FIAT DUCATO COURSE OUTLINE

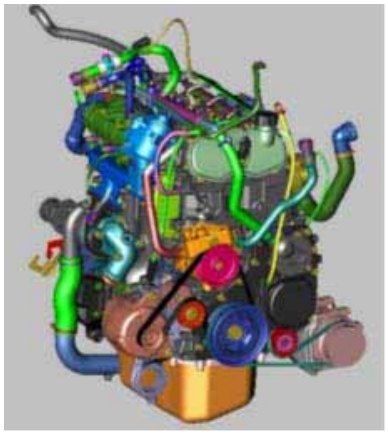
SECOND PHASE

DOCUMENTATION MODIFICATIONS / UPDATES			
Date	**Referent**	**File Name**	**Description of modification**

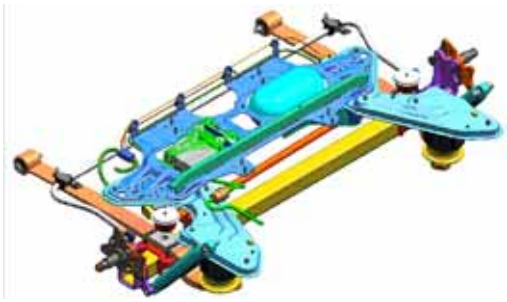
CONTENTS

1. BRIEFING

After the sales launch in June 2006, the new Fiat Ducato range is complemented by new features for improved versatility and efficiency.
The range of engine versions is complemented by the 157 bhp 3.0 Multijet engine combined with the new M40 gearbox.



The new self-levelling rear air suspension offers great comfort and consistent chassis attitude under all loading conditions (vehicle laden or unladen, load distributed evenly or unevenly). In addition, the rear loading sill can be lowered to facilitate loading and unloading and the rear end can be raised to improve ramp breakover angle and/or increase ground clearance when driving over an obstacle.



The new rear-view parking camera system with in-cab display provides better rear visibility when manoeuvring.

Lastly, the new Ducato can be equipped with a digital tachograph to monitor vehicle usage, a convenient feature for companies that operate large fleets of vehicles

2. TECHNICAL DATA

2.1 ENGINE

2.1.1 Characteristic data

Type code	SofimF1CE048ID
Cycle	Diesel
Number and arrangement of cylinders	4 in-line
Piston diameter and stroke (mm)	95.8x104
Total displacement (cm3)	2999
Compression ratio	19:1
Maximum power output EEC(kW)	117
Maximum power output EEC(bhp)	157
At (rpm)	3500
Maximum torque (EEC) (Nm)	400
At (rpm)	1600
Fuel	Diesel fuel (ENS 590 Specification)
Fuel system	Multijet" Common Rail" direct injection

2.2 CLUTCH

Type	Dry single-plate, pressure plate with automatic play take-up device
Drive	Push-type
Outer diameter of driven plate (mm)	258±1
Inner diameter of driven plate (mm)	160±5

2.3 GEARBOX

Type		C546 (M40)
Gear ratios	I	4.167
	II	2.350
	III	1.462
	IV	1.047 0.955(*)
	V	0.786 0.659(*)
	VI	0.652 0.552(*)
	RM	4.083

(*) Different versions

2.4 DIFFERENTIAL

Axle ratio	3.950 - 4.222 - 4.563 (*)

(*) Different versions

2.5 SCHEDULED MAINTENANCE PLAN

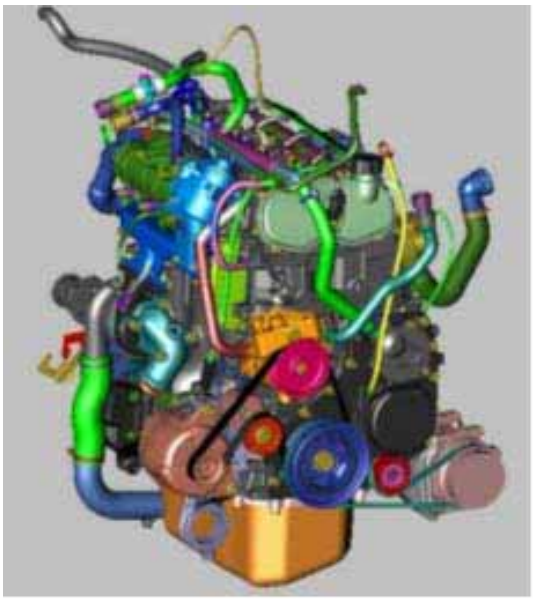
Description	45	90	135	180	225
Check tyre condition / check for wear, adjust tyre pressure (if needed).	+	+	+	+	+
Check operation of lighting system (headlamps, indicators, emergency lights, luggage compartment/passenger & driver compartment lights; instrument panel warning lights, etc.).	+	+	+	+	+
Check operation of windscreen wiper & washer; adjust nozzles if necessary.	+	+	+	+	+
Check positioning/wear of windscreen wipers	+	+	+	+	+
Check brake pads for wear; check front and rear disk pad wear indicator for proper operation (if fitted)	+	+	+	+	+
Visually inspect the conditions and soundness of body outside, underbody protection, rigid and flexible pipe lengths (exhaust, fuel feed and brake pipes and hoses), rubber parts (boots, sleeves, bushes, etc.)	+	+	+	+	+
Visually inspect the accessory drive belts		+			+
Check the fluid levels (engine cooling, brakes, windscreen washer, battery, etc.) and top up, if necessary	+	+	+	+	+
Check the handbrake lever travel and adjust as required	+	+	+	+	+
Check that the locks are clean and the levers clean/lubricated	+	+	+	+	+
Measure exhaust emissions/smoke	+	+	+	+	+
Check operation of engine control systems (via the diagnostic connector)	+	+	+	+	+
Replace the accessory drive belt			+		
Change fuel filter	+	+	+	+	+
Change air filter cartridge	+	+	+	+	+

Change engine oil and engine oil filter	+	+	+	+	+
Change brake fluid (or every 24 months)		+		+	
Change pollen filter (or every 24 months)	+	+	+	+	+

Service must be performed every 30000 km if the vehicle is chiefly used in any of the following particularly harsh conditions:

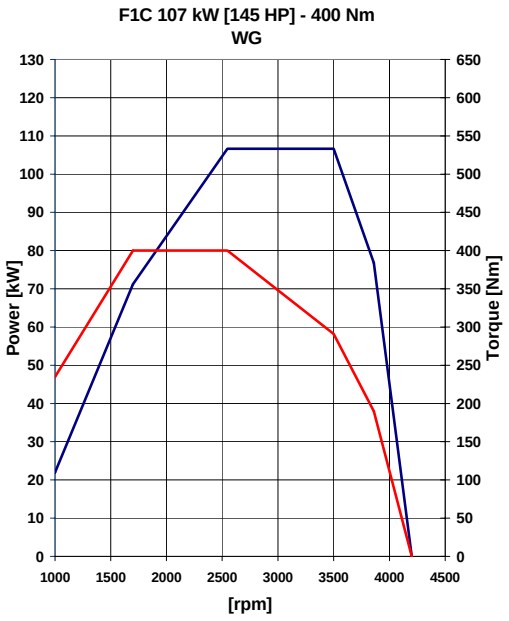
- Towing trailer or caravan;
- Dusty roads;
- Frequent short trips (less than 7-8 km) with outside temperatures below freezing;
- Engine frequently left idling or running long distances at low speed (door-to-door delivery for example), or if not used for a long time;
- City traffic.

3. ENGINE
3.1 3.0 ENGINE



3.1.1 Features

The main features of the 3.0 Multijet engine are as follows:



- turbocharged Diesel engine with fixed geometry turbocharger;
- Euro 4 emissions compliant
- power output: 160 bhp;
- four cylinders in line;
- 2998 cc displacement;
- bore: 95.8 mm;
- stroke: 104 mm;
- compression ratio: 19:1
- firing order: 1 – 3 – 4 - 2
- double overhead camshaft, 16 valves;
- aluminium alloy cylinder head;
- camshaft bearing housings incorporated in upper head section;
- chain-driven timing system;
- rocker arms with hydraulic tappets;
- centrifugal water pump incorporated in crankcase;
- engine control unit: Bosch EDC16C39;
- high-pressure pump: Bosch CP3.2 (no transfer gear pump);
- nodular cast iron engine block;
- pressed sheet metal oil sump.

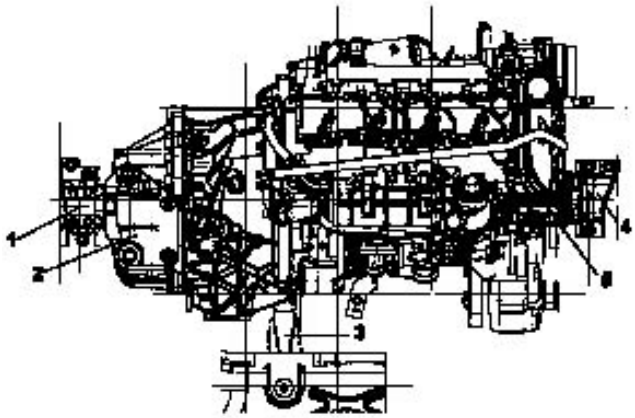
3.1.2 Engine mounts

GENERAL

The engine mounts connect engine and body.
They are designed to withstand engine weight and torque loads.
Engine mounts feature blocks made of metal and rubber that dampen engine vibration so as to significantly reduce the amount of vibration transmitted to the body.

TYPE

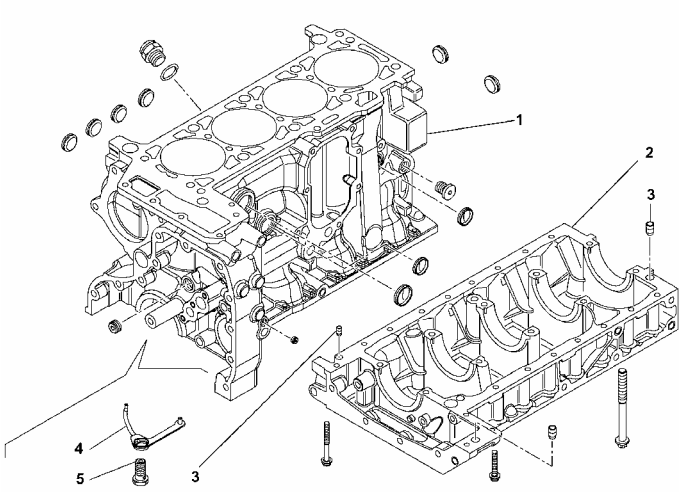
The engine support system is a special baricentre system.
The engine is retained by two mounts (one on gearbox side and one on timing gear side) and a torque linkage.



1 – Flexible mount, gearbox side
2 – Mounting bracket, gearbox side
3 – Rear mounting bracket
4 – Flexible mount, timing gear side
5 – Mounting bracket, timing gear side

3.1.3 Crankcase and lower block

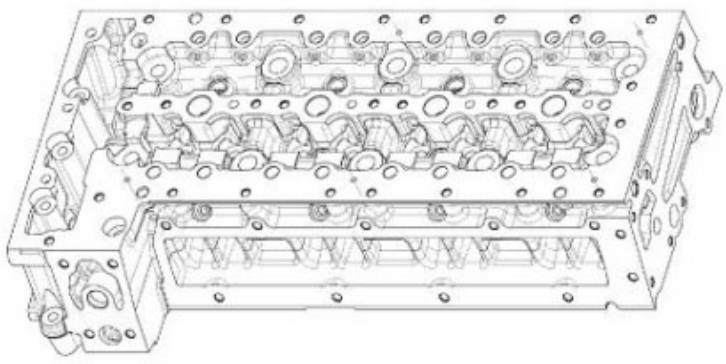
The crankcase is made of cast iron.
There are five main bearing housings.
Suitable coolant and oil galleries are provided in the crankcase walls.
Spray jets installed in crankcase bottom use engine oil to cool the pistons and lubricate the piston pins.
Crankcase and lower block are sealed with sealant.



1 - Crankcase
2 – Lower block
3 – Centring pin
4 – Piston cooling jet
5 – Jet connector

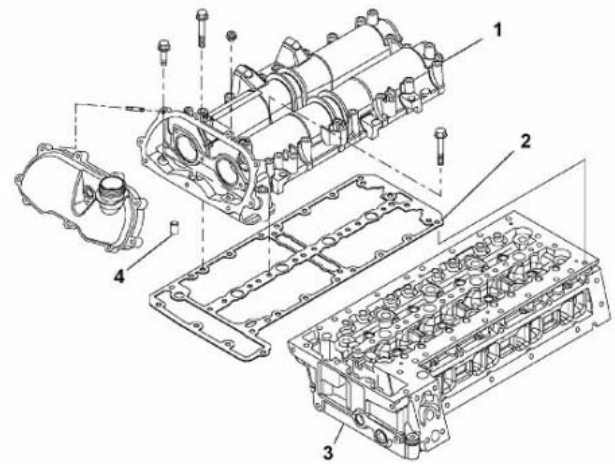
3.1.4 Cylinder head

The one-piece cylinder head is made from aluminium-silicon alloy.



Valve opening is controlled by two chain-driven hollow-section overhead camshafts; cams are fitted onto the shafts; camshafts are installed in the upper head section.
The four valves per cylinder are located in their respective guides and operated by rocker arms actuated by the cams of the camshafts; hydraulic tappets keep the rocker arms in contact with the valves.

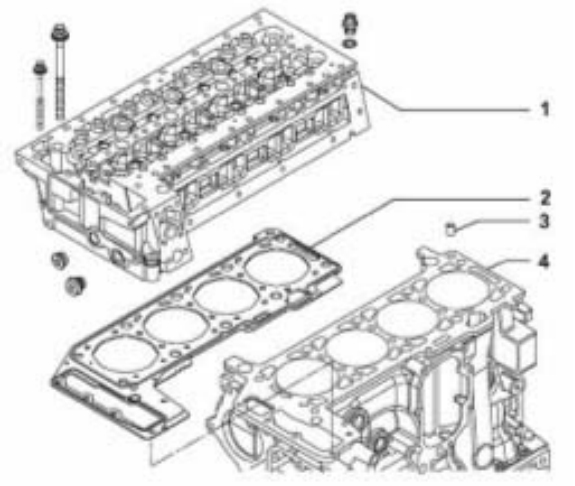
The valve guides are an interference fit in the seats in the cylinder head. The inner bore is bored to specification after installation using a special boring tool.
Unlike cylinder heads with a prechamber, the whole combustion process occurs inside the combustion chamber in the piston.



The cylinder head is made up of the following components:

- camshaft housing,
- hydraulic tappets,
- rocker arms,
- camshafts,
- exhaust and intake valves,
- valve guides,
- valve seats.

1 – Upper head section
2 – Gasket
3 – Cylinder head
4 – Centring bushes



1 – Cylinder head
2 – Gasket
3 – Centring bush
4 – Engine block

The head accommodates: intake ports; exhaust ports; valve passages; coolant galleries; oil galleries; injector holes, glow plug holes, bolt holes for fastening to the engine block.

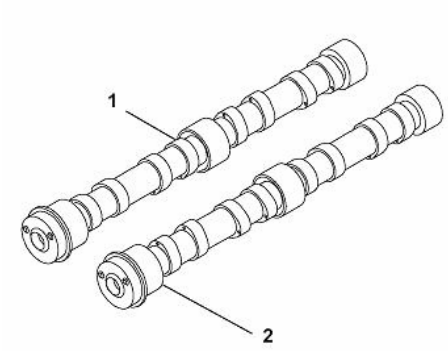
The head is installed on top of the cylinders; the aluminium alloy construction combines such advantages as ligthweight, compression strength and high heat conduction.
Two centring bushes ensure correct location of the upper head section.

Head gasket

The gasket between cylinder head and crankcase is composed of three layers of stainless steel coated with special heat-resistant rubber material.
While head gaskets of three different thicknesses are used at the factory, replacement gaskets come in one standard thickness only. Factory gaskets are differentiated by notches as follows
- 1 notch : thickness class 1
- 2 notches: thickness class 2
- 3 notches: thickness class 3

1 – Head gasket
2 – Thickness class notches

3.1.5 Camshafts

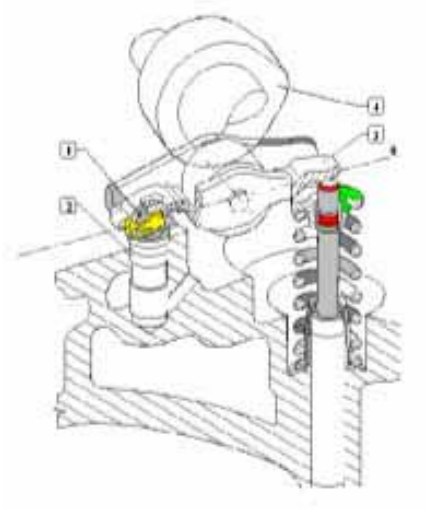


The camshafts are made from steel and feature a hollow design

1 – Exhaust camshaft
2 – Intake camshaft

The timing sensor detects the position of the intake camshaft drive gear to determine the current phase of engine operation.
The timing sensor is located on the engine oil filler cover on the upper head section.

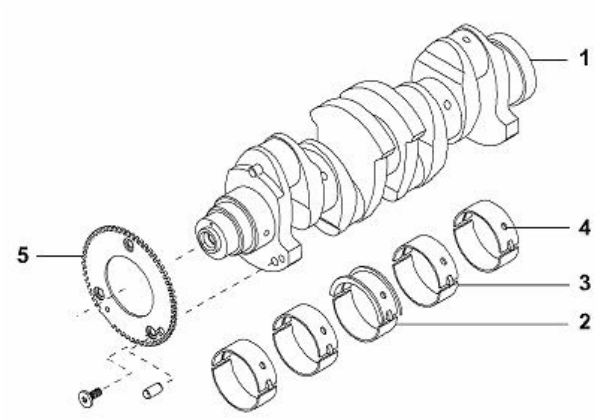
Hydraulic tappets



1. Tappet retaining spring
2. Hydraulic tappet
3. Rocker arm with spring
4. Cam

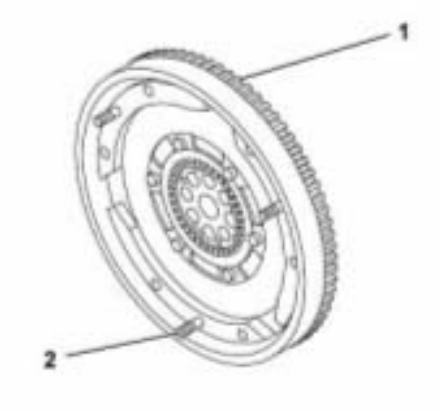
3.1.6 Crankshaft

The crankshaft is made of carbon steel and rests on five main bearing housings with plain bearings in-between.
Crankshaft end float is determined by the half bearing housed at the central main bearing housing.
Eight counterweights set at 180° balance the rotating masses to provide perfect engine balance.



1 – Crankshaft
2 – Central main bearing (incorporates end float adjustment)
3 – Main bearings
4 – Oilway hole
5. Phonic wheel

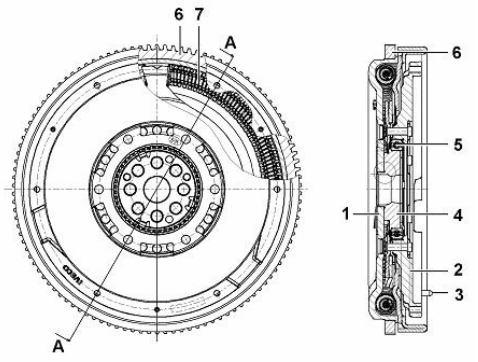
3.1.7 Flywheel



The dual-mass flywheel is secured to the crankshaft by 8 screws.
The flywheel has 3 centring pins for the clutch mechanism

The flywheel is an energy storage device that stores energy during the power stroke and gives up energy during the combustion stroke to smooth out engine rotation.
Flywheel size is designed to enable engine idling and overcome friction developed during idling.The DVA dual-mass flywheel (or clutch flywheel) consists of two separate masses for crankshaft and gearbox main shaft with a torsional damping system in-between.
Resonance points, normally found in the 800 to 2200 rpm range with conventional flywheels, occur at lower rpms, namely outside the operating range.
This flywheel design offers the following advantages over conventional flywheels:
- pulsing engine power is dampened resulting in less transmission noise;
- less overall noise translates into less in-cab noise.

The clutch disk (with springs) located between the dual-mass flywheel and the gearbox has lower inertia to enable smoother gearshifts.



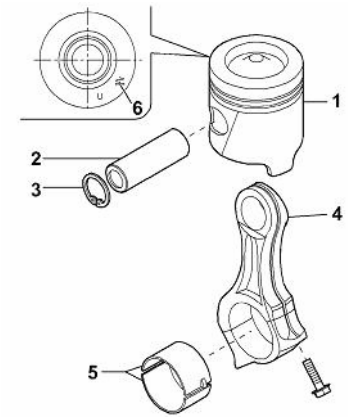
1 – Mass integral with crankshaft.
2 – Mass integral with gearbox main shaft.
3 – Centring pin for clutch mechanism
4 – Hub
5 – Ball bearing
6 – Gearwheel
7 – Torsional damping system.

3.1.8 Pistons and connecting rods

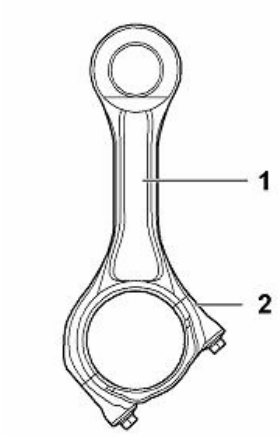
CONSTRUCTION

The pistons are obtained from aluminium alloy castings; the connecting rods are forged from hardened and tempered steel and split to obtain the con rod caps by the fracture splitting method.
The pistons have a recess for the combustion chamber.
The pistons and con rod small ends are joined by floating piston pins. Piston pins are restrained by two circlips fitted in grooves in the piston pin sleeves.

To ensure correct piston position, the mark on the piston must be pointing to the timing gear side

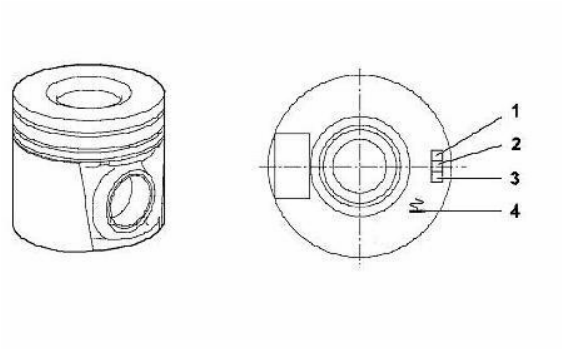


1 – Piston
2 – Piston pin
3 – Circlips
4 – Connecting rod
5 – Con rod bearings
6 – Piston mark for correct installation



1 – Connecting rod
2 – Con rod cap

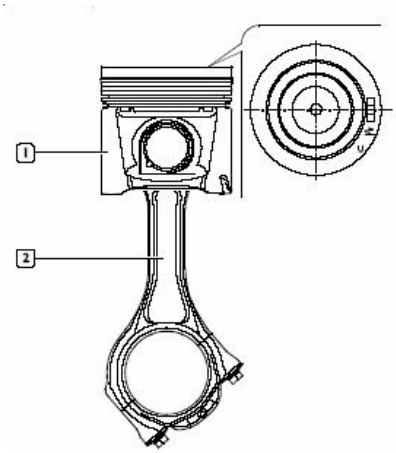
The aluminium alloy pistons are grouped into two size classes and have a mark on the crown to indicate correct mounting position



1 – Engine type
2 – Piston class
3 – Supplier
4 – Mounting position of piston inside the cylinder barrel

The piston is made up of two main components:- head, or area where the piston rings sit; its diameter is slightly smaller than the cylinder bore to accommodate heat expansion; the piston crown features the valve pockets and recessed combustion chambers,

- the skirt, which acts as a guide for the con rod small end which withstands its axial thrust. The skirt accommodates two sleeves for the piston pin and a groove matching the piston cooling jet in the crankcase.

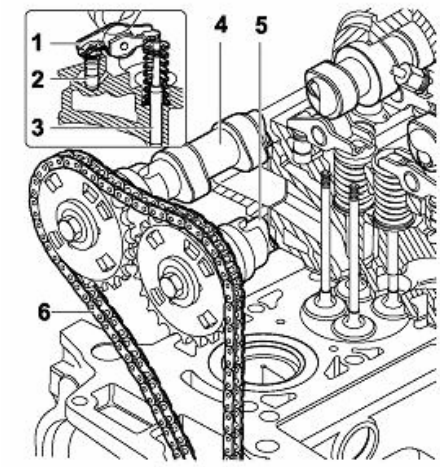


Piston (1) and connecting rod (2) with con rod cap must be assembled with piston mark, connecting rod and con rod positioned as shown in the figure.

3.1.9 Camshaft drive

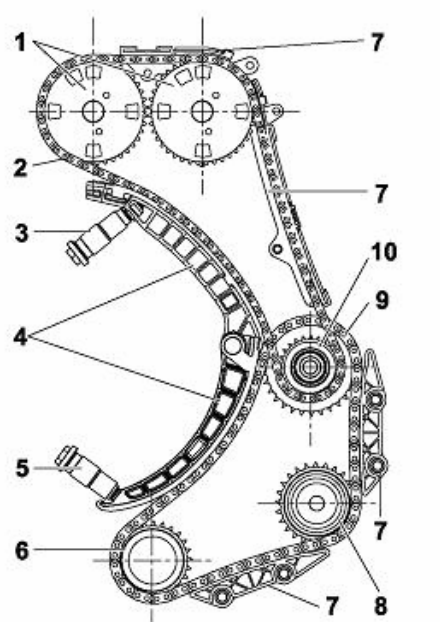
The timing system is a double overhead camshaft system with four valves per cylinder and hydraulic tappets.
Drive is transmitted by two drive chains:
- a double 3/8" chain transmits drive from the crankshaft to the oil pump/vacuum pump and high pressure pump shafts;
- a single chain transmits drive from the high pressure pump shaft to the camshafts.
The camshaft drive gears are interchangeable and feature slots for the sensor.

Each rocker arm is kept in contact with its valve by a cam and hydraulic tappet to eliminate the need for periodic adjustments.



1 – Rocker arm
2 – Hydraulic tappet
3 – Valve
4 – Exhaust camshaft
5 – Intake camshaft
6 – Cam chain

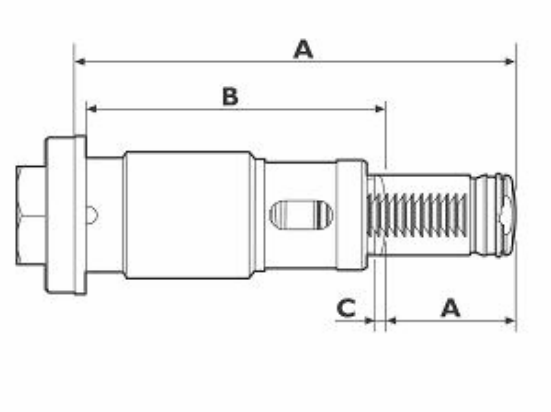
The figure below shows how timing system and auxiliary drive system are operated



1 – Camshaft drive gears
2 – Single chain
3 – Hydraulic tensioner with backstop
4 – Chain tensioner mobile sliding shoes
5 – Hydraulic chain tensioner
6 – Drive gear on crankshaft
7 – Fixed sliding shoe
8 – Oil pump/vacuum pump and power steering pump drive shaft gear
9 – Double chain
10 – High pressure pump drive shaft gear

Chain hydraulic tensioner

Timing chain tension is controlled by an automatic hydraulic tensioner with backstop that eliminates the need for tension adjustments.

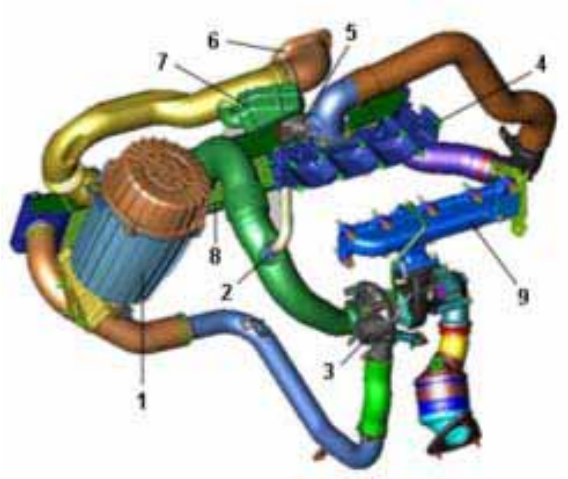


A = Fully extended: 76.9 ± 0.4 mm
B = With piston engaged: 53.6 mm
C = Minimum travel to disengage piston: 2.3 mm
D = Useful stroke: 24.5 mm

3.1.10 Air supply system

The intake air is filtered and conveyed to the exhaust gas turbocharger; before reaching the engine, the compressed air is cooled in the air-air heat exchanger (Intercooler).

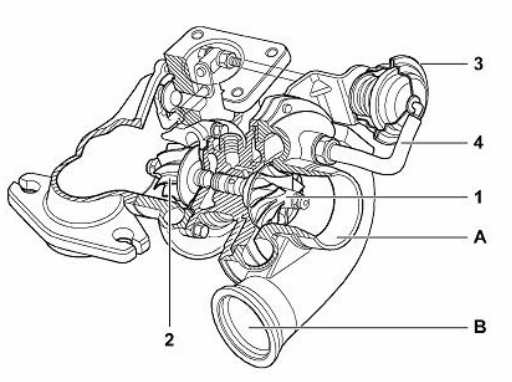
The following figure schematically illustrates the main elements comprising the air supply circuit.



1 – Air filter
2 – Oil vapour recovery fitting
3 – Turbocharger
4 – Intake manifold
5 – Throttle body actuator
6 – Air intake connector
7 – Resonator
8 – Intercooler heat exchanger
9 – Exhaust manifold

Turbocharger

The turbocharger is of the fixed geometry type with waste-gate valve



1 – Compressor
2 – Turbine
3 – Air-operated exhaust gas bypass actuator
4 – Pressure pipe to control WASTE – GATE valve
A – Air enters compressor
B – Air exits compressor

3.1.11 Fuel system

GENERAL

The fuel feed system is divided into a low pressure circuit and a high pressure circuit.

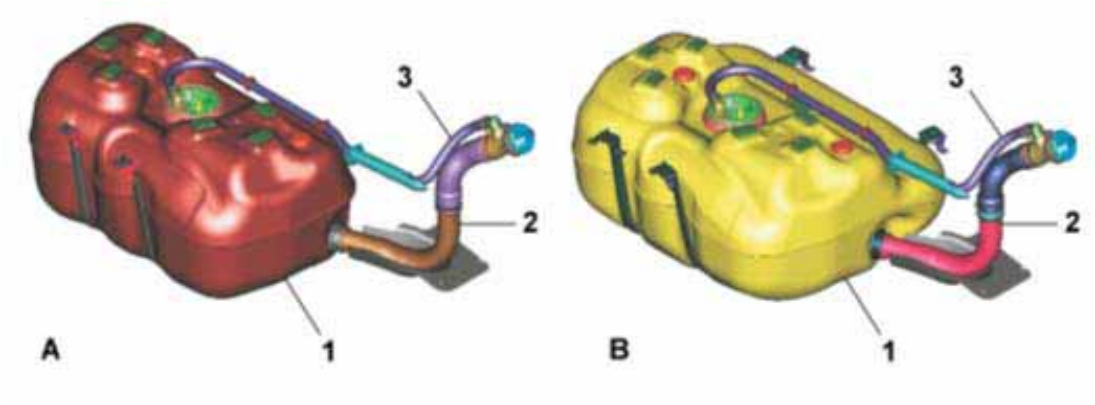
The low pressure circuit is composed of:
- tank
- submerged auxiliary motor pump;
- Diesel fuel filter;
- return manifold.

The high pressure circuit is composed of:
- pressure pump;
- distribution manifold.

Low pressure circuit

Fuel tank

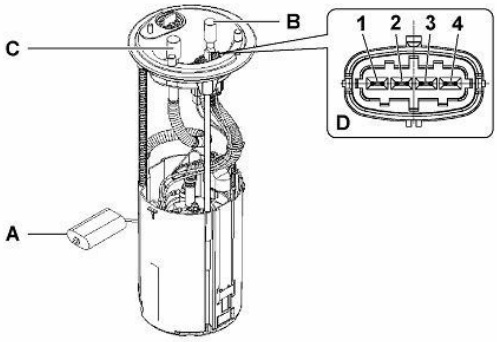
The plastic fuel tank features a flexible filler neck and incorporates a seat for electric fuel pump and fuel level meter.



A – 90-litre tank
B – 125-litre tank
1 – Fuel tank
2 – Fuel filler neck
3 – Breather pipe

Submerged pump assembly complete with level indicator control system

Main components:
- electric fuel pump
- fuel filter
- float level indicator
- diaphragm pressure regulator
- screen prefilter



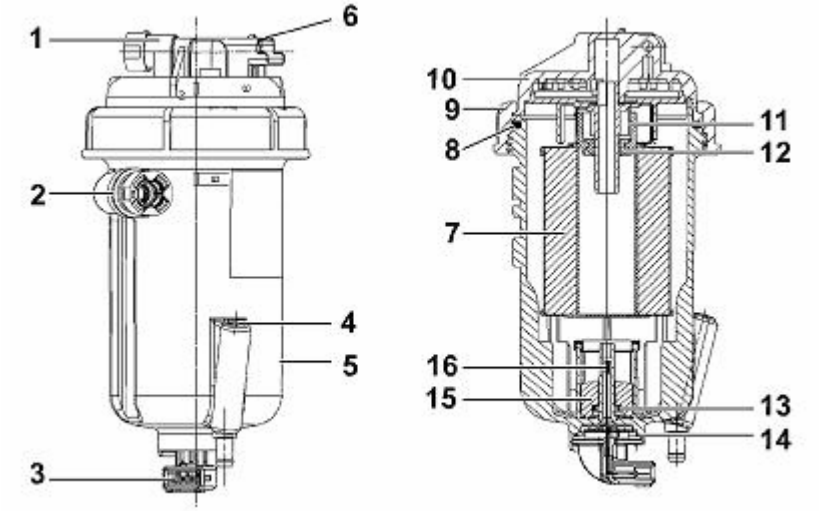
A – Float level sensor
B – Delivery fitting
B – Return fitting
D – Electric connector

1 – Fuel level sensor power supply
2 – Fuel level sensor ground
3 – Fuel pump ground
4 – Fuel pump power supply

Pump characteristic data:
- safety valve setting: 600 - 800 KPa,
- pump nominal delivery: 134 l/h (23°C),
- power supply: 12.5V.

Fuel filter

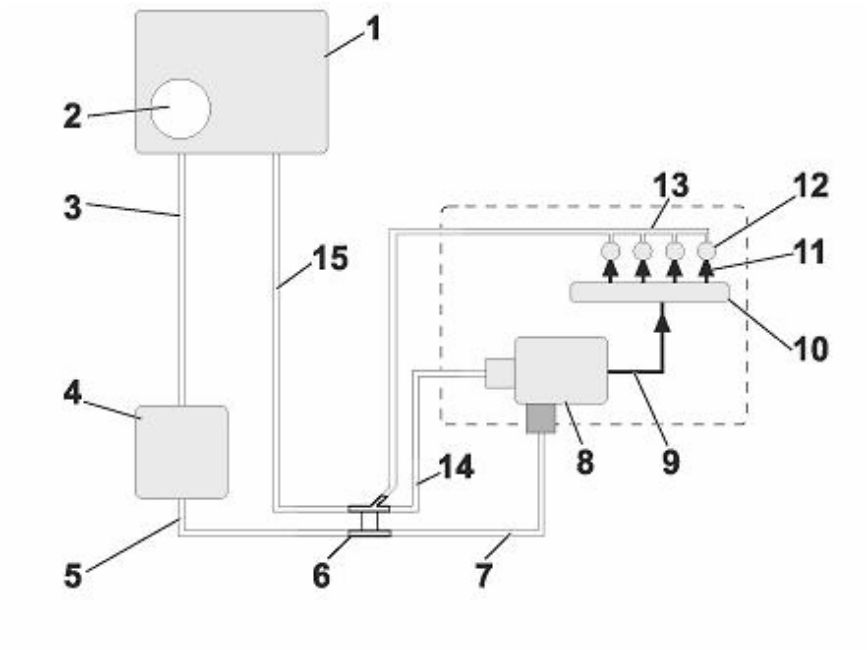
The fuel filter is fitted in the engine compartment near the fireproof bulkhead.
The filter is made of a plastic shell that contains a depth partition cartridge made of synthetic material, which ensures high efficiency, long service life and effective water separation.



1 – Fuel inlet
2 – Fuel outlet
3 – Eectric connector for water presence sensor
4 – Water drain screw
5 – Filter body
6 – Fuel temperature sensor connector
7 – Filter cartridge (sealing O-ring supplied)
8 – Cover gasket
9 – Cover fixing ring nut
10 – Cover
11 – Spacer
12 – Rubber seal
13 – Ferromagnetic ring
14 – Gasket
15 – Float
16 – Water sensor

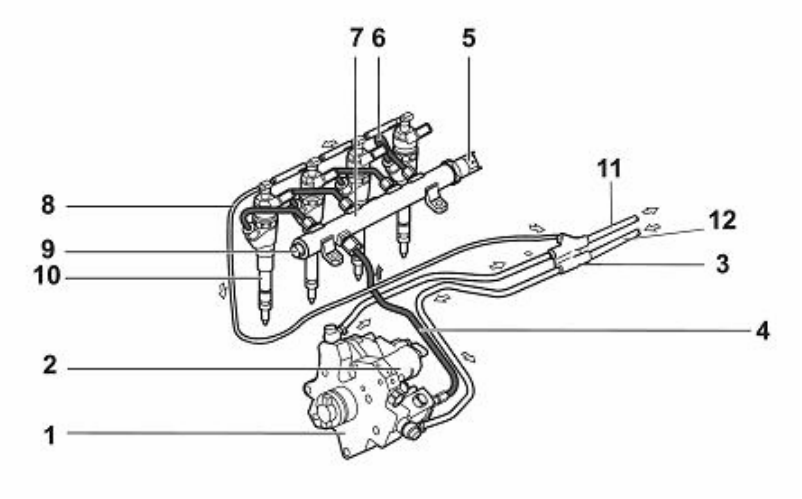
OPERATION

Diesel fuel is drawn from the tank by a 12 V electric pre-feed pump that provides adequate delivery to lubricate and cool the Radialjet pump as well.
The Diesel fuel filter is installed between the electric pump and the Radialjet pump.
High-pressure hydraulic lines are steel pipes with 2 mm inner diameter and 6 mm outer diameter.
The fuel recirculated from pump and injectors is collected in a single pipe and delivered to the tank.



1 – Fuel tank
2 – Submerged pump assembly
3 – Pipe connecting tank with fuel filter
4 – Fuel filter
5 – Pipe connecting fuel filter with fuel pressure control valve
6 – Fuel pipe fitting
7 – Pipe connecting fuel pressure control valve with high pressure pump

High pressure circuit

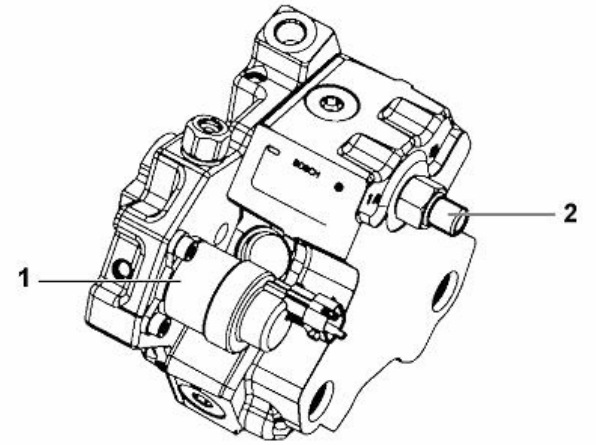


1 – Pressure pump
2 – Pressure regulator
3 – Fuel pipe fitting
4 – Pipe connecting high pressure pump with fuel manifold (Rail)
5 – Fuel pressure sensor
6 – Pipe connecting fuel manifold (Rail) with electro-injectors
7 – Fuel manifold (Rail)
8 – Return pipe from electro-injectors
9 – Plug
10 – Electro-injector
11 – Fuel pipe from filter
12 – Return to tank

High pressure pump

GENERAL'

The CP3.2 fuel pump of the Common Rail system is called Radialjet pump because pumping action is accomplished by three pumping elements (pistons) arranged radially in relation to the axis of rotation of the pump shaft. The three pistons are spaced 120° apart.
The quantity of fuel sent to the pumping pistons is controlled by a pressure regulator governed by the engine control unit

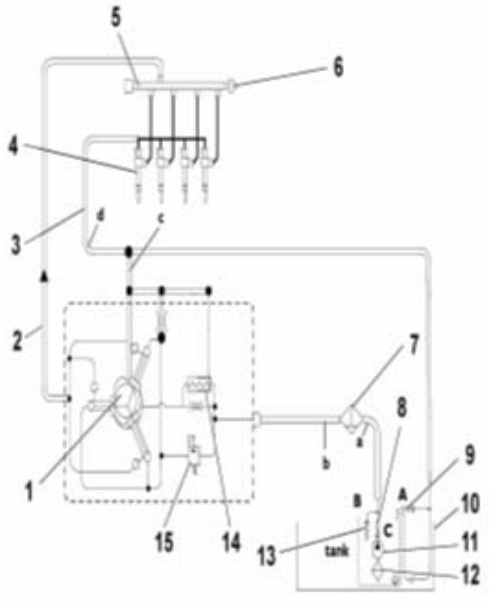


RADIALJET PUMP CHARACTERISTICS

Pump pistons are operated by a rotating triangular cam integral with pump shaft. The rotating cam moves a mechanical element (tappet) linking it to piston foot. Cam to tappet contact is ensured by a spring.
Each pumping unit has an intake valve and delivery ball valve. Fuel from the three delivery valves is collected in a single point inside the pump and conveyed to a common manifold through a single duct. A peculiar feature of this pump is that it is lubricated and cooled by the fuel circulating inside it or through suitable ports.
Delivery pressure is controlled by a low-pressure solenoid valve installed at the pump inlet end so as to compress just the amount of fuel needed to achieve required pressure according to ECU mapping.
The main features of the Radialjet pump are outlined below:
- type: Radialjet radial piston pump
- number of pistons: 3
- maximum operating pressure: 1600 bar
- feeding: Diesel fuel at 3.5 ÷ 5.0 bar
- lubrication: by Diesel fuel fed to pump
- cooling: by Diesel fuel fed to pump

Note: The high pressure pump cannot be serviced; do not remove or disturb the retaining screws.

OPERATION
The pump is driven by the crankshaft via a double chain and turns at the same speed as the engine. In this injection system, valve timing and injection duration are controlled by the electronic control system and the pump simply maintains the fuel in the manifold at the required pressure.
The figure below shows the layout of pump hydraulic feeding system.



(Relative) pressures in the circuit:
(a) 4.15 bar < p < 5.35 bar ; (b) 3.5 bar < p < 5.0 bar ; (c) p < 0.8 bar (d) 0.3 bar < p < 0.8 bar

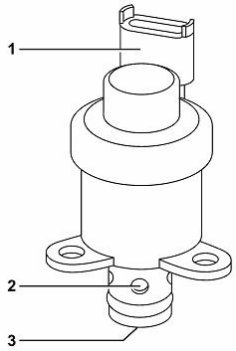
1 – High pressure pump
2 – High pressure delivery pipe
3 – Return pipe from electro-injectors
4 – Electro-injectors
5 – Common Rail
6 – Fuel pressure sensor
7 – Filter with water separator
8 – Electric fuel pump check valve
9 – Line pressure relief valve
10 – Tank
11 – Electric fuel pump
12 – Filter at electric fuel pump intake end
13 – Electric fuel pump overpressure valve
14 – Pressure relief valve
15 – Proportional pressure regulating valve.

Fuel regulator

The fuel pressure regulator is installed in the low-pressure circuit of the CP3.2 pump.
The pressure regulator meters the amount of fuel delivered to the high-pressure circuit according to the commands it receives directly from the engine control unit
The main components of the pressure regulator are listed below:
- connector,
- body,
- solenoid,
- preload spring,
- shutter cylinder.

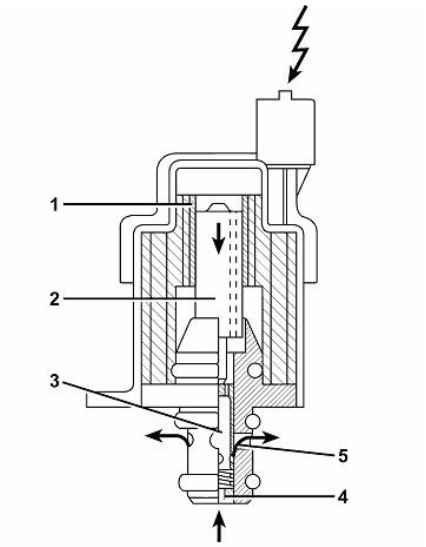
The pressure regulator is normally open unless it is receiving any input signals; in this condition, the pump will be delivering its maximum flow rate.
The engine control unit varies fuel delivery in the high-pressure circuit by partially closing or opening the fuel pipe sections in the low pressure circuit via a PWM (Pulse Width Modulation) signal

1 – Connector
2 – Fuel outlet holes
3 – Fuel inlet hole



OPERATION

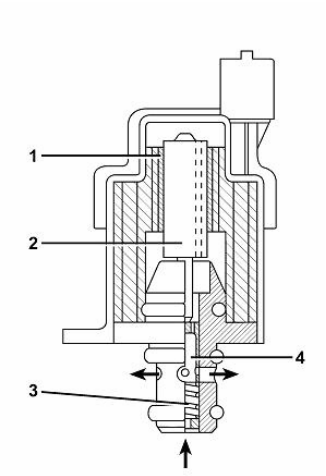
When the engine control unit governs the flow regulator (via PWM signal), the solenoid (1) is energised and displaces the magnetic core (2).
The core causes the shutter cylinder (3) to move in an axial direction and fuel flow is restricted.



1 – Solenoid
2 – Magnetic core
3 – Shutter cylinder
4 – Fuel inlet
5 – Fuel outlet

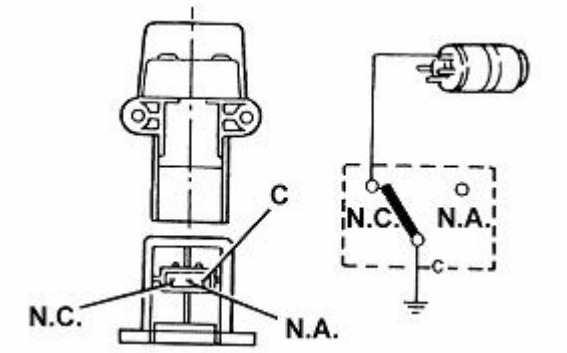
When the solenoid (1) is de-energized, the magnetic core is pushed into its rest position by the preload spring (3).
In this condition, the shutter cylinder (4) is in the position that provides a fully unrestricted fuel flow.

1 – Solenoid
2 – Magnetic core
3 – Preload spring
4 – Shutter cylinder



Inertia switch

The inertia switch is located under the dashboard on passenger side. In the event of a collision, it cuts off the fuel pump ground connection to shut off fuel delivery to the injection system.

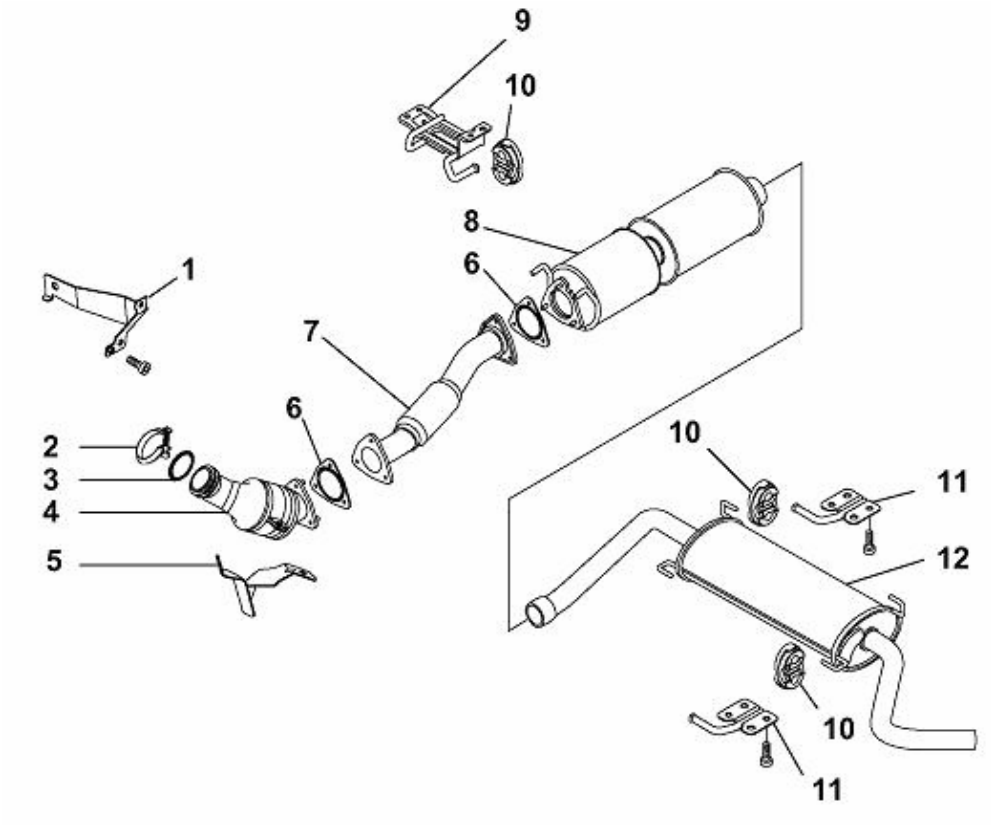


It contains a ferromagnetic ball held in place in its tapered seat by a permanent magnet.
When vehicle deceleration exceeds a certain threshold due to a collision, the ball breaks free from its seat and hits a switch, so that fuel pump relay ground is switched to the body computer.
This cuts off pump supply, releases the door locks and turns on the interior lighting.
The switch features a flexible cover to enable resetting.

NOTE: If you notice a burning smell or any leaks after an impact (including a minor collision), do no reset the switch until you have located and repaired the trouble, or a fire may result. If there are no leaks and the vehicle is capable of restarting, press the button to activate the fuel pump.

3.1.12 Exhaust system

The engine exhaust gases flow through the manifold to the three-way catalytic converter



1 – Pre-catalyst bracket
2 – Clamp
3 – Gasket
4 – Pre-catalyst
5 – Pre-catalyst bracket
6 – Gasket
7 – Exhaust pipe middle section
8 – Catalyst
9 – Catalyst bracket (on body)
10 – Flexible mounts
11 – Silencer bracket (on body)
12 – Silencer

3.1.13 EGR system

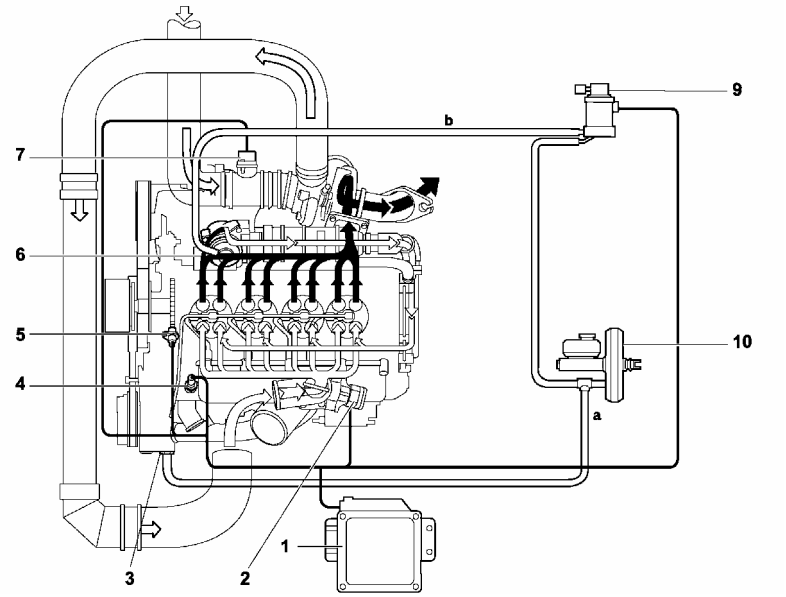
GENERAL

This system recirculates part of the exhaust gases to the intake under certain particular operating conditions.
This lowers peak temperature in the combustion chamber so as to reduce nitrogen oxide (NOx) formation. The engine control unit recirculates a portion of the exhaust gases taken from the exhaust manifold back to the engine intake.
To this end, the engine control unit processes the inputs from:
- atmospheric pressure sensor,
- water pressure sensor,
- engine rpm sensor,
- accelerator pedal potentiometer

and pilots both the vacuum control solenoid valve and the throttle valve via a PWM signal according to the mapping stored in its memory.

Each time the engine control unit signals it to do so, the vacuum control solenoid valve opens a connection between the servo brake vacuum circuit and the EGR circuit. This creates a certain amount of vacuum in the EGR circuit according to the command signal. Vacuum operates the E.G.R. pneumatic valve that retracts and lifts a shutter to open an exhaust gas passage to the intake.
This creates a connection between the exhaust and intake manifolds, so that part of the exhaust gases flow into the intake manifold.
Exhaust gases are cooled while flowing through the heat exchanger and then conveyed into the throttle valve chamber where they are mixed with the air from the intercooler and delivered to the intake manifold; in the meantime, the engine control unit adjusts the amount of fuel injected into the cylinders depending on the amount of exhaust gas recirculated.

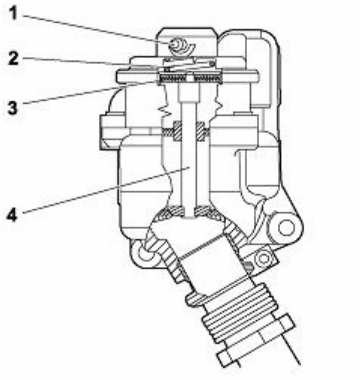
When engine operating conditions are such that no gas recirculation is required (start-up, cold engine, idle speed, load request, high altitude), the ECU sends no control signal to the vacuum control solenoid valve. The solenoid valve closes the connection between the servo brake vacuum circuit and the E.G.R. circuit and lets filtered air from the dedicated filter enter the E.G.R. circuit to restore atmospheric pressure.



a – Servo brake vacuum circuit
b – E.G.R. controlled vacuum circuit
1 – Engine control unit
2 – Throttle valve assembly
3 – Vacuum take-up point
4 – Water temperature sensor
5 – Engine rpm sensor
6 – E.G.R. pneumatic valve
7 – Air flow meter
8 – Intake air filter
9 – EGR vacuum control valve
10 – Vacuum-operated servo brake

E.G.R. valve

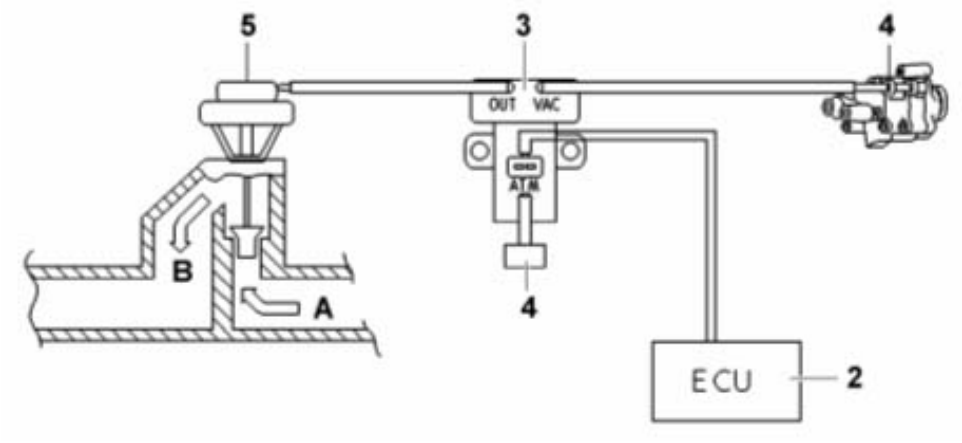
The E.G.R. valve is mounted at the end of the heat exchanger.
The valve is cooled by the engine coolant coming out of the heat exchanger to ensure improved efficiency and long life.
The amount of recirculated exhaust gas is determined by a poppet valve operated by the vacuum let in by a calibrated connector; vacuum is taken from the pipe connecting vacuum pump to servo brake.
The vacuum let in by the solenoid valve overcomes the pressure exerted by the spring (1) and raises a diaphragm (2); the shutter (3) connected to it rises and lets burnt exhaust gases flow back into the intake manifold.



