

CASE ENGINES

445/M2 445T/M2 668T/M2

SERVICE MANUAL

Part Number: 6-74500

CONTENT OF SECTIONS

	Section
General information	I
Feed	2
Duty – Industrial applications Mechanical injection Engines	3
Overhaul and technical specifications	4
Equipment	5
Installation guidelines Safety instructions	Appendix

PREFACE TO USER'S GUIDELINE MANUAL

Section 1 describes the engine illustrating its features and working in general.

Section 2 describes the type of fuel feed.

Section 3 relates to the specific duty and is divided in four separate parts:

1. Mechanical part, related to the engine overhaul, limited to those components with different characteristics based on the relating specific duty.
2. Electrical part, concerning wiring harness, electrical and electronic equipment with different characteristics based on the relating specific duty.
3. Maintenance planning and specific overhaul.
4. Troubleshooting part dedicated to the operators who, being entitled to provide technical assistance, shall have simple and direct instructions to identify the cause of the major inconveniences.

Sections 4 and 5 illustrate the overhaul operations of the engine overhaul on stand and the necessary equipment to execute such operations.

Installation general prescriptions are reported within the appendix.

Such prescriptions shall be strictly followed by the operators in-charge of installation to avoid incorrect working as well as serious failures which may reduce performance and life of the engine.

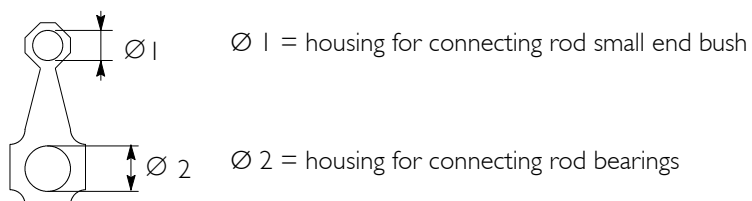
Furthermore, the appendix reports general safety prescriptions to be followed by all operators whether being in-charge of installation or maintenance, in order to avoid serious injury.

SPECIAL REMARKS

Where possible, the same sequence of procedures has been followed for easy reference.

Diagrams and symbols have been widely used to give a clearer and more immediate illustration of the subject being dealt with, (see next page) instead of giving descriptions of some operations or procedures.

Example



Tighten to torque
 Tighten to torque + angular value

Graph and symbols

	Removal Disconnection		Intake
	Refitting Connection		Exhaust
	Removal Disassembly		Operation
	Fitting in place Assembly	$\varnothing$	Compression ratio
	Tighten to torque		Tolerance Weight difference
	Tighten to torque + angle value		Rolling torque
	Press or caulk		
	Regulation Adjustment		Rotation
	Warning Note		Angle Angular value
	Visual inspection Fitting position check		Preload
	Measurement Value to find Check		Number of revolutions
	Equipment		Temperature
	Surface for machining Machine finish		Pressure
	Interference Strained assembly	$>$	Oversized Higher than.... Maximum, peak
	Thickness Clearance	$<$	Undersized Less than.... Minimum
	Lubrication Damp Grease		Selection Classes Oversizing
	Sealant Adhesive		Temperature < 0 °C Cold Winter
	Air bleeding		Temperature > 0 °C Hot Summer

UPDATING

SECTION	DESCRIPTION	PAGE	DATE OF REVISION

ENGINES

General information

Thanks to a centenary engine tradition as well as to a continuous research and development process focused on product advancement, E.B.U. is able to ensure the highest level of versatility and efficiency on the market.

The new range of Engines is the result of a project originated by the partnership among some of the most important sector manufacturers in the World to meet the expectations of the customer and comply with the new European regulations ruling preservation of the environment.

In addition to their better performances in terms of stout, power, efficiency, reliability and life, these engines comply not only with the anti-pollution Euro 3 regulations and the relevant prescriptions for noise limit allowed but will also meet the prescriptions of the future more severe specifications with no need of substantial modifications.

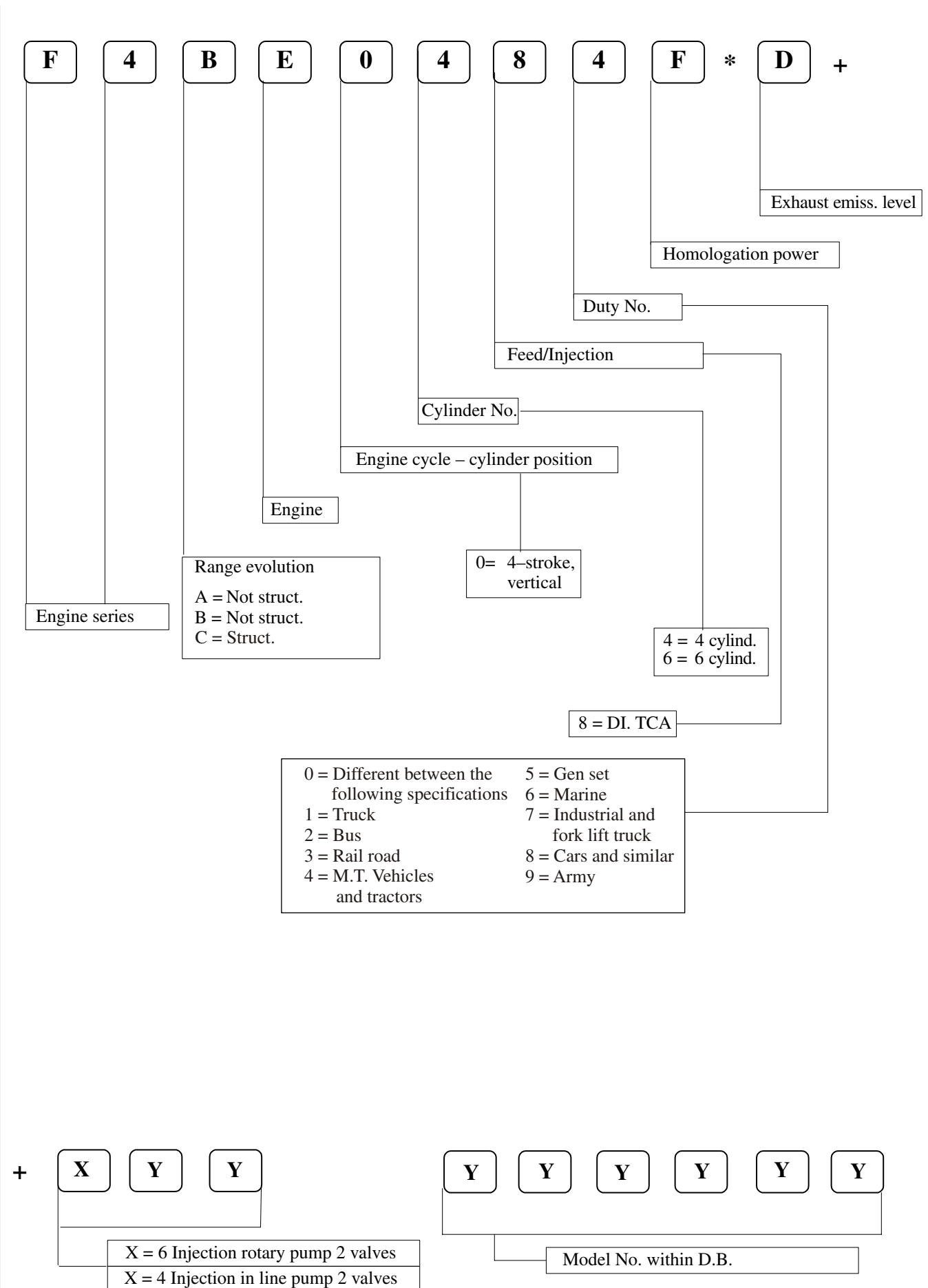
The improvement of the above mentioned features has been possible thanks to the utilisation of new materials, new technologies and technical solutions such as: cylinder head with two-four valves per cylinder; induction and exhaust manifolds improving the dynamic flow of air as well as of exhaust emissions, and pistons with new shaped combustion chamber.

Furthermore, the reliability and cost reduction has been enhanced reducing the number of components and utilising the same parts not only for engines destined to road engine applications but also for the most different purposes such as marine and station engines.

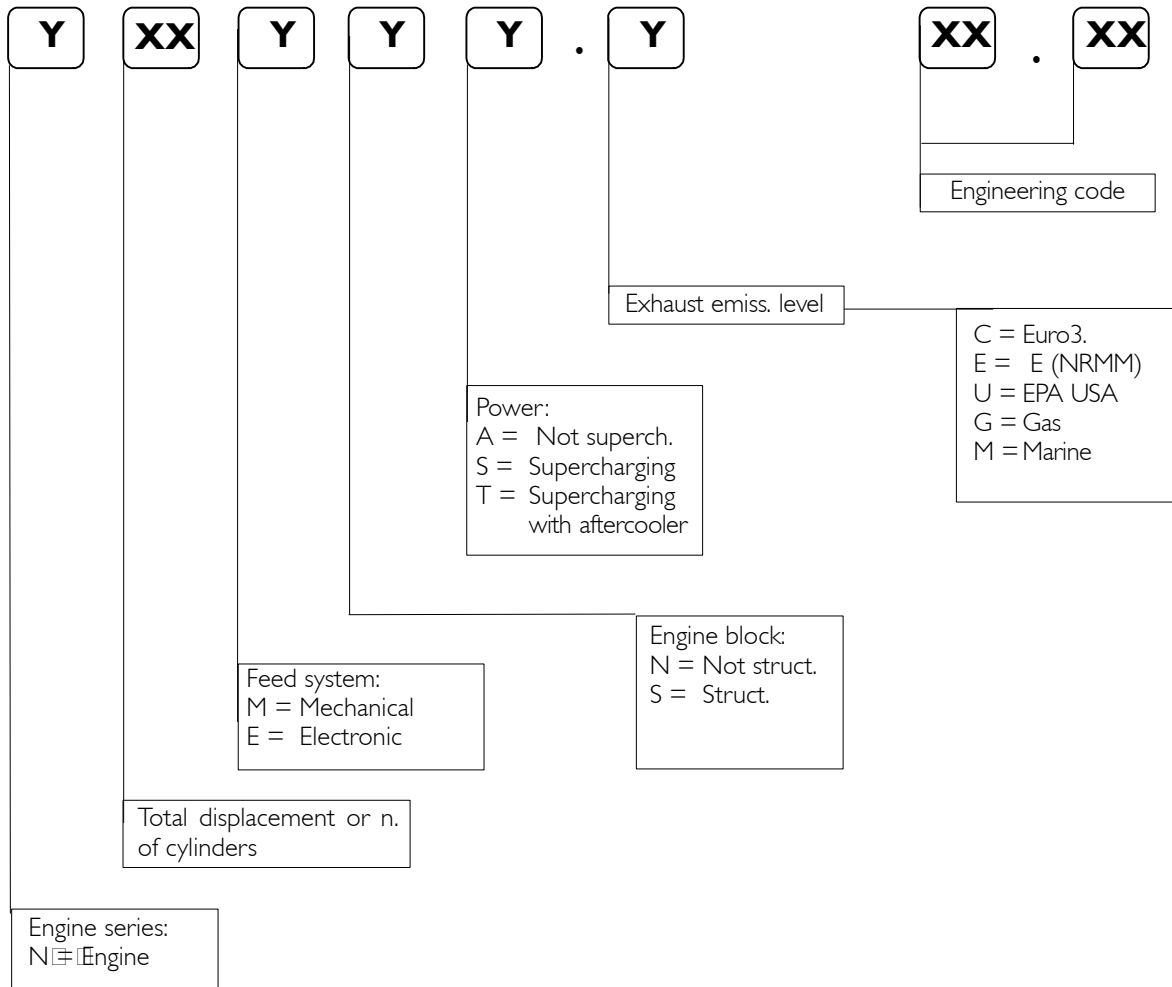
SECTION I

General Specifications

	Page
ENGINE ID. CODE	3
SPECIFIC ENGINE CODE	4
LUBRICATING CIRCUIT	5
OIL VAPOUR RECIRCULATING SYSTEM	7
COOLING CIRCUIT SYSTEM	9
BOOST FEEDING DIAGRAM	11

ENGINE IDENTIFICATION CODE

SPECIFIC ENGINE CODE



EXAMPLES:

N40ENT.C

N Engine

40 = 4 liters

E = Electronic

N = Type of Engine block

T = Supercharger with aftercooler

C = Euro3

LUBRICATION

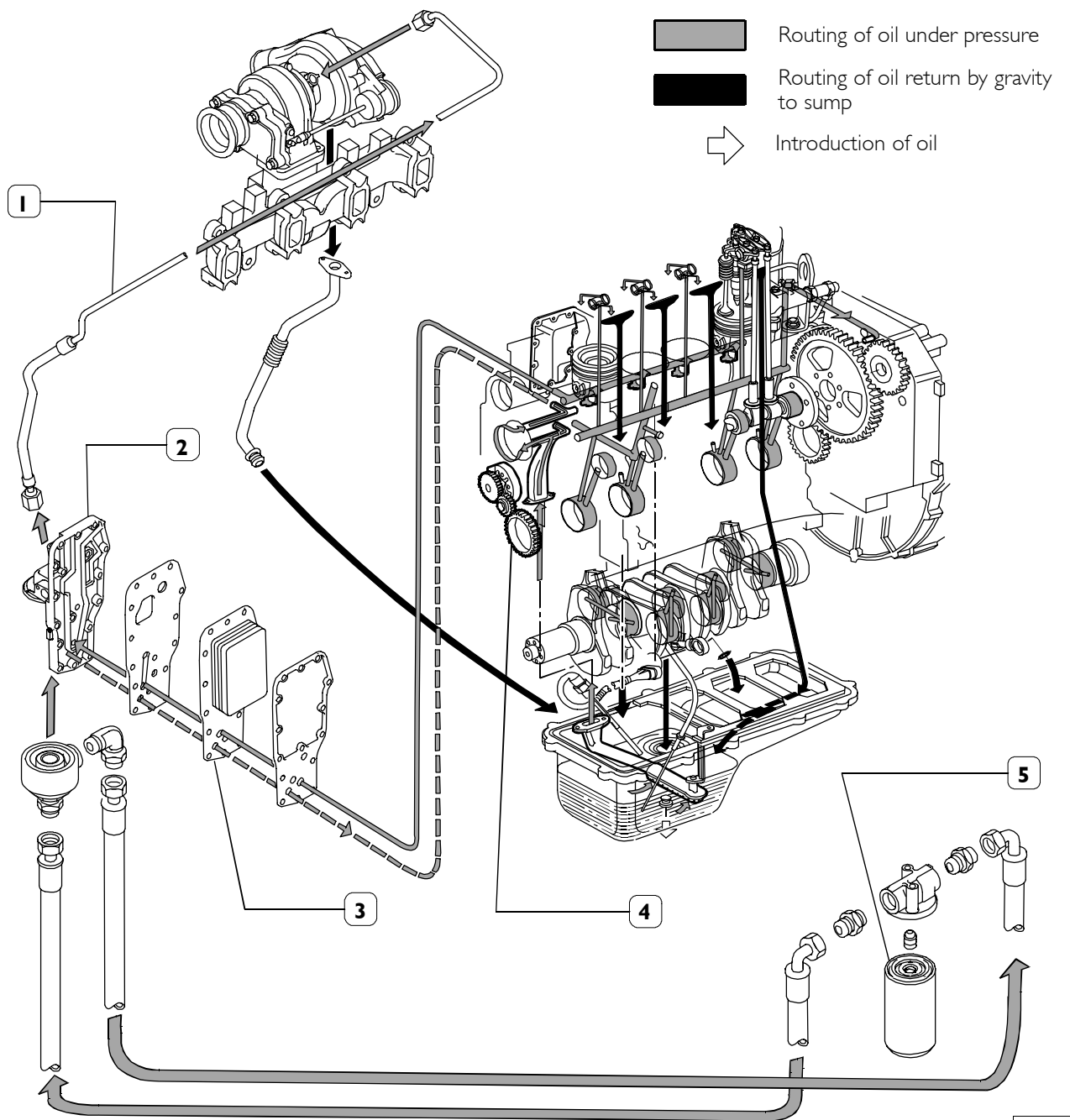
Lubrication by forced circulation is achieved through oil rotary expansion pump (4), placed in the front part of the basement, driven by the straight-tooth gear splined to the shaft's bar hold.

From the pan, the lubrication oil flows to the driving shaft, to the camshaft and to the valve drive.

Lubrication involves the heat exchanger (2,3) as well, the supercharged (through pipe 1) and the eventual compressor for any eventual compressed air system.

All these components may often vary according to the specific duty.

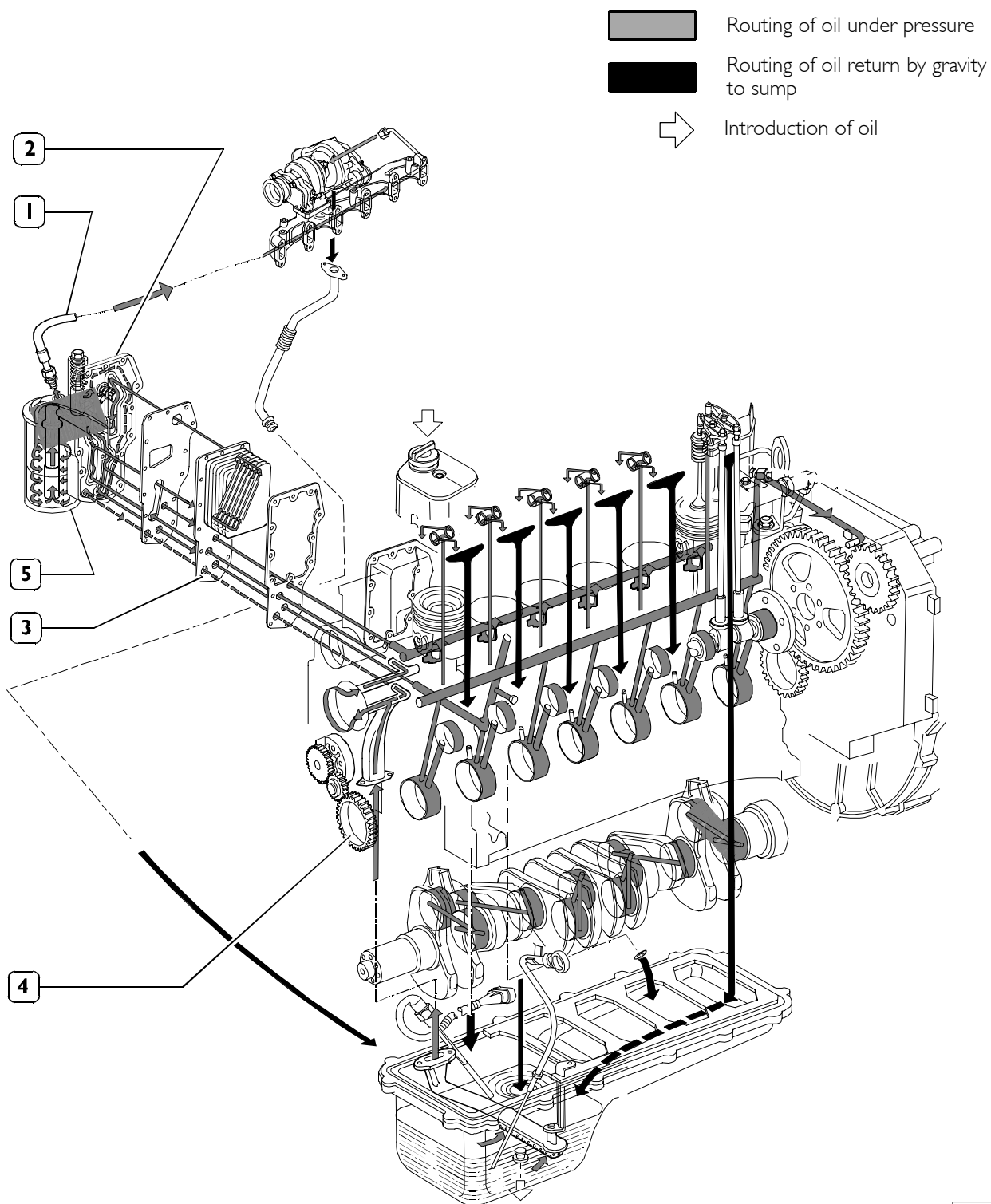
Figure 1



LUBRICATION SYSTEM LAYOUT (4 cyl. engines)

1. Lubrication oil pipe to supercharger – 2. Heat exchanger body – 3. Heat exchanger – 4. Oil rotary expansion pump – 5. Oil filter

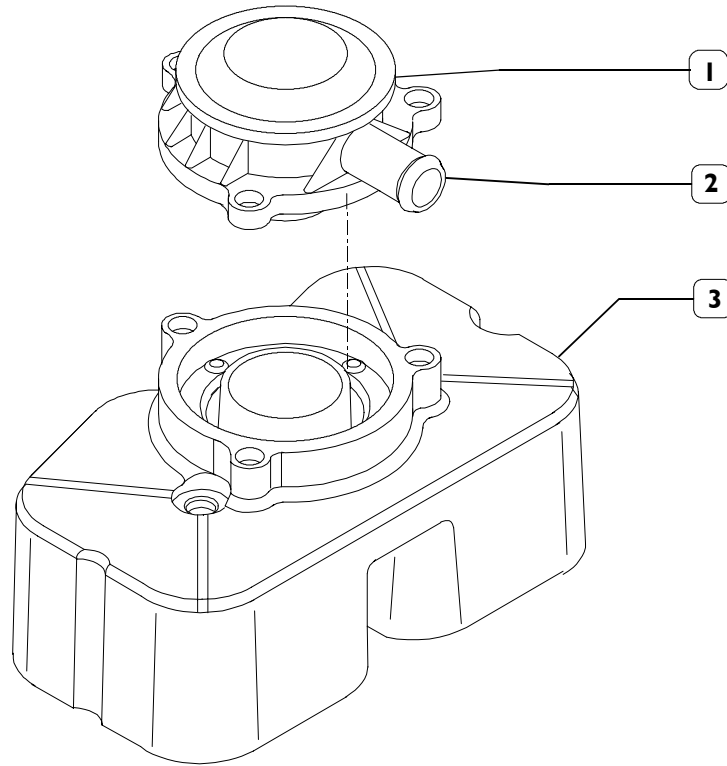
Figure 2



76212

LUBRICATION SYSTEM LAYOUT (6 cyl. engines)

1. Lubrication oil pipe to supercharger – 2. Heat exchanger body – 3. Heat exchanger – 4. Oil rotary expansion pump – 5. Oil filter

OIL VAPOUR RECIRCULATING SYSTEM**Figure 3**

003240t

1. Valve – 2. Breather pipe – 3. Tappet Cap

On the tappet cap (3) there is a valve (1) whose duty is to condense oil vapour inducing these to fall down because of gravity, to the Tappet cap underneath.

The remaining non-condensed vapours shall be properly conveyed through the breather pipe (2), by suction as an example (connection towards these vapours shall be designed by the Engineer).

COOLING SYSTEM

The engine cooling system, closed circuit forced circulation type, generally incorporates the following components:

- ☐ Expansion tank; placement, shape and dimensions are subject to change according to the engine's equipment.
- ☐ Radiator; which has the duty to dissipate the heat subtracted to the engine by the cooling liquid. Also this component will have specific peculiarities based on the equipment developed, both for what concerns the placement and the dimensions.
- ☐ Visc pusher fan, having the duty to increase the heat dissipating power of the radiator. This component as well will be specifically equipped based on the engine's development.
- ☐ Heat exchanger to cool the lubrication oil: even this component is part of the engine's specific equipment.
- ☐ Centrifugal water pump, placed in the front part of the engine block.
- ☐ Thermostat regulating the circulation of the cooling liquid.
- ☐ The circuit may eventually be extended to the compressor; if this is included in the equipment.

Figure 4

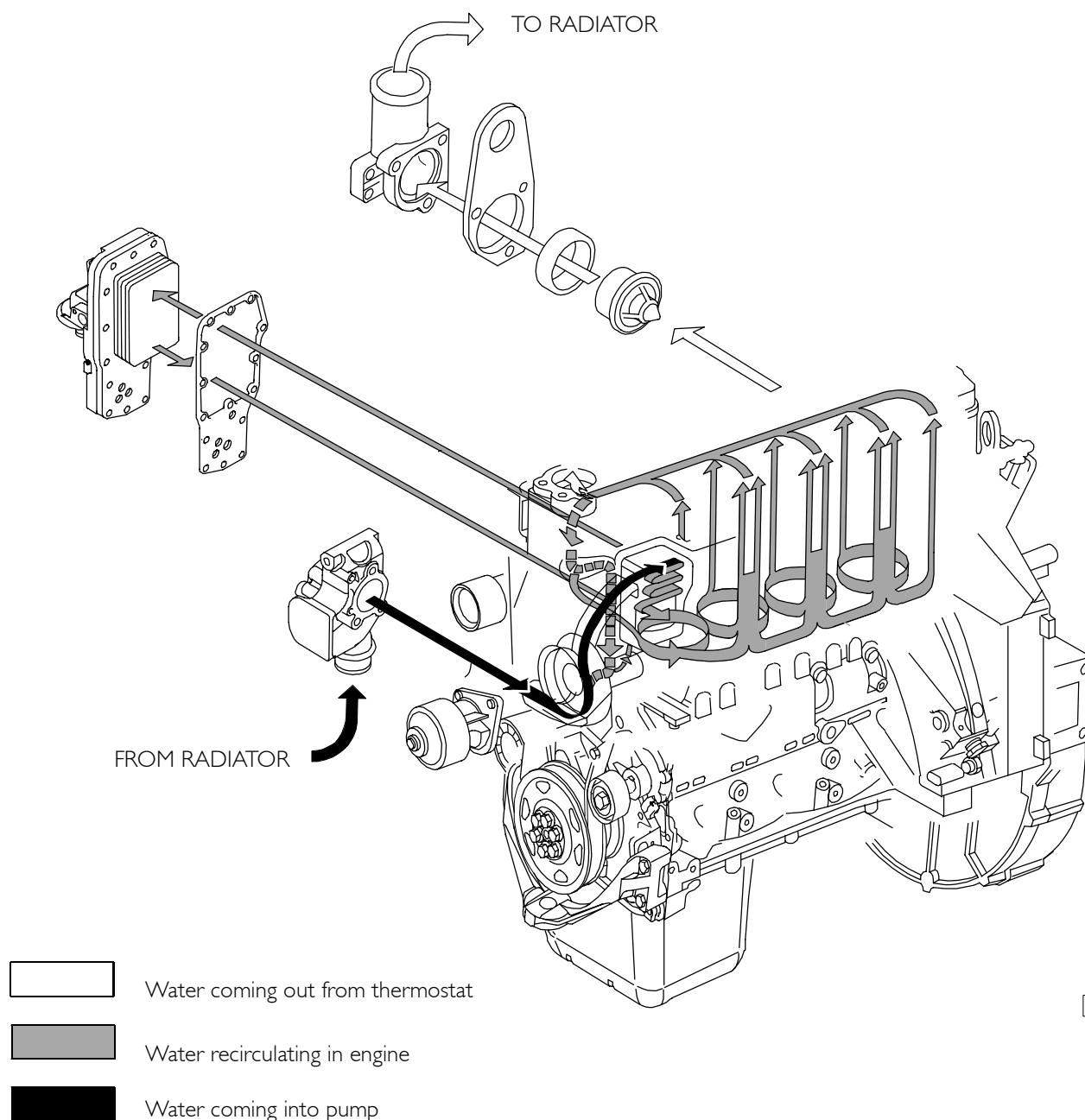
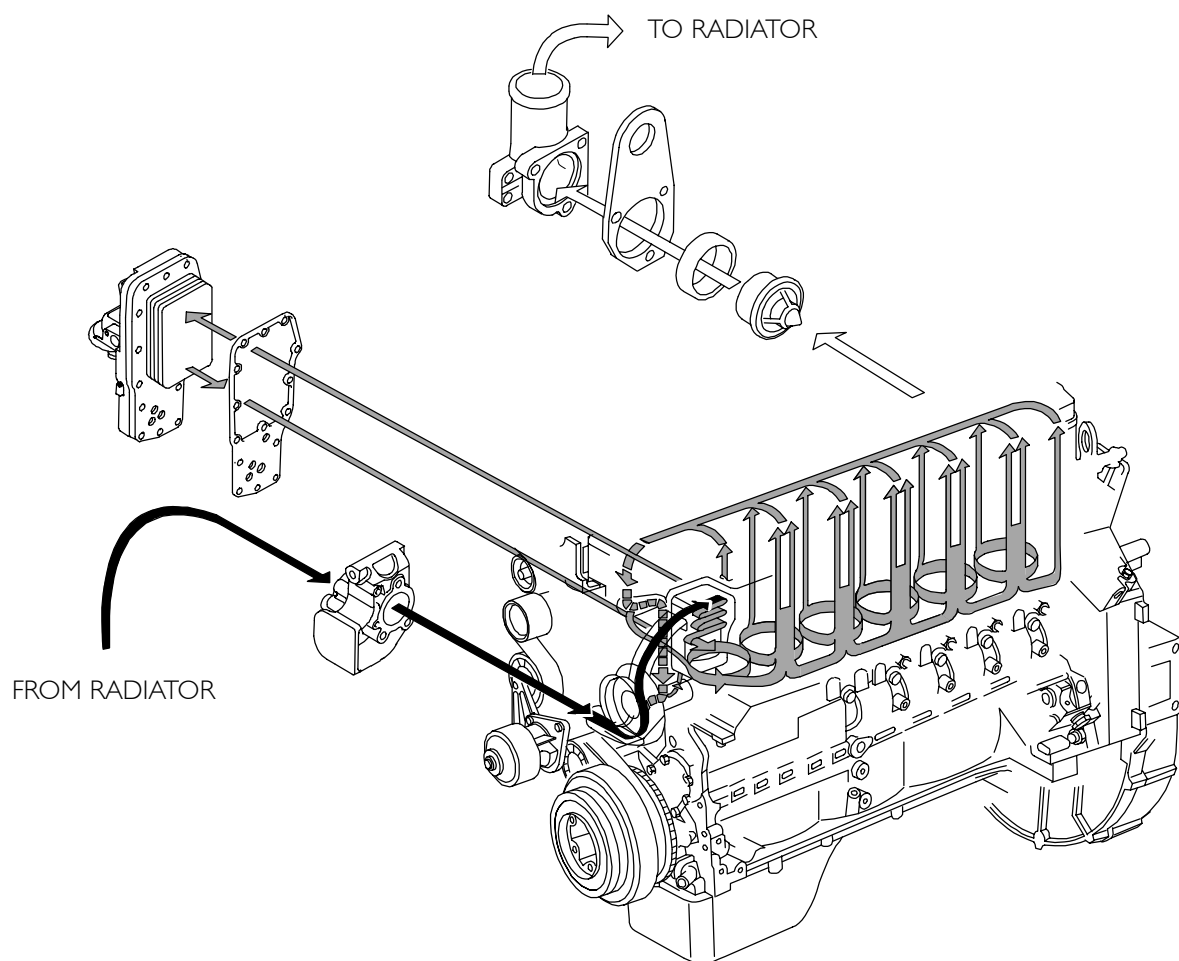
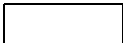


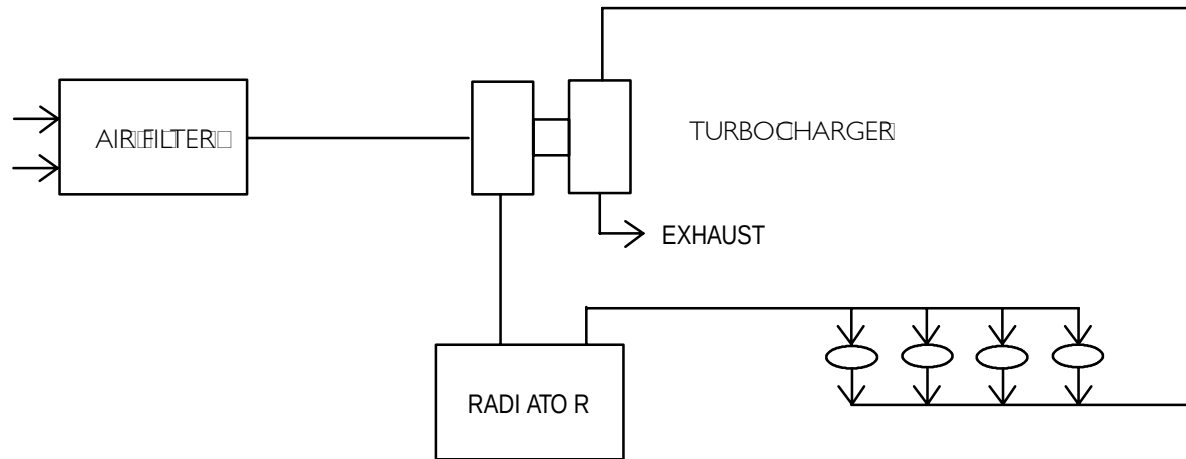
Figure 5



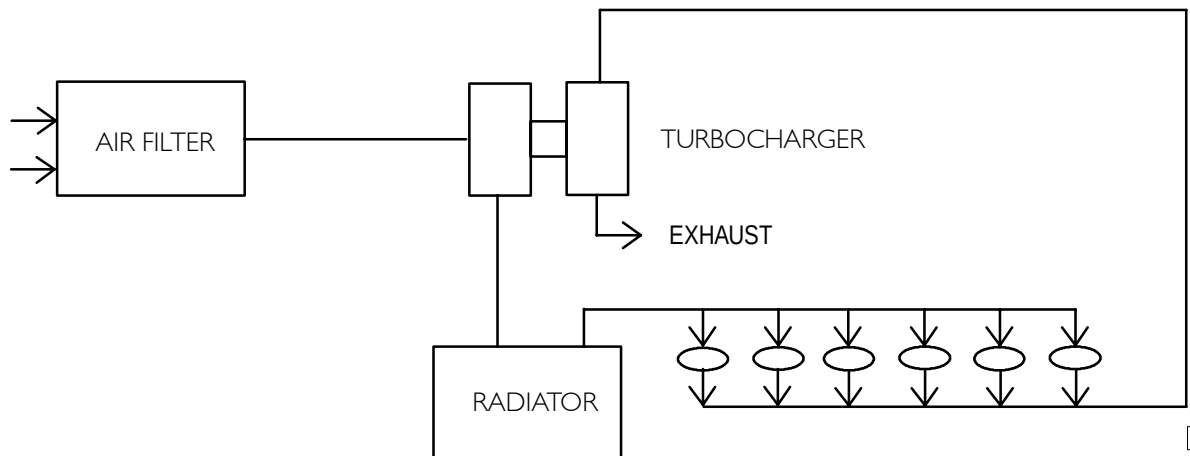
76216

-  Water coming out from thermostat
-  Water recirculating in engine
-  Water coming into pump

COOLING SYSTEM LAYOUT (6 cyl. engines)

BOOST FEEDING DIAGRAM**Figure 6**

74195



74195

Description

The turbocharger is composed by the following main parts: one turbine, one transforming valve to regulate the boost feeding pressure, one main body and one compressor.

During engine working process, the exhaust emission flow through the body of the turbine, provoking the turbine disk wheel's rotation.

The compressor rotor, being connected by shaft to the turbine disk wheel, rotates as long as this last one rotates, compressing the sucked air through the air filter.

The above mentioned air is then cooled by the radiator and flown through the piston induction collector.

The turbocharger is equipped with a transforming valve to regulate the pressure, that is located on the exhaust collector before the turbine and connected by piping to the induction collector.

It's duty is to choke the exhaust of the emissions, releasing part of them directly to the exhaust tube when the boost feeding pressure, over the compressor, reaches the prescribed bar value.

The cooling process and the lubrication of the turbocharger and of the bearings is made by the oil of the engine.

SECTION 2

	Page
INJECTION FEED SYSTEM BY MECHANICAL ROTARY PUMP	3
FEED PUMP	5
PRIMING PUMP	6
FUEL FILTER	7
INJECTION FEED SYSTEM BY MECHANICAL PUMP UNIT	9
FEED PUMP	11
FUEL FILTER	12

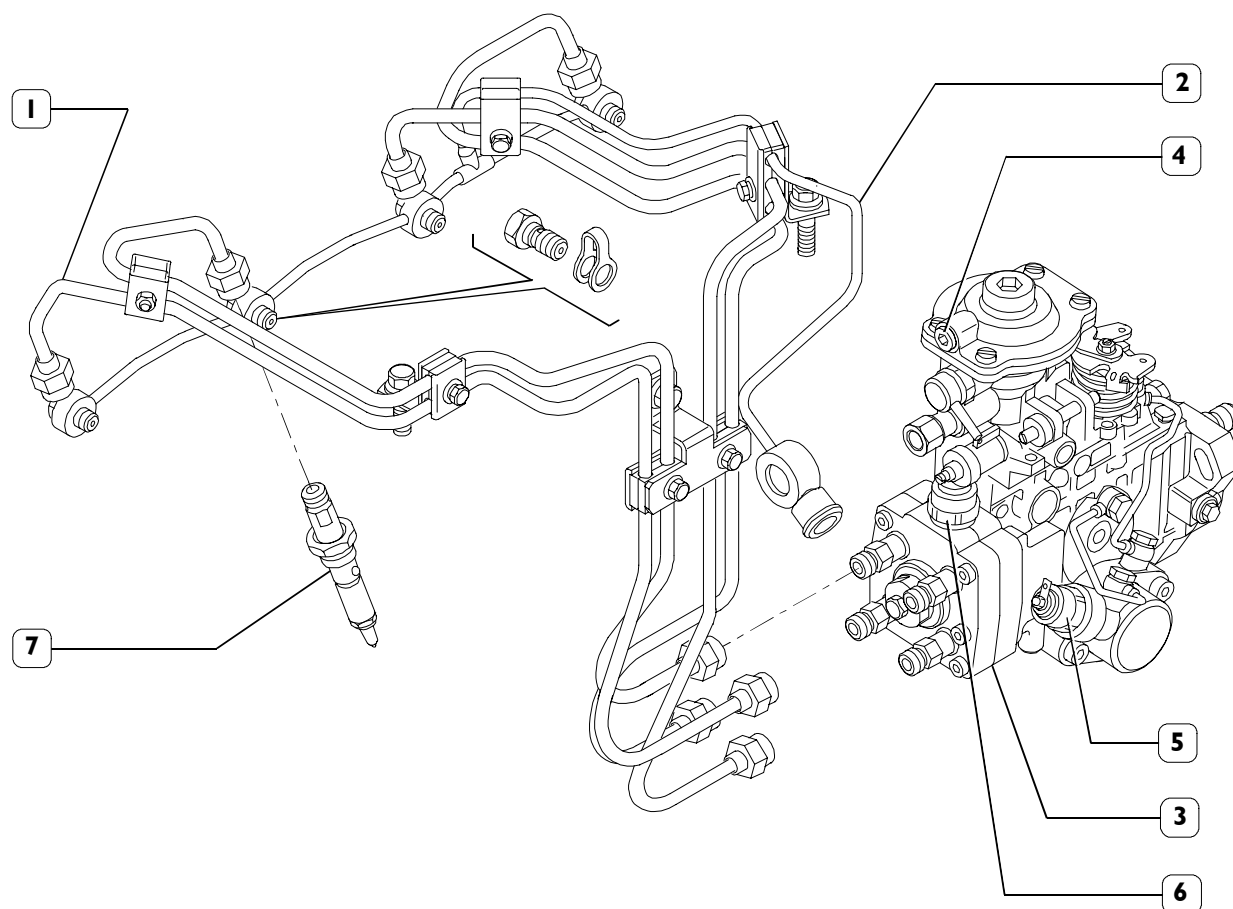
INJECTION FEED SYSTEM BY MECHANICAL ROTARY PUMP

General information

Fuel feed system is composed by:

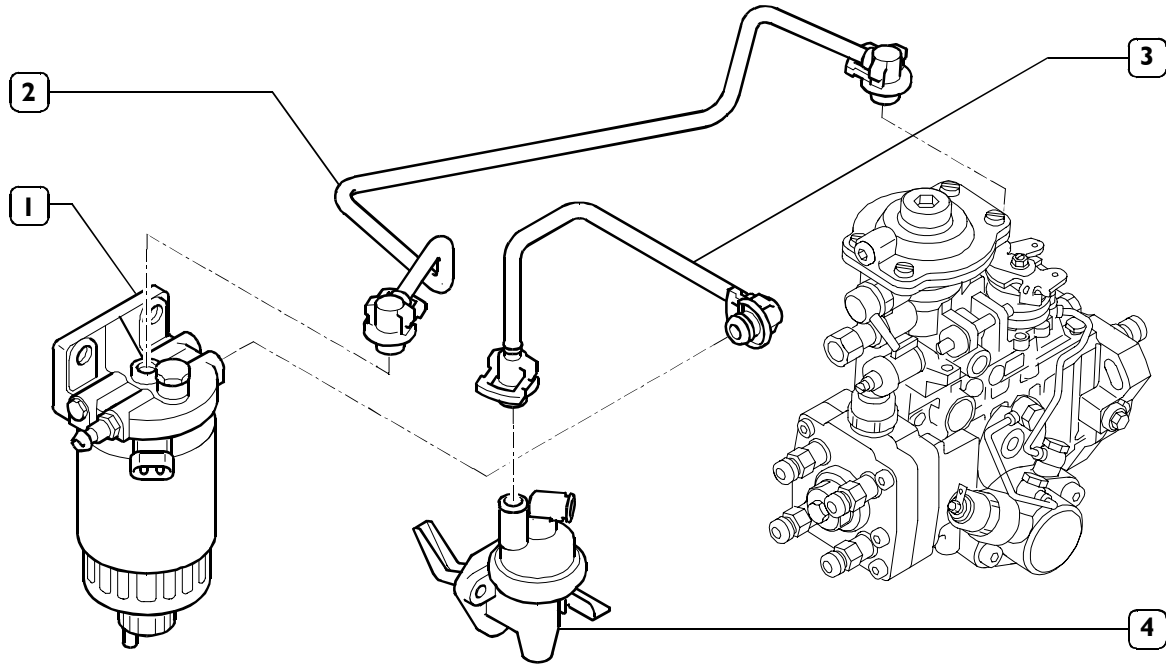
- ☐ Fuel tank (placed on the machine)
- ☐ Fuel delivery and back-flow to tank
- ☐ Fuel pre-filter (if available, it is usually placed close to the engine on the machine frame)
- ☐ Priming pump, assembled to the engine and driven by the camshaft
- ☐ Fuel filter (assembled to the engine in different positions according to equipment application and duty)
- ☐ Injector feed pipeline (from fuel feed pump to injectors)
- ☐ Injectors

Figura 1



1. Injector feed pipes – 2. Fuel exhaust pipes from injectors – 3. Fuel feed rotary pump – 4. Connector for LDA pressure gauge pipe within suction collector – 5. KKS thermal bulb – 6. Electro-valve – 7. Injector

Figura 2



75807

1. Fuel filter – 2. Feed pipeline from filter to fuel pump – 3. Feed pipeline from priming pump to filter – 4. Priming pump

Description of working principles

Fuel is sucked from the fuel tank by the priming pump. This last one is placed on the engine basement and is driven by the camshaft.

Throughout the filter/s, the fuel is piped to the union fitting vacuum chamber of the transfer pump. (For applications to be equipped in cold climate areas, the fuel filter is provided with heater).

Transfer pump is placed inside the feed pump, and is bladed type; its duty is to increase fuel pressure in correspondence with the increase of the number of revolutions.

The fuel arrives therefore to the valve gauging the pressure inside feed pump.

The distribution plunger further increases this pressure and delivers fuel throughout the delivery pipe fitting to the injectors.

The fuel drawing from the injectors is recovered and delivered to the tank again.

FEED PUMP

VE 4 12 1150L rotary type pump is driven by a gear mating the camshaft's one.

Identification

V = Distribution rotary plunger

E = Pump dimensions

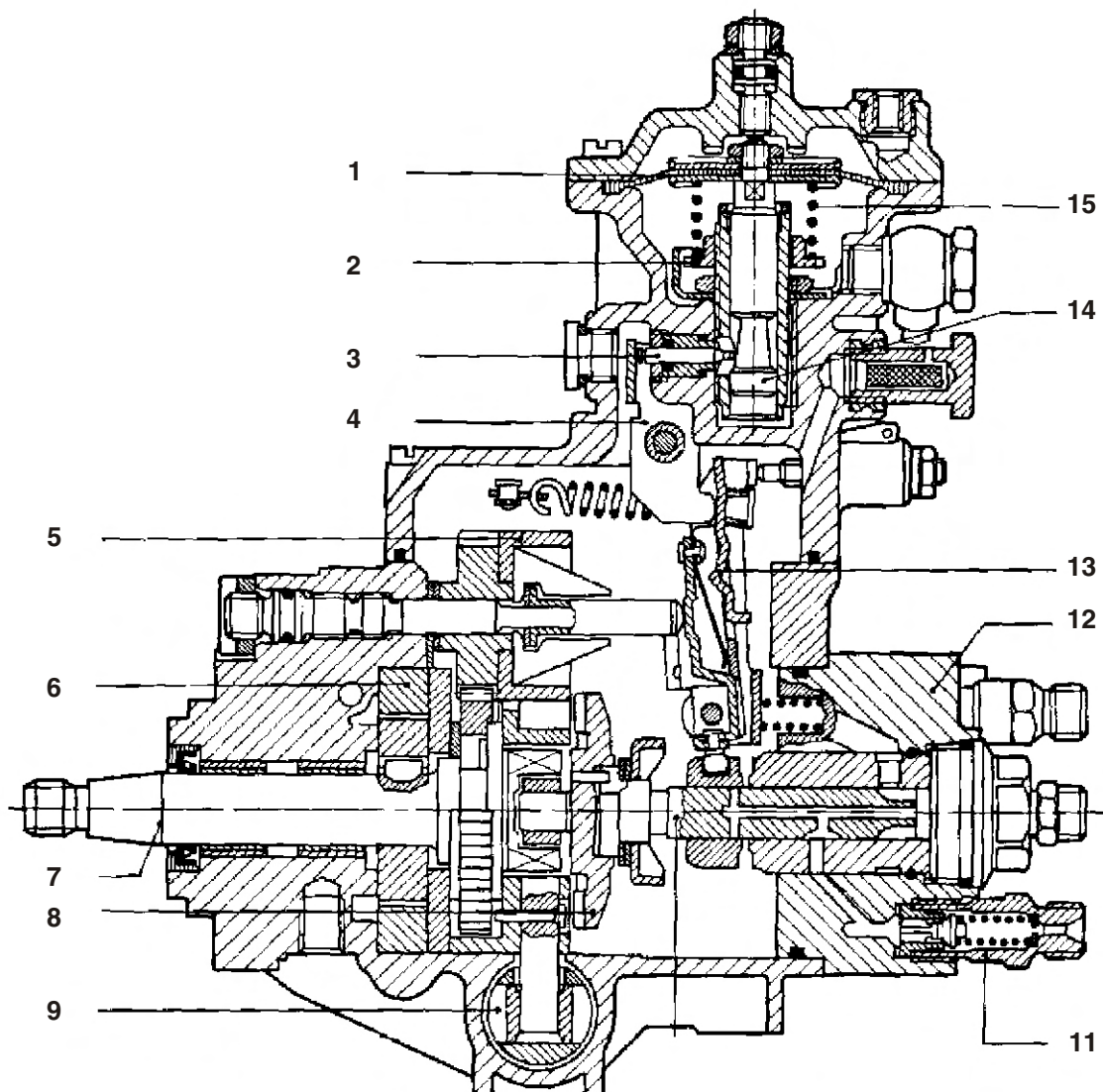
4 = 4 cylinders engine

12 = Distribution plunger in mm.

1150 = Number of pump revolutions per minute

LV = Left direction of rotation

Figura 3



Injection pump longitudinal section

30454

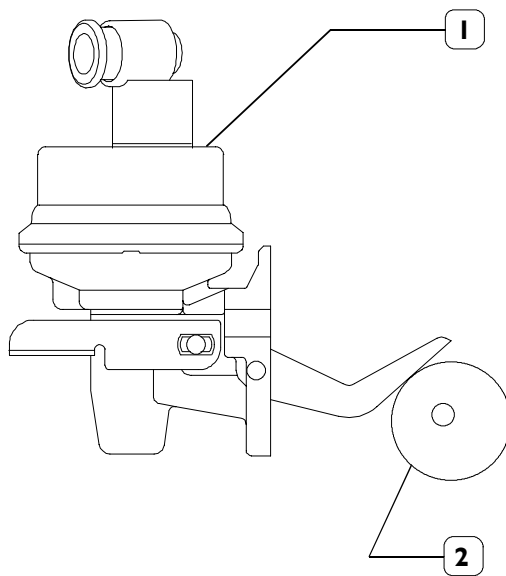
- | | | | | | | | |
|----------------------|--------------------------|---------------------------|---------------------------|-----------------|------------------|----------------|-------------|
| 1. Diafram | 2. Locking nut | 3. Pivot | 4. Drive lever | 5. Speed gauge | 6. Transfer pump | 7. Drive shaft | 8. Cam disk |
| 9. Advance converter | 10. Distribution plunger | 11. Delivery pipe fitting | 12. Hydraulic head | 13. Drive plate | | | |
| | | 14. Gauge pin | 15. Counteracting spring. | | | | |

PRIMING PUMP

This pump has the specific duty to prime the fuel available in the tank and convey it to the feed pump inlet. It is assembled to the engine basement and driven by the camshaft.

The picture here following shows the pump (1) and the position that the pump drive lever assumes depending on the camshaft rotation (2) and on its eccentricity.

