection timing device
11 Cam ring
12 Pulse rotor

General notes on the VP-30 fuel injection pump

- The VP-30 fuel injection pump is a very compact distributor-type fuel injection pump controlled by a high-pressure solenoid valve.
- The high pressure is produced mechanically with an axial piston as in earlier Bosch fuel injection pumps.
- The following components have been **eliminated** in the VP-30:
  - the control slide which was responsible for the quantity of fuel injected
  - the mechanical link from the accelerator pedal to the fuel injection pump
  - the electromagnetic shutoff valve
  - the needle lift sensor (NLS)
- The following components are **new** in the VP-30:
  - the pulse rotor and rotation angle sensor
  - the high-pressure solenoid valve for the quantity of fuel injected and for the fuel shutoff
  - the fuel injection timing solenoid (FITS) valve for the point of injection and duration of injection
  - the pump control unit (PCU)
- The PCU is located on the top of the pump. From the data supplied by the rotation angle sensor and the powertrain control module (PCM) it calculates the actuation signals for the high-pressure solenoid valve and the fuel injection timing solenoid valve.

NOTE: Before touching the electrical connector of the PCU, it is imperative to make sure that no electrostatic discharge can take place. A spark could damage the control unit.

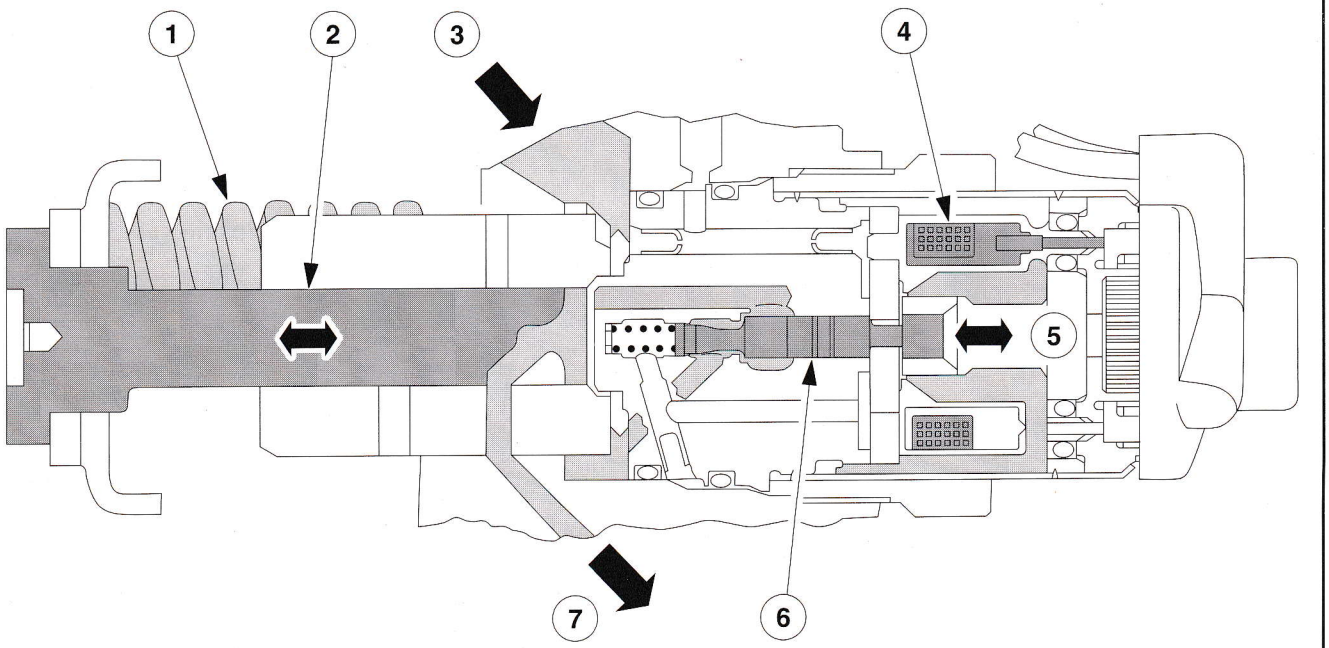
- The high-pressure solenoid valve opens and closes with a variable duty cycle as controlled by the map in the PCU.
- The hydraulic efficiency of the pump is improved due to the precise actuation of the high-pressure solenoid valve and the elimination of the mechanical control slide used previously.
- The start of fuel delivery is controlled by the PCU through the high-pressure solenoid valve without the needle lift sensor (NLS). The delivery rate is variable.
- The fuel system cannot run dry while driving. When the level of fuel in the tank drops to 2 %, the PCM causes engine bucking and ultimately switches off the fuel supply.

NOTE: The fuel system must be bled when the fuel injection pump is changed.

- To bleed the fuel injection pump, the fuel injection pipes must be disconnected at the injectors. Then the engine should be cranked on the starter motor until fuel escapes from the pipes. Refer to the current service literature for the complete procedure.

High-pressure solenoid valve

- The high-pressure solenoid valve is located centrally in the distributor assembly. It opens and closes the feed bore between the axial piston and the connector with a valve needle.
  - The start of fuel delivery is determined by the point at which the high-pressure solenoid valve closes.
  - The end of delivery is determined by the point at which the high-pressure solenoid valve opens.
  - The length of time for which the high-pressure solenoid valve is closed determines the quantity of fuel injected.

