CURSOR 13 NON EMISSIONS CERTIFIED

Power generation

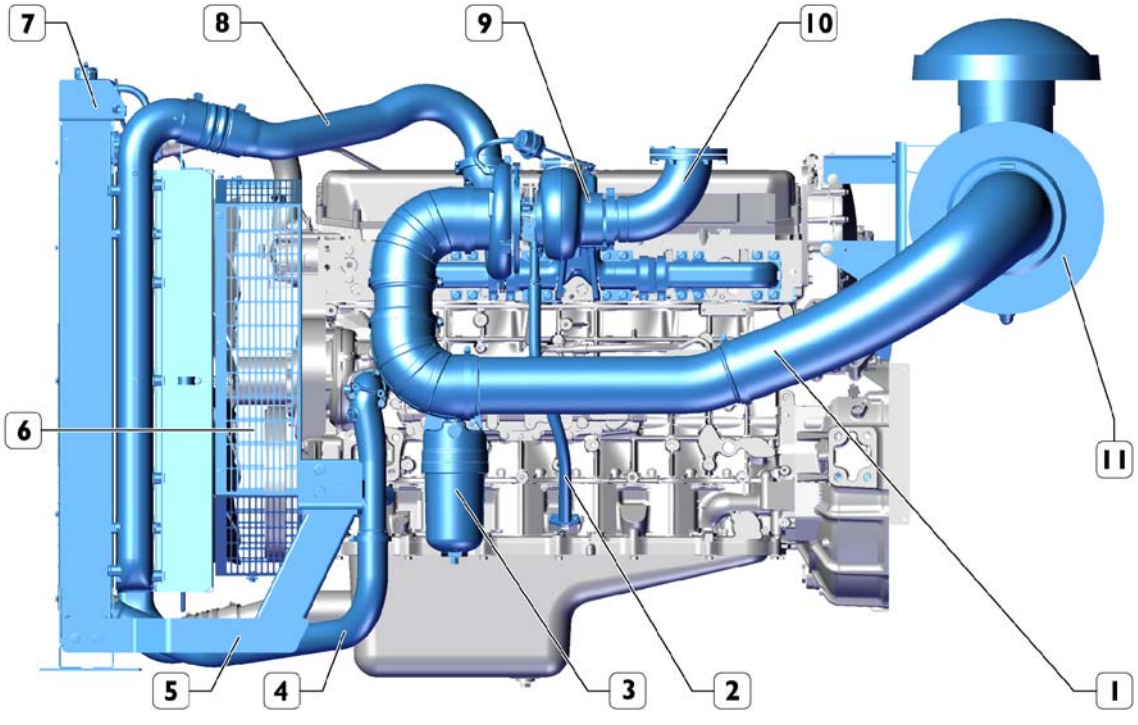
CR13 TE 7W
F3HFA615A*D001

CR13 TE 6W
F3HFA615B*D001

Technical repair manual

ENGINE VIEWS

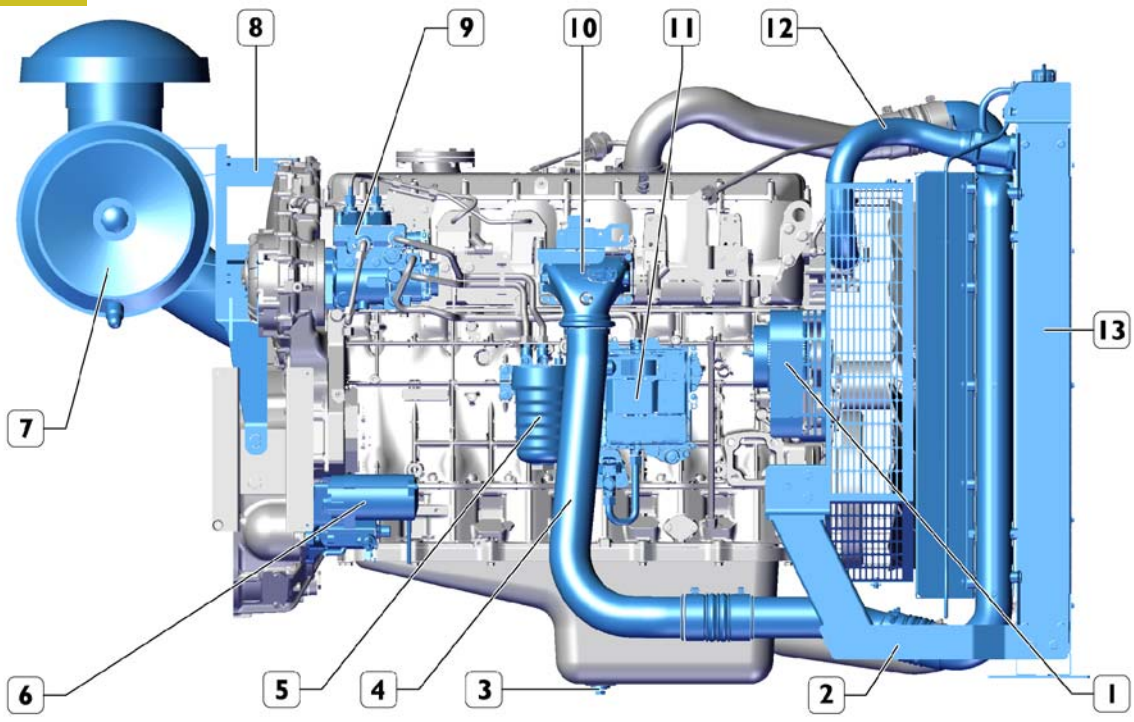
Figure 3



LEFT SIDE VIEW

1. Pipe for intake of external air to turbocharger - 2. Turbocharger oil outlet pipe - 3 . Refitting water inlet pipe to crankcase - 5. Radiator support bracket - 6. Radiator grille - 7. Radiator - 8. Hot compressed air pipe from turbocharger to radiator - 9. Turbocharger - 10. Turbocharger exhaust gas outlet

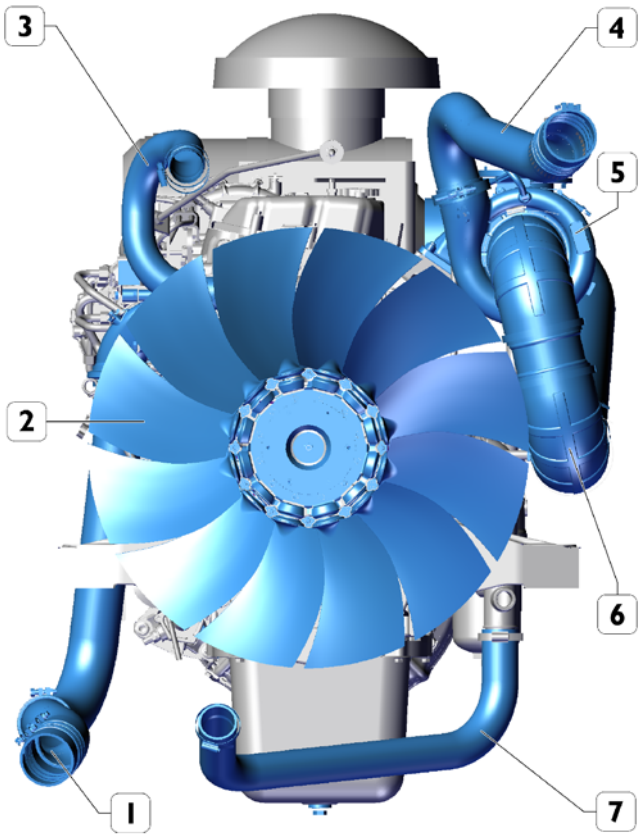
Figure 4



LATERAL VIEW, INTAKE SIDE

1. Alternator protective grille - 2. Radiator support bracket - 3. Oil sump drain plug - 4. Engine cold air inlet pipe - 5. Fuel filter - 6. Electric starter motor - 7. Engine air filter clogged - 8. Air filter support - 9. Fuel pump - 10. Intake manifold - 11. Engine management control unit - 12. Water outlet pipe from h

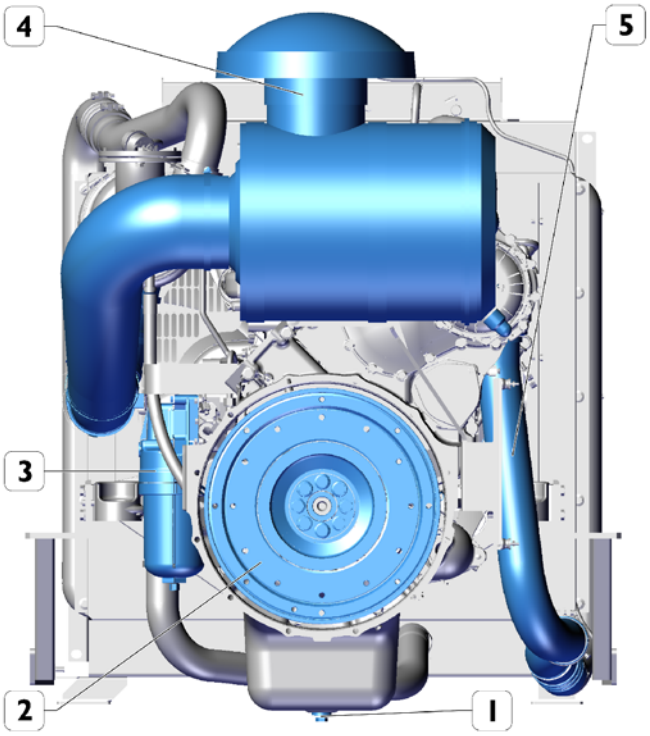
Figure 5



FRONT VIEW

1. Engine cold air inlet pipe - 2. Electric fan - 3. Water outlet pipe from head - 4. Hot compressed air pipe from turbocharger to radiator - 5. Turbocharger - 6. Pipe for intake of external air to turbocharger - 7. Refitting water inlet pipe to crankcase

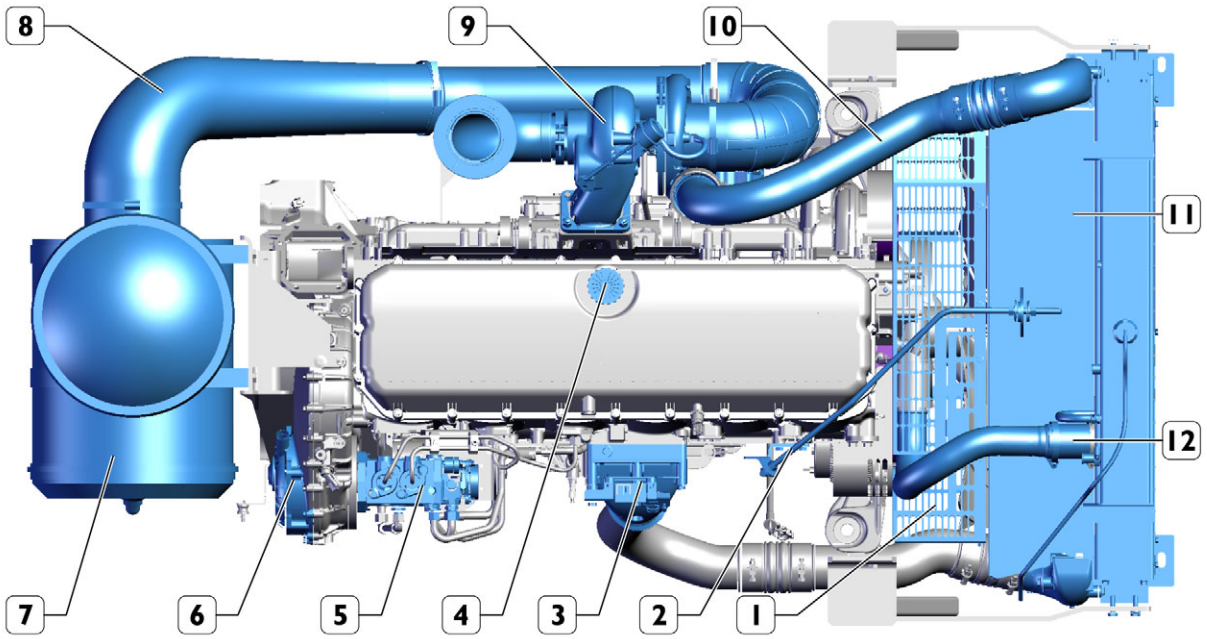
Figure 6



REAR VIEW

1. Oil sump drain plug - 2. Engine flywheel - 3. Oil filter - 4. Air filter - 5. Engine cold air inlet pipe

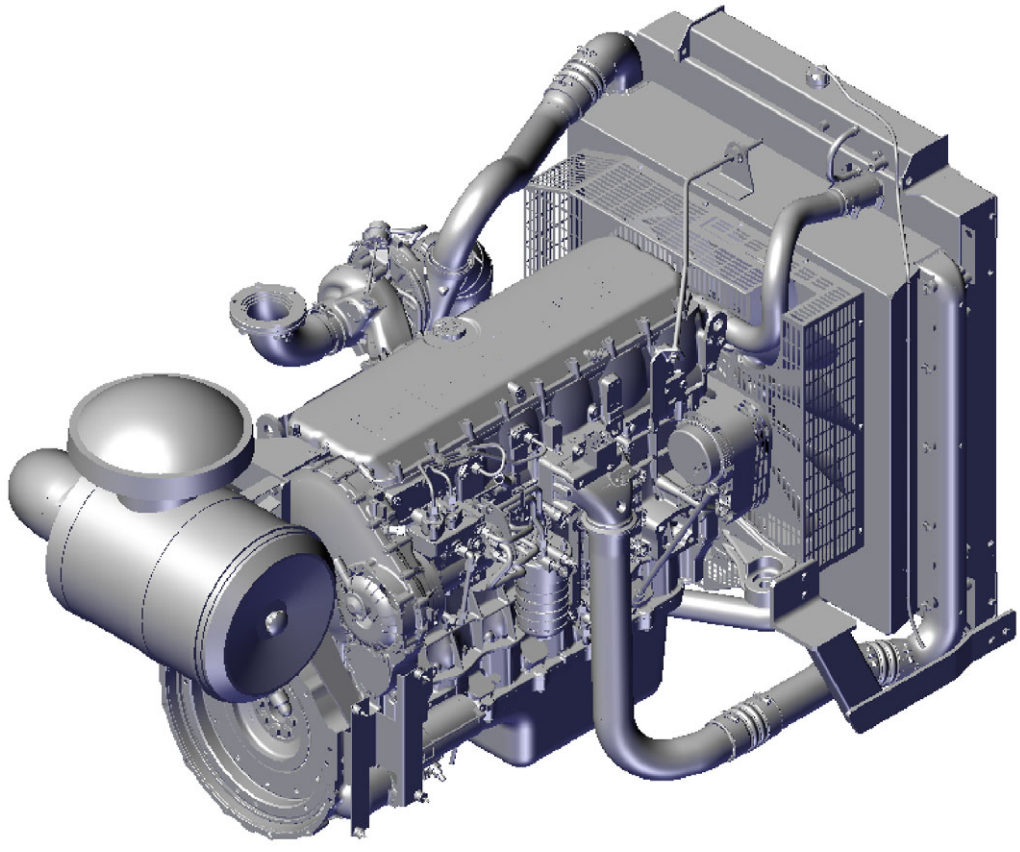
Figure 7



TOP VIEW

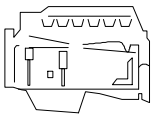
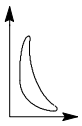
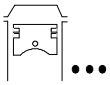
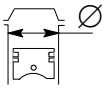
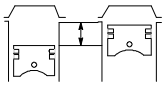
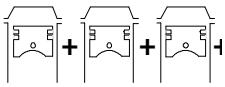
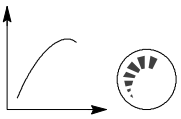
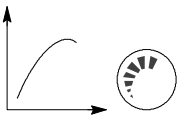
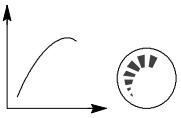
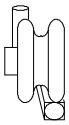
1. Radiator grille - 2. Radiator anchor - 3. Intake manifold - 4. Lubricant oil filling plug - 5. Fuel pump - 6. Blow-By cover - 7. Air filter - 8. Pipe for intake of external air to turbocharger - 9. Turbocharger - 10. Hot compressed air outlet pipe from turbocharger to radiator - 11. Radiator - 12. Water outlet pipe from head

Figure 8



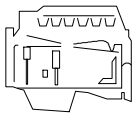
ISOMETRIC VIEW

ENGINE CHARACTERISTICS

	Type		F3HFA615A*D001		F3HFA615B*D001
	Cycle		Diesel 4-stroke		
	Supply		Turbocharged		
	Injection		Direct		
	Number of cylinders		6 in line		
	Bore	mm	135		
	Stroke	mm	150		
	Total capacity	cm^3	12882		
	Compression ratio		16.5: 1		
	Maximum power prime engine	kWm (HP) rpm Hz	415 564 1500 50	428 582 1800 60	371 504 1500 50	400 544 1800 60
	Maximum power engine in stand-by	kWm (HP) rpm Hz	459 624 1500 50	474 644 1800 60	414 563 1500 50	454 617 1800 60
	Maximum torque	Nm (kgm) rpm	- - -		- - -	
	Low idle speed	rpm	1500 at 50 Hz 1800 at 60 Hz			
	High idle speed	rpm	1570 at 50 Hz 1870 at 60 Hz			
	**SUPERCHARGE** Turbocharger type		Intercooler Waste Gate HONEYWELL			

NOTE The data, specifications and performance figures are only valid if the fitter complies with all the installation instructions provided by FPT.

Furthermore, the fitted appliances must always be in compliance with the torque, power and engine speed for which the engine was designed.

	Type	F3HFA615A*D001	F3HFA615B*D001
			
	**LUBRICATION** Oil pressure with engine warmed up: (oil temperature 120° C) - at idle speed bar - at max speed bar	Forced by gear pump, pressure relief valve, oil filter 0.6 3.5	
	COOLING Water pump drive: **Thermostat**: - opening start °C - max. opening °C	Fluid By means of belt 80 90	
REFILLING	Cooling circuit total capacity (1) Engine with radiator and pipes litres	38.1	
	Lubrication circuit(2) l (kg) total capacity l (kg)	32 (28.8) (3) 34 (30.6) (4)	
	Periodic replacement: Sump at minimum level L (Kg) Sump at maximum level l (kg)	20 (18) 28 (25)	
	Fuel tank (5)	-	
	Urea tank (6)	-	

(1) The quantities indicated only refer to the engine in its standard configuration. Use a mix only of 50% water and PARAFLU 11 / PARAFLU HT even during summer. Otherwise, use PARAFLU 11 / PARAFLU HT, employing another product compliant with specifications FPT FPI9.COOL001 and/or with standards SAE J 1034.

(2) Only use lubricants which comply with the international specifications 15W-40 ACEA E7 / API CI-4; 5W-30ACEA E4 (with fuel economy advantages). FPT recommends using original lubricant oil Urania LD 7 15W-40 / Urania FE 5W-30.

(3) The amount indicated refers to torque without filter in standard conditions.

(4) The amount indicated refers to first filling and relates to engine, oil sump and filter filling.

(5) Use STANDARD fuel which complies with standards ASTM D975 or EN 590. The indications connected to the fuel tank capacity are the responsibility of the vehicle/equipment manufacturer since these are subject to changes depending on the various vehicle/outfitting configurations.

(6) Not available.

Filling from drums or tanks can cause contamination of the diesel, with the consequent risk of damaging the injection system; if necessary, perform suitable filtration or sedimentation of the impurities before refuelling.

The data, specifications and performance figures are only valid if the fitter complies with all the installation instructions provided by FPT.

Furthermore, the fitted appliances must always be in compliance with the torque, power and engine speed for which the engine was designed.

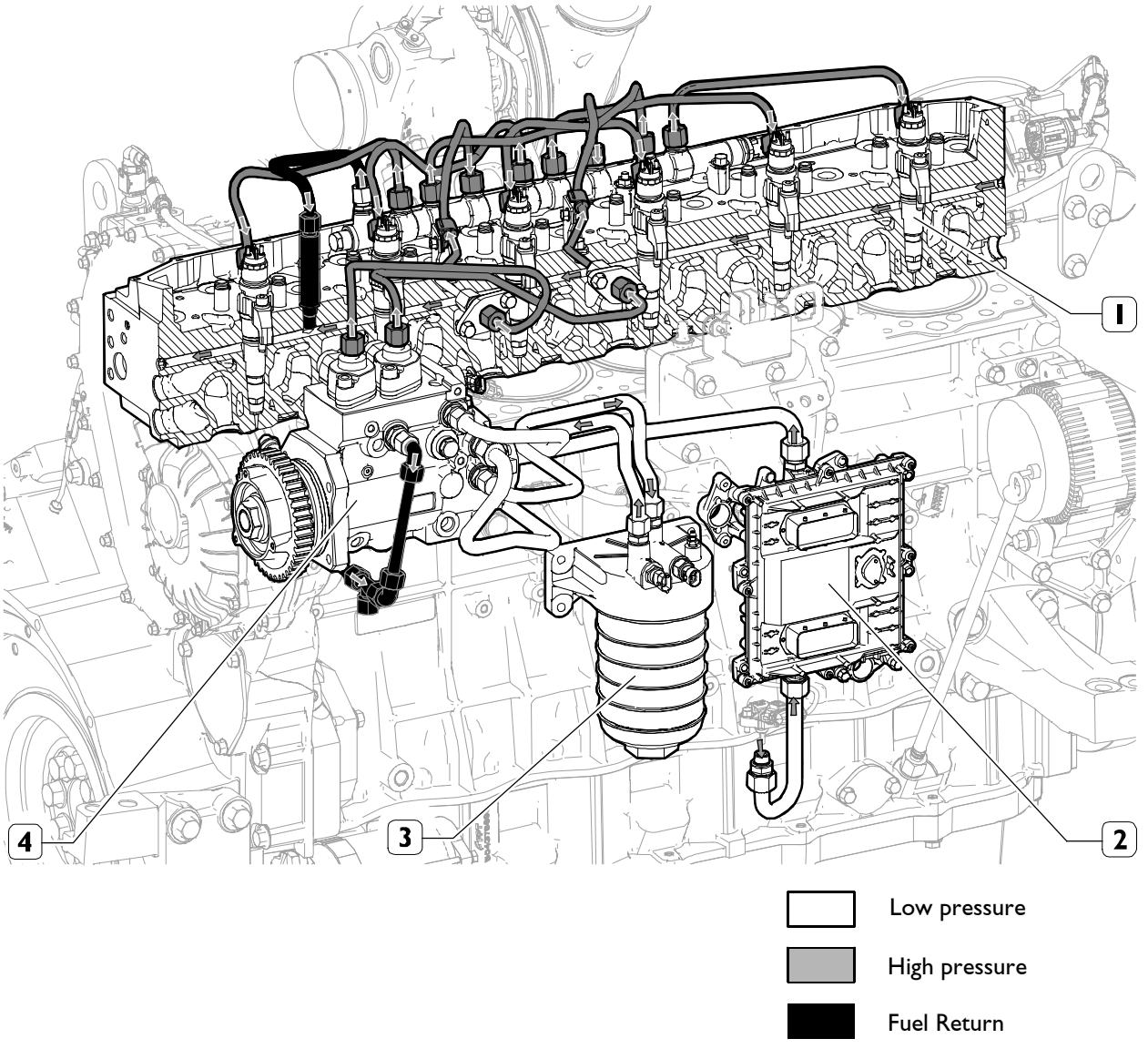
POWER SUPPLY

The Common Rail fuel system has a special pump that continuously keeps fuel at high pressure, independently from the stroke and the cylinder which is to receive the injection and accumulates fuel in a common duct for all injectors.

At the electro-injector inlet therefore, there is always fuel at the injection pressure calculated by the ECU.

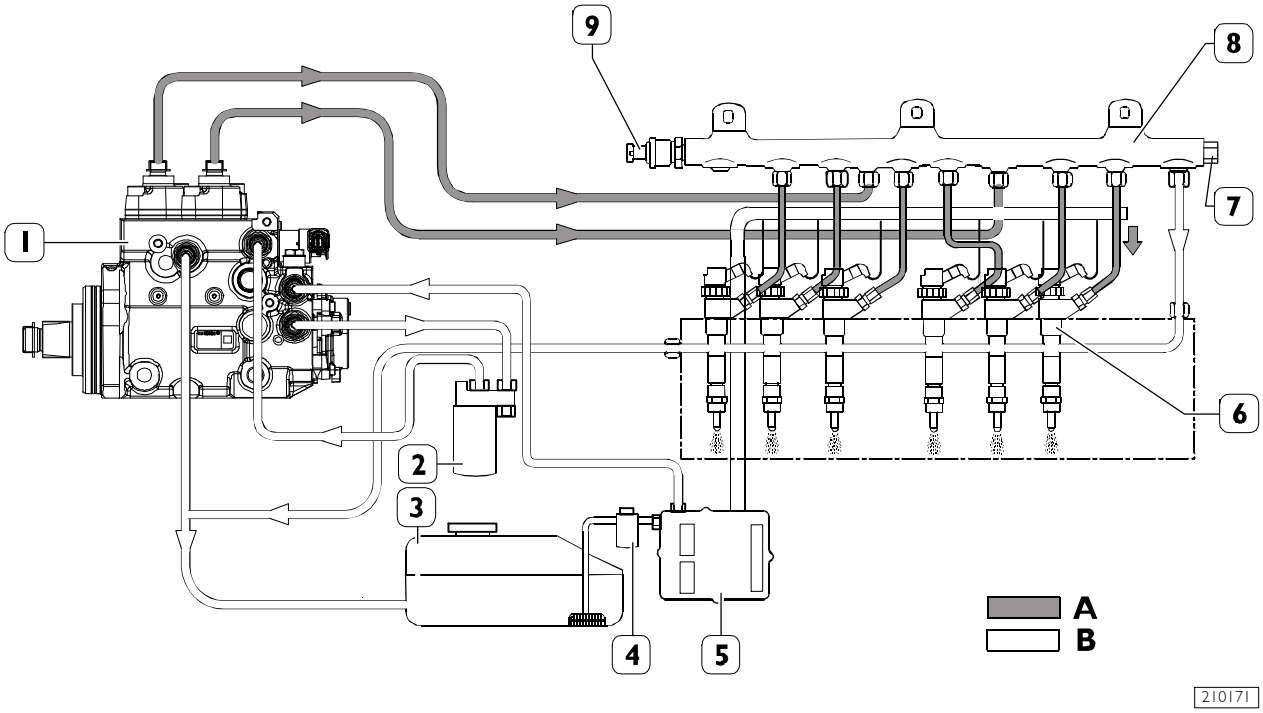
When an injector solenoid valve is energised by the electronic control unit, the injection of fuel directly taken from the rail takes place in the corresponding cylinder.

Figure 1



1. Electro-injector - 2. ECU (EDC 17 CV41) - 3. Fuel filter - 4. High pressure supply pump

Figure 2

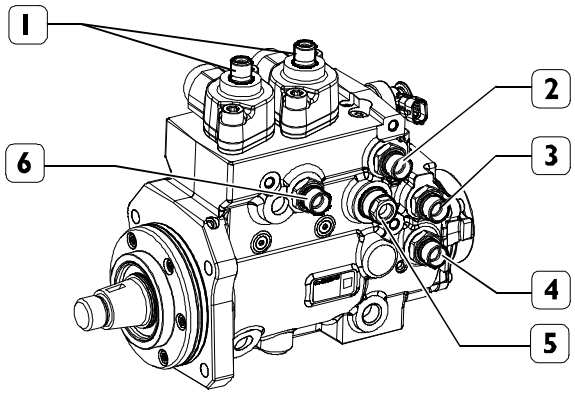


A High pressure - B Low pressure
1 High pressure pump - 2 Fuel filter - 3 Tank - 4 Fuel prefilter - 5 Engine control unit - 6 Electric injectors - 7 Overpressure valve - 8 Pressure accumulator valve - 9 Pressure sensor

HP pump CPN 5 - 22/2

It is a pump, equipped with two plungers, that takes drive from the distribution gear. The gear supply pump is installed on the same control shaft.

Figure 3



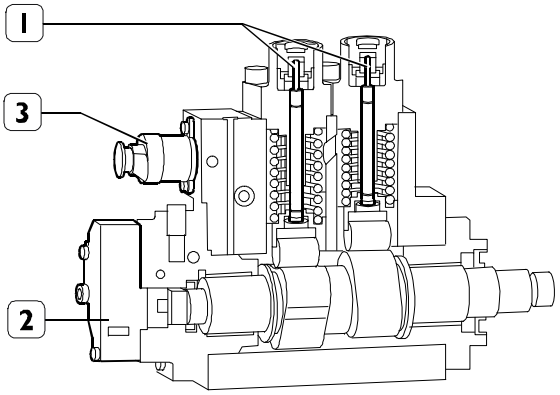
180252

1 Fuel delivery to rail - 2 Fuel supply from filter - 3 Fuel supply from tank - 4 Fuel delivery to filter - 5 Plug - 6 Fuel return to tank

Technical data

Pump characteristics	
Transmission ratio	1:1
Number of cam plungers / lobes	2 / 3
Incoming fuel temperature (gear pump)	- 40 ± 80°C (90° max 100h)
Max torque at nominal speed	Maximum 280 Nm at maximum flow
	Average 80 Nm at maximum flow
Average power required	18 kW
Weight	15.3 kg
Maximum speed in overspeed (250 h)	2625 rpm
Nominal speed	2100 rpm
Overspeed (1h) 3150 rpm	
Maximum pressure at gear pump output	13 bar abs
Pressure at gear pump intake	0.35 ± 1 bar abs

Figure 4

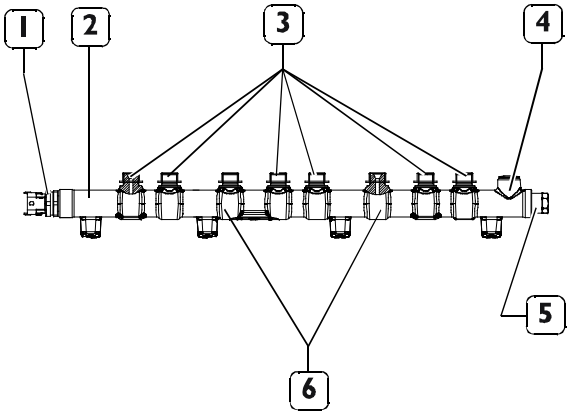


180253

1 Plunger (2x) - 2 CP5 gear plungers - 3 Flow regulator

Hydraulic accumulator (rail)

Figure 5



180254

1 Pressure sensor - 2 Rail - 3 Pipes to injectors - 4 Fuel return - 5 Overpressure valve - 6 Fuel inlets from high pressure pump

The rail volume is of reduced sizes to allow a quick pressurisation at startup, at idle and in case of high flow-rates.

It anyway has enough volume as to minimise pulsations caused by injectors openings and closings and by the high-pressure pump operation.

This function is further enabled by a calibrated hole being set downstream of the high-pressure pump.

Some calibrated holes have been made in the retaining fittings of the high pressure pipes, with the function of damping the oscillations in pressure generated by the opening of the injectors and the plungers of the high pressure pump.

A fuel pressure sensor (1) is screwed to the rail.

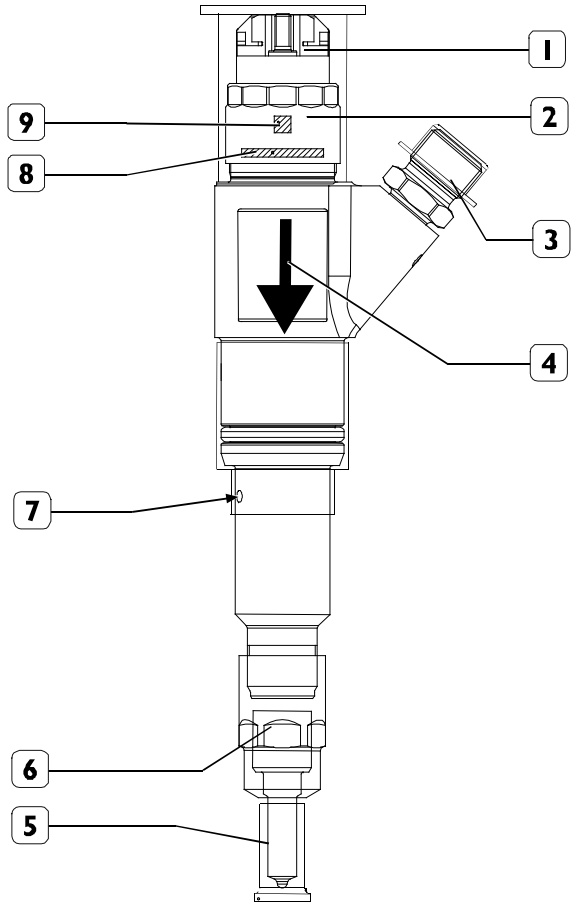
The signal sent by this sensor to the electronic control unit is a feed-back information, depending on which the rail pressure value is checked and, if necessary, corrected.

Specifications

Technical data	
Nominal rail volume	28.6 cm^3
Inner diameter	9 mm
Nominal pressure	2,200 bar
Operating temperature	-40 to 140 °C

Electro-injector CRIN 3-22

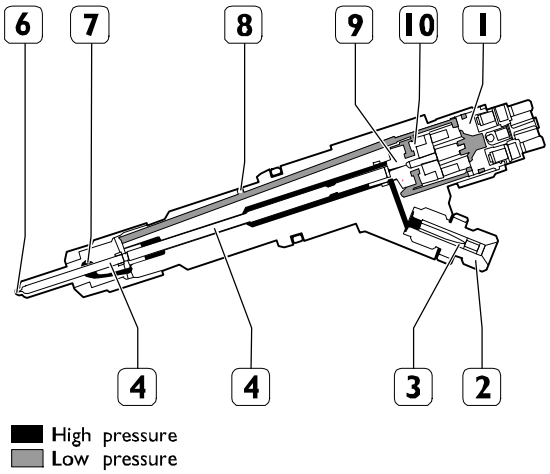
Figure 6



1 Electrical connection - 2 Coil - 3 High pressure fuel intake fitting - 4 Injector closing force - 5 Spray nozzle - 6 Injector nozzle - 7 Fuel return hole - 8 IQA codes - 9 Production code

The electro-injectors are mounted on the cylinder head and operated by the engine control unit. They are supplied by a HP fuel line and connected to a return line at atmospheric pressure required for operation of the pilot valve.

Figure 7



1 Coil - 2 High pressure fuel intake fitting - 3 Filter - 4 Pressure rod - 5 Needle - 6 Nozzle - 7 Pressure chamber - 8 Fuel return - 9 Control volume - 10 Pilot valve shutter

The electro-injector may be considered as mainly made up of two parts:

- ❑ actuator/spray nozzle consisting of pressure rod (4), needle (5) and nozzle (6).
- ❑ control solenoid valve, consisting of a coil (1) and pilot valve.

Electro-injector operation is divided into three phases:

1st Phase - Resting position

The coil (1) is not energised and the shutter (10) of the pilot valve is closed.

Under this condition, opening and closing forces are balanced as fuel pressure in the control volume (9) equals that of the pressure chamber (7).

2nd Phase- Injection start

The coil (1) is energised and causes the shutter (10) to rise.

The fuel of the control volume (9) flows off towards the return manifold (8) causing a drop in pressure.

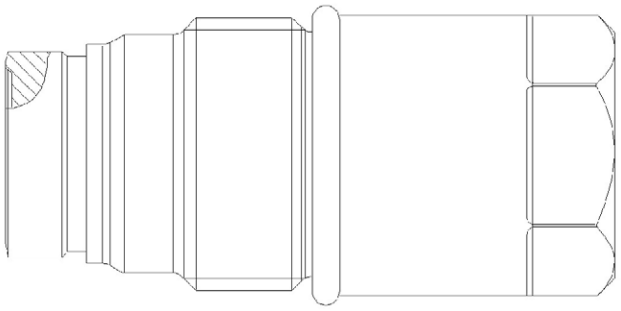
Simultaneously, the line pressure exerts an opening pressure in the pressure chamber (7) that lifts the needle (5) thus causing fuel to be injected into the cylinders.

3rd Phase - End of injection

The coil (1) is de-energised and makes the shutter (10) return to its closed position. This creates a balance in the forces acting upon the needle (5), causing it to return to its closed position and consequently halt the injection of fuel.

Pressure limiter valve

Figure 8



158450

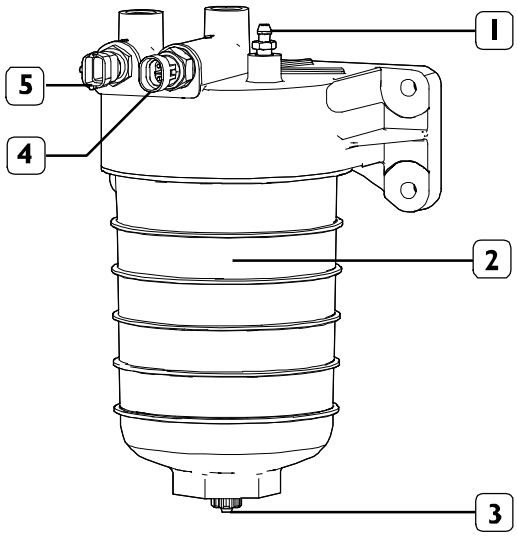
It is a safety valve mounted on the hydraulic accumulator which prevents the pressure of the fuel in the rail from exceeding the threshold 2400 bar.

It consists of a shutter and a spring, calibrated so that when the pressure in the rail reaches too high a value, the valve regulates it by releasing part of the fuel to the tank.

Furthermore, in case of failure of the injection pressure control system, it allows the engine to function with limited performance.

Fuel filter

Figure 9



221058

1. Bleed fitting - 2 . Fuel filter - 3. Drain valve - 4. Clogged filter sensor - 5. Fuel temperature sensor - 6. Fuel filter inlet - 7. Fuel filter outlet

Technical data	
Maximum load	750 l/h
Nominal pressure	< 13 bar
Operating temperature	-40 to 120 °C
Pressure drop with new filter	<0.5 bar @ 750 l/h
Pressure drop with filter at end of life	>2 bar
Capacity	≈1.7 l

Oil filter tightening torques

PART		TORQUE	
		Nm	kgm
1	Fitting for bleeding	17.5 ± 2.5	1.75 ± 0.25
2	Fuel filter	32.5 ± 2.5	3.25 ± 0.25
3	Fuel filter support	24.5 ± 2.5	2.45 ± 0.25
4	Drain valve	1.5 ± 0.5	0.15 ± 0.05
5	Clogged filter sensor	30 ± 2	3 ± 0.2
6	Fuel temperature sensor	30 ± 2	3 ± 0.2

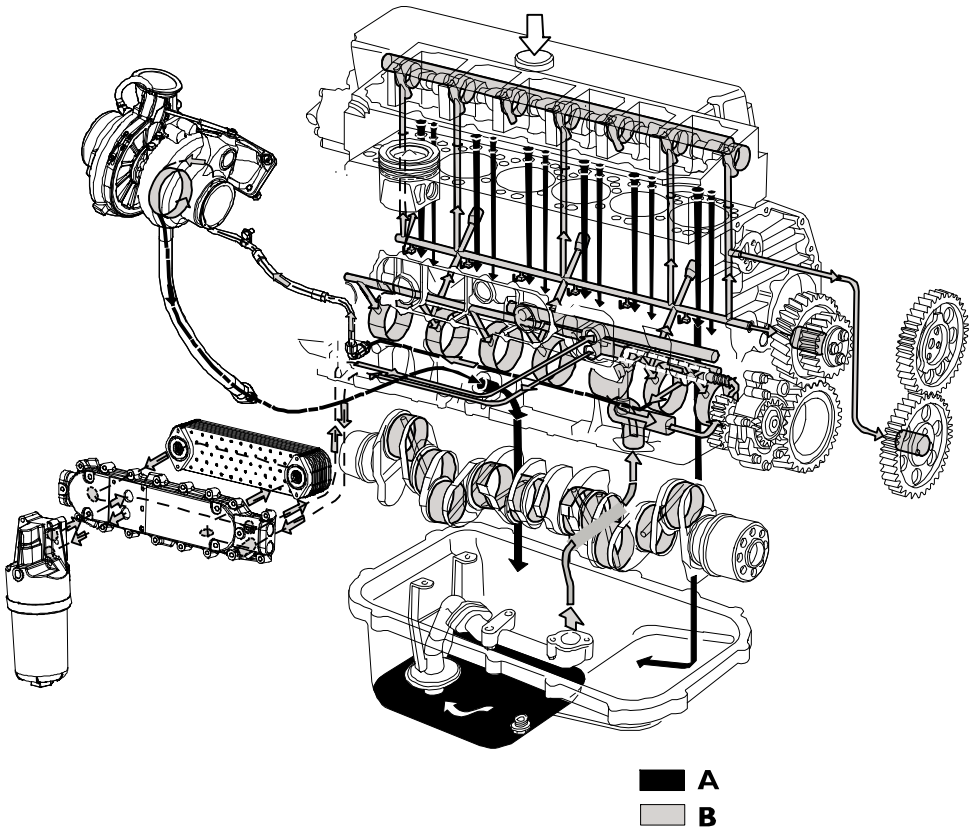
LUBRICATION

The engine is lubricated by gear pump driven via gears by the crankshaft.

A heat exchanger regulates the temperature of the lubricating oil.

It houses the oil filter, indicator sensors and safety valves.

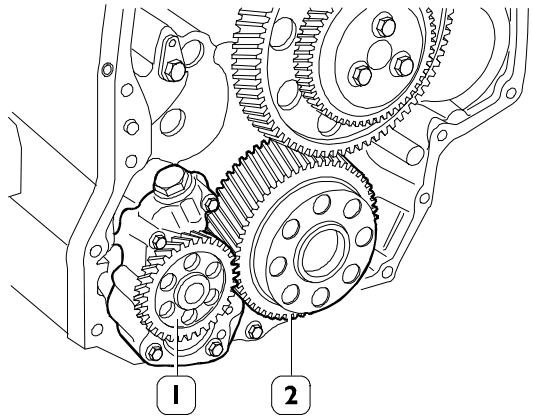
Figure 10



A Descending oil - B Oil at pressure

Oil pump

Figure 11

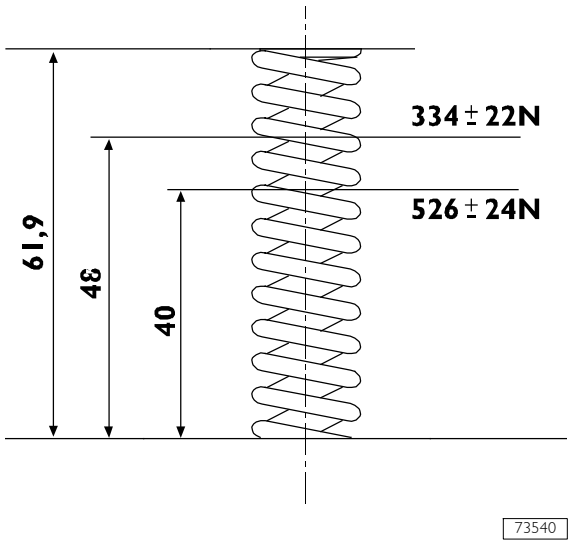


The oil pump (1) shall not be overhauled. If you find any damage, replace the entire oil pump.

To change the gearing (2) of the crankshaft, see the relevant section.

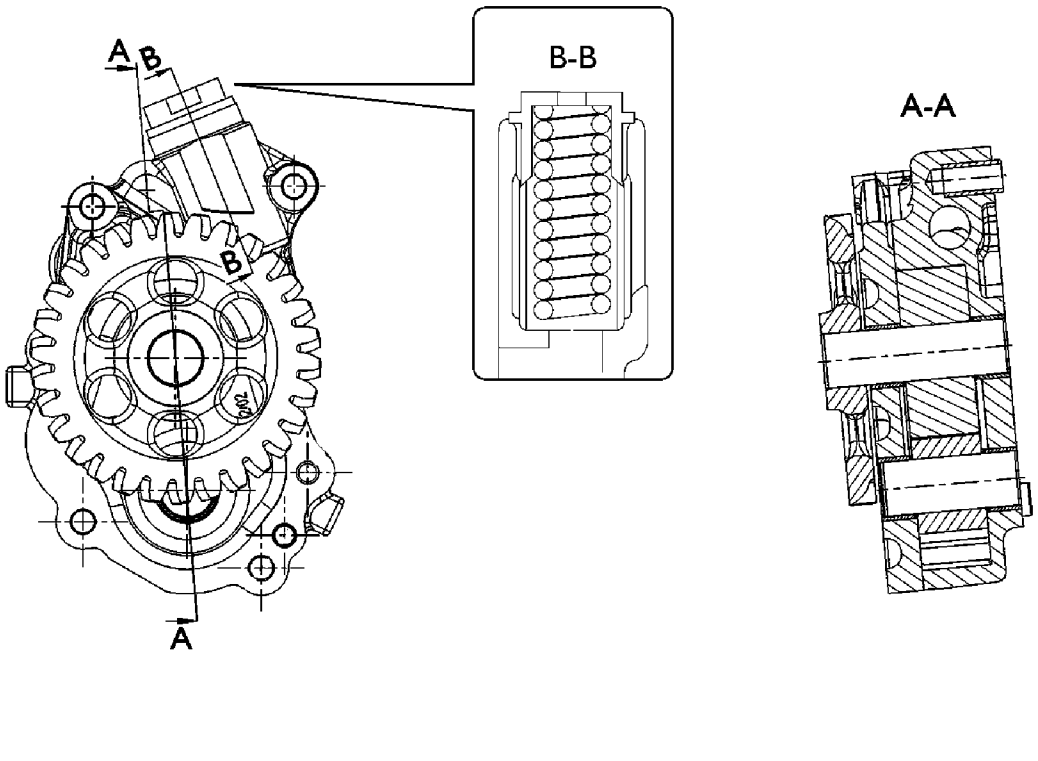
overpressure valve

Figure 12



MAIN DATA TO CHECK THE SAFETY VALVE SPRING

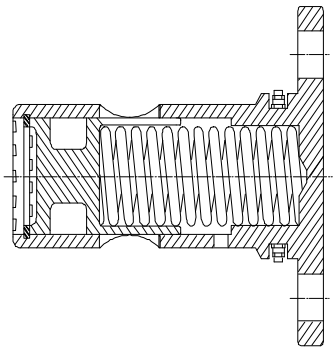
Figure 13



OIL PUMP SECTION
Overpressure safety valve - Initial opening pressure 10 ± 1 bar.

Oil pressure regulator valve

Figure 14

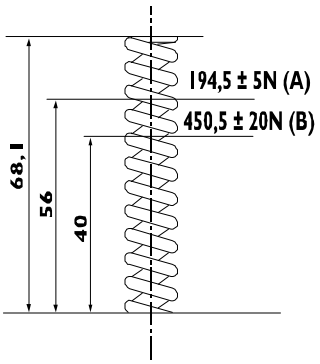


161256

The oil pressure relief valve is located on the left-hand side of the crankcase.

Start of opening pressure 5 bar.

Figure 15



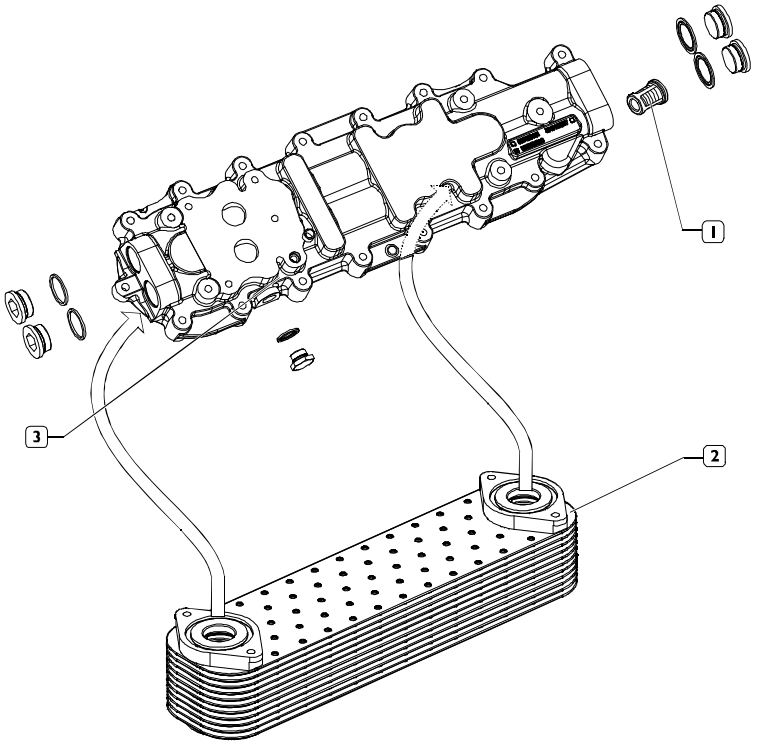
161269

A: Opening Start - B: Opening End

MAIN DATA TO CHECK THE PRESSURE RELIEF VALVE SPRING

Heat exchanger

Figure 16



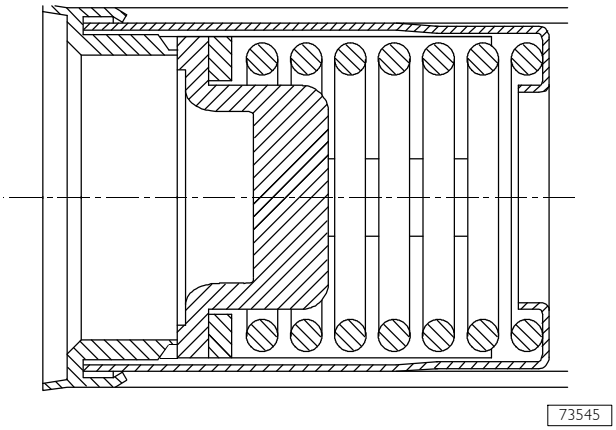
180296

1 By-pass valve - 2 Heat exchanger - 3 Oil filter support seat

TECHNICAL DATA		
	Oil circuit	**Water circuit**
Pressure	5 . 10 bar	2 bar
Operating temperature	90 to 130 °C	110 °C
Performance		
	Hot side	**Cold side**
Capacity	136 l/mn	14.3 l/s
Intake time	115 °C	90 °C
Oil temp. difference	11 to 10.45 °C	-
Oil pressure decrease	<= 65 + 20% kPA	-

Filter by-pass valve

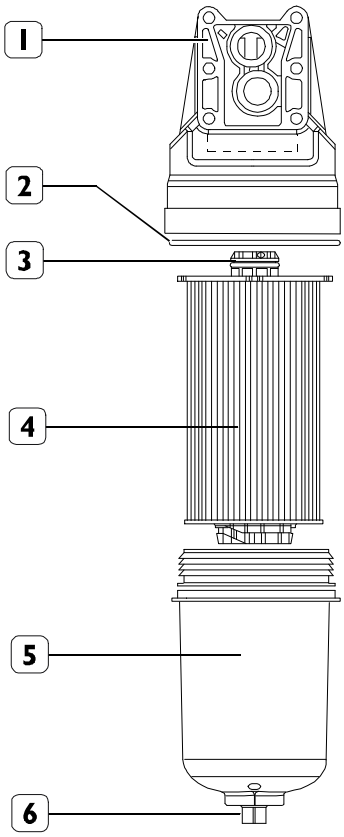
Figure 17



The valve quickly opens at a pressure of: 3.4 ± 0.3 bar.

Engine oil filter

Figure 18



1 Oil filter support - 2 Cap O-Ring - 3 Cartridge O-Ring - 4 Filter element- 5 Closing cap - 6 Drain plug

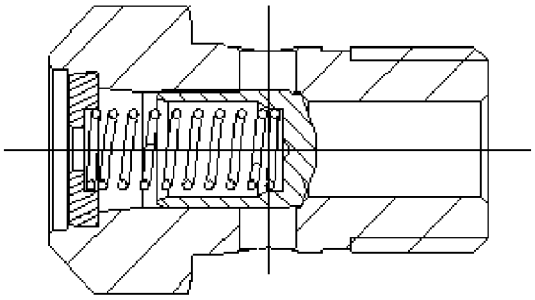
Technical data	
Maximum operating pressure	13 bar
Operating temperature	-30 to 120 °C
By-pass valve opening pressure	3.4 ±0.3 bar

tightening torque	
Oil filter retainer at the support base	60 ±5 Nm
Drain plug on the engine oil filter	6.5 ±1.5 Nm

Valve integrated in piston cooling nozzle

The valve allows oil to enter and thus lubrication of pistons only above the pressure value shown below.

Figure 19



109080

Technical data	
Valve opening pressure	1.7 ±0.2 bar

This permits filling the circuit and therefore lubricating the most stressed parts even when working at lower pressures.

Oil vapour recirculation (Blow-by)

Part of the gas produced by combustion leaks out of the piston gaskets through the openings of the piston rings, into the sump and mixes with the oil vapour it contains.

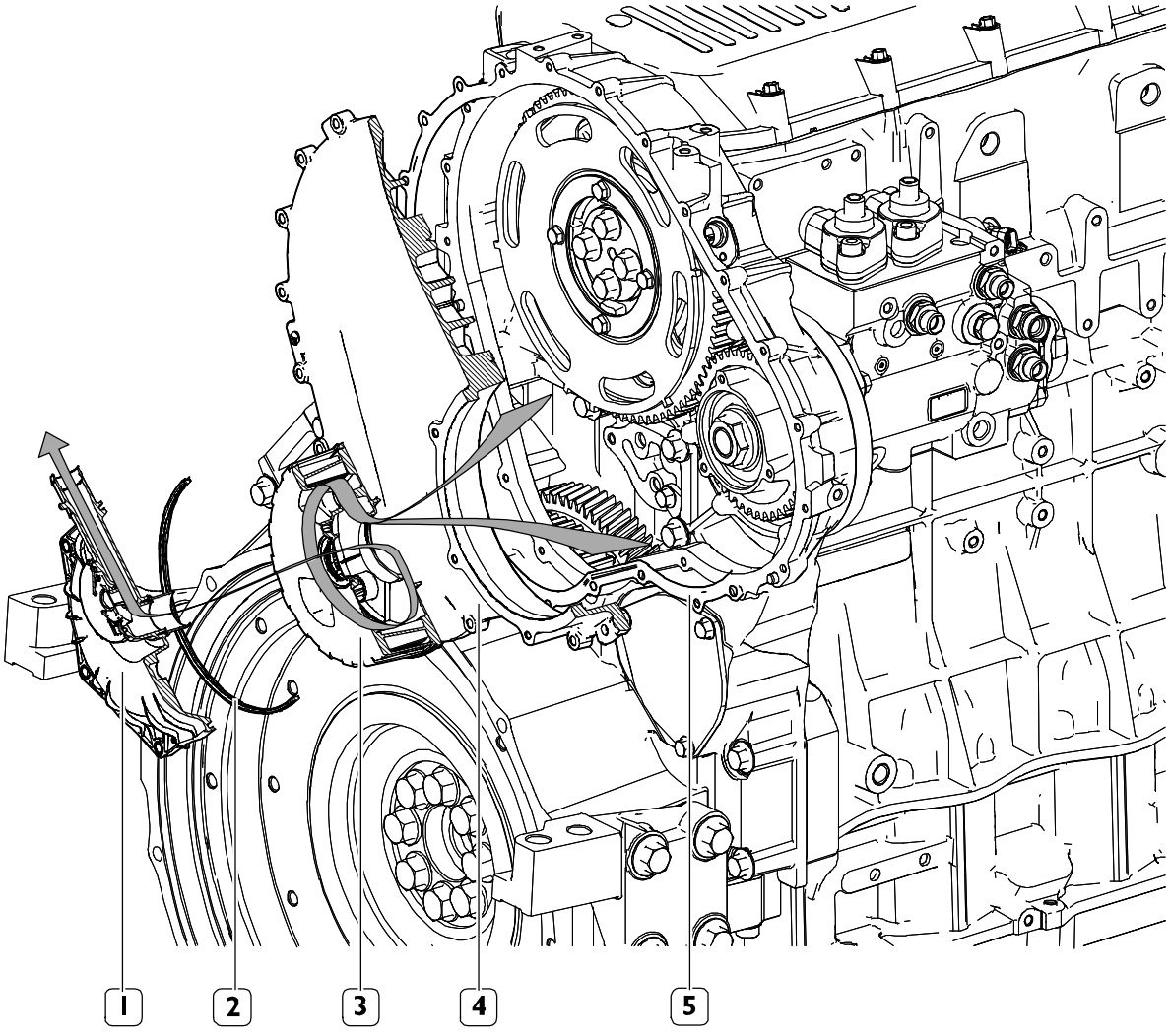
This mixture is conveyed upwards and is partially separated from the oil by a device located at the top of the timing system cover and sent into the air intake circuit.

The device is essentially composed of a rotary filter fitted to the high pressure pump/camshaft control shaft and a rear cover housing the normally closed valves that manage the flow of the mixture.

A pressure sensor that detects the clogging of the Blow-by filter is located on the rocker arm cover.

By measuring the pressure under the rocker arm cover, it is also able to detect the presence of fuel in oil.

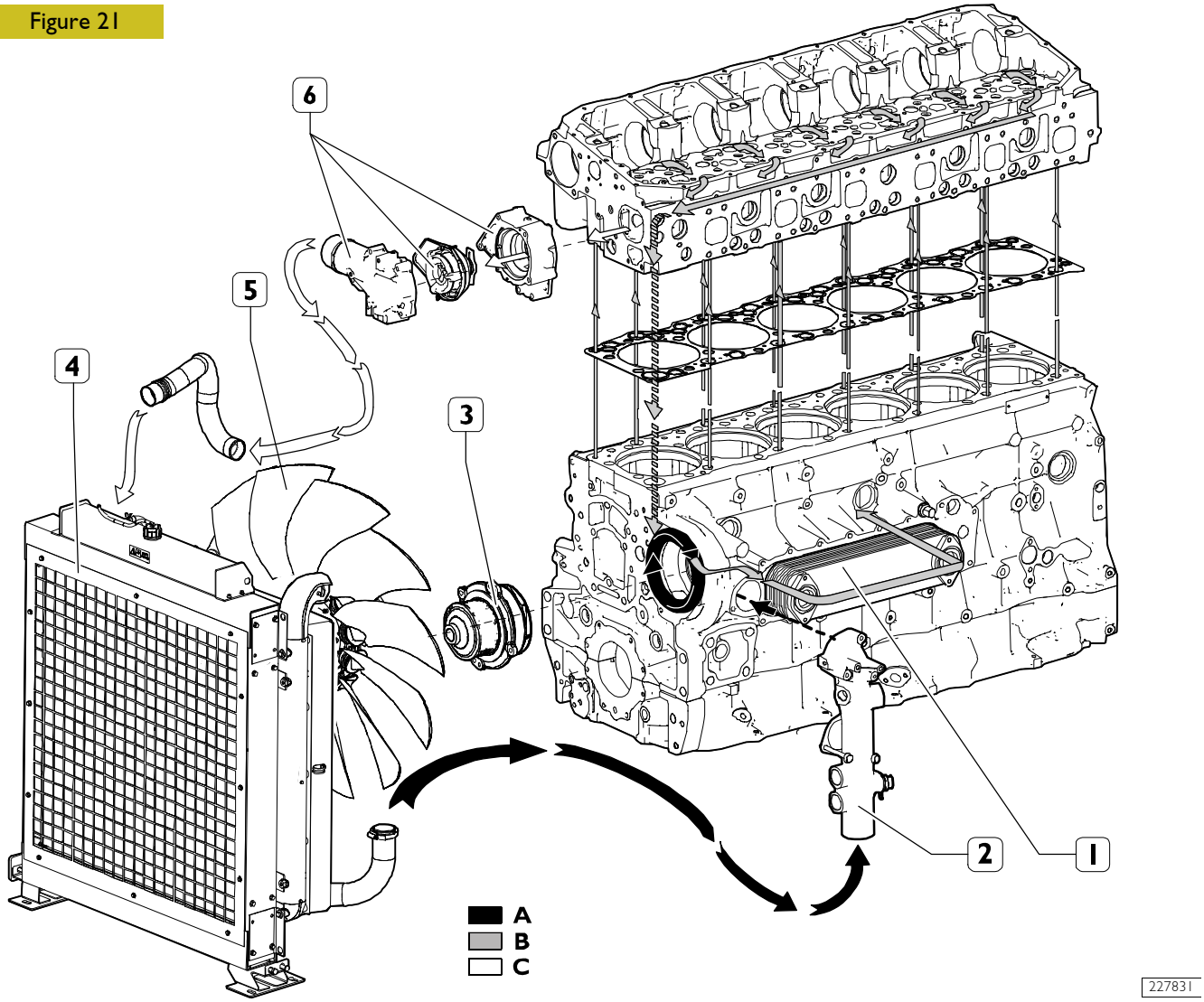
Figure 20



1. Blow-by box cover - 2. O-Ring - 3. Blow-by filtering element - 4. Cover - 5. Gasket

COOLING

Figure 21



COOLING SYSTEM DIAGRAM
A. Water coming into pump - B. Water circulating in the engine - C. Water leaving the thermostat
1. Water/oil heat exchanger - 2. Refitting water inlet pipe to pump - 3. Water pump - 4. Clean the heat exchanger with aftercooler (radiator) - 5. Fan - 6. Thermostat case

Description

The engine cooling system is a closed circuit forced circulation system and can be connected to an additional heater (if any) and to the Intarder heat exchanger.
It consists mainly of the following components:

- ❑ an expansion tank and plug with two built-in valves: an outlet and an inlet, which regulate the pressure of the system;
- ❑ a coolant level sensor
- ❑ an engine cooling unit to dissipate the heat taken by the coolant from with heat exchanger for aftercooler.
- ❑ a heat exchanger to cool the lubricant oil;
- ❑ a centrifugal water pump incorporated into the engine crankcase;
- ❑ an electric fan;
- ❑ thermostat to control coolant circulation.

operation

The water pump driven by a poly-V belt by the crankshaft sends coolant into the crankcase and with a greater head into the cylinder head.

When the coolant temperature reaches and exceeds the working temperature, it causes the thermostat to open and the fluid is channelled from here to the radiator and cooled by the fan.

The pressure inside the system depending on the temperature variation is controlled by the discharge and charge valves incorporated in the expansion reservoir filling plug.

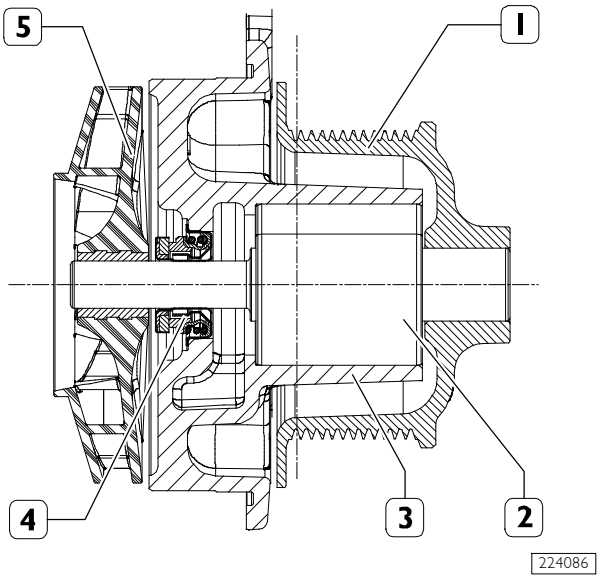
The discharge valve has a double function:

- ❑ maintain the system slightly pressurised in order to raise the boiling point of the coolant;
- ❑ vent excess pressure into the atmosphere that is caused by high temperature of the coolant.

The function of the inlet valve is to permit the transfer of coolant from the expansion tank to the radiator when a low pressure is generated inside the system due to coolant volume reduction as a result of lowering of temperature.

Water pump

Figure 22



SECTION ON WATER PUMP
1. Pulley - 2. Shaft bearing- 3. Mount - 4. Front seal - 5. Impeller

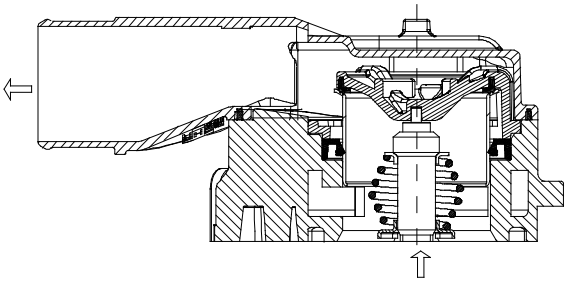
Check that the pump casing shows no sign of cracking or water leakage; replace the water pump assembly if it does.

Technical data	
Maximum operating pressure	3.5 bar
Operating temperature	-40 to 115 °C

Thermostat

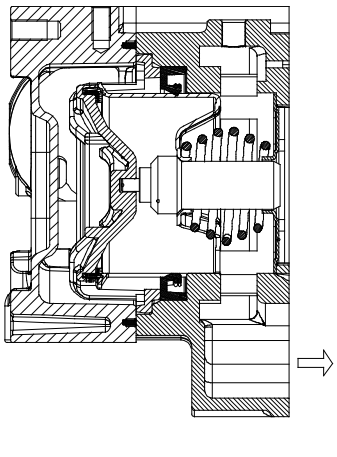
Water circulating in the engine

Figure 23



Water leaving the thermostat

Figure 24

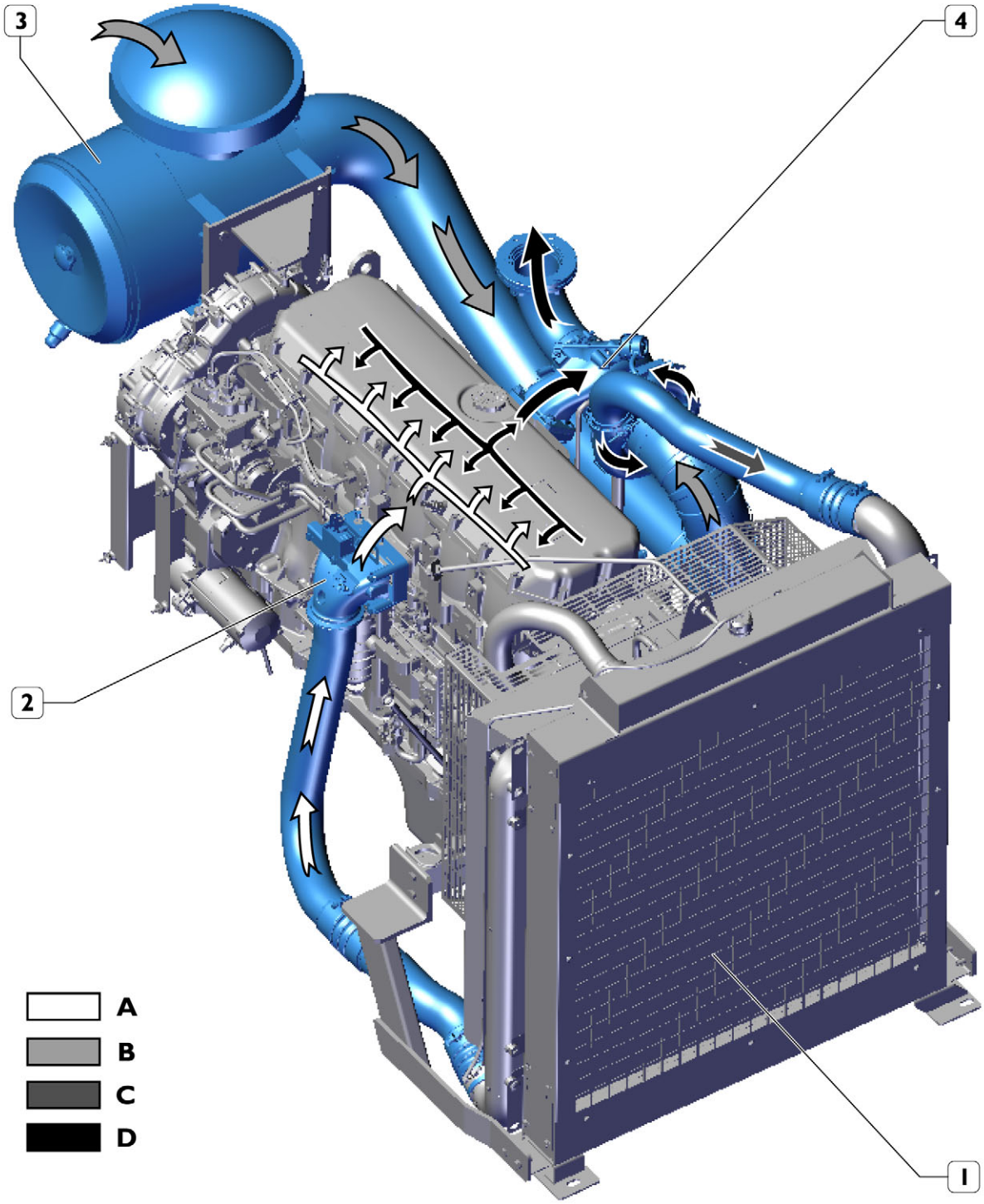


Check that the thermostat works properly, replace it if there is any doubt.

Technical data	
Start of stroke temperature	84°C ± 2°C
Minimum stroke temperature (15 mm)	94°C ± 2°C

TURBOCHARGING

Figure 25



TURBOCHARGING DIAGRAM
A. Cold compressed air - B. Intake air - C. Compressed air (hot) - D. Exhaust gas
1. Clean the heat exchanger with aftercooler (radiator) - 2. Intake manifold - 3. Air filter - 4. turbocharger

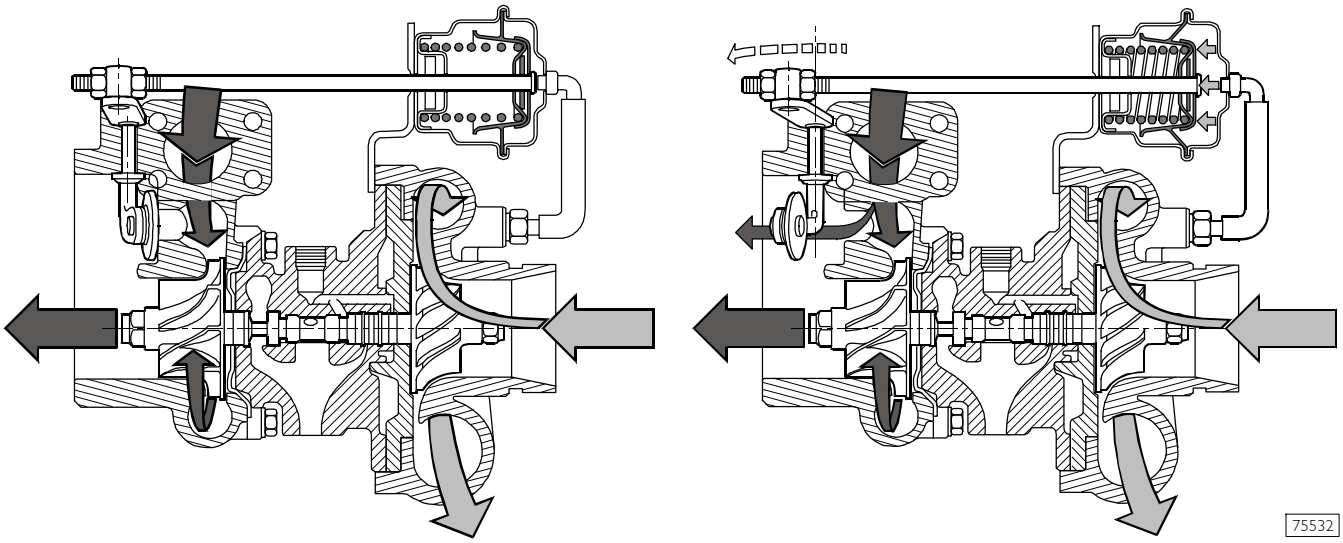
Description

The turbocharging system is composed of: an air filter, a turbocharger and an intercooler.
The air cleaner is a dry type composed of a filtering cartridge that is periodically changeable.
The function of the turbocharger is to use the energy of the engine's exhaust gas to deliver pressurized air to the cylinders.

The intercooler is composed of a radiator applied on the engine coolant radiator, and it is used for lowering the temperature of the air coming out from the turbocharger to send it to the cylinders.

turbocharger

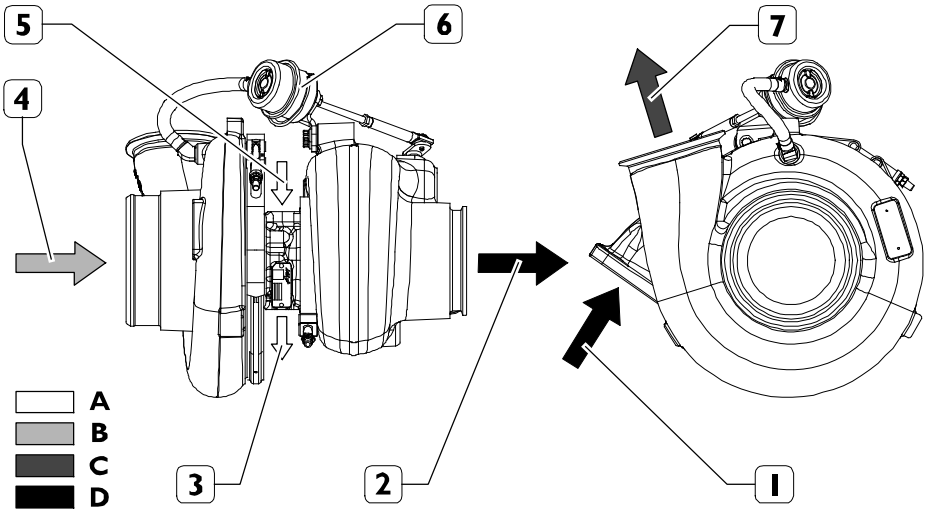
Figure 26



A. CLOSED THROTTLE VALVE

B. THROTTLE VALVE OPEN

Figure 27



A. Lubricant oil - B. Uncompressed air - C. Compressed air - D. Exhaust gas
1. Exhaust gas intake from manifold - 2. Exhaust gas outlet (to outside) - 3. Oil outlet - 4. Air inlet - 5. Oil inlet - 6. Pneumatic actuator - 7. Compressed air outlet

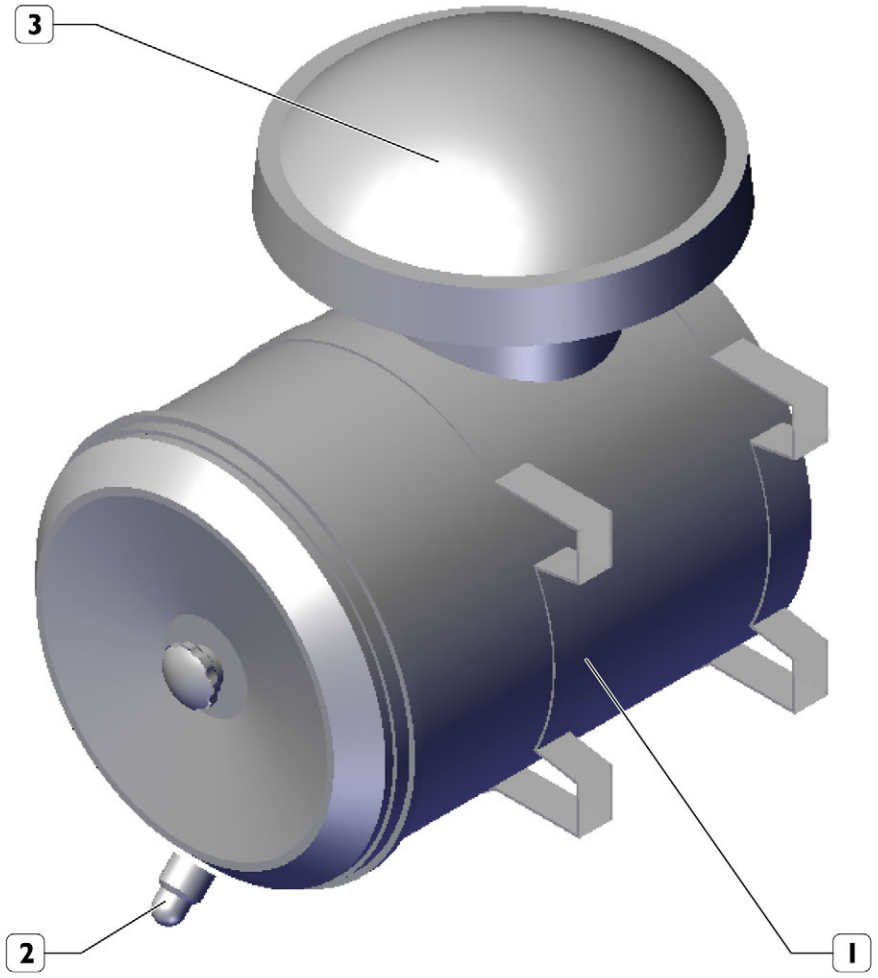
221065

Essentially this consists of:

- a central body in which a shaft is housed, supported by bushings, the ends of which are connected to: the turbine rotor and the compressor rotor;
- a turbine body and a compressor body fitted at the ends of the centre body;
- an pressure limiter valve fitted on the turbine casing. Its function is to choke the exhaust gas outlet (detail B), sending a portion of the exhaust gas directly into the exhaust pipe when the turbo charging pressure down from the turbocharger reaches a calibrated value;

Air filter

Figure 28



1. Filter element seat - 2. Condensation exhaust valve - 3. External air intake

By means of the aspiration created by the engine, the outside air flows through the air socket (3) and the centrifugal movement is imparted at high speed by the wings aimed at the filter.

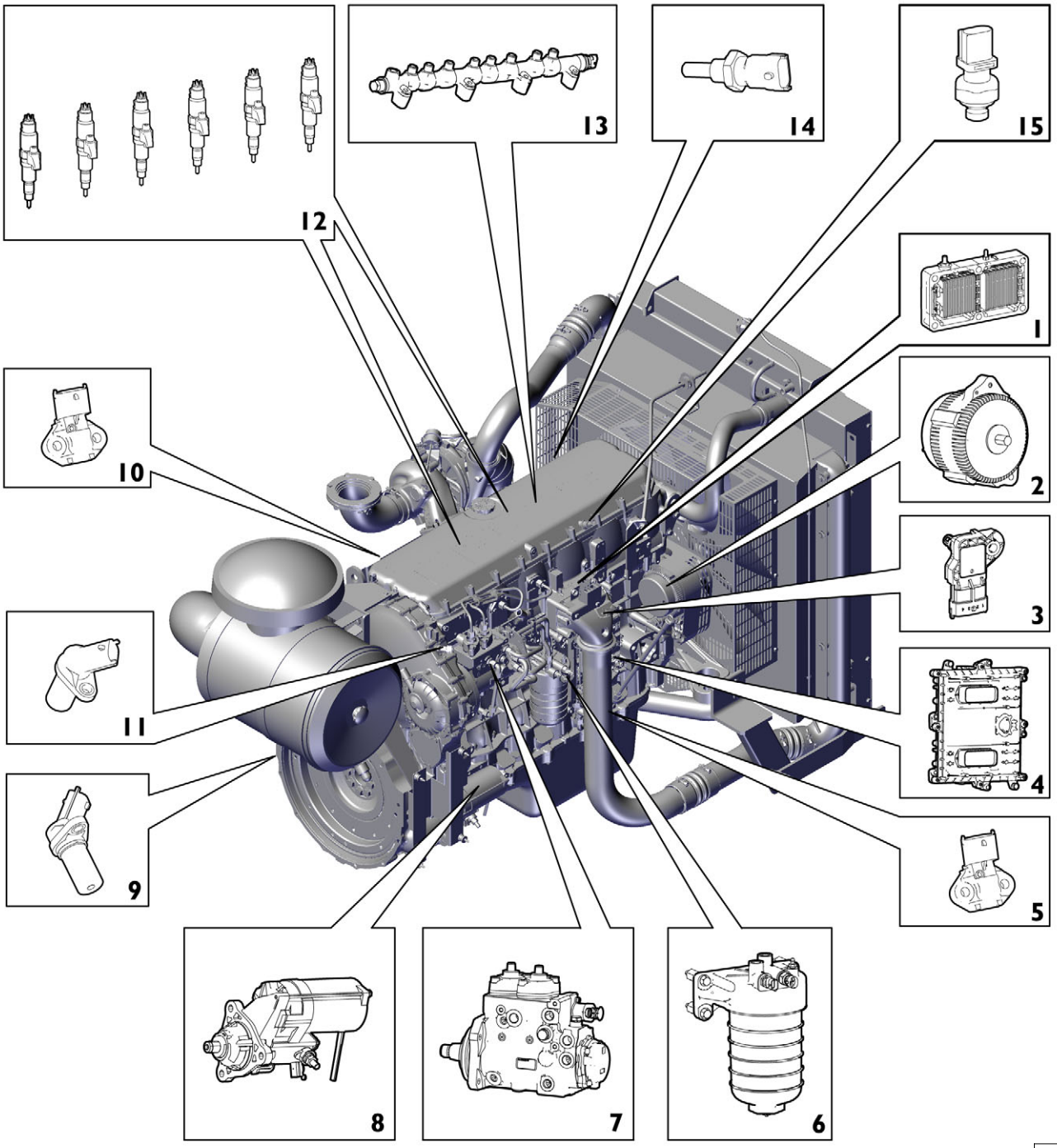
The larger particles of dust and dirt are separated from the air and collected in the condensate discharge valve (2).

The suctioned air then passes through the primary and possibly the secondary (safety) filter elements before being fed into the engine.

If present, the secondary filter (safety) ensures that unfiltered air does not enter into the engine even if the primary filter should fail.

MAIN COMPONENTS

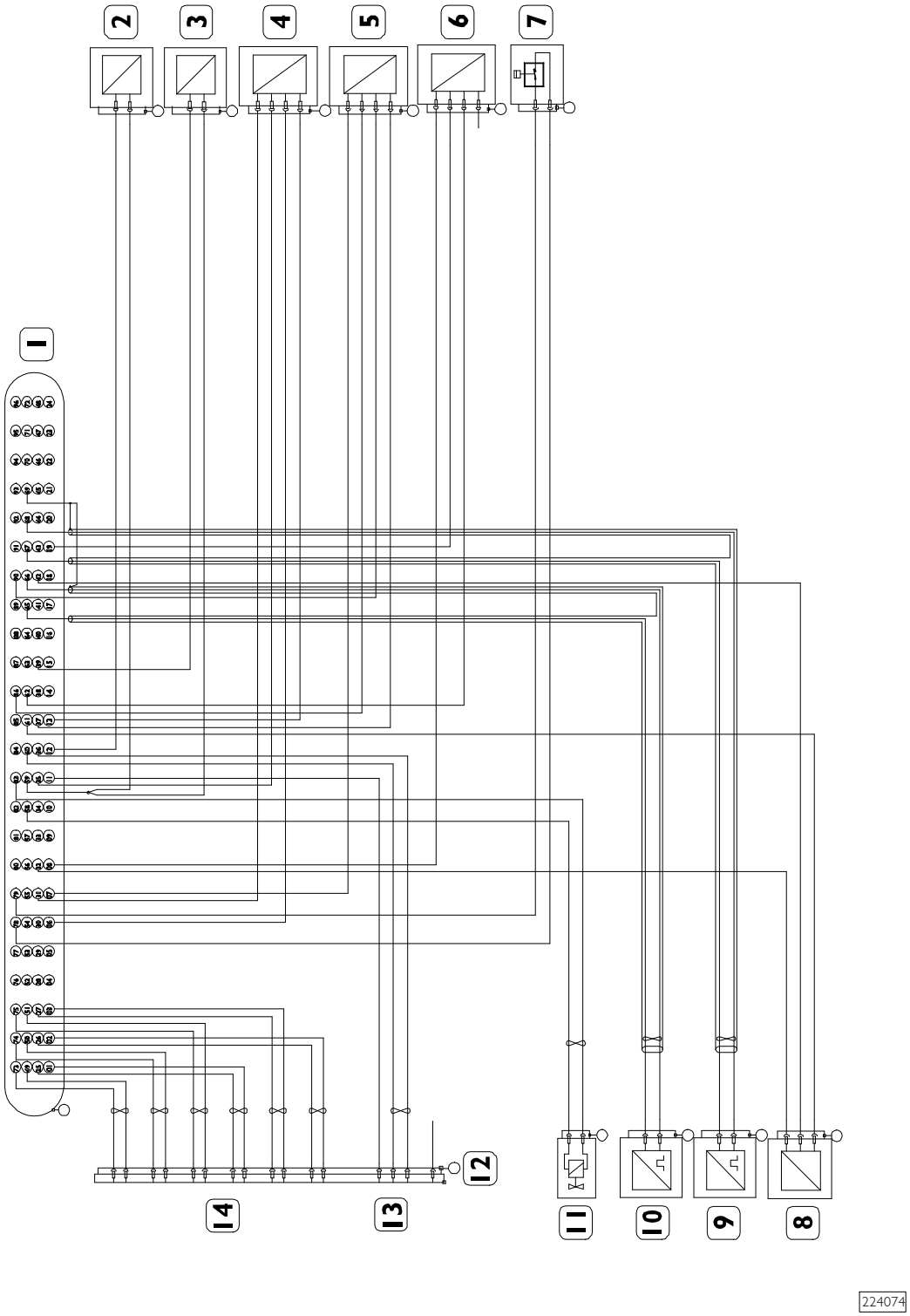
Figure 1



1. Air heater resistor - 2. Alternator - 3. Air temperature and pressure sensor - 4. Engine management control unit - 5. Fuel high pressure and temperature sensor - 6. Fuel filter with pressure and temperature sensor - 7. Fuel pump with flow rate regulator - 8. Starter motor - 9. Rpm sensor - 10. Oil high pressure and temperature sensor - 11. Timing sensor - 12. Electro-injectors - 13. Rail with fuel pressure sensor 14. Coolant temperature sensor - 15. Pressure sensor inside engine crankcase

ENGINE SIDE WIRING
Engine side wiring diagram

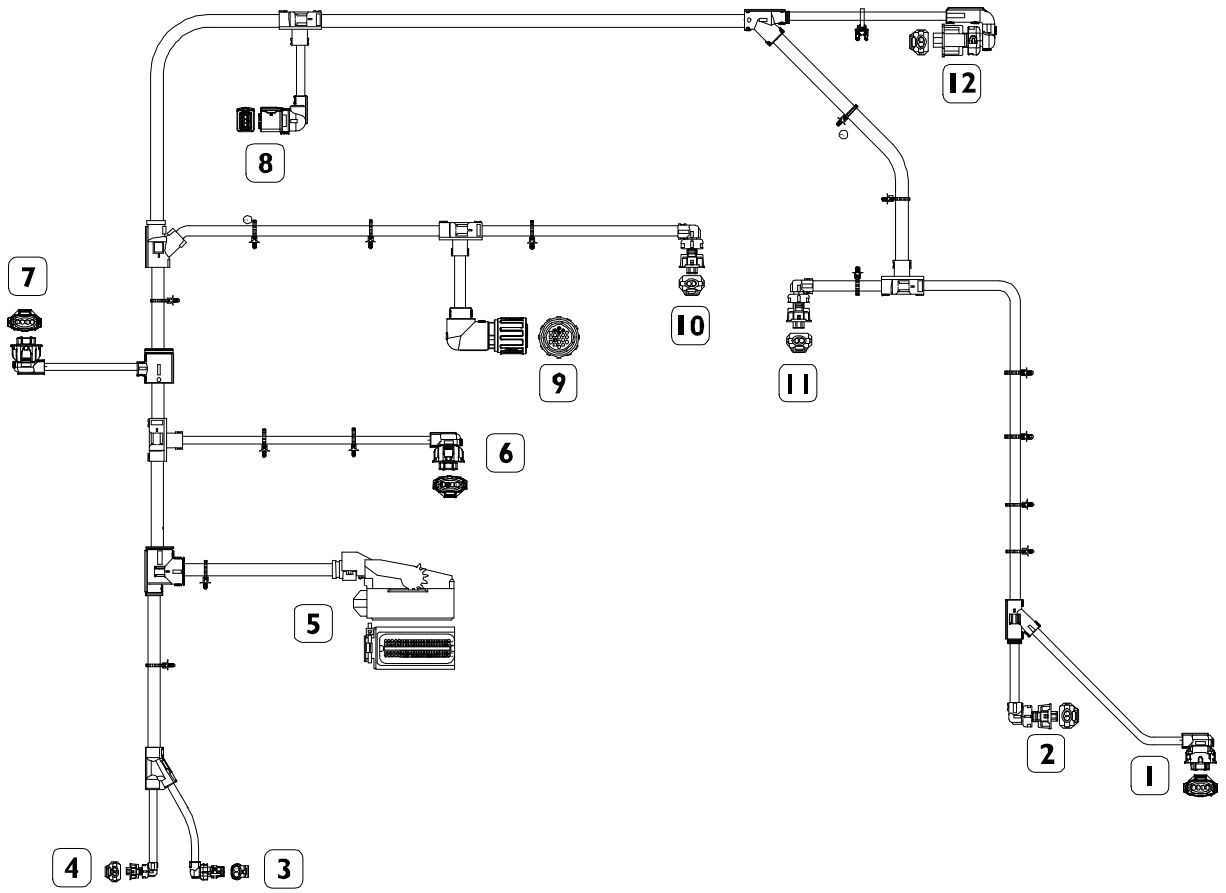
Figure 2



1. EDC connector (96-way) - 2. Fuel temperature sensor - 3. Coolant temperature sensor - 4. Oil high pressure and temperature sensor - 5. Turbocharging air pressure and temperature sensor - 6. Fuel pre-filter clogged sensor - 7. Fuel filter clogged sensor - 8. Pressure sensor inside crankcase - 9. Timing sensor - 10. Rpm sensor - 11. Fuel pump with flow rate regulator on HP pump - 12. Electro-injector wiring connection - 13. Fuel pressure sensor on rail - 14. Electro-injectors for cylinders 1-6

Engine side wiring diagram

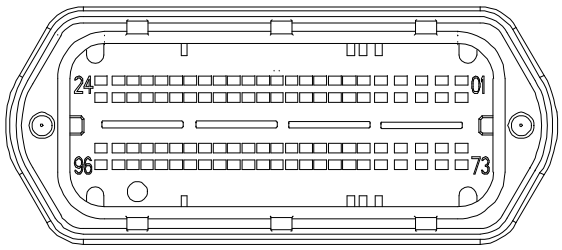
Figure 3 (Topographic view)



1. Oil high pressure and temperature sensor - 2. Rpm sensor - 3. Fuel filter clogged sensor - 4. Fuel temperature sensor - 5. EDC connector (96-way) - 6. Fuel pre-filter clogged sensor - 7. Turbocharging air pressure and temperature sensor - 8. Engine pressure sensor inside crankcase - 9. Electro-injector wiring connection - 10. Coolant temperature sensor - 11. Timing sensor - 12. Fuel pump with flow rate regulator on HP pump

PIN OUT CONNECTOR 1A (96 PIN) - CONTROL UNIT EDC 17 HP 41

Figure 4



190542

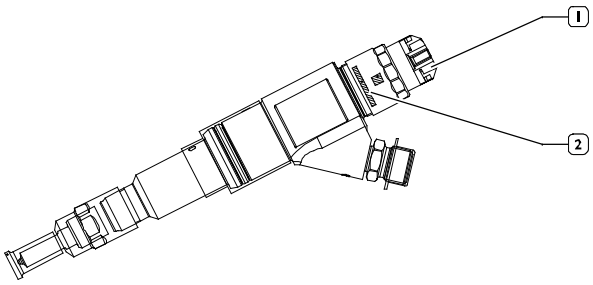
Pin	Signal
A01	Cylinder 1 injector
A02	Cylinder 6 injector
A03	Cylinder 5 injector
A04	-
A05	-
A06	Oil pressure and temperature sensor ground
A07	Air pressure temperature sensor supply
A08	Fuel pre-filter clogged power supply (5V)
A09	-
A10	-
A11	Pressure on rail sensor power supply
A12	Fuel temperature sensor signal
A13	Oil pressure and temperature sensor temperature signal
A14	-
A15	-
A16	-
A17	-
A18	-
A19	Fuel pre-filter clogged sensor ground
A20	-
A21	-
A22	-
A23	-
A24	-
A25	Cylinder 4 injector
A26	Cylinder 6 injector
A27	Cylinder 5 injector
A28	-
A29	-
A30	-
A31	Oil pressure and temperature sensor power supply (5V)
A32	Crankshaft pressure sensor power supply
A33	-
A34	-
A35	Oil pressure and temperature sensor pressure signal
A36	Rail pressure sensor signal

Pin	Signal
A37	Air pressure temperature sensor signal
A38	-
A39	Coolant temperature sensor signal
A40	-
A41	-
A42	Crankshaft pressure sensor ground
A43	-
A44	-
A45	-
A46	-
A47	-
A48	-
A49	Cylinder 1 injector
A50	Cylinder 2 injector
A51	Cylinder 3 injector
A52	-
A53	-
A54	-
A55	-
A56	-
A57	-
A58	ZME Fuel metering unit power supply
A59	Common ground (fuel temperature sensor, coolant temperature sensor)
A60	Rail pressure sensor ground
A61	Crankshaft pressure sensor signal
A62	Fuel pre-filter clogged sensor signal
A63	-
A64	-
A65	Crankshaft sensor signal (-)
A66	Crankshaft sensor signal (+)
A67	Camshaft sensor signal (+)
A68	Camshaft sensor signal (-)
A69	Common ground (input 7)
A70	-
A71	-
A72	-
A73	Cylinder 1 injector
A74	Cylinder 2 injector
A75	Cylinder 3 injector
A76	-
A77	-
A78	Fuel filter clogged sensor ground
A79	Fuel filter clogged sensor signal
A80	-
A81	-
A82	-
A83	ZME Fuel metering unit

Pin	Signal
A84	-
A85	-
A86	Air pressure temperature sensor signal
A87	-
A88	-
A89	-
A90	Air temperature and pressure sensor ground
A91	-
A92	-
A93	-
A94	-
A95	-
A96	-

CRIN INJECTOR 3.3

Figure 5



178241

1. Electrical connections - 2. Electromagnet assembly

This is an N.O. solenoid valve.

They are connected to the EDC ECU on connector 2.

The resistance of the coil of each individual injector is 0.56 - 0.57 Ω.

The electro-injector essentially consists of two parts:

- actuator - spray nozzle consisting of a pressure rod, a needle and a jet
- control solenoid valve made up of coil and pilot valve

The solenoid valve checks the lift of the nozzle needle.

START OF INJECTION

Upon being supplied with power, the coil moves up the shutter. The fuel in the control volume flows back towards the return duct resulting in a pressure drop in control volume.

At the same time, the fuel pressure in the pressure chamber moves up the needle resulting into the fuel being injected into the cylinder.

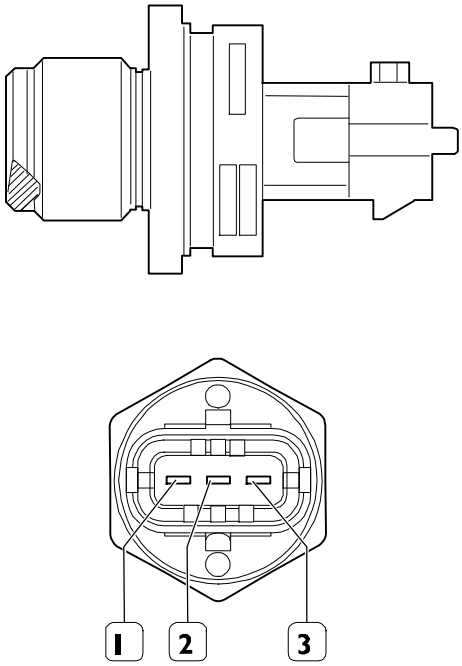
END OF INJECTION

When power to the coil is cut off, the shutter closes again so as to re-create an equilibrium which moves the needle back into its closed position and stops the injection process.

Maximum working pressure	1,800 bar
Minimum working pressure	250 bar
Electrical connection M4 nut	1.5 ±0.25 Nm

Rail pressure sensor (RSD 4)

Figure 6



190509

The value of injection pressure is used to keep the pressure level under control and to determine the time duration of the injection electronic command.

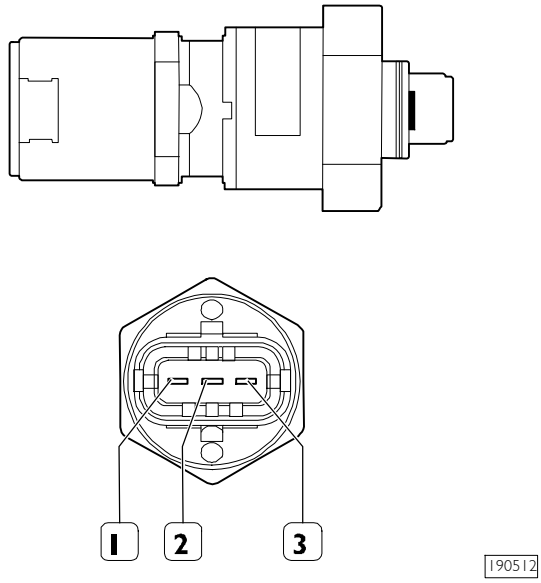
Pin	Description	ECU pin
1	Ground (-)	EDC17, pin A/60
2	Signal (Output)	EDC17, pin A/36
3	Power supply (+)	EDC17, pin A/11

Specifications	Measurement Conditions
Pressure range	0 - 2,400 bar
Power supply	5V
Output voltage	0.5 - 4.5V
Closing torque	140 Nm

Pressure sensor inside engine crankcase

The crankshaft pressure sensor is used to measure the pressure inside the engine.

Figure 7



Pin	Description	ECU pin
1	Power supply	EDC17, pin A/32
2	Ground	EDC17, pin A/42
3	Signal	EDC17, pin A/61

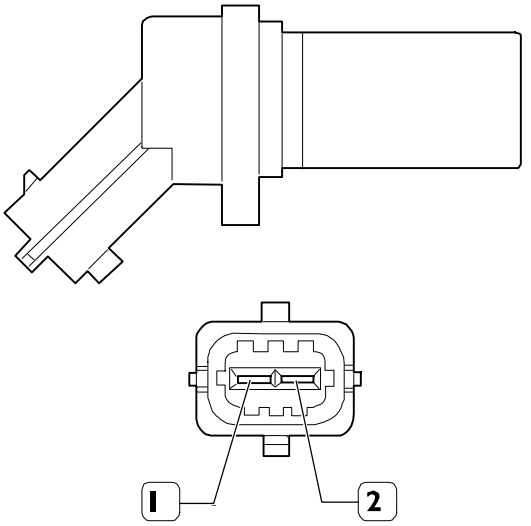
Crankshaft sensor

This sensor is an inductive one and is located on the flywheel.

NOTE If this signal fails the rev counter will not work.

WARNING The sensor gap is not adjustable.

Figure 8

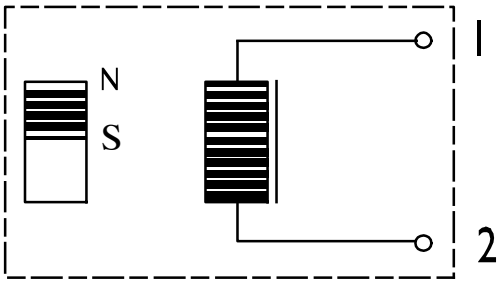


190510

Pin	Description	ECU pin
1	Signal (+)	EDC17, pin A/66
2	Signal (-)	EDC17, pin A/65

Specifications	Measurement Conditions
Resistance	850 - 870 Ω
tightening torque	6 - 10 Nm

Figure 9



190511

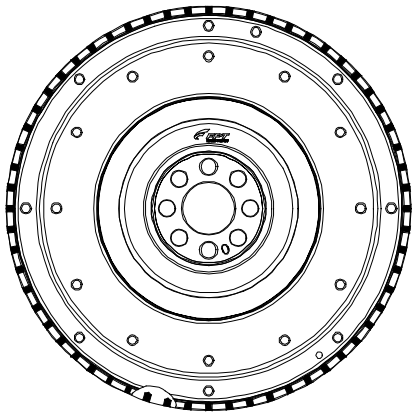
The flywheel has 60 sections, on 58 of which there is a hole.