Figura 4



1. Priming pump – 2. Camshaft

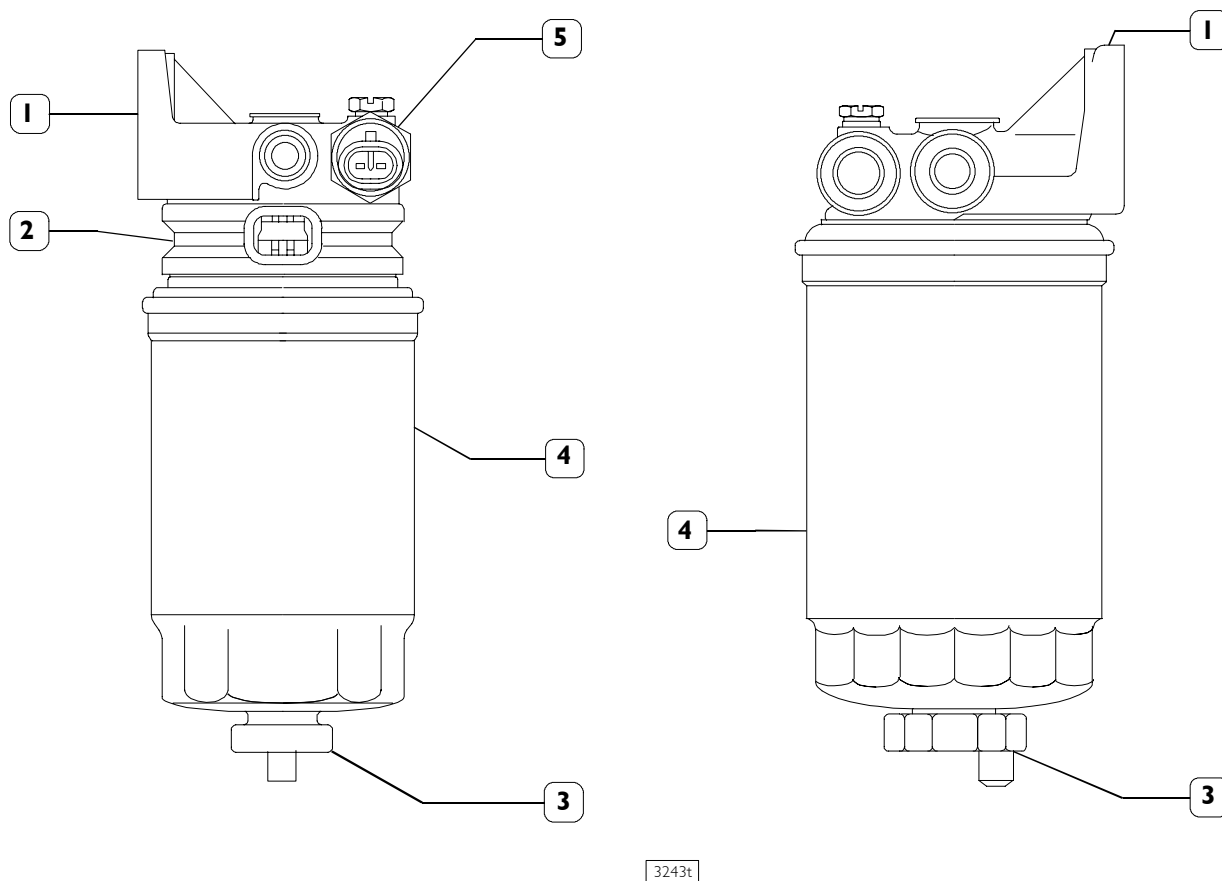
3246t

FUEL FILTER

The filter is assembled close to the feed and priming pump and has the specific duty to provide barrier to the impurities and separation of water from fuel.

On the filter cartridge base (4) there is a water dump screw, throughout which it is possible to provide regular drainage; on the bearing (1) for those equipment applications requiring it (cold climate areas), there can be a heater assembled to (2) and a temperature sensor (5).

Figura 5



1. Fuel filter bearing – 2. Heater – 3. Water dump screw – 4. Filter cartridge –
5. Temperature sensor

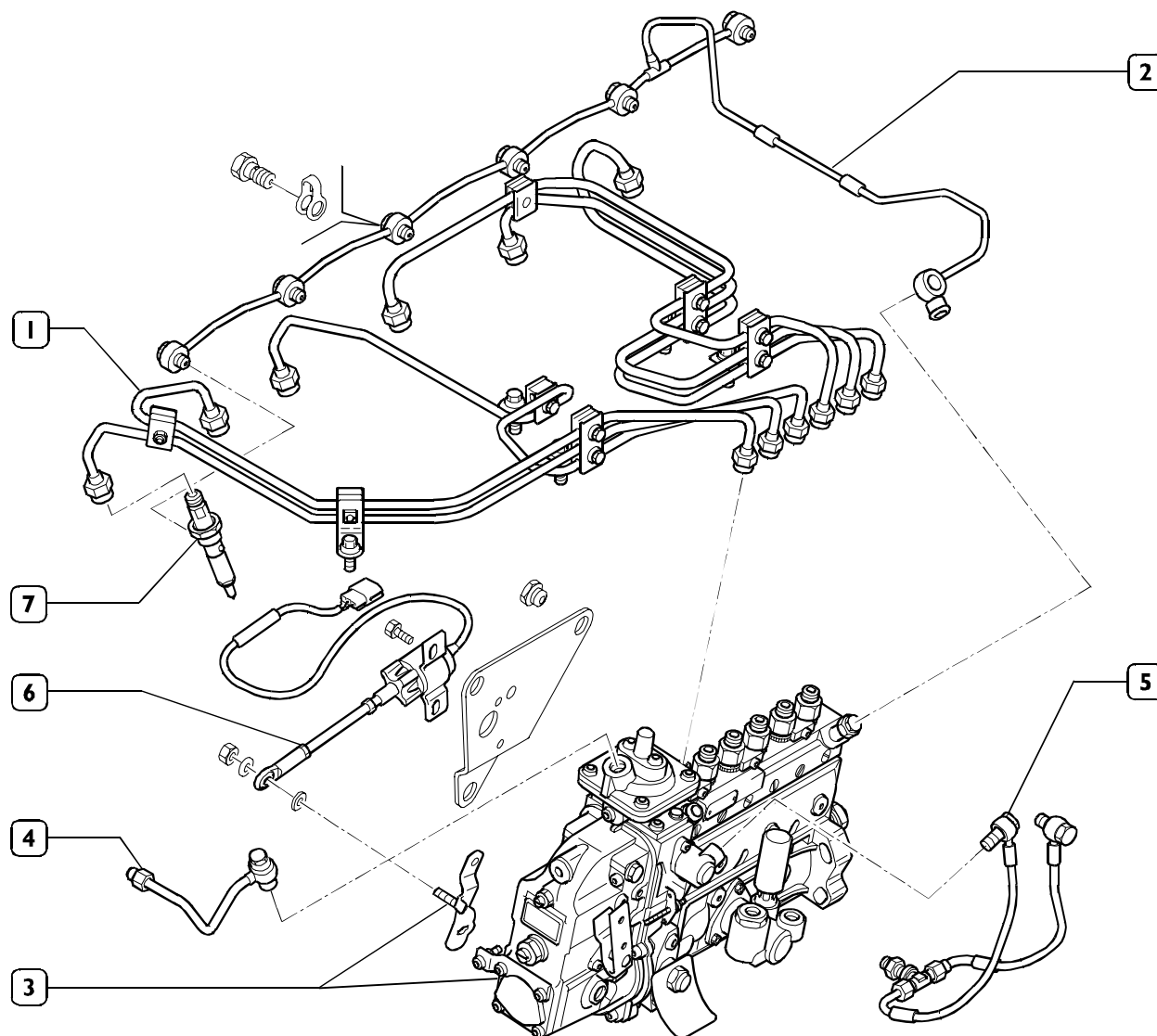
INJECTION FEED SYSTEM BY MECHANICAL PUMP UNIT

General information

Fuel feed system is composed by:

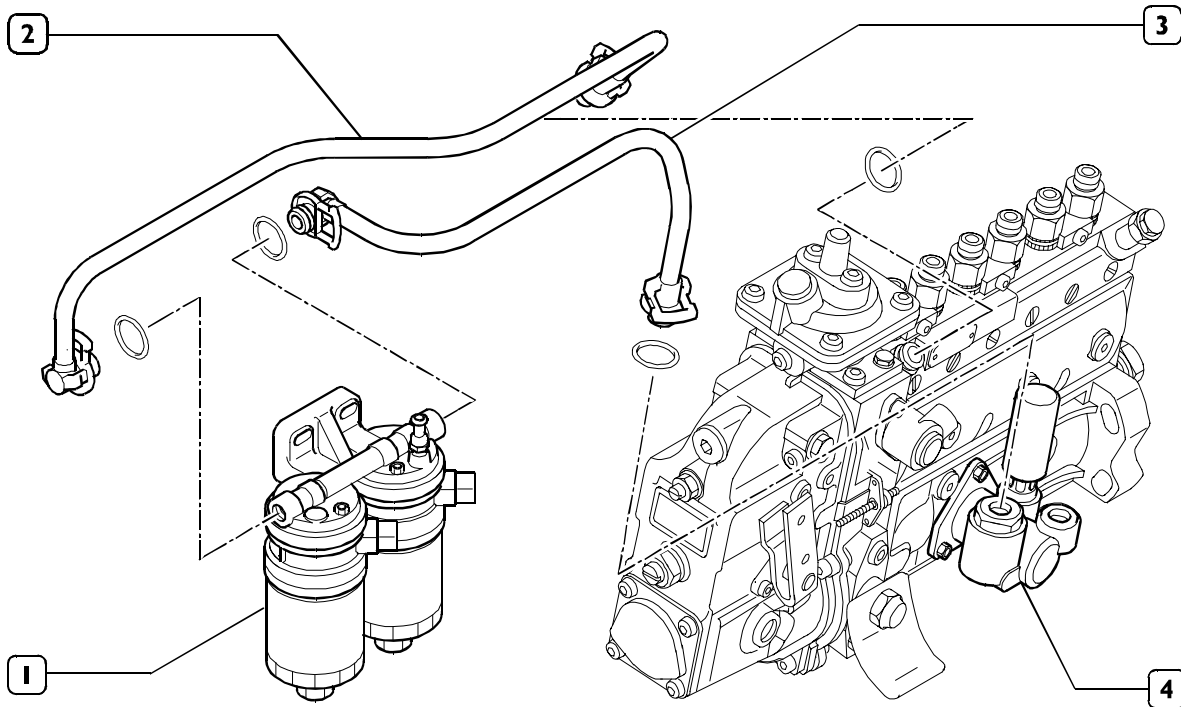
- ☐ Fuel tank (placed on the machine)
- ☐ Fuel delivery and back-flow to tank
- ☐ Fuel pre-filter (if available, it is usually placed close to the engine on the machine frame)
- ☐ Priming pump, assembled to the pump body
- ☐ Fuel filter (assembled to the engine in different positions according to equipment application and duty)
- ☐ Injector feed pipeline (from fuel feed pump to injectors)
- ☐ Injectors

Figura 6



1. Injector feed pipes – 2. Fuel exhaust pipes from injectors – 3. Fuel feed pump – 4. Connector for LDA pressure gauge pipe within suction collector – 5. Lubrication pipes – 6. Engine stop – 7. Injector

Figura 7



76519

1. Fuel filter – 2. Feed pipeline from filter to fuel pump – 3. Feed pipeline from priming pump to filter – 4. Priming pump

Description of working principles

Fuel is sucked from the fuel tank by the priming pump. This last one is placed on the engine basement and is driven by the cam-shaft.

Throughout the filter/s, the fuel is piped to the union fitting vacuum chamber of the transfer pump. (For applications to be equipped in cold climate areas, the fuel filter is provided with heater).

Transfer pump is placed inside the feed pump, and is bladed type; its duty is to increase fuel pressure in correspondence with the increase of the number of revolutions.

Fuel is delivered to the pressure gauge valve within feed pump.

Timing plungers further increase the pressure and deliver fuel to the injectors throughout the delivery pipe fittings.

Fuel bleeding from the injectors is recovered and piped back to the pump.

FEED PUMP

The pump is driven by a gear mating the camshaft's one.

Direction of rotary: Left

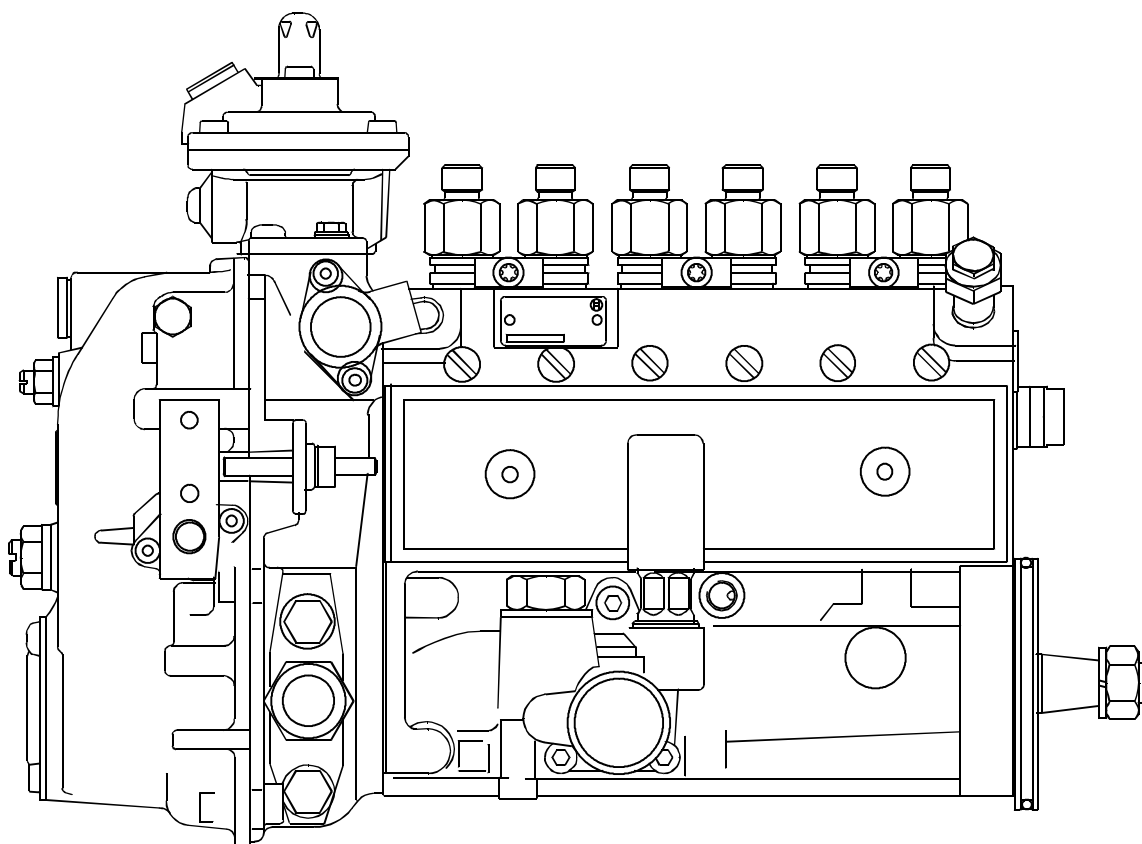
Definition of dir. of rotation "Left" means anticlockwise
when looking from the drive
end

The low pressure system must be bleed

Ambient temperature from -40° to $+120^{\circ}\text{C}$

Oil fill quantity 0.45 liters engine oil

Figura 8



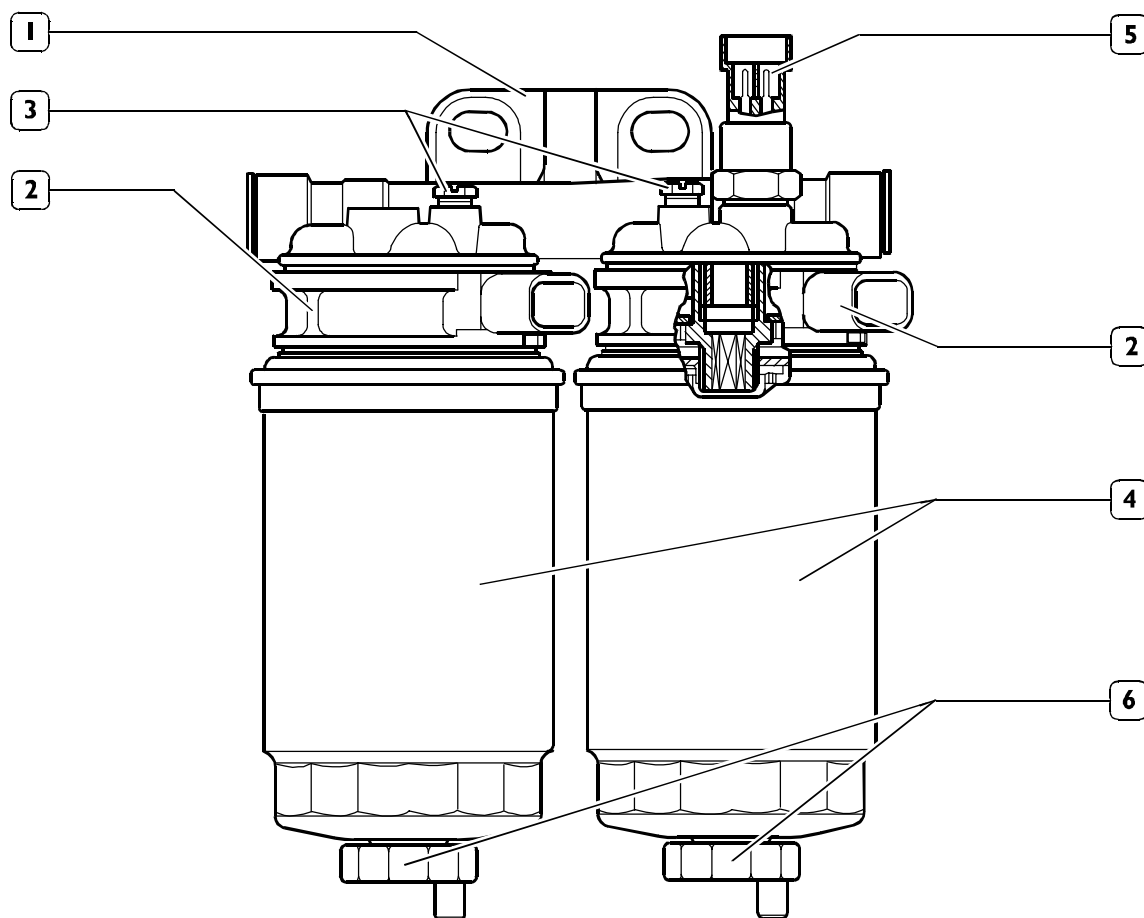
76217

FUEL FILTER

The filter is assembled close to the feed and priming pump and has the specific duty to provide barrier to the impurities and separation of water from fuel.

On the filter cartridge base (4) there is a water dump screw, throughout which it is possible to provide regular drainage; on the bearing (1) for those equipment applications requiring it (cold climate areas), there can be a heater assembled to (2) and a temperature sensor (5).

Figura 9



76142

1. Fuel filter bearing – 2. Heater – 3. Bleeder vent screw – 4. Filter cartridge –
5. Temperature sensor – 6. Water dump screw

SECTION 3**DUTY – INDUSTRIAL
EQUIPMENT**

	Pagina
GENERAL INFORMATION	3
☐ Version equipped with mechanical feed pump	3
☐ Clearance data	4
PART ONE – MECHANICAL COMPONENTS	7
OVERHAUL OF ENGINE PROVIDED WITH MECHANICAL ROTARY PUMP	9
☐ Preface	9
☐ Engine setting operations for the assembly on turning stand	9
☐ Disassembly of application components	11
☐ Installation of application components	19
☐ Completion of the engine	33
☐ Rotary feed pump disassembly and assembly procedure	35
☐ Feed system bleed procedure	38
☐ Power take-off disassembly and assembly procedure	38
☐ Check and controls	38
OVERHAUL OF ENGINE PROVIDED WITH MECHANICAL IN LINE PUMP	39
☐ Preface	39
☐ Engine setting operations for the assembly on turning stand	39
☐ Disassembly of application components	41
☐ Installation of application components	49
☐ Completion of the engine	63
☐ Feed pump unit disassembly and assembly procedure	65
☐ Feed system bleed procedure	69
☐ Power take-off disassembly and assembly procedure	69
☐ Check and controls	69
TIGHTENING TORQUE	71

Pagina

Pagina

PART TWO – ELECTRICAL EQUIPMENT

73

ELECTRICAL COMPONENT LAYOUT (4 CYL. ENGINES WITH ROTARY PUMP)

75

☐ Cooling liquid temperatur sensor 76☐ Starter 76☐ KSB water temperatur sensor 76☐ Electromagnets assembled to feed pump 77☐ Oil pressure switch 77☐ Fuel filter 77☐ Pre-post heating resistor 78☐ Alternator 78**ELECTRICAL COMPONENT LAYOUT (6 CYL. ENGINES WITH PUMP UNIT)**

79

☐ Cooling liquid temperatur sensor 80☐ Starter 80☐ KSB water temperatur sensor 80☐ Engine stop assembled to feed pump 81☐ Oil pressure switch 81☐ Fuel filters 81☐ Pre-post heating resistor 82☐ Alternator 82**PART THREE – TROUBLESHOOTING**

83

PART FOUR – MAINTENANCE PLANNING

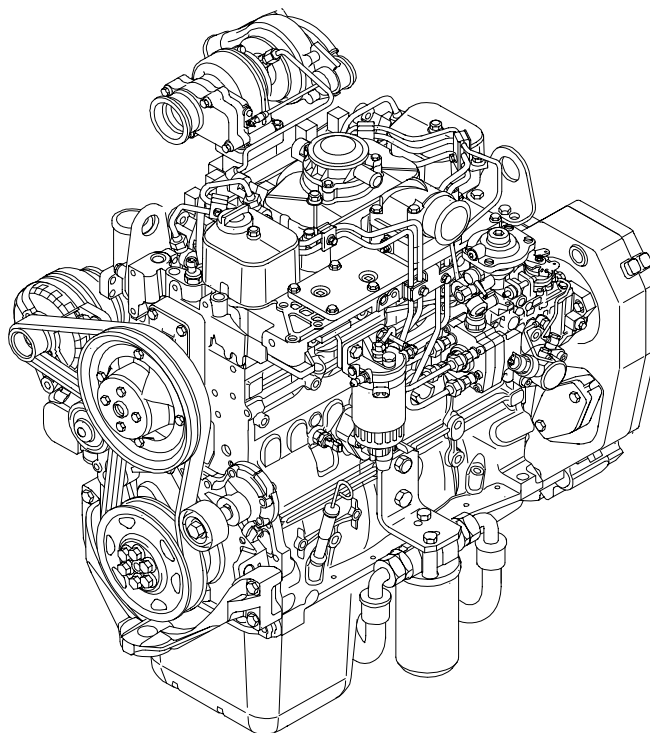
91

MAINTENANCE PLANNING 93☐ Recovery 93☐ Planning of controls and periodical intervention 93☐ Checks not included in maintenance planning – daily check 94**MAINTENANCE PROCEDURES – CHECKS AND CONTROLS** 94☐ Engine oil level check 94☐ Check of fuel system 95☐ Cooling system check 95☐ Lubricating system check 95☐ Check of water presence within fuel filter or pre-filter 95☐ Check of drive belt tensioning 96☐ Check of belt's tear and wear status 96☐ Check and setting of tapped clearance 96☐ Oil motor and filter replacement 97☐ Fuel filter replacement 98☐ Alternator belt replacement 98

GENERAL INFORMATION

Version equipped with mechanical feed pump

Figure 1



03220t

E4BE0484 engines have been designed and developed specifically for transportation by land and farming equipment in general.

They are featured by 4 stroke diesel cycle having 4 cylinder boost with 2 valves per cylinder.

Feed is provided by rotary mechanical pump or on line according to the equipment application.

It differs from other applications because of the provision of different power, power take-off for the different collector configuration, priming pump, oil pan and boost turbine.



The picture shows application designed for 4 cylinders version, 2 valves per cylinder, having fuel feed mechanical pump.



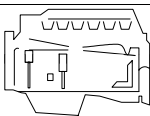
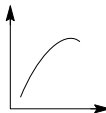
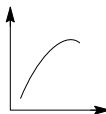
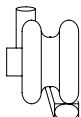
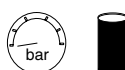
Data, technical specifications and performances granted shall be valid only if the Setter will follow and comply with all installation prescriptions.

Furthermore, the expanders assembled by the Setter must always comply with couple, power and number of revolutions based on which the engine has been designed.

The section herein described is composed of four directories:

- ☐ directory of mechanical overhaul prescribed in accordance to the engine's specific duty, illustrating all necessary operations to remove and assembly the external components of the engine, including cylinder heads, gearbox of the timing system and of the front part cover;
- ☐ electrical directory, describing the connections of the different components, of the pre-post heating gearbox (only for some versions) and of the sensors assembled to the engine;
- ☐ troubleshooting directory;
- ☐ directory of preventive and regular maintenance operations, providing instructions for the execution of the main operations.

CLEARANCE DATA – 4 CYL.

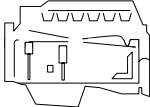
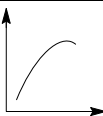
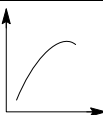
 Type			F4GE04		
			04A*D6	54A*D6	84C*D6
Compression ratio			17 : 1		
 	Max. output	kW (HP)	60 81	74 100	94 128
		rpm	2300	2300	2300
 	Max. torque	Nm (kgm)	– –	398 39.8	500 50.0
		rpm	–	1400	1400
	Loadless engine idling	rpm	850	850	850
	Loadless engine peak	rpm	2300	2300	2300
Bore x stroke			104 x 132		
Displacement			4485		
	SUPERCHARGING		with intercooler		
	Turbocharger type		HOLSET HX27W		
LUBRICATION			Forced by gear pump, relief valve single action oil filter		
	Oil pressure (warm engine)				
	– idling	bar	0.70		
	– peak rpm	bar	3.50		
COOLING			By centrifugal pump, regulating thermostat, heat exchanger, intercooler		
Water pump control			Through belt		
Thermostat					
– start of opening °C			81± 2		
FILLING					
 15W40 ACEA E3	engine sump	liters	8.5		
	engine sump + filter	liters	9.5		



Data, features and performances are valid only if the setter fully complies with all the installation prescriptions.

Furthermore, the users assembled by the setter shall always be in conformance to couple, power and number of turns based on which the engine has been designed.

CLEARANCE DATA – 6 CYL.

		Type	F4BE0684	
			04A*D6	84C*D6
Compression ratio			17.5 : 1	
	Max. output	kW (HP)	81 110	129 175
		rpm	2500	2300
	Max. torque	Nm (kgm)	- -	700 70.0
		rpm	-	1400
	Loadless engine idling	rpm	—	850
	Loadless engine peak rpm	rpm	—	2500
Bore x stroke Displacement			104 X 132 6729	
	SUPERCHARGING		with intercooler	
	Turbocharger type		HOLSET HX35W	
 	LUBRICATION Oil pressure (warm engine)		Forced by gear pump, relief valve single action oil filter	
	— idling	bar	0.70	
	— peak rpm	bar	3.50	
COOLING			By centrifugal pump, regulating thermostat, heat exchanger, intercooler	
Water pump control			Through belt	
Thermostat				
— start of opening °C			81±2	
	FILLING			
	15W40 ACEA E3 engine sump	liters	15	
	engine sump + filter	liters	16	



Data, features and performances are valid only if the setter fully complies with all the installation prescriptions.

Furthermore, the users assembled by the setter shall always be in conformance to couple, power and number of turns based on which the engine has been designed.

PART ONE – MECHANICAL COMPONENTS

OVERHAUL OF ENGINE PROVIDED WITH MECHANICAL ROTARY PUMP

Preface

Part of the operations illustrated within this section can be partially executed while the engine is assembled on the vehicle, depending on the room available for access to the engine and on the equipment application as well.



With regard to the engine disassembly operations, please apply for information consulting the specific manual. All operations of engine disassembly operations as well as overhaul operations must be executed by qualified engineers provided with the specific tooling and equipment required.

The following information relate to the engine overhaul operations only for what concerns the different components customising the engine, according to its specific duties.

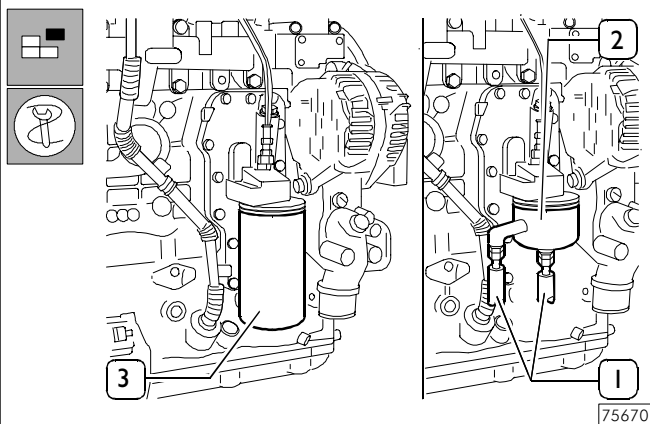


For specific application exigencies, some units can be assembled to the engine in different positions.

Within "General overhaul" section, all the operations of engine block overhaul have been contemplated. Therefore the above mentioned section is to be considered as following the part hereby described.

Engine setting operations for the assembly on turning stand

Figure 2



In order to apply the brackets to the engine block to fix it on to the stand for the overhaul, it is necessary to perform the following operations:

On the right hand side:

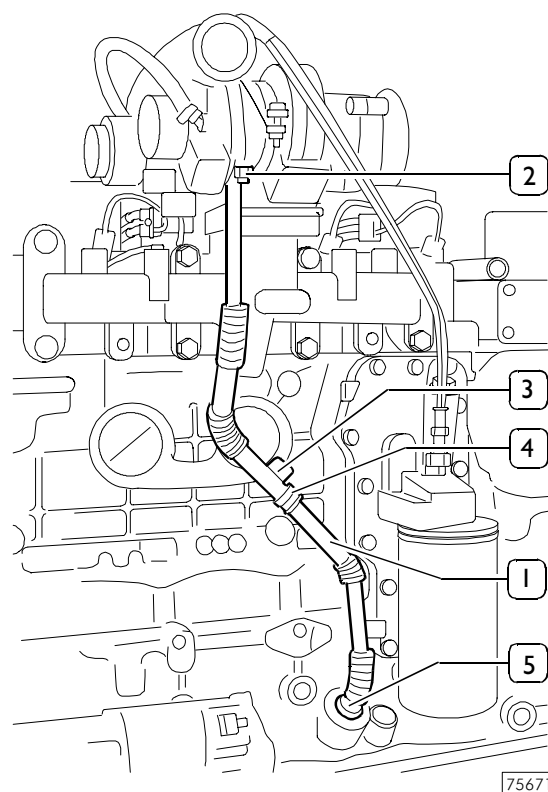
- disassemble pipes (1) from the union (2) fitting the lubrication oil filter (assembled on the opposite side): unlock the nuts fixing the pipes (1) and remove them from the union (2); drain the oil eventually still inside the pipes and plug them properly in order to avoid impurity inlet.



For some versions, the oil filter (3) is directly assembled on to the heat exchanger: in such case it shall be disassembled using acceptable tools.

Warning: the oil filter contains inside aprx. 1 kg. of engine oil. Provide for oil recovery and disposal in compliance with the law and regulations in force.

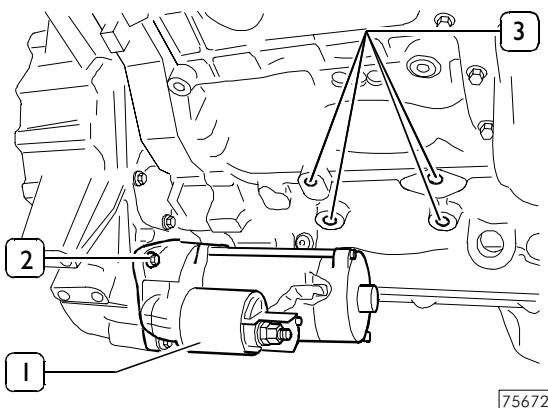
Figure 3



- disassemble lubrication oil exhaust pipe from the turbo - blower:

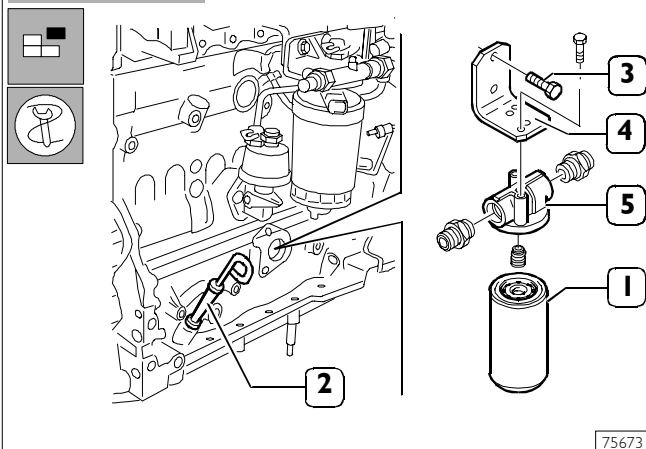
Underneath the turbo - Blower loosen the two screws (2), loosen the screw (3) fixing the pipe throughout the stop collar (4) fixing the block; finally loosen and remove the union (5) from the block; plug the pipe ends and the exhaust of the turbo - blower.

Figure 4



- Disassemble the starter ; Properly hold the starter (1) and loosen the two fixing screws (2); assemble the bracket bearing using the four screw threaded ports (3).

Figure 5



75673

On the left hand side:

- ☐ Disassemble oil filter (1) and bracket as well (for versions with engine oil filter not directly assembled on to the exchanger);
Use acceptable tool to install oil filter;
Loosen the screws (3) removing the bracket together with the filter bearing (4 and 5).



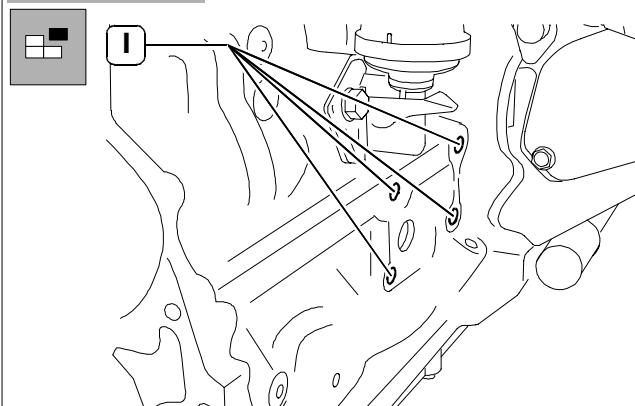
Warning: the oil filter contains inside aprx. 1 kg. of engine oil.
Provide tank with sufficient capacity to contain the liquid.

Warning: avoid contact of engine oil with the skin: in case of skin contamination rinse in running water.

Engine oil is highly pollutant: provide for disposal in compliance with the law and regulations in force.

- ☐ Remove the oil level rod together with guide pipe (2); (loosen the guide pipe disassembling from the block); properly pipe the screw-threaded port to avoid inlet of foreign matters.

Figure 6



75674

- ☐ Assemble the second bracket throughout the screw-threaded ports (1).
- ☐ Lift the engine using the rocker arm and put it on the turning stand.
- ☐ Drain the oil through the cap underneath the plug.

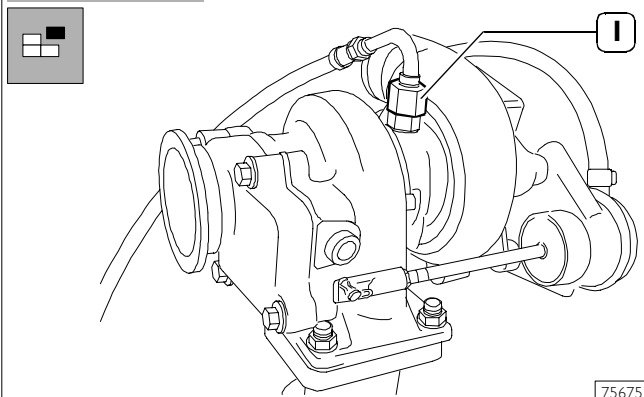


Warning: avoid contact of engine oil with the skin: in case of skin contamination, rinse in running water.

Engine oil is highly pollutant: provide for disposal in compliance with the law and regulations in force.

Disassembly of application components

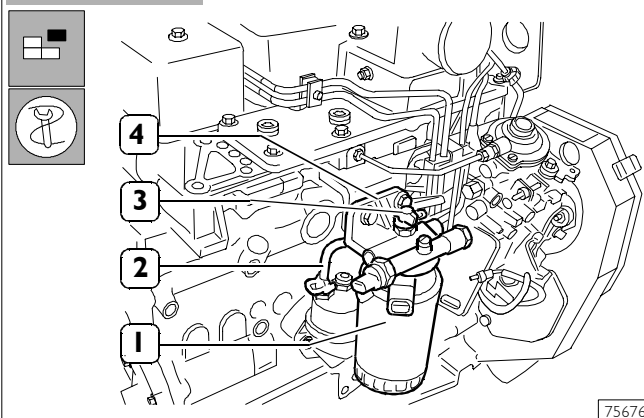
Figure 7



Proceed disassembling the supercharger:

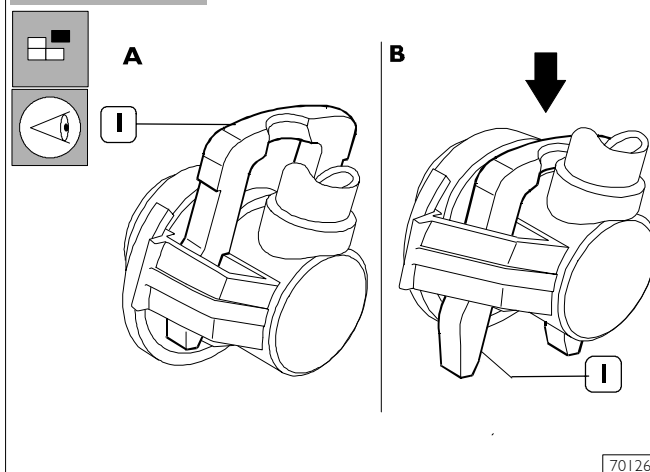
- ☐ loosen the fixing nut (I) and remove the lubrication pipe from the supercharger. Analogously carry out the same operation on the other end of the pipe and remove it from the upper part of the heat exchanger.
- ☐ Loosen the screw nuts fixing the supercharger on the exhaust manifold.
- ☐ Hold up the supercharger and after lifting it remove the gasket.

Figure 8



- ☐ Place a container under the fuel filter and screw out the condense drain faucet underneath said filter. Carry out complete drainage of the fuel contained therein.
- ☐ Screw out completely the faucet and, using acceptable tools, remove the oil filter (I).
- ☐ Disconnect fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to the feed pump.
- ☐ Remove the fuel filter bearing (4) from the bracket fixed to the engine head.

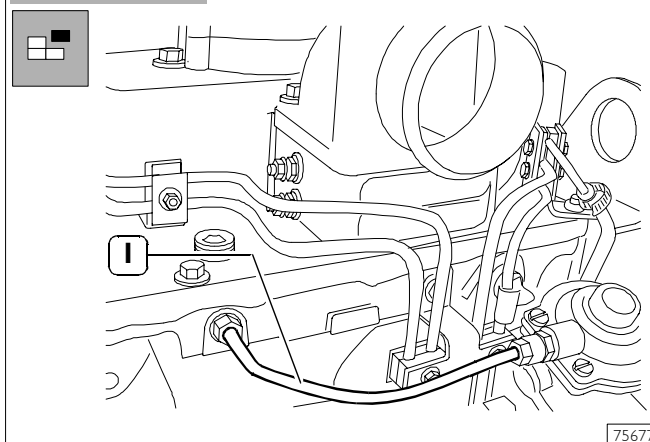
Figure 9



To disconnect fuel pipelines (2 and 3, picture 8), in low pressure from the relating pipe fittings, it is **Necessary to press the locking fastener (I) as shown in picture B.**

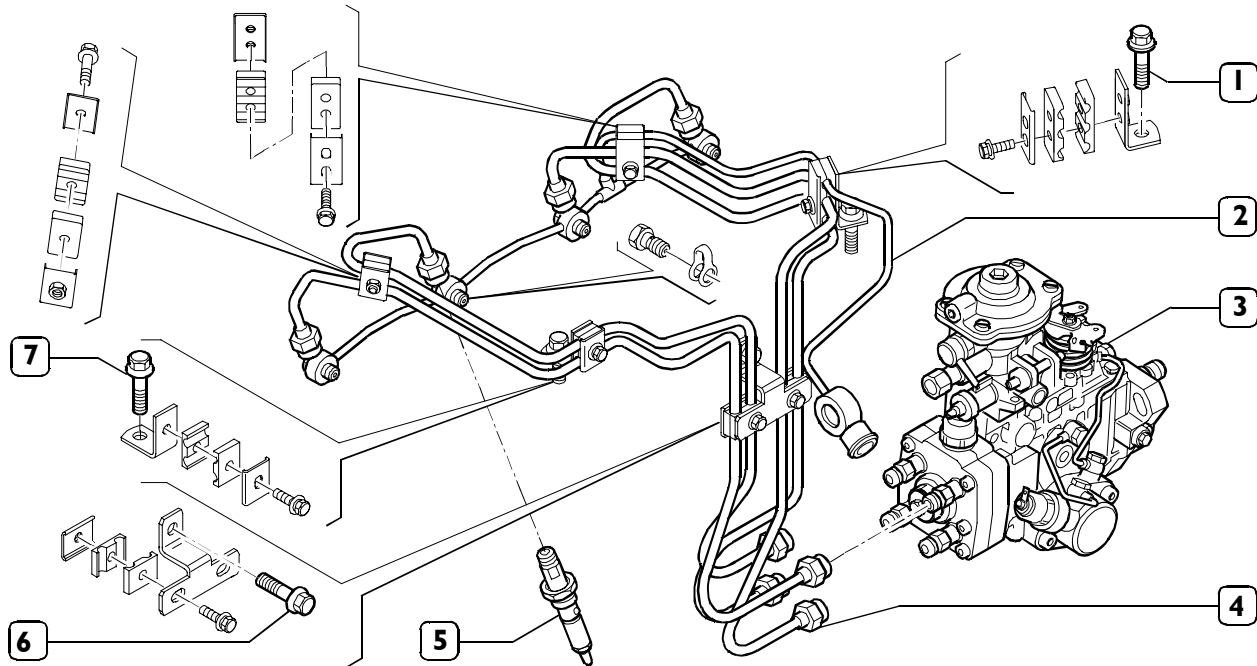
After having disconnected the pipeline, reset the locking fastener (I) in lock position as shown in. Picture A, to avoid any possible deformation of the fastener itself.

Figure 10



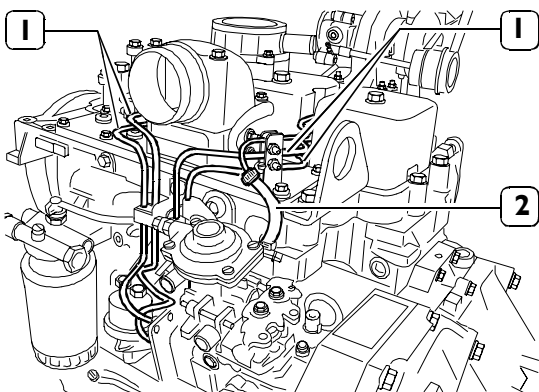
- ☐ Disconnect the LDA pipe (I) from the head and from the feed pump. Pipe the ends of the pipelines as well as the feed pump and the engine head.

Figure 11



1. Rear bracket fixing screw (on suction collector plate) – 2. Fuel recovery pipeline to pump – 3. Rotary feed pump – 4. Connection nut to pumping elements – 5. Injector – 6. Bracket fixing screw to injection pump side – 7. Front bracket fixing screw (on suction collector plate)

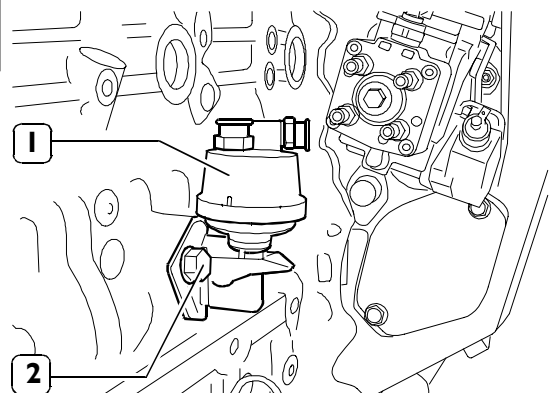
Figure 12



75679

- ☐ Disconnect the pipelines (1) and (2) that provide feed and fuel recovery between pump and injectors; screw out the nuts fixing the pipes to the pumping elements; loosen the fuel recovery pipe collar on the injection pump; operate on the nuts assembled to the injectors and loosen the screws fixing the fuel recovery pipeline; loosen the screws holding the fixing brackets of such pipelines (1, 6, and 7, Figure 11); pipe the pipeline ends.
- ☐ Disassemble the injectors and remove them from their slot: remove the gaskets.

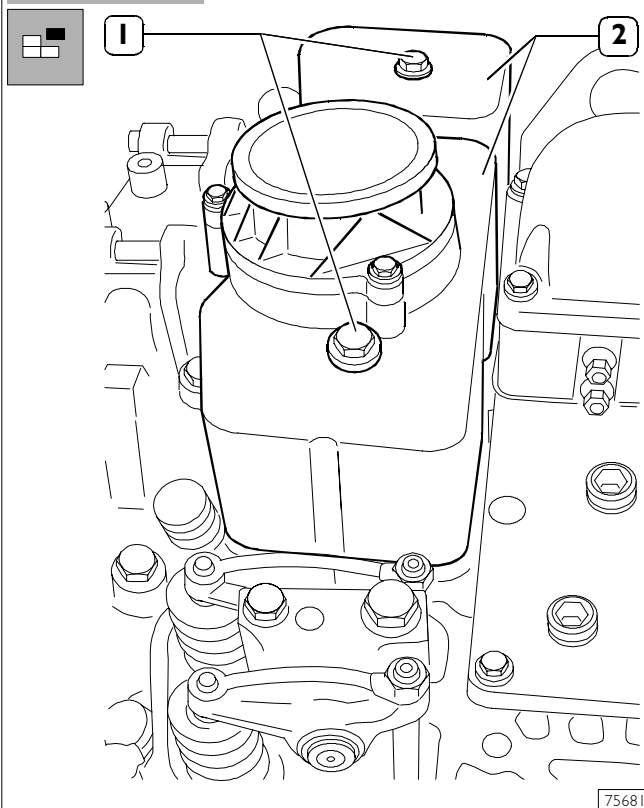
Figure 13



75678

- ☐ Loosen the two fixing screws and disassemble priming pump.

Figure 14

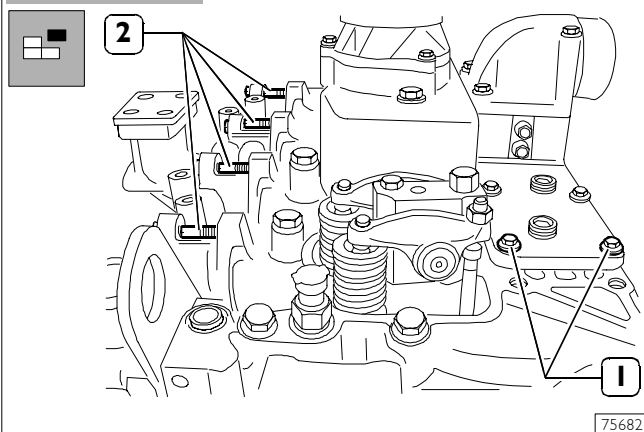


- ☐ Remove tappet caps: Loosen the four fixing screws (1) and lift the caps (2); remove the gaskets.



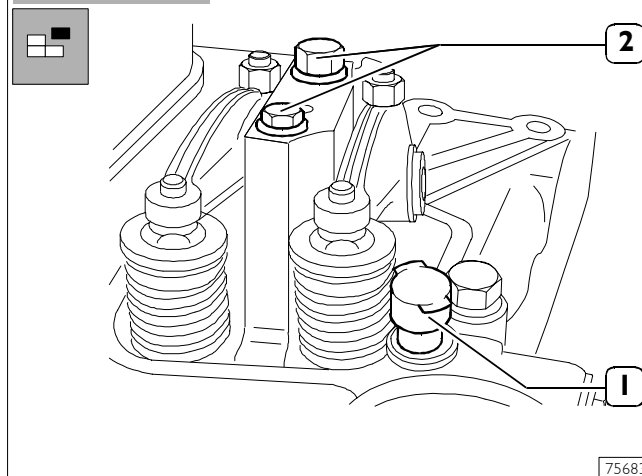
In the picture, the front cap has already been removed.
On the central cap there is a blow-by valve for the lubrication oil vapours.
All the gaskets shall always be replaced during assembly.

Figure 15



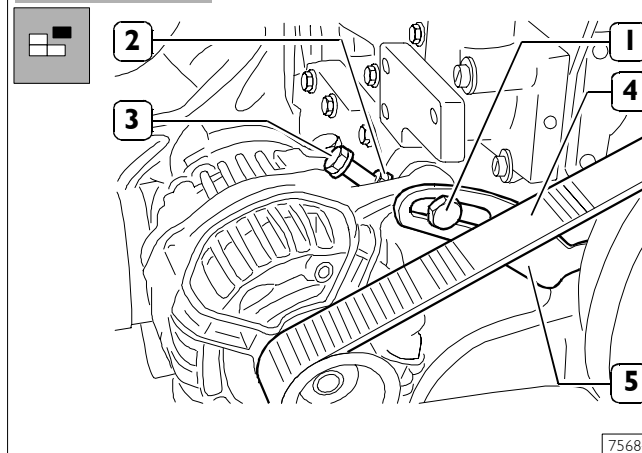
- ☐ Disassemble suction and exhaust manifolds: loosen the 8 screws (1) fixing the suction manifold plate to the cylinder head (two of them have already been screwed-out since fixing the pipe brackets to the injectors); from the exhaust manifold side; loosen the eight (2) fixing screws; remove the gaskets.

Figure 16



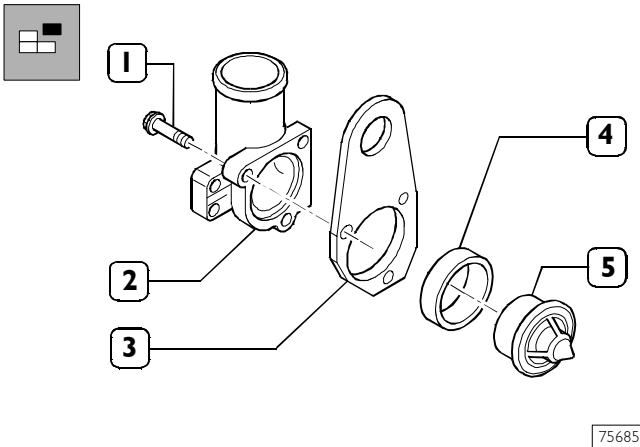
- ☐ Disassemble rocker arm bearings; loosen the two fixing screws (2) and remove the complete rocker arm bearing; withdraw tappet rods. Repeat the operation for all the remaining rocker arm bearings.
- ☐ Disassemble water temperature transmitter (1).