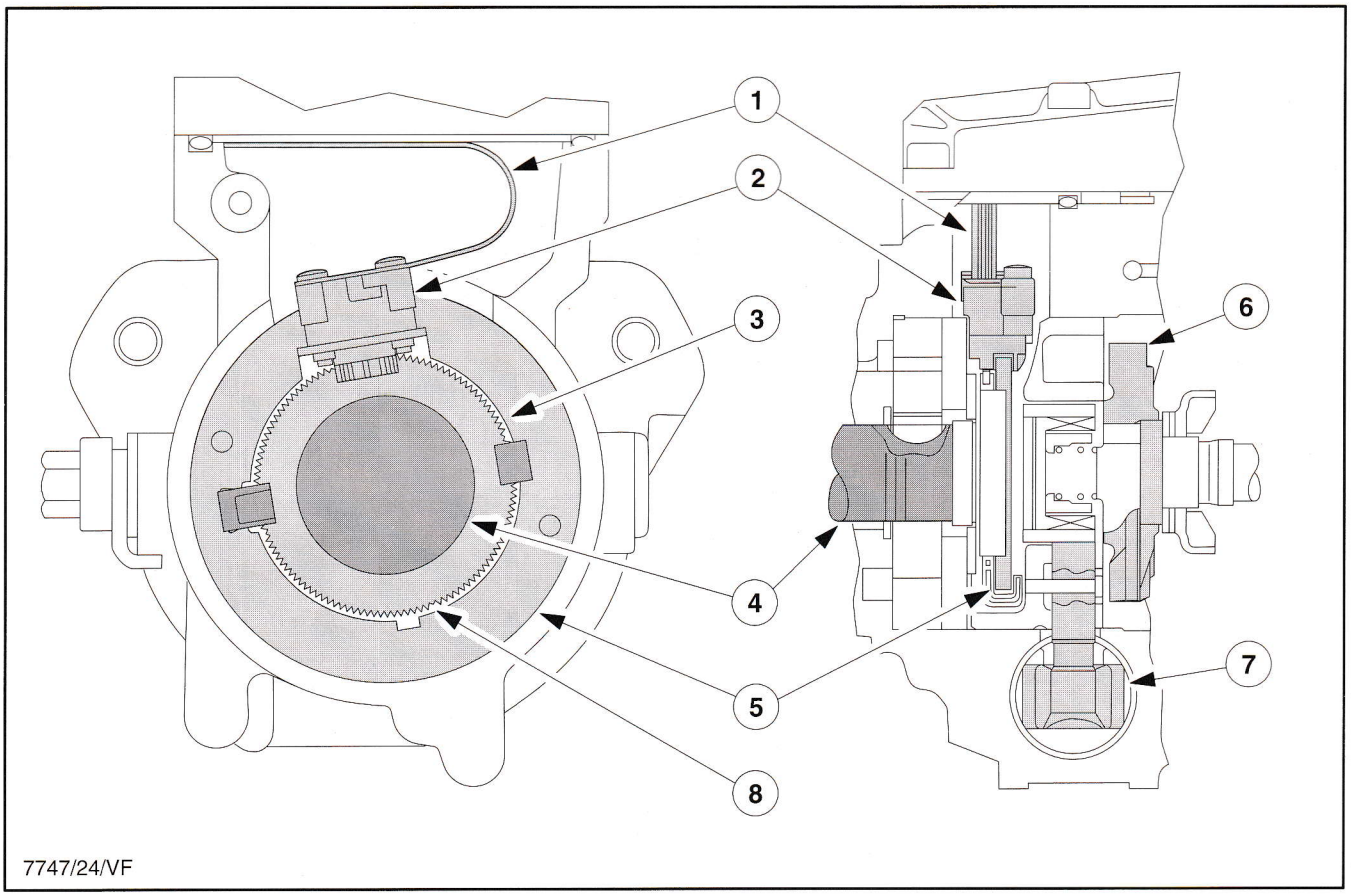


7747/23/VF

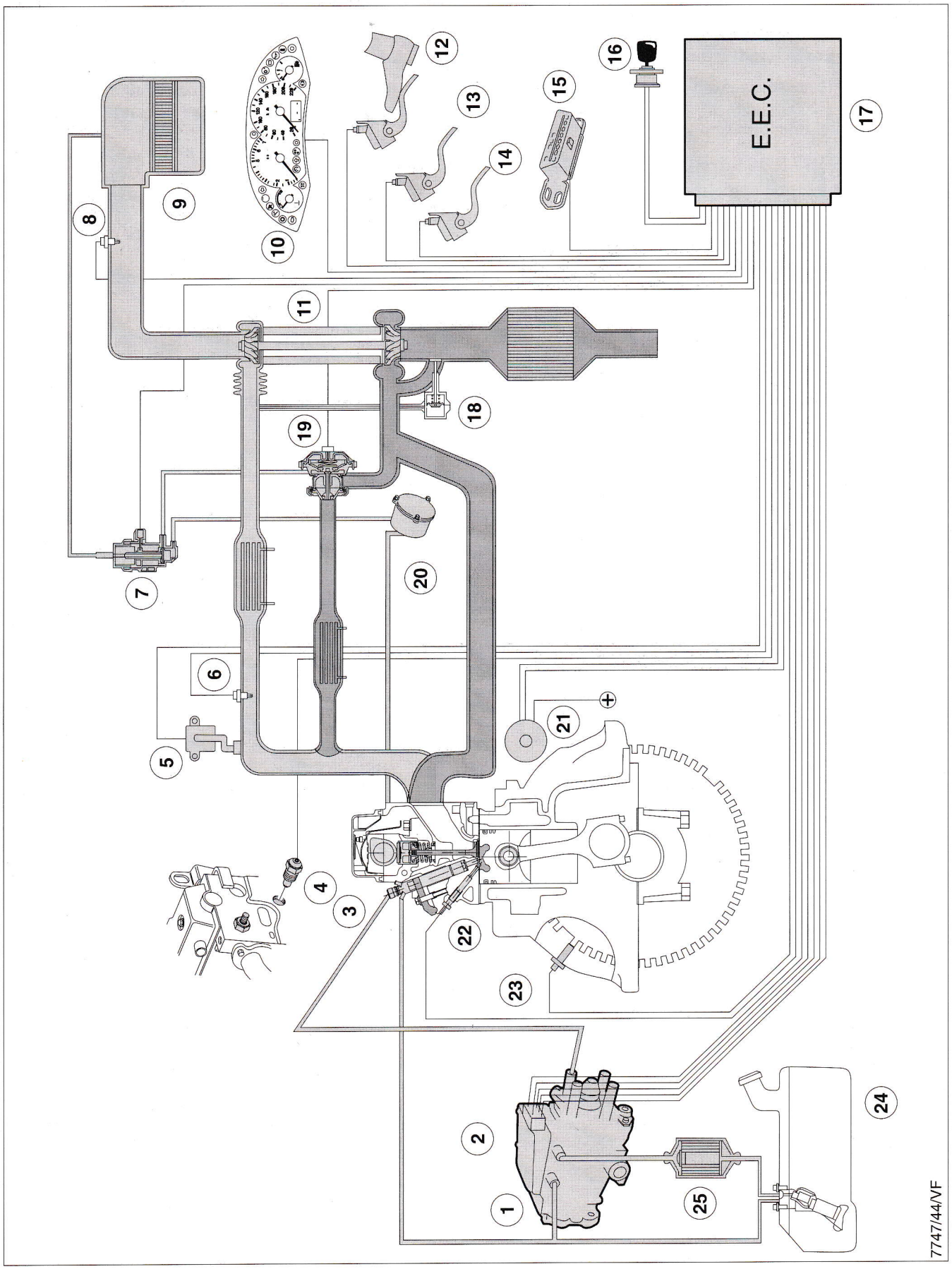
1 Compression spring
2 Axial piston
3 Supply
4 Coil
5 Closing and opening direction
6 Valve needle
7 To fuel injector

Pulse rotor and rotation angle sensor

- The pulse rotor is fixed to the driving shaft and the rotation angle sensor is fixed to the roller ring.
- When the fuel injection timing device is moved by the fuel injection timing solenoid valve, the roller ring and the rotation angle sensor are turned to advance or retard the fuel injection.
- The pulse rotor has a gap in the teeth for each cylinder. The succession of teeth and gaps is scanned by the rotation angle sensor.
- The signal is transmitted through a conductor foil to the PCU where it is used for the following purposes:
  - to determine the instantaneous angular position;
  - to measure the current fuel injection pump speed;
  - to determine the instantaneous advance position of the fuel injection timing solenoid valve.
- The instantaneous angular position determines the actuating signal for the high-pressure solenoid valve. This ensures that both the closing point and the opening point of the high-pressure solenoid valve occur at the appropriate cam lift.