The sensor reads the signal generated by these holes.

The EDC 17 uses this signal to:

- recognise the position of the pistons during normal running;
- determine the engine speed.

Figure 10



221071

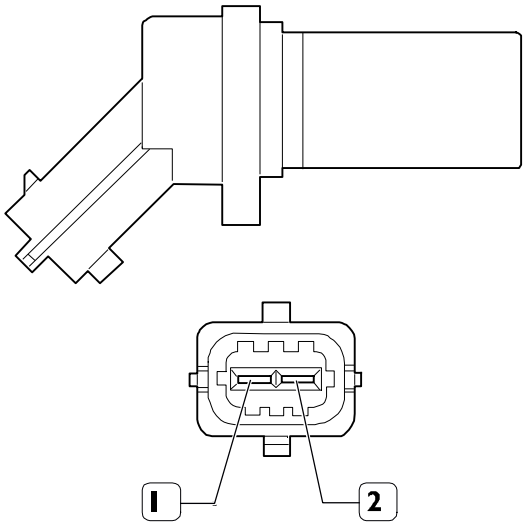
Camshaft sensor

This inductive sensor is located on the camshaft.

The signal generated by this sensor is used by the EDC17 control unit as the injection timing signal.

WARNING The sensor gap is not adjustable.

Figure 11

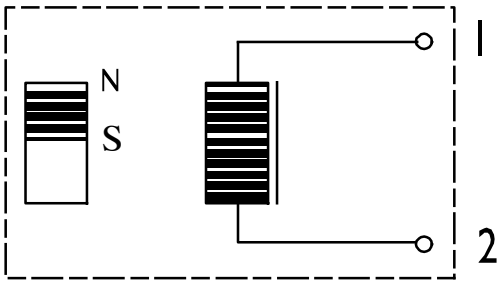


190510

Pin	Description	ECU pin
1	Signal (+)	EDC17, pin A/67
2	Signal (-)	EDC17, pin A/68

Specifications	Measurement Conditions
Resistance	850 - 870 Ω
tightening torque	6 - 10 Nm

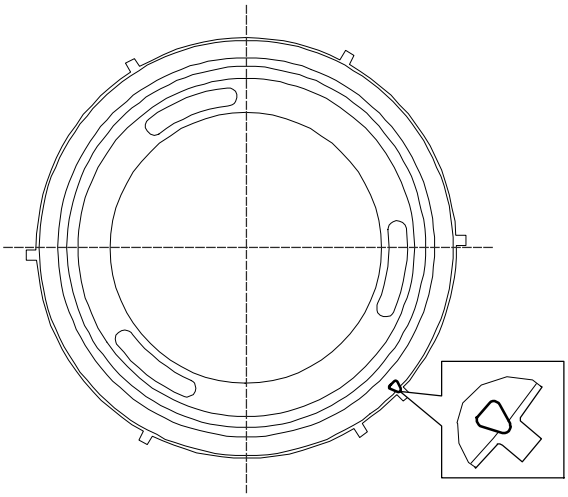
Figure 12



190511

The sensor generates signals obtained from the magnetic flow lines which come towards the teeth of the phonic wheel fitted on the shaft (number of teeth: 7).

Figure 13



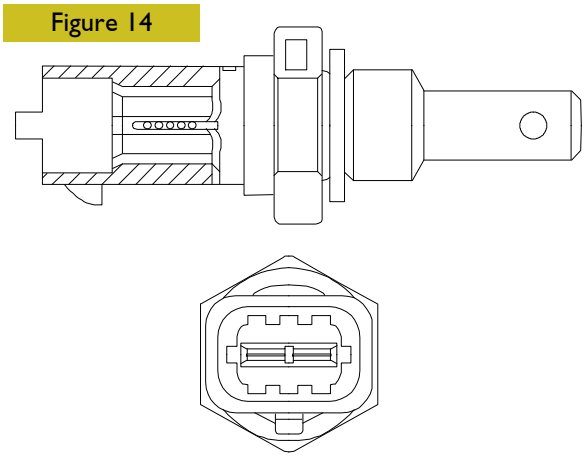
210300

Fuel temperature sensor

It is an N.T.C type sensor and is located on the fuel filter.

It detects the fuel temperature thus enabling the electronic control unit to determine the fuel density and volume and adjust the delivery.

Figure 14

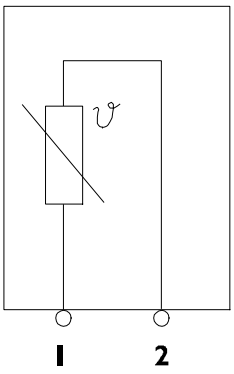


113561

Pin	Description	ECU pin
1	Signal (+)	EDC17, pin A/12
2	Ground (-)	EDC17, pin A/59*

* Common ground

Figure 15



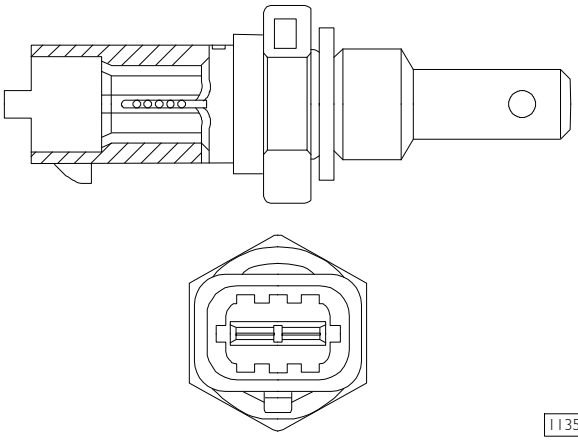
190515

Coolant temperature sensor

It is an N.T.C type sensor and is located on the fuel filter.

It detects the fuel temperature thus enabling the electronic control unit to determine the fuel density and volume and adjust the delivery.

Figure 16

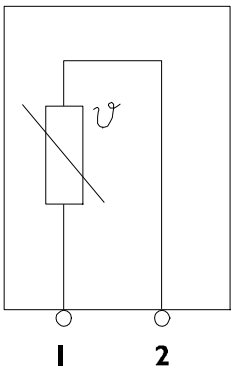


113561

Pin	Description	ECU pin
1	Signal (+)	EDC17, pin A/39
2	Ground (-)	EDC17, pin A/59*

* Common ground

Figure 17



190515

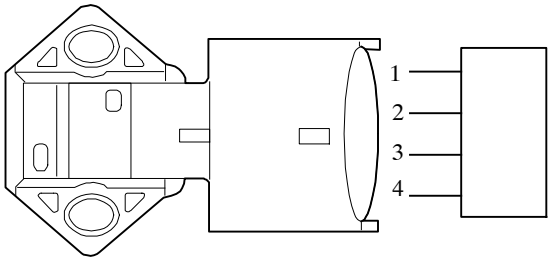
Oil pressure and temperature sensor

It is mounted on the crankcase.

The signals measured are transmitted to the EDC17 control unit which in turns sends the information to the instrument panel (indicator / pressure warning light).

NOTE The engine oil temperature is only used by the EDC 17 control unit and is not sent to the instrument panel.

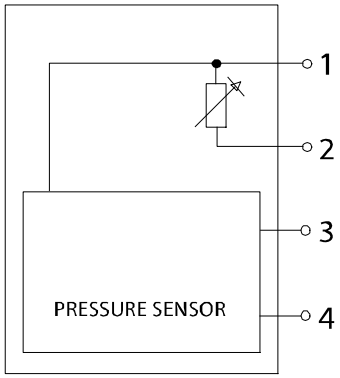
Figure 18



190517

Pin	Description	ECU pin
1	Ground (-)	EDC17, pin A/6
2	Temperature signal	EDC17, pin A/13
3	Power supply (5V)	EDC17, pin A/31
4	Pressure signal	EDC17, pin A/35

Figure 19

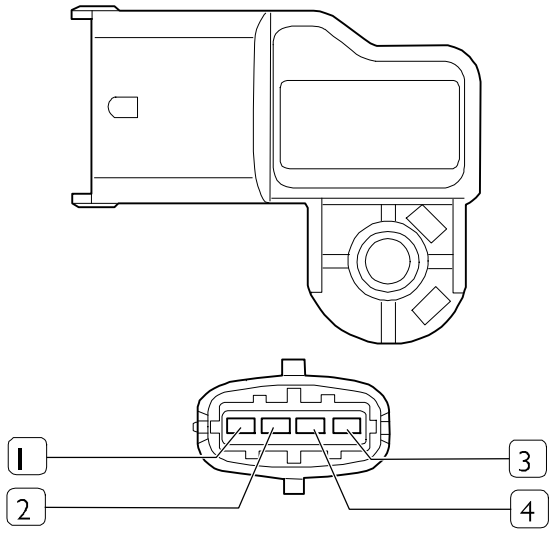


190518

Turbocharging air pressure and temperature sensor

This is fitted on the intake manifold; the sensor described serves to measure the absolute pressure on the intake manifold and the supply air flow temperature

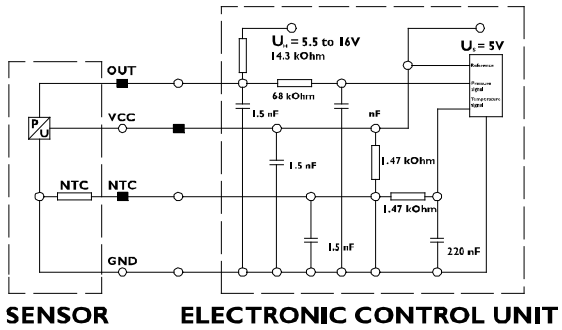
Figure 20



190519

Pin	Description	ECU pin
1	Ground (-)	EDC17, pin A/90
2	Temperature signal	EDC17, pin A/37
3	Power supply (5V)	EDC17, pin A/07
4	Pressure signal	EDC17, pin A/86

Figure 21

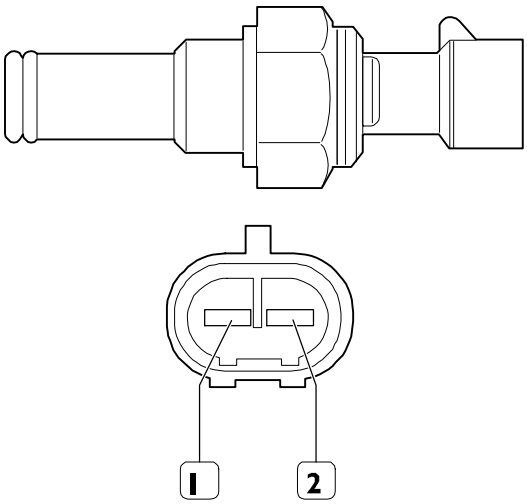


225063

Fuel filter clogged sensor

It is a normally closed electric sensor which identifies the clogged fuel filter by calculating the pressure between its two doors.

Figure 22

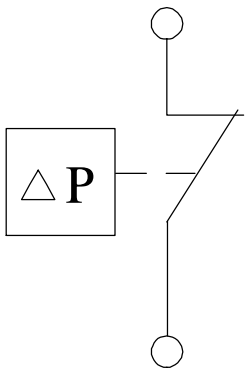


190523

Pin	Description	ECU pin
1	Ground (-)	EDC17, pin A/78
2	Signal	EDC17, pin A/79

Specifications	Measurement Conditions
Rated voltage	12 / 24 V
Maximum switched voltage	200 mA
Differential opening pressure	210 ± 10 kPa
Maximum working pressure	500 kPa
Operating temperature	- 40°C/+120°C
tightening torque	30 ± 2 Nm

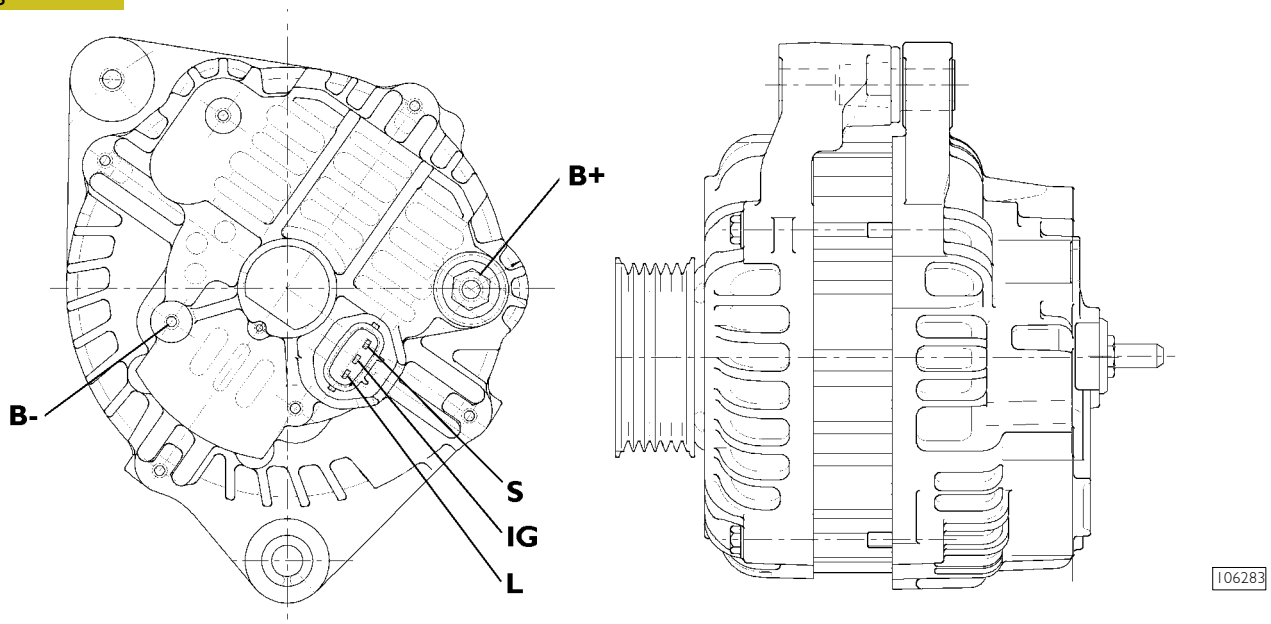
Figure 23



190524

ALTERNATOR

Figure 24

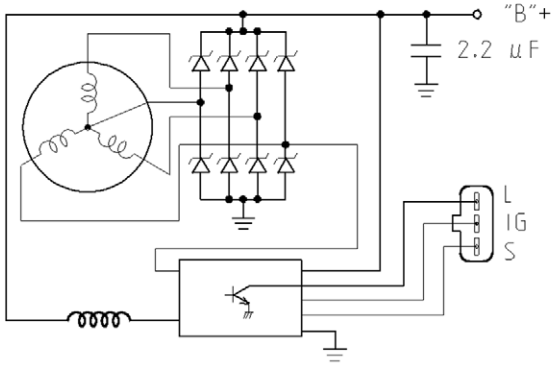


B+: Positive +30V - B-: Negative - S: battery voltage sensor - IG: alternator activation - L: to recharging indicator

Specifications

Supplier	MITSUBISHI
Rated voltage	24 V
Nominal supply current	90A
Speed	5000 rpm
Belt tension	730 N
Direction of rotation	clockwise, viewed from pulley
Weight	7.0 kg
Tightening torque on terminal B+	12.5 ± 2 Nm

Figure 25

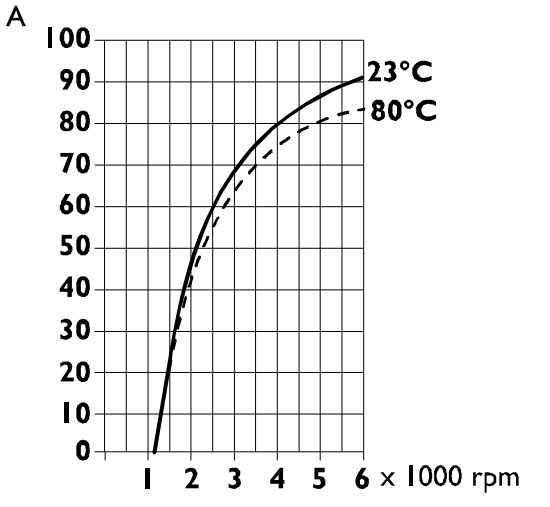


L. to the recharge warning light, IG, alternator start-up,

S. battery voltage sensor 106281

Alternator wiring diagram

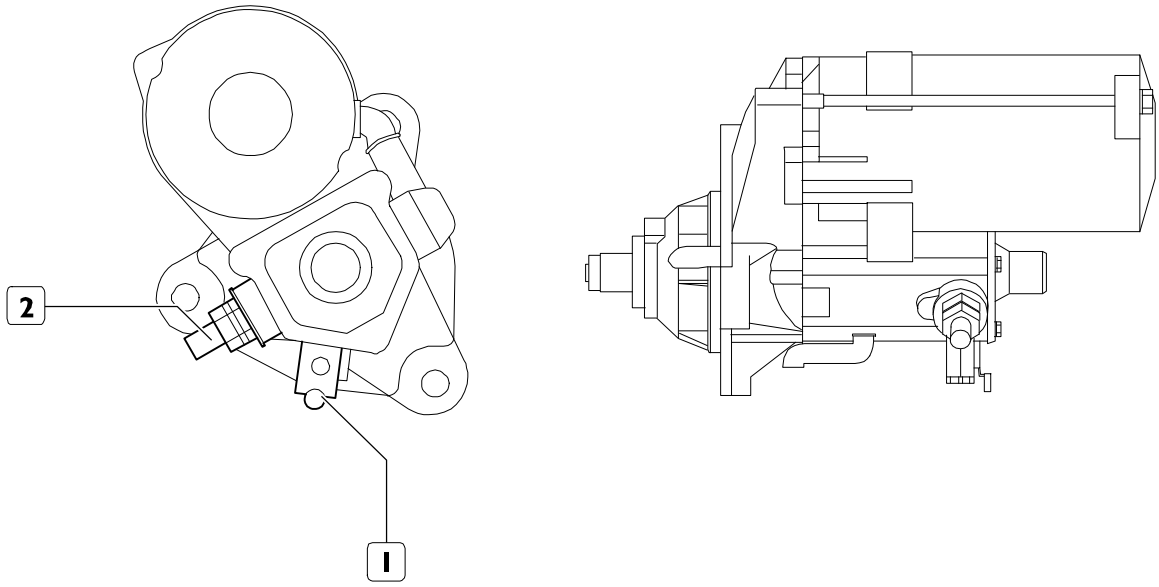
Figure 26



Alternator current delivery curve

ELECTRIC STARTER MOTOR

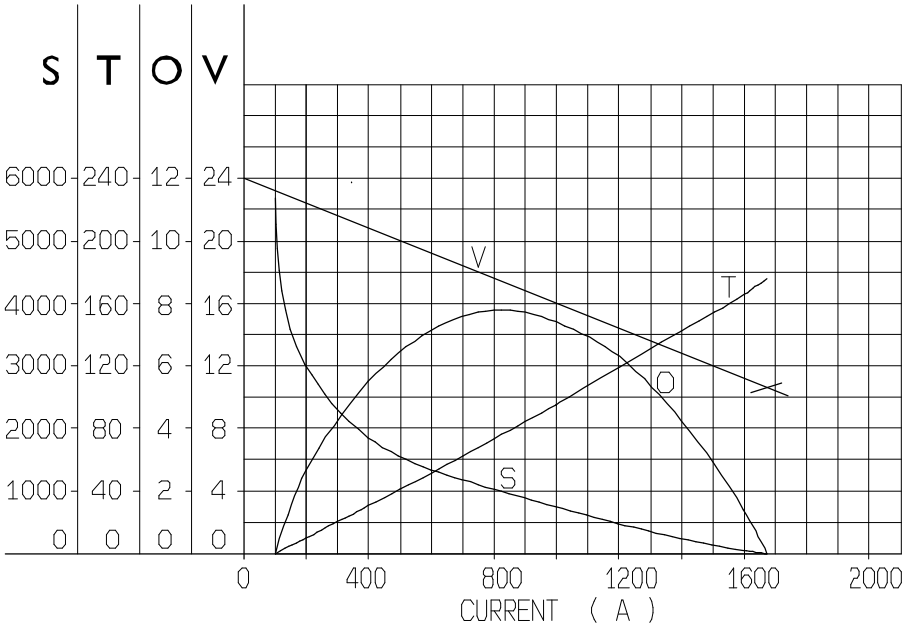
Figure 27



Voltage	24 V
Nominal power	7.8 KW (SAE J544B 24V Heavy Duty)
Rotation direction control side	clockwise
Pinion number of teeth	10
Supplier	DENSO
Weight	~ 10.5 kg
Tightening torque on terminal 30	26 ± 4 Nm
Tightening torque on terminal 50	3.6 ± 1 Nm

Electric starter motor wiring diagrams

Figure 28

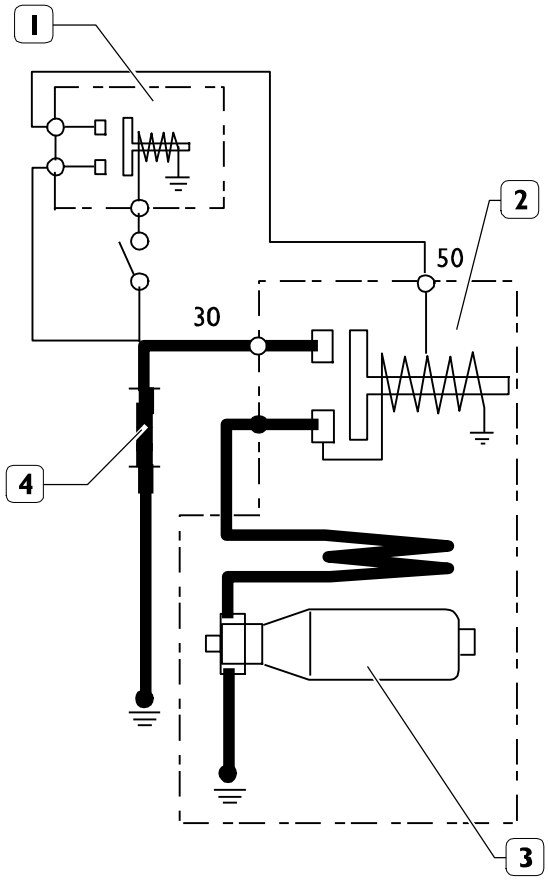


221066

Electric starter motor characteristics

Ref.	Description	Measurement unit
T	Torque	Nm
C	Current strength	A
O	Power	KW
V	Voltage	V
S	Speed	Rpm

Figure 29



WIRING DIAGRAM

1. Main current contactor - 2. Control solenoid - 3. Electric engine - 4. Battery/ies

SCHEDULED MAINTENANCE

Introduction

To ensure best operating conditions, on the following pages are indicated the checks, tests and adjustments which shall be carried out on the different parts at the established time.

The frequencies of the maintenance operations are indicative since the engine use and its characteristics are essential to evaluate replacements and checks.

Not only it is permitted, but we also suggest that the staff in charge of maintenance should also perform those checking and maintenance operations which do not fall among those listed below, but are recommended by good-practices and particular conditions of use of the engine.

Furthermore, in case of clear malfunctioning of the engine, for example excessive grade of smoke of exhaust gases, high temperature of the coolant or low oil pressure, prompt measures must be taken to verify the causes of the defect.

Operators are also reminded that any maintenance operation, even the easiest one, is to be performed in compliance with accident-prevention laws for the safety of the staff in charge of maintenance.

Checks and scheduled maintenance procedures

Checks to be made during periods of use	Frequency
Check the engine lubricant oil level	daily
Check engine coolant level	daily
Engine visual inspection	50 hours / 15 days
Inspection cleaning of the air filter and relative seat	1 monthly
Check tension and condition of ancillary belt	300 hours / 6 months
Exhaust gas pipes(s) condition check	6 months
Periodical maintenance	Frequency
Draining the water from the fuel prefilter (if any)	150 hours / 6 months
Condensed water drainage from fuel tank	150 hours / 6 months
Change engine lubricant oil	600 hours/1 year (2) (3)
Change lubricant oil filter	600 hours/1 year (2) (3) (4)
Replace fuel prefilter (if fitted)	600 hours/1 year
Replacing fuel filter	600 hours/1 year (1) (2) (3)
Change air filter	1200 hours / 2 years
Replace auxiliary member drive belt	1200 hours / 3 years
Replacing blow-by filter element	1800 hours/1 year
Unscheduled maintenance:	Frequency
Visual turbocharger inspection	1200 hours / 2 years
Clean the heat exchanger (radiator)	1200 hours / 2 years
Check the tappet clearances and adjusting if necessary	2,400 hours
Replace engine coolant	3000 hours / 2 years (5)

1) Maximum period relating to the use of high quality fuel, (specification ASTM D975 or EN 590); which is reduced in the event of fuel contamination and alarm signals caused by filter clogging and/or the presence of water in the prefilter. The filter clogging signal indicates that the filter must be replaced. If the warning light of water present in the prefilter does not go off after drainage, then the prefilter must be replaced.

2) To be performed every year even if the specified operating hours interval has not been reached.

3) Frequencies are valid for lubricant oils which comply with the international specifications as indicated in Section 1 - General table "General Characteristics".

4) Only use filters with the following specifications:
   - degree of filtering < 12 μm
   - filtering efficiency 99.5% (ß > 200).

5) To be performed every two years even if the specified operating hours interval has not been reached.

NOTE The scheduled maintenance operations are only valid if the fitter observes all installation regulations provided by FPT.

Furthermore, the fitted appliances must always be in compliance with the torque, power and engine speed for which the engine was designed.

REQUIREMENTS

- ❑ Do not disconnect the battery supply while the engine is running.
- ❑ Do not perform arc welding near the engine without first removing its electrical wiring.
- ❑ After all maintenance operations that require disconnecting the batteries, make sure that the terminals have been well secured on the poles.
- ❑ Do not use a battery charger to start the engine.
- ❑ Disconnect the battery/batteries from the on-board system while recharging.
- ❑ Do not paint the devices, components and electrical connectors of the engine equipment.
- ❑ Electrically disconnect the battery/batteries before performing any electrical work.
- ❑ Contact the Manufacturer before installing any electronic equipment.

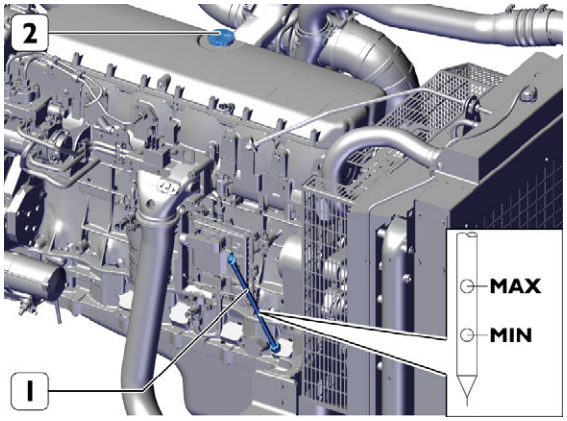
Do not perform any operation that would change the calibration of the injection pump.

It was adjusted during the engine test phase and based on its destination.

CHECKS TO BE MADE DURING PERIODS OF USE □ HOW TO PROCEED

Check the engine lubricant oil level

Figure 1



Only proceed when the engine is not turning and is at low temperature in order not to run the risk of burns; make sure the engine is level or in its normal operating position in order to obtain an accurate oil level reading.

- ❑ Use the oil level dipstick (2) to check that the lubricant oil level is between the "Min" and "Max" limits.
- ❑ If the level is insufficient, it is necessary to top up the oil by removing the cap and pouring lubricant oil through the hole (1).

For the top-up only use lubricant oil that complies with the international standards as indicated in Section 1 - General table "General Characteristics".

Clean the oil cap before performing the operation so as to minimize the risk of contaminating the system.

- ❑ Use the oil level dipstick (2) to check that the lubricant oil level does not exceed the "Max" limit on the dipstick.

Make sure that the dipstick is fully inserted and that the filler plug is tightened fully in the clockwise direction.

Engine coolant level check (example)

Only proceed when the engine is not turning and is at low temperature in order not to run the risk of burns.

- ❑ Remove the pressurization cap from the expansion tank.
- ❑ Visually check that the coolant in the expansion tank is above the minimum level.
- ❑ If necessary, top up the expansion tank with a mixture of PARAFLU 11 / PA-RAFLU HT, as indicated in Section 1 - General table "General Characteristics".
- ❑ Top up the expansion tank until the "MAX" limit is reached; if there is no level indicator on the expansion tank, make sure that the coolant in the expansion tank is a few centimetres below the filling hole in order to allow an increase in the coolant volume following a rise in temperature.

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns.

Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

Clean the pressurization cap of the expansion tank before performing the operation so as to minimize the risk of contaminating the system.

Engine visual inspection

Perform a thorough check before start-up in order to obtain maximum engine duration.

Check for any leaks (oil, coolant and fuel), broken or weakened pipes, loose clips and bolts, worn belt, wiring (loose connections, worn or frayed cables) and a build-up of dirt; in the event of any problems, perform the operations necessary to restore the engine.

Any spilt fluid must be removed for all types of leak (coolant, oil or fuel).

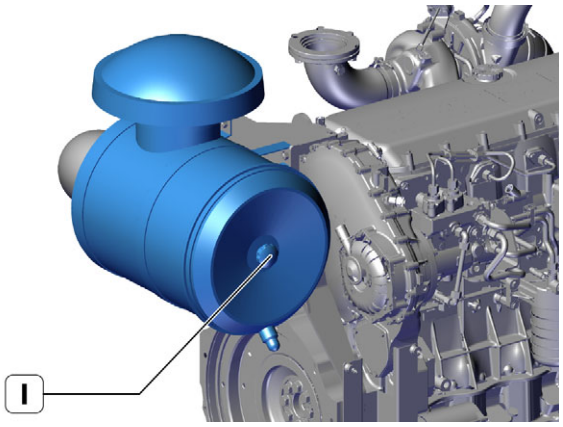
If a leak is discovered then find its source and carry out the necessary repair.

A build-up of oil or grease on the engine represents a fire risk.

Clean the cock tap (1) before performing the operation so as to minimize the risk of contaminating the system.

Inspection cleaning of the air filter and relative seat

Figure 2



Proceed only wiith engine off:

Remove the air filter (1).

Remove the filter cartridge .

Make sure there are no impurities. Otherwise, clean the filter element according to the instructions provided below.

Blow dehumidified compressed air on the filtering element, working from the inside outward (maximum pressure 200 kPa).

Do not use cleaners; do not use diesel oil.

Never strike the filter element with tools and check its condition before refitting it.

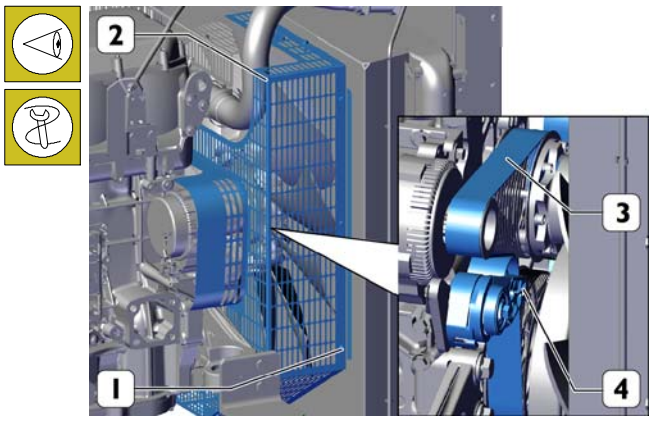
Replace it if broken or torn.

Check the condition of the gasket at its base.

Mount following the steps for removal in the reverse order.

Check tension and condition of ancillary belt

Figure 3



Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

- ❑ Undo the screws (1) and remove the grilles (2) that protect the fan.
- ❑ Check that the belt (3) is not worn, soiled with oil or fuel, or showing signs of tears. Otherwise replace the belt if necessary .
- ❑ Use a ½ inch square wrench to check the efficiency of the automatic belt tensioner(4).

When the engine is off, but still hot, the belt may start to move without warning. Wait for the engine temperature to decrease to prevent serious danger of an accident.

Exhaust gas pipes(s) condition check

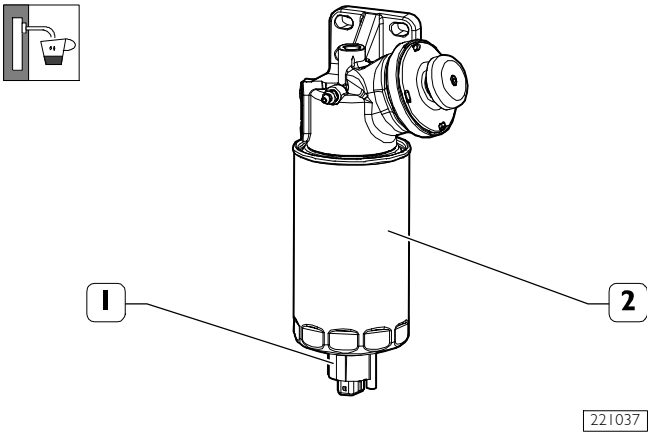
Visually check that the exhaust gas system is not blocked, corroded or damaged.

in the event of any problems, perform the operations necessary to restore the exhaust duct.

PERIODIC MAINTENANCE - HOW TO PROCEED

Draining the water from the fuel prefilter (if any)

Figure 4



In the case of a high risk of refuelling with fuel polluted with foreign agents and water, the following check should be performed at each refuelling.

Proceed when the engine is not rotating.

- ❑ Place a container for collecting liquids under the prefilter (2).
- ❑ Unscrew the valve plug (1) located at the bottom of the filter; in some versions, the plug includes the water in diesel sensor.
- ❑ Drain the liquid until only "diese" is released.
- ❑ Fully retighten the plug manually.
- ❑ Dispose of the drained liquids according to the applicable regulations in force.

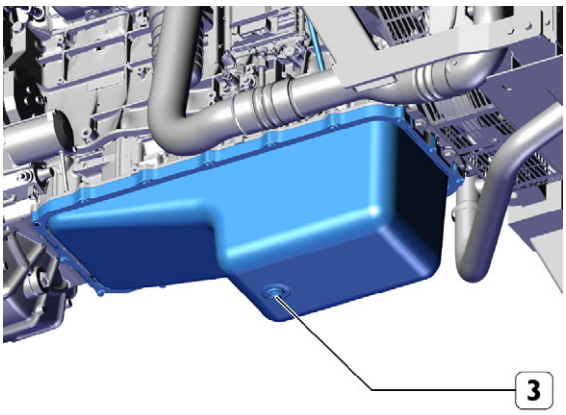
Condensed water drainage from fuel tank

Perform the drainage/suction of water, condensation and impurities from the fuel tank/s by following the instructions contained in the manual supplied by the tank manufacturer.

Proceed as necessary based on the structure or location of the tank: engines that operate in adverse environments and conditions and/or that are refuelled using drums or jerry cans, require more attention when cleaning the tank.

Change engine lubricant oil

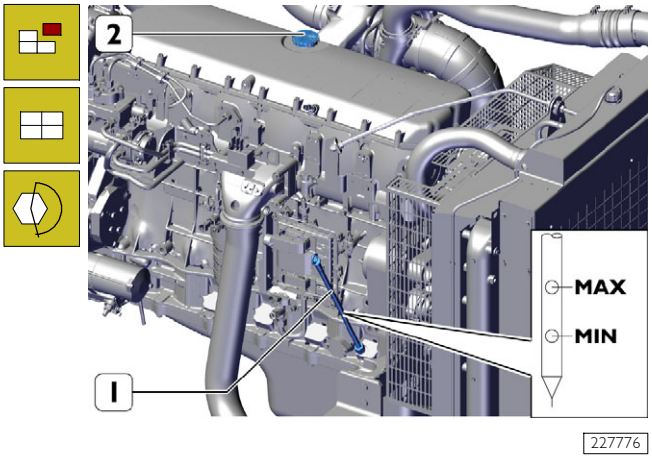
Figure 5



Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

- ❑ Place a suitable container for collecting the spent oil under the oil sump next to the lubricant oil drain plug (3).
- ❑ Unscrew the lubricant oil drain plug (3).

Figure 6



- ❑ afterwards extract the oil level dipstick (1) and remove the lubricant oil cap (2) to assist the flow of the engine lubricant oil.
- ❑ Wait until the oil sump has completely emptied, then retighten the lubricant oil drain plug (3, Figure 5) to the torque indicated in the table

Ref.	No.	Description	Torque
3	1	Oil drain plug	95 ± 10 Nm

Proceed with the refilling operation through the hole (2) situated on the tappet cover, using lubricant oil that complies with the international standards as indicated in Section 1 - General table "General Characteristics".

- ❑ Use the oil dipstick (1) to check that the lubricant oil level does not exceed the "Max" limit.
- ❑ Retighten the lubricant oil cap (2).

When changing the replacement of the engine lubricant oil it is necessary to replace the oil filter (see paragraph ENGINE OIL FILTER REPLACEMENT).

Clean the plugs before performing the operations so as to minimize the risk of contaminating the system.

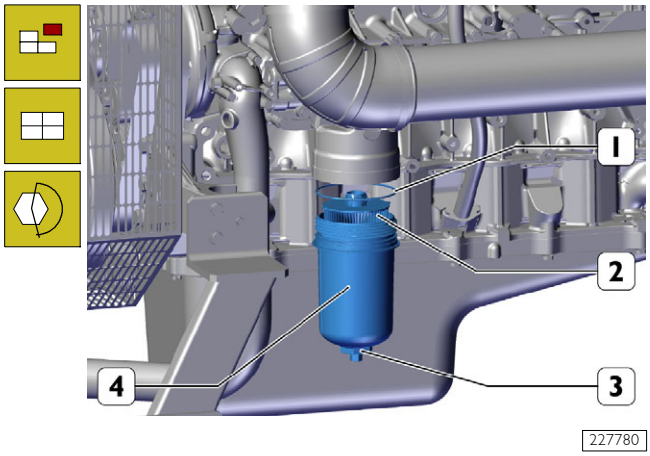
After changing the engine lubricant oil make sure that the level does not exceed the "Max" limit on the oil level dipstick.

Make sure that the dipstick is fully inserted and that the filler plug is tightened fully in the clockwise direction.

Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law.

Change lubricant oil filter

Figure 7



Only use filters with the following specifications:

- ❑ degree of filtering < 12μm.
- ❑ filtering efficiency ß > 200 (99.5%).

Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

- ❑ Proceed with draining the spent lubricant oil (see paragraph ENGINE LUBRICANT OIL REPLACEMENT).
- ❑ Place a suitable container for collecting the spent oil under the oil filter next to the drain plug (3).
- ❑ Remove the filter (4) by unscrewing it.
- ❑ Replace the filter element (2) and the O-ring seal (1) contained inside the filter (4).
- ❑ Clean the surface carefully.
- ❑ Moisten the O-ring seal (1) of the new filter with oil.
- ❑ Tighten the drain plug (3) and the filter body (4) to the torque indicated in the table.
- ❑ Proceed with the refilling operation of the lubricant oil (see paragraph ENGINE LUBRICANT OIL REPLACEMENT).

Operate the engine for a few minutes and then check the level using the dipstick.

If necessary, top up to compensate for the quantity of oil used to fill up the filtering cartridge.

Ref.	No.	Description	Torque
4	1	Engine oil filter	60 ± 5 Nm
3	1	Drain plug on engine oil filter	6.5 ± 1.5 Nm

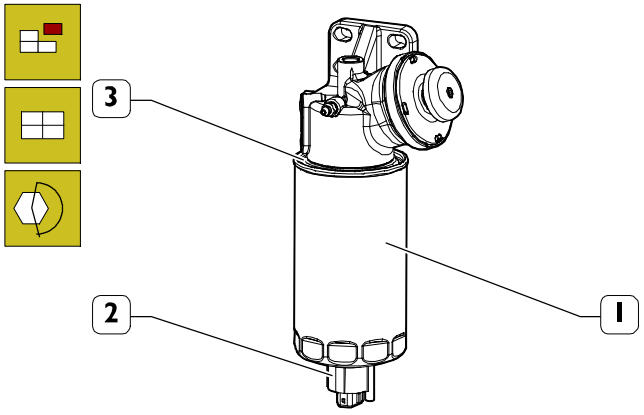
After changing the engine lubricant oil make sure that the level does not exceed the "Max" limit on the oil level dipstick.

Make sure that the dipstick is fully inserted and that the filler plug is tightened fully in the clockwise direction.

Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law.

Replace fuel prefilter (if fitted) (example)

Figure 8



Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

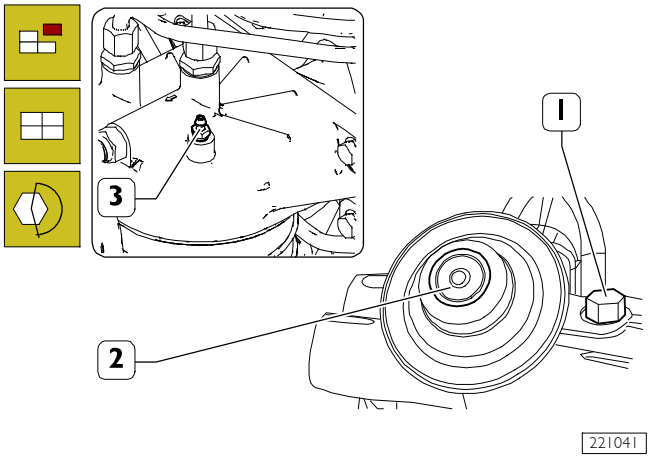
- ❑ Close the tank cock.
- ❑ Place a suitable container for collecting the fuel under the fuel prefilter next to the bleeder plug or, if present, the water presence sensor (2)
- ❑ Remove the filter cartridge (1)
- ❑ Moisten the O-ring seal (3) of the new filter with oil.
- ❑ Screw the cartridge by hand until it comes into contact with the support and then tighten it to the torque indicated in the table.
- ❑ Reconnect the lower electric connection of the water presence sensor, if present.

Ref.	No.	Description	Torque
1	1	Fuel pre-filter cartridge	19.5 ±1 Nm

Do not fill the new prefilter until it has been positioned on the support: this prevents allowing impurities to enter and damage the circuit and injection system.

Dispose of consumable materials and the parts in contact with them *(for example filters) in accordance with the law.*

Figure 9



- ❑ Loosen the following bleed connectors connecting them to the designated pipes to allow the residue to flow into suitable containers and prevent any soiling:
  - √ Screw (1) located on the prefilter support.
  - √ Bleeder connection (3) located on the filter support.
- ❑ Act on the pump (2) located on the fuel prefilter (provided by the bodybuilder) until fuel flows out without air from the bleeder screw (1); upon completion of the operation tighten the screw.
- ❑ Continue to act on the pump until fuel flows out without air from the bleeder connection (3) located on the fuel filter; upon completion of the operation tighten the screw.

Take utmost care to prevent any fuel from soiling the control belt

- ❑ Tighten the bleed screws to the prescribed torque.

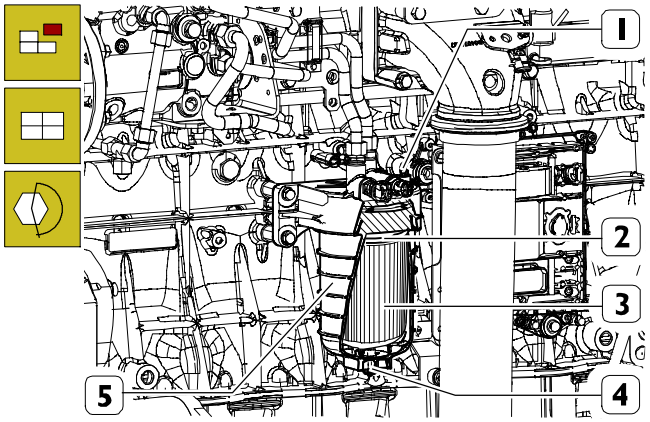
Ref.	No.	Description	Torque
1	1	Prefilter bleeder screw	18 ±2 Nm
3	1	Fitting for bleeding	18 ±2 Nm

- ❑ Start the engine and let it run idle for a few minutes to expel any residual air in the circuit.

For the engine to function correctly the fuel circuit must be free from air.

Replacing fuel filter

Figure 10



Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

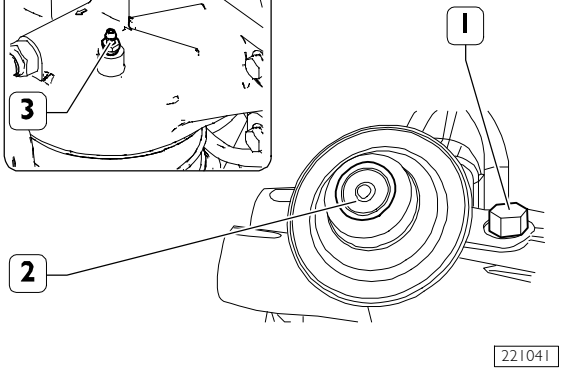
- ❑ Close the tank cock.
- ❑ Place a suitable container below the fuel filter in line with the drain plug (4) to collect the fuel.
- ❑ Open the drain plug (4) and the bleeder connection (1) and drain any residual fuel.
- ❑ Remove the filter element (3) by unscrewing the relative bell-shaped support (5).
- ❑ Replace the filtering element (3) and the O-ring seal (2) inside the bell housing support (5).
- ❑ Grease the O-ring seal (2) of the filter.
- ❑ Insert the filter element (3) and tighten the relative bell-shaped support (5) to the torque indicated in the table.

Tighten the drain plug (4) to the torque indicated in the table.

Do not fill the new filter until it has been positioned on the support: this prevents allowing impurities to enter and damage the circuit and injection system.

Ref.	No.	Description	Torque
3	1	Fuel filter	32.5 ±2.5 Nm
4	1	Threaded plug	1.5 ±0.5 Nm
5	1	Fitting for bleeding	18 ±2 Nm

Figure 11



- ❑ Loosen the following bleed connectors connecting them to the designated pipes to allow the residue to flow into suitable containers and prevent any soiling:
  - √ Screw (1) located on the prefilter support.
  - √ Bleeder connection (3) located on the filter support.
- ❑ Act on the pump (2) located on the fuel prefilter (provided by the bodybuilder) until fuel flows out without air from the bleeder screw (1); upon completion of the operation tighten the screw.
- ❑ Continue to act on the pump until fuel flows out without air from the bleeder connection (3) located on the fuel filter; upon completion of the operation tighten the screw.

Take utmost care to prevent any fuel from soiling the control belt

- ❑ Tighten the bleed screws to the prescribed torque.

Ref.	No.	Description	Torque
1	1	Prefilter bleeder screw	18 ±2 Nm
3	1	Fitting for bleeding	17.5 ±2.5 Nm

- ❑ Start the engine and let it run idle for a few minutes to expel any residual air in the circuit.

For the engine to function correctly the fuel circuit must be free from air.

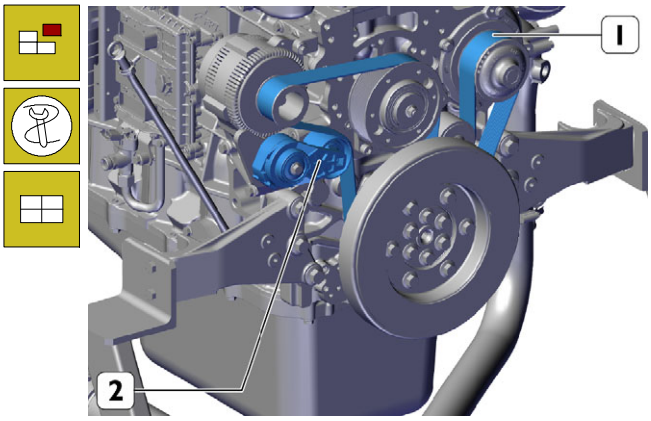
Dispose of consumable materials and the parts in contact with them *(for example filters) in accordance with the law.*

Change air filter

See the instructions in the section AIR FILTER INSPECTION AND CLEANING.

Replace auxiliary member drive belt

Figure 12



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Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

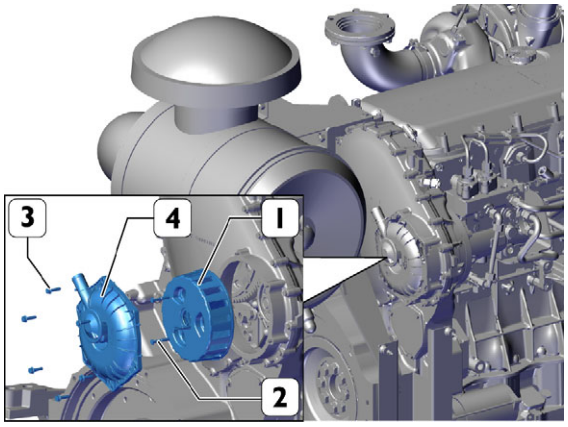
- ❑ Remove the protection grille, radiator assembly and fan complete with spacer.
- ❑ Using a 1/2 inch square wrench, operate on the belt tensioner (2) and remove the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (1) pulley.
- ❑ Replace the worn belt with a new one and fit it on the pulleys and guide rollers.
- ❑ Using the aforesaid tools, operate on the automatic belt tensioner in order to key the new belts in their operating position.
- ❑ Refit the fan complete with spacer, radiator assembly and protection grilles.

Replace the belt if it shows signs of abrasion, cracks or tears or if it is soiled with oil or fuel.

When the engine is off, but still hot, the belt may start to move without warning. Wait for the engine temperature to decrease to prevent serious danger of an accident.

Replacing blow-by filter element

Figure 13



227783

- ❑ Unscrew the screws (3) and remove the cover (4).
- ❑ Unscrew the screws (2) and remove the blow-by filter element (1)

Carefully clean the seating of the filter and the cover.

- ❑ Position the new blow-by filter element (1) in its seat.
- ❑ Apply some Loctite 243 on the screws (2) and tighten them to the torque indicated in the table.
- ❑ Position the cover (4) and tighten the screws (3) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
2	4	Screws M6 X 1 X 40 Phase 1 Phase 2	 5 Nm 15 Nm
3	6	Screws M6 X 1 X 25	10 ± 1 Nm

Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law.

UNSCHEDULED MAINTENANCE - HOW TO PROCEED

Visual turbocharger inspection

Only proceed when the engine is not turning over.

Visually check that the turbine, impellers of the compresser and the relative intake/outlet pipes are not obstructed or damaged. Otherwise replace as necessary.

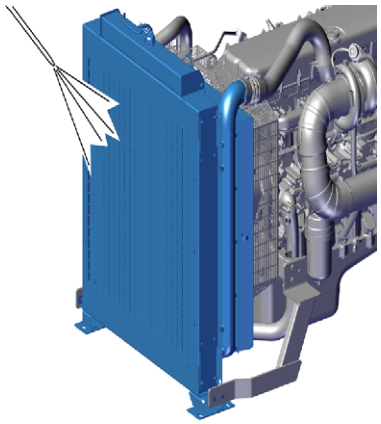
Check for any soot between the intake manifold and the turbocharger, replace the gasket if soot is found.

Check the conditions of the turbocharger gasket (e.g. breakages, deformation, ...), replace if necessary.

Make sure that the wastegate control tie-rod is well tightened, lubricated and not out of shape.

Clean the heat exchanger (radiator)

Figure 14



227785

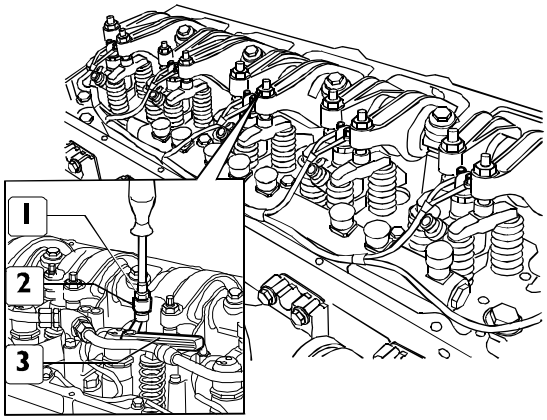
Check that the air intake surfaces of the radiators are free of impurities (dust, mud, straw etc.).

Clean them if necessary using compressed air or steam.

When using compressed air, it is required to use suitable personal protections for hands, face and eyes.

Check the tappet clearances and adjusting if necessary

Figure 15



114287

Remove the tappet cover

Take the cylinder whose clearance has to be adjusted into the combustion phase; the valves of this cylinder are closed as they balance those of the symmetric cylinder.

NOTE The correspondence of the symmetrical cylinders is 1 - 6, 2 - 5 and 3 - 4.

In order to properly operate, follow these instructions and data specified on the table.

By means of a ratchet spanner, loosen the nut (1) locking the adjustment screw.

Insert the feeler gauge blade (3) corresponding to the operating clearance indicated in the table "Data and assembly clearance" in SECTION 7 - Technical specifications.

Use a suitable wrench to screw or unscrew rocker arm (2) adjusting screw.

Check that the thickness gauge blade (3) can slide with a slight friction.

Lock the nut (1) holding the adjustment screw still.

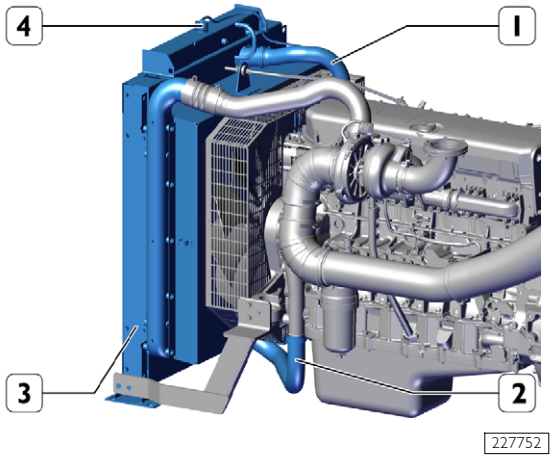
To carry out the adjustments stated above, the sequence shown in the table is mandatory.

Start and rotation in the engine direction	Balancing cylinder valves no.	Adjust valve clearance for cylinder no.
1 and 6 at T.D.C.	6	1
120 degree of angle [°]	3	4
120 degree of angle [°]	5	2
120 degree of angle [°]	1	6
120 degree of angle [°]	4	3
120 degree of angle [°]	2	5

Complete the operation by mounting the tappet cover and its gasket.

Replace engine coolant

Figure 16



- ❑ Only proceed when the engine is not turning, and is at low temperature, so as not to run the risk of burns.
- ❑ Place a container for collecting coolant under the heat exchanger (radiator) (3).
- ❑ Remove the pressurization cap (4) from the expansion tank.
- ❑ Loosen the retainers and extract the coupling sleeves (1, 2) which fasten the engine cooling circuit to the heat exchanger.
- ❑ Drain the coolant from the heat exchanger (radiator) (3) and wait until it is completely empty.
- ❑ Once emptied, restore the integrity of the cooling circuit, by ensuring the perfect seal of the sleeves.
- ❑ Refill the engine and the heat exchanger until the cooling circuit is completely full using a mixture of 50% of water and PARAFLU 11 / PARAFLU HT as indicated in Section 1 - General table "General Characteristics".
  Do not fill the expansion tank to the brim.
- ❑ With the pressure plug (4) open, start the engine and idle it for approximately one minute. This helps to completely bleed the air contained in the cooling circuit.
- ❑ Stop the engine and top up with more coolant, if necessary.
- ❑ When the engine is cold, make sure that the coolant in the expansion tank is a few centimetres below the filling hole.
- ❑ In the event of an externally located level indicator as regards the heat exchangers, proceed with the top up operation by making sure that the coolant does not overfill the internal volume of the exchanger in order to allow the expansion of coolant volume during increases in temperature.

Failure to observe the procedure described above does not guarantee the presence of the correct quantity of coolant in the engine.

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns. Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

SECTION 5

Removal-refitting of the main engine components

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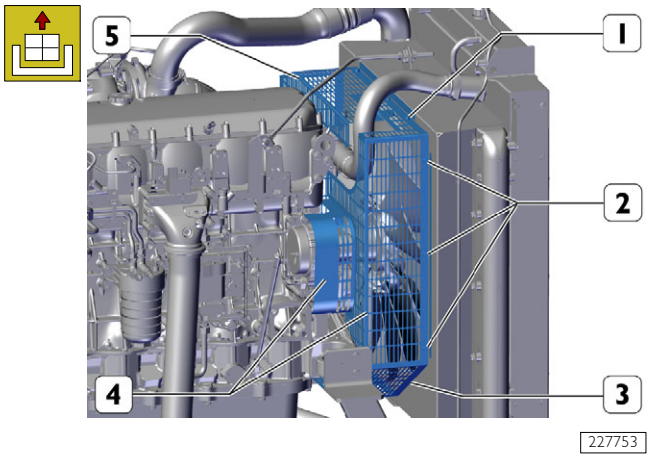
PROTECTIVE GRILLE REMOVAL - REFITTING

Removal

Figure 1

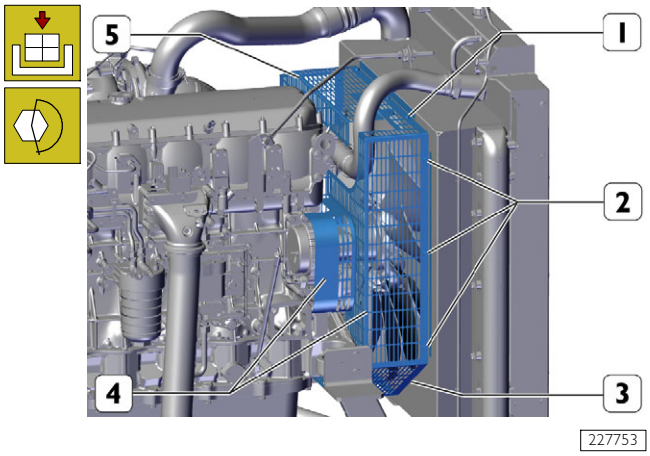


Undo the top screws (1), side screws (2) and bottom screws (3) and remove the grilles (4) and (5) that protect the fan on both sides.

Ref.	No.	Description
(1)	5	Screws M8x1.25x20
(2)	6	Screws M8x1.25x20
(3)	1	Screw M8x1.25x20

Refitting

Figure 2



Laterally install the fan protection grilles (4) and (5).

Tighten and lock the top screws (1) the bottom screw (3) and side screws (2) to the torque in the table.

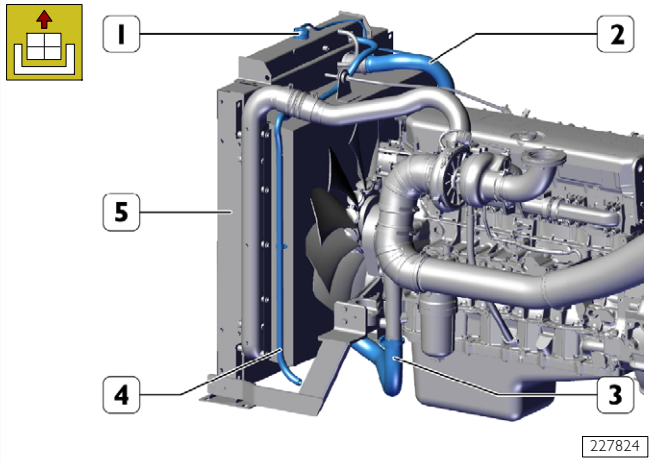
Ref.	No.	Description	Tightening torques
(1)	5	Screws M8x1.25x20	18 ± 4 Nm
(2)	6	Screws M8x1.25x20	18 ± 4 Nm
(3)	1	Screw M8x1.25x20	18 ± 4 Nm

RADIATOR ASSEMBLY REMOVAL - REFITTING

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Removal

Figure 3



Only proceed when the engine is not turning, and is at low temperature, so as not to run the risk of burns.

Place a container for collecting the coolant under the radiator assembly (5).

Remove the pressurization cap (1) from the expansion tank.

Slacken the clamps and from the radiator assembly (5) disconnect the top coolant intake pipe (2) to the heat-exchanger.

Slacken the clamp and disconnect from the engine the bottom coolant supply pipe to the engine (3).

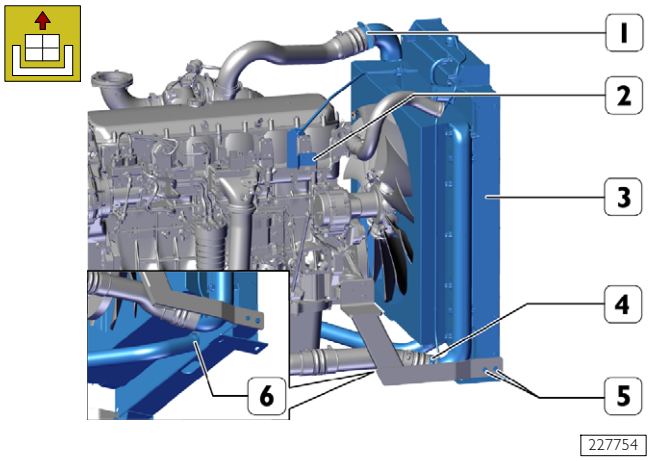
Drain the coolant from the radiators and wait until empty.

Disconnect the system supply pipe (4) from the coolant intake pipe to the engine.

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns.

Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

Figure 4



Slacken the clamp (1) and from the radiator assembly (3) disconnect the compressed air supply pipe to the aftercooler.

Undo the fastening screws of the tie road (2) of the radiator assembly.

Slacken the clamp (4) and from the radiator assembly (3) disconnect the combustion air supply pipe to the engine.

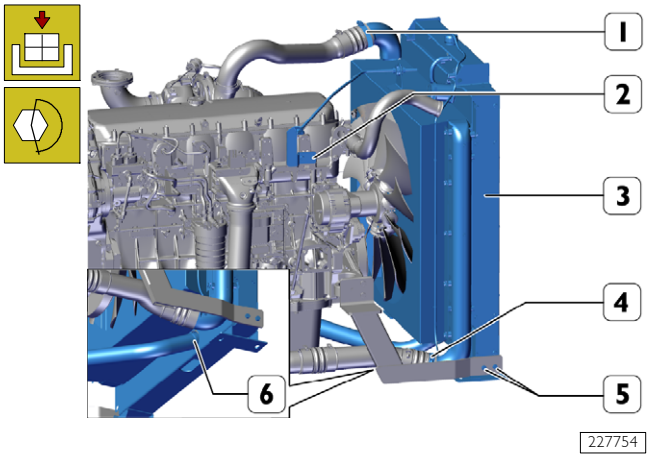
Slacken the clamp (6) and remove from the engine the bottom coolant supply pipe to the engine.

Remove the bracket fastening screws (5) from the radiator assembly (3) and slide the radiator assembly forward.

Ref.	No.	Description
(2)	2	Screws M10
(5)	4	Screws M10

Refitting

Figure 5



NOTE Before installing the radiator assembly, check the state of wear of the rubber sleeves. Replace the sleeves in question if found to be excessively worn.

Install the radiator assembly (3) on the brackets, paying attention to any interferences with the fan, and tighten the screws (5) on both sides, at the torque specified in the table.

To the radiator assembly (3) connect the engine the bottom coolant supply pipe to the engine and tighten the clamp (6).

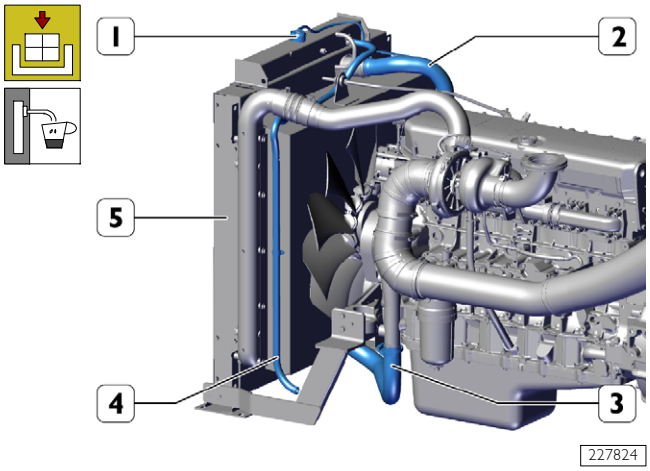
Connect the engine combustion air supply pipe to the radiator assembly (3) and tighten clamp (4).

Fit the radiator assembly (2) tie bracket into its seat and tighten to the torque in the table the fastening screws.

Connect the compressed air supply pipe to the aftercooler to the radiator assembly (3) and tighten the clamp (1).

Ref.	No.	Description	Tightening torques
(5)	4	Screws M10	37.5 ± 7.5 Nm
(2)	2	Screws M10	37.5 ± 7.5 Nm

Figure 6



Connect to the radiator assembly (5) the top coolant intake pipe (2) to the heat-exchanger and tighten the clamp.

To the engine connect the engine the bottom coolant supply pipe to the engine (3) and tighten the clamp.

Connect the system supply pipe (4) to the coolant intake pipe to the engine.

Refill the engine and heat exchanger so that cooling circuit is full with a mixture of 50% water and PARAFLU 11/PARAFLU HT.

Do not fill the expansion tank to the brim.

With the pressure plug (1) open, start the engine and idle it for approximately one minute.

This helps to completely bleed the air contained in the cooling circuit.

Stop the engine and top up with more coolant, if necessary.

When the engine is cold, make sure that the coolant in the expansion tank is a few centimetres below the filling hole.

In the event of an externally located level indicator as regards the heat exchangers, proceed with the top up operation by making sure that the coolant does not overfill the internal volume of the exchanger in order to allow the expansion of coolant volume during increases in temperature.

Refit the fan protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

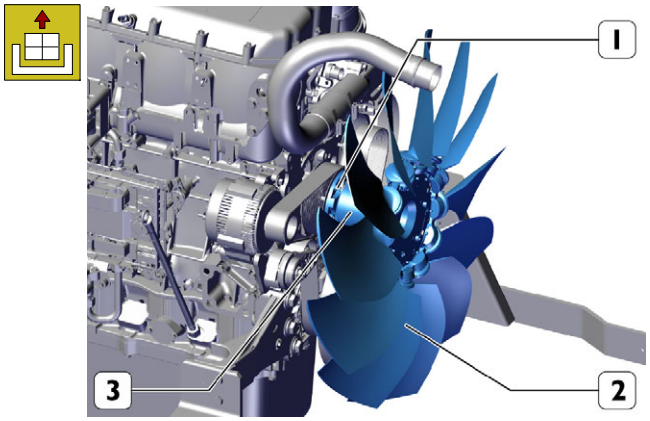
FAN REMOVAL - REFITTING

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Remove the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

Removal

Figure 7

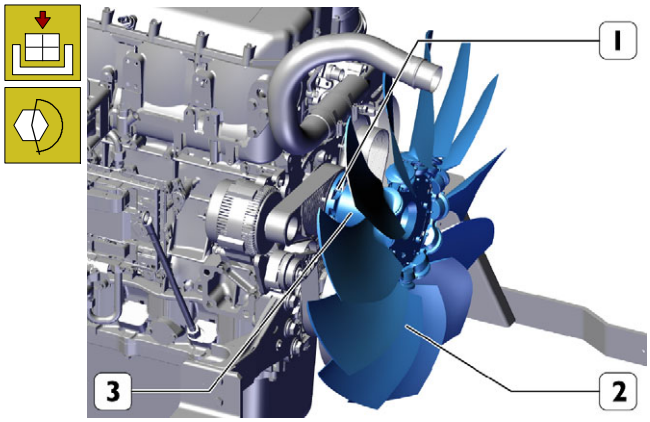


Unscrew the screws (1) and remove the fan (2) and spacer (3).

Ref.	No.	Description
(1)	6	M8x1.25 screws

Refitting

Figure 8



Fit the fan (2) together with the spacer (3) onto the pulley and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	6	M8x1.25 screws	21.5 ± 4.5 Nm

Refit the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

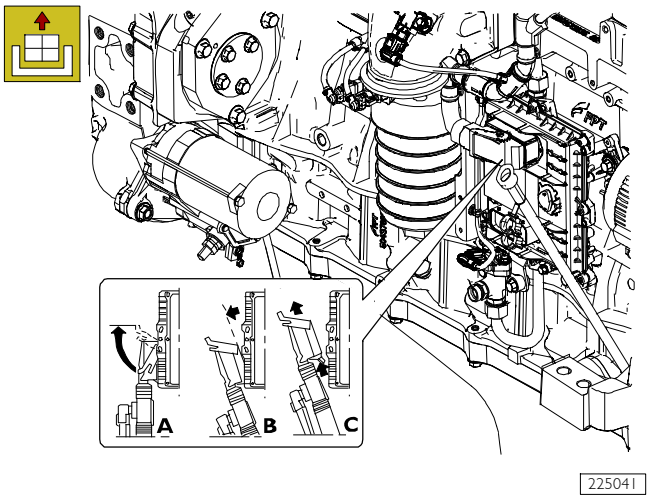
Refit the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

REMOVAL-REFITTING OF THE MAIN ENGINE COMPONENTS

ENGINE CABLE REMOVAL-REFITTING

Removal

Figure 9



Free the clips fixing the engine cable.

Disconnect the electrical connections of the sensors.

Lift the safety lever (A).

Move the connector, disconnecting it from the control unit (B).

Lift the connector, releasing the pawl (C).

Remove the engine cable.

Refitting

Make al the electrical connections and secure the engine cable with clamps to the clips.

REMOVAL-REFITTING OF ANCILLARY BELT

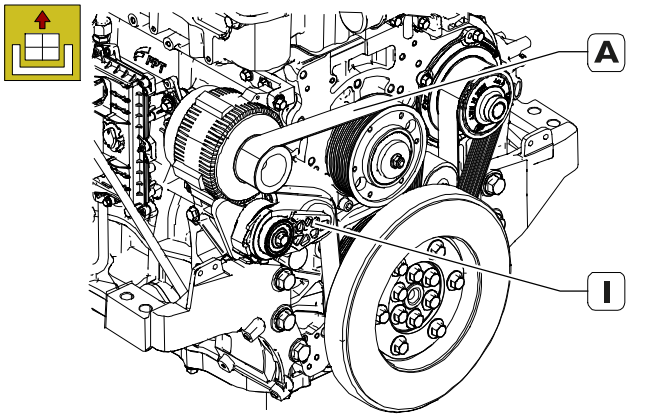
Removal

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Remove the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

Remove the fan as described in the procedure "FAN REMOVAL - REFITTING".

Figure 10

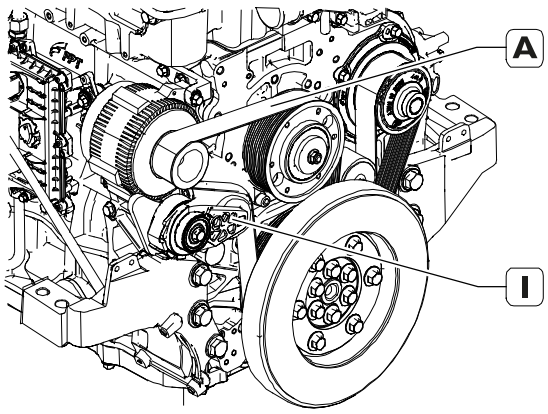


225040

Using a 1/2 inch square wrench, operate on the belt tensioner (1) and remove the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.

Refitting

Figure 11



225040

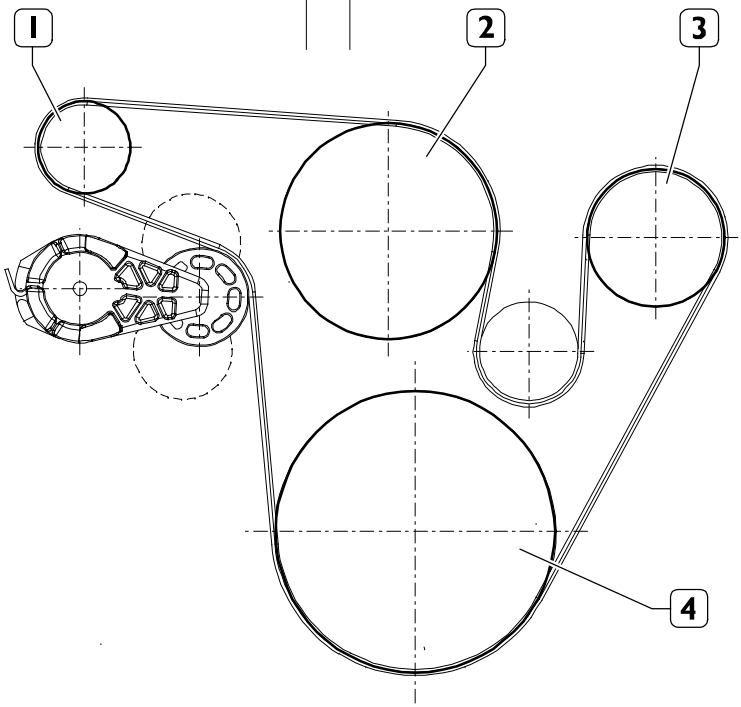
Using a 1/2 inch square wrench, operate on the belt tensioner (1) and position the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.

Refit the fan as described in the procedure "FAN REMOVAL - REFITTING".

Refit the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

Refit the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Figure 12



150675

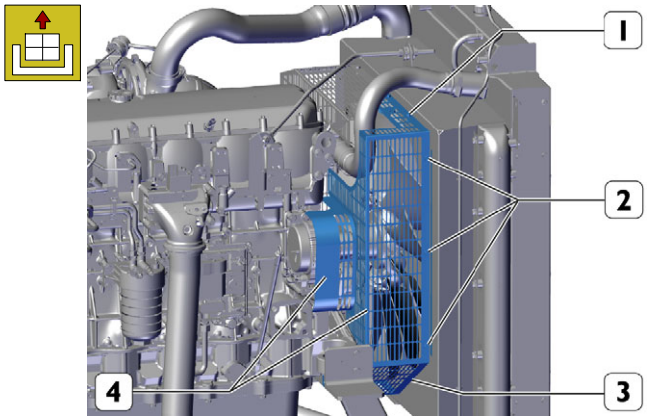
ASSEMBLY DIAGRAM OF THE PULLEY - WATER PUMP - ALTERNATOR DRIVE BELT

1. Alternator - 2. Electromagnetic coupling - 3. Water pump - 4. Crankshaft

ALTERNATOR REMOVAL-REFITTING

Removal

Figure 13

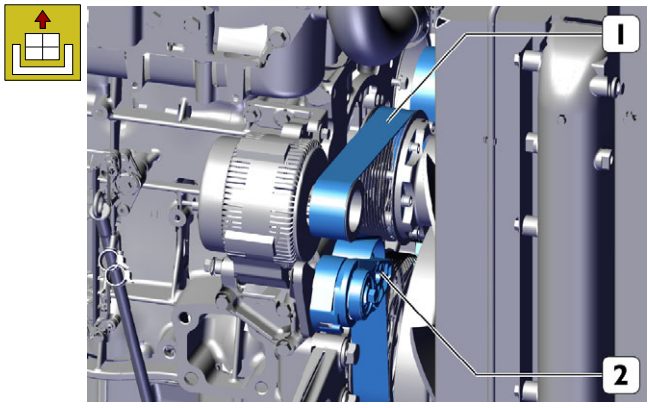


227756

Undo the top screws (1), side screws (2) on intake side and bottom screws (3) and remove the grilles (4) and () that protect the fan and alternator.

Ref.	No.	Description
(1)	3	Screws M8x1.25x20
(2)	3	Screws M8x1.25x20
(3)	1	Screw M8x1.25x20

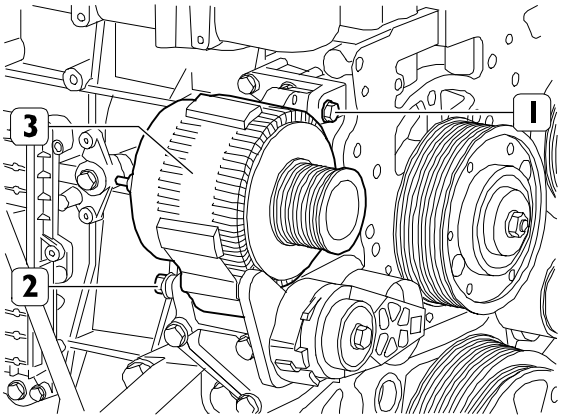
Figure 14



227757

With the help of a 1/2 square-head wrench, act on the belt tensioner (2) and remove the ancillary belt (1) from the alternator pulley.

Figure 15



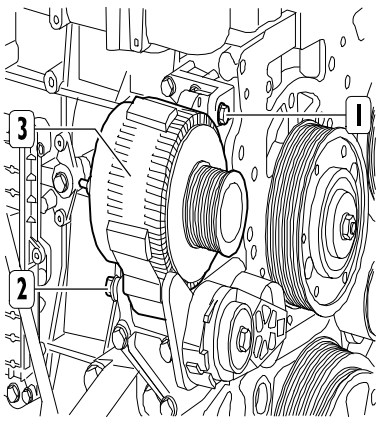
221083

Unscrew the screws (1, 2) and remove the alternator (3).

Ref.	No.	Description
(1)	1	M8 x 1.25 screws
(2)	1	M10 x 1.5 screws

Refitting

Figure 16

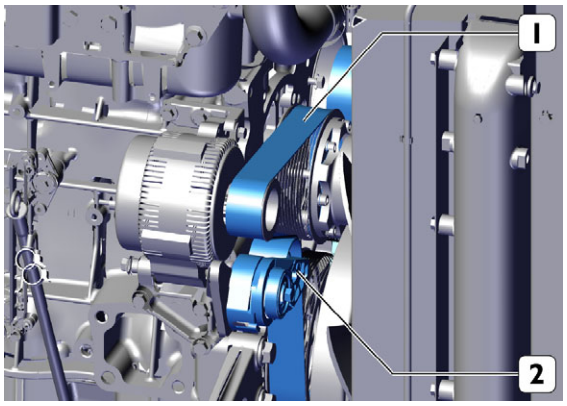


221083

Fit the alternator (3) and tighten the screws (1, 2) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	M8 x 1.25 screws	24.5 ± 2.5 Nm
(2)	1	M10 x 1.5 screws	44 ± 4 Nm

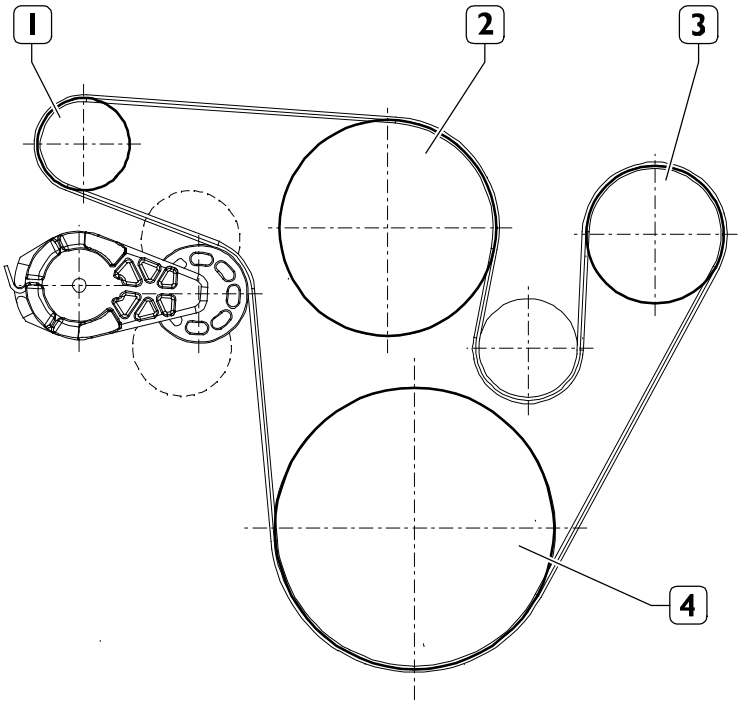
Figure 17



227757

With the help of a 1/2 square-head wrench, act on the belt tensioner (2) and fit the ancillary belt (1) on the alternator pulley.

Figure 18

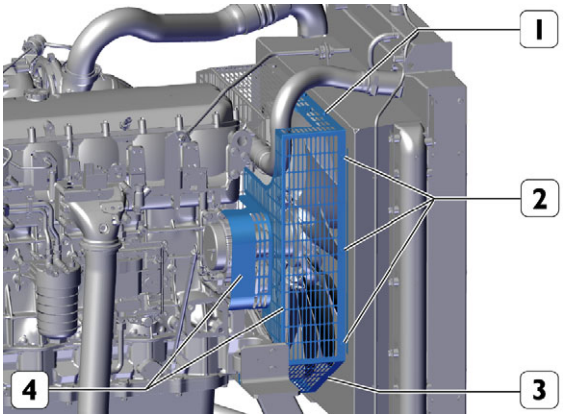


150675

ASSEMBLY DIAGRAM OF THE PULLEY - WATER PUMP - ALTERNATOR DRIVE BELT

1. Alternator - 2. Electromagnetic coupling - 3. Water pump - 4. Crankshaft

Figure 19



227756

Laterally install the fan and alternator protection grilles (4).

Tighten and lock the top screws (1) the bottom screw (3) and side screws (2) to the torque in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M8x1.25x20	18 ± 4 Nm
(2)	3	Screws M8x1.25x20	18 ± 4 Nm
(3)	1	Screw M8x1.25x20	18 ± 4 Nm

WATER PUMP REMOVAL-REFITTING

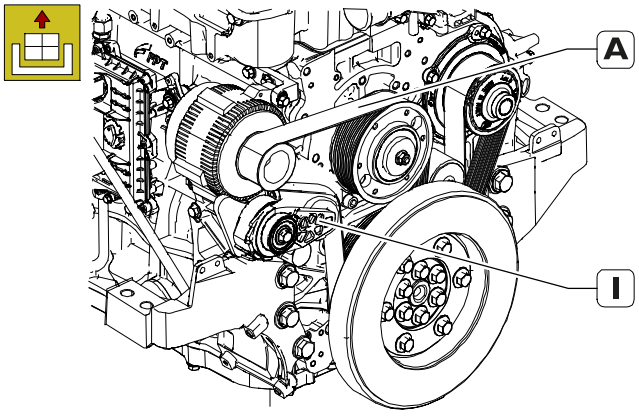
Removal

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Remove the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

Remove the fan as described in the procedure "FAN REMOVAL - REFITTING".

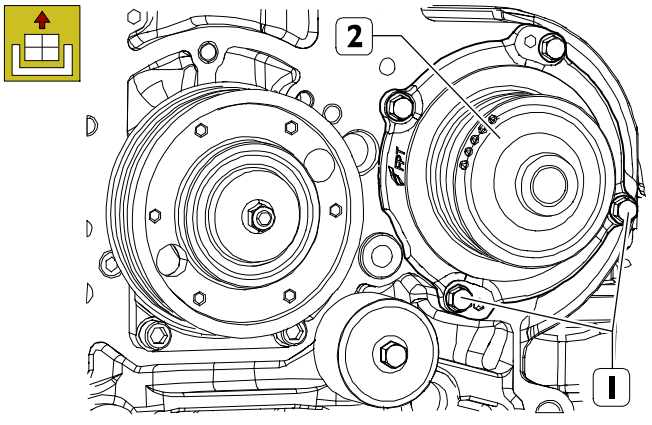
Figure 20



225040

Using a 1/2 inch square wrench, operate on the belt tensioner (1) and remove the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.

Figure 21



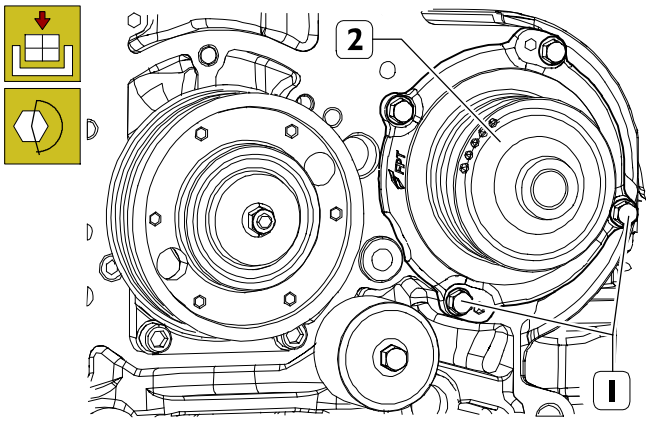
224087

Unscrew the screws (1) and remove the water pump (2) and its gasket.

Ref.	No.	Description
(1)	3	Screws M8 X 1.25 X 20

Refitting

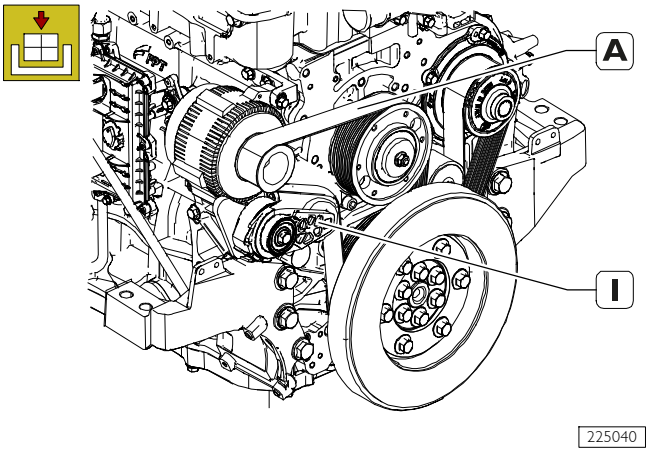
Figure 22



Fit the water pump (2) together with the new gasket and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M8 X 1.25 X 20	25 ± 2.5 Nm

Figure 23



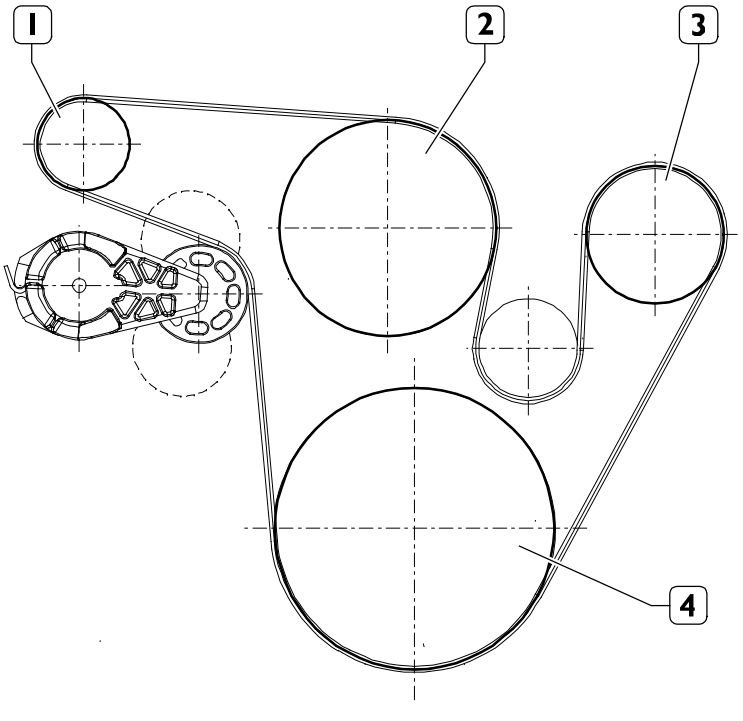
Using a 1/2 inch square wrench, operate on the belt tensioner (1) and position the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.

Refit the fan as described in the procedure "FAN REMOVAL - REFITTING".

Refit the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

Refit the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Figure 24



ASSEMBLY DIAGRAM OF THE PULLEY - WATER PUMP - ALTERNATOR DRIVE BELT

1. Alternator - 2. Electromagnetic coupling - 3. Water pump - 4. Crankshaft

ELECTROMAGNETIC COUPLING PULLEY REMOVAL-REFITTING

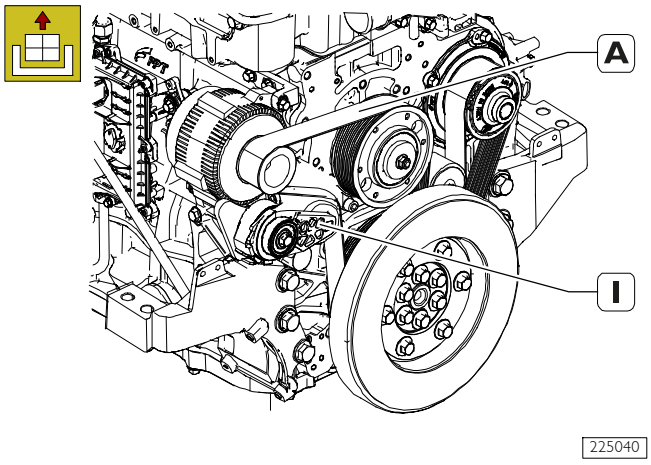
Removal

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Remove the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

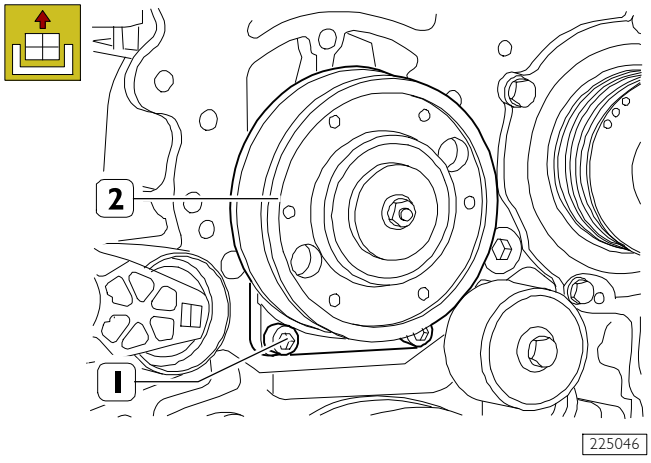
Remove the fan as described in the procedure "FAN REMOVAL - REFITTING".

Figure 25



Using a 1/2 inch square wrench, operate on the belt tensioner (1) and remove the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.

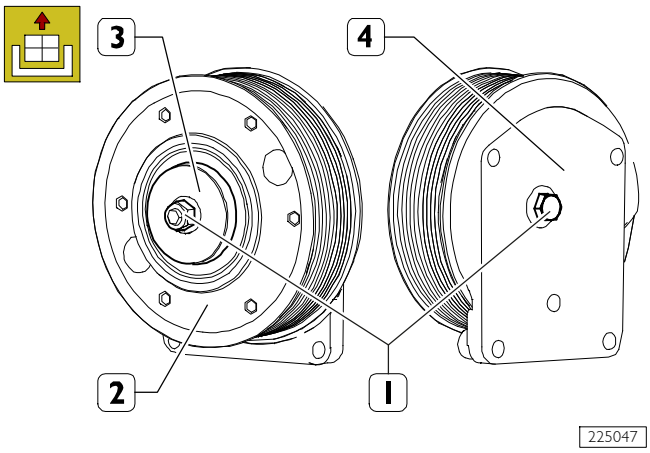
Figure 26



Unscrew the screws (1) and remove the electromagnetic coupling pulley assembly (2).

Ref.	No.	Description
(1)	5	Nut M12 X 1.75

Figure 27

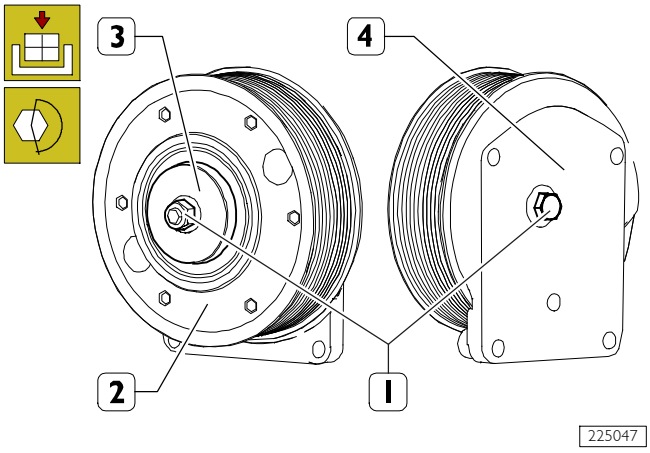


Undo the bolt (1) if necessary and remove spacer (3), pulley (2) and support (4).

Ref.	No.	Description
(1)	1	Bolt M10

Refitting

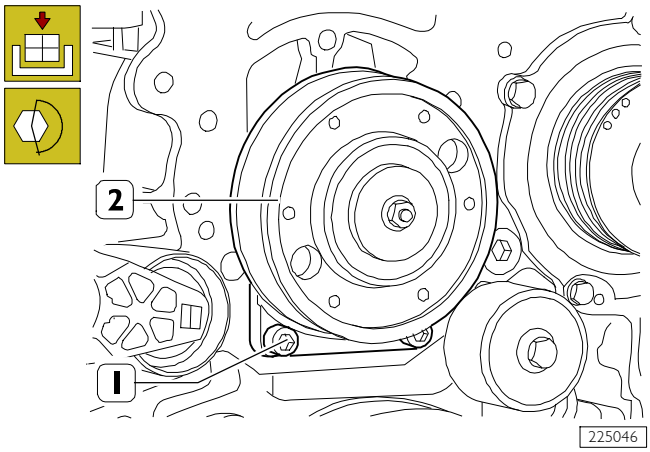
Figure 28



Fit the pulley (2) onto its support (4), spacer (3) and tighten the bolt (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Bolt M10	67.5 ± 7.5 Nm

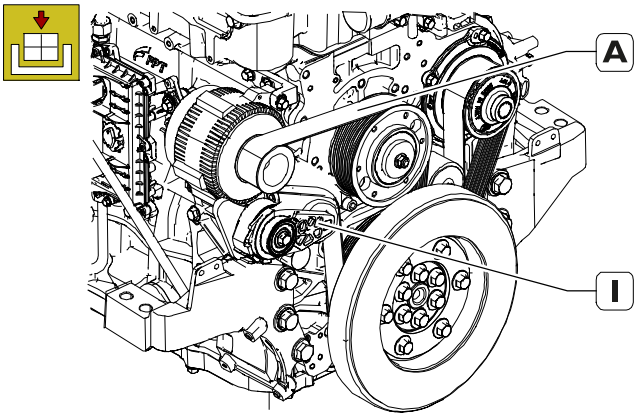
Figure 29



Fit the pulley electromagnetic coupling assembly (2) and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	5	Screws M12 X 1.75	100 ± 5 Nm

Figure 30



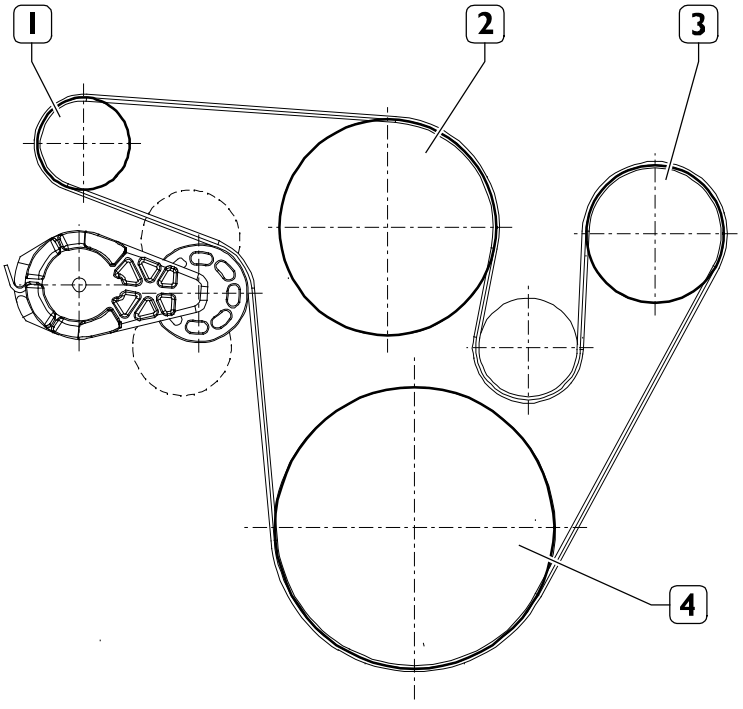
Using a 1/2 inch square wrench, operate on the belt tensioner (1) and position the control belt of the crankshaft / electromagnetic coupling / water pump / alternator (A) pulley.

Refit the fan as described in the procedure "FAN REMOVAL - REFITTING".

Refit the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING".

Refit the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Figure 31



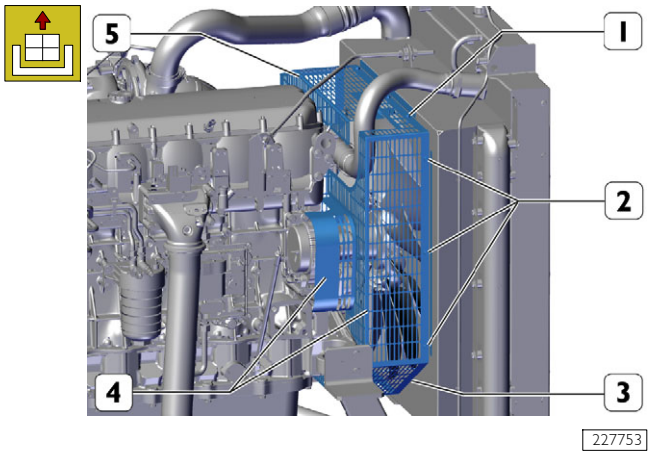
ASSEMBLY DIAGRAM OF THE PULLEY - WATER PUMP - ALTERNATOR DRIVE BELT

1. Alternator - 2. Electromagnetic coupling - 3. Water pump - 4. Crankshaft

THERMOSTAT CASE REMOVAL-REFITTING

Removal

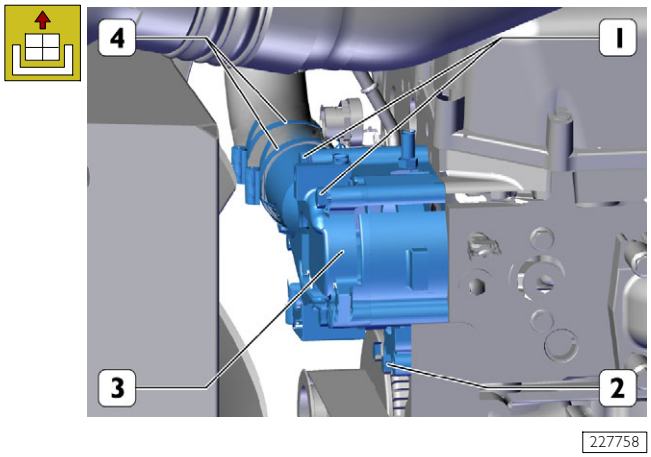
Figure 32



Undo the top screws (1), side screws (2) and bottom screws (3) and remove the grilles (4) and (5) that protect the fan on both sides.

Ref.	No.	Description
(1)	5	Screws M8x1.25x20
(2)	6	Screws M8x1.25x20
(3)	1	Screw M8x1.25x20

Figure 33



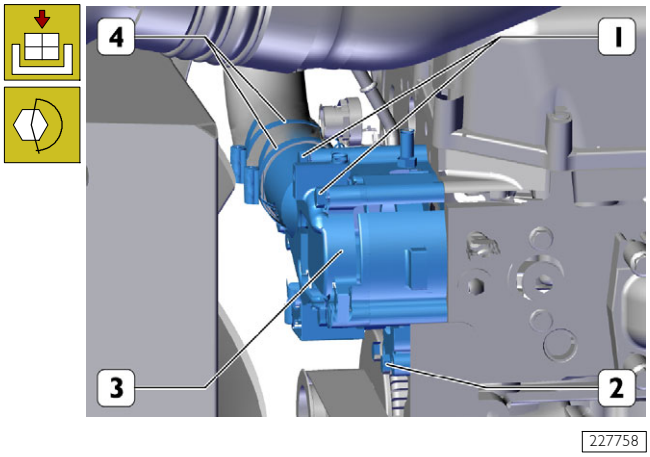
Slacken the clamps (4) and from the thermostat (3) disconnect the coolant supply pipe to the radiator assembly.

Unscrew the screws (1, 2) and remove the thermostat box (3), thermostat and relative gaskets.