Figure 17



- ☐ Loosen the screw (1) on the alternator belt tensioning hanger and by loosening the lock nut, loosen the screw as well (3) in order to slack the belt (4) until enabling withdrawal of the driven and guide pulleys. Disassemble alternator belt tensioning hanger (5).

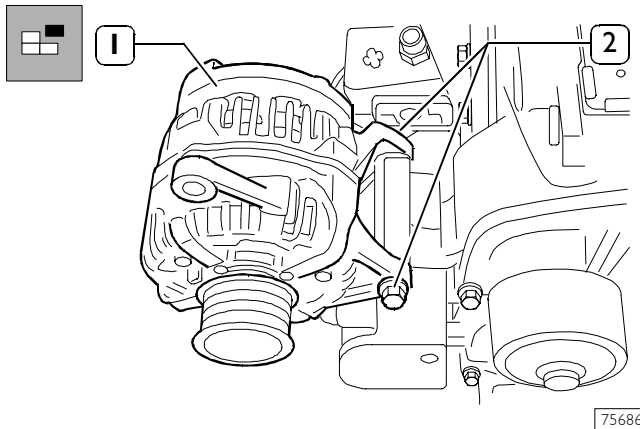
Figure 18



75685

- ☐ Disassemble thermostat unit; loosen the three fixing screws (1) and disassemble the thermostat unit (2) together with the bracket (3); remove the gasket (4) and the thermostat (5).
- ☐ Assemble the bracket in the original position fixing it with the screws of the thermostat unit.

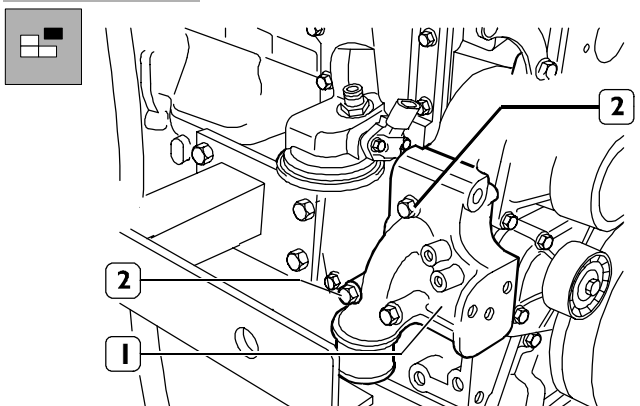
Figure 19



75686

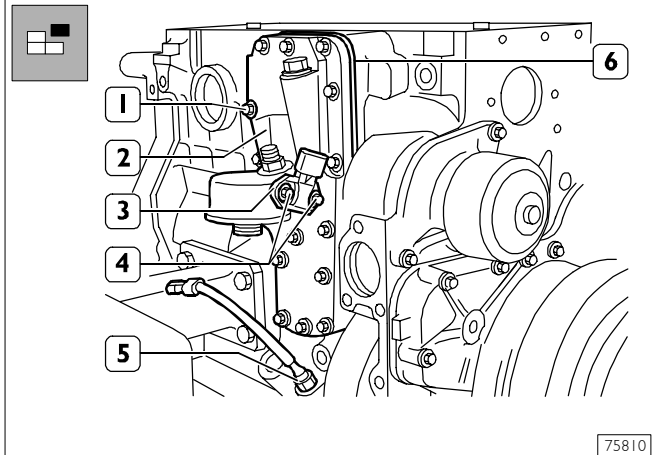
- ☐ Properly hold the alternator (1) separating it from its bearing by loosening the screw (2); remove screw nut and washer.

Figure 20



- ☐ Loosen the screws (2) and withdraw the alternator bearing (1).

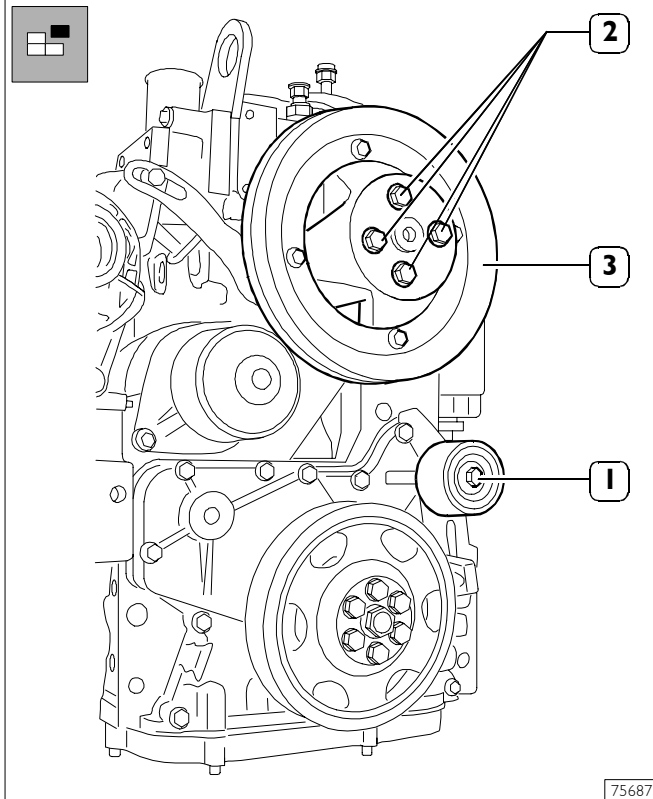
Figure 21



75810

- ☐ Loosen the screws (4) and disassemble the oil pressure/temperature sensor (3) (if fitted).
- ☐ Loosen the screws (1) and disassemble the oil filter/heat exchanger bearing (2), interlayer plate (6) and relating gaskets.
- ☐ Disassemble oil level sensor (5) (whether provided).
- ☐ Disassemble injection pump (see specific procedure) and the power take-off underneath.

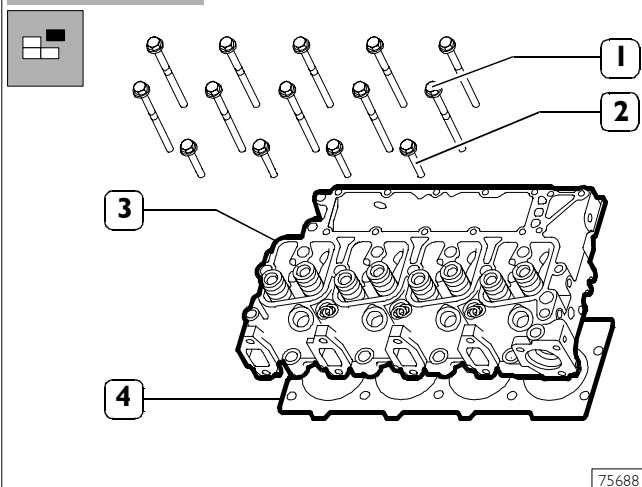
Figure 22



75687

- ☐ From the front, disassemble transmission pulley (1).
- ☐ Loosen the four screws (2) and disassemble the pulley (3) from the bearing underneath.
- ☐ Proceed disassembling the bearing.

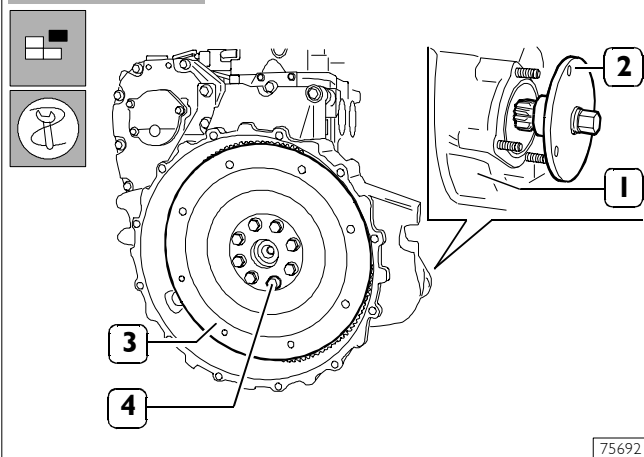
Figure 23



75688

- ☐ Disassemble cylinder head; loosen the screws (1) and (2) fixing the cylinder head (3); hook the brackets with metal ropes and, throughout a hoist withdraw cylinder head from the block.

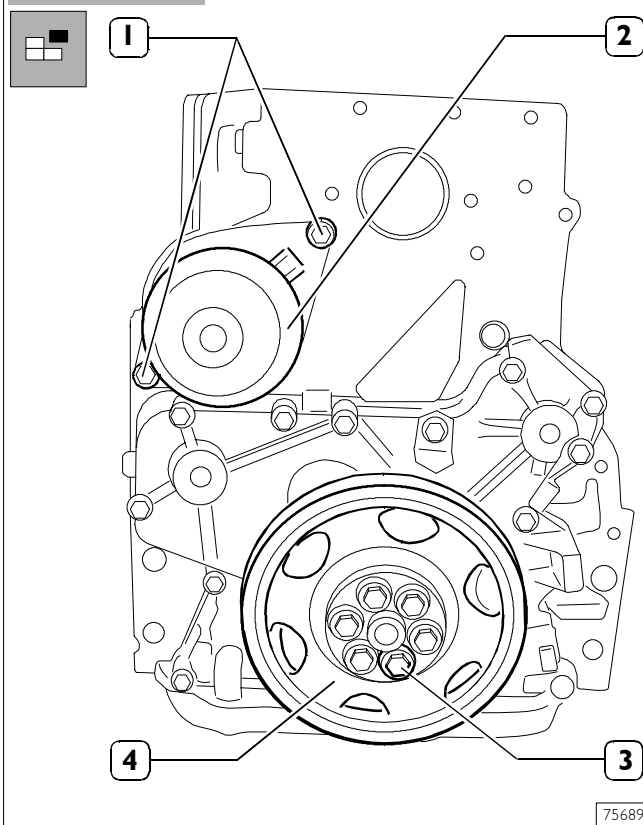
Figure 24



75692

- ☐ Use the 380000988 tool (2) to operate on the flywheel cover box (1) in order to block flywheel rotation (3). (Utilise starter holding down studs and fixing screw nuts).
- ☐ Loosen the flywheel fixing screws (4) to engine drive shaft.

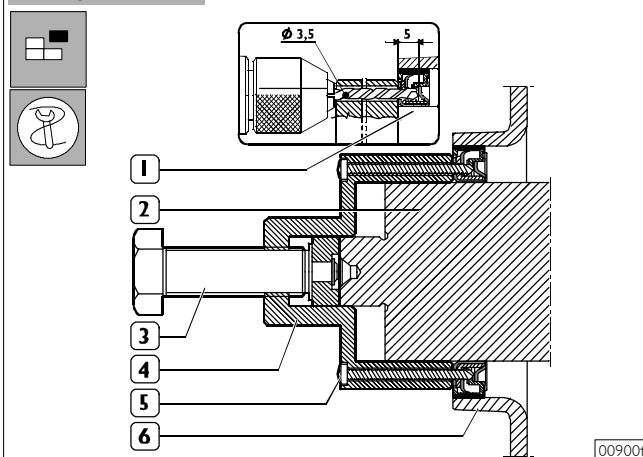
Figure 25



75689

- ☐ Loosen the screws (1) and withdraw water pump (2).
- ☐ Loosen the screws (3) and disassemble the pulley (4).

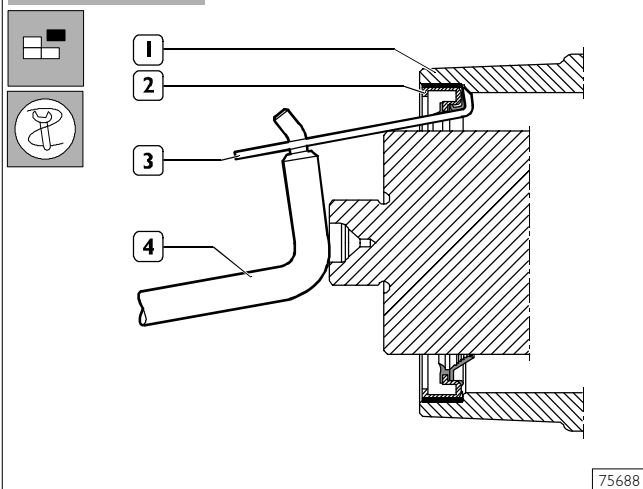
Figure 26



00900t

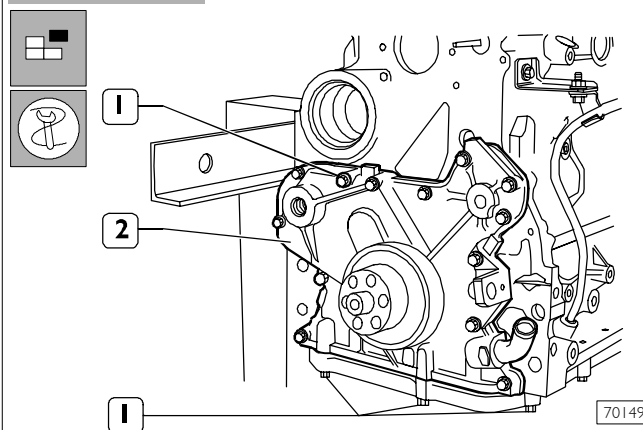
- ☐ Remove the engine drive shaft fixing ring from the front cover. Use the tool 380000665 (4) to operate on the front tang (2) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring (1) using $\varnothing 3,5$ mm drill for a 5mm depth. Fix the tool to the ring tightening the 6 screws specially provided. Proceed withdrawing the ring (1) tightening the screw (3).

Figure 27



-  Use acceptable tools (3) (4) and withdraw the external holding ring (2) from the front cover (1).

Figure 28

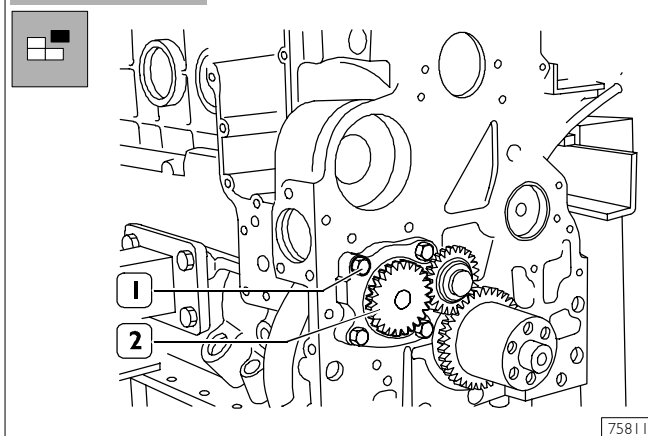


-  Loosen the screws (1) and remove the front cover (2).



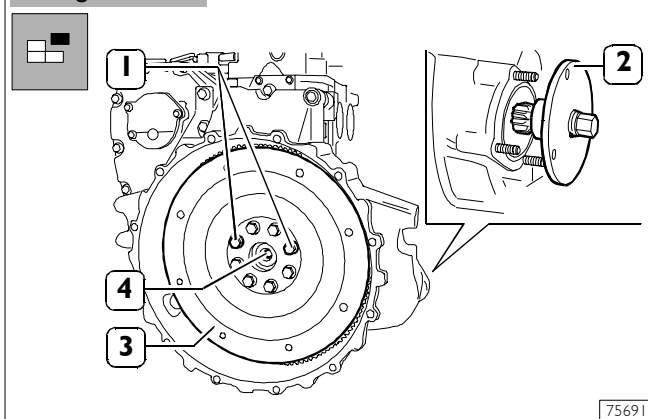
Take note of the screw (1) assembly position, since the screws have different length.

Figure 29



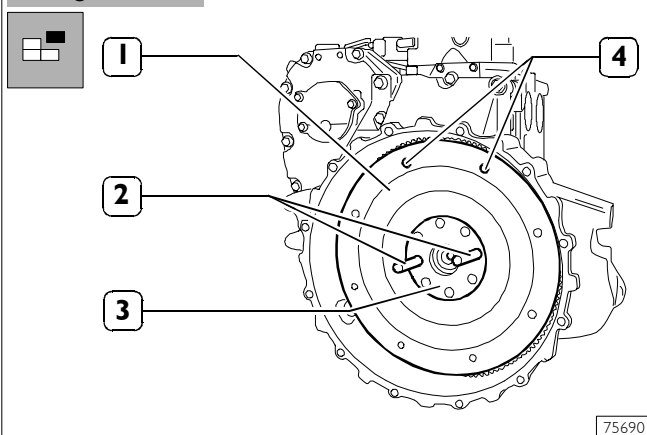
-  Loosen the screws (1) and remove oil pump (2).

Figure 30



-  Screw out the opposite screws (1) from the ports where the withdrawal pins shall be introduced (see picture following).
-  Loosen remaining flywheel fixing screws (3) to the engine drive shaft (4).
-  Remove the flywheel block tool (2).

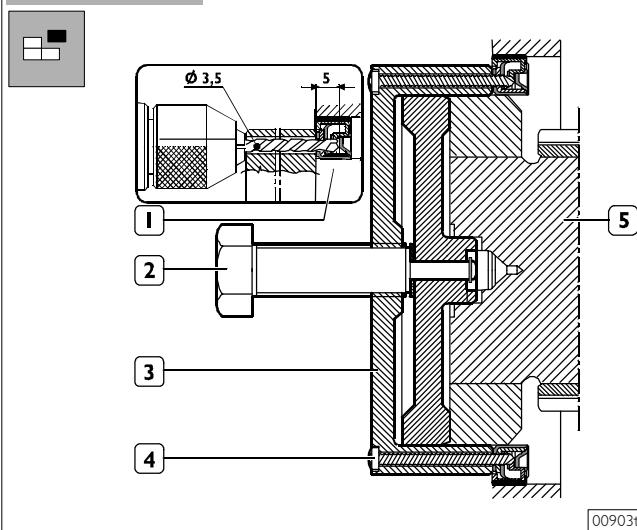
Figure 31



75690

- ☐ Screw up two medium length screws in the ports (4) to sling the flywheel with a hoist. Throughout two guide pins (2) previously screwed up into the engine drive shaft ports (3) control the engine flywheel withdrawal by means of a hoist.

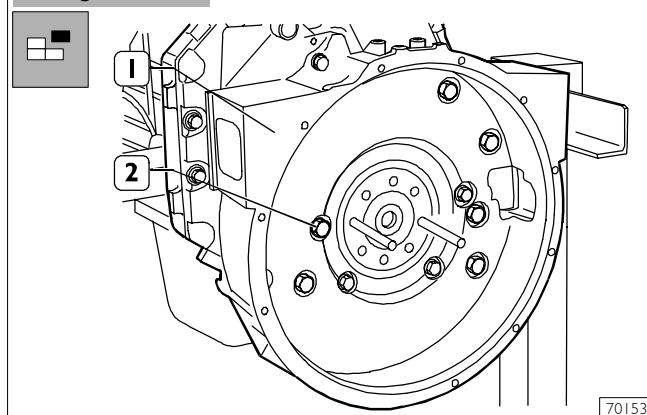
Figure 32



00903t

- ☐ Remove the flywheel cover box fixing ring using the tool 380000663 (3) to operate on the back tang (5) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring using Ø 3,5 mm drill for a 5mm depth.
- ☐ Fix the tool 380000663 (3) to the ring (1) tightening the 6 screws specially provided (4).
- ☐ Proceed with drawing the ring (1) tightening the screw (2).
- ☐ Use acceptable tools (3) (4) and withdraw the external holding ring of the flywheel cover box.

Figure 33



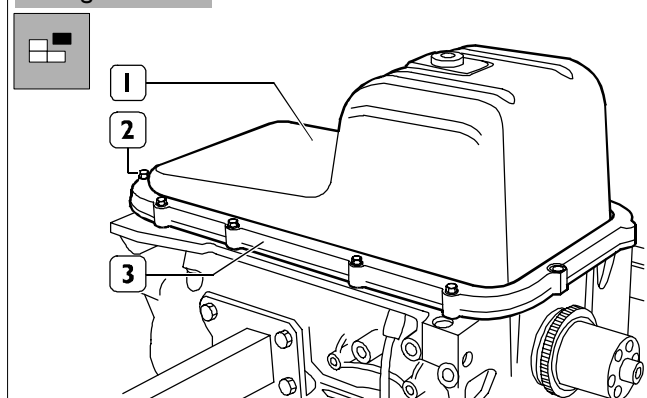
70153

- ☐ Loosen the screws (2) and remove the flywheel cover box (1).



Take note of the screw (1) assembly position, since the screws have different length.

Figure 34



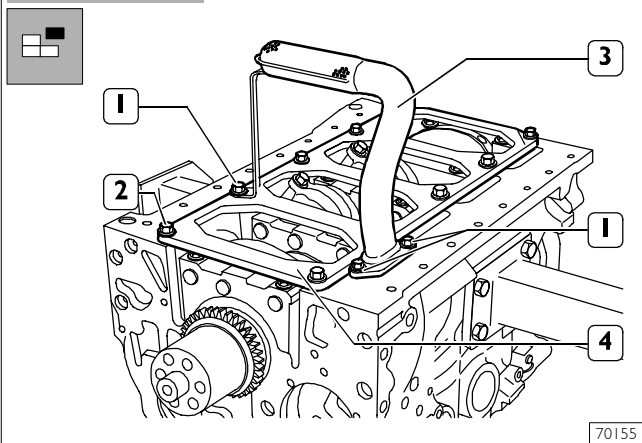
70154

- ☐ Turn the engine upside-down.
- ☐ Loosen the screws (2), disassemble the plate (3) and remove the oil pan (1).



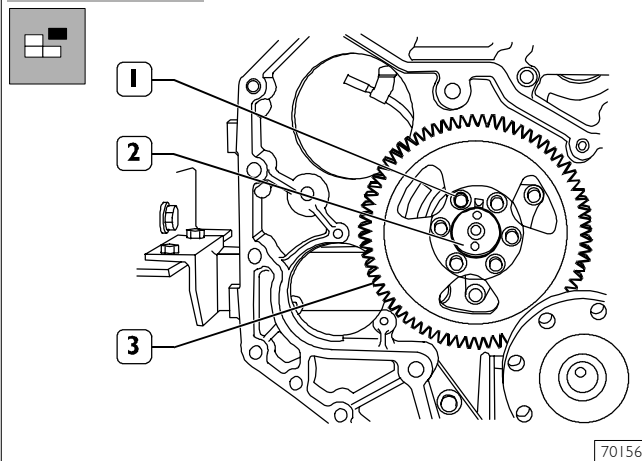
The shape and dimensions of the pan and of the rose pipe may vary according to the engine application. The relating illustrations provide general guidelines of the operation to be performed. The procedures described are applicable anyway.

Figure 35



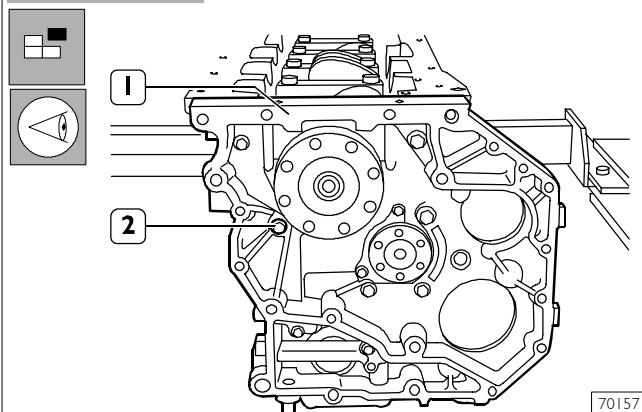
- ☐ Loosen the screws (1) and disassemble the oil suction rose pipe (3).
- ☐ Loosen the screws (2) and remove the stiffening plate (4).

Figure 36



- ☐ Loosen the screws (1) and disassemble the gear from the camshaft (2).

Figure 37



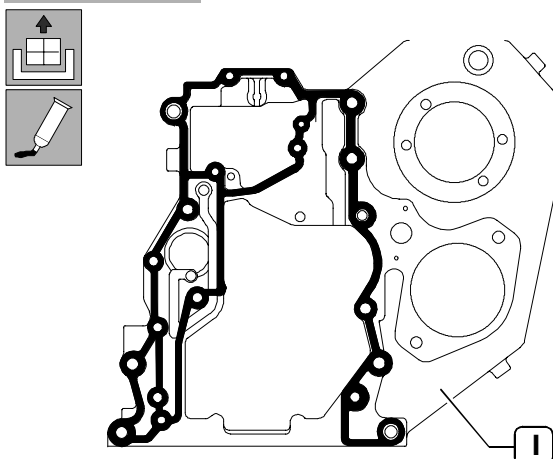
- ☐ Loosen the screws (2) and disassemble the timing gearbox (1).



Take note of the screw (2) assembly position, since the screws have different length.

Installation of application components

Figure 38



75712

DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION WITHIN GEARBOX AREAS

- ☐ Accurately clean the timing gearbox (1) and the engine block.



It is necessary and essential to clean the surface to be sealed in order to achieve excellent tight seal.

Apply sealing LOCTITE 5205 on the box in order to form a kerbstone of a few mm. Diameter.

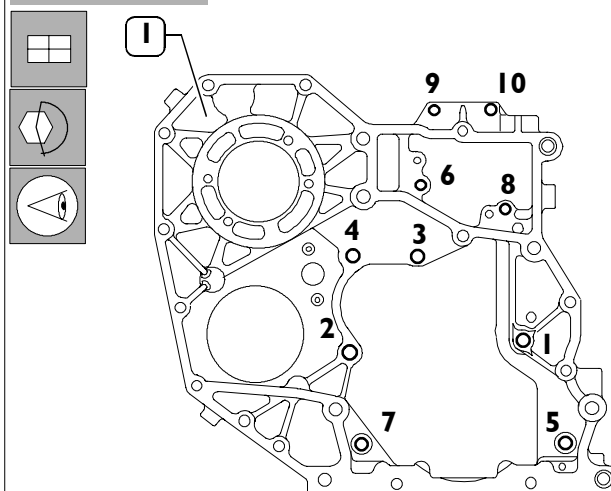
It must be uniform (no crumbs), with no air blisters, thinner or irregular zones.

Any eventual imperfection shall be correct as soon as possible.

Avoid using material in excess to seal the joint. Too much sealing material would drop out on both sides of the joint and obstruct lubricant passages.

After having completed seal application, the joints must be immediately assembled (10–20 minutes time).

Figure 39



75711

DIAGRAM SHOWING SCREW TIGHTENING TO FIX REAR GEARBOX

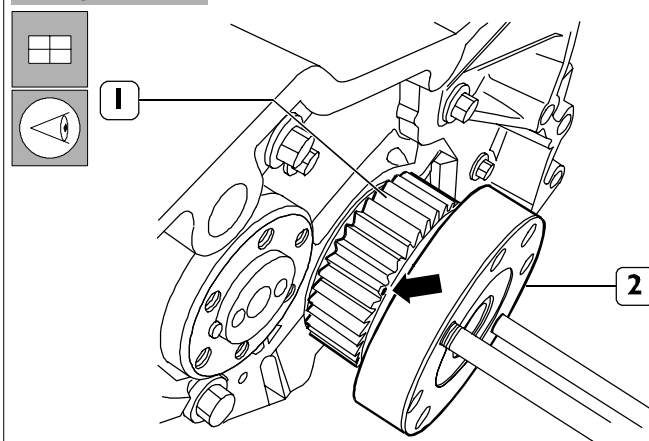
- ☐ Reassemble to box (1) to the engine block.
- ☐ Tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking couples listed here below, following the order as shown in the picture.

Screws M12	65 ÷ 89 Nm
Screws M8	20 ÷ 28 Nm
Screws M10	42 ÷ 52 Nm



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure 40



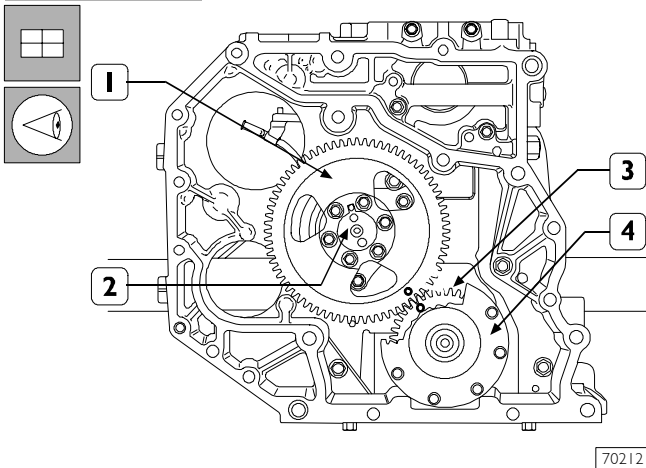
70211

- ☐ With a pen marker, mark the tooth (1) of the driving gear assembled to the engine drive shaft with (2) (→) timing notch.



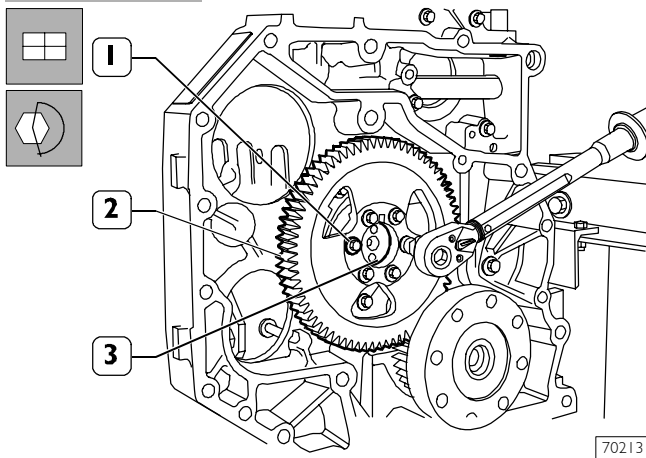
Screw up two pins to facilitate operation of engine drive shaft rotation.

Figure 41



- Orient engine drive shaft (4) and camshaft (2) taking care that in phase of assembly of the driving gear (2) to the camshaft, the notches marked on the gears (1 and 3) shall match.

Figure 42



- Tighten the screws (1) fixing the gear to the camshaft (3) and lock them to the prescribed couple.

Figure 43

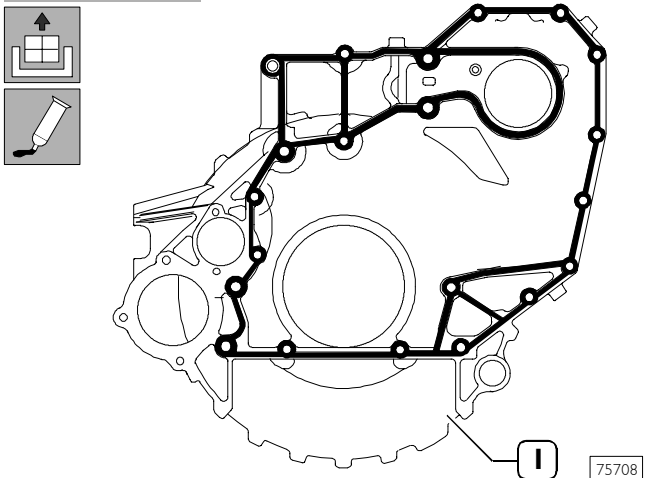


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION.



It is necessary and essential to clean the surface to be sealed in order to achieve excellent tight seal.

Apply sealing LOCTITE 5205 on the box in order to form a kerbstone of a few mm. Diameter: It must be uniform (no crumbs), with no air blisters, thinner or irregular zones.

Any eventual imperfection shall be correct as soon as possible.

Avoid using material in excess to seal the joint. Too much sealing material would drop out on both sides of the joint and obstruct lubricant passages.

After having completed seal application, the joints must be immediately assembled (10–20 minutes time).

Figure 44

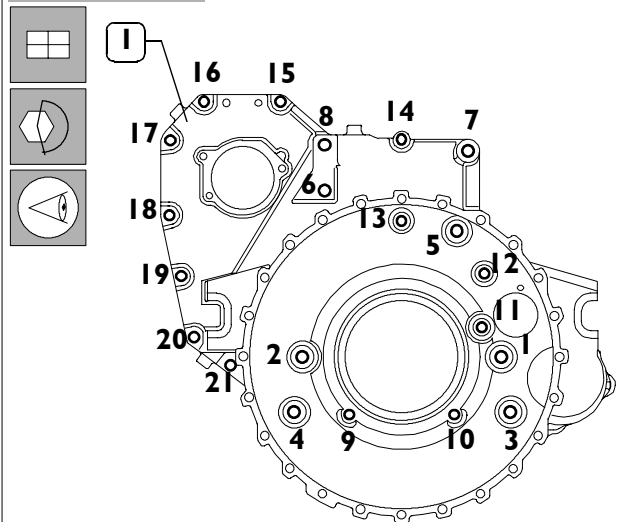


DIAGRAM SHOWING SCREW TIGHTENING TO FIX FLYWHEEL COVER BOX.

- Reassemble the box (1) to the engine block, tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking couples listed here below, following the order as shown in the picture.

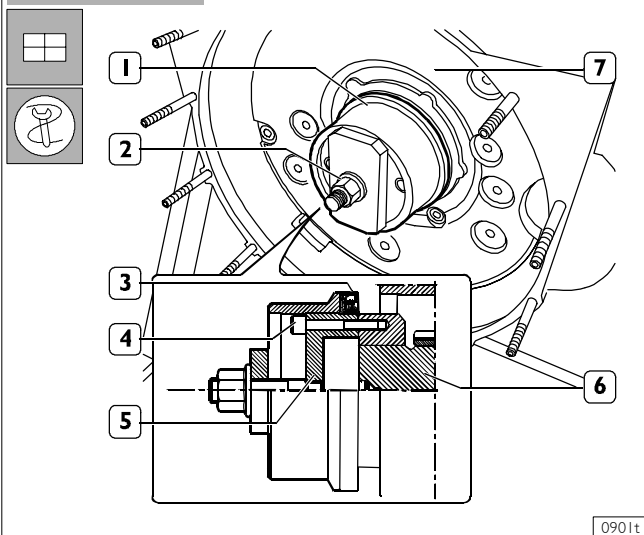
Screws M12 $75 \div 95$ Nm

Screws M10 $44 \div 53$ Nm



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

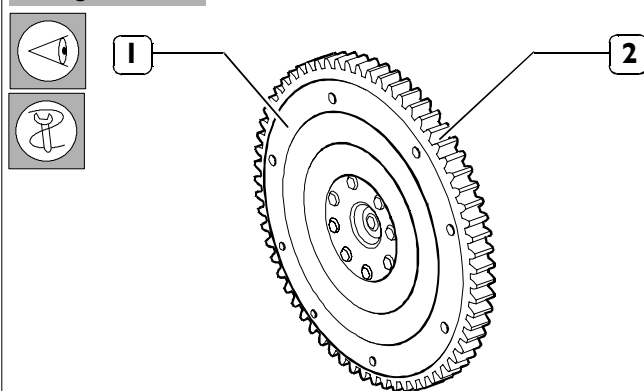
Figure 45



0901t

- ☐ Apply to engine drive shaft rear tang (6), the detail (5) of the tool 380000666, fix it tightening the screws (4) and key the new holding ring on it (3).
- ☐ Place detail (1) on detail (5), tighten the screw nut (2) until complete assembly of the fixing ring (3) into the flywheel cover box (7).

Figure 46



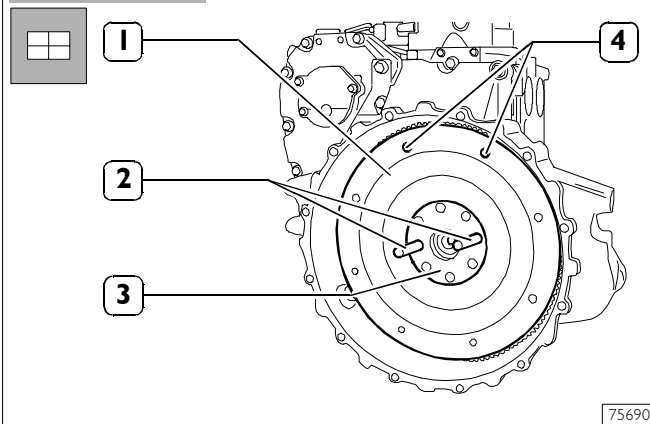
75696



In case of engine coupling with mechanical gears in presence of friction, verify surface status of the flywheel and eventually work it out to maintain rated engine flywheel thickness, which is $49,6 \pm 0,13$ mm.

- ☐ Check the conditions of the rim tooth (2). Whether tooth break or excessive wear is detected, disassemble the rim from the engine flywheel using a common willow and replace with a new one, previously heated to 150°C degrees for $15' \div 20'$ seconds; bevelling must be made towards engine flywheel direction.

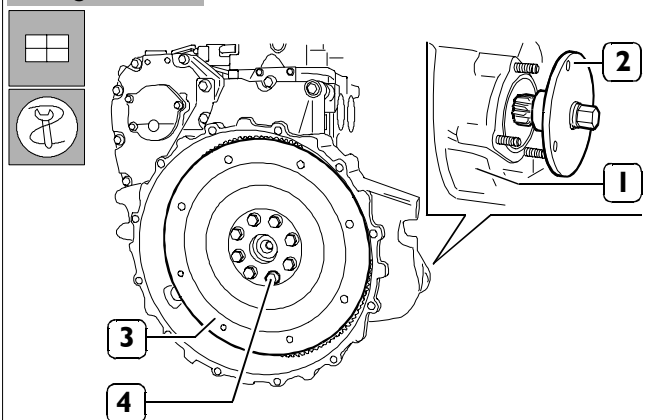
Figure 47



75690

- ☐ Screw up two hooks or trail rings in the flywheel (1) threaded ports (4) for handling.
- ☐ Using a hoist, handle the flywheel to place it in its housing inside the flywheel cover box.
- ☐ Screw up to pins (2) having appropriate length, in the shaft ports (3) and using them as guide, assemble the engine flywheel (1) properly placing it inside the flywheel cover box.

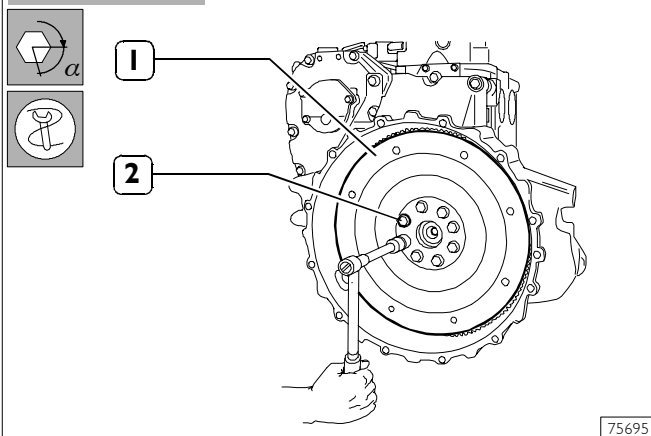
Figure 48



75692

- ☐ Tighten the screws (4) fixing the engine flywheel (3) to the engine shaft. Use 380000988 tool (2) to operate on the flywheel cover box (1) to block engine flywheel rotation.

Figure 49



75695

Tighten the engine flywheel (1) fixing screws (2) in two phases:

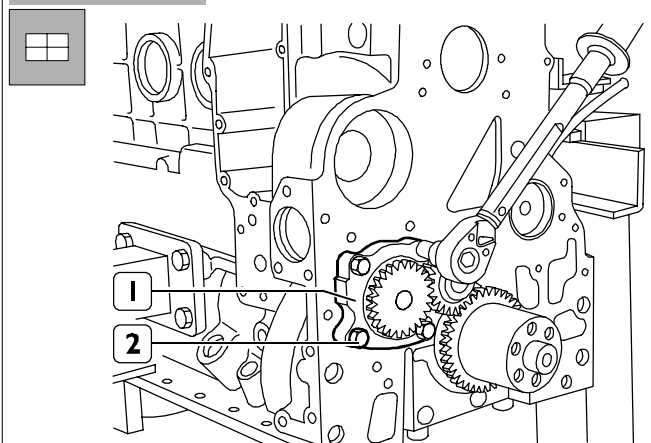
- ☐ 1st phase; tightening by means of dynamometric wrench to couple $30 \div 40 \text{ Nm}$;
- ☐ 2nd phase, $60^\circ \pm 5^\circ$ angle dwell.



Angle dwell shall always be performed using **acceptable tool**.

Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

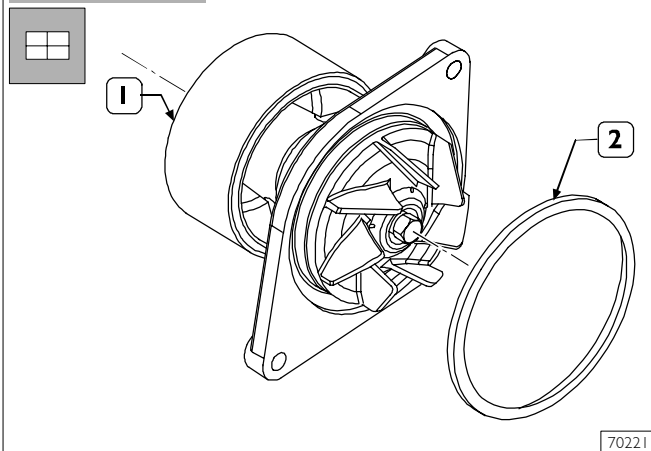
Figure 50



70220

- ☐ Assemble oil pump (1).
- ☐ Tighten fixing screws (2) and lock them to the prescribed couple.

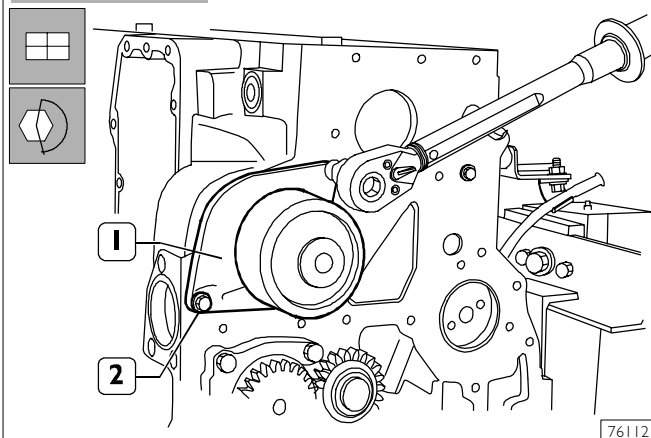
Figure 51



70221

- ☐ Apply to the water pump (1) a new fixing ring (2).

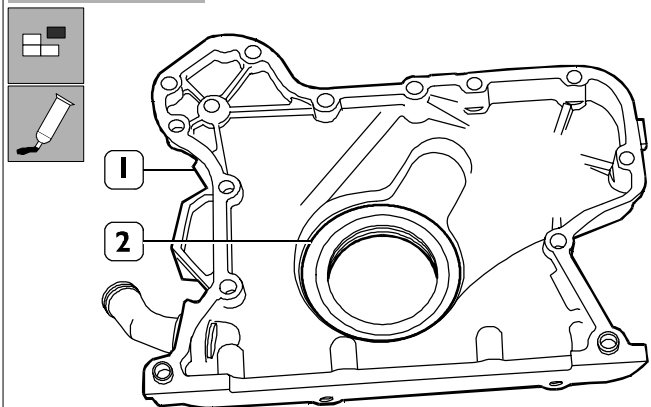
Figure 52



76112

- ☐ Assemble the water pump (1).
- ☐ Tighten the screws (2) and lock them to the prescribed couple.

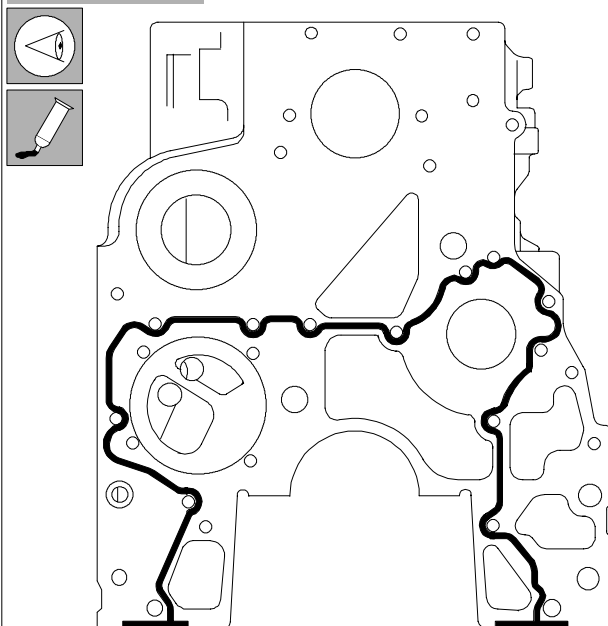
Figure 53



70223

- ☐ Remove the fixing ring (2) from the front cover (1), accurately clean the plug surface.

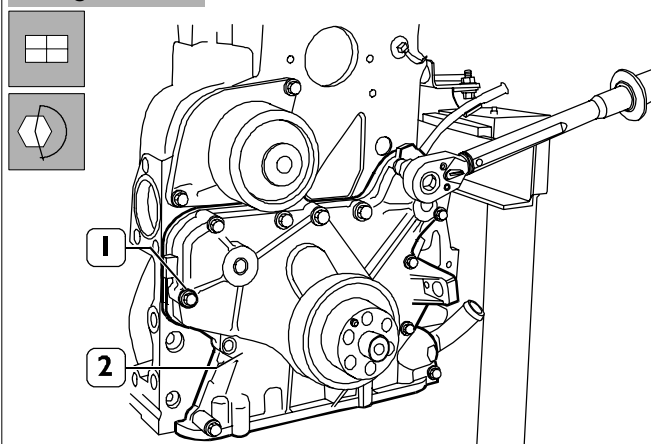
Figure 54



75710

- ☐ Accurately clean the contact surface of engine block and apply sealing LOCTITE 5205 on it in order to form a uniform and continuous kerbstone with no crumbs.

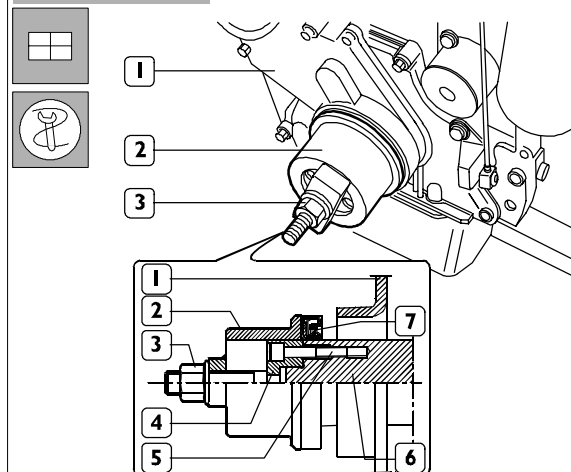
Figure 55



75812

- ☐ Assemble the front cover (2) to the block and tighten the screws (1) fixing them to the prescribed couple.

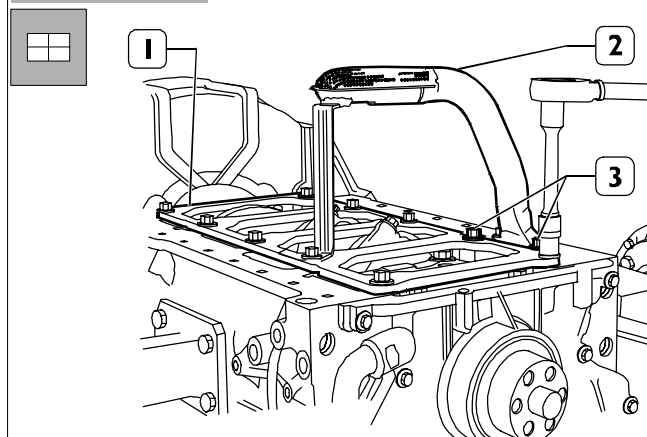
Figure 56



00902t

- ☐ Apply on engine drive shaft front tang (6) the detail (4) of the tool 380000666, fix it with the screws (5) and key the new holding ring on it (7).
- ☐ Place the detail (2) on the detail (4), screw-up the threaded nut until carrying out the complete assembly of the holding ring (7) to the front cover.

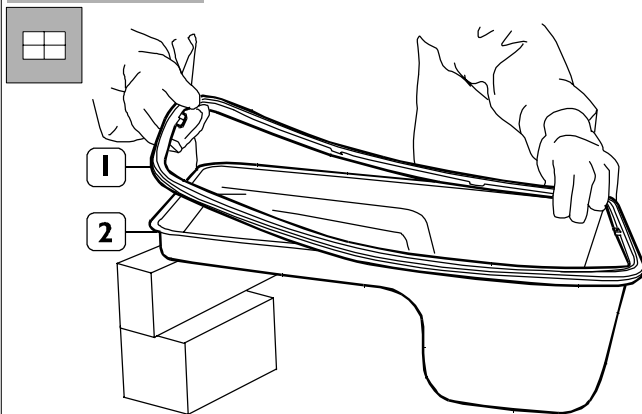
Figure 57



75813

- ☐ Assemble the plate (1), the rose pipe (2), tighten the fixing screws (3) and fix them to the prescribed couple.

Figure 58

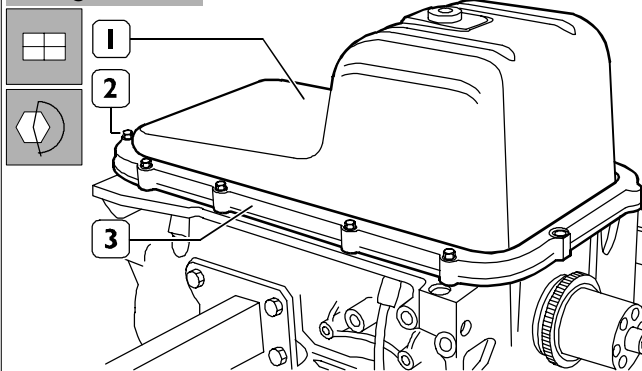


- ☐ Provide for new gasket replacement (1) of the oil pan (2).



The pictures illustrating the pan and of the rose pipe may not correspond to the ones of your model. However the procedures described are applicable anyway.