1 – Vacuum duct,
2 – Spring
3 – Diaphragm.
4 – Shutter.

E.G.R. solenoid valve

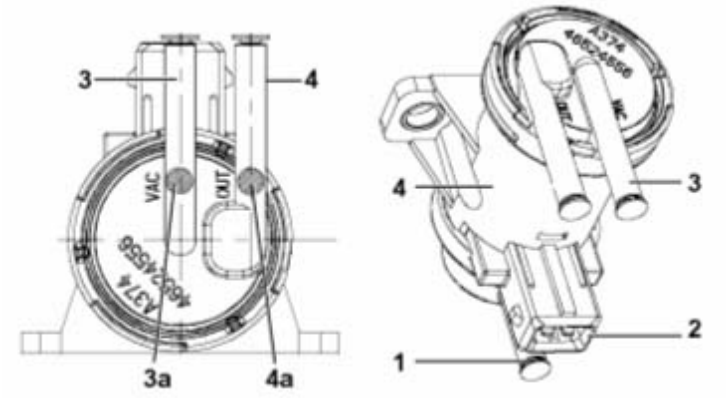
The E.G.R. solenoid valve operates the E.G.R. valve to determine the amount of exhaust gases to be delivered to the intake duct.
The duty-cycle-controlled solenoid valve determines the amount of servo brake pump vacuum to be connected to the E.G.R. valve so as to recirculate a certain amount of exhaust gas.
The figure below shows the layout of the EGR circuit.



1 – Servo brake vacuum pump
2 – Engine control unit
3 – E.G.R. solenoid valve
4 – Filter for connection to the atmosphere
5 – E.G.R. valve on engine

A – Exhaust gas from exhaust manifold
B – Exhaust gas recirculated to the intake manifold

The figure below shows a detail diagram of the E.G.R. solenoid valve

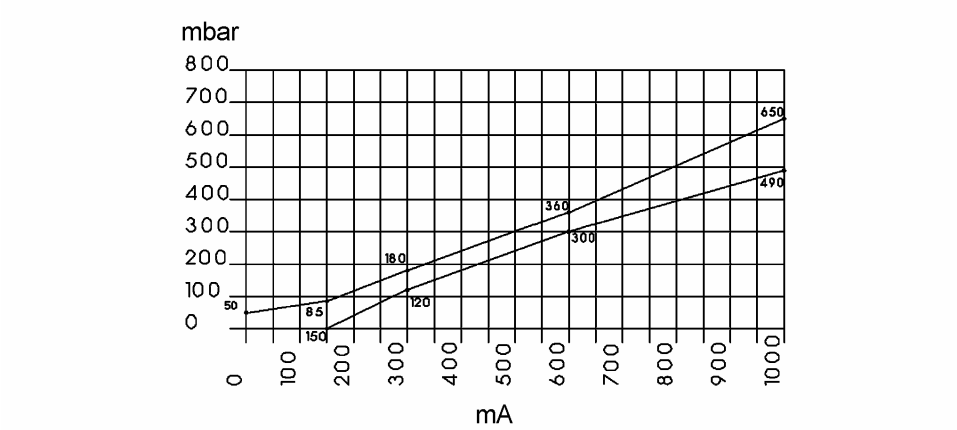


1 – Connection to the atmosphere
2 – Electrical connector
3 – Connection to vacuum source
3a – White identification dot
4 – Connection to E.G.R. valve
4a – Yellow identification dot

Solenoid valve characteristic data

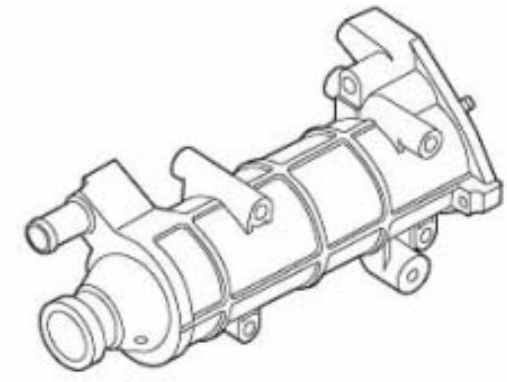
Pilot frequency: 140 ± 7Hz.
Minimum duty cycle value: 6%.
Maximum duty cycle value: 6%.
Maximum feed vacuum: 930 mbar.
Winding resistance: 5.5 ±5 Ohm at 20 ± 5°C

The following graph shows the solenoid valve characteristic curve.



Heat exchanger

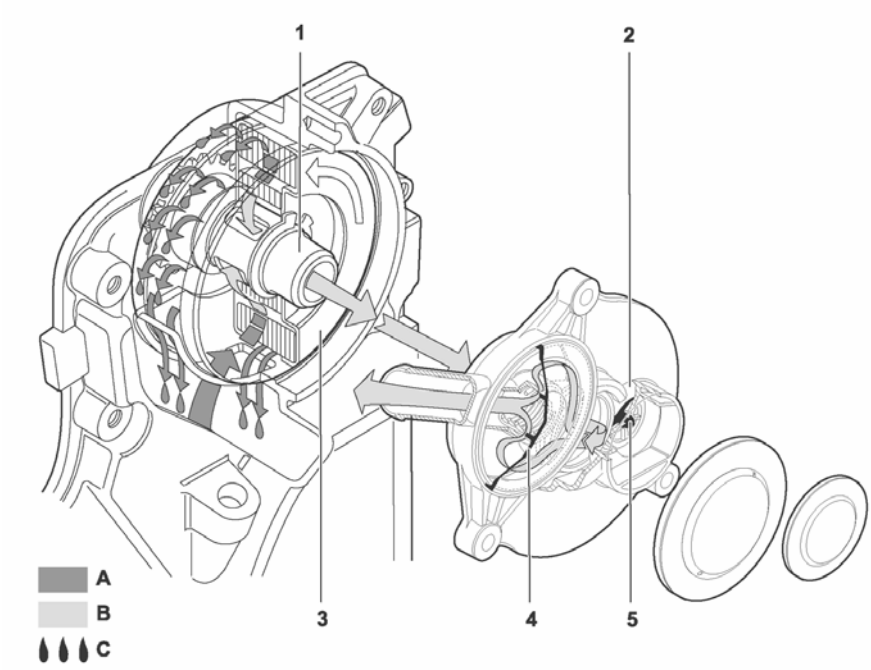
The heat exchanger installed between turbocharger and throttle valve assembly cools down exhaust gas to reduce its volume.
Its body accommodates a set of corrugated pipes. The recirculated exhaust gas passing through the pipes is cooled down by the engine coolant flowing inside the body.



3.1.14 Crankcase oil vapour recovery system

General

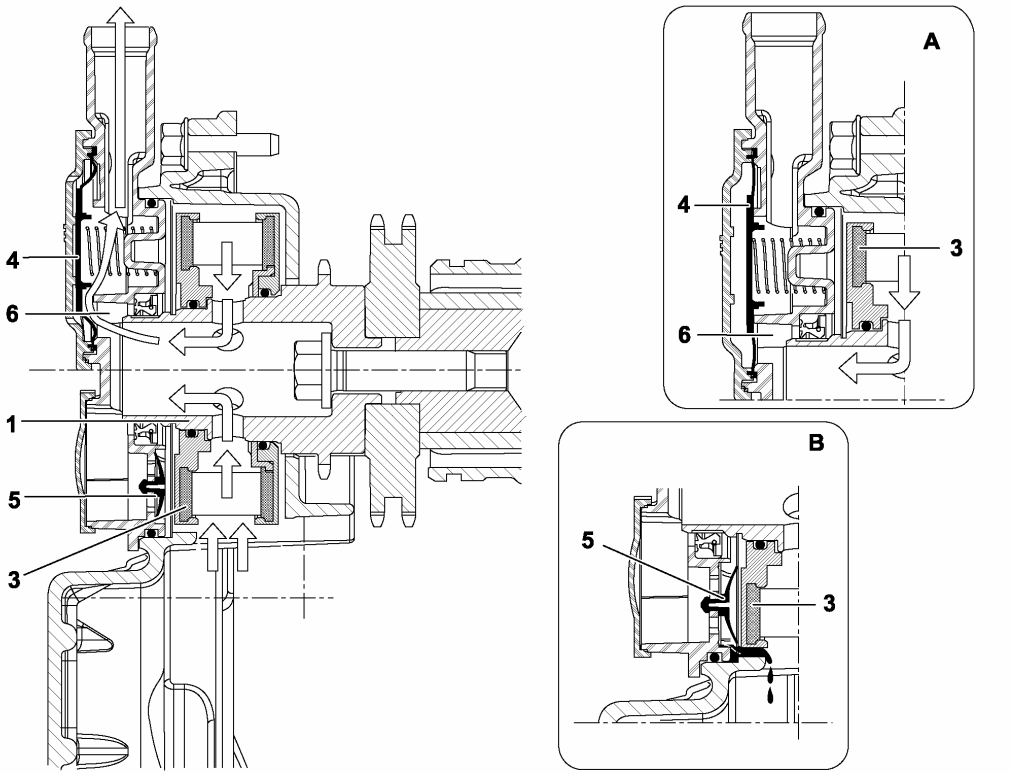
A portion of combustion gases escapes past the end gaps of the piston rings into the sump; the oil fumes in the sump become mixed with the exhaust gases.
From the chain compartment, this mixture is conveyed upwards, and oil is partly extracted by a device located on top of the timing cover and conveyed into the air intake circuit. This device consists of a rotary filter (3) splined to the shaft (1) of the high pressure/camshaft pump and a cover (2) that accommodates two normally closed valves (4 and 5).
The diaphragm valve (4) controls the release of the partially filtered mixture to keep pressure inside the chain compartment at ~ 10 ÷ 15 mbar. The umbrella valve (5) releases part of the remaining oil contained in the mixture exiting the filter (3) into the chain compartment and oil condenses inside chamber (6).



A – Gas with an oil content greater than 10 g/h
B – Gas with an oil content ~ 0.2 g/h
C – Condensed oil returning to oil sump

OPERATION

As the mixture passes through the rotary filter (3), oil particles are extracted by centrifugal force, hit the cover walls, condense and are conveyed back into the lubrication circuit.



The filtered mixture is made to pass through the shaft holes (1) and the diaphragm valve (4) lets it flow into the air conveyor upstream of the turbocharger. The valve (4) is opened or closed by the combined action of the pressure acting on the diaphragm (4) and the vacuum underneath it. Any oil left in the mixture exiting the rotary filter (3) condenses inside chamber (6) and is released into the chain compartment by the umbrella valve (5) when the engine is stopped and the vacuum keeping the valve closed is removed

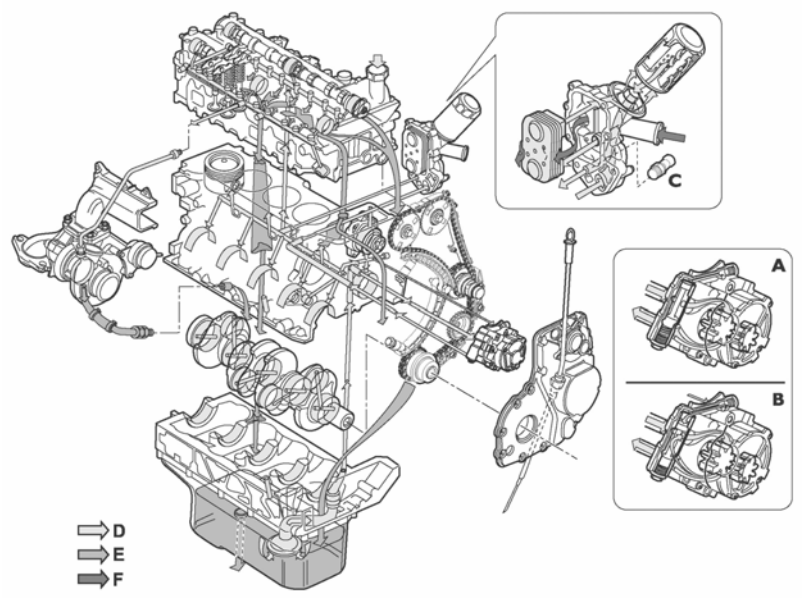
3.1.15 Engine lubrication system

GENERAL

The forced lubrication system consists of the following components:
- gear oil pump incorporated in the same assembly as the vacuum pump;
- pressure regulator incorporated in the oil pump;
- five-element heat exchanger;
- duel-filtration oil filter with incorporated safety valve.

OPERATION

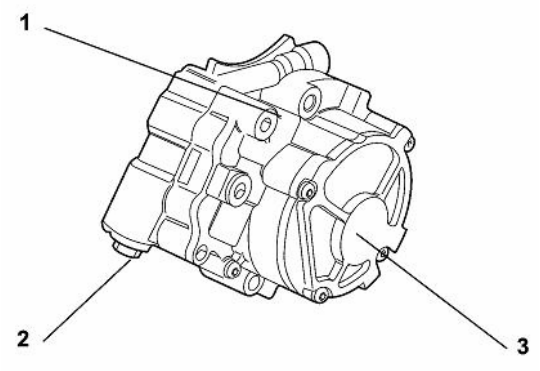
Engine oil is drawn from the sump through the suction rose by the oil pump, pressurised and delivered to the heat exchanger for cooling.
Oil flows through the oil filter and is conveyed to all lubrication points through galleries or pipes.
After the lubrication cycle, the oil drips back into the sump. The safety valve incorporated in the oil filter cuts off the filter from the circuit when it becomes clogged.
In addition, the lubricating oil feeds the hydraulic tensioners of the auxiliary drive shafts and camshafts as well as the hydraulic tappets.



A – Pressure regulator closed
B – Pressure regulator open
C – Oil pressure switch
D – Pressurised oil
E – Dripping oil
E – Coolant

Oil pump/vacuum pump assembly

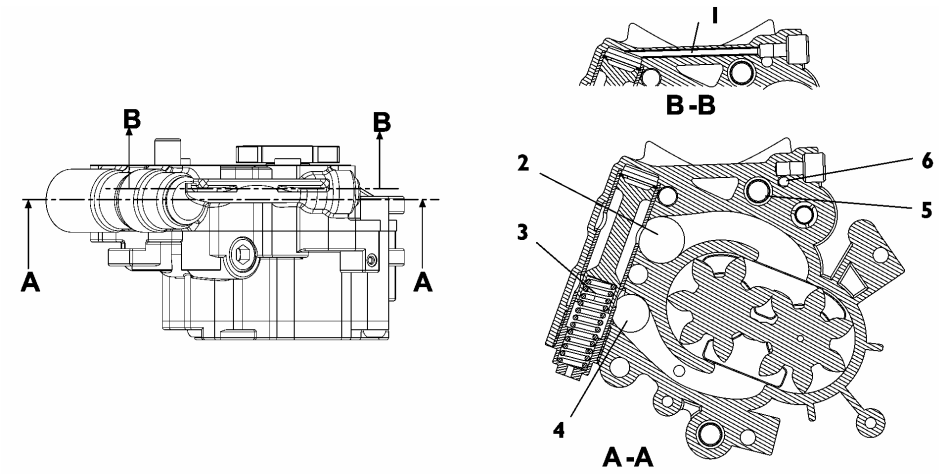
The oil pump/vacuum pump assembly is mounted on the crankcase on timing gear side.
The oil pump drive gear is driven by the crankshaft via a chain and transmits motion to the vacuum pump.
Note: this assembly cannot be serviced and must be replaced when faulty.



1 – Oil pump
2 – Oil pressure regulator
3 – Vacuum pump

The oil pump is a gear pump; the vacuum pump is a radial vane pump.

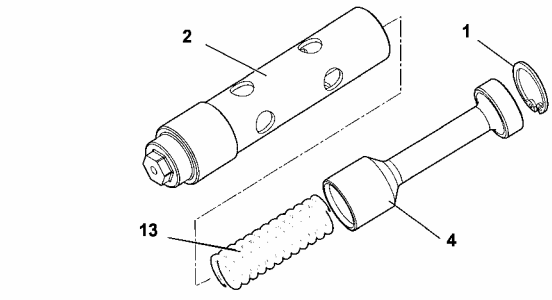
The figure below shows a cross-section view of the oil pump



1 – Inlet duct for crankcase oil
2 – Oil intake duct
3 – Oil pressure regulator
4 – Oil delivery duct
5 – Vacuum pump air intake duct
6 – Vacuum pump oil intake duct

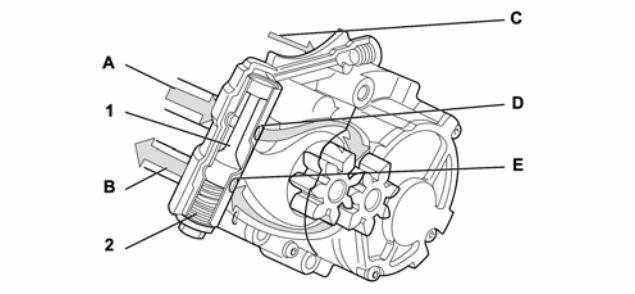
Oil pressure regulator

The oil pressure regulator is housed inside the pump. The figure below shows its components.



1 – Circlip
2 – Valve
3 – Spring
4 – Valve body.

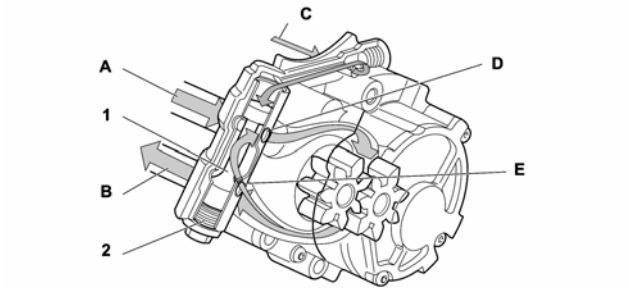
Oil pressure regulator valve closed



When oil pressure in duct C drops below 4.4 bar, the valve (1) shuts holes D and E and the pressurised oil is delivered to the crankcase.

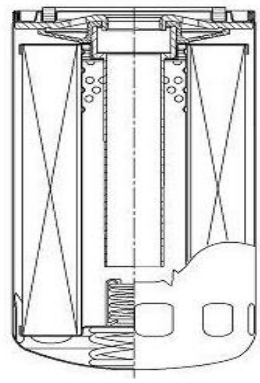
1 – Valve
2 – Spring
A – Sump oil intake duct
B – Oil delivery duct to crankcase
C – Oil return duct from crankcase
D – Oil drain hole
E – Oil drain hole

Oil pressure regulator valve open



When pressure in duct C is 4.4 bar or higher, it helps the valve (1) overcome the spring (2); the valve lowers and opens the drain holes D-E that connect delivery duct A and intake duct B, so that pressure drops.
As soon as pressure drops below 4.4 bar, the spring (2) pushes the valve (1) back into the closed position.

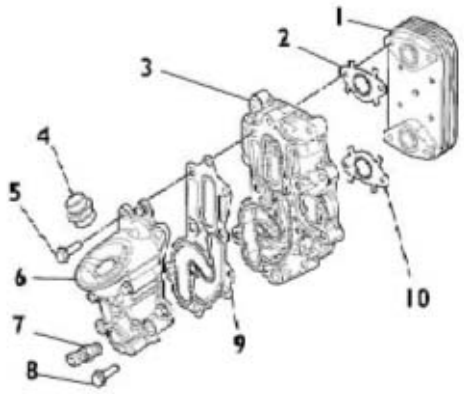
Oil filter



The oil filter is of the simple filtration type with incorporated by-pass valve and opens at a differential pressure of 2.5 ± 0.2 bar.

Heat exchanger

The figure below shows the heat exchanger.

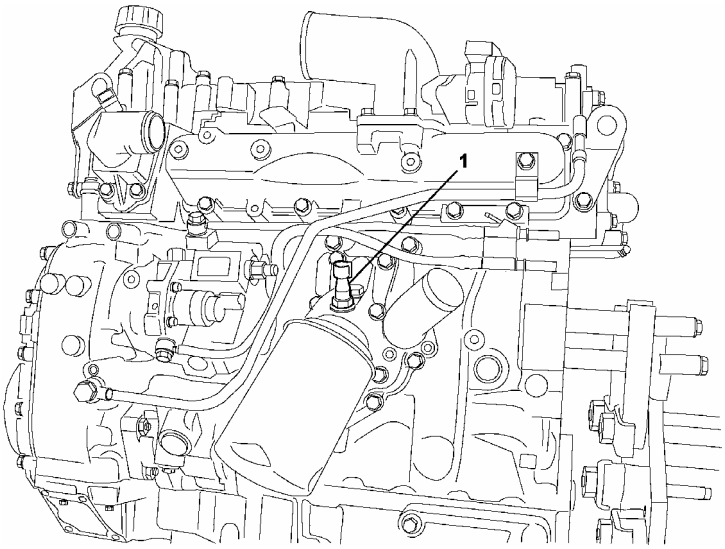


1 – Five-element heat exchanger
2 – Gasket
3 – Case
4 – Fitting
5 – Screw
6 – Oil filter mount
7 – Oil pressure switch
8 – Screw
9 – Heat exchanger case
10 – Gasket

The amount of oil in the circuit and oil pressure are continually monitored by:
- oil pressure sensor,
- oil level sensor,
- engine oil level control unit.

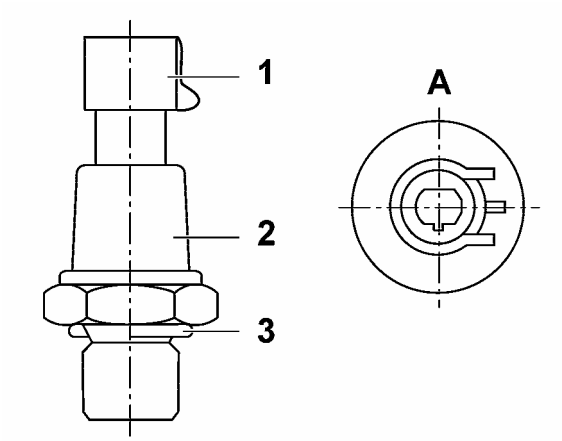
Engine oil pressure sensor

The engine oil pressure sensor is located near the oil filter on the water-oil heat exchanger.



1 – Engine oil pressure sensor

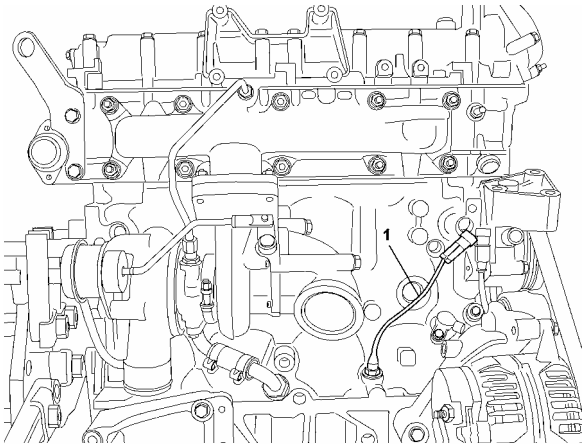
The figure below shows the engine oil pressure sensor.



A – Detail of connector
1 – Connector
2 – Engine oil pressure sensor body
3 – Gasket

Engine oil level sensor

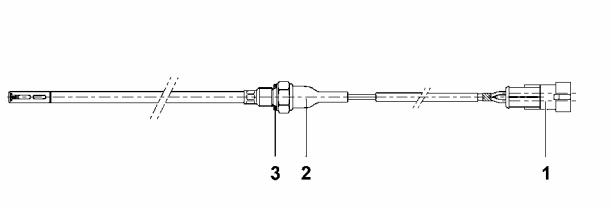
The engine oil level sensor is located near the alternator, on the crankcase exhaust side.



1 – Engine oil level sensor

The engine oil level sensor is a hot-wire sensor.

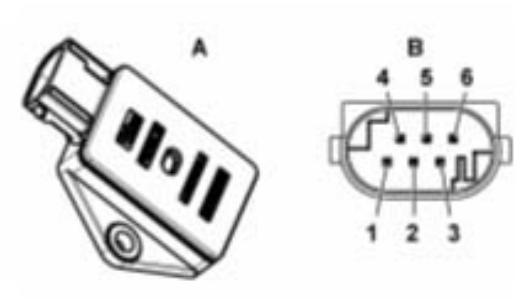
The figure below shows the engine oil level sensor.



1 – Connector
2 – Engine oil level sensor body
3 – Gasket

Engine oil level measurement

The system consists of an electronic control unit located near the engine control unit in the engine compartment and a hot-wire sensor.

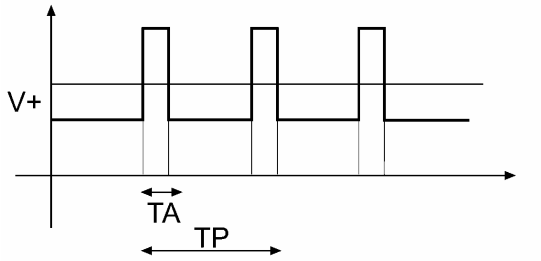


A – Engine oil level control unit
B – Detail of connector
1 – +12 Volt
2 – Output signal level
3 – Oil level sensor +
4 – Ground
5 – Ground signal
6 – Oil level sensor ground

Engine oil level is checked when the ignition key is turned to On to start the engine.
The system uses the heat dissipating properties of oil.
The current flowing through the hot wire causes its temperature and resistance to rise, while voltage drops.
When the hot wire is submerged in oil, the oil will take up part of the heat; as a result, temperature, resistance and voltage drop will be lower.
When the key is turned to On, the control unit feeds 210.5mA to the hot wire of the sensor. After a time delay to allow for power supply to stabilise (t0 ÷ t1 = 150 mSec), the control unit takes a first voltage reading (t1 ÷ t2 = 10 mSec).
After another time delay (t0 ÷ t1 = 865 mSec), the control unit takes a second voltage reading and compares it to the first reading.
At this point, one of the following may occur:

1) if the difference between the two readings is less than 125mV, it means that oil level is correct;
2) a difference greater than 445mV indicates minimum oil level;
3) if the second reading is greater than 3.5mV, it means that the sensor is interrupted;
4) if voltage is less than 1mV, it means that the sensor is shorted.

The oil control unit converts the reading into a PWM signal and sends it to the engine control unit. The engine control unit sends the corresponding parameter over the C-CAN network to trigger the necessary indications on the instrument panel.

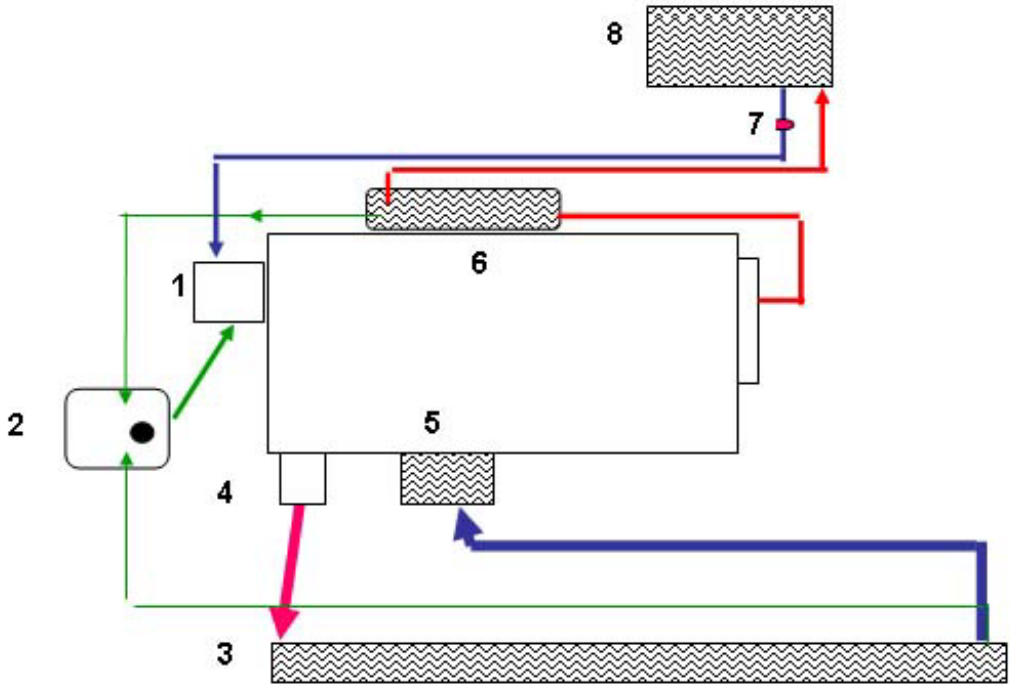


PWM frequency : 125 ± 10Hz
Tolerance at ambient temperature PWM ± 3.5%
Oil level PWM signal represented by duty cycle TA / TP.
At the minimum level the PWM will be at 30% (440mV) whereas at the max level it will be 90% (125mV).
Between 10% and 15%, data acquisition is in progress.
Between 3% and 7%, an error has occurred.

3.1.16 Engine cooling circuit

The engine forced cooling system is a closed circuit and consists of the following components:
- expansion tank with an inlet and outlet valve incorporated in the plug to regulate circuit pressure;
- engine cooling module to dissipate the heat removed from the engine by the coolant;
- heat exchanger that cools lubricating oil;
- heat exchanger for exhaust gas (EGR) cooling;
- centrifugal water pump incorporated in crankcase;
- thermostat controlling coolant circulation

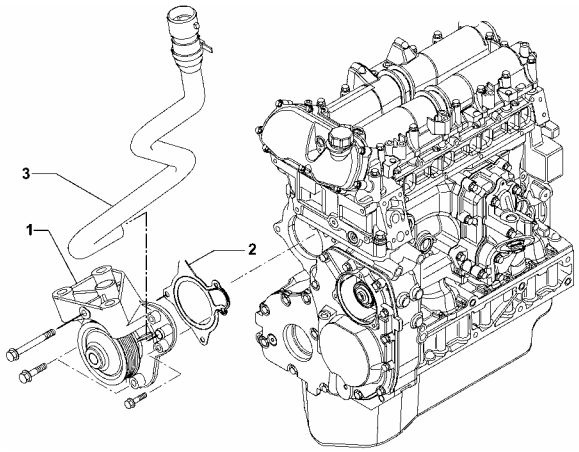
Diagram showing engine cooling system operation



1. Coolant pump
2. Coolant tank
3. Radiator
4. Thermostat
5. Oil/coolant heat exchanger
6. Exhaust gas/coolant heat exchanger
7. Bleed screw
8. In-cab heater

Engine coolant pump

The engine coolant pump is driven by the crankshaft via a poli-V belt; the pump delivers coolant to the crankcase and - with greater pressure head - to the cylinder head.
The engine coolant pump is located on the crankcase on timing gear side.



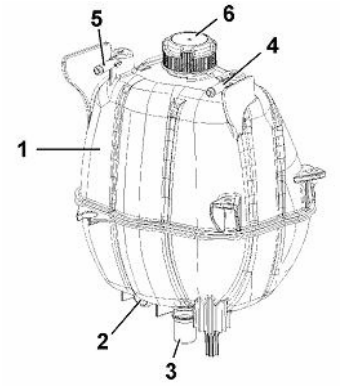
1 – Engine coolant pump
2 – Seal
3 – Pipe connecting pump to expansion tank

When coolant temperature reaches or exceeds operating temperature, the thermostat trips and conveys coolant to radiator and cooling fan.
Pressure in the circuit varies with temperature and is controlled by the inlet and outlet valves incorporated in the expansion tank filler plug.

Supplemental engine coolant tank

The tank feeds coolant to the circuit and takes up excess coolant when it expands from heat as engine temperature rises.

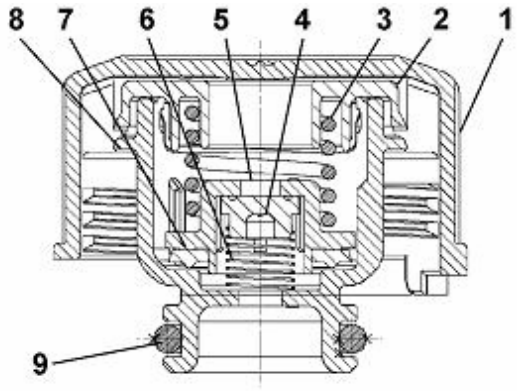
A calibrated valve in the sealed plug
- lets air exit the circuit; this is the air drawn from the pipe coming from the coolant outlet fitting on the head; or
- lets air in when the engine has cooled down and vacuum is created in the circuit.



1 – Expansion tank
2 – Engine coolant level sensor connector
3 – Fitting for coolant delivery to engine cooling circuit
4 – Engine breather fitting
5 – Radiator breather fitting
6 – Expansion tank plug

Expansion tank plug

The expansion tank plug maintains pressure in the cooling circuit within the specified range.
The plug accommodates two valves:
- one is set at 0.02÷0.07 kg/cm² and lets air at atmospheric pressure into the circuit to prevent vacuum (inlet valve);
- the other valve is set at 1.4±0,1 kg/ cm² and releases exceeding pressure (outlet valve).

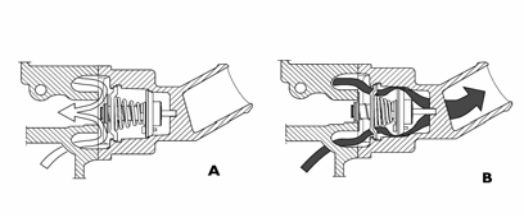


1 – Threaded cover
2 – Cover
3 – Outlet valve spring
4 – Inlet valve
5 – Outlet valve
6 – Inlet valve spring
7 – Outlet valve
8 – Lower cover
9 – Sealing O-ring

The outlet valve serves two purposes:
- it maintains a slight pressure in the circuit so as to increase coolant boiling point;
- it releases excess pressure to the atmosphere when coolant temperature rises.
The inlet valve lets air into the circuit when coolant cools down and shrinks in volume, creating vacuum in the circuit.

Thermostat

The thermostat is housed inside the outlet manifold for the engine coolant exiting the head on the intake side, and its purpose is to maintain ideal engine temperature:



A – Thermostatic valve closed
B – Thermostatic valve open

The by-pass thermostat requires no adjustment.
If you suspect a malfunction, replace it.
The water temperature sensor is mounted on thermostat body.
Valve travel at 79°C ± 2°C = 0.1 mm
Valve travel at 94°C ± °C = 7 mm
Valve travels 7 mm in less than 60”.

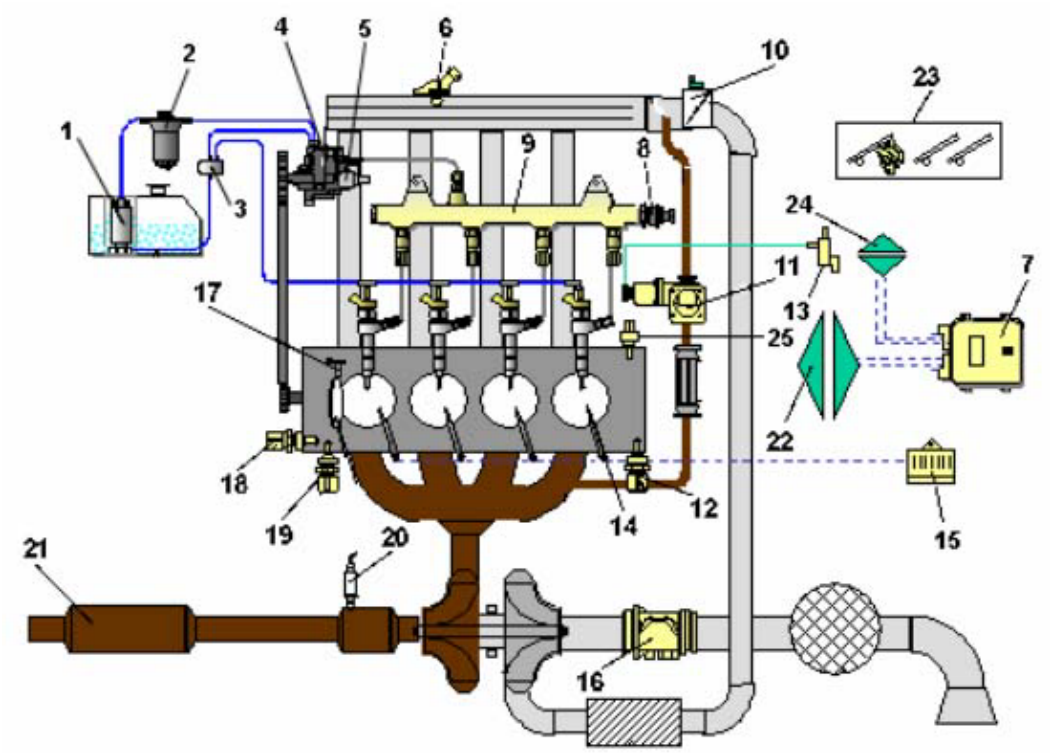
3.2 ELECTRONIC ENGINE MANAGEMENT

FEATURES

The EDC16C39 Common Rail system is a high-pressure electronic injection system for fast direct-injection diesel engines.

Its main features comprise:
- high injection pressures (1600 bar);
- pressure control range from 150 bar up to maximum operating pressure (1600 bar), regardless of engine speed and loading;
- operation at high engine rpm (up to 6000 rpm under full loading);
- high pressure pump with three pumping elements;
- accurate injection (advance and duration) control;
- less consumption;
- less emissions.

The main features of the system are outlined below:
- fuel temperature control;
- engine coolant temperature control;
- injected fuel control;
- idle speed control;
- fuel cut-off during deceleration;
- cylinder balance control at idle speed;
- surge control;
- exhaust smoke control under acceleration;
- exhaust recirculation control (E.G.R.)
- torque limitation control;
- rpm limitation control;
- glow plug control;
- air conditioner control (where fitted);
- electric fuel pump control;
- cylinder position control;
- main and pilot injection advance control;
- closed-loop injection pressure control;
- electrical balance control;
- turbocharging pressure control;
- self-diagnosis;
- connection to Fiat CODE (Immobilizer) control unit.



1 – Auxiliary fuel pump
2 – Fuel filter
3 – Fuel return manifold
4 – CP3.2 pressure pump
5 – Pressure regulator on pump
6 – Supercharging sensor
7 – Injection control unit
8 – Pressure sensor
9 – Rail
10 – Throttle body
11 – E.G.R. solenoid valve
12 – Oil level sensor
13 – E.G.R. actuator
14 – Glow plug
15 – Glow plug control unit
16 – Air flow meter
17 – Rpm sensor
18 – Timing sensor
19 – Oil minimum pressure switch
20 – Lambda sensor on pre-catalyst
21 – Main catalyst
22 – Engine wiring harness
23 – Pedal unit
24 – Vehicle wiring harness
25 – Water temperature sensor

3.2.1 EDC 16 C 39 engine control

FEATURES

In this Common Rail fuel injection system equipped with CP3.2 pump, the flow regulator located at the high pressure pump inlet controls the fuel flow required by the low pressure circuit. The high pump pressure then feeds the Rail as appropriate.

This way, only the necessary amount of fuel is pressurised, there is less need to heat fuel in the system and overall energy efficiency is improved

The CP3.2 pump maintains fuel at high pressure regardless of the current stroke of the cylinder that is expecting the fuel and stores the fuel in a common duct for all electro-injectors (Rail).

As a result, fuel at the injection pressure determined by the ECU is constantly available at injector inlets.

When the ECU energises the solenoid valve of an injector, fuel is drawn from the rail and injected into the corresponding cylinder.

The hydraulic system is comprised of a low pressure and high pressure circuit. The high pressure circuit consists of the following pipes:

- pipe connecting high pressure pump outlet to Rail;
- Common Rail;
- feed pipes from Rail to injectors.

The low pressure circuit consists of the following pipes:

- suction pipe from tank to prefilter
- pipes feeding the mechanical supply pump and prefilter;
- pipes feeding the high pressure pump through the fuel filter;
- return pipe from high pressure pump;
- return pipe from electro-injectors;
- return pipe to tank.

Because of the high pressures in this hydraulic circuit, the following safety precautions must be strictly observed:

- make sure to tighten the high pressure pipe fittings to the correct torque;
- do not disconnect high pressure pipes while the engine is running (DO NOT attempt to bleed the circuit, this would be useless and dangerous!)

A low pressure circuit in good running order is critical to proper operation of the system, so do not make changes to the circuit and repair any leaks without delay.

INJECTED FUEL CONTROL

The control unit controls fuel pressure regulator and electro-injectors based on the inputs from accelerator pedal potentiometer, air flow meter or air pressure sensor in intake manifold and engine rpm sensor.

When the engine is started, injection timing and firing order are determined using the inputs from the engine rpm sensor and the timing sensor (synchronisation); afterwards, injection timing is dependant on the engine rpm sensor inputs only and the standard firing order of the 3000 JTD engine (1 – 3 – 4 – 2) is resumed.

The control unit inhibits the injection when:

- fuel pressure exceeds 1700 bar;
- fuel pressure drops below 100 bar;
- engine rpm exceeds 5000 rpm.

INJECTION ADVANCE CONTROL

The electronic control unit basically relies on two factors to calculate injection advance: the amount of fuel to be injected and engine rpm.
Injection advance is adjusted according to engine coolant temperature so as to compensate for the increasing injection delay during warm-up, while the combustion chambers are still cold.

INJECTION PRESSURE CONTROL

This is a critical feature, as injection pressure affects the following parameters:
- amount of fuel fed into the cylinders (injection duration being equal);
- fuel atomisation;
- injection depth;
- time delay after command signal before fuel is actually injected;
- duration of fuel injection into combustion chamber.

These parameters significantly affect engine operation and performance in terms of power output, exhaust emissions, noise and driveability.
The engine control unit uses engine rpm and load inputs to control the pressure regulator at the high pressure pump inlet so as to achieve and maintain optimal line pressure.
When the engine is cold, injection pressure is adjusted based on engine coolant temperature to meet varying engine demand as operating temperature changes.
Fuel pressure is adjusted to instantaneous engine operating conditions (rpm, load, etc.).
The lower the pressure, the longer the injection times (and vice versa), also depending on load requirements.
Up to 2800 rpm, a pre-injection feature reduces the noise typically associated with direct injection systems.
Pre-injection advance angles, intervals between pre-injection and main injection and main injection advance angles vary according to the instantaneous operating conditions of the engine.

ELECTRIC FUEL PRE-FEED PUMP CONTROL

The auxiliary fuel pump submerged in the tank is powered by the engine control unit through a contactor when the ignition key is set to RUN.
Power supply to the electric pump is removed when:
- the engine has not started after the ignition key has been in the RUN position for 10 seconds;
- the inertia switch has tripped.

FUEL CUT-OFF DURING DECELERATION

Fuel cut-off occurs when the engine control unit receives an input from the potentiometer indicating that the accelerator has been released.
In this condition, the control unit cuts off power supply to electro-injectors and restores it before idle rpm is reached; the ECU also controls the fuel pressure regulator accordingly.

IDLE SPEED CONTROL

The control unit controls fuel pressure regulator and electro-injector timing based on the inputs from the engine rpm and coolant sensors so as to keep idle rpm stable. Under certain conditions, the ECU will also use battery voltage to control idle speed.

MAXIMUM RPM LIMITATION CONTROL

The engine control unit achieves rpm limitation in two ways:
- it lowers line pressure to reduce the amount of fuel injected as the engine is approaching the maximum rpm limit (4500 rpm);
- it shuts down the electro-injectors in the event the engine exceeds 5000 rpm.

MAXIMUM TORQUE LIMITATION CONTROL

The injection control unit uses rpm to calculate maximum torque parameters and maximum smoke rate allowed based on the mapping stored in its memory. The control unit adjusts these parameters based on engine coolant temperature and vehicle speed, and uses the resulting corrected parameters to meter out the correct amount of fuel through the pressure regulators and the electro-injectors.

FUEL TEMPERATURE CONTROL

The injection control unit continually monitors fuel temperature through the sensor in the fuel filter.
When fuel reaches a predetermined temperature (80°C), the engine control unit begins to gradually decrease maximum power and keeps cutting power up to 90°C, until achieving a minimum value of 60% of rated power.

ENGINE COOLANT TEMPERATURE CONTROL

The injection control unit continually monitors engine coolant temperature through the sensor on the thermostat.
If engine coolant temperature exceeds certain predetermined values, the control unit will:
- signal the fuel pressure regulator and the electro-injectors to reduce the amount of fuel injected (power reduction starting from 106°C).
- actuate the engine cooling fan (switch-on/off temperatures: 95 / 91°C for first speed, 99 / 95°C for second speed).
When the ignition key is turned to STOP (and temperature is higher than the cooling system switch-on threshold), the fan will keep running for up to 20 sec., so that temperature drops below the switch-on threshold.
When the ignition key is turned to RUN (and coolant temperature is higher than the cooling system switch-on threshold), the fans will not switch on until engine speed rises above 770 rpm (rpm with a warm engine is 800 rpm).

EXHAUST SMOKE RATE CONTROL

The injection control unit also provides smoke limitation, for event smoke emissions are produced under sharp acceleration
To meet this requirement, the control unit processes the signals sent by accelerator pedal potentiometer, engine rpm sensor and intake air sensor (air flow meter or pressure/temperature sensor); the injection control unit controls the fuel pressure regulator and the electro-injectors so that the right amount of fuel to reduce exhaust smoke is injected into the combustion chamber .

EXHAUST RECIRCULATION CONTROL (E.G.R.)

To ensure compliance with EURO 4 emissions standard, the control unit reduces the amount of fresh air taken in according to engine load and accelerator pedal potentiometer inputs, and signals the pneumatic EGR valve to open so as to draw a portion of the exhaust gas.

AIR CONDITIONER CONTROL

The engine control unit controls the air conditioner compressor clutch so as to preserve engine performance when the air conditioner is on.
When the air conditioner is switched on, the engine control unit provides more fuel at idle speed to meet the increased demand from the engine and shuts down the air conditioner in the event of:
- exceeding engine coolant temperature (AC is shut down at 105°C and re-enabled at 100°C).

ENGINE IMMOBILIZER

The system offers an engine immobilizer feature. This is achieved thanks to a Fiat CODE control unit that communicates with the engine control unit and an electronic key that incorporates a code transponder. Each time the key is turned to STOP, the Fiat CODE system shuts down the engine control unit completely.
When the key is turned to RUN, the following occurs in the order:
- the engine control unit (which has the secret code stored in its memory) asks the Fiat CODE control unit to transmit the secret code required to cancel the inhibit condition;
- the Fiat CODE control unit will only send the secret code after receiving the identification code from the key transponder;
- when the secret code is recognised, the engine control unit inhibit is disabled and the unit is restored to normal operation.

SELF-DIAGNOSIS

The injection system can be fully diagnosed by connecting the EXAMINER equipment to the diagnostic connector located in the engine compartment.
The system includes a self-diagnosis feature to recognise, store and warn of possible malfunctions.
In the event a sensor or actuator is found to be malfunctioning, preset signal recovery strategies ensure acceptable engine operation. This way, the vehicle can be driven to nearest service centre for the necessary repairs.

FIXED GEOMETRY TURBINE CONTROL (VGT)

The control unit processes the supercharging sensor inputs at varying engine rpm and determines the amount of fuel to be injected:
- the ECU adjusts injection duration;
- it adjusts the amount of exhaust gas flowing through the turbocharger so as to ensure optimal performance under all operating conditions.

LAMBDA SENSOR CONTROL

The control unit uses the inputs from the Lambda sensor to prepare “correction maps” for the main injection and compensate for injection component decay (EGR, injectors, pressure rail, air flow meter, Lambda sensor)

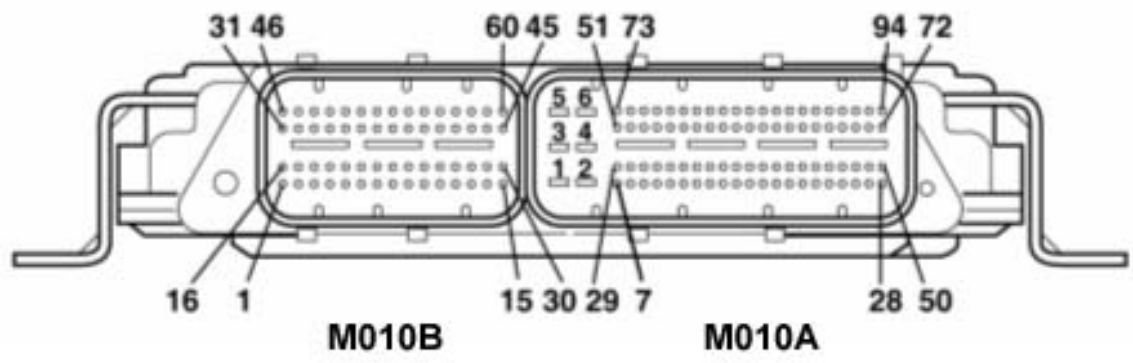
SOLENOID VALVE CONTROL
The control unit switches on the cooling fans at the first or second speed depending on engine coolant temperature and coolant pressure in the air conditioning system.

CRUISE CONTROL (WHERE FITTED)

The control unit directly adjusts the amount of fuel injected depending on the position of the cruise control lever so as to control and maintain the vehicle speed stored in the memory.
It also controls a status light on the instrument panel to indicate whether the system is on or off.
The cruise control system is temporarily disabled:
- when the brake is operated,
- when the clutch is operated;
- pressing the "resume" button brings the vehicle back to the stored speed.

The cruise control is not disabled when the accelerator pedal is depressed (for instance, when overtaking) and automatically brings the vehicle back to stored speed as soon as the accelerator is released.
For safety reasons, the ASR (antispin) feature overrides the cruise control.