Ref.	No.	Description
(1)	5	Screws M8 X 1.25 X 100
(2)	2	Screws M8 X 1.25 X 50

Refitting

Figure 34

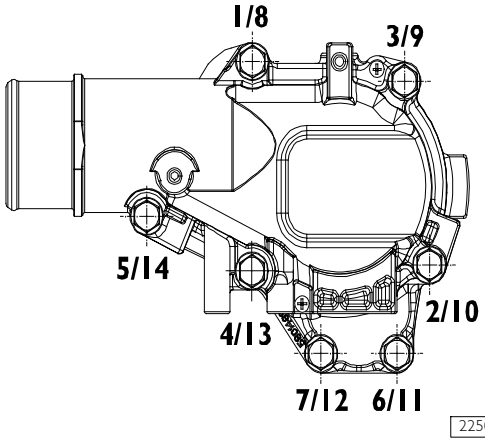


Assemble the thermostat, the thermostat box (3), with relative gaskets and tighten screws (1, 2) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	5	Screws M8 X 1.25 X 100	30 ± 3 Nm
(2)	2	Screws M8 X 1.25 X 50	30 ± 3 Nm

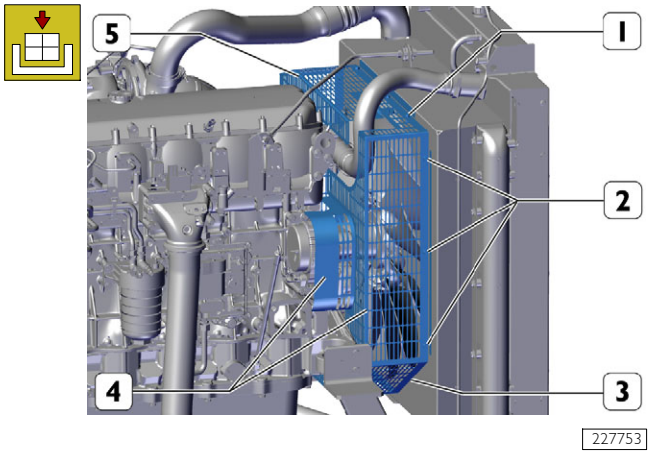
Connect to the thermostat (3) the coolant supply pipe to the radiator assembly and tighten the clamps (4).

Figure 35



Tighten the screws securing the thermostat case following the sequence indicated in the figure.

Figure 36



Laterally install the fan protection grilles (4) and (5).

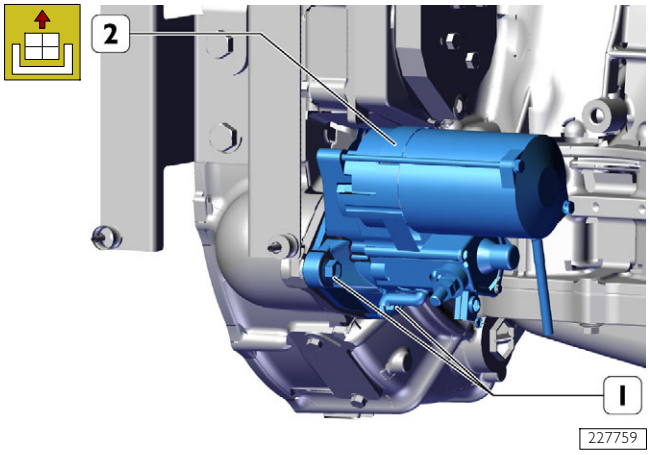
Tighten and lock the top screws (1) the bottom screw (3) and side screws (2) to the torque in the table.

Ref.	No.	Description	Tightening torques
(1)	5	Screws M8x1.25x20	18 ± 4 Nm
(2)	6	Screws M8x1.25x20	18 ± 4 Nm
(3)	1	Screw M8x1.25x20	18 ± 4 Nm

STARTER MOTOR REMOVAL-REFITTING

Removal

Figure 37



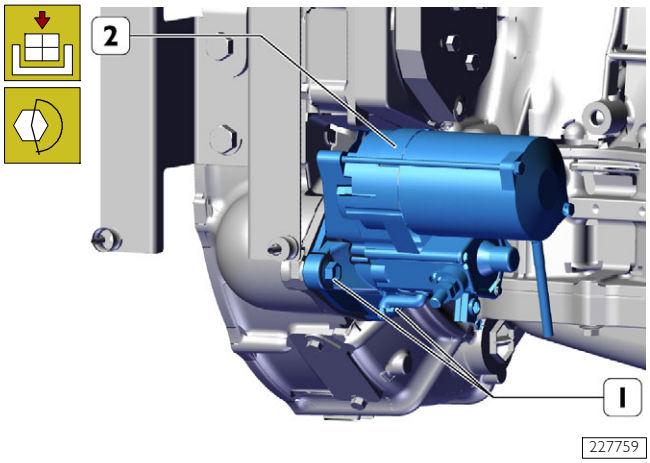
Remove the nuts (1) from the studs.

Remove the electric starter motor (2).

Ref.	No.	Description
(1)	3	Nuts M12 X 1.75

Refitting

Figure 38



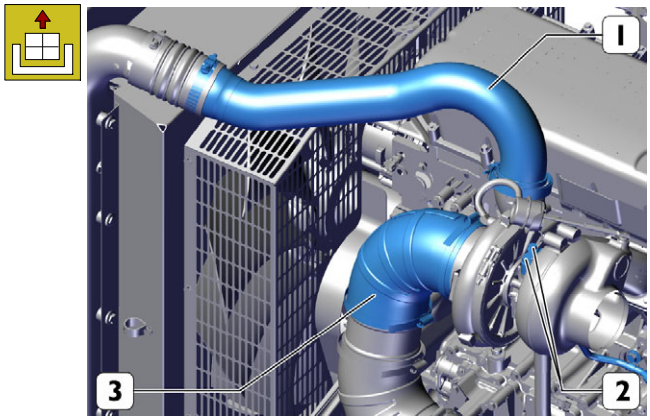
Fit the starter motor (2) and tighten the nuts (1) onto the captive screws to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Nuts M12 X 1.75	74 ± 8Nm

TURBOCHARGER REMOVAL-REFITTING

Removal

Figure 39



227760

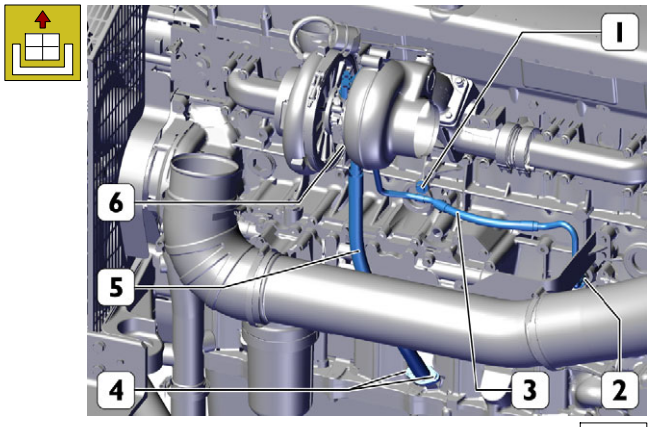
Slacken the clamp and collar and remove the combustion air intake pipe (1) to the aftercooler.

Undo the screws (2) of the oil deliver pipe to turbocharger

Ref.	No.	Description
(2)	2	M8 x 1.25 screws

Slacken the clamps and remove the sleeve (3) of the combustion air intake pipe to the turbocharger.

Figure 40



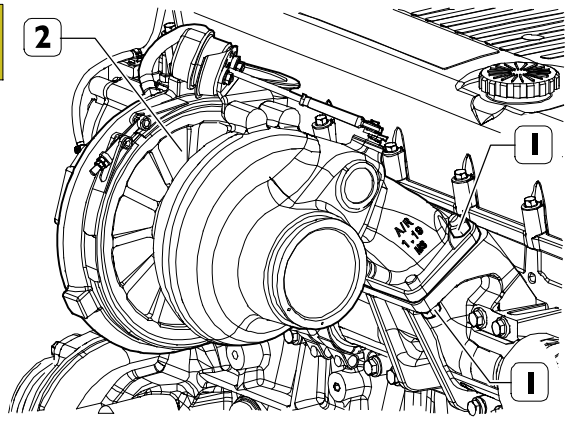
227761

Loosen the screw of the bracket (1) and fitting (2) and remove the oil supply pipe to the turbocharger (3).

Undo the screws (4, 6) and remove the oil return pipe from the turbocharger (5) with its gaskets.

Ref.	No.	Description
(1)	1	M10 screw
(2)	1	Fitting M16 X 1.5 X 12
(4, 6)	4	M8 x 1.25 screws

Figure 41



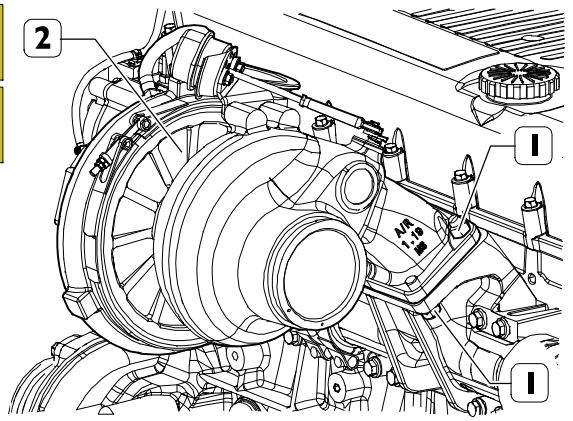
225025

Unscrew the nuts (1) extract the pins and remove the turbocharger (2) from the exhaust manifold along with its gasket.

Ref.	No.	Description	Tightening torques
(1)	4	Nuts M12 X 1.75	75 Nm

Refitting

Figure 42

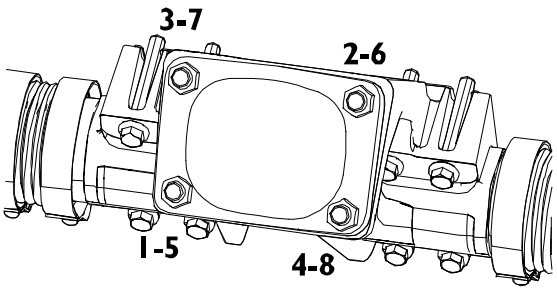


225025

Fit the turbocharger (2) onto the exhaust together with the new gasket, position the pins and tighten the nuts (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	4	Nuts M12 X 1.75	75 Nm

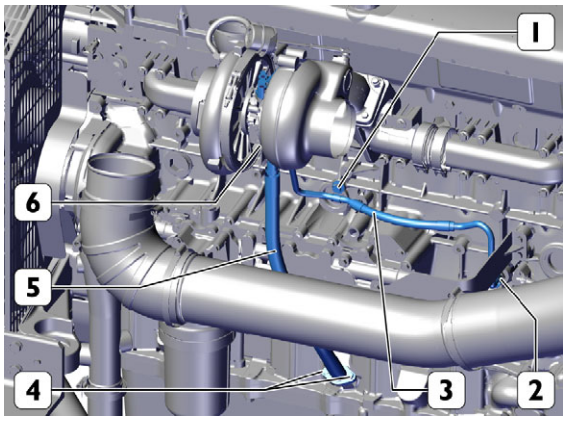
Figure 43



225062

Tighten the screws securing the turbocharger following the sequence indicated in the figure.

Figure 44



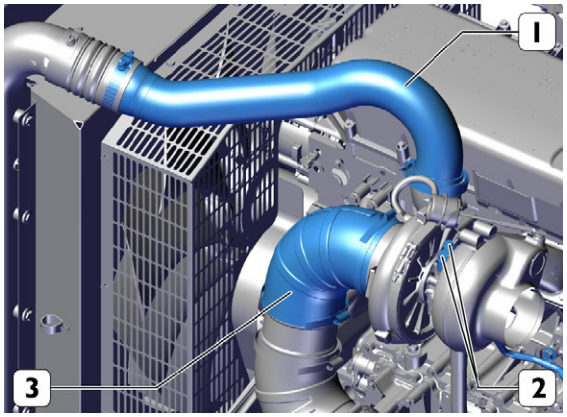
227761

Mount the oil delivery pipe to turbocharger (3) and tighten screws of the bracket (1) and the fitting (2) to the torque shown in the table.

Fit the engine oil return pipe from the turbocharger (5) with the new gaskets and tighten the screws (4, 6) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	M10 screw	10 ± 1 Nm
(2)	1	Fitting M16 X 1.5 X 12	42.5 ± 2.5Nm
(4, 6)	4	M8 x 1.25 screws	24.5 ± 2.5 Nm

Figure 45



227760

Connect the sleeve (3) of the combustion air intake pipe to the turbocharger and tighten the clamps.

Tighten the screws (2) of the oil delivery pipe to the turbocharger to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(2)	2	M8 x 1.25 screws	24.5 ± 2.5 Nm

Connect the air intake pipe (1) to the aftercooler and tighten clamp and collar.

EXHAUST MANIFOLD REMOVAL-REFITTING

Removal

Figure 46

227760

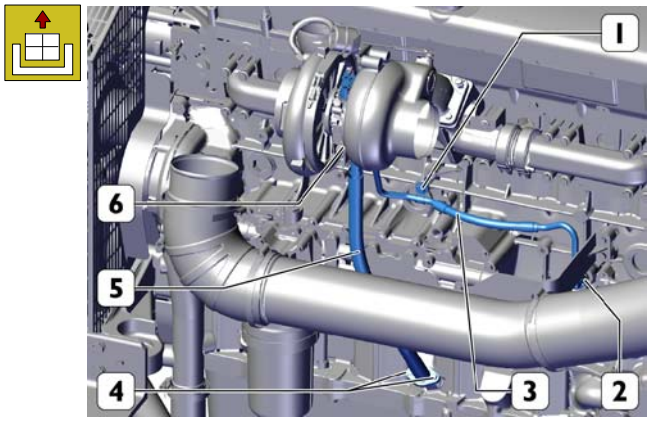
Slacken the clamp and collar and remove the combustion air intake pipe (1) to the aftercooler.

Undo the screws (2) of the oil deliver pipe to turbocharger

Ref.	No.	Description
(2)	2	M8 x 1.25 screws

Slacken the clamps and remove the sleeve (3) of the combustion air intake pipe to the turbocharger.

Figure 47



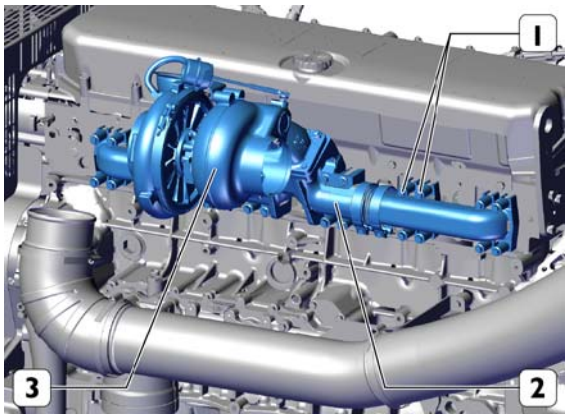
227761

Loosen the screw of the bracket (1) and fitting (2) and remove the oil supply pipe to the turbocharger (3).

Undo the screws (4, 6) and remove the oil return pipe from the turbocharger (5) with its gaskets.

Ref.	No.	Description
(1)	1	M10 screw
(2)	1	Fitting M16 X 1.5 X 12
(4, 6)	4	M8 x 1.25 screws

Figure 48



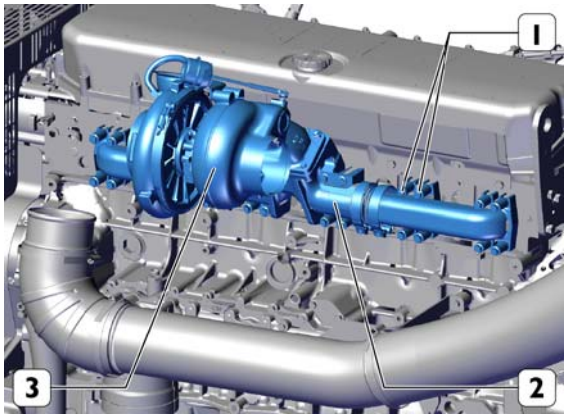
227762

Unscrew the fastening screws (1) and remove the exhaust manifold (2) together with the turbocharger (3) and the gaskets.

Ref.	No.	Description
(1)	24	Screws M10 X 1.5 X 70

Refitting

Figure 49

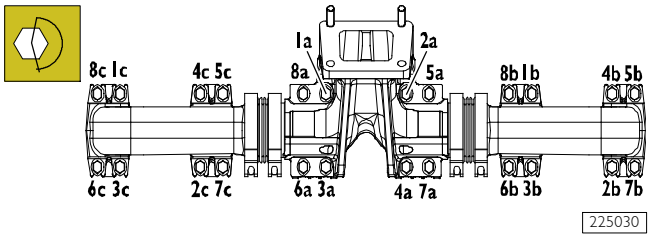


227762

Fit the exhaust manifold (3) with new gaskets together with the turbocharger (2). Fit the fastening screws (1) to the exhaust manifold and tighten them to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	24	Screws M10 X 1.5 X 70 Step 1 Step 2	 30 ± 5 Nm 60 ± 5 Nm

Figure 50

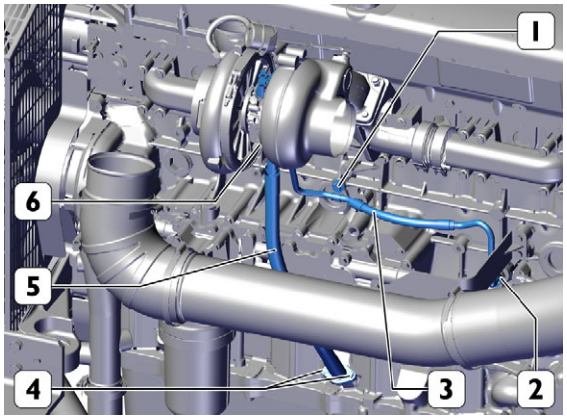


225030

Tighten the fastening screws following the sequence indicated in the figure.

NOTE Lubricate the screws with graphite oil.

Figure 51



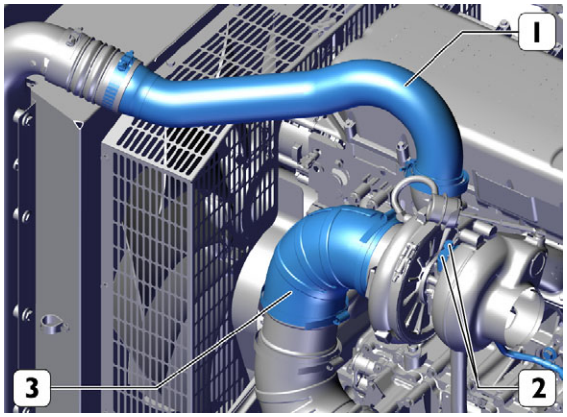
227761

Mount the oil delivery pipe to turbocharger (3) and tighten screws of the bracket (1) and the fitting (2) to the torque shown in the table.

Fit the engine oil return pipe from the turbocharger (5) with the new gaskets and tighten the screws (4, 6) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	M10 screw	10 ± 1 Nm
(2)	1	Fitting M16 X 1.5 X 12	42.5 ± 2.5Nm
(4, 6)	4	M8 x 1.25 screws	24.5 ± 2.5 Nm

Figure 52



227760

Connect the sleeve (3) of the combustion air intake pipe to the turbocharger and tighten the clamps.

Tighten the screws (2) of the oil delivery pipe to the turbocharger to the torque indicated in the table.

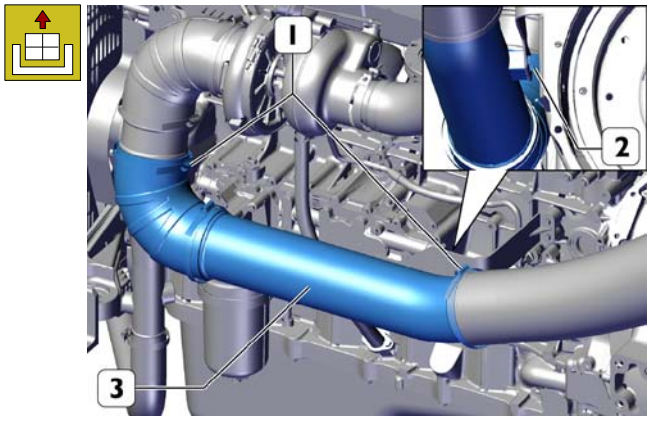
Ref.	No.	Description	Tightening torques
(1)	2	M8 x 1.25 screws	24.5 ± 2.5 Nm

Connect the air intake pipe (1) to the aftercooler and tighten clamp and collar.

OIL FILTER AND MOUNT REMOVAL-REFITTING

Removal

Figure 53

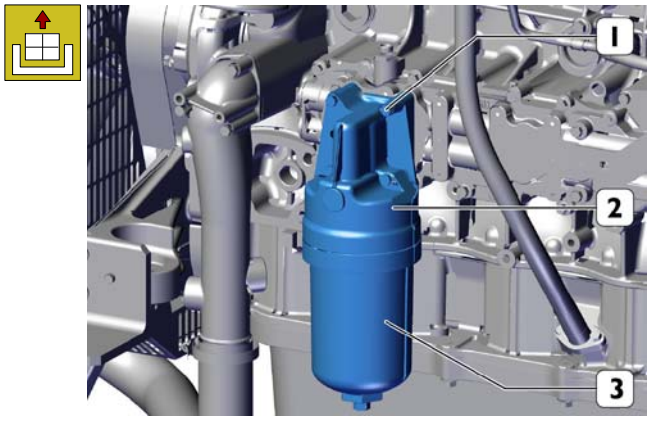


227763

Slacken the clamps (1), undo the screws (2) and remove the fuel combustion air intake pipe (3) to the turbocharger.

Ref.	No.	Description
(2)	2	M8x1.25 screws

Figure 54



227786

Using a suitable tool, unscrew the oil filter body (3) and remove the filter element.

Unscrew the screws (1) and remove the engine oil filter (2) and gasket.

Ref.	No.	Description
(1)	4	Screws M8 X 1.25 X 65

The oil filter contains approximately 2 kg of engine oil inside.

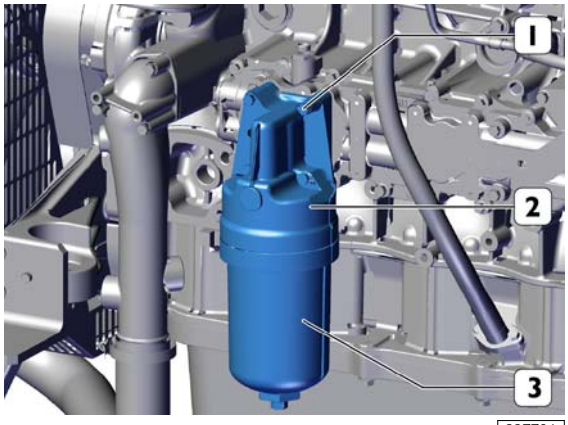
Position a suitable container to collect the oil.

Avoid skin contact with the engine oil: in case of contact, wash thoroughly with water.

The engine oil is highly pollutant: it must be disposed of according to applicable laws.

Refitting

Figure 55



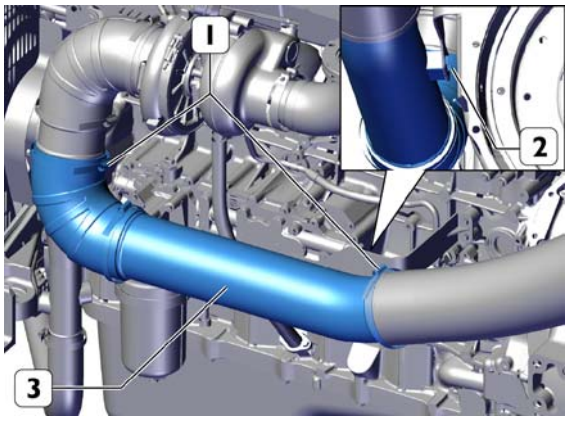
227786

Fit the engine oil filter mount (2) together with the new gasket and tighten the screws (1) to the torque indicated in the table.

Fit the filter element of the oil filter (3) onto its support (2) and tighten it to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	4	Screws M8 X 1.25 X 65	24.5 ± 2.5 Nm
(3)	1	-	60 ± 5 Nm

Figure 56



227763

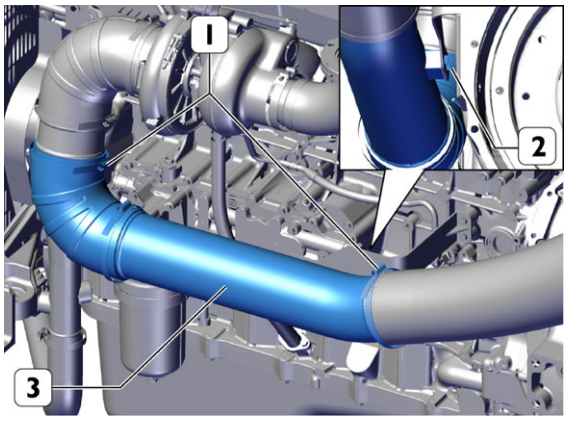
Refit the combustion air intake pipe to the turbocharger pipe (3) into its seat, tighten the clamps (1) and the screws (2) that fasten to the bracket to the torque in the table.

Ref.	No.	Description	Tightening torques
(2)	2	M8 x 1.25 screws	-

HEAT EXCHANGER REMOVAL-REFITTING

Removal

Figure 57

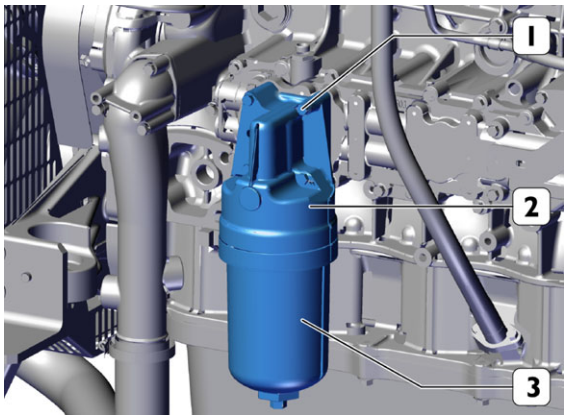


227763

Slacken the clamps (1), undo the screws (2) and remove the fuel combustion air intake pipe (3) to the turbocharger.

Ref.	No.	Description
(2)	2	M8x1.25 screws

Figure 58



227786

Using a suitable tool, unscrew the oil filter body (3) and remove the filter element.

Unscrew the screws (1) and remove the engine oil filter (2) and gasket.

Ref.	No.	Description
(1)	4	Screws M8 X 1.25 X 65

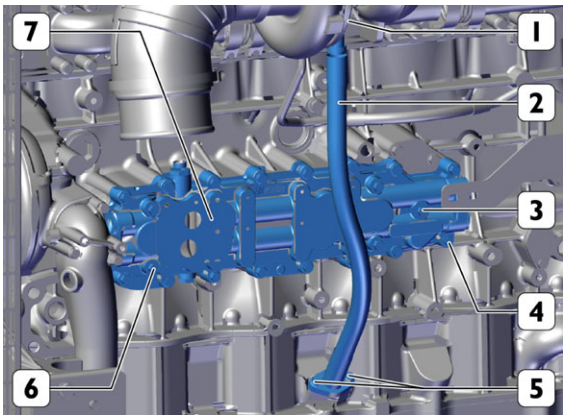
The oil filter contains approximately 2 kg of engine oil inside.

Position a suitable container to collect the oil.

Avoid skin contact with the engine oil: in case of contact, wash thoroughly with water.

The engine oil is highly pollutant: it must be disposed of according to applicable laws.

Figure 59



227764

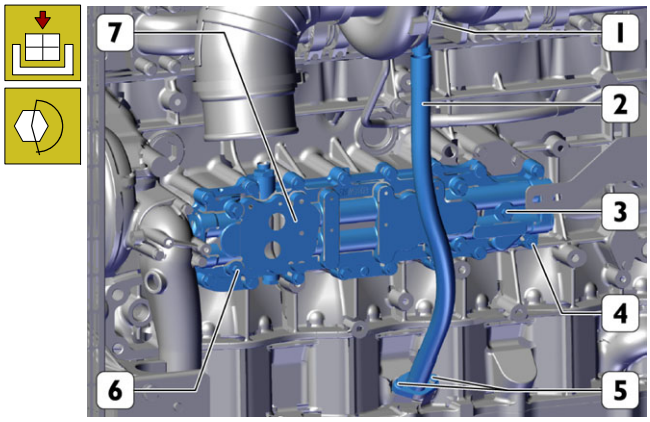
Undo the screws (1, 5) and remove the oil return pipe from the turbocharger (2) with its gaskets.

Unscrew the screws (3, 4, 6) and remove the complete heat exchanger (7) and its gasket.

Ref.	No.	Description
(1)	2	M8x1.25 screws
(5)	2	M8x1.25 screws
(3)	1	Screw M8x1.25x55
(4)	17	Screws M8x1.25x40
(6)	4	Screws M8x1.25x45

Refitting

Figure 60



227764

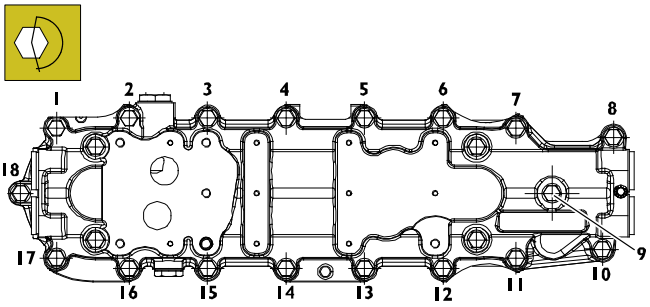
Fit the heat exchanger (7) together with the new gasket and tighten the screws (3, 4, 6) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(3)	1	Screws M8 X 1.25 X 55 Step 1 Step 2	 11.5 ± 3.5 Nm 24.5 ± 2.5 Nm
(4)	17	Screws M8 X 1.25 X 40 Step 1 Step 2	 11.5 ± 3.5 Nm 24.5 ± 2.5 Nm
(6)	4	Screws M8 X 1.25 X 45	19 ± 3.8 Nm

Fit the engine oil return pipe from the turbocharger (2) with the new gaskets and tighten the screws (1, 5) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	2	M8x1.25 screws	24.5 ± 2.5 Nm
(5)	2	M8x1.25 screws	24.5 ± 2.5 Nm

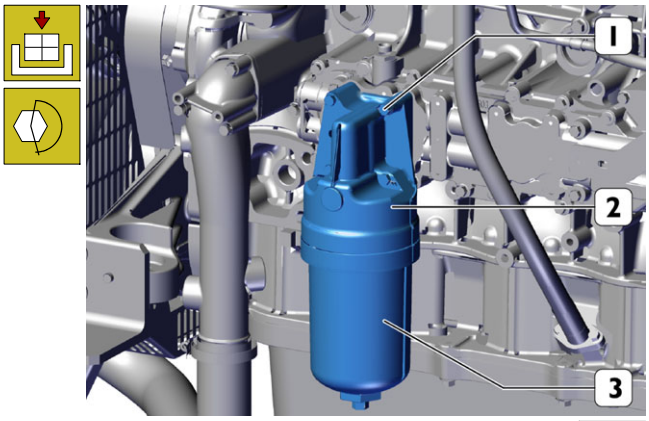
Figure 61



225031

Tighten the fastening screws following the sequence indicated in the figure.

Figure 62



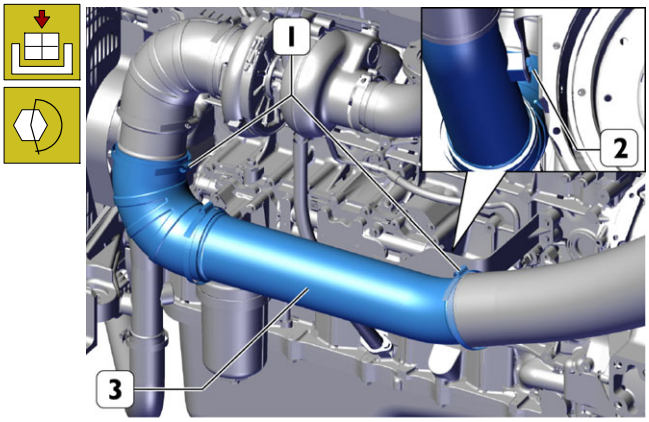
227786

Fit the engine oil filter mount (2) together with the new gasket and tighten the screws (1) to the torque indicated in the table.

Fit the filter element of the oil filter (3) onto its support (2) and tighten it to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	4	Screws M8 X 1.25 X 65	24.5 ± 2.5 Nm
(3)	1	-	60 ± 5 Nm

Figure 63



227763

Refit the combustion air intake pipe to the turbocharger pipe (3) into its seat, tighten the clamps (1) and the screws (2) that fasten to the bracket to the torque in the table.

Ref.	No.	Description	Tightening torques
(2)	2	M8 X 1.25	-

OIL SUMP REMOVAL-REFITTING

Removal

NOTE Position a suitable container below the sump to collect the oil as it drains out of the drain plug.

Drain the engine oil by removing the plug from the oil sump.

Ref.	No.	Description
(-)	1	Plug M22 X 1.5

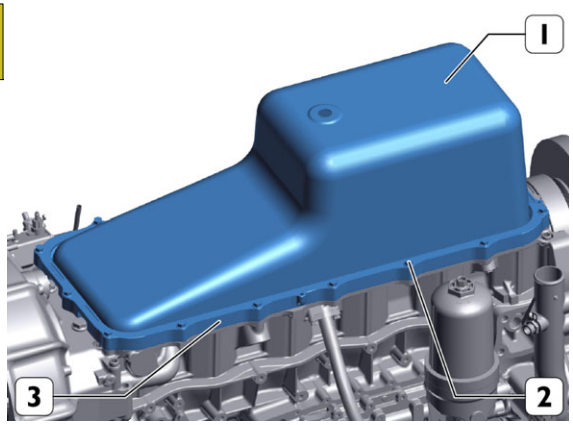
The engine oil is highly pollutant and noxious.

In case of contact with skin, wash thoroughly with water and detergent.

Suitably protect skin and eyes; proceed in accordance with accident prevention standards.

Suitably dispose of the residuals and in accordance with regulations.

Figure 64



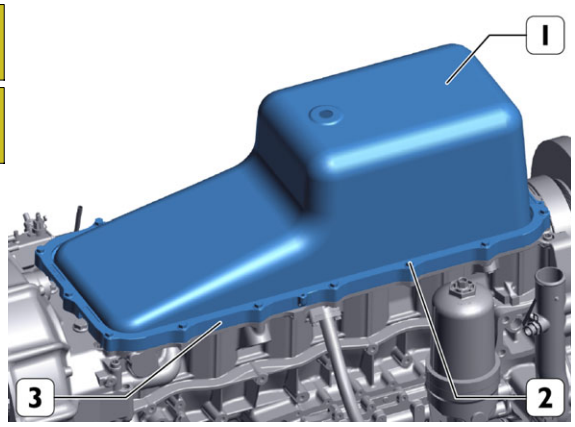
227765

Slacken the screws (2) and remove the engine oil sump (1) with the frame (3) and the gasket.

Ref.	No.	Description
(2)	16	M10 x 1.5 screws

Refitting

Figure 65

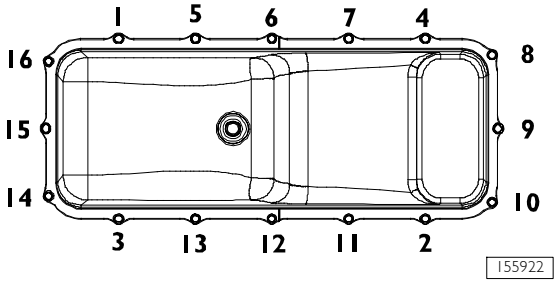


227765

Arrange the gasket on the oil sump (1), position the spacer (3) and fit the sump on crankcase screwing in the screws (2) to the torque as in the table.

Ref.	No.	Description	Tightening torques
(2)	16	M10 x 1.5 screws Step 1 Step 2	 45 ± 4.5 Nm 45 ± 4.5 Nm

Figure 66



155922

Tighten the screws securing the toil sump following the sequence indicated in the figure.

Fit the drain plug of the oil sump and tighten to the torque indicated in the table

Ref.	No.	Description	Tightening torques
(-)	1	M22 X 1.5	40 ± 10 Nm

Through the filler cap, introduce the oil in the specified quantity and quality prescribed.

Only use recommended oils or oils with the properties required for proper engine operation.

If topping up, do not mix oils with different properties.

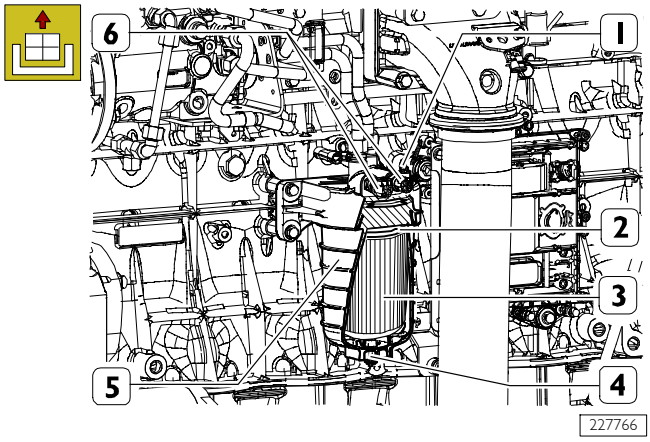
Failure to observe these standards will invalidate the service warranties.

Check the level with the dipstick until obtaining a filling near the maximum level notch shown on the dipstick.

FUEL FILTER REMOVAL-REFITTING

Removal

Figure 67



Only proceed when the engine is not turning and is at low temperature so as not to run the risk of burns.

Close the tank cock.

Disconnect the electrical connections of the pressure and temperature sensor (6).

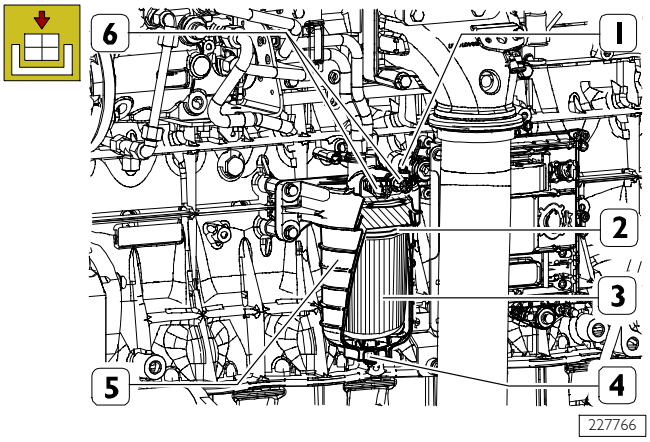
Place a suitable container below the fuel filter in line with the drain plug (4) to collect the fuel.

Open the drain plug (4) and the bleeder connection (1) and drain any residual fuel.

Remove the filter element (3) by unscrewing the relative bell-shaped support (5), remove the O-ring (2).

Refitting

Figure 68



Replace the filtering element (3) and the O-ring seal (2) inside the bell housing support (5).

Grease the O-ring seal (2) of the filter.

Insert the filter element (3) and tighten the relative bell-shaped support (5) to the torque indicated in the table.

Tighten the drain plug (4) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Bleeding union	17.5 ± 2.5 Nm
(4)	1	Threaded plug	1.5 ± 0.5 Nm
(5)	1	Filter cap	32.5 ± 2.5 Nm

Do not fill the new filter until it has been positioned on the support: this prevents allowing impurities to enter and damage the circuit and injection system.

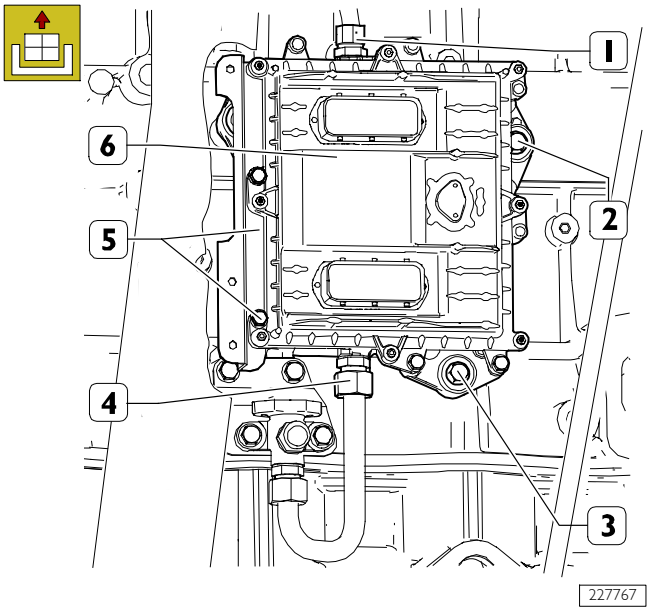
Connect the electrical connections of the pressure and temperature sensor (6).

ENGINE CONTROL UNIT REMOVAL-REFITTING

Removal

Disconnect the engine cable connector by disconnecting it from the control unit as described in the relevant section.

Figure 69



Unscrew the screws and remove the bracket (5).

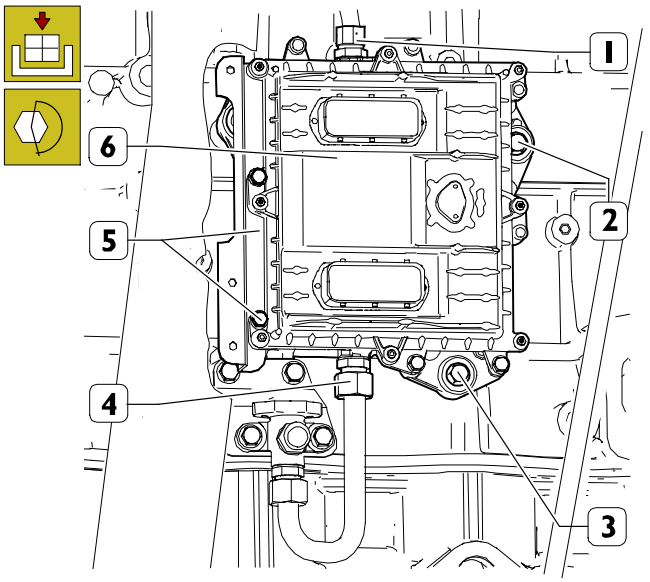
Unscrew couplings (1, 4) and disconnect the low pressure fuel pipes from the control unit.

Unscrew the screws of the control unit mount (2, 3) and remove the engine control unit (6) and its mount.

Ref.	No.	Description
(1, 4)	2	Fittings M22 X 1.5
(2)	2	Screws M8 X 1.25 X 60
(3)	1	Screws M8 X 1.25 X 45
(5)	2	Screws M6 X 1 X 25

Refitting

Figure 70



Fit the engine control unit (6) and tighten the screws of the mount (2, 3) to the torque indicated in the table.

Fit the bracket and tighten screws (5) to the torque indicated in the table.

Connect the low pressure fuel pipes and tighten the fittings (1 , 4) to the torque indicated in the table.

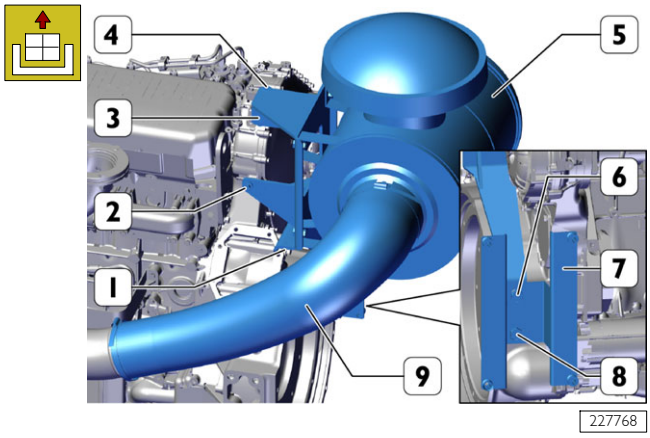
Ref.	No.	Description	Tightening torques
(1, 4)	2	Fittings M22 X 1.5	50 ± 5 Nm
(2)	2	Screws M8 X 1.25 X 60	24.5 ± 2.5 Nm
(3)	1	Screws M8 X 1.25 X 45	24.5 ± 2.5 Nm
(5)	2	Screws M6 X 1 X 25	8 ± 2 Nm

Connect the engine cable connector by connecting it to the control unit as described in the relevant section.

AIR FILTER REMOVAL - REFITTING

Removal

Figure 71



Disconnect and remove the combustion air intake pipe (9) to the turbocharger acting on the clamps.

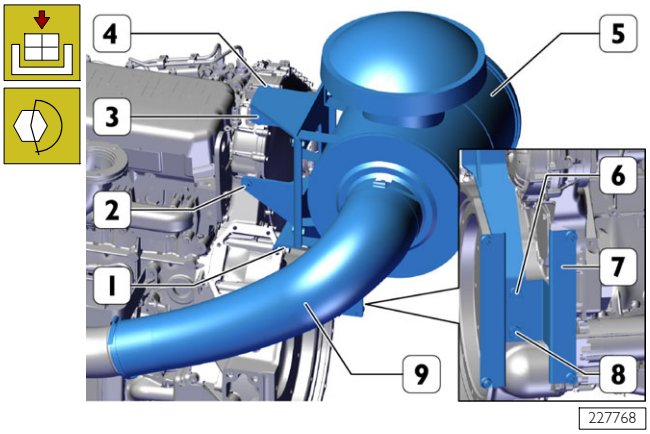
Remove the air filter (5) by unscrewing the screws (1, 2, 3, 4, 6) and remove it from its seat together with the support.

Unscrew the screw (8) and remove the bracket (7).

Ref.	No.	Description
(1)	1	M10 screw
(2)	1	M8 screw
(3)	1	M6 screw
(4)	1	M10 screw
(6)	1	M18 screw
(8)	1	M18 screw

Refitting

Figure 72



Mount the bracket (7) and tighten the screws (8) to the torque in the table.

Mount the air filter (5) along with the support and tighten screws (1, 2, 3, 4, 6) to table torque.

Connect the combustion air intake pipe (9) to the turbocharger by closing the clamps.

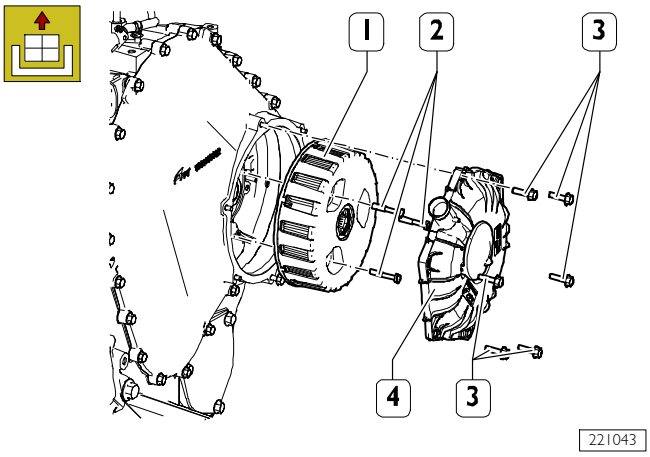
Ref.	No.	Description	Tightening torques
(1)	1	M10 screw	37.5 ± 7.5 Nm
(2)	1	M8 screw	18 ± 4 Nm
(3)	1	M6 screw	8 ± 2 Nm
(4)	1	M10 screw	37.5 ± 7.5 Nm
(6)	1	M18 screw	245 ± 50 Nm
(8)	1	M18 screw	245 ± 50 Nm

BLOW-BY REMOVAL-REFITTING

Remove the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING".

Removal

Figure 73



Unscrew the screws (3) and remove the blow-by cover (4).

Unscrew the screws (2) and remove the blow-by filter element (1)

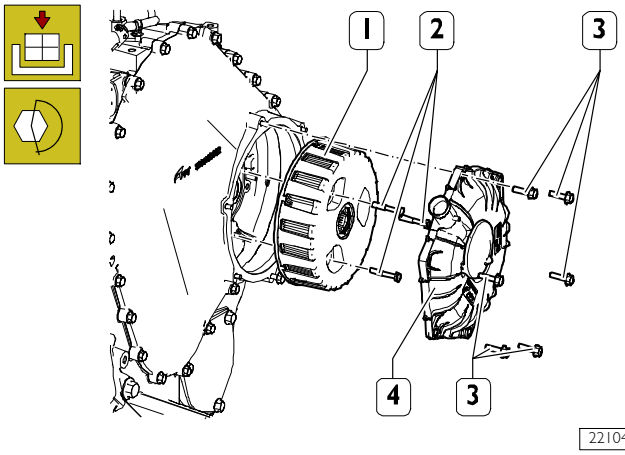
Ref.	No.	Description
(2)	3	Screws M6 X 1 X 40
(3)	6	Screws M6 X 1 X 25

Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law.

Refitting

NOTE Carefully clean the seating of the filter and the cover.

Figure 74



Fit the new blow-by filtering element (1) into its seat and tighten the screws (2) to the torque indicated in the table.

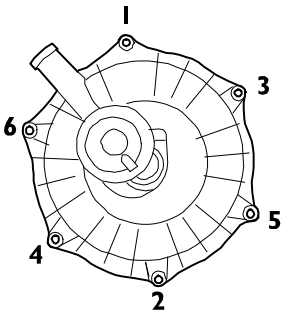
Ref.	No.	Description	Tightening torques
(2)	3	Screws M6 X 1 X 40 Step 1 Step 2	 5 Nm 15 ± 1.5 Nm

NOTE Apply Loctite 243 to the screws (2).

Position the blow-by cover (4) and tighten the screws (3) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(3)	6	Screws M6 X 1 X 25	7 ± 1 Nm

Figure 75



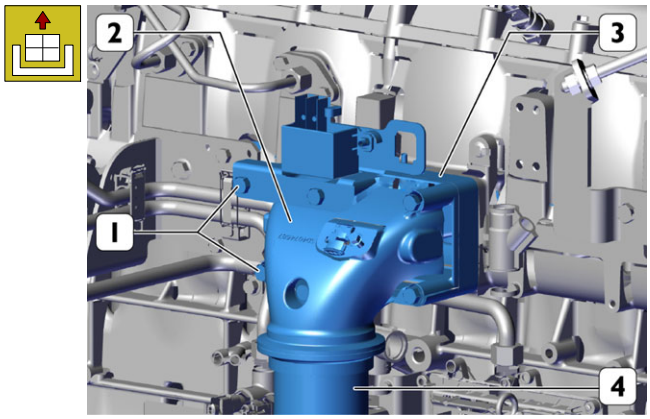
Tighten the fastening screws following the sequence indicated in the figure.

Refit the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING".

INTAKE MANIFOLD REMOVAL-REFITTING

Removal

Figure 76



Disconnect the combustion air intake pipe to the engine (4) acting on the clamp.

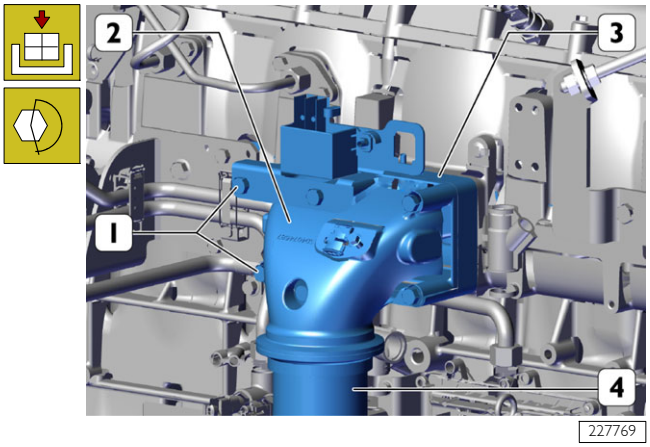
Disconnect the electrical connection of the air temperature and pressure sensor.

Unscrew the screws (1) and remove the intake manifold (2) together with the engine preheating resistor (3) and its gasket.

Ref.	No.	Description
(1)	3	Screws M10 X 1.5 X 100
(1)	2	Screws M10 X 1.5 X 130
(1)	1	Screws M10 X 1.5 X 150

Refitting

Figure 77



Fit the intake manifold (2) together with the engine preheating resistor (3) and its gasket and tighten screws (1) to the torque shown in the table.

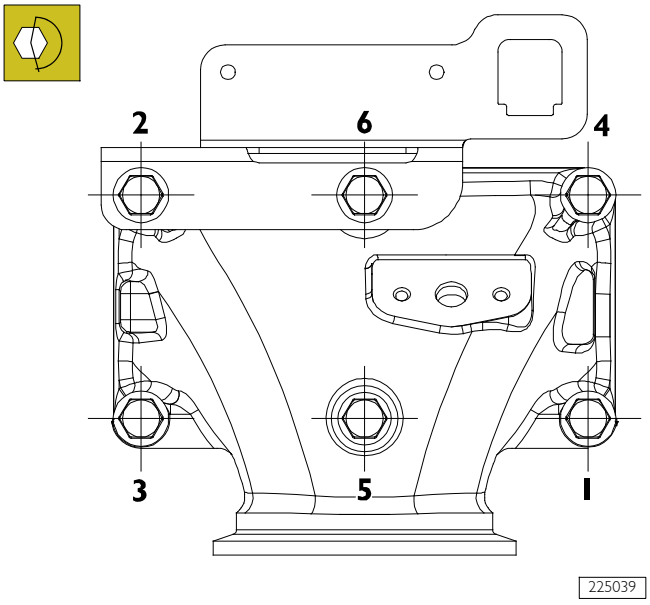
Connect the combustion air intake pipe to the engine (4) and tighten the clamp.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M10 X 1.5 X 100	50± 5 Nm
(1)	2	Screws M10 X 1.5 X 130	50 ± 5 Nm
(1)	1	Screws M10 X 1.5 X 150	50 ± 5 Nm

Connect the electrical connection of the air temperature and pressure sensor.

Connect the combustion air intake pipe to the engine (4) and tighten the clamp.

Figure 78



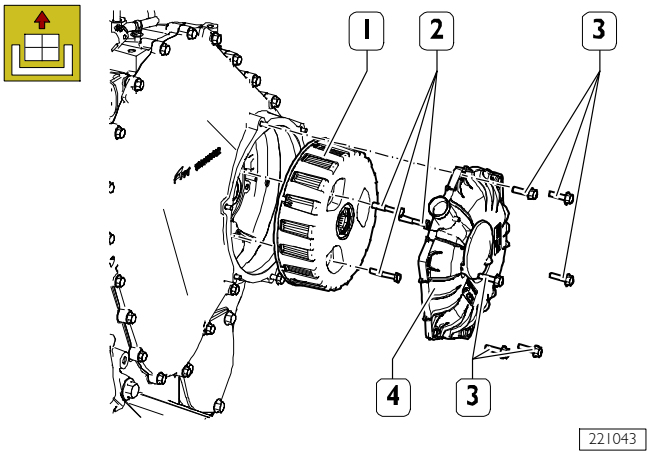
Observe the order of tightening indicated in the diagram.

FUEL PUMP REMOVAL-REFITTING

Remove the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING".

Removal

Figure 79



Unscrew the screws (3) and remove the blow-by cover (4).

Unscrew the screws (2) and remove the blow-by filter element (1)

Ref.	No.	Description
(2)	3	Screws M6 X 1 X 40
(3)	6	Screws M6 X 1 X 25

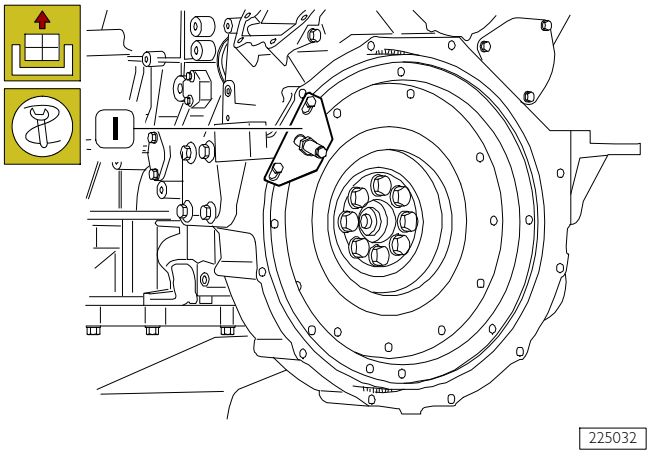
Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law.

Bring the flywheel to 36° before TDC of the first cylinder.

NOTE This position can be obtained by turning the engine flywheel in the direction opposite of the operating direction to the 30° position marked by THREE notches and continuing to turn the flywheel in the same direction until reaching the next hole (by 6°).

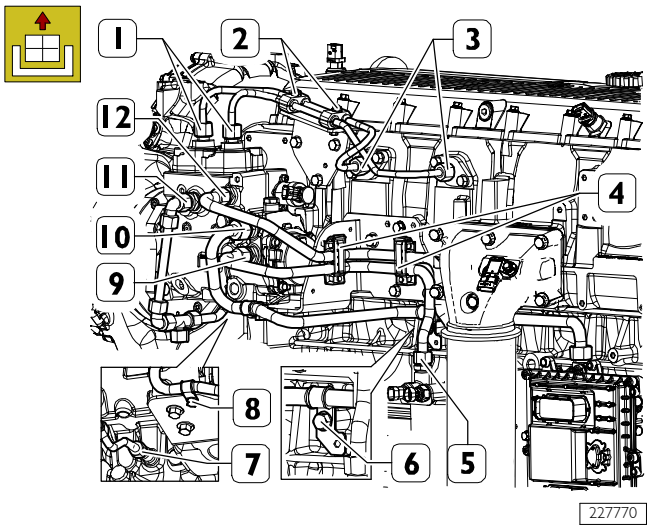
If the engine flywheel does not have 3 notches, to identify the reference hole simply: turn the flywheel in the direction opposite of the operating direction until reaching the position marked with 2 notches (54° before cyl. 1 T.D.C.); continue rotating in the engine operating direction for 3 holes (remember that each hole corresponds to a flywheel rotation of 6°).

Figure 80



Lock the engine flywheel in place using tool 99360351 (1) so it does not spin.

Figure 81



227770

Disconnect the electrical connection from the fuel flow regulator.

Unscrew the nutes (2), remove the plugs, undo the fittings (1, 3) and remove the HP fuel pipes.

Ref.	No.	Description
(1, 3)	4	Fittings M16 X 1.5
(2)	2	Nuts M6 X 1

The HP pipes that are disassembled cannot be used again and must be replaced.

Open springs (4), remove the fittings (5, 9, 12) and remove the LP fuel pipes from pump to filter and vice-versa.

Ref.	No.	Description
(5, 9, 12)	4	Fittings M18 X 1.5

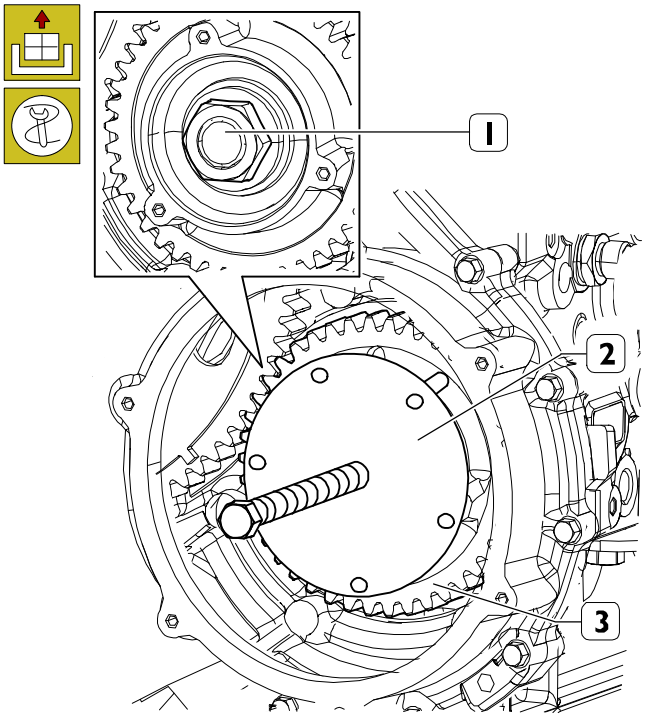
Undo the fitting (10), bracket retainer screws (6, 8) and move the LP fuel pipe from control unit to pump off to the side.

Ref.	No.	Description
(6, 8)	2	Screws M8 X 1.25 X 16
(10)	1	Fitting M22 X 1.5

Unscrew the fittings (7, 11) and remove the fuel return pipe.

Ref.	No.	Description
(7, 11)	2	Fittings M18 X 1.5

Figure 82



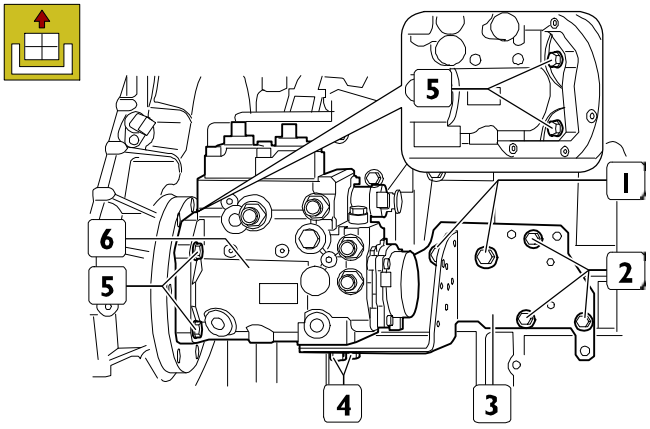
225036

Undo the nut (1).

Apply the tool to extract the high pressure pump gear 99366198 (2) and remove the high pressure pump control gear (3).

Ref.	No.	Description
(1)	1	Nut M24 X 1.5

Figure 83



221104

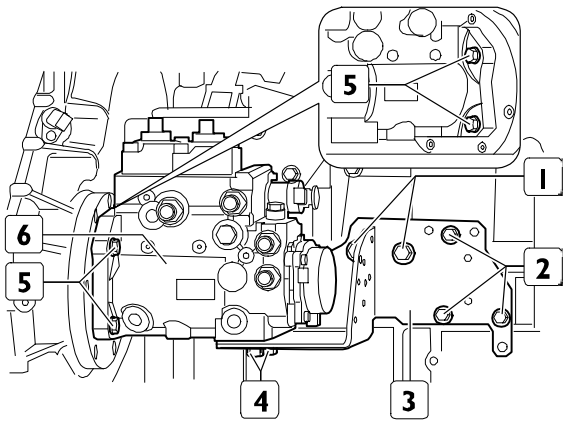
Unscrew the screws (1,2,4) and remove the bracket (3).

Unscrew the screws (5) and remove the high pressure pump (6).

Ref.	No.	Description
(1)	2	Screws M10 X 1.5 X 20
(2)	2	Screws M8 X 1.25 X 20
(4)	2	Screws M12 X 1.75 X 30
(5)	4	Screws M12 X 1.5

Refitting

Figure 84

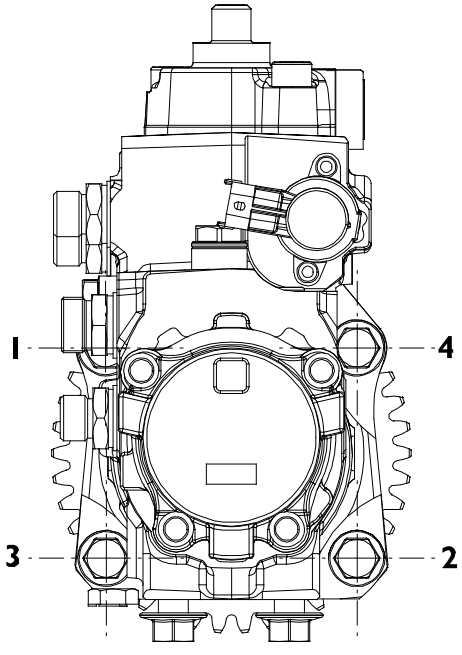


Position the bracket (3) and tighten the screws (1, 2).

Position the high pressure pump (6) and tighten the screws (4, 5) to torque shown in the table.

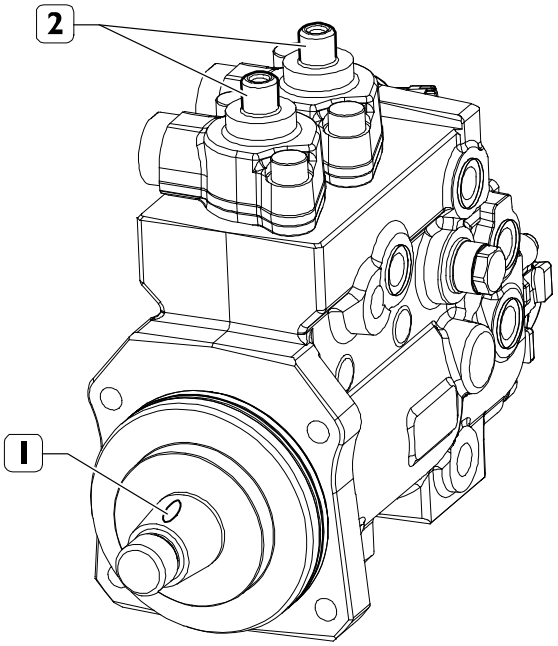
Ref.	No.	Description	Tightening torques
(1)	2	Screws M10 X 1.5 X 20	37.5 ± 5 Nm
(2)	3	Screws M8 X 1.25 X 20	24.5 ± 2.5 Nm
(4)	2	Screw M12 X 1.75 X 30	32.5 ± 2.5 Nm
(5)	4	Screws M12 X 1.5	37.5 ± 2.5 Nm

Figure 85



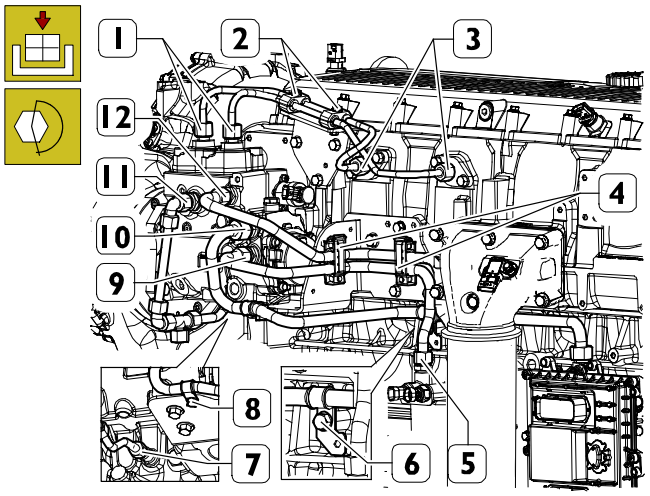
Observe the order of tightening indicated in the diagram.

Figure 86



Fit the high pressure pump and make sure that the seat of the key (1) on the pump shaft is facing the pump intakes (2) .

Figure 87



227770

Fit the HP fuel pipes, fit the plugs onto the bracket and tighten the fittings (1, 3) and nuts to the torque (2) shown in the table.

Ref.	No.	Description	Tightening torques
(1, 3)	4	Fittings M16 X 1.5	42.5 ± 2 Nm
(2)	2	Nuts M6 X 1	8 ± 2 Nm

Position the LP fuel pipe from control unit to pump, tighten the fitting (10)and bracket screws (6, 8) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(10)	1	Fitting M22 X 1.5	50 ± 5 Nm
(6, 8)	2	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm

Position the LP fuel pipe from pump to filter and vivc-versa and tighten fittings (5, 9, 12) to the torque shown in the table. close springs (4).

Ref.	No.	Description	Tightening torques
(5, 9 12)	4	Fittings M18 X 1.5	37 ± 3 Nm

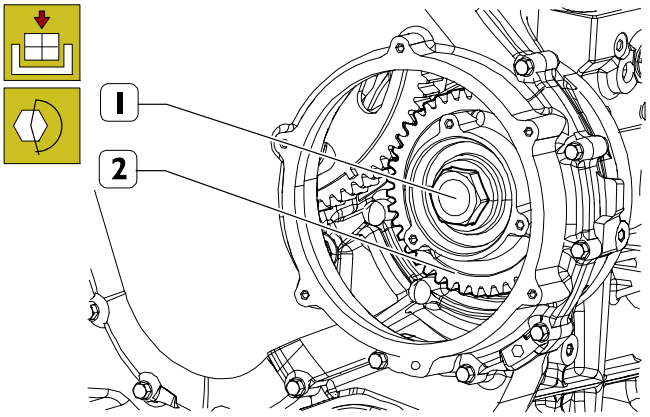
Fit the new fuel return pipe (7, 11) and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(7, 11)	2	Fittings M18 X 1.5	37 ± 3 Nm

NOTE Make sure that the pipe is not damaged after mounting and that there are no fuel leaks while engine is running.

The HP pipes that are disassembled cannot be used again and must be replaced.

Figure 88



225037

Fit the gear (2) and tighten the nut (1) to the torque shown in the table.

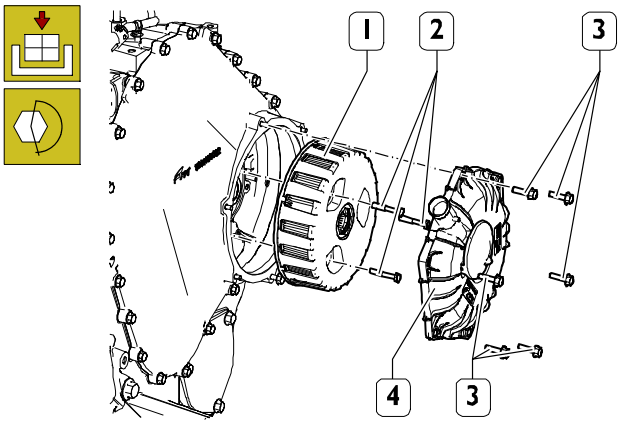
Ref.	No.	Description	Tightening torques
(1)	1	Nut M24 X 1.5	275 ± 25 Nm

Connect the electrical connection from the fuel flow regulator.

Remove the tool 99360351 for engine flywheel locking.

NOTE Carefully clean the seating of the filter and the cover.

Figure 89



221043

Fit the new blow-by filtering element (1) into its seat and tighten the screws (2) to the torque indicated in the table.

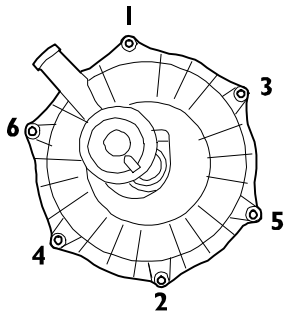
Ref.	No.	Description	Tightening torques
(2)	3	Screws M6 X 1 X 40 Step 1 Step 2	 5 Nm 15 ± 1.5 Nm

NOTE Apply Loctite 243 to the screws (2).

Position the blow-by cover (4) and tighten the screws (3) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(3)	6	Screws M6 X 1 X 25	7 ± 1 Nm

Figure 90



221126

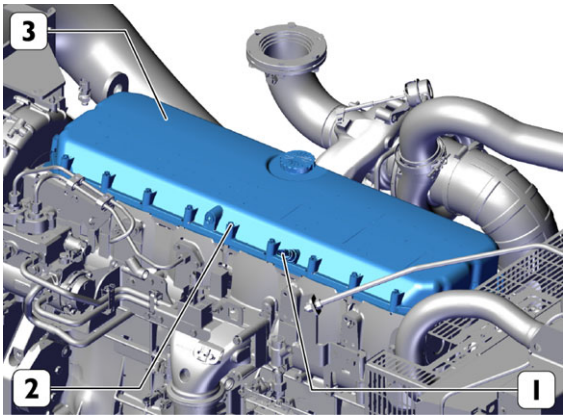
Tighten the fastening screws following the sequence indicated in the figure.

Refit the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING".

TAPPET COVER REMOVAL-REFITTING

Removal

Figure 91



227771

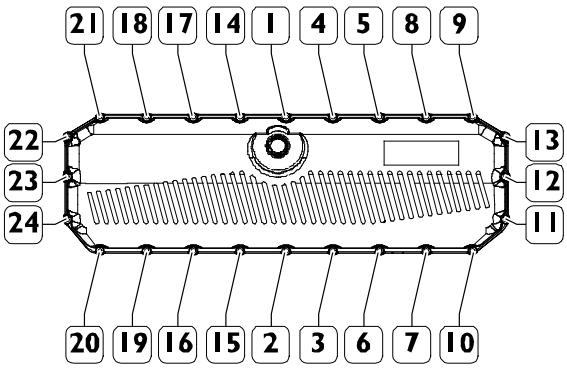
Disconnect the electric connection of engine crankcase pressure sensor (1).

Unscrew the fastening screws (2) and remove the tappet cover (3) together with the gasket.

Ref.	No.	Description
(2)	24	M6 x 1 screws

Refitting

Figure 92



221122

Position the cover and new gasket and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

Tighten the screws (1-24) to the torque specified in the table.

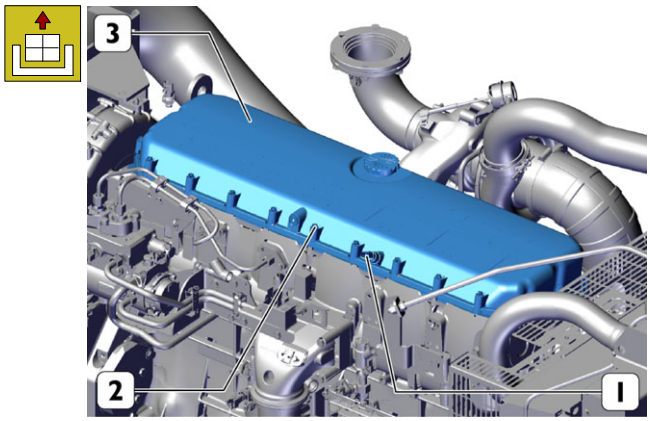
Ref.	No.	Description	Tightening torques
(-)	24	M6 x 1 screws	8.5 ± 1.5 Nm

Connect the electric connection of engine crankcase pressure sensor (1).

COMMON RAIL REMOVAL-REFITTING

Removal

Figure 93

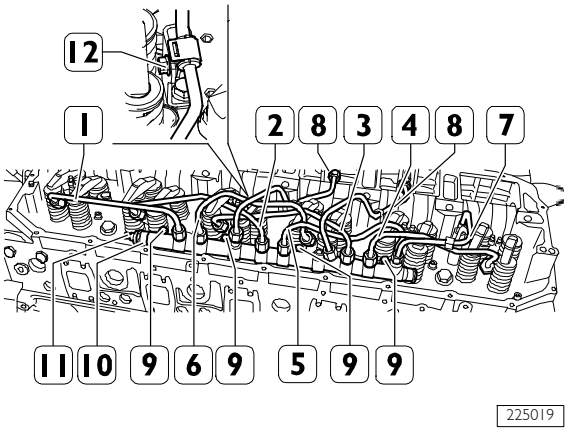


Disconnect the electric connection of engine crankcase pressure sensor (1).

Unscrew the fastening screws (2) and remove the tappet cover (3) together with the gasket.

Ref.	No.	Description
(2)	24	M6 x 1 screws

Figure 94



Unscrew the fittings (8) on rail and head side, screw on bracket (12) and remove the high pressure fuel supply pipes.

Unscrew the fittings from the rail side and detach the high pressure fuel pipes (1, 2, 3, 4, 5) e (6) and the fuel return pipe (7) to the head.

The high pressure fuel pipes must be replaced at each disassembly.

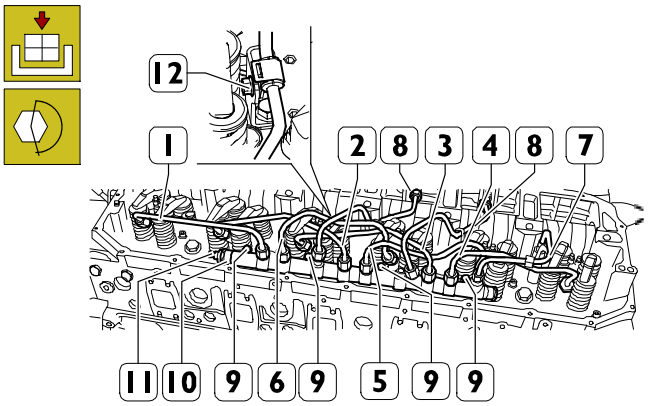
Disconnect the electric connection from pressure sensor on the rail (11).

Unscrew the fastening screws (9) and remove the rail (10).

Ref.	No.	Description
(1 - 6)	12	Fittings M16 X 1.5
(7)	2	Fittings M16 X 1.5
(8)	4	Fittings M16 X 1.5
(9)	3	Screws M8 X 1.25 X 55
(12)	2	Screws M6

Refitting

Figure 95



225019

Fit the rail (10) onto the head and tighten the fastening screws (9) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(9)	3	Screws M8 X 1.25 X 55	24.5 ± 2.5 Nm

Connect the high pressure fuel pipes and tighten the fittings by hand in the sequence (1, 2, 3, 6, 5, 4) to the rail and the injectors.

NOTE Before tightening the couplings to torque make sure that the pipes are not touching each other.

The high pressure fuel pipes must be replaced at each disassembly.

Complete assembly of the high pressure fuel pipes (1, 2, 3, 6, 5, 4) by first tightening the injector side fittings and then those on the rail side to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1 - 6)	12	Fittings M16 X 1.5	42.5 ± 2 Nm

Connect the high pressure fuel supply pipes (8) and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(8)	4	Fittings M16 X 1.5	42.5 ± 2 Nm

Fix the fuel supply pipe to their brackets, tightening the screws (12) to the required torque.

Ref.	No.	Description	Tightening torques
(12)	2	Screws M6	10 ± 1 Nm

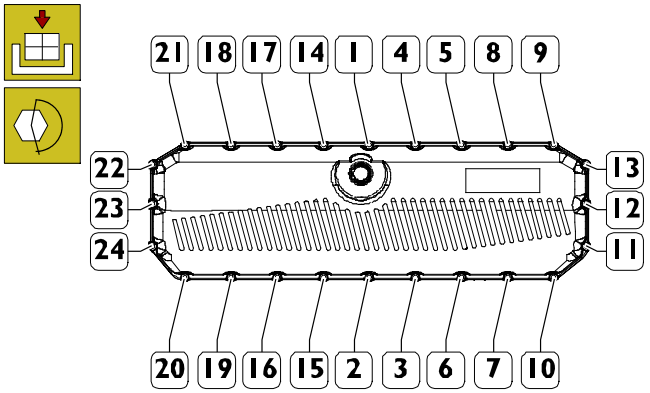
Connect the fuel return pipe (7) from the rail and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(7)	2	Fittings M16 X 1.5	35 ± 2 Nm

Connect the electrical connection of the rail pressure sensor.

NOTE Use torque wrench 99389833 to tighten fittings of the HP fuel pipes.

Figure 96



221122

Position the cover and new gasket and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

Tighten the screws (1-24) to the torque specified in the table.

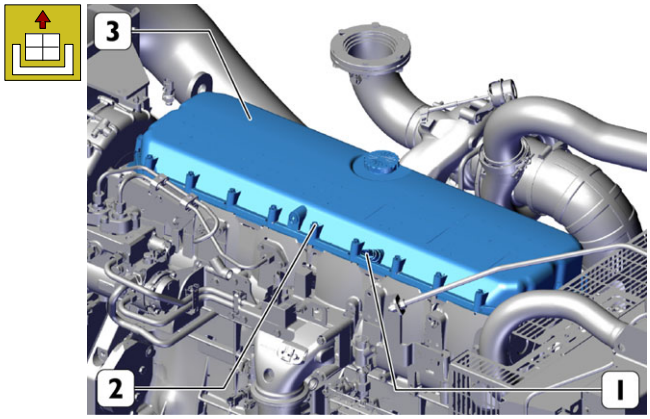
Ref.	No.	Description	Tightening torques
(-)	24	M6 x 1 screws	8.5 ± 1.5 Nm

Connect the electric connection of engine crankcase pressure sensor.

ELECTRO-INJECTOR REMOVAL-REFITTING

Removal

Figure 97

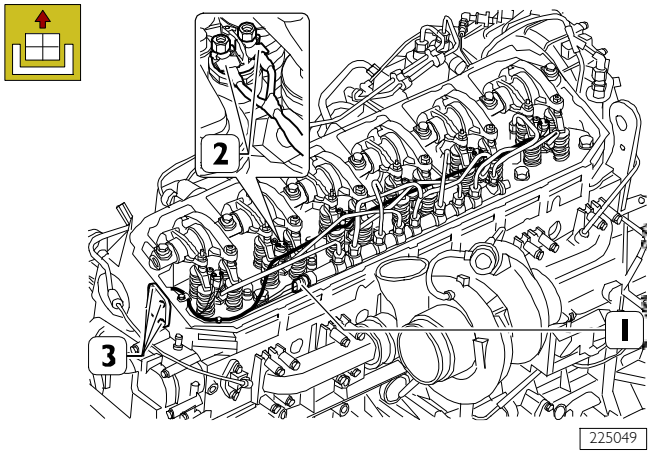


Disconnect the electric connection of engine crankcase pressure sensor.

Unscrew the fastening screws (2) and remove the tappet cover (3) together with the gasket.

Ref.	No.	Description
(2)	24	M6 x 1 screws

Figure 98



Remove the wiring clamps.

Disconnect the connector from the rail pressure sensor (1).

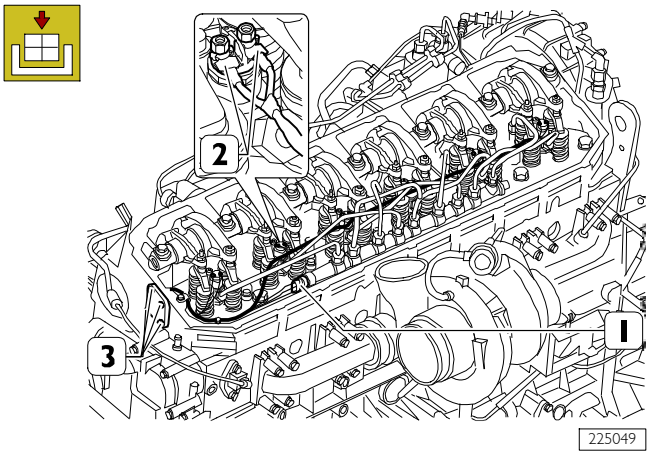
Unscrew the nuts and disconnect the electrical connections (2) from the injectors.

Ref.	No.	Description
(2)	12	Nuts M4

Remove the screws (3) securing the connector and remove all the wiring.

Refitting

Figure 99



Position the wiring and secure it appropriately with clamps.

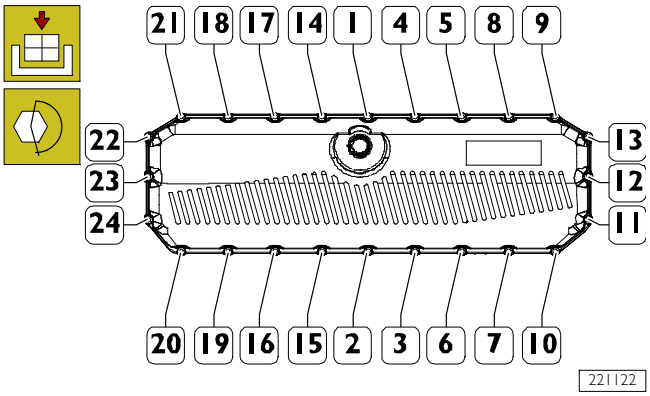
Connect the elctrical connections (2) to the injectors and tighten the nuts to the torque indicated in the table.

Connect the connector from the rail pressure sensor (1).

Fasten the connects using the screws (3) and tighten them to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(2)	12	Nuts M4	1.5 ± 0.25
(3)	4	Screws	8 ± 2

Figure 100



Position the cover and new gasket and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

Tighten the screws (1-24) to the torque specified in the table.

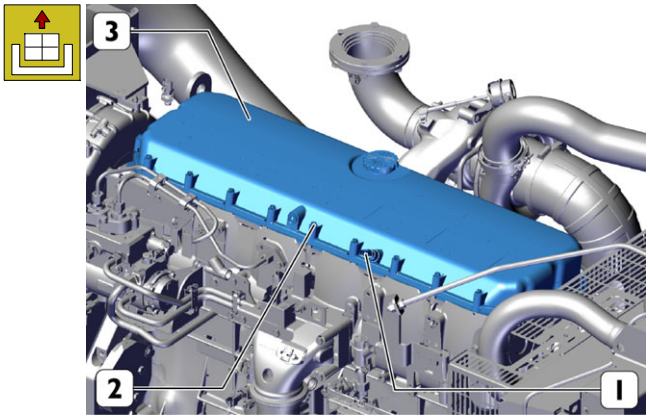
Ref.	No.	Description	Tightening torques
(-)	24	M6 x 1 screws	8.5 ± 1.5 Nm

Connect the electric connection of engine crankcase pressure sensor.

ROCKER ARM SHAFT REMOVAL-REFITTING

Removal

Figure 101

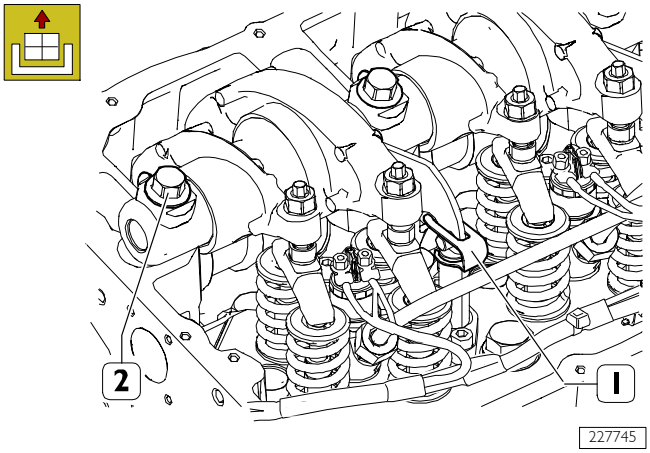


Disconnect the electric connection of engine crankcase pressure sensor.

Unscrew the fastening screws (2) and remove the tappet cover (3) together with the gasket.

Ref.	No.	Description
(2)	24	M6 x 1 screws

Figure 102

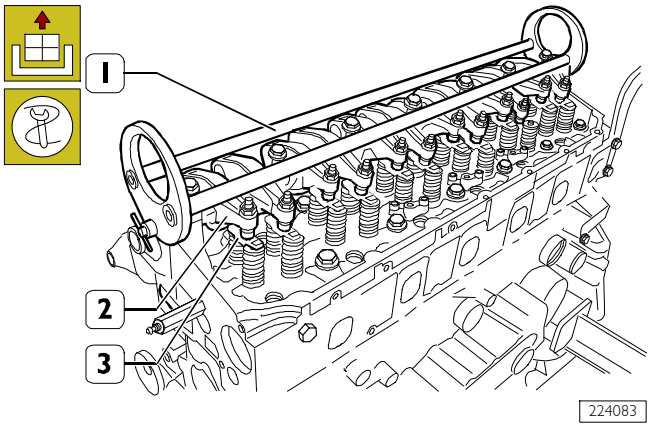


Release the retainer springs of the engine brake (1).

Unscrew the screws (2) securing the rocker arm shaft.

Ref.	No.	Description
(2)	7	Screws M16 X 1.5 X 76

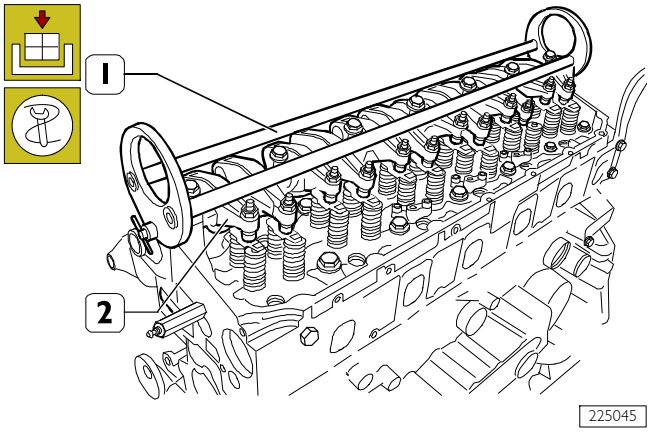
Figure 103



Use the specified tool 99360553 (1) on the rocker arm shaft (2) and remove the shaft (2) from the cylinder head. Remove the crosspieces (3) from the cylinder head.

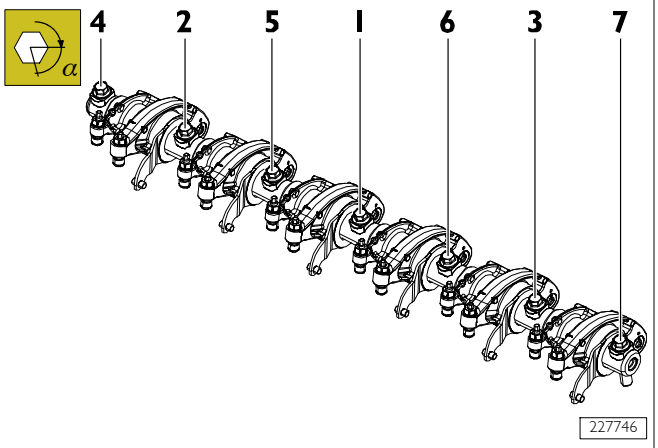
Refitting

Figure 104



Apply the tool 99360553 (1) to the rocker arm shaft (2) and mount the shaft on the cylinder head.

Figure 105



227746

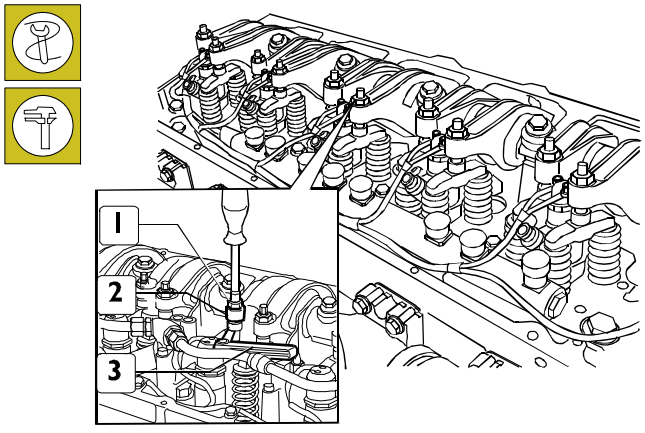
Screw the screws in four steps as follows:

Ref.	No.	Description	Tightening torques
(1 - 7)	7	Screws M16 X 1.5 X 76	
		Step 1	25 Nm
		Step 2	60 Nm
		Step 3	80 Nm
		Step 4	60°

Tightening sequence: 1 - 2 - 3 - 4 - 5 - 6 - 7

Setting rocker free play

Figure 106



114287

Take the cylinder whose clearance has to be adjusted into the combustion phase; the valves of this cylinder are closed as they balance those of the symmetric cylinder.

NOTE The correspondence of the symmetrical cylinders is 1 - 6, 2 - 5 and 3 - 4.

In order to properly operate, follow these instructions and data specified on the table.

By means of a ratchet spanner, loosen the nut (1) locking the adjustment screw.

Insert the feeler gauge blade (3) corresponding to the operating clearance indicated in the table "Data and assembly clearance" in SECTION 7 - Technical specifications.

Use a suitable wrench to screw or unscrew rocker arm (2) adjusting screw.

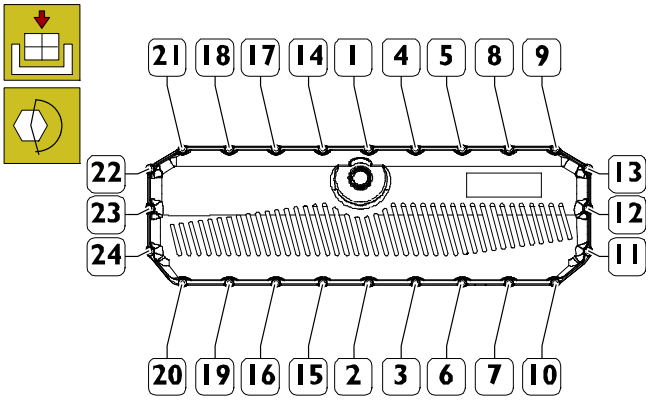
Check that the thickness gauge blade (3) can slide with a slight friction.

Lock the nut (1) holding the adjustment screw still.

To carry out the adjustments stated above, the sequence shown in the table is mandatory.

Start and rotation in the Engine operation	Balancing Adjusting clearance	Adjust valve clearance Adjusting clearance
1 and 6 at T.D.C.	6	1
120 degree of angle [°]	3	4
120 degree of angle [°]	5	2
120 degree of angle [°]	1	6
120 degree of angle [°]	4	3
120 degree of angle [°]	2	5

Figure 107



221122

Position the cover and new gasket and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

Tighten the screws (1-24) to the torque specified in the table.

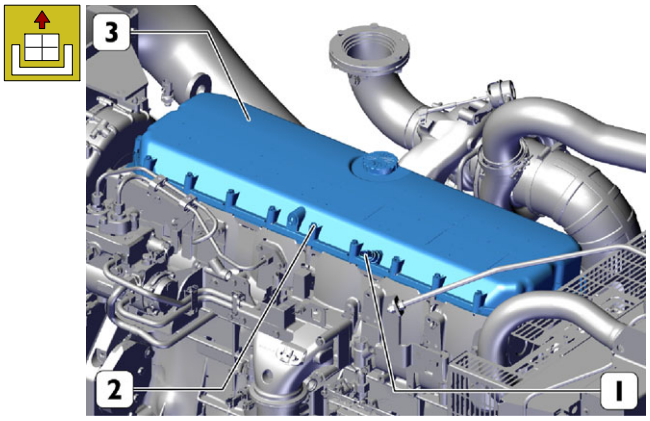
Ref.	No.	Description	Tightening torques
(-)	24	M6 x 1 screws	8.5 ± 1.5 Nm

Connect the electric connection of engine crankcase pressure sensor.

ELECTRO - INJECTORS REMOVAL-REFITTING

Removal

Figure 108

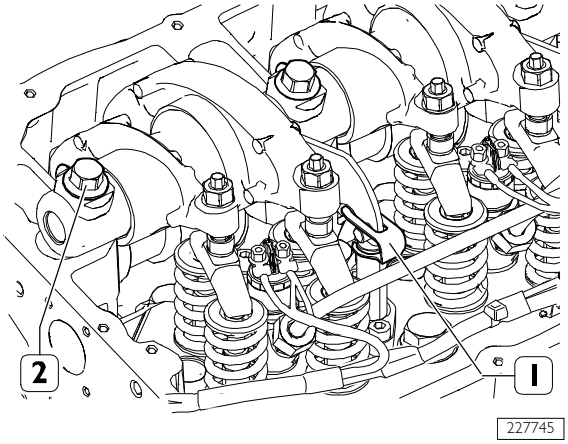


Disconnect the electric connection of engine crankcase pressure sensor.

Unscrew the fastening screws (2) and remove the tappet cover (3) together with the gasket.

Ref.	No.	Description
(2)	24	M6 x 1 screws

Figure 109

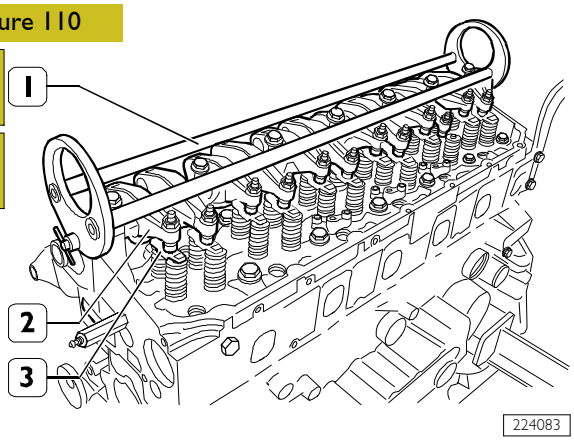


Release the retainer springs of the engine brake (1).

Unscrew the screws (2) securing the rocker arm shaft.

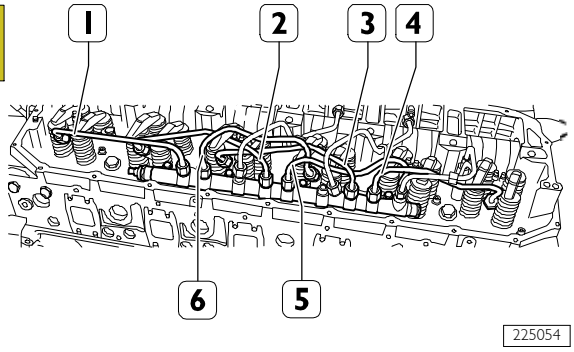
Ref.	No.	Description
(2)	7	Screws M16 X 1.5 X 76

Figure 110



Use the specified tool 99360553 (1) on the rocker arm shaft (2) and remove the shaft (2) from the cylinder head. Remove the crosspieces (3) from the cylinder head.

Figure 111

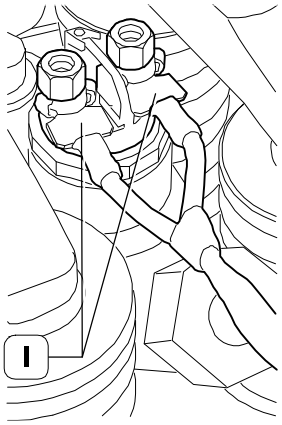


Unscrew fittings on rail side, injector side, and remove the HP fuel pipes (1, 2, 3, 4, 5, 6).

The high pressure fuel pipes must be replaced at each disassembly.

Ref.	No.	Description
(1 - 6)	12	Fittings M16 X 1.5

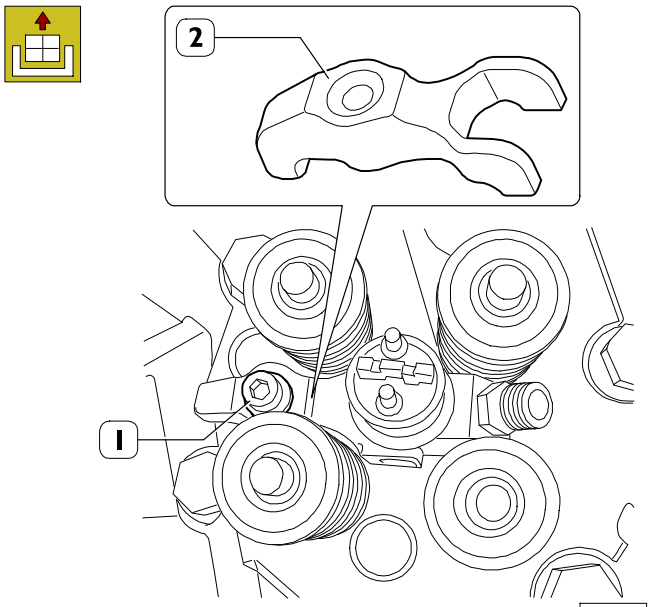
Figure 112



Unscrew the nuts and disconnect the electrical connections (1) from the electro-injectors.

Ref.	No.	Description
(1)	12	Nuts M4

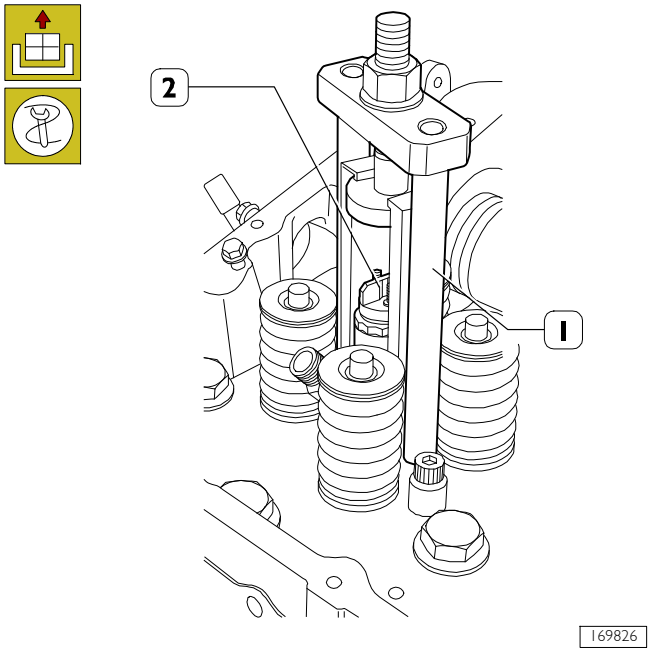
Figure 113



Remove the screws (1) from the brackets (2) supporting the injectors.