Figure 59

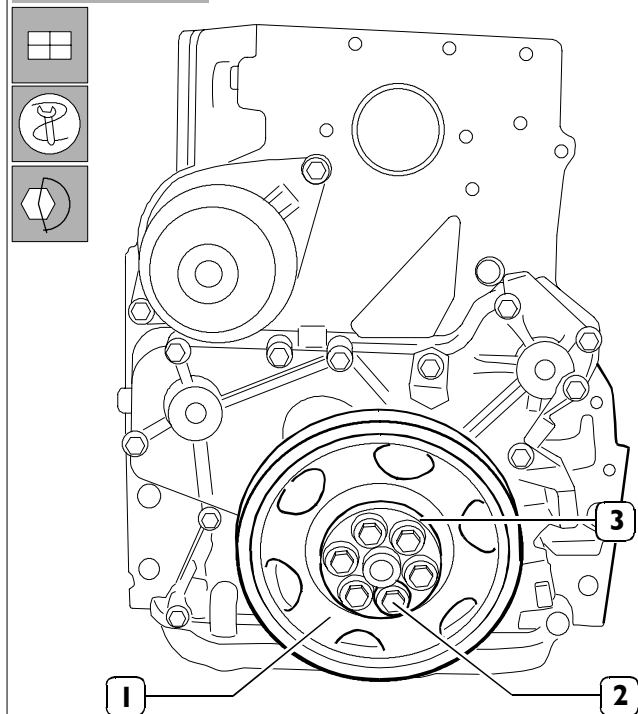


- ☐ Assemble oil pan (1), apply the plate over it (2). Tighten the screws (3) and lock them to the prescribed couple.



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

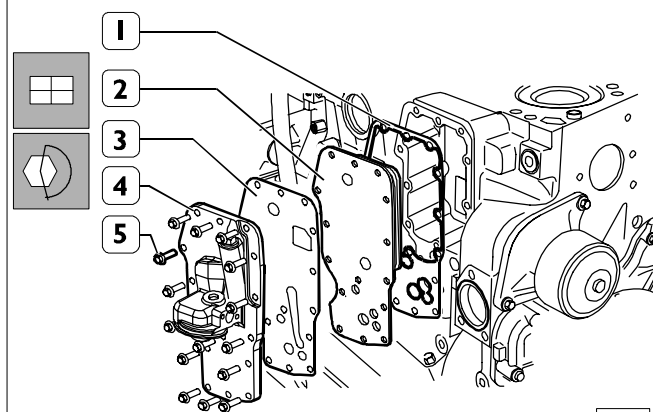
Figure 60



75697

- ☐ Assemble the pulley (1) to the engine drive shaft, and the distance ring (3).
- ☐ Tighten the fixing screws (2) and lock them to the 68 ± 7 Nm couple

Figure 61



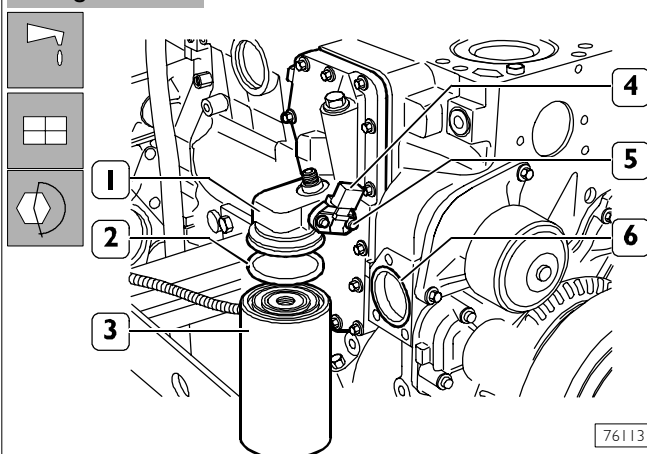
75814

- ☐ Assemble the following elements to the block: new gasket (1), heat exchanger (2), new gasket (3), oil filter bearing (4). Tighten the screws (5) and lock them to the prescribed couple.



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure 62



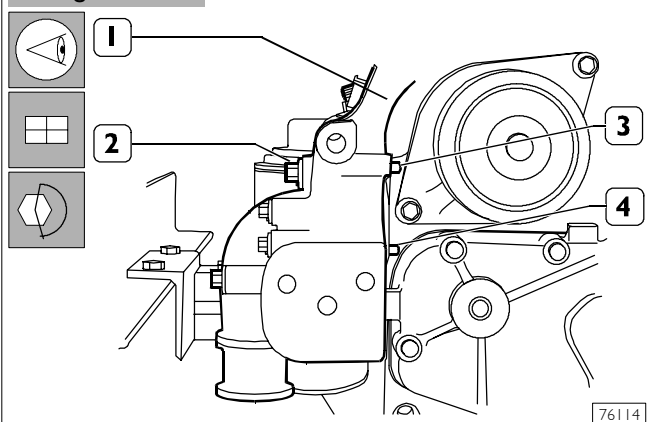
- ☐ Lubricate the fixing ring (2) using engine oil and place it on the oil filter (3).
- ☐ Manually start the oil filter (3) on the bearing union (1) until counter-boring, further screw up the oil filter (3) by 3/4 turn.
- ☐ Apply, (if needed) new fixing ring on the oil temperature/pressure sensor (4) and assemble it to the bearing (1) tightening the fixing screws to the prescribed couple.



In some applications, the bearing of the exchanger shall be assembled to a screw threaded union connected to the filter on the opposite side of the engine, throughout two pipelines (see picture 2).

- ☐ Place a new fixing ring on the block housing (6).

Figure 63

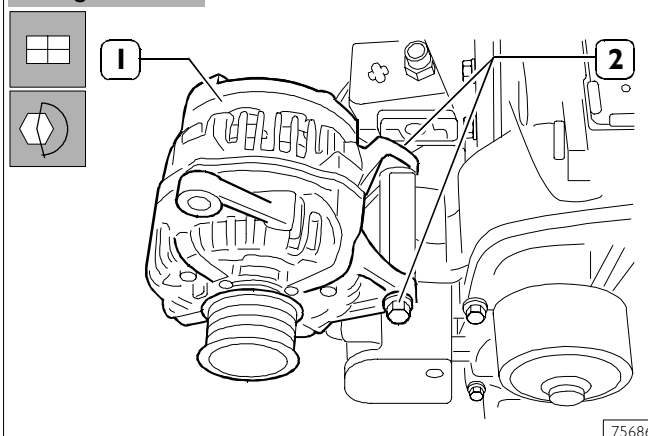


- ☐ Assemble the alternator bearing (1) ensuring that the pins (3 and 4) are against the engine block.
- ☐ Tighten the screws (2) and lock them to the prescribed couple.



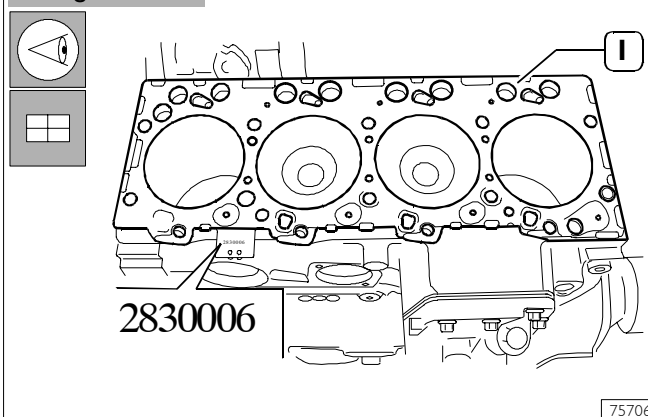
Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure 64



- ☐ Reassemble the alternator (1).
- ☐ Tighten the screw (2) and lock it to the prescribed couple.

Figure 65



- ☐ Place the gasket (1) over the block. The choice of the gasket's thickness shall be made in consideration of the cylinder protrusion measured with respect to the block's upper surface.

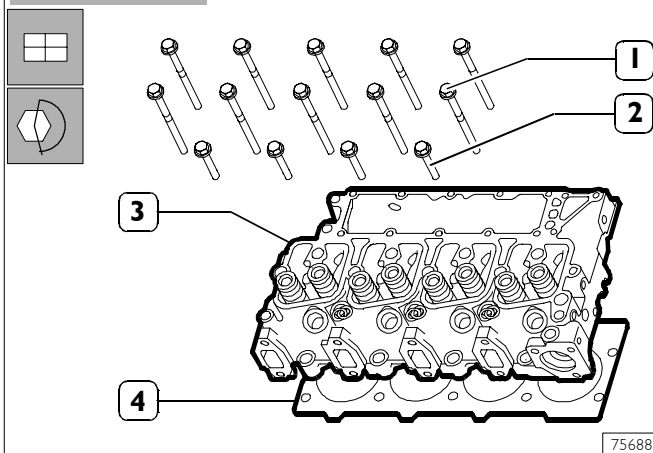


Verify that the engine block stand is clean.

Do not grease the gasket. It is recommended to keep the gasket inside packaging until assembly to the cylinder head.

Gasket assembly shall be made following the direction of wording printed on the gasket itself so that this will be readable as indicated in the picture.

Figure 66



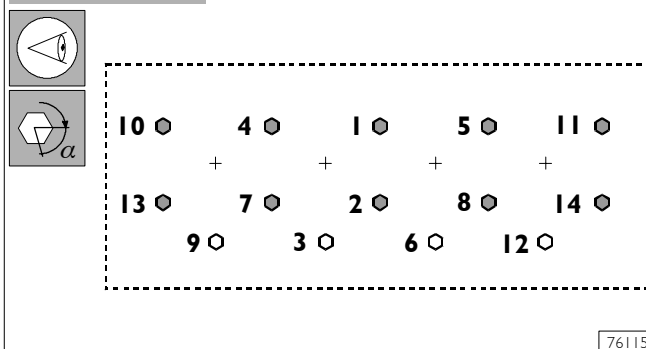
75688

- ☐ Place the head (3) over the block and insert screws (1) and (2).



If the valves have been removed from the head, it is necessary to assemble them before assembling the head itself on the engine block.

Figure 67

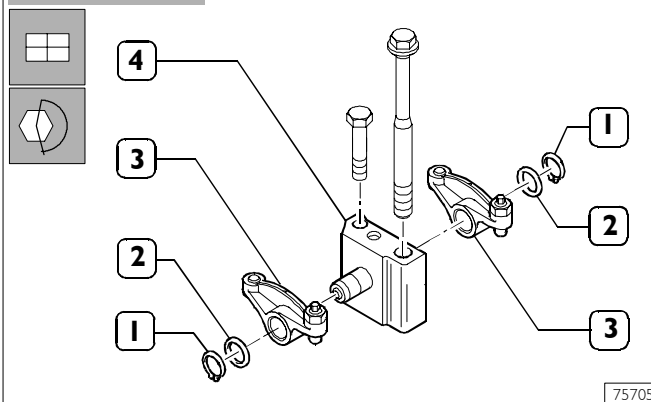


76115

- ☐ Lubricate cylinder head bolts and install to head.
- ☐ Bolts must be torqued using stitching pattern starting with the centre bolts and moving out. Bolts to be torqued in stages: all bolts torqued to snug torque, then 90 degrees rotation for all bolts. Then a further 90 degrees for the M12 x 140 and M12 x 180.

M12 x 70	50 Nm + 90 deg's
M12 x 140	40 Nm + 180 deg's
M12 x 180	70 Nm + 180 deg's

Figure 68



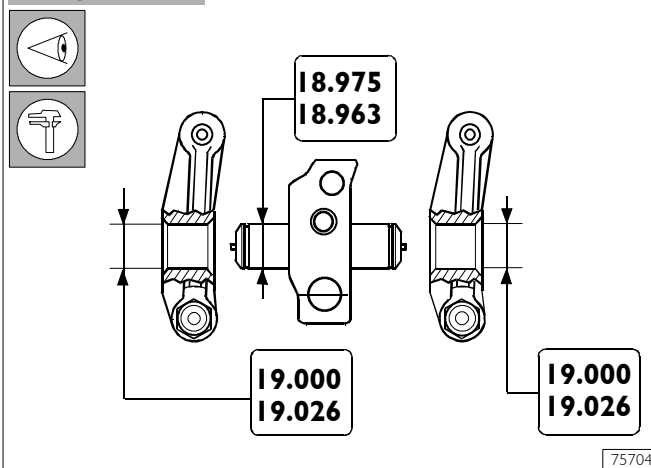
75705

- ☐ Carry out the assembly of the rocker arms after previous check of the components.

ROCKER ARM UNIT COMPONENTS:

1. Elastic ring – 2. Spacer – 3. Rocker arms – 4. Support.

Figure 69

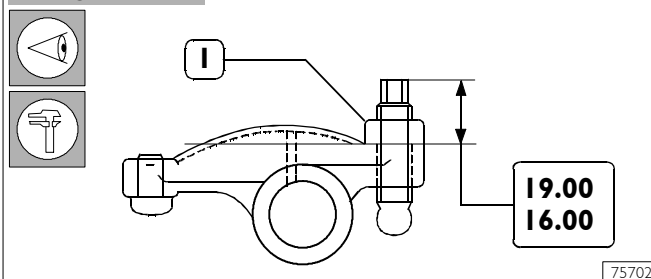


75704

SHAFT AND ROCKER ARM BASIC DATA

Check the coupling surfaces of bearing and shaft: no evidence of excessive wear shall be detected or damages. Replace if necessary.

Figure 70

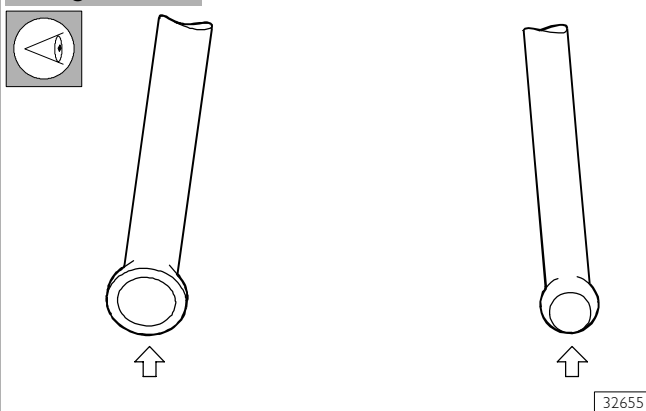


75702

ROCKER ARM ADJUSTMENT SCREW

If unscrewed, check adjustment quota.
Tighten the screw-threaded nut (1) to the 0.25 – 0.75 Nm couple.

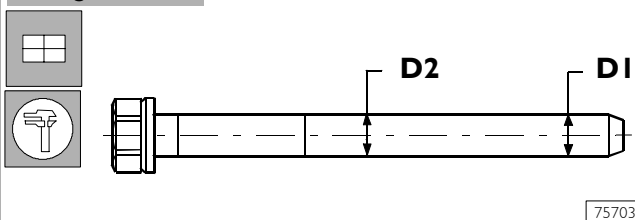
Figure 71



Before executing assembly, check the Rocker Arm driving rods: these shall not be deformed; the spherical ends in contact with the Rocker Arm adjustment screw and with the tappet (arrows) shall not present evidence of seizure or wear: in case of detection proceed replacing them.

The rods driving the suction and exhaust valves are identical and therefore interchangeable.

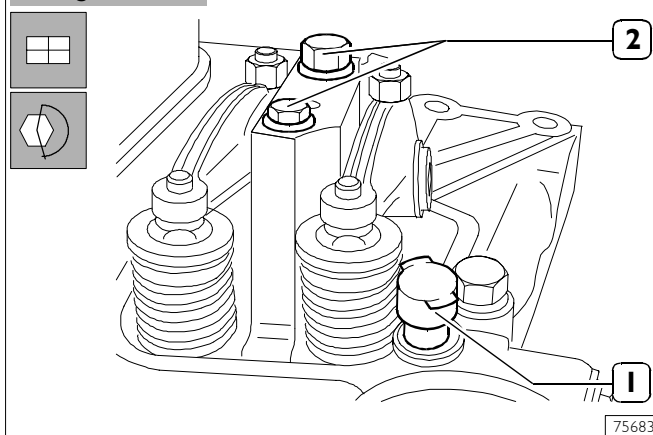
Figure 72



- Insert the tappet driving rods and the Rocker Arm unit. Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:

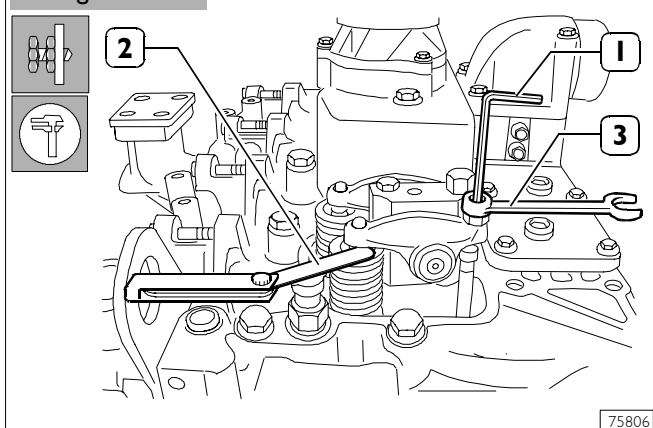
if $D1 - D2 < 0,1$ mm the screw can be utilised again;
if $D1 - D2 > 0,1$ mm the screw must be replaced;

Figure 73



- Tighten the screws (2) to the prescribed couple and assemble water temperature sensor (1).

Figure 74



Adjust the slack between rocker arms and valves using socket wrench (1), point wrench (3) and feeler gauge (2).

Correct working slack is:

- suction valves 0.30 ± 0.05 mm
- exhaust valves 0.55 ± 0.05 mm.



In order carry out a quicker adjustment of the working slack between rocker arms and valves, proceed as following:

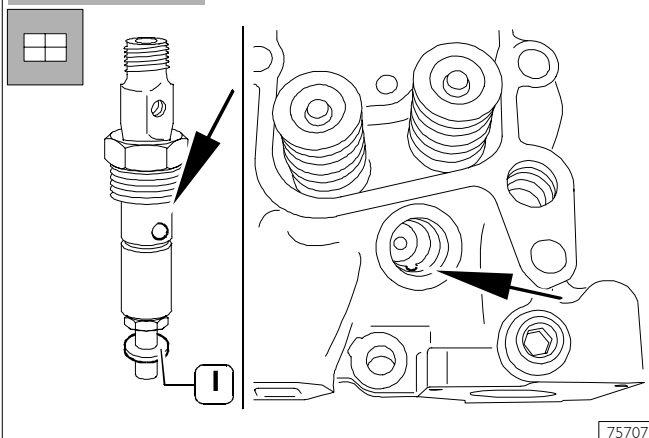
Rotate the engine drive shaft, balance the valves of cylinder 1 and adjust the valves identified by star symbol, as indicated in the following table:

Cylinder n	1	2	3	4
Suction	*	—	—	—
Exhaust	*	*	*	—

Rotate the engine drive shaft of 360 deg., balance the valves of cylinder 4 and adjust the valves identified by star symbol, as indicated in the following table:

Cylinder n°	1	2	3	4
Suction	—	*	*	*
Exhaust	—	—	—	*

Figure 75

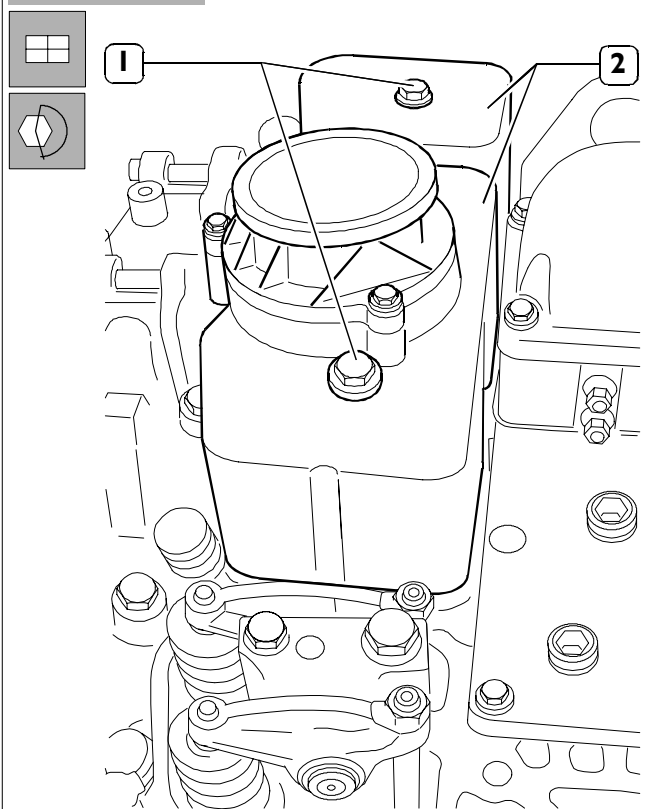


75707

- ☐ Assemble injectors after having replaced the sealing gasket (1).

 During assembly of injectors, verify that the injector sphere is correctly positioned on the head housing.

Figure 76



75681

- ☐ Assemble cylinder covers (2) with the respective gaskets;
- ☐ Fit the seal nodes and tighten the screws fixing them to the prescribed couple.

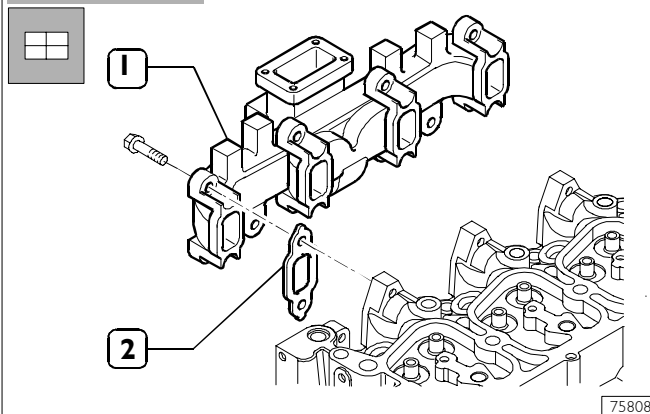


Always replace the gaskets using new ones.

Check the threads of the fixing screws: there shall be no evidence of wear or dirt deposit.

Seal nodes shall have no visible deformation. In such case provide for replacement with new nodes.

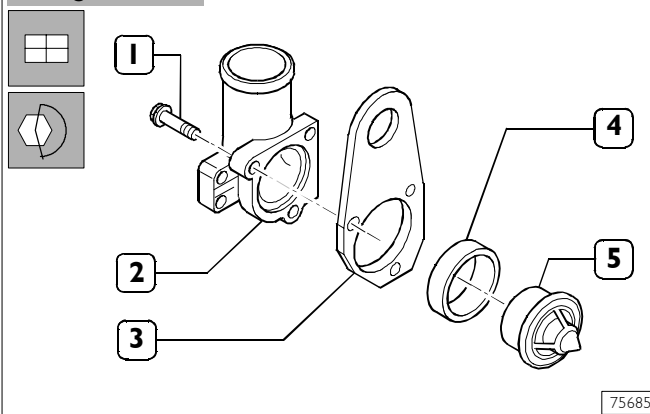
Figure 77



75808

- ☐ Assemble exhaust manifold (1) providing new gaskets (2).

Figure 78



75685

- ☐ Assemble thermostat unit (2) including thermostat (5) and gasket (4).
- ☐ Tighten the screws to the prescribed couple.

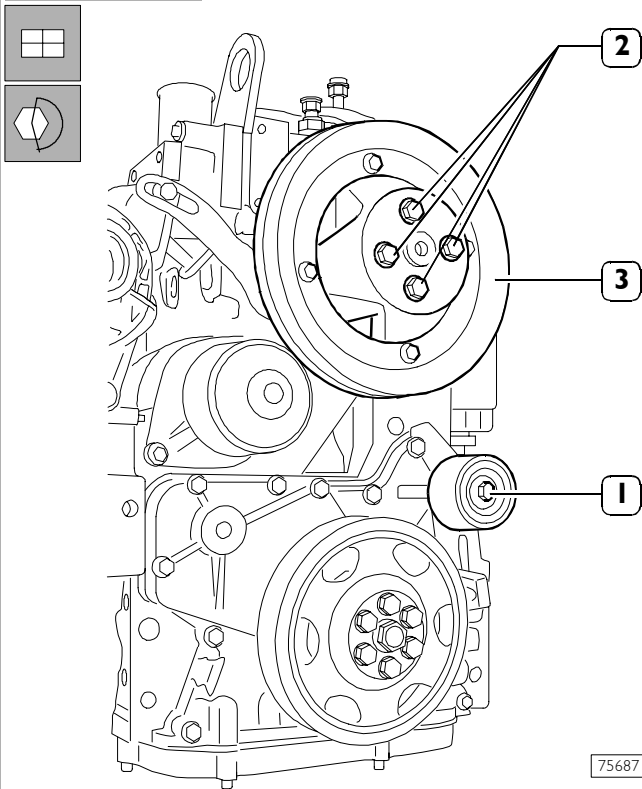


The screws (1) have been utilised to fix the bracket (3).

Disassemble the bracket and reassemble components from 1 to 5 as shown in the picture.

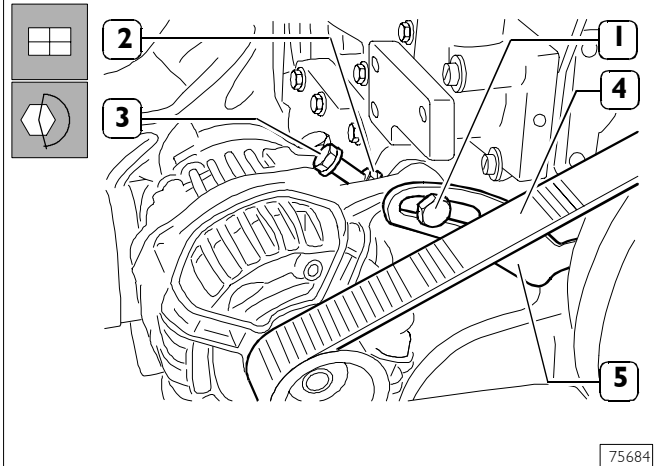
The gasket must be new.

Figure 79



- ☐ Assemble the pulley fan bearing tightening the screws to the prescribed couple.
- ☐ Assemble the alternator tensioning bracket.
- ☐ Assemble the two pulleys (3) and fix them tightening the screws (2) of the bearing.
- ☐ Assemble the transmission pulley (1).

Figure 80

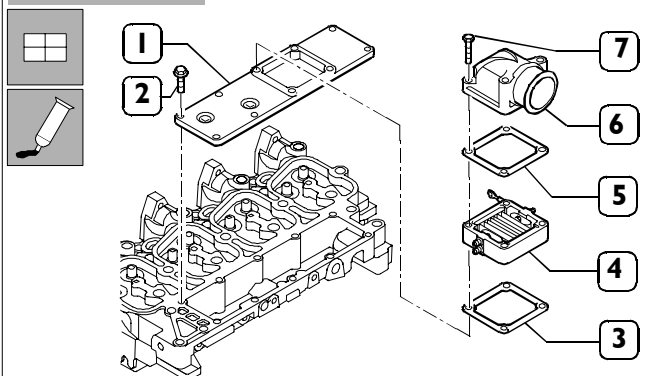


- ☐ Assemble the driving belt (4) tighten the screw (1) without locking it in order to let it slide within the bracket hole (5).
- ☐ Adjust belt tensioning by tightening the screw (3). After having set correct tensioning block the check nut (2) and the screw (1).



In case the same belt priory removed is assembled again, proceed examining it carefully to check there

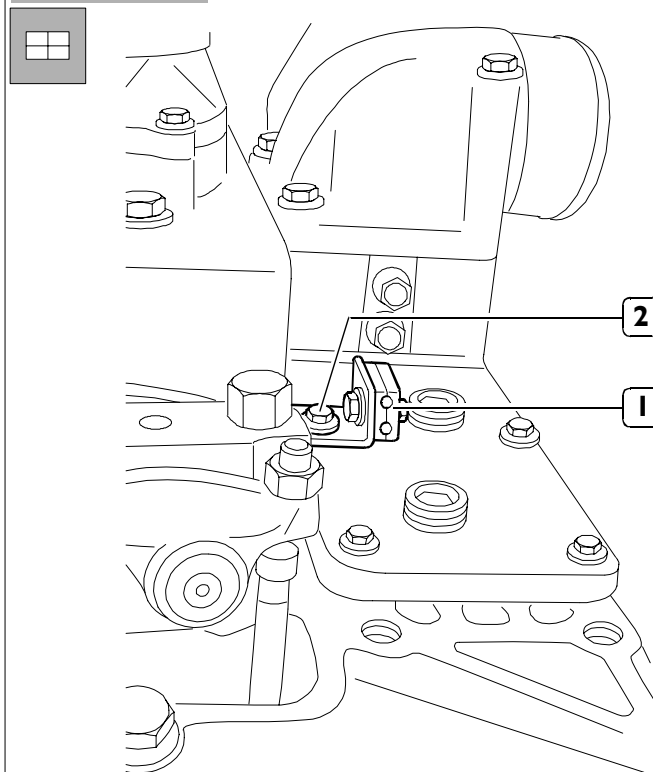
Figure 81



75701

- ☐ Apply on the surface joining the suction manifold plate (1) a sufficient coat of Loctite 5999 and provide, fixing the screws to the prescribed couple.
- ☐ If the pipe (6) of the suction manifold plate (1) has been removed, reassemble it after having fit a new gasket (5).
- ☐ Tighten the screws (7) to the prescribed couple.

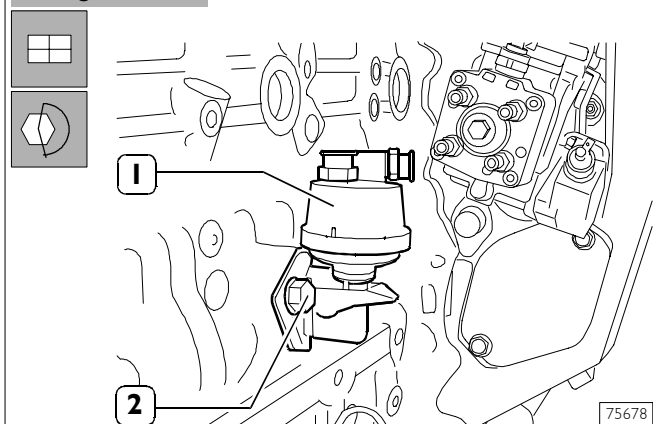
Figure 82



75700

- ☐ Also assemble the brackets (1) fixing the fuel pipelines to the injectors: use the same screws (2) fixing the manifold plate as shown in the picture.

Figure 83



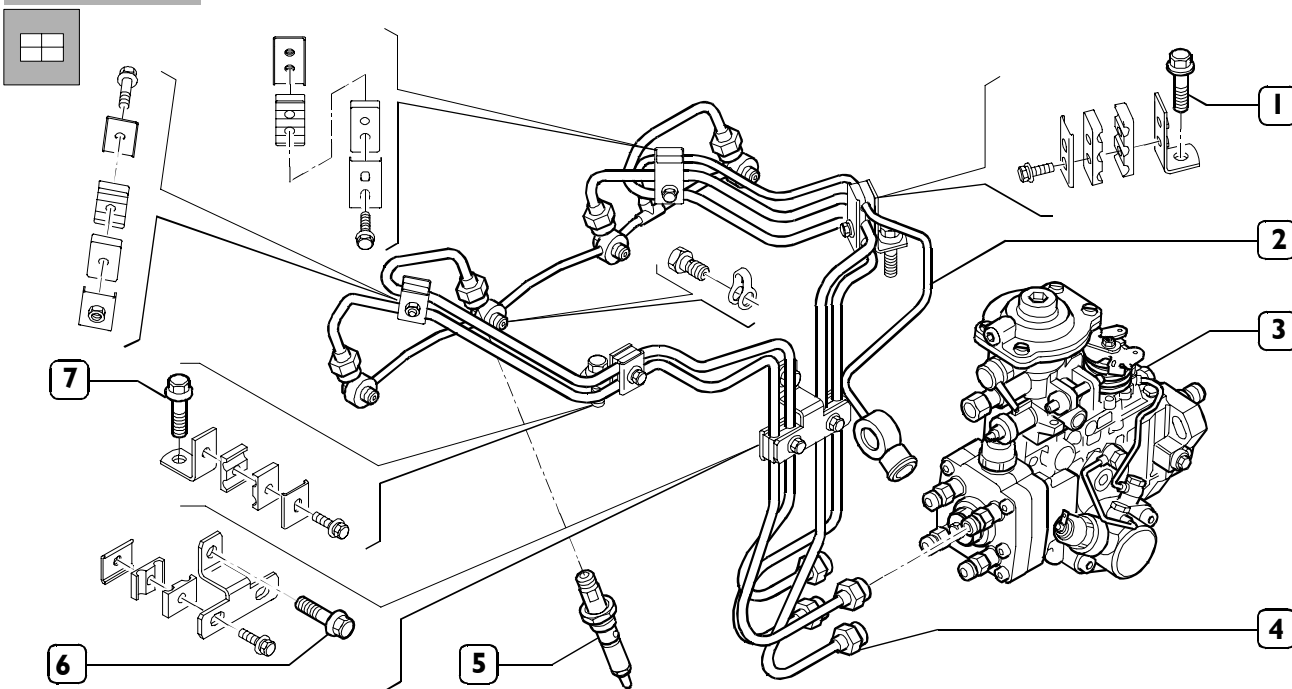
75678

- ☐ Assemble priming pump (1) providing new gasket and tighten the screws (2) to the prescribed couple.
- ☐ Also assemble feed pump (see specific procedure) and the power take-off underneath.



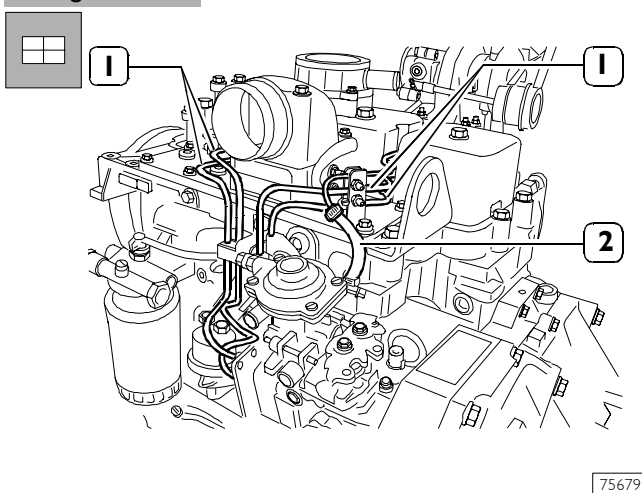
Pump assembly requires specific procedure as reported at the end of the hereby section.

Figure 84



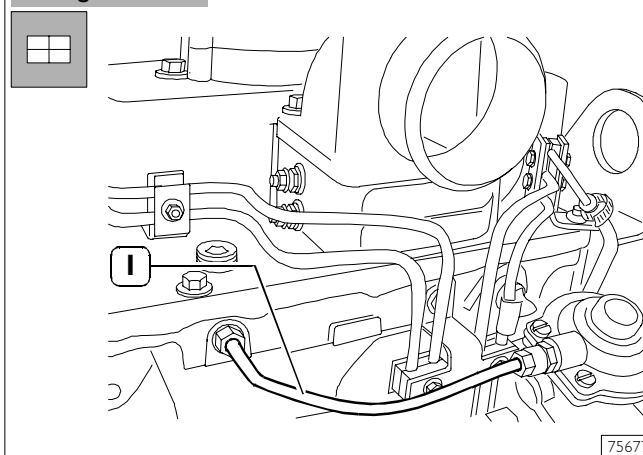
1. Rear bracket fixing screw (on suction collector plate) – 2. Fuel recovery pipeline to pump – 3. Rotary feed pump – 4. Connection nut to pumping elements – 5. Injector – 6. Bracket fixing screw to injection pump side – 7. Front bracket fixing screw (on suction collector plate)

Figure 85



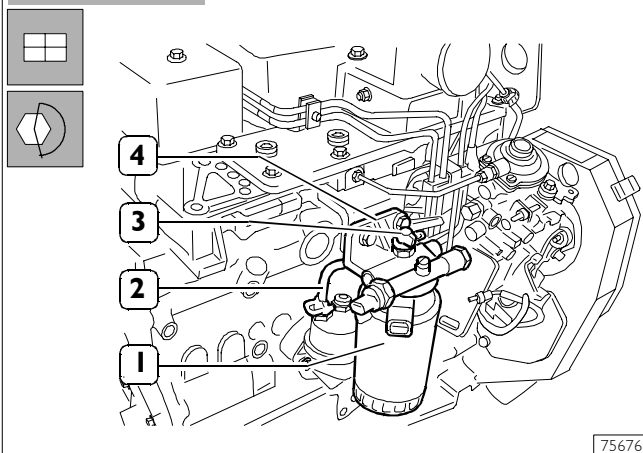
- ☐ Assemble the pipes (1) and (2) providing fuel feed and recovery between pump and injectors; Screw up the locking nuts and tighten the screws fixing the fuel recovery manifold; fix the pipes to the injectors throughout the brackets previously assembled.

Figure 86



- ☐ Fix the LDA pipeline (1) to the engine head and to the feed pump.

Figure 87

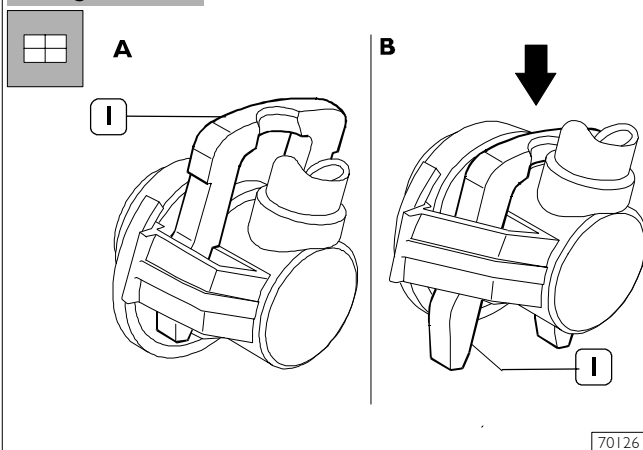


- ☐ Assemble the fuel filter bearing (4) to the bracket fixed to the engine head.
- ☐ Connect the fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to feed pump.
- ☐ ☐ Using acceptable tools assemble fuel filter (1).



The filter shall be priority filled with fuel to facilitate feed system bleed operations.

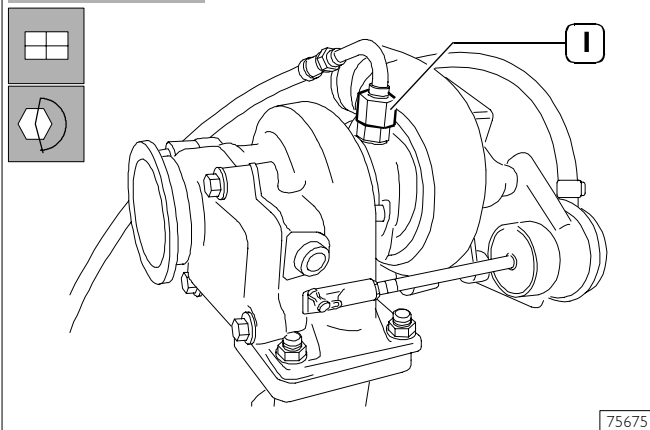
Figure 88



To connect fuel pipelines (2 and 3, Figure 87) in low pressure from the relating connection unions it is necessary to press the locking fastener (1) as shown in picture B.

After having connected the pipeline, reset the fastener (1) into block position as shown in picture A.

Figure 89

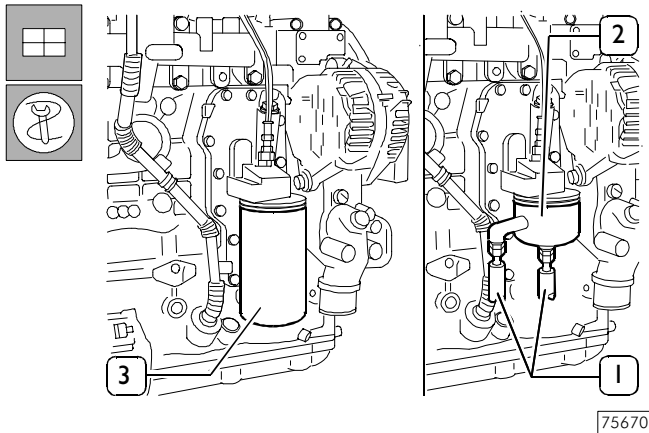


Proceed assembling the turbocharger:

- ☐ Hold the turbocharger and place it on the exhaust manifold after having interposed the gasket.
- ☐ Screw up the fixing nuts of the turbocharger to the exhaust manifold tightening them to the prescribed couple.
- ☐ Tighten the lubrication pipe fixing ring. Operate in the same way on the other end of the pipe. Connect it to the upper part of the heat exchanger.

To complete engine assembly it is necessary to remove it from the turning stand.

- ☐ ☐ Using acceptable tools, hold the engine and loosen the screws fixing the brackets to the turning stand.
- ☐ Disassemble the brackets from the engine after having properly put it on a wooden bearing.

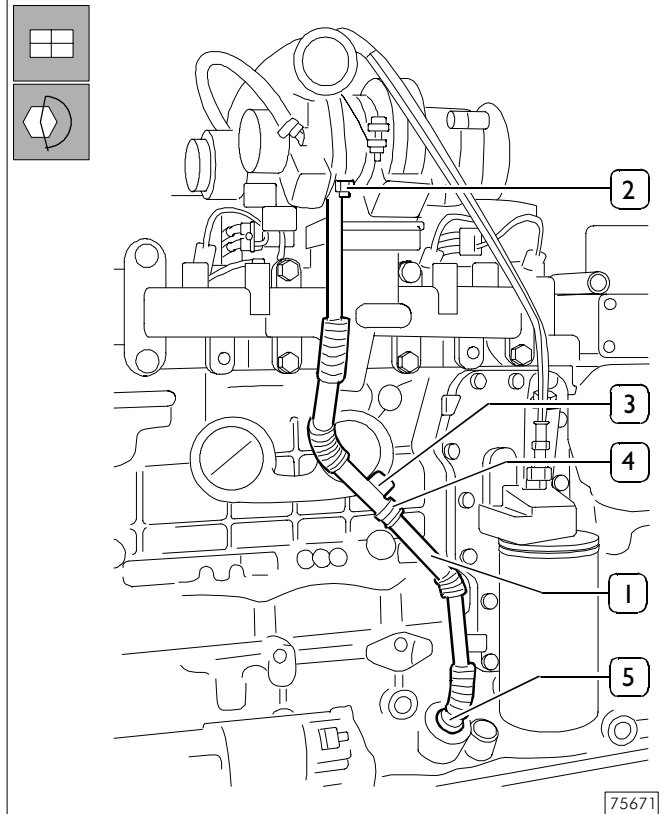
Completion of the engine**Figure 90**

On the right hand side:

- reassemble the pipes (1) from the union (2) to the lubrication oil filter (placed on the opposite side): tighten the pipe rings (1) and connect them to the union

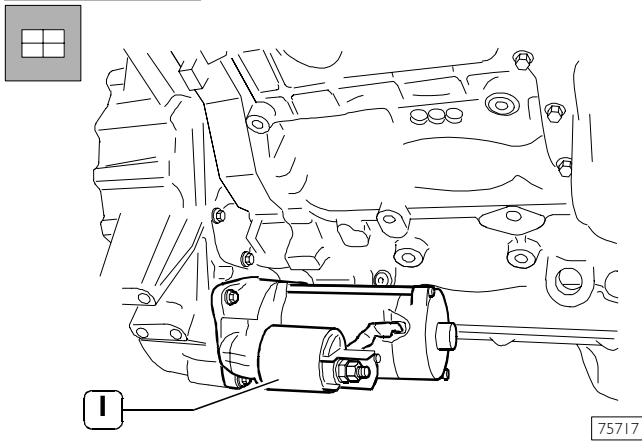


In some cases, the oil filter (3) is directly placed on the heat exchanger: in this case it shall be assembled using acceptable tools.

Figure 91

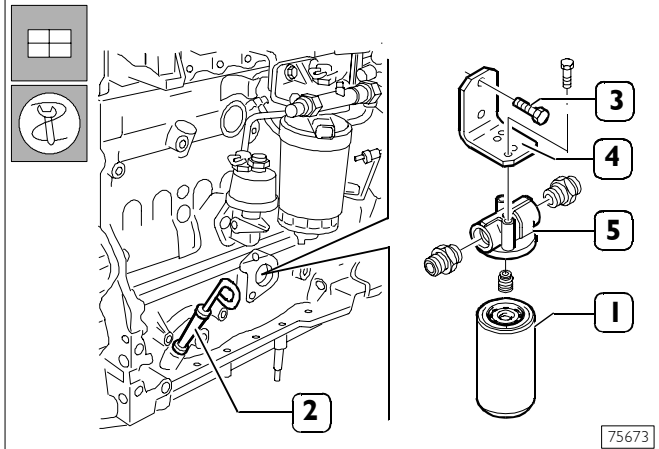
- Reassemble the lubrication oil exhaust pipeline (1) from the turbocharger: from underneath the turbocharger tighten the two screws (2); tighten the screw (3) fixing the pipeline to the block throughout the fixing collar (4) to the block; finally tighten the union (5) to the block.

Figure 92



- ☐ Reassemble the starter; properly hold the starter (1) and tighten the fixing screws (2) to the prescribed couple.

Figure 93



On the left hand side:

- ☐ Assemble oil filter (1) together with bracket (for the versions with engine oil filter not directly assembled to the exchanger); tighten the screws (3) assembling the bracket (4) including filter bearing (5).
Use acceptable tools to install the oil filter;
- ☐ Assemble oil level rod together with guide pipe (2). Fill up engine oil.
- ☐ Install the engine on the machine (for installation operations please apply to specific issue).

Rotary feed pump disassembly e assembly procedure



This procedure prescribes that:

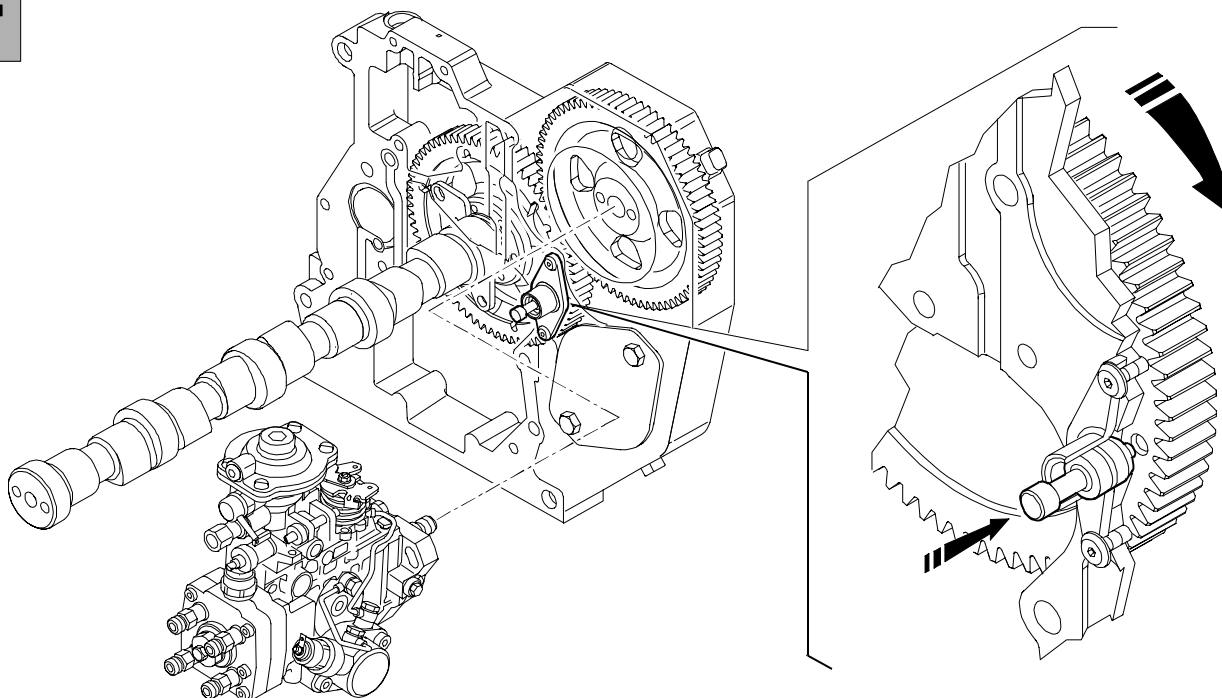
- ☐ The fuel pipelines (from pumping elements to injectors, bleeding recovery pipes from injectors to pump, LDA pipeline and feed provided by priming pump) shall all be disassembled.
- ☐ Electrical connection to feed pump shall be disconnected.
- ☐ Accelerator cable shall be disconnected.

In case feed pump replacement is necessary, this shall be supplied pre-set already as spare part.

On the other hand, in case the pump shall be disassembled and reassembled later on without being repaired it will be necessary to pr-set it while it is still assembled to the engine and disassemble it only afterwards.

The following procedure analyses this second hypothesis since it is the more complex.

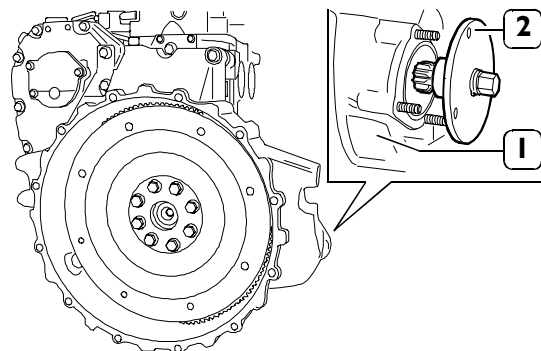
Figure 95



75698

- ☐ Rotate with caution the flywheel following its own rotation sense to annul the gear slacks and at the same time keep the (→) pin pressed until when this last one is fitting into the port of the camshaft gear. This way the P.M.S. shall be determined within N.I. cylinder.