3.2.2 Engine Control unit pinout



M010A connector

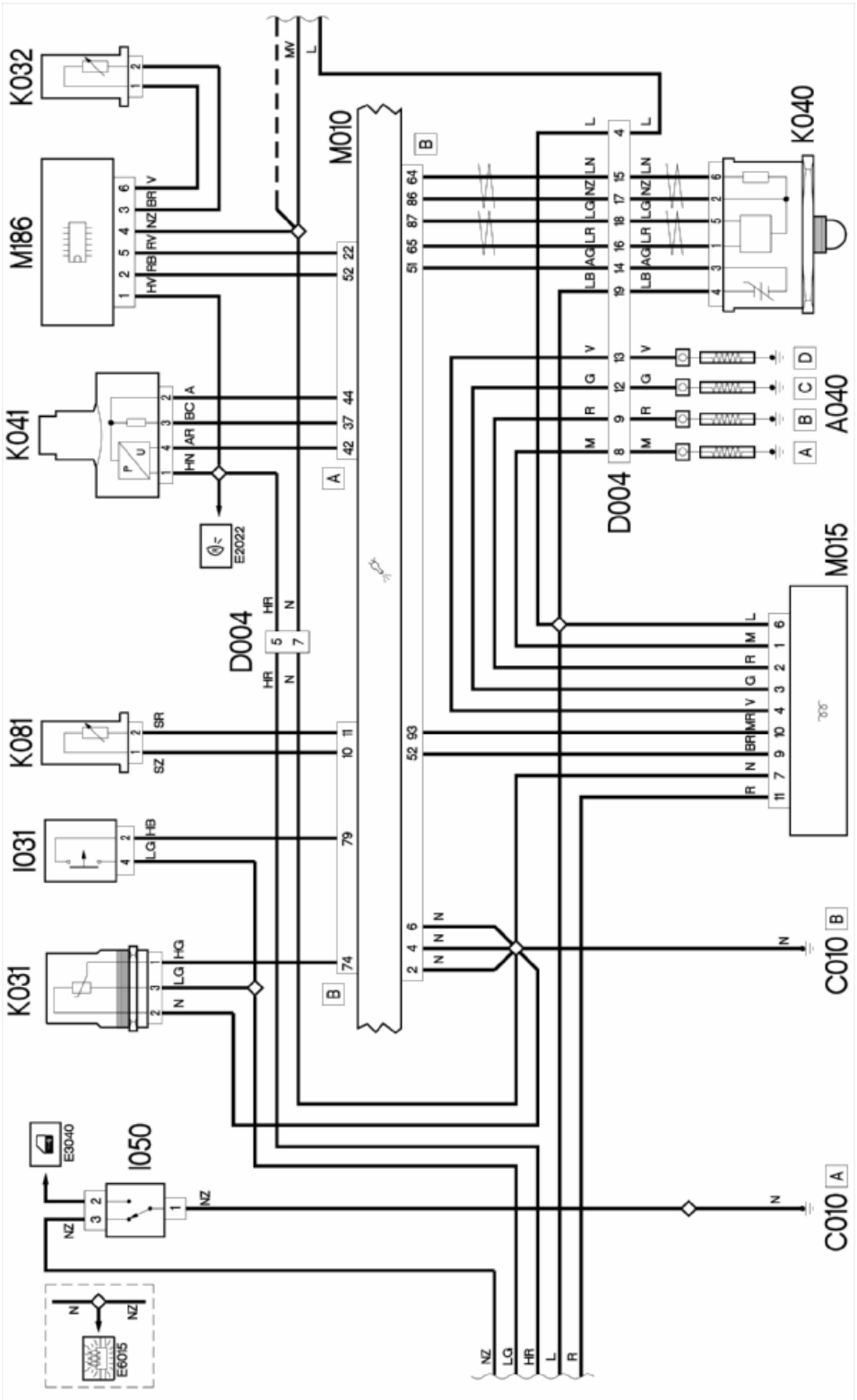
1 – Key-on power source from main contactor
2 – Control unit ground 1
3 – NC
4 – Control unit ground 2
5 – Key-on power source from main contactor
6 – Control unit ground 3
7 – NC
8 – Accelerator pedal potentiometer 2 ground
9 – Accelerator pedal potentiometer 1 signal
10 – Fuel temperature signal (ground)
11 – Fuel temperature signal (signal)
12 – Air conditioner linear pressure sensor (ground)
13 – Air conditioner linear pressure sensor (signal)
14 – NC
15 – NC
16 – NC
17 – Brake pedal switch (signal)
18 – NC
19 – NC
20 – Fuel pump contactor power supply (positive)
21 – NC
22 – Air conditioner linear pressure sensor (power supply)
23 – NC
24 – NC
25 – K line for diagnosis
26 – NC
27 – NC
28 – Direct power supply from switch +15
29 – Compressor cut-in contactor control
30 – Accelerator pedal potentiometer 1 ground
31 – Accelerator pedal potentiometer 2 signal
32 – DPF exhaust gas temperature signal (where fitted)
33 – DPF exhaust gas temperature ground (where fitted)
34 – Exhaust gas temperature sensor 1 signal (where fitted)
35 – Exhaust gas temperature sensor 1 ground (where fitted)
36 – Particulate filter differential sensor signal (where fitted)
37 – Particulate filter differential sensor negative power supply (where fitted)
38 – Resume from cruise control command
39 – NC
40 – NC
41 – NC
42 – NC
43 – NC
44 – Particulate filter differential sensor power supply (where fitted)
45 – Accelerator pedal potentiometer 1 power supply
46 – Accelerator pedal potentiometer 2 power supply
47 – NC
48 – NC
49 – NC
50 – NC
51 – Lambda sensor heating (negative)
52 – Glow plug preheating time/fault detection feedback input
53 – NC
54 – Compressor cut-in request from pushbutton positive signal
55 – NC
56 – Cruise control for “set / acc.”
57 – NC
58 – NC
59 – NC
60 – NC
61 – NC
62 – NC
63 – NC
64 – Lambda sensor Nerst cell reference voltage signal
65 – Lambda sensor pumping current
66 – NC
67 – NC
68 – (Provision for) Diesel filter heater contactor command
69 – Engine cooling fan speed contactor 2 cut-in command
70 – NC
71 – Malfunction indicator light (EOBD/MIL)
72 – Direct power supply from battery
73 – NC
74 – Water in fuel sensor (signal)
75 – NC
76 – NC
77 – Cruise control on/off control lever positive
78 – Cruise control “set/dec.” command positive
79 – Clutch pedal pressed positive signal (NC switch)

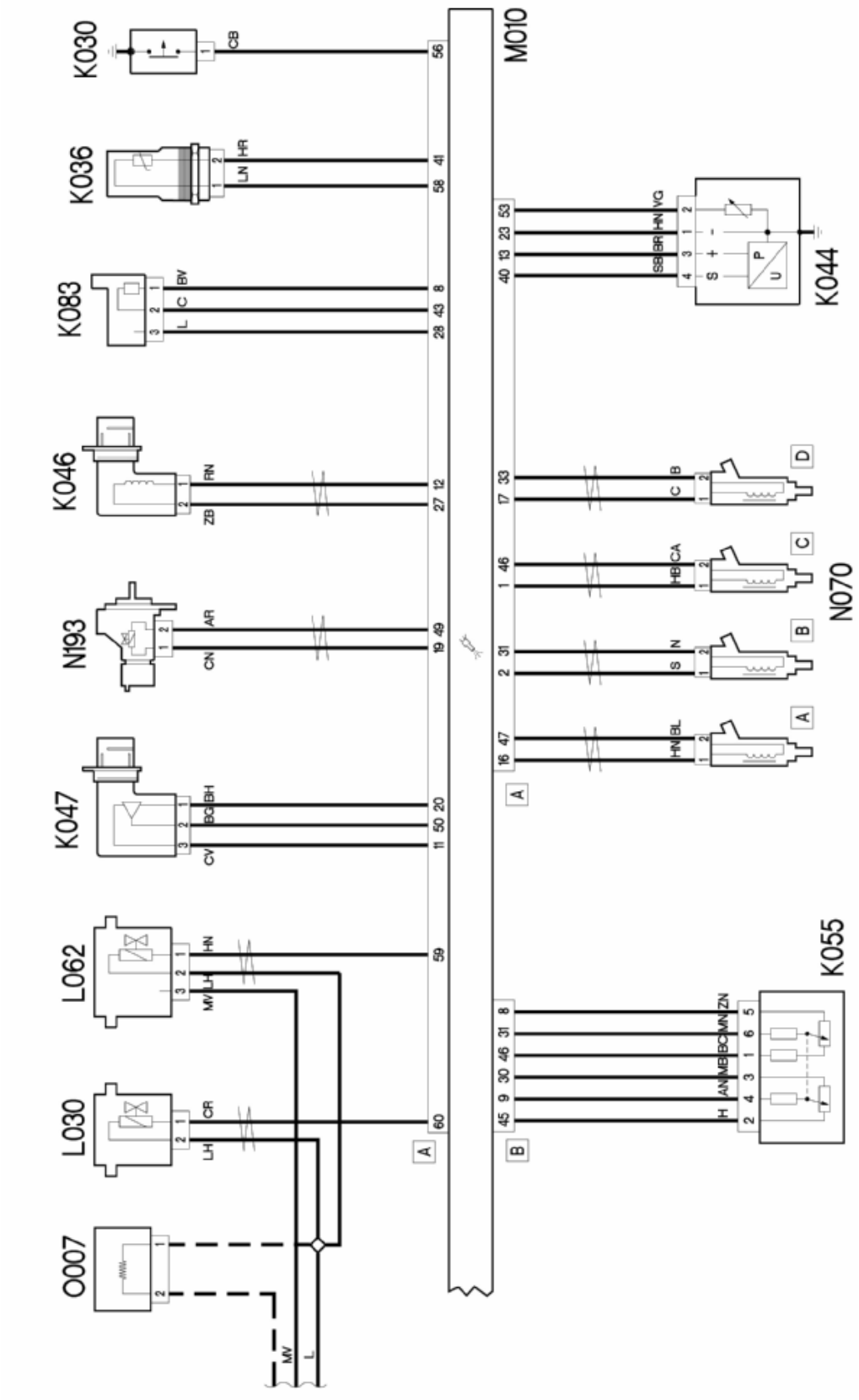
80 – Clutch pedal pressed redundant signal (positive), normally closed.
81 – NC
82 – NC
83 – Can line from NBC – (Can low)
84 – Can line from NBC – (Can High)
85 – NC
86 – Ground for Lambda sensor signal
87 – Lambda sensor reference current
88 – NC
89 – NC
90 – Engine cooling fan speed contactor 1 cut-in command
91 – NC
92 – NC
93 – Glow plug preheating contactor
94 – Engine cooling fan speed contactor 3 cut-in command

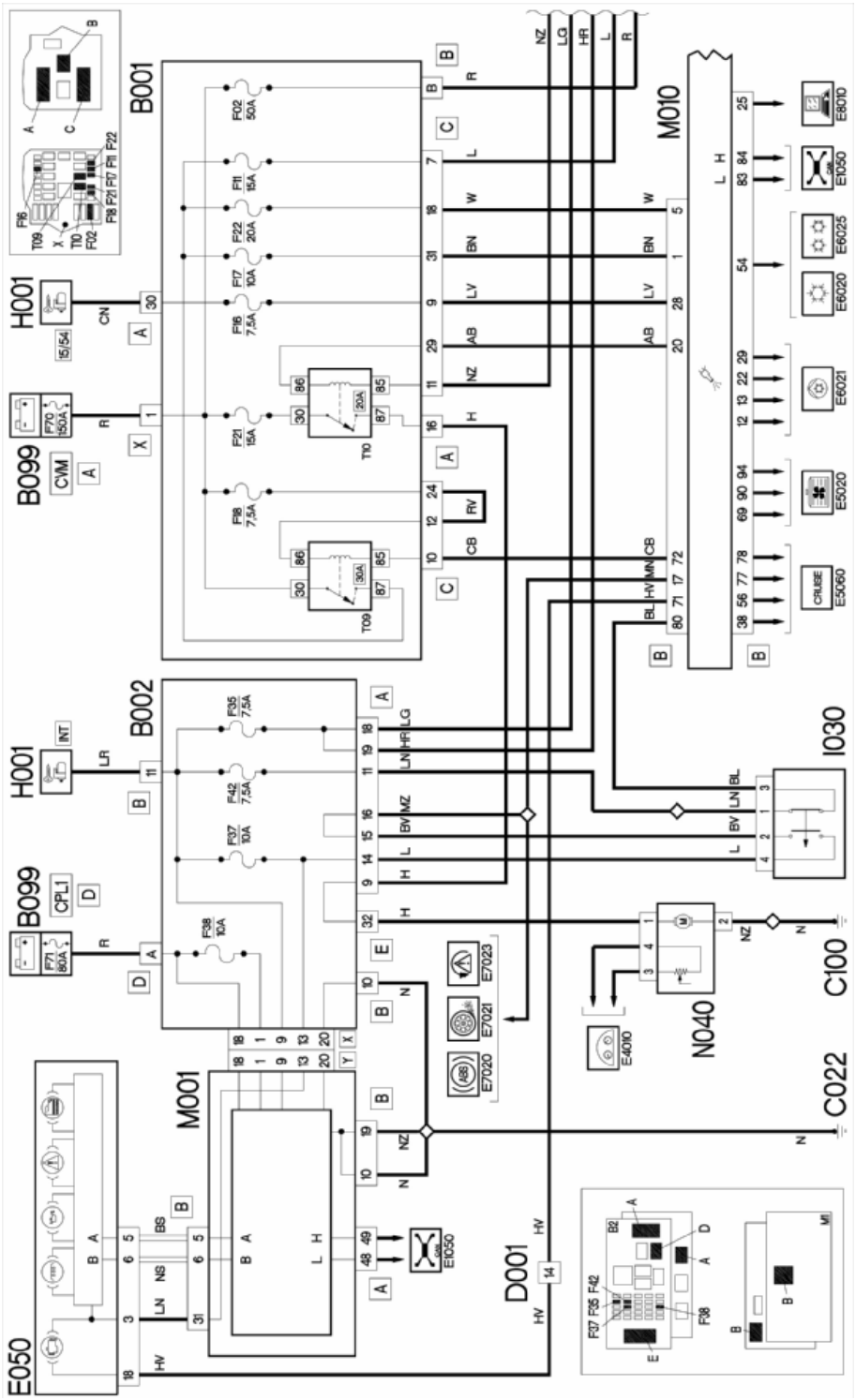
M010B Connector

1 – Injector no. 3, supply
2 – Injector no. 2, supply
3 – NC
4 – NC
5 – NC
6 – NC
7 – NC
8 – Fuel pressure sensor (ground)
9 – NC
10 – NC
11 – Timing sensor (power supply)
12 – Rpm sensor (negative input)
13 – Absolute pressure sensor (power supply)
14 – NC
15 – NC
16 – Injector no. 1, supply
17 – Injector no. 4, supply
18 – NC
19 – Fuel flow regulator (power supply)
20 – Timing sensor (negative)
21 – NC
22 – Oil level sensor (ground)
23 – Absolute pressure sensor (negative)
24 – NC
25 – NC
26 – NC
27 – Rpm sensor (positive input)
28 – Rail pressure sensor (positive)
29 – NC
30 – NC
31 – Injector 2 (negative command)
32 – NC
33 – Injector 4 (negative command)
34 – NC
35 – NC
36 – NC
37 – Air temperature sensor (signal) inside air flow meter
38 – NC
39 – NC
40 – Absolute pressure sensor (signal)
41 – Water temperature sensor (ground)
42 – Air mass quantity in flow meter signal
43 – Fuel pressure sensor on rail (signal)
44 – Air flow meter (ground)
45 – NC
46 – Injector 3 (negative command)
47 – Injector 1 (negative command)
48 – NC
49 – Flow regulator control (negative)
50 – Timing sensor (signal)
51 – NC
52 – Oil level sensor (signal)
53 – Air temperature signal of absolute pressure sensor
54 – NC
55 – NC
56 – Signal oil pressure sensor (normally closed)
57 – NC
58 – Water temperature sensor (signal)
59 – Powered throttle actuator command
60 – EGR negative command

3.2.3 Engine management wiring diagram







Key to engine management wiring diagram components

A040. Preheating glow plugs
B001. Engine compartment connector box
B002. Connector box under dashboard
B099. Pmaxi-fuse box on battery
C010. Front left ground
C022. Central dashboard ground
C100. Cab ground
D001. Dashboard/front junction
D004. Engine/front junction
E050. Instrument panel
H001. Ignition switch
I030. Brake pedal switch
I031. Clutch pedal switch
I050. Inertia switch
K030. Engine oil pressure sensor
K031. Water in diesel filter sensor
K032. Engine oil level sensor
K036. Engine water temperature sensor
K040. Lambda sensor
K041. Air flow meter
K044. Intake air pressure and temperature sensor
K046. Rpm sensor
K047. Timing sensor
K055. Accelerator pedal potentiometer
K081. Fuel temperature sensor
K083. Fuel pressure sensor
L030. EGR solenoid valve
L062. Throttle body
M001. Body computer
M010. Engine control unit
M015. Glow plug preheating control unit
M186. Engine oil level control unit
N040. Electric fuel pump and fuel level meter
N070. Electro-injectors
N193. Fuel flow regulator
O007. Oil vapour heating resistor

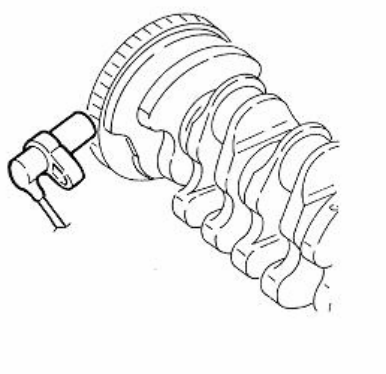
3.2.4 Injection/ignition system components

ENGINE CONTROL UNIT

It is fitted in the engine compartment on the right-hand side panel.The control unit is of the "flash e.p.r.o.m." type, i.e. it can be reprogrammed from outside without removing the hardware.
The injection control unit incorporates the absolute pressure sensor.
The figure below shows the control unit.

RPM SENSOR

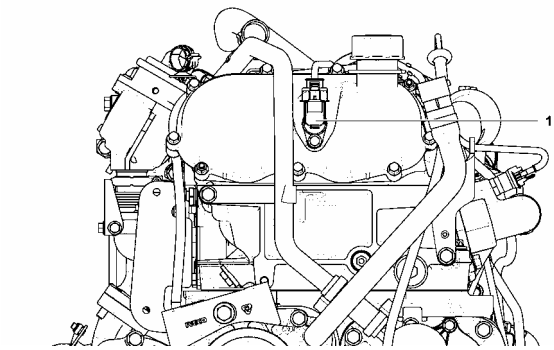
Features



The rpm sensor is fitted on the crankcase with its sensing surface facing the phonic wheel on the engine flywheel. It is an inductive sensor that changes its output as it senses the changes in the magnetic field caused by the phonic wheel teeth (60 - 2 teeth) passing across it.
The injection control unit uses the rpm sensor signal to:
- determine the rotation speed;
- determine the angular position of the crankshaft.

TIMING SENSOR

Features

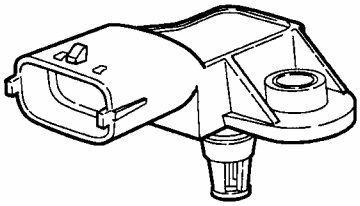


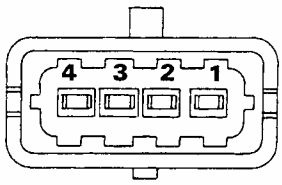
The timing sensor is a Hall sensor fitted on engine oil filler cover on the upper cylinder head section.
It determines engine timing by sensing the position of intake camshaft drive gear.
The injection control unit uses the signal of the timing sensor to determine T.D.C. at the end of the compression stroke.
1 –Timing sensor

INTAKE AIR TEMPERATURE AND OVERPRESSURE SENSOR

Features

The intake air overpressure and temperature sensor is an integrated component used to measure the pressure and temperature of the air inside the intake manifold.
The sensor is fitted on the intake manifold and its output is used by the engine control unit:
- to adjust turbocharger pressure
- to protect the engine from overheating
- to diagnose air flow meter operation





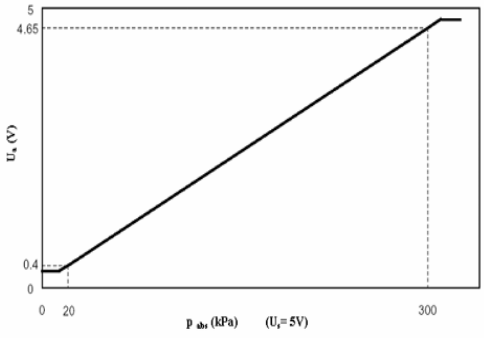
Sensor pinout:

1 – Ground
2 – Air temperature signal
3 – 5 V power supply (from engine control unit)
4 – Turbocharging pressure output signal

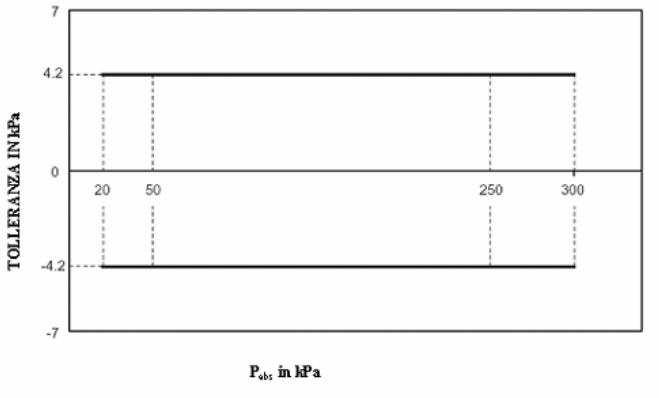
Sensor output voltage changes with absolute pressure according to the following law:

Ua=(c1*pabs+c0)*Us

where:
- Ua = signal output voltage in V
- Us = power supply voltage in V
- pabs = absolute pressure in kPa
- c0 = 5.4/280
- c1 = 0.85/280 kPa-1



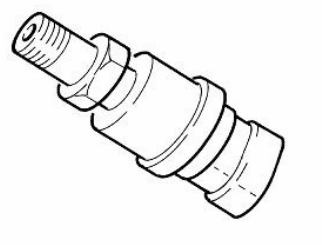
The graph below shows output signal tolerance in relation to pressure.



The following table lists temperature sensor resistance values in relation to air temperature

Temperature (°C)	Resistance in Ohm		
	Minimum	Rated	Maximum
-40	45301	48153	51006
-35	33703	35763	37823
-30	25350	26854	28359
-25	19265	20376	21487
-20	14785	15614	16443
-15	11453	12078	12702
-10	8951	9426	9901
-5	7055	7419	7783
0	5605	5887	6168
5	4487	4707	4926
10	3618.7	3791.1	3693.5
15	2938.5	3074.9	3211.3
20	2401.9	2510.6	2619.3
25	1975.8	2062.9	2150.1
30	1644.7	1715.4	1786.2
35	1374.2	1431.8	1489.5
40	1152.4	1199.6	1246.7
45	969.9	1008.6	1047.4
50	819.1	851.1	883.0
55	694.2	720.7	747.1
60	590.3	612.3	634.2
65	503.6	521.9	540.2
70	431.0	446.3	461.6
75	370.1	382.89	395.7
80	318.68	329.48	340.27
85	275.25	284.37	293.48
90	238.43	246.15	253.86
95	207.12	213.67	220.23
100	180.42	186.00	191.58
105	157.37	162.35	167.32
110	137.63	142.08	146.52
115	120.68	124.66	128.63
120	106.09	109.65	113.21
125	93.48	96.68	99.88
130	82.58	85.45	88.32

ENGINE COOLANT TEMPERATURE SENSOR



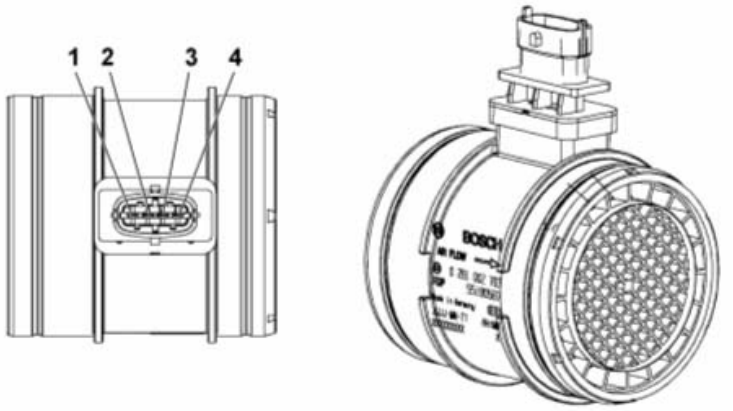
The engine coolant temperature sensor is mounted on a thermostatic plate and detects coolant temperature by means of a double NTC (negative temperature coefficient) thermistor.

One NTC thermistor sends a signal to the injection control unit, while the other sends a signal to temperature indicator and light on the instrument panel.
The sensor uses semiconductor technology; as sensor temperature increases with coolant temperature, sensor resistance drops.
The change in resistance is not linear; temperature increase being equal, resistance will drop faster in the low temperature range than at higher temperatures.

AIR FLOW METER WITH INCORPORATED AIR TEMPERATURE SENSOR

Features

The hot-film air flow meter is located on the air intake sleeve.
It incorporates the intake air temperature sensor.



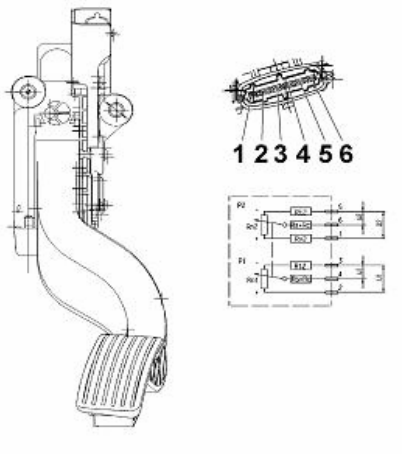
Air flow meter pinout:

1 – Power supply
2 – Ground
3 – Air temperature sensor signal
4 – Air mass quantity signal

ACCELERATOR PEDAL POTENTIOMETER

Features

The sensor casing is secured to the accelerator pedal and accommodates two (main and safety) potentiometers connected by an axial shaft.
The shaft is fitted with two springs: a coil spring provides the correct resistance when pressure is applied to the pedal, the second is the return spring for when the pedal is released.



1 – Accelerator pedal potentiometer 2 power supply
2 – Accelerator pedal potentiometer 1 power supply
3 – Accelerator pedal potentiometer 1 ground
4 – Accelerator pedal potentiometer 1 signal
5 – Accelerator pedal potentiometer 2 ground
6 – Accelerator pedal potentiometer 2 signal

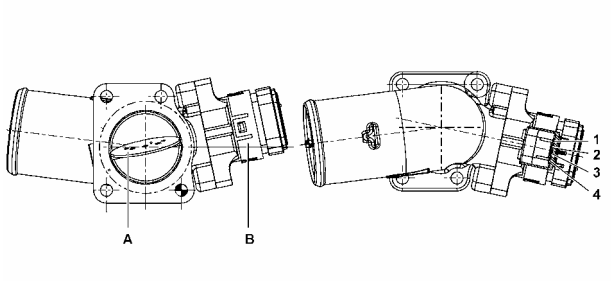
Sensor output voltage changes with accelerator pedal position and is sent to the injection control unit.
The accelerator pedal position signal is processed together with the rpm input to calculate injection times and pressure.

MOTOR-DRIVEN THROTTLE BODY

Double potentiometer = factor 2
Power supply voltage (U1, U2) = 5 V ± 0.3 V
Series and contact resistance (Rs + Rc) = 1 kOhm ±0.4 kOhm
Maximum load on sliding contact = 0.5 micro Ampere
Potentiometer resistance Rn1 = 1.2 kOhm ±0.5 kOhm
Potentiometer resistance Rn2 + Rv2 = 1.7 kOhm ±0.8 kOhm
Linearity = ±0.02 u/U
P1/P2 synchronisation = absolute value(u1/(U1/2)-u2/U2) ≤ 0.014 u

The (normally open) throttle valve assembly fitted on the intake manifold controls the flow rate of intercooler air to be mixed with the exhaust gases recirculated by the E.G.R. valve, according to a programmed percentage.
Recirculated exhaust gas is mixed with intercooler air in a duct inside the cylinder head.
The throttle valve is operated by an electric actuator controlled by a PWM signal from the EDC 16 control unit.
If the throttle valve jams, the control unit will reduce engine performance to prevent engine damage.

The motor-driven throttle body performs two functions:
- shut-off management
- it controls exhaust gas temperature by restricting the cross-section area of the intake duct.



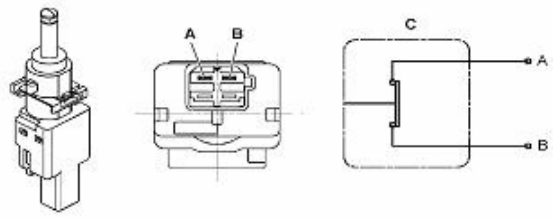
Connector pinout

1 – PWM (Pulse Width Modulate) command
2 – Power supply
3 – Ground
4 – Position signal

A– Throttle valve
B – Electrical actuator

CLUTCH PEDAL POSITION SWITCH

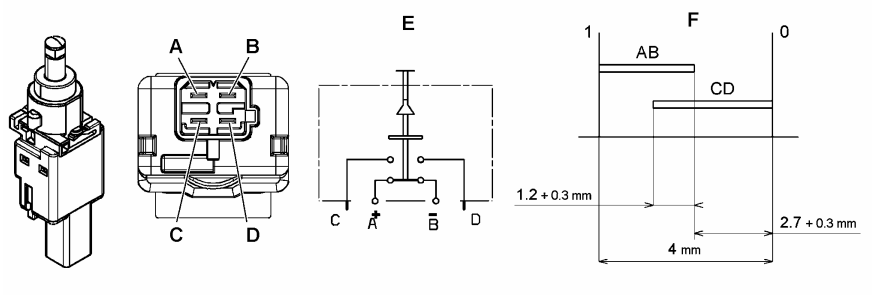
The clutch pedal position switch is mounted on the pedal assembly and generates a positive signal for the electronic control unit when the clutch is engaged (pedal released).
Whenever the clutch is disengaged to shift gears, the control unit senses that the switch signal is missing and disables the Cruise Control (where fitted).



A – Power supply positive
B – Electrical load
C – Wiring diagram (pedal depressed)

BRAKE PEDAL POSITION SWITCH

The brake pedal position switch is mounted on the pedal assembly. When the brake pedal is released, the switch generates a positive signal. The control unit uses this signal to determine when the brake is operated so as to disable the Cruise Control (where fitted) and cut off fuel.
The switch also operates the brake lights.



A – Power supply positive
B – Electrical load
C – Not connected
D – Not connected

E – Wiring diagram (pedal depressed)
F – Diagram showing operation
0 – Brake pedal released
1 – Brake pedal depressed

3.3 DIAGNOSIS

3.3.1 Parameter section

Exhaustive system information can be viewed in the parameter screen, starting with typical engine operation parameters (rpm, water temperature, etc.).
The system is derived from the EDC16C39 SYSTEM developed for Fiat Croma and Alfa 159, so the following parameters should be noted:
SPEED LIM FUNCTION: Possible states are:LEARNT: After proxi alignment, when the vehicle did not exceed the speed limit set in the ECU
SPEED LIMITATION: Displays vehicle speed limitation set in the ECU

WARNING: The following OPTIONAL parameters:

- AC cut-in request
- AC control relay
- Air conditioner pressure
- Cruise control switch
- Request from Cruise control lever
- Irrev. Cruise control error state

will be labelled 'Not available' unless the teach-in procedure for that function has been performed

Parameter description can be viewed by pressing the HELP button in the PARAMETER SELECTION screen

DESCRIPTION	HELP
Engine rpm	ENGINE RPM: Shows engine rotation speed
Accelerator pedal	
Accelerator pos. 1 AD/C	ACCELERATOR POSITION 1 AD/C: Voltage reading of accelerator potentiometer channel 1
Accelerator pos. 2 AD/C	ACCELERATOR POSITION 2 AD/C: Voltage reading of accelerator potentiometer channel 2.
Fuel COR CYL 1	FUEL CORRECTION CYL 1/2/3/4: Amount of fuel added/subtracted for each injector to obtain the same performance from all cylinders and correct possible engine malfunctions.
Fuel COR CYL 2	FUEL CORRECTION CYL 1/2/3/4: Amount of fuel added/subtracted for each injector to obtain the same performance from all cylinders and correct possible engine malfunctions.
Fuel COR CYL 3	FUEL CORRECTION CYL 1/2/3/4: Amount of fuel added/subtracted for each injector to obtain the same performance from all cylinders and correct possible engine malfunctions.
Fuel COR CYL 4	FUEL CORRECTION CYL 1/2/3/4: Amount of fuel added/subtracted for each injector to obtain the same performance from all cylinders and correct possible engine malfunctions.
TOTAL FUEL QTY	TOTAL FUEL QTY: Total overall quantity of Diesel fuel injected
Target fuel PRESS	TARGET FUEL PRESSURE: This is the pressure calculated by the control unit and estimated to occur in the high pressure fuel circuit.
Measured fuel PRESS	MEASURED FUEL PRESSURE: This is the pressure reading taken in the high pressure fuel circuit.
Fuel pressure AD/C	FUEL PRESSURE AD/C: Voltage reading at sensor output.
Press reg opng (MPROP)	PRESS REG OPNG (MPROP): Opening rate of pressure regulator fitted on the high pressure pump at the low pressure circuit end
Meas TURBO PRESS	MEASURED TURBOCHARGING PRESSURE: This is the pressure reading taken in the turbocharging circuit.
Turbo PRESS	TURBOCHARGING PRESSURE AD/C: Voltage reading at sensor

AD/C	output.
Engine oil pressure	
Target air mass	TARGET AIR MASS: Air quantity calculated by control unit according to sensor inputs.
Measured air mass	MEASURED AIR MASS: Quantity of air measured by air flow meter.
EGR control	
EGR valve opening	EGR VALVE OPENING: EGR valve opening rate dictated by ECU signal
Atmospheric pressure	ATMOSPHERIC PRESSURE: Pressure reading taken by sensor housed inside control unit
Air Temp (air flow meter)	AIR TEMP (AIR FLOW METER): Air temperature measurement taken by digital air flow meter
Air Temp (Turbo)	AIR TEMPERATURE (TURBO): Air temperature reading taken inside turbo sensor.
Air Temp AD/C (Turbo)	AIR TEMPERATURE AD/C: Voltage reading at air temperature sensor output.
Water temperature	WATER TEMPERATURE: Engine coolant temperature
Water Temp AD/C	WATER TEMPERATURE AD/C: Voltage reading at water temperature sensor output
Fuel temperature	FUEL TEMPERATURE: Fuel temperature inside Diesel fuel pump.
Fuel temperature AD/C	FUEL TEMPERATURE AD/C: Voltage reading at Diesel fuel temperature sensor output
Battery voltage	BATTERY VOLTAGE: Power supply voltage fed to control unit
Lambda sensor voltage	LAMBDA SENSOR VOLTAGE: Voltage at sensor expressed in milliVolts.
Lambda oxygen conc	LAMBDA OXYGEN CONC: Concentration rate . . of Lambda sensor, range is 0% to 21%.
Vehicle speed	VEHICLE SPEED: Vehicle speed.
Preheat ECU Diag	PREHEATING CONTROL UNIT DIAG: 'ON' means that the glow plug preheating control unit has cut in
Fuel pump relay command	FUEL PUMP RELAY COMMAND: State of Diesel fuel low pressure pump relay command
Fan speed	
Throttle SV opening	THROTTLE SV OPENING: Opening rate of throttle in intake duct (5% = throttle wide open, 95% = throttle closed)
Throttle state	
AC cut-in request	AC CUT-IN REQUEST: Request to switch on air condition compressor
AC relay command	AC RELAY COMMAND: State of air conditioner relay command from control unit.
AC PRESS	
Brake pedal state	BRAKE PEDAL STATE: Indicates whether brake pedal is 'Pressed or 'Released'.
Brake contact 2	BRAKE CONTACT 2: Brake pedal position detected by secondary contact of brake pedal.
Clutch pedal	CLUTCH PEDAL: Clutch pedal position.
Water in diesel filter	
Cruise control switch	CRUISE SWITCH: Possible states are 'On' and 'Off'; when set to 'On', it automatically maintains the cruising speed set by the driver.
Request from Cruise lever	REQUEST FROM CRUISE LEVER: Request triggered by cruise lever (None, Cruise Resume Button (RCL), Set Cruise deceler (-),Set Cruise

	deceler (+)
Target cruise speed	TARGET CRUISE SPEED: Reference speed used by cruise control for vehicle cruising speed
Irrev. Cruise error state	IRREV. CRUISE ERROR STATE: Covers all events leading to cruise control inhibition. To re-enable the cruise control, perform a 'Key Off' (STOP)-'Key On' (RUN) sequence and proceed to re-enable the cruise control.
Current gear	CURRENT GEAR: Gear currently in use
Fuel consumption	FUEL CONSUMPTION: Fuel consumption expressed in L/100KM
Fuel level indicator	FUEL LEVEL INDICATOR : Quantity of fuel in the tank.
Gearbox type fitted	GEARBOX TYPE FITTED: Type of gearbox used in the vehicle. A 'Not plausible' state indication may only occur when the engine control units of vehicles with different transmission types (manual/automatic) have been swapped
Injection control unit	INJECTION CONTROL UNIT: Indicates whether the injection control unit has been programmed
Engine start	ENGINE START: Indicates whether the injection control unit enables engine starting
Universal code	UNIVERSAL CODE: Indicates whether the injection control unit is receiving a universal code from the Electronic Key Control Unit/Body Computer
Max engine rpm	MAX ENGINE RPM: Maximum rpm reached by engine
Max rpm time counter	MAX RPM TIME COUNTER: Indicates how long engine kept running at maximum rpm
Overrev events	OVERREV EVENTS: Indicates how many times the engine overrevved.
Programming sessions	PROGRAMMING SESSIONS: Indicates how many times the control unit has been programmed.
Speed limitation	SPEED LIMITATION: Displays the vehicle speed limitation set in the control unit.
Speed LIM function	SPEED LIM FUNCTION: State 'LEARNT' indicates that proxi alignment was performed and the vehicle did not exceed the speed limit set in the Engine Control Unit.
Odometer	ODOMETER: Distance travelled by vehicle in km.
Odo count last time prog	ODOMETER COUNT LAST TIME PROGRAMMED: Odometer count when control unit was last programmed.

3.3..2 Error Section

Errors are divided into the following classes:
TRANSIENT: Error detected for a short time, namely too short to be classified as present
INTERMITTENT: Error no longer detected by the control unit but stored in the error memory.
PRESENT: Error is still detected by the control unit.

Pressing the 'Del. Errors' key deletes errors in the non-volatile memory.

In this system, the trouble code is displayed before the description in the ERROR environment.

P0016 - Timing/rpm synchronisation
P0053 - Lambda sensor resistance
P0090 - Fuel Press (regulator at HI press pump inlet)
P0091 - Fuel Press (regulator at HI press pump inlet)
P0092 - Fuel Press (regulator at HI press pump inlet)
P0093 - Fuel Press (regulator at HI press pump inlet)
P0094 - Fuel Press (regulator at HI press pump inlet)
P0095 - Air Temp sensor (inside turbo)
P0100 - Air flow meter

P0101 - Air flow meter signal
P010F - Air mass/air flow meter mismatch
P0110 - Air flow meter air temp signal
P0111 - Air flow meter air temp signal
P0115 - Water temperature sensor
P0116 - Water temperature sensor
P0120 - Accelerator pedal sensor 1
P0122 - Accelerator pedal connector
P0130 - Lambda sensor electrical diagnosis
P0135 - Lambda sensor electrical diagnosis
P0168 - Limit for high fuel temp
P0180 - Fuel temperature sensor
P0190 - Fuel high pressure sensor
P0191 - Fuel pressure signal
P0201 - Cylinder 1 injector
P0202 - Cylinder 2 injector
P0203 - Cylinder 3 injector
P0204 - Cylinder 4 injector
P0216 - Injection time
P0219 - High engine rpm
P0220 - Accelerator pedal sensor 2
P0230 - Fuel pump relay command
P0234 - Turbocharging pressure
P0235 - Turbocharging pressure sensor
P0262 - Cylinder 1 injector
P0265 - Cylinder 2 injector
P0268 - Cylinder 3 injector
P0271 - Cylinder 4 injector
P0335 - Engine rpm sensor
P0340 - Timing sensor
P0380 - Preheating unit command
P0401 - EGR valve
P0402 - EGR valve
P0403 - EGR valve
P0480 - Fan 1 or PWM
P0481 - Cooling fan command 2
P0482 - Cooling fan command 3
P0500 - Vehicle speed signal (CAN)
P0504 - Brake switch
P0520 - Oil pressure switch
P0530 - Air conditioner pressure sensor
P0560 - Battery voltage
P0564 - Cruise control (irreversible cut-off)
P0579 - Cruise cut-in commands
P0601 - ECU faulty (EEPROM)
P0606 - ECU faulty (Microprocessor)
P060A - Monitoring interrupted during initialisation
P060B - Adc control
P0611 - Injection control
P061B - ECU calibration
P061C - Shut-off control
P062D - ECU faulty (injector control)
P062E - ECU faulty (injector control)
P0638 - Throttle valve command
P0641 - Sensor power supply 1
P0645 - AC relay command
P0651 - Sensor power supply 2
P0683 - Preheating control unit (feedback)
P0685 - Main relay
P0697 - Sensor power supply 3
P0700 - Request to turn on MIL from AT
P0704 - Clutch switch
P0748 - Fuel Press reg (at HI press pump inlet)
P1131 - Upstream Lambda 1 signal (plausibility)
P1132 - Upstream Lambda 1 signal (plausibility)

P1140 - Lambda sensor
P1205 - Particulate filter
P1206 - Particulate filter
P1218 - ECU faulty (HW recovery)
P1219 - Regeneration time too long
P1301 - Injector registration
P1605 - ECU faulty (HW CY310)
P1606 - ECU faulty (communication)
P1607 - Lambda sensor control circuit
P1611 - Lambda sensor control circuit
P1618 - ECU faulty (HW CY940)
P1619 - ECU faulty (HW CY940)
P1623 - ECU faulty (BUS com)
P2084 - Temp snsr at particulate filter inlet
P2085 - Temp snsr at particulate filter inlet
P2135 - Accelerator pedal power (plausibility)
P2146 - Group 1 injector command
P2148 - Group 1 injector command
P2149 - Group 2 injector command
P2151 - Group 2 injector command
P2226 - Atmospheric press sensor
P2231 - Lambda sensor resistance
P2243 - Lambda sensor electrical diagnosis
P2264 - Water in fuel filter sensor
P2299 - Accelerator brake plausibility
P2452 - Differential pressure sensor
P2453 - Differential pressure sensor signal
P2455 - Differential pressure sensor
P2505 - Key input
2626 - Lambda sensor electrical diagnosis
P2A00 - Lambda sensor
U1601 - C-CAN line error
U1700 - CAN network (NCM - NBC)
U1706 - CAN network (NCM - NFR)
U1711 - CAN network (NCM - NCA)
U0426 - Electronic key
P0102 - Air flow meter adapt offset presetting
P0103 - Air flow meter adapt offset
P0104 - Air flow meter adapt offset (engine idling)
P0105 - Air flow meter adapt offset (engine under loading)
P011A - Water temperature sensor
P0336 - Rpm sensor (phonic wheel)
P250A - Engine oil level sensor
P0089 - Fuel Press (regulator at HI press pump inlet)
P1303 - Speed limitation
P1304 - Speed limitation

3.3.3 Active diagnosis displayed with the examiner

DESCRIPTION	HELP
CODE CARD START	Lets you start the engine using the vehicle's Code Card in the event the Key or the Electronic Key Control Unit/Body computer (if fitted) is faulty.
	If the key is turned to STOP, the Code Card starting procedure will have to be repeated
FUEL PUMP RELAY	The Diesel fuel pump is operated for a few seconds. You should hear a hissing sound coming from the fuel fittings.
EGR VALVE ACTUATION	You should hear a clicking sound from the valve
FAN LOW SPEED ACTUATION	You should hear the fan running .
FAN HIGH SPEED ACTUATION	The cooling fan is operated at high speed for a few seconds
PREHEATING RELAY	The relay should keep clicking for a few seconds
AC RELAY ACTUATION	You should hear the compressor clutch engage repeatedly for about 10 seconds.
FUEL PRESS REG (HIGH PRESS PUMP INLET)	Operates the Diesel fuel pressure regulator several times NOTE: The Diesel fuel pressure regulator is installed on the high pressure pump (low pressure circuit end)
MALFUNCTION LAMP ACTUATION	The lamp flashes for a few seconds WARNING: In vehicles equipped with Body Computer, lamp actuation command is sent to the Body Computer, that physically actuates the lamp. However, the lamp not turning on DOES NOT indicate a Body Computer malfunction.
PREHEATING LAMP ACTUATION	The lamp flashes for a few seconds WARNING: In vehicles equipped with Body Computer, lamp actuation command is sent to the Body Computer, that physically actuates the lamp. However, the lamp not turning on DOES NOT indicate a Body Computer malfunction.
CRUISE LAMP	The lamp flashes for a few seconds WARNING: In vehicles equipped with Body Computer, lamp actuation command is sent to the Body Computer, that physically actuates the lamp. However, the lamp not turning on DOES NOT indicate a Body Computer malfunction.

WATER TEMPERATURE LAMP	The lamp flashes for a few seconds WARNING: In vehicles equipped with Body Computer, lamp actuation command is sent to the Body Computer, that physically actuates the lamp. However, the lamp not turning on DOES NOT indicate a Body Computer malfunction.
WATER IN FUEL FILTER LAMP	Check that the indicator light is flashing WARNING: In vehicles equipped with Body Computer, lamp actuation command is sent to the Body Computer, that physically actuates the lamp. However, the lamp not turning on DOES NOT indicate a Body Computer malfunction.
OIL PRESSURE LAMP ACTUATION	Check that the indicator light is flashing WARNING: In vehicles equipped with Body Computer, lamp actuation command is sent to the Body Computer, that physically actuates the lamp. However, the lamp not turning on DOES NOT indicate a Body Computer malfunction.
THROTTLE SOLENOID VALVE	You should hear a clicking sound from the valve
TEACH-IN RESET	This command resets the teach-in parameters (air conditioner and cruise control) stored in the control unit When the teach-in functions are reset, the state of parameters (available in the selection list) is updated as follows: - air conditioner presence is stored automatically upon switch-on - cruise control presence is stored automatically upon switch-on WARNING: Teach-in reset should only be used after swapping the ECUs of vehicles featuring different functions

3.3.4 Configurations displayed with the examiner

VIEW INJECTOR CODES	This command lets you view the injector codes stored in the control unit
	WARNING: On 4-cylinder vehicles (1.9 engine), parameter 'CYL 5 injector code' will read 'Not available'
CYL 1…..4 REPLACEMENT	This command lets you store the code of a new injector into the control unit
	If you replaced an injector, you must perform the 'Injector registration' procedure, i.e. enter the code stamped on the magnet of the new injector
INJECTOR REPLACEMENT (BANK)	This command lets you store the code of a new injector into the control unit
	The 'Injector replacement (bank)' procedure must be used when you replace all injectors.

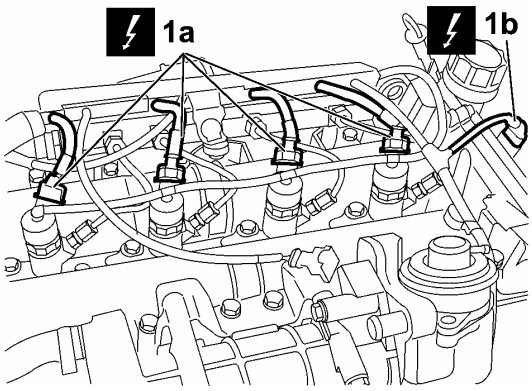
CONTROL UNIT REPLACEMENT	WARNING: This procedure should be carried out: - when the control unit has been replaced This procedure is aimed at reducing engine noise and enhancing compliance with emission regulations. This command stores the injector codes (when the injectors were not replaced) into the control unit and resets the following parameters: - Pilot injection fuel amount correction (to compensate for injector ageing) - Main injection fuel amount correction (dependant on Lambda sensor reading)
CONTROL UNIT AND INJECTOR(S) REPLACEMENT	WARNING: This procedure should be carried out: - when the control unit and one or more injectors have been replaced This procedure is aimed at reducing engine noise and enhancing compliance with emission regulations. This command stores the code of the new injector(s) into the control unit and resets the following parameters: - Pilot injection fuel amount correction (to compensate for injector ageing) - Main injection fuel amount correction (dependant on Lambda sensor reading)
RAIL PRESSURE SENSOR REPLACEMENT	WARNING: This procedure should be carried out: - when the rail pressure sensor has been replaced This procedure is aimed at reducing engine noise and enhancing compliance with emission regulations. This command resets the following parameters stored in the control unit: - Pilot injection fuel amount correction (to compensate for injector ageing) - Main injection fuel amount correction (dependant on Lambda sensor reading)
RAIL PRESSURE SENSOR AND INJECTOR(S) REPLACEMENT	WARNING: This procedure should be carried out: - when the rail pressure sensor has been replaced This procedure is aimed at reducing engine noise and enhancing compliance with emission regulations. This command stores the code of the new injector(s) into the control unit and resets the following parameters: - Pilot injection fuel amount correction (to compensate for injector ageing) - Main injection fuel amount correction (dependant on Lambda sensor reading)
LAMBDA SENSOR REPLACEMENT (ONLY FOR VERSIONS WITH LAMBDA SENSOR)	WARNING: This procedure should be carried out: - when the Lambda sensor has been replaced This procedure is aimed at enhancing compliance with emission regulations. This command resets all fuel correction values for the main injection stored in the control unit for the different Lambda sensor readings.
AIR FLOW METER REPLACEMENT (ONLY FOR VERSIONS WITH LAMBDA SENSOR)	WARNING: This procedure should be carried out: - when the air flow meter has been replaced This procedure is aimed at enhancing compliance with emission regulations. This command resets all fuel correction values for the main injection stored in the control unit for the different Lambda sensor readings.

3.4 PROCEDURES

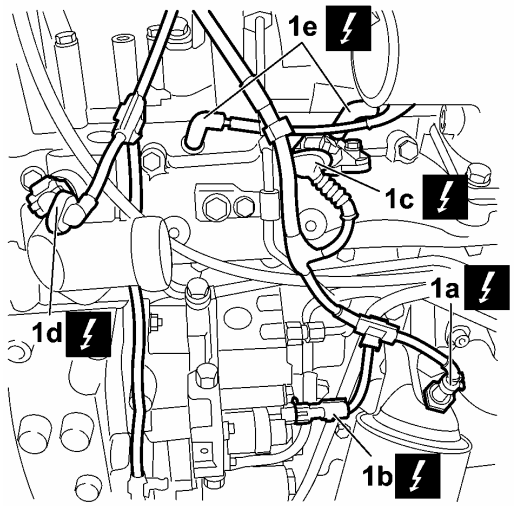
3.4.1 Engine removed - removal of head/and cylinders and oil sump for inspection, includes placement on stand and removal

1. Disconnect the wiring connections of engine rpm sensor (1a), engine oil level sensor (1b) and alternator (1c).

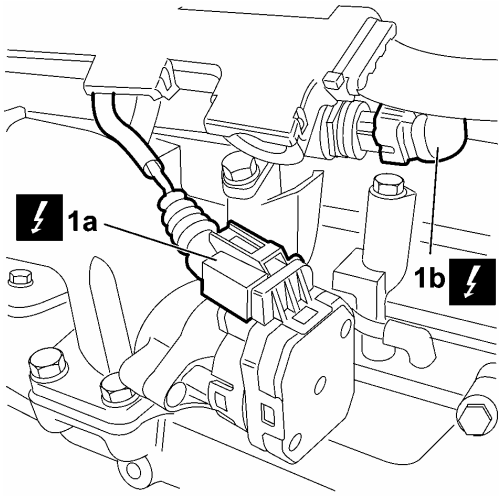
2. Disconnect the wiring connections of electro-injectors (1a) and timing sensor (1b).



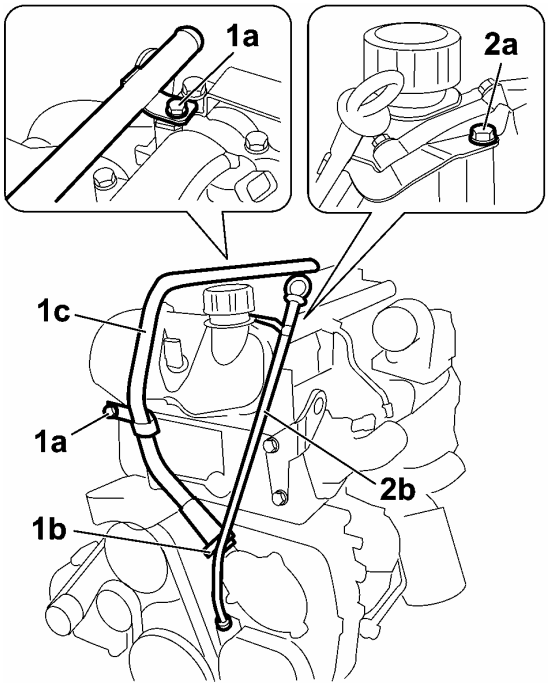
3. Disconnect the wiring connections of engine oil pressure sensor (1a), fuel pressure regulator (1b), air temperature / pressure sensor (1c), engine coolant temperature sensor (1d) and preheating glow plugs (1e).



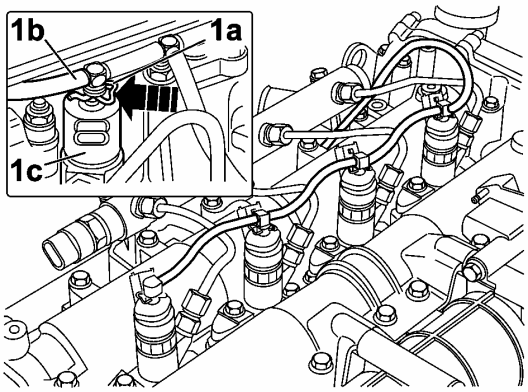
4. Disconnect the wiring connections of throttle body actuator (1a) and fuel pressure sensor (1b).
5. Release wiring harness from its retainers and remove.



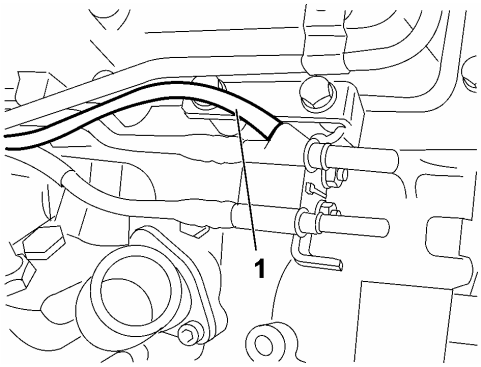
6. Unscrew the retaining screws (1a), remove the clamp (1b), disconnect and remove the oil vapour recovery pipe (1c).
7. Unscrew the retaining screw (2a) and remove the engine oil dipstick (2b).



8. Press the retaining clips (1a) in the direction shown by the arrow and disconnect the fuel recovery pipes (1b) from the electro-injectors (1c).

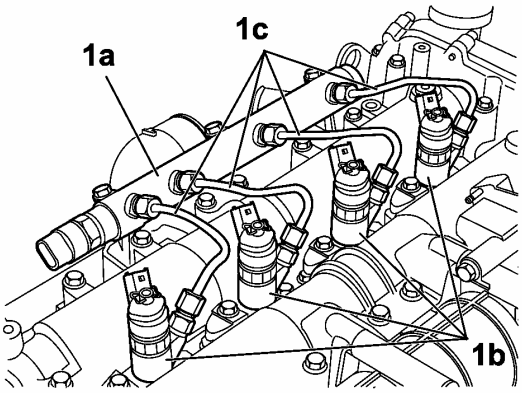


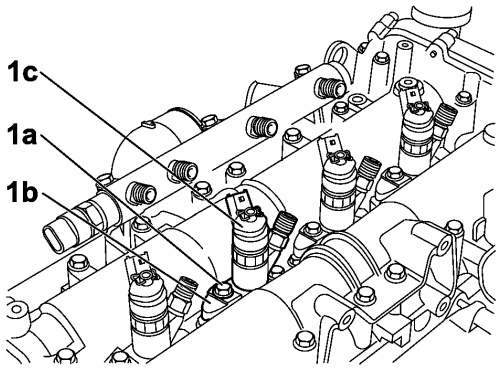
9. Detach the fuel recovery pipe (1) from the fitting and remove it.



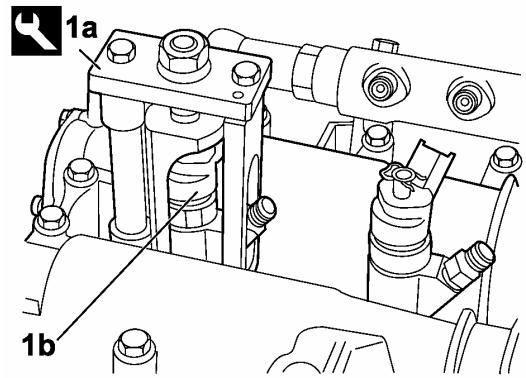
10 Loosen the retaining screws of the fuel collector pipe and of the electro-injector retaining brackets.

11. Unscrew the fittings on the fuel collector pipe (1a) and on the electro-injectors (1b); remove the fuel pipes (1c).

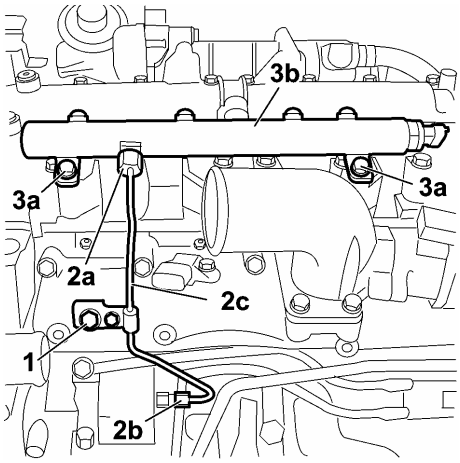




12. Install tool 99342153 (1a) and extract the electro-injectors (1b).

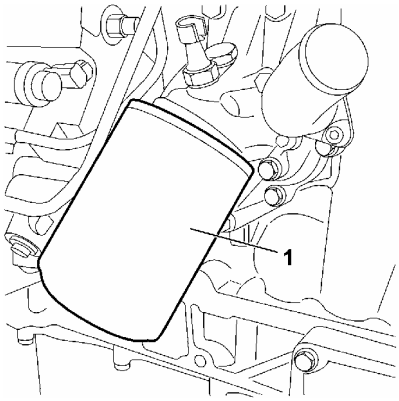


13. Unscrew the retaining screw of the fuel delivery pipe.
14. Unscrew fittings (2a) on the fuel collector pipe and (2b) on the high pressure pump and remove the fuel delivery pipe (2c).
15. Remove the screws (3a) and the fuel collector pipe (3b).

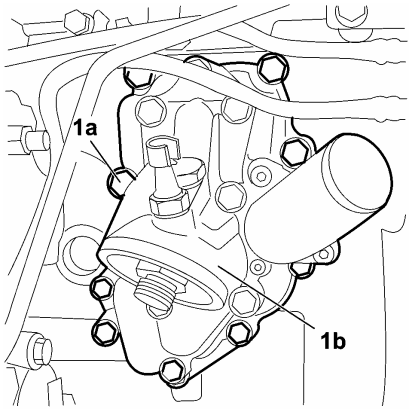


16. Remove the screws (1a) and the retaining brackets (1b) of the electro-injectors (1c).

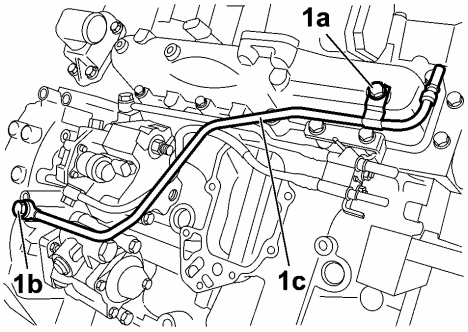
17. Use a suitable tool to unscrew and remove the engine oil filter (1).



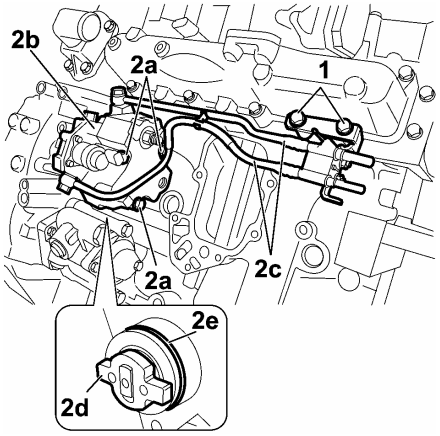
18. Unscrew the retaining screws (1a) and remove the water-oil heat exchanger (1b) along with its gasket.



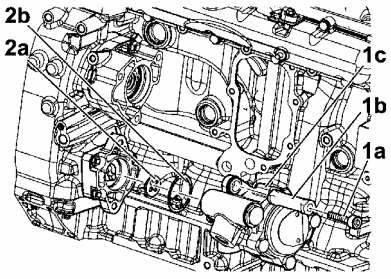
19. Unscrew the retaining screw (1a) at the intake manifold end and the fitting (1b), and then remove the vacuum pipe (1c).



20. Unscrew the retaining screws of the retaining bracket for the fuel low pressure pipes.
21. Unscrew the retaining screws (2a), remove the spacers and the high pressure fuel pump (2b) along with the low pressure pipes (2c); collect the coupling (2d) and remove the seal (2e).