Ref.	No.	Description
(1)	6	Screws M8 X 1.25 X 45

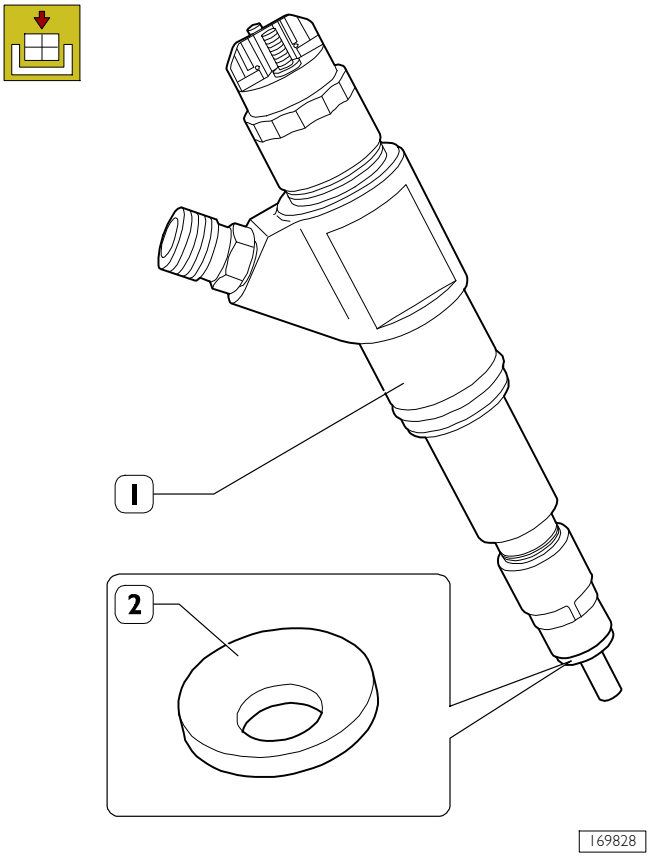
Figure 114



Position the specified tool 99342157 (1) and extract the injectors (2) from the head.

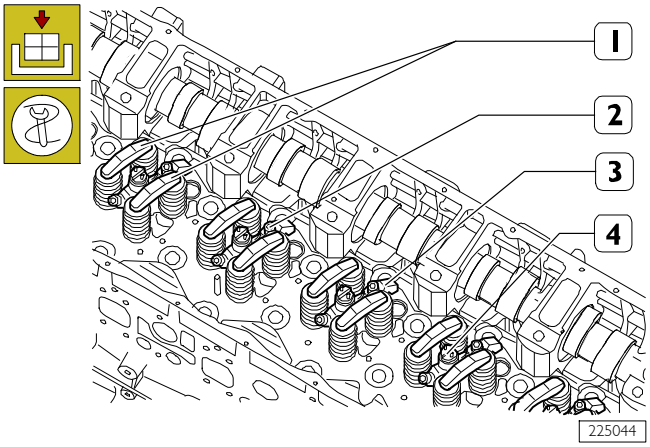
Refitting

Figure 115



Fit the sealing gasket (2) on the injectors (1).

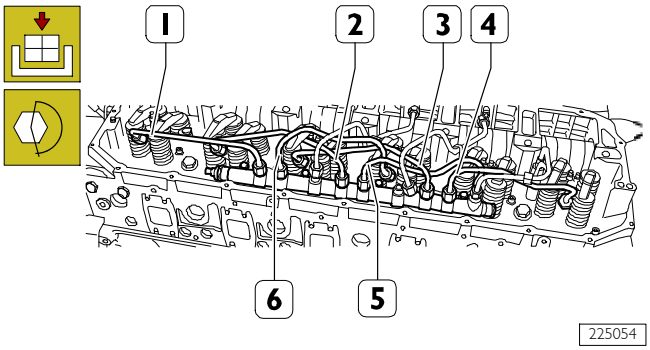
Figure 116



Fit the retaining brackets (3) on the injectors (4) and position them in the relevant seats in the cylinder head. Position the screws (2)

Fit the crosspieces (1) on the valve stem all with the largest hole on the same side.

Figure 117



Connect the high pressure fuel pipes and tighten the fittings by hand in the sequence (1, 2, 3, 6, 5, 4) to the rail and the injectors.

NOTE Before tightening the fittings to torque make sure that the pipes (1) are not touching each other.

The high pressure fuel pipes must be replaced at each disassembly.

Complete injector assembly operations by tightening the bracket fastening screws to the torque shown in the table.

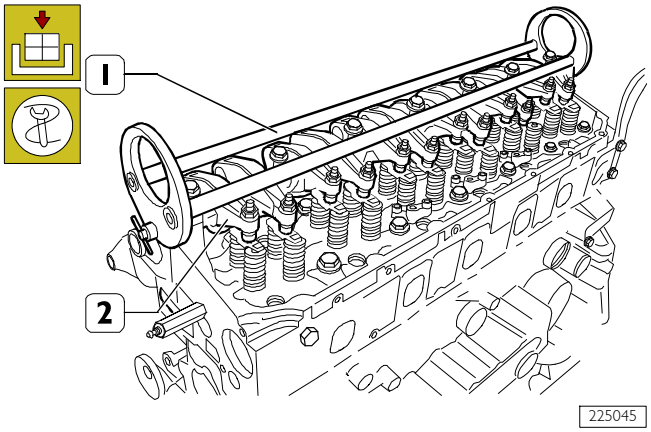
Ref.	No.	Description	Tightening torques
(-)	6	Screws M8 X 1.25 X 45	35 ± 2 Nm

Complete assembly of the high pressure fuel pipes (1, 2, 3, 6, 5, 4) by first tightening the injector side fittings and then those on the rail side to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1 - 6)	12	Fittings M16 X 1.5	42.5 ± 2 Nm

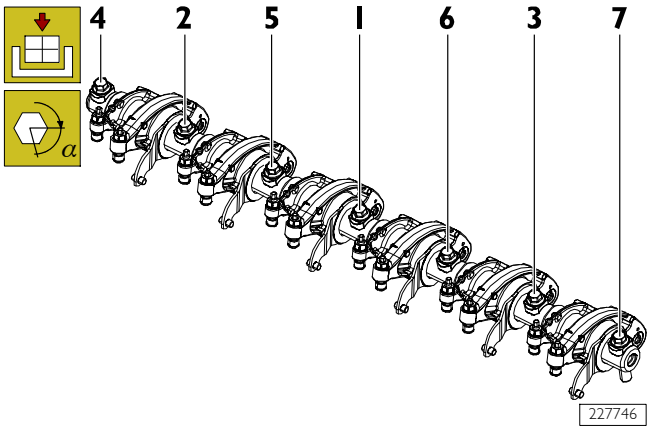
NOTE before refitting the rocker-arm shaft assembly, make sure that all the adjustment screws have been fully unscrewed.

Figure 118



Apply the tool 99360553 (1) to the rocker arm shaft (2) and mount the shaft on the cylinder head.

Figure 119



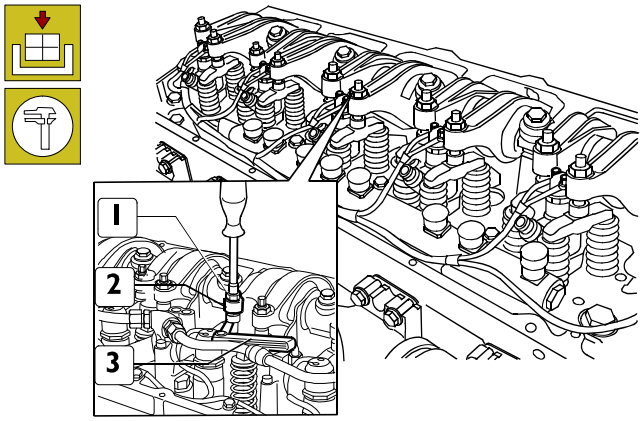
Screw the screws in four steps as follows:

Ref.	No.	Description	Tightening torques
(1 - 7)	7	Screws M16 X 1.5 X 76	
		Step 1	25 Nm
		Step 2	60 Nm
		Step 3	80 Nm
		Step 4	60°

Tightening sequence: 1 - 2 - 3 - 4 - 5 - 6 - 7.

Setting rocker free play

Figure 120



114287

Take the cylinder whose clearance has to be adjusted into the combustion phase; the valves of this cylinder are closed as they balance those of the symmetric cylinder.

NOTE The correspondence of the symmetrical cylinders is 1 - 6, 2 - 5 and 3 - 4.

In order to properly operate, follow these instructions and data specified on the table.

By means of a ratchet spanner, loosen the nut (1) locking the adjustment screw.

Insert the feeler gauge blade (3) corresponding to the operating clearance indicated in the table "Data and assembly clearance" in SECTION 7 - Technical specifications.

Use a suitable wrench to screw or unscrew rocker arm (2) adjusting screw.

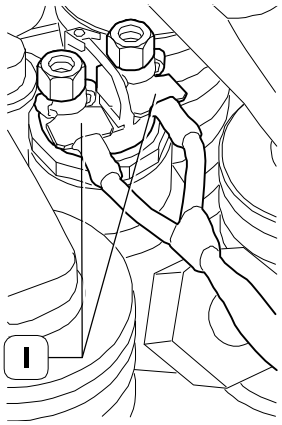
Check that the thickness gauge blade (3) can slide with a slight friction.

Lock the nut (1) holding the adjustment screw still.

To carry out the adjustments stated above, the sequence shown in the table is mandatory.

Start and rotation in the engine direction	Balancing cylinder valves no.	Adjust valve clearance for cylinder no.
1 and 6 at T.D.C.	6	1
120 degree of angle [°]	3	4
120 degree of angle [°]	5	2
120 degree of angle [°]	1	6
120 degree of angle [°]	4	3
120 degree of angle [°]	2	5

Figure 121

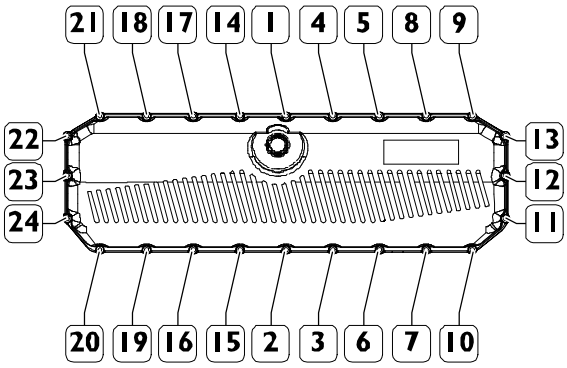


183457

Connect the electrical connections (1) to the injectors and block the cables using cable clamps.

Ref.	No.	Description	Tightening torques
(1)	12	Nuts M4	1.5 ± 0.25 Nm

Figure 122



221122

Position the cover and new gasket and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

Tighten the screws (1-24) to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(-)	24	M6 x 1 screws	8.5 ± 1.5 Nm

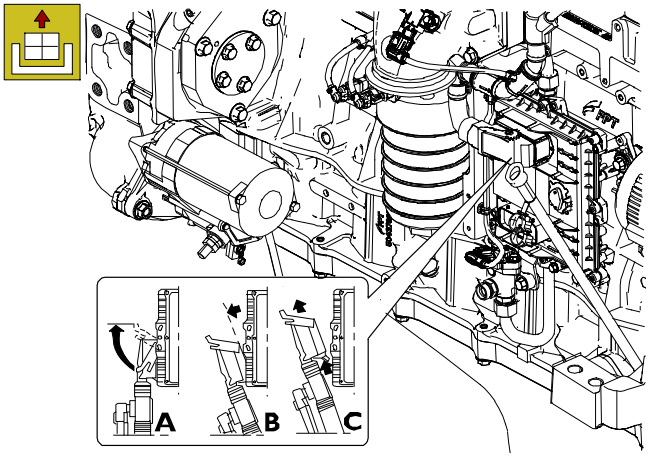
Connect the electric connection of engine crankcase pressure sensor.

CYLINDER HEAD REMOVAL-REFITTING

Remove the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING".

Removal

Figure 123



225041

Free the clips fixing the engine cable.

Disconnect the electrical connections of the sensors.

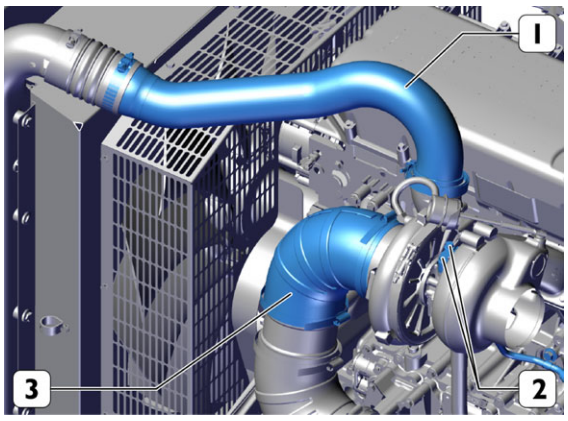
Lift the safety lever (A).

Move the connector, disconnecting it from the control unit (B).

Lift the connector, releasing the pawl (C).

Remove the engine cable.

Figure 124



227760

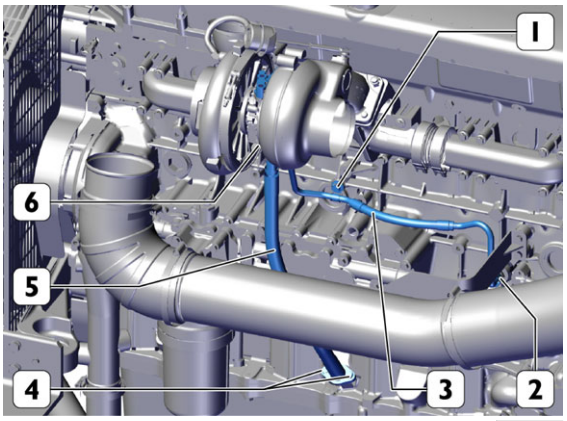
Slacken the clamp and collar and remove the combustion air intake pipe (1) to the aftercooler.

Undo the screws (2) of the oil deliver pipe to turbocharger

Ref.	No.	Description
(2)	2	M8 x 1.25 screws

Slacken the clamps and remove the sleeve (3) of the combustion air intake pipe to the turbocharger.

Figure 125



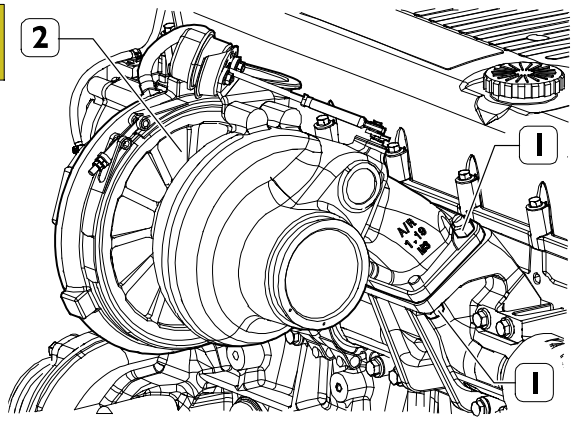
227761

Loosen the screw of the bracket (1) and fitting (2) and remove the oil supply pipe to the turbocharger (3).

Undo the screws (4, 6) and remove the oil return pipe from the turbocharger (5) with its gaskets.

Ref.	No.	Description
(1)	1	M10 screw
(2)	1	Fitting M16 X 1.5 X 12
(4, 6)	4	M8 x 1.25 screws

Figure 126



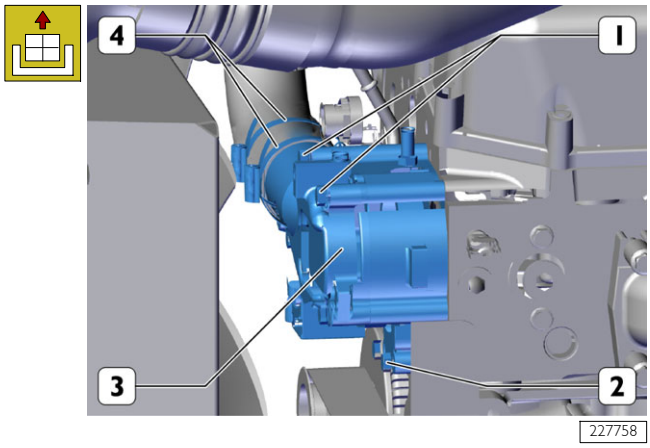
225025

Unscrew the nuts (1) and remove the turbocharger (2) from the exhaust manifold along with its gasket.

Ref.	No.	Description
(1)	4	Nuts M12 X 1.75

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

Figure 127

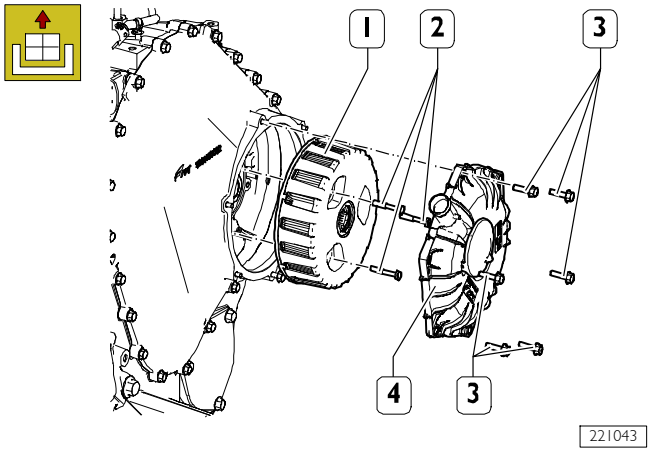


Slacken the clamps (4) and from the thermostat (3) disconnect the coolant supply pipe to the radiator assembly.

Unscrew the screws (1, 2) and remove the thermostat box (3), thermostat and relative gaskets.

Ref.	No.	Description
(1)	5	Screws M8 X 1.25 X 100
(2)	2	Screws M8 X 1.25 X 50

Figure 128



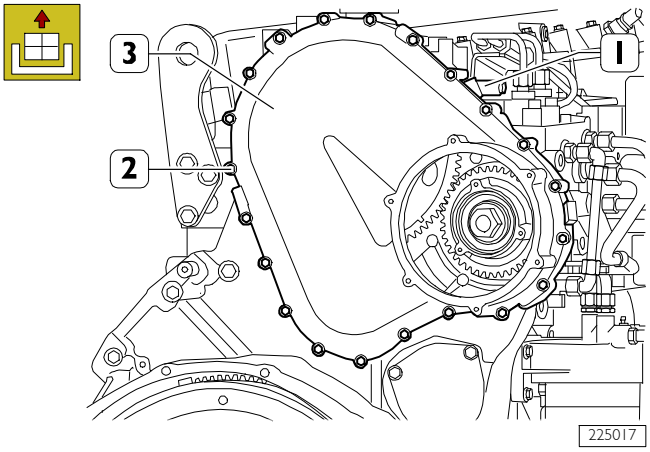
Unscrew the screws (3) and remove the blow-by cover (4).

Unscrew the screws (2) and remove the blow-by filter element (1)

Ref.	No.	Description
(2)	3	Screws M6 X 1 X 40
(3)	6	Screws M6 X 1 X 25

Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law.

Figure 129

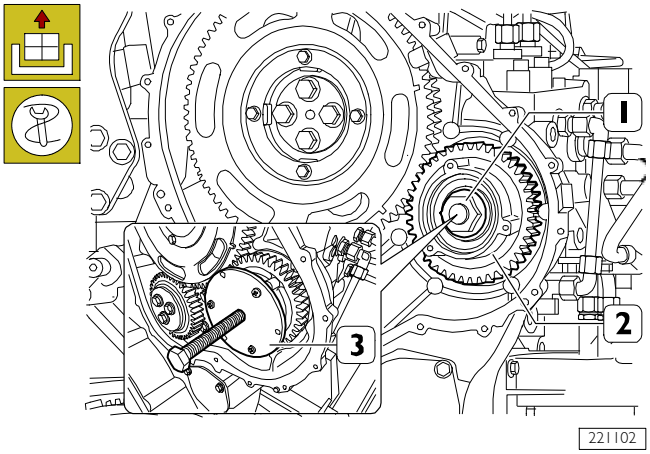


Remove the timing sensor (1).

Unscrew the screws (2) and remove the distribution cover (3).

Ref.	No.	Description
(1)	1	M6 X 12
(2)	21	Screws M6 X 1.0 X 25

Figure 130

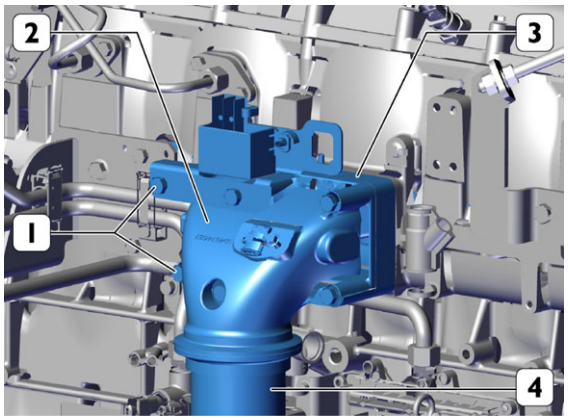


Undo the nut (1).

Apply the tool to extract the high pressure pump gear 99366198 (3) and remove the high pressure pump control gear (2).

Ref.	No.	Description
(1)	1	Nut M24 X 1.5

Figure 131

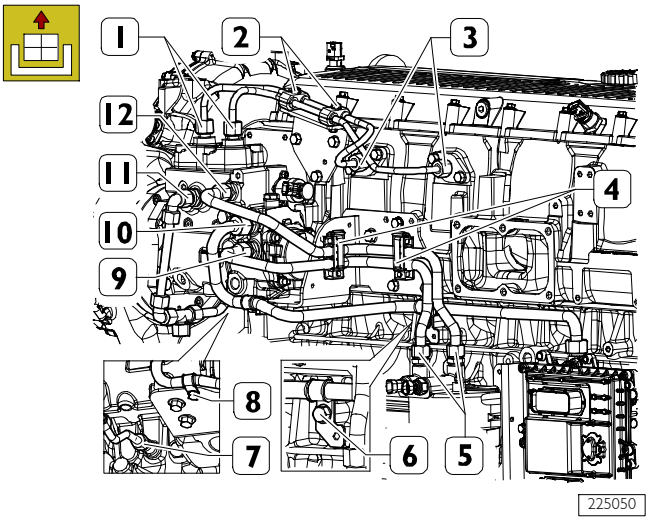


Disconnect the combustion air intake pipe to the engine (4) acting on the clamp.

Unscrew the screws (1) and remove the intake manifold (2) together with the engine preheating resistor (3) and its gasket.

Ref.	No.	Description
(1)	3	Screws M10x1.5x100
(1)	2	Screws M10x1.5x130
(1)	1	Screw M10x1.5x150

Figure 132



Unscrew the nutes (2), remove the plugs, undo the fittings (1, 3) and remove the HP fuel pipes.

Ref.	No.	Description
(1, 3)	4	Fittings M16 X 1.5
(2)	2	Nuts M6 X 1

The HP pipes that are disassembled cannot be used again and must always be replaced.

Open springs (4), remove the fittings (5, 9, 12) and remove the LP fuel pipes from pump to filter and from filter to pump.

Ref.	No.	Description
(5, 9, 12)	4	Fittings M18 X 1.5

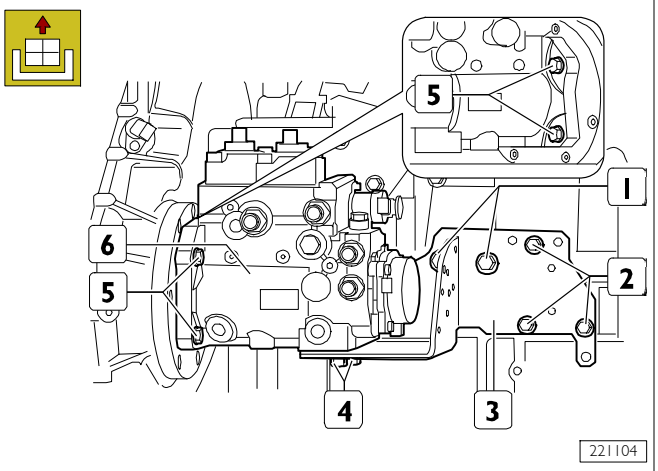
Undo the fitting (10), bracket retainer screws (6, 8) and move the LP fuel pipe from control unit to pump off to the side.

Ref.	No.	Description
(6, 8)	2	Screws M8 X 1.25 X 16
(10)	1	Fitting M22 X 1.5

Unscrew the fittings (7, 11) and remove the fuel return pipe.

Ref.	No.	Description
(7, 11)	2	Fittings M18 X 1.5

Figure 133

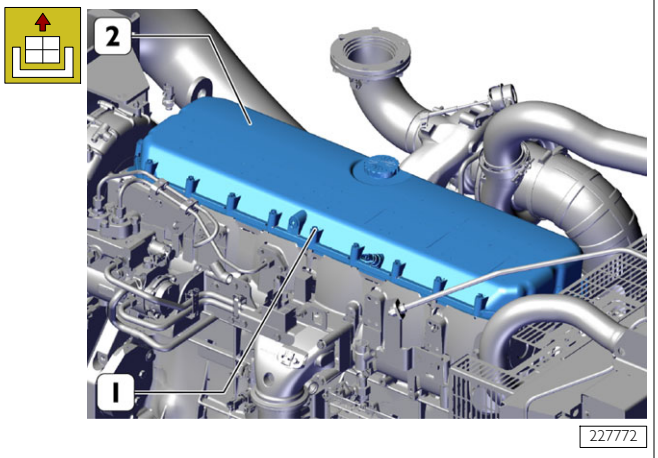


Unscrew the screws (1,2,4) and remove the pump support bracket (3).

Unscrew the screws (5) and remove the high pressure pump (6).

Ref.	No.	Description
(1)	2	Screws M10 X 1.5 X 20
(2)	2	Screws M8 X 1.25 X 20
(4)	2	Screws M12 X 1.75 X 30
(5)	4	Screws M12 X 1.5

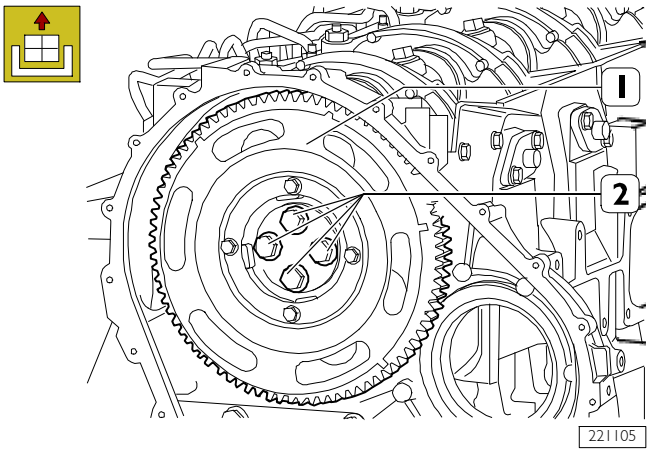
Figure 134



Unscrew the fastening screws (1) and remove the head cover (2) together with the gasket.

Ref.	No.	Description
(1)	24	M6 X 1

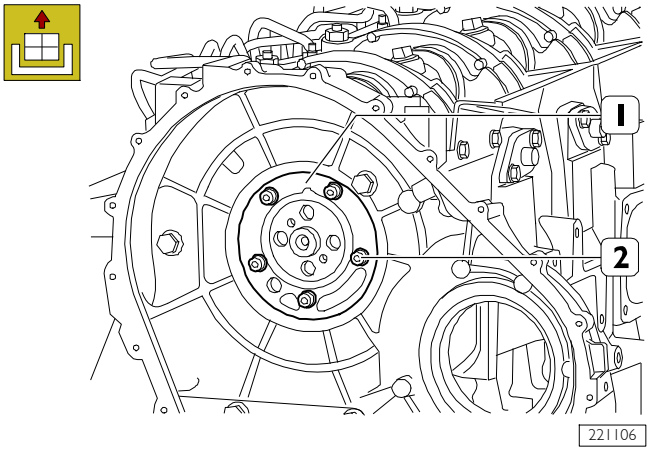
Figure 135



Unscrew the screws (2) and remove the gear (1) fitted with phonic wheel.

Ref.	No.	Description
(2)	4	Screws M14 X 4 X 60

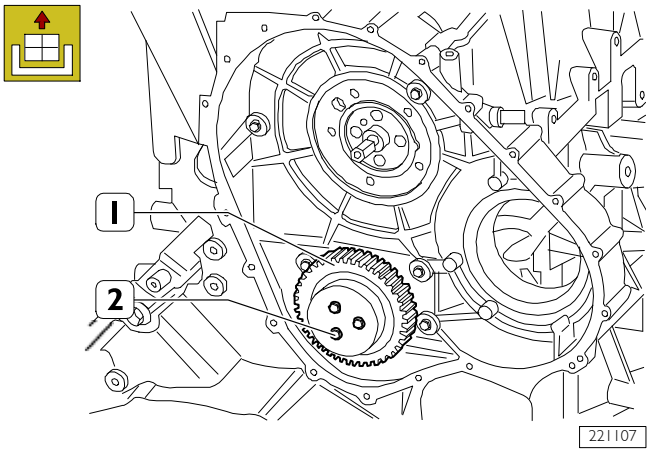
Figure 136



Unscrew the screws (2) and remove the thrust plate (1) and the sheet gasket.

Ref.	No.	Description
(2)	5	Screws M8 X 1.25 X 25

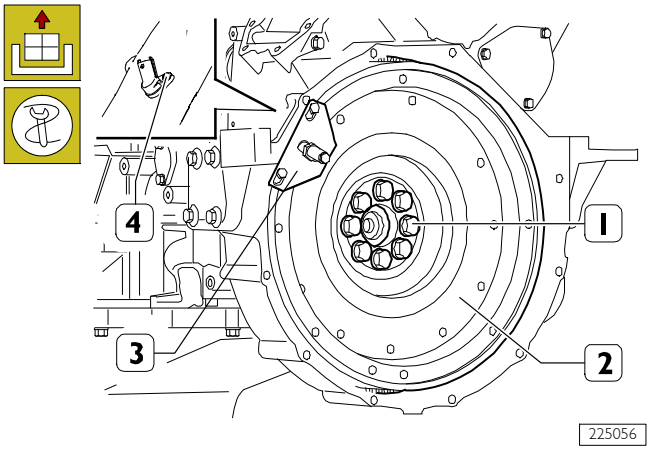
Figure 137



Unscrew the screws (2) and remove the transmission gear (1).

Ref.	No.	Description
(2)	3	Screws M12 X 1.75 X 110

Figure 138

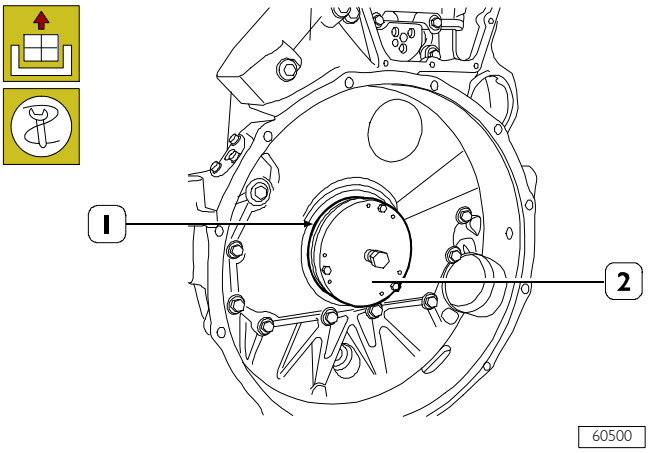


Unscrew the screw and remove the rpm sensor (4).

Using the tool 99360351 to lock the mounted engine flywheel (3) unscrew the retaining screws (1); then remove the tool (3) and remove the engine flywheel (2).

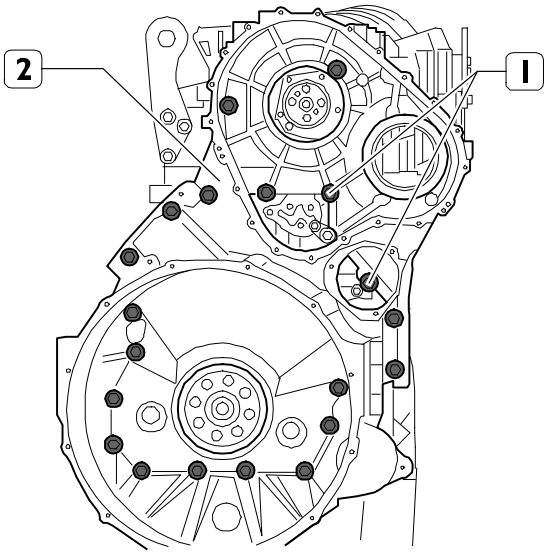
Ref.	No.	Description
(1)	8	Screws M18 X 1.5 X 72
(4)	1	M6 x 12 screw

Figure 139



Fit puller 99340053 (2) and take off the seal (1).

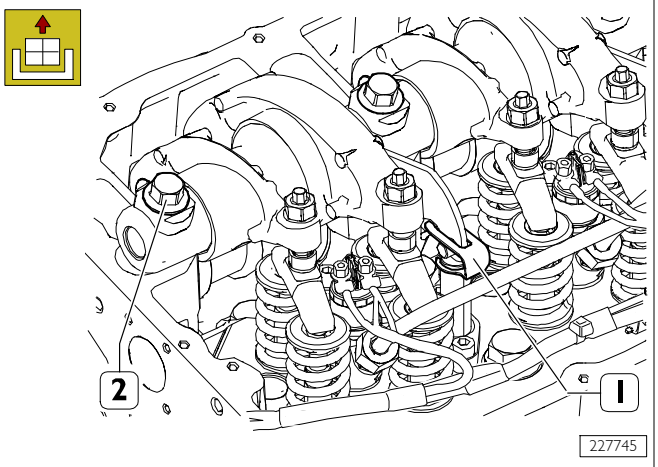
Figure 140



Unscrew the screws (1) and remove the flywheel case (2).

Ref.	No.	Description
(1)	10	Screws M12 X 1.75 X 100
(1)	4	Screws M12 X 1.75 X 40
(1)	1	Screws M12 X 1.75 X 120
(1)	2	Screws M12 X 1.75 X 193
(1)	2	Screws M12 X 1.75 X 70
(1)	2	Screws M10 X 1.5 X 30

Figure 141

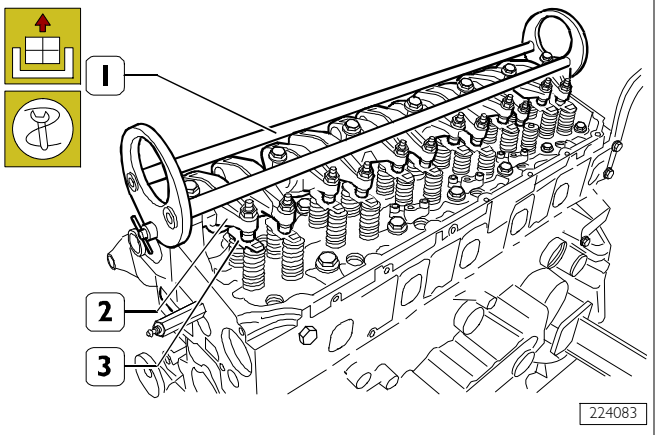


Release the retainer springs of the engine brake (1).

Unscrew the screws (2) securing the rocker arm shaft.

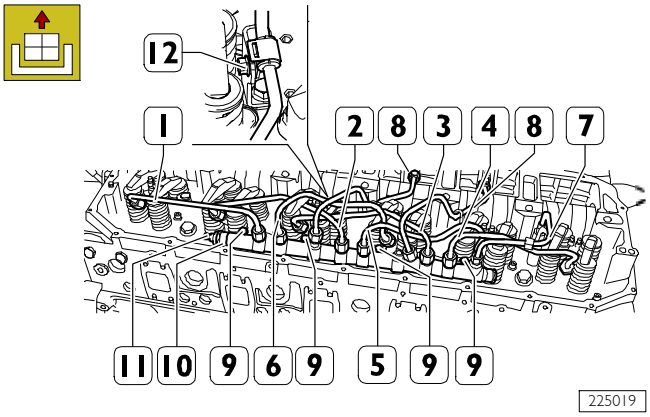
Ref.	No.	Description
(2)	7	Screws M16 X 1.5 X 76

Figure 142



Use the specified tool 99360553 (1) on the rocker arm shaft (2) and remove the shaft (2) and crosspieces (3) from the cylinder head.

Figure 143



Unscrew the fittings (8), the screw of the bracket (12) and remove the high pressure fuel supply pipes (8).

Unscrew the fittings from the rail and the injectors and remove the high pressure fuel pipes (1, 2, 3, 4, 5, 6) and the fuel return pipe (7) from the head.

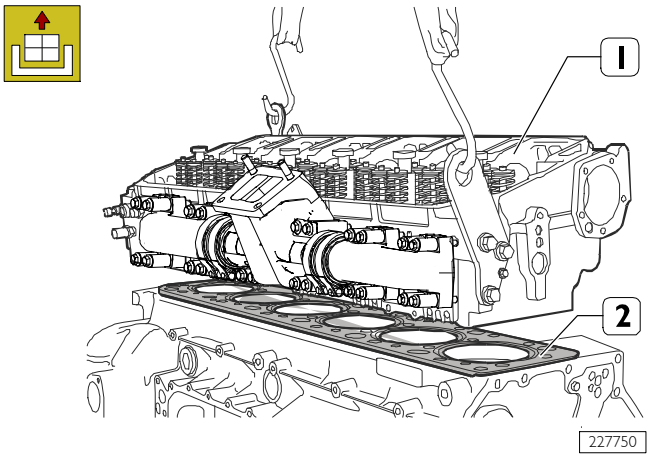
The high pressure fuel pipes must be replaced at each disassembly.

Disconnect the electric connection from pressure sensor (11).

Unscrew the fastening screws (9) and remove the rail (10).

Ref.	No.	Description
(1 - 6)	12	Fittings M16 X 1.5
(7)	2	Fittings M16 X 1.5
(8)	4	Fittings M16 X 1.5
(9)	3	Screws M8 X 1.25 X 55
(12)	2	Screws M8 X 1.25 X 16

Figure 144



Unscrew the cylinder head screws .

Ref.	No.	Description
(-)	20	Screws M18 X 2 X 196
(-)	6	Screws M18 X 2 X 175

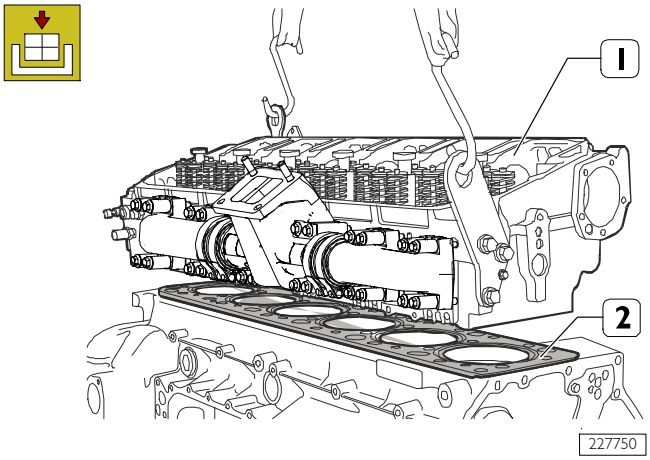
NOTE The cylinder head fastening screws are to be replaced each time you remove them.

By means of metal ropes, lift the cylinder head (1).

Remove the seal gasket (2).

Refitting

Figure 145

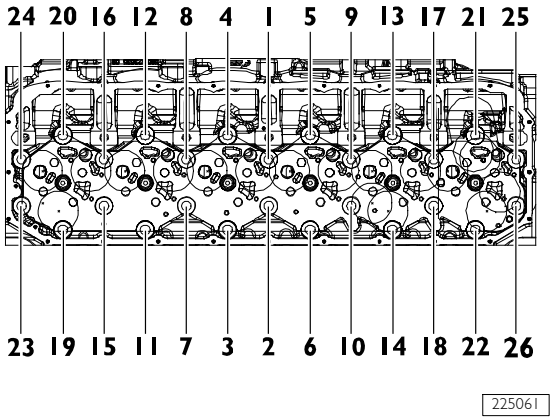


Check that the pistons: 1 and 6 are exactly at the T.D.C.

Put the sealing gasket (2) on the crankcase.

Place the cylinder head (1) on the crankcase.

Figure 146

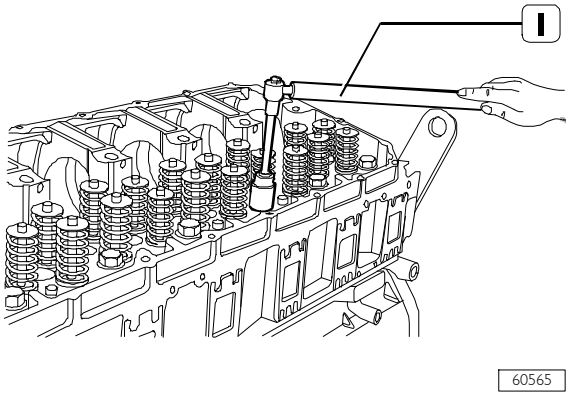


Tighten the fastening screws in the sequence shown in the figure.

NOTE New screws must be used at each assembly of the head.

Lubricate the thread of the screws with engine oil before assembly.

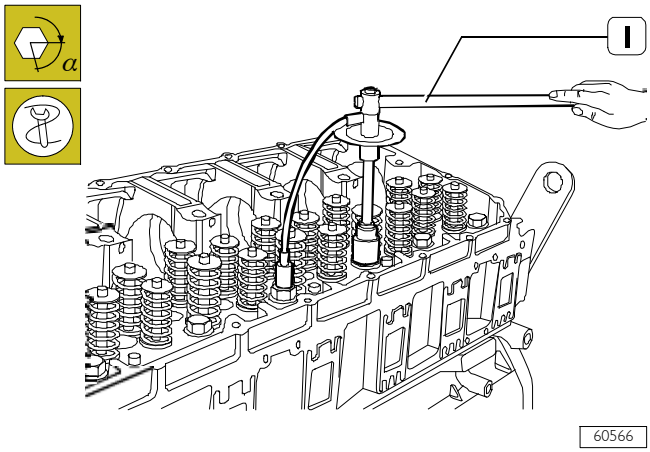
Figure 147



Pre-tighten using the torque wrench (1) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(-)	20	Screws M18 X 2 X 196	
(-)	6	Screws M18 X 2 X 175 Step 1 Step 2	 75 Nm 150 Nm

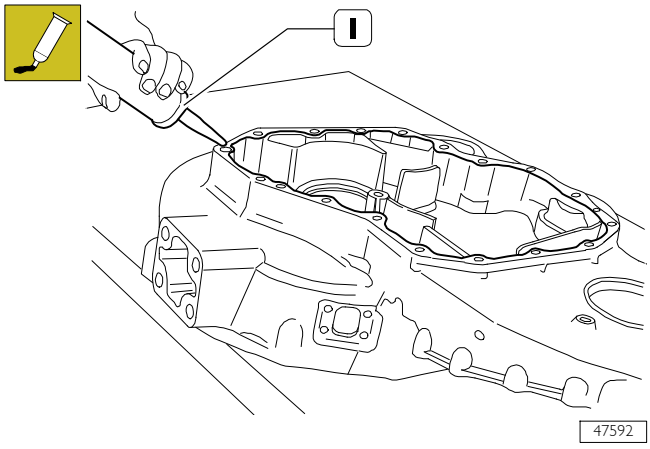
Figure 148



Use tool 99395216 (1) for angle tightening to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(-)	20	Screws M18 X 2 X 196	
(-)	6	Screws M18 X 2 X 175 Step 1 Step 2	 90 ° 90 °

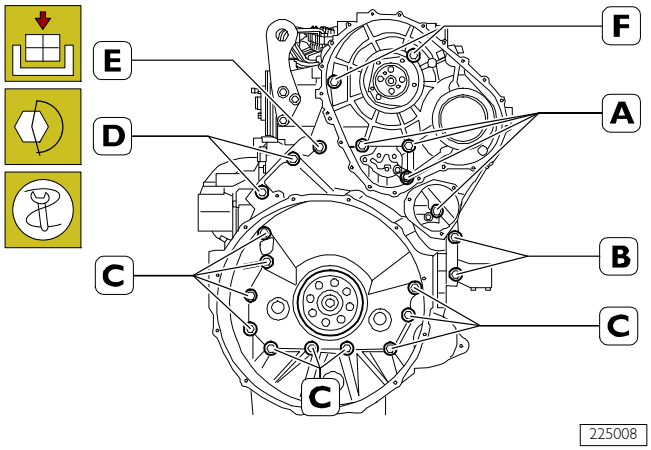
Figure 149



Apply LOCTITE 5970 onto the housing using the designated tool (1) as indicated in the figure.

NOTE Fit the flywheel housing within 10 minutes of applying the sealant.

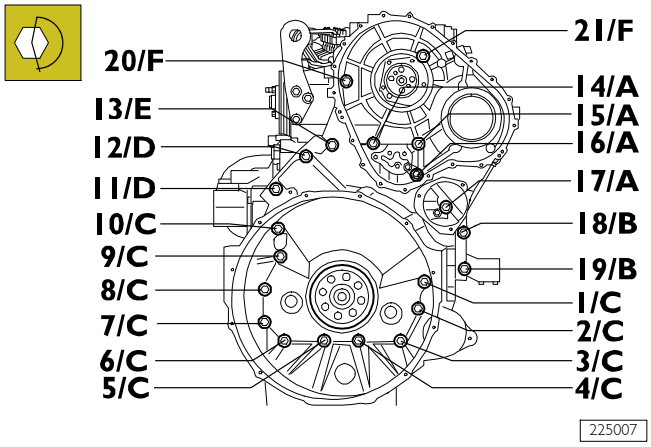
Figure 150



Use a torque wrench to tighten the screws to the torque shown in the table.

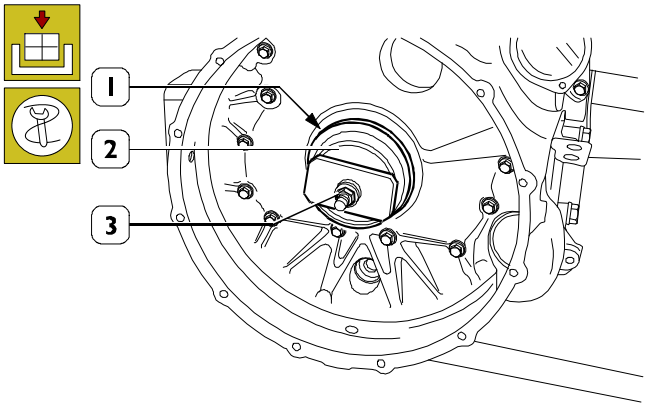
Ref.	No.	Description	Tightening torques
(A)	4	Screws M12 X 1.75 X 40	63 ± 7 Nm
(B)	2	Screws M12 X 1.75 X 70	63 ± 7 Nm
(C)	10	Screws M12 X 1.75 X 100	63 ± 7 Nm
(D)	2	Screws M12 X 1.75 X 193	63 ± 7 Nm
(E)	1	Screws M12 X 1.75 X 120	63 ± 7 Nm
(F)	2	Screws M10 X 1.5 X 30	45.5 ± 4.5 Nm

Figure 151



Tighten the fastening screws following the sequence indicated in the figure.

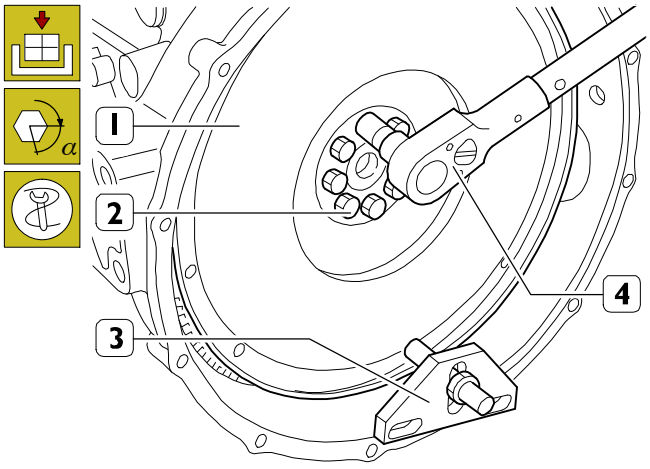
Figure 152



60568

Key the sealing gasket (1) onto the crankshaft, fit the keying device 99346260 (2) and while tightening the nut (3) drive in the sealing gasket.

Figure 153



49037

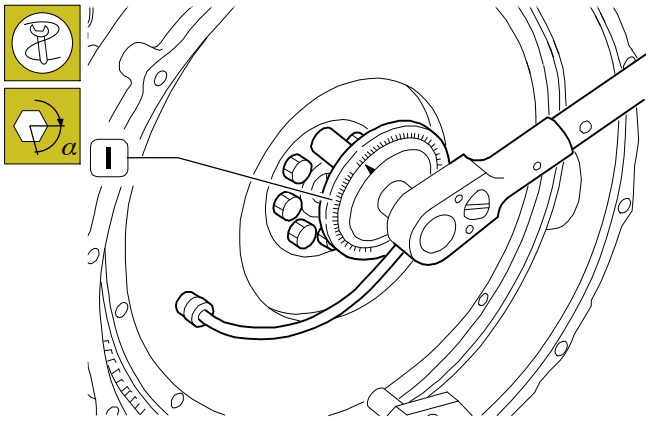
Position the flywheel (1) on the crankshaft, lubricate the thread of the screws (2) with engine oil and screw them down.

Block rotation using the tool used to fasten the engine flywheel housing 99360351 (3); Using the torque wrench (4), tighten the screws (2) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(2)	8	Screws M18 X 1.5 X 72 Step 1 Step 2	 120 ± 6 Nm 90 °

NOTE Lubricate the screws with engine oil.

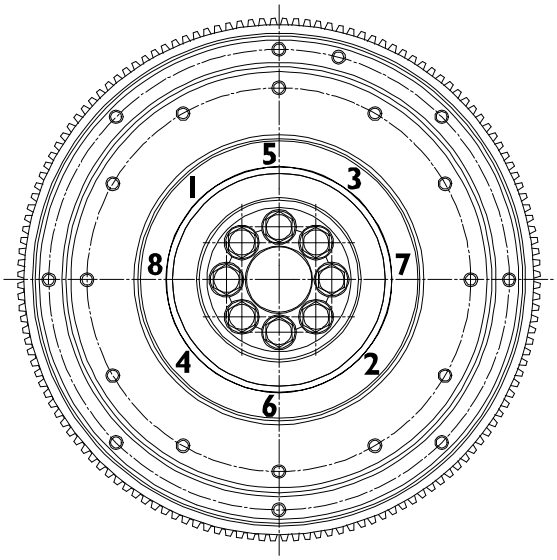
Figure 154



49036

Tighten to angle with wrench 99395216 (1).

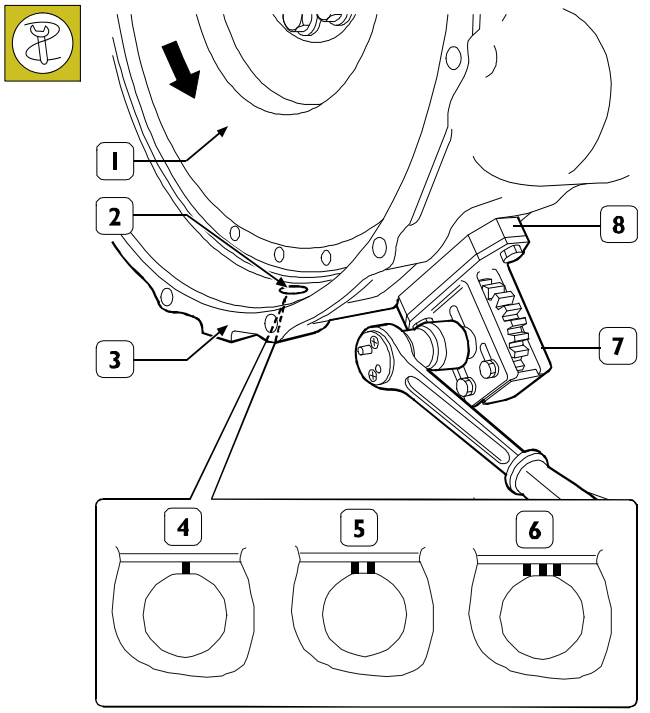
Figure 155



225022

Observe the order of tightening indicated in the diagram.

Figure 156



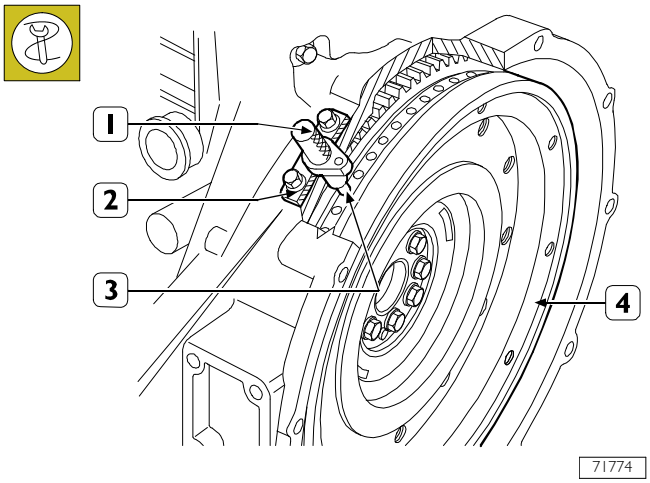
Apply the tool for engine flywheel rotation 99360321 (7) and the specific spacer 99360325 (8) to the gear housing (3).

NOTE The arrow shows the direction of rotation of the engine when running.

With the aforementioned tool, turn the flywheel (1) in the direction of the engine rotation so as to bring cylinder piston 1 to 54° before the T.D.S. during compression (cylinder 6 in discharge phase).

NOTE This condition occurs when the hole with two notches (5) on the engine flywheel (1), can be seen through the small inspection window (2).

Figure 157



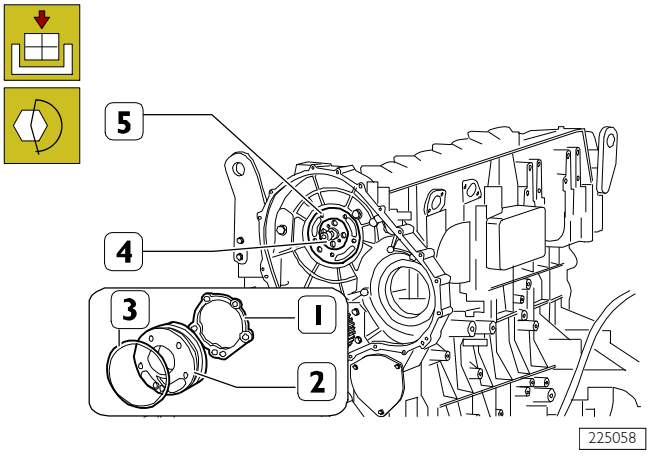
Check that the tool for positioning the T.D.C 99360612 (1), through the seat (2) of the engine speed sensor , enters the hole (3) in the engine flywheel (4). in

in this condition, the flywheel is in the reference position (piston no. 1 to 54° before T.D.C.).

If this is not the case, turn and adjust the engine flywheel (4) appropriately.

Remove tool 99360612 (1).

Figure 158

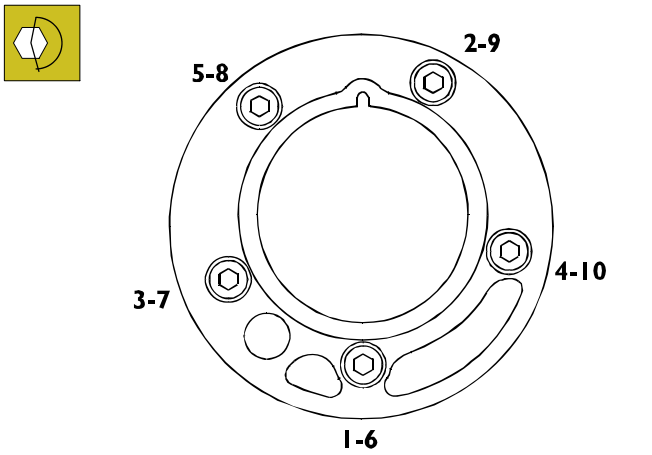


Lubricate the seal (3) and fit it on the shoulder plate (2).

Fit the shoulder plate (2) with the sheet metal gasket (1) and tighten the screws (5) to the torque shown in the table and in the order indicated in the next figure.

Ref.	No.	Description	Tightening torques
(5)	5	Screws M8 X 1.25 X 25	24.5 ± 2.5 Nm

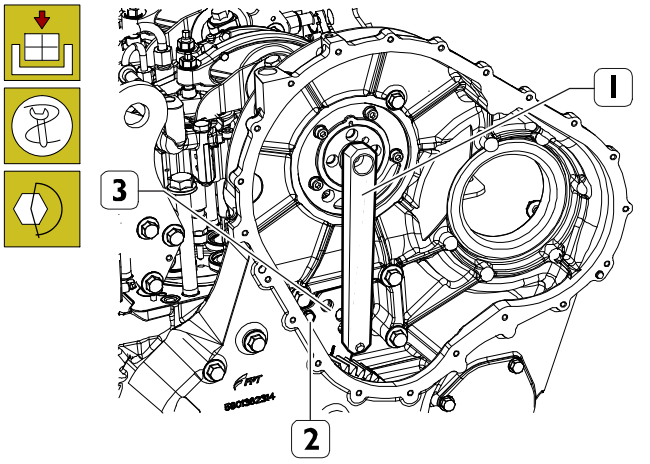
Figure 159



225010

Tightening sequence	
Step 1	1 - 2 - 3 - 4 - 5
Step 2	6 - 7 - 8 - 9 - 10

Figure 160



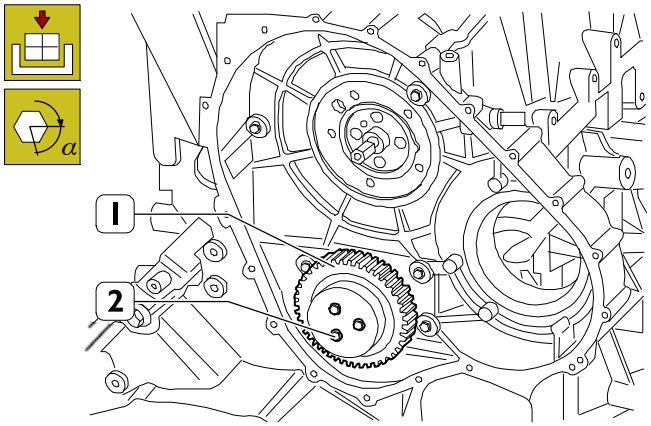
160654

Apply the gauge 99395225 (1).

Check and adjust the position of the connecting rod (3) for the transmission gear; tighten the screw (2) to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(2)	1	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm

Figure 161



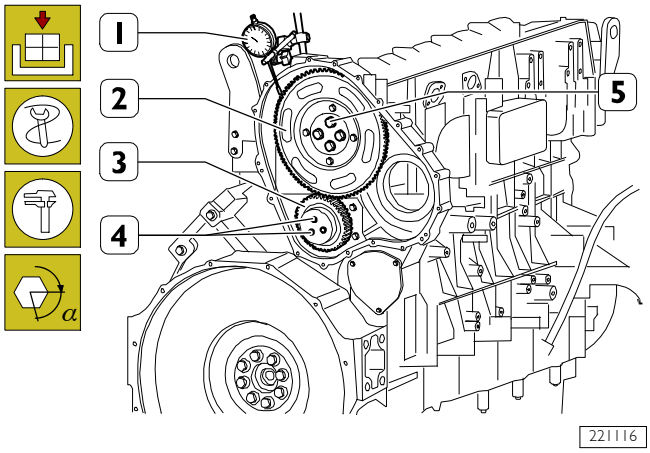
221107

Fit the transmission gear (1) and tighten the screws (2) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(2)	8	Screws M12 X 1.7 X 110 Step 1 Step 2	 30 ± 1.5 Nm 90 °

NOTE Lubricate the screws (2) with engine oil before assembly.

Figure 162



221116

Position the gear (2) on the camshaft so that the 4 slots are centred with the holes for fixing the camshaft, without fully locking the screws (5).

NOTE Lubricate the screws (5) with engine oil before assembly.

With a magnetic dial gauge (1) check clearance between the gears (2, 3), which must be between 0.074 - 0.195 mm, otherwise adjust the clearance as indicated below:

Loosen the screws (4) securing the transmission gear (3).

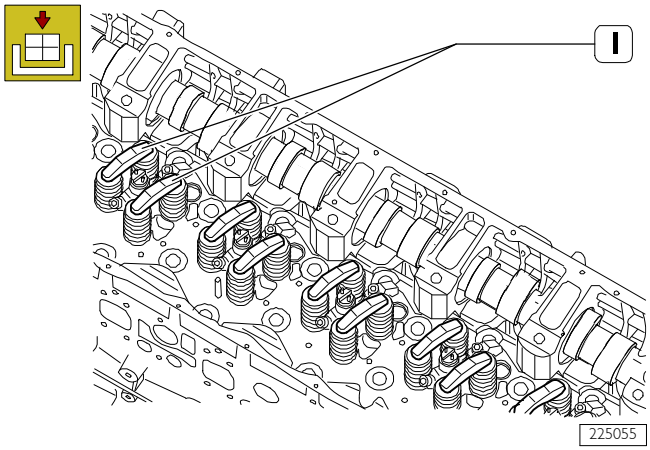
Loosen the connecting rod fixing screw , move the connecting rod in order to obtain the required clearance.

Lock the rod fastening screw (4) and the idle gear fastening screws to the required torque.

Tighten the camshaft drive gear fastening screws (5) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(5)	4	Screws M14 X 4 X 60 Step 1 Step 2	 60 ± 3 Nm 60°

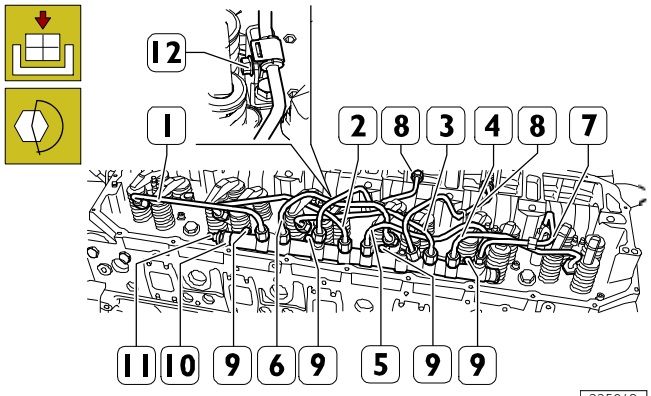
Figure 163



225055

Fit the crosspieces (1) on the valve stem all with the largest hole on the same side.

Figure 164



225019

Fit the rail (10) onto the head and tighten the fastening screws (9) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(9)	3	Screws M8 X 1.25 X 55	24.5 ± 2.5 Nm

Connect the high pressure fuel pipes and tighten the fittings by hand in the sequence (1, 2, 3, 6, 5, 4) to the rail and the injectors.

NOTE Before tightening the couplings to torque make sure that the pipes are not touching each other.

The high pressure fuel pipes must be replaced at each disassembly.

Complete assembly of the high pressure fuel pipes (1, 2, 3, 6, 5, 4) by first tightening the injector side fittings and then those on the rail side to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1 - 6)	12	Fittings M16 X 1.5	42.5 ± 2 Nm

Connect the high pressure fuel supply pipes (8) and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(8)	4	Fittings M16 X 1.5	42.5 ± 2 Nm

Fix the fuel supply pipe to their brackets, tightening the screws (12) to the required torque.

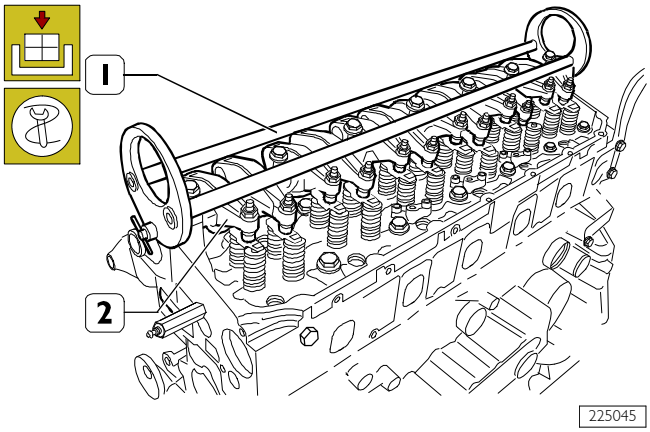
Ref.	No.	Description	Tightening torques
(12)	2	Screws M6	10 ± 1 Nm

Connect the fuel return pipe (7) from the rail and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(7)	2	Fittings M16 X 1.5	35 ± 2 Nm

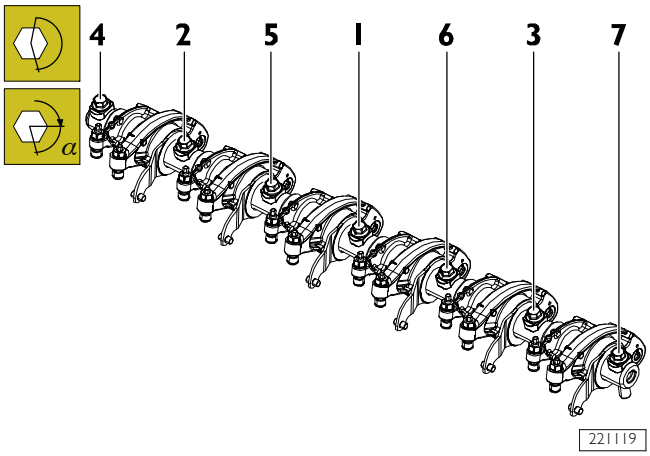
NOTE Use torque wrench 99389833 to tighten fittings of the HP fuel pipes.

Figure 165



Apply the tool 99360553 (1) to the rocker arm shaft (2) and mount the shaft on the cylinder head.

Figure 166

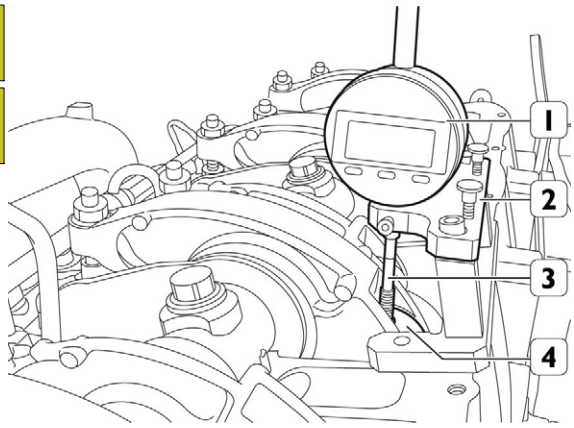


Screw the screws in four steps as follows:

Ref.	No.	Description	Tightening torques
(7)	7	Screws M16 X 1.5 X 76	
		Step 1	25 Nm
		Step 2	60 Nm
		Step 3	80 Nm
		Step 4	60°

Tightening sequence: 1 - 2 - 3 - 4 - 5 - 6 - 7.

Figure 167



Carefully clean the surface of the head on which the rocker arm cover rests.

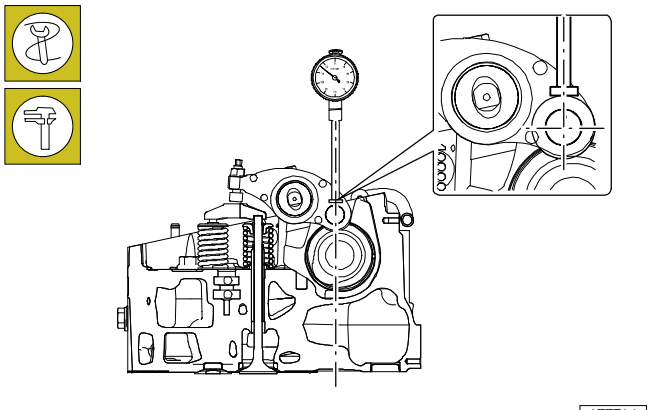
Using the magnetic support 99370400 (2), as shown in the figure, arrange the dial gauge (0-30mm) 99395606 (1) with theflat based rod (3) positioned on the rocker arm roller (4) which controls the exhaust valves of cylinder no. 3 and preload to at least 7 mm.

Position the flat based dial gauge so that its axis passes through the centre of the roller on which it is resting.

During the CHECK phase, not during the engine overhaul phase, the allowed tolerance of the measurement is between -0.05 - +0.12 mm.

The allowed measurement tolerance during OVERHAUL is ± 0.05 mm.

Figure 168



177714

Using the specific tool to turn the engine flywheel 99360321, turn the crankshaft in the opposite direction to that of operation until the pointer of the dial gauge reaches the minimum value beyond which it can no longer fall.

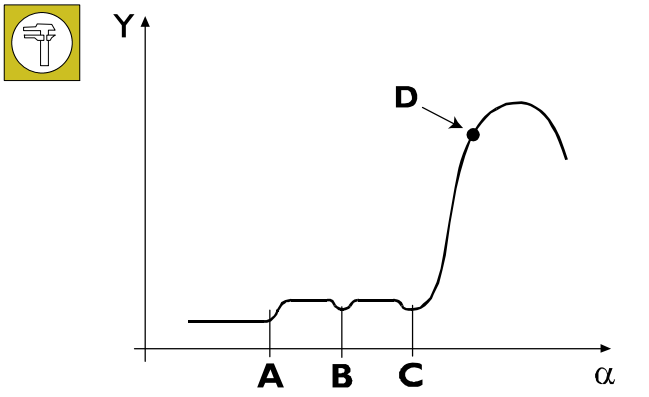
NOTE The measurement must be taken holding the rocker roller in contact with the profile of the exhaust cam of the camshaft.

reset the dial gauge.

NOTE The dial gauge is to be zeroed with the rocker arm roller in contact with the base radius of the cam profile .

This occurs when the flywheel is turned in the opposite direction of the operating direction approx. 1 and 1/4 rotations.

Figure 169



185524

α Camshaft rotation angle

Y Cam lift based on the rotation angle of the camshaft

D Cam lift in correspondence of the 54° before the top dead centre , 1st cylinder end of compression

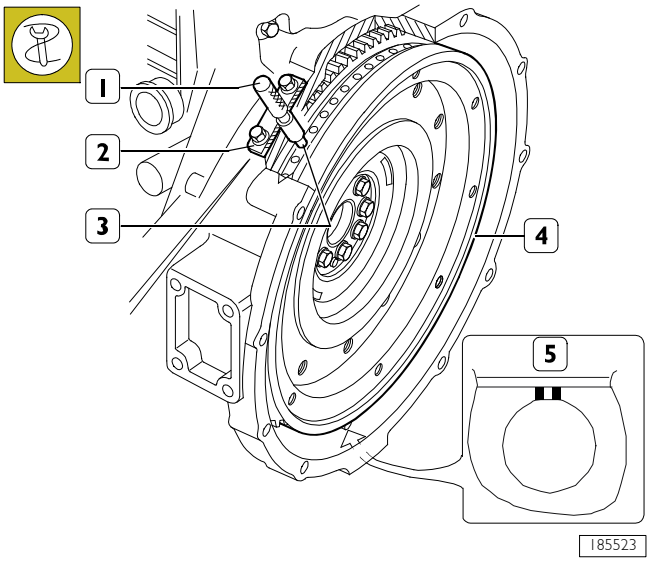
reset the dial gauge first in point A.

NOTE The dial gauge is to be zeroed with the rocker arm roller in contact with the base radius of the cam profile .

For this, turn the flywheel until it exceeds protrusions (A-B) and (B-C) on the cam profile connected to the engine brake operation.

This condition occurs when the flywheel is turned in the opposite direction of the operating direction by approx. 1 and 1/4 rotations.

Figure 170



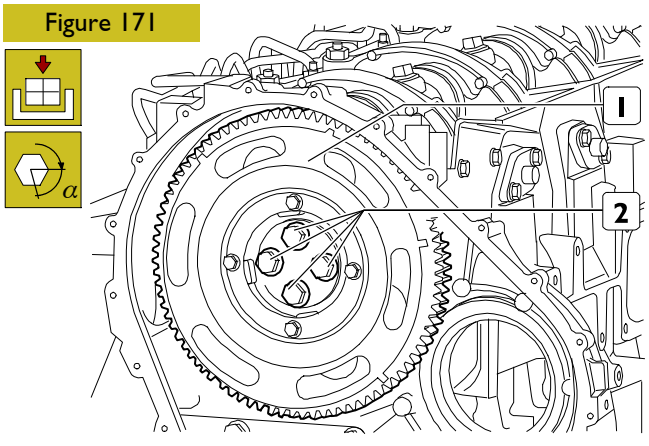
Turn the engine flywheel in the engine operating direction until the dial gauge indicates the required camshaft lift value.

Technical data	
Cam timing dial gauge value	5.95 ± 0.05 mm

Check that the required cam lift values are displayed under the following conditions:

- ❑ The hole with two notches (5) is visible through the small inspection window.
- ❑ The tool 99360612 (1), through the seat (2) of the engine speed sensor , enters the hole (3) in the engine flywheel (4).

Figure 171



Perform the following if the conditions stated have not been obtained:

Turn the engine flywheel until the required cam lift value appears on the dial gauge.

Loosen the screws (2) that fasten the gear (1) to the camshaft and use the slots on the gear (1).

Act on the engine flywheel to obtain the conditions indicated while keeping the cam lift value unchanged.

Lock the screws (2) and repeat timing check as described above.

NOTE While performing this operation recover the clearance between the camshaft gears.

Tighten the screws (2) to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(2)	4	Screws M14 X 4 X 60 Step 1 Step 2	 60 ± 3 Nm 60°

NOTE Lubricate the screws with engine oil.

When adjustment via the slots is not sufficient for recovering the offset, proceed as follows:

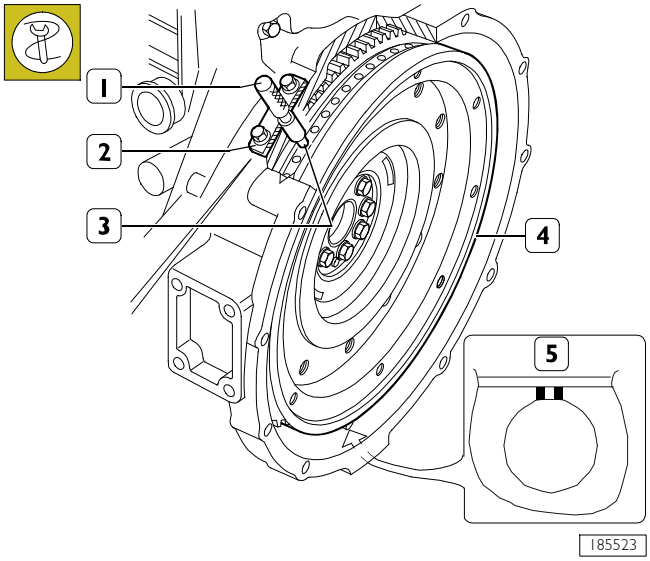
Lock the screws (2) and turn the engine flywheel a 1/2 turn in the opposite direction of the operating direction.

Turn the engine flywheel in the engine operating direction until the dial gauge indicates the required camshaft lift value.

Technical data	
Cam timing dial gauge value	5.95 ± 0.05 mm

Remove the screws (2) and disassemble the camshaft gear (1).

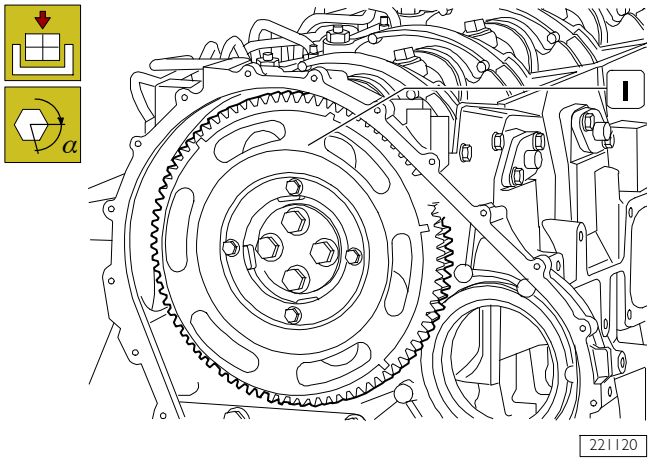
Figure 172



Turn the flywheel (4) again until it reaches the following conditions:

- ❑ The hole with two notches (5) is visible through the small inspection window.
- ❑ The tool 99360612 (1), through the seat (2) of the engine speed sensor , enters the hole (3) in the engine flywheel (4).

Figure 173



Fit the gear (2) with the four slotted holes (1) centred in relation to the holes securing the camshaft and tighten the screws to the torque shown in the table.

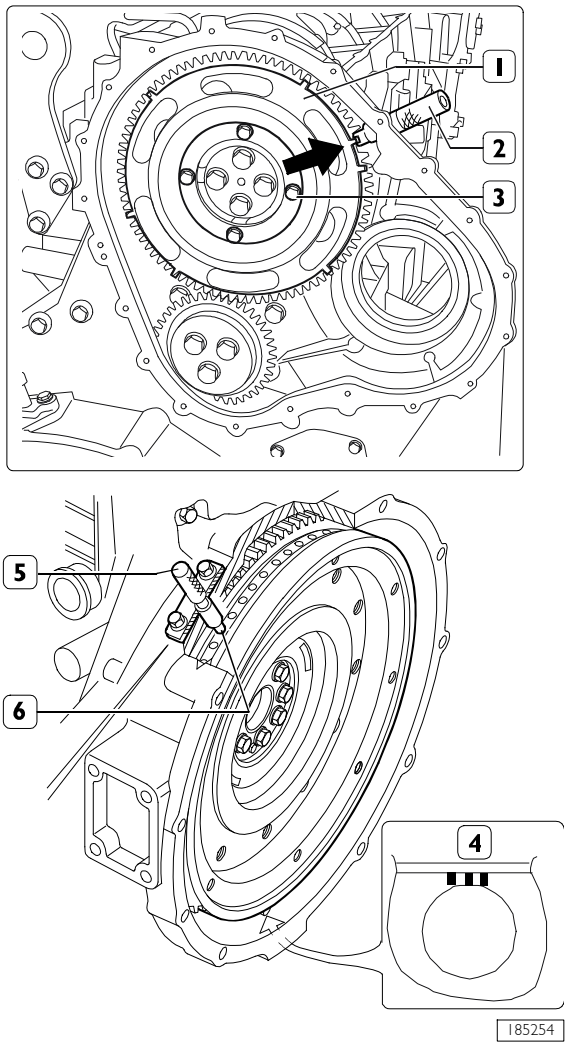
Ref.	No.	Description	Tightening torques
(1)	4	Screws M14 X 4 X 60 Step 1 Step 2	 60 ± 3 Nm 60°

NOTE Lubricate the screws with engine oil.

Recover the clearance between the timing system gears by turning the flywheel in the opposite direction of the engine rotation direction and subsequently turning it in the engine rotation direction until the dial gauge shows the specific value. Check the previously described conditions.

Technical data	
Cam timing dial gauge value	5.95 ± 0.05 mm

Figure 174



Turn the crankshaft bringing cylinder piston no. 1 in compression stage to TDC; turn the flywheel by approximately 1/4 turn in the opposite direction to the normal direction of rotation.

Turn the flywheel again according to normal direction of rotation (anti-clockwise) until the hole marked with the three notches can be seen through the inspection hole under the flywheel housing (4).

NOTE If the engine flywheel does not have 3 notches, to identify the reference hole simply: turn the flywheel in the opposite direction to the operating direction until you reach the position marked with 2 notches (54° before cyl. 1 T.D.C.); continue rotating in the engine operating direction for 4 holes (remember that each hole corresponds to a flywheel rotation of 6°).

Fit tool 99360612 (5) into the flywheel sensor seat (6).

Through the timing sensor, insert the tool for phonic disc timing on the camshaft 99360613 (2) on the tooth (↑) recovered from the phonic wheel.

If the tool (2) is difficult to fit, loosen the screws (3) and direct the phonic wheel (1) properly so as to position the tool (2) on the tooth correctly.

Tighten the screws (3).

Ref.	No.	Description	Tightening torques
(3)	4	M8X1.25 screws	24.5 ± 2.5 Nm

Remove tools 99360612 and 99360613.

High pressure pump assembly

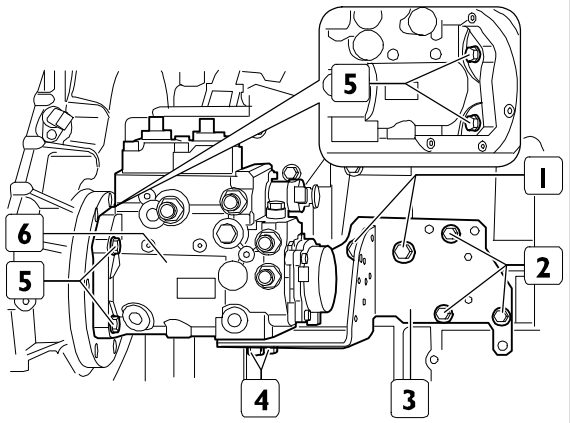
Bring the flywheel to 36° before TDC of the first cylinder.

NOTE This position can be obtained by turning the engine flywheel in the opposite direction to the operating direction in the 30° position marked by THREE notches (4) and continuing to turn the flywheel in the same direction until reaching the next hole (by 6°).

If the engine flywheel does not have 3 notches, to identify the reference hole simply: turn the flywheel in the opposite direction to the operating direction until reaching the position marked with 2 notches (54° before cyl. 1 T.D.C.); continue rotating in the engine operating direction for 3 holes (remember that each hole corresponds to a flywheel rotation of 6°).

Insert the specific tool 99360612 through the seat of the flywheel sensor into the corresponding hole on the flywheel.

Figure 175

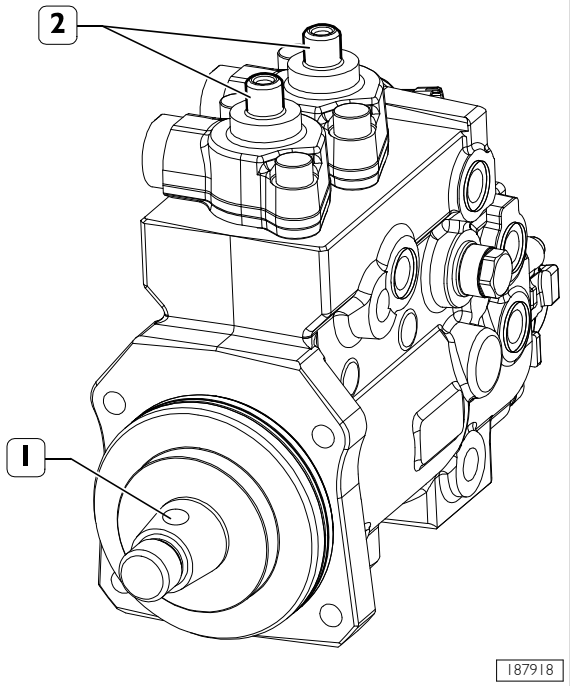


Position the bracket (3) and tighten the screws (1,2).

Position the high pressure pump (6) and tighten the screws (4, 5).

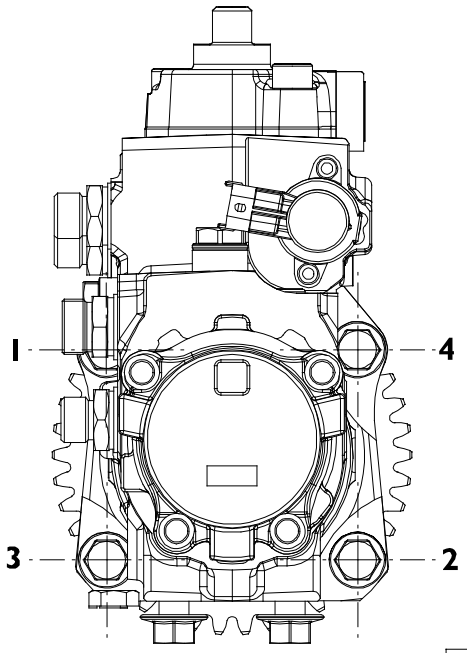
Ref.	No.	Description	Tightening torques
(1)	2	Screws M10 X 1.5 X 20	37.5 ± 5 Nm
(2)	3	Screws M8 X 1.25 X 20	24.5 ± 2.5 Nm
(4)	2	Screws M12 X 1.75 X 30	32.5 ± 2.5 Nm
(5)	4	Screws M12 X 1.5	37.5 ± 2.5 Nm

Figure 176



Fit the high pressure pump and make sure that the seat of the key (1) on the pump shaft is facing the pump intakes (2) .

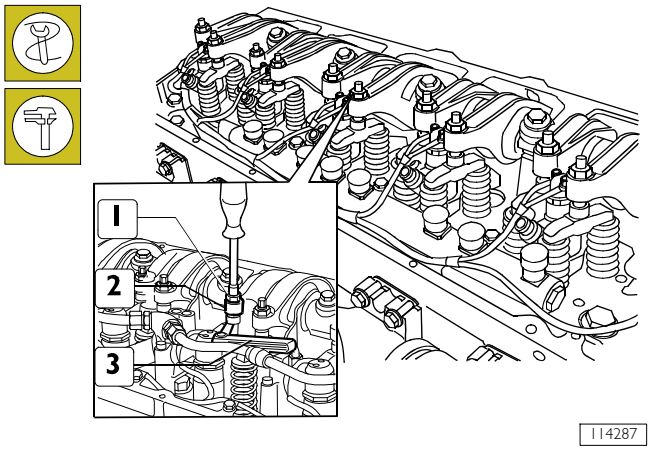
Figure 177



Observe the order of tightening indicated in the diagram.

Setting rocker free play

Figure 178



Take the cylinder whose clearance has to be adjusted into the combustion phase; the valves of this cylinder are closed as they balance those of the symmetric cylinder.

NOTE The correspondence of the symmetrical cylinders is 1 - 6, 2 - 5 and 3 - 4.

In order to properly operate, follow these instructions and data specified on the table.

By means of a ratchet spanner, loosen the nut (1) locking the adjustment screw.

Insert the feeler gauge blade (3) corresponding to the operating clearance indicated in the table "Data and assembly clearance" in SECTION 7 - Technical specifications.

Use a suitable wrench to screw or unscrew rocker arm (2) adjusting screw.

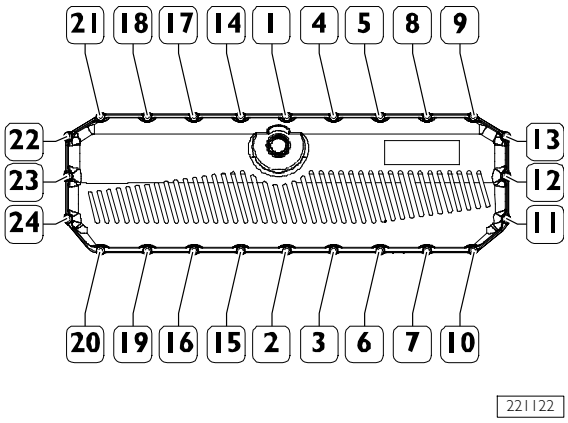
Check that the thickness gauge blade (3) can slide with a slight friction.

Lock the nut (1) holding the adjustment screw still.

To carry out the adjustments stated above, the sequence shown in the table is mandatory.

Start and rotation in the Engine operation	Balancing Adjusting clearance	Adjust valve clearance Adjusting clearance
1 and 6 at T.D.C.	6	1
120 degree of angle [°]	3	4
120 degree of angle [°]	5	2
120 degree of angle [°]	1	6
120 degree of angle [°]	4	3
120 degree of angle [°]	2	5

Figure 179



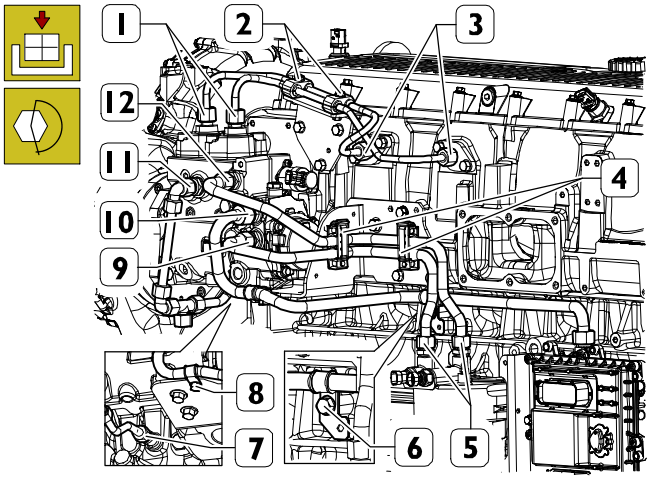
Position the cover and new gasket and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

Tighten the screws (1-24) to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(-)	24	M6 x 1 screws	8.5 ± 1.5 Nm

Figure 180



Fit the HP fuel pipes, fit the plugs onto the bracket and tighten the fittings (1, 3) and nuts (2) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1, 3)	4	Fittings M16 X 1.5	42.5 ± 2 Nm
(2)	2	Nuts M6 X 1	8 ± 2 Nm

Position the LP fuel pipe from control unit to pump, tighten the fitting (10)and bracket screws (6, 8) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(10)	1	Fitting M22 X 1.5	50 ± 5 Nm
(6, 8)	2	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm

Position the LP fuel pipe from pump to filter and vivc-versa and tighten fittings (5, 9, 12) to the torque shown in the table. close springs (4).

Ref.	No.	Description	Tightening torques
(5, 9 12)	4	Fittings M18 X 1.5	37 ± 3 Nm

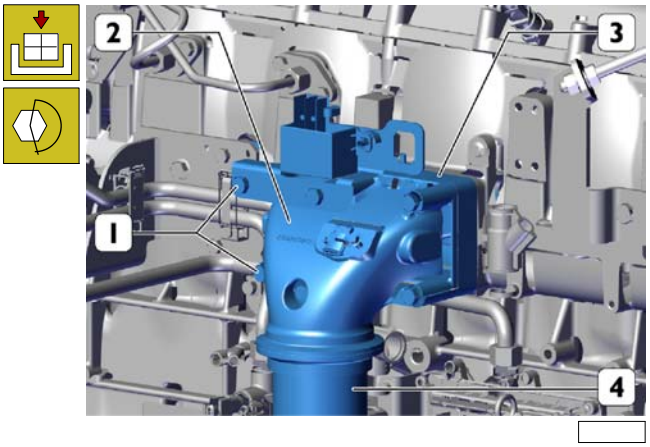
Fit the new fuel return pipe (7, 11) and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(7, 11)	2	Fittings M18 X 1.5	37 ± 3 Nm

NOTE Make sure that the pipe is not damaged after mounting and that there are no fuel leaks while engine is running.

The HP pipes that are disassembled cannot be used again and must be replaced.

Figure 181

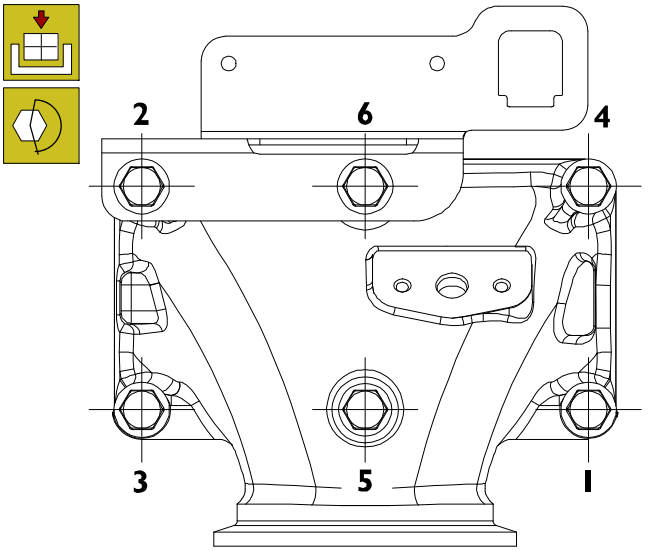


Fit the intake manifold (2) together with the engine preheating resistor (3) and its gasket and tighten screws (1) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M10x1.5x100	50 ± 5 Nm
(1)	2	Screws M10x1.5x130	50 ± 5 Nm
(1)	1	Screw M10x1.5x150	50 ± 5 Nm

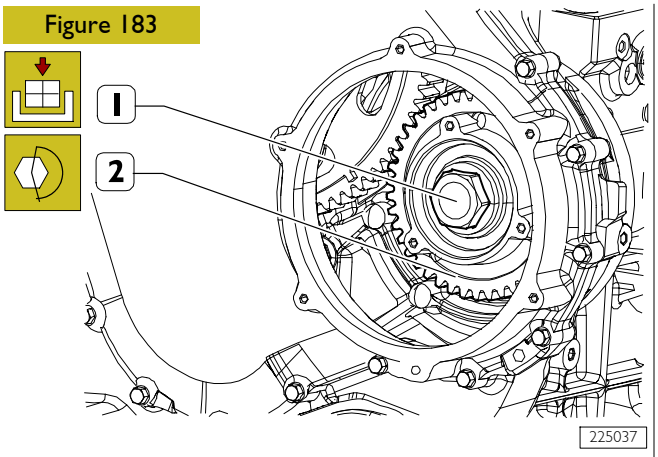
Connect the combustion air intake pipe to the engine (4) and tighten the clamp.

Figure 182



Observe the order of tightening indicated in the diagram.

Figure 183



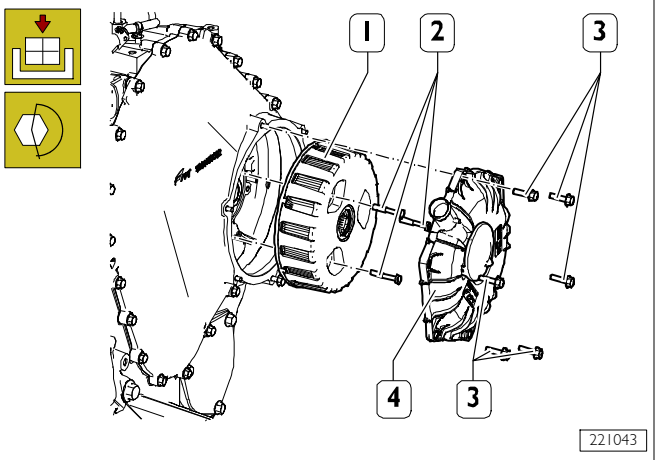
Fit the gear (2) and tighten the nut (1) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Nut M24 X 1.5	275 ± 25 Nm

Remove the tool 99360612 for engine flywheel locking.

NOTE Carefully clean the seating of the filter and the cover.

Figure 184



Fit the new blow-by filtering element (1) into its seat and tighten the screws (2) to the torque indicated in the table.

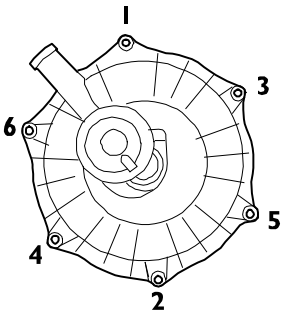
Ref.	No.	Description	Tightening torques
(2)	3	Screws M6 X 1 X 40 Step 1 Step 2	 5 Nm 15 ± 1.5 Nm

NOTE Apply Loctite 243 to the screws (2).

Position the blow-by cover (4) and tighten the screws (3) to the torque indicated in the table.

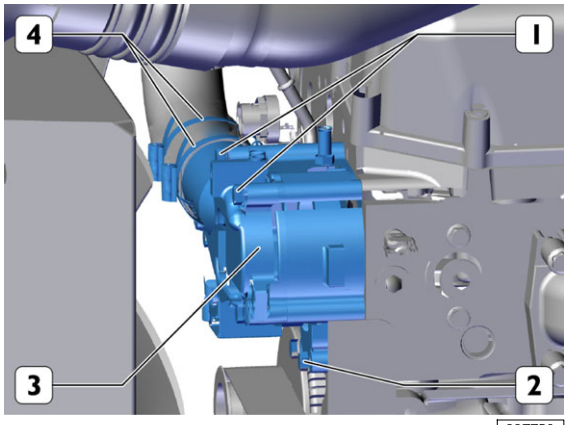
Ref.	No.	Description	Tightening torques
(3)	6	Screws M6 X 1 X 25	7 ± 1 Nm

Figure 185



Tighten the fastening screws following the sequence indicated in the figure.

Figure 186



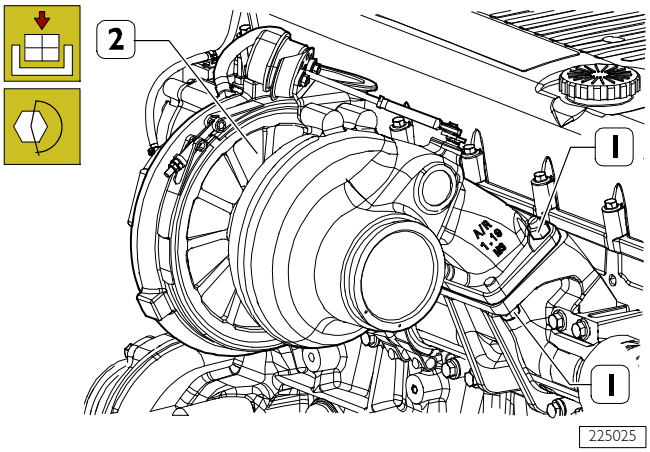
Assemble the thermostat, the thermostat box (3), with relative gaskets and tighten screws (1, 2) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	5	M8 X 1.25 X 100	30 ± 3 Nm
(2)	2	M8 X 1.25 X 50	30 ± 3 Nm

Connect to the thermostat (3) the coolant supply pipe to the radiator assembly and tighten the clamps (4).

Refit the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING".

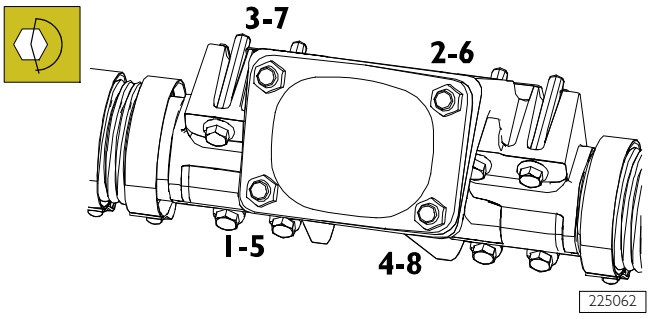
Figure 187



Fit the turbocharger (2) together with the new gasket onto the exhaust manifold and tighten the nuts (1) to the torque indicated in the table.

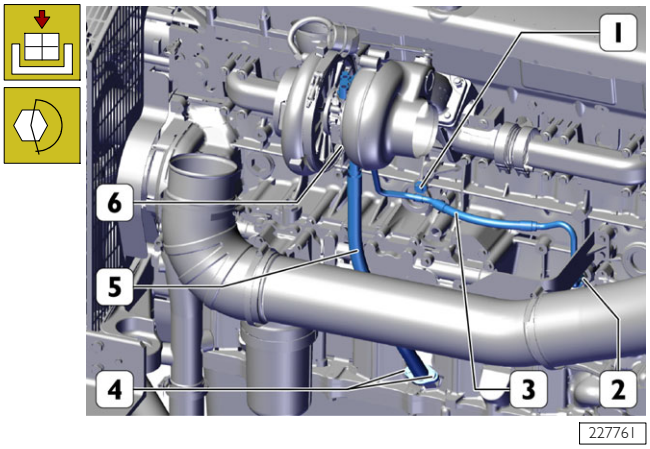
Ref.	No.	Description	Tightening torques
(1)	4	Nuts M12 X 1.75	75 Nm

Figure 188



Tighten the screws securing the turbocharger following the sequence indicated in the figure.