1 Conductor foil
2 Rotation angle sensor
3 Pulse rotor
4 Driving shaft
5 Rotatable bearing ring
6 Cam ring
7 Fuel injection timing device
8 Gap in teeth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Key to the illustration opposite:

1 Bosch VP-30 distributor-type fuel injection pump

2 Pump control unit (PCU)

3 Five-hole fuel injector

4 Cylinder head temperature (CHT) sensor

5 Manifold absolute pressure (MAP) sensor

6 Intake air temperature (IAT) sensor in intercooler

7 EGR vacuum regulator

8 Intake air temperature (IAT) sensor in front of turbocharger

9 Air cleaner

10 Instrument cluster

11 Garrett GT15 turbocharger

12 Accelerator pedal (AP) sensor

13 Clutch pedal position (CPP) sensor

14 Stoplamp switch (BPP)

15 Data link connector (DLC)

16 Ignition switch

17 EEC V powertrain control module (PCM) with 104 pins and integral PATS

18 Turbocharger flap valve

19 Exhaust gas recirculation (EGR) valve with EGR position sensor

20 Vacuum pump

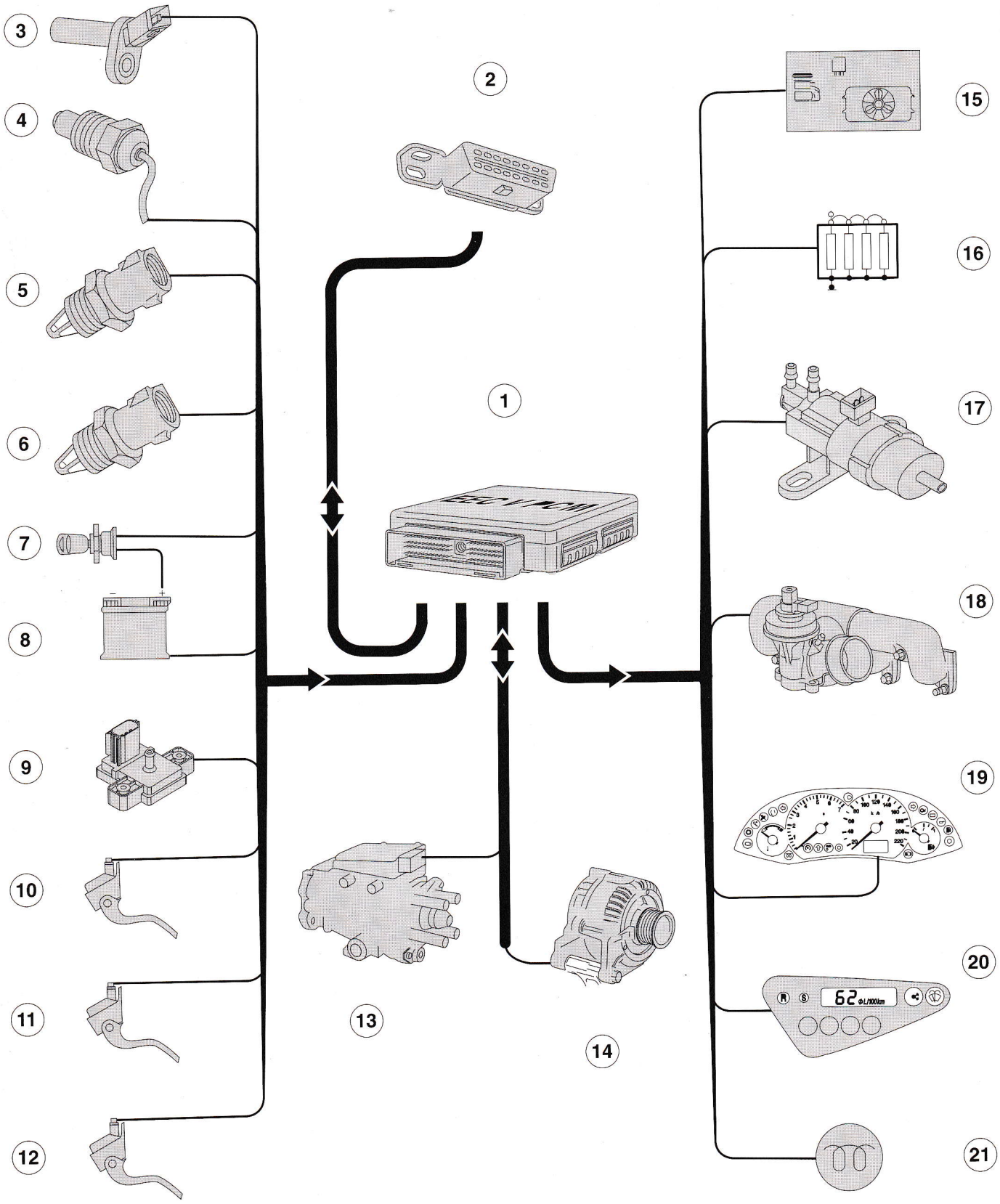
21 Controlled battery charging (smart charging)

22 Pencil-type glow plug

23 Crankshaft position (CKP) sensor

24 Fuel tank

25 Fuel filter



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Key to the illustration opposite:

1 EEC V powertrain control module (PCM) with 104 pins and integral PATS

2 Data link connector (DLC)

3 Crankshaft position (CKP) sensor

4 Cylinder head temperature (CHT) sensor

5 Intake air temperature (IAT) sensor in intercooler

6 Intake air temperature (IAT) sensor in front of turbocharger

7 Ignition switch

8 Battery

9 Manifold absolute pressure (MAP) sensor

10 Accelerator pedal (AP) sensor

11 Clutch pedal position (CPP) sensor

12 Stoplamp switch (BPP)

13 Bosch VP-30 distributor-type fuel injection pump with pump control unit (PCU)

14 Controlled battery charging (smart charging)

15 Air conditioning (A/C) controller

16 Pre-heat module

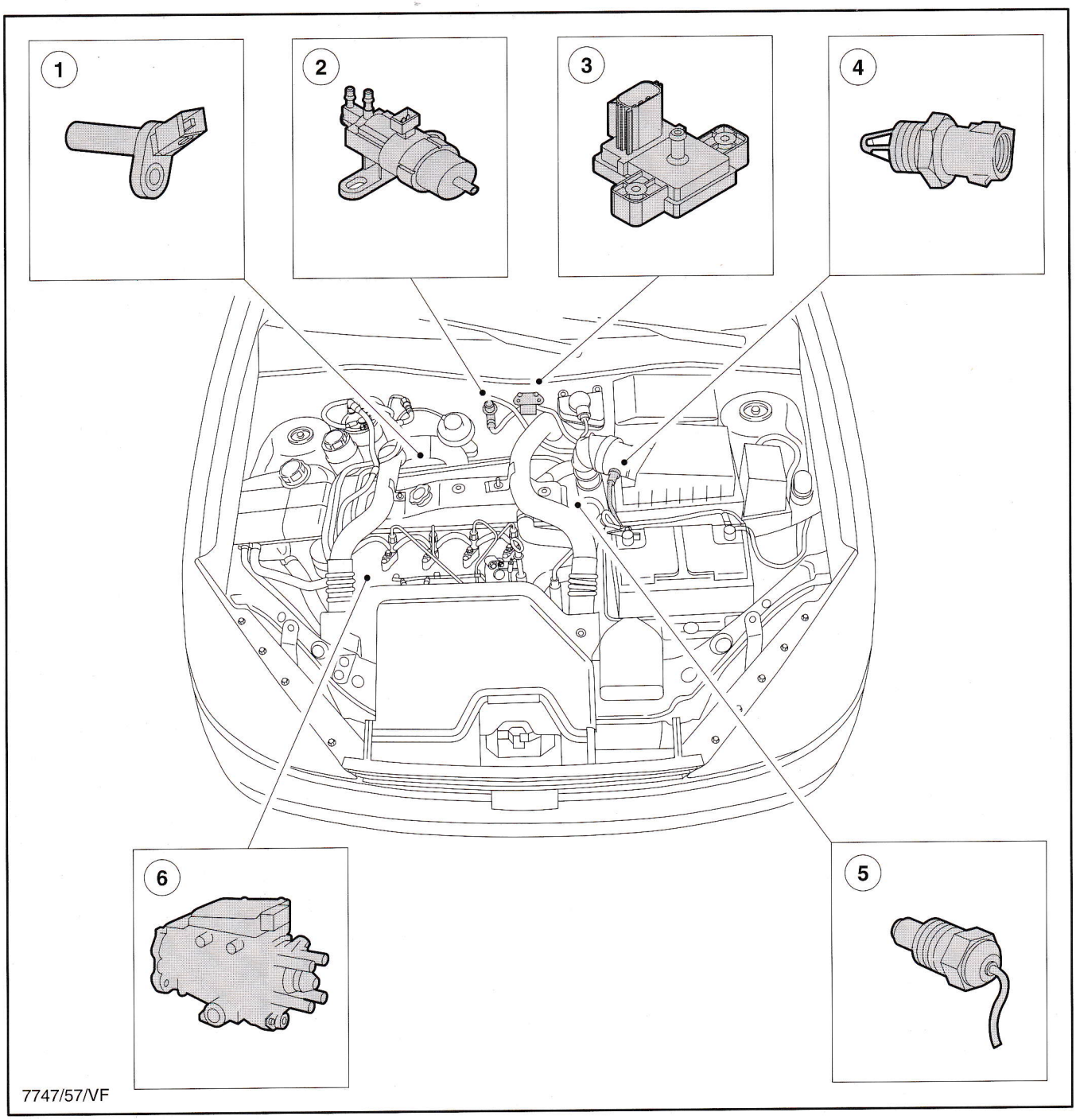
17 EGR vacuum regulator

18 Exhaust gas recirculation (EGR) valve with EGR position sensor

19 Instrument cluster

20 Trip computer

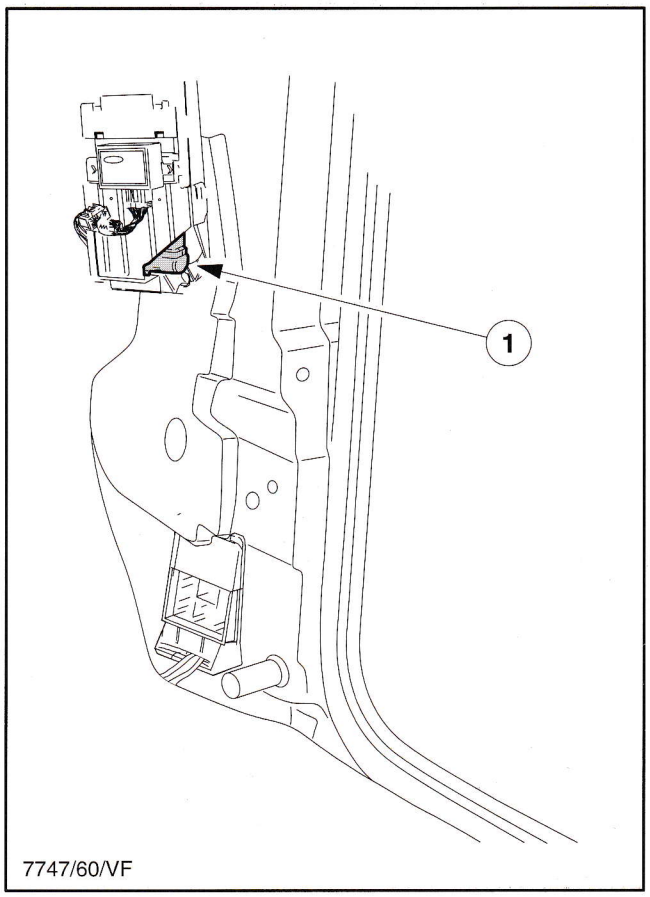
21 Glow plug indicator



1 Crankshaft position (CKP) sensor
2 EGR vacuum regulator
3 Manifold absolute pressure (MAP) sensor
4 Intake air temperature (IAT) sensor in front of turbocharger
5 Cylinder head temperature (CHT) sensor
6 Bosch VP-30 distributor-type fuel injection pump with pump control module (PCU)

Powertrain control module (PCM)

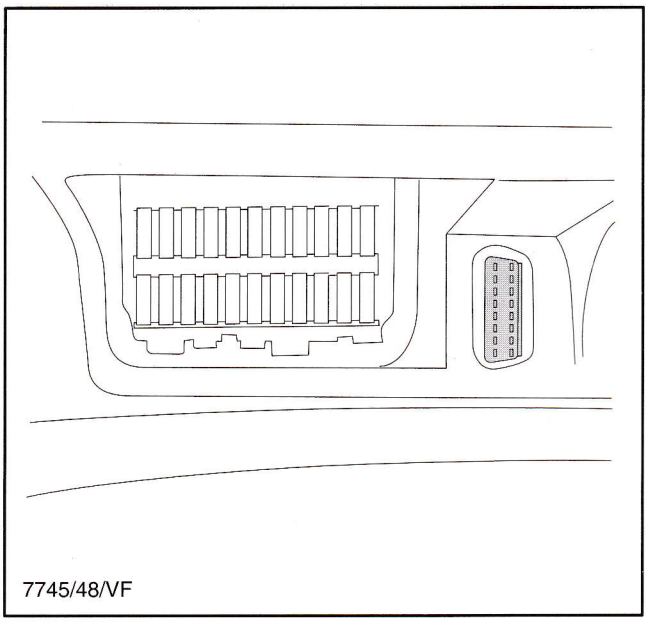
- The EEC V engine management system is used for the Endura-DI. It controls the engine management, EGR system and passive anti-theft system (PATS).
- The PCM (which has 104 pins) evaluates the incoming signals from the sensors, compares these with the stored maps and produces signals to control the actuators.
- It is located under the trim panel on the right-hand A-pillar.



1 EEC V PCM

Data link connector (DLC)

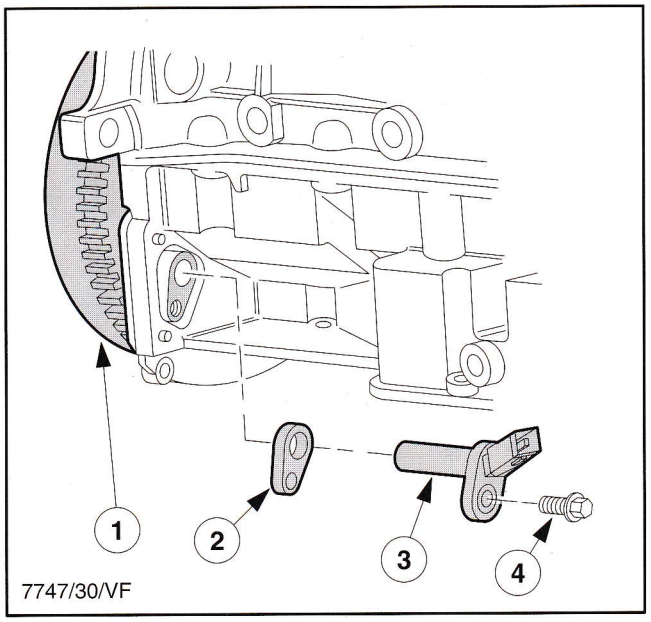
- Diagnosis and testing is carried out with FDS 2000 through the data link connector (DLC).
- It is located behind a cover near by the central junction box.



Crankshaft position (CKP) sensor

- The CKP sensor is an inductive pulse generator. It scans a toothed ring which is mounted on the flywheel and has two missing teeth. The PCM uses the missing teeths as a reference mark for the crankshaft position.
- The gap between the CKP sensor and the toothed ring is determined by the fixture of the sensor to the cylinder block.