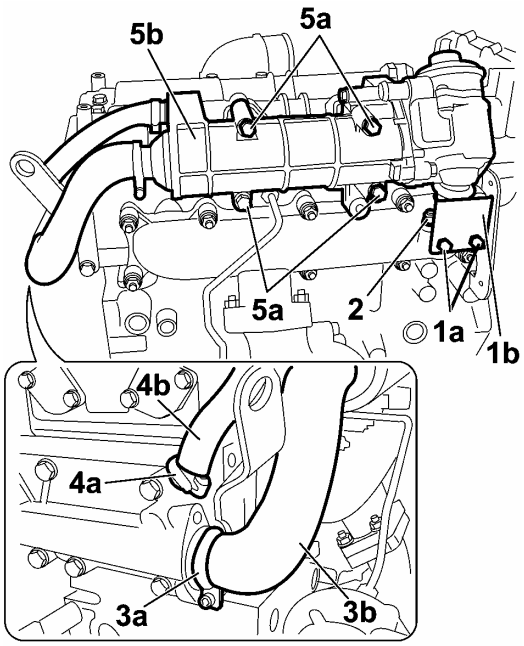


22. Unscrew the retaining screws (1a) and remove spacers (1b) and power steering pump (1c).
23. Collect the coupling (2a) and remove the seal (2b).

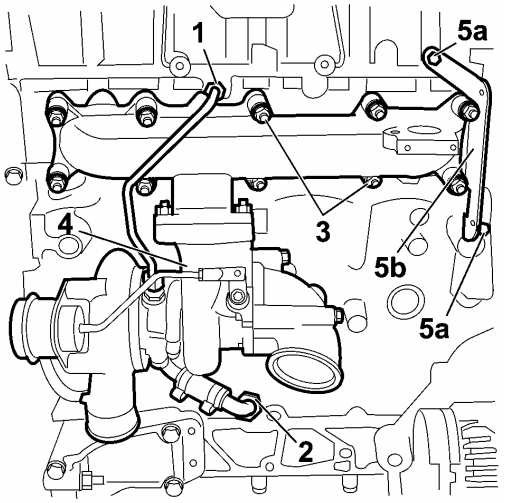


24. Unscrew the retaining screws (1a) and remove the guard (1b).
25. Unscrew the screws retaining EGR valve pipe to exhaust manifold.
26. Unscrew the retaining screw and loosen collar (3a), disconnect the pipe (3b) and collect the gasket.
27. Remove the clamp (4a) and disconnect the water pipe (4b).
28. Unscrew the retaining screws (5a) and remove the EGR heat exchanger (5b) along with valve and pipes.

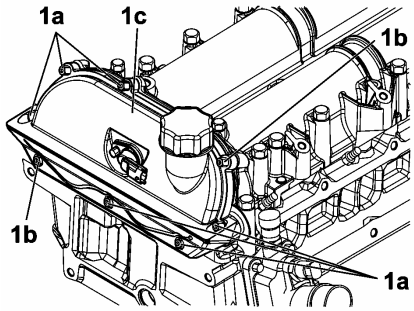
***NOTE**: Collect the gasket at the exhaust manifold end.*



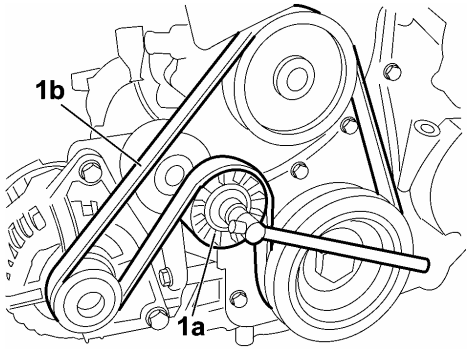
29. Unscrew the oil delivery fitting (delivery from cylinder head to turbocharger).
30. Unscrew the oil return fitting (return from crankcase to turbocharger).
31. Unscrew the retaining nuts and collect the spacers.
32. Remove the exhaust manifold-and-turbocharger assembly and collect the gasket.
33. Unscrew the retaining screws (5a) and remove the bracket (5b).



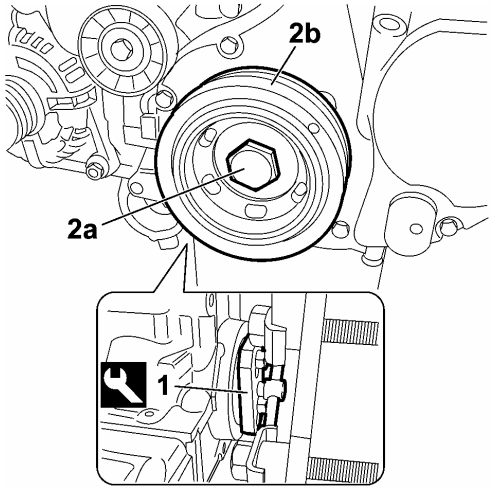
34. Unscrew the retaining screws (1a) and nuts (1b) and remove the upper timing cover (1c).



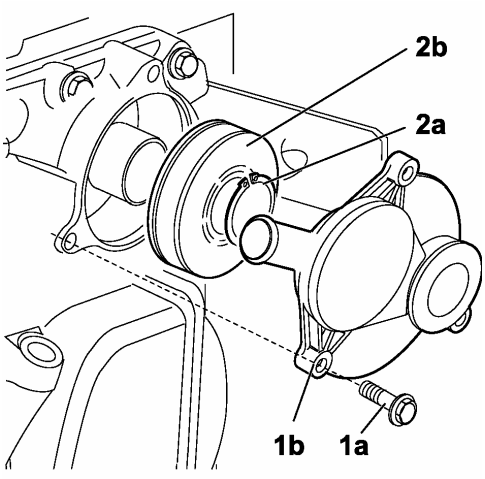
35. Work the automatic belt tensioner (1a) with a suitable key so as to slacken the auxiliary drive belt (1b) and remove the belt.



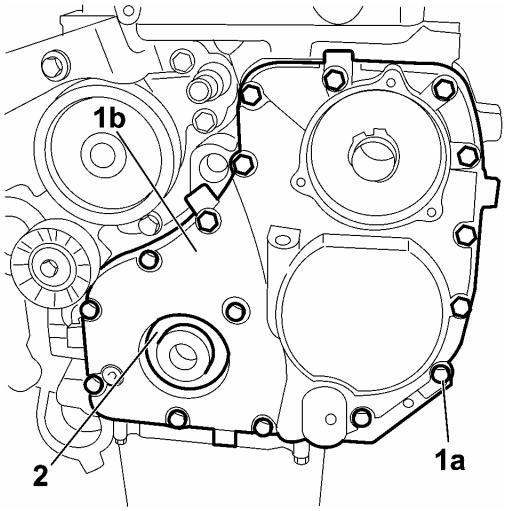
36. Fit tool 1.860.815.000 to the crankshaft (1).
37. Unscrew the retaining screw (2a) and remove the auxiliary drive belt pulley (2b).



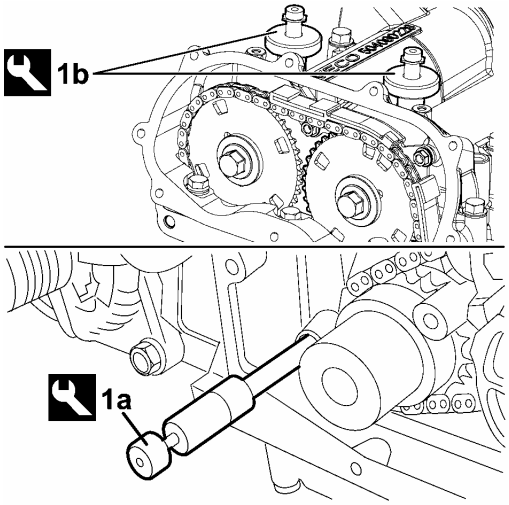
38. Unscrew the retaining screws (1a) and remove the oil vapour separator (1b).
39. Remove the circlip (2a) and extract the centrifugal filter (2b).



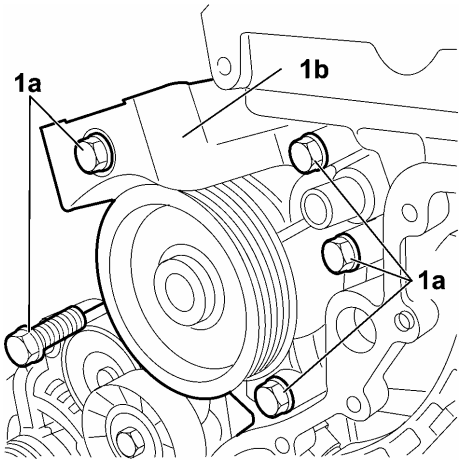
40. Unscrew the retaining screws (1a) and remove the lower timing cover (1b) along with its gasket.
41. Remove the front crankshaft oil seal.



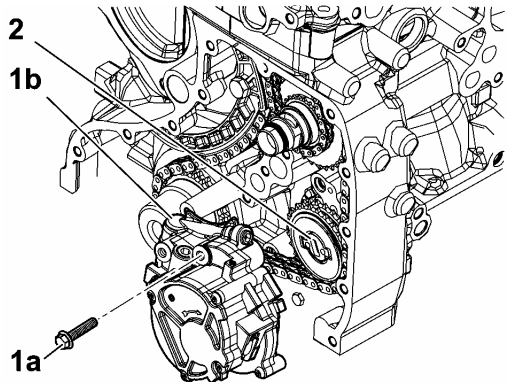
42. Rotate the crankshaft and install the crankshaft timing tools 99360615 (1a) and the camshaft timing tool 99360614 (1b)



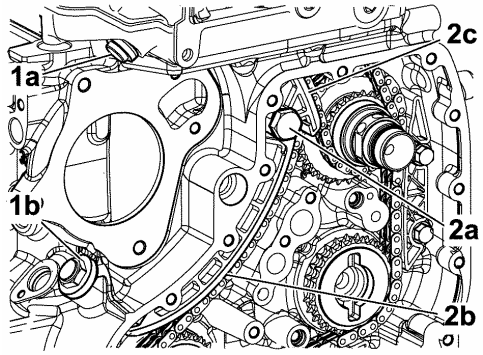
43. Unscrew the retaining screws (1a) and remove water pump/rigid engine mount (1b).



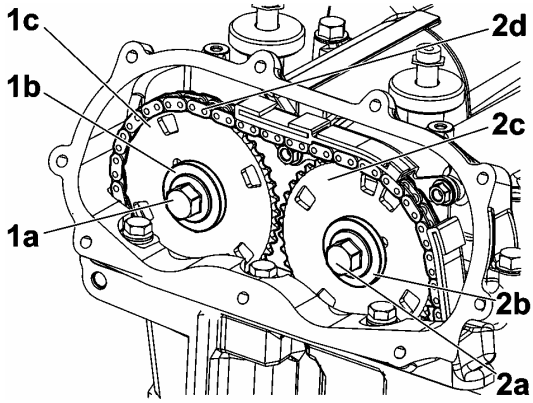
44. Unscrew the retaining screws (1a) and remove the oil pump–vacuum pump assembly (1b).
45. Remove the key (2).



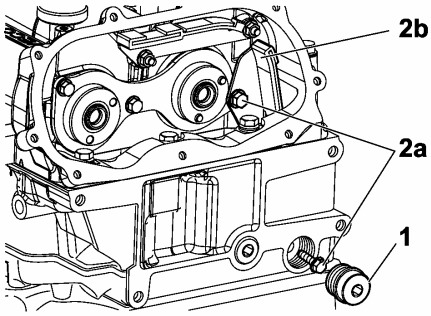
46. Unscrew and remove the upper (1a) and lower (1b) hydraulic chain tensioners.
47. Unscrew the retaining pin (2a) and remove the lower (2b) and upper sliding shoe (2c).
***NOTE**: The upper hydraulic chain tensioner is equipped with a backstop and must be replaced after each removal*



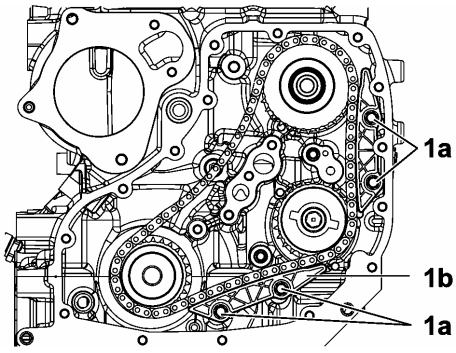
48. Unscrew the retaining screw (1a), collect the washer (1b) and remove the gear (1c).
49. Unscrew the retaining screw (2a), collect the washer (2b) and remove gear (2c) and upper timing chain (2d).



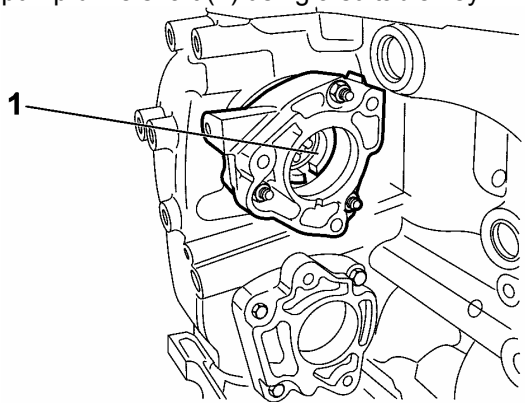
50. Unscrew and remove the plug (1).
51. Unscrew the retaining screws (2a) and remove the fixed upper sliding shoe (2b).



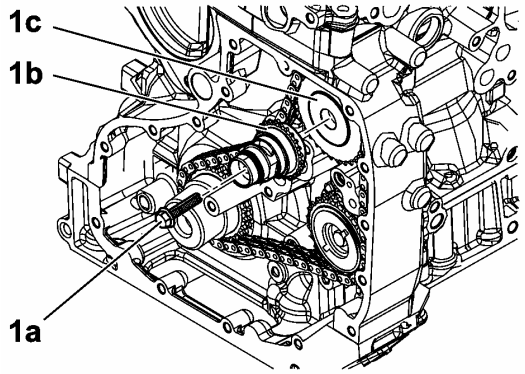
52. Unscrew the retaining screws (1a) and remove the fixed sliding shoes (1b).



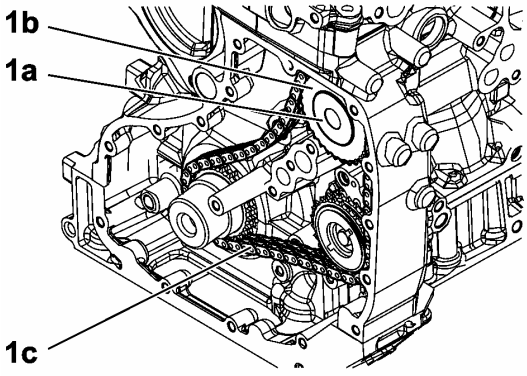
53. Lock out rotation of the high pressure pump drive shaft (1) using a suitable key.



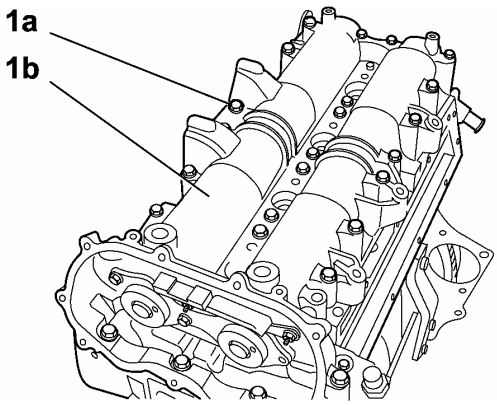
54. Unscrew the retaining screw (1a) and separate the shaft along with the drive gear of the oil pump-vacuum pump assembly (1b) from the high pressure drive shaft (1c).



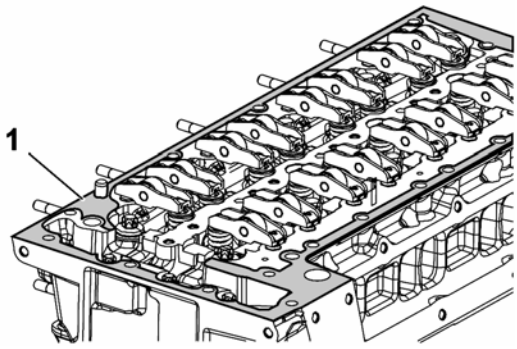
55. Remove gear (1b) and lower timing chain (1c) from the high pressure pump drive shaft (1a).



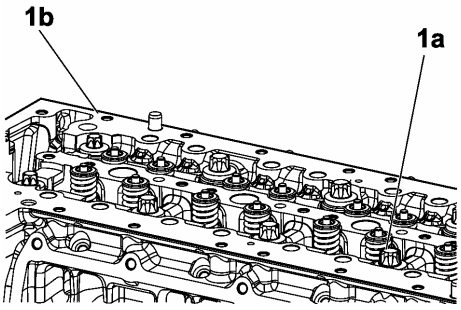
56. Unscrew the retaining screws (1a) and remove the upper head section (1b).



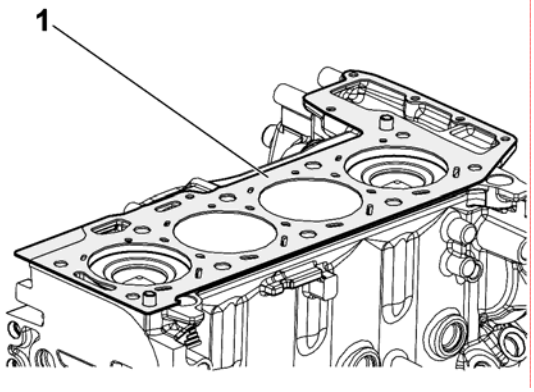
57. Remove the upper head gasket (1).



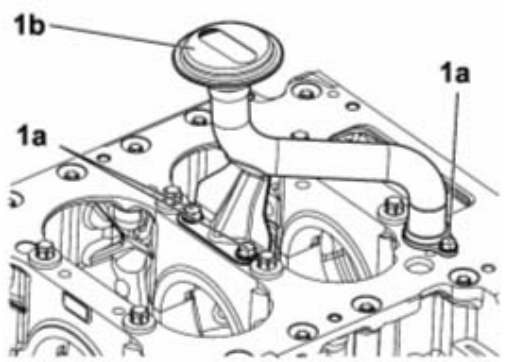
58. Unscrew the retaining screws (1a) and remove the cylinder head (1b).



59. Remove the cylinder head gasket.

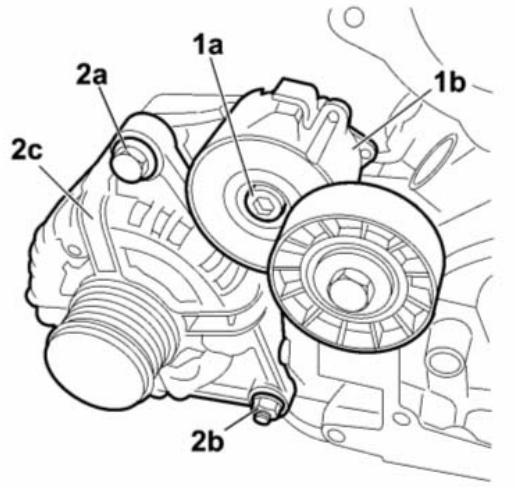


60. Unscrew the retaining screws (1a) and remove the engine oil suction funnel (1b).

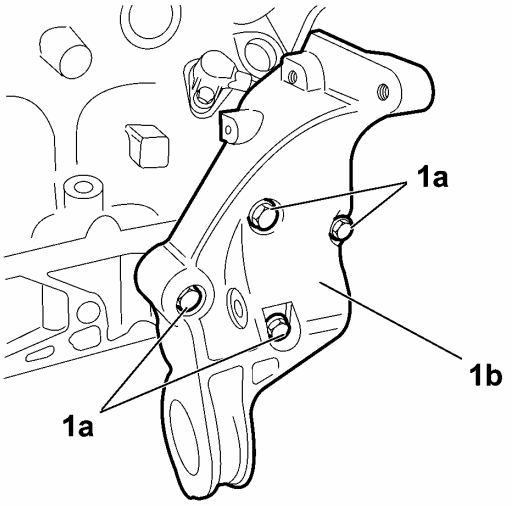


3.4.2 Engine - Reassembly. Washing and inspecting removed parts - Cylinder head and oil sump installation - Does not include procedures for cylinder head and auxiliary drive assembly

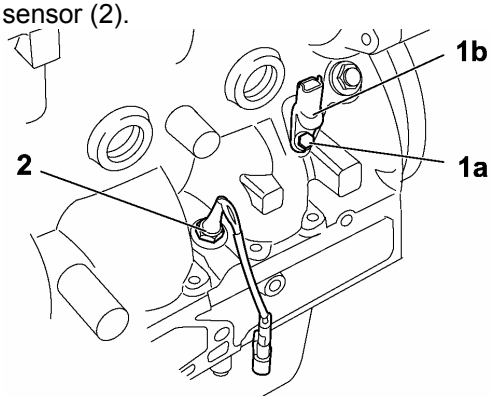
1. Unscrew the retaining screw (1a) and remove the automatic tensioner (1b) of the auxiliary drive belt pulley.
2. Unscrew the screw (2a) and the retaining bolt (2b) and remove the alternator (2c).



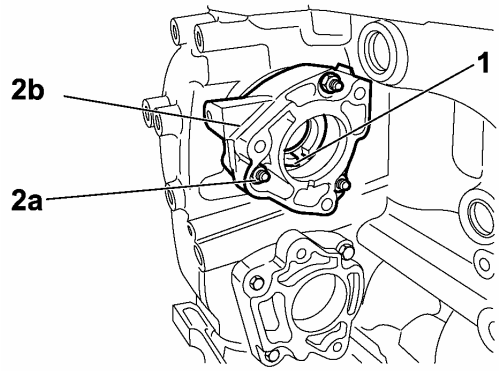
3. Unscrew the retaining screws (1a) and remove the alternator / intermediate shaft mount (1b).



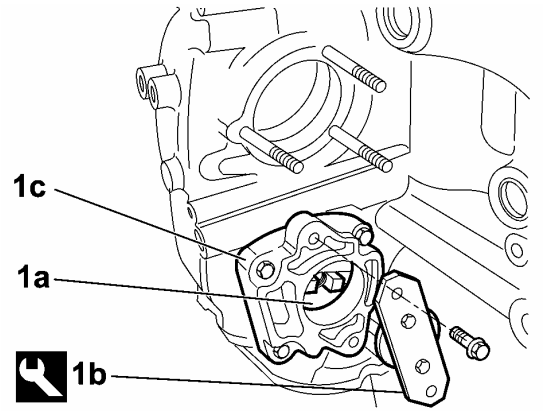
4. Unscrew the retaining screw (1a) and remove the rpm sensor (1b).
5. Unscrew and remove the engine oil level sensor (2).



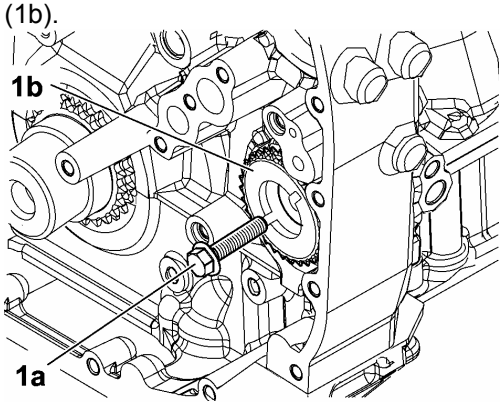
6. Remove the fuel high pressure pump drive shaft (1).
7. Unscrew the retaining nuts (2a) and remove the fuel high pressure pump mount (2b).



8. Secure tool 99360187 (1b) to the power steering pump mount (1c) to lock out rotation of the power steering drive shaft (1a).

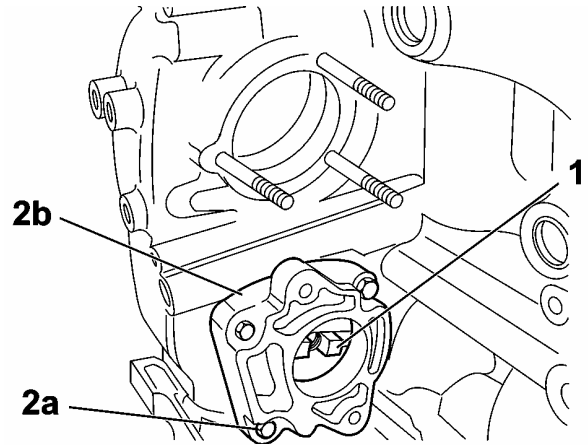


9. Unscrew the retaining screw (1a) and remove the power steering pump shaft gear (1b).



10. Unscrew the retaining screw and remove the tool you used to lock the power steering pump shaft.

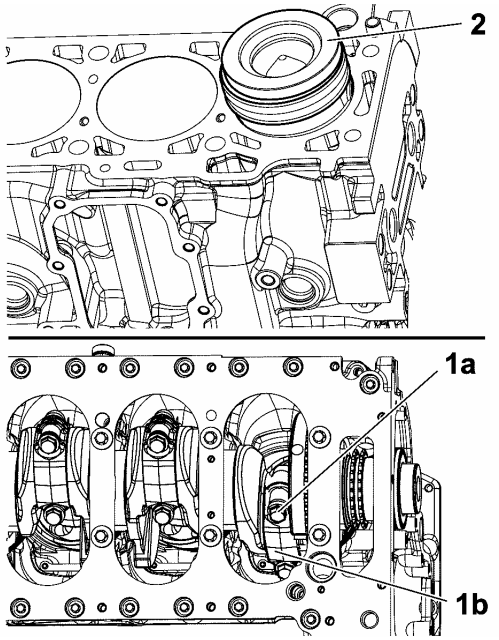
11. Remove the power steering pump drive shaft (1).
12. Unscrew the retaining nuts (2a) and remove the power steering pump mount (2b).



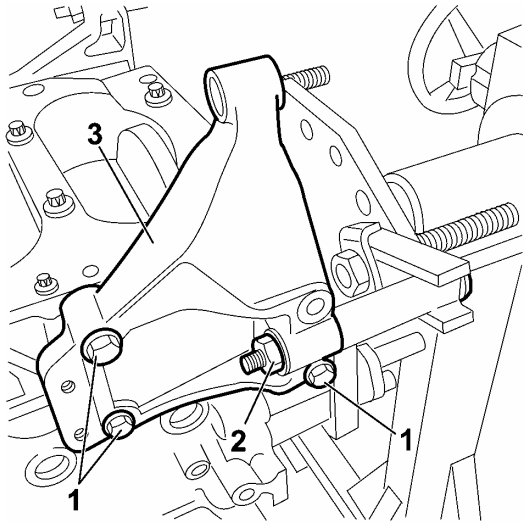
13. Rotate the crankshaft until bringing pistons no. 1 and 4 close to BDC.
14. Unscrew the retaining screws (1a) and remove the con rod caps (1b) of pistons 1 and 4 and their bearings.

15. Withdraw pistons no. 1 and 4 (2) along with the connecting rods and bearings.
- Follow the same procedure to remove pistons no. 2 and 3 and their con rod caps, connecting rods and con rod bearings.

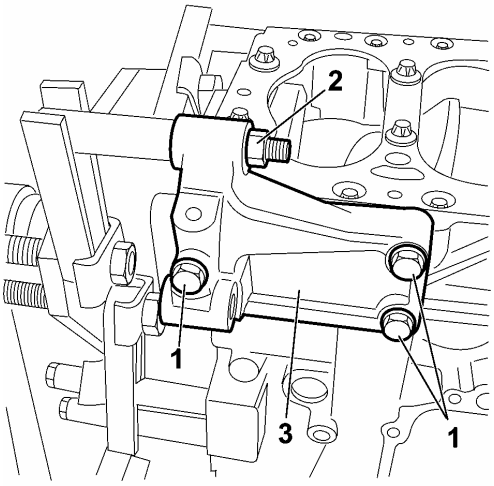
***NOTE**: Mark connecting rods and con rod caps with the number of the cylinder they were removed from and their relative mounting positions; keep the con rod bearings in their housings. If reused, all components must be refitted in their original positions.*



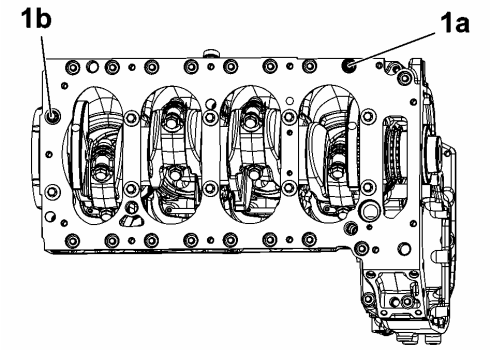
16. Rotate the service stand.
17. Unscrew the screws retaining the rear engine mount (1) to the lower engine block.
18. Unscrew the nut retaining the rear engine mount (2) to the service stand.
19. Remove the rear engine mount (3).



20. Unscrew the screws retaining the front engine mount (1) to the lower engine block.
21. Unscrew the nut (2) retaining the front engine mount to the service stand.
22. Remove the front engine mount (3).

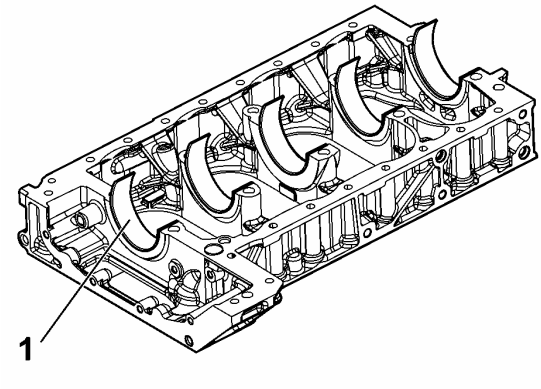


23. Unscrew the retaining screws (1a) and (1b) and remove the lower block.



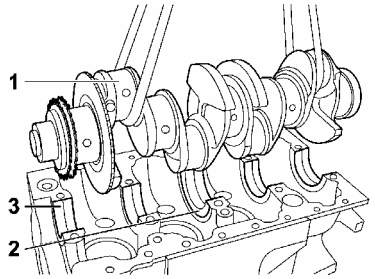
24. Remove the lower main bearings (1).

***NOTE**: Mark the main bearings with their mounting positions; if reused, all bearings must be refitted in their original positions.*

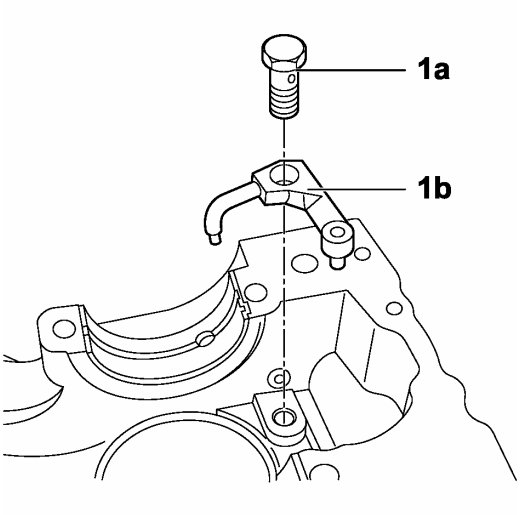


25. Remove the crankshaft (1) from the lower block. You will need a hydraulic hoist or an assistant.
26. Remove the upper main bearing (2) and the thrust half-rings.
27. Remove the upper main bearings (3).

***NOTE**: Mark the main bearings with their mounting positions; if reused, all bearings must be refitted in their original positions.*



28. Unscrew the fittings (1a) and remove the piston cooling jets (1b).



- Remove the water/oil sealing plugs from the engine crankcase using suitable tools.
- Unscrew the retaining screws and remove the crankcase from the service stand.

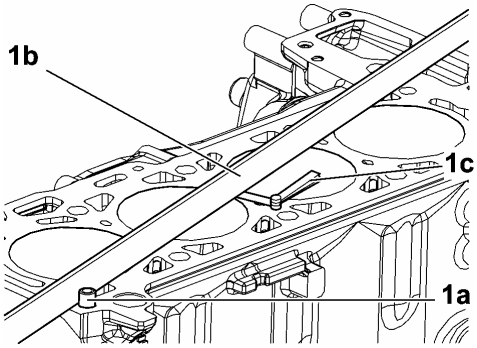
Installation

- Thoroughly clean all parts you have removed and inspect their condition.
- Fit the water/oil sealing plugs - smeared with LOCTITE 270 sealant - to the engine crankcase using suitable tools.
- Lubricate all mechanical mating parts with engine oil.

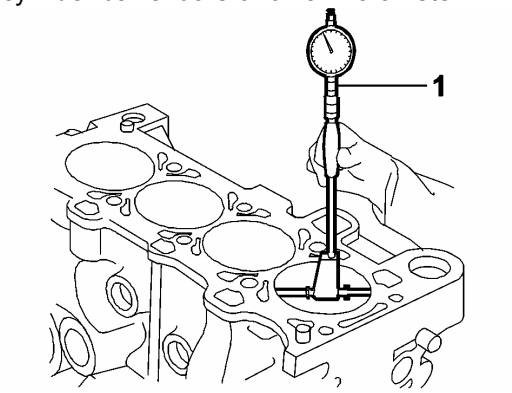
WARNING: *On refitting, always renew the following components: snap rings and circlips, seals and gaskets, and the screws with the threads coated with sealant.*

1. Inspect the head mating face of the cylinder assembly for distortion; you may use a calibrated ruler (1b) and a feeler gauge (1c) (remove the centring dowels (1a) first).
- If you find any distortion, grind the mating face.

NOTE*: Before grinding the crankcase, make sure that piston height over cylinder barrel and the difference in height among the four pistons will not exceed the specified values after grinding.*
Piston height over crankcase (mm): 0.3 ÷ 0.6
Difference in height over crankcase among the four pistons
(mm) ≤ 0.15

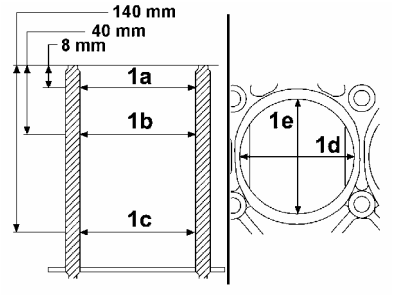


2. Inspect the cylinders: check barrel surface for signs of seizure, scoring, oval and exceeding wear.
3. To check cylinder barrel inner diameter and measure oval, taper and wear, use a bore gauge (1) with a dial gauge you will have set to zero on the ring gauge of the cylinder barrel bore or on a micrometer.

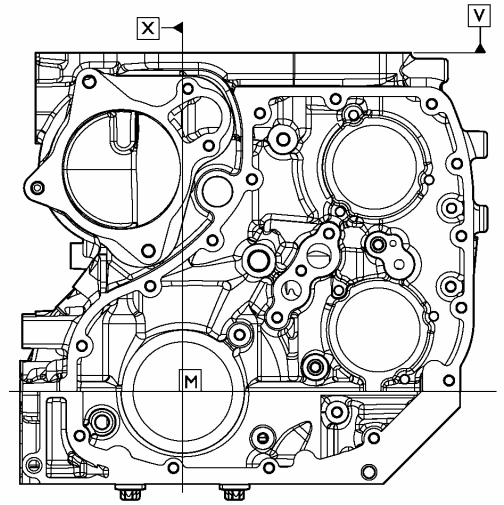


4. Check the inside diameter of each individual cylinder at three different heights (1a), (1b) and (1c) on two planes at right angles to each other: one plane should be parallel to engine longitudinal axis (1d), the other should be at right angles to it (1e); the worst wear is normally found on the latter plane and in the first measurement.
- If you find any oval, taper or wear, bore/grind and plateau hone the barrels.

NOTE*: When regrinding the cylinder barrels, ensure to obtain the specified fit and clearance to the replacement pistons; spare pistons come with a 0.4 mm oversize with respect to nominal value.*



- The figure below shows the planes and reference axes for bore diameter measurements.



NOTE: Planes and reference axes are also shown in the figure above.

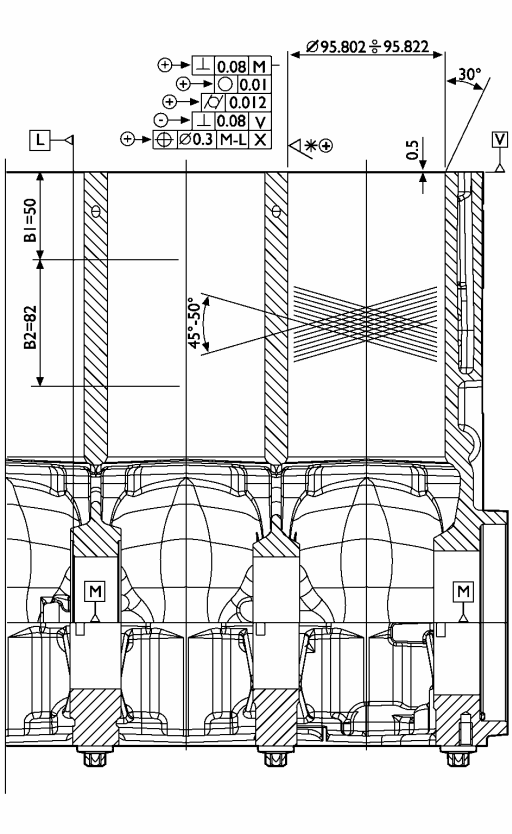
* Surface roughness parameters:

R1 = 4 ÷ 10 µm
Rz = 3 ÷ 8 µm
Ra = 0.3 ÷ 0.6 µm
W1 < 2 µm

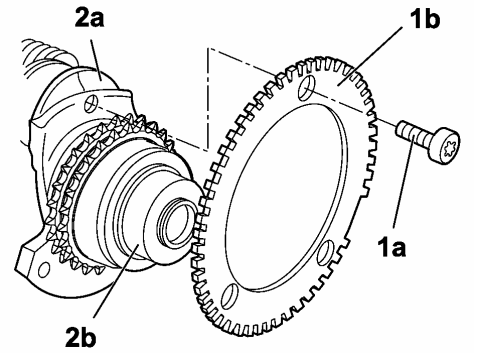
- Carefully check surface porosity after regrinding:

AREA B1= Area subjected to maximum mechanical stress (piston rings contact barrel), maximum porosity allowed: 2 non-continuous items max. 0.5 x 0.5

AREA B2= Area where piston rings rub against barrel, maximum porosity allowed: 2 non-continuous items max. 1 x 0.8

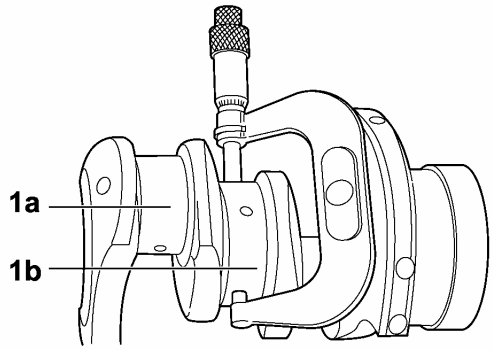


1. Unscrew the retaining screws (1a) and remove the phonic wheel (1b).
2. Remove the timing drive gear (2b) from the crankshaft (2a) using a suitable extractor.



- Check main journals and crank pins and grind them if you find any signs of seizure, scoring or exceeding oval.

1. Before grinding the crank pins (1a), measure the main journals (1b) with a micrometer to determine to what diameter the crank pins should be ground.



1. We recommend noting your measurements in a table as shown below:

- nominal diameter of main journals no. 1-2-3-4 (1a);
- nominal diameter of main journal no. 5 (1b);
- main journal diameter measurements (min-max) (1c);
- nominal diameter of crank pins (1d);
- crank pin diameter measurements (min-max) (1e).

Diameter of main journals no. 1-2-3-4 (mm)	76.182 ÷ 76.208
Diameter of main journal no. 5 (mm)	83.182 ÷ 83.208
Diameter of crank pins (mm)	64.015 ÷ 64.038

NOTE: Main journals and crank pins must always be ground to the same undersize class. Main journal or crank pin undersize must be marked on the side of the crank pin no. 1:
- Use letter M for undersize crank pins.
- Use letter B for undersize main journals.
- Use letters MB for undersize crank pins and main journals.

Main journal undersize (mm)	0,254 - 0,508
Crank pin undersize (mm)	0,254 - 0,508

- Measure crank pin and main journal oval.

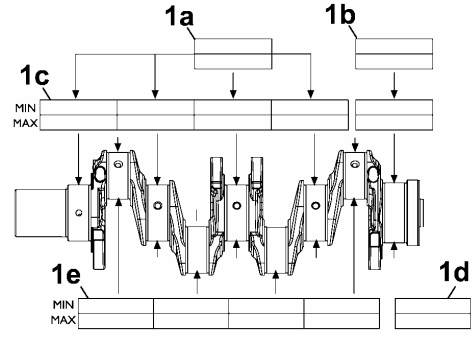
Main journal oval (mm)	0.006
Crank pin oval (mm)	0.006
Flywheel mounting flange oval (mm)	0.01

- Measure crank pin and main journal taper.

Main journal taper (mm)	0.007
Crank pin taper (mm)	0.007
Flywheel mounting flange taper (mm)	0.04

- Check the parallelism of crank pin surfaces.

Crank pin parallelism	0.017

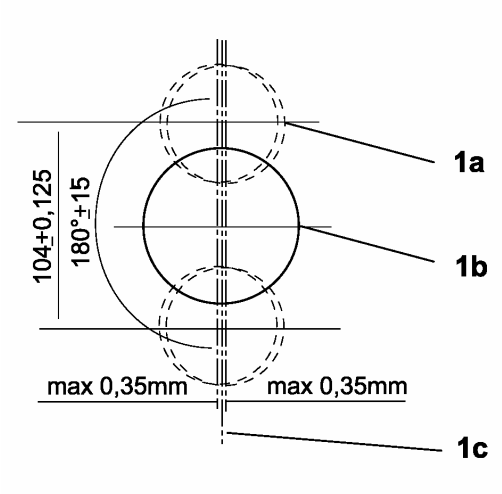


***NOTE:** If crankshaft journals need grinding, check the following tolerances after grinding.*

1. Check that the crank pins (1a) and main journals (1b) are symmetrical with respect to the nominal position (1c) of the main journals.

Crank pin symmetry (deviation from nominal position of main journal) (mm)	Max 0.35
Crank pin symmetry (distance between centres allowed) (mm)	104 ± 0.125
Crank pin symmetry (angle allowed)	180° ± 15

WARNING: *Round off the edges of main journal and crank pin lubrication holes.*



- Grinding the crank pins and main journals to an undersize may damage the rolled areas of their side grooves. Turn and roll the grooves to the following specifications:

- Rolling force: main journal no. 1 925 ±25 daN, main journals no. 2-3-4-5 1850 ±50 daN, crank pins 1850 ±50 daN.
- Rolling turns: 3 approach turns, 12 rolling turns, 3 exit turns.
- Rolling speed: 56 rpm.
- Reduction of crank pin groove diameter after rolling:
0.15 ÷ 0.30 mm.
- Reduction of main journal grooves after rolling 0.15 ÷ 0.30
mm.

Relief radius for crank pins and main journals (mm)	1.6 ÷ 1.7

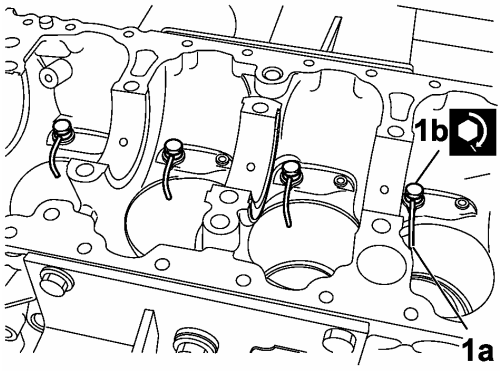
,

- Heat the timing drive gear up to 180ºC for 15 minutes maximum and install it on the crankshaft.
- Wait for the timing drive gear to cool down and perform a slip strength test.

15.0	Slip strength testing of timing drive gear on crankshaft

- Install the phonic wheel and tighten the retaining screw to **1.5 daN m**

1. Install the piston cooling jets (1a) and tighten the fittings (1b) to **2.5 daN m**.



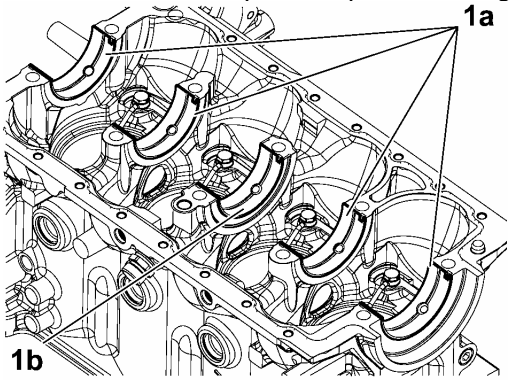
1. Clean the upper main bearings (1a) and (1b) thoroughly and place them in their original positions in the crankcase.

NOTE: *Replacement main bearings (1a) come with an undersize inner diameter.*

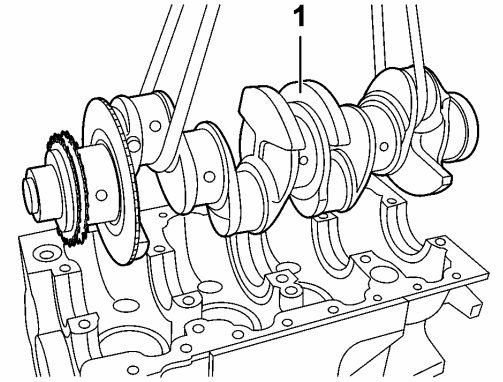
Main bearing undersize (mm)	0.254 - 0.508

NOTE: *The central main bearing (1b) has thrust rings.*

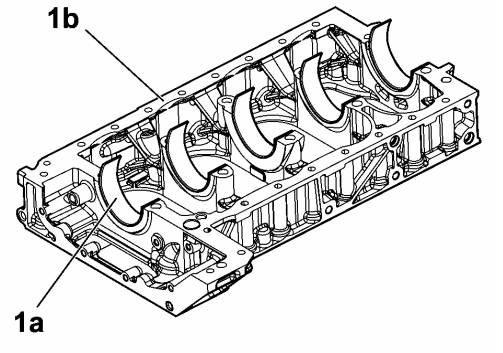
NOTE: *Do not attempt to adapt the bearings.*



1. Refit the crankshaft into place in the crankcase. You will need a hydraulic hoist or an assistant.



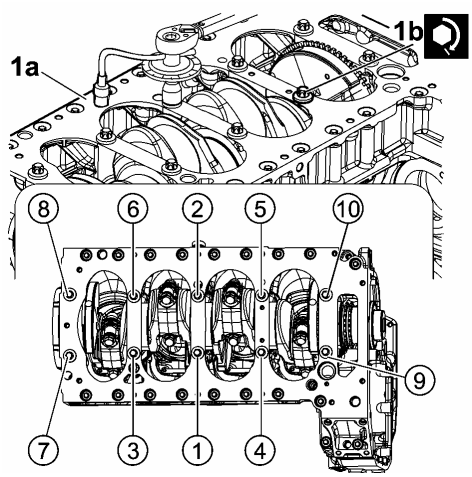
1. Clean the lower main bearings (1a) thoroughly and place them in their original positions in the lower block (1b).



- Position the calibrated wire (filagage) to measure clearances between main bearings and main journals.

1. Install the lower block (1a) and tighten the retaining screws (1b) to the specified torque.

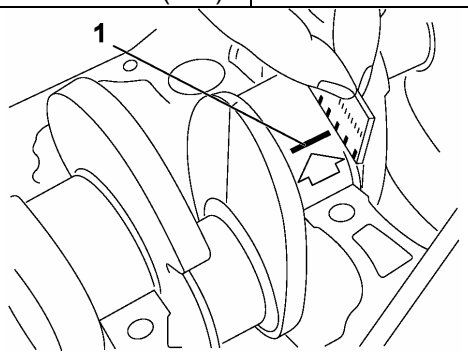
5.0 + 60° + 60°	Screw	Inside lower block
2.6	Screw	Outside lower block



- Unscrew the retaining screws and remove the lower block.

1. To determine the clearance between main bearing and main journal, compare the width of the squeezed calibrated wire at the position where it is thinnest with the scale included in the package. The marks on the calibrated scale indicate clearance (in millimetres). If clearance is not as specified, change the bearings and repeat the inspection.

Main bearings to main journal clearance (mm)	0.032 ÷ 0.102

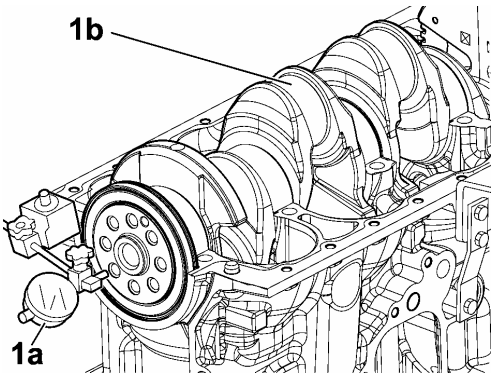


1. Measure crankshaft end float using a dial gauge with a magnetic base (1a) positioned on the crankshaft (1b) as shown in the figure.

Crankshaft end float (mm)	0.060 ÷ 0.310

- If end float is greater than specified, change the thrust main bearings and check clearance between main journals and main bearings again. If end float is still outside the specified range, replace the crankshaft.

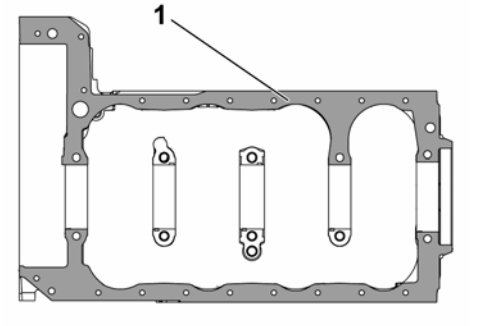
NOTE: *The thrust rings are integral with the central main bearing. The central main bearing comes in one standard size (including replacements).*



- Clean the mating faces of crankcase and lower block thoroughly.

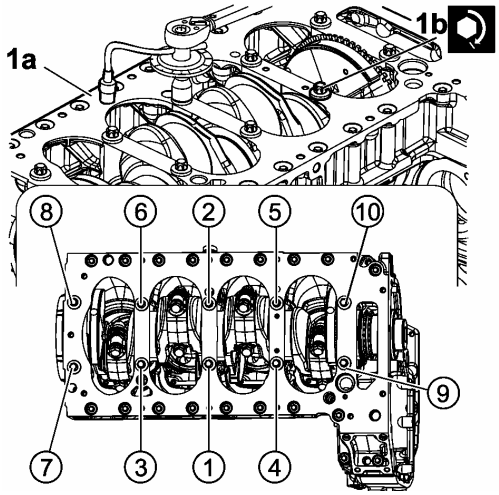
1. Apply LOCTITE 510 sealant to the crankcase as shown in the diagram, taking care to spread it evenly over the whole mating face.

NOTE: *Install the lower block within 10 minutes of applying the sealant.*

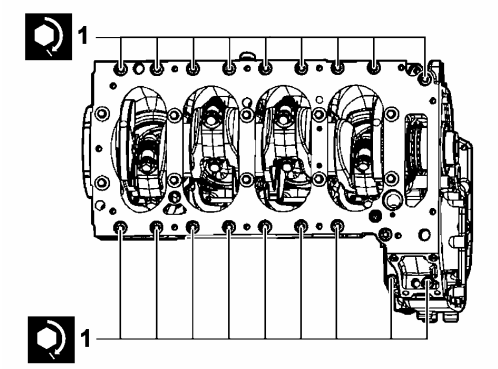


1. Install the lower block (1a) and tighten the retaining screws (1b) to the specified torque and in the specified order.

5.0 + 60° + 60°	Screw	Inside lower block

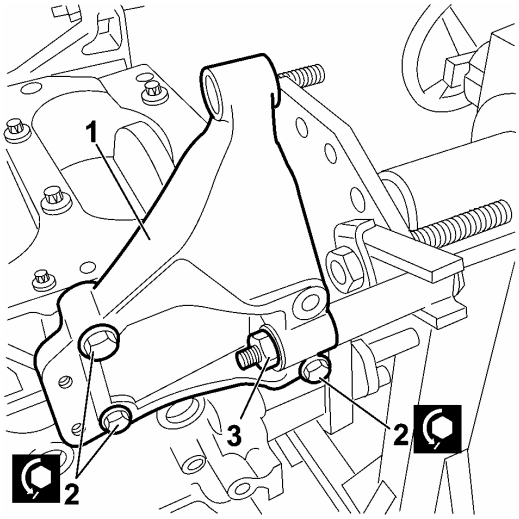


1. Tighten the outer retaining screws of the lower block to
2.6 daN m.



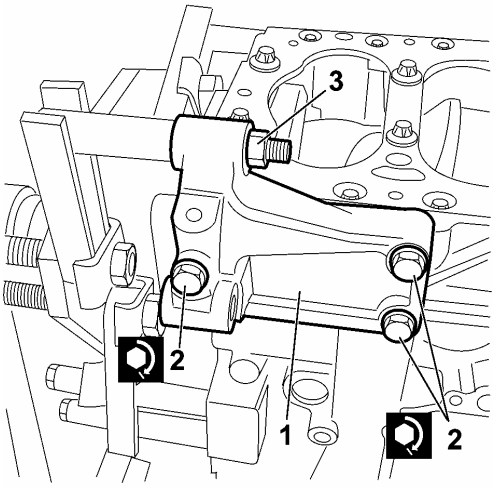
1. Install the rear engine mount and its centring pins.
2. Tighten the screws retaining the rear engine mount to the lower engine block to the specified torque.

3. Tighten the nut retaining the rear engine mount to the service stand.



1. Install the front engine mount and its centring pins.
2. Tighten the screws retaining the front engine mount to the lower engine block to the specified torque.

3. Tighten the nut retaining the front engine mount to the service stand.



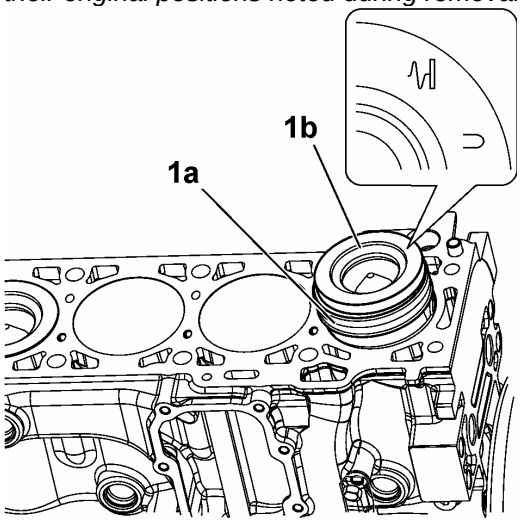
- Lubricate pistons, circlips and the inner bore of the cylinder barrels properly.
- Rotate the crankshaft until bringing the crank pins of pistons no. 1 and 4 close to BDC.

1. Using a piston ring compressor (1a), fit the connecting rod-and-piston assemblies (1b) into the cylinder barrels and ensure that:

- connecting rod number matches con rod cap number;
- piston ring end gaps are spaced 120° apart from one another;
- pistons are all the same weight;
- the symbol stamped on piston crown is pointing to engine flywheel; or the recess in piston skirt is located at the position of the oil squirts.

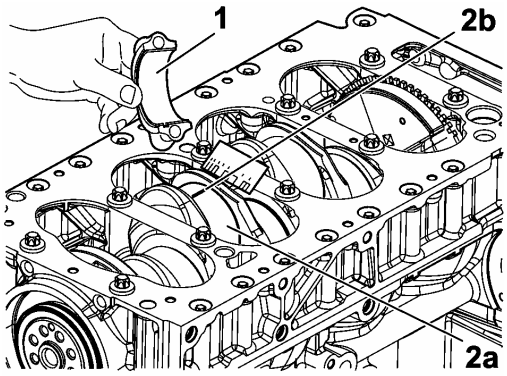
- Install the con rod caps of pistons no. 1 and 4 in the same order noted during removal and install the retaining screw, but do not tighten yet.
- Follow the same procedure to install pistons no. 2 and 3 and their con rod caps, connecting rods and con rod bearings.

NOTE: *If the con rod bearings do not need replacing, refit them in the same order and in their original positions noted during removal.*



1. Remove the con rod cap and clean crankshaft journal and con rod bearing thoroughly so as to remove any trace of oil.
2. Place a length of calibrated wire (2b) (filagage) on the crankshaft journal (2a).
- Fit the con rod cap and tighten the retaining screws to **50 daN m + 70°.**

- Repeat the procedure for the other con rod caps.