Figure 189

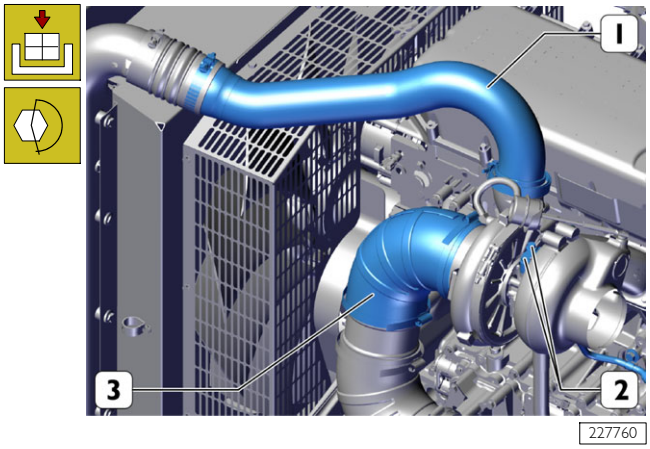


Mount the oil delivery pipe to turbocharger (3) and tighten screws of the bracket (1) and the fitting (2) to the torque shown in the table.

Fit the engine oil return pipe from the turbocharger (5) with the new gaskets and tighten the screws (4, 6) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	M10 screw	24.5 ± 2.5 Nm
(2)	1	Fitting M16 X 1.5 X 12	42.5 ± 2.5Nm
(4, 6)	4	M8 x 1.25 screws	24.5 ± 2.5 Nm

Figure 190



Connect the sleeve (3) of the combustion air intake pipe to the turbocharger and tighten the clamps.

Tighten the screws (2) of the oil delivery pipe to the turbocharger to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	2	M8 x 1.25 screws	24.5 ± 2.5 Nm

Connect the air intake pipe (1) to the aftercooler and tighten clamp and collar.

Make al the electrical connections and secure the engine cable with clamps to the clips.

Refit the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING".

ENGINE DISASSEMBLING

Disassembly of G-Drive components

Remove the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING" - Section 5.

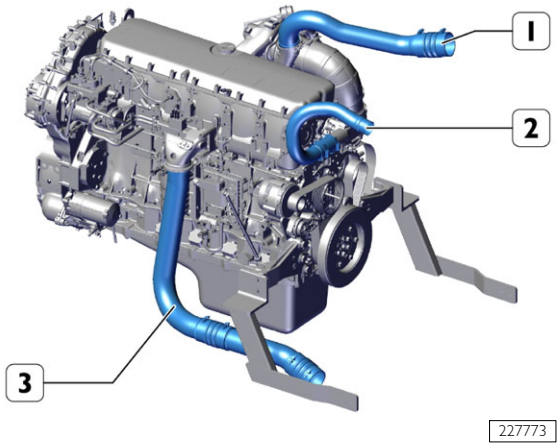
Remove the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING" - Section 5.

Remove the fan as described in the procedure "FAN REMOVAL - REFITTING" - Section 5.

Remove the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING" - Section 5.

Removal of radiator assembly pipes from engine

Figure 1

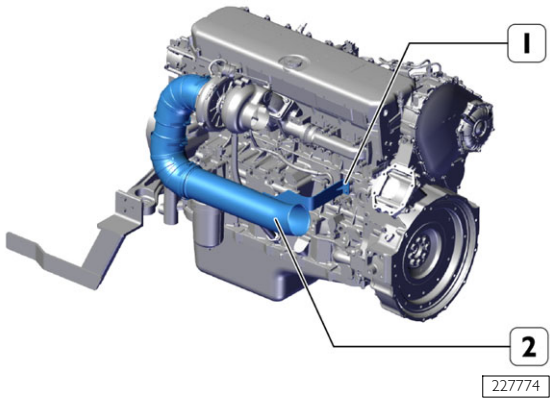


Slacken the clamp and from the engine remove the combustion air intake pipe (1) to the aftercooler.

Slacken the clamps and from the engine remove the coolant intake pipe (2) to the radiator assembly.

Slacken the clamp and from the engine remove the combustion air intake pipe (3) to the engine.

Figure 2

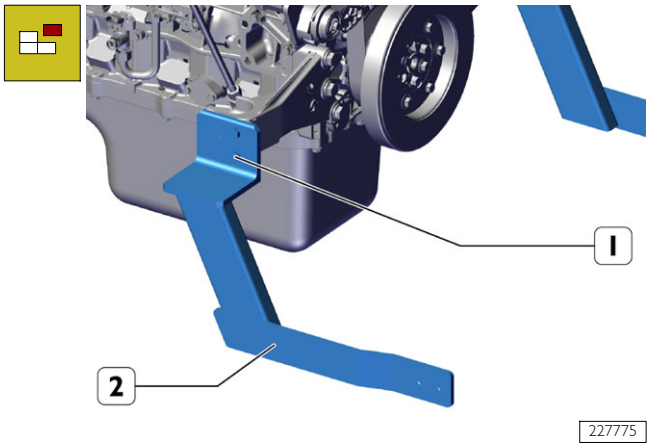


Slacken the clamps, undo the screws (1) and from the engine remove the fuel combustion air intake pipe to the turbocharger (2) and bracket.

Ref.	No.	Description
(1)	2	Screws M8

Removal of radiator assembly brackets

Figure 3



Unscrew the fastening screws (1) of the raditor assembly brackets (2).

Ref.	No.	Description
(1)	4	M12x1.75 screws

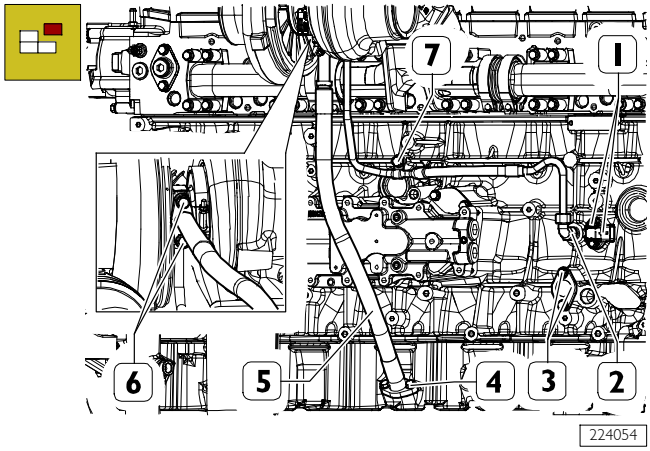
Removal of components hindering bracket assembly

Engine cable removal

Protect the electrical parts before washing wish pressurised water spray. Before securing the engine onto the rotating stand 99322230, remove the engine cable disconnecting it from the control unit and from all sensors/senders to which it is connected.

Removal of the turbocharger oil supply and return pipe oil pressure and temperature sensor and oil pressure regulator valve

Figure 4



Unscrew the screws (1) and remove the oil pressure and temperature sensor together with the O-ring.

Ref.	No.	Description
(1)	2	Screws M6

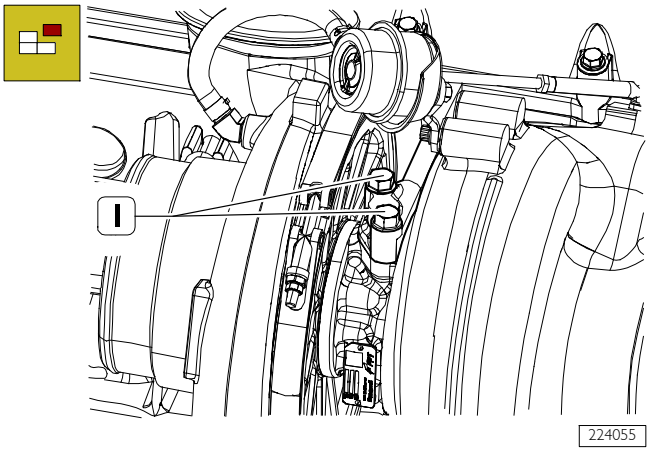
Unscrew the screws (3) and remove the oil pressure regulator valve.

Unscrew the screws (4) and (6) and remove the turbocharger oil outlet pipe and its gasket.

Unscrew the fitting (2) and screw (7) that secures the oil supply pipe of the turbocharger to the crankcase.

Ref.	No.	Description
(4)(6)	4	M8 x 1.25 screws
(3)	2	Screws M6
(2)	1	Fitting M16 X 1.5 X 12
(7)	1	M10 screw

Figure 5

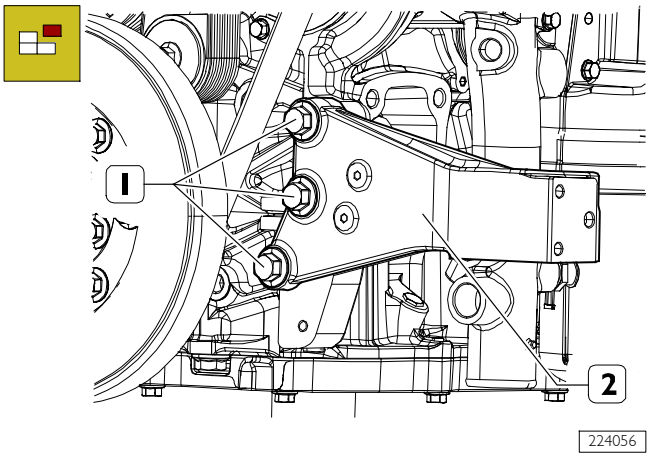


Unscrew the screws (1) and remove the oil supply pipe to the turbocompressor and its gasket.

Ref.	No.	Description
(1)	2	M8 x 1.25 screws

Removing engine front suspensions.

Figure 6



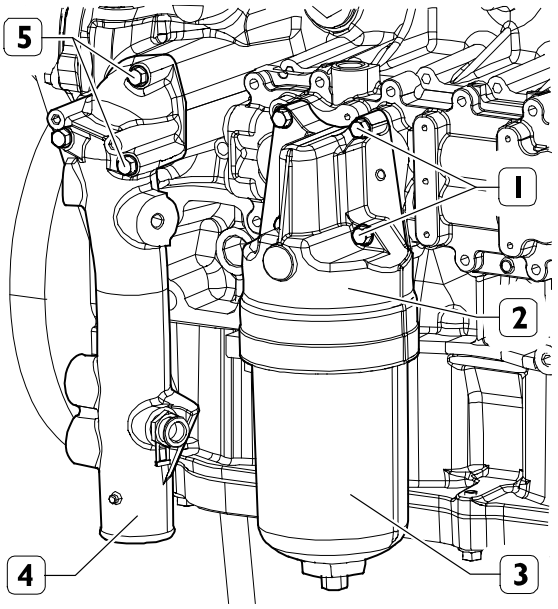
Unscrew the screws (1) and engine front suspension on the left (2).

Proceed likewise to remove the suspenion on the right.

Ref.	No.	Description
(1)	3	M16 x 2 screws

Removal of the oil filter with relative support and water inlet pipe to crankcase

Figure 7



Using a suitable tool, unscrew the oil filter body (3) and remove the filter element.

Unscrew the screws (1) and remove the engine oil filter (2) and gasket.

Unscrew the screws (5) and remove the water intake pipe to crankcase (4) together with the gasket.

Ref.	No.	Description
(1)	4	Screws M8 X 1.25 X 65
(5)	3	M8 x 1.25 screws

The oil filter contains approximately 2 kg of engine oil inside.

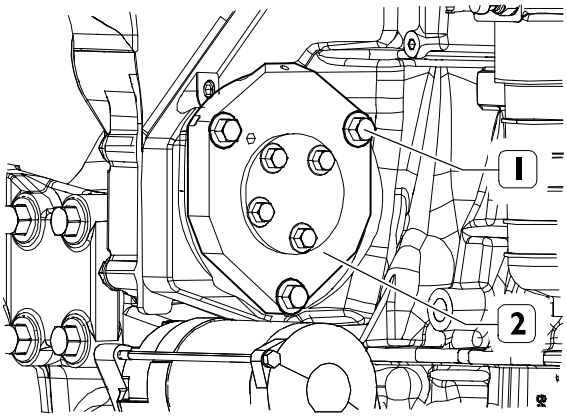
Position a suitable container to collect the oil.

Avoid skin contact with the engine oil: in case of contact, wash thoroughly with water.

The engine oil is highly pollutant: it must be disposed of according to applicable laws.

Removal of the air compressor input point

Figure 8

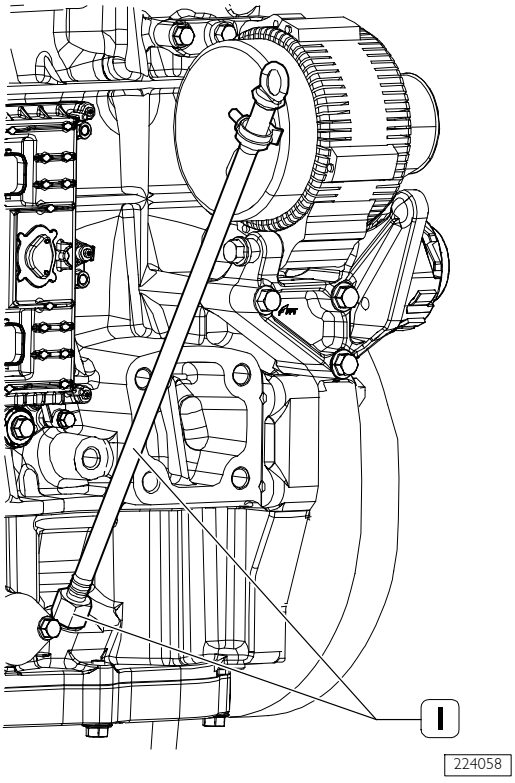


Undo the screws (1) and remove the air compressor input point support (2).

Ref.	No.	Description
(1)	3	Screws M12 X 1.75

Removal of the dipstick for checking the oil

Figure 9



Uscrew the nuts and remove the oil level dipstick (1).

Ref.	No.	Description
(1)	1	Nut M18 X 1.5

Fitting the engine on the rotating stand

NOTE Position a suitable container below the sump to collect the oil as it drains out of the drain plug.

Drain the engine oil by removing the plug from the oil sump.

Ref.	No.	Description
(-)	1	Plug M22 X 1.5

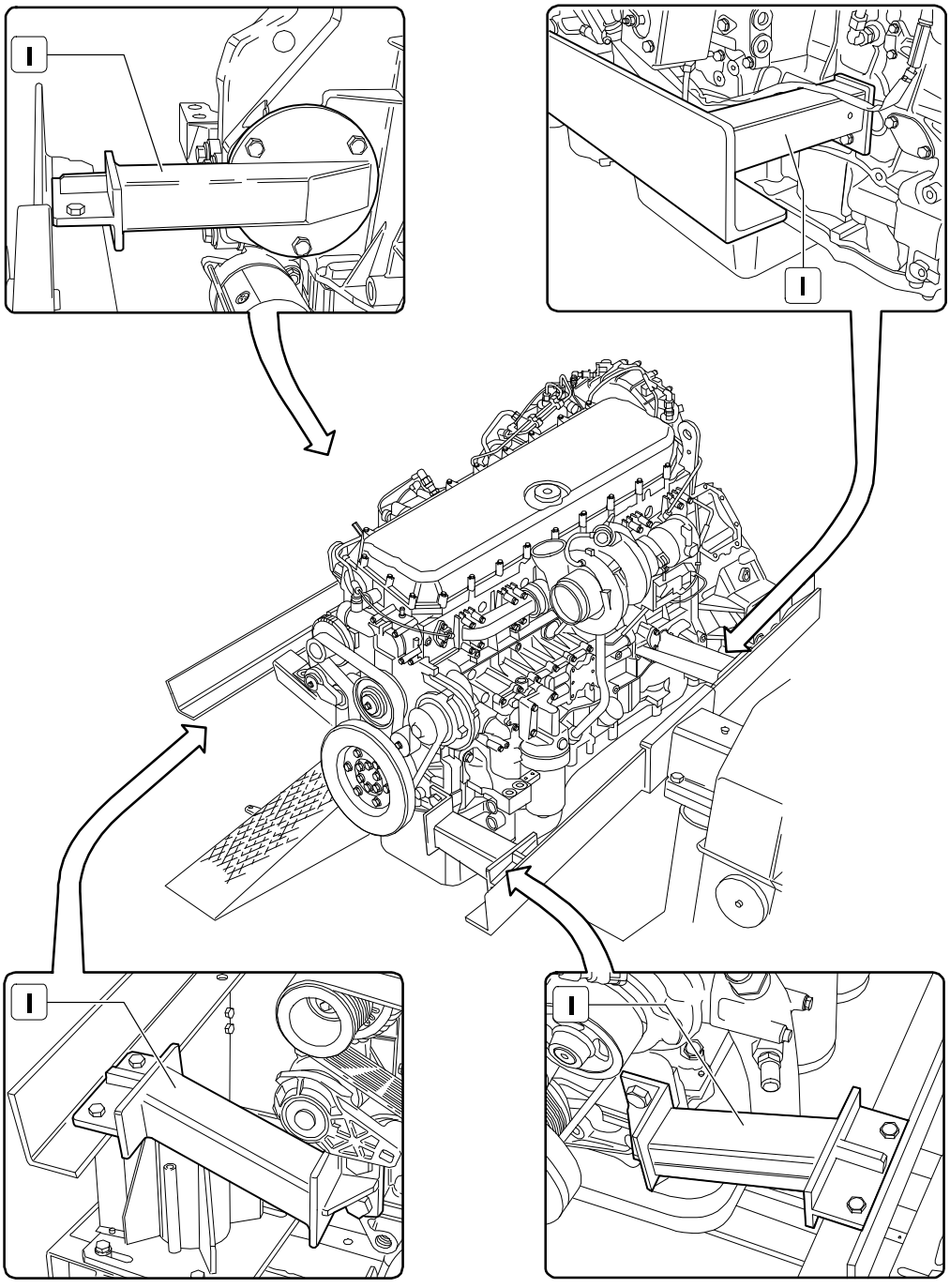
The engine oil is highly pollutant and noxious.

In case of contact with skin, wash thoroughly with water and detergent.

Suitably protect skin and eyes; proceed in accordance with accident prevention standards.

Suitably dispose of the residuals and in accordance with regulations.

Figure 10

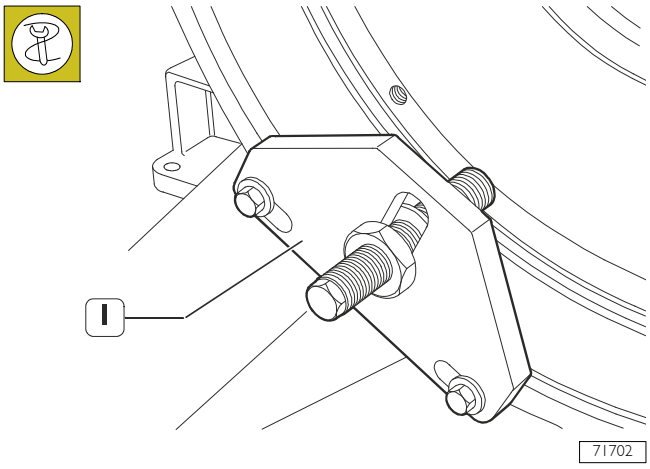


Secure the engine to the rotating stand 99322230 with the brackets 99361036 (1).

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE FRONT)

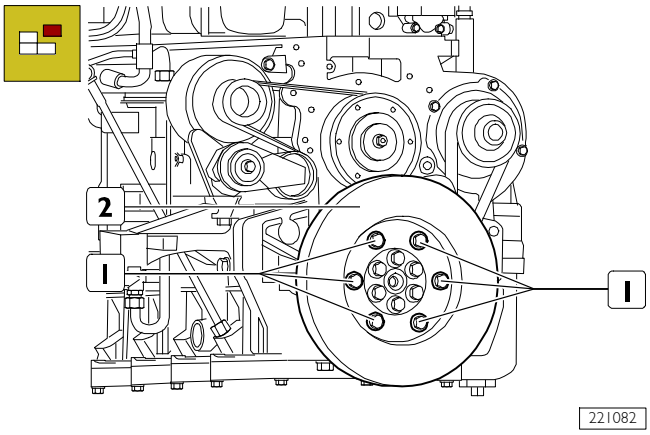
Damper flywheel removal

Figure 11



Lock the flywheel using the tool 99360351 (1).

Figure 12

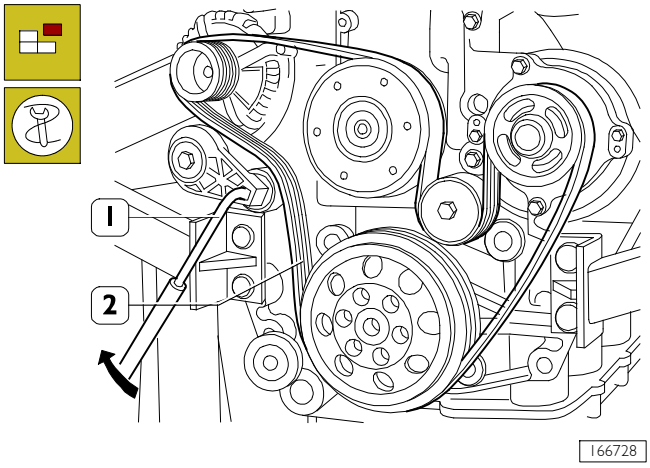


Remove the damper flywheel (2) by acting on the screws (1).

Ref.	No.	Description
(1)	6	M14 x 2 screws

Coolant pump alternator drive belt disassembly

Figure 13

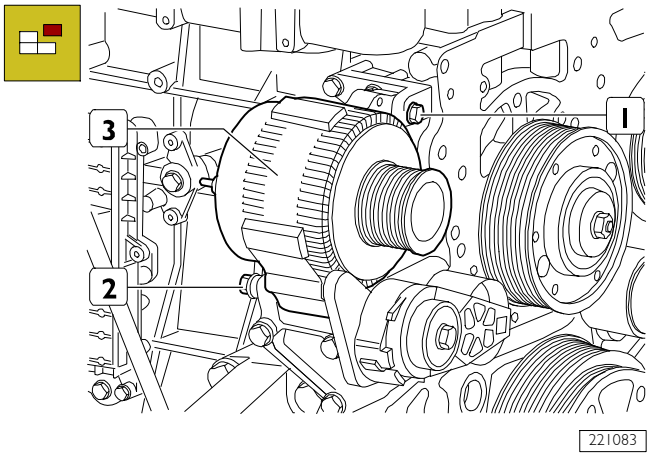


Using a 1/2 inch square wrench (1), act in the direction of the arrow, remove the ancillary drive belt (2).

NOTE The elastic belt must be replaced after every disassembly.

Alternator removal

Figure 14

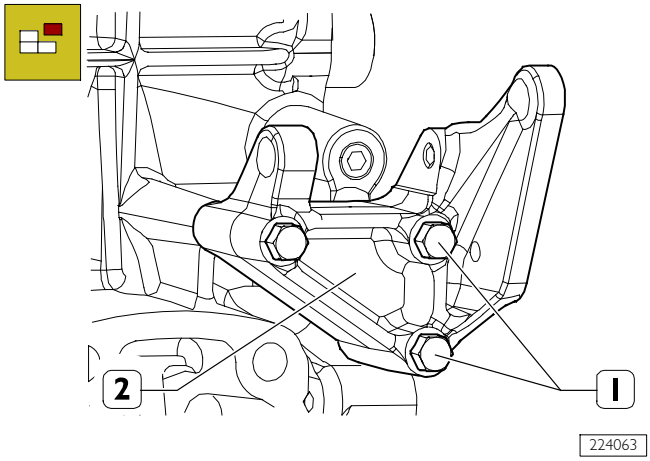


Unscrew the screws (1, 2) and remove the alternator (3).

Ref.	No.	Description
(1)	1	M8 x 1.25 screws
(2)	1	M10 x 1.5 screws

Alternator support removal

Figure 15

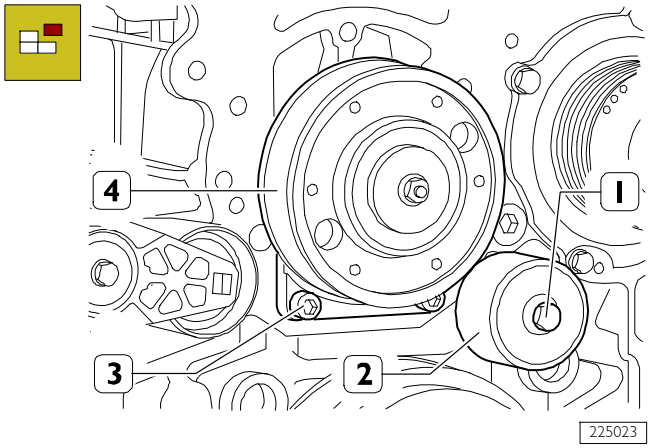


Unscrew the screws (1) and remove the alternator support (2).

Ref.	No.	Description
(1)	3	M10 x 1.5 screws

Electromagnetic coupling pulley removal

Figure 16

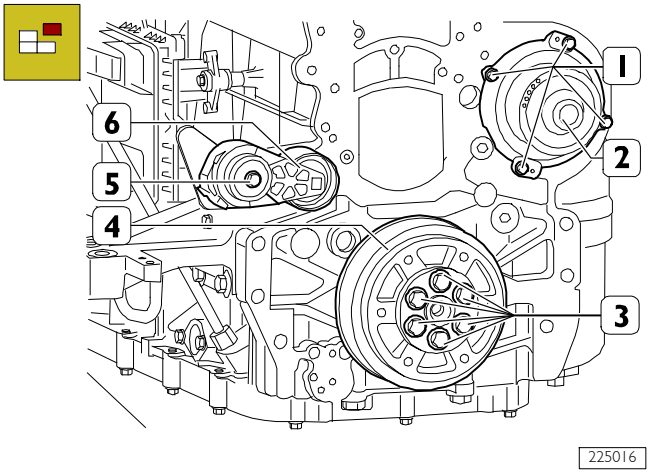


Unscrew the screws (1) and remove the fixed belt tensioner (2), undo the screws (3) and remove the electromagnetic coupling pulley assembly (4).

Ref.	No.	Description
(1)	1	M12 x 1.75 screw
(3)	5	Screws M12 X 1.75

Assembly of auxiliary parts

Figure 17



Unscrew the screw (5) and remove the automatic belt tensioner (6).

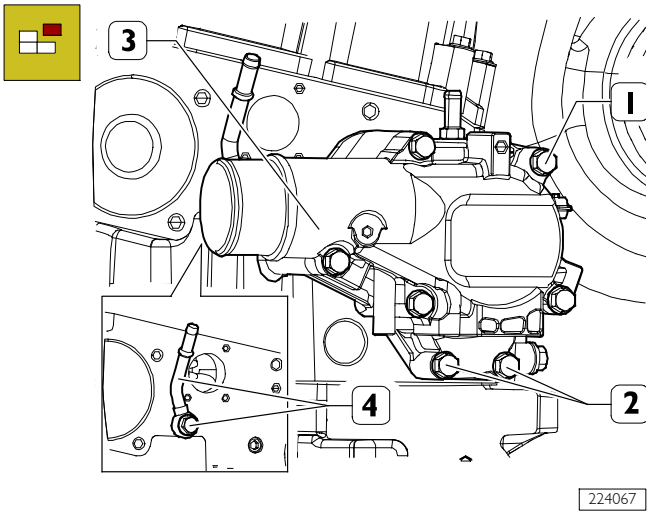
Unscrew the screws (3) and remove the crankshaft pulley (4).

Unscrew the screws (1) and remove the water pump (2) and its gasket.

Ref.	No.	Description
(1)	3	Screws M18 X 1.25 X 20
(3)	6	M14 x 2 screws
(5)	1	M10 x 1.5 screw

Thermostat case removal

Figure 18



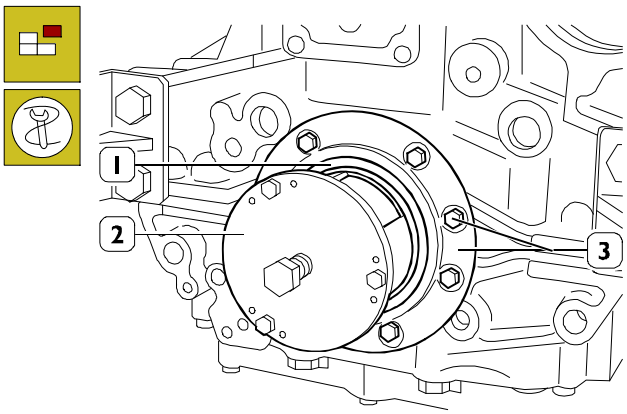
Unscrew the screws (1, 2) and remove the thermostat cover and relative gaskets.

Unscrew the fixing screws and remove the degasing pipe (4).

Ref.	No.	Description
(1)	5	Screws M8 X 1.25 X 100
(2)	2	Screws M8 X 1.25 X 50
(4)	1	Fitting M10 X1.5

Crankshaft front gasket removal

Figure 19



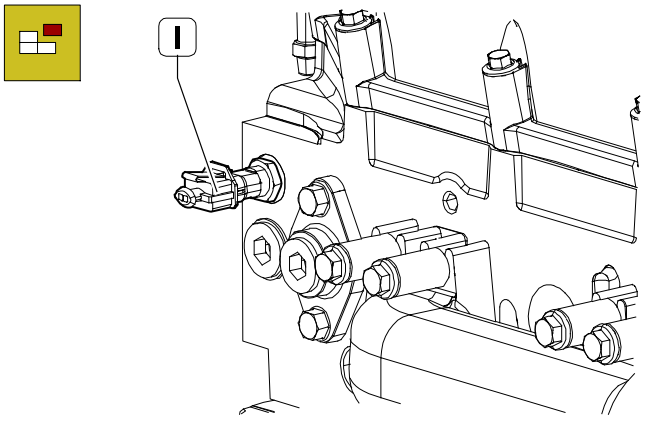
Fit puller 99340053 (2) and take off the crankshaft seal (1). Extract the flange (3).

Ref.	No.	Description
(3)	8	Screws M8 X 1.25 X 16

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT EXHAUST SIDE)

Turbocharger and exhaust manifold removal

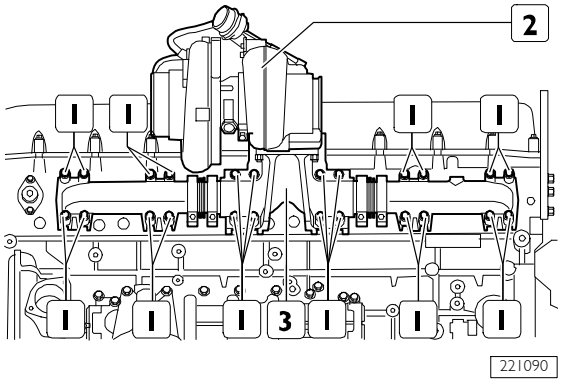
Figure 20



Unscrew and remove the coolant temperature sensor (1).

Ref.	No.	Description
(1)	1	M12 X 1.5

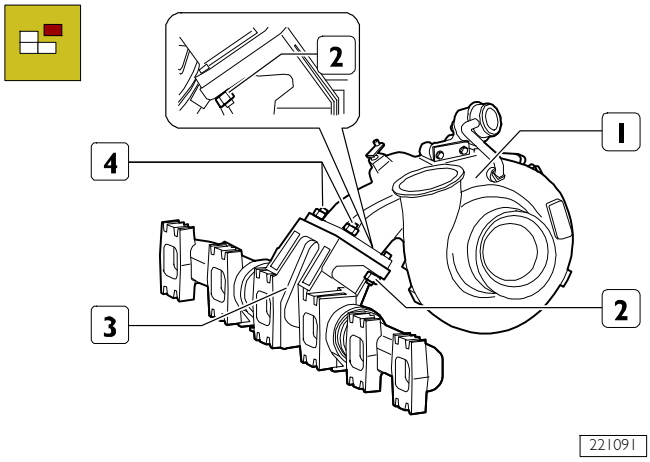
Figure 21



Unscrew the fastening screws (1) and remove the exhaust manifold (3) together with the turbocharger (2) and gaskets.

Ref.	No.	Description
(1)	24	Screws M10 X 1.5 X 70

Figure 22

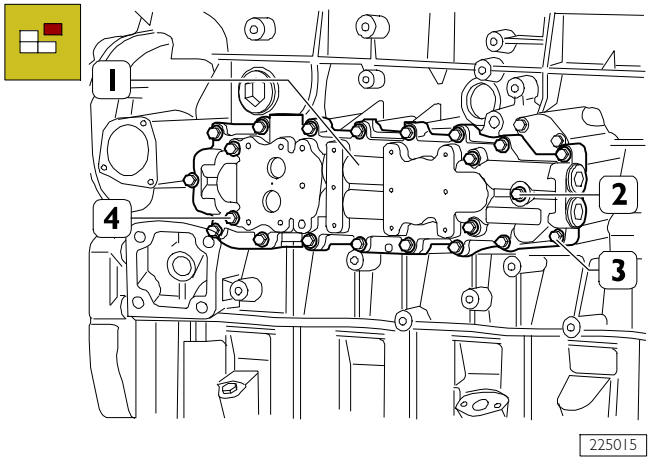


Unscrew the nuts (2, 4) and detach the turbocharger (4) from the exhaust manifold (3). remove the gasket.

Ref.	No.	Description
(2, 4)	4	Nuts M12 X 1.75

Heat exchanger removal

Figure 23



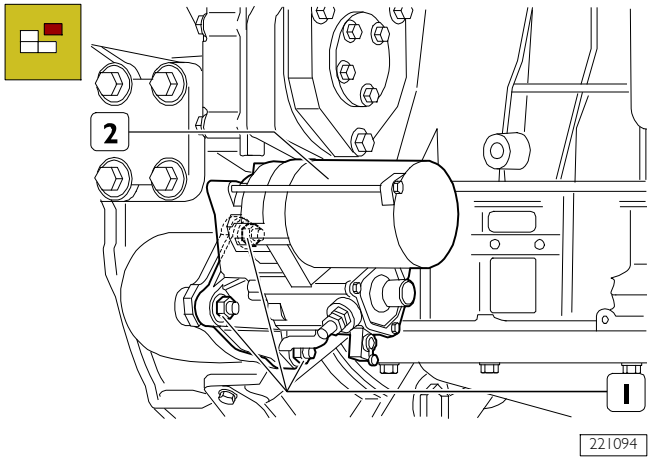
Unscrew the screws (2,3,4) and remove the complete heat exchanger (1) and its gasket.

Ref.	No.	Description
(2)	1	Screws M8 X 1.25 X 55
(3)	17	Screws M8 X 1.25 X 40
(4)	4	Screws M8 X 1.25 X 45

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE INTAKE SIDE PART 1)

Disassembly of the starter motor

Figure 24



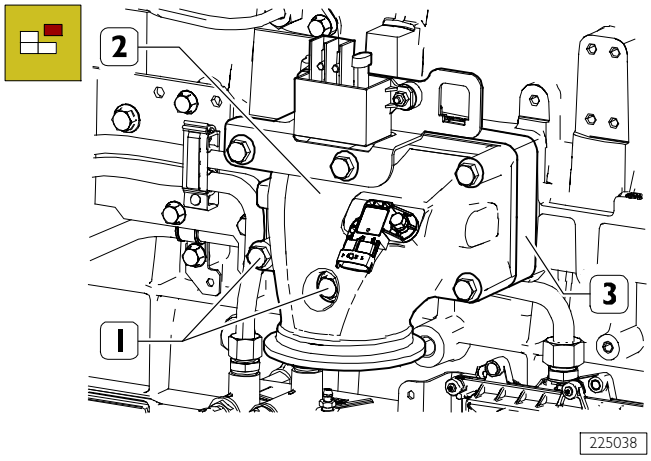
Remove the nuts (1) from the studs.

Remove the starter motor (2).

Ref.	No.	Description
(1)	3	M12 X 1.75

Inlet manifold removal

Figure 25

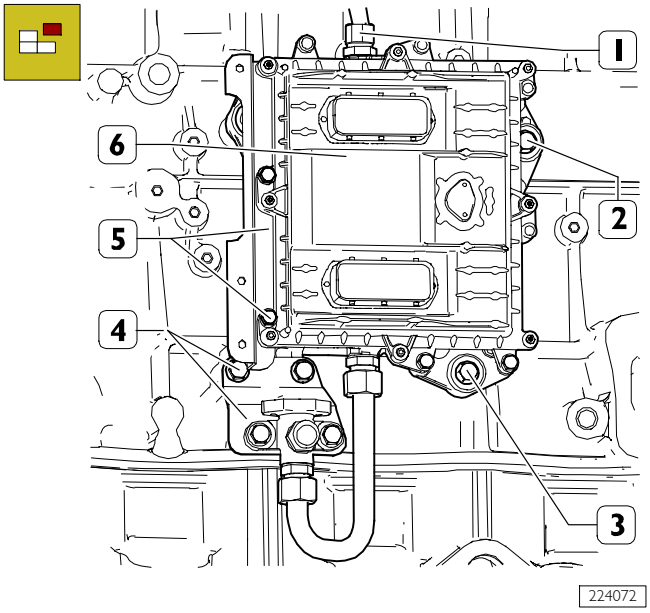


Unscrew the screws (1) and remove the intake manifold (2) together with the engine preheating resistor (3).

Ref.	No.	Description
(1)	3	Screws M10 X 1.5 X 100
(1)	2	Screws M10 X 1.5 X 130
(1)	1	Screws M10 X 1.5 X 150

Engine control unit removal

Figure 26



Unscrew the screws and remove the bracket (5).

Unscrew fittings (1) and disconnect the low pressure fuel pipes from the control unit.

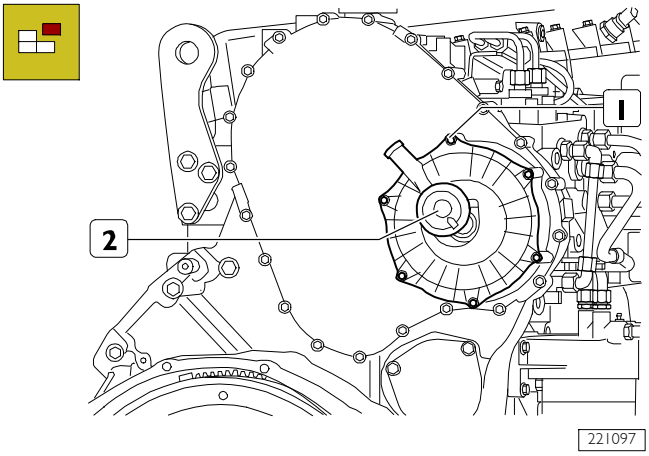
Unscrew the screws of the control unit mount (2, 3), the screws of the bracket (4) and remove the engine control unit (6).

Ref.	No.	Description
(1)	1	Fitting M22 X 1.5
(2)	2	Screws M8 X 1.25 X 60
(3)	1	Screws M8 X 1.25 X 45
(4)	2	Screws M8 X 1.25 X 16
(5)	2	Screws M6 X 1 X 25

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE REAR SIDE PART 1)

Blow-by case removal

Figure 27

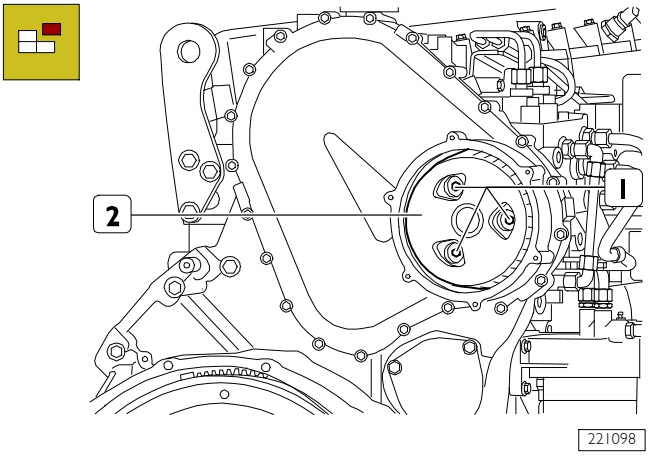


Unscrew the screws (1) and remove the blow-by case (2).

Ref.	No.	Description
(1)	6	Screws M6 X 1 X 25

Blow-by filter removal

Figure 28

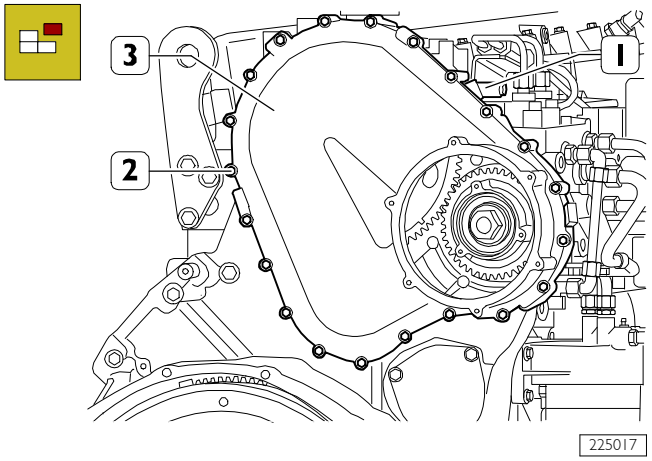


Unscrew the screws (1) and remove the blow-by filter (2).

Ref.	No.	Description
(1)	3	Screws M6 X 1 X 40

Timing gear cover removal

Figure 29



Remove the timing sensor (1)

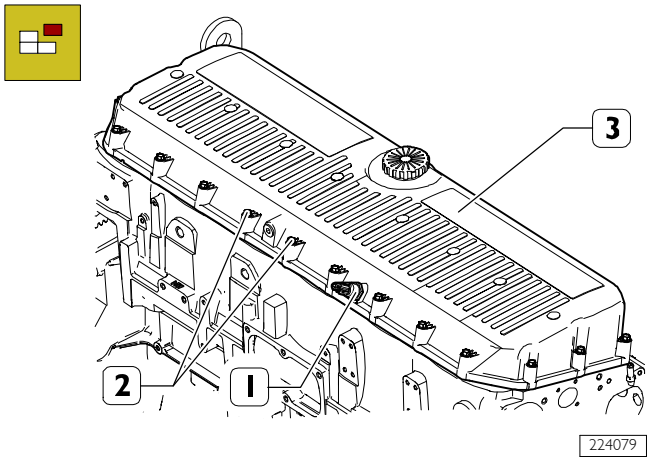
Unscrew the screws (2) and remove the distribution cover (3).

Ref.	No.	Description
(1)	1	M6 X 12
(2)	21	Screws M6 X 1.0 X 25

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE TOP PART 1)

Removal of head cover

Figure 30



Unscrew and remove the pressure sensor (1).

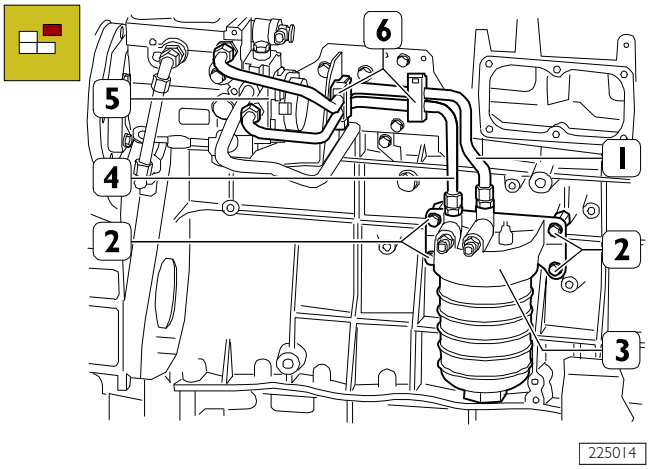
Unscrew the fastening screws (2) and remove the head cover (3).

Ref.	No.	Description
(1)	1	M10 X 1
(2)	24	M6 X 1

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE INTAKE SIDE PART 2)

Fuel filter removal

Figure 31



Unlock the cable ties (6).

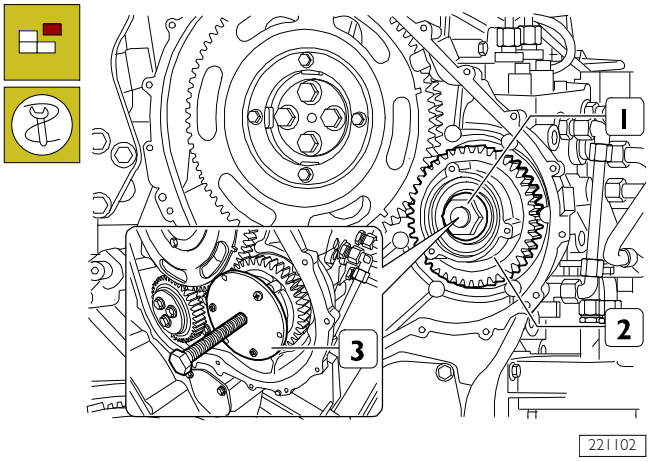
Unscrew the fittings, dsconnect and remove the fuel inlet (4) and outlet (1) pipes from the high pressure pump (5) and the fuel filter (3).

Unscrew the screws (2) and remove the oil filter housing together with the support (3).

Ref.	No.	Description
(1, 4)	4	Fitting M18 X 1.5
(2)	4	M8 x 1.25 screws

High pressure pump removal

Figure 32

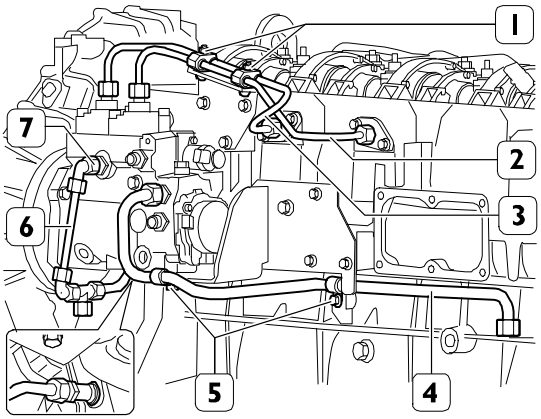


Undo the nut (1).

Apply thetool to extract the high pressure pump gear 99366198 (3) and remove the high pressure pump control gear (2).

Ref.	No.	Description
(1)	1	Nut M24 X 1.5

Figure 33



227747

Unscrew the nutes (1), remove the plugs, undo the fittings, and remove the HP fuel pipes (2).

Ref.	No.	Description
(1)	2	Nuts M6 X 1
(2)	4	Fittings M16 X 1.5

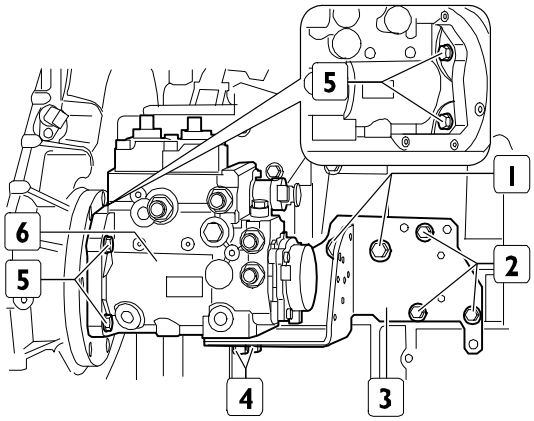
The high pressure pipes which have been removed cannot be used again and must be replaced.

Undo screws (5), fitting (7), disconnect the collars and remove the LP fuel pipe (4).

Unscrew the fittings and remove the fuel return pipe (6).

Ref.	No.	Description
(5)	2	Screws M8 X 1.25 X 16
(6)	2	Fittings M18 X 1.5
(7)	1	Fitting M18 X 1.5

Figure 34



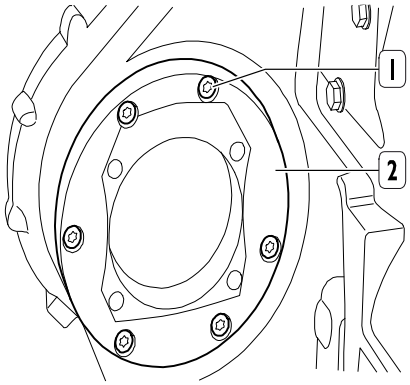
221104

Unscrew the screws (1,2,4) and remove the bracket (3).

Unscrew the screws (5) and remove the high pressure pump.

Ref.	No.	Description
(1)	2	Screws M10 X 1.5 X 20
(2)	2	Screws M8 X 1.25 X 20
(5)	4	Screws M12 X 1.5

Figure 35



160624

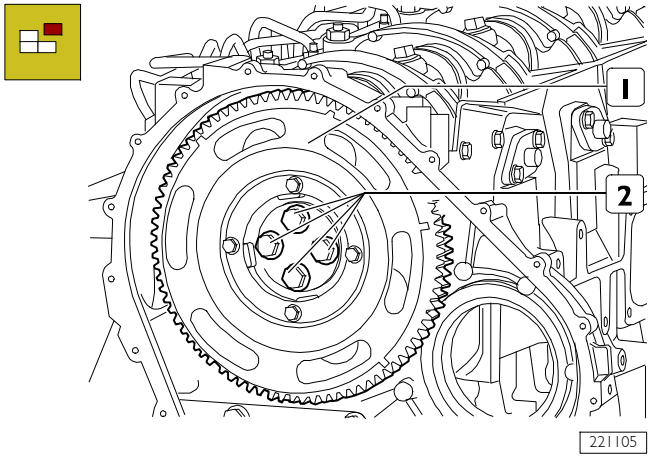
Unscrew the retaining screws (1) and remove the flange (2) supporting the high pressure pump.

Ref.	No.	Description
(1)	6	Screws M8 X 1.25 X 30

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE REAR SIDE PART 2)

Timing gear removal

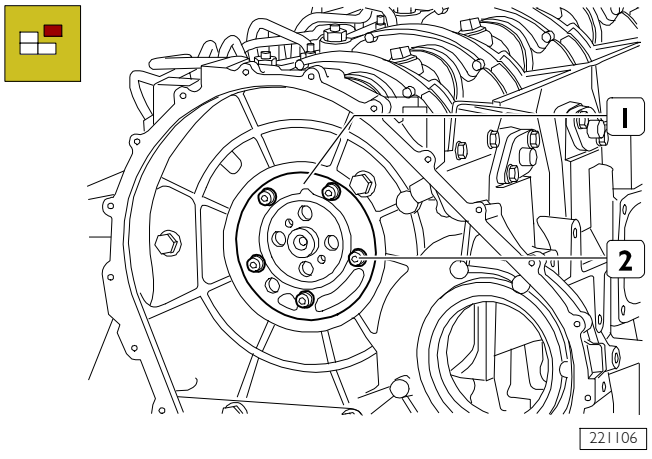
Figure 36



Unscrew the screws (2) and remove the gear (1) fitted with phonic wheel.

Ref.	No.	Description
(2)	4	Screws M14 X 4 X 60

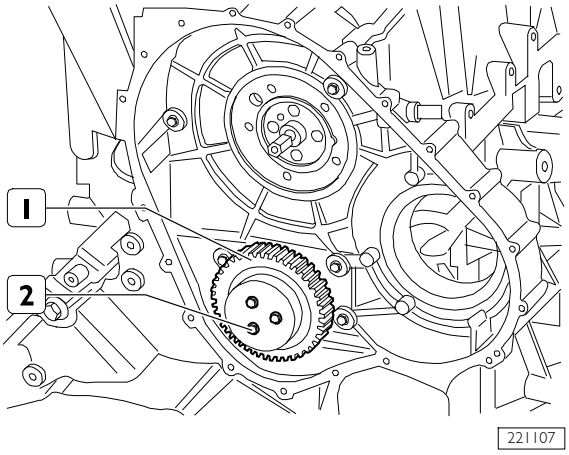
Figure 37



Unscrew the screws (2) and remove the thrust plate (1) and the sheet gasket.

Ref.	No.	Description
(2)	5	Screws M8 X 1.25 X 25

Figure 38

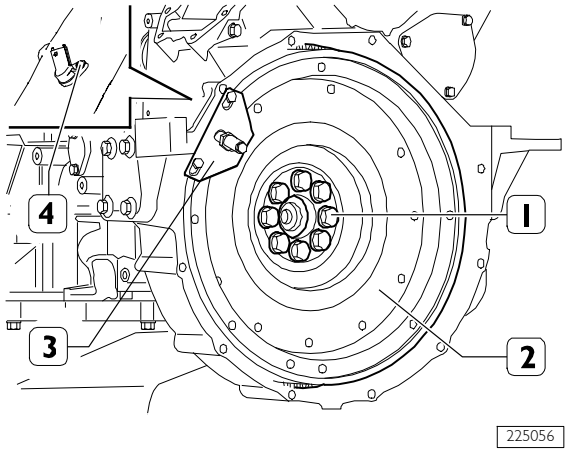


Unscrew the screws (2) and remove the idle gear (1).

Ref.	No.	Description
(2)	3	Screws M12 X 1.75 X 110

Flywheel removal

Figure 39



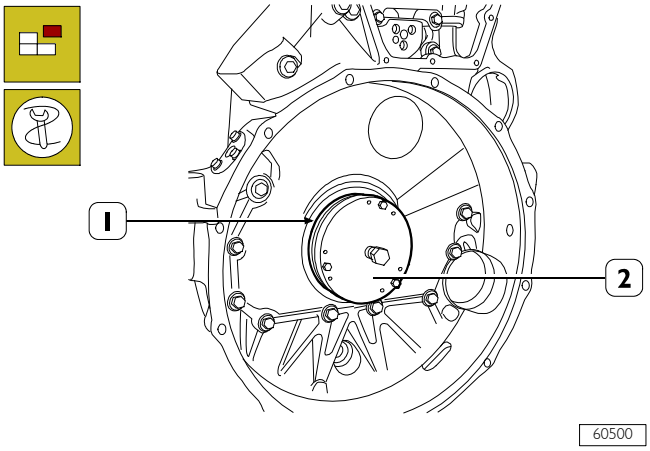
Unscrew the screw and remove the rpm sensor (4).

Using the tool 99360351 to lock the mounted engine flywheel (3) unscrew the retaining screws (1); then remove the tool (3) and remove the engine flywheel (2).

Ref.	No.	Description
(1)	8	Screws M18 X 1.5 X 72
(4)	1	M6 x 12 screws

Crankshaft rear gasket removal

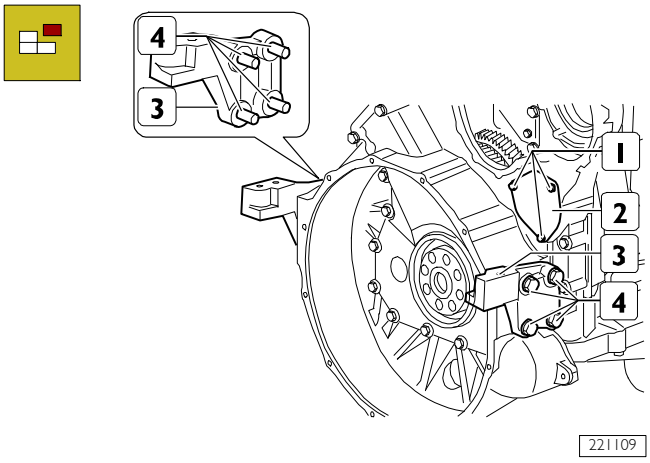
Figure 40



Fit puller 99340053 (2) and take off the seal (1).

Removing engine mounts

Figure 41



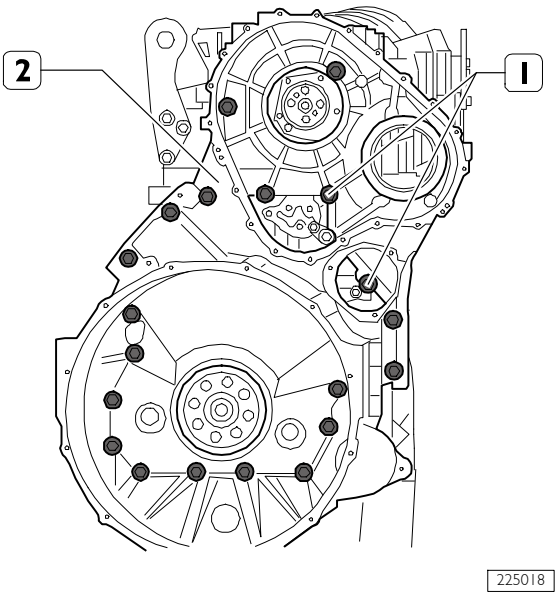
Unscrew the screws (4) and remove the engine suspension (3).

Undo the screws (1) and remove cover (2) complete with O-ring.

Ref.	No.	Description
(1)	3	Screws M8 X 1.25 X 20
(4)	8	M16 x 2 screws

Flywheel case removal

Figure 42

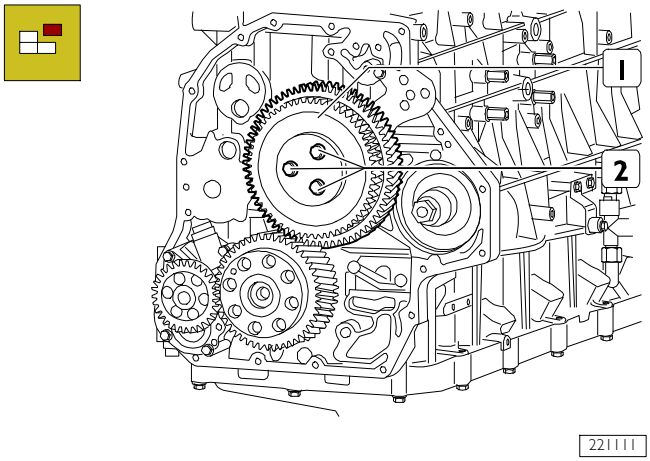


Unscrew the screws (1) and remove the flywheel case (2).

Ref.	No.	Description
(1)	10	Screws M12 X 1.75 X 100
(1)	4	Screws M12 X 1.75 X 40
(1)	1	Screws M12 X 1.75 X 120
(1)	2	Screws M12 X 1.75 X 193
(1)	2	Screws M12 X 1.75 X 70
(1)	2	Screws M10 X 1.5 X 30

Double gear removal

Figure 43

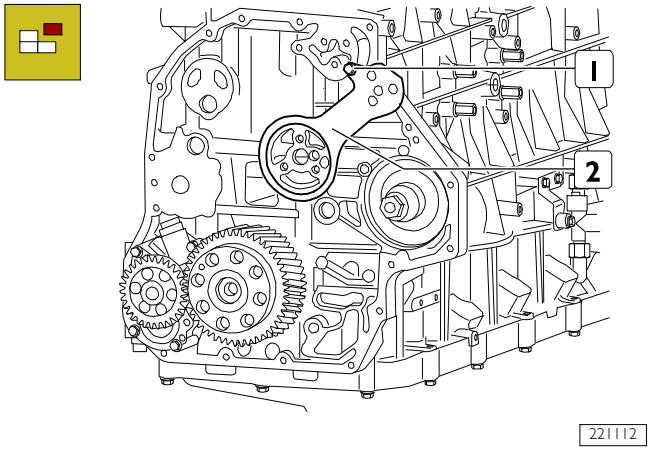


Remove screws (2) and disassembly the double gear (1).

Ref.	No.	Description
(2)	3	Screws M12 X 1.75 X 90

Connecting rod removal

Figure 44

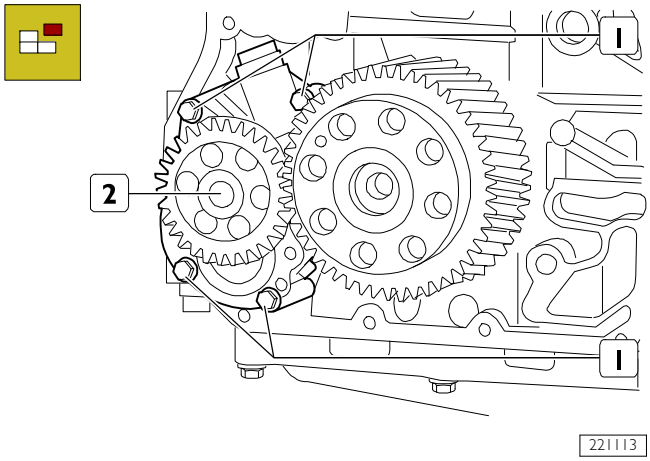


Unscrew the screw (1) and remove the connecting rod (2).

Ref.	No.	Description
(1)	1	Screws M8 X 1.25 X 16

Disassembling the oil pump

Figure 45



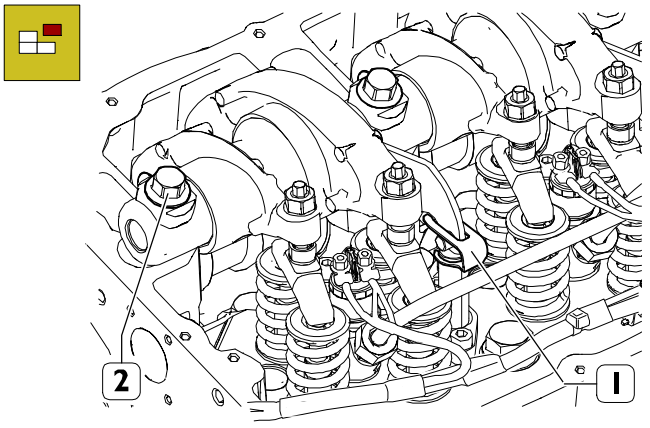
Unscrew the fastening screws (1) and remove the oil pump (2).

Ref.	No.	Description
(1)	1	Screws M8 X 1.25 X 35
(1)	3	Screws M8 X 1.25 X 70

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE TOP PART 2)

Rocker arm shaft removal

Figure 46

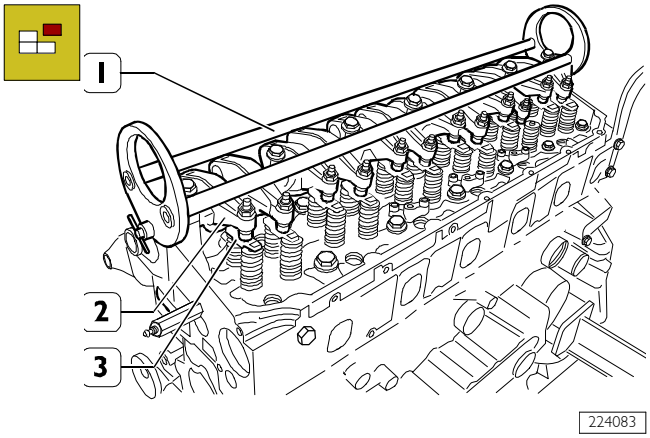


Release the retainer springs of the engine brake (1).

Unscrew the screws (2) securing the rocker arm shaft.

Ref.	No.	Description
(2)	7	Screws M16 X 1.5 X 76

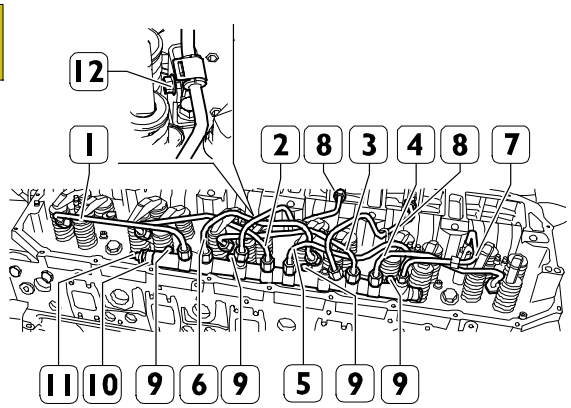
Figure 47



Use the specified tool 99360553 (1) on the rocker arm shaft (2) and remove the shaft (2) from the cylinder head. Remove the crosspieces (3) from the cylinder head.

Rail removal

Figure 48



225019

Unscrew the fittings (8), the screw of the bracket (12) and remove the high pressure fuel supply pipes (8).

Unscrew the fittings from the rail and the injectors and remove the high pressure fuel pipes (1, 2, 3, 4, 5, 6) and the fuel return pipe (7) from the head.

NOTE The high pressure fuel pipes must be replaced at each disassembly.

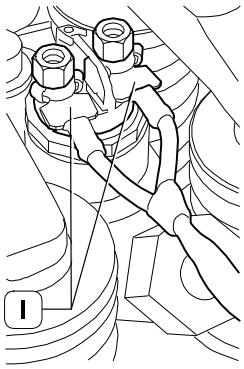
Disconnect the electric connection from pressure sensor (11).

Unscrew the fastening screws (9) and remove the rail (10).

Ref.	No.	Description
(1 - 6)	12	Fittings M16 X 1.5
(7)	2	Fittings M16 X 1.5
(8)	4	Fittings M16 X 1.5
(9)	3	Screws M8 X 1.25 X 55
(12)	2	Screws M8 X 1.25 X 16

Injector removal

Figure 49

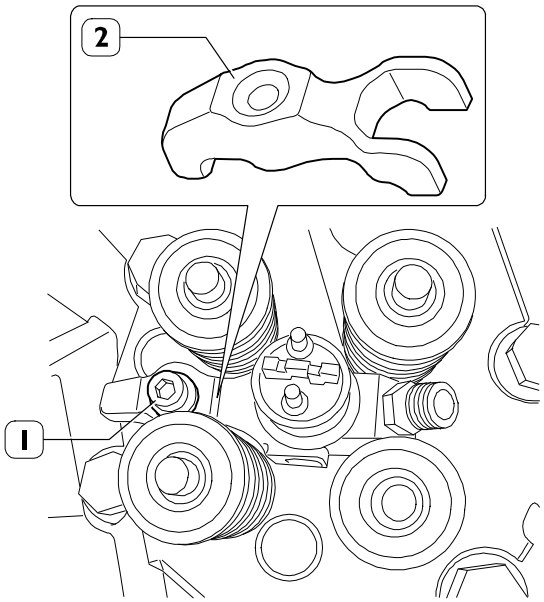


183457

Unscrew the nuts and disconnect the electrical connections (1) from the electro-injectors.

Ref.	No.	Description
(1)	12	Nuts M4

Figure 50

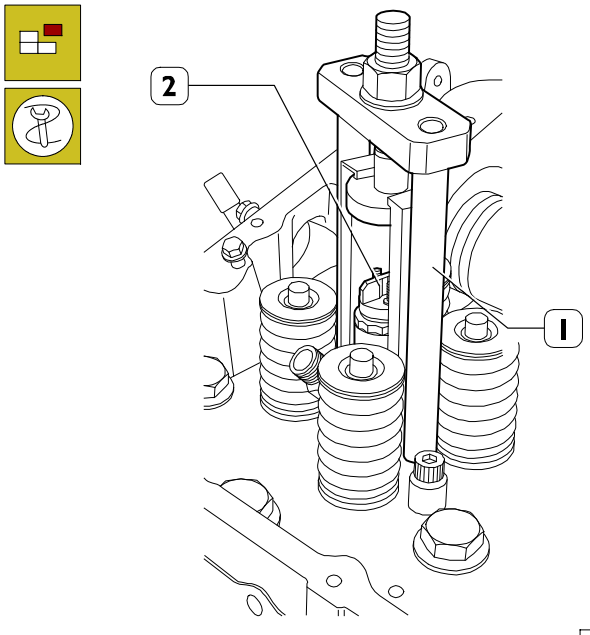


169827

Remove the screws (1) from the brackets (2) supporting the injectors.

Ref.	No.	Description
(1)	6	Screws M8 X 1.25 X 45

Figure 51

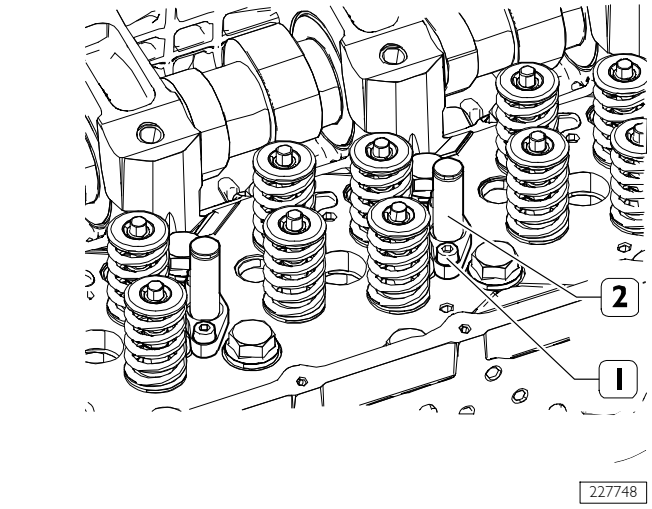


Position the tool 99342157 for extraction the injectors (1) and remove the injectors (2) from the head.

Removing the engine brake cylinders

Unscrew the screws (1) and remove the engine brake cylinders (2).

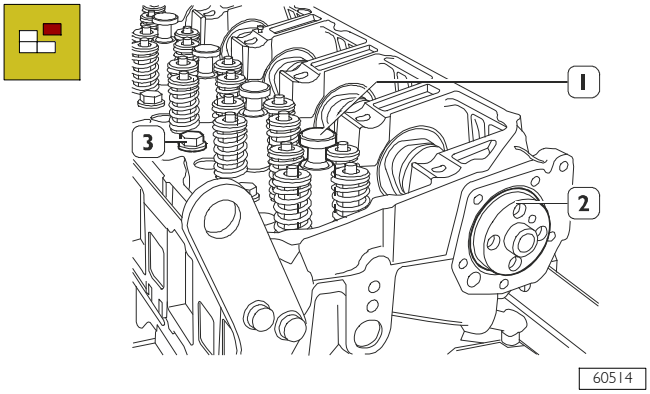
Figure 52



Ref.	No.	Description
(1)	12	Screws M8 X 1.25 X 20

Camshaft removal

Figure 53

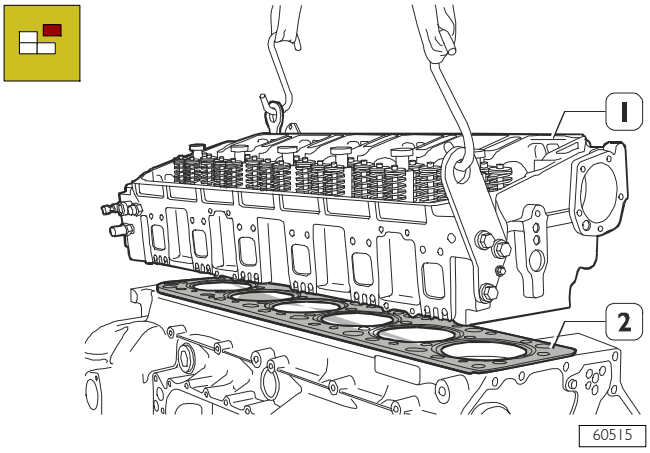


Mount suitable plugs inside electro-injector seats (1).

Remove the camshaft (2).

Cylinder head removal

Figure 54



Unscrew the cylinder head screws .

NOTE The cylinder head fastening screws are to be replaced each time you remove them.

Ref.	No.	Description
(-)	20	Screws M18 X 2 X 196
(-)	6	Screws M18 X 2 X 175

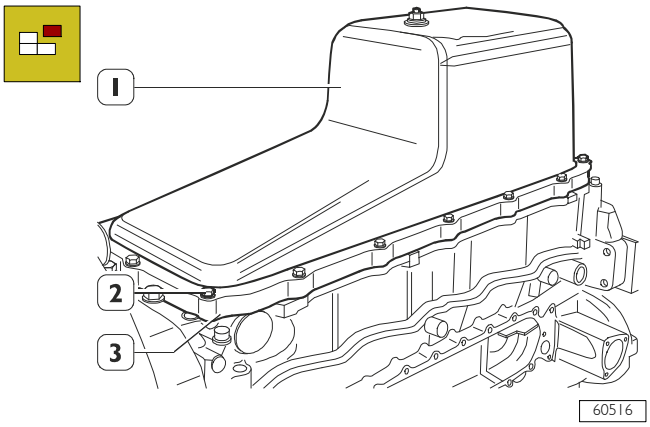
By means of metal ropes, lift the cylinder head (1).

Remove the seal gasket (2).

DISASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE BOTTOM)

Oil sump removal

Figure 55



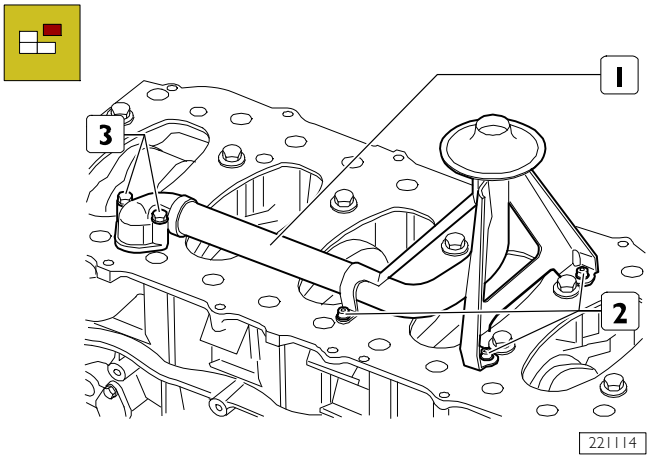
Turn the engine on the rotating stand.

Slacken the screws (2) and remove the engine oil sump (1) with the frame (3) and the gasket.

Ref.	No.	Description
(2)	16	M10 x 1.5 screws

Suction strainer removal

Figure 56



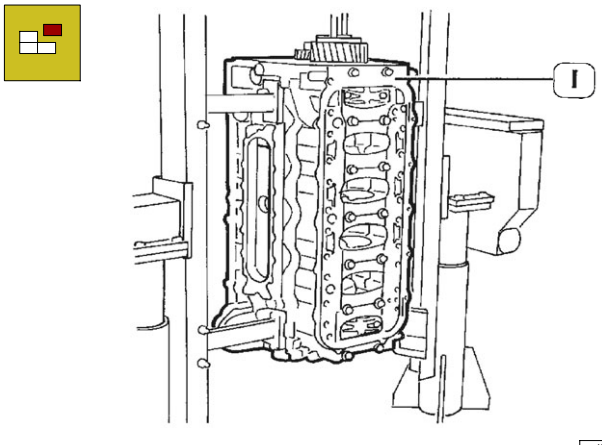
Unscrew the screws (2, 3) and remove the suction strainer (1).

Ref.	No.	Description
(2, 3)	6	M8 X 1.25

DISASSEMBLY OF ENGINE AT BENCH (CRANKCASE COMPONENTS SIDE)

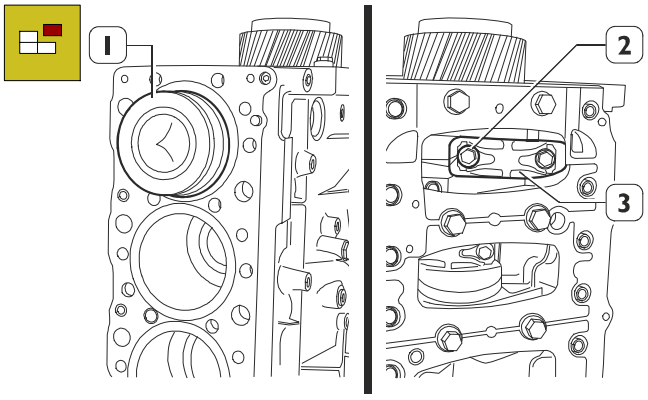
Connecting rod removal

Figure 57



Turn the crankcase (1) into vertical position.

Figure 58



Move pistons 1 and 6 at T.D.C.

Unscrew the screws (2) securing the connecting rod cap (3) and remove them.

Extract pistons 1 and 6 complete with rods.

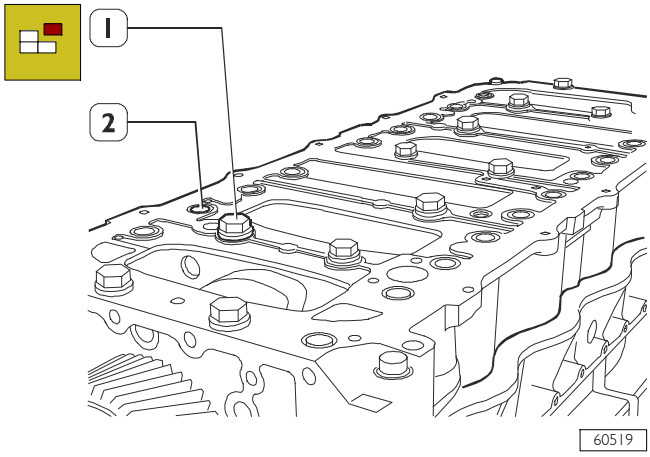
Repeat operation for remaining pistons.

Ref.	No.	Description
(2)	12	M14 x 2 screws

NOTE Keep the big end half-bearings in their respective housings and/or note down their assembly position since, if reusing them, they will need to be fitted in the position found upon removal.

Lower crankcase removal

Figure 59



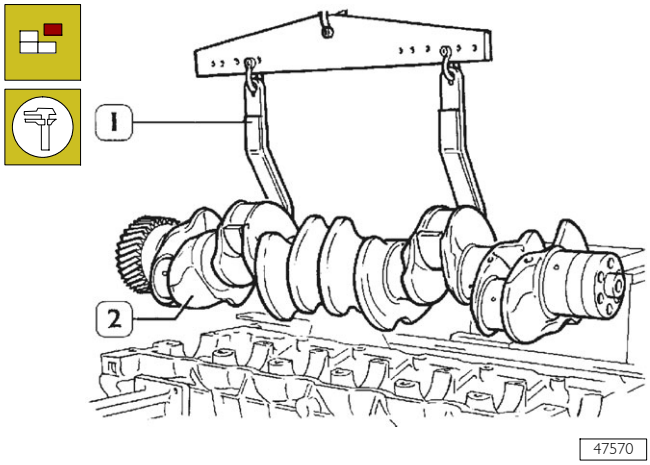
Using an appropriate wrench and the hex wrench unscrew the screws (1) and (2) and take off the lower crankcase.

Ref.	No.	Description
(1)	14	M18 x 2 screws
(2)	26	Screws M12 X 1.75

NOTE Note down the assembly position of the top and bottom main half-bearings since, if reusing them, they will need to be fitted in the position found upon removal.

Crankshaft removal

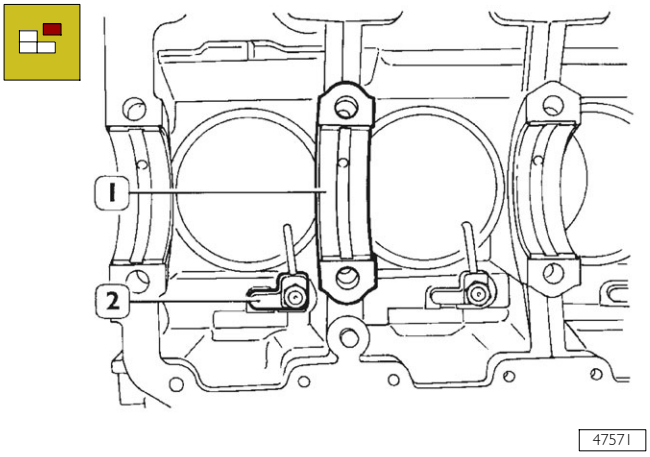
Figure 60



Using the tool for lifting the crankshaft 99360500 (1), remove the crankshaft (2).

Main bearings and oil nipples removal

Figure 61



Remove the main half-bearings (1).

Unscrew the screws and remove the oil sprayers (2).

Ref.	No.	Description
(2)	6	M14 x 1.5 screws

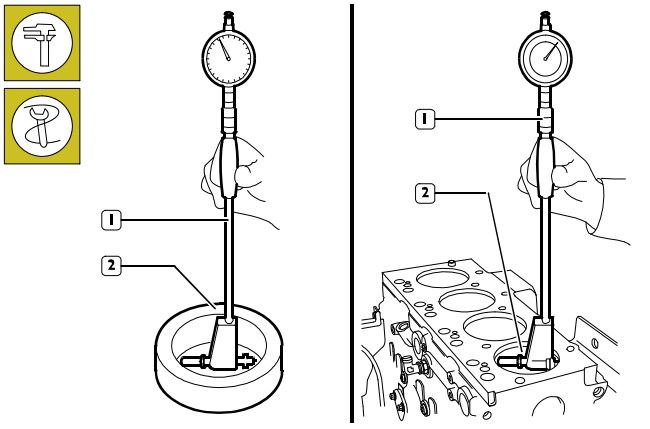
NOTE once the engine disassembly is complete, clean accurately the removed parts and check their integrity.

The following pages give instructions for checks and main measurements to do as to determine whether the parts can be reused.

CRANKCASE ASSEMBLY CHECKS

Crankcase checks

Figure 62



70166

After disassembling the engine, thoroughly clean the cylinder--crankcase assembly.

Carefully inspect the crankcase for cracks.

Check the condition of casting hole plugs.

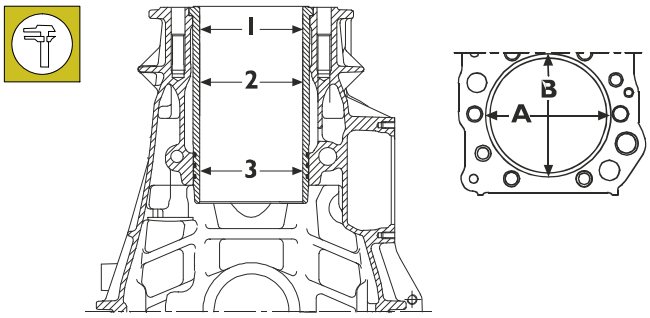
If the caps are rusted or there is any doubt over the efficiency of the seal the produce, replace the caps with new ones.

During fitting operations, apply LOCTITE 270 to the caps.

The internal diameter of the cylinder liners is checked to ascertain the extent of ovalization, taper and wear, using the bore meter (2) fitted with a dial gauge (1) previously reset on the ring gauge (3) of the diameter 135 mm.

NOTE If the 135 mm ring gauge is not available, use a micrometer.

Figure 63

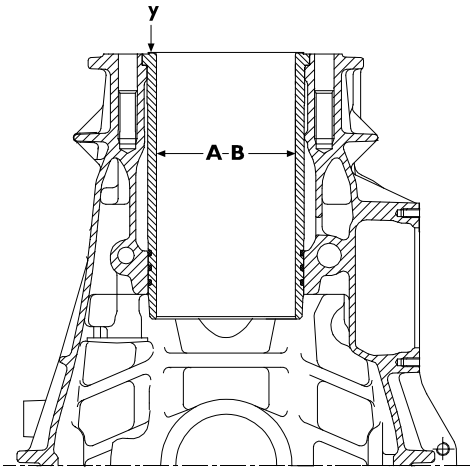


60596

1 = 1st measurement
2 = 2nd measurement
3 = 3rd measurement

Measurements should be carried out for every single cylinder liner at three different heights and on two (A-B) perpendicular plane levels as shown in the figure.

Figure 64



60595

A = Selection class Ø 135.000 - 135.013

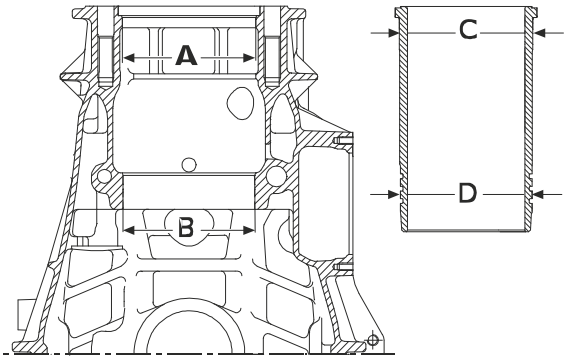
B = Selection class Ø 135.011 - 135.024

Y = Marking area

When wear is over 0.150 mm or maximum ovalisation is 0.100 mm compared to the values shown in the figure, replace the cylinder liner since it is not possible to adjust, lap or dress it.

NOTE Cylinder liners are equipped with spare parts belonging to selection class "A".

Figure 65



60597

A = Ø 153.500 - 153.525

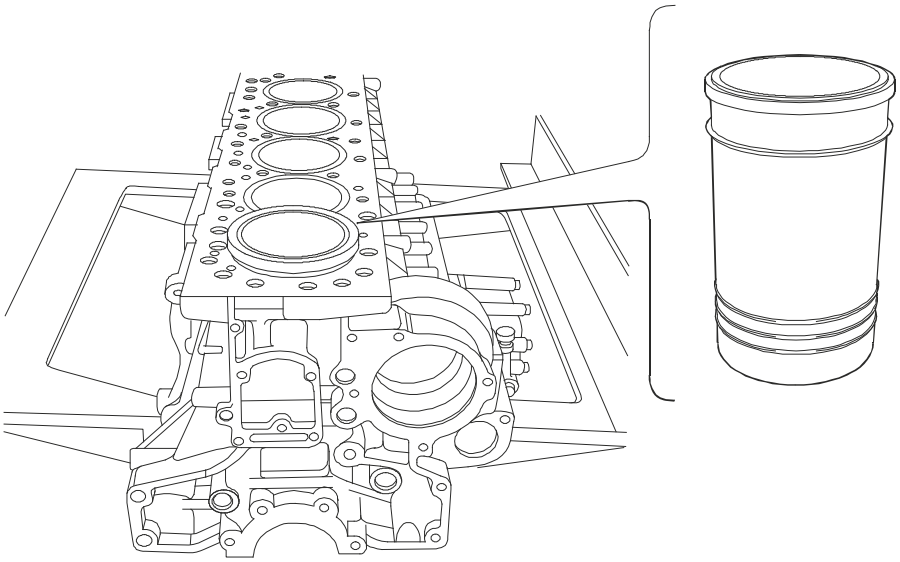
B = Ø 152.000 - 152.025

C = Ø 153.461 - 153.486

D = Ø 151.890 - 151.915

The illustrated diagram refers to the outer diameters of cylinder liners (C) and (D) and the inner diameters of their seats (A) and (B).

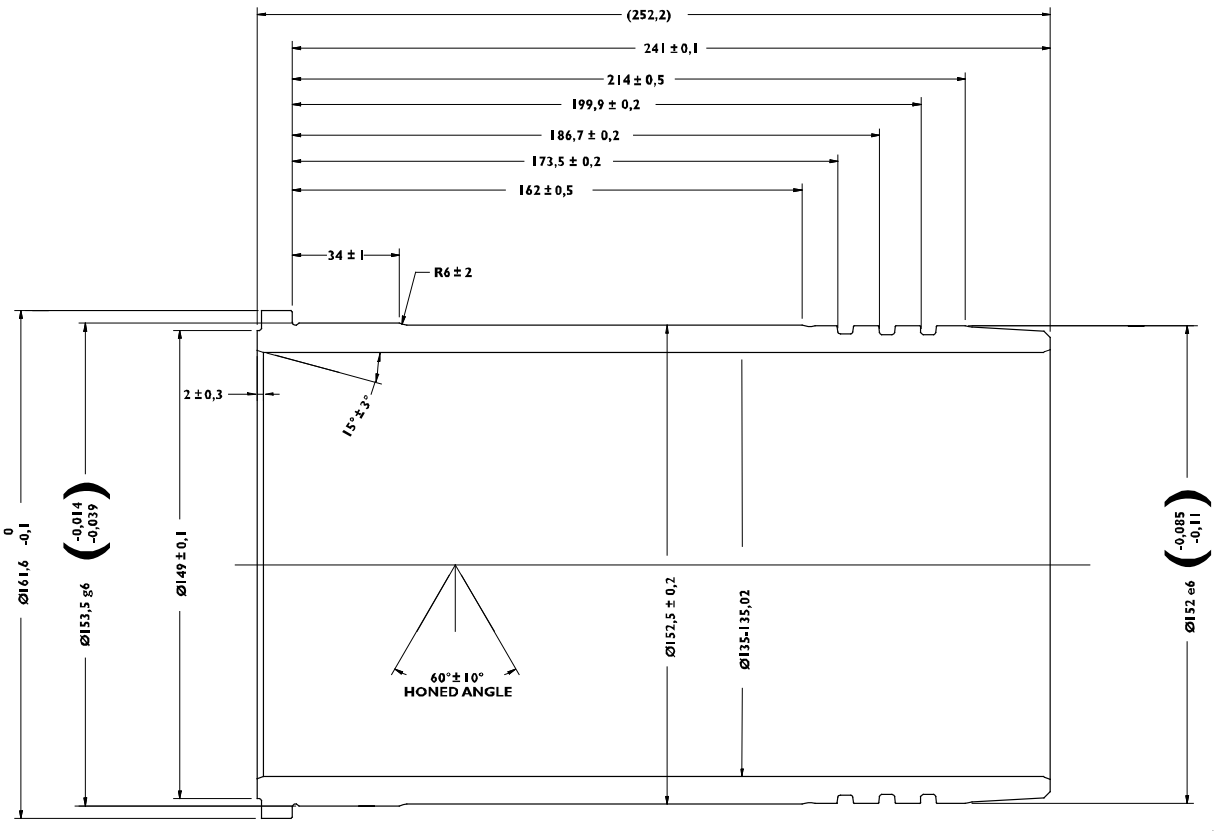
Figure 66



60598

Cylinder liners can be removed and fitted several times into different seats, if needed.

Figure 67

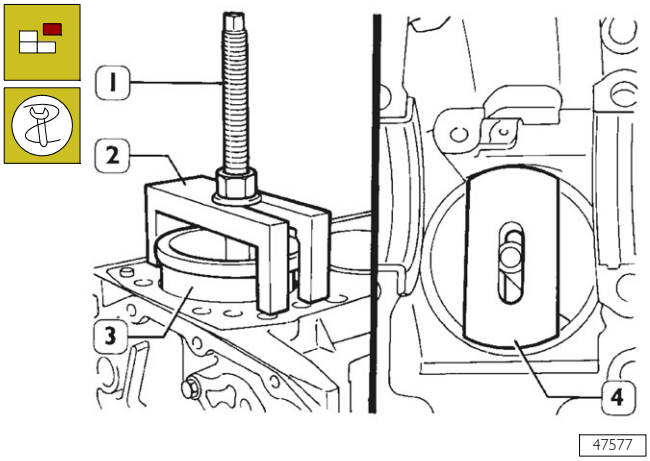


221075

During checks, make sure that the main data for the cylinder liners is the same as in the figure.

Cylinder liners Removal

Figure 68

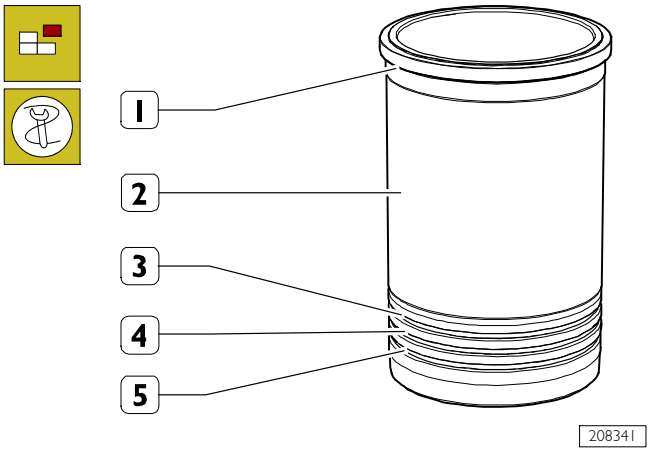


Position the extraction tool 99360706 (2) and the plate 99360728 (4), as shown in the figure, making sure that the plate (4) rests correctly on the cylinder liner.

Fasten the screw nut (1) and take off the cylinder liner (3) from the crankcase.

Cylinder liner refitting and protrusion check

Figure 69

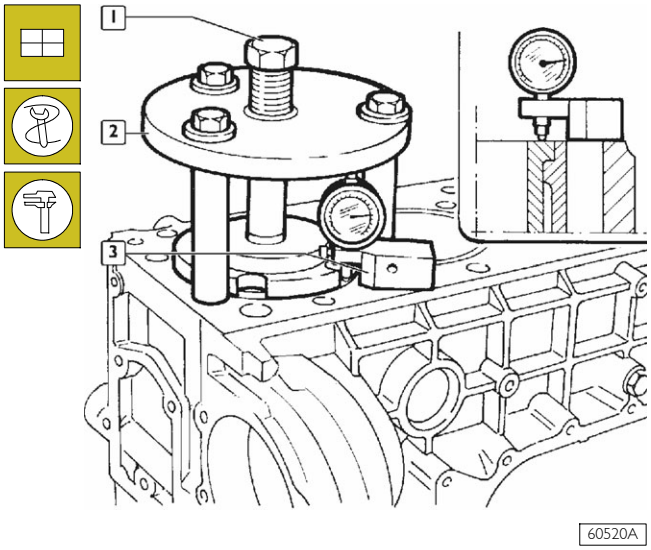


Always replace the watertight rings (3, 4 and 5).

Install the adjustment ring (1) on the cylinder liner (2); lubricate the lower part of the liner and install it in the cylinder assembly using the proper tool.

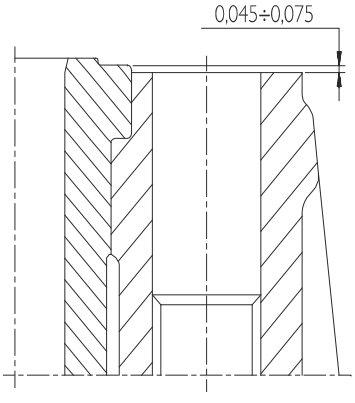
NOTE The adjustment ring (1) is supplied as spare parts in the following thicknesses: 0.08 mm - 0.10 mm - 0.12 mm - 0.14 mm.

Figure 70



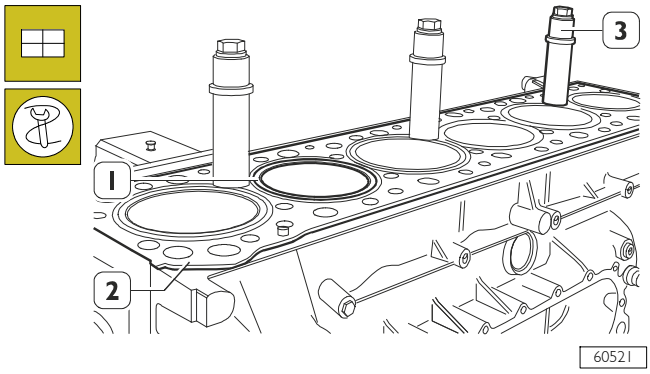
Check the protrusion of the cylinder liners using the tool 99360334 (2) together with spacers 99360336 and tightening the screw (1) to a torque of 225 Nm

Figure 71



Using the dial gauge (0-5mm) 99395603 supplied with a base with dial gauge carrier 99370415 (3), check that the protrusion of the cylinder liners in relation to the contact surface of the cylinder heads is 0.045 - 0.075, if this is not the case, replace the adjustment ring (1, Figure 69), supplied as a spare part in different thicknesses.

Figure 72

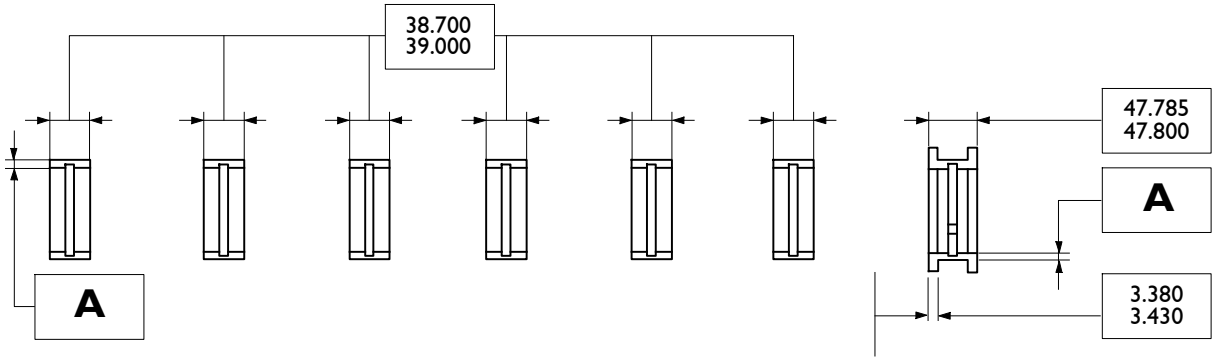


Once assembly is complete, block the cylinder liners (1) at the crankcase (2) with stud bolts 99360703 (3).

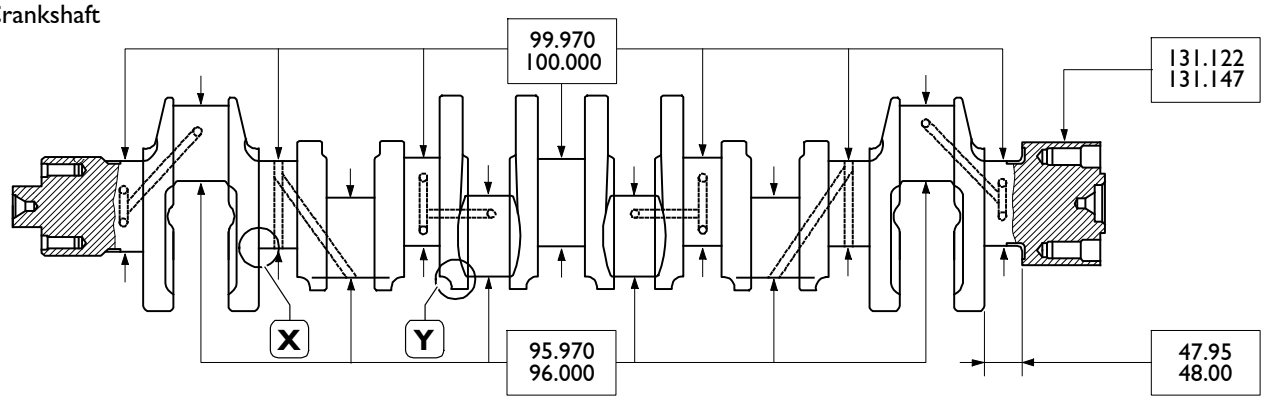
Crankshaft measurements

Figure 73

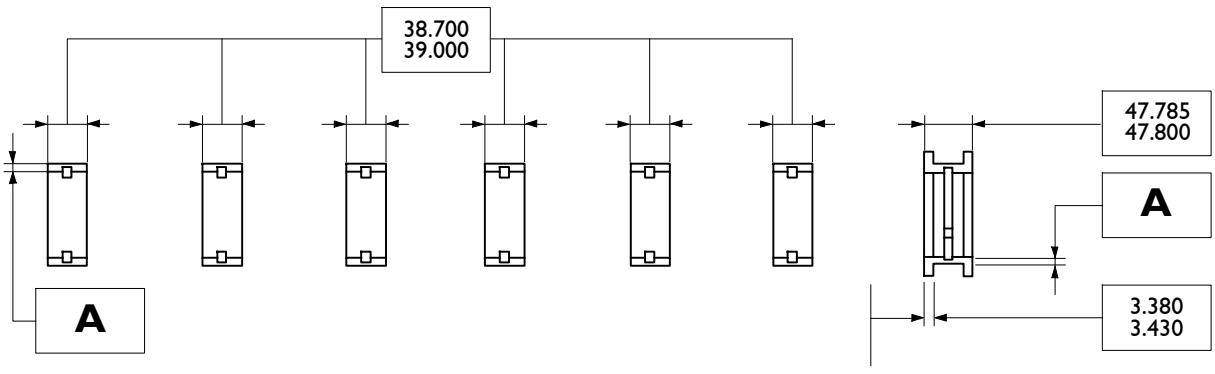
Main journals upper bearing shells



Crankshaft



Main bearing lower half bearings



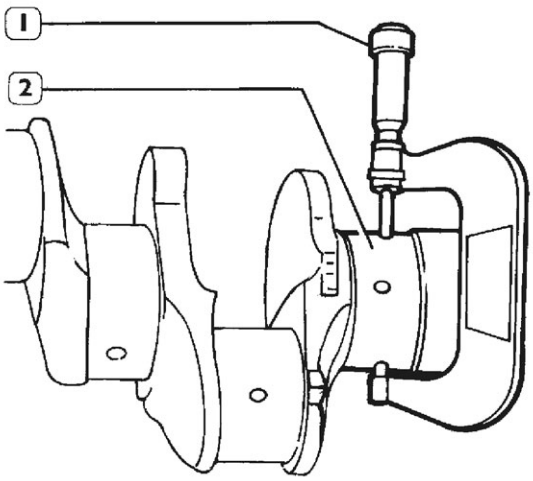
A = 3.115 - 3.146

Main half-bearings thickness

Check the condition of the crankshaft main journals; there must no be signs of scoring, ovalisation or excessive wear . The values shown refer to rated pin diameter.