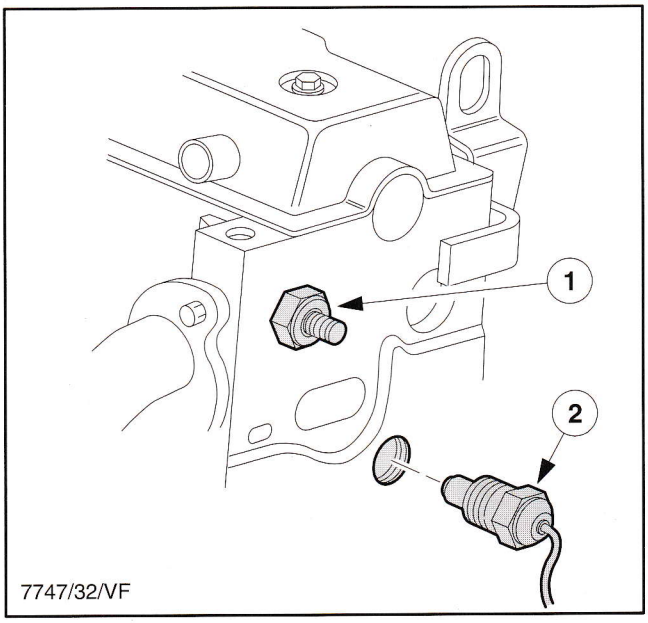
NOTE: When the sensor is refitted, the spacer must be inserted again. It must never be omitted.



1 Flywheel
2 Spacer
3 CKP sensor
4 Retaining bolt

Cylinder head temperature (CHT) sensor

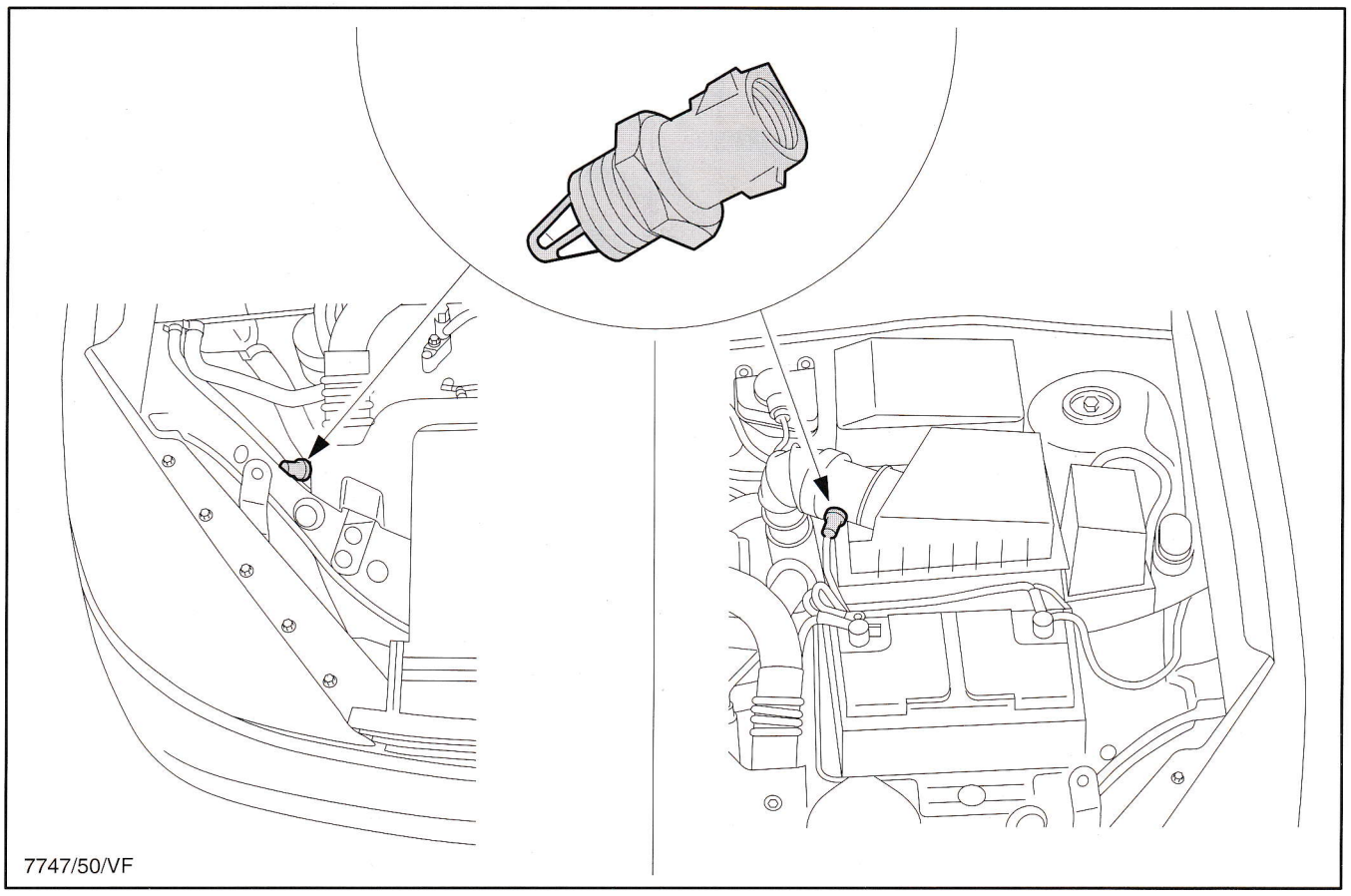
- The CHT sensor takes the place of the ECT sensor used until now.
- It influences the quantity of fuel injected and the fuel injection timing, fan control and idle speed.
- It is seated in a blind hole and measures the temperature of the metal of the cylinder head. This temperature is converted into a signal and sent to the PCM.
- The PCM uses the signal for engine management and for the engine coolant temperature warning indicator in the instrument cluster.



1 Oil pressure switch
2 CHT sensor

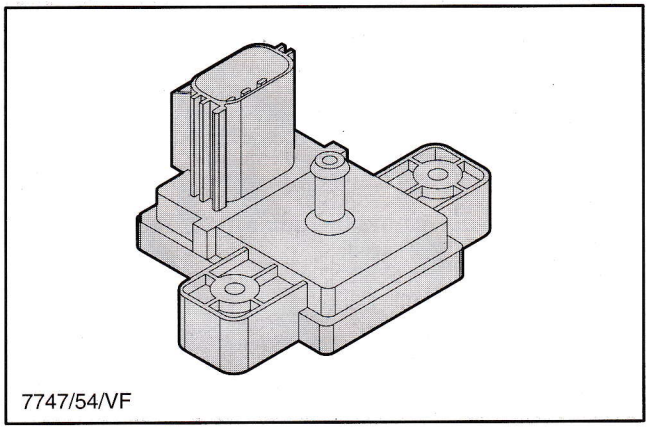
Intake air temperature (IAT) sensor

- The IAT sensor is a temperature-sensitive resistor with a negative temperature coefficient (NTC). It measures the intake air temperature which is required to determine the quantity of fuel to be injected.
- On the Endura-DI two sensors are used which measure different intake air temperatures:
  - the intake air temperature in front of the turbocharger
  - the intake air temperature after the intercooler
- The IAT sensor in front of the turbocharger is used for the smart charging system.
- The IAT sensor after the intercooler serves as a correcting element to take account of the influence of the temperature on the density of the charge air.
- It influences the EGR system, the fuel injection timing and the quantity of fuel injected.