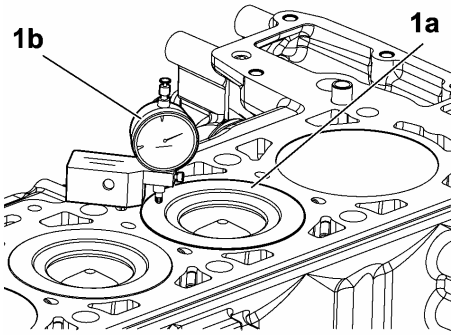
- Unscrew the retaining screws and remove the con rod cap.

- To determine the clearance between con rod bearing and connecting rod, compare the width of the squeezed calibrated wire at the position where it is thinnest with the scale included in the package. The marks on the calibrated scale indicate clearance (in millimetres). Clearance should be 30.035 ÷ 0.08 mm; if clearance is not as specified, change the bearings and repeat the inspection.

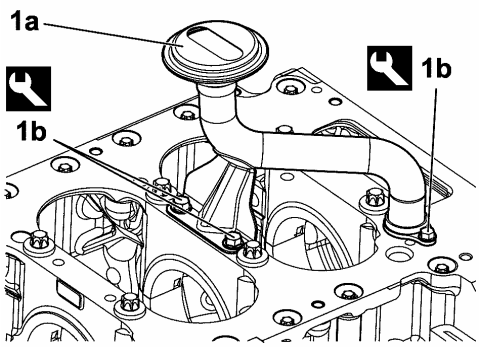
- Repeat the procedure for the other con rod caps.
- Fit the con rod caps and install new retaining screws; tighten to **5.0 daN m + 70°.**

1. After installing the connecting rod-and-piston assemblies, check piston height over crankcase face (1a) with the pistons at TDC using a dial gauge with a magnetic base (1b).

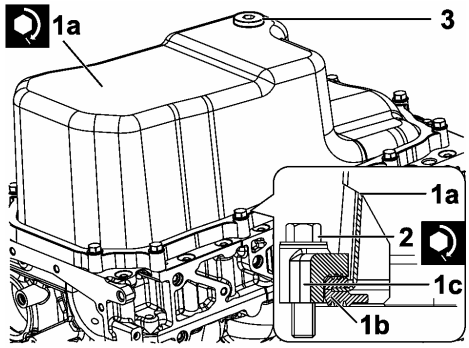
Piston height over crankcase (mm)	0.3 ÷ 0.6
Difference in height over crankcase among the four pistons (mm)	0.15



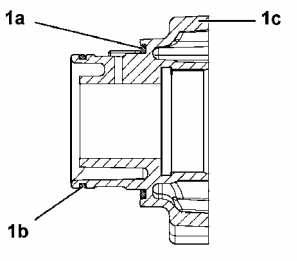
1. Install the engine oil suction funnel (1a) with a new seal and tighten the retaining screws (1b) to **1.0 daN m.**



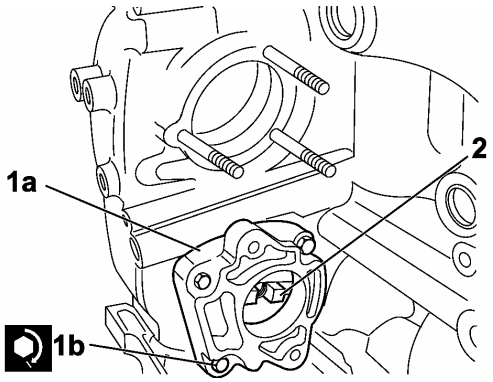
1. Install oil sump (1a), gasket (1b) and trim (1c).
2. Tighten the retaining screws to **2.5 daN m.**
3. Tighten the oil drain plug to **5.0 ± 1 daN m**



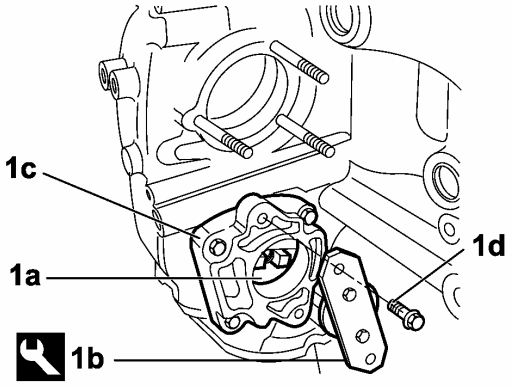
1. Lubricate new seals (1a) and (1b) with engine oil and fit them on the power steering pump mount (1c).



1. Install the power steering pump mount (1a) and tighten the retaining nuts (1b) to **2.5 daN m**.
2. Refit the power steering pump drive shaft.

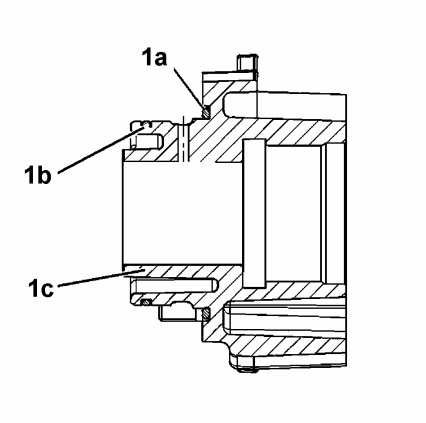


1. Insert tool 9936017 (1b) into to the power steering pump drive shaft (1a) to lock out shaft rotation and secure the tool to mount (1c) using the screws (1d).

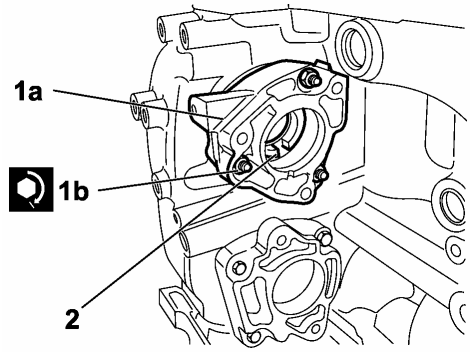


1. Fit the gear (1a) to the power steering pump drive shaft (1b).
2. Install the retaining screw but do not tighten yet.

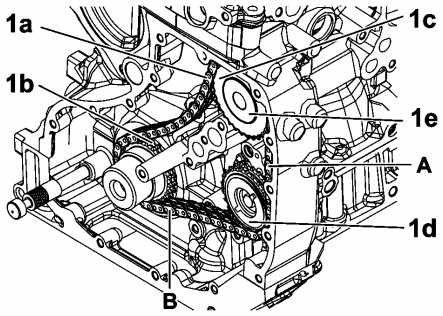
1. Lubricate new seals (1a) and (1b) with engine oil and fit them on the high pressure pump mount (1c).



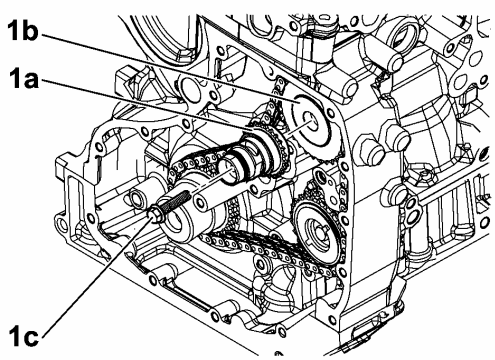
1. Install the high pressure pump mount (1a) and tighten the retaining nuts (1b) to **2.5 daN m**.
2. Refit the high pressure pump drive shaft.



1. Wrap a new chain (1a) around gears (1b), (1c) and (1d) and install the gear (1c) on the shaft (1e) so as to tension up portions A and B of the chain.

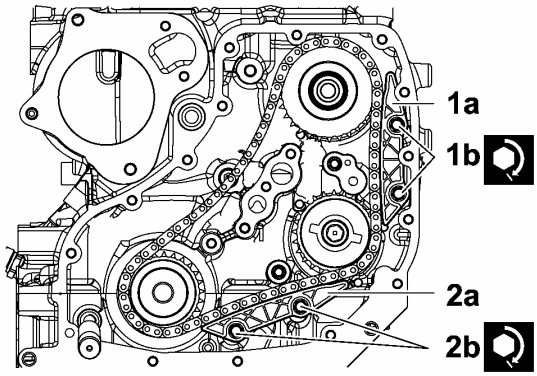


1. Fit the shaft with drive gear (1a) on the high pressure pump shaft (1b) and tighten the retaining screw (1c).



- Inspect the fixed sliding shoes and replace them if worn.
1. Position the fixed sliding shoe (1a) and tighten the retaining screws (1b) to **2.5 daN m**.

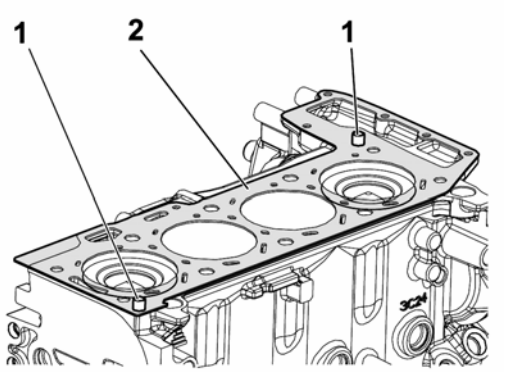
2. Position the fixed sliding shoe (2a) and tighten the retaining screws (2b) to **2.5 daN m**.



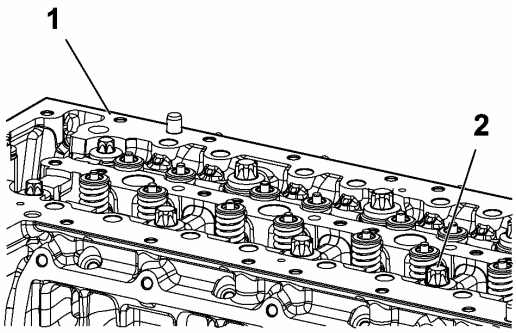
- Ensure that the mating faces of cylinder head and crankcase are clean.
1. If you had removed the cylinder head centring dowels, refit them into place on the crankcase.
2. Position the cylinder head gasket with the work “ALTO” (UP) facing the cylinder head.

NOTE: *Keep the head gasket sealed in its package until shortly before installation and avoid contact with dirt.*

NOTE: *Head gaskets come in one standard thickness.*



1. With the aid of an assistant, install the cylinder head.
2. Install the retaining screws but do not tighten yet.



1. Tighten the cylinder head retaining screws to the specified torque in 3 steps; follow the order shown in the figure and observe the following procedure:

1st STEP (torque)

13.0	Screw	Cylinder head 1-2-3-4-5-6 (1st step)	M15x1.5 L193
6.5	Screw	Cylinder head 7-8-9-10 (1st step)	M12x1.5 L165

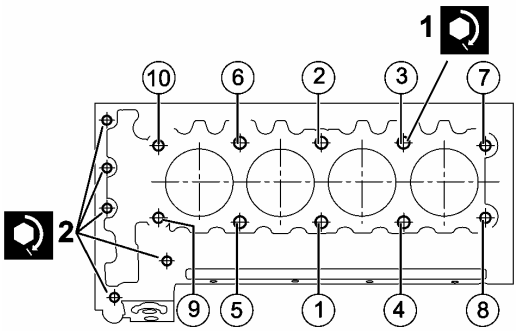
2nd STEP (angle)

90°	Screw	Cylinder head 1-2-3-4-5-6 (2nd step)	M15x1.5 L193
90°	Screw	Cylinder head 7-8-9-10 (2nd step)	M12x1.5 L165

3rd STEP (angle)

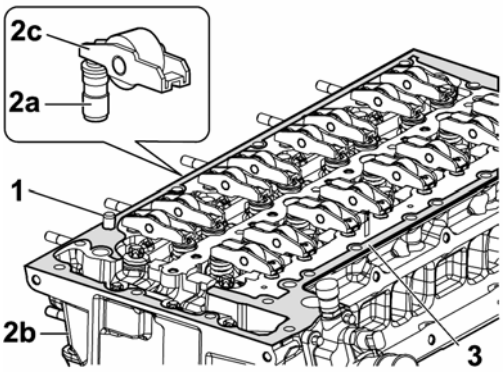
90°	Screw	Cylinder head 1-2-3-4-5-6 (3rd step)	M15x1.5 L193
60°	Screw	Cylinder head 7-8-9-10 (3rd step)	M12x1.5 L165

2. - Tighten the cylinder head retaining screws on timing chain compartment side to **2.5 daN m**



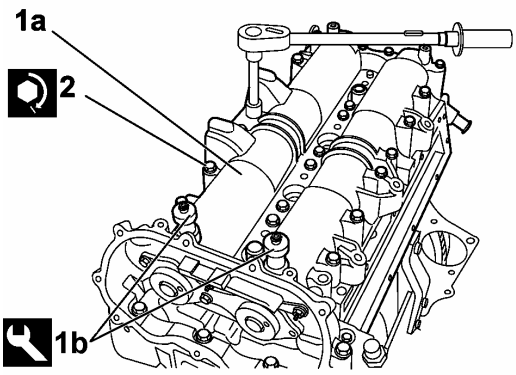
1. If you had removed the upper head section centring dowels, refit them into place on the cylinder head.
2. Clean the hydraulic tappets (2a) thoroughly, lubricate them and install into the cylinder head (2b), making sure to fit the rocker arms (2c) in their correct positions on the valves.

3. Install the upper head gasket.



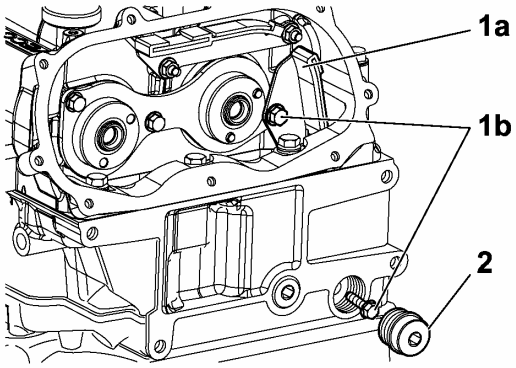
1. Position the upper head section (1a) complete with the camshaft timing templates 99360614 (1b).

2. Tighten the retaining screws to **2.5 daN m.**



1. Position the fixed upper sliding shoe (1a) and tighten the retaining screws (1b) to **1.0 daN m**.

2. Fit the plug into place with a new gasket and tighten to the specified torque.

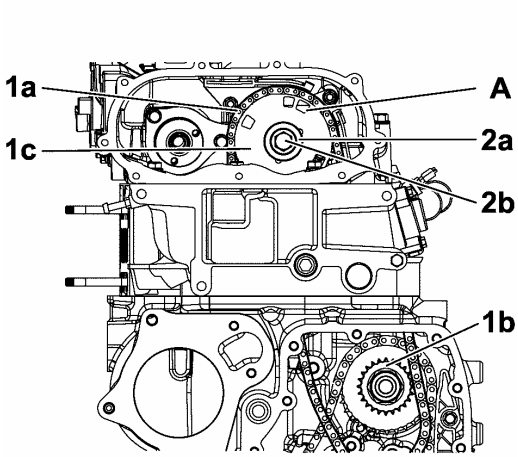


1. Wrap a new chain (1a) around gear (1b) and gear (1c).

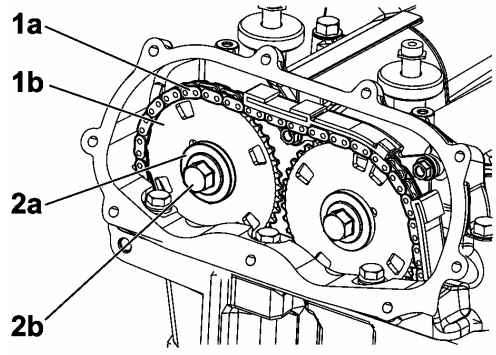
NOTE: *Install the gear so that when it engages the centring dowel on the intake camshaft, slots A are in the position shown in the figure.*

NOTE: *The portion of chain between the two gears must be taut.*

2. Fit the washer (2a) and install the retaining screw (2b), but do not tighten yet.

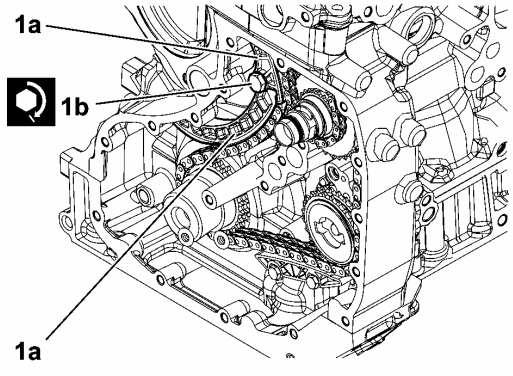


1. Wrap the chain (1a) around gear (1b) and mount the gear on the exhaust camshaft.
2. Fit the washer (2a) and install the retaining screw (2b), but do not tighten yet.

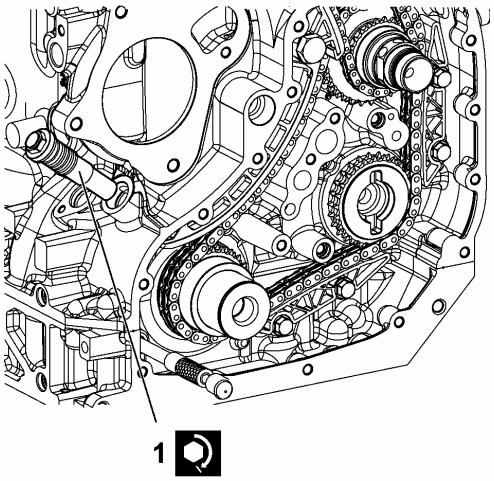


- Inspect the mobile sliding shoes and replace them if worn.

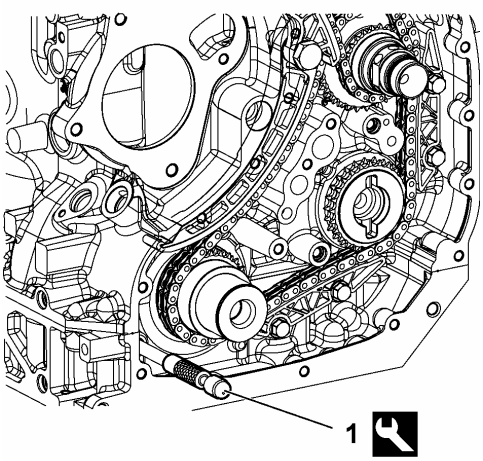
1. Position the mobile sliding shoes (1a) and tighten the retaining pin (1b) to **4.0 daN m**.



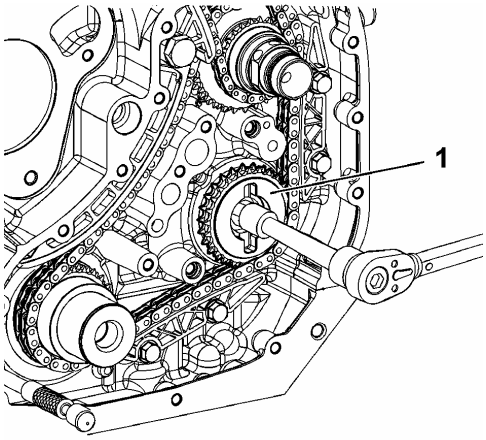
1. Fit the lower hydraulic chain tensioner into place and tighten to **5.0 daN m**.



1. Rotate the crankshaft into the appropriate position that will permit installation of the crankshaft timing tool 99360615 in the correct position.



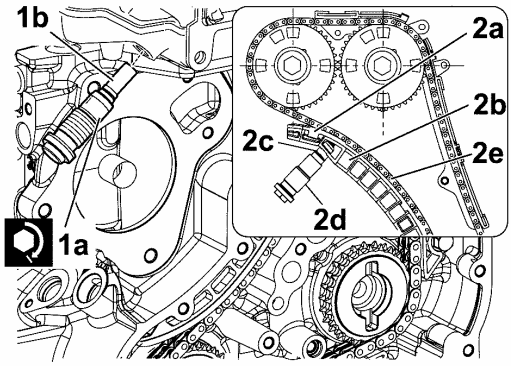
1. Tighten the screw retaining the gear to power steering pump shaft to **13.0 daN m**.



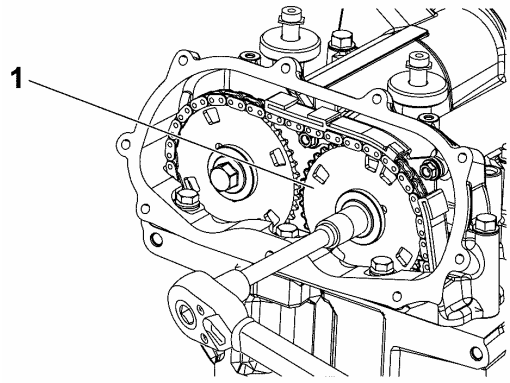
1. Fit a new upper hydraulic chain tensioner (with backstop) (1a) and tighten to **5.0 daN m**.

WARNING: *Never reuse the upper hydraulic chain tensioner (with backstop). If the piston (1b) slips off the new chain tensioner accidentally, another new chain tensioner must be used.*

2. Insert a suitable screwdriver through the opening in the upper head section and push down on the mobile sliding shoe (2b) tab (2a) until pushing the piston (2c) of the upper hydraulic chain tensioner (2d) to end of travel position. Release the mobile sliding shoe (2b) and ensure that the piston (2c) pulls the chain (2e) taut as it slides out of its housing.

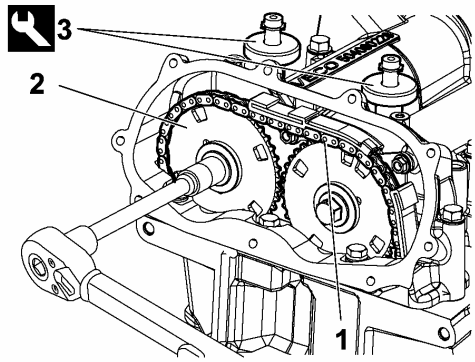


1. Tighten the retaining screw of the intake camshaft drive gear to **1.0 daN m**.

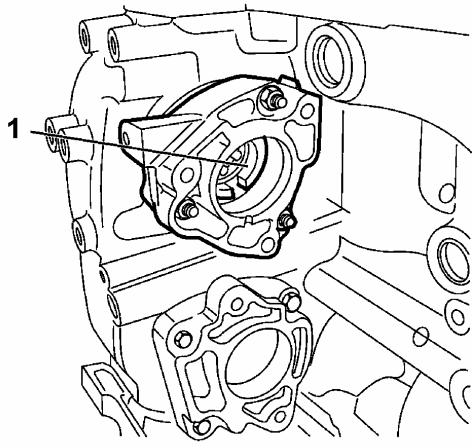


1. Ensure that the portion of chain between the camshaft drive gears is taut.
2. Tighten the retaining screw of the exhaust camshaft drive gear to **11.0 daN m**.

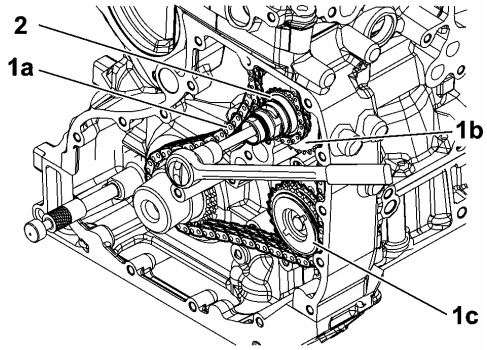
3. Remove the camshaft timing tools 99360614.



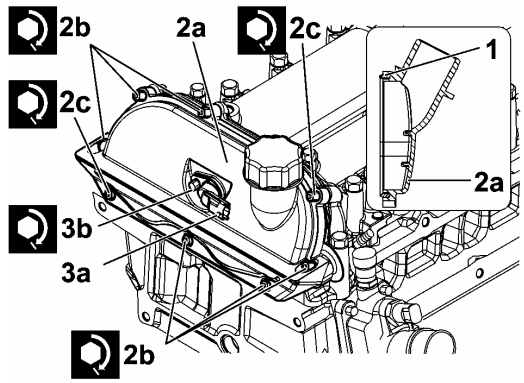
1. Lock out rotation of the high pressure pump drive shaft using a suitable key.



1. Ensure that the portion of chain (1a) between the high pressure pump drive gear (1b) and the power steering pump drive gear (1c) is taut.
2. Tighten the retaining screw of the shaft with drive gear to **11.0 daN m.**

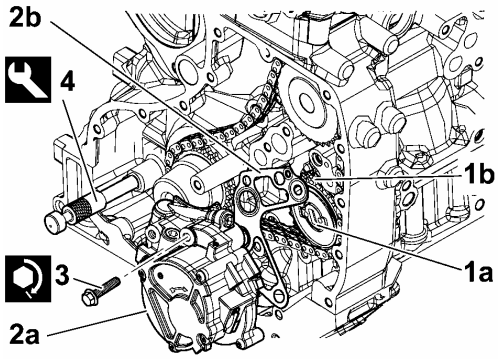


1. Fit a new gasket to the upper timing cover.
2. Install the upper timing cover (2a) and tighten retaining screws (2b) and nuts (2c) to **1.0 daN m**.
3. If you had removed the timing sensor (3a), refit it and tighten the retaining screw (3b) to **1.0 daN m**.



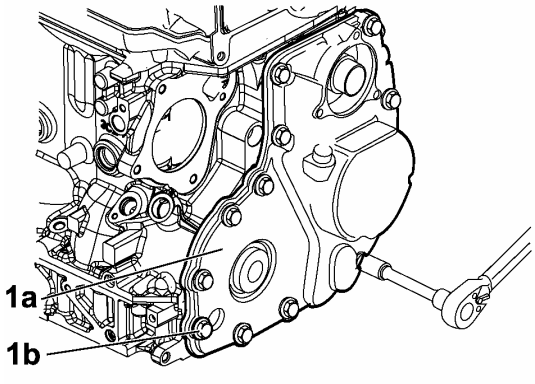
1. Fit the coupling (1a) into the power steering pump drive gear (1b).
2. Position the oil pump–vacuum pump assembly (2a); use a new gasket (2b).
3. Tighten the retaining screws to **2.5 daN m.**

4. Remove the crankshaft timing tool 99360615.



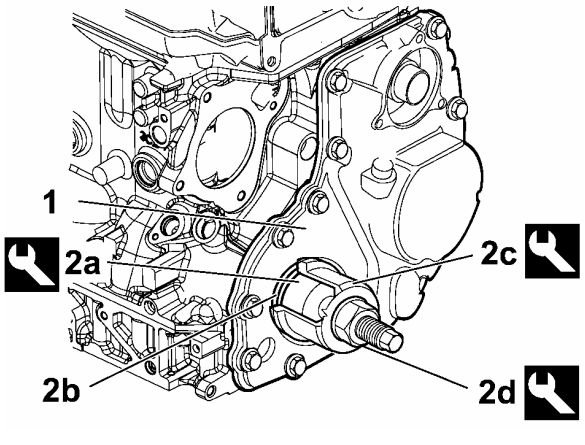
- Unscrew the retaining screw and remove the tool 99360187 you used to lock the power steering pump shaft.

1. Fit the lower timing cover (1a) with a new gasket and install the retaining screws (1b), but do not tighten yet.



1. Clean the seat for the front crankshaft seal thoroughly.

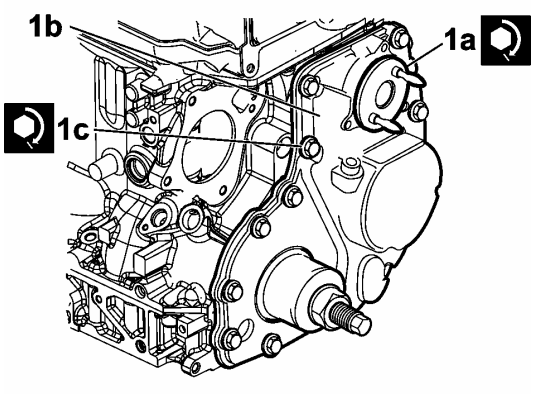
2. Screw part (2a) of tool 99346258 into the crankshaft extension. Lubricate crankshaft extension and outer side of part (2a); fit the new front seal (2b) for the crankshaft onto the tool part. Place part (2c) over part (2a) and tighten the nut (2d) until the crankshaft front oil seal (2b) slides fully into place in the lower timing cover.



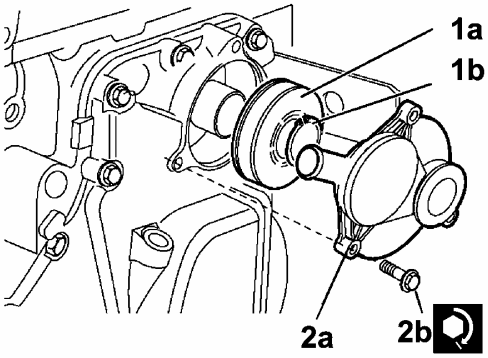
1. Fit the lower timing cover (1b) centring tool 99396039 into the seat of the centrifugal filter and tighten the retaining screws (1c) to **2.5 daN m**.

- Remove the crankshaft timing tool 99360615 and the

lower timing cover centring tool 99396039.



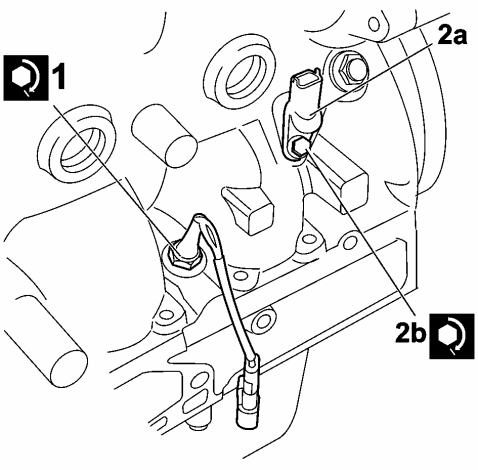
1. Install a new centrifugal filter (1a) and a new circlip (1b).
2. Fit the cover (2a) and tighten the retaining screws (2b) to the specified torque.



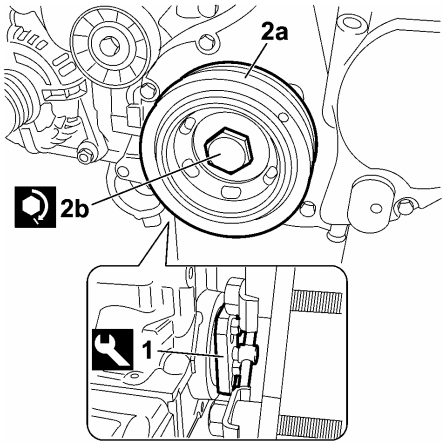
1. Fit the engine oil level sensor into place and tighten to **2.5 daN m**.

2. Fit the rpm sensor (2a) into place and tighten the retaining screw (2b) to

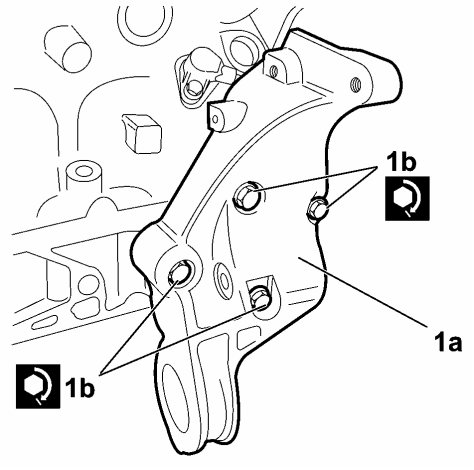
1.0 daN m.



1. Fit tool 1.860.815.000 to the crankshaft.
2. Install the auxiliary drive pulley (2a) and tighten the retaining screw (2b) to **35 daN m**.

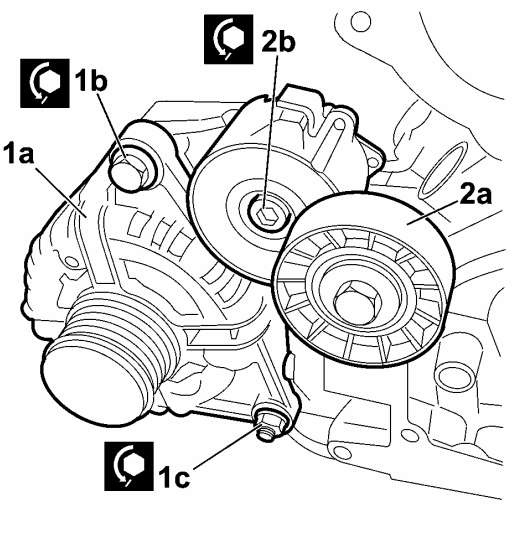


1. Fit the alternator mount / intermediate shaft (1a) into place and tighten the retaining screws (1b) to the specified torque.

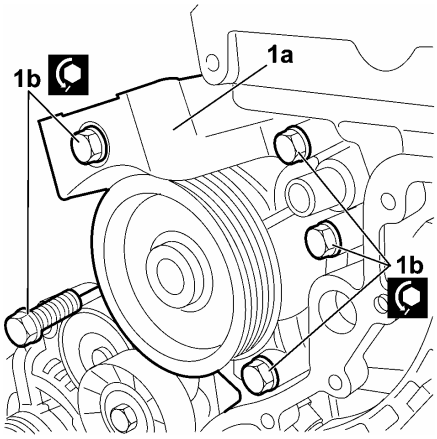


1. Fit the alternator (1a) and tighten retaining screw (1b) and bolt (1c) to **5.0 daN m.**

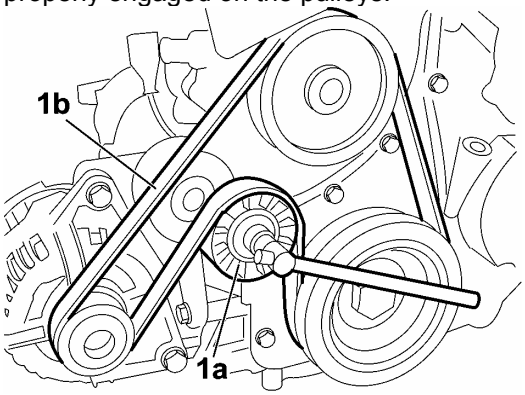
2. Install the automatic belt tensioner (2a) for the auxiliary drive belt and tighten the retaining screw (2b) to **2.5 daN m**.



1. Fit the water pump / rigid engine mount (1a) into place and tighten the retaining screws (1b) to the specified torque.



1. Work the automatic belt tensioner (1a) with a suitable key and install the auxiliary drive belt (1b) making sure the belt ribs engage the pulley grooves.
- Rotate the crankshaft through one turn to help the auxiliary drive belt become properly engaged on the pulleys.



- Remove tool 1.860.815.000 from the crankshaft.

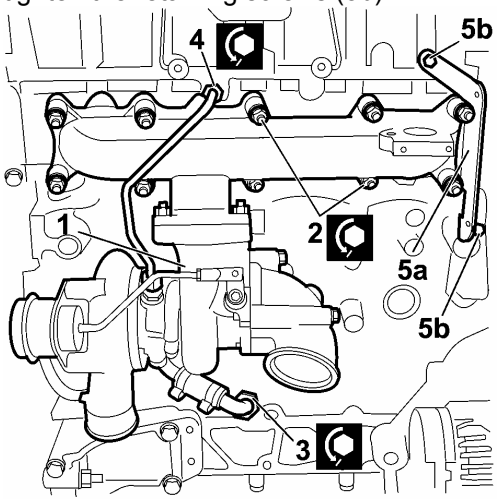
1. Fit a new gasket and the exhaust manifold-and-turbocharger assembly into place.

2. Fit the spacers and tighten the retaining nuts to **2.5 daN m**

3. Tighten the oil return fitting (from turbocharger to crankcase) to **4.5 daN m**.

4. Tighten the oil delivery fitting (from turbocharger to cylinder head) to **3.5 daN m**.

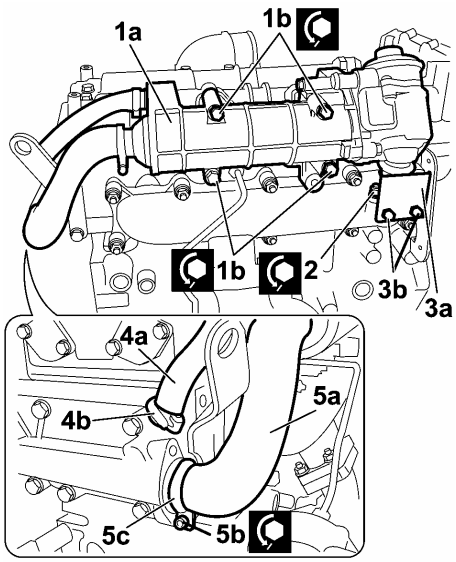
5. Fit the retaining bracket (5a) and tighten the retaining screws (5b).



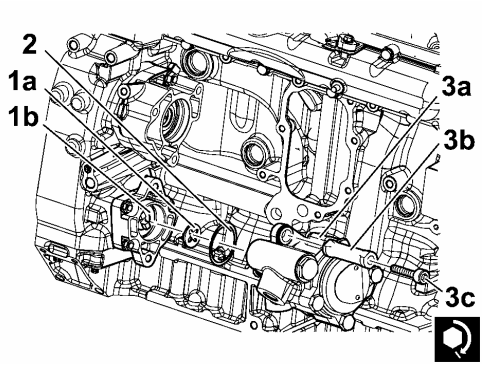
- Fit a new gasket to the exhaust manifold.
1. Install the EGR heat exchanger (1a) complete with valve and pipes and tighten the retaining screws (1b) to the specified torque.

2. Tighten the screws retaining EGR valve pipe to exhaust manifold to the specified torque.

3. Fit the guard (3a) and tighten the retaining screws (3b).
4. Connect the water pipe (4a) and secure it with a new clamp (4b).
5. Fit a new gasket and connect pipe (5a); tighten the collar (5c) retaining screw (5b) to the specified torque.

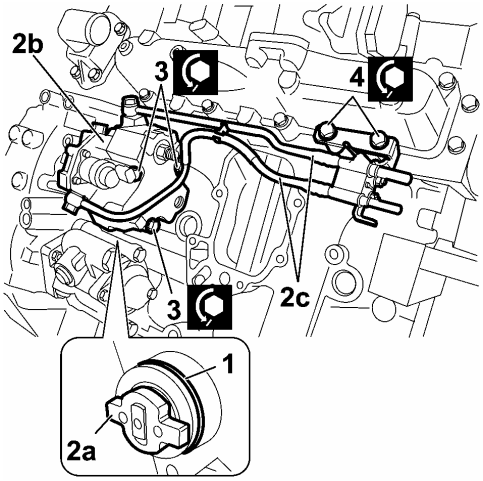


1. Fit the coupling (1a) to the shaft (1b).
2. Lubricate a new seal and fit it to the power steering pump.
3. Install the power steering pump (3a) and the spacers (3b) and tighten the retaining screws (3c) to **4.0 daN m**.

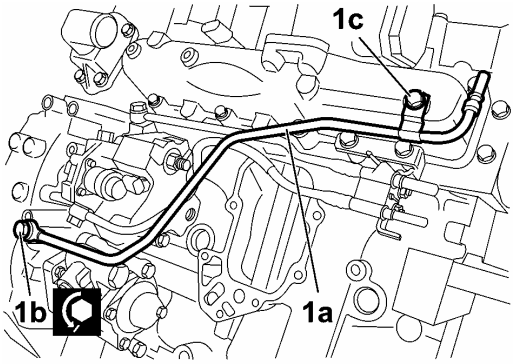


1. Lubricate a new seal and fit it to the high pressure steering pump.
2. Fit the coupling (2b) and the high pressure pump (2c) complete with low pressure pipes (2c).
3. Fit the spacers and tighten the high pressure pump retaining screws to **2.5 daN m**

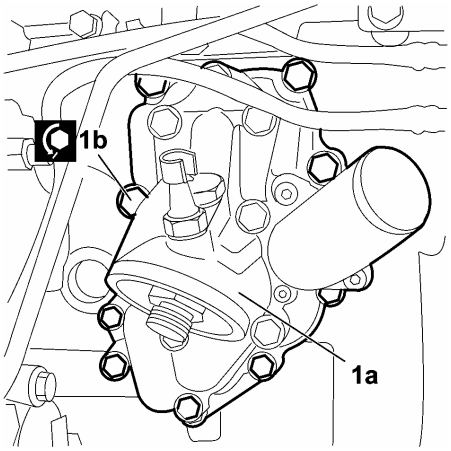
4. Tighten the retaining screws of the low pressure pump retaining bracket to **2.5 daN m**



1. Fit the vacuum pipe (1a) and tighten the fitting (1b) to **3.5 daN m**; tighten the retaining screw (1c) at the intake manifold end.



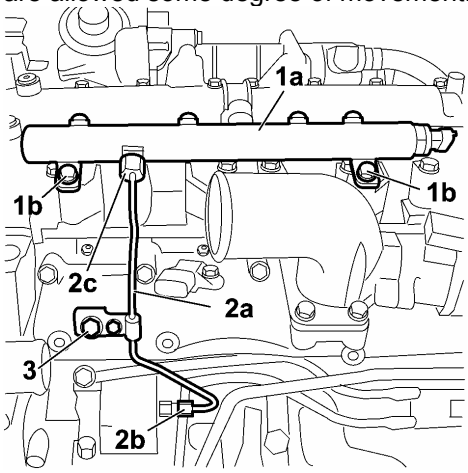
1. Fit the water-oil heat exchanger (1a) with a new gasket into the crankcase and tighten the retaining screws (1b) to the specified torque.



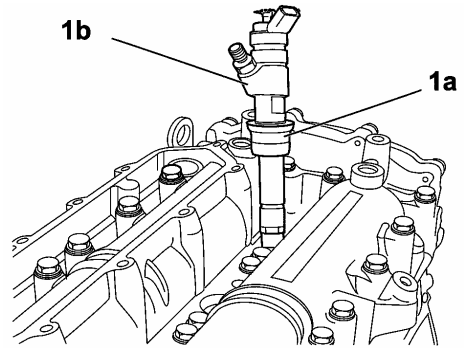
2. Install the fuel delivery pipe (2a) and tighten the fittings (2b) on high pressure pump (2c) and fuel collector pipe.

***WARNING**: Whenever you disconnect the fuel pipes, replace them to avoid fuel leaks from the fittings.*

3. Tighten the fuel delivery pipe retaining screw loosely by a few turns so that the fuel collector / fuel delivery pipe assembly are allowed some degree of movement.

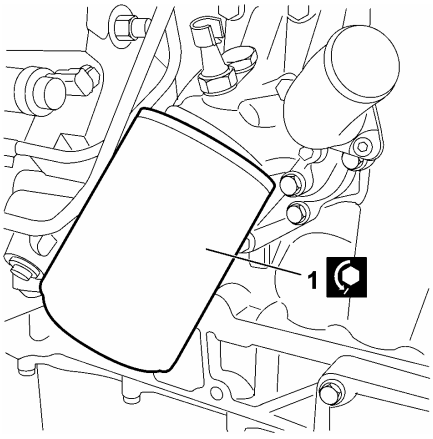


1. Install a new gasket (1a) and fit the electro-injectors (1b).

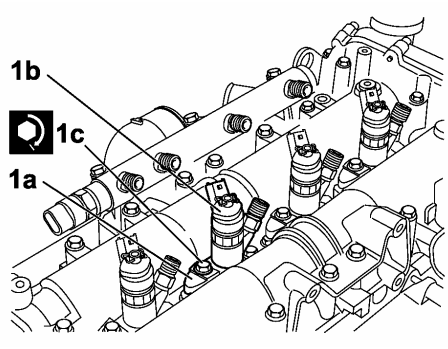


1. Install the electro-injector (1b) retaining brackets (1a) and tighten the retaining screws (1c) to **2.8 daN m**.

1. Lubricate the oil filter gasket with engine oil and tighten it into place to **2.5 daN m**.

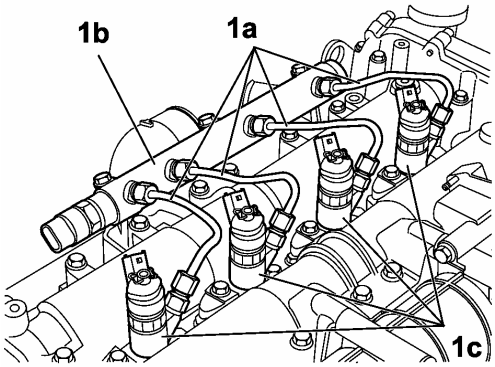


1. Install the fuel collector pipe (1a) and screw the retaining screws (1b) loosely (just a few turns) to allow some degree of movement.



1. Install the fuel pipes (1a) and tighten the fittings loosely onto fuel collector pipe (1b) and electro-injectors (1c).

***NOTE**: Whenever you disconnect the fuel pipes, replace them to avoid fuel leaks from the fittings.*



- Tighten the fuel collector pipe retaining screws to **2.8 daN m**.

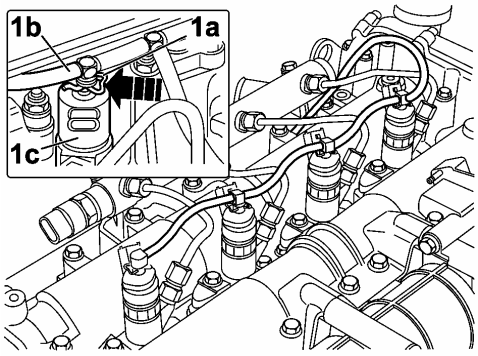
- Tighten the fuel pipe fittings and the retaining screw of the fuel delivery pipe mounting bracket to the specified torque.

1.9 ± 0.2	Filler neck	Fuel delivery pipe fitting

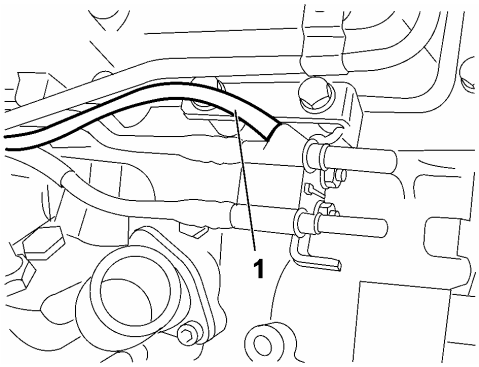
2.5 ± 0.2	Filler neck	Fuel delivery pipe fitting

2.5	Screw	Fuel delivery pipe mounting bracket

1. Press the retaining clips (1a) in the direction shown by the arrow and connect the fuel recovery pipes (1b) from the electro-injectors (1c).

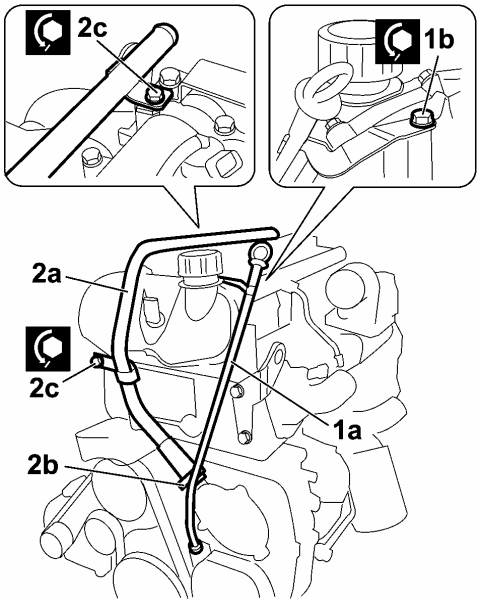


1. Connect the fuel recovery pipe to the fitting.

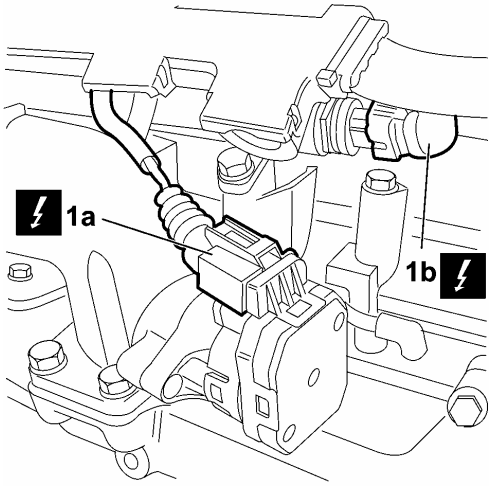


1.Lubricate and install a new seal, install the engine oil dipstick (1a) and tighten the retaining screw (1b) to **1.0 daN m**.

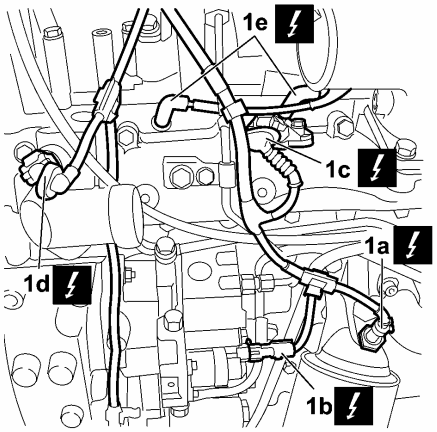
2. Connect the oil vapour recovery pipe (2a) and secure it with a new clamp (2b); tighten the retaining screws (2c) to **2.8 daN m**.



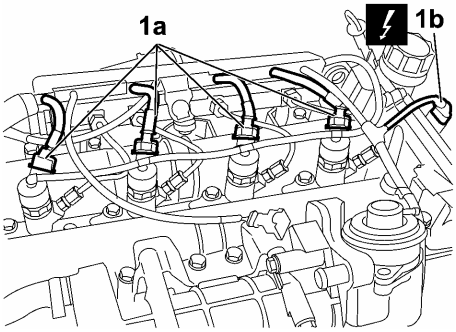
- Install the wiring harness.
1. Connect the wiring connections of throttle body actuator (1a) and fuel pressure sensor (1b).



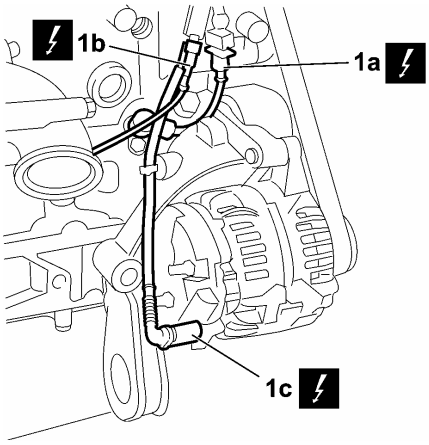
1. Connect the wiring connections of engine oil pressure sensor (1a), fuel pressure regulator (1b), air temperature / pressure sensor (1c), engine coolant temperature sensor (1d) and preheating glow plugs (1e).



1. Connect the wiring connections of electro-injectors (1a) and timing sensor (1b).



1. Connect the wiring connections of engine rpm sensor (1a), engine oil level sensor (1b) and alternator (1c).



3.4.3 Engine tools

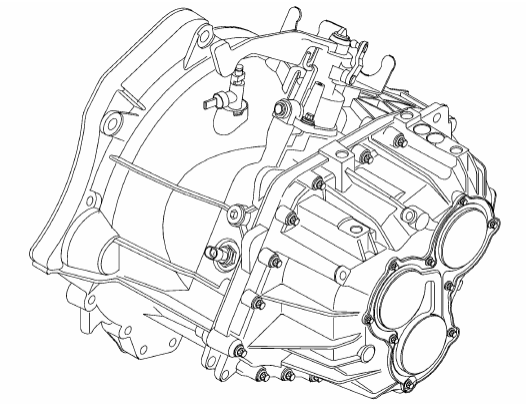
99360615	**Engine:** 3.0 Jtd 16V	Crankshaft timing pin	Existing
99360614	**Engine:** 3.0/2.3 Jtd 16V	Camshaft timing pins	Existing
99360260	**Engine:** 3.0/2.3 Jtd 16V	Valve spring compressor	Existing
2000003100	**Engine:** 3.0/2.3 Jtd 16V	Glow plug key	Existing
1860804000	**Engine:** 3.0 Jtd 16V	Valve retaining plate	Existing
1870894000	**Engine:** 3.0 Jtd 16V	Valve oil seal pliers	Existing
1860470000	**Engine:** 3.0 Jtd 16V	Head stand	Existing
1871003100	**Engine:** 3.0 Jtd 16V	Luk clutch installation tool kit	Existing
1860846000	**Engine:** 3.0 Jtd 16V	Flywheel locking tool	Existing
1860815000	**Engine:** 3.0 Jtd 16V	Crankshaft cranking tool	Existing
99360187	**Engine:** 3.0 Jtd 16V	Torque arm for power steering pump shaft	IVECO-derived tools
99342153	**Engine:** 3.0/2.3 Jtd 16V	Injector extractors	IVECO-derived tools
99340059	**Engine:** 3.0 Jtd 16V	Crankshaft oil seal extractor (timing gear side)	IVECO-derived tools

99346258	**Engine:** 3.0 Jtd 16V	Crankshaft oil seal drift tool (timing gear side)	IVECO-derived tools
99396039	**Engine:** 3.0 Jtd 16V	Timing cover centring tool (to oil pump)	IVECO-derived tools
99346259	**Engine:** 3.0 Jtd 16V	Crankshaft oil seal drift tool (flywheel side)	IVECO-derived tools
2000015900	**Engine:** 3.0 Jtd 16V	Crankshaft oil seal extractor (flywheel side)	New
2000016000	**Engine:** 3.0 Jtd 16V	Clutch centring tool kit	New
2000016100	**Engine:** 3.0 Jtd 16V	Valve guide reamer	New
2000016200	**Engine:** 3.0/2.3 Jtd 16V	Slide hammer for valve guides	New
2000016300	**Engine:** 3.0/2.3 Jtd 16V	Valve guide drift tool	New
2000020400	**Engine:** 3.0 Jtd 16V	Tool to install flexible belt on compressor	New
2000020500	**Engine:** 3.0 Jtd 16V	Engine hoisting bracket	New
2000020900	**Engine:** 3.0 Jtd 16V	Tachograph extractor	New
2000021000	**Engine:** 3.0 Jtd 16V	Connector for engine oil pressure check (for use with 2000018801)	Prototype

4 TRANSMISSION

4.1 - GEARBOX AND DIFFERENTIAL TYPE C 546 (M40)

The vehicle is equipped with an advanced C546 gearbox designed to improve handling and reliability; this gearbox is used with 3.0 Multijet engines.



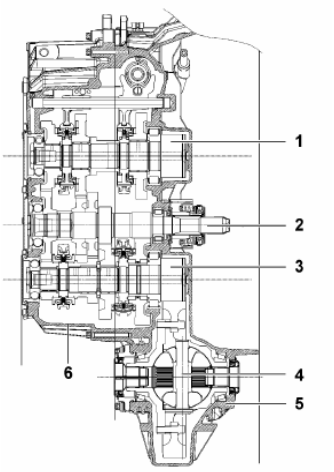
4.1.1 Construction

GEARBOX

Superior gear materials, an upgraded differential with oversize bevel gears and a gearwheel case with screw connection ensure great reliability.
Main features comprise:
- easy to operate gear shift control
- quiet operation
- lightweight.

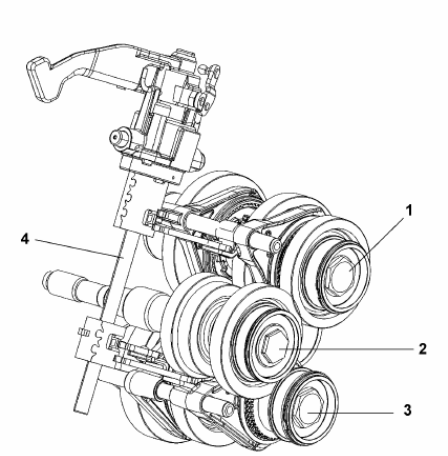
The gearbox features the transverse 3-shaft configuration with differential.

The figure below shows a cross-section view of the gearbox.



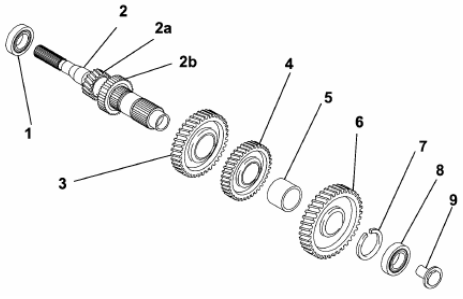
1 – Upper secondary shaft
2 – Main shaft
3 – Lower secondary shaft
4 – Differential assembly
5 – Differential case
6 – Gearbox gearing case

The figure below shows gearbox shafts and gear selector mechanism.