Measuring main journals

Figure 74



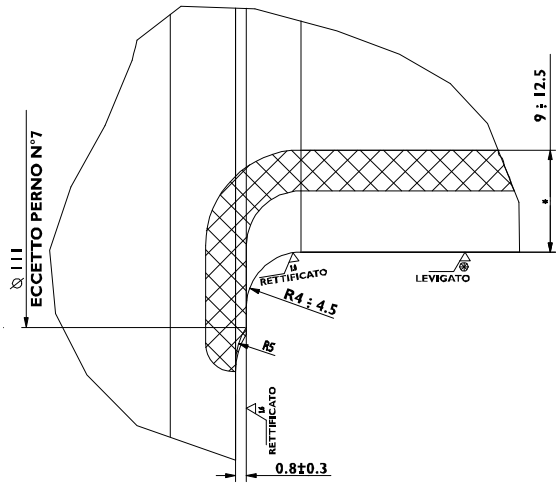
47535

Before grinding the pins using a micrometer (1), measure the main journals and the crank pins (2) and decide, on the basis of the undersizing of the half-bearings, the final diameter to which the pins are to be ground.

NOTE It is advisable to enter readings in a table.

NOTE For a more accurate reading, take different measurements on more than one point of the shaft and calculate the average value.

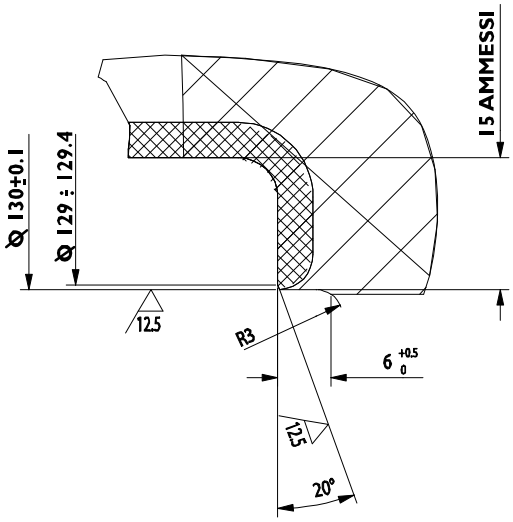
Figure 75



224076

X = Main journals fitting detail N.° 1-6

Figure 76



224078

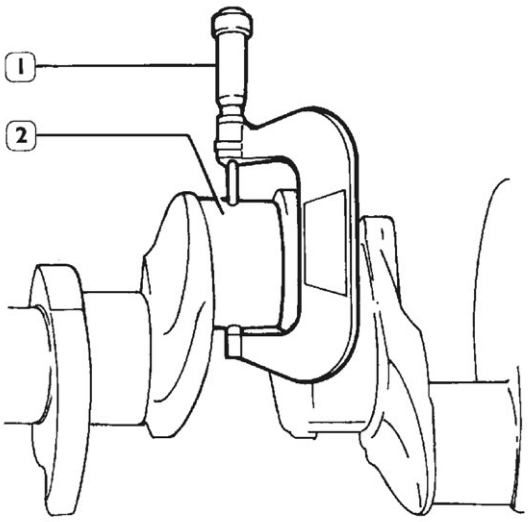
X = Main journals fittings detail N.° 7

During the adjustment operation, pay attention to the values of the main journal coupling shown in figure

NOTE All main journals and crankpins must also be ground to the same undersizing class, in order to avoid any alteration to shaft balance.

Measuring crankpins

Figure 77

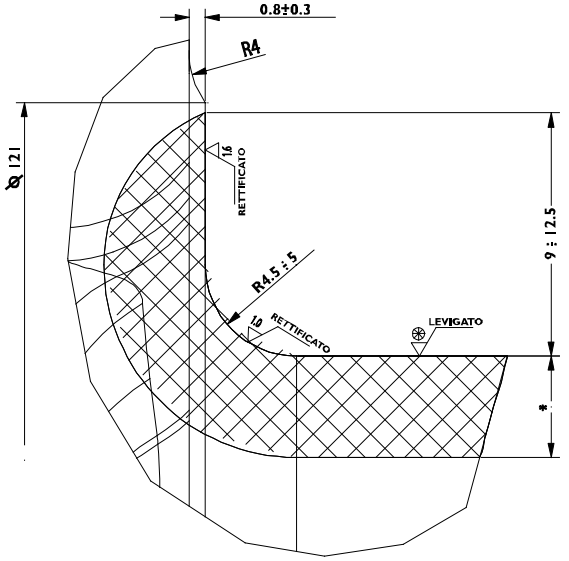


47536

Before grinding the pins, using a micrometer (1), measure the main journals of the shaft (2) and decide, on the basis of the undersizing of the half-bearings, the final diameter to which the pins are to be ground.

NOTE For a more accurate reading, take different measurements on more than one point of the shaft and calculate the average value.

Figure 78



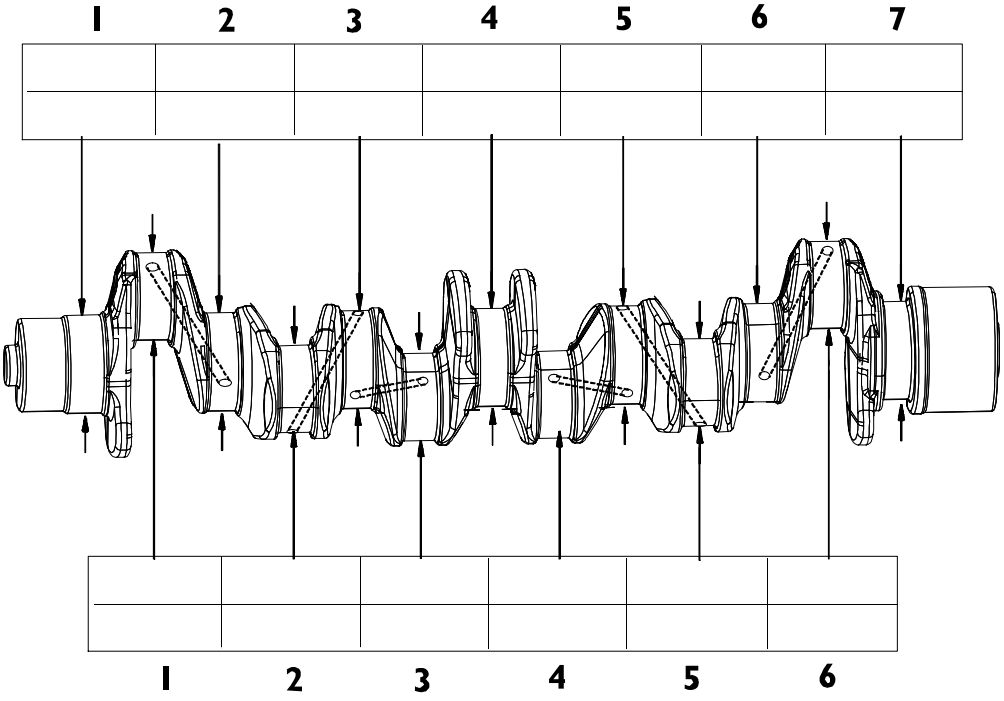
224077

Y=Crankpin fitting detail

During the grinding operation, pay attention to the values of the crankpins shown in Y.

NOTE All main journals and crankpins must also be ground to the same undersizing class, in order to avoid any alteration to shaft balance.

Figure 79

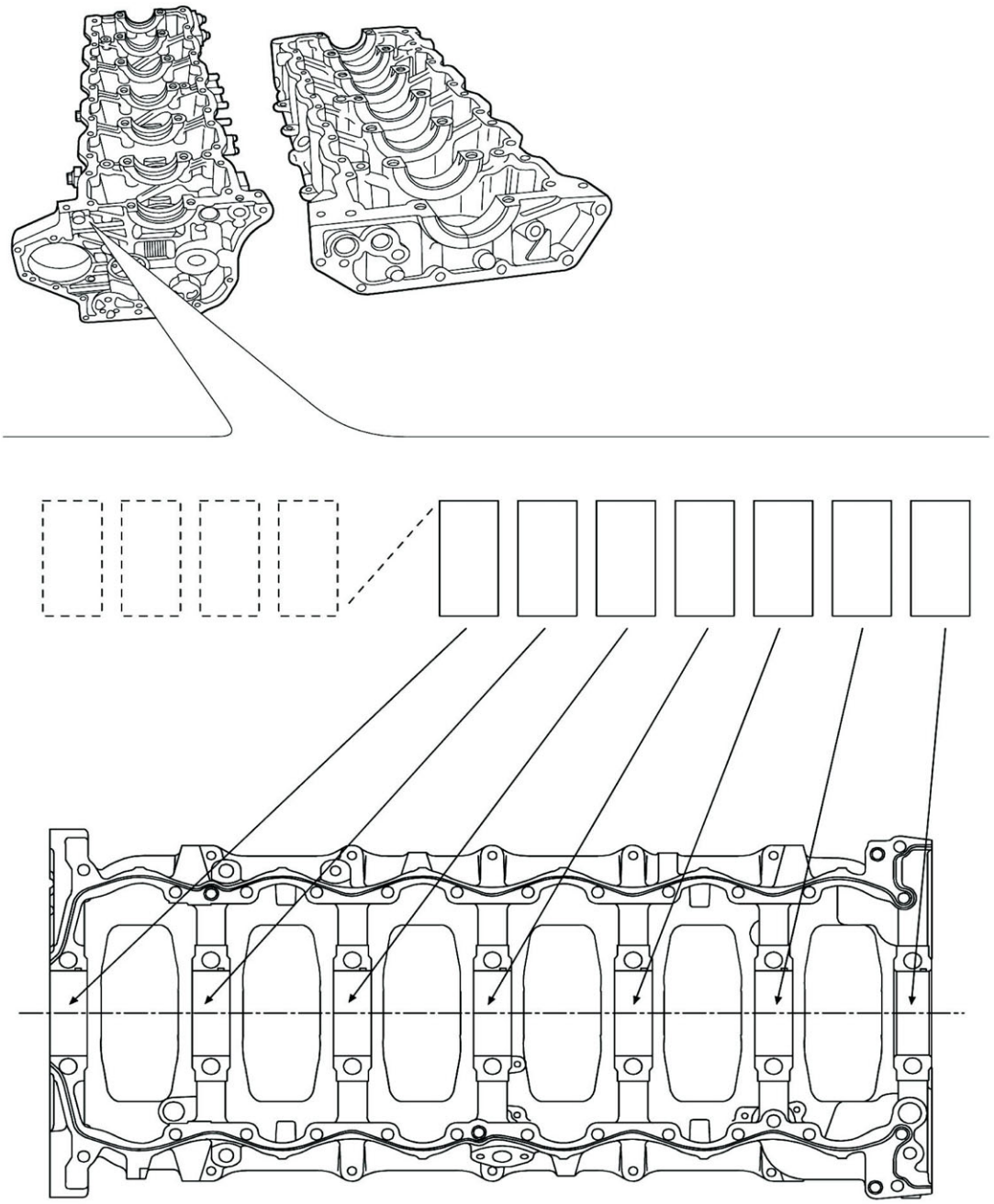


114045

Write down the measurements of the main journals and crankpins of the crankshaft in the table.

Defining the diameter class of the seats for half-bearings on the crankcase

Figure 80



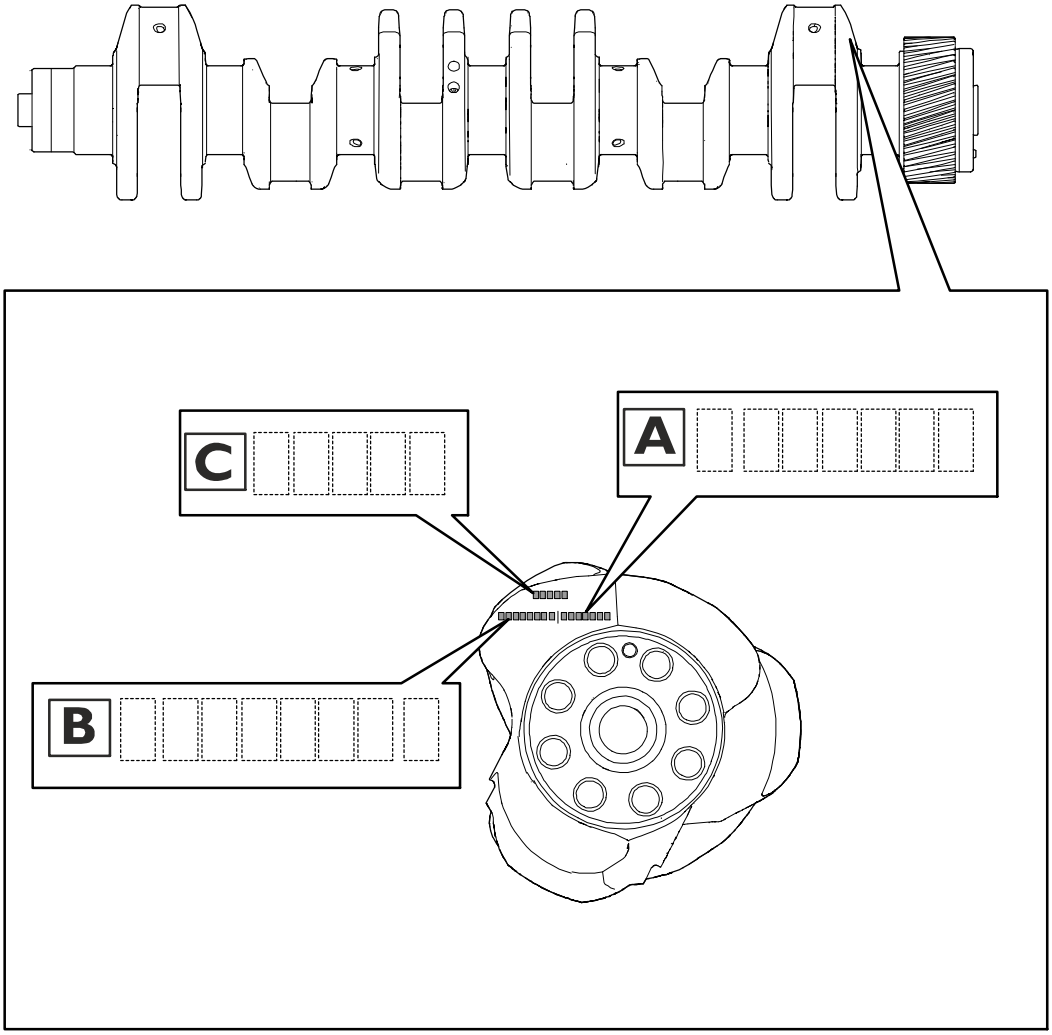
190208

To identify the diameter class of the seats for the main half-bearings, look at the front part of the crankcase in the position as indicated in the figure.

Defining the diameter class of the main journals and crankpins

In order to identify the diameter class of the crankpins and main journals, identify the three sets of figures marked on the front of the crankshaft.

Figure 81



210301

A: The set of seven digits refers to the crankpin, more specifically:

- ❑ The isolated digit indicates the state of the pins (1 = STD, 2 = - 0.127)
- ❑ The six digits, taken individually, represent the diameter class of each crankpin to which they refer.

B: The set of eight digits refers to the crankpin, more specifically:

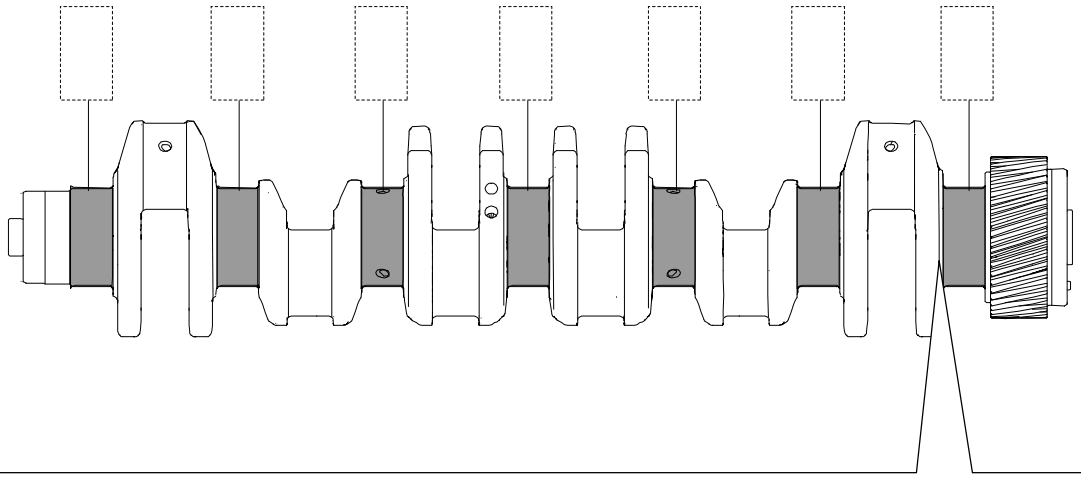
- ❑ The isolated digit indicates the state of the pins (1 = STD, 2 = - 0.127)
- ❑ The seven digits, taken individually, represent the diameter class of each crankpin to which they refer.

C: The first number, of five digits, is the part number of the shaft.

Defining the diameter class of the main journals (nominal diameter)

In order to identify the diameter class of the main journals, identify the three sets of figures marked on the front of the crankshaft

Figure 82



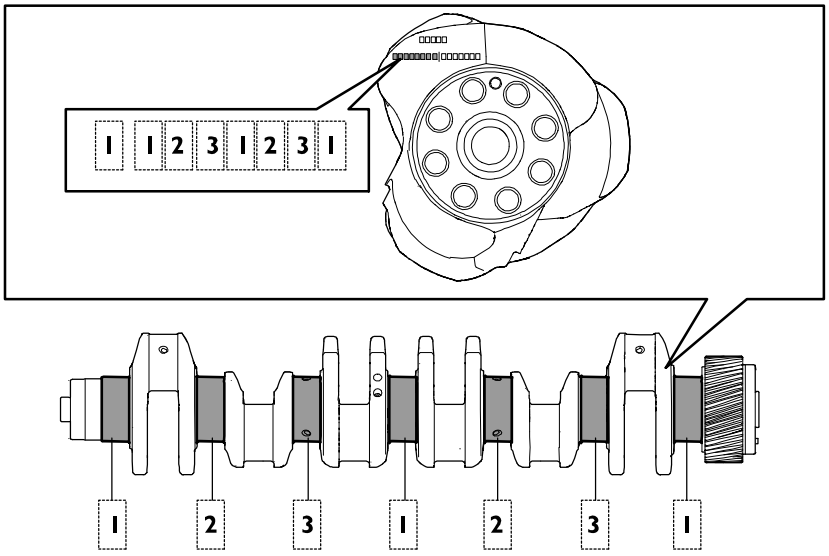
CLASS	STATUS OF MAIN JOURNAL
1	STD
2	-0.127

CLASS	RATED DIAMETER OF MAIN JOURNALS
1	99.970 - 99.977
2	99.978 - 99.985
3	99.986 - 99.993
4	99.994 - 100.00

221130

Example:

Figure 83

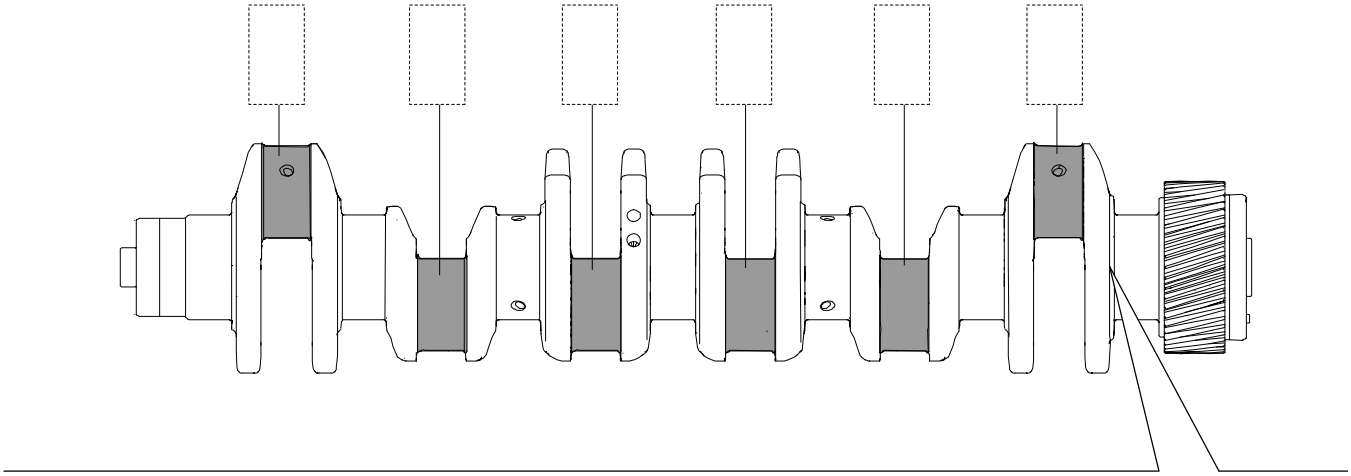


210315

Defining the diameter class of the crankpins (nominal diameter)

In order to identify the diameter class of the crankpins, identify the three sets of figures marked on the front of the crankshaft.

Figure 84



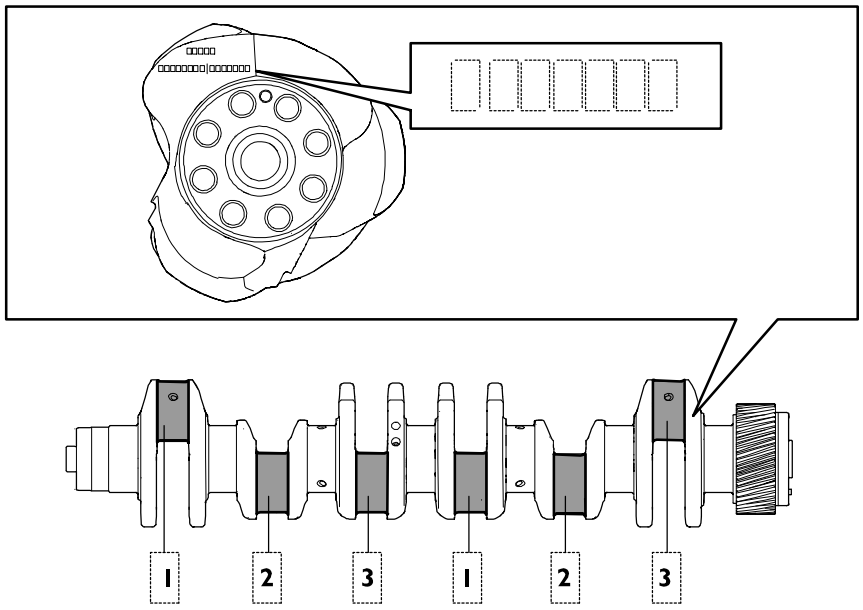
CLASS	STATUS OF MAIN JOURNAL
1 2	STD -0.127

CLASS	CRANKPINS NOMINAL DIAMETER
1 2 3	95.970 - 95.979 95.980 □ 95.989 95.990 □ 96.000

223408

Example:

Figure 85



210316

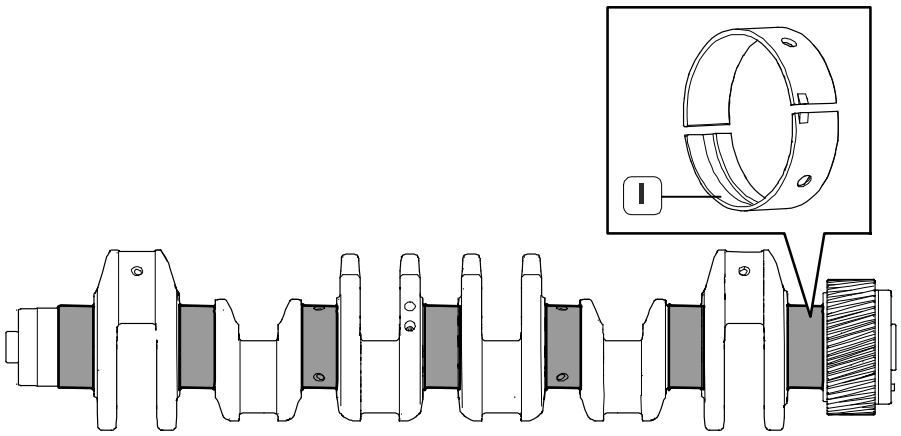
SELECTION OF MAIN HALF-BEARINGS

Depending on the thickness of the half-bearings, the tolerance classes are selected, distinguished by a coloured mark.

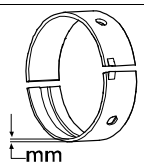
The tables give the specifications of the main bearings available as spare parts in the standard sizes (STD) and in the permissible oversizes (+0.127, +0.254, +0.508).

Main half-bearing thickness

Figure 86

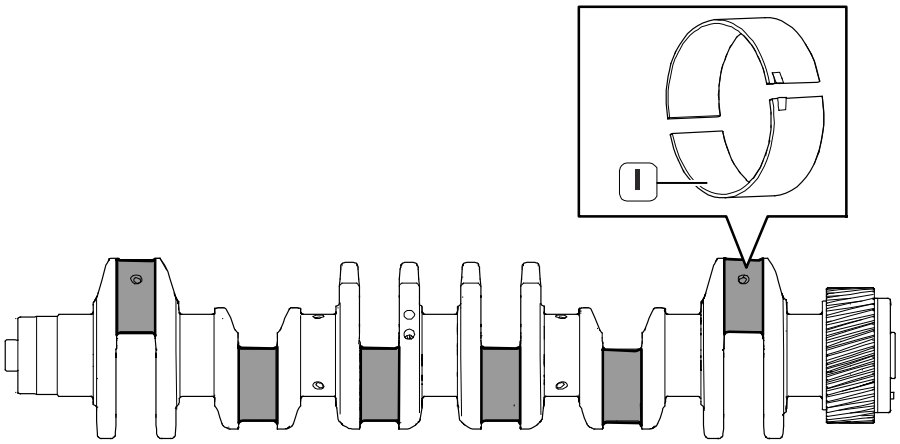


1. Coloured marking area

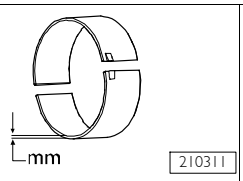
	STD	+0.127	+0.254	+0.508
Red	3.115 - 3.122	-	3.242 - 3.249	3.369 - 3.376
Red/Black	-	3.179 - 3.186	-	-
Green	3.123 - 3.130	-	-	-
Green\Black	-	3.187 - 3.194	-	-
Yellow*	3.131 -3.138	-	-	-
Yellow/Black *	-	3.195 - 3.202	-	-
Black*	3.139 -3.146	-	-	-
Black/Black	-	3.203 - 3.210	-	-

* Not supplied as a spare part.

Figure 87



1. Coloured marking area

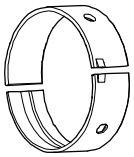
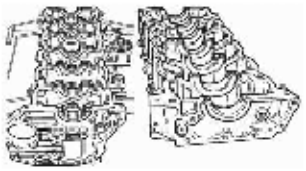
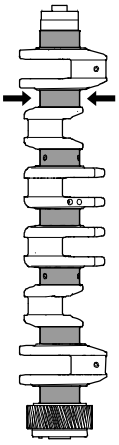
 mm 210311	STD	+0.127	+0.254	+0.508
Red	1.960 □ 1.970	-	2.087 - 2.097	2.214 - 2.224
Red/Black	-	2.023 - 2.033	-	-
Green	1.970 -1.980	-	2.097 - 2.107	2.224 - 2.234
Green\Black	-	2.033 - 2.043	-	-
Yellow*	1.980 -1.990	-	-	-
Yellow/Black **	-	2.043 - 2.053	-	-

* Not supplied as a spare part. If necessary, replace with Green half-bearing

** Not supplied as a spare part. If necessary, replace with Green\Black half-bearing

Main half-bearing selection (nominal diameter)

After detecting, for each main journal, the necessary data on crankcase and crankshaft, select the type of half-bearings to be used, in compliance with the following table:.

 210306					
STD	CLASS	1 106.300 106.307	2 106.308 106.315	3 106.316 106.323	4 106.324 106.330
 210307	1 99.970 99.977	Green	Yellow*	Yellow*	Black
		Yellow*	Yellow*	Black	Black
	2 99.978 99.985	Green	Green	Yellow*	Yellow*
		Green	Yellow*	Yellow*	Black
	3 99.986 99.993	Red	Green	Green	Yellow*
		Green	Green	Yellow*	Yellow*
	4 99.994 100.000	Red	Red	Green	Green
		Red	Green	Green	Yellow*

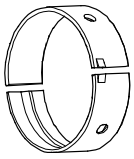
* Not supplied as a spare part. If necessary, replace with Green\Black half-bearing

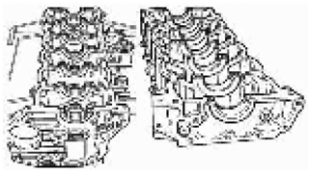
NOTE If using main end half-bearings of a different thickness, fit the thicker bearing at the bottom.

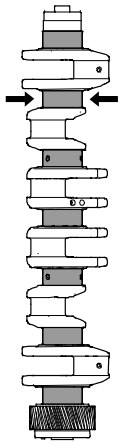
Main half-bearings selection (rectified pins)

If the journals have been rectified, the procedure described cannot be applied.

In this case, make sure that the new diameters of the pins is as indicated in the table and fit the only type of half-bearing indicated for the undersizing in question.

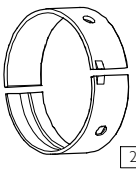

210306

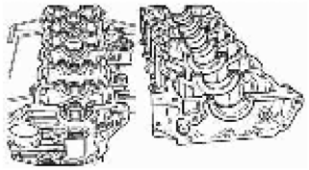


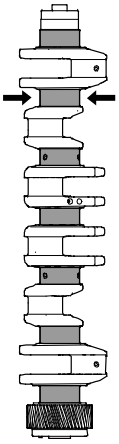
-0.127	CLASS	1 106.300 106.307	2 106.308 106.315	3 160.316 106.323	4 106.324 106.330
 210307	1 99.843 99.850	Green/Black	Yellow/Black*	Yellow/Black*	Black / Black
		Yellow/Black*	Yellow/Black*	Black / Black	Black / Black
	2 99.851 99.858	Green/Black	Green/Black	Yellow/Black*	Yellow/Black*
		Green/Black	Yellow/Black*	Yellow/Black*	Black / Black
	3 99.859 99.866	Red / Black	Green/Black	Green/Black	Yellow/Black*
		Green/Black	Green/Black	Yellow/Black*	Yellow/Black*
	4 99.867 99.873	Red / Black	Red / Black	Green/Black	Green/Black
		Red / Black	Green/Black	Green/Black	Yellow/Black*

* Not supplied as a spare part. If necessary, replace with Green half-bearing

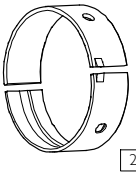
NOTE If using main half-bearings of a different thickness, fit the thicker bearings at the bottom (plate side).

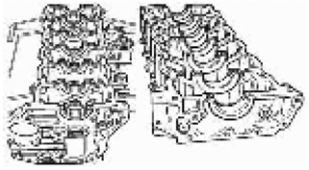

210306

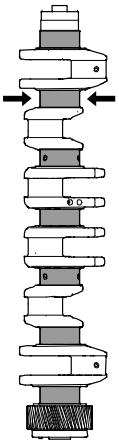


-0.254	CLASS	1 106.300 106.307	2 106.308 106.315	3 106.316 106.323	4 106.324 106.330
 210307	3 99.726	Red	Red	Red	Red
	4 99.746	Red	Red	Red	Red

NOTE If using main half-bearings of a different thickness, fit the thicker bearings at the bottom (plate side).


210306



-0.508	CLASS	1 106.300 106.307	2 106.308 106.315	3 160.316 106.323	4 106.324 106.330
 210307	3 99.472	Red	Red	Red	Red
	4 99.492	Red	Red	Red	Red

NOTE If using main half-bearings of a different thickness, fit the thicker bearings at the bottom (plate side).

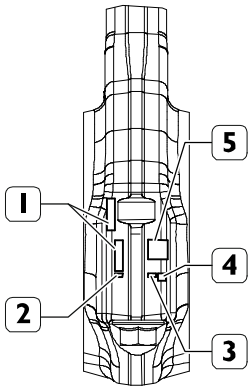
Big-end half-bearing selection (nominal diameter pins)

Select the big end half-bearings by referring to the markings on the connecting-rod body, in the indicated position.

NOTE The number indicating the diameter class of the seat for half-bearings can be: 1, 2 or 3

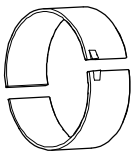
1) Serial No.
2) Letter indicating the weight class
   A = 5502 - 5535 g.
   B = 5536 - 5569 g.
   C = 5570 - 5602 g.
3) Number indicating the selection of the diameter of the big end bearing seat
   1 = 100.000- 100.010mm
   2 = 100.011- 100.020mm
   3 = 100.021- 100.030mm
4) Engine type
5) Connecting rod identification plate

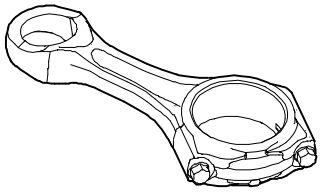
Figure 88

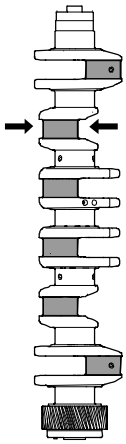


155939

Big end half-bearings selection (nominal diameter pins)


210309


210312

STD	CLASS	1 100.000 100.010	2 100.011 100.020	3 100.021 100.030
 210310	1 95.990 96.000	Red	Red	Green
		Red	Green	Green
	2 95.980 95.989	Red	Green	Green
		Green	Green	Yellow*
	3 95.970 95.979	Green	Green	Yellow*
		Green	Yellow*	Yellow*

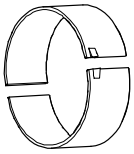
* Not supplied as a spare part. If necessary, replace with Green half-bearing

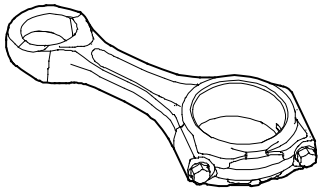
NOTE If using big end half-bearings of a different thickness, fit the thicker bearing at the bottom.

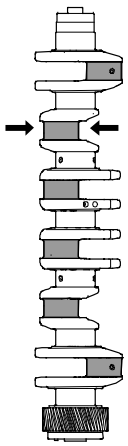
Big end half-bearings selection (pins with rectified diameter)

If the crankpins have been rectified, the procedure described cannot be applied.

In this case, it is necessary to check (for each of the undersizings) which field of tolerance includes the new diameter of the crankpins and to mount the bearing shells identified with the relevant table.

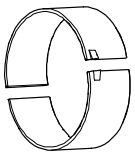

210309

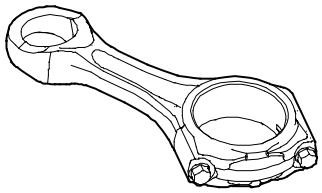

210312

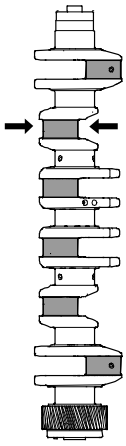
-0.127	CLASS	1 100.000 100.010	2 100.011 100.020	3 100.021 100.030
 210310	1 95.863 95.873	Red/Black	Red/Black	Green\Black
		Red/Black	Green\Black	Green\Black
	2 95.853 95.862	Red/Black	Green\Black	Green\Black
		Green\Black	Green\Black	Yellow/Black *
	3 95.843 95.852	Green\Black	Green\Black	Yellow/Black *
		Green\Black	Yellow/Black *	Yellow/Black *

* Not supplied as a spare part. If necessary, replace with Green\Black half-bearing

NOTE If using big end half-bearings of a different thickness, fit the thicker bearing at the bottom.

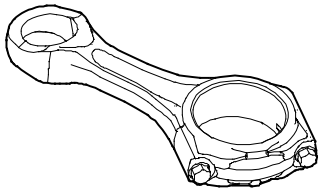

210309

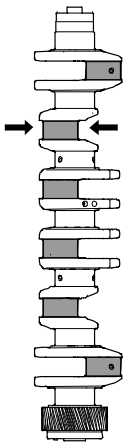

210312

-0.254	CLASS	1 100.000 100.010	2 100.011 100.020	3 100.021 100.030
 210310	1 95.736 95.746	Red	Red	Green
		Red	Red	Green
	2 95.726 95.735	Red	Green	Green
		Red	Green	Green

NOTE If using big end half-bearings of a different thickness, fit the thicker bearing at the bottom.


210309

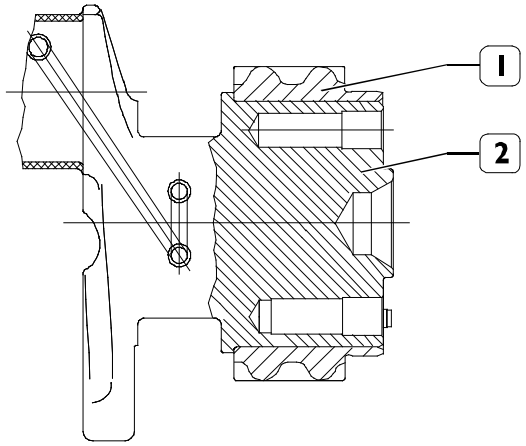

210312

-0.508	CLASS	1 100.000 100.010	2 100.011 100.020	3 100.021 100.030
 210310	1 95.482 95.492	Red	Red	Green
		Red	Red	Green
	2 95.472 95.481	Red	Green	Green
		Red	Green	Green

NOTE If using big end half-bearings of a different thickness, fit the thicker bearing at the bottom.

Checking the timing and oil pump gear control

Figure 89



Check that the toothing of the gear is neither damaged nor worn; if it is, take it out with an appropriate extractor and replace it.

When fitting the gear (1) on the crankshaft (2), heat it for no longer than 2 hours in an oven at the temperature indicated below .

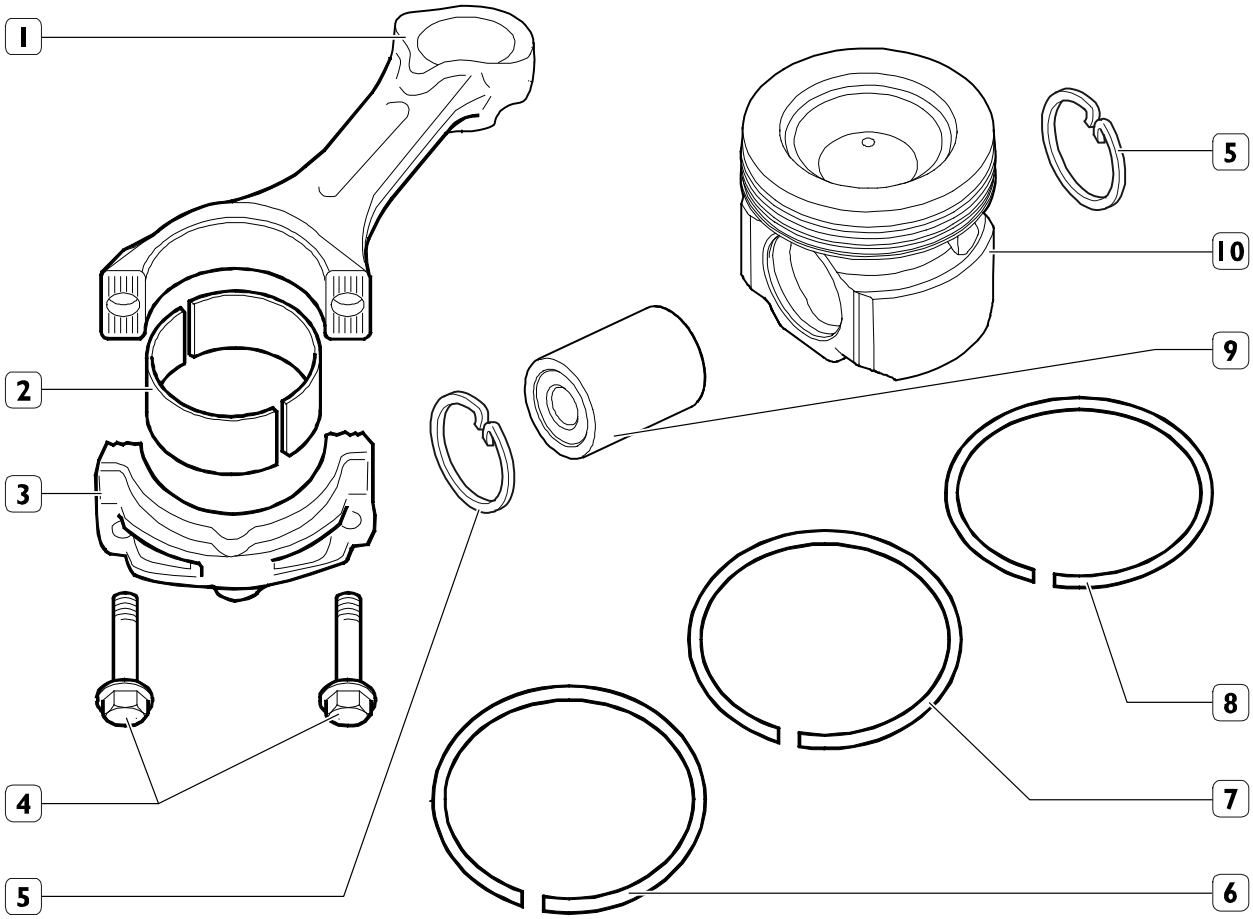
Technical data	
Heating temperature for gear fitting	180°C

Let it cool down after pressing

If changing the pin (3), after fitting it on, check it protrudes from the crankshaft as shown in the figure.

OVERHAULING THE CONNECTING ROD-PISTON ASSEMBLY

Figure 90

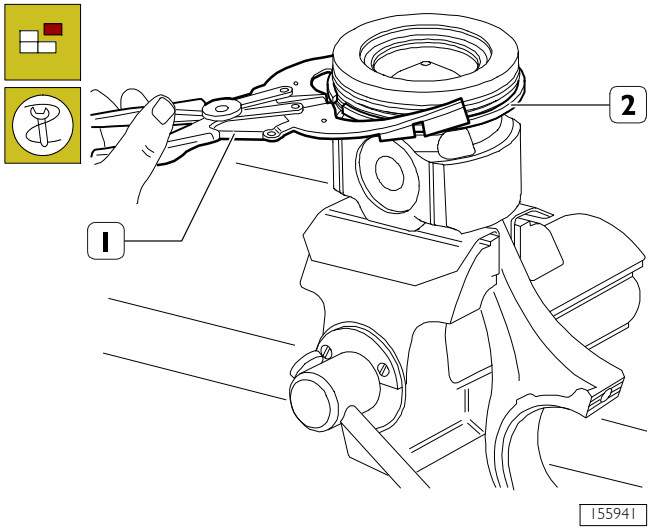


1. Connecting rod body - 2. Half-bearings - 3. Connecting rod cap - 4. Cap fastening screw - 5 Circlip - 6. Slotted oil scraper ring with spiral spring - 7. Claw seal ring - 8. Trapezoidal seal ring - 9. Piston pin - 10. Piston

Make sure the pistons do not show any sign of seizing, scoring, cracking or excessive wear; otherwise, replace as necessary.

Circlips removal

Figure 91



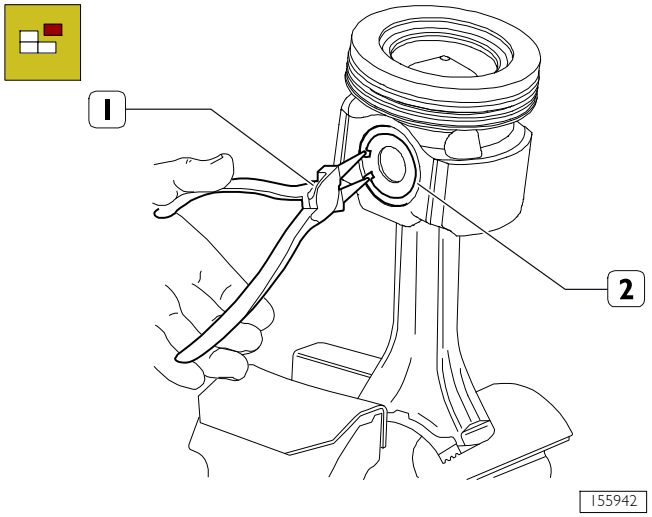
Remove the piston circlips (2) using the caliper 99360184 (1).

NOTE Pistons are equipped with three circlips: the first is a sealing ring, with trapezoidal section; the second is a claw seal ring; the third oil scraper.

NOTE Pistons are grouped into classes A and B depending on diameter.

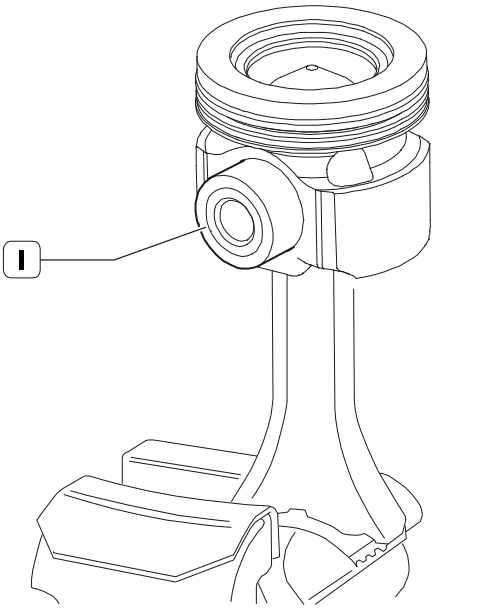
Piston removal

Figure 92



Remove the piston pin circlips (2) using the round tipped calipers (1).

Figure 93

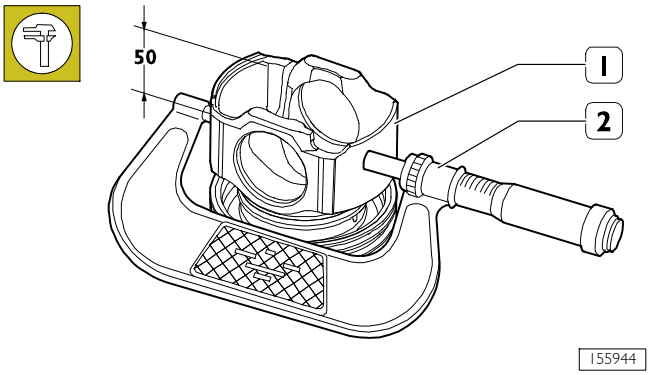


Remove the piston pin (1).

If removal is difficult use the appropriate drift.

Measuring the piston diameter

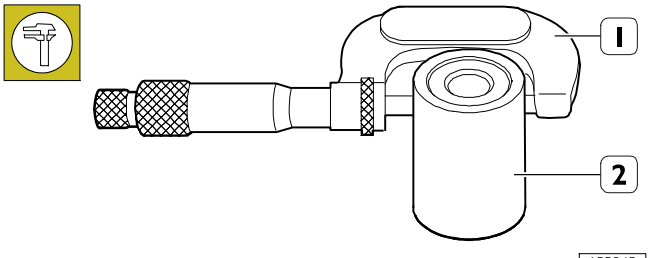
Figure 94



Using a micrometer (2), measure the piston diameter (1) to determine the assembly clearance; The diameter has to be detected at the value indicated.

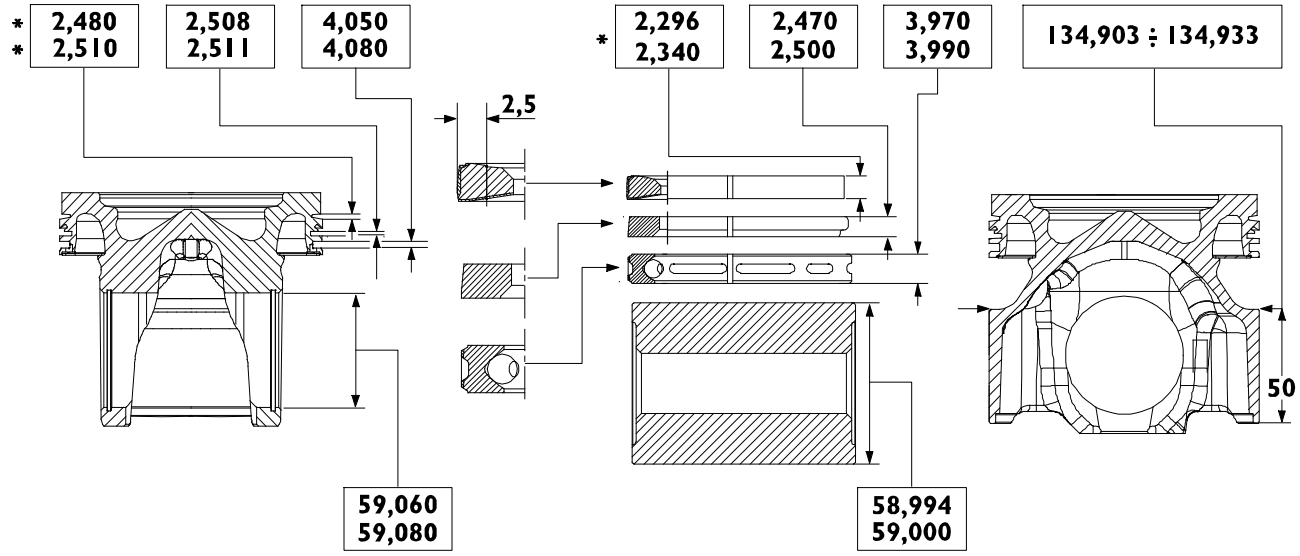
Measuring the piston pin diameter

Figure 95



Measuring the pin diameter (2) with a micrometer (1).

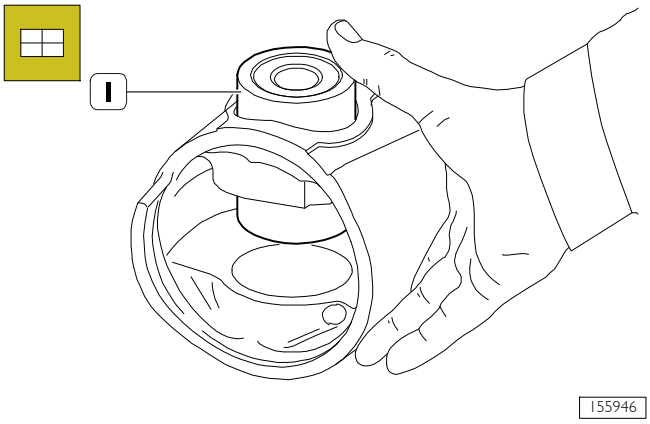
Figure 96



* = The measurement is taken on diameter 130 mm - X = 0.8 ± 0.1 mm

Conditions for correct pin-piston coupling

Figure 97

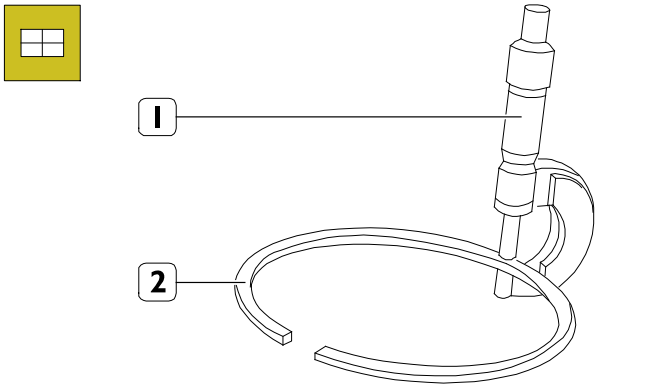


During the coupling phase, make sure that the main data for the pin and piston is the same as that indicated in Figure 96.

Lubricate the pin (1) and the relevant housings on the internal piston hubs with engine oil; the pin must be inserted in the piston with a light finger pressure and it should not come out by gravity.

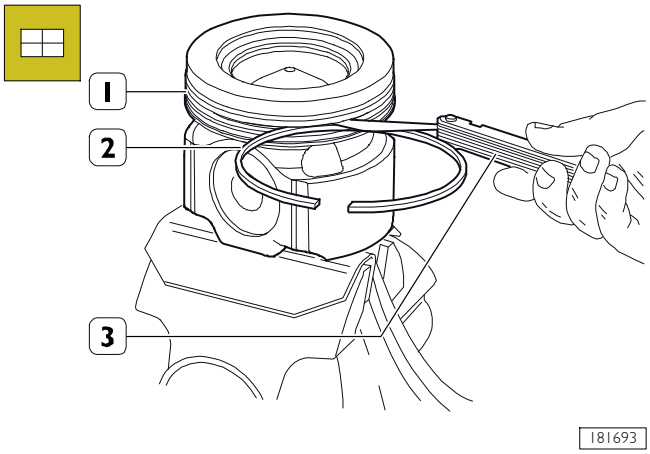
Measuring seal rings

Figure 98



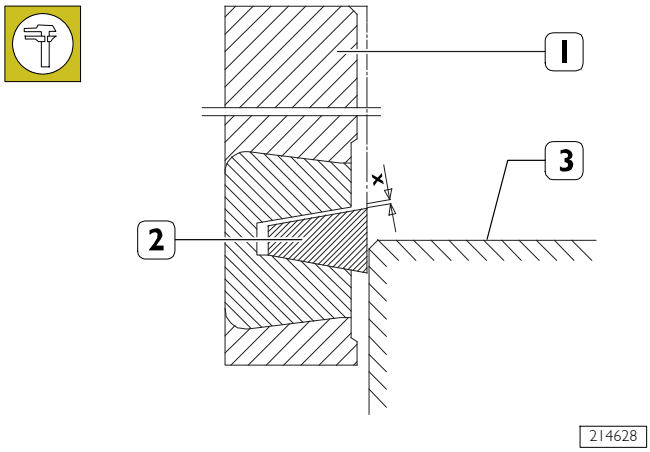
Check the thickness of the circlip using a micrometer 2(1).

Figure 99



Check the clearance between the sealing ring (2) and the related housings on the piston (1) using a feeler gauge (3).

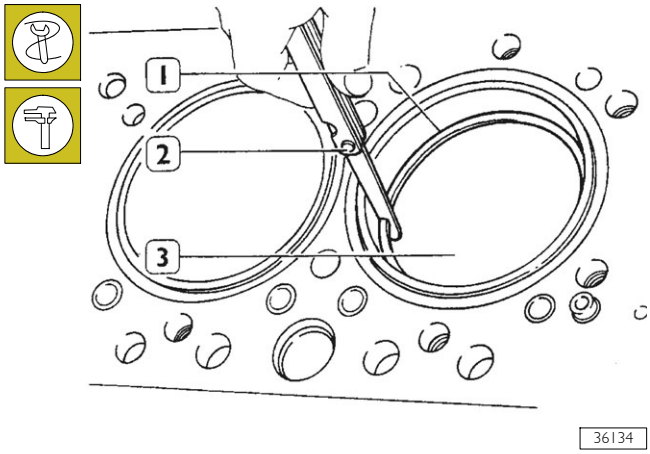
Figure 100



The sealing ring (2) of the 1° seat is trapezoidal.

The clearance measurement "X" between the sealing ring and the housing is done by placing the piston (1) with the related ring in the cylinder sleeve (3) so the half of the sealing ring protrudes from the cylinder sleeve.

Figure 101

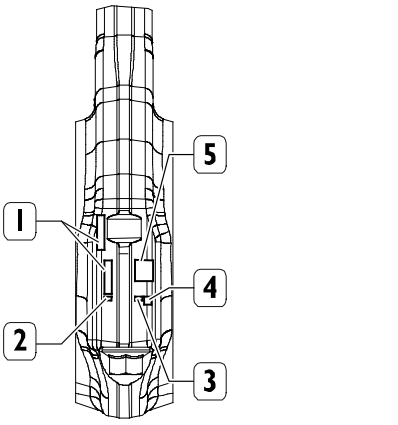


Check the end gap of the sealing rings (1), using a feeler gauge (2), entered in the cylinder liner (3).

If the distance between ends is lower or higher than the value required, replace the circlips.

Connecting rod checks

Figure 102



1 Standard numbers

2 Letter indicating the weight class
A = 5502 - 5535 g.
B = 5536 - 5569 g.
C = 5570 - 5602 g.

3 Number indicating the selection of the diameter of the big end bearing seat:
1 = 100.000 ÷ 100.010 mm
2 = 100.011 ÷ 100.020 mm
3 = 100.021 ÷ 100.030 mm

4 Engine type

5 Connecting rod identification plate

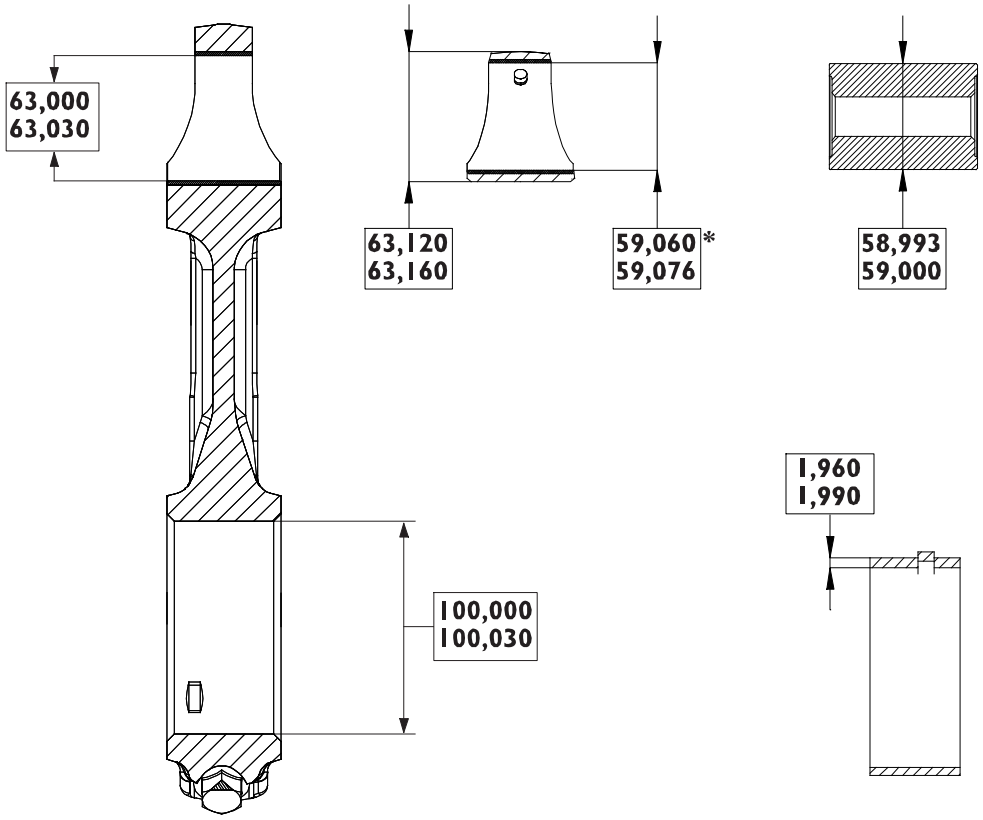
Connecting rods weight class

warning during assembly

When installing connecting rods, make sure they all belong to the same weight class.

Data concerning the class section of connecting rod housing and weight are stamped on the connecting rod.

Figure 103

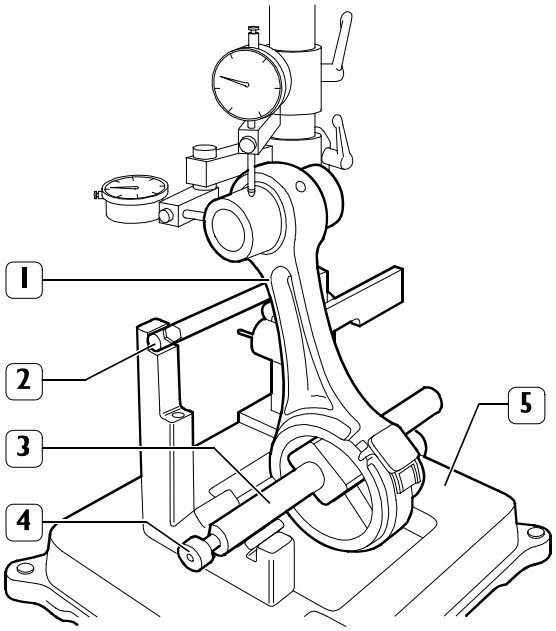


* =Values to be obtained after fitting the bush

During checks make sure that the main data of the bushing, connecting rod, pin and half bearings is that shown in the diagram.

Axis alignment check

Figure 104



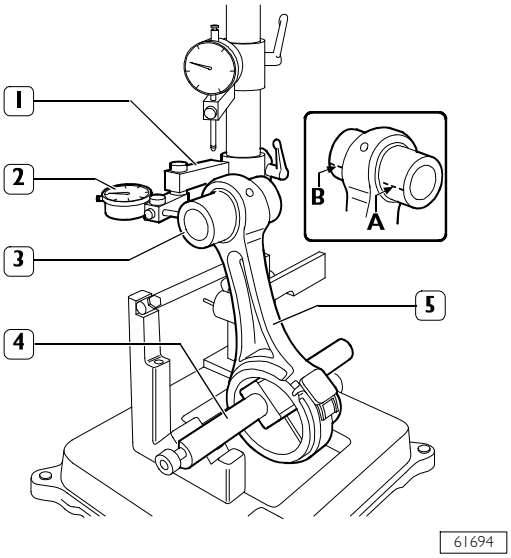
Check the connecting rods axes for parallelism (1) using a suitable device (5) and proceeding as follows.

Fit the connecting rod (1) on the spindle of the tool (5) and lock it with the screw (4).

Set the spindle on the on the V prisms resting the connecting rod 1 on the stop bar (2).

Torsion check

Figure 105

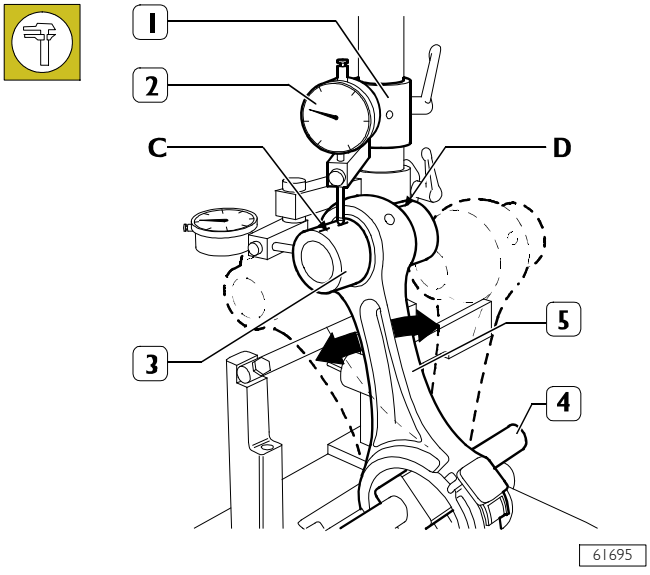


Check the torsion of the connecting rod (5) by comparing two points (A and B) of the pin (3) on the horizontal plane of the axis of the connecting rod.

Position the mount (1) of the dial gauge (2) so that this pre-loads by approx. 0.5 mm on the pin (3) at point A and zero the dial gauge (2). Move the spindle (4) with the connecting rod (5) and compare any deviation on the opposite side B of the pin (3): the difference between A and B must be no greater than 0.08 mm.

Bending check

Figure 106



Check the bending of the connecting rod (5) by comparing two points C and D of the pin (3) on the vertical plane of the axis of the connecting rod.

Position the vertical mount (1) of the dial gauge (2) so that this rests on the pin (3) at point C.

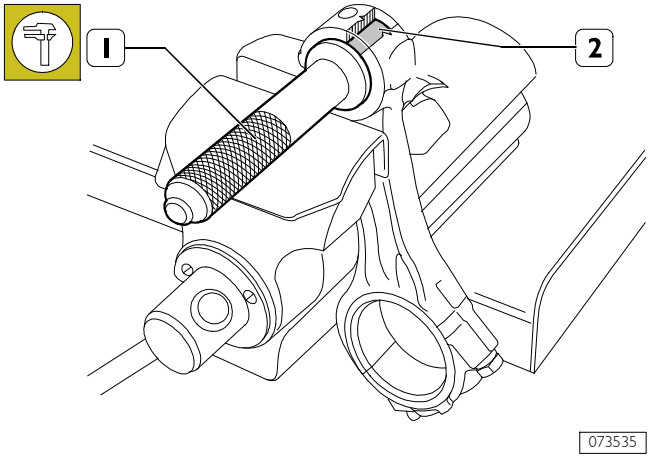
Swing the connecting rod to and fro, establishing the highest position of the pin and reset the dial gauge (2) in this condition.

Shift the spindle (4) with the connecting rod (5) and repeat the check on the highest point on the opposite side D of the pin (3).

The difference between points C and D must not exceed 0.08 mm.

Connecting rod small end bush check

Figure 107



Check that the bushing in the small end has not come loose and shows no sign of seizure or scoring. Otherwise replace it.

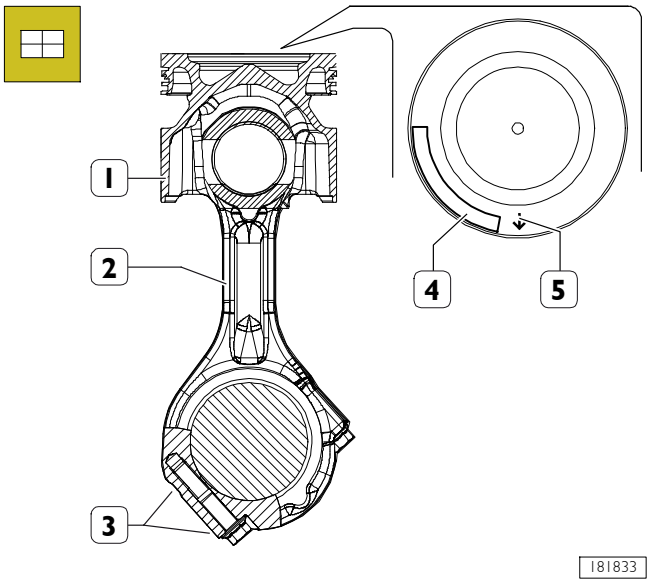
The bushing (2) is removed and fitted with a suitable drift (1).

When driving it in, make absolutely sure that the holes for the oil to pass through in the bushing and small end coincide.

Using a reamer, rebore the bushing so as to obtain a diameter of 59.060 to 59.076 mm.

Piston assembly

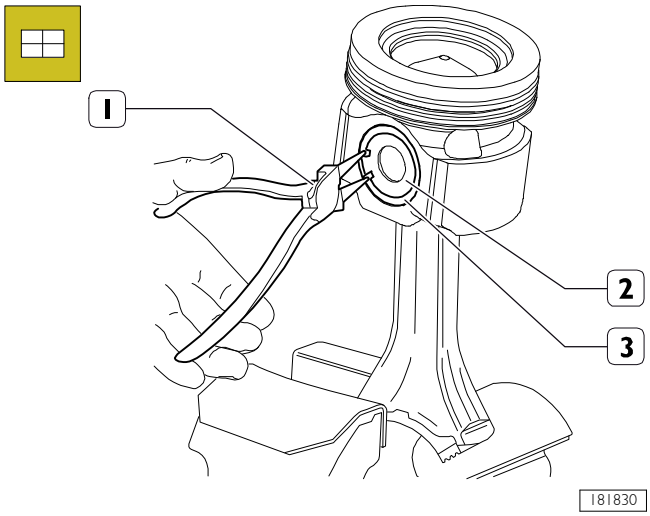
Figure 108



The piston (1) must be mounted on the connecting rod (2) so that the ideogram (4), that indicates the fitting direction of the cylinder liner and the punching (3) of the connecting rod are seen as in the figure.

NOTE The arrow (5) must face the engine flywheel.

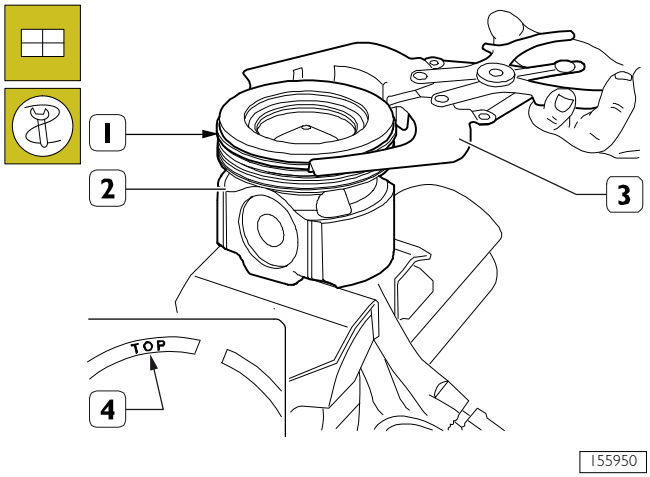
Figure 109



Fit the pin (2) and fasten it on the piston (1) with the circlips (3).

Fitting circlips

Figure 110



To fit the circlips (1) on the piston (2) use the pliers 99360184 (3).

Position the rings so that the word "TOP" (4) is facing upwards, direct the ring openings so they are staggered 180° apart.

CYLINDER HEAD OVERHAUL

Main operation

Before removing cylinder head, check hydraulic tightness using specific tool; in case of leaks not caused by core plugs or threaded plugs, replace cylinder head.

NOTE When replacing the cylinder head, it is supplied as a spare part with a threaded plug, which must be removed during assembly.

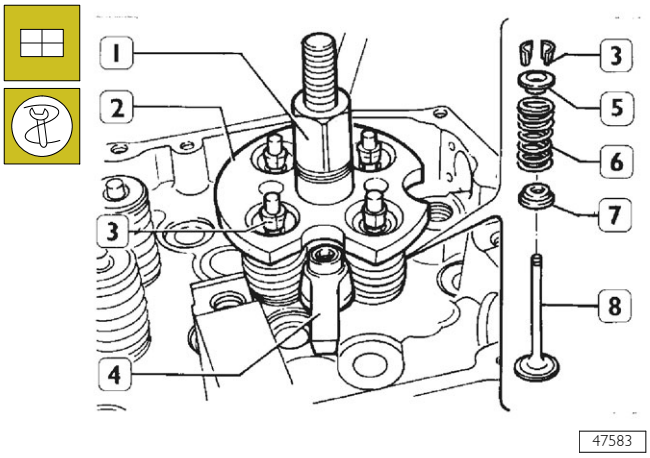
NOTE In case of plugs removal/replacement, when assembling apply sealant Loctite 121078 on the plugs.

Valve removal

NOTE Before removing cylinder head valves, number them so that when they are refitted, if not overhauled or replaced, they are refitted in the same positions as when they where removed.

Intake valves are different form exhaust valves in that they have a notch placed at valve head centre.

Figure 111



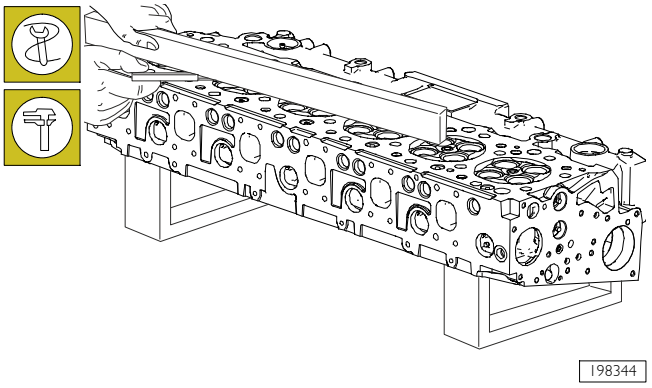
Fit and secure tool 99360263 (2) with the bracket (4); screw down with the device 99360259 (1) so the cotters (3) can be removed; take out the tool (2) and extract the top plate (5), spring (6) and bottom plate (7).

NOTE Repeat this operation for all the valves.

Overturn the cylinder head and withdraw the valves (8).

Checking the planarity of the head on the cylinder block

Figure 112


198344

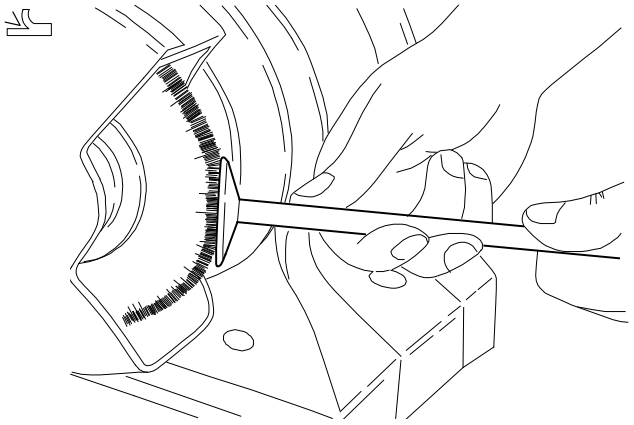
Check the supporting surface (1) of the head on the cylinder assembly with a rule (2) and a feeler gauge (3).

If you find any deformation, level the head on a surface grinder; maximum amount of material that can be removed 0.2 mm.

NOTE After this operation, check valve recessing and injector protrusion.

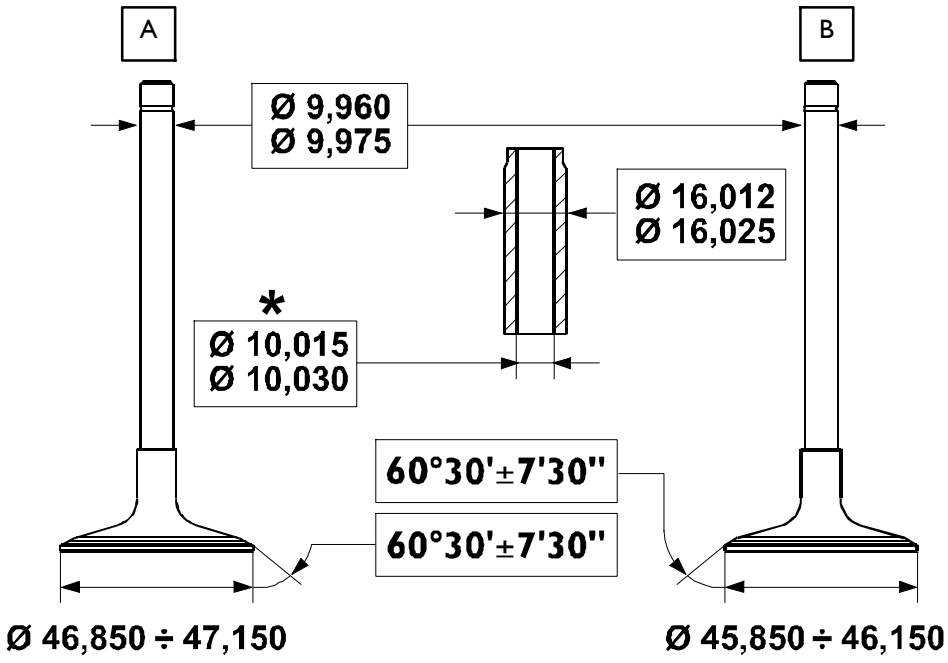
Valve descale and check

Figure 113


204301

Remove all carbon deposits from the valves using a wire brush.

Figure 114



155953

* = Value to be obtained after driving in the valve guides
A = intake - B = exhaust

Check that the valves show no signs of seizure or cracking and also check with a micrometer that the valve stem diameter is within the required values: replace the valves if it is not.

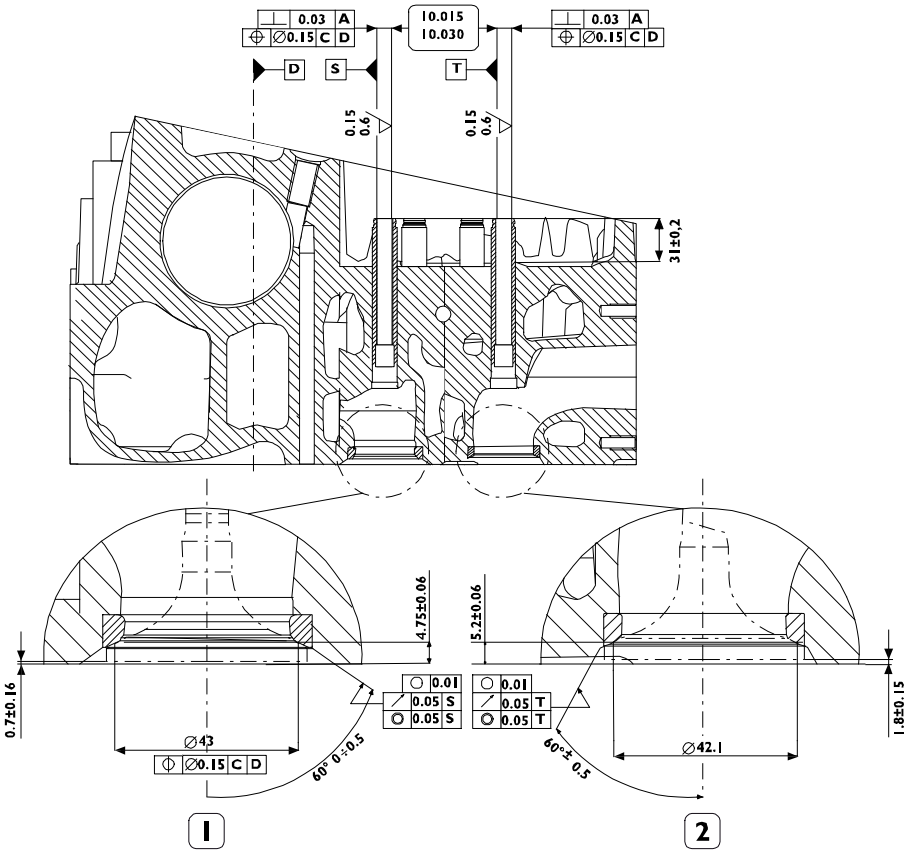
Regrind the valve seats, if required, using a grinding machine and removing as less material as possible.

Use a bore gauge to check that the diameter inside the valve guide corresponds to the value indicated, after fitting.

Regrinding - replacing the valve seats

NOTE The valve seats are reground whenever the valves or the valve guides are ground and replaced.

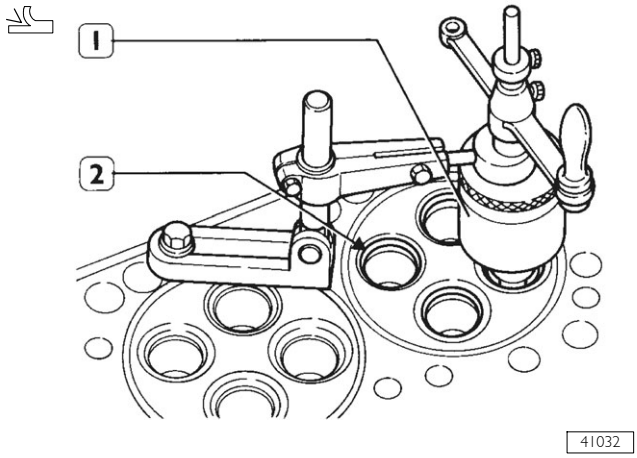
Figure 115



1 Intake valve seat 2 Exhaust valve seat

When replacing/checking the valve seats, refer to the main data provided in the figure.

Figure 116



Check the valve seats (2). If there are light scorings or burnings, regrind them with a suitable tool (1) according to angles shown in the previous figure.

If they need to be replaced, using the same tool and taking care not to accidentally damage the cylinder head, remove as much material as possible from the valve seats until it is possible to extract them from the cylinder head using a punch .

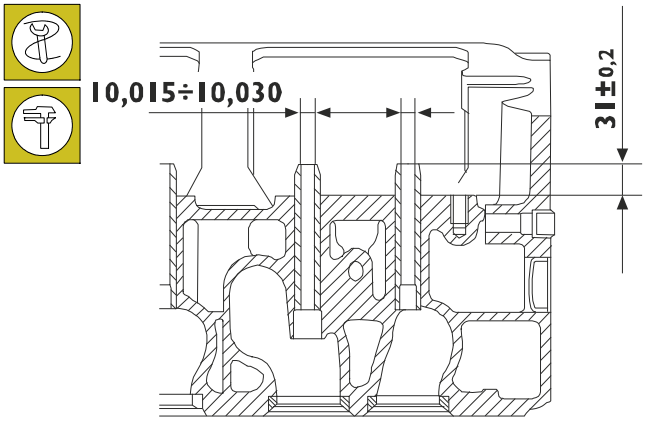
Heat the cylinder head to 80 - 100 °C and, using a drift, fit in the new valve seats (2), chilled beforehand in liquid nitrogen. Using the tool (1), regrind the valve seats according to the angles shown in the previous figure .

After regrinding the valve seats and using a dial gauge (0-5mm) 99395603 with base 99370415, check that the position of the valves in relation to the cylinder head surface respects the values shown below:

Technical data	
Intake valves recessing	-0.54 - -0.86 mm
Exhaust valves recessing	-1.47÷-1.79mm

Replacing the valve guides

Figure 117



* = Measurement to be obtained after driving in the valve guides

The valve guides are removed with the drift 99360143. Assembly is carried out with the drift 99360296 equipped with tool 99360143.

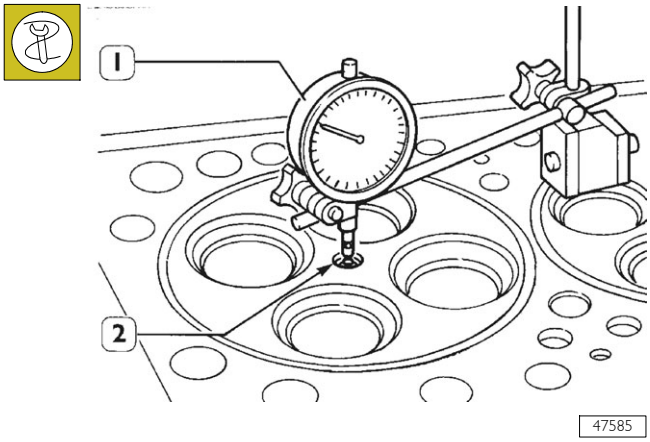
It determines the exact position of the valve guides fitted in the cylinder head; if they are not available, you need to drive the valve guides into the cylinder head so they protrude by a value equal to the one given below .

Technical data	
Valve guide standout	30.80 - 31.2 mm

After driving in the valve guides, smooth their holes with sleeker 99390330.

Checking protrusion of injectors

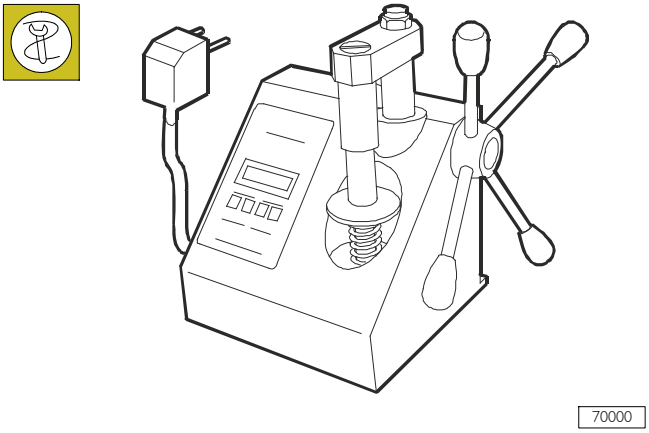
Figure 118



Check injector protrusion (2) using a dial gauge (1).

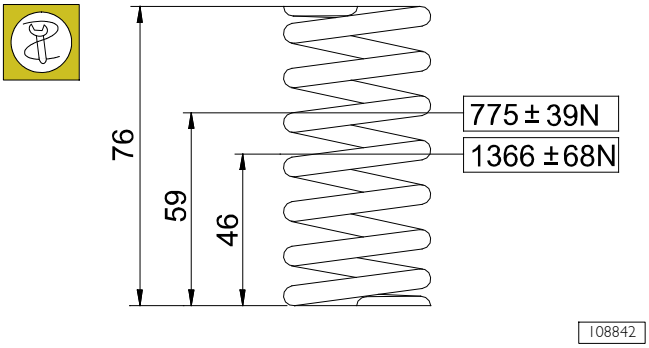
Valve spring check

Figure 119



Before fitting, the flexibility of the valve springs has to be checked using a suitable device.

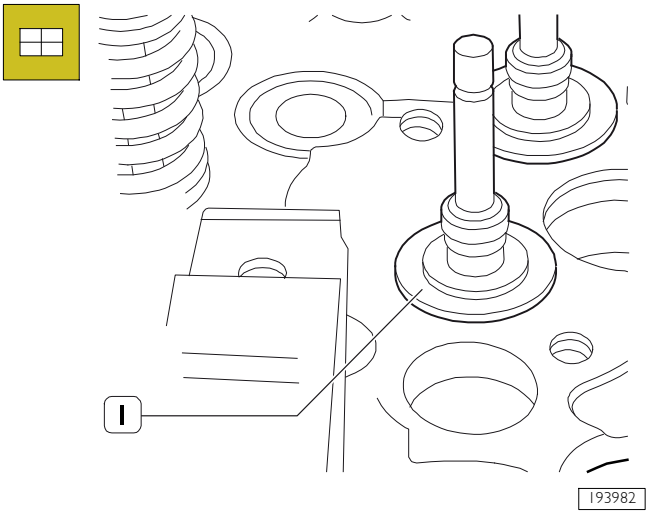
Figure 120



Compare the load and elastic deformation data with that of the new springs indicated in the figure.

Valve assembly

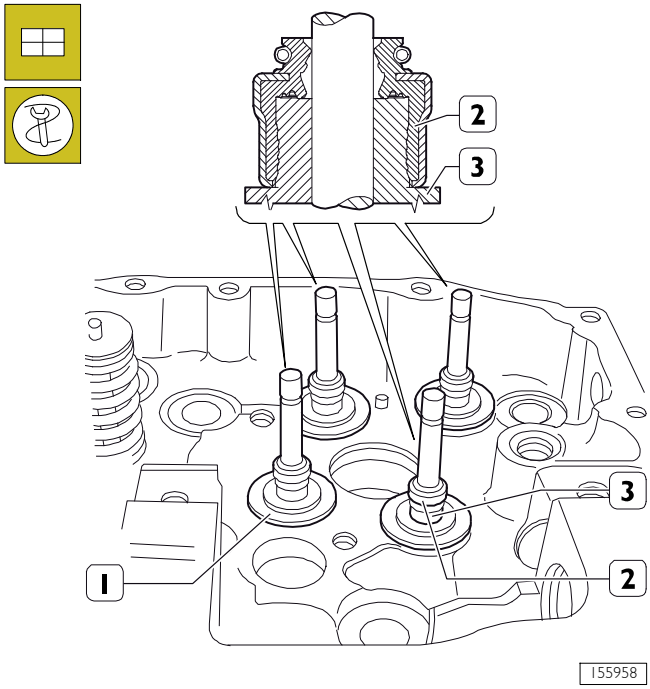
Figure 121



Lubricate the valve stem and insert the valves in the respective valve guides; fit the lower plates (1).

Mounting the oil seal ring

Figure 122

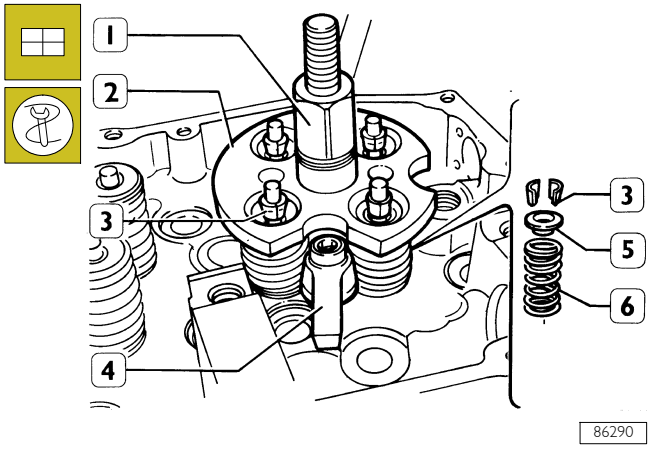


Using the specific keying device 99360329, fit the oil seal ring (2) on the valve guides (3) and then fit the valves as follows.

NOTE If the valves not have been overhauled or replaced, refit them according to the numbering noted during removal.

Intake valves are different from exhaust valves in that they have a notch placed at the centre of the poppet valve.

Figure 123



Fit the springs (6), the upper plate (5).

Fit tool 99360263 (2) and secure it with the bracket (4). screw down with device 99360259 (1) so the cotters (3) can be fitted; remove the tool (2).

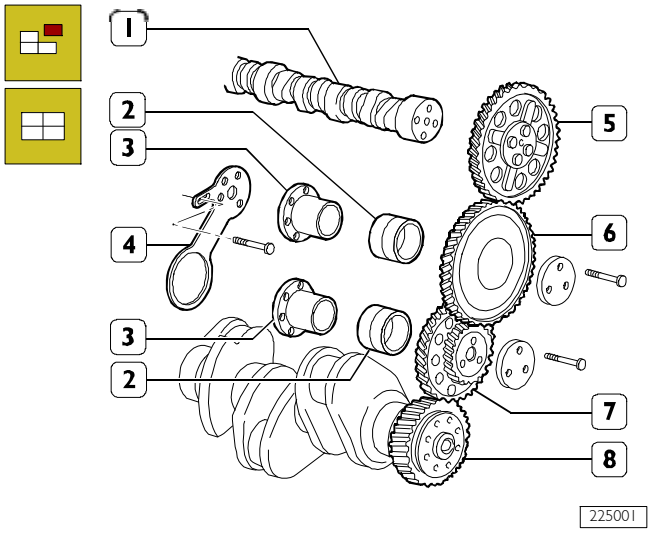
TIMING SYSTEM ASSEMBLY

Technical data	
Intake valve control cam lift	9.231 mm
Exhaust valve control cam lift	9.5607 mm
rated assembling clearance between gear bushings and pins	0.045 to 0.085 mm

Main operation

Change transmission gear bushing.

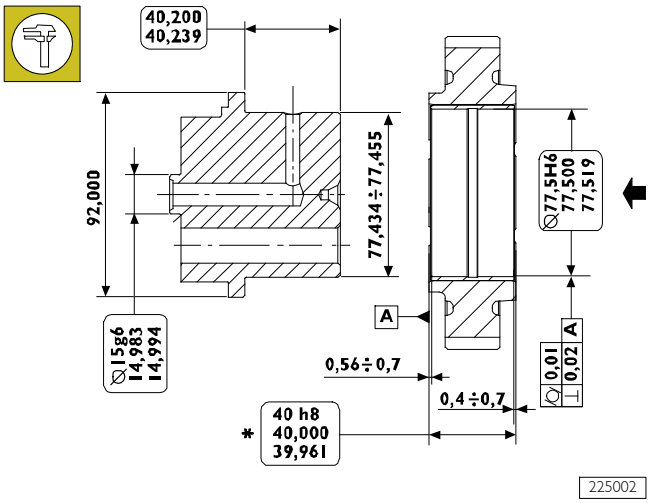
Figure 124



1. Camshaft - 2. Bushing - 3. Pin - 4. Connecting rod - 5. Camshaft control gear - 6. Transmission gear - 7. Double transmission - gear - 8. Crankshaft driving gear

Replace the bushings (2) when worn.

Figure 125



After driving the bushing, bore it to obtain the diameter shown in the figure.

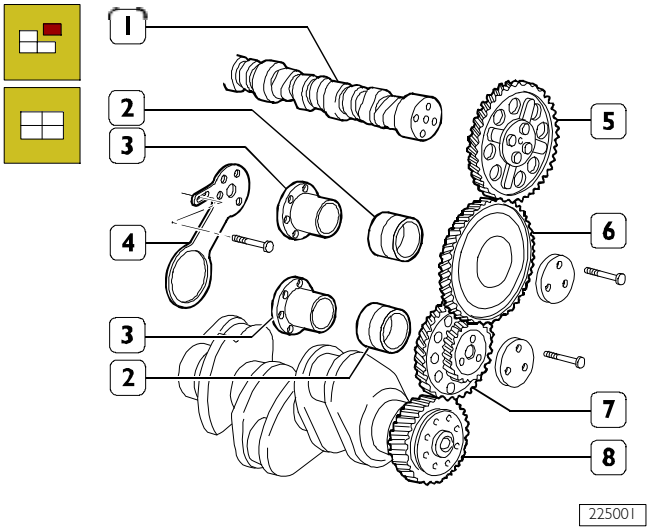
NOTE The bushing must be driven into the gear in the direction of the arrow setting the latter to the dimension shown.

At the end of the boring operation, check that the gear bushing/journal assembly clearance is equal to the indicated value.

Technical data	
rated assembling clearance between gear bushings and pins	0.045 - 0.085 mm

Replacement of the dual idle gear bushes

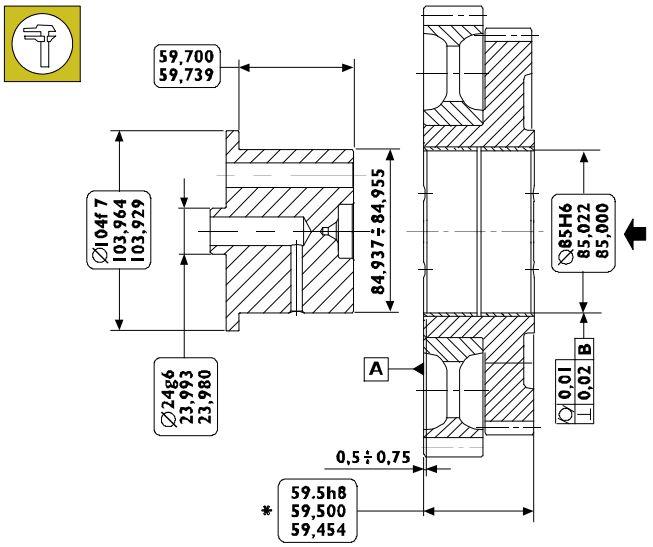
Figure 126



1. Camshaft - 2. Bushing - 3. Pin - 4. Connecting rod - 5. Camshaft I control gear - 6. Transmission gear - 7. Double transmission gear - 8. Crankshaft driving gear

Replace the bushings (2) when worn.

Figure 127



After driving the bushing, bore it to obtain the diameter shown in the figure.

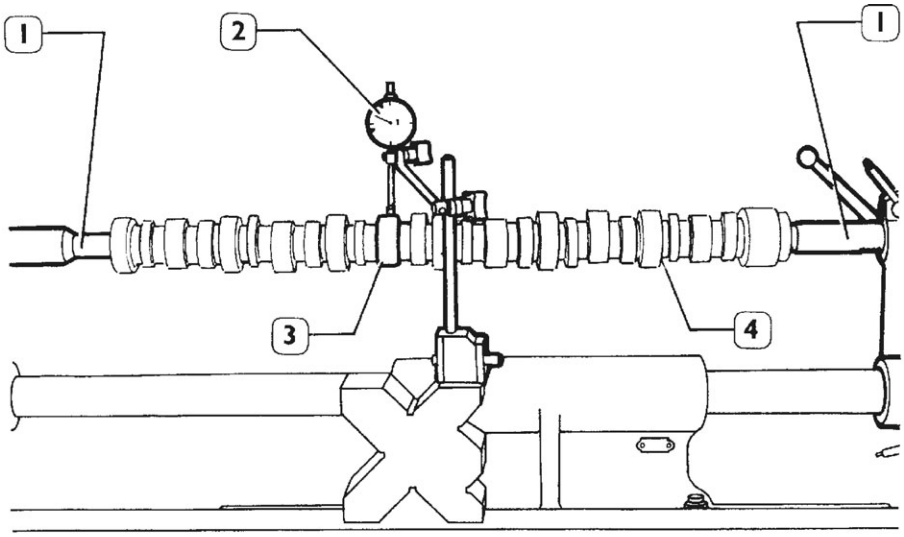
NOTE The bushing must be driven into the gear in the direction of the arrow setting the latter to the dimension shown.

Check that the nominal assembly clearance between gear bushings and pins is equal to the value stated below.

Technical data	
rated assembling clearance between gear bushings and pins	0.045 - 0.085 mm

Checking cam lift and camshaft pins alignment

Figure 128

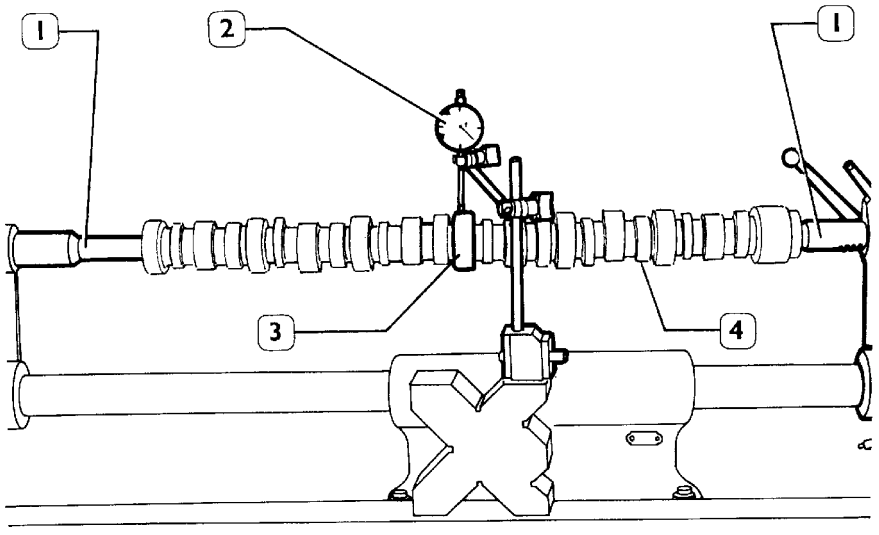


47506

Place the camshaft (4) on the tailstocks (1) and check the lift of the cams (3) using a dial gauge (2), comparing the values with those specified below.

Technical data	
Intake valve control cam lift	9.231 mm
Exhaust valve control cam lift	9.5607 mm

Figure 129

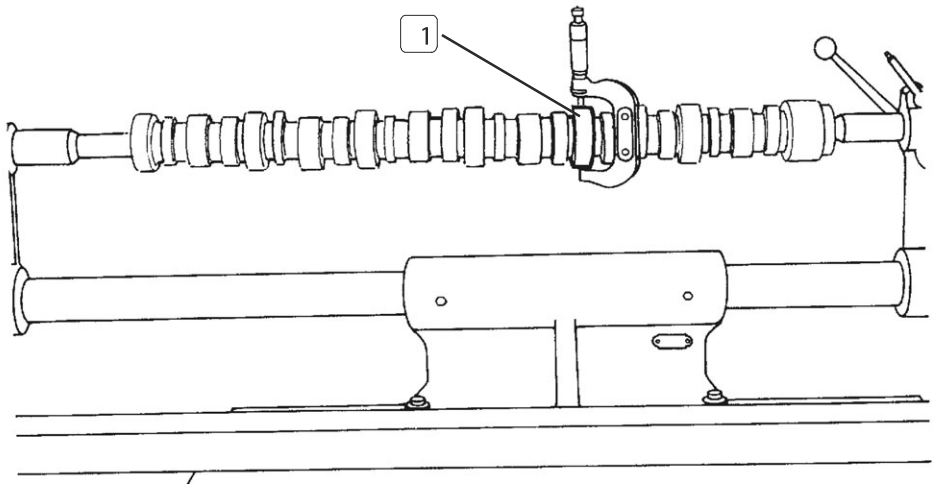


47507

Still with the camshaft (4) set on tailstocks (1), check the alignment of the supporting pins (3) with the dial gauge (2); it must not exceed 0.030 mm.