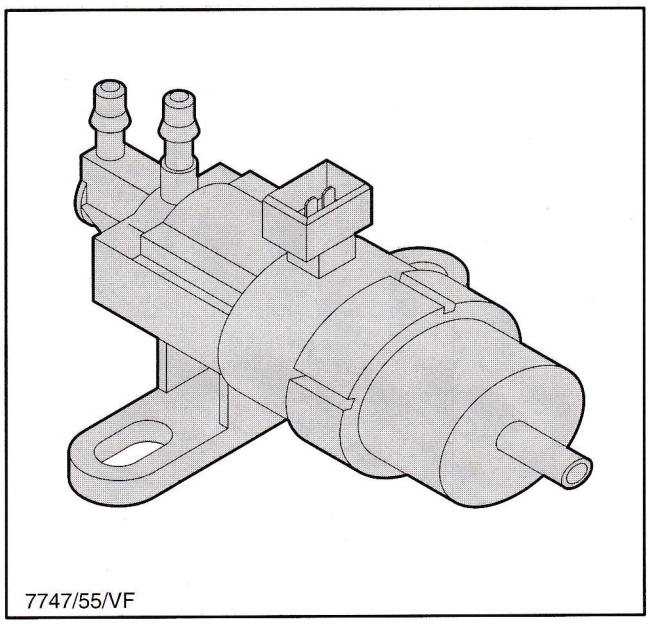
Manifold absolute pressure (MAP) sensor

- The MAP sensor is connected to the intake manifold by a vacuum hose and measures the absolute pressure in the intake system.
- From the input signals from the MAP and the IAT sensors the PCM infers the mass of air induced by the engine.
- The absolute pressure is required for the quantity of fuel injected.


7747/54/VF

EGR vacuum regulator solenoid

- The EGR vacuum regulator solenoid is supplied by the vacuum pump and actuated by the PCM by pulsed signals.
- When actuated by the PCM, a magnetic field is created in the coil which attracts or holds the valve plate in the vacuum regulator. This leads to a build-up of vacuum which acts on the diaphragm in the EGR valve and opens it.
- It is controlled so that the position of the EGR valve achieved in the closed loop matches the specified value in the map stored in the PCM.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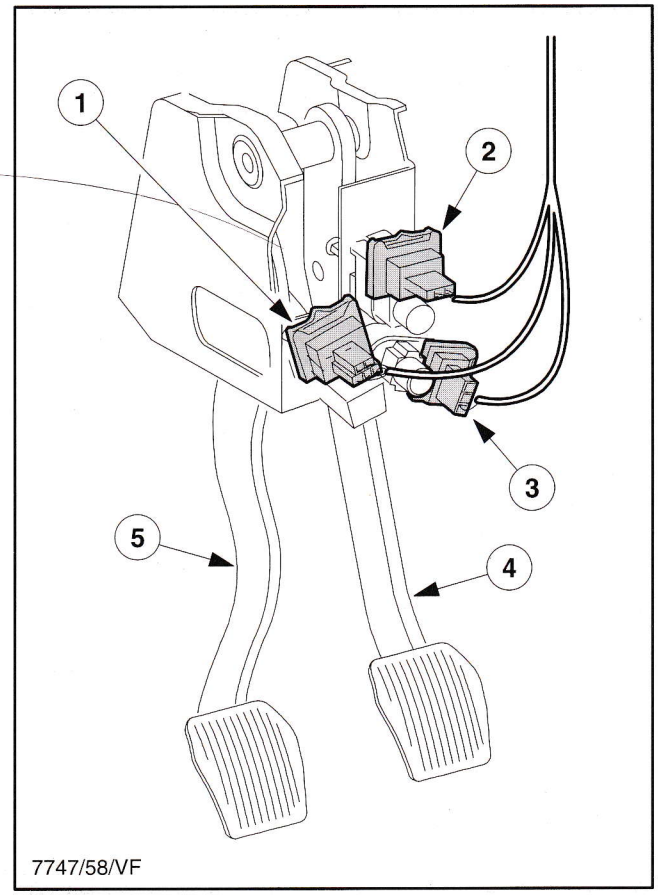
Clutch pedal position (CPP) switch

- The CPP switch tells the PCM whether the clutch is engaged or disengaged.
- When the clutch pedal is depressed, the quantity of fuel being injected is momentarily reduced to prevent engine bucking while a gear is shifted.

Stoplamp switch and brake pedal position (BPP) switch

- For safety reasons the stoplamp switch and the brake switch both supply the "brake operated" signal to the PCM.

NOTE: The two switches must be set so that their switching points are the same. Refer to the current service literature for the adjustment procedure.



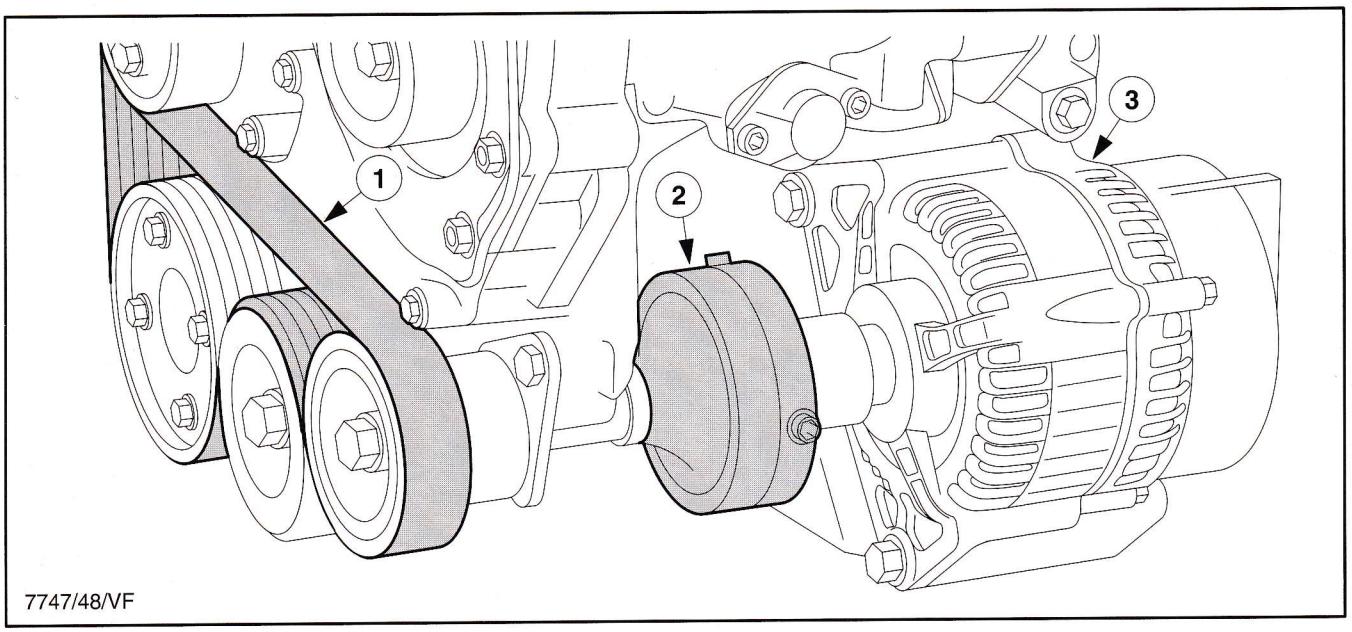
1 CPP switch
2 Stoplamp switch
3 BPP switch
4 Brake pedal
5 Clutch pedal

Accelerator pedal (AP) sensor

- From the AP sensor the PCM receives the signal for the current position of the accelerator pedal.
- The PCM calculates the quantity of fuel to be injected from the signals from the AP sensor and further parameters.