1 – Upper secondary shaft
2 – Main shaft
3 – Lower secondary shaft
4 – Gear selector mechanism

Main shaft
The main shaft comprises:
- 1st and 2nd speed gears integral with shaft;
- 3rd, 4th, 6th and 5th speed gears splined to the shaft;
The main shaft rides in:
- a roller bearing at the front end,
- a ball bearing at the rear end



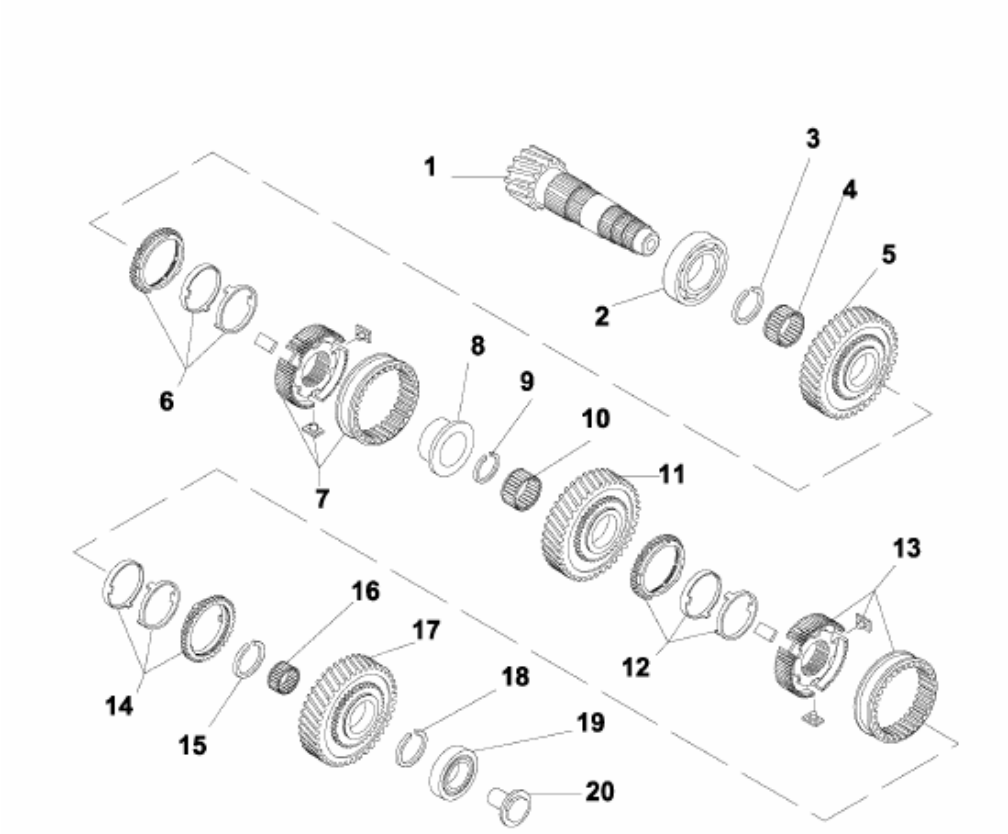
1 – Front roller bearing
2 – Main shaft
2a – 1st speed gear (integral with shaft)
2b – 2nd speed gear (integral with shaft)
3 – 5th speed drive gear
4 – 3rd speed drive gear
5 – Spacer
6 – 4th/6th speed drive gear
7 – Circlip
8 – Rear ball bearing
9 – Gear fixing ring nut

Upper secondary shaft

The upper secondary shaft comprises:
- reverse, 3rd and 4th speed gears splined to the shaft;

The upper secondary shaft rides in:
- a roller bearing at the front end,
- a ball bearing at the rear end.

The reverse gear is driven by the 1st speed gear splined to the lower secondary shaft.



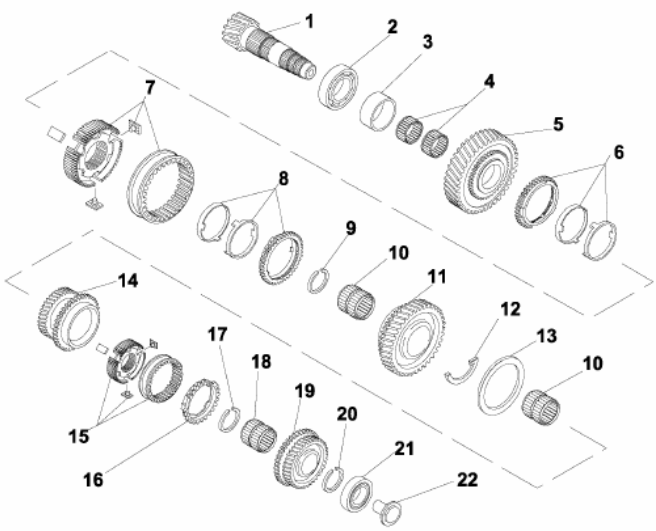
1 – Upper secondary shaft
2 – Front roller bearing
3 – Circlip
4 – Roller cage
5 – Reverse driven gear
6 – Reverse synchroniser rings
7 – Reverse synchroniser
8 – Spacer
9 – Circlip
10 – Roller cage
11 – 3rd speed driven gear
12 – 3rd speed synchroniser rings
13 – 3rd/4th speed synchroniser
14 – 4th speed synchroniser rings
15 – Circlip
16 – Roller cage
17 – 4th speed driven gear
18 – Circlip
19 – Rear ball bearing
20 – Gear fixing ring nut

Lower secondary shaft

The lower secondary shaft comprises:
- 1st, 2nd, 5th and 6th speed gears splined to the shaft;

The lower secondary shaft rides in:
- a roller bearing at the front end,
- a ball bearing at the rear end.

The 1st speed gear drives the reverse gear splined to the upper secondary shaft



1 – Lower secondary shaft
2 – Front roller bearing
3 – Spacer
4 – Roller cage
5 – 1st speed driven gear
6 – 1st speed synchroniser rings
7 – 1st and 2nd speed synchroniser
8 – 2nd speed synchroniser rings
9 – Circlip
10 – Roller cage
11 – 2nd speed driven gear
12 – Half rings
13 – Retaining ring
14 – 5th speed driven gear
15 – 5th and 6th speed synchroniser
16 – 6th speed synchroniser ring
17 – Circlip
18 – Roller cage
19 – 6th speed driven gear
20 – Circlip
21 – Rear ball bearing
22 – Gear fixing ring nut

Gears

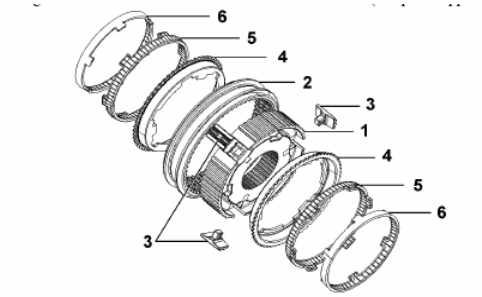
Helical gears are used for all speeds, including reverse. All gears are of the HCR (High Contact Ratio) type. Lubrication for gearsets and moving parts inside the gearbox is provided through oil holes in the hollow secondary shafts and galleries in the gearbox case, with the following advantages: - improved efficiency in torque transmission and wear resistance - smooth shifting at low temperatures ensured by multi-grade synthetic oil.

Synchronisers

Gear synchronisation for all gears (including reverse) is of the brass free-ring (Borg-Warner) type and its layout is as follows:
- 3rd, 4th gear and reverse synchronisers are fitted to the upper secondary shaft;
- 1st, 2nd, 5th and 6th gear synchronisers are fitted to the lower secondary shaft.

– 1st and 2nd gear synchroniser

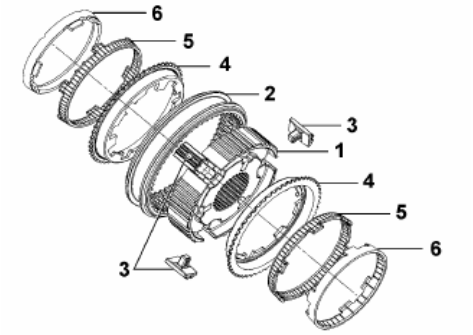
The figure below shows the 1st and 2nd gear synchroniser.



1 – Hub
2 – Sleeve
3 – Presynchroniser block
4 – Outer synchroniser ring
5 – Intermediate synchroniser ring
6 – Inner synchroniser ring

– 3rd and 4th gear synchroniser

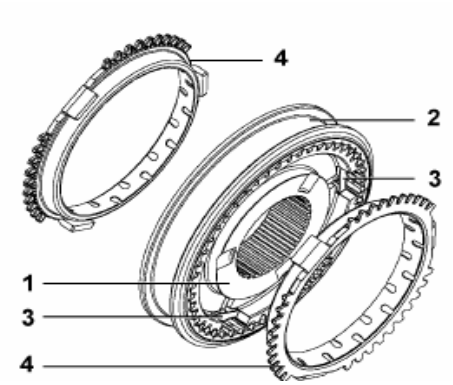
The figure below shows the 3rd and 4th gear synchroniser.



1 – Hub
2 – Sleeve
3 – Presynchroniser block
4 – Outer synchroniser ring
5 – Intermediate synchroniser ring
6 – Inner synchroniser ring

5th and 6th gear synchroniser

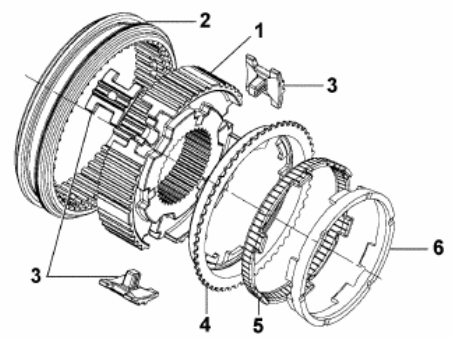
The figure below shows the 5th and 6th gear synchroniser



1 – Hub
2 – Sleeve
3 – Presynchroniser block
4 – Synchroniser ring

Reverse synchroniser

The figure below shows reverse synchroniser components.

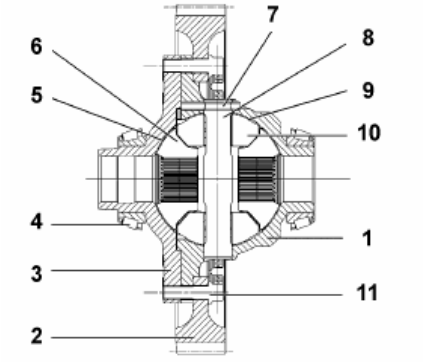


1 – Hub
2 – Sleeve
3 – Presynchroniser block
4 – Outer synchroniser ring
5 – Intermediate synchroniser ring
6 – Inner synchroniser ring

DIFFERENTIAL

The differential assembly is located at the rear end of the gearbox case.
It consists of:
- reduction spur gearset
- one-piece differential case that incorporates sun and planet gears.

The differential is supported by two taper roller bearings.
The planet gears feature a grooved section inside for the two couplings connected to
to the two axle shafts that drive the wheels.
The back end of sun and planet gears is rounded; suitable spacers are installed between gears and case

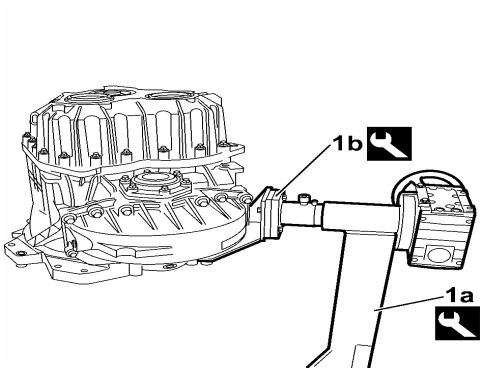


1 – Differential gear case
2 – Wormwheel
3 – Flanged differential cover
4 – Taper roller bearings
5 – Sun gear thrust washer
6 – Sun gear
7 – Planet carrier retaining pin
8 – Planet carrier pin
9 – Planet gear thrust washer
10 - Planet gear
11 – Wormwheel retaining screw

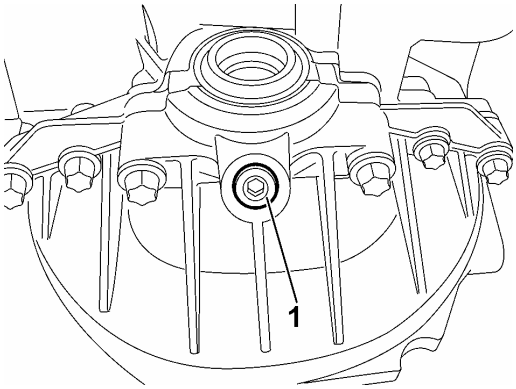
4.2 PROCEDURES

4.2.1 (6-SPEED') MECHANICAL GEARBOX WITH DIFFERENTIAL - DISASSEMBLY AND REASSEMBLY - PART WASHING AND INSPECTION - SYNCHRONISER, INTERNAL CONTROL DEVICE, GEARSET, SHAFT AND BEARING REPLMT (IF NEEDED)

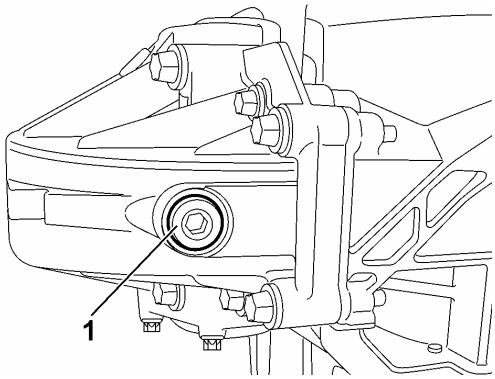
1. Place the gearbox on the rotary stand (1a) using the support (1b).



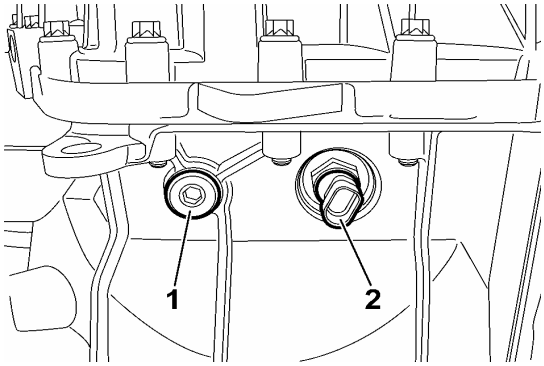
2. Unscrew the oil drain plug on the differential cover (1).



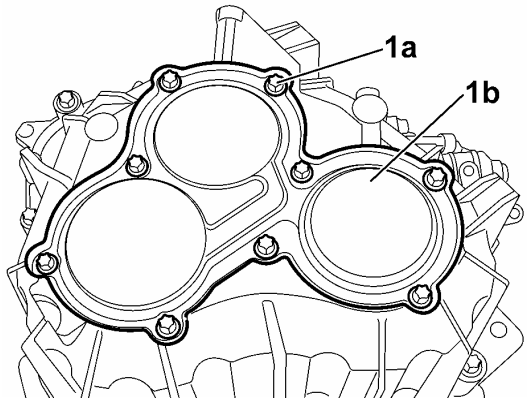
3. Unscrew the magnetic plug on the differential cover (1).



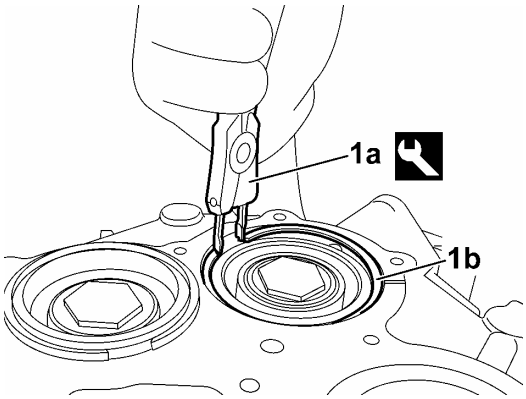
4. Unscrew the oil filler plug on the gearbox case (1); unscrew and remove the reverse switch (2).



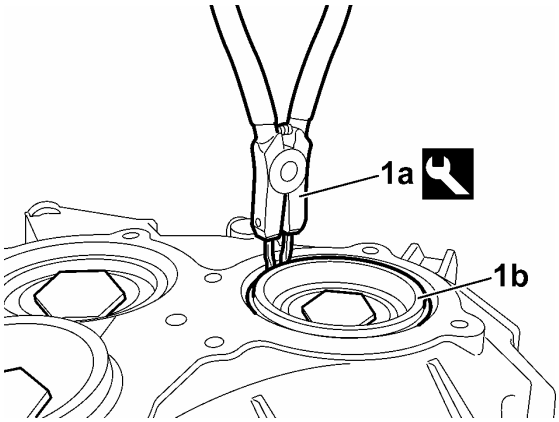
5. Unscrew the retaining screws (1a) and remove the rear cover (1b).



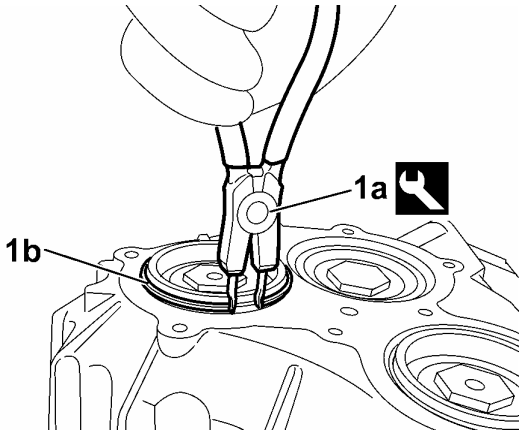
6. Use tweezers (1a) to remove the circlip (1b) from the main shaft bearing.



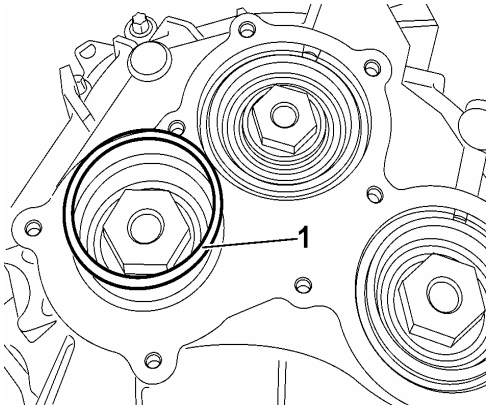
7. Use tweezers (1a) (1870492000) to remove the circlip (1b) from the upper secondary shaft bearing.



8. Use tweezers (1a) to remove the circlip (1b) from the lower secondary shaft bearing.

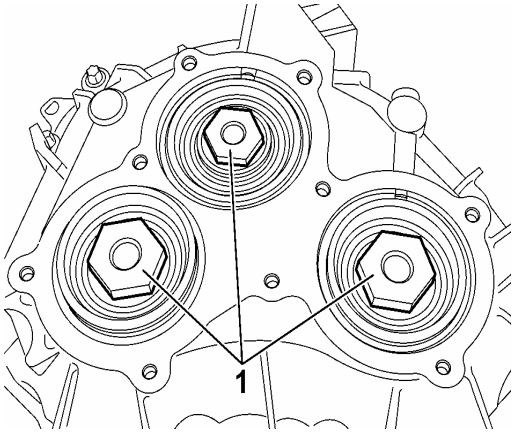


9. Remove the shim (1) from the lower secondary shaft bearing.

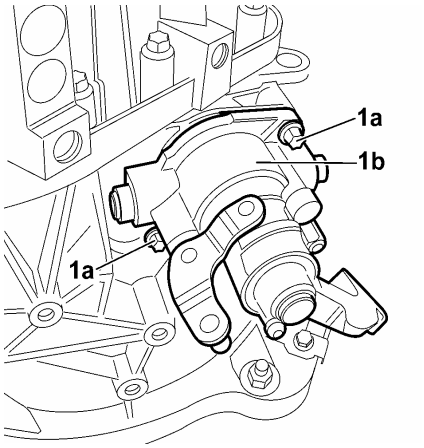


10. Engage two gears.
Note: Engaging two gears at the same time locks up the gearbox shafts; this will make it easier to release the ring nuts that hold the gears in place on the shafts.

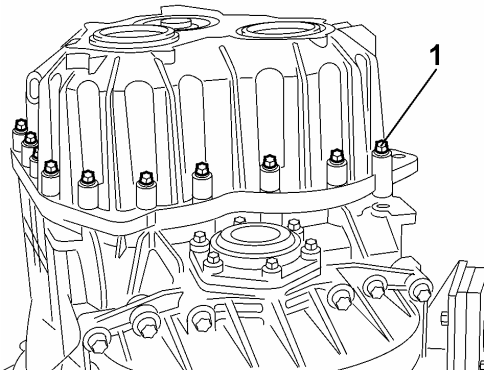
11. Unscrew the ring nuts that secure the gears to the gearbox shafts (1).



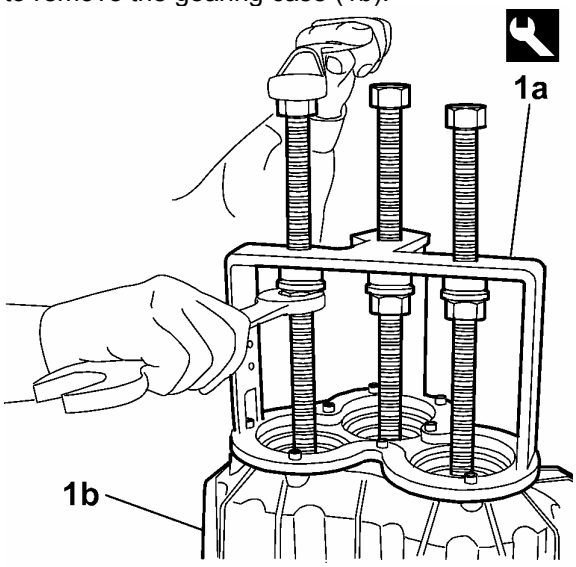
12. Unscrew the screws (1a) and remove the gear selector mechanism (1b).



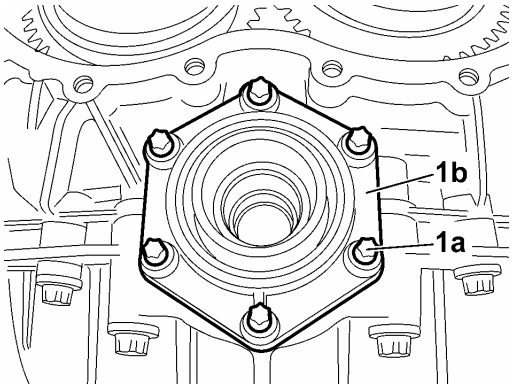
13. Unscrew the retaining of the gearbox gearing
case.



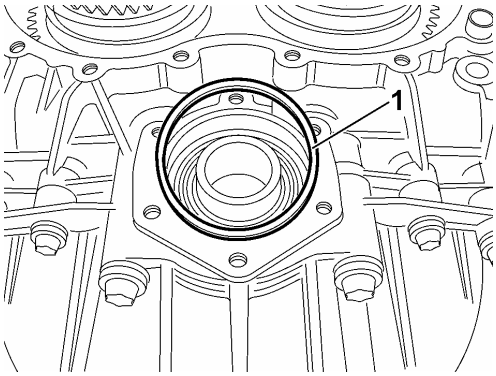
14. Use the extractor/drift tool (1a) (2000019400) to remove the gearing case (1b).



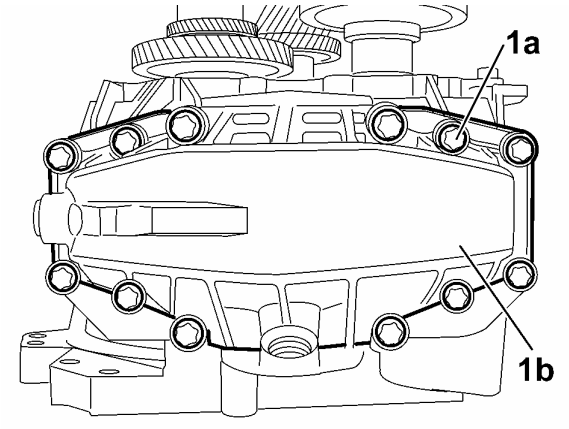
15. Unscrew the screws (1a) and remove the flange (1b).



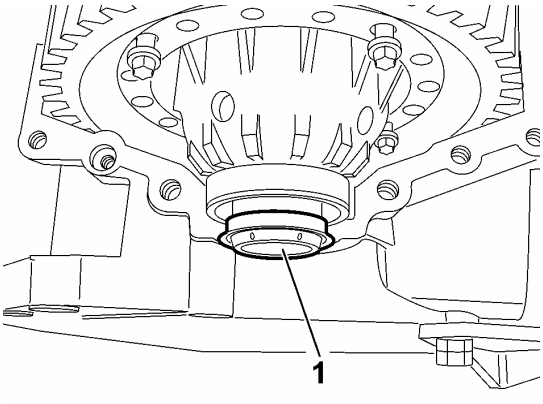
16. Remove the case adjusting ring Differential (1).



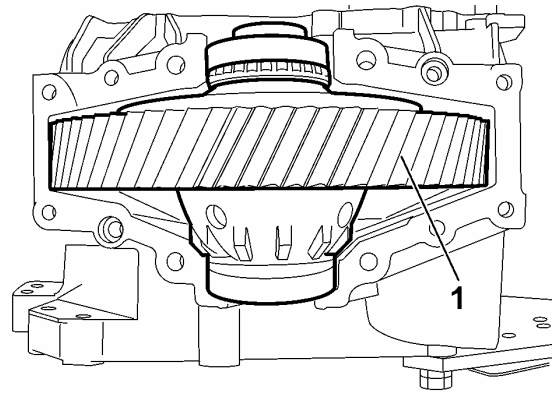
17. Unscrew the screws (1a) and remove the differential cover (1b).



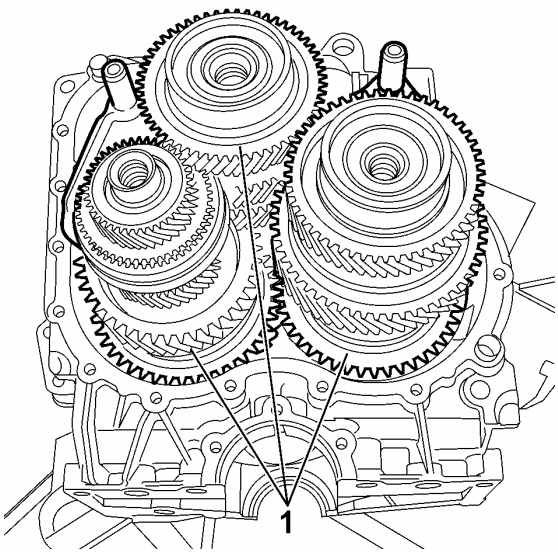
18. Remove the oil seal (1) from the differential case (clutch side)



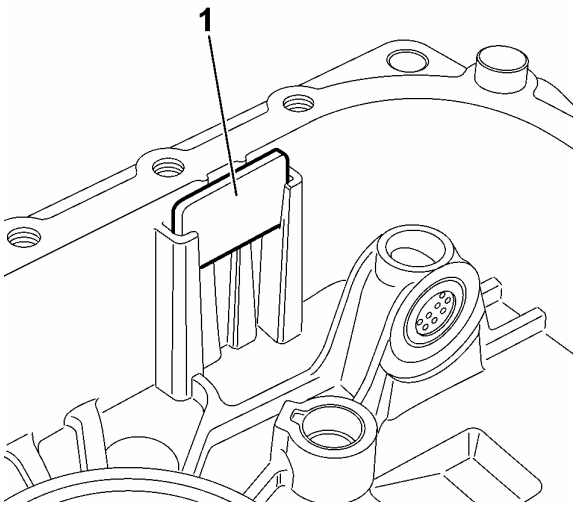
19. Remove the differential (1).



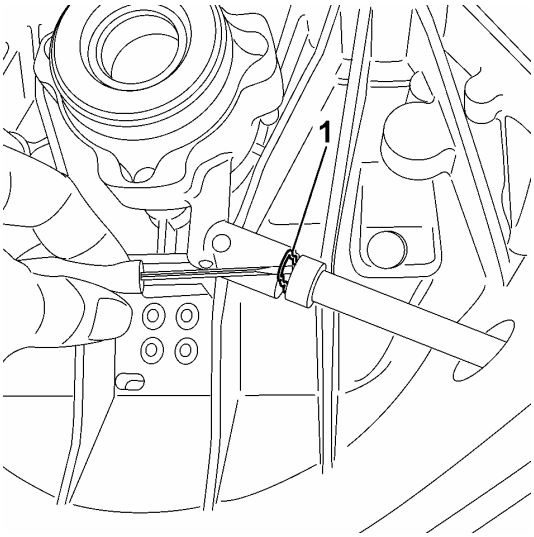
20. Remove main shaft and secondary shafts complete with gears and gear selector levers with their forks (1).



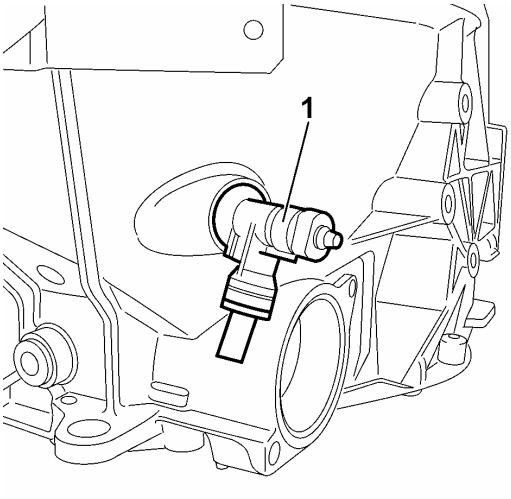
21. Extract the magnet from its housing and remove any metal grit (1).



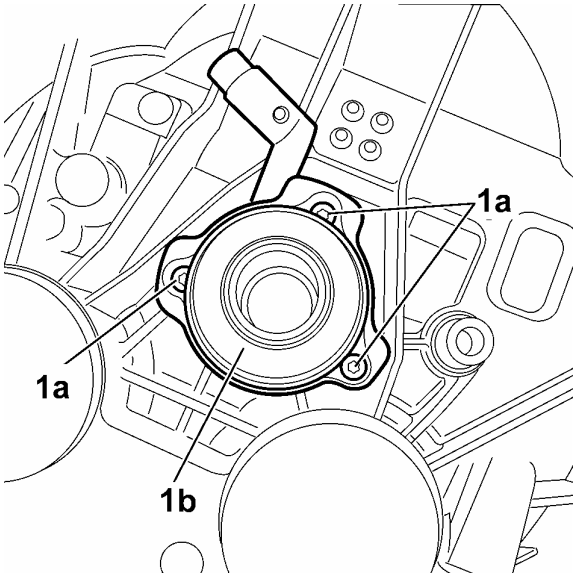
22. Extract the clip that secures the pipe connecting clutch delivery pipe and clutch disengagement sleeve to the sleeve (1).



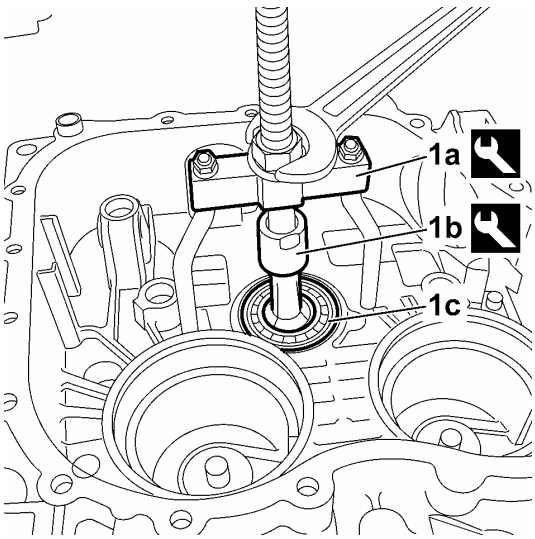
23. Remove the fitting connecting clutch delivery pipe and clutch disengagement sleeve (1).



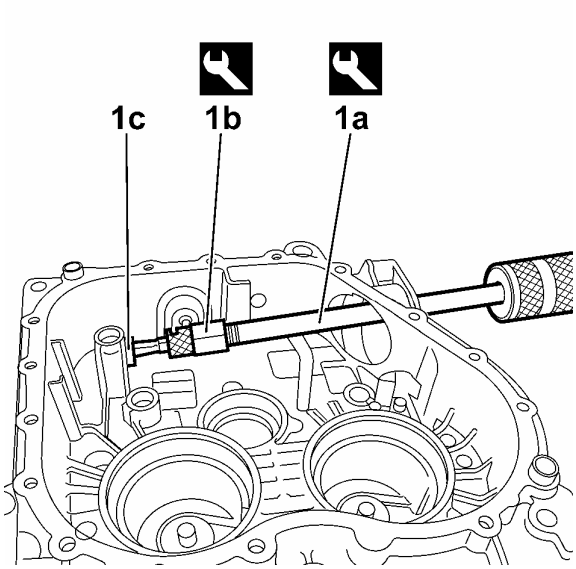
24. Unscrew the screws (1a) and remove the clutch disengagement sleeve (1b).



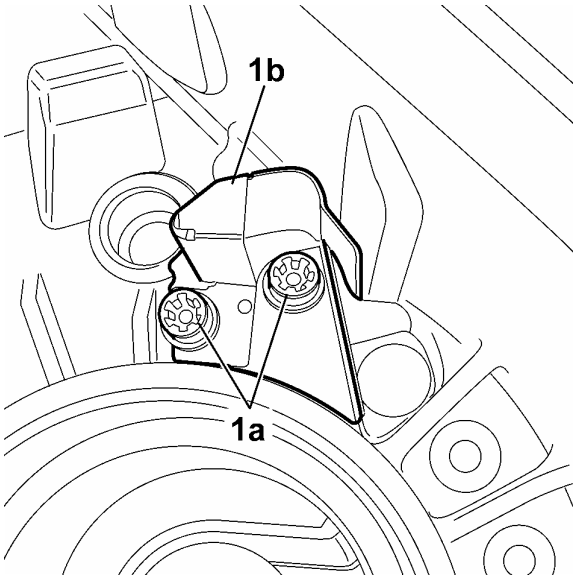
25. Use tools (1a) (Usag 468/1) and (1b) (Usag 468°/5) to remove the main shaft bearing (1c) from the gearbox support case.
Note: Check outer ring, inner ring and rollers for scoring, signs of overheating and wear; the bearing should turn freely with no tight points, otherwise replace the bearing as an assembly.



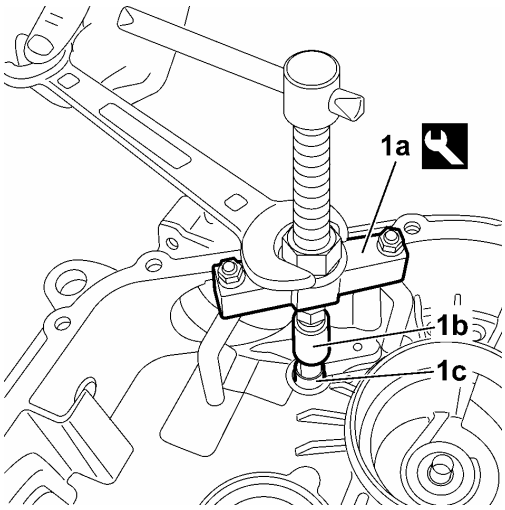
26. Use tools (1a) (1847017000) and (1b) (1840207813) to remove the gear selector/engagement shaft bearing (1c).
Note: Ensure that the bearing turns freely and has no tight points; replace the bearing if needed.



27. Unscrew the screws (1a) and remove the oil conveyor (1b).



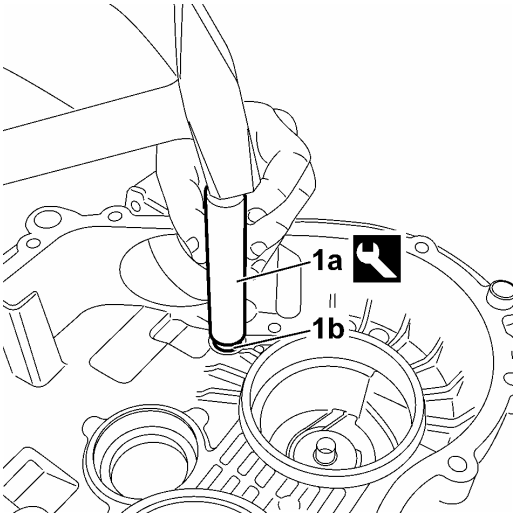
28. Use tools (1a) (Usag 468/1) and (1b) (Usag 468/3) to remove the mounting bushes for the for selector fork shafts (1c).



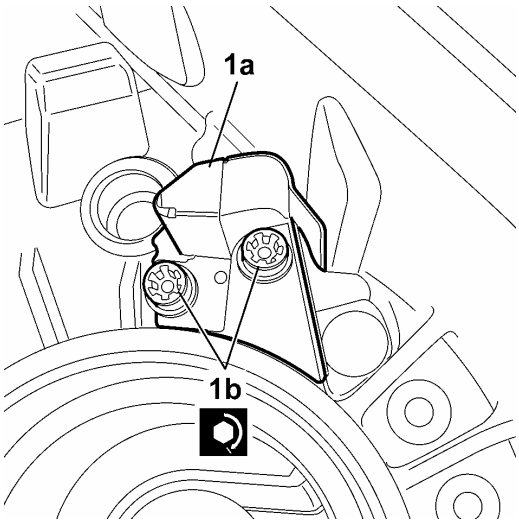
Installation

1. Wash the complete gearbox case and the gearing case.

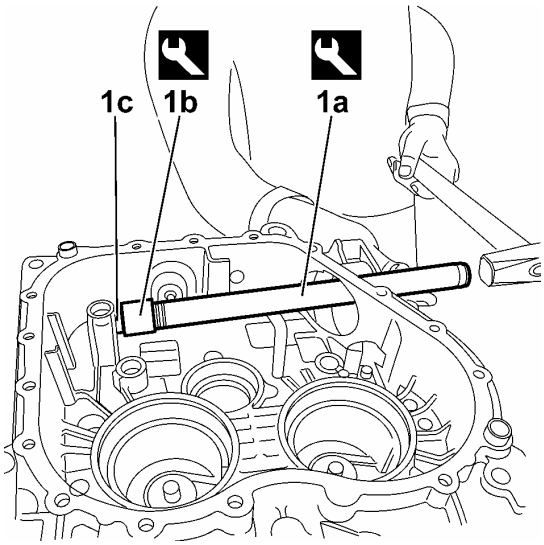
1. Use tool (1a) (1860858000) to insert the mounting bushes (1b) for the selector fork shafts both into the gearbox case and the gearing case.



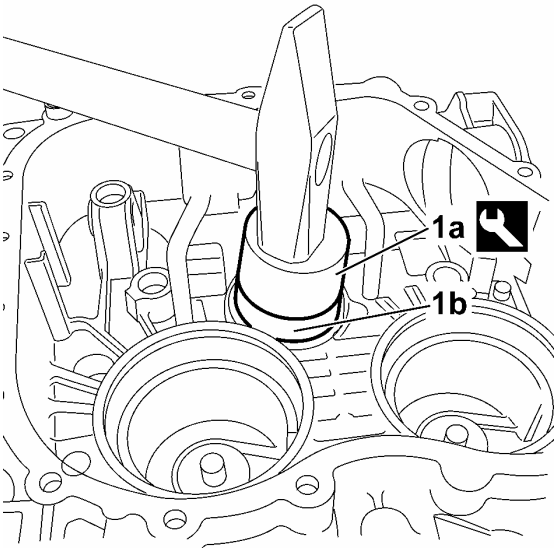
3. Fit the oil conveyor (1a) and tighten the retaining screws (1b) to the specified torque.



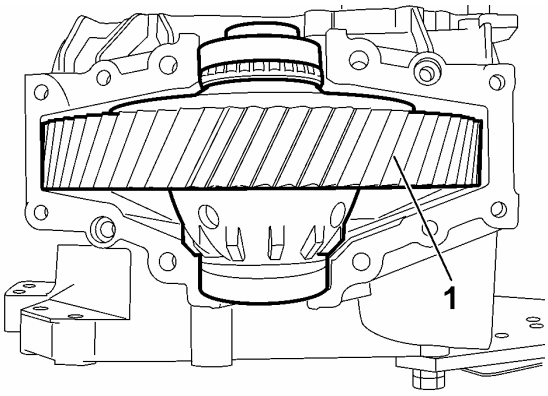
4. Use tools (1a) (2000004900) and (1b) (1874365000) to install the gear selector/engagement shaft bearing (1c).



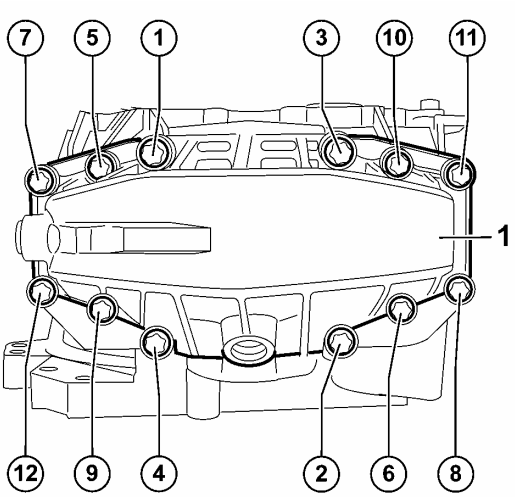
5. Use tool (1a) (2000019700) to install the main shaft bearing (1b) on the gearbox case.



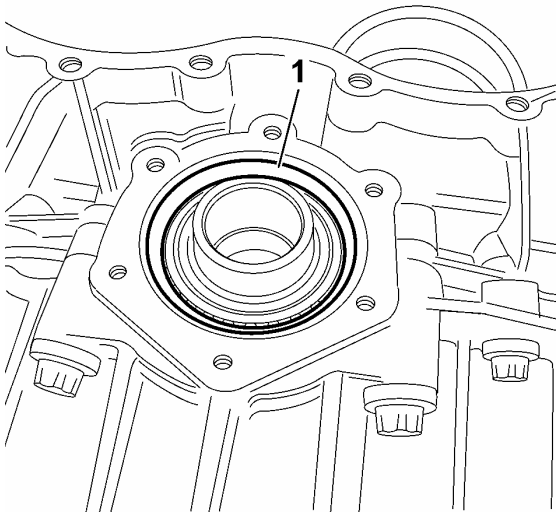
6. Install the differential case assembly (1a) and its bearings (1b) and (1c) on the gearbox case.



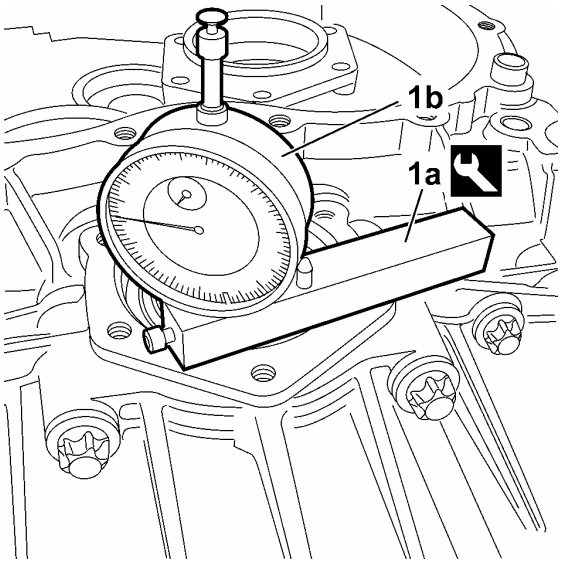
7. Fit the differential case cover and tighten the retaining screws to the specified torque in the specified order.



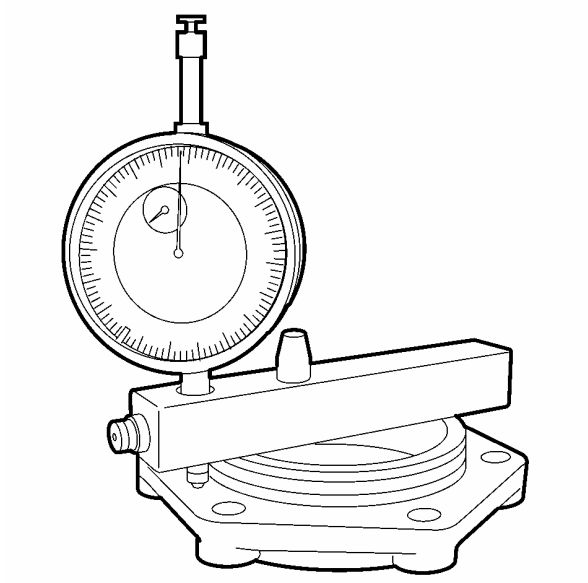
8. Ensure that the outer ring of the differential bearing on differential sealing cover becomes properly seated in its housing.



9. Position tool (1a) (1895655000) complete with a dial gauge (1b) graduated in hundredths of a millimetre on the mating face of the differential sealing cover and set gauge stylus in contact with the outer ring of the taper roller bearing. Set dial gauge to zero with 1 mm preload.



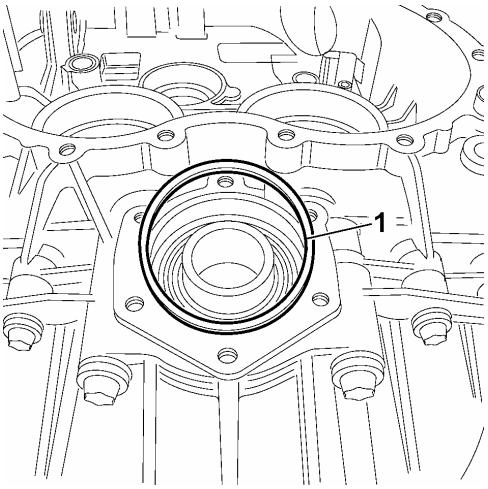
10. Position the tool (1a) complete with the 1/100 dial gauge on the differential sealing cover (1b) as shown in the figure and measure the difference.



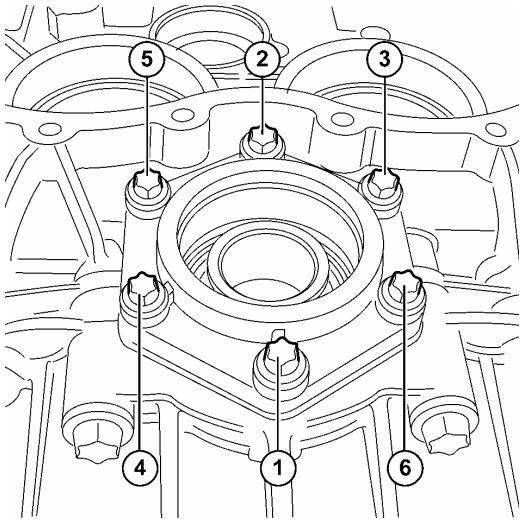
11. Add 0.23 to the difference measured to obtain the required shimming that will give the correct differential bearing prelod.

12. The 0.23 mm value is the required interference fit for the differential bearings to bed in properly and to achieve the correct preload.
Note: If you cannot obtain the exact shimming value using one shim or a combination of two shims, choose one or two shims that will give the next higher total thickness.

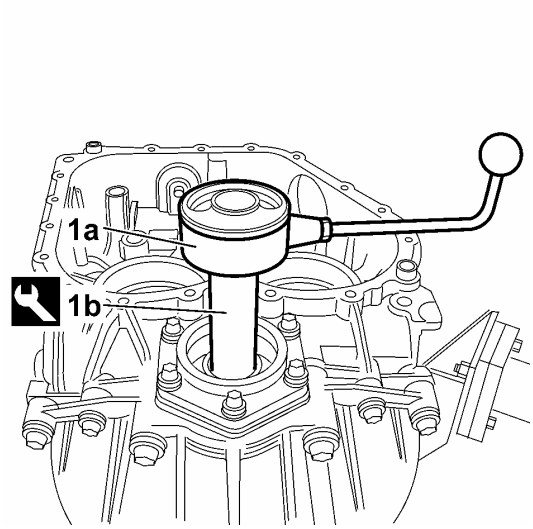
13. Install a differential bearing preload shim having the required thickness determined during the shimming procedure or choose the next bigger shim.



14. Fit the differential sealing cover and tighten the retaining screws to the specified torque in the specified order.

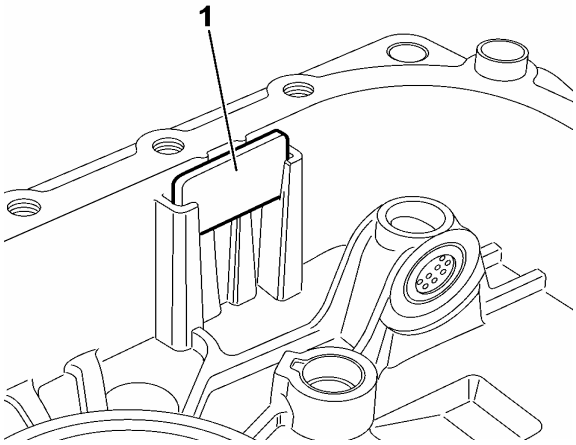


15. Use a torque meter (1a) and the suitable tool (1b) (2000019600b) to measure differential unit rolling torque and ensure it falls within the specified range. (0-3 Nm)



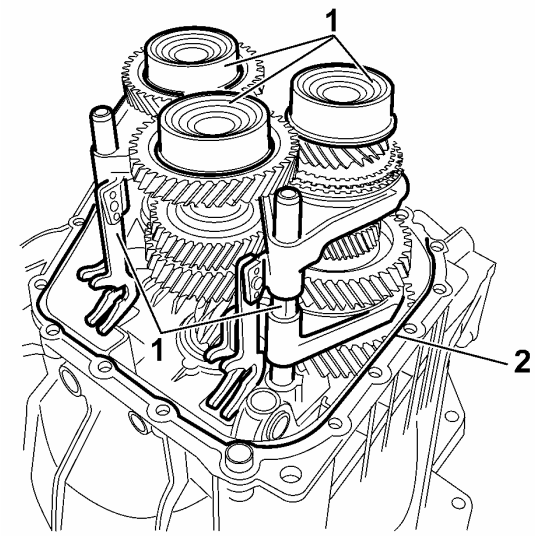
- Unscrew the retaining screws and remove the differential sealing cover.
- Remove the differential bearing preload shim.
- Unscrew the retaining screws and remove the differential case cover.
- Remove the differential case assembly and its bearings from the gearbox case.

16. Position the magnet into its seat in the gearbox case.

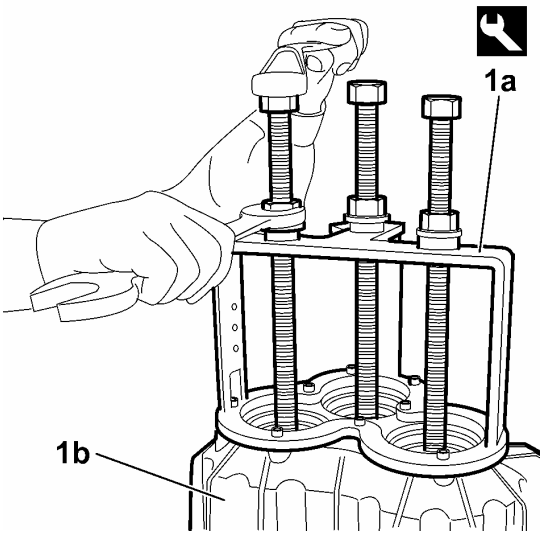


17. Fit the gearbox shafts (1) complete with selector forks into place in the gearbox case.

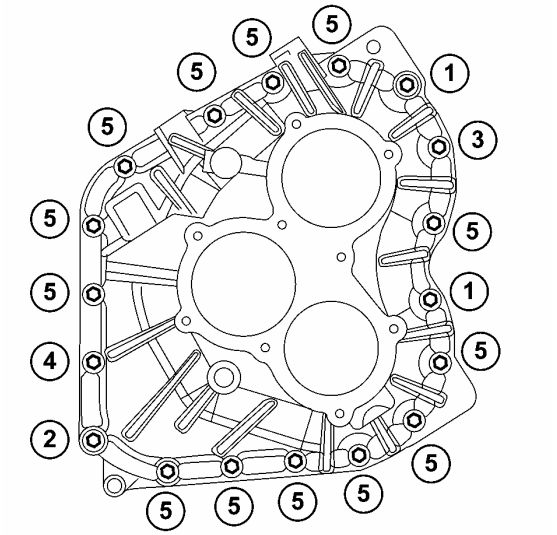
18. Spread an even layer of sealant (2) over the mating surface between gearbox case and gearing case.



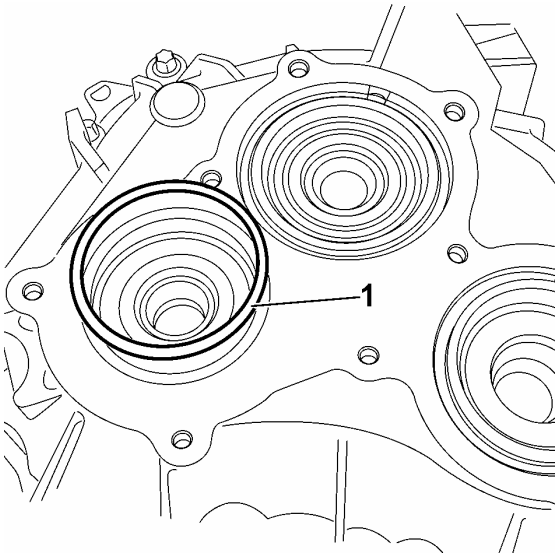
19. Use the extractor/drift tool (1a) to install the gearbox gearing case (1b).



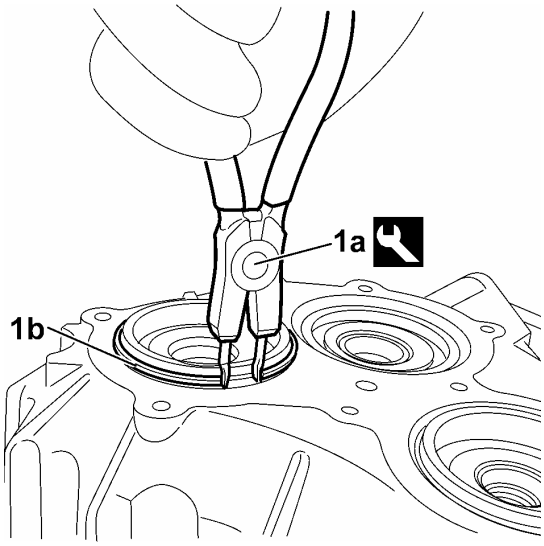
20. Tighten the retaining screws of the gearbox gearing case to the specified torque in two steps and following the specified sequence.
First step: tighten all screws to half the nominal torque.
Second step: tighten all screws to the final nominal torque.



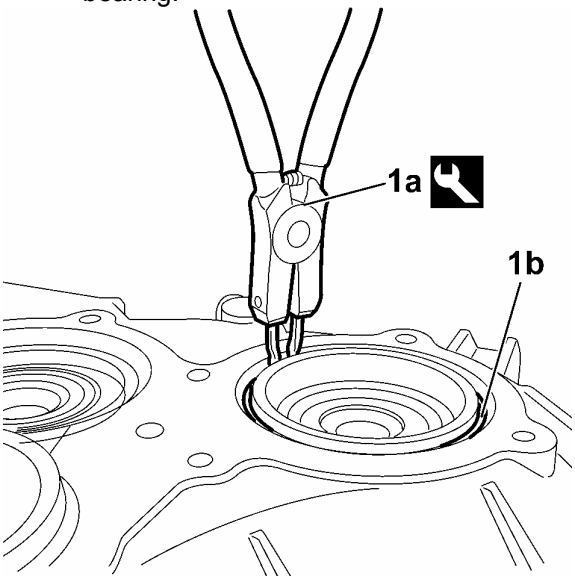
21. Fit the shim (1) for the lower secondary gearbox shaft bearing.