Figure 94



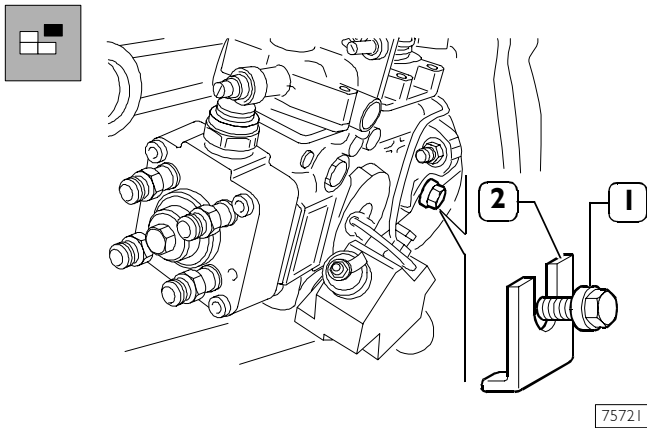
75714

- ☐ Disassemble the starter from the flywheel box (1) and use the 380000988 tool (2) to rotate the flywheel.



Flywheel rotation shall be carried out with extreme caution. The pin charged by excessive shearing stress may get damaged.

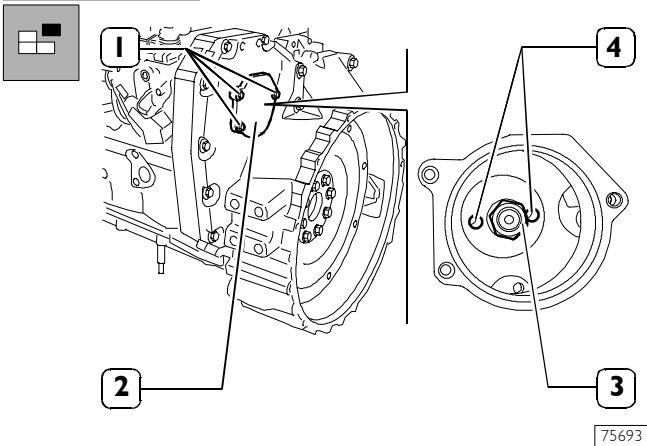
Figure 96



75721

- ☐ Partially loosen the lateral screw (2) locking the pump shaft and remove the slip washer (2). Absolutely keep the slip washer (it is recommended to fix it with stripe or wire to the pump).
- ☐ Tighten the lateral screw (1) blocking rotation of the pump shaft.

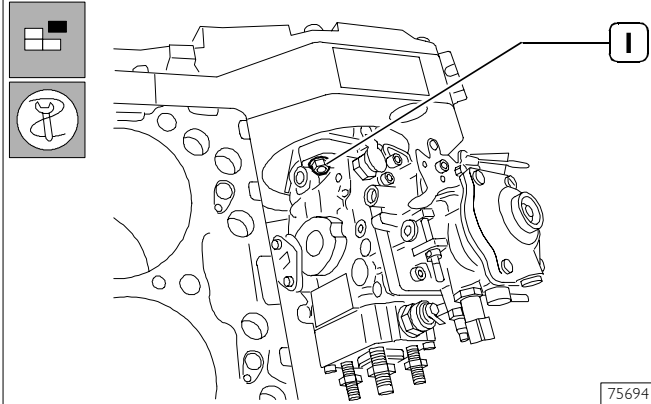
Figure 97



75693

- ☐ From timing side, remove the cover (2) loosening the screws (1) in order to have access to the union fixing nut (3) to the pump driving gear.
- ☐ Loosen the fixing nut (3) and remove the relating washer.

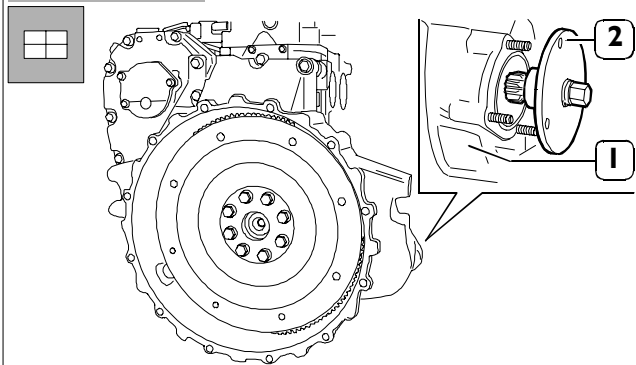
Figure 98



75694

- ☐ From the pump side, loosen the fixing nuts (1) without removing them in order to enable moving the pump backwards using 380000979 extractor.
- ☐ Assemble the 380000979 extractor throughout the two threaded ports (4, Figure 97) and withdraw the gear from the pump shaft.
- ☐ Properly hold the feed pump and loosen completely the fixing nuts.
- ☐ Withdraw the pump from the studs, together with the gasket.

Figure 99



75714

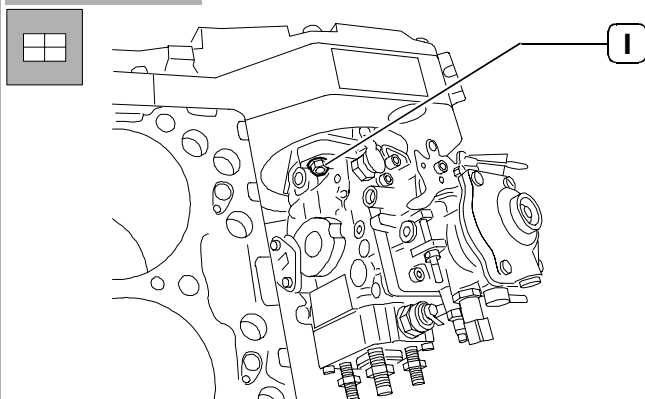
When assembling the feed pump to the engine, it is necessary to meet the P.M.S. requirements for the N.I. cylinder.

- ☐ Use the 380000988 tool (2) on the flywheel box (1) to carry out flywheel rotation and operate using the pin as previously described.



Hold the pump driving gear to avoid interference or crawling during timing gear rotation.

Figure 100

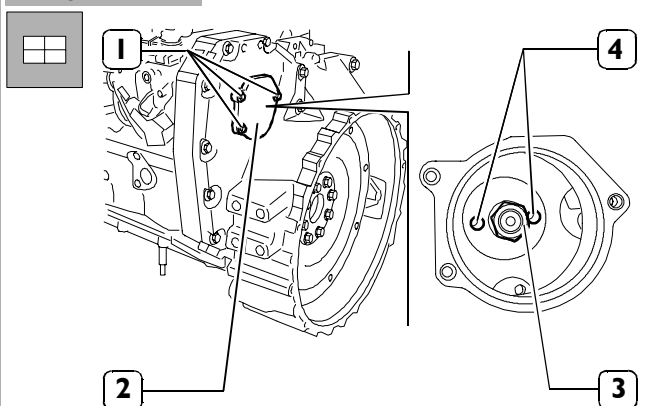


- ☐ Assemble the pump pre-set in its housing on the engine, fitting the shaft into the gear port (not provided with wrench).
- ☐ Tighten the fixing nuts (1) locking the pump flange in the slot centre.



The gasket removed during pump disassembly shall not be utilised again.
Always use original spare parts.

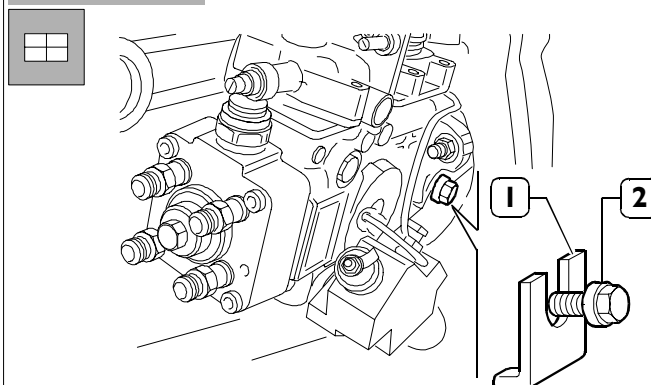
Figure 101



75715

- ☐ On the timing side, throughout the specially appointed port, fit the washer and screw up the fixing nut (3) to the pump shaft. Lock the nut to the 90–95 Nm couple.

Figure 102



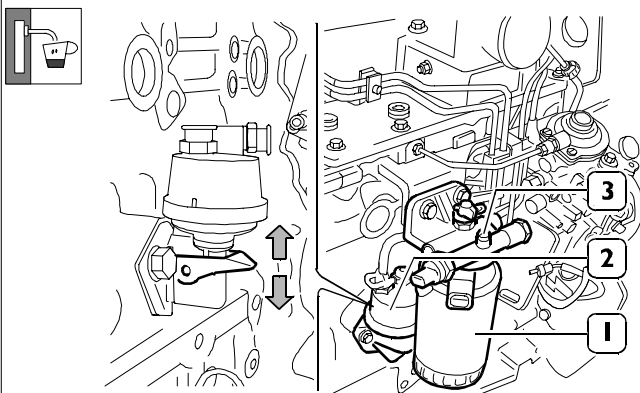
- ☐ Partially loosen the screw (2) locking the pump shaft rotation and fit the slip washer (1). Tighten the screw fixing above said washer: this way the feed pump shaft is free to rotate.
- ☐ Assemble the cover (2, Figure 101) including gasket and tighten the screws (1, Figure 101).
- ☐ Pull the pin outwards setting the camshaft gear free.
- ☐ Disassemble the 380000988 tool locking flywheel rotation; place the starter in its housing.
- ☐ Connect all pipelines (from pumping elements to injectors, bleeding recovery pipes from injectors to pump, LDA pipeline and feed provided by priming pump).
- ☐ Connect electrical connections to electro-magnets on the hydraulic head and on KKSBB.



In case pump removal has been carried out while the engine was assembled, connect acceleration cable.

Feed system bleed procedure

Figure 103



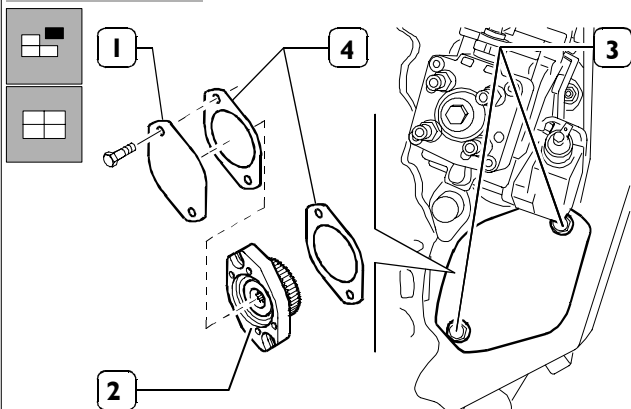
76211

In case any operation has been executed on the components of the feed circuit, it is necessary to execute bleeding of air within the system.

- ☐ Loosen the bleeder vent screw (3) on the fuel filter (1) and keep working on the bleed lever of the priming pump (2).
- ☐ Continue executing this operation until when fuel drains from the bleeder vent screw.
- ☐ Tighten the bleeder vent screw (3)

Power take-off disassembly and assembly procedure

Figure 104



75720

Where designed, there is a power take-off able to transmit motion to different auxiliary parts.

Disassembly of such mechanism shall be executed as following:

- ☐ Loosen the two screws (3) and after having removed the cover (1) with a specially provided extractor, withdraw the power take-off (2).
- ☐ The two gaskets (4) shall be replaced in phase of reassemble.

- ☐ Vary out the assembly fitting the power take-off in its housing, providing new gasket and checking the sprocket gear meshing.
- ☐ Assemble cover and gasket and tighten the screws to the prescribed couple.

Checks and controls



The following tests shall be made after engine assembly to the vehicle.

Preventively check that the liquid levels have been correctly restored.



Start the engine, let it run at revolution regimen slightly higher than idling and wait that the cooling liquid temperature reaches the value enabling thermostat opening, then check that:



- ☐ There is no water bleeding from the manifolds connecting engine cooling circuit pipelines and cabin internal heating, eventually providing to further tighten the locking rings.
- ☐ Carefully check the fuel connection pipes to the respective unions.
- ☐ There is no oil leakage from the lubrication circuit of the various pipelines connecting cover and.
- ☐ Cylinder head, oil pan and bearing, oil filter and heat exchanger as well as relating housings.
- ☐ There is no fuel leakage from fuel pipelines.
- ☐ There is no blow-by from pneumatic pipes (if provided).
- ☐ Verify correct working of the lighting leds of the dashboard containing the tools as well as of the equipment that was disconnected during engine disconnection.
- ☐ Check and blow by with care the engine cooling system, carrying out frequent drainage.

OVERHAUL OF ENGINE PROVIDED WITH MECHANICAL IN LINE PUMP

Preface

Part of the operations illustrated within this section can be partially executed while the engine is assembled on the vehicle, depending on the room available for access to the engine and on the equipment application as well.



With regard to the engine disassembly operations, please apply for information consulting the specific manual. All operations of engine disassembly operations as well as overhaul operations must be executed by qualified engineers provided with the specific tooling and equipment required.

The following information relate to the engine overhaul operations only for what concerns the different components customising the engine, according to its specific duties.

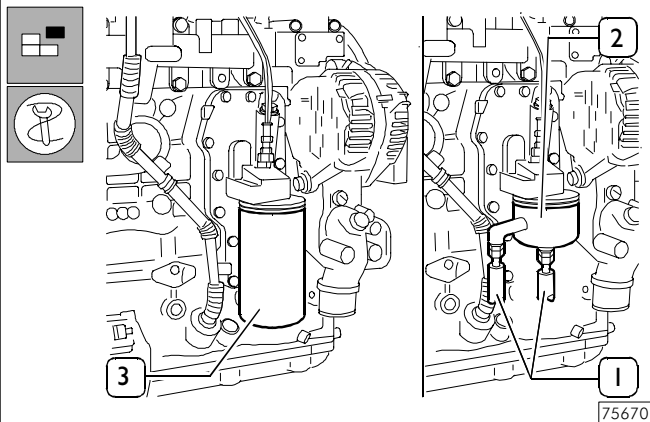


For specific application exigencies, some units can be assembled to the engine in different positions.

Within "General overhaul" section, all the operations of engine block overhaul have been contemplated. Therefore The above mentioned section is to be considered as following the part hereby described.

Engine setting operations for the assembly on turning stand

Figure 105



In order to apply the brackets to the engine block to fix it on to the stand for the overhaul, it is necessary to perform the following operations:

On the right hand side:

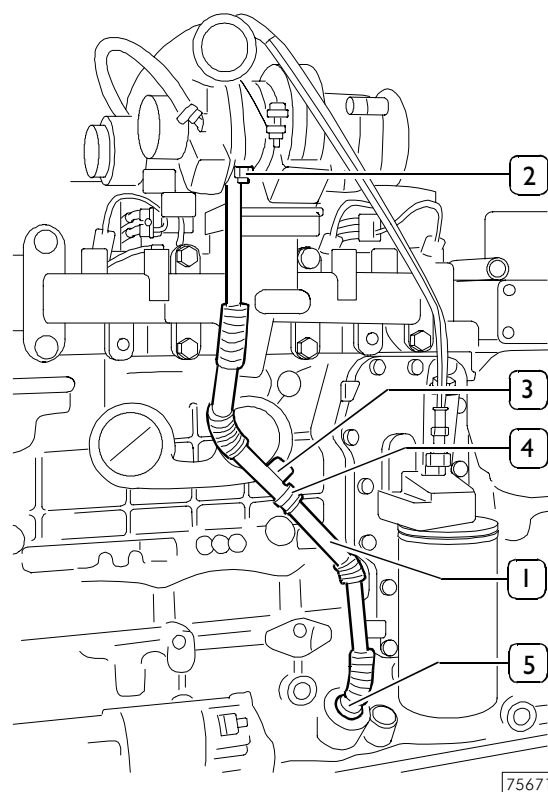
- disassemble pipes (1) from the union (2) fitting the lubrication oil filter (assembled on the opposite side): unlock the nuts fixing the pipes (1) and remove them from the union (2); drain the oil eventually still inside the pipes and plug them properly in order to avoid impurity inlet.



For some versions, the oil filter (3) is directly assembled on to the heat exchanger: in such case it shall be disassembled using acceptable tools.

Warning: the oil filter contains inside aprx. 1 kg. of engine oil. Provide for oil recovery and disposal in compliance with the law and regulations in force.

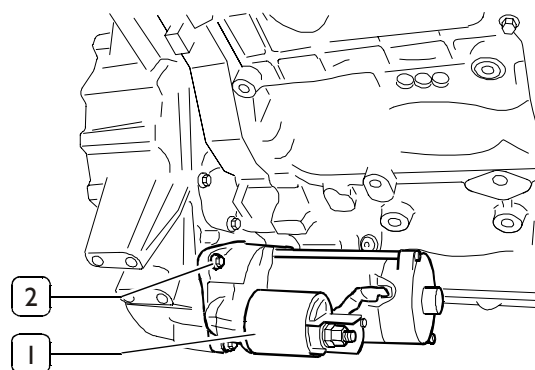
Figure 106



- disassemble lubrication oil exhaust pipe from the turbo-blower:

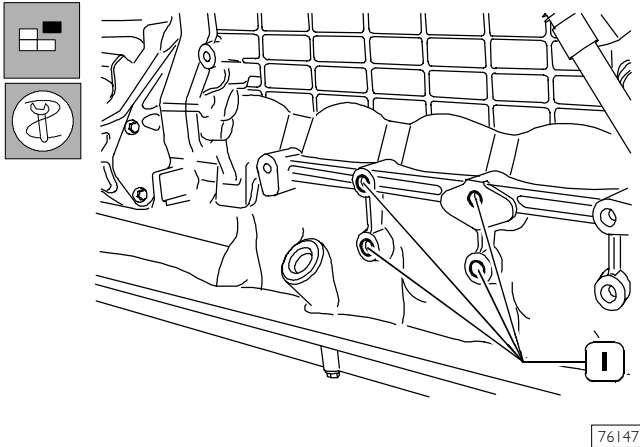
Underneath the turbo-blower loosen the two screws (2), loosen the screw (3) fixing the pipe throughout the stop collar (4) fixing the block; finally loosen and remove the union (5) from the block; plug the pipe ends and the exhaust of the turbo-blower.

Figure 107



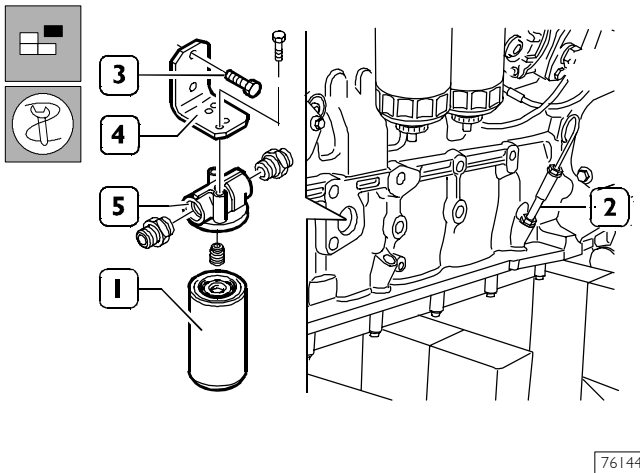
- Disassemble the starter; Properly hold the starter (1) and loosen the two fixing screws (2)

Figure 108



- ☐ Assemble the bracket using the four screw threaded ports (I).

Figure 109



On the left hand side:

- ☐ Disassemble oil filter (1) and bracket as well (for versions with engine oil filter not directly assembled on to the exchanger);
Use acceptable tools to remove the oil filter;
Loosen the screws (3) removing the bracket (4) together with the filter bearing (5).



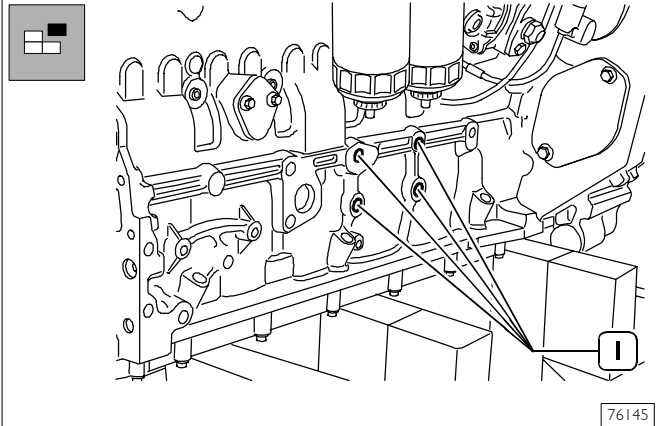
Warning: the oil filter contains inside aprx. 1 kg. of engine oil.
Provide tank with sufficient capacity to contain the liquid.

Warning: avoid contact of engine oil with the skin: in case of skin contamination rinse in running water.

Engine oil is highly pollutant: provide for disposal in compliance with the law and regulations in force.

- ☐ Remove the oil level rod together with guide pipe (2); (loosen the guide pipe disassembling from the block); properly pipe the screw-threaded port to avoid inlet of foreign matters.

Figure 110

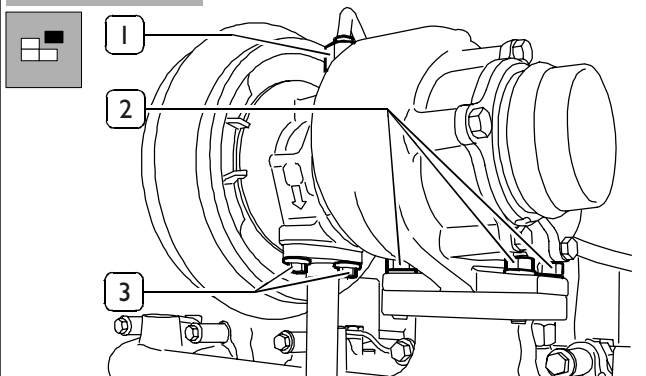


- ☐ Assemble the second bracket throughout the screw-threaded ports (I).
- ☐ Lift the engine using acceptable tools and put it on the turning stand.
- ☐ Drain the oil through the cap underneath the plug.



Warning: avoid contact of engine oil with the skin: in case of skin contamination, rinse in running water.

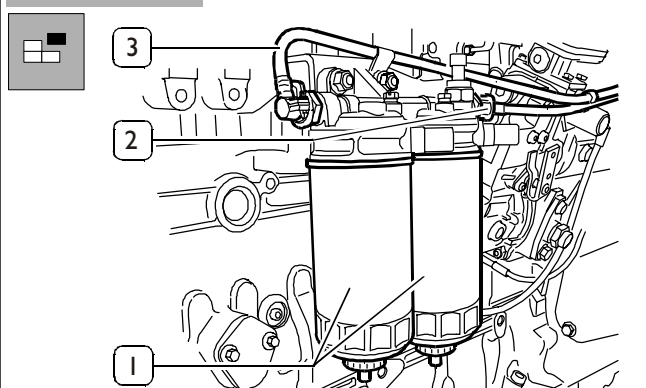
Engine oil is highly pollutant: provide for disposal in compliance with the law and regulations in force.

Disassembly of application components**Figure 111**

76143

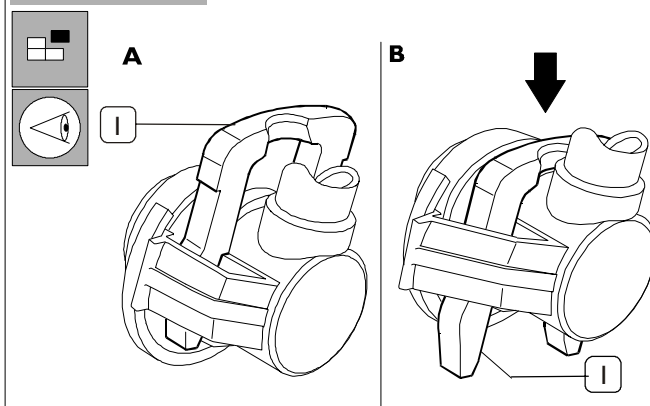
Proceed disassembling the supercharger:

- ☐ Loosen the fixing nut (1) and remove the lubrication pipe from the supercharger. Analogously carry out the same operation on the other end of the pipe and remove it from the upper part of the heat exchanger.
- ☐ Loosen the fixing screw (3) and remove the exhaust lubrication pipe from the supercharger.
- ☐ Loosen the screw nuts fixing the supercharger on the exhaust manifold.
- ☐ Hold up the supercharger and after lifting it remove the gasket.

Figure 112

76141

- ☐ Place a container under the fuel filter and screw out the condensate drain faucet underneath said filter. Carry out complete drainage of the fuel contained therein.
- ☐ Screw out completely the faucet and use acceptable tools to disassemble oil filters (1).
- ☐ Disconnect fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to the feed pump.
- ☐ Remove the fuel filter bearing from the bracket fixed to the engine head.

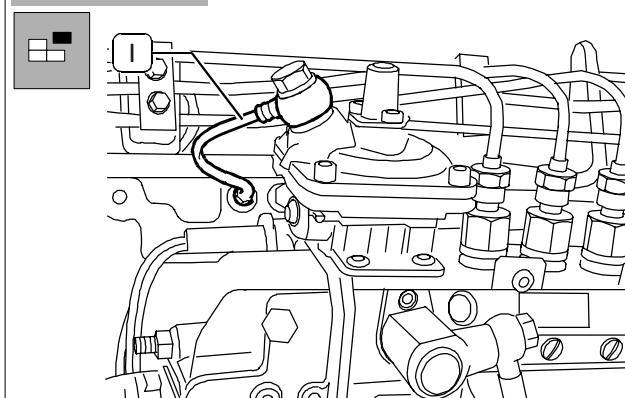
Figure 113

70126



To disconnect fuel pipelines (2 and 3, picture 8), in low pressure from the relating pipe fittings, it is **Necessary to press the locking fastener (1) as shown in picture B.**

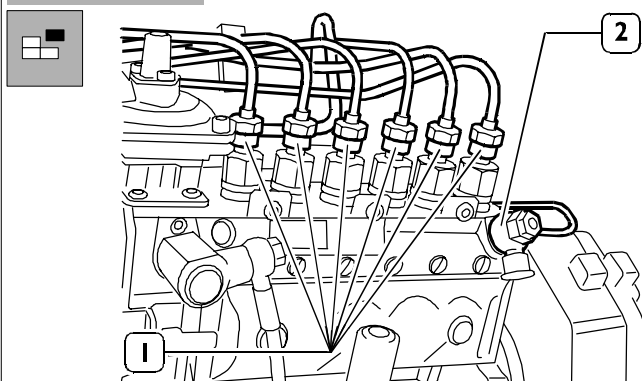
After having disconnected the pipeline, reset the locking fastener (1) in lock position as shown in Picture A, to avoid any possible deformation of the fastener itself.

Figure 114

76139

- ☐ Disconnect the LDA pipe (1) from the head and from the feed pump. Pipe the ends of the pipelines as well as the feed pump and the engine head.

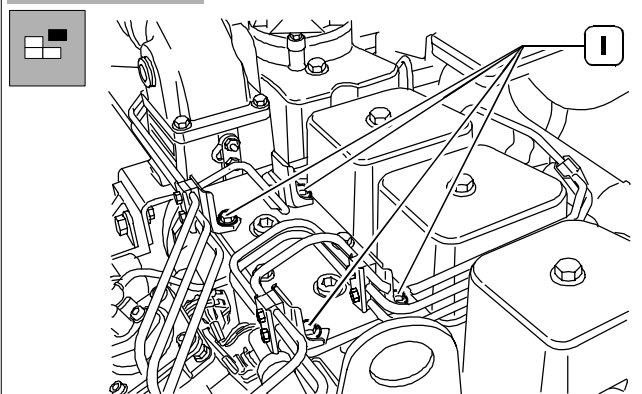
Figure 115



76138

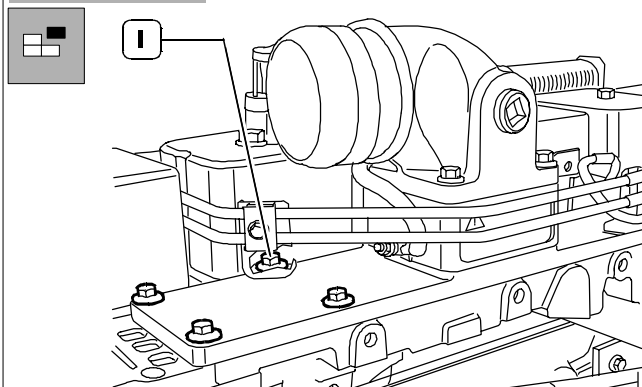
- ☐ Disconnect the pipelines (1) and (2) that provide feed and fuel recovery between pump and injectors; screw out the nuts fixing the pipes to the pumping elements; loosen the fuel recovery pipe collar on the injection pump; operate on the nuts assembled to the injectors and loosen the screws fixing the fuel recovery pipeline.

Figure 116



76148

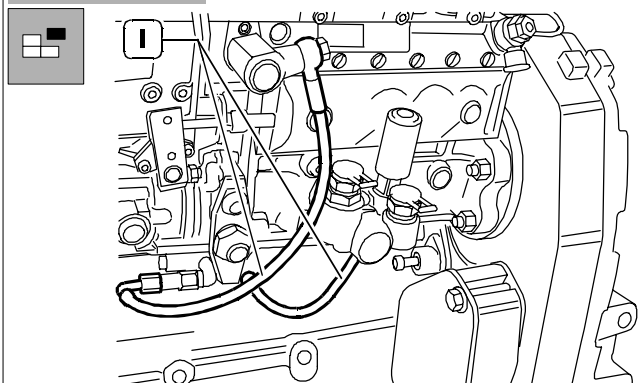
Figure 117



76150

- ☐ Loosen the screws (1, Figure 116) and (1, Figure 117) holding the fixing brackets of such pipelines; pipe the pipeline ends.

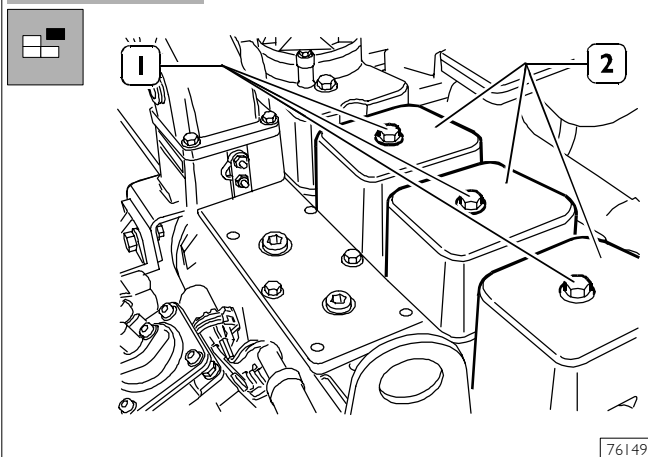
Figure 118



76132

- ☐ Disconnect lubrication pipes (1) from feed pump.
- ☐ Disassemble the injectors and remove them from their slot: remove the gaskets.

Figure 119



76149

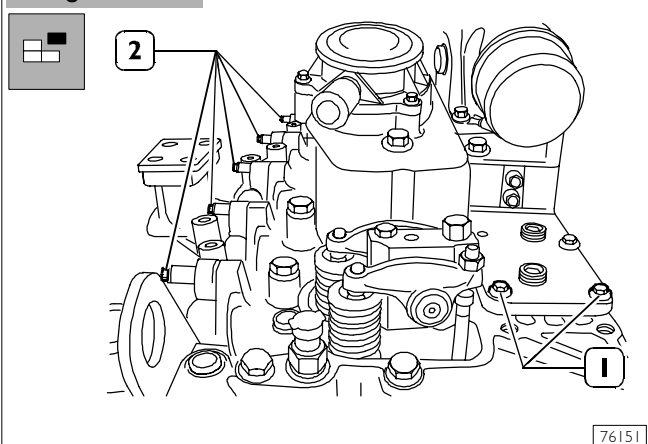
- ☐ Remove tappet caps:
Loosen the fixing screws (1) and lift the caps (2);
remove the gaskets.



On the central cap there is a blow-by valve for the lubrication oil vapours.

All the gaskets shall always be replaced during assembly.

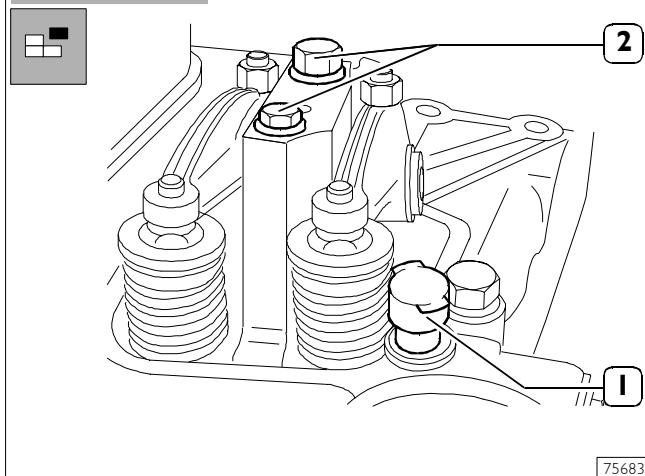
Figure 120



76151

- ☐ Disassemble suction and exhaust manifolds: loosen the screws (1) fixing the suction manifold plate to the cylinder head (some of them have already been screwed-out since fixing the pipe brackets to the injectors); from the exhaust manifold side loosen the eight (2) fixing screws; remove the gaskets.

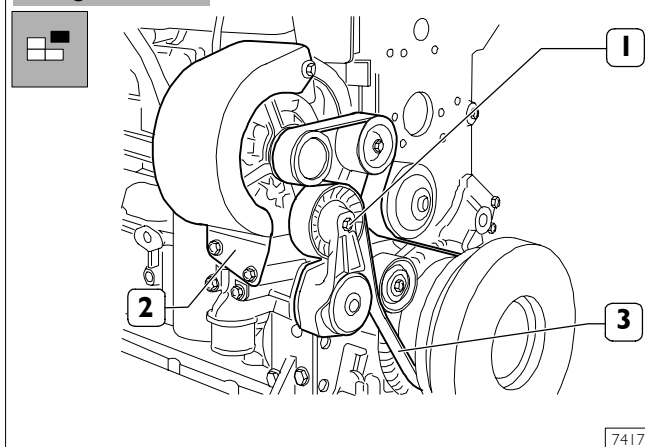
Figure 121



75683

- ☐ Disassemble rocker arm bearings; loosen the two fixing screws (2) and remove the complete rocker arm bearing; withdraw tappet rods. Repeat the operation for all the remaining rocker arm bearings.
- ☐ Disassemble water temperature transmitter (1).

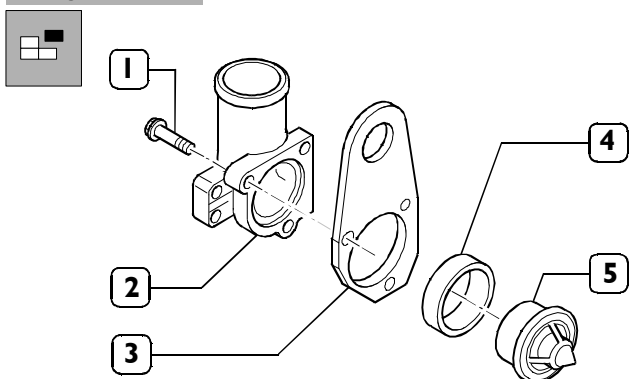
Figure 122



74171

- ☐ Unloose the screws fixing the alternator's protection to the support and remove it.
- ☐ Work on the drive belt tensor (1) and extract the belt (3) from the belt pulleys, from the water pump ones and from the belt rebound pulleys.
- ☐ Disassemble the belt tensor.
- ☐ Unloose the screw fixing the alternator to the upper bracket.

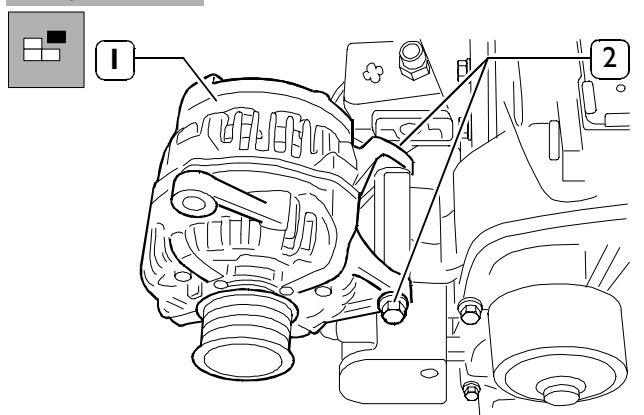
Figure 123



75685

- ☐ Disassemble thermostat unit; loosen the three fixing screws (1) and disassemble the thermostat unit (2) together with the bracket (3); remove the gasket (4) and the thermostat (5).
- ☐ Assemble the bracket in the original position fixing it with the screws of the thermostat unit.

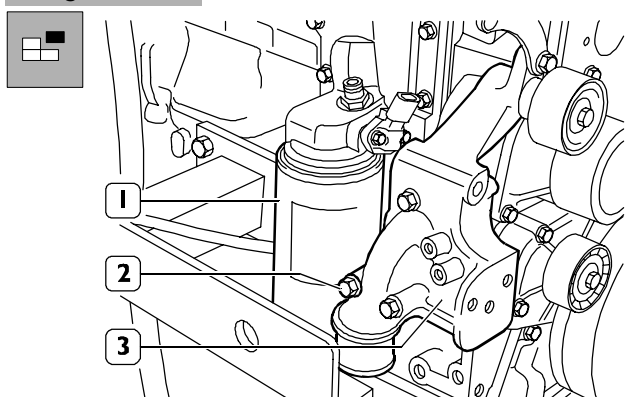
Figure 124



75686

- ☐ Properly hold the alternator (1) separating it from its bearing by loosening the screw (2); remove screw nut and washer.

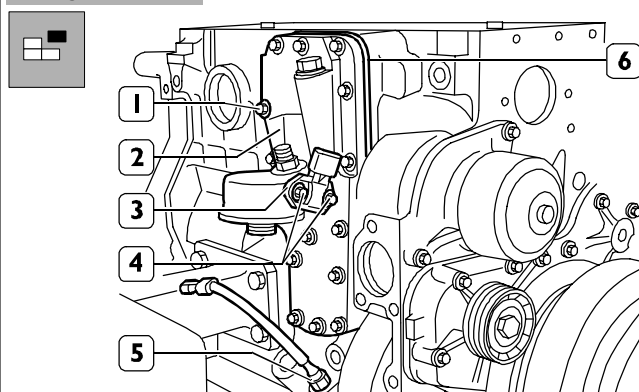
Figure 125



70140

- ☐ Loosen the screws (2) and withdraw the alternator bearing (1).

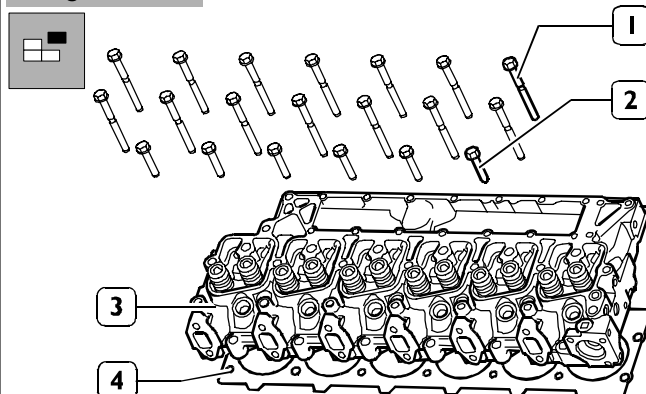
Figure 126



70141

- ☐ Loosen the screws (4) and disassemble the oil pressure/temperature sensor (3) (if fitted).
- ☐ Loosen the screws (1) and disassemble the oil filter/heat exchanger bearing (2), interlayer plate (6) and relating gaskets.
- ☐ Disassemble oil level sensor (5) (whether provided).
- ☐ Disassemble injection pump (see specific procedure) and the power take-off underneath.

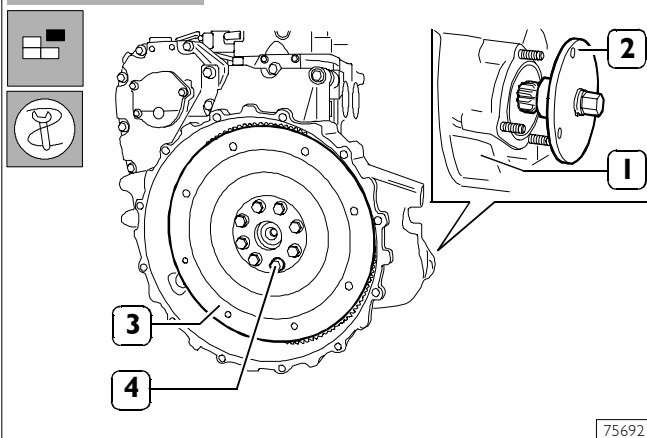
Figure 127



76152

- ☐ Disassemble cylinder head; loosen the screws (1) and (2) fixing the cylinder head (3); hook the brackets with metal ropes and, throughout a hoist withdraw cylinder head from the block.

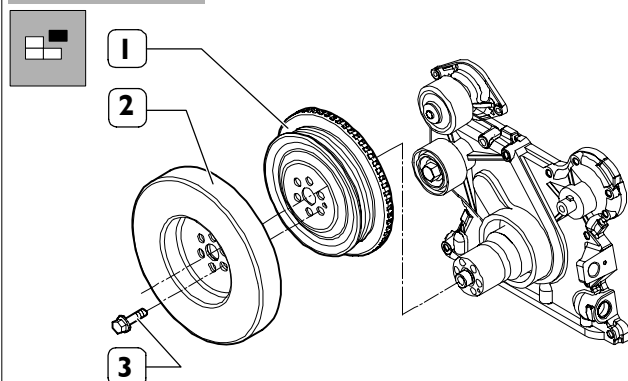
Figure 128



75692

- ☐ Use the 380000988 tool (2) to operate on the flywheel cover box (1) in order to block flywheel rotation (3). (Utilise starter holding down studs and fixing screw nuts).
- ☐ Loosen the flywheel fixing screws (4) to engine drive shaft.

Figure 129



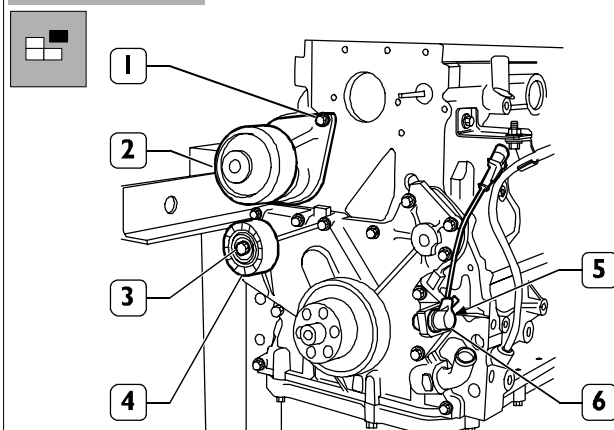
74175

- ☐ Unloose the screws (3) and disassemble the damping flywheel (2) and the pulley (1).



In same versions, the phonic wheel to be assembled to the pulley (1) cannot be provided along with the equipment.

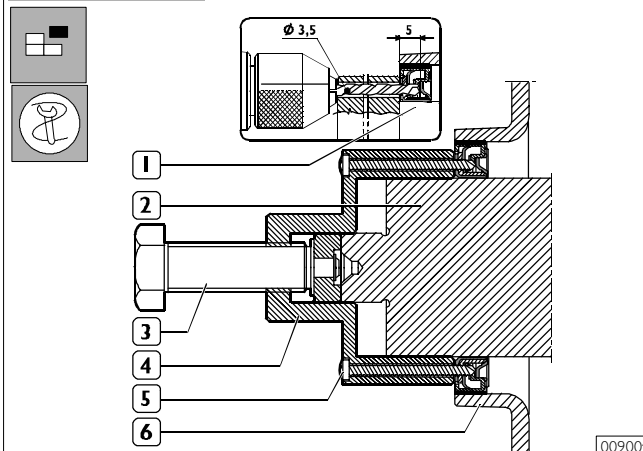
Figure 130



70148

- ☐ Remove the screws (1) and disconnect the water pump (2).
- ☐ Remove the screw (3) and the roller (4).
- ☐ Remove the screw (5) and disconnect the engine speed sensor (6).

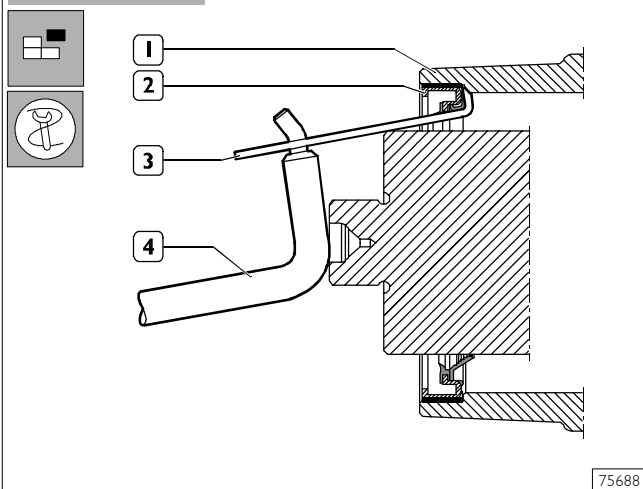
Figure 131



00900t

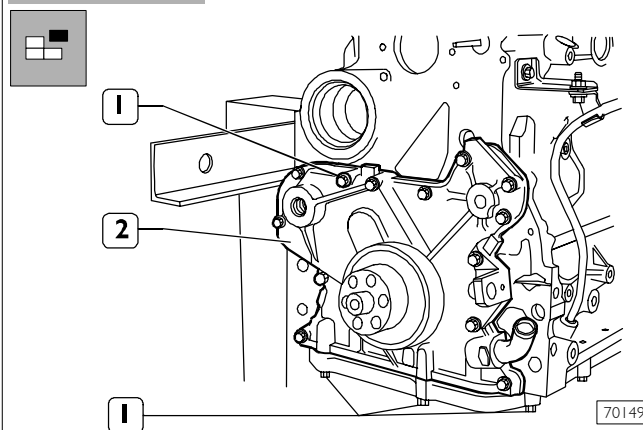
- ☐ Remove the engine drive shaft fixing ring from the front cover. Use the tool 380000665 (4) to operate on the front tang (2) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring (1) using $\varnothing 3,5$ mm drill for a 5mm depth. Fix the tool to the ring tightening the 6 screws specially provided. Proceed withdrawing the ring (1) tightening the screw (3).

Figure I32



-  Use acceptable tools (3) (4) and withdraw the external holding ring (2) from the front cover (1).

Figure I33

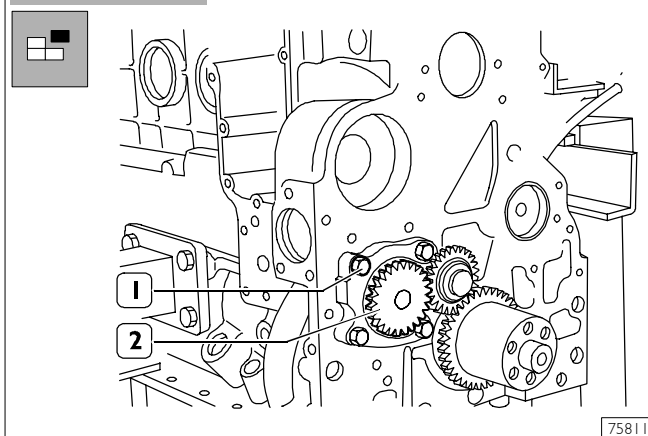


-  Loosen the screws (1) and remove the front cover (2).



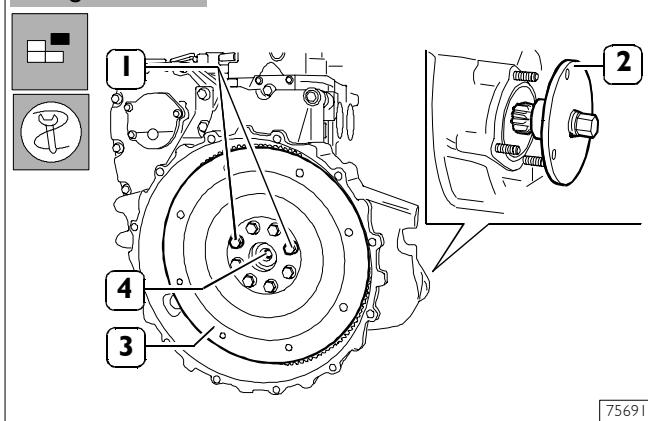
Take note of the screw (1) assembly position, since the screws have different length.

Figure I34



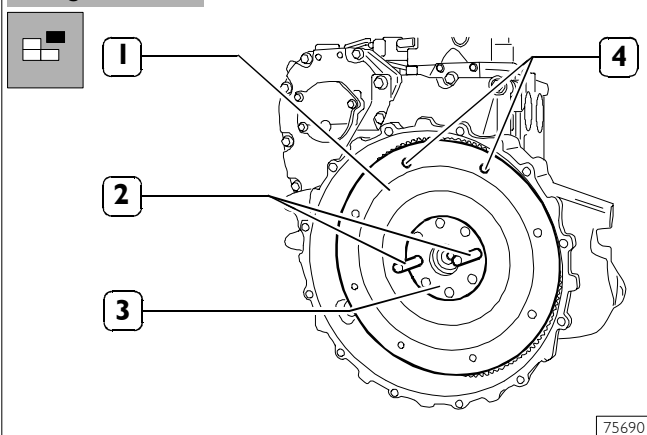
-  Loosen the screws (1) and remove oil pump (2).

Figure I35



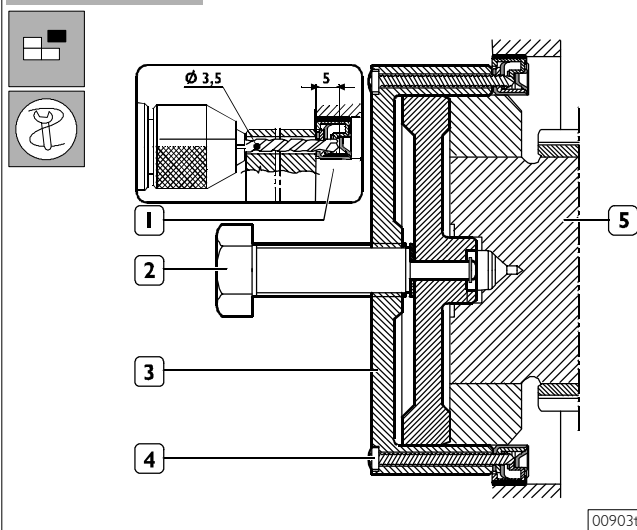
-  Screw out the opposite screws (1) from the ports where the withdrawal pins shall be introduced (see picture following).
-  Loosen remaining flywheel fixing screws (3) to the engine drive shaft (4).
-  Remove the flywheel block tool (2).