If the disalignment exceeds this value, replace the shaft:

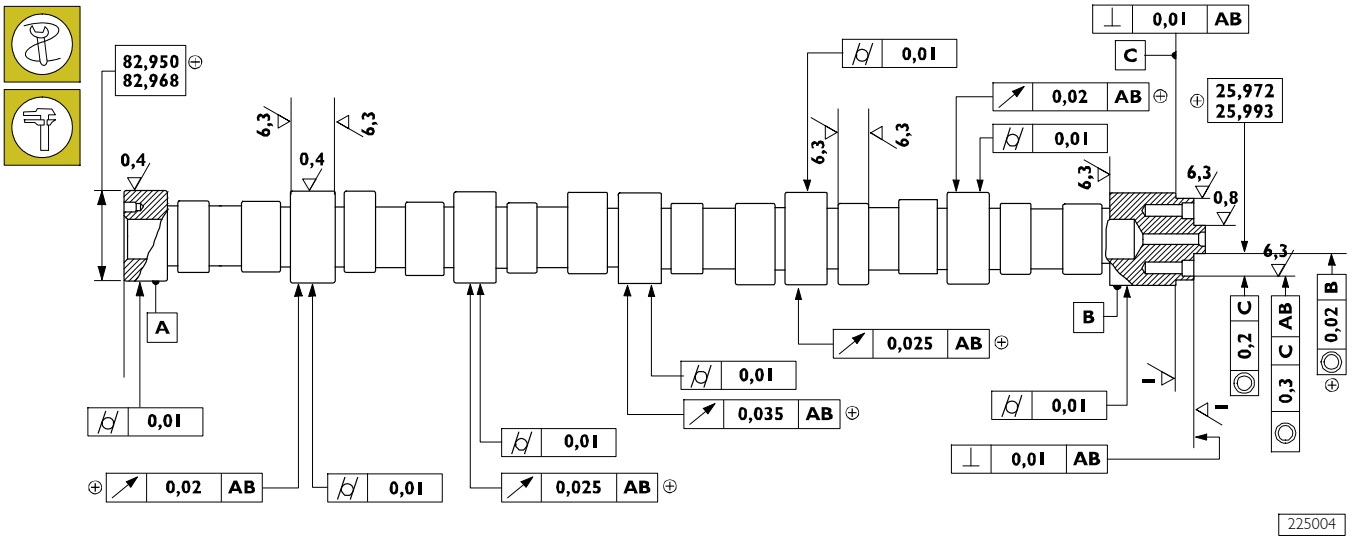
Figure 130



To check the assembly clearance, measure the internal diameter of the bush and the diameter of the camshaft pins (1), the difference represents the existing clearance.

If you find any clearances exceeding 0.135 mm replace the bushings and , if necessary, the camshaft.

Figure 131



The surfaces of the supporting pins of the shaft and those of the cams need to be extra smooth; whereas, if they show any signs of seizing or scoring, the shaft and the relevant bushings should be replaced.

Tolerance characteristics

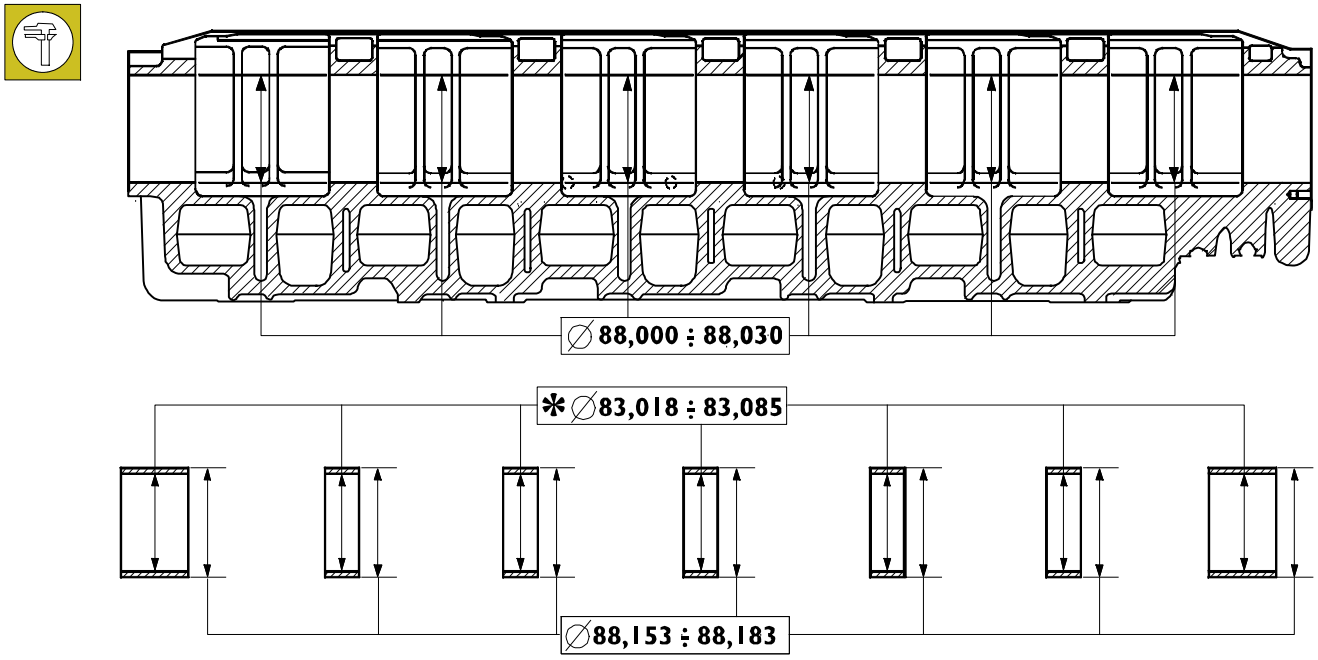
TOLERANCES	TYPICAL TOLERANCE	GRAPHIC SYMBOL
ORIENTATION	Perpendicularity	⊥
POSITION	Concentricity or coaxiality	◎
OSCILLATION	Circular oscillation	↗

Class of importance product characteristics

CLASS OF IMPORTANCE ASSIGNED TO PRODUCT CHARACTERISTICS	GRAPHIC SYMBOL
CRITICAL	©
IMPORTANT	⊕
SECONDARY	⊖

Camshaft bushings check

Figure 132

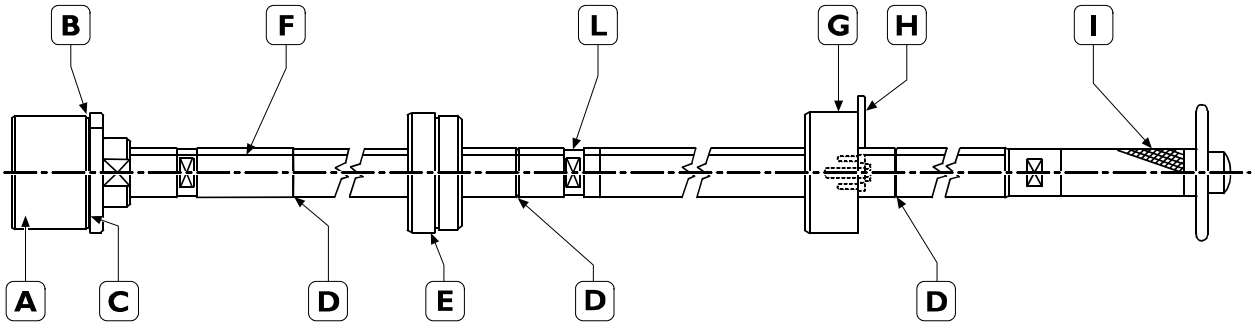


* = Bush inner diameter after installation

The surface of the bushings must show no sign of seizing or scoring; replace them if they do.

Measure the bush inner diameters with a bore meter and replace them if the value measured exceeds the tolerance value.

Figure 133



A. Drift with seat for bushings to insert/extract - B. Dowel pin for positioning bushings. - C. Reference mark to insert seventh bushing correctly - D. Reference mark to correctly insert bushings 1, 2, 3, 4, 5, 6. - E. Guide bushing - F. Guide line - G. Guide bushing to secure to the seventh bushing mount - H. Plate fixing bushing G to cylinder head - I. Grip - L. Extension coupling.

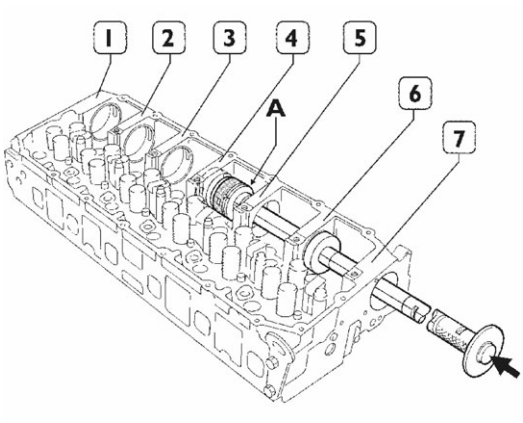
To remove and refit the bushes, use the drift 99360499.

Replacing camshaft bushings using beater

Disassembly

NOTE Position the drift 99360499 accurately during the removal phase.

Figure 134



Remove the bushes in the following order (7, 6, 5, 4, 3, 2, 1).

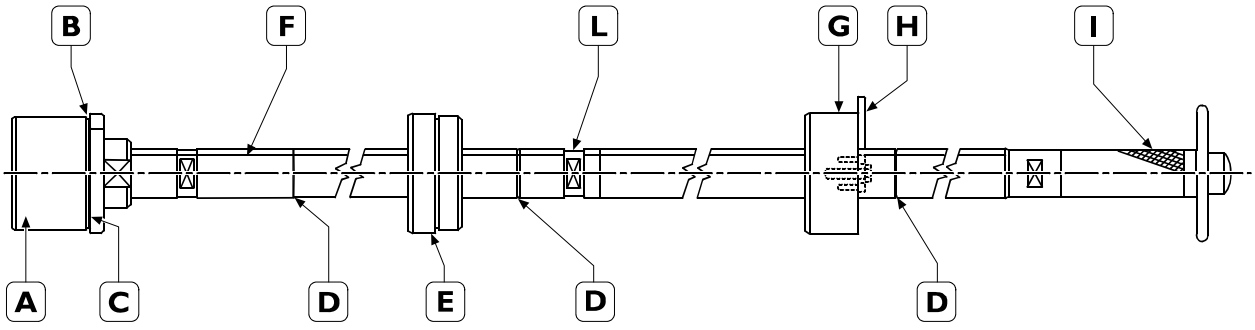
NOTE The bushings are extracted from the front of each seat.

NOTE Removal does not require the drift extension for bushes 5, 6 and 7 and it is not necessary to use the guide bushing. For bushes 1, 2, 3 and 4 it is necessary however to use the extension and the guide bushings.

Assembly

To insert the bushes (1, 2, 3, 4 , 5), proceed as follows.

Figure 135



Assemble the drift 99360499 together with the extension.

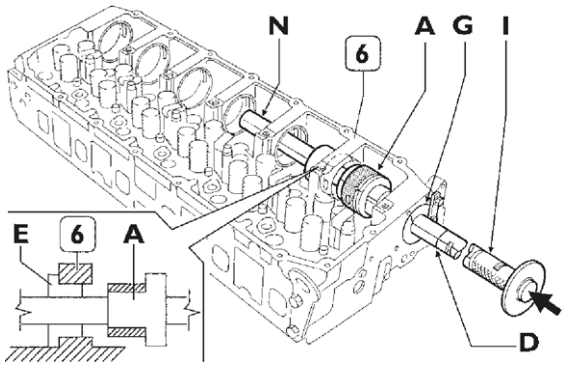
Position the bush to insert on the drift (A) making the dowel pin (B) on it coincide with the seat on the bush.

Position the guide bush (E) and secure the guide bush (G) on the seat of the 7th bush with the plate (H) .

While driving in the bush, make the reference mark (F) match the notch (M). In this way, when it is driven home, the lubrication hole on the bush will coincide with the oil pipe in its seat.

NOTE Bushing fitting is finished when the 1st reference notch (D) is flush with the guide bushing (G).

Figure 136



To insert the bushing (6), proceed as follows:

Unscrew the grip (I) and the extension (N).

Position the extension (N) and the guide bush (E) as shown in the figure.

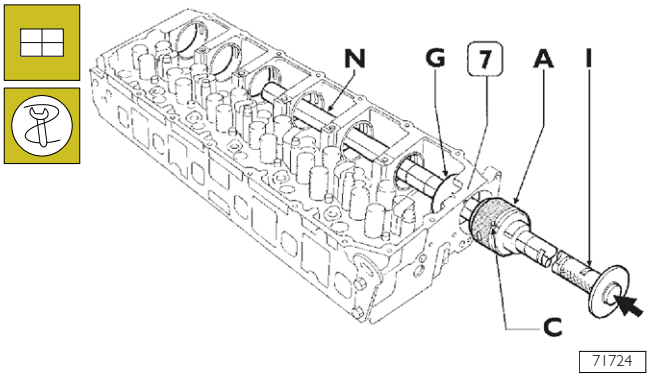
Position the bush to insert on the drift (A) making the dowel pin (B) on it coincide with the seat on the bush.

Position the guide bush (E) and secure the guide bush (G) on the seat of the 7th bush with the plate (H) .

While driving in the bushing, make the reference mark (F) match the notch (M). In this way, when it is driven home, the lubrication hole on the bush will coincide with the oil pipe in its seat.

NOTE Bush fitting is finished when the 1st reference notch (D) is flush with the guide bush (G).

Figure 137



To insert the bush (7), proceed as follows.

Unscrew the grip (I) and the extension (N).

Refit the guide (G) from the inside as shown in the figure.

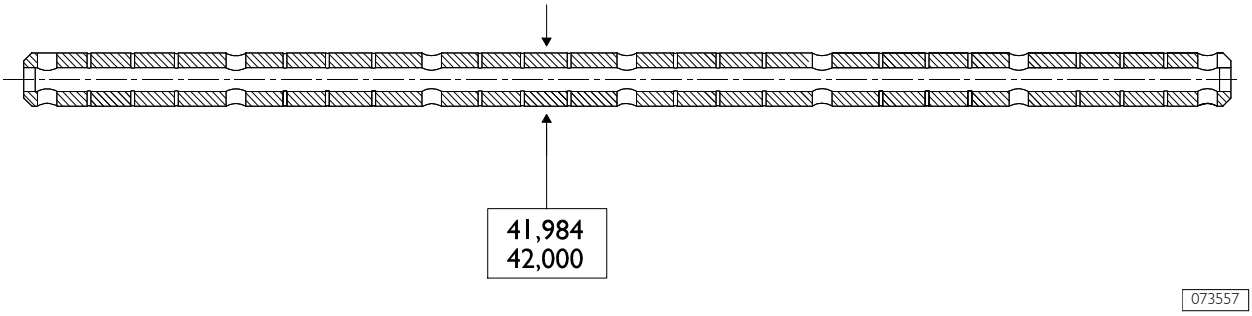
Position the bush on the drift (A) and bring it close to the seat, making the bush hole coincide with the lubrication hole in the head.

Drive it.

The 7th bush is fully driven in when the reference mark (C) is flush with the bush seat.

Rocker shaft check

Figure 138

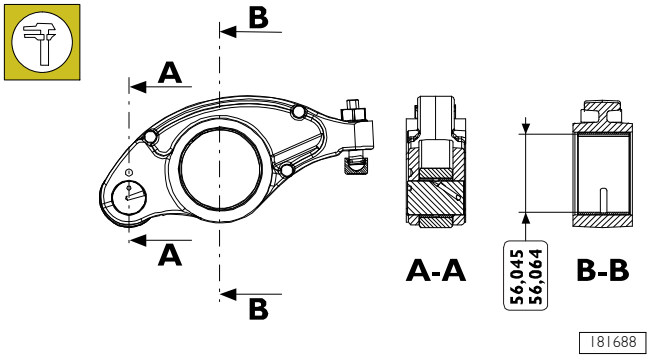


NOTE The camshaft cams directly control the 12 rocker arms for the valves.
The intake valve control rocker arms are keyed directly onto the rocker arms shaft.
Exhaust valves control rocker arms are keyed onto the rocker arms shaft interposing the levers with engine brake control eccentric pin. The rockers slide on the cam profiles via rollers.
The other end acts on a bar supported by the stem of the two valves.
There is a pad between the rocker arm adjustment screw and the crosspiece.
There are two lubrication pipes inside the rocker arms.

Check the shaft surfaces for signs of seizure, scoring or wear. Otherwise replace the shaft.

Exhaust valve rocker arm check

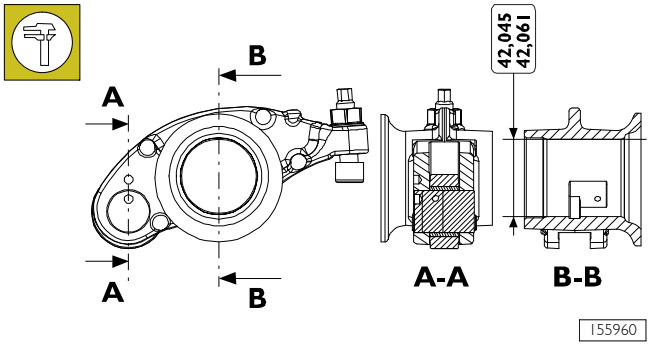
Figure 139



Check that the bush surfaces do not show any sign of scoring of excessive wear; otherwise, replace the whole rocker arm.

Intake valve rocker arms check

Figure 140



Check that the bush surfaces do not show any sign of scoring of excessive wear; otherwise, replace the whole rocker arm.

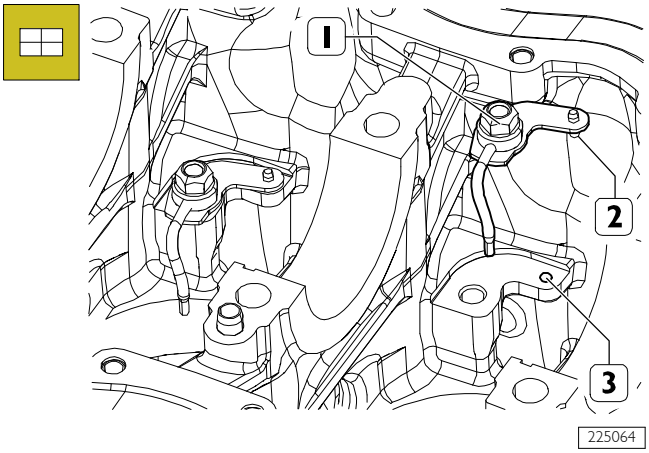
ENGINE ASSEMBLY

Crankcase compoennts

Use the specific brackets to secure the engine crankcase to the rotating stand 99322230 with brackets 99361036.

Oil sprayer assembly

Figure 141

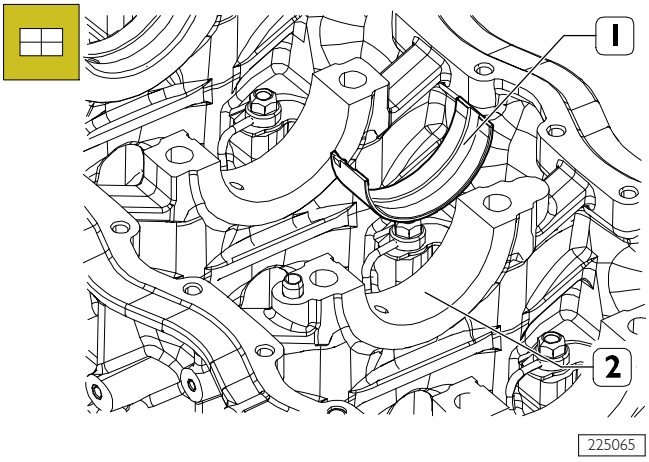


Fit the oil spray nozzles (1), making the dowel (2) match the hole (3) on the crankcase and tighten the screws to torque.

Ref.	No.	Description	Tightening torques
(1)	6	M14 X 1.5	55 ± 5 Nm

Main bearings assembly

Figure 142



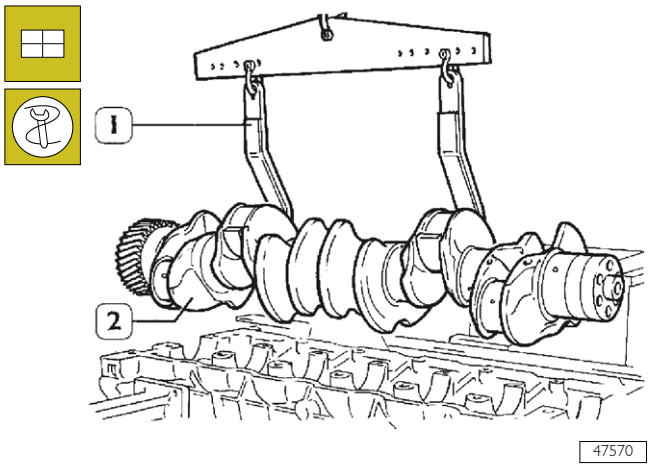
Arrange the half-bearings (1) on the main bearings in the crankcase (2).

NOTE If it is found that the main bearings do not need to be replaced, fit them back in exactly the same sequence and position as in removal.

If they need to be replaced, select the bearings as described in the chapter "Defining the diameter class of the seats for half-bearings on the crankcase".

Crankshaft assembly

Figure 143

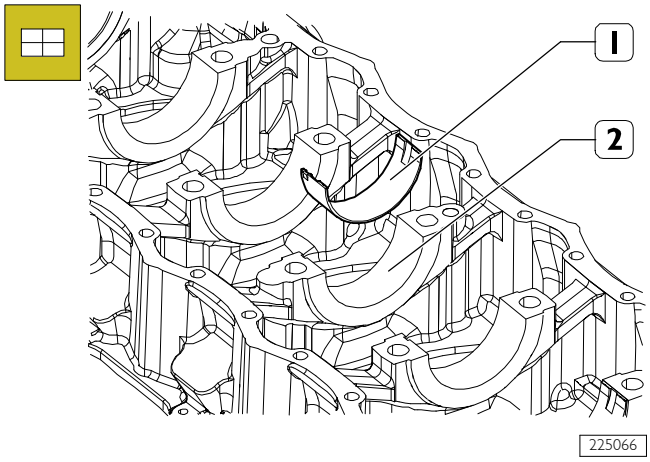


Lubricate the half-bearings.

Using the tool for lifting the crankshaft 99360500 (1), fit the crankshaft (2).

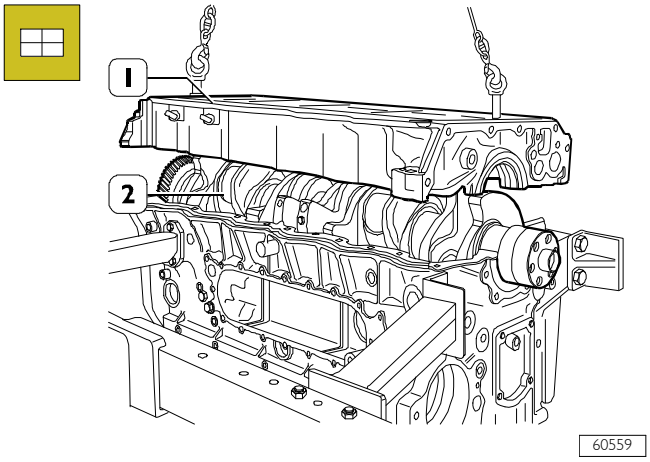
Main bearings and pin clearance measurement

Figure 144



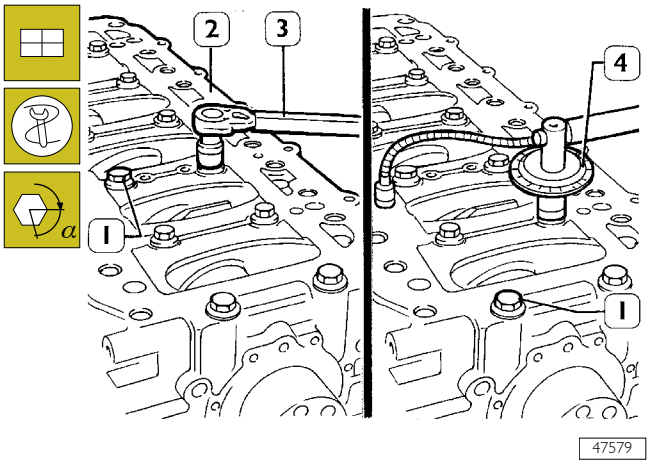
Arrange the half-bearings (1) on the main bearing supports in the lower crankcase (2).

Figure 145



Fit the lower crankcase by means of a suitable hoist and hooks (1).

Figure 146

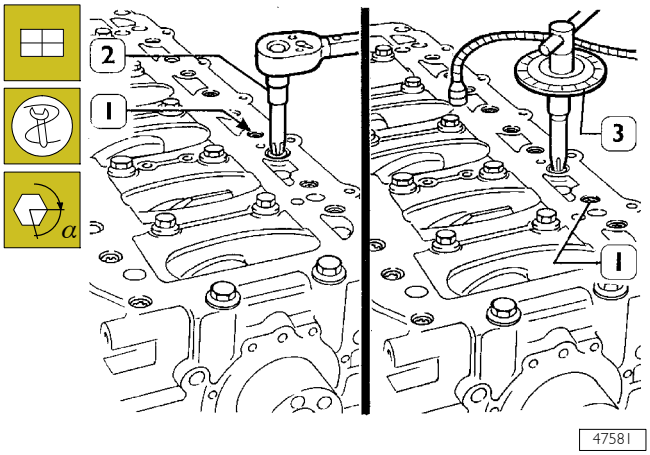


Using a torque wrench (3), tighten the internal screws (1) to the prescribed torque, then angle tighten using tool 99395216 (4).

Ref.	No.	Description		Tightening torques
(1)	14	Lower crankcase inner tightening screws M 18 X 2	Step 1 Step 2 Step 3	160 Nm 60° 60°

NOTE Always use new screws each time you fit the lower part of the crankcase.

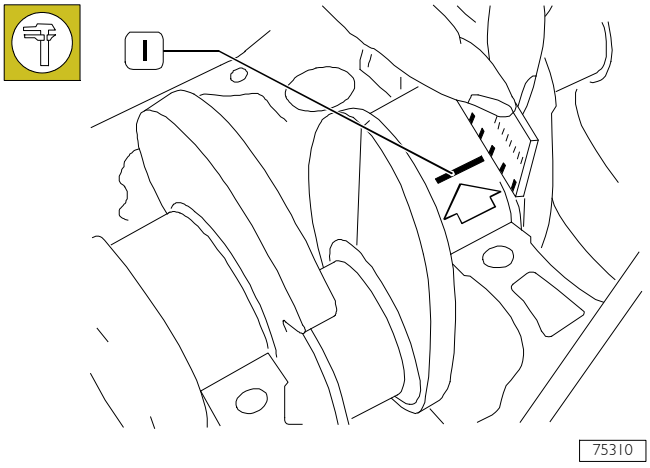
Figure 147



Using a torque wrench 99395216 (2), tighten the outer hex-socket screws (1) to the prescribed torque, then use the specific tool (3) tighten to a specific angle.

Ref.	No.	Description	Tightening torques
(1)	26	Outer screws fixing lower crankcase M12X 1.75 Step 1 Step 2	30 Nm 60°

Figure 148



Remove the lower crankcase.

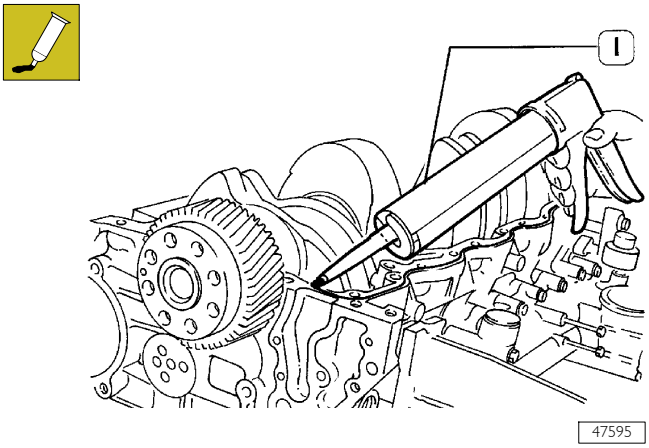
The clearance between the main bearings and their pins is measured by comparing the width of the calibrated wire (1), at the point subjected to the greatest crushing forces, with the graduated scale on the casing containing the calibrated wire.

The numbers on the scale indicate the clearance in millimetres which should be between 0.055 and 0.083 mm.

If the clearance is not as prescribed, replace the bearings and repeat the check.

lower crankcase assembly

Figure 149

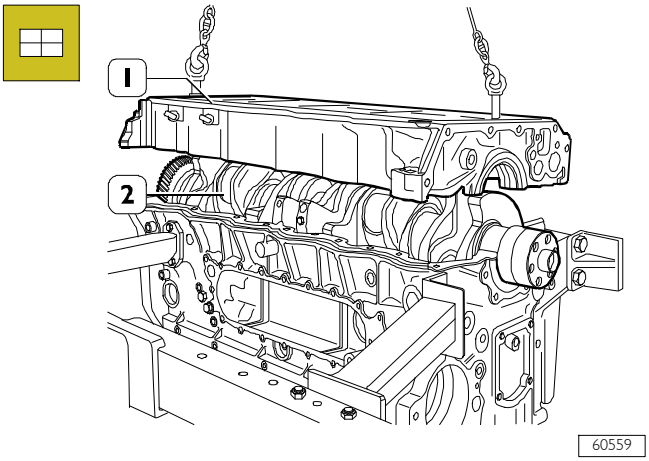


Apply LOCTITE 5970 onto the crankcase using the designated tool (1)

Apply the sealant (LOCTITE 5970) following the indications the figure.

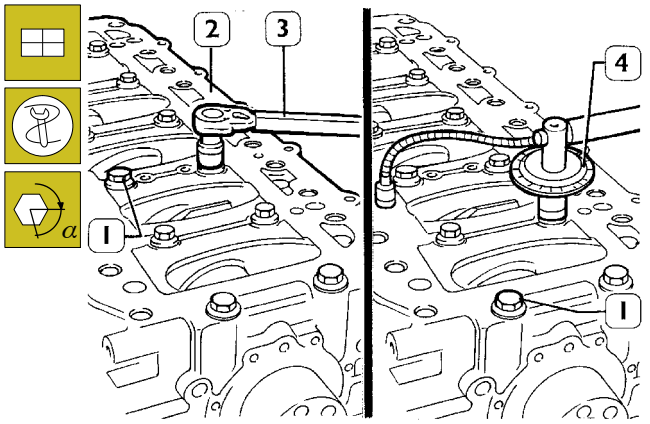
NOTE Fit the lower crankcase within 10 minutes of applying the sealant.

Figure 150



Fit the lower crankcase by means of a suitable hoist and hooks (1).

Figure 151

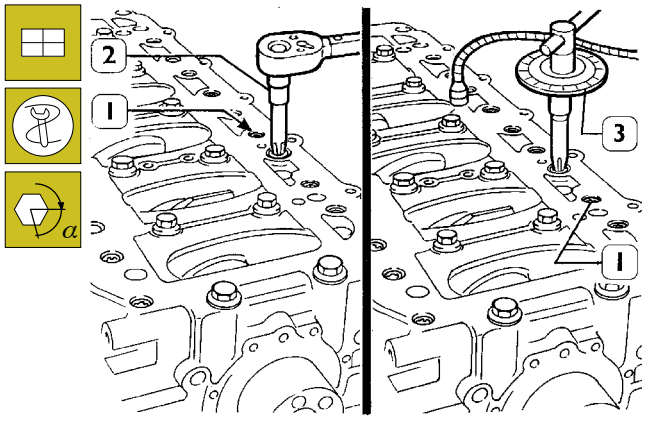


Using a torque wrench (3), tighten the internal screws (1) to the prescribed torque, then angle tighten using tool 99395216 (4).

Ref.	No.	Description	Tightening torques
(1)	14	Lower crankcase inner tightening screws	
		Step 1	160 Nm
		Step 2	60°
		Step 3	60°

NOTE Always use new screws each time you fit the lower part of the crankcase.

Figure 152



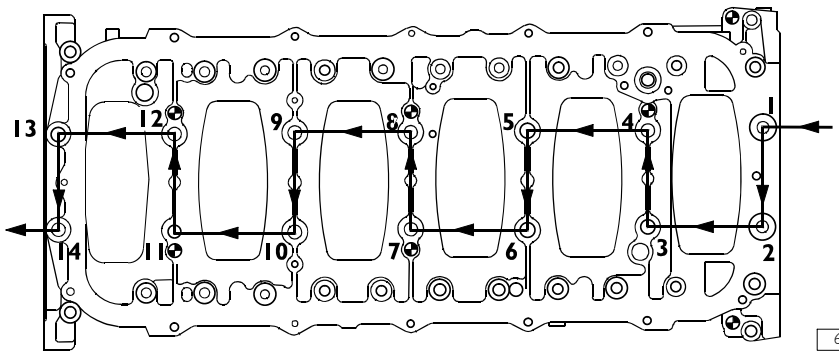
Using a torque wrench 99395216 (2), tighten the outer hex--socket screws (1) to the prescribed torque, then use the specific tool (3) tighten to a specific angle.

Ref.	No.	Description	Tightening torques
(1)	26	Outer screws fixing lower crankcase	
		Step 1	30 Nm
		Step 2	60°

See the figure for tightening order.

DIAGRAM OF TIGHTENING SEQUENCE OF LOWER CRANKCASE FIXING SCREWS

FRONT SIDE

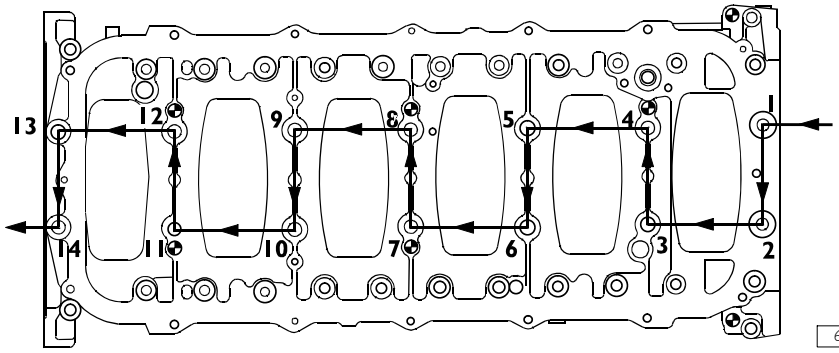


First step:

inner screws preliminary tightening

160 Nm

FRONT SIDE

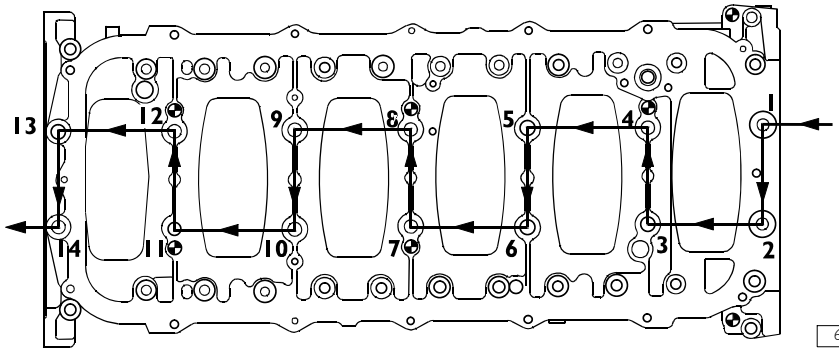


Second step:

internal bolt angle tightening

60°

FRONT SIDE

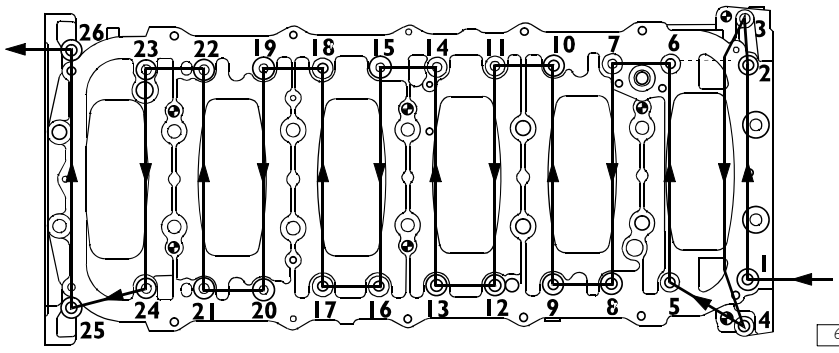


Third step:

internal bolt angle tightening

60°

FRONT SIDE

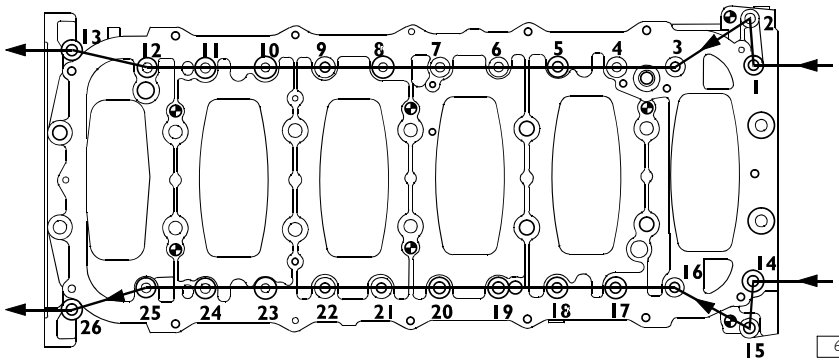


Fourth step:

outer screws preliminary tightening

30 Nm

FRONT SIDE



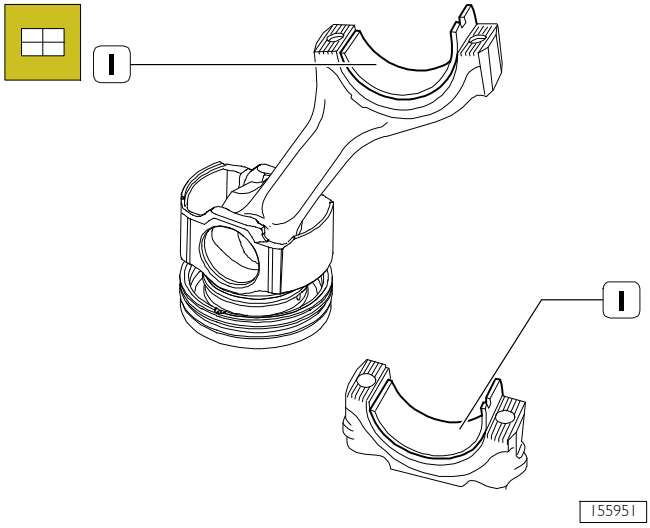
Fifth step:

external bolt angle tightening

60°

Big end half-bearing fitting

Figure 153



Lubricate the half-bearings (1) and fit them onto the connecting rod and the cap.

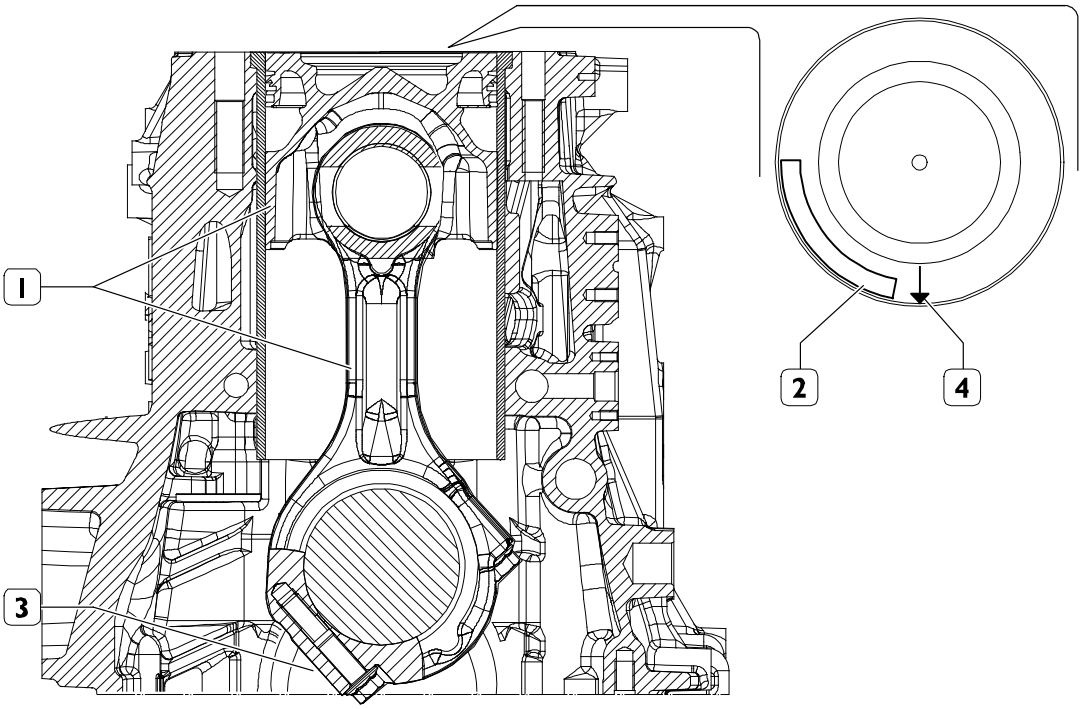
NOTE If it is found that the big-end bearings do not need to be replaced, fit them back in exactly the same sequence and position as in removal.

If they need to be replaced, select the big-end bearings as described in the chapter: "Defining the diameter class of the main journals and crankpins".

NOTE Do not try to adapt the half-bearings.

Assembling connecting rod - piston assemblies in the cylinder liners

Figure 154

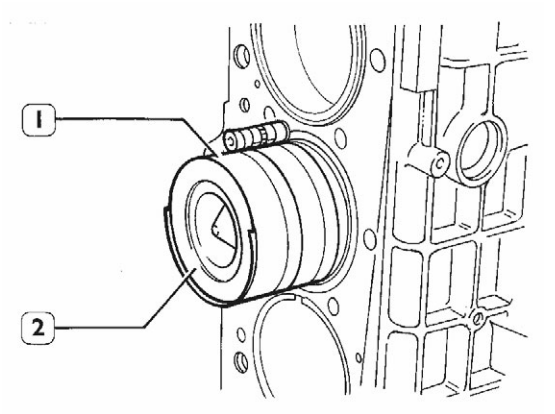


1. Rod-piston assembly - 2. Marking area on the piston crown of ideogram specifying the assembly position and the selection class - 3. Area of connecting rod marking - 4. Arrow indicating the assembly orientation of the connecting rod - piston assembly (turned towards the flywheel)

Rotate the crankcase placing it vertically.

Lubricate the pistons, circlips and inside the cylinder liners.

Figure 155



60616

Using the clamp to introduce the piston into the cylinder liner 99360603 (1), fit the piston-connecting rod assembly (2) into the cylinder liners following the diagram in the previous Figure.

Check that the number of each connecting rod corresponds to the cap coupling number .

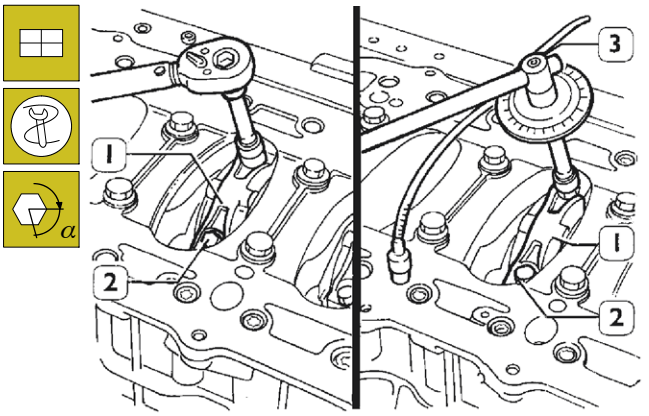
During assembly, make absolutely sure that the connecting rod does not hit against the cylinder liner walls.

Check that the ideogram stamped on the piston crown faces the engine flywheel; or the recess in the piston skirt matches the position of oil nozzles .

NOTE The pistons are supplied as class A spare parts and can also be fitted in class B cylinder liners.

Crankpin fitting clearance check

Figure 156



47594

Connect the connecting rods to the relevant journals of the crankshaft, placing a length of calibrated wire on the journals.

mount the connecting rod caps (1) together with half-bearings; tighten the screws (2) securing the connecting rod caps to the prescribed torque.

Use tool 99395216 (3) to additionally tighten the screws to the prescribed angle.

Ref.	No.	Description	Tightening torques
(2)	12	Screws fixing connecting rod cap M14 X 2 Step 1 Step 2	70 Nm 60°

NOTE The thread of the screws (2), before assembly, has to be lubricated with engine oil.

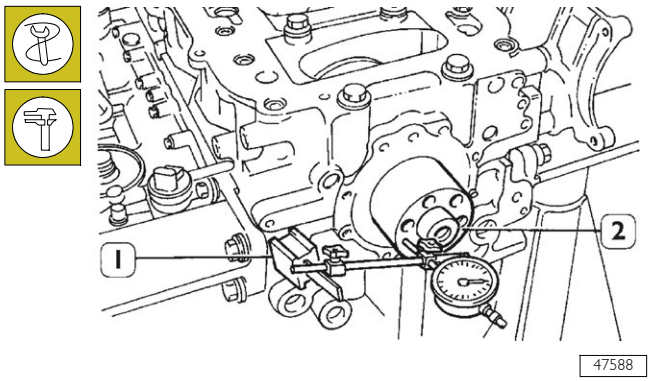
Remove the caps and check the clearance by comparing the width of the calibrated wire with the scale calibration on the envelope containing the wire.

Upon final assembly: check the diameter of the threading of the screws (2) which must not be less than 13.4 mm, otherwise replace the screw;

lubricate the crankpins and big end bearings; tighten the screws (2) as described above.

Checking crankshaft shoulder clearance

Figure 157



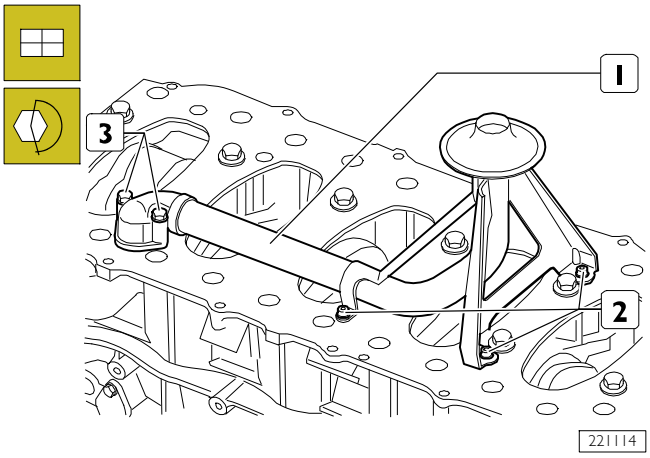
The thrust clearance is checked by placing a specific dial gauge (0 ÷ 5mm) 99395603 (1) on the crankshaft (2) as shown in the figure.

If the value obtained is higher than specified, replace the rear thrust half-bearings and repeat the clearance check.

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE BOTTOM)

Suction strainer installation

Figure 158



Turn the engine and position the oil suction strainer (1).

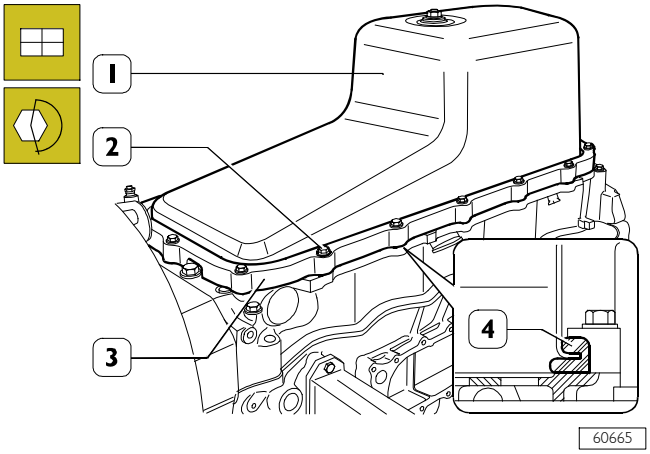
Tighten the screws (3) and secure the flange.

Tighten the screws (2) and secure the supports.

Ref.	No.	Description	Tightening torques
(2,3)	6	M8 X 1.25	24.5 ± 2.5 Nm

Oil sump assembly

Figure 159

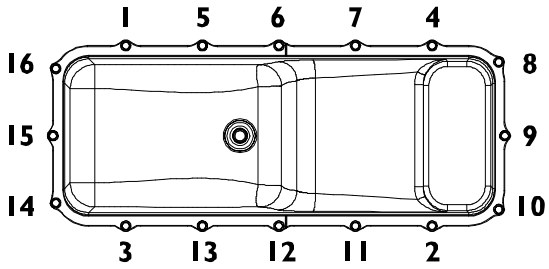


Arrange the gasket (4) on the oil sump (1), position the spacer (3) and fit the sump onto the engine crankcase screwing in the screws (2) to the torque in the table.

Ref.	No.	Description	Tightening torques
(2)	16	M10X1.5 screws	
(2)	12	Step 1	45 ± 4.5 Nm
		Step 2	45 ± 4.5 Nm

Tightening sequence

Figure 160



155922

Fit the drain plug of the oil sump and tighten to the torque indicated in the table.

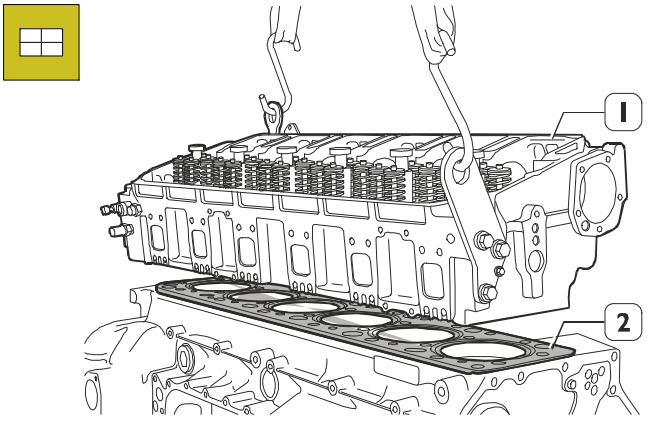
Ref.	No.	Description	Tightening torques
(-)	1	M22 X 1.5	40 ± 10 Nm

Turn the engine on the rotating stand.

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE TOP PART 1)

Cylinder head assembly

Figure 161



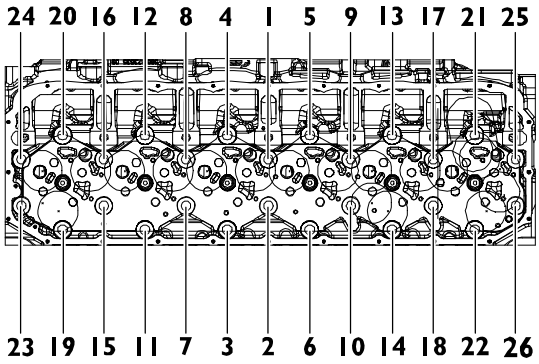
60515

Check that the pistons: 1 and 6 are exactly at the T.D.C.

Put the sealing gasket (2) on the crankcase.

Place the cylinder head (1) on the crankcase.

Figure 162



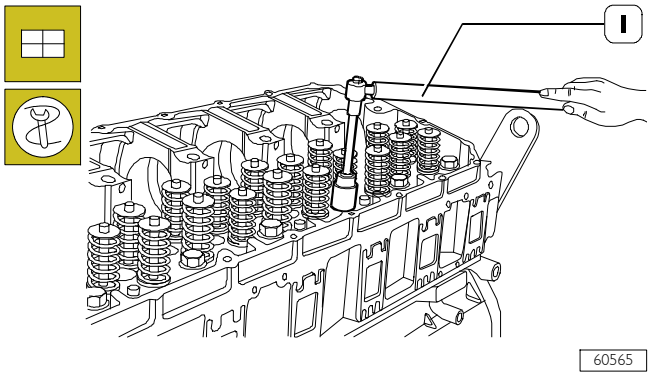
225061

Tighten the fastening screws in the sequence shown in the figure.

NOTE New screws must be used at each assembly of the head.

Lubricate the thread of the screws with engine oil before assembly.

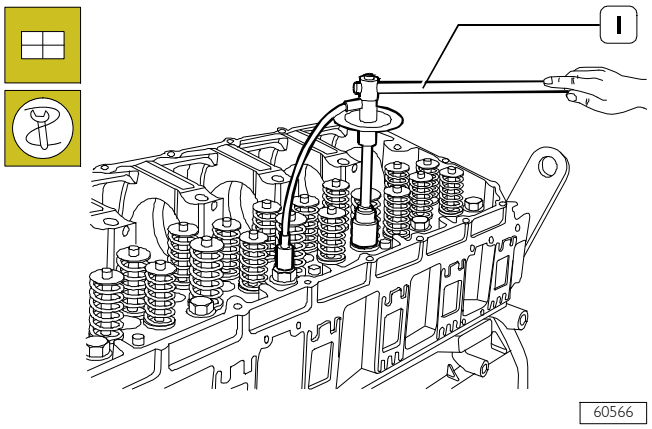
Figure 163



Pre-tighten using the torque wrench (1):

Ref.	No.	Description	Tightening torques
(-)	20	M18x2x196 M18x2x175	
	6	Step 1	75 Nm
		Step 2	150 Nm

Figure 164



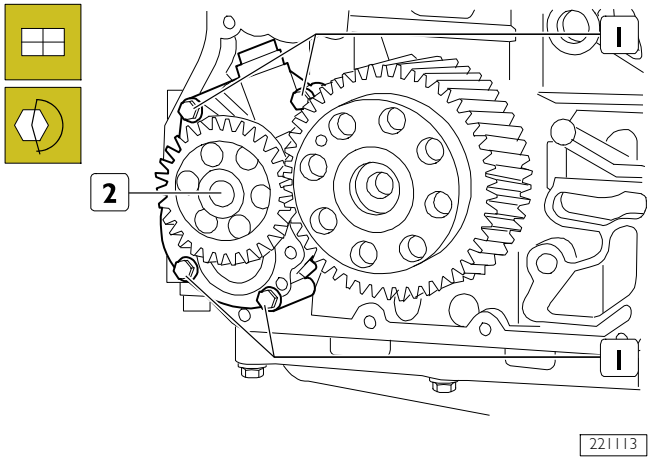
Use tool 99395216 (1) for angle tightening:

Ref.	No.	Description	Tightening torques
(-)	20	M18x2x196 M18x2x175	
(-)	6	Step 1	90 °
		Step 2	90 °

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE REAR PART 1)

Installing the oil pump

Figure 165

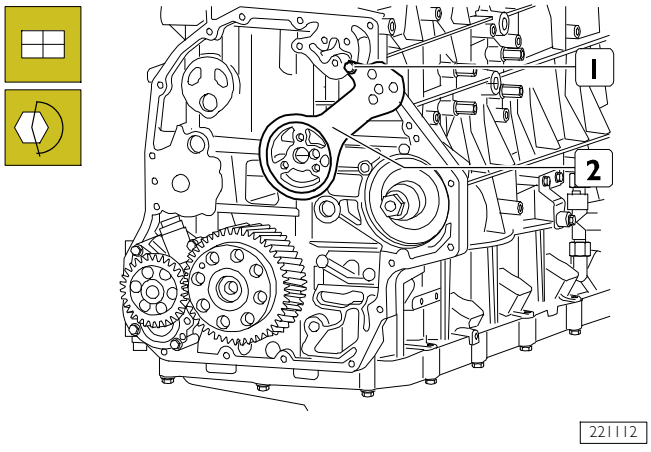


Fit the oil pump (2) and tighten the fastening screw (1) to torque stated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Screws M8 X 1.25 X 35	25 ± 2.5 Nm
(1)	3	Screws M8 X 1.25 X 70	25 ± 2.5 Nm

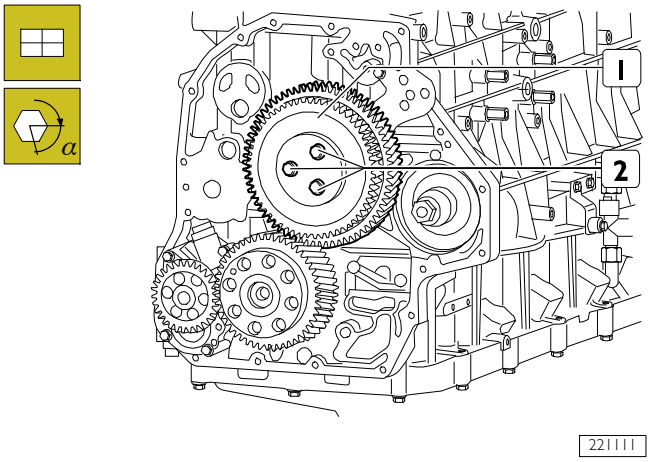
Double gear assembly

Figure 166



Fit the articulated rod (2) and screw in but do not tighten the relative screw (1).

Figure 167



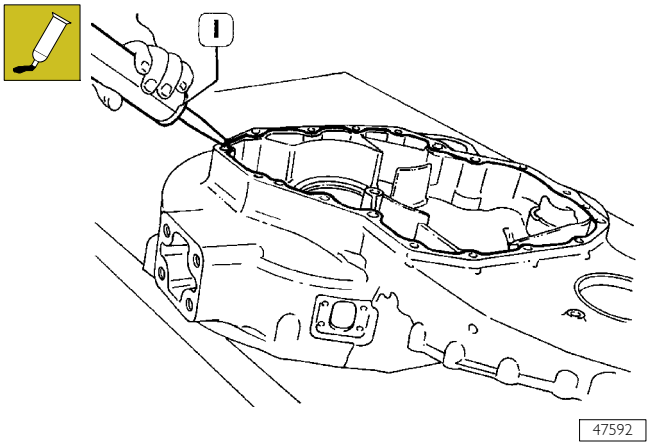
Fit the double gear (1) and tighten the screws (2) to the torque indicated in the table.

NOTE Lubricate the screws (2) with engine oil before assembly.

Ref.	No.	Description	Tightening torques
(2)	3	Screws M12 X 1.75 X 90 Step 1 Step 2	 30 ± 1.5 Nm 90°

Fitting flywheel case

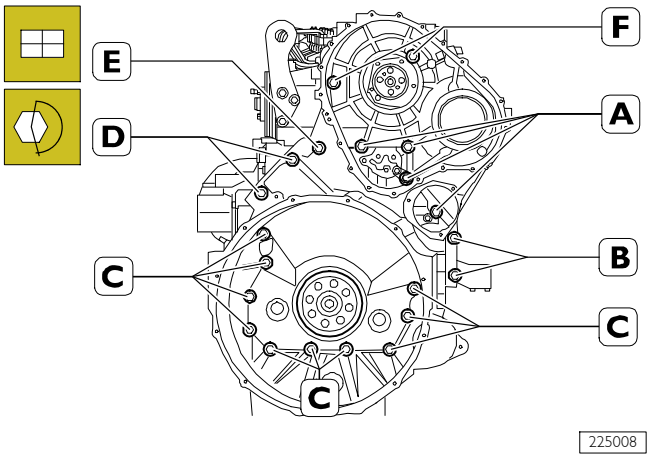
Figure 168



Apply LOCTITE 5970 onto the housing using the designated tool (1) as indicated in the figure.

NOTE Fit the flywheel housing within 10 minutes of applying the sealant .

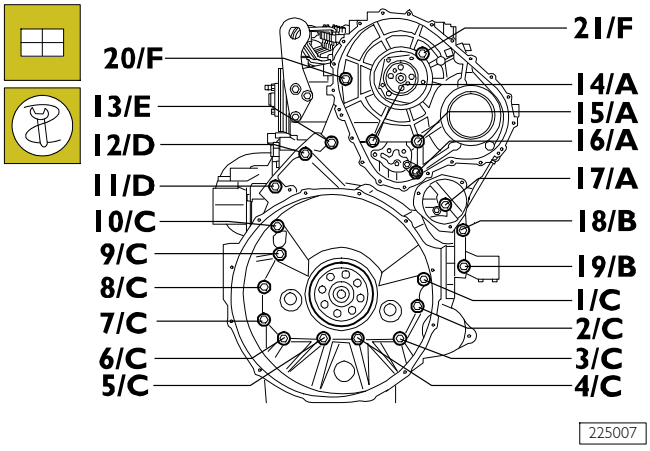
Figure 169



Use a torque wrench to tighten the screws to the specific tightening torque in the sequence shown in the figure.

Ref.	No.	Description	Tightening torques
(A)	4	Screws M12 X 1.75 X 40	63 ± 7Nm
(B)	2	Screws M12 X 1.75 X 70	63 ± 7Nm
(C)	10	Screws M12 X 1.75 X 100	63 ± 7Nm
(D)	2	Screws M12 X 1.75 X 193	63 ± 7Nm
(E)	1	Screws M12 X 1.75 X 120	63 ± 7Nm
(F)	1	Screws M10 X 1.5 X 30	45.5 ± 4.5 Nm

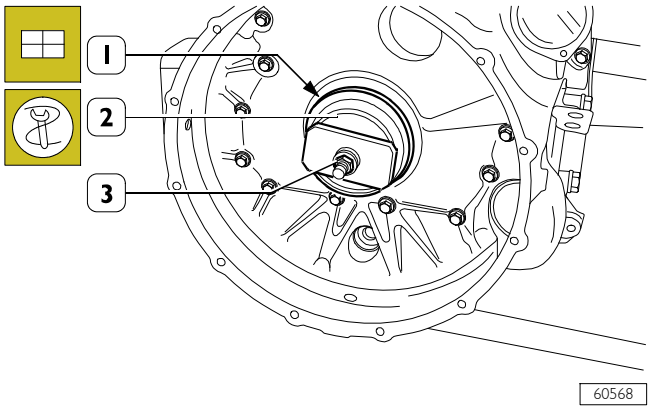
Figure 170



Tighten the screws securing the flywheel housing to the crankcase following the sequence indicated in the figure.

Crankshaft rear gasket assembly

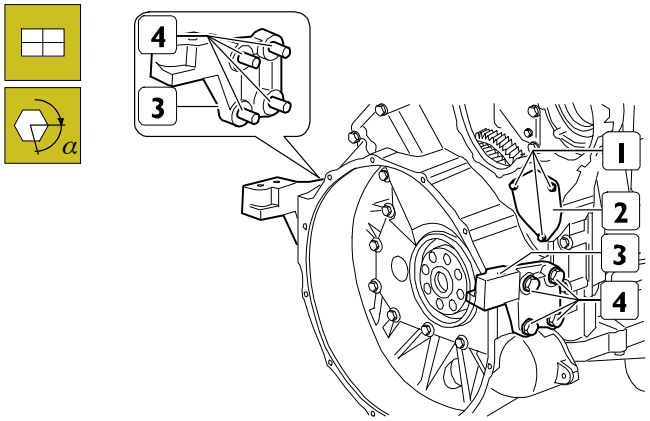
Figure 171



Key the sealing gasket (1) onto the crankshaft, fit the keying device 99346260 (2) and while tightening the nut (3) drive in the sealing gasket.

Engine support Assembly

Figure 172



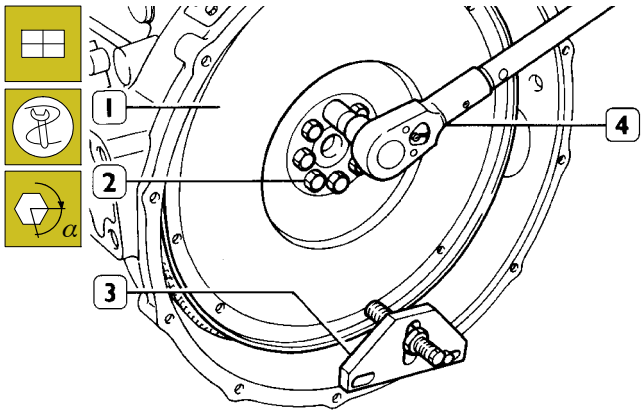
Fit the cover (2) together with the new O-ring and tighten the screws (1) to the torque indicated in the table.

Fit the engine suspensions (3) onto the flywheel case and tighten the screws (4) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M8 X 1.25 X 20	20.5 ± 2.5 Nm
(4)	8	M16 x 2 screws Step 1 Step 2	 120 Nm 55°

Engine flywheel assembly

Figure 173



Position the flywheel (1) on the crankshaft, lubricate the thread of the screws (2) with engine oil and screw them down.

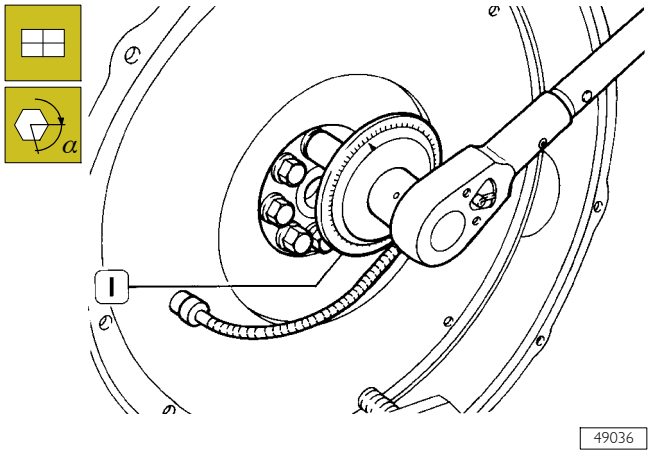
Block rotation using the tool used to fasten the engine flywheel housing 99360351 (3);

Using the torque wrench (4), tighten the screws (2) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(2)	8	Screws M18 X 1.5 X 72 Step 1 Step 2	 120 ± 6 Nm 90°

NOTE Lubricate the screws with engine oil.

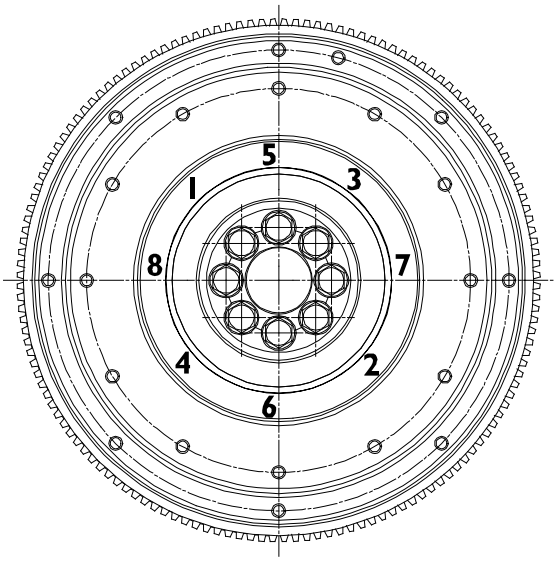
Figure 174



Tighten to angle with wrench 99395216 (1).

Tightening sequence

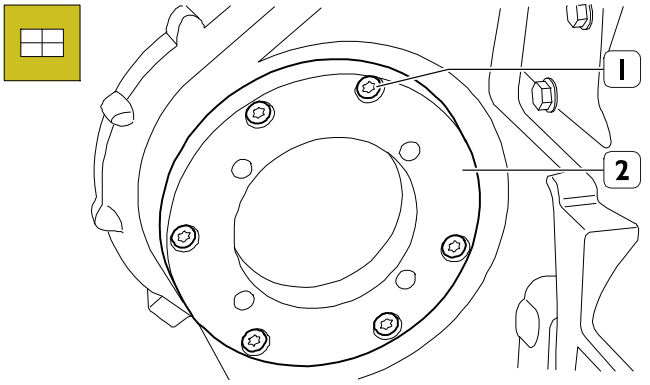
Figure 175



225022

High pressure pump flange assembly

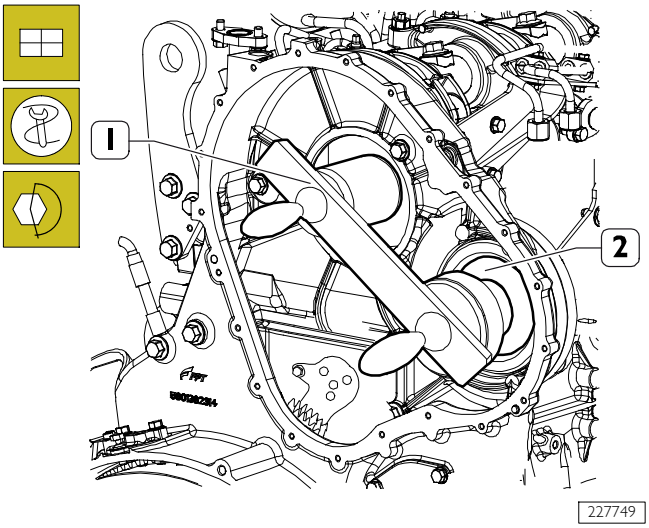
Figure 176



225006

Fit the high pressure pump support flange (2) and tighten the fastening screws (1) without locking in place.

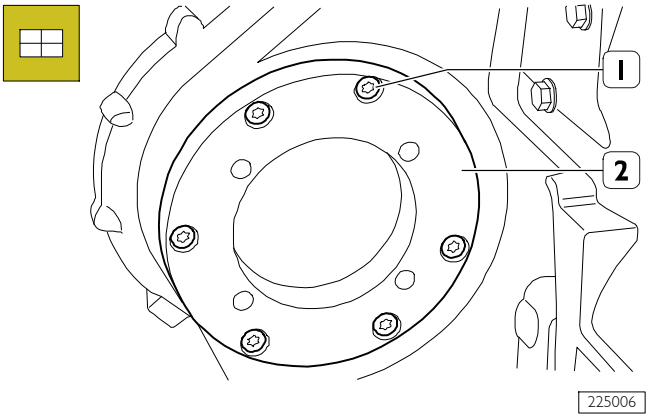
Figure 177



227749

Apply the gauge 99395226 (1) to correctly position the high pressure pump support flange (2).

Figure 178



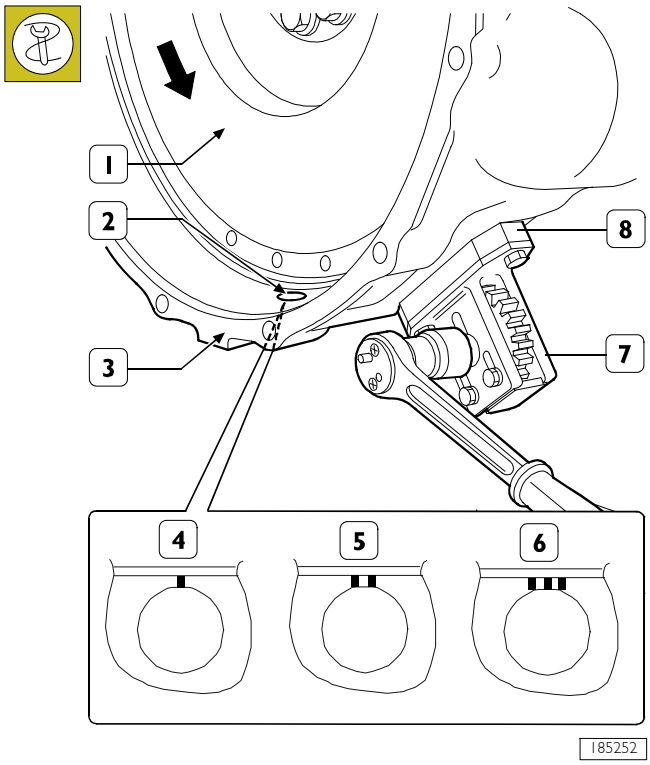
225006

Tighten the screws to torque stated in the table.

Ref.	No.	Description	Tightening torques
(1)	6	Screws M8 X 1.25 X 30	20.5 ±2.5 Nm

Fitting camshaft

Figure 179



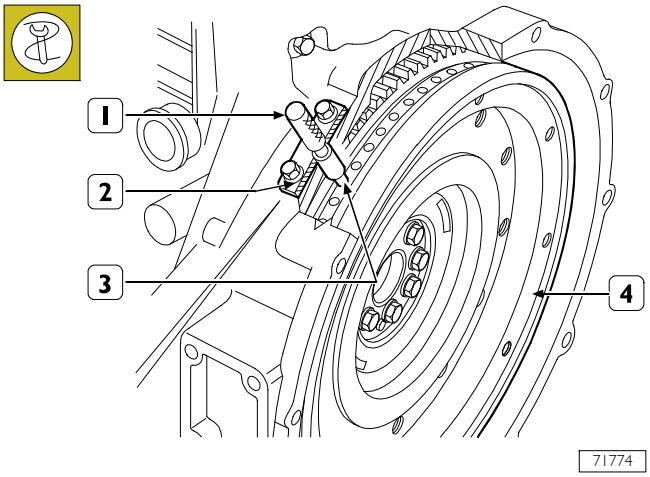
Apply the tool for engine flywheel rotation 99360321 (7) and the specific spacer 99360325 (8) to the gear housing (3).

NOTE The arrow shows the direction of rotation of the engine when running .

With the aforementioned tool, turn the flywheel (1) in the direction of the engine rotation so as to bring cylinder piston 1 to 54° before the T.D.S. during compression (cylinder 6 in discharge phase).

NOTE This condition occurs when the hole with two notches (5) on the engine flywheel (1), can be seen through the small inspection window (2).

Figure 180

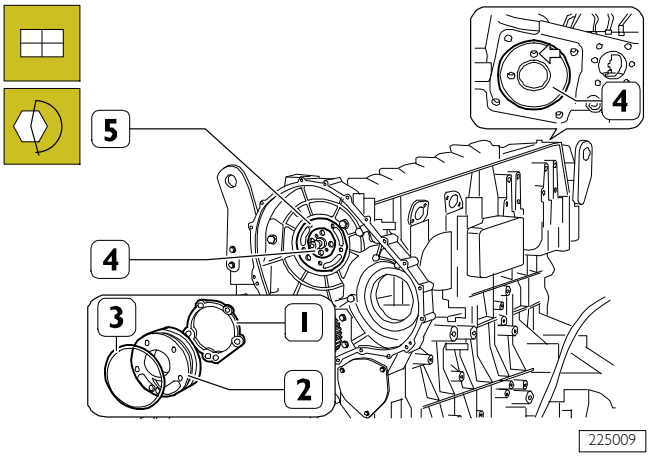


Check that the tool for positioning the T.D.C 99360612 (1), through the seat (2) of the engine speed sensor , enters the hole (3) in the engine flywheel (4). in this condition, the flywheel is in the reference position (piston no. 1 to 54° before T.D.C.).

If this is not the case, turn and adjust the engine flywheel(4) appropriately.

Remove tool 99360612 (1).

Figure 181



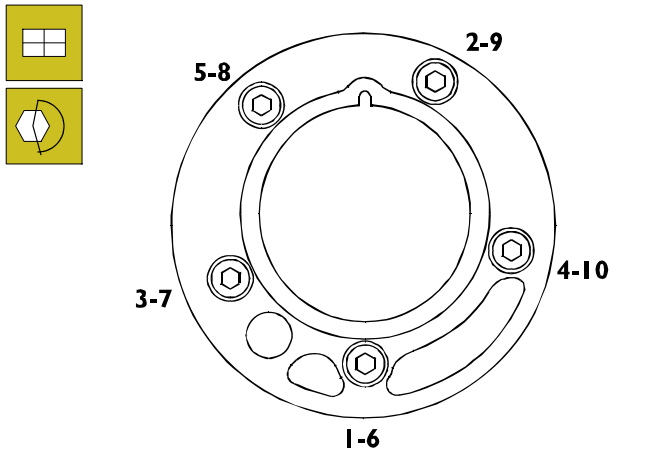
Fit the camshaft (4), positioning it with the reference marks (→) as shown in the figure.

Lubricate the seal ring (3) and fit it onto the shoulder plate (2).

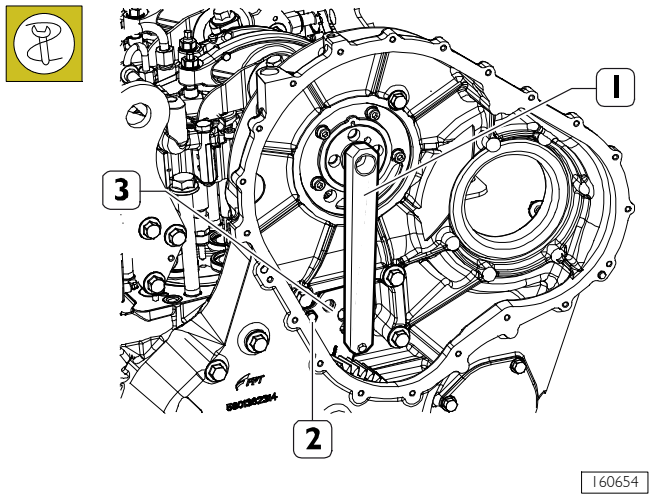
Fit the shoulder plate (2) with the sheet metal gasket (1) and tighten the screws (5) to the specific torque and in the order indicated in Figure 182.

Ref.	No.	Description	Tightening torques
(-)	5	Screws M8 X 1.25 X 25	24.5 ± 2.5 Nm

Figure 182



Tightening sequence	
Step 1	1 - 2 - 3 -4 - 5
Step 2	6 - 7 - 8 - 9 - 10

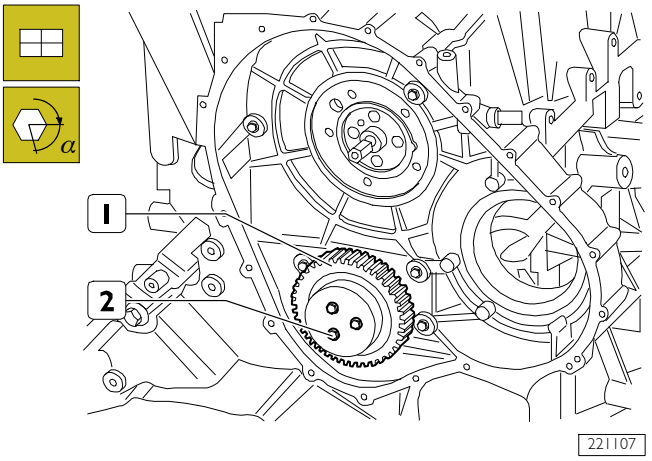


Apply the gauge 99395225 (1).

Check and adjust the position of the connecting rod (3) for the transmission gear; tighten the screw (2) to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(2)	1	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm

Figure 183

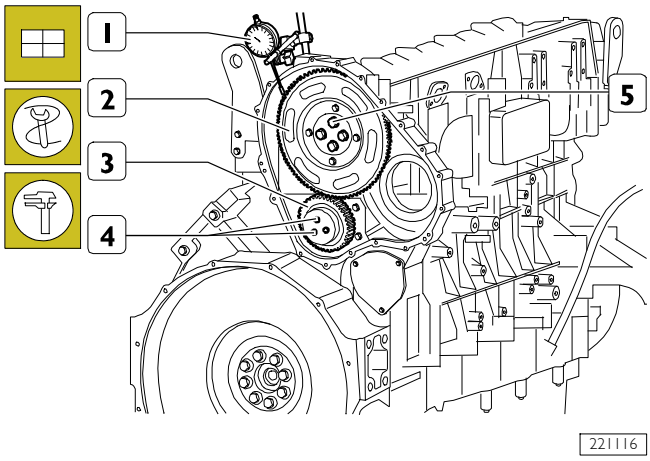


Fit the transmission gear (1) and tighten the screws (2) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(2)	3	M8 x 1.25 screws Step 1 Step 2	 30 Nm 90°

NOTE Lubricate the screws (2) with engine oil before assembly.

Figure 184



Position the gear (2) on the camshaft so that the 4 slots are centred with the holes for fixing the camshaft, without fully locking the screws (5).

NOTE Lubricate the screws (5) with engine oil before assembly.

With a magnetic dial gauge (1) check clearance between the gears (2, 3), which must be between 0.074 - 0.195 mm, otherwise adjust the clearance as indicated below:

Loosen the screws (4) securing the transmission gear (3).

Loosen the connecting rod fixing screw , move the connecting rod in order to obtain the required clearance.

Lock the screw securing the connecting rod and the screws (4) securing the transmission gear to the prescribed torque.

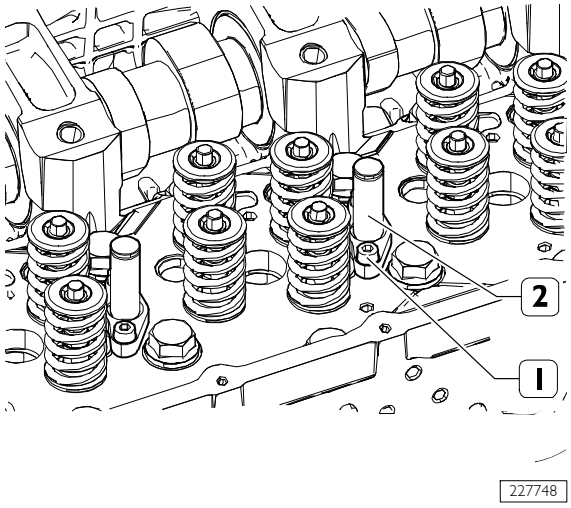
Tighten the camshaft drive gear fastening screws (5) to the torque prescribed.

Ref.	No.	Description	Tightening torques
(5)	4	Screws M14 X 4 X 60 Step 1 Step 2	 20 ± 3 Nm 60°

Assembling the engine brake cylinders

Fit the engine brake cylinders (2) onto the cylinder head and tighten the screws (1) to the torque indicated in the table.

Figure 185

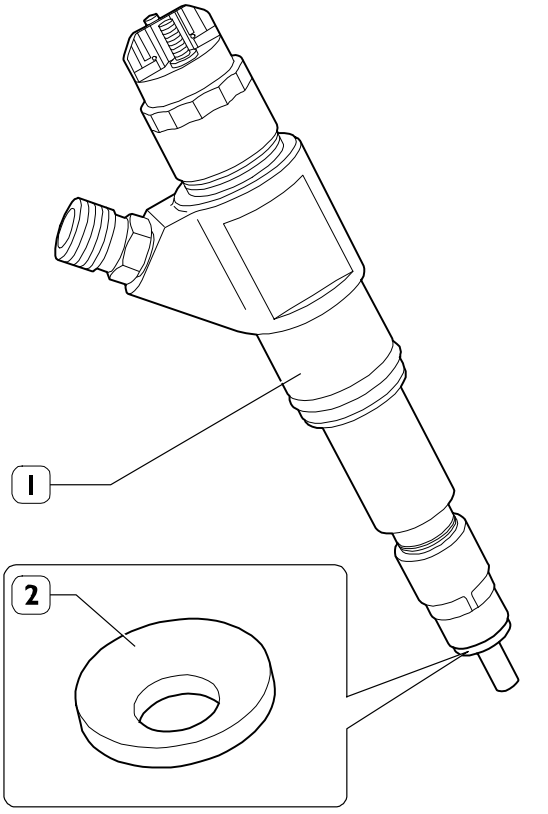


Ref.	No.	Description	Tightening torques
(1)	12	M8 X 1.25 X 20	25 ± 2.5 Nm

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE TOP PART 2)

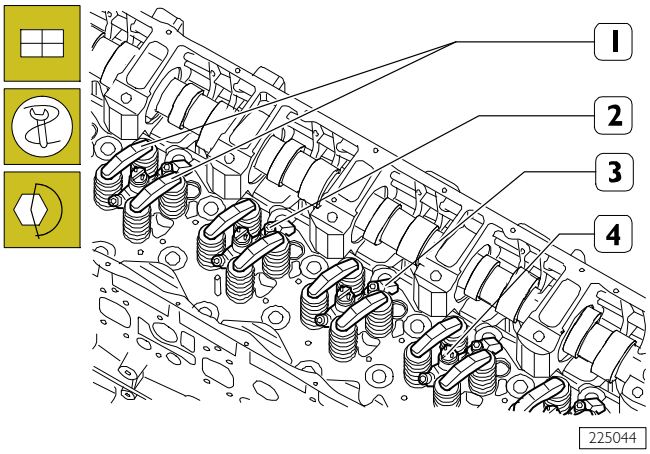
Injector assembly

Figure 186



Fit the sealing gasket (2) on the injectors (1).

Figure 187



Fit the retaining brackets (3) on the injectors (4) and position them in the relevant seats in the cylinder head.

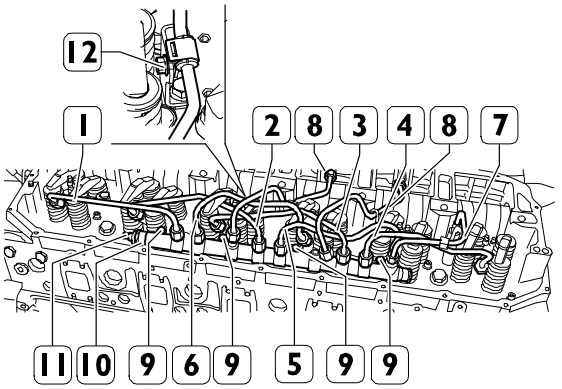
Position the screws (2)

Fit the crosspieces (1) on the valve stem all with the largest hole on the same side.

Rail installation

NOTE The high pressure fuel pipes cannot be re-used but must be replaced each time they are removed

Figure 188



Fit the rail (10) onto the head and tighten the fastening screws (9) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(9)	4	Screws M8 X 1.25 X 55	24.5 ± 2.5 Nm

Connect the high pressure fuel pipes and tighten the fittings by hand in the sequence (1, 2, 3, 6, 5, 4) to the rail and the injectors.

NOTE Before tightening the couplings to torque make sure that the pipes are not touching each other.

Complete injector assembly operations by tightening the fastening screws to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(-)	6	Screws M8 X 1.25 X 45	35 ± 2 Nm

Complete assembly of the high pressure fuel pipes (1, 2, 3, 6, 5, 4) by first tightening the injector side fittings and then those on the rail side to torque stated in the table.

Ref.	No.	Description	Tightening torques
(1 - 6)	12	Fittings M16 X 1.5	42.5 ± 2 Nm

Connect the high pressure fuel supply pipes (8) and tighten them to the prescribed torque.

Ref.	No.	Description	Tightening torques
(8)	4	Fittings M16 X 1.5	42.5 ± 2 Nm

Fix the fuel supply pipe support brackets, tightening the screws to torque stated in the table.

Ref.	No.	Description	Tightening torques
(12)	2	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm

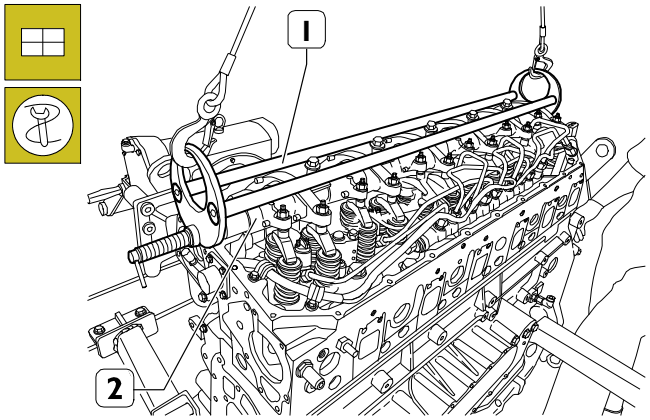
Connect the fuel return pipe (7) from the rail and tighten to torque stated in the table.

Ref.	No.	Description	Tightening torques
(7)	2	Fittings M16 X 1.5	42.5 ± 2 Nm

Fitting rocker shaft assembly

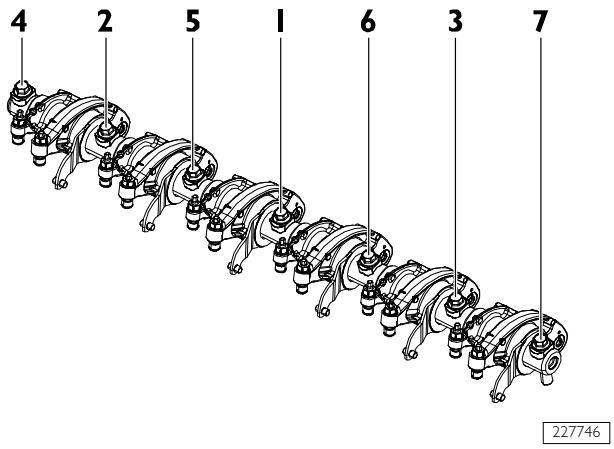
NOTE Use torque wrench 99389833 to tighten fittings of the HP fuel pipes.

Figure 189



Apply the tool 99360553 (1) to the rocker arm shaft (2) and fit the shaft on the cylinder head.

Figure 190

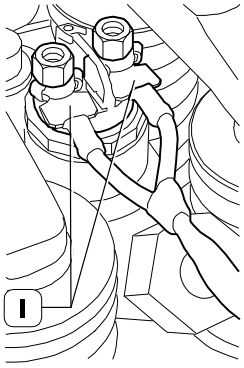


Screw the screws in four steps as follows:

Ref.	No.	Description	Tightening torques
(1 - 7)	7	Screws (M16 X 1.5 X 76)	
		Step 1	25 Nm
		Step 2	60 Nm
		Step 3	80 Nm
		Step 4	60°

Tightening sequence	
Step 1 - 4	1 - 7

Figure 191

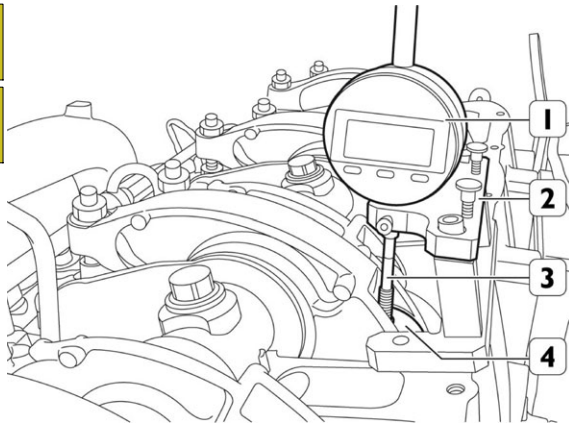


Connect the electrical connections (1) to the injectors and block the cables using cable clamps.

Ref.	No.	Description	Tightening torques
(1)	12	Cable clamps	1.5 ± 0.25 Nm

Camshaft timing

Figure 192



185253

Carefully clean the surface of the head on which the rocker arm cover rests.

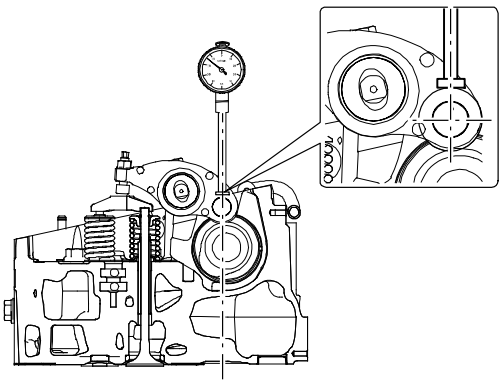
Using the magnetic support 99370400 (2), as shown in the figure, arrange the dial gauge (0-30mm) 99395606 (1) with the-flat based rod (3) positioned on the rocker arm roller (4) which controls the exhaust valves of cylinder no. 3 and preload to at least 7 mm.

Position the flat based dial gauge so that its axis passes through the centre of the roller on which it is resting.

During the CHECK phase, not during the engine overhaul phase, the allowed tolerance of the measurement is between -0.05 - +0.12 mm.

The allowed measurement tolerance during OVERHAUL is ± 0.05 mm.

Figure 193



177714

Using the specific tool to turn the engine flywheel 99360321, turn the crankshaft in the opposite direction to that of operation until the pointer of the dial gauge reaches the minimum value beyond which it can no longer fall.

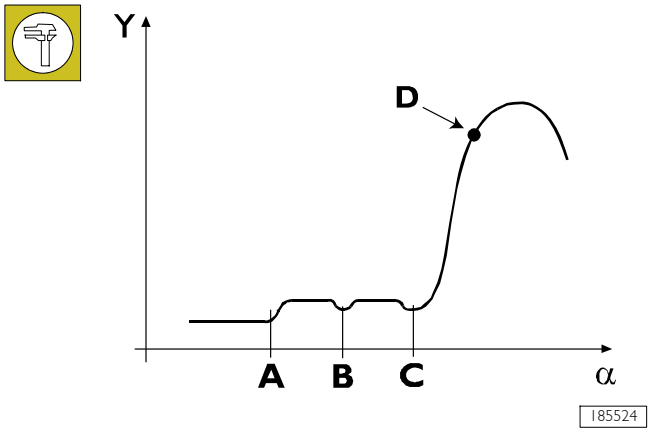
NOTE The measurement must be taken holding the rocker roller in contact with the profile of the exhaust cam of the camshaft.

reset the dial gauge

NOTE The dial gauge is to be zeroed with the rocker arm roller in contact with the base radius of the cam profile .

This occurs when the flywheel is turned in the opposite direction of the operating direction approx. 1 and 1/4 rotations.

Figure 194



α Camshaft rotation angle

Y Cam lift based on the rotation angle of the camshaft

D Cam lift in correspondence of the 54° before the top dead centre , 1st cylinder end of compression

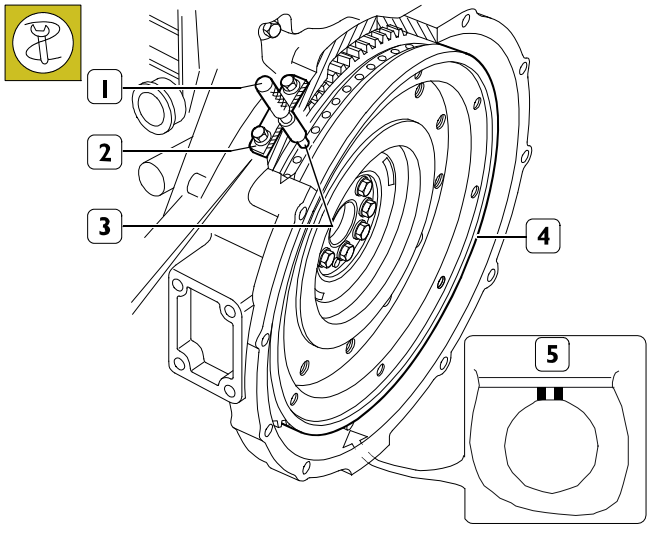
Reset the dial gauge first in point A.

NOTE The dial gauge is to be zeroed with the rocker arm roller in contact with the base radius of the cam profile .

For this, turn the flywheel until it exceeds protrusions (A-B) and (B-C) on the cam profile connected to the engine brake operation.

This condition occurs when the flywheel is turned in the opposite direction of the operating direction by approx. 1 and 1/4 rotations.

Figure 195



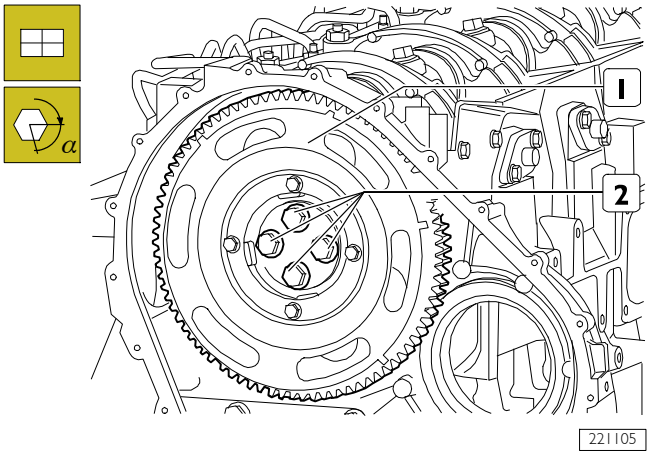
Turn the engine flywheel in the engine operating direction until the dial gauge indicates the required camshaft lift value.

Technical data	
Cam timing dial gauge value	5.95 ± 0.05 mm

Check that the required cam lift values are displayed under the following conditions:

- ❑ The hole with two notches (5) is visible through the small inspection window.
- ❑ The tool 99360612 (1), through the seat (2) of the engine speed sensor , enters the hole (3) in the engine flywheel (4).

Figure 196



Perform the following if the conditions stated have not been obtained:

Turn the engine flywheel until the required cam lift value appears on the dial gauge.

Loosen the screws (2) that fasten the gear (1) to the camshaft and use the slots on the gear (1).

Act on the engine flywheel to obtain the conditions indicated while keeping the cam lift value unchanged.

Lock the screws (2) and repeat timing check as described above.

NOTE While performing this operation recover the clearance between the camshaft gears.

Tighten the screws (2) to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(2)	4	Screws M14 X 4 X 60 Step 1 Step 2	 60 ± 3 Nm 60°

NOTE Lubricate the screws with engine oil.

When adjustment via the slots is not sufficient for recovering the offset, proceed as follows:

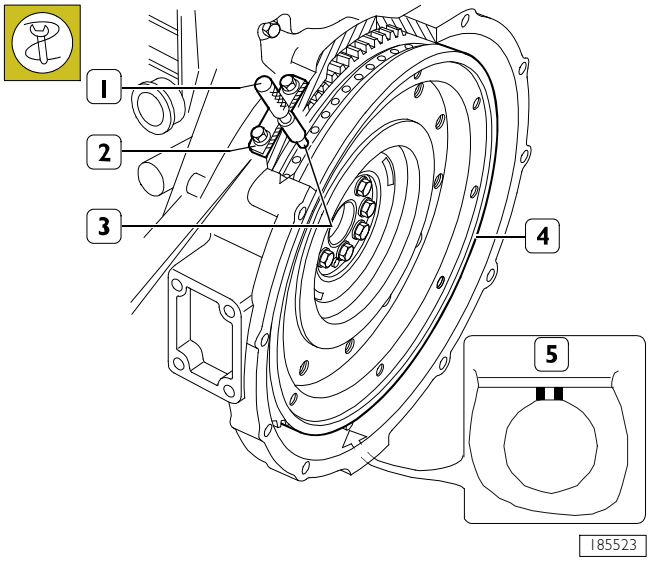
Lock the screws (2) and turn the engine flywheel a 1/2 turn in the opposite direction of the operating direction.

Turn the engine flywheel in the engine operating direction until the dial gauge indicates the required camshaft lift value.

Technical data	
Cam timing dial gauge value	5.95 ± 0.05 mm

Remove the screws (2) and disassemble the camshaft gear (1).

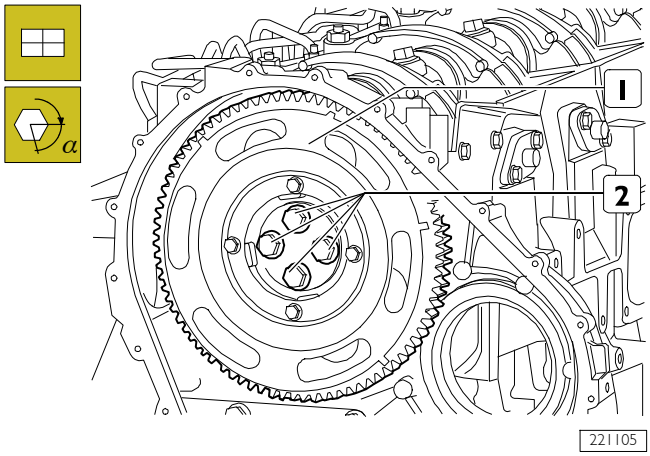
Figure 197



Turn the flywheel (4) again until it reaches the following conditions:

- ❑ The hole with two notches (5) is visible through the small inspection window.
- ❑ The tool 99360612 (1), through the seat (2) of the engine speed sensor , enters the hole (3) in the engine flywheel (4).

Figure 198



Fit the gear (1) with the four slotted holes (2) centred in relation to the holes securing the camshaft and tighten the screws to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(2)	4	Screws M14 X 4 X 60 Step 1 Step 2	 60 ± 3 Nm 60°

NOTE Lubricate the screws with engine oil.

Recover the clearance between the timing system gears by turning the flywheel in the opposite direction of the engine rotation direction and subsequently turning it in the engine rotation direction until the dial gauge shows the specific value.