Alternator

- Between the pulley and the alternator there is a clutch which ensures that the alternator starts smoothly and also serves as a vibration damper.
- The alternator voltage is controlled by the PCM according to the temperature of the electrolyte and the level of charge of the battery.
- The IAT in front of the turbocharger measures the ambient temperature with the aid of which the battery electrolyte temperature is determined.



1 Accessorys belt drive 2 Clutch 3 Alternator

Component faults/failure

- The following table shows the effect of a component fault/failure.

Fault/failure	EGR is switched off	Increased idle speed	Reduced engine power output	Engine is stopped
PCM				X
CKP sensor				X
PCU/PCM monitoring signal				X
PCU				X
Break in PCU/PCM CAN data bus		X		
Failure of two accelerator pedal sensors		X		
EGR vacuum regulator	X			
CHT sensor			X	
MAP sensor			X	
IAT sensor			X	
VSS sensor			X	

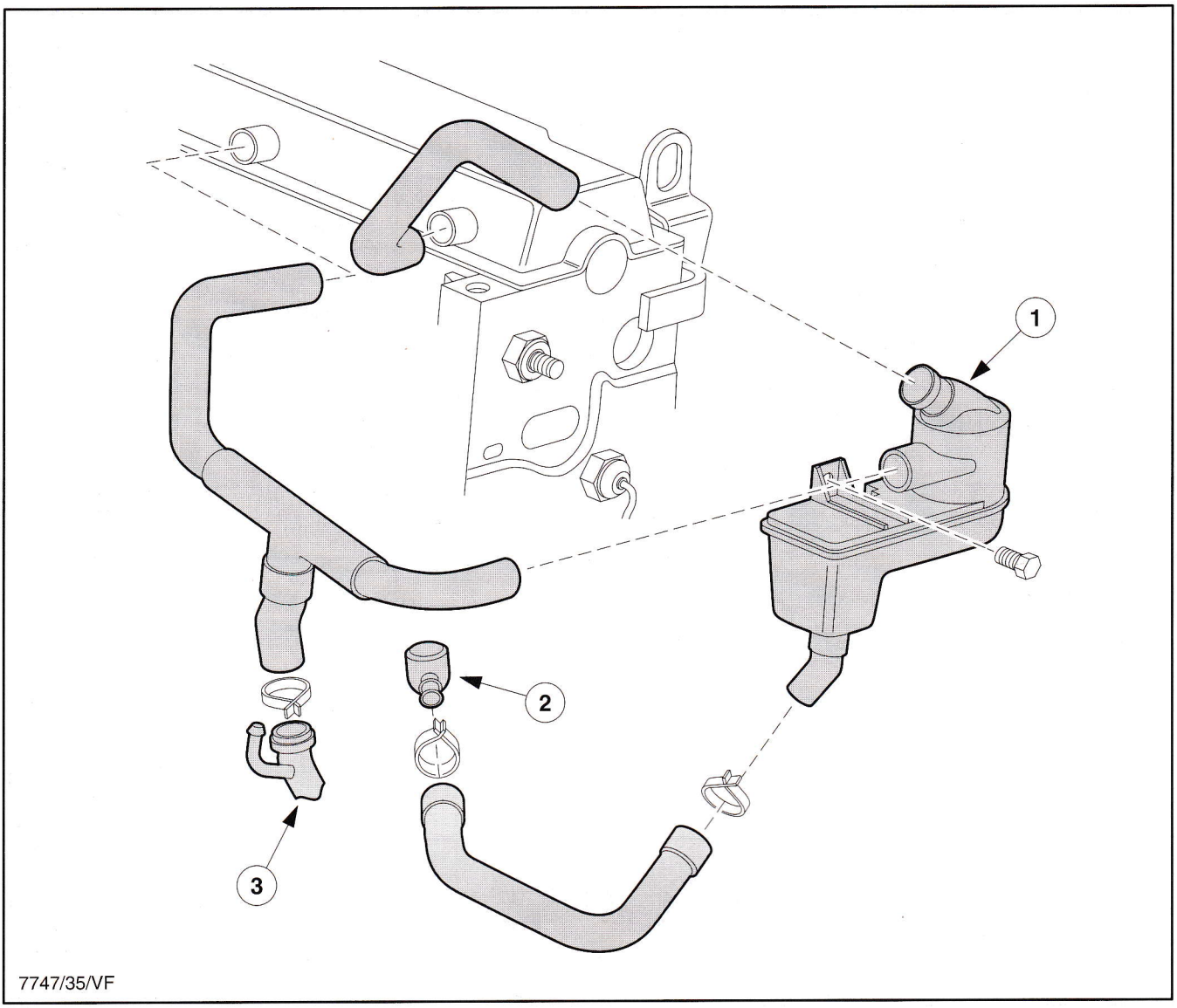
Important notes:

NOTE: The fuel system cannot run dry while driving. When the fuel in the tank falls to 2 % the PCM causes engine bucking and finally switches off the fuel supply.

NOTE: A failure in the glow plug system will be indicated by flashing glow plug indicator in the instrument cluster.

NOTE: If the CHT sensor detects that the engine is overheating, the power output is reduced. If the engine still does not cool down after a certain time, it is stopped.

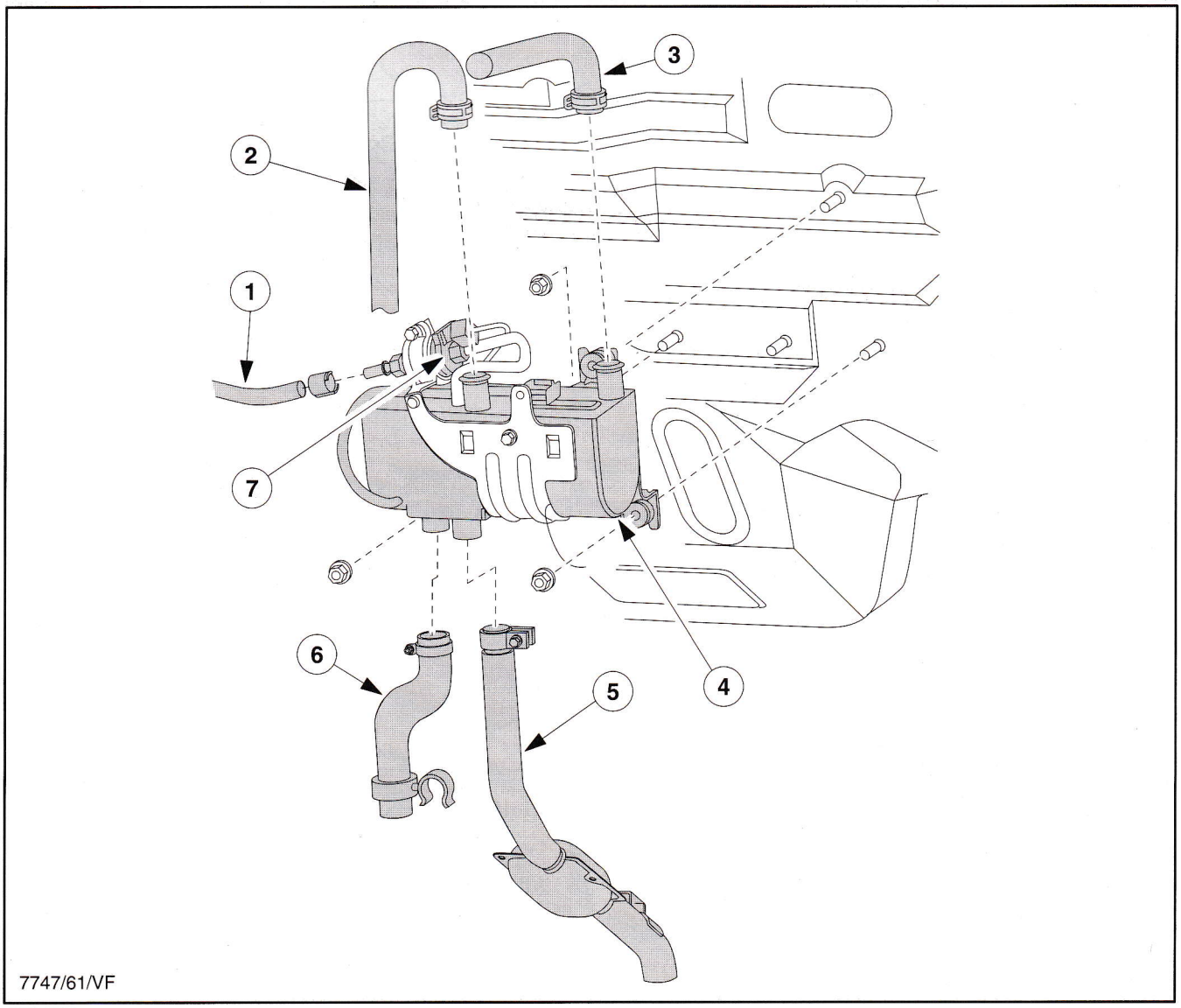
- The crankcase ventilation system is a completely sealed system. All the combustion gases which enter the crankcase flow through hoses into the oil trap and from there into the valve cover.
- Controlled by the ventilation valve, the combustion gases are returned to the combustion chamber with the fresh air.
- The oil trap is mounted on a bracket and secured with a bolt.