Figure 136



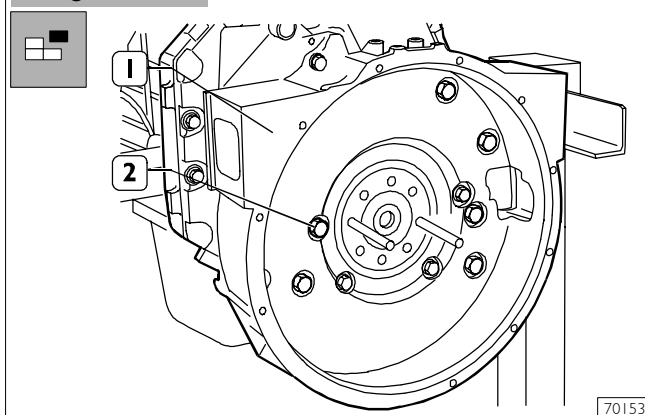
- ☐ Screw up two medium length screws in the ports (4) to sling the flywheel with a hoist. Throughout two guide pins (2) previously screwed up into the engine drive shaft ports (3) control the engine flywheel withdrawal by means of a hoist.

Figure 137



- ☐ Remove the flywheel cover box fixing ring using the tool 380000663 (3) to operate on the back tag (5) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring using Ø 3,5 mm drill for a 5mm depth.
- ☐ Fix the tool 380000663 (3) to the ring (1) tightening the 6 screws specially provided (4).
- ☐ Proceed with drawing the ring (1) tightening the screw (2).
- ☐ Use acceptable tools (3) (4) and withdraw the external holding ring of the flywheel cover box.

Figure 138

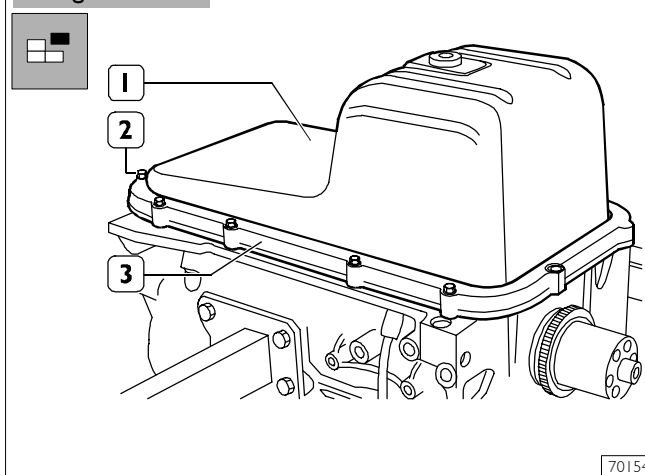


- ☐ Loosen the screws (2) and remove the flywheel cover box (1).



Take note of the screw (1) assembly position, since the screws have different length.

Figure 139



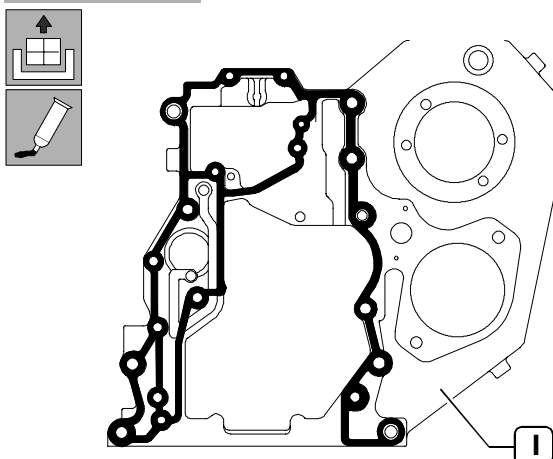
- ☐ Turn the engine upside-down.
- ☐ Loosen the screws (2), disassemble the plate (3) and remove the oil pan (1).



The shape and dimensions of the pan and of the rose pipe may vary according to the engine application. The relating illustrations provide general guidelines of the operation to be performed. The procedures described are applicable anyway.

Installation of application components

Figure I43



75712

DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION WITHIN GEARBOX AREAS

- ☐ Accurately clean the timing gearbox (I) and the engine block.



It is necessary and essential to clean the surface to be sealed in order to achieve excellent tight seal.

Apply sealing LOCTITE 5205 on the box in order to form a kerbstone of a few mm. Diameter.

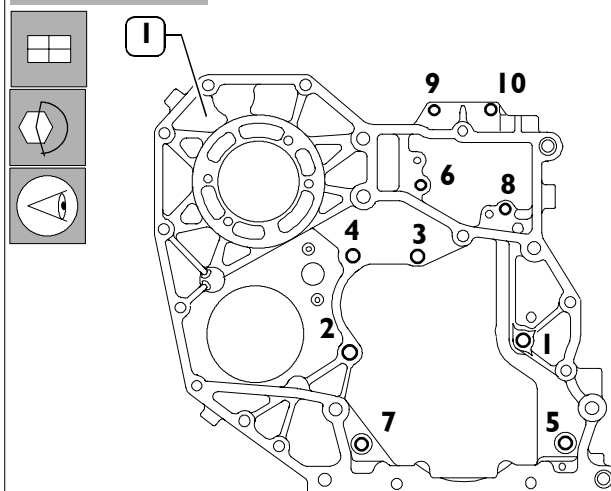
It must be uniform (no crumbs), with no air blisters, thinner or irregular zones.

Any eventual imperfection shall be correct as soon as possible.

Avoid using material in excess to seal the joint. Too much sealing material would drop out on both sides of the joint and obstruct lubricant passages.

After having completed seal application, the joints must be immediately assembled (10–20 minutes time).

Figure I44



75711

DIAGRAM SHOWING SCREW TIGHTENING TO FIX REAR GEARBOX

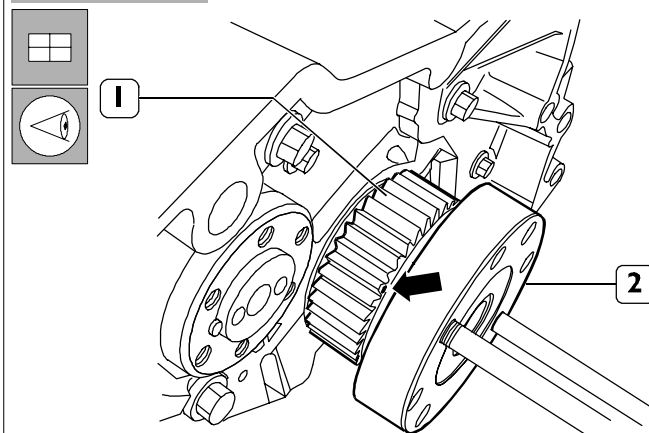
- ☐ Reassemble to box (I) to the engine block.
- ☐ Tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking couples listed here below, following the order as shown in the picture.

Screws M12	65 ÷ 89 Nm
Screws M8	20 ÷ 28 Nm
Screws M10	42 ÷ 52 Nm



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure I45



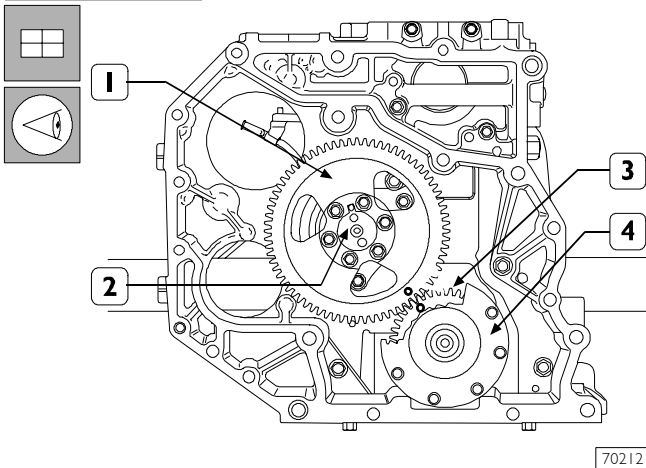
70211

- ☐ With a pen marker, mark the tooth (I) of the driving gear assembled to the engine drive shaft with (2) (→) timing notch.



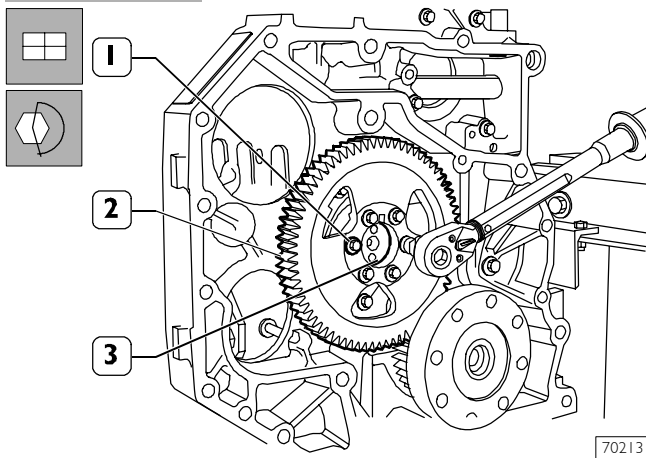
Screw up two pins to facilitate operation of engine drive shaft rotation.

Figure I46



- ☐ Orient engine drive shaft (4) and camshaft (2) taking care that in phase of assembly of the driving gear (2) to the camshaft, the notches marked on the gears (1 and 3) shall match.

Figure I47



- ☐ Tighten the screws (1) fixing the gear to the camshaft (3) and lock them to the prescribed couple.

Figure I48

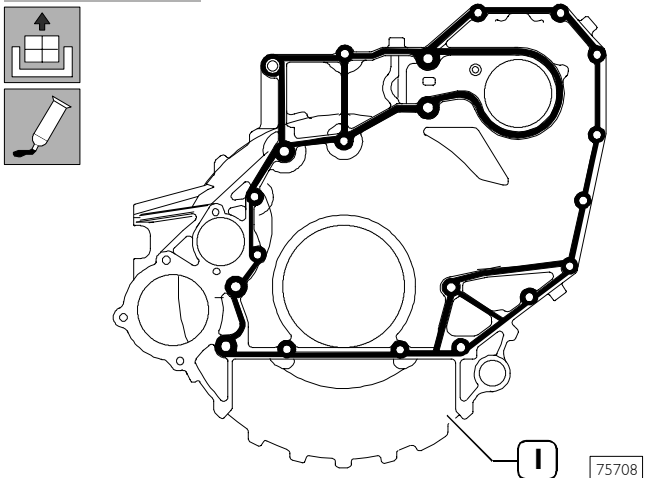


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION.



It is necessary and essential to clean the surface to be sealed in order to achieve excellent tight seal.

Apply sealing LOCTITE 5205 on the box in order to form a kerbstone of a few mm. Diameter: It must be uniform (no crumbs), with no air blisters, thinner or irregular zones.

Any eventual imperfection shall be correct as soon as possible.

Avoid using material in excess to seal the joint. Too much sealing material would drop out on both sides of the joint and obstruct lubricant passages.

After having completed seal application, the joints must be immediately assembled (10–20 minutes time).

Figure I49

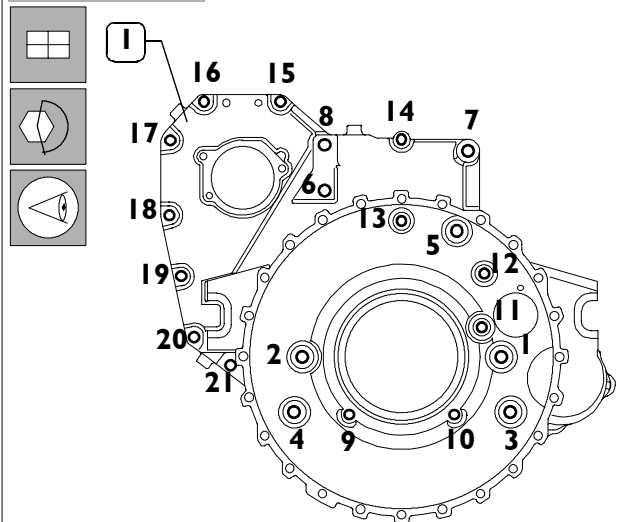


DIAGRAM SHOWING SCREW TIGHTENING TO FIX FLYWHEEL COVER BOX.

- ☐ Reassemble the box (1) to the engine block, tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking couples listed here below, following the order as shown in the picture.

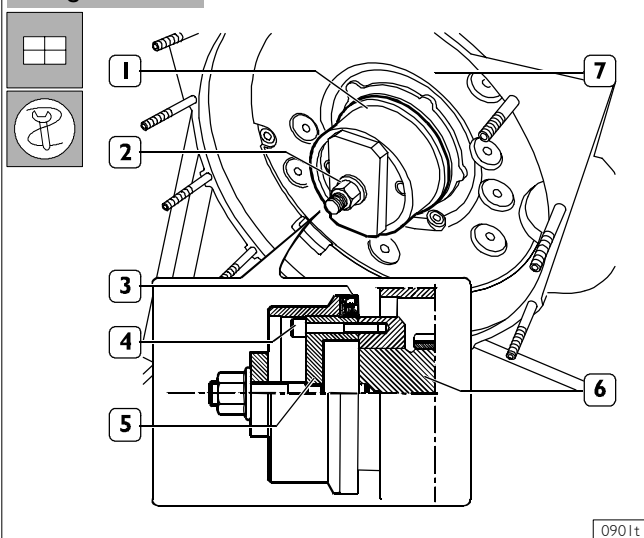
Screws M12 $75 \div 95$ Nm

Screws M10 $44 \div 53$ Nm



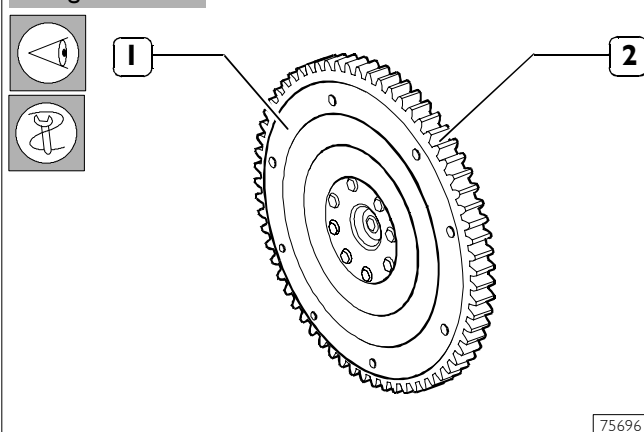
Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure 150



- ☐ Apply to engine drive shaft rear tang (6), the detail (5) of the tool 380000666, fix it tightening the screws (4) and key the new holding ring on it (3).
- ☐ Place detail (1) on detail (5), tighten the screw nut (2) until complete assembly of the fixing ring (3) into the flywheel cover box (7).

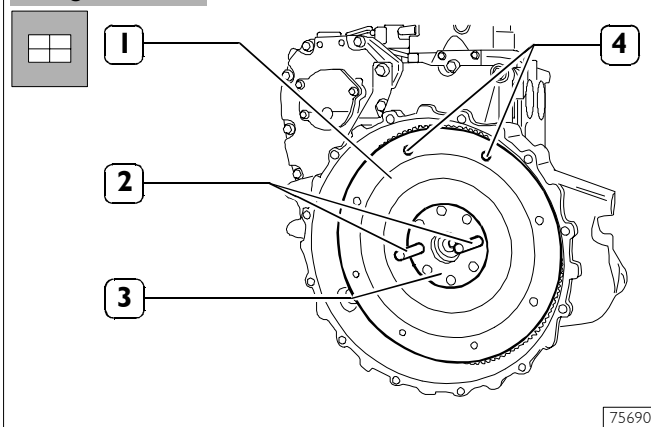
Figure 151



In case of engine coupling with mechanical gears in presence of friction, verify surface status of the flywheel and eventually work it out to maintain rated engine flywheel thickness, which is $49,6 \pm 0,13$ mm.

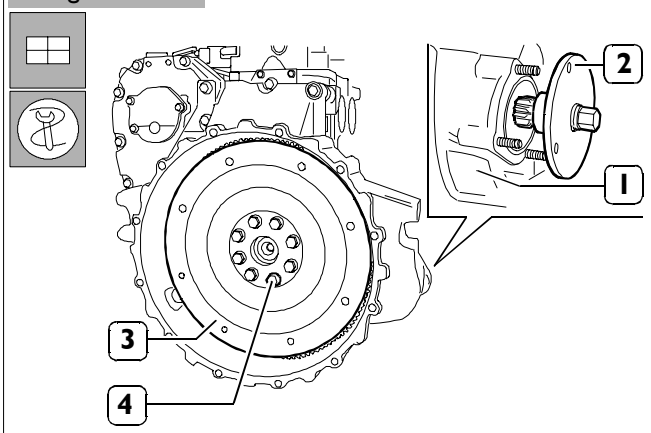
- ☐ Check the conditions of the rim tooth (2). Whether tooth break or excessive wear is detected, disassemble the rim from the engine flywheel using a common willow and replace with a new one, previously heated to 150°C degrees for $15' \div 20'$ seconds; bevelling must be made towards engine flywheel direction.

Figure 152



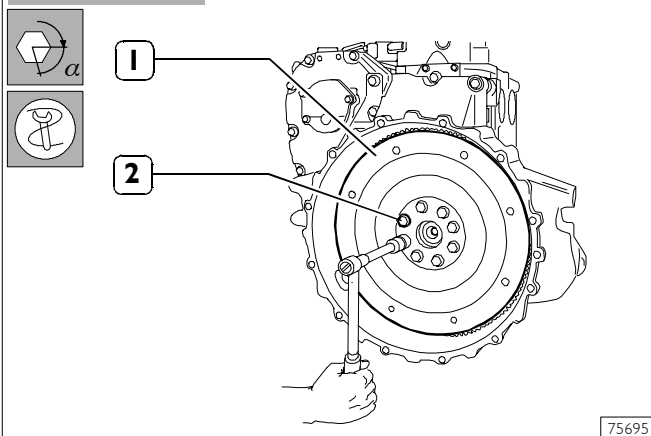
- ☐ Screw up two hooks or trail rings in the flywheel (1) threaded ports (4) for handling.
- ☐ Using a hoist, handle the flywheel to place it in its housing inside the flywheel cover box.
- ☐ Screw up to pins (2) having appropriate length, in the shaft ports (3) and using them as guide, assemble the engine flywheel (1) properly placing it inside the flywheel cover box.

Figure 153



- ☐ Tighten the screws (4) fixing the engine flywheel (3) to the engine shaft. Use 380000988 tool (2) to operate on the flywheel cover box (1) to block engine flywheel rotation.

Figure I54



75695

Tighten the engine flywheel (1) fixing screws (2) in two phases:

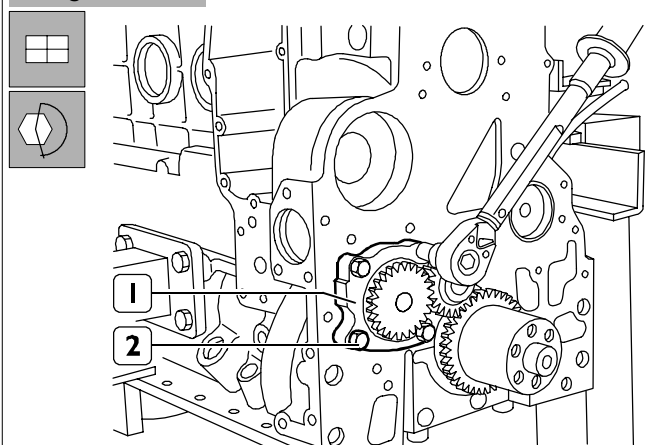
- ☐ 1st phase; tightening by means of dynamometric wrench to couple $30 \div 40 \text{ Nm}$;
- ☐ 2nd phase, $60^\circ \pm 5^\circ$ angle dwell.



Angle dwell shall always be performed using **acceptable tools**.

Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

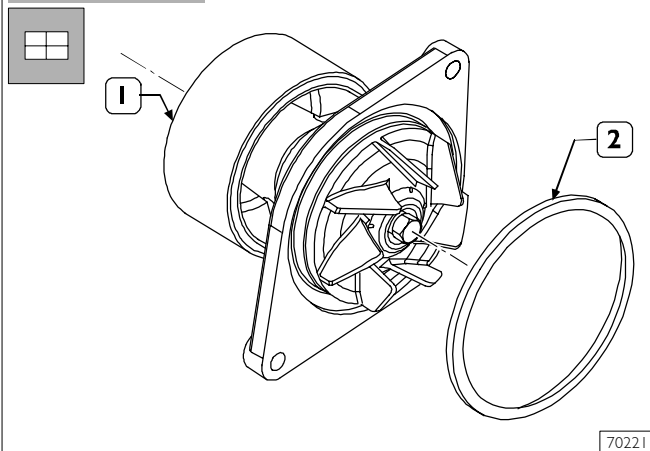
Figure I55



70220

- ☐ Assemble oil pump (1).
- ☐ Tighten fixing screws (2) and lock them to the prescribed couple.

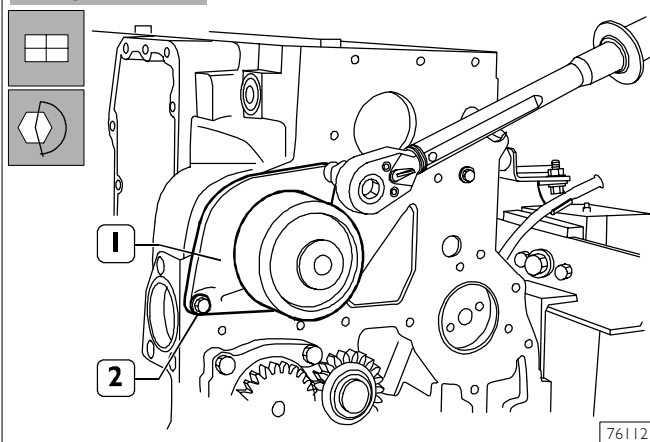
Figure I56



70221

- ☐ Apply to the water pump (1) a new fixing ring (2).

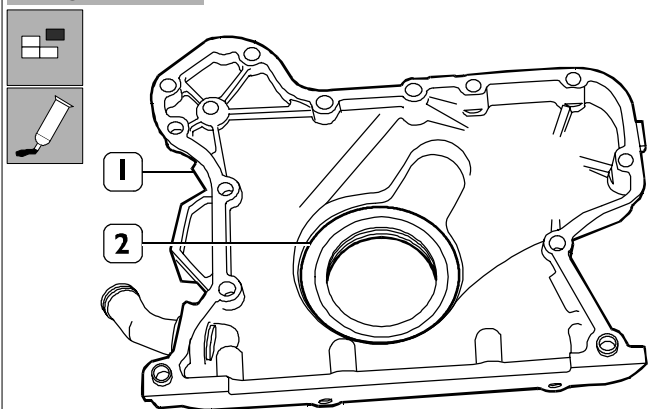
Figure I57



76112

- ☐ Assemble the water pump (1).
- ☐ Tighten the screws (2) and lock them to the prescribed couple.

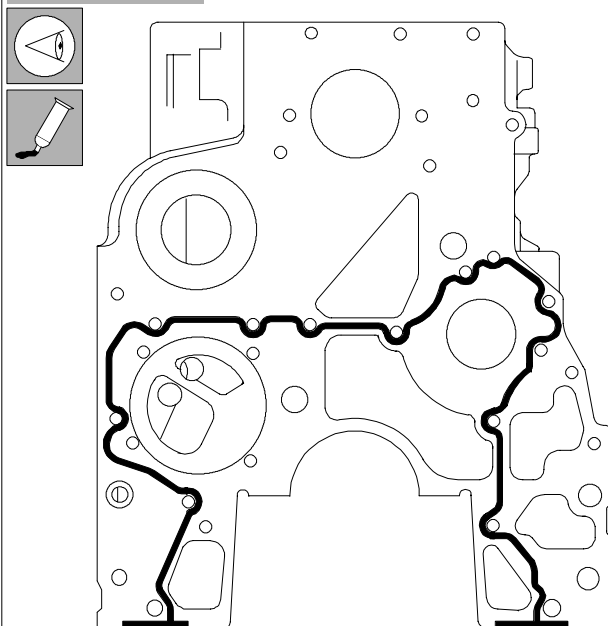
Figure I58



70223

- ☐ Remove the fixing ring (2) from the front cover (1), accurately clean the plug surface.

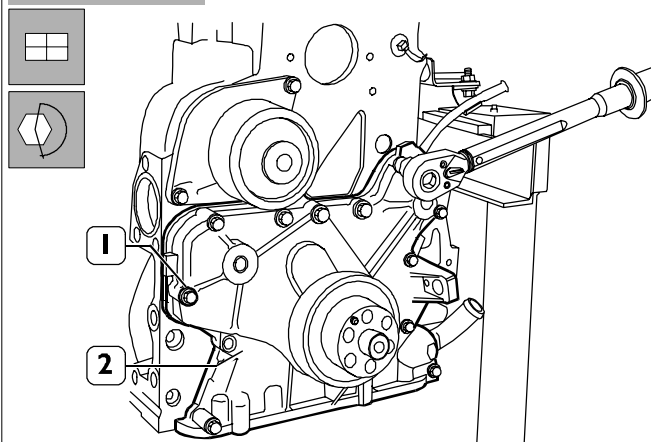
Figure 159



75710

- ☐ Accurately clean the contact surface of engine block and apply sealing LOCTITE 5205 on it in order to form a uniform and continuous kerbstone with no crumbs.

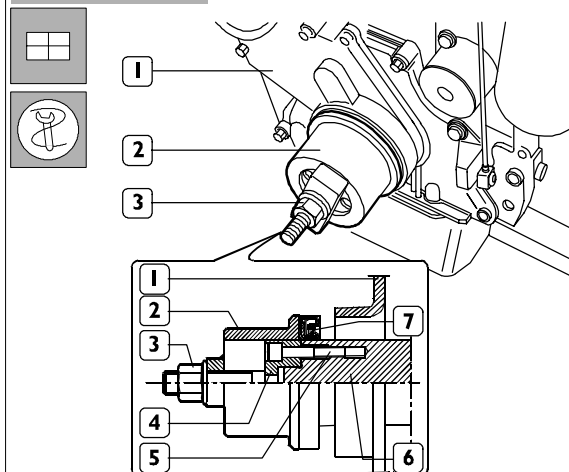
Figure 160



75812

- ☐ Assemble the front cover (2) to the block and tighten the screws (1) fixing them to the prescribed couple.

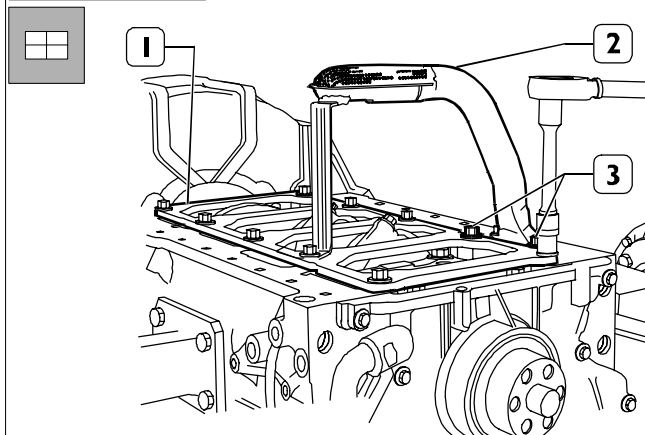
Figure 161



00902t

- ☐ Apply on engine drive shaft front tang (6) the detail (4) of the tool 380000666, fix it with the screws (5) and key the new holding ring on it (7).
- ☐ Place the detail (2) on the detail (4), screw-up the threaded nut until carrying out the complete assembly of the holding ring (7) to the front cover.

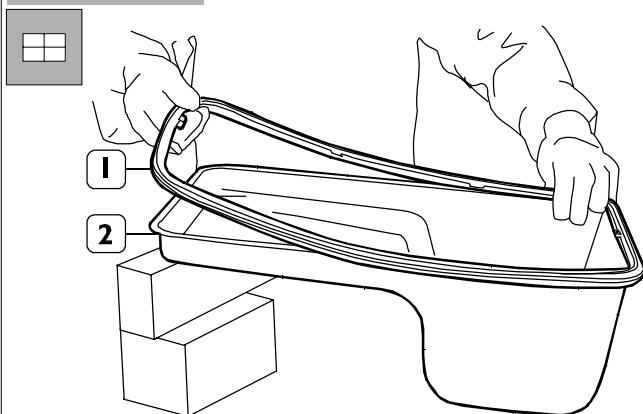
Figure 162



75813

- ☐ Assemble the plate (1), the rose pipe (2), tighten the fixing screws (3) and fix them to the prescribed couple.

Figure I 63

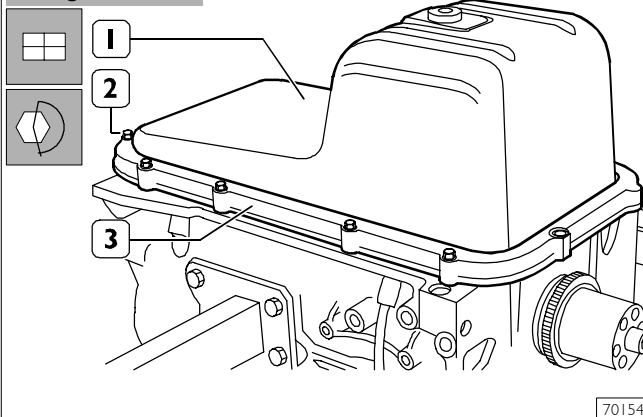


- ☐ Provide for new gasket replacement (1) of the oil pan (2).



The pictures illustrating the pan and of the rose pipe may not correspond to the ones of your model. However the procedures described are applicable anyway.

Figure I 64

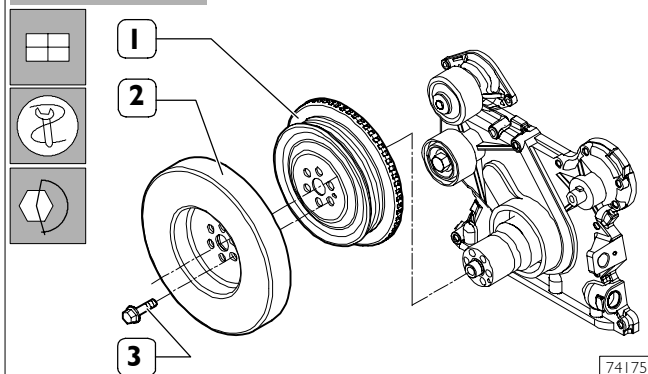


- ☐ Assemble oil pan (1), apply the plate over it (2). Tighten the screws (3) and lock them to the prescribed couple.



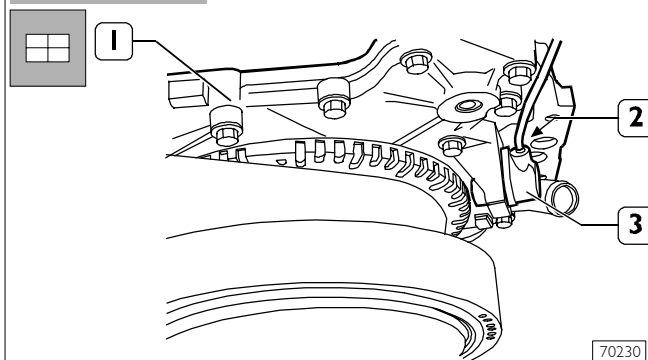
Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure I 65



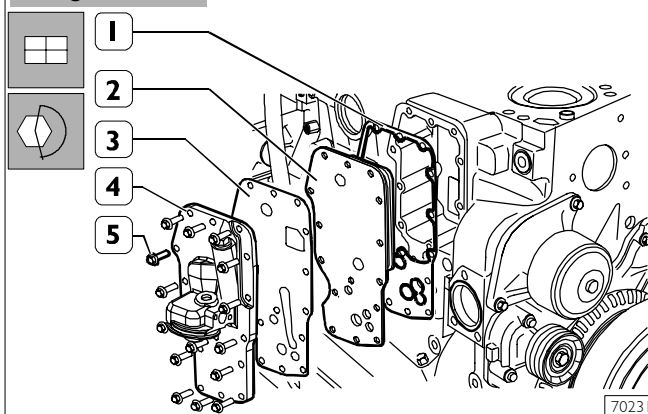
- ☐ Assemble the pulley (1) and the dumping flywheel (2) to the driving shaft.
- ☐ Tighten the fixing screws (3) and clamp them to the couple 68 ± 7 Nm.

Figure I 66



- ☐ Fit a new sealing ring on the speed sensor (3) (if fitted).
- ☐ Fit the speed sensor (3) on the front cover (1) and tighten the screw (2) to the specified torque (if fitted).

Figure I 67

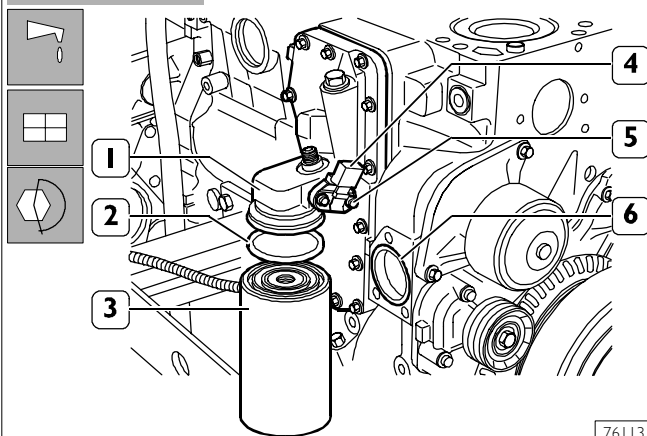


- ☐ Assemble the following elements to the block: new gasket (1), heat exchanger (2), new gasket (3), oil filter bearing (4). Tighten the screws (5) and lock them to the prescribed couple.



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

Figure 168



76113

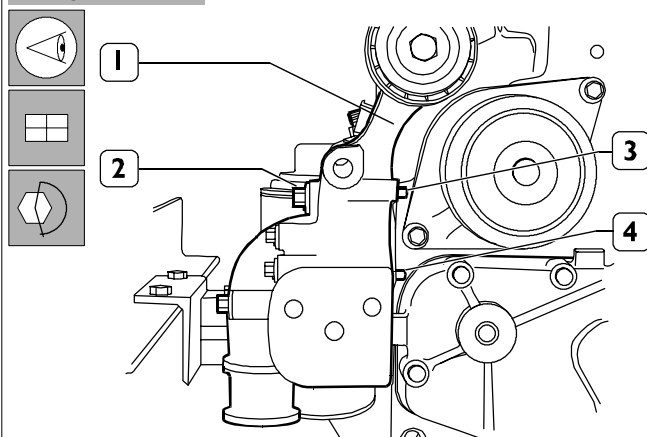
- ☐ Lubricate the fixing ring (2) using engine oil and place it on the oil filter (3).
- ☐ Manually start the oil filter (3) on the bearing union (1) until counter-boring, further screw up the oil filter (3) by 3/4 turn.
- ☐ Apply, (if needed) new fixing ring on the oil temperature/pressure sensor (4) and assemble it to the bearing (1) tightening the fixing screws to the prescribed couple.
- ☐ Tighten the screw (5) and lock it to the prescribed couple.



In some applications, the bearing of the exchanger shall be assembled to a screw threaded union connected to the filter on the opposite side of the engine, throughout two pipelines (see Figure 105).

- ☐ Place a new fixing ring on the block housing (6).

Figure 169



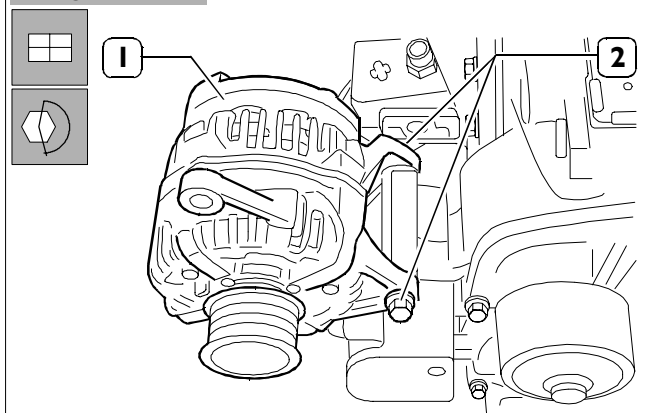
70234

- ☐ Assemble the alternator bearing (1) ensuring that the pins (3 and 4) are against the engine block.
- ☐ Tighten the screws (2) and lock them to the prescribed couple.



Before assembly, always check that the threads of the ports and of the screws have no evidence of tear and wear nor dirt.

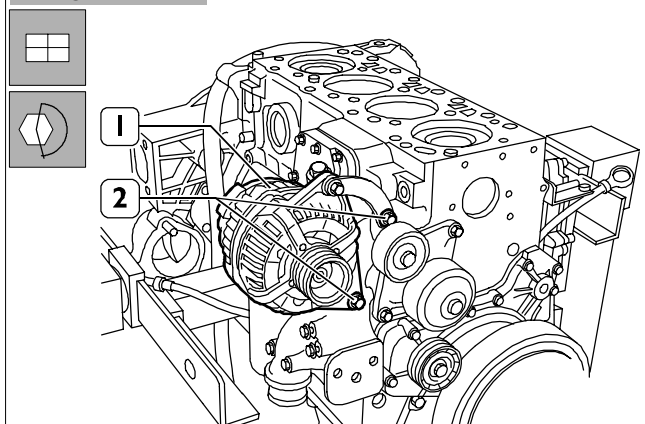
Figure 170



75686

- ☐ Reassemble the alternator (1).
- ☐ Tighten the screw (2) and lock it to the prescribed couple.

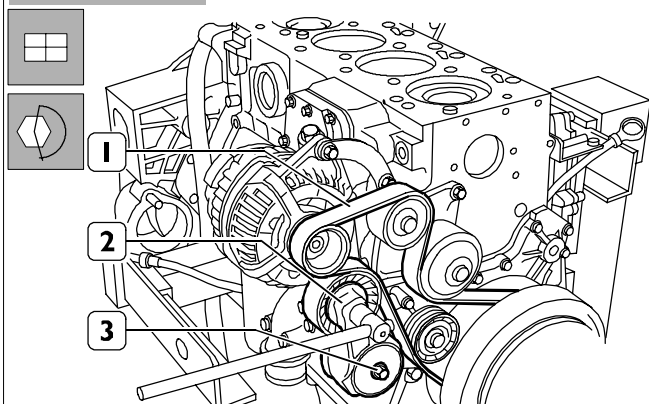
Figure 171



74177

- ☐ Refit the alternator (1).
- ☐ Tighten the screw (2) to the specified torque.

Figure 172



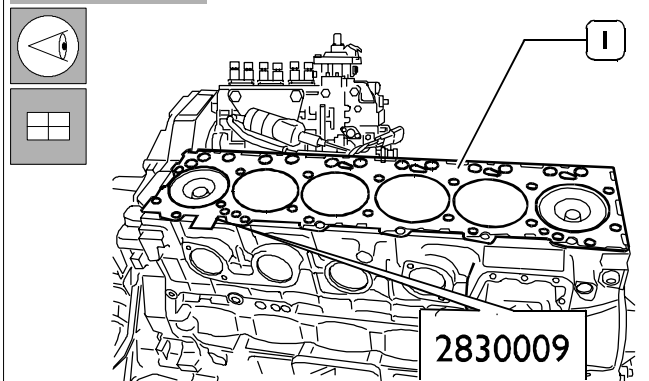
74178

- ☐ Refit the automatic belt tensioner (2).
- ☐ Tighten the screw (3) to the specified torque.
- ☐ Turn the automatic belt tensioner (2) to fit the belt (1) on pulleys and guide rollers.
- ☐ Assemble alternator safety guard.



In case the same belt priory removed is assembled again, proceed examining it carefully to check there

Figure 173



76153

- ☐ Place the gasket (1) over the block.
The choice of the gasket's thickness shall be made in consideration of the cylinder protrusion measured with respect to the block's upper surface.

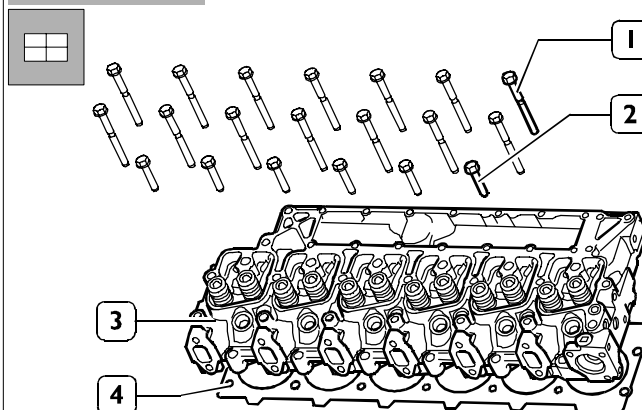


Verify that the engine block stand is clean.

Do not grease the gasket. It is recommended to keep the gasket inside packaging until assembly to the cylinder head.

Gasket assembly shall be made following the direction of wording printed on the gasket itself so that this will be readable as indicated in the picture.

Figure 174



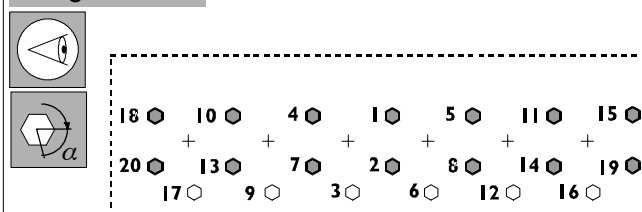
76152

- ☐ Place the head (3) over the block and insert screws (1) and (2).



If the valves have been removed from the head, it is necessary to assemble them before assembling the head itself on the engine block.

Figure 175

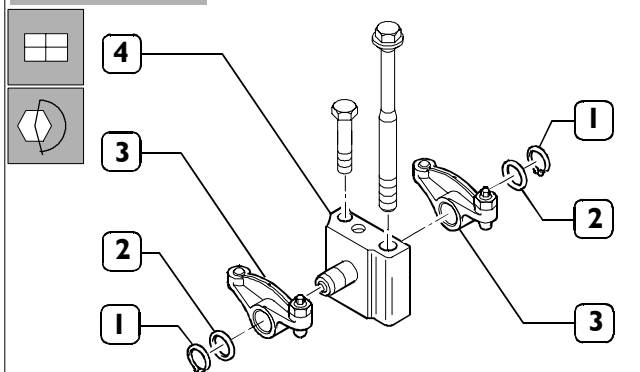


76214

- ☐ Lubricate cylinder head bolts and install to head.
- ☐ Bolts must be torqued using stitching pattern starting with the centre bolts and moving out. Bolts to be torqued in stages: all bolts torqued to snug torque, then 90 degrees rotation for all bolts. Then a further 90 degrees for the M12 x 140 and M12 x 180.

M12 x 70	50 Nm + 90 deg's
M12 x 140	40 Nm + 180 deg's
M12 x 180	70 Nm + 180 deg's

Figure 176

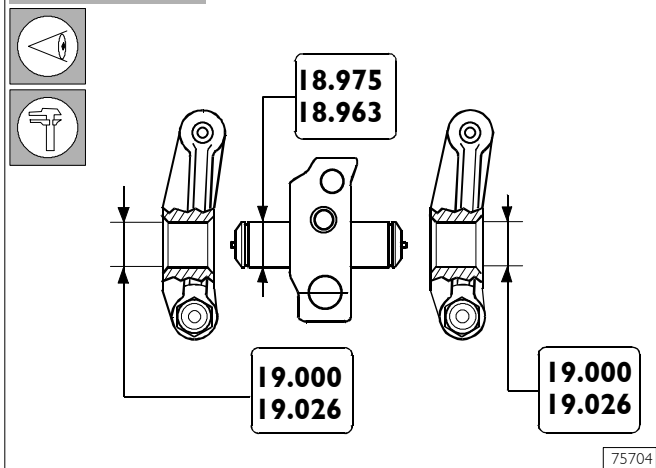


ROCKER ARM UNIT COMPONENTS:

1. Elastic ring – 2. Spacer – 3. Rocker arms –
4. Support.

- ☐ Carry out the assembly of the rocker arms after previous check of the components.

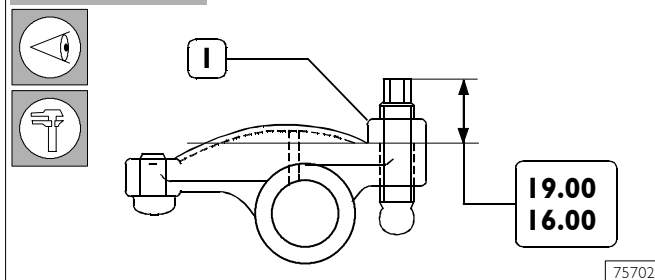
Figure 177



SHAFT AND ROCKER ARM BASIC DATA

Check the coupling surfaces of bearing and shaft: no evidence of excessive wear shall be detected or damages.
Replace if necessary.

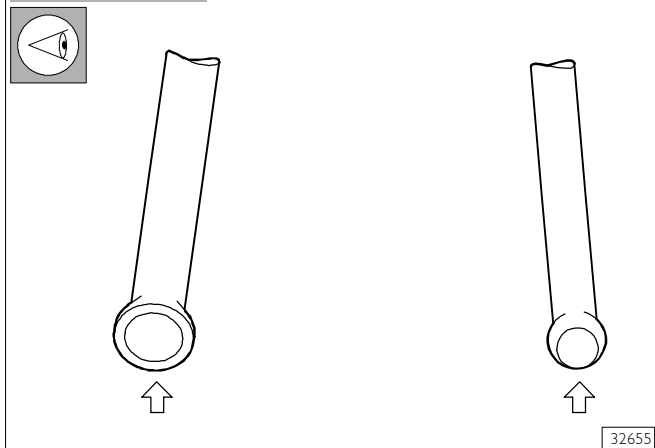
Figure 178



ROCKER ARM ADJUSTMENT SCREW

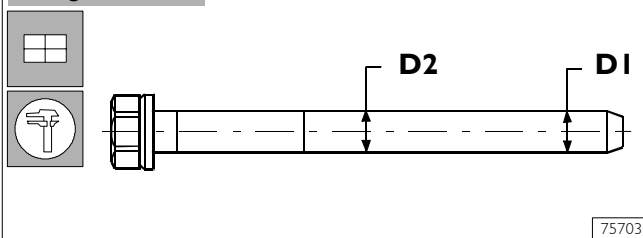
If unscrewed, check adjustment quota.
Tighten the screw-threaded nut (1) to the 0.25 – 0.75 Nm couple.

Figure 179



Before executing assembly, check the Rocker Arm driving rods: these shall not be deformed; the spherical ends in contact with the Rocker Arm adjustment screw and with the tappet (arrows) shall not present evidence of seizure or wear: in case of detection proceed replacing them.
The rods driving the suction and exhaust valves are identical and therefore interchangeable.

Figure I80

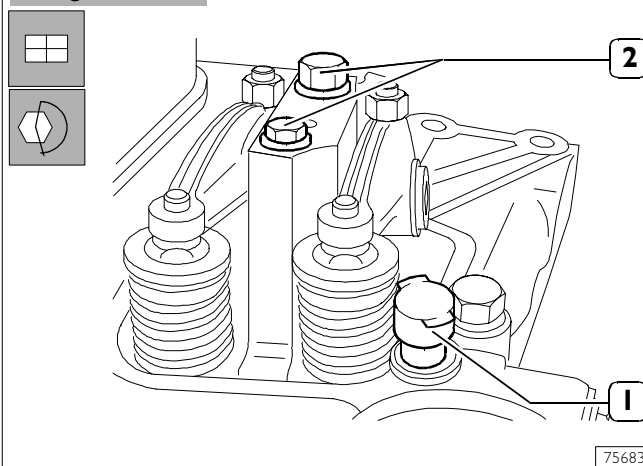


- ☐ Insert the tappet driving rods and the Rocker Arm unit. Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:

if $D1 - D2 < 0,1 \text{ mm}$ the screw can be utilised again;

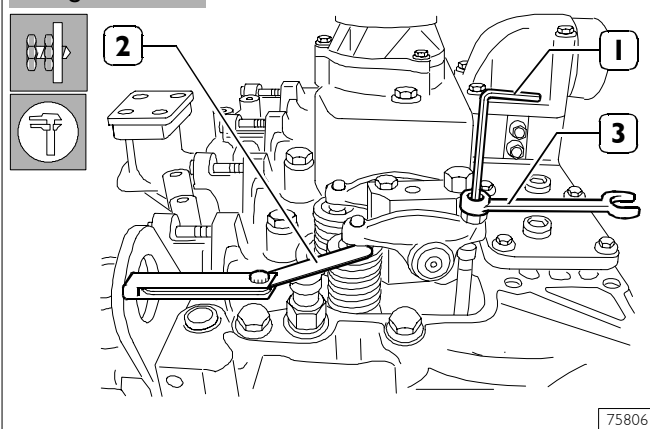
if $D1 - D2 > 0,1 \text{ mm}$ the screw must be replaced;

Figure I81



- ☐ Tighten the screws (2) to the prescribed couple and assemble water temperature sensor (1).

Figure I82



Adjust the slack between rocker arms and valves using socket wrench (1), point wrench (3) and feeler gauge (2).

Correct working slack is:

- suction valves $0.30 \pm 0.05 \text{ mm}$
- exhaust valves $0.55 \pm 0.05 \text{ mm}$.