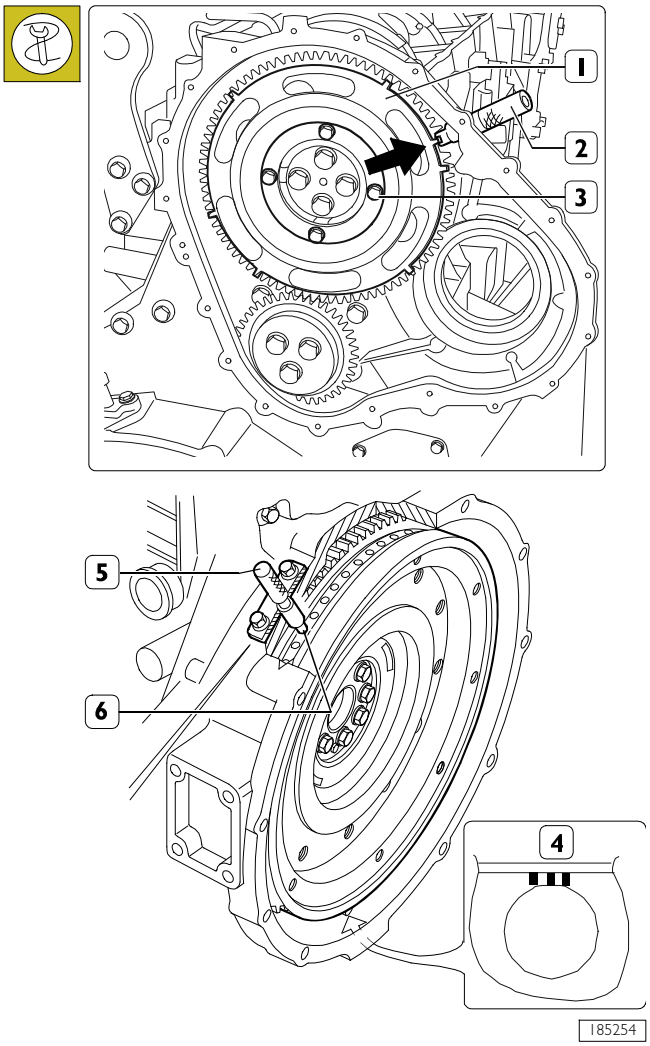
Check the previously described conditions.

Technical data	
Cam timing dial gauge value	5.95 ± 0.05 mm

Remove tool 99360612 (1).

Phonic wheel timing

Figure 199



Turn the crankshaft bringing cylinder piston no. 1 in compression stage to TDC; turn the flywheel by approximately 1/4 turn in the opposite direction to the normal direction of rotation.

Turn the flywheel again according to normal direction of rotation (anti-clockwise) until the hole marked with the three notches can be seen through the inspection hole under the flywheel housing (4).

NOTE If the engine flywheel does not have 3 notches, to identify the reference hole simply: turn the flywheel in the opposite direction to the operating direction until you reach the position marked with 2 notches (54° before cyl. 1 T.D.C.); continue rotating in the engine operating direction for 4 holes (remember that each hole corresponds to a flywheel rotation of 6°).

Fit tool 99360612 (5) into the flywheel sensor seat (6).

Through the timing sensor, insert the tool for phonic disc timing on the camshaft 99360613 (2) on the tooth (↑) recovered from the phonic wheel.

If the tool (2) is difficult to fit, loosen the screws (3) and direct the phonic wheel (1) properly so as to position the tool (2) on the tooth correctly.

Tighten the screws (3).

Ref.	No.	Description	Tightening torques
(3)	4	M8X1.25 screws	24.5 ± 2.5 Nm

Remove tools 99360612 and 99360613.

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE INTAKE SIDE)

High pressure pump assembly

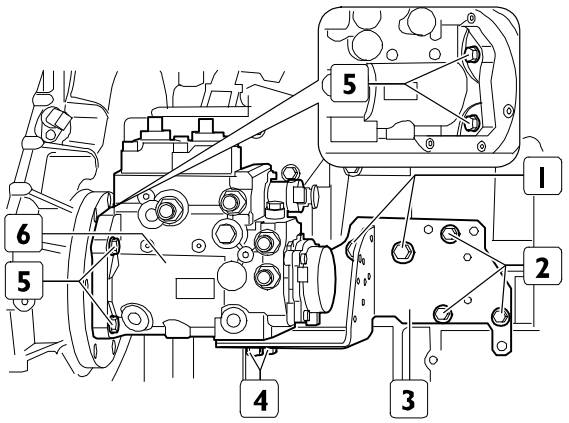
Bring the flywheel to 36° before TDC of the first cylinder.

NOTE This position can be obtained by turning the engine flywheel in the opposite direction to the operating direction in the 30° position marked by THREE notches (4) and continuing to turn the flywheel in the same direction until reaching the next hole (by 6°).

If the engine flywheel does not have 3 notches, to identify the reference hole simply: turn the flywheel in the opposite direction to the operating direction until reaching the position marked with 2 notches (54° before cyl. 1 T.D.C.); continue rotating in the engine operating direction for 3 holes (remember that each hole corresponds to a flywheel rotation of 6°).

Insert the specific tool 99360612 through the seat of the flywheel sensor into the corresponding hole on the flywheel.

Figure 200



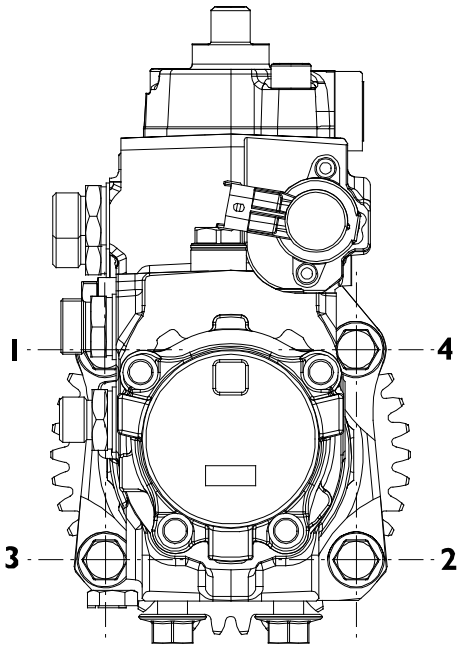
221104

Position the bracket (3) and tighten the screws (1,2).

Position the high pressure pump (6) and tighten the screws (4, 5) to torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	2	Screws M10 X 1.5 X 20	37.5 ± 5 Nm
(2)	3	Screws M8 X 1.25 X 20	24.5 ± 2.5 Nm
(4)	2	Screw M12 X 1.75 X 30	32.5 ± 2.5 Nm
(5)	4	Screws M12 X 1.5	37.5 ± 2.5 Nm

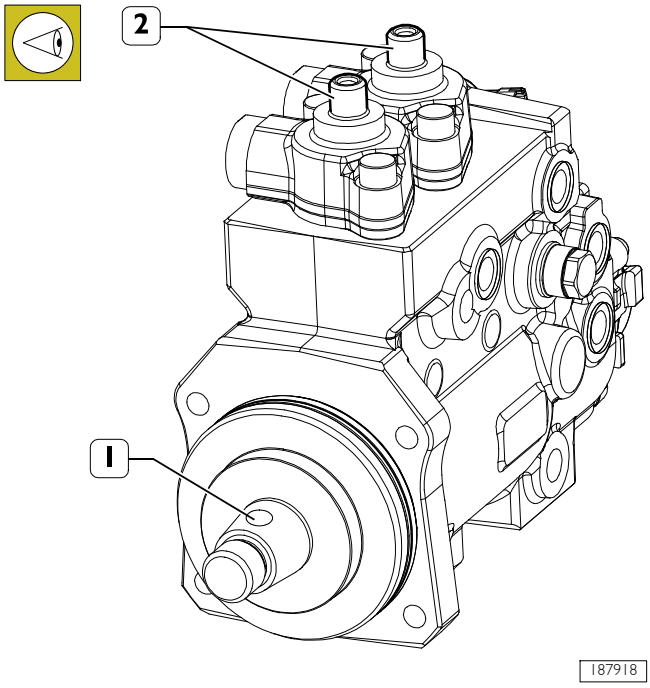
Figure 201



225012

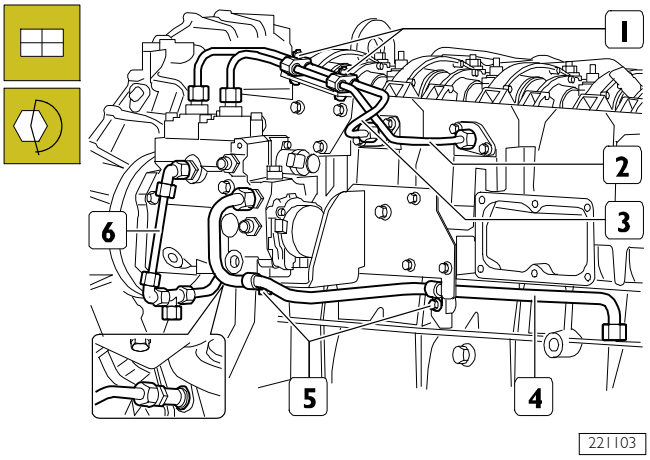
Observe the order of tightening indicated in the diagram.

Figure 202



Fit the high pressure pump and make sure that the seat of the key (1) on the pump shaft is facing the pump intakes (2) .

Figure 203



Fit the HP fuel pipes (2, 3), fit the plugs onto the bracket and tighten the fittings and nuts (1) to the torque shown in the table.

Fit the low pressure pipe (4) and tighten the fittings and collars (5) to the torque indicated in the table.

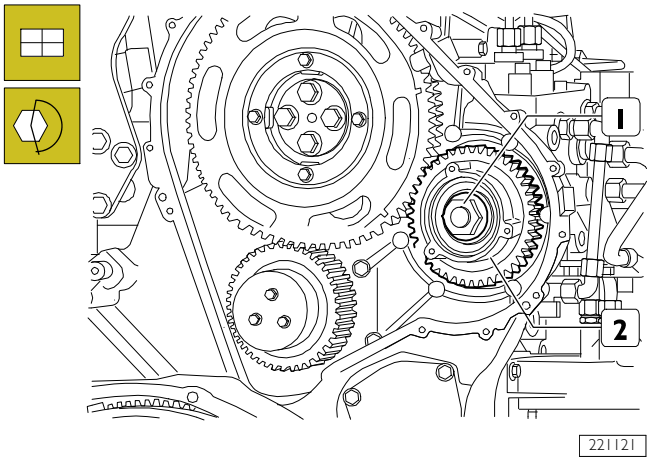
Fit the fuel return pipe (6) and tighten the fittings to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	2	Nuts M6 X 1	8 ± 2 Nm
(2)(3)	4	Fittings M16 X 1.5	42.5 ± 2 Nm
(4)	2	Fittings M22 X 1.5	50 ± 5 Nm
(5)	2	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm
(6)	2	Fittings M18 X 1.5	37 ± 3 Nm

NOTE Make sure that the pipe is not damaged after mounting and that there are no fuel leaks while engine is running.

The high pressure pipes which have been removed cannot be used again and must be replaced.

Figure 204



Fit the gear (2) and tighten the nut (1) to the torque shown in the table.

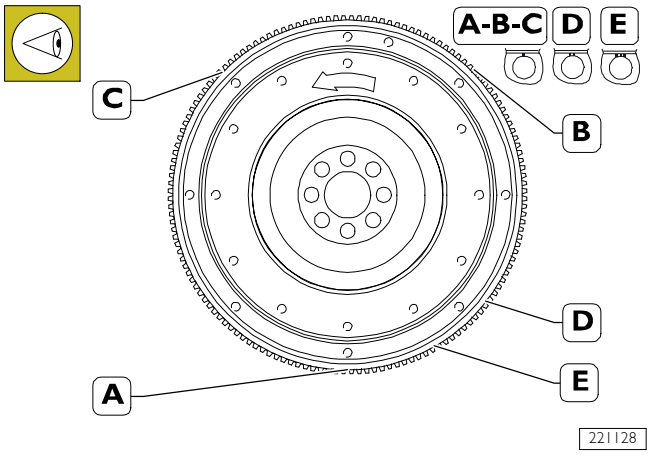
Remove tool 99360612.

Ref.	No.	Description	Tightening torques
(1)	1	Nut M24x1.5	275 ± 25 Nm

Intake and exhaust rocker arm clearance adjustment

NOTE The adjustment of clearance between the rocker arms and crosspieces controlling the intake and exhaust valves must be done very carefully.

Figure 205



A Hole on flywheel with reference mark, corresponding to the TDC of pistons 1-6

B Hole on flywheel with reference mark, corresponding to the TDC of pistons 2-5

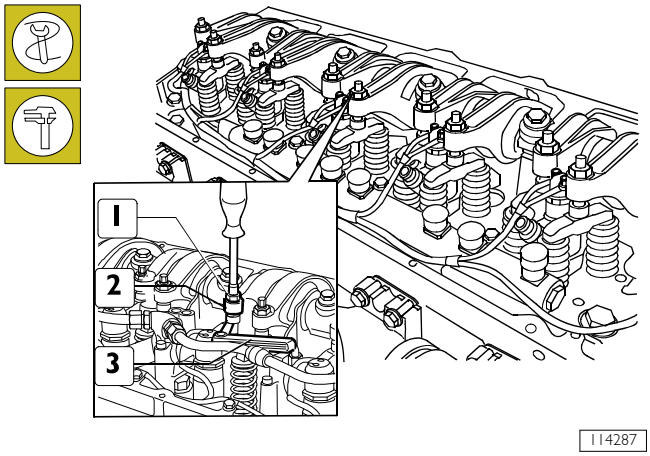
C Hole on flywheel with reference mark, corresponding to the TDC of pistons 3-4

D Flywheel hole with two notches corresponding to position 54° before TDC of pistons 1-6 (camshaft timing reference);

E Flywheel hole with three notches corresponding to position 30° before TDC of pistons 1-6 (reference to high pressure fuel pump timing system and phonic wheel timing).

In order to perform adjustments correctly, during each rotation phase, check the positioning accuracy using the tool for TDC Engine 99360612, inserting it into the hole marked with a notch on the flywheel corresponding to the position of the pistons.

Figure 206



Take the cylinder whose clearance has to be adjusted into the combustion phase; the valves of this cylinder are closed while they balance the symmetric cylinder valves.

NOTE The correspondence of the symmetrical cylinders is 1 - 6, 2 - 5 and 3 - 4.

In order to carry out these operations correctly, follow the indications below in accordance with the indications in the table.

Using a box wrench, loosen the nut (1) locking the adjustment screw.

Insert the feeler gauge blade (3) corresponding to the operating clearance indicated in the table "Data and assembly clearance" in SECTION 7 - Technical specifications.

Use a suitable wrench to screw or unscrew rocker arm (2) adjusting screw.

Check that the blade of the feeler gauge (3) can slide with a light amount of friction.

Lock the nut (1) holding the adjustment screw still.

To carry out the adjustments stated above, the sequence shown in the table is **mandatory**.

FIRING ORDER 1-4-2-6-3-5

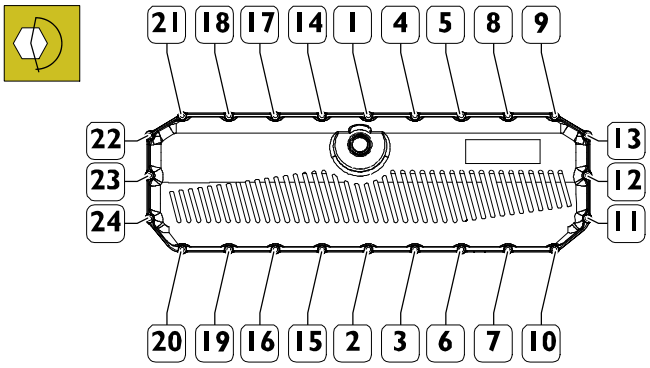
Start and rotation in the engine direction	Balancing cylinder valves no.	Adjust valve clearance for cylinder no.
1 and 6 at T.D.C.	6	1
120 degree of angle [°]	3	4
120 degree of angle [°]	5	2
120 degree of angle [°]	1	6
120 degree of angle [°]	4	3
120 degree of angle [°]	2	5

NOTE Check during each rotation phase, the accuracy of the position by using the specific pin and inserting it into the hole marked with a notch on the flywheel corresponding to the position of the pistons.

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE TOP PART 3)

Tappet cover assembly

Figure 207



Position the cover and insert all the screws.

Replace the screws in the sequence 1-10-20-21-9 and then in the sequence shown in the figure until contact.

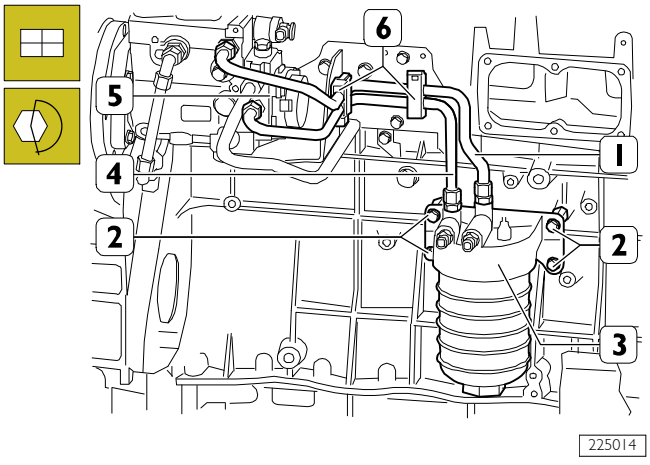
Tighten the screws 1-24 in the sequence shown to the prescribed torque.

Ref.	No.	Description	Tightening torques
(1 - 24)	24	Screws M6x1	8.5 ±1.5 Nm

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE INTAKE SIDE)

Fuel filter assembly

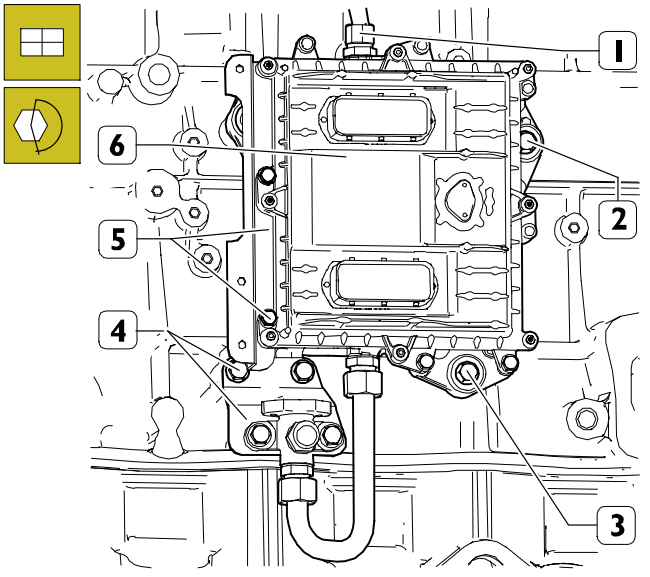
Figure 208



Position the fuel filter together with the support (3), tighten the screws (2) to the prescribed torque, connect the fuel inlet (4) and outlet (1) pipes onto the filter support

Ref.	No.	Description	Tightening torques
(2)	4	M8x1.25	24.5 ± 2.5Nm
(1,4)	2	Fittings M18x1.5	37 ± 3Nm

Figure 209



Fit the engine control unit (6) and tighten the screws of the mount (2, 3) to the torque indicated in the table.

Fit the low pressure pipe bracket and tighten screws (4) to the torque indicated in the table.

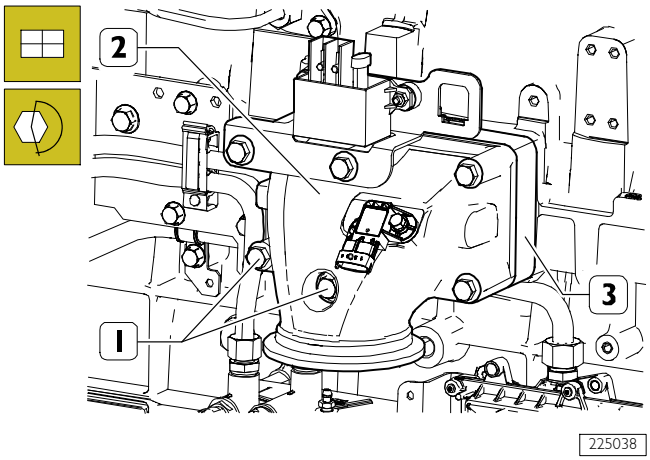
Fit the bracket and tighten screws (5) to the torque indicated in the table.

Connect the low pressure pipefrom control unit to pump and tighten fitting (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Fitting M22 X 1.5	50 ± 5 Nm
(2)	2	Screws M8 X 1.25 X 60	24.5 ± 2.5 Nm
(3)	1	Screws M8 X 1.25 X 45	24.5 ± 2.5 Nm
(4)	2	Screws M8 X 1.25 X 16	24.5 ± 2.5 Nm
(5)	2	Screws M6 X 1 X 25	8 ± 2 Nm

Inlet manifold assembly

Figure 210

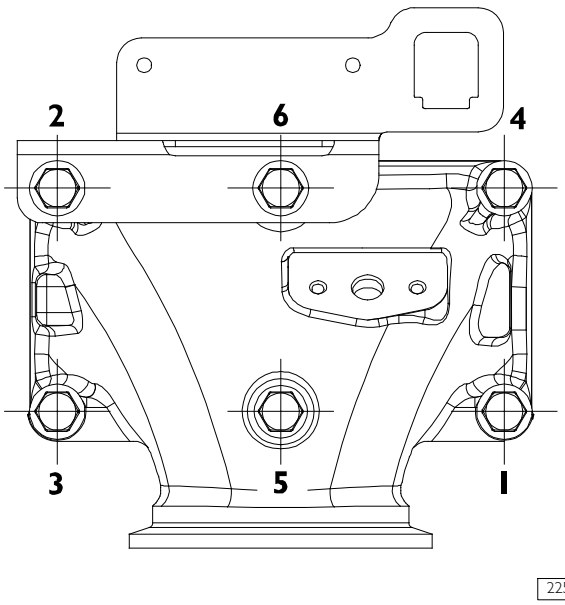


Fit the intake manifold (2) together with the engine preheating resistor (3) and tighten the screws (1) to the to torque stated in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M10 X 1.5 X 100	50 ± 5 Nm
(1)	2	Screws M10 X 1.5 X 130	50 ± 5 Nm
(1)	1	Screws M10 X 1.5 X 150	50 ± 5 Nm

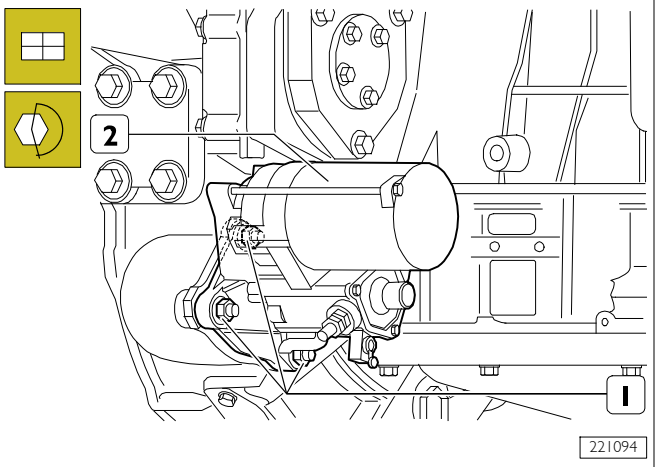
Tightening sequence

Figure 211



Starter motor assembly

Figure 212



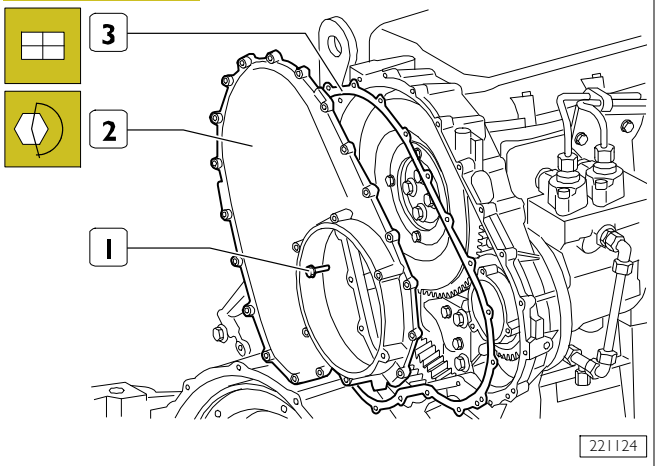
Fit the starter motor (2) and tighten the nuts (1) on the studs to the prescribed torque.

Ref.	No.	Description	Tightening torques
(1)	3	Nuts M12X1,75	74 ± 8 Nm

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE REAR PART 2)

Timing gear assembly cover mounting

Figure 213



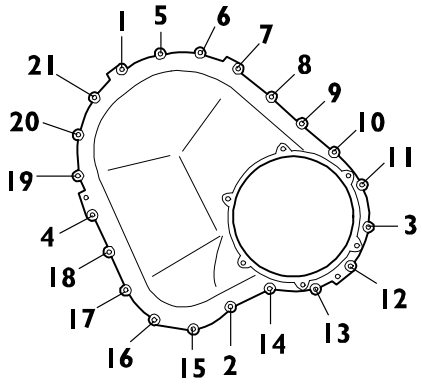
Mount timing gear cover (2) complete with gasket (3).

Tighten the screws (1) to the prescribed torque.

Ref.	No.	Description	Tightening torques
(1)	21	Screws M6 X 1 X 25	10 ± 1 Nm

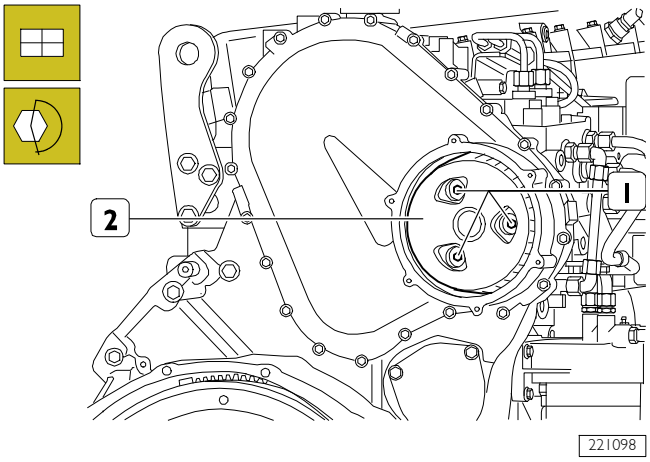
Tightening sequence

Figure 214



Blow-by filter fitting

Figure 215



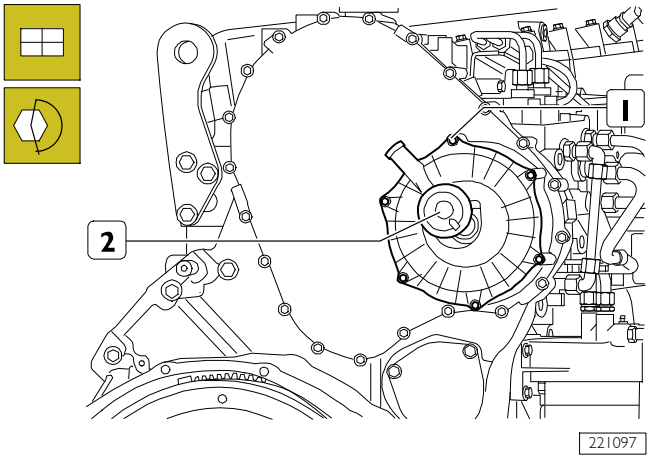
Fit the blow-by case (2) and tighten the screws (1) to the specified torque.

NOTE During assembly, apply LOCTITE 243 to the screws (1).

Ref.	No.	Description	Tightening torques
(1)	3	Screws M6 X 1 X 40 Step 1 Step 2	 5 Nm 15 ± 1.5Nm

Blow-by case fitting

Figure 216

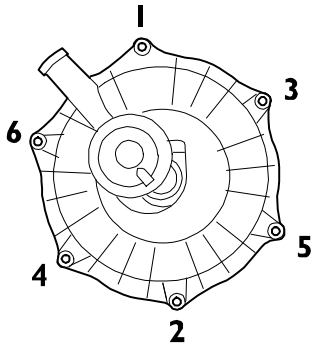


Position the blow-by case (2)and tighten the screws (1).

Ref.	No.	Description	Tightening torques
(1)	6	Screws M6 X 1 X 25	7 ± 1 Nm

Tightening sequence

Figure 217



Assembly of rpm and timing sensor

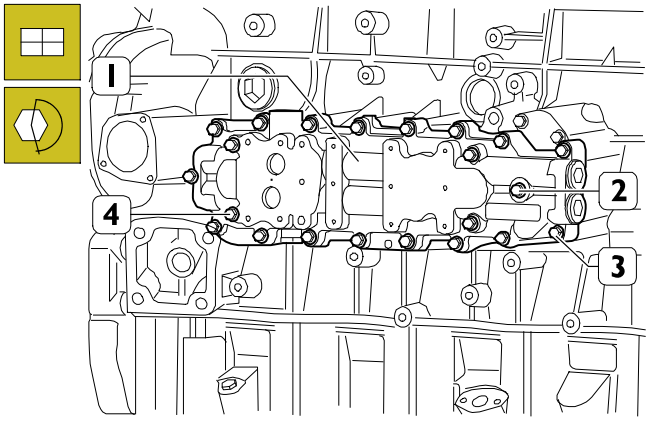
Mount the rpm and timing sensors into their seats on the flywheel case and tighten screws to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(-)	2	M6 x 12 screws	8 ± 2 Nm

ASSEMBLY OF ENGINE AT BENCH (COMPONENTS AT THE EXHAUST SIDE)

Heat exchanger assembly

Figure 218

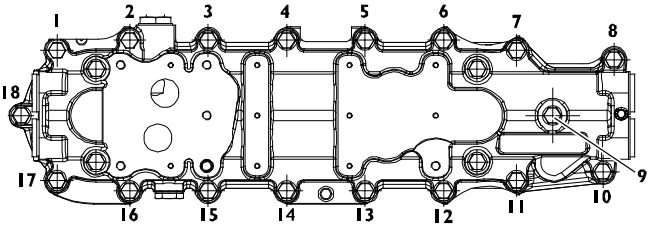


Fit the heat exchanger (1) and tighten the fastening screws (2, 3, 4) to torque stated in the table.

Ref.	No.	Description	Tightening torques
(2)	1	Screws M8 X 1.25 X 55 Step 1 Step 2	 11.5 ± 3.5 Nm 24.5 ± 2.5 Nm
(3)	17	Screws M8 X 1.25 X 40 Step 1 Step 2	 11.5 ± 3.5 Nm 24.5 ± 2.5 Nm
(4)	4	Screws M8 X 1.25 X 45	19 ± 3.8 Nm

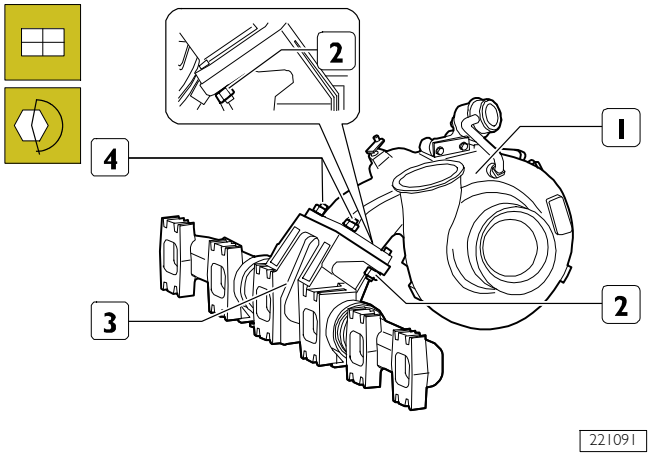
Tightening sequence

Figure 219



Turbocharger assembly

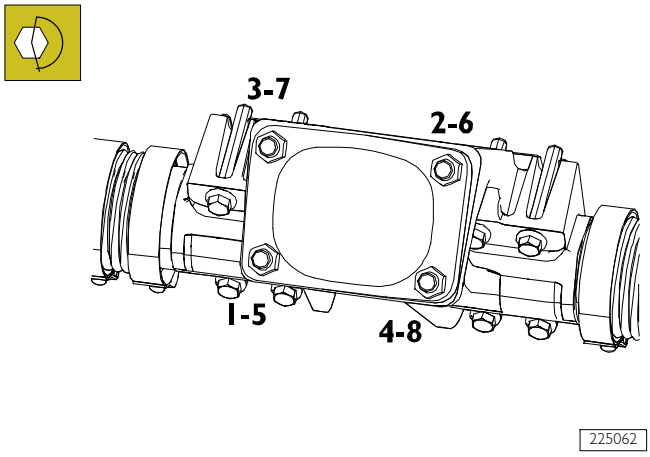
Figure 220



Fit the turbocharger (1) with a new gasket on the exhaust manifold (3), tightening the screws (4) and the nuts (2) to torque stated in the table.

Ref.	No.	Description	Tightening torques
(2, 4)	4	Nuts M12 X 1.75	75 Nm

Figure 221

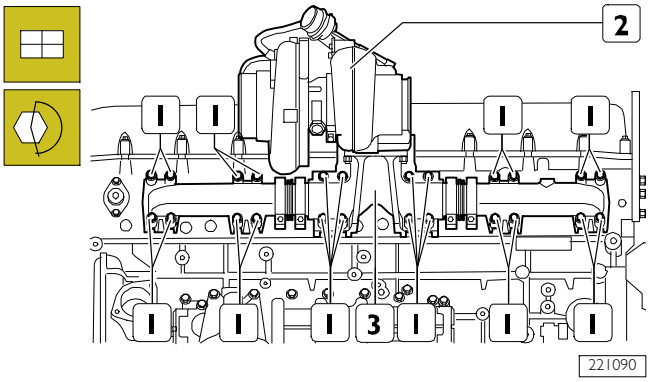


Tighten the screws securing the turbocharger to the prescribed torque following the sequence indicated in the figure.

NOTE Lubricate the screws with graphite oil.

Exhaust manifold assembly

Figure 222



Fit the exhaust manifold (3) with new gaskets together with the turbocharger (2).

Tighten the screws (1) securing the exhaust manifold to the prescribed torque.

Ref.	No.	Description	Tightening torques
(1)	24	Screws M10X1.5X70 Step 1 Step 2	 30 ±5 Nm 60 ±5 Nm

NOTE Lubricate the screws with graphite oil.

Tightening sequence

Figure 223

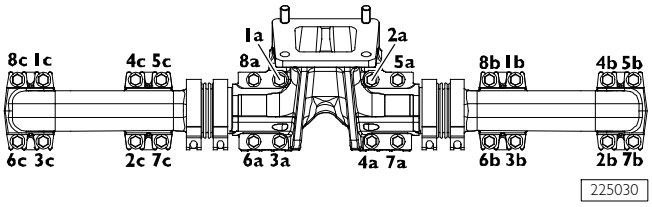
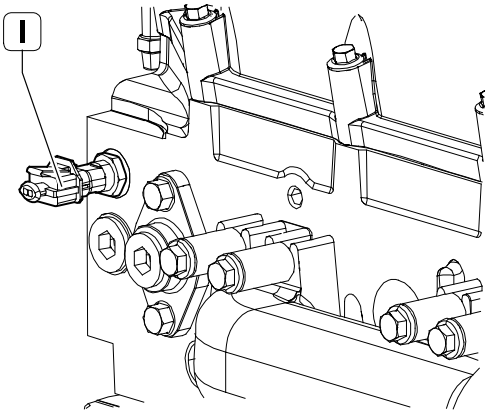


Figure 224

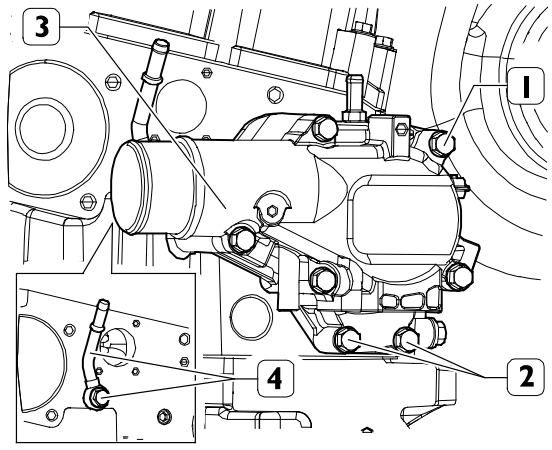


Fit the coolant sensor (1) and tighten to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	2	M12 X 1.5	20 ± 5 Nm

Thermostat case assembly

Figure 225



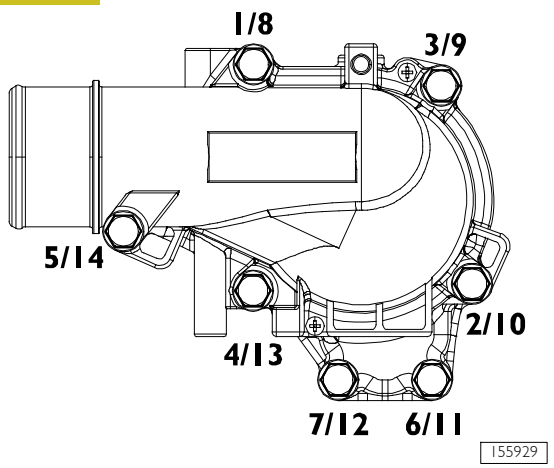
Mount the degasing pipe (4) and tighten the screw to the torque specified in the table.

Ref.	No.	Description	Tightening torques
(4)	1	M10 X 1.5	25 ± 2.5 Nm

Fit the thermostat case (3) with a new gasket and tighten the fastening screws (1, 2) to the prescribed torque according to the sequence indicated in the next figure.

Ref.	No.	Description	Tightening torques
(1-2)	5	Screws M8 X 1.25 X 100	
	2	Screws M8 X 1.25 X50	
		Step 1	30 ± 3 Nm
		Step 2	30 ± 3 Nm

Figure 226

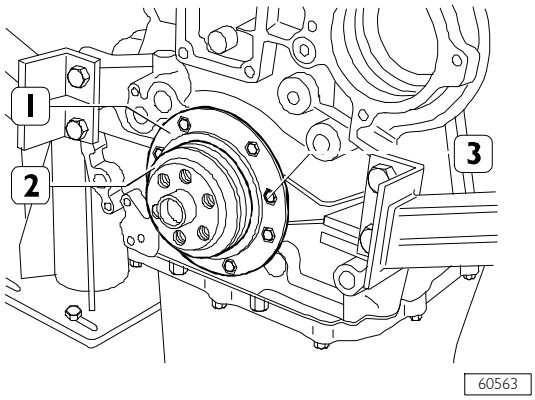


Tighten the fastening screws following the order indicated in the table.

Tightening sequence	
Step 1	1 - 2 - 3 - 4 - 5 - 6 - 7
Step 2	8 - 9 - 10 - 11 - 12 - 13 - 14

Crankshaft front gasket installation

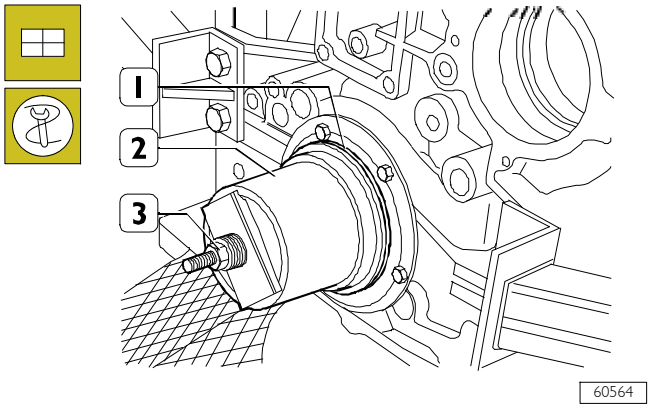
Figure 227



Using the centring ring 99396035 (2), check the exact position of the cover (1), otherwise act as necessary and tighten the screws (3) to torque stated in the table.

Ref.	No.	Description	Tightening torques
(3)	8	M8 X 1.25 X 16	25 ± 2.5 Nm

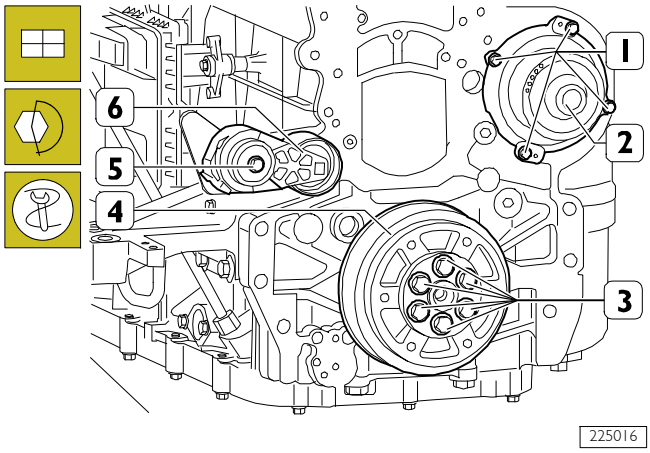
Figure 228



Position the sealing gasket (1) onto the crankshaft, fit the keying device 99346250 (2) and while tightening the nut of the tool (3) drive in the sealing gasket (1).

Assembly of auxiliary parts

Figure 229



Block rotation of the flywheel with the tool 99360351.

Mount the automatic belt tensioner (6) and the nuts (5) to the torque indicated in the table.

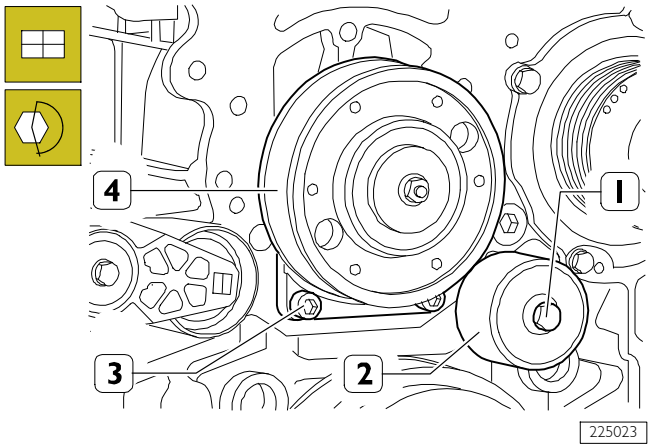
Fit the crankshaft pulley (4) and tighten the screws (3) to the torque indicated in the table.

Fit the water pump (2) together with the new gasket and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	4	Screws M8 X 1.25 X 20	25 ± 2.5 Nm
(3)	6	M14 x 2 screws Step 1 Step 2	 70 Nm 50°
(5)	1	M10 x 1.5 screw	45 ± 5 Nm

Electromagnetic coupling assembly

Figure 230



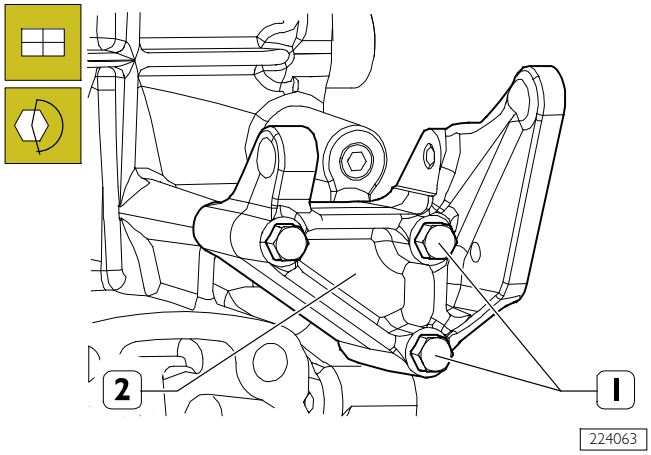
Fit the pulley electromagnetic coupling assembly (4) and tighten the screws of the plate (3) to the torque indicated in the table.

Mount the fixed belt tensioner (2) and the nuts (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Screws M12 X 1.75	105 ± 5 Nm
(3)	5	Screws M12 X 1.75	100 ± 5 Nm

Alternator support assembly

Figure 231

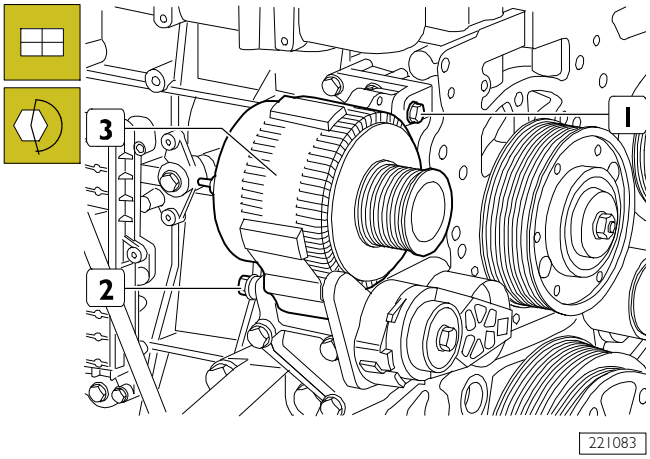


Fit the alternator support (2) and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	3	M10 x 1.5 screws	44 ± 4 Nm

Alternator assembly

Figure 232

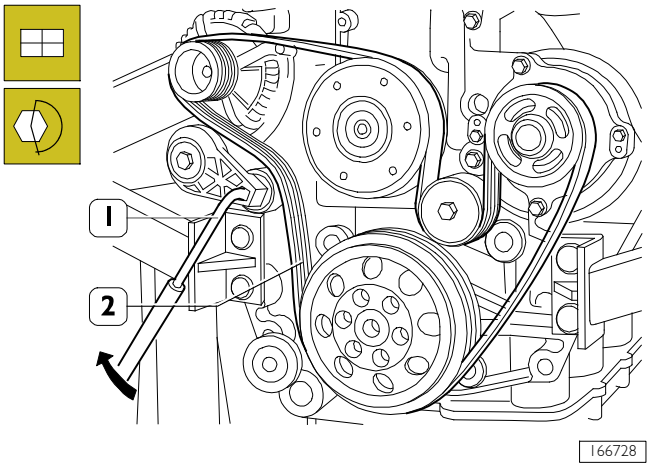


Fit the alternator (3) and tighten the screws (1, 2) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	1	M8x1.25 screw	24.5 ± 2.5 Nm
(2)	1	Screw M10x1.5	44 ± 4 Nm

Alternator/water pump drive belt assembly

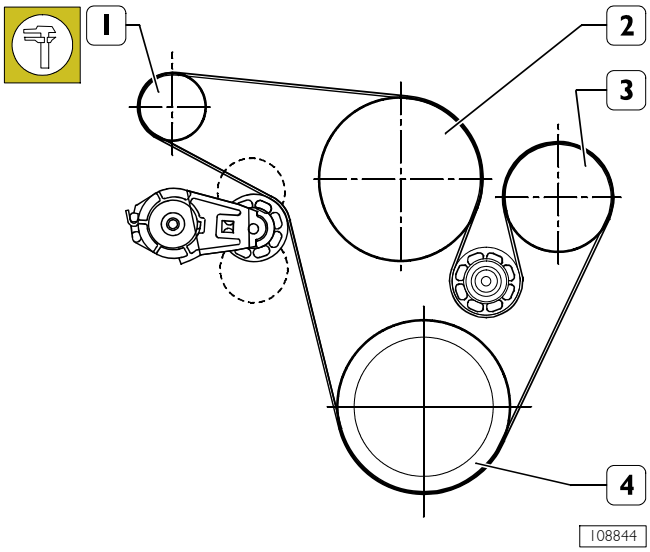
Figure 233



To fit the belt (2) use suitable equipment to adjust the belt tensioner (1) in the direction indicated by the arrow in the figure.

NOTE Belt tensioner is of automatic type; therefore, further adjusting is not provided after mounting.

Figure 234

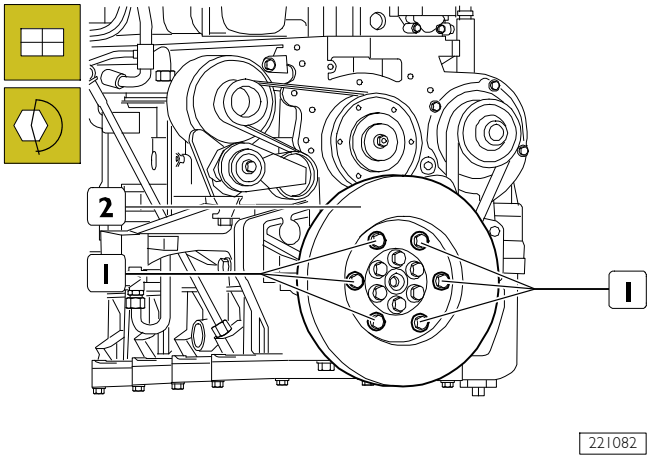


1 Alternator - 2 Electromagnetic connector - 3 Water pump - 4 Crankshaft

Upon assembly, check the correct installation as shown in the figure.

Damper flywheel installation

Figure 235



Fit the flywheel damper (2) onto the head and tighten the fastening screws (1) to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	6	Screws M14X2 Step 1 Step 2	 70 Nm 50°

NOTE Before fitting, lubricate the screw thread (1) with engine oil.

Removing the engine from the rotating stand

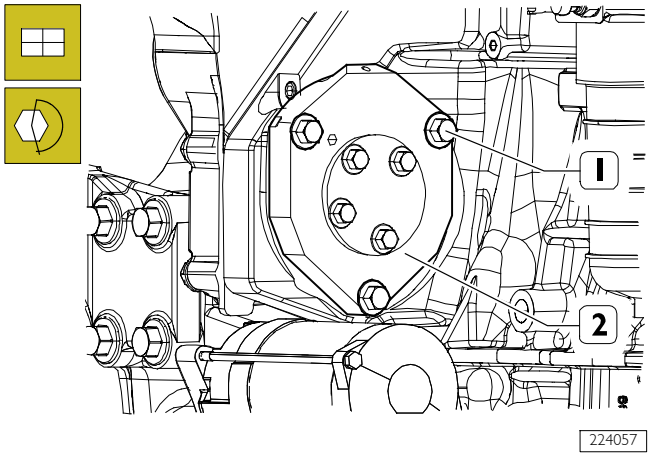
Remove the engine from the rotating stand 99361036 and remove the brackets securing the engine 99361036.

ENGINE ASSEMBLY

Asembly of bracket interference components

Assembly of the air compressor input point

Figure 236

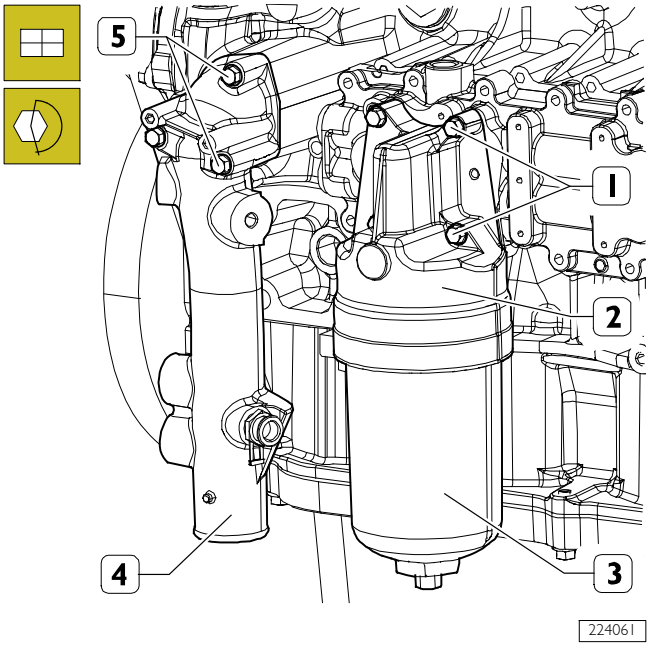


Fit the air compressor input tap (2) and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	3	Screws M12 X 1.75	74 ± 8 Nm

Assembly of the oil filter with relative support and water inlet pipe to crankcase

Figure 237



Fit the water inlet pipe to the crankcase (4) together with the new gasket and tighten the screws (5) to the torque indicated in the table.

Fit the engine oil filter mount (2) together with the new gasket and tighten the screws (1) to the torque indicated in the table.

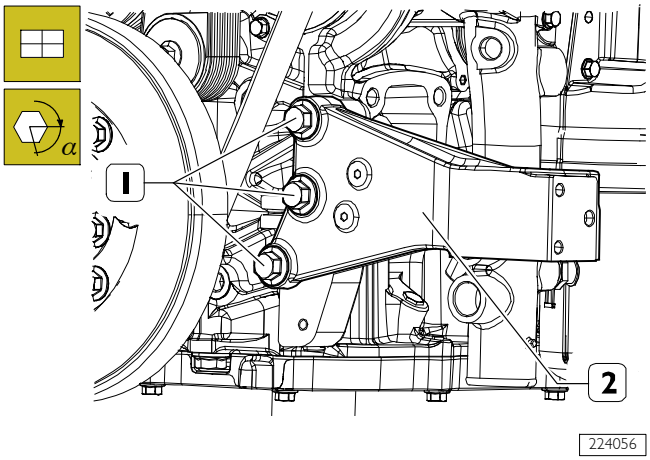
Fit the filter element of the oil filter (3) onto its support (2) and tighten it to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	4	Screws M8 X 1.25 X 65	24.5 ± 2.5 Nm
(3)	1	-	60 ± 5 Nm
(5)	3	M8 x 1.25 screws	34.5 ± 3.5 Nm

Avoid skin contact with the engine oil: in case of contact, wash thoroughly with water.

Assembling the engine front suspensions.

Figure 238



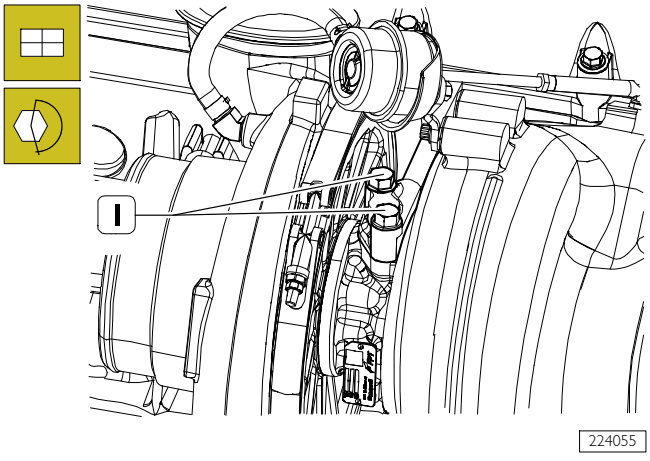
Fit the LH front engine suspension (2) and tighten the screws (1) to the torque indicated in the table.

Proceed likewise to assemble the suspension on the right.

Ref.	No.	Description	Tightening torques
(1)	3	M16 x 2 screws Step 1 Step 2	 120 Nm 45°

Assembly of the turbocharger oil supply and return pipe oil pressure and temperature sensor and oil pressure regulator valve

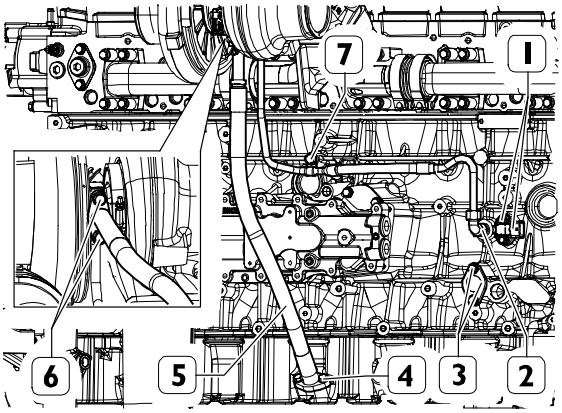
Figure 239



Fit the engine oil delivery pipe to the turbocharger with new gaskets and tighten the fastening screws (1) to the turbocharger to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	2	M8 x 1.25 screws	24.5 ± 2.5 Nm

Figure 240



Screw the fitting (2) of the oil intake pipe to the turbocharger and the screw of the bracket (7) to the torque indicated in the table.

Fit the turbocharger oil outlet pipe with the new gaskets and tighten the screws (4) and (6) to the torque indicated in the table.

Fit the oil pressure control valve and tighten the screws (3) to the torque indicated in the table.

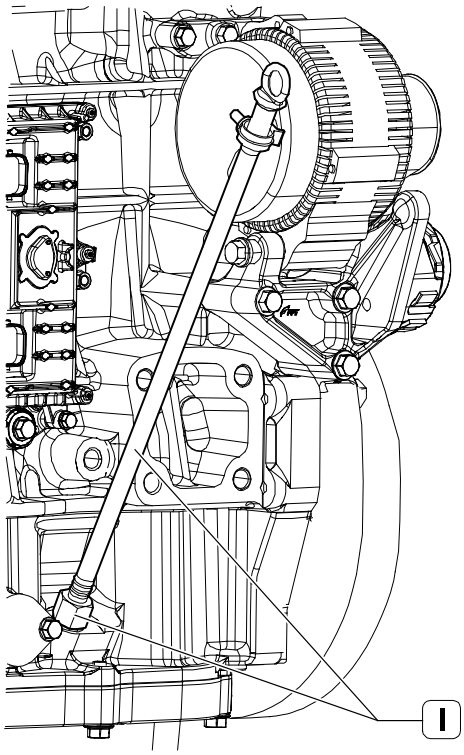
Ref.	No.	Description	Tightening torques
(2)	1	Fitting M16 X 1.5 X 12	42.5 ± 2.5 Nm
(4) (6)	4	M8 x 1.25 screws	24.5 ± 2.5 Nm
(3)	2	Screws M8 X 1.25 X 20	25 ± 2.5 Nm

Fit the oil pressure and temperature sensor with the new O-ring and tighten the screws (1) to the torque indicated in the table.

Ref.	No.	Description	Tightening torques
(1)	2	Screws M6	11.5 Nm

Assembly of the dipstick for checking the oil

Figure 241



Reposition the oil dipstick (1) into its seat and tighten the nut to the torque shown in the table.

Ref.	No.	Description	Tightening torques
(1)	1	Nut M18 X 1.5	50 ± 5 Nm

Fitting the engine cable

Fit the engine electric cable into its seat connecting it to the control unit and all sensors/transmitters to which it is connected.

When completing assembly, refill with engine oil using type and amount specified.

Use only engine oil with recommended specifications.

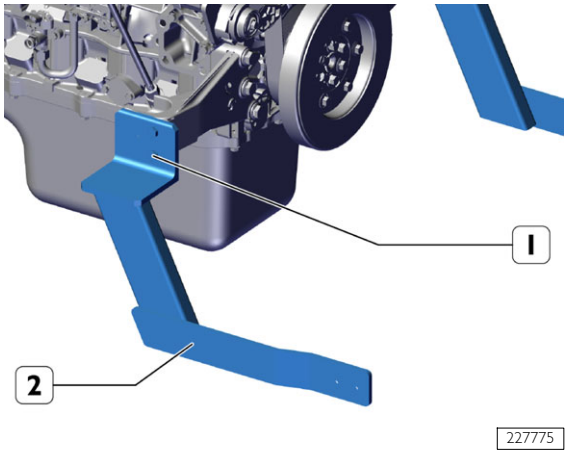
Failure to observe this requirement may void the warranty.

Check oil level using the dipstick; the level must be around the MAX mark n the dipstick.

Assembly of G-Drive components

Fitting of radiator assembly brackets

Figure 242

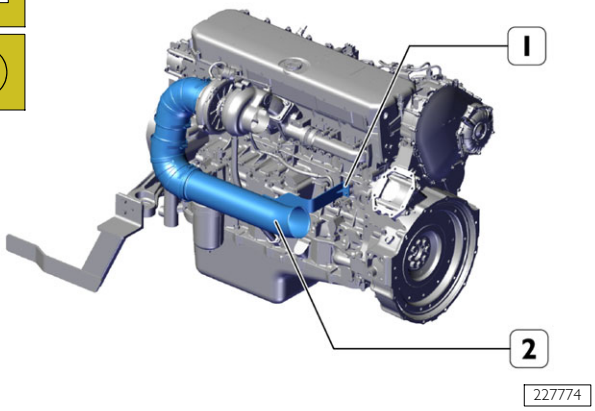


Fit the brackets (2) that support the radiator assemblies into their seats and tighten screws (1) totorque in table.

Ref.	No.	Description	Tightening torques
(1)	4	M12x1.75 screws	69 ± 14 Nm

Assembly of radiator assembly pipes tp engine

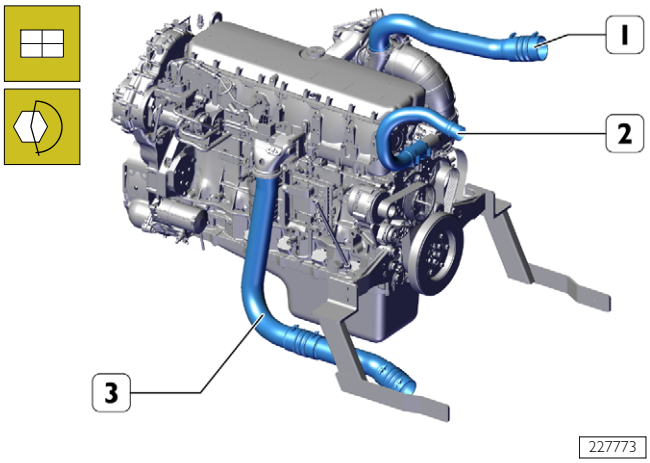
Figure 243



Connect combustion air intake pipe to the turbocharger (2) and, tighten bracke and screws (1) to the torque in the table.

Ref.	No.	Description	Tightening torques
(1)	2	Screws M8	18 ± 4 Nm

Figure 244



To the intake manifold connect the combustion air intake pipe to the engine (3) and tighten the clamp.

To the thermostat, connect the coolant intake pipe (2) to the radiator assembly and tighten clamp.

To the turbocharger, connect the air intake pipe (1) to the aftercooler and tighten clamp.

Refit the air filter as described in the procedure "AIR FILTER REMOVAL - REFITTING" - Section 5.

Refit the fan as described in the procedure "FAN REMOVAL - REFITTING" - Section 5.

Refit the radiator assembly as described in the procedure "RADIATOR ASSEMBLY REMOVAL - REFITTING" - Section 5.

Refit the protection grilles as described in the procedure "PROTECTION GRILL REMOVAL - REFITTING" - Section 5.

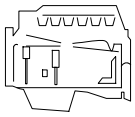
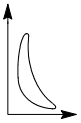
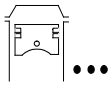
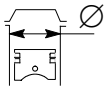
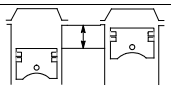
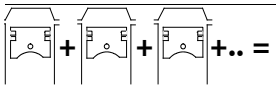
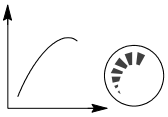
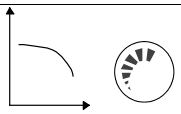
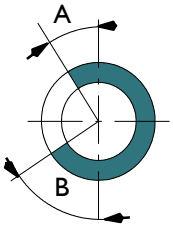
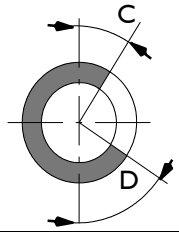
CHECKS

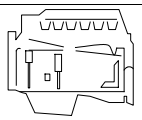
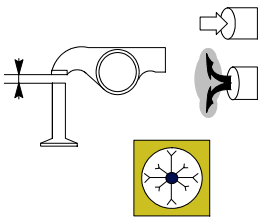
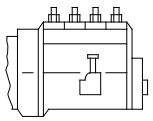
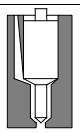
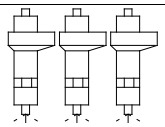
NOTE The following checks must be performed after mounting the engine onto the vehicle.

Start the engine, leave running at an rpm slightly greater than the idle speed and wait for the coolant to heat sufficiently to open thermostat. Once open, check that:

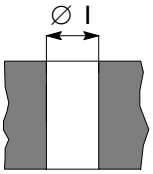
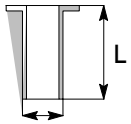
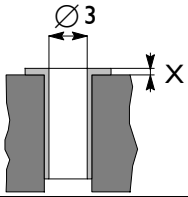
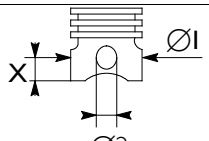
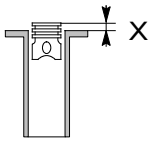
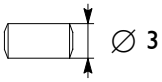
- ❑ water is not lost from leaks in the connecting pipes of the engine cooling circuit and the cab heating system. Tighten the hose clips if necessary;
- ❑ thoroughly check the connections of the low pressure fuel pipe to the respective fittings;
- ❑ that there are no oil leaks between the cover and the cylinder head, between oil sump and engine block, between heat exchanger oil filter and the relevant housings and between the different pipes in the lubricating circuit;
- ❑ that there are no fuel leaks from the fuel pipes;
- ❑ that there are no air leaks from pneumatic pipes;
- ❑ Check also proper operation of the warning lights set on the instrument panel and of the equipment disconnected when engine was removed;
- ❑ check and vent the engine cooling system with extreme care with repeated bleeding operations.

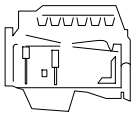
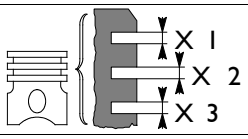
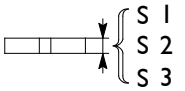
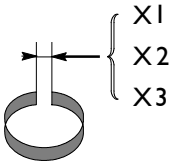
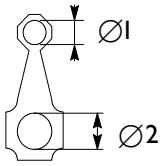
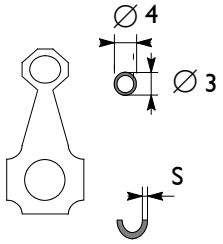
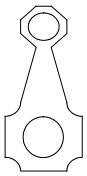
GENERAL CHARACTERISTICS

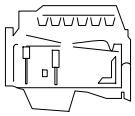
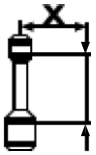
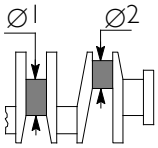
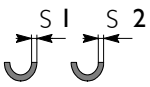
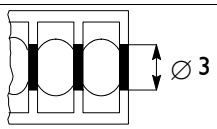
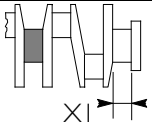
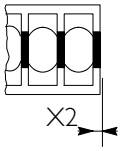
	Type		F3HFA615A*D001		F3HFA615B*D001	
	Cycle Supply Injection		Diesel 4-stroke Turbocharged with aftercooler Direct			
	Number of cylinders		6 in line			
	Bore	mm	135			
	Stroke	mm	150			
	Total displacement	cm^3	12882			
	Compression ratio		16.5 : 1			
	Maximum power prime engine	kWm (HP) revs/min Hz	415 (564) 1500 50	428 (582) 1800 60	371 (504) 1500 50	400 (544) 1800 60
	Maximum power engine in stand-by	kWm (HP) revs/min Hz	459 (624) 1500 50	474 (644) 1800 60	414 (563) 1500 50	454 (617) 1800 60
	maximum torque	Nm (kgm) revs/min.	- - .			
	Idle speed with no load	rpm	1500 at 50 Hz 1800 at 60 Hz			
	Maximum engine idle speed	rpm	1570 at 50 Hz 1870 at 60 Hz			
	DISTRIBUTION					
	Start before T.D.C. End after B.D.C.		A = 17° B = 30°			
	Start before B.D.C. End after T.D.C.		D = 50° C= 9°			

	Type		**F3HFA615A*D001**	**F3HFA615B*D001**
	Of operation	mm	0.40 ± 0.05	
	X	mm	0.60 ± 0.05	
	POWER SUPPLY		The high pressure fuel supply system is managed by the BOSCH EDC 17. It consists of the CPN 5 22/2 high-pressure pump, electro-injectors, hydraulic accumulator (rail), EDC 17 control unit and pressure and temperature sensors.	
	Injection		Common Rail electronics	
	High pressure supply pump		Bosch CPN5 22/2	
	Electro-injectors type		Bosch CRIN3-22	
	Firing order		1 - 4 - 2 - 6 - 3 - 5	
	Varying injection pressure bar	bar	-	

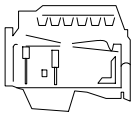
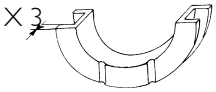
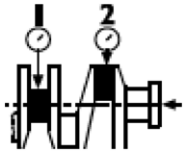
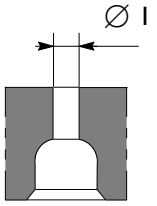
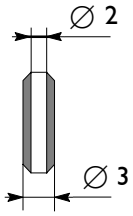
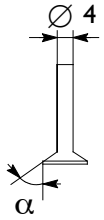
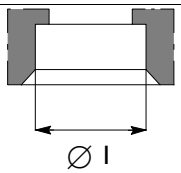
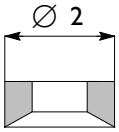
DATA - INSTALLATION CLEARANCES

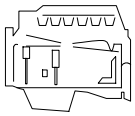
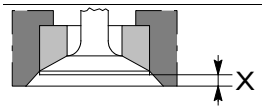
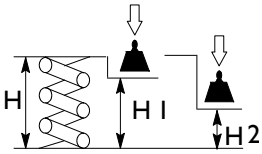
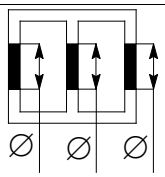
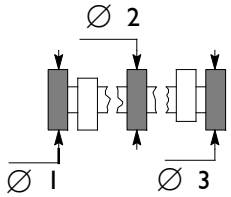
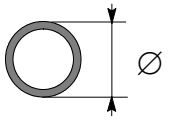
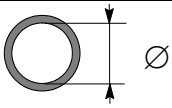
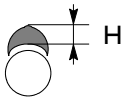
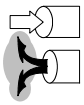
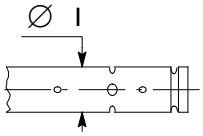
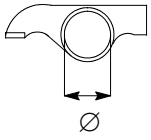
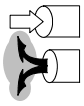
	Type		F3HFA615A*D001	F3HFA615B*D001
			mm	
	CRANK GEAR AND CYLINDER ASSEMBLY DATA			
	Cylinder liner housings			
	Ø1	upper	153.500 - 153.525	
		lower	152.000 - 152.025	
	Cylinder liners: outer diameter			
	Ø2	upper	153.461 - 153.486	
		lower	151.890 - 151.915	
	length	L	252.2	
	Cylinder liners - crankcase seat			
	upper		0.014 - 0.039	
	lower		0.085 - 0.135	
	Outer diameter	Ø2	-	
	Cylinder liners:			
	Inner diameter	Ø3	135.000 - 135.020	
	Protrusion	X**	0.045 - 0.075	
** With a load of 8,000 kg				
	Pistons:			
	measuring point	X	50	
	Outer diameter Ø1	Ø1	134.903 - 134.933	
	pin housing	Ø2	59.060 - 59.080	
	Piston - cylinder liners		0.067 - 0.117	
	Piston diameter	Ø1	-	
	Piston protrusion	X	-	
	Piston pin	Ø3	58.994 - 59.000	
	Piston pin - pin seat		0.060 - 0.086	

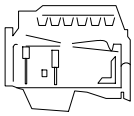
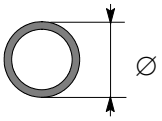
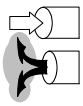
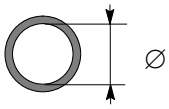
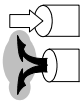
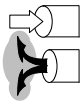
			F3HFA615A*D001	F3HFA615B*D001
	Type		mm	
	Piston ring slots	X1	2.480 - 2.510	
		X2	2.508 - 2.511	
		X3	4.050 - 4.080	
	Piston rings:			
	trapezoidal sealing	S1	2.296 - 2.340	
	bevelled	S2	2.470 - 2.500	
	milled scraper ring with slots and internal spring	S3	3.970 - 3.990	
	Piston rings - slots	1	0.10 - 0.12	
		2	0.07 - 0.10	
		3	0.03 - 0.07	
	Piston rings		-	
	Piston ring end gap in cylinder liner:			
		X1	0.35 - 0.45	
		X2	0.65 - 0.80	
		X3	0.40 - 0.75	
	Connecting rod small end bush seat	Ø1	63.000 - 63.030	
	Connecting rod bearing seat	Ø2	100.000 - 100.030	
	Classes	1	100.000 - 100.010	
		2	100.011 - 100.020	
		3	100.021 - 100.030	
	Bushing diameter at connecting rod small end			
	external	Ø4	63.120 - 63.160	
	internal	Ø3	59.060 - 59.076	
	Connecting rod half-bearings (S) thickness			
	Red colour		1.960 - 1.970	
	Green colour		1.970 -1.980	
	Yellow colour*		1.980 -1.990	
* Fitted in production only and not supplied as spare part.				
	Bush at connecting rod small end - housing		0.090 - 0.160	
	Piston pin - bushing		0.060 - 0.082	
	Connecting rod half-bearings		-	
	Connecting rod weight			
	Class	A	g. 5502 - 5535	
		B	g. 5536 - 5569	
		C	g. 5570 - 5602	

			F3HFA615A*D001	F3HFA615B*D001
	Type		mm	
	Measuring point	x	-	
	Maximum error in parallelism of connecting rod axes	/	-	
	Main journals	Ø1	nominal value 99.970 - 100.000	
	Selection class	1	99.970 - 99.977	
		2	99.978 - 99.985	
		3	99.986 - 99.993	
		4	99.994 - 100.000	
	**Crankpins**	Ø2	nominal value 95.970 - 96.000	
	Selection class	1	95.970 - 95.979	
		2	95.980 - 95.989	
		3	95.990 - 96.000	
	**Main half-bearings**	YES		
	Red colour		3.115 - 3.122	
	Green colour		3.123 - 3.130	
	Yellow colour*		3.131 -3.138	
	Black colour*		3.139 -3.146	
	Connecting rod half-bearings	S2		
	Red colour		1.960 - 1.970	
	Green colour		1.970 -1.980	
	Yellow colour*		1.980 -1.990	
* Half-bearings only fitted in production				
	**Main bearings**	Ø3	106.300 - 106.330	
	Main half bearings (★)		0.060 - 0.108* 0.061 - 0.119** 0.060 - 0.130***	
	Big end bearing shells (★)		0.060 - 0.100	
	Main half-bearings		0.060 - 0.108* 0.061 - 0.119** 0.060 - 0.130***	
	Connecting rod half-bearings		0.050 - 0.108* 0.051 - 0.109** 0.050 - 0.098***	
	Thrust main journal	X1	47.95 - 48.00	
	Thrust main bearing	X2	40.94 - 40.99	

(★) Supplied as spares: standard: ** = 0.127; *** = 0.254 - 0.508

			F3HFA615A*D001	F3HFA615B*D001
	Type		mm	
	Half thrust washers (thickness)	X3	3.115 - 3.139	
	Crankshaft end play		0.15 - 0.215	
	Alignment	1 - 2	-	
	Centring	1 - 2	-	
CYLINDER HEAD - TIMING SYSTEM				
	Valve guide housing on cylinder head	Ø1	15.980 - 15.997	
	Valve guides	Ø2	10.015 - 10.030	
		Ø3	16.012 - 16.025	
	Valve guides and seats on the head		0.015 - 0.045	
	Valve guides		-	
	Valves:	Ø4	9.960 - 9.975	
		α	60° 30' ± 7' 30"	
		Ø4	9.960 - 9.975	
		α	60° 30' ± 7' 30"	
	Valve stem and related guide		0.040 - 0.070	
	Housing on head for valve seat:	Ø1	49.185 - 49.220	
		Ø1	46.985 - 47.020	
	Outside diameter of valve seats: valve housing inclination on cylinder head:	Ø2	49.260 - 49.275	
		Ø2	47.060 - 47.075	
	Valve seat		0.2	

			F3HFA615A*D001	F3HFA615B*D001
	Type		mm	
	Recessing	 X	0.54- 0.86	
		 X	1.47 - 1.79	
	Between valve seat and cylinder head	 X	0.040 - 0.090	
		 X		
	Valve spring height: free spring under a load of: 504 N/mm^2 887 N/mm^2	 H H1 H2	 76 59 46	
	Camshaft bush housing fitted in the cylinder head: 1 ⇒ 7	Ø	88.000- 88.030	
	Camshaft journals: 1 ⇒ 7	Ø	82.950 - 82.968	
	Camshaft bushing outer diameter:	Ø	88.153 - 88.183	
	Bushing inner diameter	Ø	83.018 - 83.085	
	Bushings and seats in cylinder head		0.103 - 0.163	
	Bushings and supporting pins		0.050 - 0.135	
	Useful cam height:		9.231 9.5607	
	Rocker-arm shaft	Ø 1	41.984 - 42.000	
	Internal rocker arm diameter:			
			42.045 - 42.061 59.000 - 59.019	

			F3HFA615A*D001	F3HFA615B*D001
	Type		mm	
	Rocker arm bush outer diameter:		-	59.070 - 59.110
	Rocker arm bush inner diameter:		-	56.045 - 56.064
	Bushes and housing:		-	0.051 - 0.110
	Rocker arm bushes and shaft:		0.045 - 0.077	

TIGHTENING TORQUES

DETAIL			TORQUE	
			Nm	kgm
Screws securing the crankcase to the lower crankcase★				
Inner screws	M18x2	1st Phase pre-tightening	160	16
		2nd Phase Tightening to angle	60°	
		3rd Phase Tightening to angle	60°	
Outer screws	M12x1.75	4th Phase	30	3
		5th Phase	60°	
Union for piston cooling nozzle	M14x1.5		55 ± 5	5.5 ± 0.5
Screws securing heat exchanger to crankcase ★	M8x1.25x40 / 55	pre-tightening	11.5 ± 3.5	1.15 ± 0.35
		tightening	24.5 ± 2.5	2.4 ± 0.25
	M8x1.25x45		19 ± 4	1.9 ± 0.4
Screws fixing suction strainer to lower crankcase	M8x1.25		24.5 ± 2.5	2.4 ± 0.25
Screws securing spacer and oil sump★	M10x1.5	1st Phase	45 ± 4.5	4.5 ± 0.45
		2nd Phase	45 ± 4.5	4.5 ± 0.45
Oil sump drain plug	M22X1.5		40 ± 10	4 ± 1
Oil level dipstick retainer	M18x1.5		50 ± 5	5 ± 0.5
Screws securing flywheel case to crankcase★	M12x1,75x40/70/ 100/120/193	tightening	63 ± 7	6.3 ± 0.7
Screws securing flywheel case to head★	M10x1.5x30		45.5 ± 4.5	4.55 ± 0.45
Timing flywheel cover fastening screws	M6x1x25		10 ± 1	1 ± 0.1
Screw fixing cylinder head: (*) ★	M18x2x175/196	1st Phase pre-tightening	75	7.5
		2nd Phase pre-tightening	150	15
		3th Phase Tightening to angle	90°	
		4th Phase Tightening to angle	90°	
Rocker arm shaft ★ fastening screw	M16x1.5x76	1st Phase pre-tightening	25	2.5
		2nd Phase pre-tightening	60	6
		3rd Phase pretightening	80	8
		4th Phase Tightening to angle	60°	
Exhaust brake cylinder fastening screws	M8x1.25x20		25 ± 2.5	2.5 ± 0.25
Rocker arm cover fastening screws	M6x1		8.5 ± 1.5	0.8 ± 0.1
Lock nut for rocker arm adjustment screw★	M10x1.25		39 ± 5	3.9 ± 0.5
Screws for injector mounting brackets	M8x1.25x45		35 ± 2	3.5 ± 0.2
Screws fixing camshaft shoulder plate to head★	M8x1.25x25		24.5 ± 2.5	2.45 ± 0.25
Screws securing bracket on cylinder head to lift engine	M12x25 M12x30		117.5 ± 12.5	11.75 ± 1.25
Screws fixing engine mount bracket to flywheel casing	M16x2	1st Phase pre-tightening	120	12
		2nd Phase Tightening to angle	55°	
Screws securing engine suspension to crankcase	M16x2	1st Phase pre-tightening	120	12
		2nd Phase Tightening to angle	45°	

DETAIL			TORQUE	
			Nm	kgm
Camshaft gear fastening screws (*)	M14x4x60	1st Phase pre-tightening	60 ± 3	6 ± 0,3
		2nd PhaseTightening to angle	60°	
Screw fixing pulser ring to timing gear	M8x1.25		24.5 ± 2.5	2.5 ± 0.2
Exhaust manifold fastening screws (**)★	M10x1.5x70	1st Phase pre-tightening	30 ± 5	3 ± 0.5
		2nd Phase tightening	60 ± 5	6 ± 0.5
Screws fastening connecting rod cap	M14x2	1st Phase pre-tightening	70	7
		2nd Phase Tightening to angle	60°	
Screws fixing engine flywheel (*)★	M18x1.5x72	1st Phase pre-tightening	120 ± 6	12 ± 0,6
		2nd Phase Tightening to angle	90°	
Screws fixing the damper flywheel to the drive pulley (*)	M14x2	1st Phase pre-tightening	70	7
		2nd Phase Tightening to angle	50°	
Screws securing guide pulley to crankshaft (*)	M14x2	1st Phase pre-tightening	70	7
		2nd Phase Tightening to angle	50°	
Fixing screw of transmission gear pin (*)	M12x1.75x110	1st Phase pre-tightening	30 ± 1.5	3 ± 0,15
		2nd Phase Tightening to angle	90°	
Screw fixing link rod for idle gear	M8x1.25x16		24.5 ± 2.5	2.4 ± 0.25
Double gear fastening screws	M12x1.75x90	1st Phase	30 ± 1.5	3 ± 0,15
		2nd Phase	90°	
Screws fixing the oil pump	M8x1,25x35 / 70		25 ± 2.5	2.5 ± 0.2
Screw fixing crankshaft gasket front cover	M8x1.25x16		25 ± 2.5	2.5 ± 0.2
Diesel filter breather			17.5 ± 2.5	1.75 ± 0.25
Screw fastening fuel filter support	M8x1.25		24.5 ± 2.5	2.4 ± 0.2
Fuel filter cap			32.5 ± 2.5	3.2 ± 0.2
Fuel filter drain			1.5 ± 0.5	0.2 ± 0.1
Screw fastening oil filter support	M8x1.25x65		24.5 ± 2.5	2.45 ± 0.2
Oil filter cap			60 ± 5	6 ± 0.5
Oil filter drain plug			6.5 ± 1.5	0.7 ± 0.1
ECU mount retaining screws	M8x1.25x16		24.5 ± 2.5	2.45 ± 0.25
Control unit protection bracket	M6x1x25		8 ± 2	0.8 ± 0.2
Fuel pipe from tank to control unit support bracket screws	M8x1.25x16		24.5 ± 2.5	2.45 ± 0.25
Screws and nuts securing turbocharger	M12x1.75		75	7.5
Oil deliver pipe to turbocharger	M8x1.25	Screws	24.5 ± 2.5	2.45 ± 0.25
Oil deliver pipe to turbocharger	M16	UNION	42.5 ± 2.5	4.25 ± 0.25
Screws fastening turbocharger oil deliver pipe to crankcase	M10		10 ± 1	1 ± 0.1
Screws fastening oil return pipe to turbocharger	M8x1.25		24.5 ± 2.5	2.4 ± 0.2
Screws securing thermostat assembly★	M8x1,25x50 / 100		30 ± 3	3 ± 0.3
Cylinder head degas pipe	M10x1.5		25 ± 2.5	2.5 ± 0.25

DETAIL			TORQUE	
			Nm	kgm
Screws securing water pump	M8x1.25x20		25 ± 2.5	2.5 ± 0.25
Screws fixing water inlet pipe to crankcase	M8x1.25		34.5 ± 3.5	3.4 ± 0.3
Bolt fastening electromagnetic joint pulley to relative support	M10		67.5 ± 7.5	6.75 ± 7.5
Screws fixing the electromagnetic coupling to the crankcase	M12x1.75		100 ± 5	10 ±0.5
Screw fixing the automatic belt tensioner	M10x1.5		45 ± 5	4.5 ± 0.5
Screws securing steady tensioner	M12x1.75		105 ± 5	10.5 ± 0.5
Nuts securing starter motor	M12x1.75		74 ± 8	7.4 ± 0.8
Screws securing the air heater and intake manifold to the cylinder head★	M10x1.5x100 / 130 / 150		50 ± 5	5 ± 0.5
Fastening screws of air compressor input point	M12x1.75		74 ± 8	7.4 ± 0.8
Screws fastening the HP pump to the support flange★	M12x1.5		37.5 ± 2.5	3.75 ± 0.25
Screws fastening the HP pump support flange to the timing system casing	M8x1.25x30		20.5 ± 2.5	2.05 ± 0.2
Nut for fastening high pressure pump gear	M24x1.5		275 ± 25	27.5 ± 2.5
Screws fastening to head the HP fuel pipes brackets running from pump to head.	M8x1.25x16		24.5 ± 2.5	2.45 ± 0.25
Nuts fastening to head the HP fuel pipes brackets running from pump to head.	M6x1		8 ± 2	0.8 ± 0.02
Screws securing the high pressure pump support and pipe support from pump to filter	M12x1.75x30	pump - bracket	50±5	5±0.5
	M10x1.5x20	bracket - head	37.5±5	3.75±0.5
	M8x1.25x20		24.5±2.5	2.45±0.25
Fittings fastening to head the HP fuel pipes running from pump to head and head to rail.	M16x1.5		42.5 ± 2	4.25 ± 0.2
Fittings to fasten HP fuel pipes from rail to injectors	M16x1.5		42.5 ± 2	4.25 ± 0.2
Fittings LP fuel pipes running from pump to filter and from filter to pump	M18x1.5		37 ± 3	3.7 ± 0.3
LP fuel pipe fittings from control unit to pump	M22x1.5		50 ± 5	5 ± 0.5
LP fuel pipe fitting from tank to control unit	M22x1.5		50±5	5±0.5
Bracket fastening to crankcase LP fuel pipe from control unit to pump	M8x1.25x16		24.5 ± 2.5	2.45 ± 0.25
Fuel return pipe fitting from pump to crankcase	M18x1.5		37 ± 3	3.7 ± 0.3
Fuel return pipe fastening fitting from rail to head	M16x1.5		42.5 ± 2	4.25 ± 0.2
Brackets fastening to head fuel supply pipe from head to rail	M6		10 ± 1	1 ± 0.1
Rail to head fastening screws	M8x1.25x55		24.5 ± 2.5	2.5 ± 0.3
Heater electrical connections fastening nut	M8x1.25		16 ± 1	1.6 ± 0.1

DETAIL			TORQUE	
			Nm	kgm
Screws securing Blow-by filter☆★	M6x1x40	1st Phase pre-tightening	5	0.5
		2nd Phase tightening	15 ± 1.5	1.5 ± 0.15
Fastening screws for blow-by cover	M6x1x25		7 ± 1	0.7 ± 0.1
Screws fastening alternator support	M10x1.5		44 ± 4	4.4 ± 0.4
Alternator fixing screws	M10x1.5		44 ± 4	4.4 ± 0.4
	M8x1.25		24.5 ± 2.5	2.45 ± 0.25
Screws fastening hydraulic pump compartment cover to distribution housing	M8x1.25x20		20.5 ± 2.5	2.05 ± 0.25
Rev sensor fastening screw	M6x12		8 ± 2	0.8 ± 0.2
Timing sensor fastening screw	M6x12		8 ± 2	0.8 ± 0.2
Securing rail pressure sensor	M18x1.5		70 ± 5	7 ± 0.5
Rail overpressure safety valve	M20x1.5		110 ± 5	11 ± 0.5
Water temperature sensor retainer screws	M12x1.5		20 ± 5	2 ± 0.5
Air pressure and temperature fastening screws	M6		11.5	1.15
Fuel pressure and temperature fastening screws	M6		8 ± 2	0.8 ± 0.2
Oil pressure and temperature fastening screws	M6		11.5	1.15
Screws fastening oil pressure regulating valve	M8x1.25x20		25.5 ± 2.5	2.55 ± 0.2
Pressure sensor retainer on the rocker cover	M10x1		27.25 ± 2.75	2.7 ± 0.28
Nuts for injector electrical connection	M4		1.5 ± 0.25	0.15
Head wiring connector fixing screw			8 ± 2	0.8 ± 0.2
Fan grille fastening screws	M8x1.25x20		18 ± 4	1.8 ± 0.4
Fastening screw for radiator assembly tie bracket	M10		37.5 ± 7.5	3.75 ± 0.75
Fastening screw for radiator assembly to support bracket.	M10		37.5 ± 7.5	3.75 ± 0.75
Fan fastening screws	M8x1.25		21.5 ± 4.5	2.15 ± 0.45
Air filter mount fastening screws	M8		18 ± 4	1.8 ± 0.4
	M6		8 ± 2	0.8 ± 0.2
	M10		37.5 ± 7.5	3.75 ± 0.75
	M18		245 ± 50	24.5 ± 5
Fastening screw for radiator assembly support bracket.	M12x1.75		69 ± 14	6.9 ± 1.4
Screws fixing combustion air intake pipe to turbocharger	M8		18 ± 4	1.8 ± 0.4

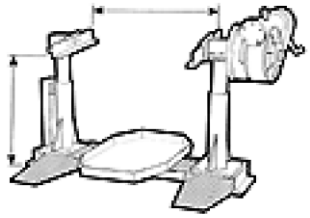
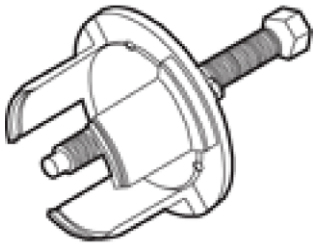
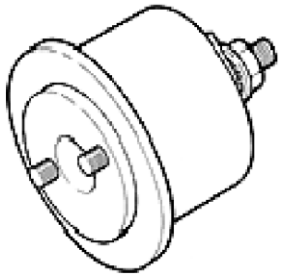
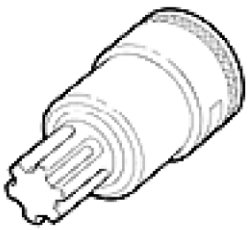
* Lubricate with engine oil before assembly

** Lubricate with graphitised oil before assembly

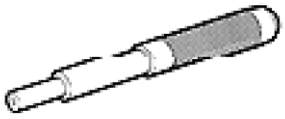
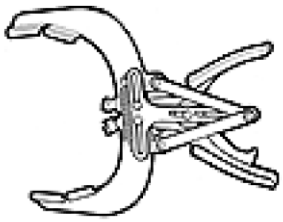
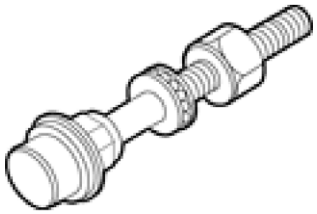
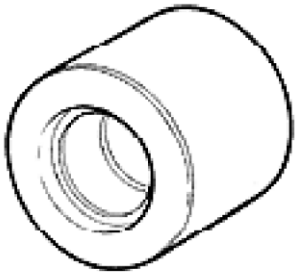
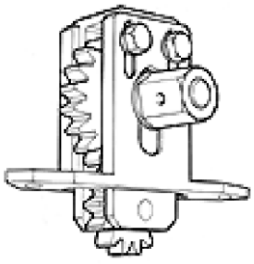
☆ Apply LOCTITE 243 before assembly

★ See tightening sequence

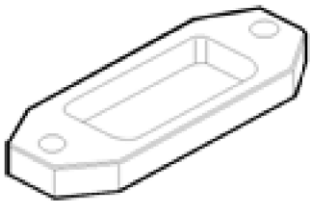
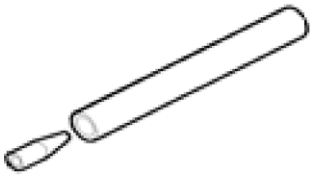
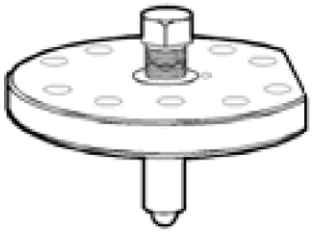
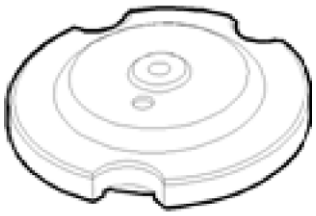
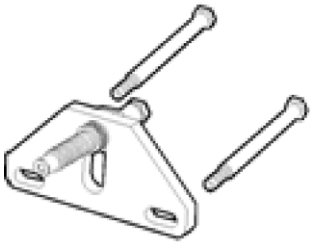
TOOLS

TOOL No.		NAME
99322230		Rotary telescopic stand (range 2000 daN, torque 375 daNm)
99340053		Extraction tool for crankshaft front ring seal
99342157		Extraction tool for injectors
99346250		Key to fit crankshaft front gasket
99346260		Key to fit crankshaft rear gasket
99350072		Box wrench for block junction bolts to the lower crankcase

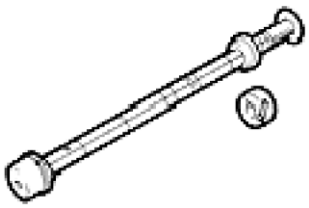
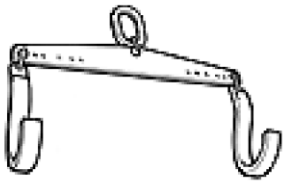
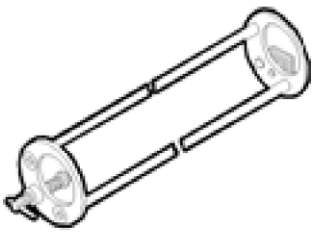
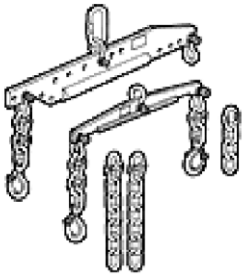
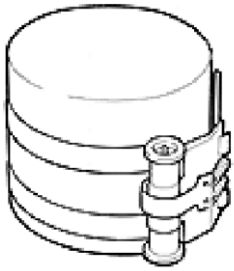
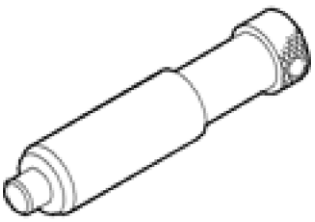
TOOLS

TOOL No.		NAME
99360143		Punch for valve guide removal
99360184		Pliers for removing/refitting piston rings (105 -160 mm)
99360259		Tool to remove and refit engine valves (to be used with special plates)
99360263		Plate to remove and refit engine valves (to be used with 99360259)
99360296		Tool for valve guide refitting (to be used with 99360143)
99360321		Tool for rotating the flywheel

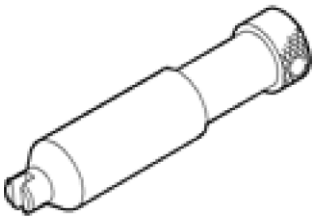
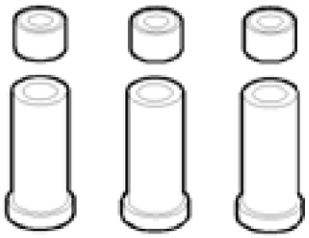
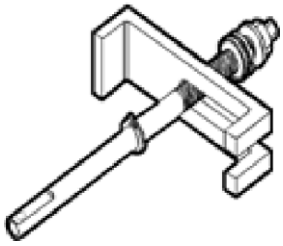
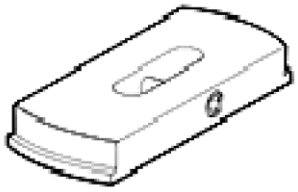
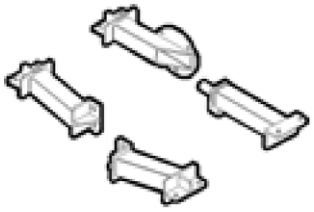
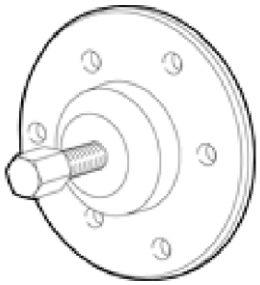
TOOLS

TOOL No.		NAME
99360325		Spacer (to be used with 99360321)
99360329		Adjuster for gasket assembly on valve guide
99360334		Cylinder liner protrusion gauge (to be used with 99370415-99395603 and special plates)
99360336		Spacer (to be used with 99360334)
99360338		Plate for cylinder liners compression (to be used with 99360334 -99360336)
99360351		Tool to retain engine flywheel

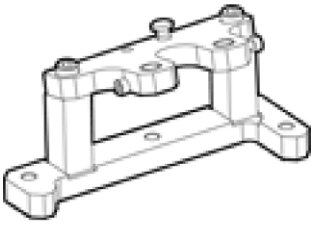
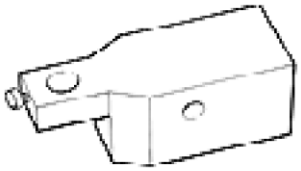
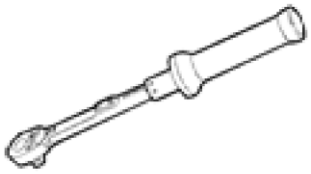
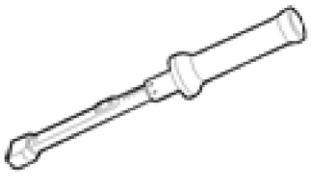
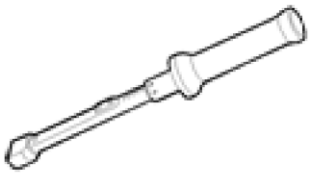
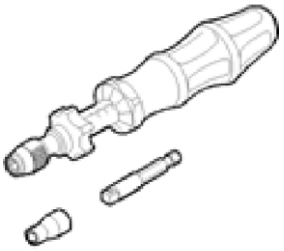
TOOLS

TOOL No.		NAME
99360499		Drift to take down and fit back camshaft bushes
99360500		Tool for lifting the crankshaft
99360553		Tool for assembling and installing rocker arm shaft
99360585		Arm for removing and installing engine
99360603		Clamp for fitting piston into cylinder liner (90 - 175 mm)
99360612		Tool for engine T.D.C. positioning

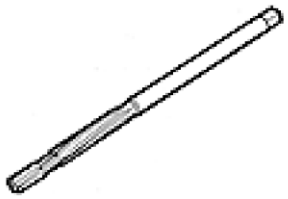
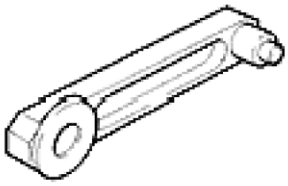
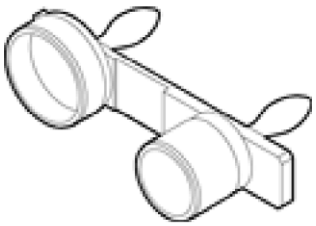
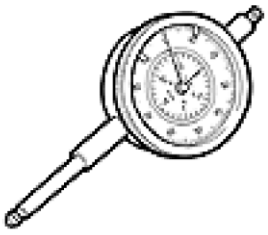
TOOLS

TOOL No.		NAME
99360613		Tool for timing of phonic wheel on camshaft
99360703		Check tool for cylinder liners
99360706		Tool to extract cylinder liners (use with specific rings)
99360728		Ring (135 mm - 141mm) (to be used with 99360706)
99361036		Brackets for fastening engine to 99322230 rotary stand
99366198		Tool for removing the high pressure pump gear

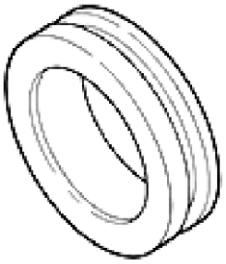
TOOLS

TOOL No.		NAME
99370400		Tool for checking engine timing (use with 99395606)
99370415		Stand for dial gauge for checking cylinder liner protrusion (to be used with 99395603)
99389813		Torque wrench (20-120 Nm) with 1/2" square head
99389829		9X12 coupling torque wrench (5-60 Nm)
99389833		14X18 coupling torque wrench (20-120 Nm)
99389834		Torque screwdriver (1-6 Nm) for adjusting injector solenoid valve connector retainer nut

TOOLS

TOOL No.		NAME
99390330		Sleeker for valve guide
99395216		Pair of gauges for angular tightening with 1/2" and 3/4" square heads
99395225		Gauge for defining the distance between the centres of cam-shaft and transfer case gear
99395226		Gauge to determine centre distance between camshaft and high pressure pump
99395603		Dial gauge (0-5 mm)
99395606		Dial gauge (0 -30 mm)

TOOLS

TOOL No.		NAME
99396035		Centering ring of crankshaft front gasket cover