1 Oil trap
2 Oil dipstick guide
3 Crankcase ventilation connection

- The booster heater is used to bring the coolant up to or keep it at normal operating temperature.
- In its design and operation the booster heater is the same as the heater used in the Mondeo '97.
- The water connections, fresh air connection and exhaust pipe have changed because the heater is now installed horizontally.
- Diagnosis and testing are carried out with FDS 2000.

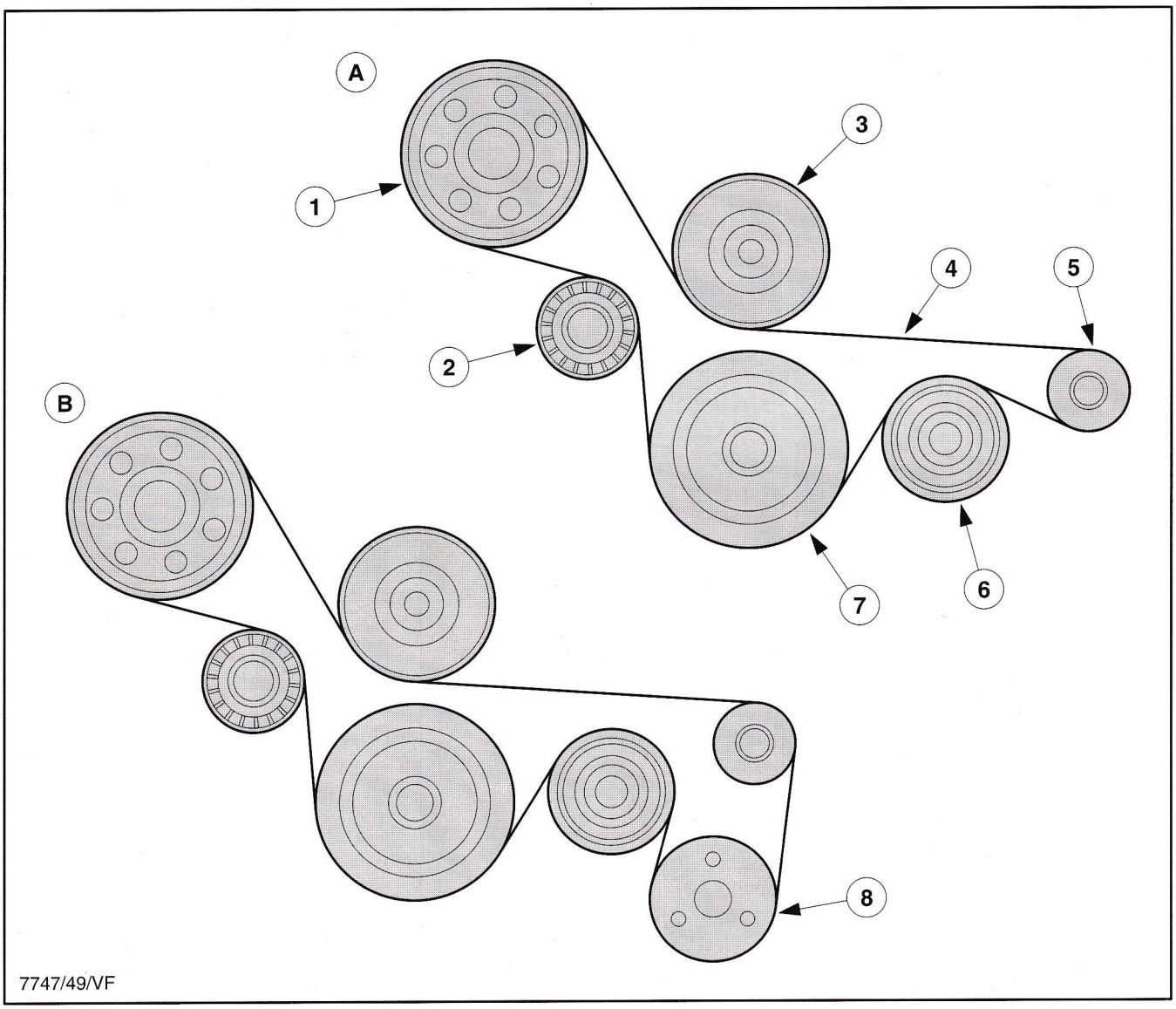
NOTE: Occasionally black smoke may be formed after several attempts at starting the booster heater. At low ambient temperatures condensation may be expected in the exhaust gas when the booster heater is first started.



1 Supply pipe from fuel tank
2 Coolant outlet (hot)
3 Coolant inlet (cold)
4 Booster heater
5 Exhaust pipe with muffler
6 Fresh air supply
7 Fuel metering pump

- The accessorys are driven by a multigroove belt with six grooves. The belt is tensioned with an automatic belt tensioner.

NOTE: Refer to the current service literature for the interval for changing the multigroove belt.



A Belt routing without air conditioning (A/C)
B Belt routing with air conditioning
1 Power steering pump
2 Belt tensioner
3 Water pump
4 Multi-groove belt
5 Generator
6 Idler pulley
7 Crankshaft pulley/vibration damper
8 Air conditioning (A/C)

The abbreviations conform to standard SAE J1930 with the exception of those marked with an asterisk *.

A/C Air Conditioning

AP Accelerator Pedal

BPP Brake Pedal Position

CHT* Cylinder Head Temperature

CKP CranKshaft Position

CPP Clutch Pedal Position

DI* Direct Injection

DLC Data Link Connector

EEC V Electronic Engine Control 5th Generation

EGR Exhaust Gas Recirculation

FDS* Ford Diagnostic System

FITS* Fuel Injection Timing Solenoid

IAT Intake Air Temperature

MAP Manifold Absolute Pressure

MLS Multi Layered Steel

NLS Needle Lift Sensor

NTC Negative Temperature Coefficient

PATS* Passive Anti-Theft System

PCM Powertrain Control Module

PCU Pump Control Unit

PCV Positiv Crankcase Ventilation

VSS Vehicle Speed Sensor