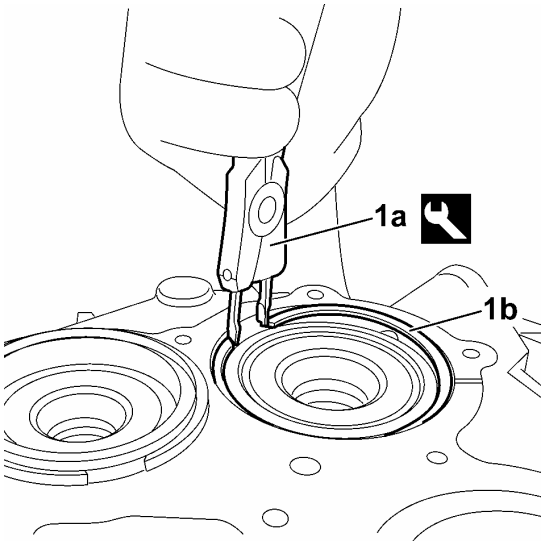
22. Use tweezers (1a) to install the circlip (1b) on shaft bearing



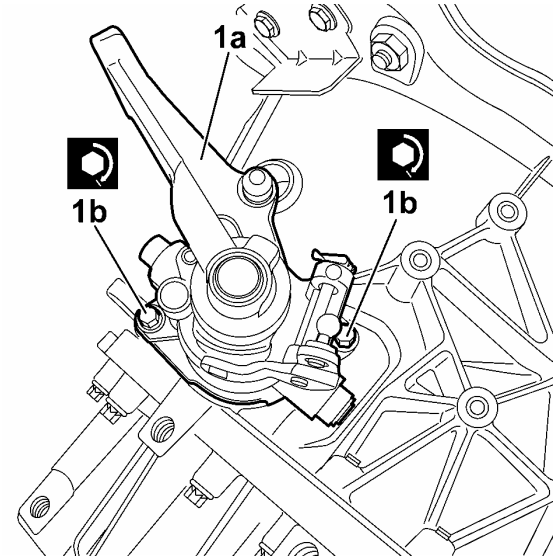
23. Use tweezers (1a) to install the circlip (1b) on the upper secondary shaft bearing.



24. Use tweezers (1a) to install the circlip (1b) on the main shaft bearing.



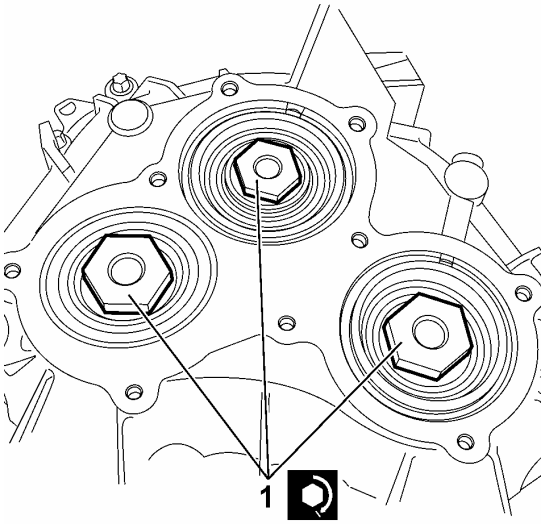
25. Fit the gear selector/engagement mechanism (1a) and tighten the screws (1b) to the specified torque.



- Engage two gears.

Note: Engaging two gears at the same time locks up the gearbox shafts; this will make it easier to tighten the ring nuts that hold the gears in place on the shafts to the specified torque.

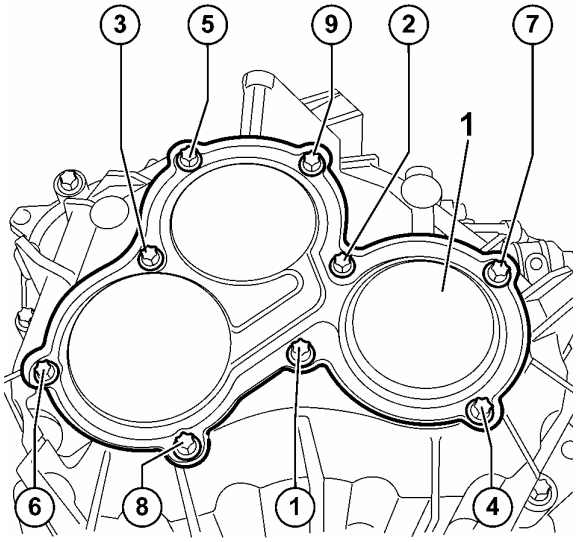
26. Tighten the ring nuts (1) that secure the gears on the gearbox shafts to the specified torque.



27. Fit the rear cover (1a) and tighten the retaining screws to the specified torque in two steps and in the sequence shown.

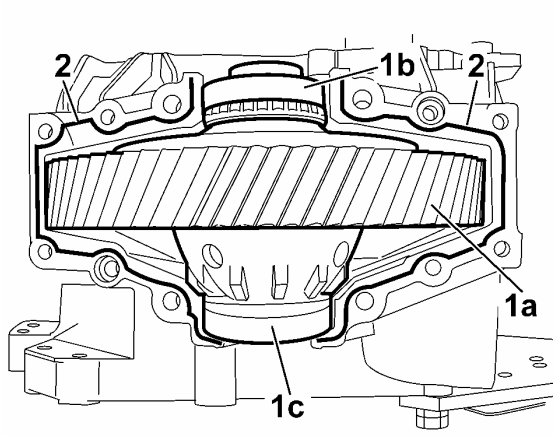
First step: tighten all screws to half the nominal torque.

Second step: tighten all screws to the final nominal torque.



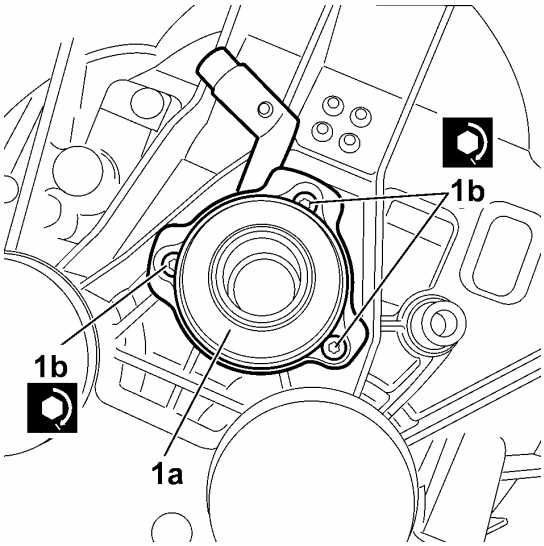
28. Install the differential case assembly (1a) and its bearings (1b) and (1c) on the gearbox case.

29. Spread an even layer of sealant over the mating surface (2) between gearbox case and differential case.

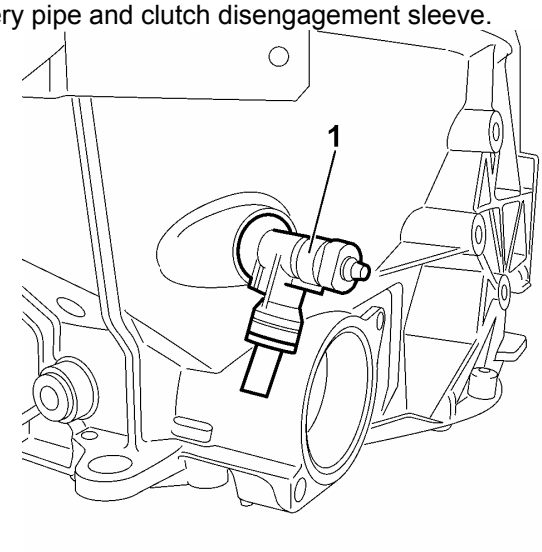


- Refit differential case cover, differential bearing preload shim and differential sealing cover as outlined above.

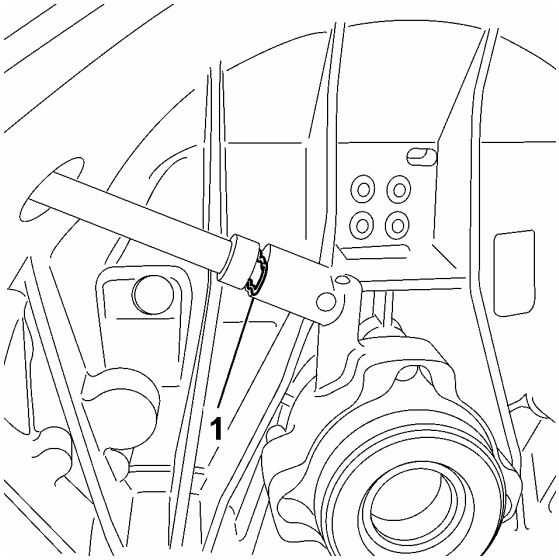
30. Fit the clutch disengagement sleeve (1a) and tighten the screws (1b) to the specified torque.



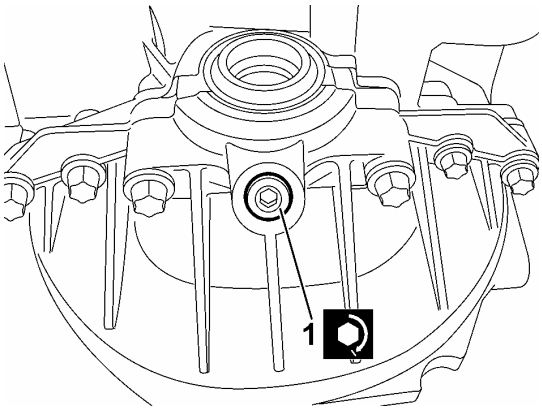
31. Insert the fitting connecting clutch delivery pipe and clutch disengagement sleeve.



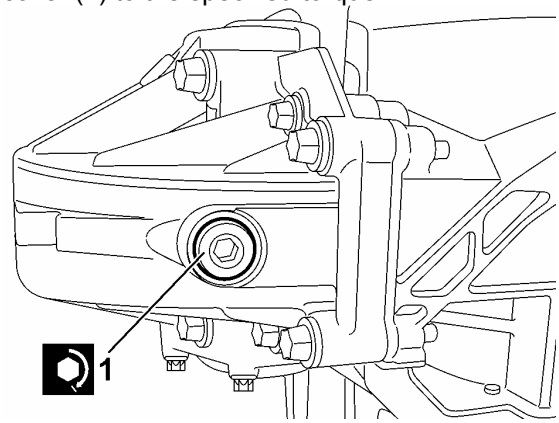
32. Install the clip that secures the pipe connecting clutch delivery pipe and clutch disengagement sleeve on the sleeve.



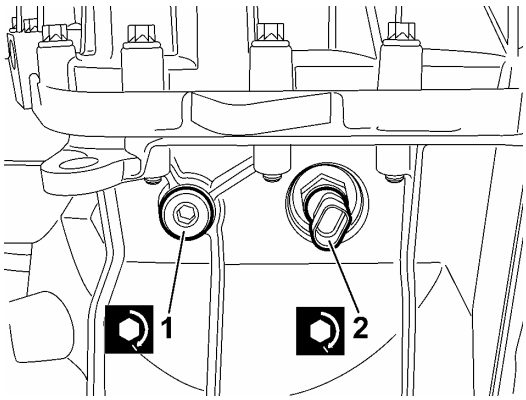
33. Tighten the oil drain plug on the differential cover (1) to the specified torque.



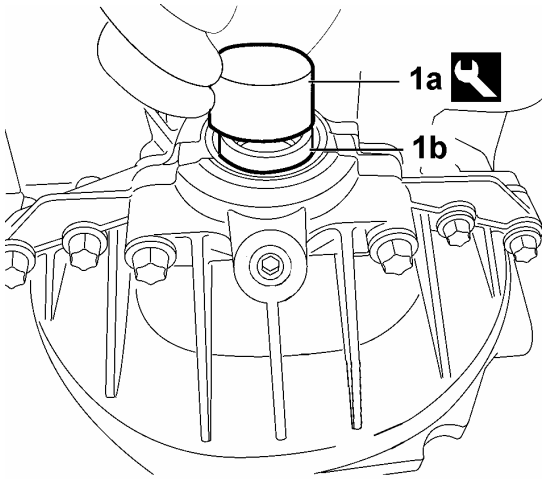
34. Tighten the magnetic plug onto the differential cover (1) to the specified torque.



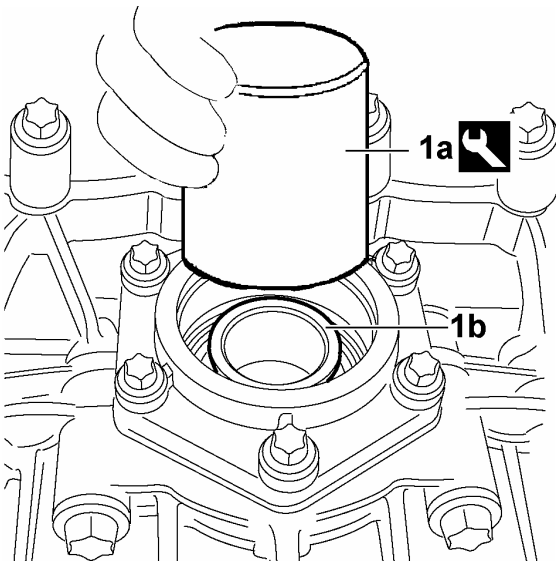
35. Tighten the oil filler plug on the gearbox case (1) to the specified torque.
36. Tighten the reverse switch (2) to the specified torque.



37. Use tool (1a) to install the oil seal (1b) on the clutch-side differential case.



38. Use tool (1a) to install the oil seal (1b) on the differential case on gearing case side.



4.2.2 Gearbox tools

Tool Code	Make Model c.c.	Designation	Type
2000019400	**M40 gearbox** Fiat Ducato 3.0	Gearbox case extractor/drift kit	New
2000019500	**M40 gearbox** Fiat Ducato 3.0	Torque bush/rolling torque tool	New
2000019600	**M40 gearbox** Fiat Ducato 3.0	Adapter for differential rolling torque inspection	New
2000019700	**M40 gearbox** Fiat Ducato 3.0	Bearing drift tool	New
2000019800	**M40 gearbox** Fiat Ducato 3.0	Tool to check differential rolling torque (on bench)	New
1.840.207.813	**M40 gearbox** Fiat Ducato 3.0	Gear selector bearing extractor	Existing
1.874.365.000	**M40 gearbox** Fiat Ducato 3.0	Drift tool for gear selector bearing installation	Existing
2.000.004.900	**M40 gearbox** Fiat Ducato 3.0	Slide hammer	Existing
1.860.858.000	**M40 gearbox** Fiat Ducato 3.0	Drift tool to install gear selector fork shaft bushes	Existing
1.860.954.000	**M40 gearbox** Fiat Ducato 3.0	Drift tool for main shaft bearing removal/installation	Existing
2.000.005.000	**M40 gearbox** Fiat Ducato 3.0	Supporting plates	Existing
1.845.028.000	**M40 gearbox** Fiat Ducato 3.0	Torque plate for secondary shaft bearing removal	Existing
1.870.658.000	**M40 gearbox** Fiat Ducato 3.0	Drift tool for secondary shaft bearing installation	Existing
1.870.812.000	**M40 gearbox** Fiat Ducato 3.0	Torque plate for secondary shaft bearing removal	Existing
1.870.675.000	**M40 gearbox** Fiat Ducato 3.0	Supporting plates	Existing
1.870.100.002	**M40 gearbox** Fiat Ducato 3.0	Drift tool for secondary shaft synchroniser installation	Existing
1.871.006.700	**M40 gearbox** Fiat Ducato 3.0	Drift tool for corteco installation	Existing
1.870.710.000	**M40 gearbox** Fiat Ducato 3.0	Torque plate for differential bearing removal	Existing
70465	**M40 gearbox** Fiat Ducato 3.0	Driver tool for main shaft bearing installation	Drift tool

SAT-A 95655	**M40 gearbox** Fiat Ducato 3.0	Dial gauge base	Existing
Usag 468A/5	**M40 gearbox** Fiat Ducato 3.0	Extractor for main shaft bearing removal	Generic tool
Usag 468A/3	**M40 gearbox** Fiat Ducato 3.0	Drift tool to remove gear selector fork shaft bushes	Generic tool
Usag 454N/2	**M40 gearbox** Fiat Ducato 3.0	Extractor for secondary shaft bearing removal	Generic tool
Usag 472/3	**M40 gearbox** Fiat Ducato 3.0	Extractor for differential bearing removal	Generic tool
Usag 472A/3	**M40 gearbox** Fiat Ducato 3.0	Extractor for differential bearing removal	Generic tool
Usag 468/1	**M40 gearbox** Fiat Ducato 3.0	Extractor for differential bearing removal	Generic tool

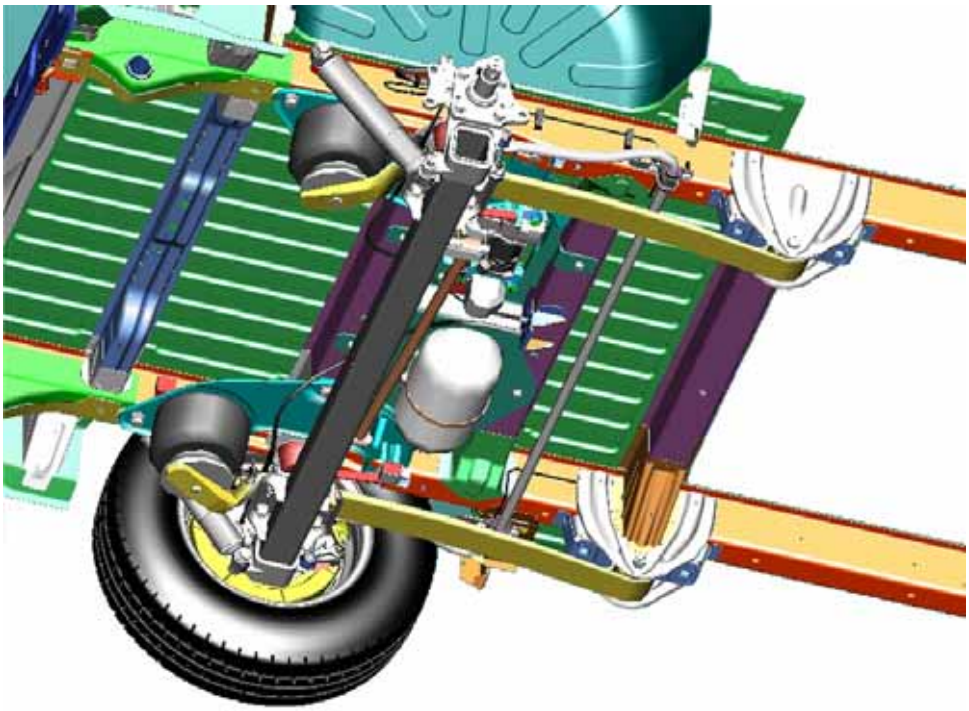
5. Self-levelling rear air SUSPENSION

Features

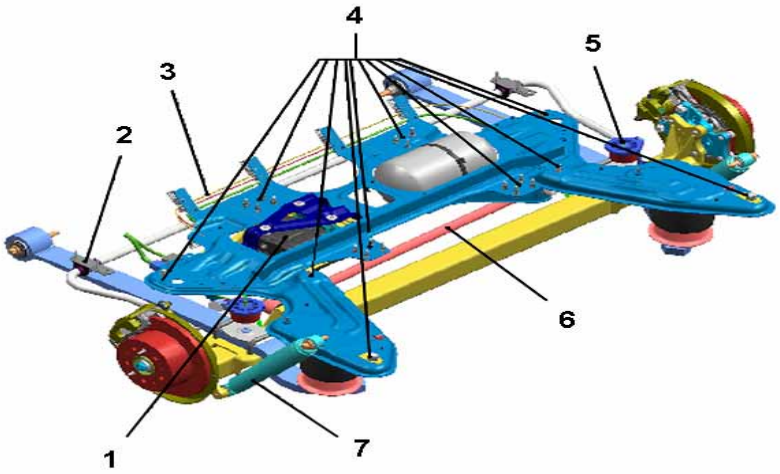
In addition to such advantages as high flexibility and enhanced vibration damping, the self-levelling air suspension is capable of maintaining a constant ground clearance (distance from underside of chassis to road) regardless of vehicle load.
The electronically controlled air suspension is automatically enabled upon engine starting. When the vehicle is stopped, ground clearance - and vehicle platform loading height - can be set manually using the in-cab controls.
The electronic control unit incorporated in the compressor-and-valve assembly automatically controls ground clearance by comparing the actual readings supplied by sensors with the nominal values stored in its memory.
When a change in ride height is detected during running, the electronic control unit signals an electro-pneumatic unit to correct actual level according to the nominal level set or stored by the driver.

The system controls the rear axle to maintain a constant chassis attitude at the rear end regardless of load, thus ensuring improved ride comfort. When the vehicle is stopped, preferred rear ride height can be selected choosing from 7 different settings to facilitate access to the rear load compartment.

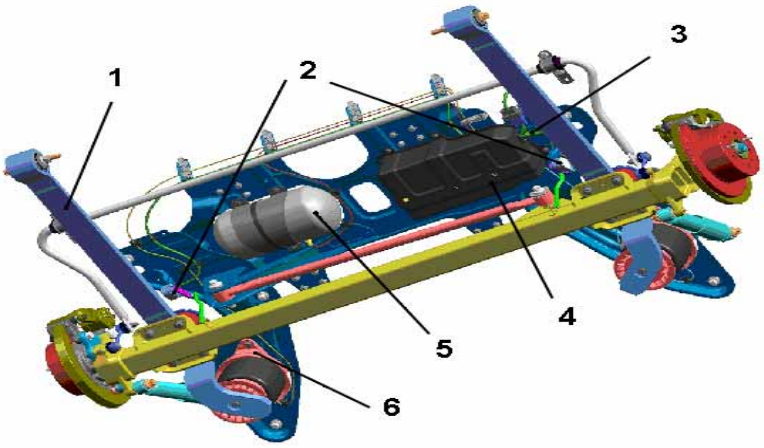
The system installed on the vehicle is shown in the figure below.



The system consists of:
- two air springs,
- an ASU (Air Supply Unit) Module: electric air compressor complete with valves, electronic control unit (ECU) and mounting bracket to facilitate module installation,
- tank complete with mounting bracket,
- two level sensors located between body and rear axle (close to the wheels) complete with drives,
- a suction tube with air filter,
- three air lines (in different colours to facilitate identification),
- a splashguard,
- a dedicated wiring harness,
- an upper cross member to hold system components,
- a Panhard rod,
- two quarter-elliptic leaf springs with spring saddle pads,
- axle with Panhard rod mount,
- two bump stops,
- two dampers,
- an Anti-Roll bar,
- a dash plate with two momentary pushbuttons,
- “Comfort” style NQS instrument panel with indicator light and appropriate messages.



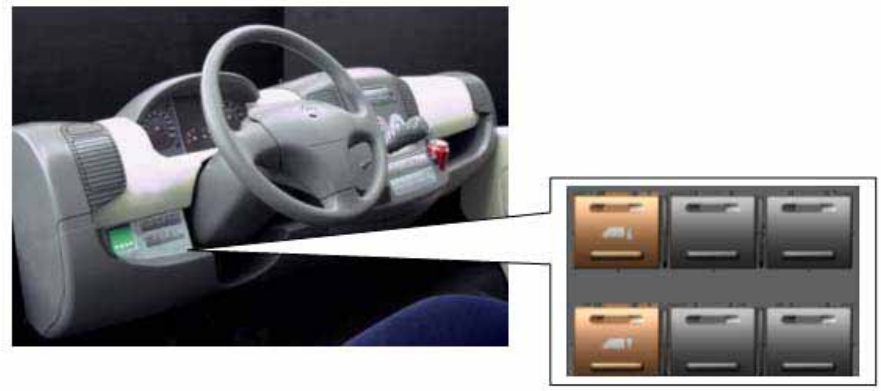
1 – Compressor
2 – Anti-roll bar
3 – Air lines
4 – Body mounts
5 – Bump stop
6 – Panhard rod
7 – Damper



1 – Quarter-elliptic leaf spring
2 – Height sensors
3 – Wiring harness for connection to electric system
4 – Compressor guard
5 – Tank
6 – Air spring

Operation

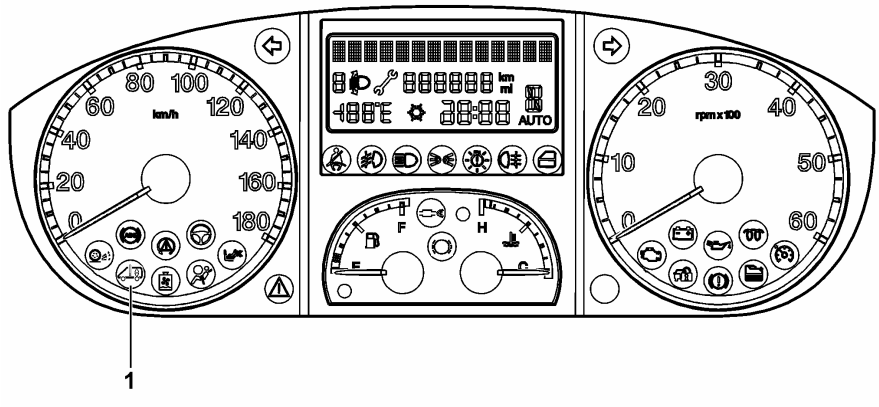
When the vehicle is stopped, ground clearance can be set to one of 7 preset levels ranging from “ride height -3” to “ride height 0”, through to “ride height +3” by pressing the pushbuttons on the dash.
While setting ground clearance, the amber LED on the push-button that corresponds to the direction of movement will blink.
A LED turning steady on after the push-button has been pressed indicates that:
- process has been aborted due to low circuit pressure,
- compressor has been temporarily cut off due to overheating



1 – Up push-button
2 – Down push-button

The multifunction display in the middle of the instrument panel can display current ride height (while either one of the pushbuttons is activated).

In the event of a malfunction, the red malfunction indicator light on the instrument panel will turn on.



1 – (Red) self-levellling suspension malfunction indicator light

Automatic levelling

During running, the system automatically restores and maintains “ride height 0”.
When automatic levelling kicks in, the LED on the up or down push-button will blink to indicate the direction of the adjustment.
The system can compensate for up to 300 Kg side-to-side load unbalance and 35 mm height variation approximately.
The system recognises reverse and will not kick in if transient pressure and height variations occur when reversing.
The system recognises when the vehicle is negotiating a curve and will not kick in when it detects a height unbalance while running at any speed greater than zero.

Manual setting

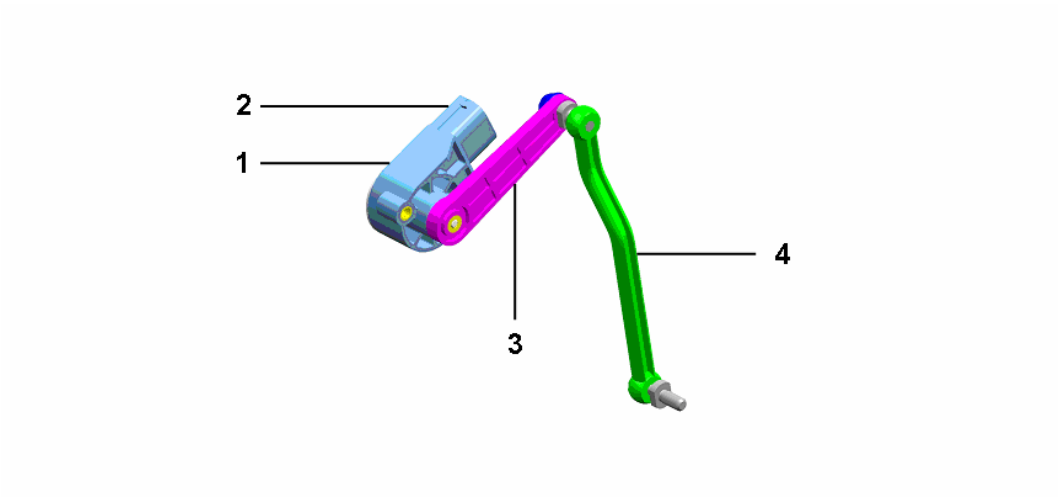
The desired height can be set when the vehicle is stopped (regardless of whether the engine is running or stopped). With a full load (a total of about 1900 Kg at rear axle) and the engine is stopped, rear ride height can be raised from level -3 (full bump) to level 0 only two times.
Pressing the up push-button for less than 1 second selects the next higher level; holding the push-button depressed for more the 1 second jumps to maximum level: ride height +3.
Pressing the down push-button for less than 1 second selects the next lower level; holding the push-button depressed for more the 1 second jumps to minimum level: ride height -3.
During the setting procedure, the LED on the up or down push-button will blink to indicate the direction of the adjustment.
If the LED stays on steady (for about 5 seconds) instead of blinking after a push-button has been pressed, it means that the setting mode is not available at the moment.
This may be due to one of the following reasons:
– air stored insufficient: operation will be restored when engine is started;
– system reached max operating temperature limit: allow a few minutes for the system to cool down before pressing a push-button.
The level selected when the vehicle is stopped is maintained up to a speed of 20km/h approximately; when the vehicles exceeds this speed, the system automatically restores standard ride height (“ride height 0”).

Lifting the vehicle

If you need to raise the vehicle, disable the system by holding both pushbuttons depressed for at least 5 seconds.
This activates a special mode designed for vehicle lifting; both pushbuttons LEDs turn on steady and the vehicle can be lifted.
To exit this mode, press both pushbuttons for 5 more seconds; both push-button LEDs turn off and the system is restored to normal operation.
This mode shuts off automatically when the vehicle exceeds 5 km/h.

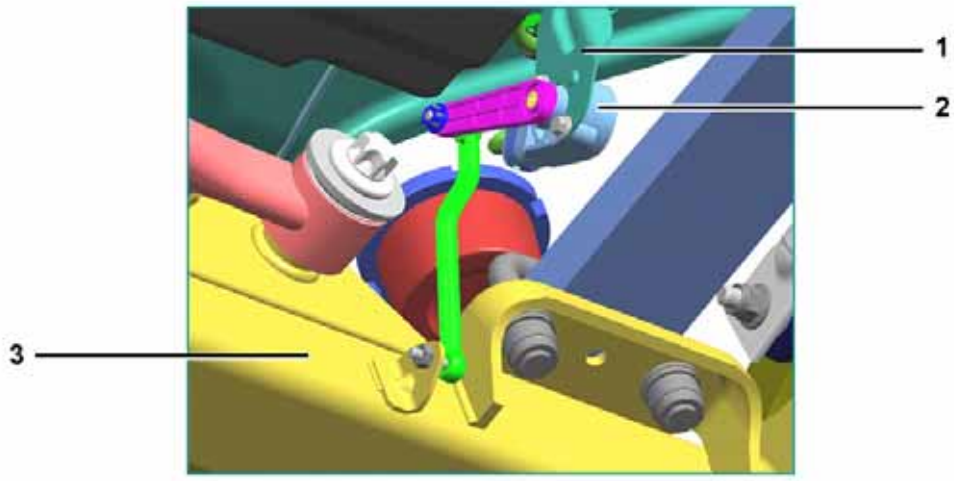
Description of components
Self-levelling system components
Level sensors

The self-levelling suspension system uses two level sensors.



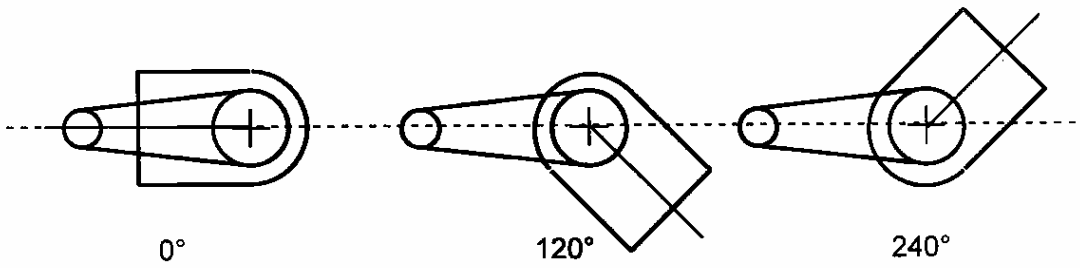
1 – Level sensor
2 – Electrical connector
3 – Sensor arm
4 – Linkage for connection to axle

The level sensors are placed between the upper cross member that holds system components and the axle

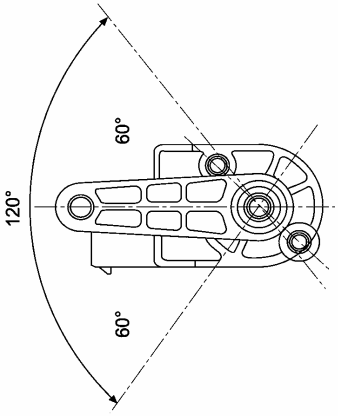


1 – Mounting bracket on component carrier cross-member
2 – Level sensor
3 – Axle

Sensor arm will fit in three different positions relative to sensor, but only one position is correct, namely at 0°.

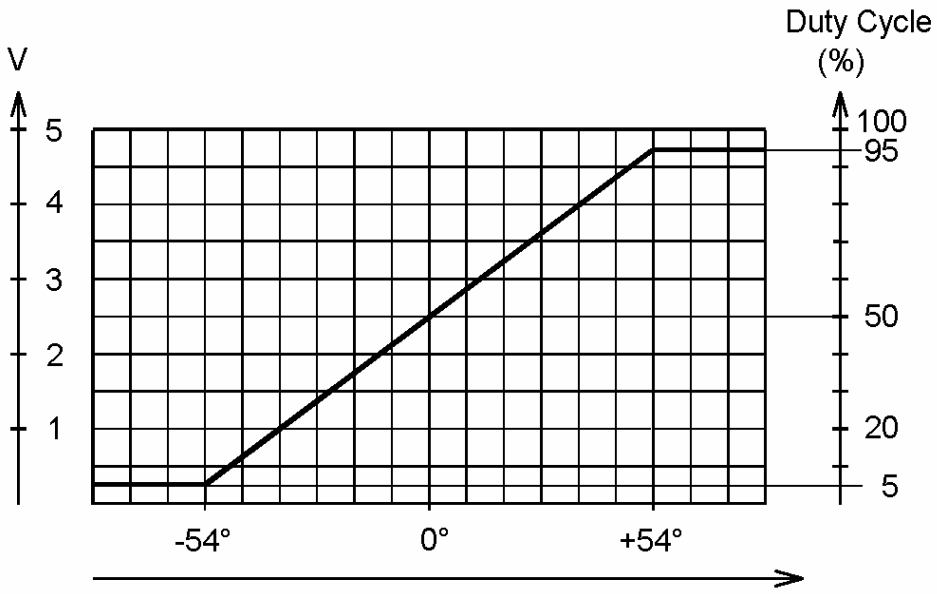


Each position provides an operating range of 120°.

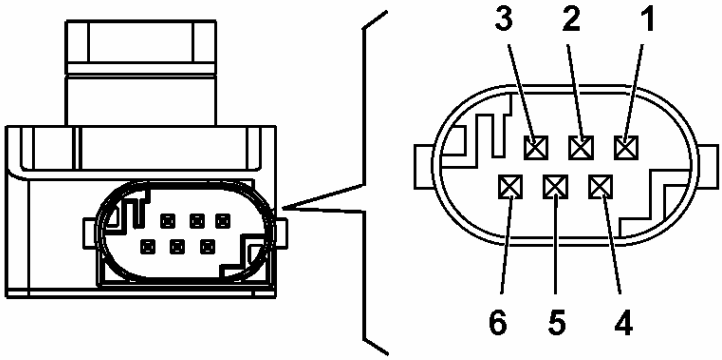


The sensor has two outputs that change as sensor arm changes its angle to the sensor; sensor outputs provide:
- an analogue signal (that varies between 5% and 95% of sensor supply voltage),
- PWM digital signal (800Hz ± 25% frequency).

The system uses the PWM signal to control the self-levelling suspension: ride height 0 corresponds to a 50% duty cycle.



The figure below shows sensor pinout.

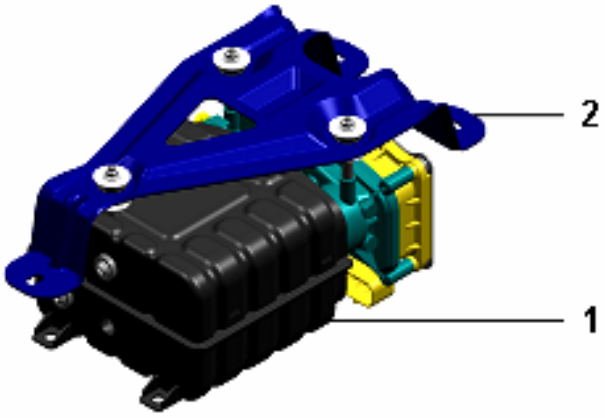


1 – Ground
2 – Not connected
3 – Not connected
4 – Analogue signal
5 – +5V power supply
6 – PWM signal

Sensors are fed 5V ± 0.5V directly from the self-levelling suspension control unit.

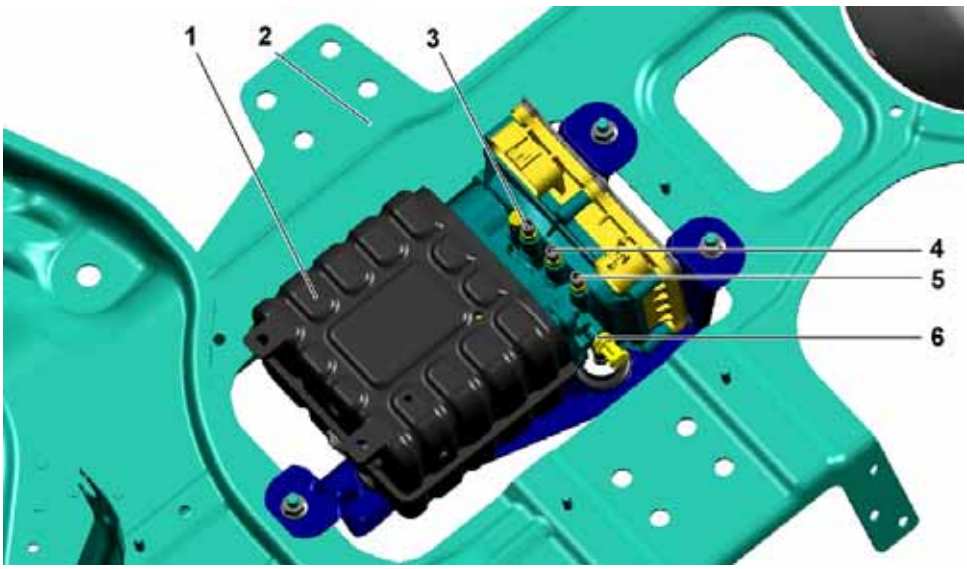
ASU (Air Supply Unit) Module

The ASU Module is comprised of compressor, valve assembly and control unit. The Module cannot be taken apart and is only enabled when the engine is running.
The module is retained to the upper component carrier cross-member by a bracket.



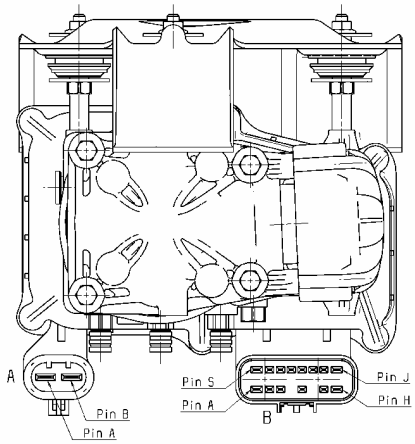
1 – ASU Module
2 – Mounting bracket

The figure below shows a bottom view of the ASU module.



1 – ASU Module
2 – Upper cross member holding system components
3 – Air connection for left spring
4 – Air connection for right spring
5 – Air connection for tank
6 – Air connection for air suction

The following figure shows a front view of the ASU module and its electrical connectors.



Connector A pinout (power supply)
A – Power supply
B – Ground

Connector B pinout (signals)
A – Right sensor ground
B – Left sensor ground
C – “Down” command (from pushbutton)
D – N.C.
E – Power supply from battery
F – N.C.
G – Right sensor power supply
H – LED on Up push-button
J – LED on Down push-button
K – Left sensor power supply
L – C-Can H
M – C-Can L
N – “Up” command (from pushbutton)
P – Left sensor signal
R – Right sensor signal
S – Ground

The control unit sends information messages for the instrument panel over the CAN line and receives vehicle speed, brake pedal, handbrake, reverse and engine rpm input signals from the network.

LIST OF PARAMETERS

_VIN (Vehicle ID No.)
_Energy saving
_RL height sensor absolute incr.
_RR height sensor absolute incr.
_Programming sessions
_Sensor power supply
_H deviation from 0 (LH PB)
_H deviation from 0 (RH PB)
_H deviation from Target (RH PB)

_H deviation from Target (LH PB)
_Average deviation from 0

_Led Up Pos.
_Led Down Pos.
_PB up
_PB Down
_Door opening
_Key position
_Vehicle speed
_Compressor state
_Tank valve state
_Battery voltage
_Longitudinal acceleration
_Recirculation Key
_Exhaust valve state
_Spring valve sensor (RH PB)
_Spring valve sensor (LH PB)
_Rear exhaust valve
_Available reserve
_Compressor pressure
_LH height sensor
_RH height sensor

TROUBLE CODE LIST

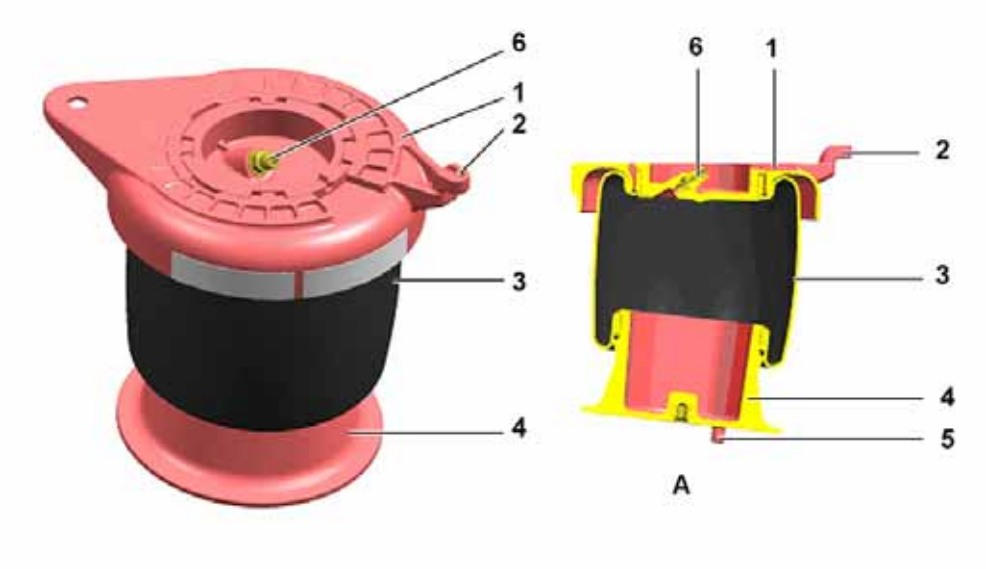
DTC	DESCRIPTION	SYMPTOM
5001	Battery voltage	Below lower limit
		Above plausible upper limit
5002	Key up	Signal not plausible
		No signal
5003	Key Down	Signal not plausible
		No signal
5004	ECU faulty (Microprocessor)	No additional information
5005	Height actuator up	ECU internal error
5006	Height actuator down	ECU internal error
5007	Height actuator up	Electrical fault
		Electrical fault
5008	Solenoid valve 1	No signal
		Below lower limit
		Above plausible upper limit
5009	Solenoid valve 2	No signal
		Below lower limit
		Above plausible upper limit
5010	Solenoid valve 3	No signal
		Below lower limit
		Above plausible upper limit
5011	Solenoid valve 4	No signal
		Below lower limit
		Above plausible upper limit
5012	Compress. enable relay	ECU internal error

5013	ECU temperature	Above plausible upper limit
5014	Pressure sensor	No signal
		Not calibrated
5015	Sensor power supply	Above plausible upper limit
		Below lower limit
5016	Sensor power supply	Left
		Below lower limit
		No signal
5017	Sensor power supply	No additional information
		Below lower limit
		No signal
5018	Left spring valve	Excess air
5019	Right spring valve	Excess air
5020	Breather valve	Excess air
5021	Reserve valve	Excess air
5022	Manual pitch correction	No additional information
5023	Compressor state	Excess air
5024	Air adaptation	No additional information
5025	Wrong end-of-line configuration	No additional information
5026	Initialisation failed	No additional information
5027	Wrong ECU or wrong calibration	No additional information
D602	Bus off	No additional information
D700	NBC node missing	Above plausible upper limit
D701	NCM node error	No signal
D706	NFR node error	No signal
5028	Vehicle speed inconsistent	Above plausible upper limit
5029	Engine rpm threshold	Above plausible upper limit

Characteristic data:
Power supply voltage: 12V (+4V, -3V)

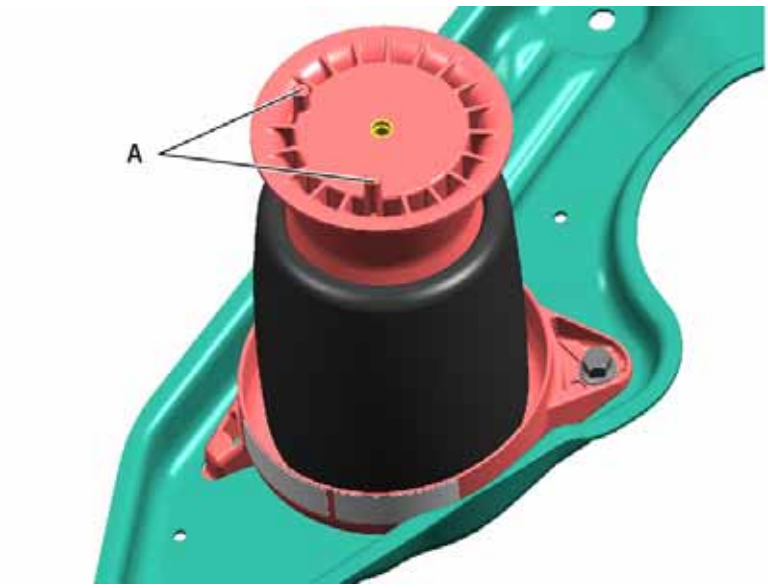
Compressor maximum draw: 25A
Solenoid valve maximum draw: 5A
Operating temperature: -40°C up to +80°C
Operation limit: < 3 minutes at 100°C
Burst pressure: > 35 bar
Maximum operating pressure (w/limitation): absolute 17 bar (relative 16 bar)

Air springs
Air springs are made up of a top plate for fastening to cross-member, bellows and a lower piston with fastening system and locators for installation to quarter-elliptic leaf spring.
Pressure inside the springs is about 1.5 bar under no-load and about 6.5 bar under full load when the vehicle is stopped.



A – Cross-section view
1 – Upper plate
2 – Jig for installation on component carrier cross-member
3 – Bellows
4 – Lower piston
5 – Locating pin for installation on quarter-elliptic leaf spring
6 – Air line fitting

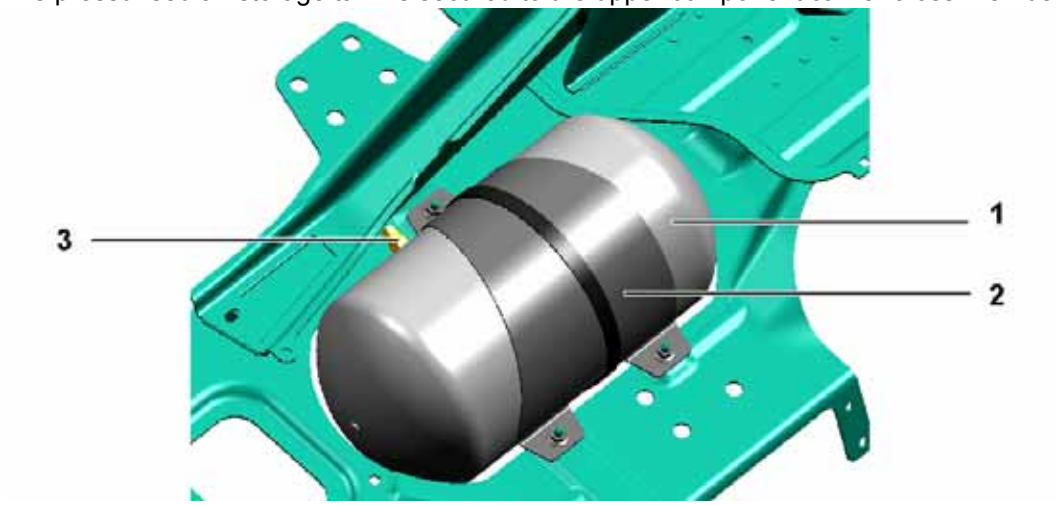
The figure below shows a bottom view of the air spring.



– Locating pins for installation on quarter-elliptic leaf spring

Tank

The pressurised air storage tank is secured to the upper component carrier cross-member by a bracket.



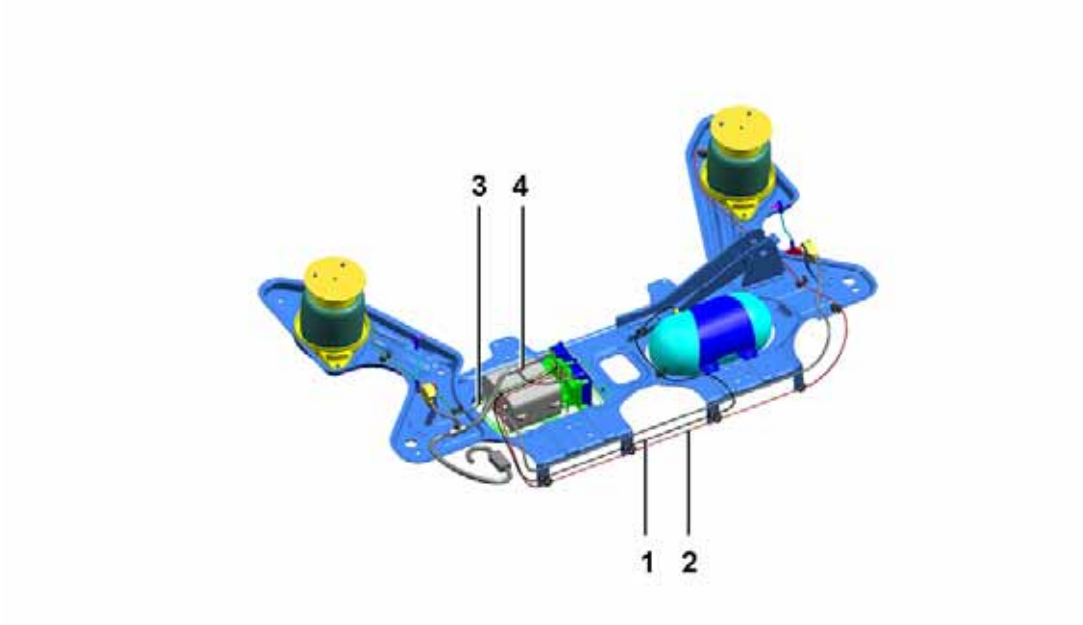
1 – Tank
2 – Mounting bracket
3 – Air line fitting

Characteristic data:
Volume: 5.4 l
Burst pressure: > 40 bar
Operating pressure: > 16 bar

Air lines

The air lines are semirigid pipes with a 4 mm diameter in different colours; the specified bending radius must not be exceeded.
The air quick fittings (Voss air connections) feature a spring collar that must be replaced each time the lines are disconnected.

To avoid wrong assembly, match the colour on the label affixed to the compressor to the quick fittings of the valve assembly.



1 – Line from compressor to tank (BLACK)
2 – Line from compressor to right spring (RED)
3 – Line from compressor to left spring (GREEN)
4 – Wiring harness

Chassis components

Upper component holder cross member

The upper cross member is a structural component that connects:
- vehicle floor to air springs,
- vehicle floor to Panhard rod.

Panhard rod

The Panhard rod is a round-section steel rod with a rubber-and-metal bush at both ends; it connects the axle to the upper cross member that holds system components.

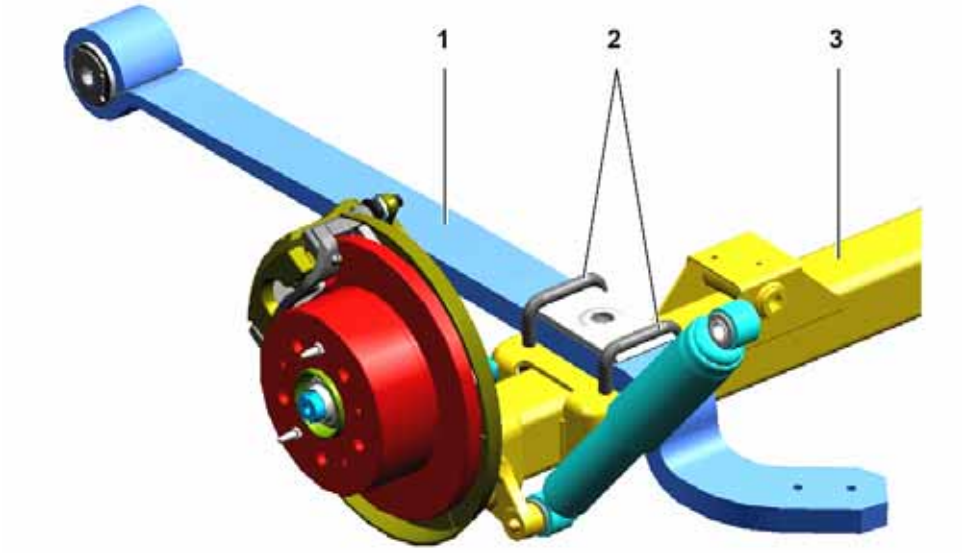
Axle

The axle carries the retaining bracket for the Panhard rod.

1 – Panhard rod retaining bracket

Quarter-elliptic leaf springs

The quarter-elliptic leaf springs (one on the left and one on the right) are specifically designed for the air suspension and are secured to the axle by two U bolts.



1 – Quarter-elliptic leaf spring
2 – U bolts
3 – Axle

6. DIGITAL TACHOGRAPH

REGULATIONS
After the publication of Art. 27 of Regulation (EC) no. 561/2006, the **law requires** that all vehicles registered for the first time in the European Union **from 1st May 2006** (newly registered M2-N2-N1 vehicles) be equipped with a digital tachograph.
Affected Fiat Ducato vehicles are:
- **minibuses** - **M2** vehicles seating more than 9 persons
- **goods vehicles having a maximum laden mass > 3.5t** - **N2** vehicles
- **goods vehicles having a maximum laden mass < 3.5t and with an overall mass > 3.5t when towing a trailer** - **N1** vehicles

The digital tachograph is not mandatory on all other vehicles in the range.
To equip the Fiat Ducato vehicle with the digital tachograph Smartach® and its associated speed sensor, FIAT Auto adopted the ACTIA Group system.

Drivers' hours rules introduced with Reg. (EEC) 3820/85

Weekly rest
As a general rule, 45 consecutive hours rest must be taken. The following concessions apply

Driving hours
As a general rule, daily driving limit is nine hours.
The following options are possible:

-continuous driving: maximum 4.5 hours continuous driving followed by a 45-minute break, only once. The 45-minute break may be split into several breaks, each at least 15 minutes long for a total of 45 minutes.

-daily driving: nine hours extendable to 10 consecutive hours twice a week.

-fortnightly driving: maximum of 90 hours driving during a maximum of 6 consecutive days after which compensation rest must be taken.
- can be reduced to 36 consecutive hours if taken at drivers' or vehicle's base. Reductions must be compensated en bloc before the end of the third week following the week of reduction and attached to another rest period at least eight hours long.

- can be reduced to 24 consecutive hours if taken in a place other than drivers' or vehicle's base. Reductions must be compensated before the end of the third week following the week of reduction and attached to another rest period at least eight hours long.
Special provisions have been laid down for occasional international passenger transport. In this case, the driver may drive for 12 consecutive days up to 90 hours maximum; compensation rest for two weeks must be taken en-bloc at the end of the 12-day period.

Daily rest

As a general rule, 11 consecutive hours rest must be taken. The following concessions apply:
- can be reduced to 9 consecutive hours, up to three days a week. Reductions must be compensated before the end of the following week and attached to another rest period at least eight hours long taken at the driver's domicile.