In order carry out a quicker adjustment of the working slack between rocker arms and valves, proceed as following:

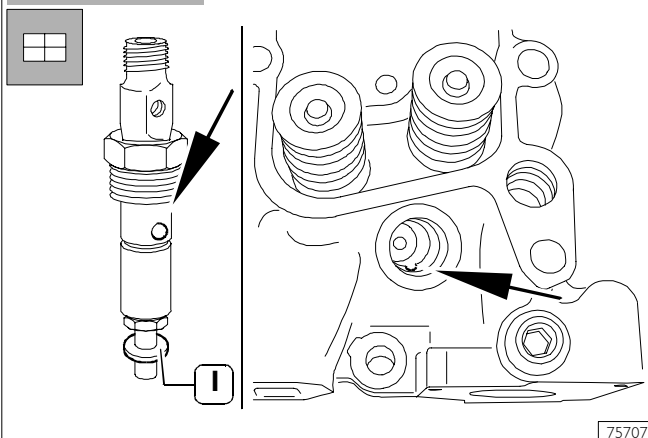
Rotate the engine drive shaft, balance the valves of cylinder 1 and adjust the valves identified by star symbol, as indicated in the following table:

Cylinder n.	1	2	3	4	5	6
Suction	*	*	—	*	—	—
Exhaust	*	—	*	—	*	—

Rotate the engine drive shaft of 360 deg., balance the valves of cylinder 6 and adjust the valves identified by star symbol, as indicated in the following table:

Cylinder n.	1	2	3	4	5	6
Suction	—	—	*	—	*	*
Exhaust	—	*	—	*	—	*

Figure 183

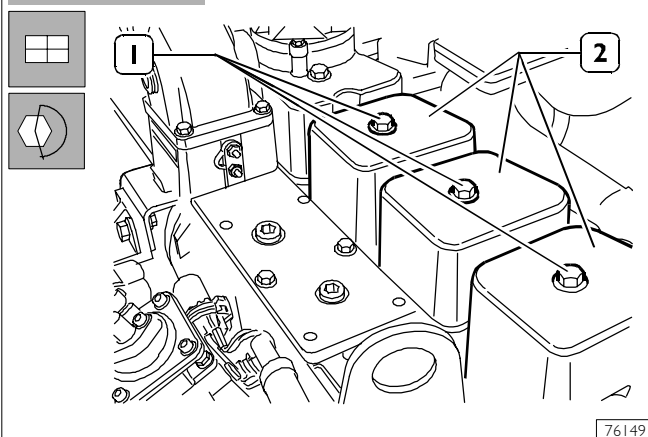


75707

- ☐ Assemble injectors after having replaced the sealing gasket (1).

 During assembly of injectors, verify that the injector sphere is correctly positioned on the head housing.

Figure 184



76149

- ☐ Assemble cylinder covers (2) with the respective gaskets;
- ☐ Fit the seal nodes and tighten the screws (1) fixing them to the prescribed couple.

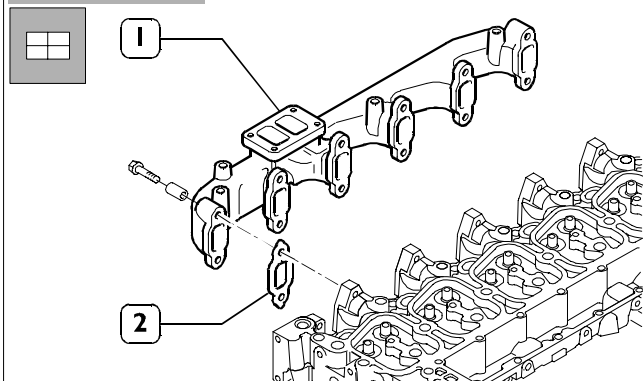


Always replace the gaskets using new ones.

Check the threads of the fixing screws: there shall be no evidence of wear or dirt deposit.

Seal nodes shall have no visible deformation. In such case provide for replacement with new nodes.

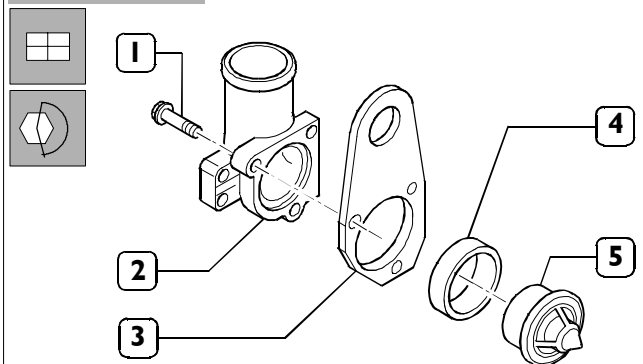
Figure 185



76206

- ☐ Assemble exhaust manifold (1) providing new gaskets (2).

Figure 186



75685

- ☐ Assemble thermostat unit (2) including thermostat (5) and gasket (4).
- ☐ Tighten the screws to the prescribed couple.

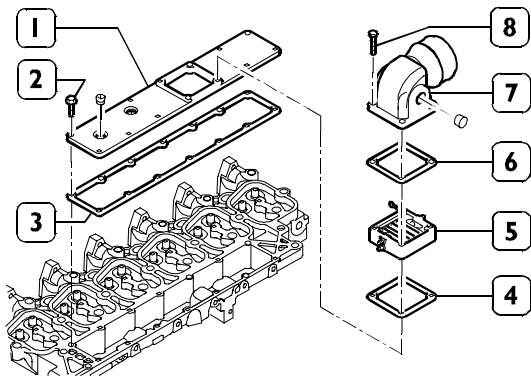


The screws (1) have been utilised to fix the bracket (3).

Disassemble the bracket and reassemble components from 1 to 5 as shown in the picture.

The gasket (4) must be new.

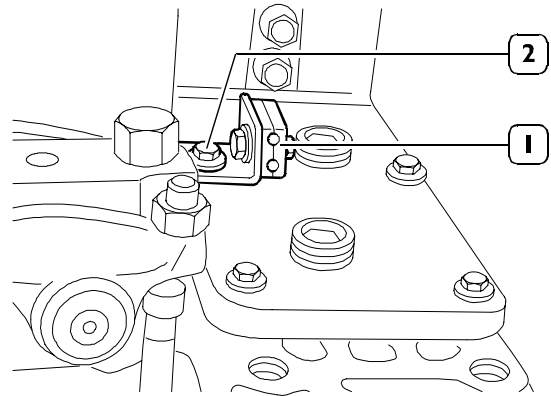
Figure I 87



76207

- ☐ Apply on the surface joining the suction manifold plate (1) the gasket (3) and provide. Fixing the screws (2) to the prescribed couple.
- ☐ If the pipe (7) of the suction manifold plate (1) has been removed, reassemble it after having fit a new gasket (6).
- ☐ Tighten the screws (8) to the prescribed couple.

Figure I 88



76208

- ☐ Also assemble the brackets (I) fixing the fuel pipelines to the injectors: use the same screws (2) fixing the manifold plate as shown in the picture.
- ☐ Also assemble feed pump (see specific procedure) and the power take-off underneath.

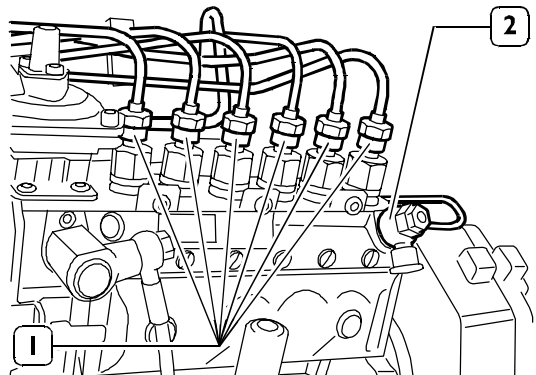


For the versions provided with heater; also assemble components (4) and (5).



Pump assembly requires specific procedure as reported at the end of the hereby section.

Figure I 89



76138

- ☐ Assemble the pipes (1) and (2) providing fuel feed and recovery between pump and injectors; Screw up the locking nuts and tighten the screws fixing the fuel recovery manifold.

Figure 190

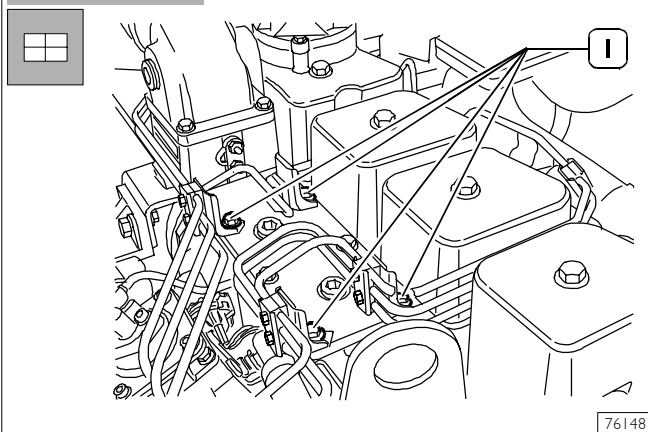
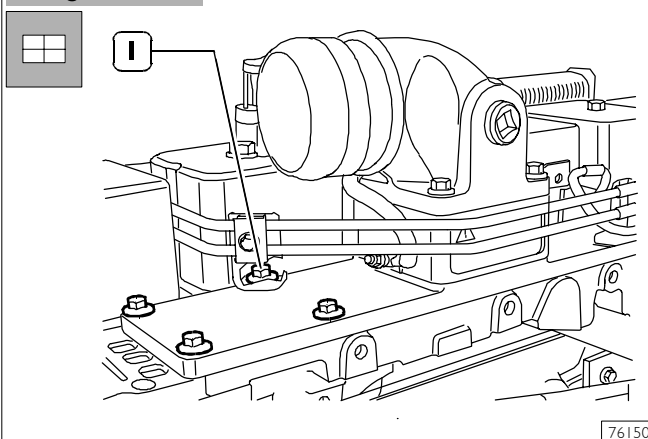
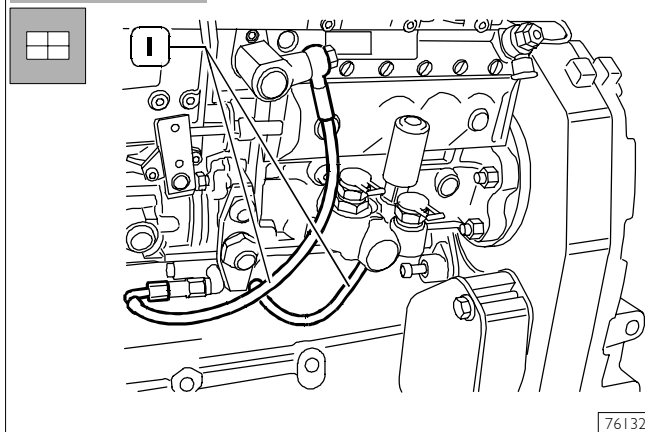


Figure 191



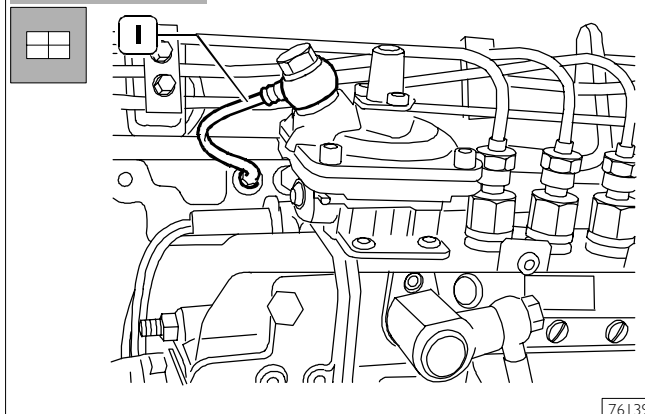
- ☐ Fix the pipes to the injectors throughout the brackets previously assembled (fixing screw 1, Figure 190 and 2, Figure 191).

Figure 192



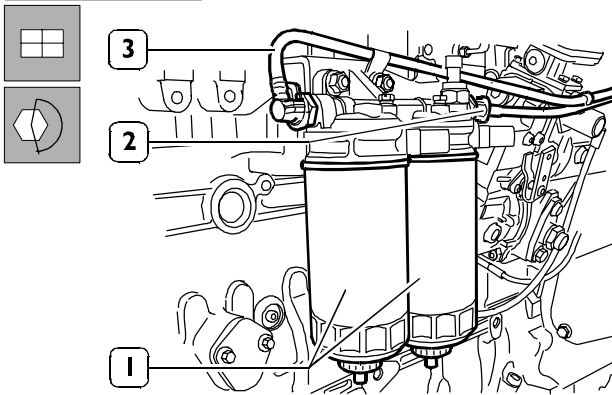
- ☐ Assemble lubrication pipes to feed pump.

Figure 193



- ☐ Fix the LDA pipeline (1) to the engine head and to the feed pump.

Figure 194



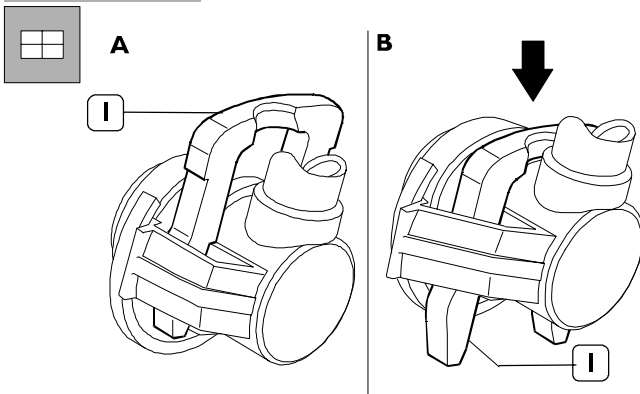
76141

- ☐ Assemble the fuel filter bearing (4) to the bracket fixed to the engine head.
- ☐ Connect the fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to feed pump.
- ☐ Use acceptable tools to install fuel filter (1).



The filter shall be priority filled with fuel to facilitate feed system bleed operations.

Figure 195



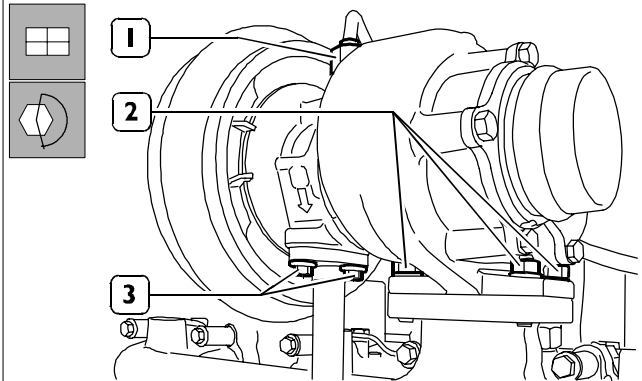
70126



To connect fuel pipelines (2 and 3, Figure 194) in low pressure from the relating connection unions it is necessary to press the locking fastener (1) as shown in picture B.

After having connected the pipeline, reset the fastener (1) into block position as shown in picture A.

Figure 196



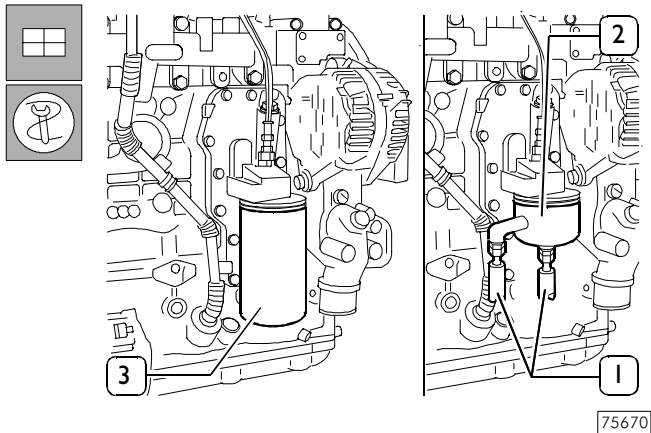
76143

Proceed assembling the turbocharger:

- ☐ Hold the turbocharger and place it on the exhaust manifold after having interposed the gasket.
- ☐ Screw up the fixing nuts (2) of the turbocharger to the exhaust manifold tightening them to the prescribed couple.
- ☐ Tighten the lubrication pipe fixing ring. Operate in the same way on the other end of the pipe. Connect it to the upper part of the heat exchanger.
- ☐ Assemble the turbocharger lubrication exhaust pipe by tightening the screws (3); connect the end to the engine block.

To complete engine assembly it is necessary to remove it from the turning stand.

- ☐ Use acceptable tools to hold the engine and loosen the screws fixing the brackets to the turning stand.
- ☐ Disassemble the brackets from the engine after having properly put it on a wooden bearing.

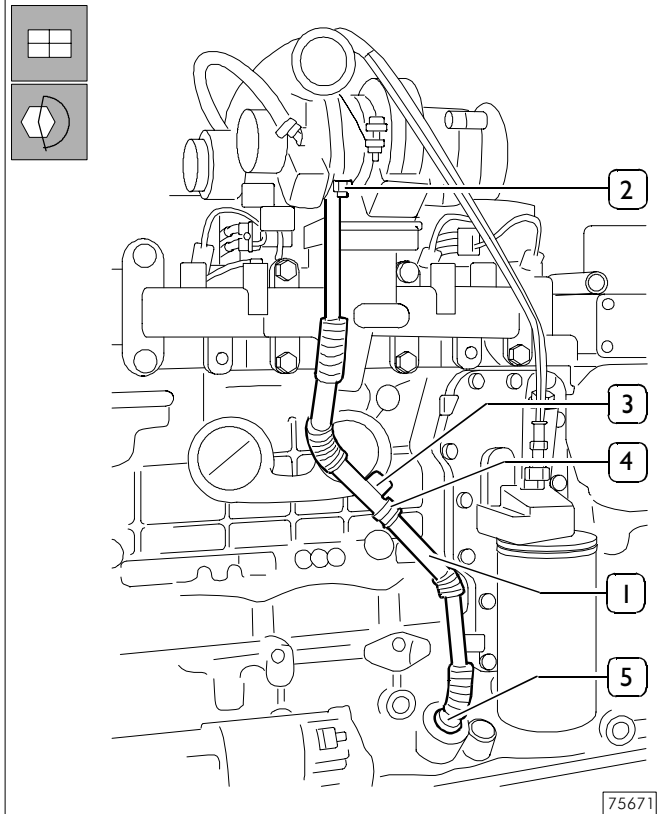
Completion of the engine**Figure 197**

On the right hand side:

- ▣ reassemble the pipes (1) from the union (2) to the lubrication oil filter (placed on the opposite side): tighten the pipe rings (1) and connect them to the union

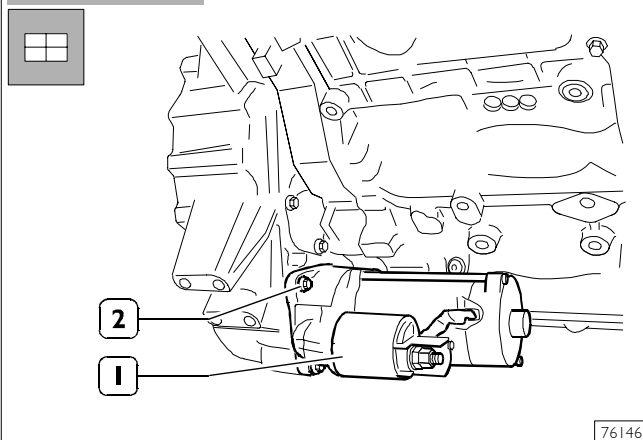


In some cases, the oil filter (3) is directly placed on the heat exchanger: in this case it shall be assembled using acceptable tools.

Figure 198

- ▣ Reassemble the lubrication oil exhaust pipeline (1) from the turbocharger: from underneath the turbocharger tighten the two screws (2); tighten the screw (3) fixing the pipeline to the block throughout the fixing collar (4) to the block; finally tighten the union (5) to the block.

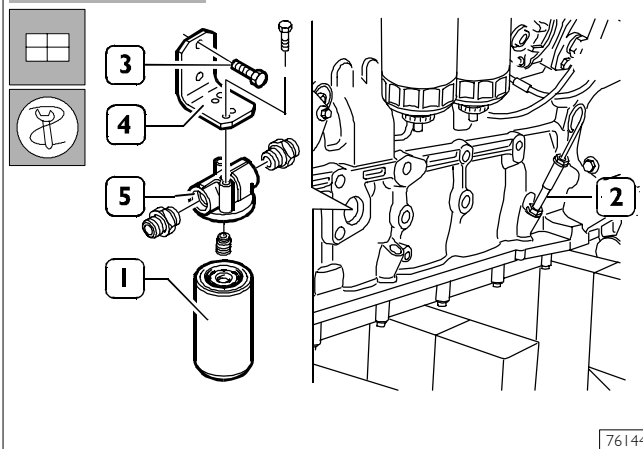
Figure 199



76146

- ☐ Reassemble the starter; properly hold the starter (1) and tighten the fixing screws (2) to the prescribed couple.

Figure 200



76144

On the left hand side:

- ☐ Assemble oil filter (1) together with bracket (for the versions with engine oil filter not directly assembled to the exchanger); tighten the screws (3) assembling the bracket (4) including filter bearing (5).
Use acceptable tools to install oil filter;
- ☐ Assemble oil level rod together with guide pipe (2). Fill up engine oil.
- ☐ Install the engine on the machine (for installation operations please apply to specific issue).

Feed pump unit assembly and disassembly procedure



This procedure prescribes that:

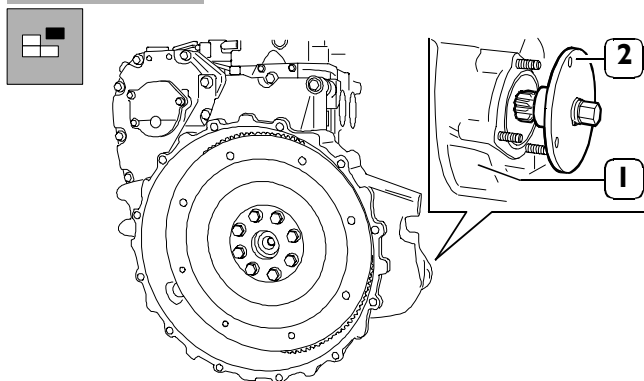
- ☐ The fuel pipelines (from pumping elements to injectors, bleeding recovery pipes from injectors to pump, LDA pipeline and feed provided by priming pump) shall all be disassembled.
- ☐ Electrical connection to feed pump shall be disconnected.
- ☐ Accelerator cable shall be disconnected.

In case feed pump replacement is necessary, this shall be supplied pre-set already as spare part.

On the other hand, in case the pump shall be disassembled and reassembled later on without being repaired it will be necessary to pre-set it while it is still assembled to the engine and disassemble it only afterwards.

The following procedure analyses this second hypothesis since it is the more complex.

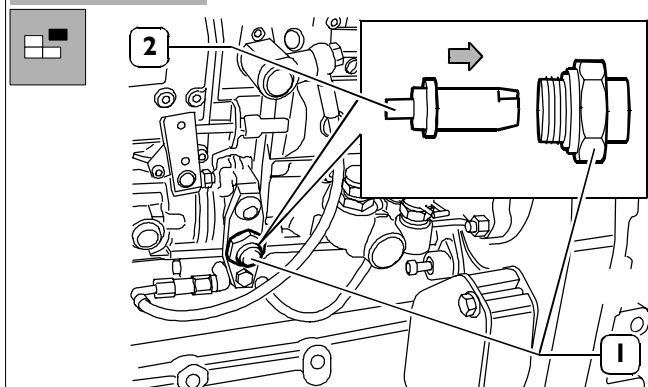
Figure 201



75714

- ☐ Disassemble the starter from the flywheel box (1) and use the 380000988 tool (2) to rotate the flywheel.

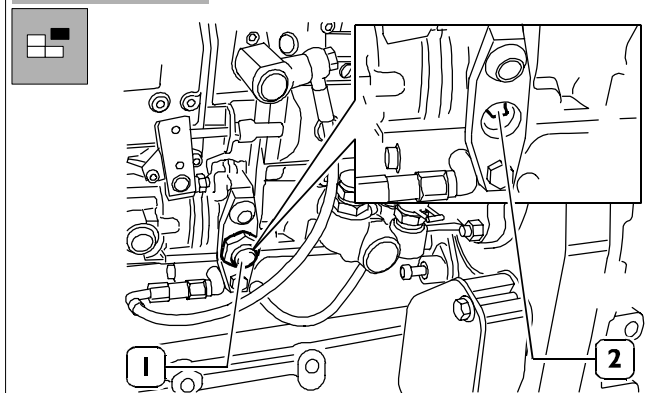
Figure 202



76134

- ☐ Disassemble hexagon (1) shaped cap from the speed gauge box and the pin (2) underneath.

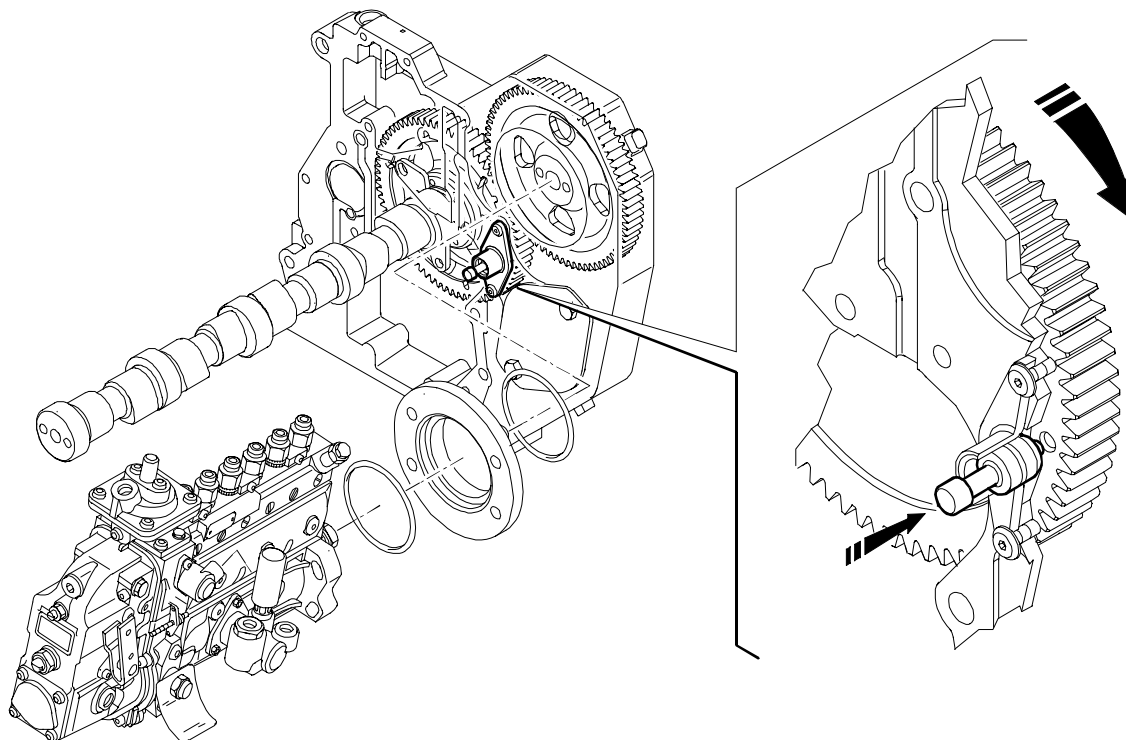
Figure 203



76136

- ☐ Verify, checking through the hole of the box, that the reference index of the gauge unit is displayed.

Figure 204



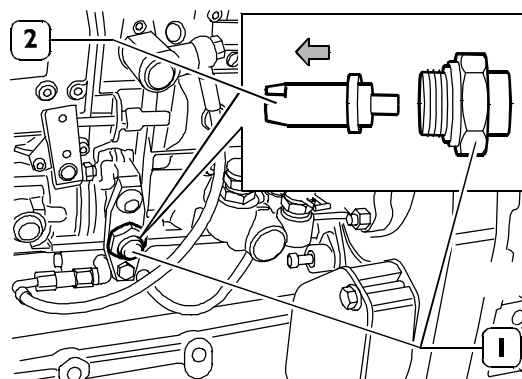
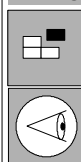
76209

- ☐ Rotate with caution the flywheel following its own rotation sense to annul the gear slacks and at the same time keep the (→) pin pressed until when this last one is fitting into the port of the camshaft gear. This way the P.M.S. shall be determined within N.6 cylinder.



Flywheel rotation shall be carried out with extreme caution. The pin charged by excessive shearing stress may get damaged.

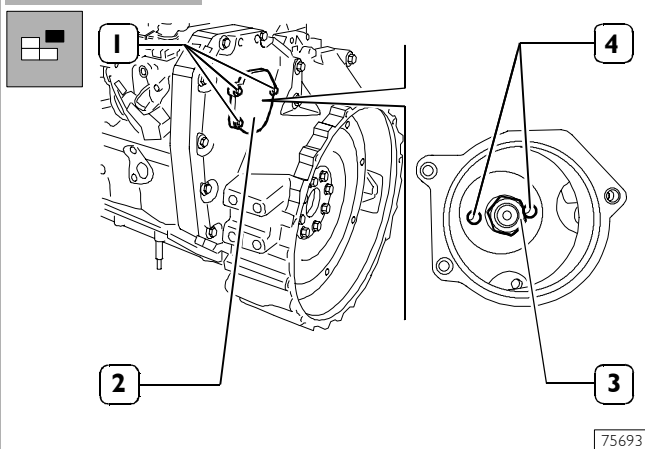
Figure 205



76135

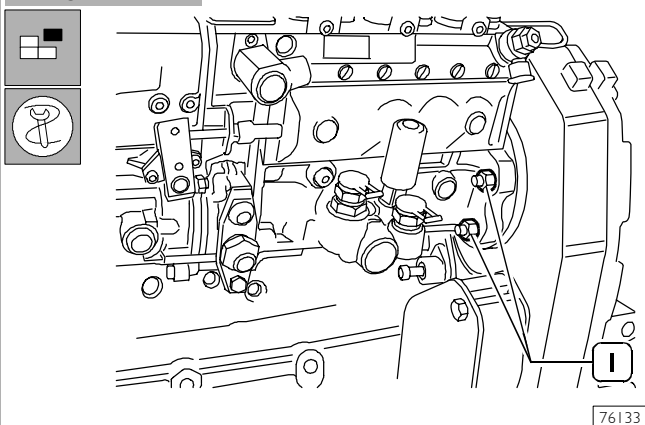
- ☐ Plugh the previously removed pin into the gauge housing following the direction indicated in the figure. The pin (2) shall be plugged until end of stroke to bind the index and lock rotation of the pump's camshaft.
- ☐ Assemble hexagon shaped cap (1).

Figure 206



- ☐ From timing side, remove the cover (2) loosening the screws (1) in order to have access to the union fixing nut (3) to the pump driving gear.
- ☐ Loosen the fixing nut (3) and remove the relating washer.

Figure 207

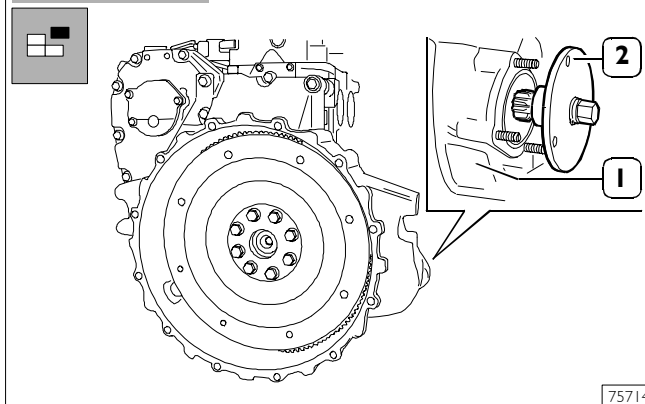


- ☐ From the pump side, loosen the fixing nuts (1) without removing them in order to enable moving the pump backwards using 380000979 extractor.
- ☐ Assemble the 380000979 extractor throughout the two threaded ports (4, Figure 206) and withdraw the gear from the pump shaft.
- ☐ Hold the feed pump using acceptable tools and unscrew completely the fixing nuts.
- ☐ Withdraw the pump from the holding studs together with the gasket.



In these conditions the pump is pre-set and can be assembled to the engine further.

Figure 208



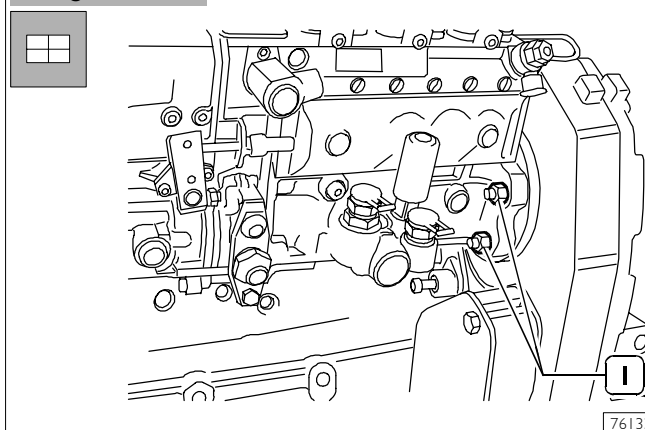
When assembling the feed pump to the engine, it is necessary to meet the P.M.S. requirements for the N.I. cylinder.

- ☐ Use the 380000988 tool (2) on the flywheel box (1) to carry out flywheel rotation and operate using the pin as previously described.



Hold the pump driving gear to avoid interference or crawling during timing gear rotation.

Figure 209

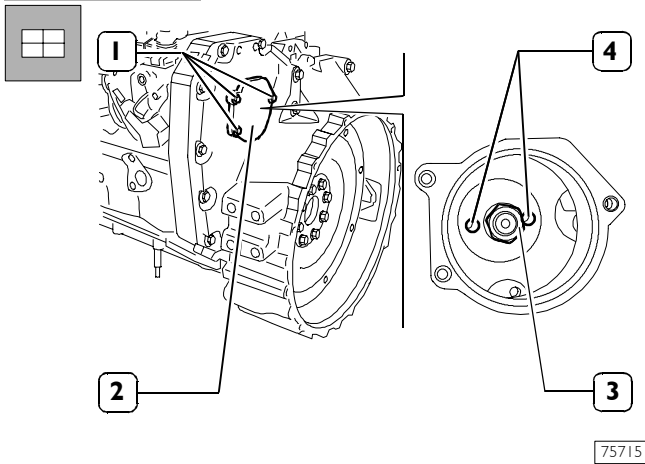


- ☐ Hold the feed pump using acceptable tools and assemble it (pre set pump) to the engine in its housing: insert the camshaft capule into the port of the pump's driving gear (not provided with key).
- ☐ Tighten the fixing nuts (1) centering and locking the pump's flange within the slot.



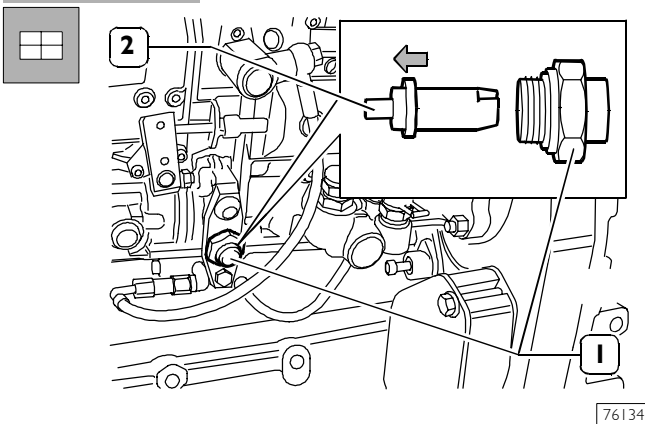
The gasket removed during pump disassembly shall not be utilised again.
Always use original spare parts.

Figure 210



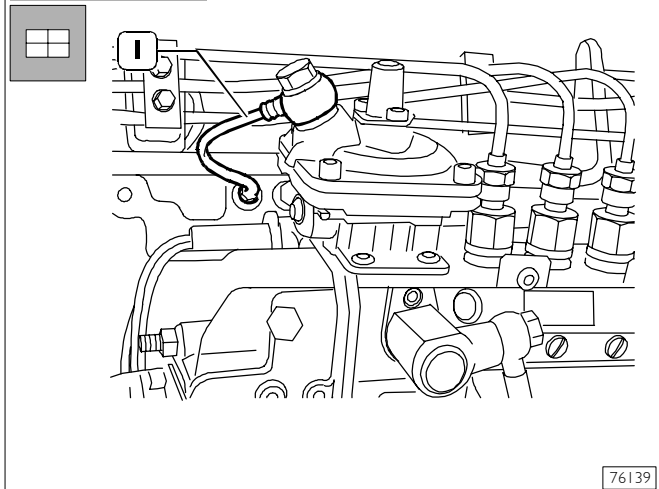
- On the timing side, throughout the specially appointed port, fit the washer and screw up the fixing nut (3) to the pump shaft. Lock the nut to the 90–95 Nm couple.

Figure 211



- Remove the hexagonal shaped cap (1) from the speed gauge box and withdraw locking pin (2) from the camshaft.
- Turn the locking pin (2) upsidedown and place it in its housing: this operation enables free rotation of the pump's camshaft.
- Assemble the hexagonal shaped cap (1) to the speed gauge box.

Figure 212



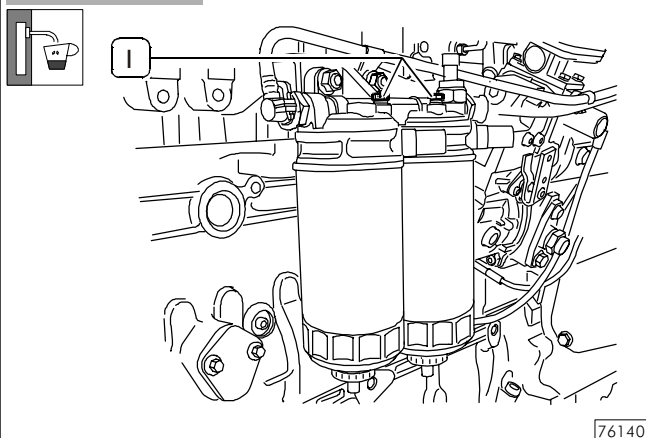
- Assemble the cover (2, Figure 210) including gasket and tighten the screws (1, Figure 210).
- Pull the pin outwards setting the camshaft gear free.
- ☐ Remove the 380000988 tool locking flywheel rotation; place the starter in its housing.
- Connect all pipelines (from pumping elements to injectors, bleeding recovery pipes from injectors to pump, LDA pipeline (1) and feed provided by priming pump and lubrication pipelines).
- Connect electrical switch devices to engine stop.



In case pump removal has been carried out while the engine was assembled, connect acceleration cable.

Feed system bleed procedure

Figure 213

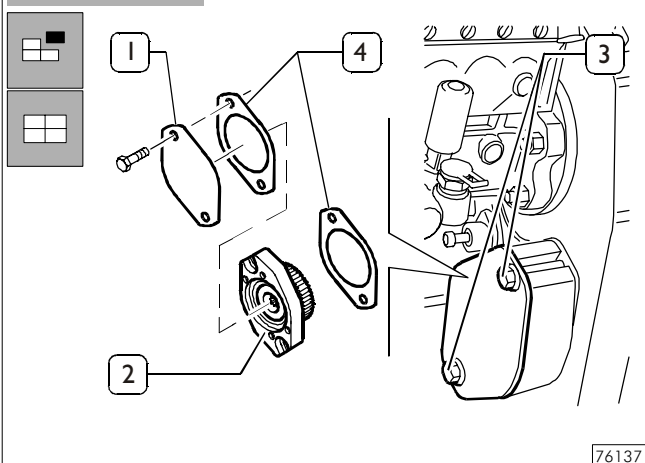


In case any operation has been executed on the components of the feed circuit, it is necessary to execute bleeding of air within the system.

- ☐ Loosen the bleeder vent screws (1) on the fuel filter supports.
- ☐ Switch starter revolution on, activating the priming pump and driving fuel delivery to the filters.
- ☐ Continue executing this operation until when fuel drains from the bleeder vent screws, then tighten the screws.

Power take-off disassembly and assembly procedure

Figure 214



Where designed, there is a power take-off able to transmit motion to different auxiliary parts.

Disassembly of such mechanism shall be executed as following:

- ☐ Loosen the two screws (3) and after having removed the cover (1) with a specially provided extractor, withdraw The power take-off (2).
- ☐ The two gaskets (4) shall be replaced in phase of reassemble.

- ☐ Vary out the assembly fitting the power take-off in its housing, providing new gasket and checking the sprocket gear meshing.
- ☐ Assemble cover and gasket and tighten the screws to the prescribed couple.

Checks and controls



The following tests shall be made after engine assembly to the vehicle.

Preventively check that the liquid levels have been correctly restored.



Start the engine, let it run at revolution regimen slightly higher than idling and wait that the cooling liquid temperature reaches the value enabling thermostat opening, then check that:



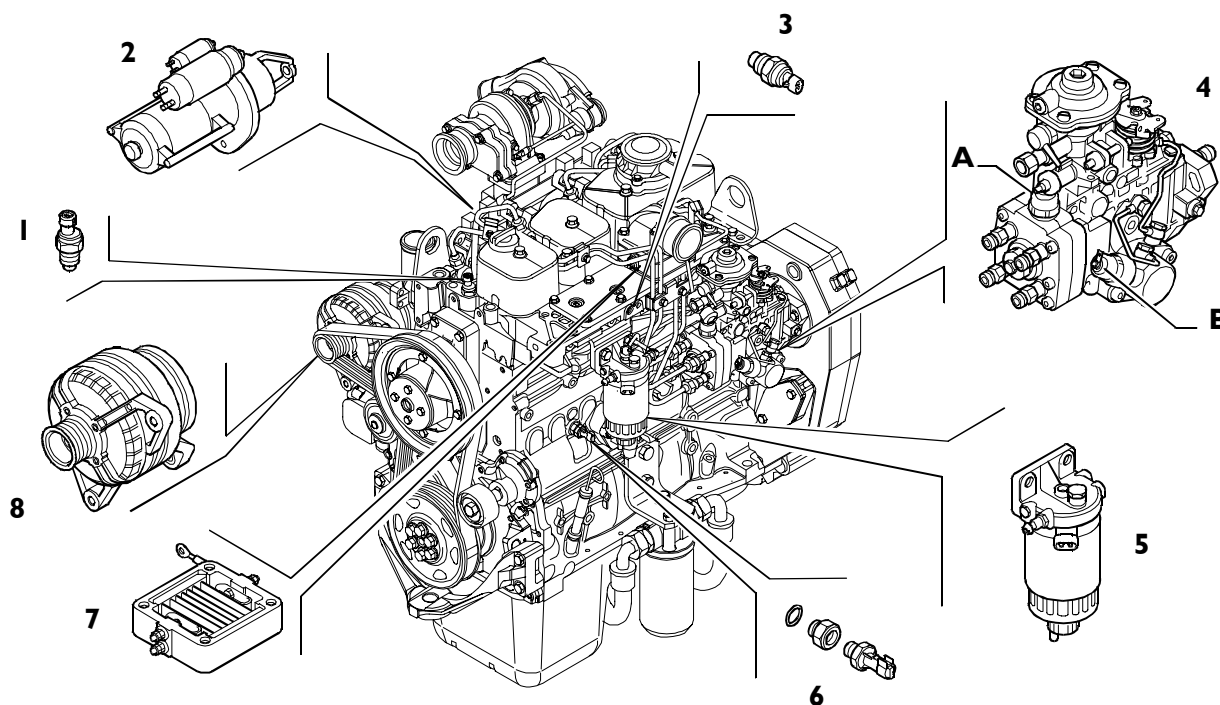
- ☐ There is no water bleeding from the manifolds connecting engine cooling circuit pipelines and cabin internal heating, eventually providing to further tighten the locking rings.
- ☐ Carefully check the fuel connection pipes to the respective unions.
- ☐ There is no oil leakage from the lubrication circuit of the various pipelines connecting cover and.
- ☐ Cylinder head, oil pan and bearing, oil filter and heat exchanger as well as relating housings.
- ☐ There is no fuel leakage from fuel pipelines.
- ☐ There is no blowby from pneumatic pipes (if provided).
- ☐ Verify correct working of the lighting leds of the dashboard containing the tools as well as of the equipment that was disconnected during engine disconnection.
- ☐ Check and blow by with care the engine cooling system, carrying out frequent drainage.

TIGHTENING TORQUE (FOR 4 AND 6 CYL.)

COMPONENT		TORQUE	
		Nm	kgm
Cooling Nozzles (M8x1.25x10)		15 ± 3	1.5 ± 0.3
Main bearing cap	1st stage	50 ± 6	5.0 ± 0.6
	2nd stage	80 ± 6	8.0 ± 0.6
	3rd stage	90° ± 5°	
Rear gear housing assembly (M8x1.25x40)		24 ± 4	2.4 ± 0.4
(M8x1.25x25)		24 ± 4	2.4 ± 0.4
(M10x1.5)		49 ± 5	4.9 ± 0.5
Oil pump (M8x1.25x30)		8 ± 1	0.8 ± 0.1
Front cover assembly (M8x1.25x45)		24 ± 4	2.4 ± 0.4
(M8x1.25x30)		24 ± 4	2.4 ± 0.4
Connecting rod bolts (M11x1.25)	1st stage	30 ± 3	3.0 ± 0.3
	2nd stage	60 ± 5	6.0 ± 0.5
	3rd stage	60° ± 5°	
Ladder frame assembly (M10x1.25x25)		43 ± 5	4.3 ± 0.5
Oil rifle plugs (M10x1)		6 ± 1	0.6 ± 0.1
(M14x1.5)		11 ± 2	1.1 ± 0.2
Assemble oil suction tube (M8x1.25x20)		24 ± 4	2.4 ± 0.4
Oil pan assembly (M8x1.25x25)		24 ± 4	2.4 ± 0.4
(M18x1.50)		60 ± 9	6.0 ± 0.9
Set timing pin		5 ± 1	0.5 ± 0.1
Fuel pump assembly			
M8 screw		24 ± 4	2.4 ± 0.4
M6 screw		10 ± 1	1.0 ± 0.1
M6 nut		10 ± 1	1.0 ± 0.1
M10x1.5 flange head nuts	pre-torque	10 – 15	1.0 – 1.5
		50 – 55	5.0 – 5.5
Fuel pump gear (drive gear nut)	Snug torque	15 – 20	1.5 – 2.0
	Final torque	85 – 90	8.5 – 9.0
Timing pin cap of fuel pump		30 – 35	3.0 – 3.5
Rocker assys (M8)		24 ± 4	2.4 ± 0.4
Cylinder head bolts (M12x70)		50 + 90°	5.0 + 90°
(M12x140)		40 + 180°	4.0 + 180°
(M12x180)		70 + 180°	7.0 + 180°
Assy rocker covers (M8x1.25x25)		24 ± 4	2.4 ± 0.4
Intake manifold (M8x1.25)		24 ± 4	2.4 ± 0.4
Assy air intake connection (M8x1.25)		24 ± 4	2.4 ± 0.4
Oil bypass valve into lube filter head (M22x1.5x10)		80 ± 8	8.0 ± 0.8
Plug (M12x1.5x12)		10 ± 1	1.0 ± 0.1
Exhaust manifold (M10x1.5x65)		43 ± 6	4.3 ± 0.6
Water pump (M8x1.25x25)		24 ± 4	2.4 ± 0.4
Water outlet connection (M8x1.25x35)		24 ± 4	2.4 ± 0.4
(M8x1.25x70)		24 ± 4	2.4 ± 0.4
Fan support (M10x1.5x20)		33 ± 5	3.3 ± 0.5
Fan pulley (M6)		10 ± 2	1.0 ± 0.2
(M10)		43 ± 6	4.3 ± 0.6

COMPONENT	TORQUE	
	Nm	kgm
Rear lifting bracket (M12x1.75x30)	77 ± 12	7.7 ± 1.2
Crankshaft pulley (M12x1.75x10.9)	110 ± 5	11.0 ± 0.5
Flywheel housing (M12x120)	85 ± 10	8.5 ± 1.0
(M12x80)	85 ± 10	8.5 ± 1.0
(M10x80)	49 ± 5	4.9 ± 0.5
(M10x40)	49 ± 5	4.9 ± 0.5
Flywheel housing (M12x1.25)	1st stage 2nd stage	30 ± 4 60° ± 5° 3.0 ± 0.4
Assy rear cover plate to flywheel housing (M8x1.25x16)	24 ± 4	2.4 ± 0.4
Fuel injectors	60 ± 5	6.0 ± 0.5
Fuel lift pump	24 ± 4	2.4 ± 0.4
Turbocharger to exhaust manifold (M10)	43 ± 6	4.3 ± 0.6
Oil feed to oil filter head	24 ± 4	2.4 ± 0.4
Oil feed to turbocharger (M12x1.5)	35 ± 5	3.5 ± 0.5
Oil drain (M8x1.25x16)	24 ± 4	2.4 ± 0.4
Alternator to alternator support (M8x1.25x30)	24 ± 4	2.4 ± 0.4
Alternator to water inlet conn. assy (M8x1.25x30)	24 ± 4	2.4 ± 0.4
Lower alternator mounting (M10x1.25x25)	24 ± 4	2.4 ± 0.4
Alternator upper pivot to support (M10)	49 ± 5	4.9 ± 0.5
Alternator mounting hardware (M12x1.75x120)	43 ± 6	4.3 ± 0.6
Alternator wiring (M6x1.0 nut)	10 ± 2	1.0 ± 0.2
Starter motor to gear case (M10)	49 ± 5	4.9 ± 0.5

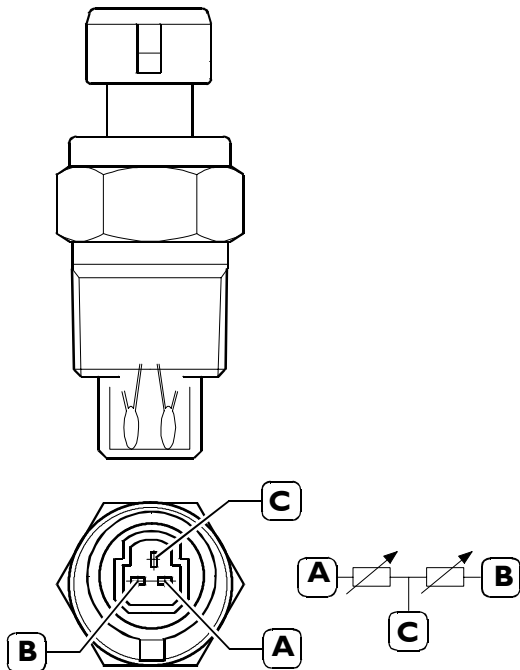
PART TWO – ELECTRICAL EQUIPMENT

ELECTRICAL COMPONET LAYOUT (4 CYL. ENGINES WITH ROTARY PUMP)**Figure 215**

75724

The electrical components provided with F4BE0484 Engine are listed here following:

1. Cooling liquid temperature sensor;
2. Starter;
3. KSB Water temperature sensor;
4. Electromagnets assembled to feed pump:
(A) on hydraulic head unit
(B) on KKS B;
5. Fuel heater;
6. Oil pressure switch;
7. Resistor for cold start (whether specifically designed);
8. Alternator;

Cooling liquid temperature sensor**Figure 216**

75718

It is a component integrating a temperature sensor.