- can be split in up to three breaks during one day, in which case one the three following options must be observed: 12 hours total daily rest, with one break of at least 8 consecutive hours and anyway never less than one hour at a time.

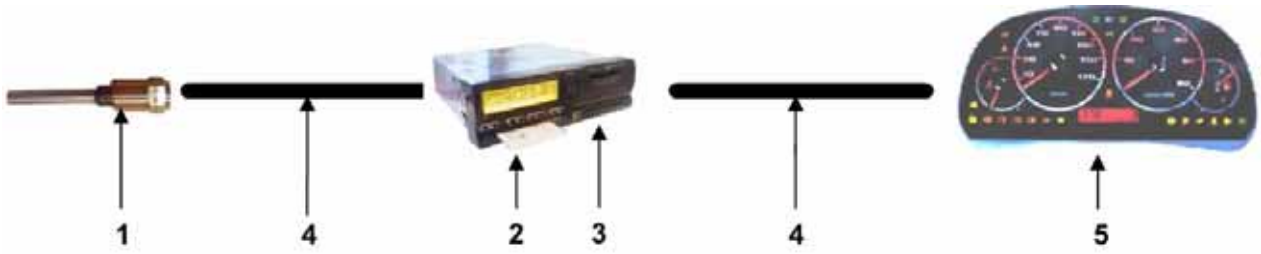
Double manning concessions

Each driver must have a rest period of not less than 8 consecutive hours during each period of 30 hours.

General description

The mandatory use of the digital tachograph to record driving hours has been introduced because analogue tachographs proved easy to tamper with and their time recordings are not reliable for law enforcement purposes.
The digital tachograph consists of three main components (1-2-3):

Example of connection.



Key

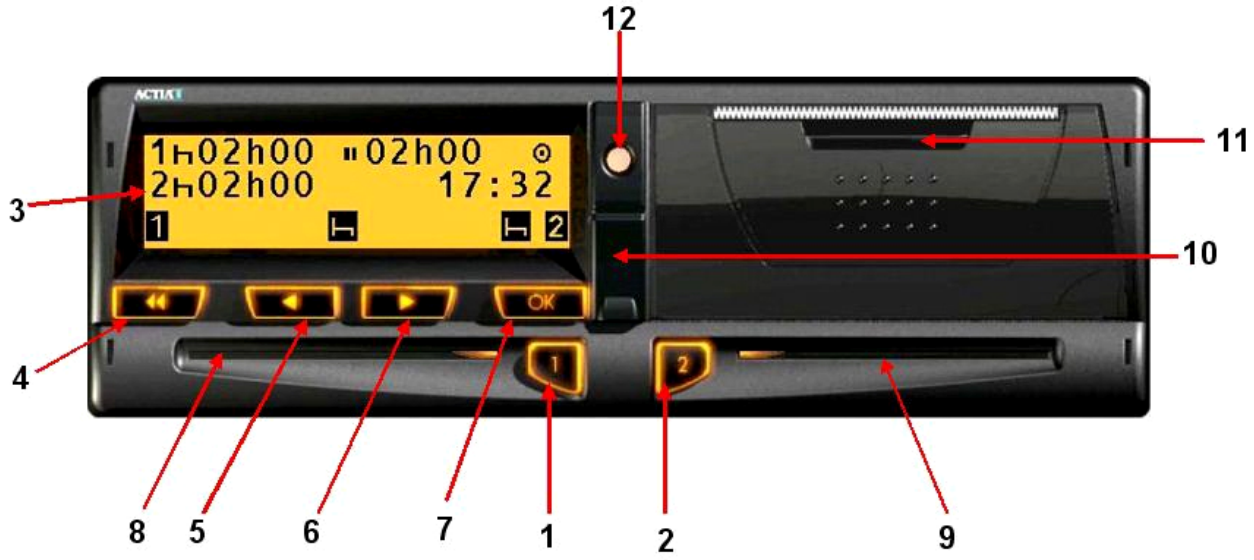
1. speed sensor mounted on gearbox
- rotary sensor on MLGU mechanical gearbox + antitampering wire;
- static sensor on M40 gearbox + antitampering wire;
- static on axle (automatic transmission) + antitampering wire.

2. smart card **4. wiring harness**
3. vehicle unit **5. instrument panel**

ACTIA SMART TACH TACHOGRAPH

The equipment, also termed **VU** (Vehicle Unit), consists of an electronic unit equipped with display, printer, two smart card readers and a set of control pushbuttons.
The unit can only be activated by inserting a registered smart card and a PIN which is issued by local chambers of commerce.
Two smart card readers are provided for double manned long journeys, when two drivers are required by law to take turns in driving.

The figure shows a front view of the equipment.



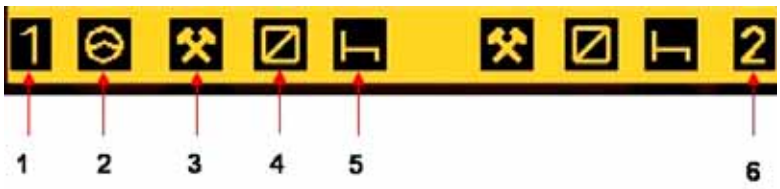
KEY:

(1) Key to extract smart card from reader slot (8) or toggle driver 1 activity.
(2) Key to extract smart card from slot (9) or toggle driver 2 activity;
(3) Display (lights up upon KEY ON).
The default screen always shows:
-current Driver 1 activity and his/her total rest time.
-whether smart cards are present in the 2 readers and selected Driver 1 and Driver 2 activities. If needed individual menu items such as error log, programming data, etc. are shown.
(4) CANCEL key returns to previous menu or cancels current selection.
(5) PREVIOUS key returns to previous menu or menu item or changes a set value;
(6) NEXT key goes to next menu or menu item or changes a set value;
(7) OK key selects a submenu or confirms a setting;
(8) Reader for electronic driver's licence of first driver.
The workshop card used to activate the customisation and setup procedure must be inserted into this reader;
(9) Reader for electronic driver's licence of second driver;
(10) Connector for programming – data download cable, protected by rubber cover;
(11) Printer to print set parameters;
(12) Warning light comes on in the event of a fault (while an error message appears on display).

Symbols

Activity symbols

The display shows a set of symbols that represent equipment activity states.
First driver activities are shown in the left portion of the display; second driver activities in the right portion of the screen.



The symbols signify the following:

1 First driver's smart card inserted.
2 Activity: driving.
3 Activity: working.
4 Activity: available.
5 Activity: rest.
6 Second driver's smart card inserted.

Operation mode symbols

A symbol on the display indicates which type of smart card is inserted.

Ideogrammi	Tipo carta	Modalità operativa
	Azienda	Modalità azienda
	Controllo	Modalità Contr.
	Conducente	Modalità operativa
	Centro Tec.	Modalità taratura

Other symbols

Other symbols may appear on the screen depending on the settings and information displayed.

	Ora
	Unità veicolo
	Stampa
	Inizio del periodo
	Fine del periodo
	Località

	Carta azienda
	Guida con equipaggio
	Luogo di partenza del periodo giornaliero di lavoro
	Stesso periodo giornaliero di lavoro?

Tachograph main features

Event recording:

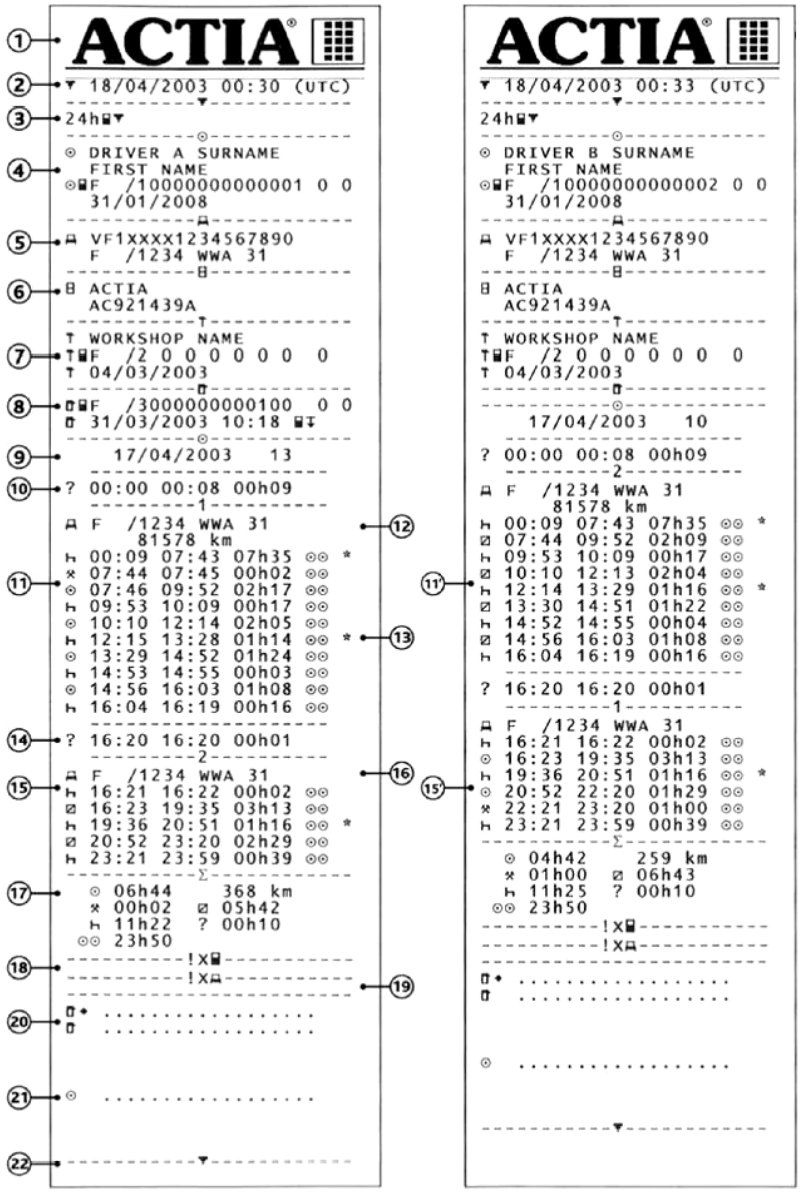
-Infringement alarms: Ex: after 4 h and 15 min continuous driving, an alarm informs the driver that he/she must take a break within the next 15 min. After 4.5 h the system informs the driver that he/she is committing an infringement. Ex. overspeed.
-System malfunction alarms : for instance, printer or tachograph card failure, sensor/tachograph power supply failure.
-General system safety checks (e.g. sensor authentication)
-The tachograph can communicate with the other on-board electronic devices; (e.g. transmission of speed information to speedometer)

Vehicle Unit memory
-The vehicle unit can store up to about 365 days duty and the speeds during the last 24 hours (field. 1 s). The latest data overwrite the oldest data (365 days, assuming average utilisation).
-Data download every 3 months (Europe).

Tachograph card memory:
-The driver card holds up 28 days driver duty data. Latest data overwrite the oldest data.
-Data download every 3 weeks (Europe).

Tickets:
All data on tachograph and user activities can be printed on a ticket.
All tachographs that use symbols have the same format.
There are six types of tickets:
-Daily driver duty printout from smart card.
-Daily driver duty printout from equipment memory.
-Printout of events and failure events from smart card.
-Printout of events and failure events from equipment memory.
-Printout of technical data.
-Printout of speed infringements.

Example of a ticket



Key to ticket data.

1. ACTIA Smartach printout heading logo.
2. Current print date and time.
3. Type of printout: daily from smart card.
4. Driver card information: surname, name, state, card number, card validity.
5. Vehicle identification: Vehicle Identification Number, country, vehicle registration number.
6. Tachograph identification. Brand and part number

7. Workshop card identification: name of workshop, state, card number, last calibration date.
8. Control card identification: state, card number, date and time of last control, type of control.
9 .Date ticket was printed, number of days driver card has been used.
10. Previous unknown activities of the day (starting at 00.00) while smart card was not inserted in tachograph.
11. Activities done while card was in slot 1 as first driver.
- Activities done while card was in slot 2 as second driver.
12. Vehicle registration number and odometer where card was inserted.
13. Driving mode indication: **OO** indicates double manning; ***** indicates that a rest period of more than one hour was taken.
14. Unknown activities while card was not inserted in the tachograph.
15. Activities done while card was in slot 2 as second driver.
- Activities done while card was in slot 1 as driver.
16. Vehicle registration number of vehicle where the card was inserted.
17. Cumulative summaries of activities and distances travelled.
18. Events and/or faults stored in the card, details if any, type of fault, date, time, duration, ID number.
19. Events and/or faults stored in tachograph, details if any, type of fault, date, time, duration, card number.
20. Control place and space for control officer's signature
21. Space for driver's signature.
22. End of printout.

SMART CARDS

The **Council of the European Union** has brought into force the mandatory fitment and use of **digital tachographs**; these are electronic devices that **record the activities of vehicles** used for the carriage of passenger or goods.
The **tachograph card** is a smart card that interfaces with the digital tachograph to store driver's driving and rest time information.
From 5 August 2005, card applications may be submitted to all Italian Chambers of Commerce; **from 1 January 2006**, all vehicles registered for the first time having a mass exceeding 3.5 t or seating over 9 persons must be equipped with a digital tachograph.
Under the European Regulation, competent authorities must **make tachograph cards available** at least **three months before** the mandatory installation of digital tachographs takes effect**.**
To obtain a tachograph card, an application must be submitted to the local Chamber of Commerce using the suitable form (available at http://www.unioncamere.net/Web_tachigrafo).
Within 15 days of submission, the Chamber of Commerce issues the tachograph card to the card holder and, if the applicant is a workshop, a PIN.
Tachograph cards and digital tachographs have been introduced in place of analogue equipment because the need was felt to make **a safer, more user-friendly and more reliable technology** available to drivers, transport undertakings, workshops and enforcement authorities. The intent of the European Union is to improve the working conditions of lorry drivers and - as a result - road safety.
All member countries, including some non-member countries, take part in this initiative.
(EC Regulation no.2135/98 of 24 September 1998 amending EEC Regulation no. 3821/85)

There are 4 types of tachograph cards (smart cards), each with its specific purpose and application depending on who the card holder is:
- Driver card
- Company card
- Control card
- Workshop card.

In Italy, tachograph cards are issued by the local Chamber of Commerce in the place of residence of the applicant.

Driver smart card

It has a white background; it is a personal card with 5 year validity required to drive certain vehicles as provided for by Regulation 3820/85. The driver must insert it before he/she starts driving.
It records the following data: travel/stop time, speed, distance, significant events.

Company smart card

If has a yellow background; validity is 5 years; this card identifies the company that owns the vehicle, facilitates fleet management and enables inspection, downloading and/or printing of utilisation data for all vehicles of the company equipped with a digital tachograph.

Control smart card

It has a blue background and 5-year validity; it enables the verification of driving times and speeds by viewing, printing and downloading the information stored in the tachograph.

Activities of enforcement authorities

-Verification of rest times: 4.5.
-Enforcement of traffic rules and regulations.
-Overspeed events.
-Periodic system calibration/activation.
-Fraud enforcement.
-Tachograph card session errors.

Fraud enforcement.
• Improper tachograph calibration.
-On digital tachograph.
• Period : N/A
• Where/how to check :
-Test at service centre

Workshop smart card

It has a red background and 5-year validity; it is issued by national authorities to workshops authorised to activate, calibrate, program tachograph systems and download data.

AUTHORISED SERVICE NETWORK

The new digital tachograph system complies with certain safety rules specifically designed to make it impossible for the digital equipment to be tampered with so as to ensure the accuracy of speed and driving time data, as enforcement of the relevant rules is considered to be critical to ensuring road safety. As a result, the technical and professional skills at workshops authorised to install and service digital tachographs also play a critical role.
European and national regulations lay down the requirements for workshops and installers authorised to install and service new digital equipment as well as authorisation criteria for tacograph service centre approval.
In Italy, service centre approval is issued by the Ministry of Production Activities (MAP); applications are to be submitted to Chambers of Commerce, that initiate the control procedure for submission to MAP. The Ministry of Production Activities notifies issued approvals to Unioncamere (the Association of the Chambers of Commerce), that prepares a list of authorised service centres. The list is available to the public and can be viewed at any time. This information is available at:

http://www.unioncamere.net/Web_tachigrafo/index.php

CUSTOMER INFORMATION

Dealers/workshops are required to provide **Customers who purchase a vehicle equipped with digital tachograph** with the following information:
- The Customer is required by law to contact an authorised ACTIA service centre and have the first mandatory calibration performed **within 15 days after the date of registration**. The calibration procedure is at Customer's charge. (rates are around €150).
- The Customer must submit an application to obtain a Driver card for every driver employed with the company.
Driver cards are issued to the driver's name and are personal. In Italy, card applications must be submitted to the local Chambers of Commerce.
- Daily duty data stored in the digital tachograph must be downloaded every three months, whereas the data stored in the Driver card must be downloaded every three weeks.
Data must be retained for twelve months.
- The Company that owns the vehicles may apply for a Company card that allows management of downloaded data or may appoint an authorised ACTIA service centre to take care of data management.
- Communication between tachograph and sensor is always active, which means the system draws current even when the ignition key is removed from the switch; in the event the vehicle is to be left unused for long periods, the battery must be disconnected or it will run flat.

Tachograph activation
Upon vehicle registration, the tachograph must be activated at an authorised service centre, that will perform the following procedures:
-Tachograph activation (data storage)
-Tachograph sensor to Vehicle Unit authentication.
-Vehicle information entry (VIN, license plate, company details,..)
-Tachograph calibration.

Periodic inspections
After the first calibration, periodic inspections (in Italy, yearly inspections) and recalibration procedures must be performed.
Periodic inspections are at the Customer's charge and must be performed by authorised ACTIA service centres. (rates are around €190).

Inspection is mandatory in the following events :
-After tachograph repair.
-When changes have been made to the driveline (wheels, gearbox, etc.)
-If clock drift exceeds 20 min.
-Every two years.

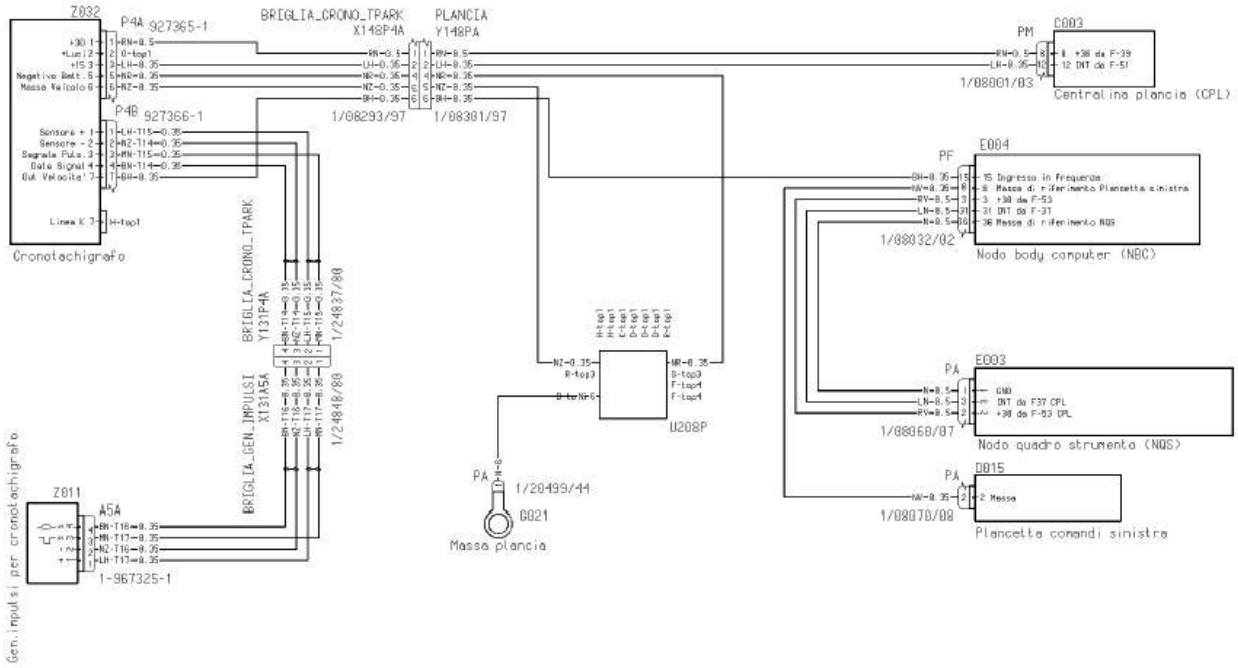
Voluntary inspections at request :
-Installation verification.
-Component verification.
-Tachograph calibration (see “Parameters” section).
-Data update.

Data management
If the tachograph is replaced.
-Data download from faulty tachograph and upload to the new tachograph.
-Secure delivery of tachograph data to concerned company.

-Additional services (small carriage businesses):
-Secure Data download from Driver to other medium and storage every 21 days
-Digital Tachograph: Secure Data download from Smart Card to other medium every 3 months (provision not yet finally approved).
- Upgrade from Analogue to Digital Tachograph.

Warranty
Warranty service for the digital tachograph and its speed sensor is provided by the ACTIA Group through their approved ACTIA service centres. To have the system serviced or repaired, contact an approved ACTIA service centre. The ACTIA Group bears the labour costs incurred in replacing a faulty component at approved ACTIA service centres, the costs for the download of old equipment data and delivery to the Client Company (where feasible) and for faulty components (digital tachograph and/or speed sensor) replaced under warranty.

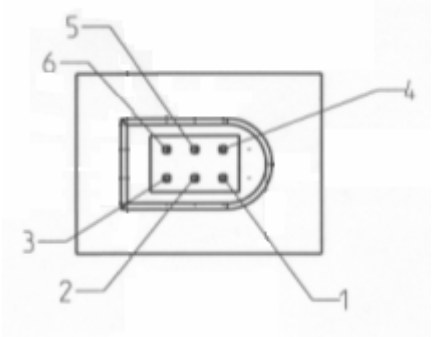
Wiring diagram



Tachograph pinout

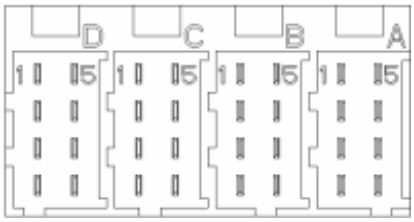
The connector on the front end is used to:
-download data via RS 232 interface;
- diagnose, calibrate and program equipment via K line;
- test signal input/output (motion sensor signal output, clock signal output, or vehicle speed input).

Front connector for tachograph programming, data read/write.



Description	Notes
Ground	
K line for diagnosis	To EOBD connector
RxD–Downloading	data download (RS232)
Calibration I/O line	
+30 power supply	
TxD–Downloading	data download (RS232)

Rear connectors.



Power supplies		Opt. RPM sensor connection
+30 power supply protected by fuse		*Not used*
+12 lighting		*Not used*
+ 15 (protected by external fuse)		*Not used*
N.C.		*Not used*
Battery negative		*N.C.*
Ground		*N.C.*
N.C.		*N.C.*
N.C.		*N.C.*
Motion sensor signals		**Additional functions**
Power supply for motion sensor (8 VDC +/- 10%)		*N.C.*
Motion sensor negative		*N.C.*
Pulses from motion sensor		*N.C.*
Data exchange with sensor		*N.C.*

Not used		*Not used*
Not used		*Not used*
Speed signal output		K line for diagnosis
Not used		K line for data broadcast

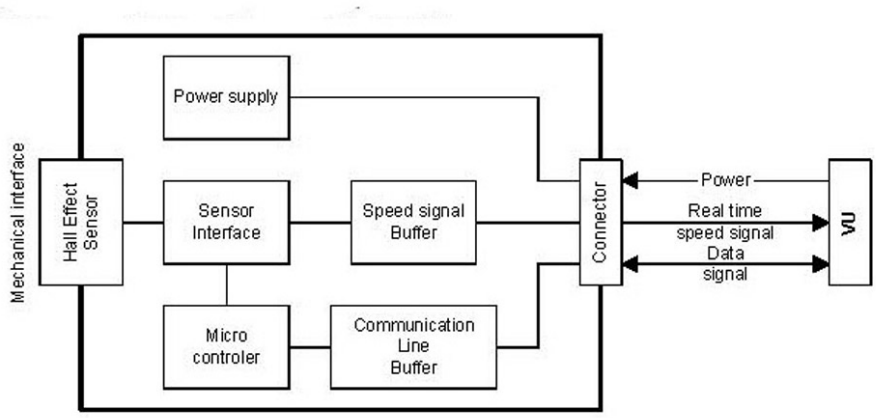
VEHICLE SPEED SENSOR

This is a Hall motion sensor designed for installation on road vehicles. The sensor meets the requirements of Annex 1B to Regulation 2135/98/EC and its conformity must be certified. Conformity certification includes a safety certification (ITSEC level: E3 high).

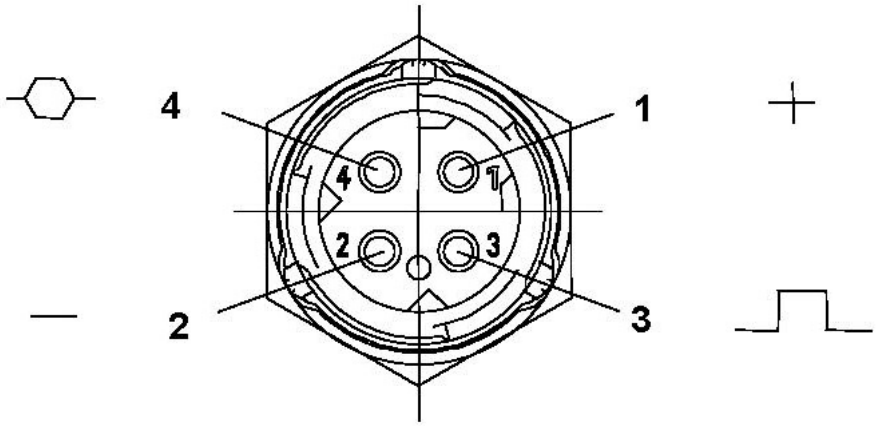
The sensor provides the tachograph (VU) with accurate information on vehicle motion (speed and distance travelled). The sensor must be screwed into its housing in the gearbox and a suitable seal must be affixed.
Motion sensors are available in different versions to suit different transmission configurations; all versions have the same specifications except for the length of the portion that enters the gearbox or sensor design (rotary or static).
Input/output signals are available at a 4-pin connector.
- the sensor is permanently fed 8 VDC +/- 10% from the VU it is connected to.
- it sends real-time speed pulses to the VU.
- a secure, two-way communication line provides for data exchange between sensor and VU.

The secure communication line allows:
- sensor to VU communication (including mutual authentication of sensor and VU);
- transmission of a feedback value representing the number of real-time speed pulses sent to the VU over the speed signal line during a certain period of time;
- transmission of other data at VU's request.

The sensor block diagram is provided below for reference only:



Sensor pinout

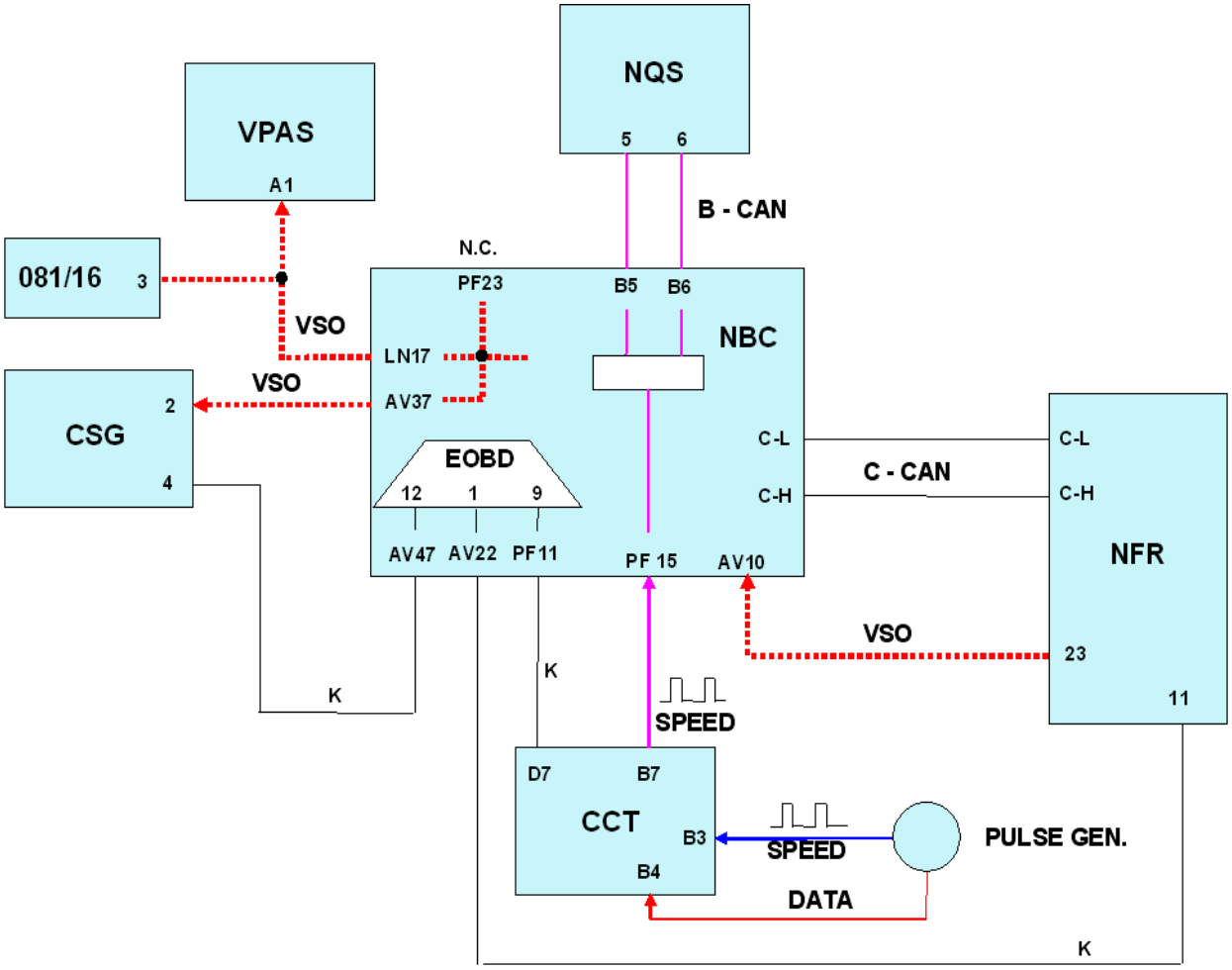


Pin occupancy is as follows:

Pin	Signal
1	8 VDC power supply
2	Electrical ground
3	Speed signal
4	Data communication signal

VSO (Vehicle Speed Output)

In vehicles not equipped with a tachograph, the VSO (vehicle speed) signal is generated by the NFR (pin 23) and sent to the NBC via a dedicated connection (dash lines in the diagram). The NBC encodes the signal and makes it available both over the network for the NQS and over the bus for the CSG (power steering) and VPAS (park assist camera) control units.
If the vehicle is equipped with a tachograph, the speed values recorded by the tachograph and the speedometer readouts must be synchronised.
To achieve synchronisation, the signal generated by the tachograph is used to obtain the VSO signal for the speedometer; the signal is sent from pin B7 to the NBC where it is processed and adapted and then sent over the B – CAN network to the NQS. In the diagram, the tachograph VSO signal is marked SPEED and highlighted in purple, whereas the conventional VSO signal generated by the NFR is represented by a dash line.



Key.

NBC: computer body node; NFR: brake node; NQS: instrument panel node; CSG: power steering control unit; 081/16: opt. for body shops, pin 16; VPAS: park assist camera; CCT: tachograph control unit; PULSE GENERATOR: pulse generator on gearbox; SPEED: vehicle speed pulses; DATA: two-way serial data bus connecting CCT and pulse generator: VSO: vehicle speed output (vehicle speed signal)

Gearbox servicing

The speed sensor is mounted on the gearbox and sealed with a lead seal.
In the event the vehicle is repaired at the FIAT service network and repair procedures require removal of the sensor from the gearbox, after repair the vehicle must be brought to an authorised ACTIA service centre (included in the list published by Unioncamere) to have a new seal affixed. Seal application is at supplier's charge. (rates are around €30).

Tachograph configuration and calibration.

Tachograph configuration and calibration may only be performed by authorised service centres whose personnel has received specific ACTIA training.

6.1. Diagnosis with Examiner

The diagnostic procedure supported by the examiners available to the FIAT service network is limited to viewing control unit parameters and any errors present, and a few settings that do not affect unit security.

FOREWORD

To establish communication with the control unit, the A-16 HS cable with the red connector must be connected to the diagnostic connector. The control unit is in the compartment above the imperial node on all versions except the SCUDO versions, where the control unit is in the dashboard. The control unit connected to two wiring harnesses by two "ISO autoradio" connectors; the yellow connector is for the speed sensor (at gearbox output) and the white one is for control unit power supply. The standardised 16-pin diagnostic connector is under the fuse carrier near the driver's side.

PARAMETER SCREENS

All system information can be retrieved in the parameter and parameter selection environment. The following parameters are available :

-vehicle speed parameters : vehicle speed, overspeed, gearbox output signal, etc.
-driver parameters : smart card in slot, driver duty.
-control unit date and time parameters: GMT date and time, local time and minute offset, etc.
-vehicle speed calculation parameters : K, L and W factors, control unit state, etc.
-vehicle identification configuration: Country of registration, Vehicle license number, type of tyres, etc.
-control unit configuration : distance measurement unit, trip reset menu, local time, language selection, etc.
In addition, the following parameters are worth mentioning:
-Odometer
-Vehicle state (indicates whether vehicle is moving or stopped)

PARAMETER SELECTION ENVIRONMENT

The Select key lets you select the parameters you want displayed.

The less parameters you select, the faster the refresh speed. Maximum refresh speed is achieved when one parameter is selected.

LIST OF PARAMETERS

Description	Measurement Unit / State Value
Serial number	-
Sensor serial number	-
Type approval number	-
Country of registration	-
Vehicle license number	-
K factor	Pulses/m
L factor	mm
W factor	Pulses/m
Type of tyres	-
Maximum speed	Km/h
Local time offset	h
Local minutes offset	min
Odometer	km
Vehicle speed	Km/h
Gearbox output signal	Pulses/m
Lighting	Can
	Dedicated line
Distance Meas Unit	Km/h
	mph
Language selection	From control unit
	From smart card
Trip reset menu	Disabled
	Enabled
Local time menu	Disabled
	Enabled
Control unit language	Danish
	Dutch
	English
	Finnish

Description	Measurement Unit / State Value
	French
	German
	Irish
	Greek
	Italian
	Portuguese
	Spanish
	Swedish
	Wrong
Smart card in slot 1	None
	Driver
	Workshop
	Control
	Special
	error
Smart card in slot 2	None
	Driver
	Workshop
	Control
	Special
	error
Driver 1 duty	Break
	Available
	Working
	Driving
	error
Driver 2 duty	Break
	Available
	Working
	Driving
	error
Vehicle state	Stopped
	Moving
Control unit state	normal
	control
	calibration
	special
	error
Overspeed	No
	Yes

PARAMETER SCREENS HELP

Parameter	Help
Sensor serial no.	Serial number of speed sensor
Type approval number	Type approval number of speed sensor
Lighting	Indicates how display lighting is controlled. On this vehicle, default setting is “dedicated line”.
Country of registration	This entry must conform to vehicle document information. If no so, contact an approved tachograph centre to have the control unit updated. Upon first activation, it is mandatory to have the equipment calibrated and the parameters updated at an authorised service centre.
Vehicle license number	This entry must conform to vehicle document information. If no so, contact an approved tachograph centre to have the control unit updated. Upon first activation, it is mandatory to have the equipment calibrated and the parameters updated at an authorised service centre.
Distance Meas Unit	Unit of measurement used for distance (km/h or mph). If set to the wrong measurement unit, perform the configuration procedure to correct this setting.
Language selection	LCD display language may be set to match either control unit language (see parameter “Control unit language”) or the language of the smart card in the slot (default setting). To change this setting, perform the configuration procedure.
Trip reset menu	Lets you enable or disable the corresponding menu on the control unit LCD. If the driver (or fleet manager) wishes to use this menu on the control unit LCD, perform the configuration procedure to change this setting.
Local time menu	Lets you enable or disable the corresponding menu on the control unit LCD. If the driver (or fleet manager) wishes to use this menu on the control unit LCD, perform the configuration procedure to change this setting.
Control unit language	To change this setting, perform the configuration procedure.
K factor	This configuration parameter set in the control unit is used to calculate the distance travelled by the vehicle. If you find that the distance travelled or speed indication on the control unit LCD is inaccurate, have the control unit calibrated at an authorised tachograph centre. Upon first activation, it is mandatory to have the equipment calibrated and the parameters updated at an authorised service centre.
L factor	This configuration parameter set in the control unit is used to calculate the distance travelled by the vehicle. If you find that the distance travelled or speed indication on the control unit LCD is inaccurate, have the control unit calibrated at an authorised tachograph centre. Upon first activation, it is mandatory to have the equipment calibrated and the parameters updated at an authorised service centre.

Parameter	Help
W factor	This configuration parameter set in the control unit is used to calculate the distance travelled by the vehicle. If you find that the distance travelled or speed indication on the control unit LCD is inaccurate, have the control unit calibrated at an authorised tachograph centre. Upon first activation, it is mandatory to have the equipment calibrated and the parameters updated at an authorised service centre.
Type of tyres	This entry must conform to vehicle document information. If no so, contact an approved tachograph centre to have the control unit updated.
Maximum speed	Indicates the maximum speed limit set in the control unit. To change speed limit setting, contact an approved tachograph centre to have the control unit updated.
Local time offset	To set local time, perform the configuration procedure to change this setting or use the appropriate control unit menu (if enabled).
Local minuses offset	To set local time, perform the configuration procedure to change this setting or use the appropriate control unit menu (if enabled).
Odometer	If you find that the distance travelled or speed indication on the control unit LCD is inaccurate, have the control unit calibrated at an authorised tachograph centre. (calculated based on the W factor)
Smart card in slot 1	Indicates the type of smart card inserted in the slot
Smart card in slot 2	Indicates the type of smart card inserted in the slot
Driver 1 duty	Indicates driver duty. This information is recorded in the smart card inserted in the slot
Driver 2 duty	Indicates driver duty. This information is recorded in the smart card inserted in the slot
Vehicle state	Indicates whether vehicle is moving or stopped
Control unit state	Indicates control unit state. Any state other than “normal” indicates that the smart card in the slot is not a Driver card.
Overspeed	Indicates whether vehicle exceeds speed limit or not.
Vehicle speed	VEHICLE SPEED: Vehicle speed in Km/h.
Gearbox output signal	Indicates the number of pulses per second received from gearbox output

Notes:

- K factor

Control equipment constant: expressed in **k** = pulses/km. Indicates how many revolutions or pulses it takes before the equipment records 1 km travel.
Default setting:

- W factor

Vehicle characteristic coefficient: expressed in **w** = pulses/km. This number represents the vehicle on-board speed sensor output when the vehicle travels a 1 km distance. In other words, it indicates the number of revolutions or pulses generated by the mechanism connected to the power takeoff when the vehicle has travelled 1 km.

-L factor

Actual circumference of tyres installed on vehicle: expressed in **l** = mm. Indicates the linear distance covered by a wheel during one full revolution. This parameter is critical to device calibration. These values must be always be reported on the installation plate.
K and W are equal.
W = Vehicle characteristic coefficient (pulses\km)
K = Tachograph characteristic coefficient (pulses\km), i.e. the conversion factor the tachograph uses to process the pulses from the vehicle.
This conversion factor is =1 (same as tachograph of previous generation).

K -was a significant factor in first generation tachographs because they incorporated mechanical parts and the ratio of these parts would affect the information from the vehicle.

ERROR ENVIRONMENT

Errors are divided into the following classes:

-Present (fault is still detected by control unit).

-Intermittent (fault stored previously that is no longer present when control unit is queried). The error environment provides an error delete key.

NOTE

The only authorised service for speed sensor and/or tachograph control unit is wiring and connector inspection.
In the event of speed sensor or control unit replacement or calibration, the vehicle must be brought to an authorised tachograph service centre.
These centres are also authorised to perform first activation and/or sensor unit- control unit- vehicle calibration.
This control unit must be powered permanently. In the event the battery is disconnected, it will indicate and record an error.

HOW TO DELETE ERRORS

The error environment provides a key to delete (intermittent) errors from the control unit memory.

LIST OF ERRORS

Code	Description 1	Description 2	Type
9001	Speed sensor power supply	-	Above upper limit
			Below lower limit
			No signal
9002	Control unit power supply	-	Above upper limit
			Below lower limit
9006	Vehicle speed signal	Speed signal	No signal
9007	Vehicle speed signal	Speed invalid or Serial line fault	Signal faulty
9008	Vehicle speed sensor	Serial line	No signal
9010	Wrong time or date	-	No additional information
9011	Vehicle moving when no Key ON	-	No additional information
9012	Control unit	-	Checksum error
9014	Control unit	-	Calibration
9016	Control unit	-	LCD
9017	Vehicle speed sensor	-	Internal error
9018	Control unit	Speed signal output for instrument panel	No additional information
9019	Control unit	-	No additional information
9020	Vehicle moving when no card in slot	-	No additional information

LIKELY CAUSES

DTC	DTC description	Likely cause
9001	Speed sensor power supply	Faulty connections Faulty wiring Faulty sensor Faulty control unit
9002	Control unit power supply	Faulty connections Faulty wiring Faulty control unit
9006	Vehicle speed sensor - Speed signal - No signal	Faulty connections Faulty wiring Faulty sensor Faulty control unit
9007	Vehicle speed sensor - Speed invalid or Serial line - Signal faulty	Faulty connections Faulty wiring Faulty sensor Faulty control unit
9008	Vehicle speed sensor - Serial line - No signal	Faulty connections Faulty wiring Faulty sensor Faulty control unit
9010	Wrong time or date	Configuration error Faulty control unit
9011	Vehicle moving when no Key ON	Faulty connections Faulty wiring Faulty sensor Faulty control unit
9012	Control unit - Checksum error	Faulty control unit
9014	Control unit - Calibration	Wrong calibration Faulty control unit
9016	Control unit - LCD	Faulty control unit
9017	Vehicle speed sensor - Internal error	Faulty sensor Faulty control unit
9018	Speed signal output for instrument panel	Faulty connections Faulty wiring Faulty instrument panel Faulty control unit
9019	Control unit	Faulty control unit
9020	Vehicle moving when no card in slot	No smart card in slot Faulty sensor Faulty control unit

ACTIVE DIAGNOSIS ENVIRONMENT

Available active diagnosis features are as follows:
- "Light ON", turns on malfunction indicator lamp (when off).
- "Light OFF", turns off malfunction indicator lamp (when on).
- "Buzzer", sounds control unit buzzer.

Screen helps are provided for all active diagnosis procedures.

LIST OF ACTIVE DIAGNOSIS FEATURES

Active Diagnosis	Help
Light ON	The malfunction indicator lamp is operated for a few seconds.
Light OFF	The malfunction indicator lamp is operated for a few seconds.
BUZZER	You should hear the Buzzer.

PROCEDURES / CONFIGURATIONS

This environment can be accessed from Active Diagnosis and holds the following procedures:

"Write control unit setup":
Allows configuration of the following parameters:
-Distance Meas Unit
-Trip reset menu
-Local time menu
-Language selection
-Control unit language

"Summer/Winter time date":

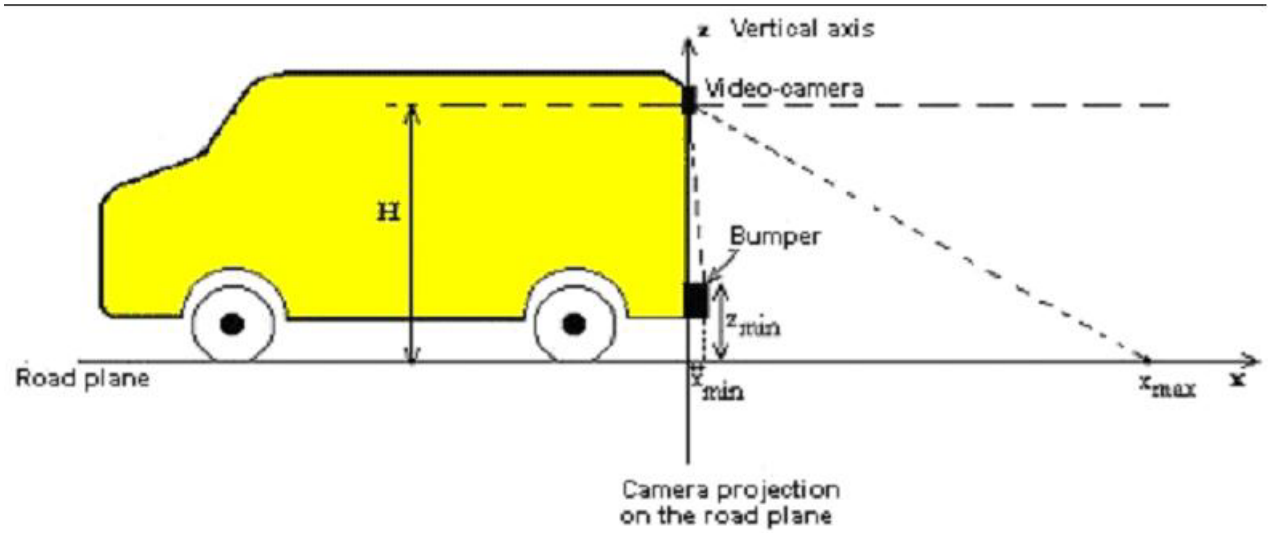
This procedure lets you set the next Summer/Winter time changeover date (normally in March and October every year) and time change offset (summer time: local time + 1 hour). Upon the set date, the clock will be automatically advanced/set back by the selected offset.
Up to 5 summer/winter time changeovers can be entered.

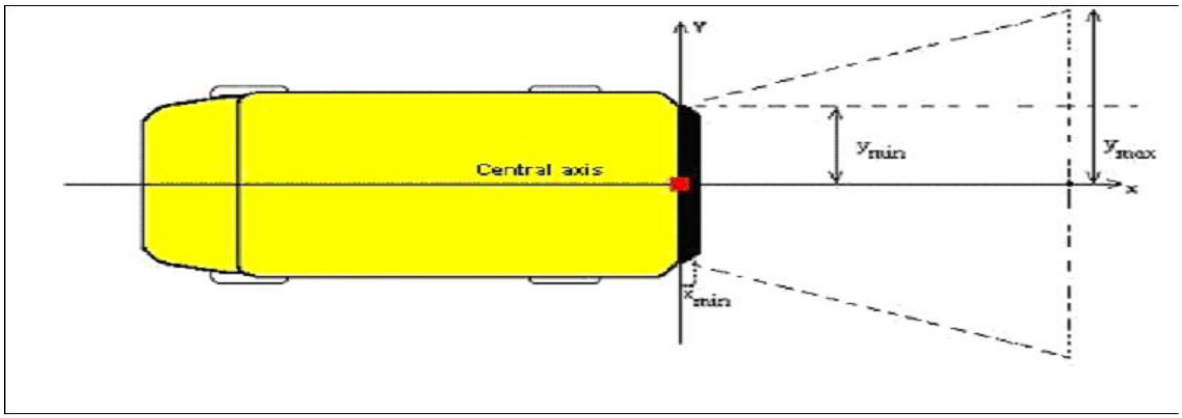
7. REAR-VIEW CAMERA

SYSTEM DESCRIPTION

The main purpose of the rear view camera is to assist the driver during parking and loading/unloading.

The system displays a mirror-like image of the view from the vehicle rear end when reverse is engaged or an ON/OFF key is pressed.





COMPONENTS

The system consists of the following components:

- camera with optics unit;
- connection cables (not included in scope of supply);
- third stop light (not included in scope of supply);
- housing for camera and third stop light;
- display;
- mounting bracket to install display near rear view mirror;
- ON/OFF key, display backlighting and brightness adjustment keys.

TECHNICAL SPECIFICATIONS

DISPLAY

The display performs the following tasks:

- operates and feeds the park assist rear view camera;
- displays the images sent by the park assist rear view camera;
- displays warning messages for the driver in several languages.

Display module – most significant specifications:

Technology	TFT-active matrix-LCD
Dimensions (diagonal)	13 cm [5"]
Signal mode	NTSC(M)
Image size	4:3
Viewing angle	Min: 45º vertical up - 45° vertical down / 60º horizontal left - 60° horizontal right; Typ: 50° vertical high - 70° vertical down / 70° horizontal left - 70° horizontal right.
Resolution	74,880 pixel (320 x 234 pixel)
Dot pitch	0.107 (hor.) x 0.319 (vert.)
Dot configuration	R·G·B strip configuration
Contrast ratio	100 min. / 200 typ.
Luminance	300 cd/m^2 min. / 350 cd/m^2 tip.
Active surface	102.2 (hor.) x 74.76 (vert.) mm
Response time	30 ms (rise time); 15 ms (drop time)
Power supply	10 – 16 V
Current draw	900 mA
Dimensions (unpacked)	127 x 90 x 13 mm
Pixel size	3 x 0.107 x 0.319 mm
Weight (unpacked)	183 g
Backlighting	Adjustable, in 16 steps
Brightness	Adjustable, in 16 steps
Key lighting	2 cd/m^2 ± 20% fixed
Key chromatic characteristics	Orange – X = 0.65 ± 0.02; Y = 0.35 ± 0.02

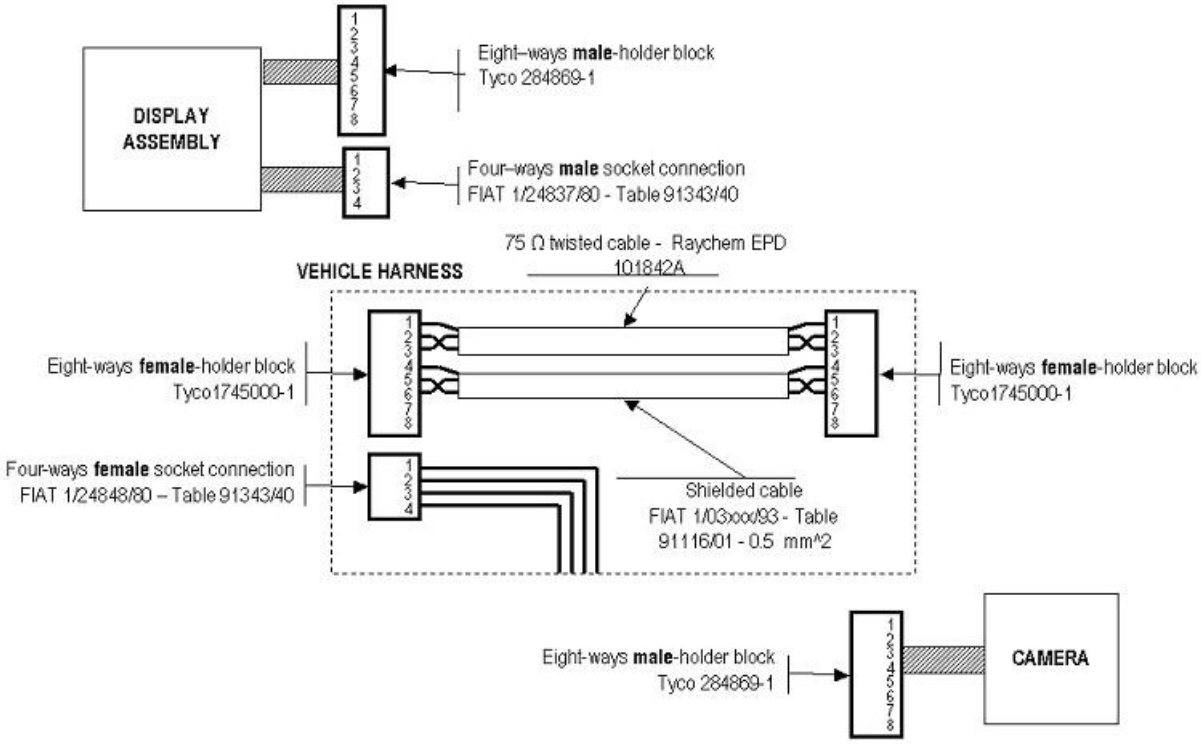
PARK ASSIST REAR VIEW CAMERA

The colour camera acquires a picture of the rear view behind the vehicle.

Camera module – specifications:

Colour	CMOS sensor
Power supply	9 – 16 V
Current draw	120 mA typ. 150 mA max.
Resolution	640 x 480 pixel
Range of vision	80°(hor.); 65°(vert.); 87°(diag.)
Image size	4:3
Size	25 x 30 x 28 mm
Weight (unpacked)	80 g
Output format	NTSC, composite, asymmetrical (75 Ω)
Signal/noise ratio	> 48 dB
Low light sensitivity threshold	< 2 lux
Mirror-like image	Provided
Dynamic field	> 60 dB
Lens	2.1 mm
Other specifications	Fiat Specification 9.90110

BLOCK DIAGRAM AND CONNECTIONS



The display requires the following connections:

- reverse signal (digital signal – manifold open);
- vehicle speed signal (VSO)

NFR transmits vehicle speed information (VSO); the same information is sent over the CAN network after vehicle speed has been calculated.
The VSO signal is set at 275.714 mm/pulses. For the VSO receiver, speed is calculated by the following formula:

Vehicle speed [mm/s] = VSO frequency [Hz] * 275.714 [mm/pulses]

The VSO signal will have 0 pulses/sec and a high digital level when vehicle speed is 0 km/h; conversely, when vehicle speed does not apply, the VSO signal will have a low digital level.

Frequency: 7 pulses/1930 mm
Duty cycle: 50% ± 20% (30% to 70%)
Max. current I_{OUT}: < 1A

- Display to camera connection.
  A shielded cable (75 Ω) is used to connect camera to display.

OPERATING SPECIFICATIONS

SYSTEM CUT-IN / CUT-OFF

The system cuts in when the following conditions are verified:

- key on and reverse engaged;
- key on, On key pressed, speed lower than 15 km/h.

When reverse is disengaged, the image is displayed for 5 seconds.

The system does not provide standard diagnostic features. When video input is missing, an appropriate error message in several languages is displayed (Table 6). No messages or images are displayed in the event of a display fault.

USER INTERFACE

The display user interface features:

- ON/OFF key: on-board, allows display of camera images regardless of the gear engaged;
- backlighting adjustment: 2 digital keys;
- brightness adjustment: 2 digital keys.

Key size: 14 x 8 mm.
Key symbol size: 3 x mm.

Brightness indicates video signal compensation to modify intensity. It is used to enhance detail in dark images or reduce intensity when images are too bright.
Backlighting means display lighting lamp control. It is used to improve vision in strong sunlight or to reduce dazzling in the dark.
User preferences (backlighting or brightness) must be stored in the system when the On key or reverse state are deactivated. These settings - if different from default settings - must be retrieved the next time the system is activated.

Display image is the same as that shown on the internal rear view mirror.
Multi-language messages must be displayed when:

- reverse is engaged (for 2 seconds);
- speed exceeds 18 km/h and only the On key is activated.
  The system will go into stand-by mode 5 seconds after the multi-message has appeared on the display;
- when speed exceeds 18 km/h with reverse engaged.
  In this case, the message remains displayed until speed drops below 15 km/h or reverse is disengaged;
- when video input is missing.

If reverse is engaged, the multi-language message are superimposed on display image; in all other cases, messages are shown on a dark background.

Language	Reverse engagement	On key ON and speed > 18 km/h Reverse engaged and speed > 18 km/h	Video input missing
Italian	Guardare attorno per evitare urti	Velocità massima raggiunta	Sistema non disponibile
French	Regarder en arrière avant de reculer	Vitesse dépassée	Système pas disponible
English	Check surroundings for safety	Max speed reached	System not available
German	Einschalten der Sichthilfe um Schäden zu vermeiden	Maximale Geschwindigkeit erreicht	System nicht vorhanden
Spanish	Mirar detras por seguridad	Velocidad máxima conseguida	Sistema no disponible

Table 6: The multi-language warning messages are displayed in the order shown