It is assembled to the engine head close to the thermostat unit and its duty is to detect engine cooling liquid temperature.

Specifications:

Range of working temperatures:

Connection side $-40 \div +150\text{ }^{\circ}\text{C}$ for $< 10\text{ min.}$

Bulb side on engine: $-40 \div +140\text{ }^{\circ}\text{C}$

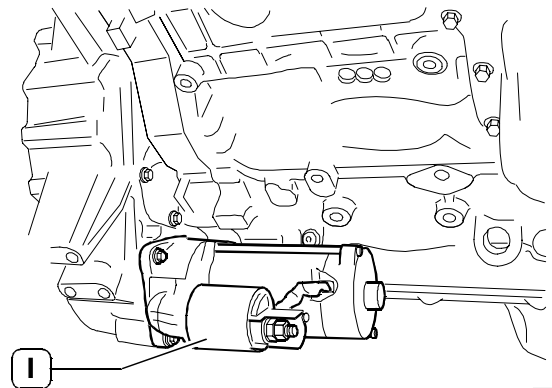
Working tensions: $6 \div 28\text{ V}$

Settings:

$80\text{ }^{\circ}\text{C}$ $0.304 \div 0.342\text{ k}\Omega$

$20\text{ }^{\circ}\text{C}$ $2.262 \div 2.760\text{ k}\Omega$

$-10\text{ }^{\circ}\text{C}$ $8.244 \div 10.661\text{ k}\Omega$

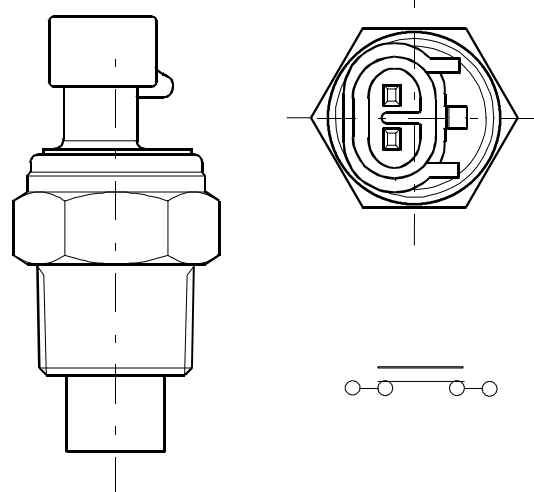
Starter**Figure 217**

75717

Starter is usually driven by starting unit placed on the vehicle dashboard and provides positive tension to the tele-switch assembled to the starter itself.

Specifications:

BOSCH 3 kW – 12V

KSB Water temperature sensor**Figure 218**

75719

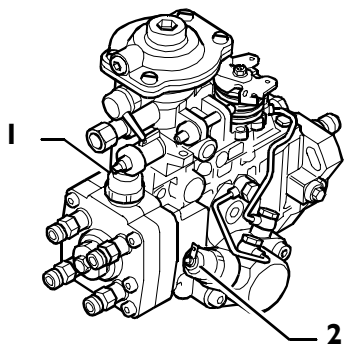
It is assembled to the cylinder head on the engine left hand side.

Specifications:

Working tensions: $12 \div 24\text{ V}$

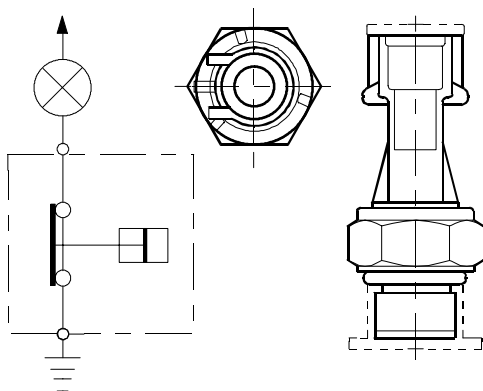
Electrical Power load: 2.5 A (induction)
 5.0 A (resistance)

Setting: $32 \pm 2\text{ }^{\circ}\text{C}$ Contact opening
upon increasing temperature
 $22 \pm 2\text{ }^{\circ}\text{C}$ Contact closure
upon decreasing temperature

Electromagnets assembled to feed pump**Figure 219**

75724a

1 – Hydraulic head Electro-magnet; 2 – KKS Electro-magnet

Oil pressure switch**Figure 220**

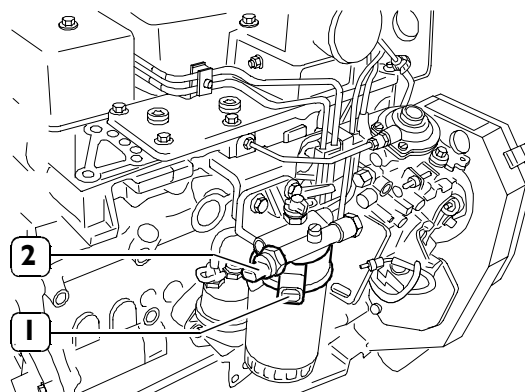
75722

It is assembled to the block on the engine's left hand side. Specifications:

Working tensions: 12 ÷ 24 V

Contact closure
upon lower pressure: 0.2 bar

Contact opening
upon higher pressure: 0.9 bar

Fuel filter**Figure 221**

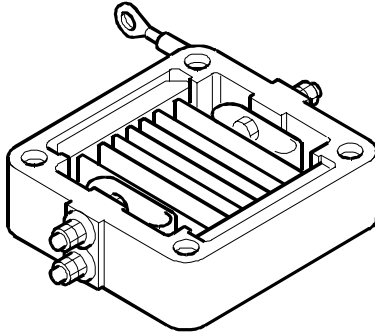
75716

1 – Fuel temperature sensor; 2 – Resistor for filter heating;

On the fuel filter bearing there is the temperature sensor and the fuel filter heating resistor connection.

Pre-post heating resistor

Figure 222



75723

It is a resistor assembled to the suction collector and is utilised to heat the air during pre-post heating operations.

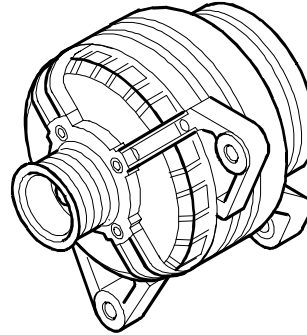
It is fed by a tele-switch usually placed very close to the engine.

Specifications:

Working tensions: 12 V Maximum possible
Air flow: 2 cc / min
(pressure 138 kPa)

Alternator

Figure 223

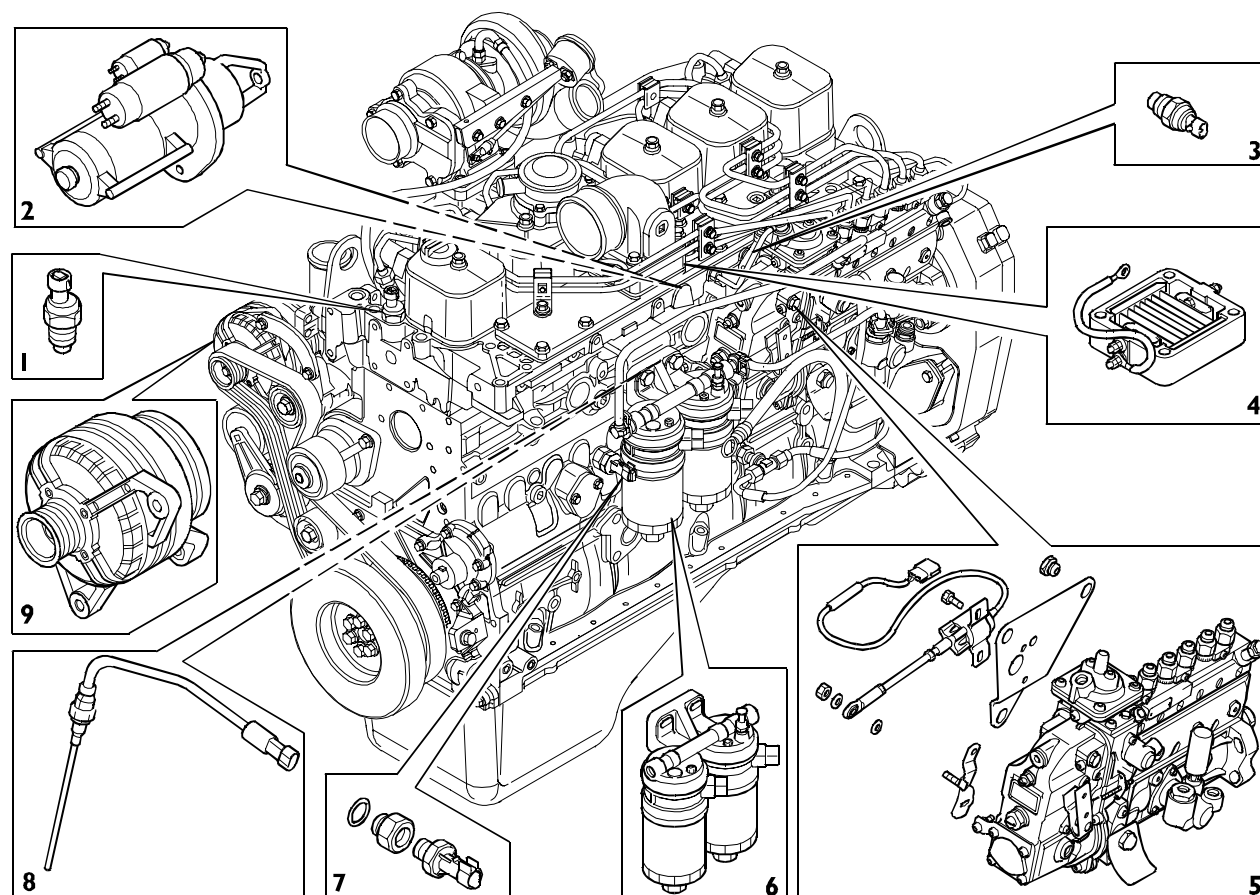


75725

It is place front view on the right hand side of the engine, and is driven by tooth belt.

Specifications:

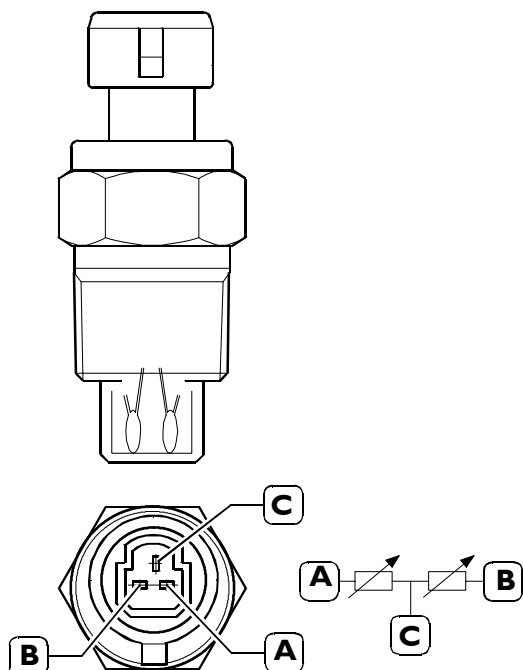
Rated tensions: 12 V
Current delivered: 90A (at 6000 rpm)
Absorption in stand-by: $\leq 1\text{mA}$
Sense of rotation: clockwices

ELECTRICAL COMPONET LAYOUT (6 CYL. ENGINES WITH PUMP UNIT)**Figure 224**

76521

The electrical components provided with F4BE0684 Engine are listed here following:

1. Cooling liquid temperature sensor;
2. Starter;
3. KSB Water temperature sensor;
4. Resistor for cold start (whether specifically designed);
5. Engine stop assembled to feed pump;
6. Fuel heater;
7. Oil pressure switch;
8. Engine oil lever transmitted;
9. Alternator;

Cooling liquid temperature sensor**Figure 225**

75718

It is a component integrating a temperature sensor.

It is assembled to the engine head close to the thermostat unit and its duty is to detect engine cooling liquid temperature.

Specifications:

Range of working temperatures:

Connection side $-40 \div +150\text{ }^{\circ}\text{C}$ for $< 10\text{ min.}$

Bulb side on engine: $-40 \div +140\text{ }^{\circ}\text{C}$

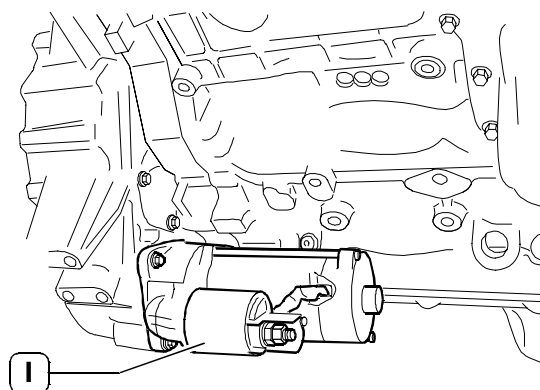
Working tensions: $6 \div 28\text{ V}$

Settings:

$80\text{ }^{\circ}\text{C}$ $0.304 \div 0.342\text{ k}\Omega$

$20\text{ }^{\circ}\text{C}$ $2.262 \div 2.760\text{ k}\Omega$

$-10\text{ }^{\circ}\text{C}$ $8.244 \div 10.661\text{ k}\Omega$

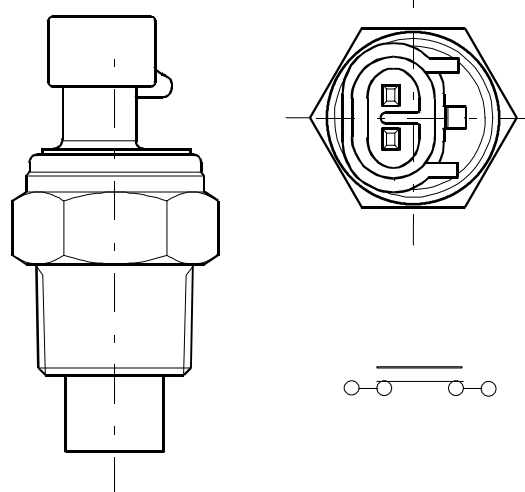
Starter**Figure 226**

75717

Starter is usually driven by starting unit placed on the vehicle dashboard and provides positive tension to the tele-switch assembled to the starter itself.

Specifications:

BOSCH 4 kW – 24V

KSB Water temperature sensor**Figure 227**

75719

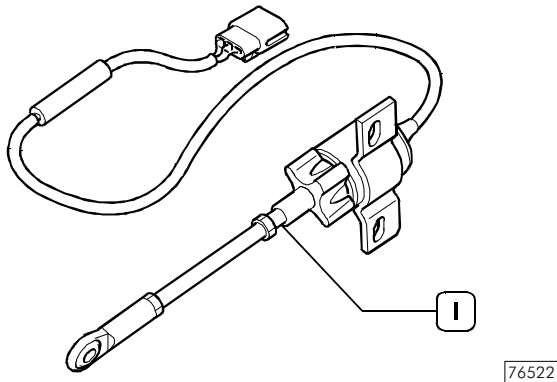
It is assembled to the cylinder head on the engine left hand side.

Specifications:

Working tensions: $12 \div 24\text{ V}$

Electrical Power load: 2.5 A (induction)
 5.0 A (resistance)

Setting: $63 \pm 3\text{ }^{\circ}\text{C}$ Contact opening
upon increasing temperature
 $53 \pm 3\text{ }^{\circ}\text{C}$ Contact closure
upon decreasing temperature

Engine stop assembled to feed pump**Figure 228**

1–Engine stop.

Nominal rated voltage: 24 Vdc

Nominal rated temperature: 20°C (68°F)

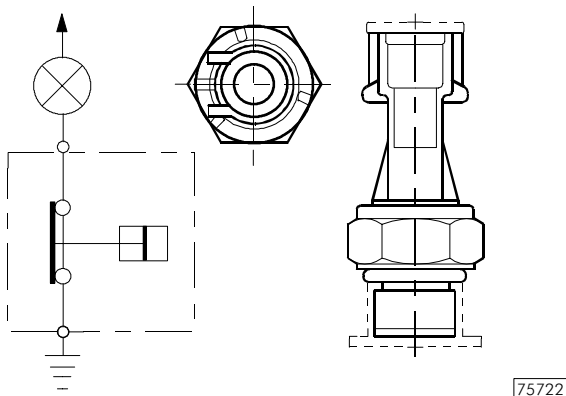
Pull coil current: 24.6 Amps

Hold coil current: 46 Amps

Hold coil resistance: 51.72 Ohms

Pull force: 89 N (18.9 lbs)
at rated conditions

Hold force: 178 N (40 lbs)

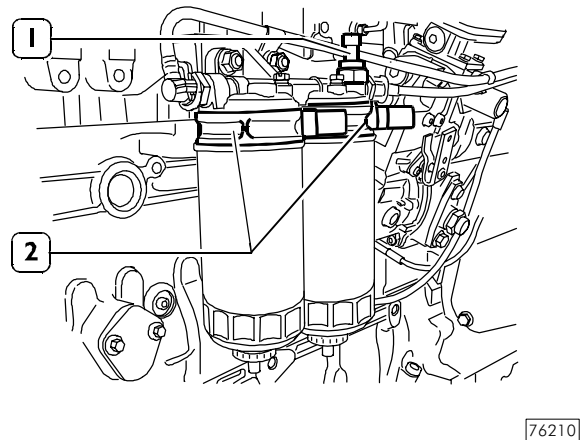
Oil pressure switch**Figure 229**

It is assembled to the block on the engine's left hand side. Specifications:

Working tensions: 12 ÷ 24 V

Contact closure upon lower pressure: 0.2 bar

Contact opening upon higher pressure: 0.9 bar

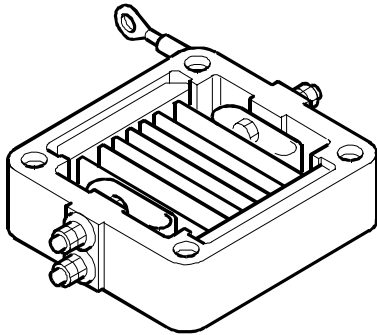
Fuel filters**Figure 230**

1–Fuel temperature sensor; 2 –Resistor for filter heating;

On the fuel filter bearing there is the temperature sensor and the fuel filter heating resistor connection.

Pre-post heating resistor

Figure 231



75723

It is a resistor assembled to the suction collector and is utilised to heat the air during pre-post heating operations.

It is fed by a tele-switch usually placed very close to the engine.

Specifications:

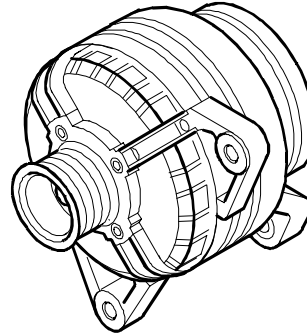
Working tensions: 24 V

Maximum possible

Air flow: 2 cc / min
(pressure 138 kPa)

Alternator

Figure 232



75725

It is place front view on the right hand side of the engine, and is driven by tooth belt.

Specifications:

Rated tensions: 24 V

Current delivery  90A (at 6000  rpm)

Absorption in stand-by: $\leq 1\text{mA}$

Sense of rotation: clockwices

PART THREE – TROUBLESHOOTING

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
The engine does not start	Battery flat or faulty.	Check and recharge battery. Replace battery if necessary.	
	Connections to battery terminals corroded or loose.	Clean, examine and tighten the nuts on the battery terminals. Replace the cable terminals and the nuts if excessively corroded.	
	Incorrect timing of injection pump.	Check and correctly time the injection pump.	See your  dealer.
	Deposits or water in the fuel tank.	Disconnect the hoses and clean them using a jet of compressed air. Dismantle and clean the injection pump. Remove water from tank and refuel.	Drain feed system.
	No fuel in tank.	Refuel.	
	No power supply.	Overhaul or replace the fuel or transfer pump.	
	Air bubbles in the fuel lines or injection pump.	Check the hoses to ensure that air is in fact present and also check the fuel pump. Eliminate the air from the injection pump by unscrewing the cap and working the fuel pump by hand.	
	Faulty starter motor.	Repair or replace the starter motor.	

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
The engine does not start at low temperatures	Fuel system clogged with paraffin crystals forming due to the use of unsuitable fuel.	Replace the fuel with fuel suitable for use at low temperatures. Replace the fuel filters.	
	K.K.S.B. device for cold spark advance control operating incorrectly.	Check or replace the injection pump.	See your dealer.
The engine cuts out.	Idle rpm too low.	Adjust with adjustment screw.	
	Irregular flow of injection pump.	Adjust flow.	See your dealer.
	Impurities or water in the fuel lines.	Disconnect the hoses and clean them using a jet of compressed air. Dismantle and clean the injection pump. Remove water from fuel tank and refuel.	Drain feed system.
	Clogged fuel filter.	Dismantle and replace if necessary.	
	Presence of air in the fuel and injection system.	Check that the hoses are not cracked or the unions loose. Replace worn parts, remove the air from the hoses and deaerate the injection pump and fuel filter by unscrewing the caps and working the primer pump by hand.	
	Broken injection pump controls.	Replace the faulty parts.	
	Abnormal clearance between camshaft cams and tappets.	Adjust clearance by replacing shims.	
	Burnt, corroded or chalky valves.	Replace the valves, rectify or replace the cylinder head seatings.	

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
The engine overheats	Faulty water pump.	Check the unit and replace if necessary. Re-place the gasket.	
	Malfunctioning thermostat.	Replace the thermostat.	
	Fouling in coolant openings in the cylinder head and cylinder groups.	Wash following the standards specified for the type of descaling product used.	
	Water pump drive belt slack.	Check and adjust the tightness of the belt.	On applications provided with automatic tensioner, check correct working of such device.
	Coolant level too low.	Top-up radiator with coolant.	
	Incorrect engine timing.	Check timing and tune correctly.	
	Incorrect calibration of injection pump.	Correct the delivery rate of the pump on a bench so that the injection is at the specified rate.	See your Dealer.
	Dry air cleaner blocked.	Clean the air filter or replace if necessary.	
	Incorrect timing of injection pump.	Check timing and correctly set pump.	
	K.K.S.B. automatic cold advance device malfunctioning.	Check or replace injection pump.	
Engine operation is irregular and lacks power	Excessive piston wear.	Check or replace injection pump.	
	Incorrect calibration of speed regulator.	Check and correctly calibrate the regulator.	See your Dealer.

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
Engine operation is irregular and lacks power	Partial blockage of nozzles or faulty operation of injectors.	Clean the nozzles of the atomisers using the appropriate tools and completely overhaul the injectors.	
	Impurities or water in the fuel and injection system.	Carefully clean the system and refuel.	If necessary drain feed system.
	Incorrect play between camshaft cams and tappets.	Check and correct play	
	Faulty turbocharger.	Replace complete unit.	
	Air cleaner blocked.	Clean or replace air cleaner.	
	Faulty operation of L.I.D.A. device	Check that the diaphragm is not perforated, that the counter spring is suitable and that it has the correct loading (check on test bench). Check that there is adequate air pressure inside the intake manifold in relation to the engine rpm under full-load conditions.	See your dealer.
	Tie rods between accelerator pedal and regulation lever incorrectly adjusted.	Adjust the tie-rods so that the command lever can be moved to the full delivery position.	
Engine running with abnormal knocking	Faulty operation of injectors.	Replace all injectors.	
	Fuel lines blocked.	Dismantle the hoses, clean them and replace those that are seriously dented.	
	Incorrect set-up of injection pump.	Correct the set-up of the pump so that injection occurs at the specified angle.	See your dealer.

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
Engine running with abnormal knocking	Knocking of crankshaft causing excessive play on one or more main or rod bearings or excessive play on shoulders.	Rectify the pins of the crankshaft and install smaller bearings. Replace the thrust half-rings.	
	Crankshaft unbalanced.	Check alignment of crankshaft.	
	Loosening of screws securing flywheel.	Replace the loosened screws and tighten all the screws to the specified torque.	
	Misalignment of rods.	Replace the rods.	
	Noise from piston journals due to excessive play of piston hubs and in the rod bushing.	Replace the piston journal and/or the piston and rod bushing.	
	Loose bushings in the rod seatings.	Replace with new bushings.	
	Noisy timing.	Adjust the play between camshaft cams and tappets and check that there are no broken springs, that there is no excessive play between the valve stems and the valve guides, tappets and seatings.	
The engine smokes abnormally. Black or dark grey smoke.	Excessive maximum pump output.	Disconnect the pump and adjust delivery in accordance with the data given in the calibration table.	See your dealer.
	K.K.S.B. device out of calibration or malfunctioning.	Check operation by a tester and adjust correctly as described in the manual.	
	There is an excessive delay on the injection pump.	Correct the set-up.	

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
The engine smokes abnormally. Black or dark grey smoke. Blue, grey-blue, grey smoke tending to white.	The injection pump has an excessive advance.	Correct the set-up.	
	The holes in the atomisers (or some of them) are partially or entirely blocked.	Replace the injectors with a series of new injectors or clean and rectify the original ones using suitable equipment.	
	Air cleaner blocked or deteriorated.	Clean or replace the filter element.	
	Loss of compression in the engine due to: stuck or worn flexible rings; worn cylinder liners; valves deteriorated or badly adjusted.	Overhaul the engine or limit the interventions to the relative parts.	
	Unsuitable injectors, different types of injectors or incorrectly calibrated.	Replace or calibrate the injectors.	
	Injection hoses with an unsuitable internal diameter; end of hoses pinched due to repeated blocking.	Check conditions of the end or unions and where necessary replace the hoses.	
	Excessive delay in injection pump.	Correct the set-up of the pump.	See your ☐ dealer.
	K.K.S.B. automatic cold advance device malfunctioning.	Check or replace injection pump.	See your ☐ dealer.
	Faulty injector:	Replace the injector.	
	Leaking of oil from the piston rings caused by glued or worn rings or wearing of cylinder liner walls.	Overhaul the engine.	
	Engine oil passing through the intake guides – valves following wearing of guides or valve stems.	Recondition the cylinder head.	
	Engine too cold (thermostat blocked or inefficient).	Replace the thermostat.	

PART FOUR – MAINTENANCE PLANNING

MAINTENANCE PLANNING

Recovery

To ensure optimised working conditions, in the following pages we are providing instructions for the overhaul control interventions, checks and setting operations that must be performed on the engine at due planned dates.

The frequency of the maintenance operations is just an indication since the use of the engine is the main characteristic to determine and evaluate replacements and checks.

It is not only allowed but recommended that the staff in charge of the maintenance should also carry out the necessary maintenance and controlling operations even if not being included in the ones listed here below but that may be suggested by common sense and by the specific conditions in which the engine is run.

Planning of controls and periodical intervention

Controls and periodical intervention	Frequency (hours)
Visual check of engine	Daily
Check presence of water in fuel filter or pre-filter	Daily
Check of belt wear status	–
Check and setting of tappet clearance	4000
Replacement of engine's oil and filter	500
Replacement of fuel pre-filter	1 000
Replacement of fuel filter	500
Replacement of belt	1 500



The frequency of the maintenance operations is just an indication since the use of the engine is the main characteristic to determine and evaluate replacements and checks.

The maintenance operations are valid only if the setter fully complies with all the installation prescriptions.

Furthermore, the users assembled by the setter shall always be in conformance to couple, power and number of turns based on which the engine has been designed.

Checks not included in maintenance planning—daily checks

It is a good habit to execute, before engine start, a series of simple checks that might represent a valid warranty to avoid inconveniences, even serious, during engine running. Such checks are usually up to the operators and to the vehicle's drivers.

- Level controls and checks of any eventual leakage from the fuel, cooling and lubricating circuits.
- Notify the maintenance if any inconvenience is detected or if any filling is necessary.

After engine start and while engine is running, proceed with the following checks and controls:

- check presence of any eventual leakage from the fuel, cooling and lubricating circuits.
- Verify absence of noise or unusual rattle during engine working.
- Verify, using the vehicle devices, the prescribed pressure temperature and other parameters.
- Visual check of fumes (colour of exhaust emissions)
- Visual check of cooling liquid level, in the expansion tank.

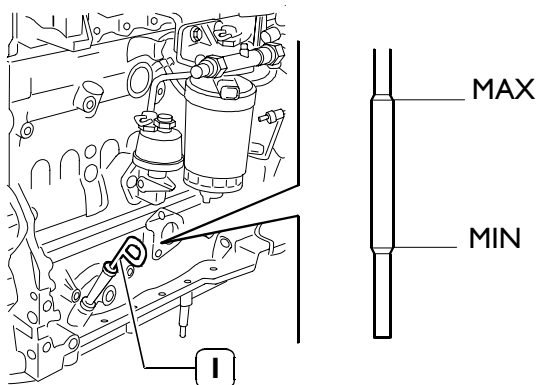
MAINTENANCE PROCEDURES – CHECKS AND CONTROLS

Engine oil level check.

The check must be executed when the engine is disconnected and possibly cool.

The check can be made using the specially provided flexible rod (1).

Figure 233



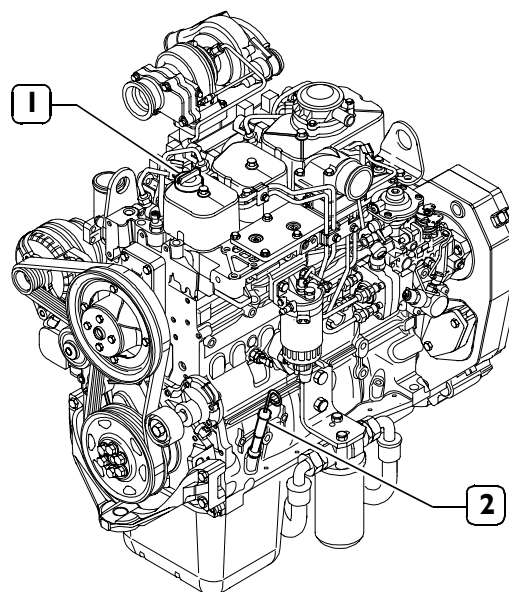
75748

Draw off the rod from its slot and check that the level is within the etched tags of minimum and maximum level.

Whether it should be difficult to make the evaluation, proceed cleaning the rod using a clean cloth with no rag grinding and put it back in its slot. Draw it off again and check the level.

In case the level results being close to the tag showing minimum level, provide filling lubrication of the engine's components.

Figure 234



75749

To provide filling, operate through the upper top (1) or through the lateral top (2). During filling operation, the tops must be removed as well as the rod in order to make the oil flow easier".

Some applications are equipped with a level transmitter alerting dashboard instruments in case of insufficient lubrication oil within the pan.



The engine oil is highly polluting and harmful.

In case of contact with the skin, rinse well with water and detergent.

Adequately protect the skin and the eyes, operate in full compliance with safety regulations.

Disposal must be carried out properly, and in full compliance with the law and regulations in force.

Check of fuel system

The check must be executed both when the engine disconnected and when it is running.

The check operation consists in examining the fuel pipelines running from the tank to the pre-filter (if provided in the specific equipment), to the filter, to the injection pump and to the injectors.

Cooling system check

The check must be executed both when the engine disconnected and when it is running.

Check the pipelines from the engine to the radiator; from the expansion tank and vice-versa. Find out any blow-by, verify the status of the pipes specially close to the holding strips.

Verify that the radiator is clean, the correct working of the fan flywheels, the presence of any leakage from the connectors, from the manifold and from the radiating unit.



Due to the high temperatures achieved by the system, do not operate immediately after the engine's disconnection, but wait for the time deemed necessary for the cooling.

Protect the eyes and the skin from any eventual high pressure jet of cooling liquid.

The density of the cooling liquid must be checked any how every year before winter season and be replaced in any case every two year.



In case of new filling, proceed bleeding system, through the bleeds on the engine.

If bleeding of the system is not carried out, serious inconvenience might be caused to the engine due to the presence of air pockets in the engine's head.

Lubricating system check

The check must be executed both when the engine disconnected and when it is running.

Verify the presence of any oil leakage or blow-by from the head, from the engine pan or from the heat exchanger.



The engine oil is highly polluting and harmful.

In case of contact with the skin, rinse well with water and detergent.

Adequately protect the skin and the eyes, operate in full compliance with safety regulations.

Disposal must be carried out properly, and in full compliance with the law and regulations in force.

Check of water presence within fuel filter or pre-filter



The components of the system can be damaged very quickly in presence of water or impurity within the fuel.

Timely proceed operating on the pre-filter (not available on the engine block) to carry out the drainage of the water within the feed circuit.

Fuel filter is equipped with pump screw-valve to drain the water eventually mixed with fuel (some applications of 6 cylinders engines will be equipped with two fuel filters, both provided with drainage).

Place a container underneath the filter and slightly loosen the screw. Drain the water eventually contained in the filter's bottom.

Lock the screw (max 0.5 Nm locking couple) as soon as fuel starts bleeding.

Check of drive belt tensioning

Some applications are equipped with an automatic tensioner that provides correcting belt tensioning.

Check of belt's tear and wear status

Carefully verify the belt's surface in order to detect any sign of incision, crack, excessive wear in correspondence of tothing; check end and surface grinding.

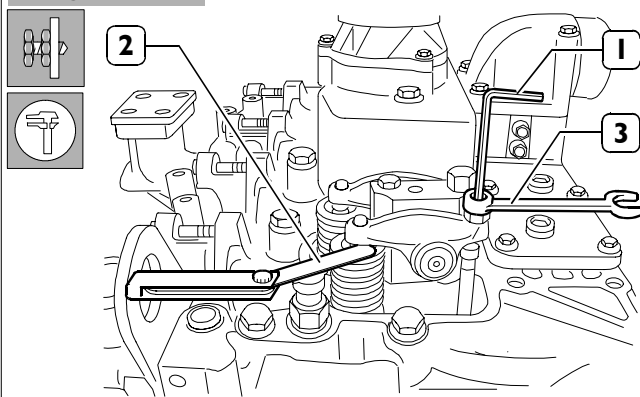


Danger: if the engine is switched off but is still hot, unexpected motion of the belt may occur.

Wait for engine temperature cooling as a precaution in order to avoid serious danger injury.

Check and setting of tappet clearance

Figure 235



75806

Adjust clearance between rockers and valves using setscrew wrench (1), box wrench (3) and feeler gauge (2).

Working clearance shall be as follows:

- intake valves 0.30 ± 0.05 mm
- exhaust valves 0.55 ± 0.05 mm.



In order to more quickly perform the operating clearance adjustment for rocker arms – valves, proceed as follows:

rotate the drive shaft, balance cylinder 1 valves and adjust the valves marked by the asterisk as shown in the table:

cylinder n.	1	2	3	4	5	6
intake	*	*	–	*	–	–
exhaust	*	–	*	–	*	–

Rotate the drive shaft of 360 deg., balance cylinder 6 valves and adjust the valves marked by the asterisk as shown in the table:

cylinder n.	1	2	3	4	5	6
intake	–	–	*	–	*	*
exhaust	–	*	–	*	–	*

Engine with 4 cylinder: rotate the drive shaft, balance cylinder 1 valves and adjust the valves marked by the asterisk as shown in the table:

cylinder n.	1	2	3	4
intake	*	–	–	–
exhaust	*	*	*	–

Rotate the drive shaft of 360 deg., balance cylinder 4 valves and adjust the valves marked by the asterisk as shown in the table:

cylinder n.	1	2	3	4
intake	–	*	*	*
exhaust	–	–	–	*

Oil motor and filter replacement



Warning: We recommend to wear proper protections because of high motor service temperature.

The motor oil reaches very high temperature: you must always wear protection gloves.

Due to the several applications, the pan shape and the oil quantity can change slightly. However, the following operations are valid for all applications.

We recommend to carry out the oil drainage when the motor is hot.

- ☐ Place a proper container for the oil collecting under the pan connected with the drain plug.
- ☐ Unscrew the plug and then take out the control dipsick and the inserting plug to ease the downflow of the lubrication oil.



The oil motor is very pollutant and harmful.

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

Protect properly skin and eyes: operate according to safety rules.

Dispose of the residual properly following the rules.

- ☐ After the complete drainage, screw the plug and carry out the clean oil filling.



Use only the recommended oil or oil having the requested features for the correct motor functioning.

In case of topping up, don't mix oils having different features.

If you don't comply with theses rules, the service warranty is no more valid.

- ☐ Check the level through the dipsick until when the filling is next to the maximum level notch indicated on the dipsick.

Whereas you replace the lubrication oil, it is necessary to replace the filter.

According to the application the filter can be located in different positions: the following procedure is a valid guide for all applications.

- ☐ The filter is composed by a support and a filtering cartridge.
For the cartridge replacement use acceptable tools.



Warning: the oil filter contains inside a quantity of oil of about 1 kg.

Place properly a container for the liquid.

Warning: avoid the contact of skin with the motor oil: in case of contact wash the skin with running water.

The motor oil is very pollutant: it must be disposed of according to the rules.

- ☐ Replace the filtering cartridge with a new one and screw manually until when the gasket is in contact with the support.
- ☐ ☐ **Tighten by means of acceptable tools three fourth turn.**
- ☐ Operate the motor for some minutes and check the level through the dipsick again. If it is necessary, carry out a topping up to compensate the quantity of oil used for the filling of the filtering cartridge.

Fuel filter replacement



During this operation don't smoke and don't use free flames.

Avoid to breathe the vapors coming from filter.



After filters replacement the supply equipment deaeration must be carried out.

According to the applications the filters position and the quantity can change.

However the following operations are valid for all applications.

- ☐ Drain the fuel inside the filter by operating the water release screw. Collect the fuel in a container without impurities.
- ☐ Unscrew the cartridge by using acceptable tools.
- ☐ Collect the eventual fuel inside the filtering cartridge.
- ☐ Clean the gasket seat on the support and oil slightly the gasket on the new filtering cartridge.
- ☐ Screw manually the new filtering cartridge until when the gasket is completely on its seat.
- ☐ Tighten using acceptable tools to 5-10 Nm torque.

Alternator belt replacement

Due to several applications the belt run can change very much.

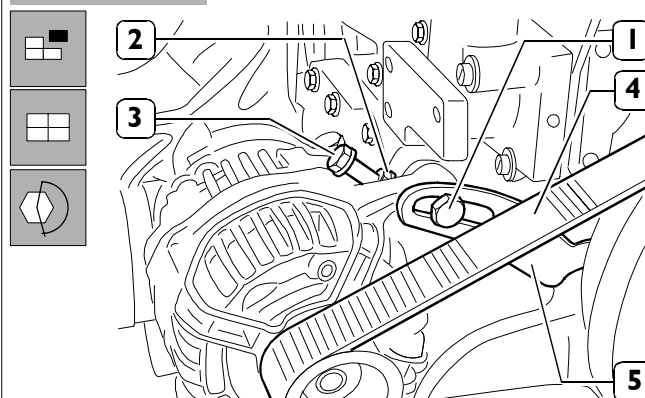
We describe the replacement of a belt mounted on a 4-cylinders motor with traditional belt tension and a 6-cylinders motor with an automatic screw coupling.



Warning: with switched off motor (but still hot) the belt can operate without advance notice.

Wait for the motor temperature lowering to avoid very serious accidents.

Figure 236

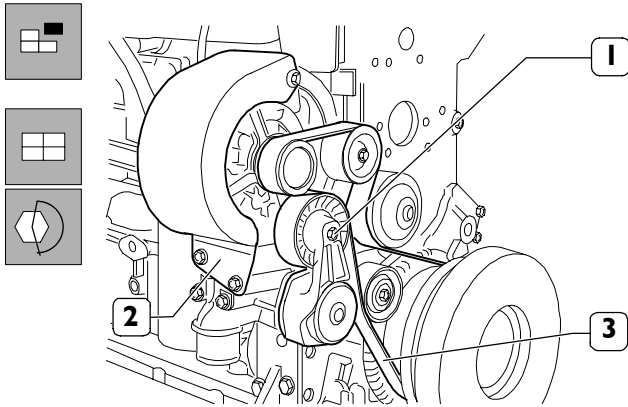


75684

- ☐ Unloose the screw (1) on the tension staff of the alternator belt by unloosing the lock nut (2). Unscrew the screw (3) in order to unloose the belt (4) until when it is possible to withdraw the control and driven pulleys.
- ☐ Replace the toothed belt with a similar one.
- ☐ Mount the belt (4) and screw it without clamping the screw (1) so that it can slide inside the staff slot (5).
- ☐ Adjust the belt tension by operating the screw. After achieving a correct tension lock the lock nut (2) and the screw (1).
- ☐ Operate the motor for some hours and check the correct belt tension.

For the application with an automatic screw coupling the procedure is the following:

Figure 237



74171

- ☐ Unscrew the screws which fix the belt guard (2) to the support and dismount it.
- ☐ Operate on the tightener (1) and withdraw the belt (3) from the alternator and water pumps from pulleys and from the returns pumps.
- ☐ Replace the worn belt with a new part.
- ☐ Place the belt on the pulleys and the guide rollers.
- ☐ Place the automatic tightener in order to key the belt in the functioning position.
- ☐ Further adjustments are not required.

SECTION 4**Overhaul and technical specifications**

	Pagina
GENERAL SPECIFICATIONS	3
CLEARANCE DATA	4
ENGINE OVERHAUL	11
ENGINE REMOVAL AT THE BENCH	11
REPAIR OPERATIONS	12
CYLINDER UNIT	12
☐ Checks and measurements	12
☐ Checking head supporting surface on cylinder unit	13
TIMING SYSTEM	13
☐ Camshaft	13
☐ Checking cam lift and pin alignment	14
BUSHES	14
☐ Bush replacement	16
☐ Tappets	16
☐ Fitting tappets – camshaft	16
OUTPUT SHAFT	17
☐ Measuring journals and crankpins	17
☐ Replacing oil pump control gear	21
☐ Fitting main bearings	21
☐ Finding journal clearance	21
☐ Checking output shaft shoulder clearance	22
CONNECTING ROD – PISTON ASSEMBLY	22
☐ Pistons	23
☐ Measuring piston diameter	23
☐ Piston pins	24
☐ Conditions for proper pin–piston coupling	24
☐ Split rings	24
☐ Connecting rods	25
☐ Bushes	25
☐ Checking connecting rods	26
☐ Checking torsion	26

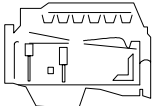
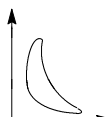
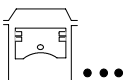
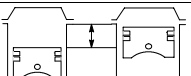
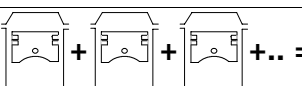
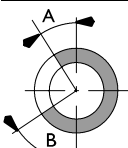
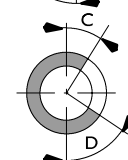
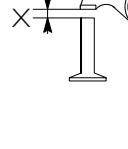
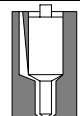
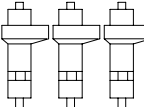
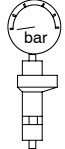
Pagina

☐ Checking bending	26
☐ Fitting connecting rod-piston assembly	26
☐ Connecting rod-piston coupling	26
☐ Fitting split rings	27
☐ Fitting connecting rod-piston assembly into cylinder barrels	27
☐ Finding crankpin clearance	28
☐ Checking piston protrusion	29
CYLINDER HEAD	30
☐ Removing the valves	30
☐ Checking cylinder head wet seal	31
☐ Checking cylinder head supporting surface	31

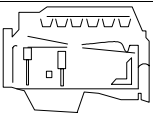
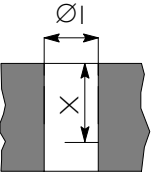
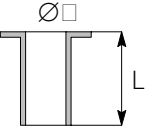
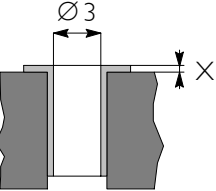
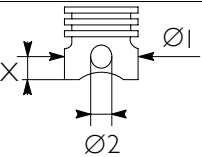
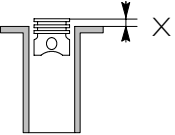
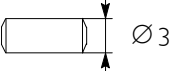
Pagina

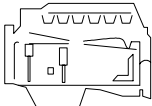
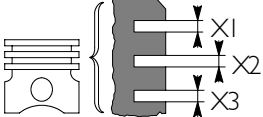
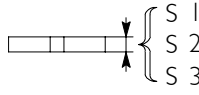
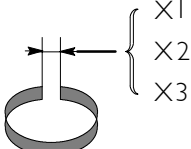
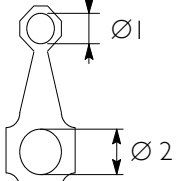
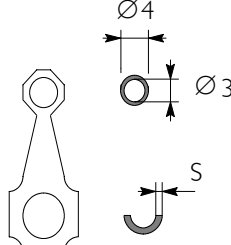
VALVES	32
☐ Removing carbon deposits, checking and grinding valves	32
☐ Checking clearance between valve stem and valve guide and valve centering	32
VALVE GUIDE	33
VALVE SEATS	33
☐ Regrinding – replacing the valve seats	33
VALVE SPRINGS	34
FITTING CYLINDER HEAD	34
☐ Refitting the cylinder head	35
TIGHTENING TORQUE	36

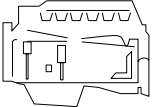
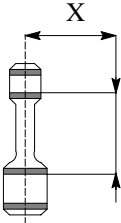
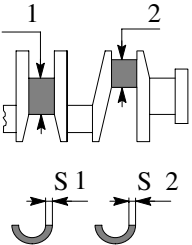
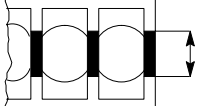
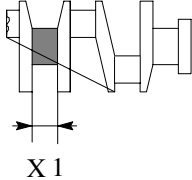
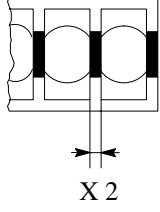
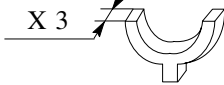
GENERAL SPECIFICATIONS

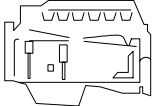
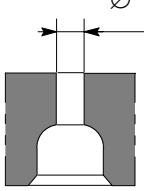
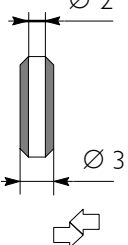
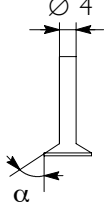
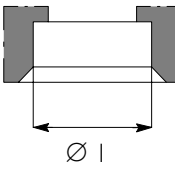
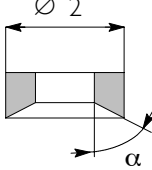
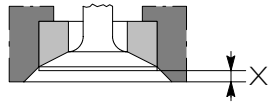
	Type	4 CYLINDERS	6 CYLINDERS
	Cycle	Four-stroke diesel engine	
	Power	Supercharged with intercooler	
	Injection	Direct	
	Number of cylinders	4 in-line	6 in-line
	Bore	mm	
	Stroke	mm	
	Total displacement	cm ³	
TIMING   start before T.D.C. end after B.D.C.		A	—
  start before B.D.C. end after T.D.C.		D	—
  Checking timing		X	—
  Checking operation		X	0.152 to 0.381
FUEL FEED			
	Injection Type:	Bosch	VE 4/12F 1150LV
	Nozzle type	Injectors DSL A 145 IP	
	Injection sequence	1 - 3 - 4 - 2	1 - 5 - 3 - 6 - 2 - 4
	Injection pressure	bar	245 for F4GE0404A*D6 260 for others

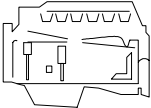
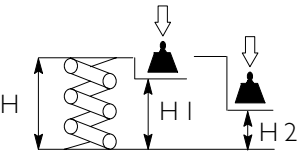
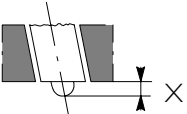
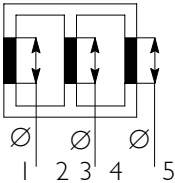
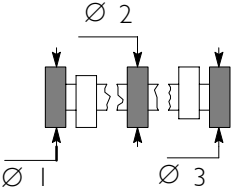
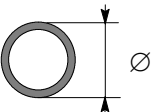
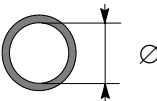
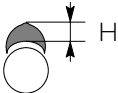
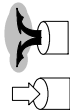
CLEARANCE DATA

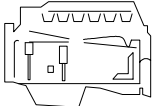
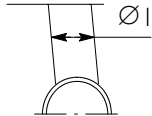
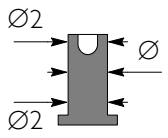
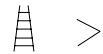
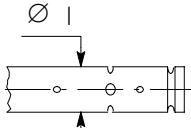
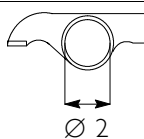
 Type		4 CYLINDERS	6 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		mm	
	Cylinder barrels  Ø 1	104.000 to 1 04.024	
	Cylinder barrels: outside diameter Ø 2 length L	— —	
	Cylinder barrels – housings on engine block (interference)	—	
	Outside diameter Ø 2	—	
	Cylinder barrels: inside diameter  Ø 2	—	
	Spare pistons type: Size X Outside diameter Ø 1 Pin housing Ø 2	55.9 103.730 to 103.748 38.010 to 38.016	
	Piston – cylinder barrels	0.252 to 0.294	
	Piston diameter Ø 1	0.5	
	Piston protrusion X	0.28 to 0.42	
	Piston pin Ø 3	38.000 to 38.006	
	Piston pin – pin housing	0.004 to 0.016	

 Type	4 CYLINDERS	6 CYLINDER
CYLINDER UNIT AND CRANKSHAFT COMPONENTS	mm	
 Split ring slots	X1* X 2 X 3	2.690 2.440 to 2.460 4.030 to 4.050
 Split rings * measured on 98 mm Ø	S 1* S 2 S 3	2.560 to 2.605 2.350 to 2.340 3.970 to 3.990
 Split rings – slots	1 2 3	0.245 to 0.265 0.100 to 0.110 0.004 to 0.080
 Split rings		0.5
 Split ring end opening in cylinder barrel:	X 1 X 2 X 3 X 1 X 2 X 3	0.30 to 0.40 0.25 to 0.55 0.25 to 0.55
 Small end bush housing Big end bearing housing	Ø 1 Ø 2	40.987 to 41.013 72.987 to 73.013
 Small end bush diameter Outside Inside Spare big end half bearings	Ø 4 Ø 3 Ø 4 Ø 3 S	40.987 to 41.013 38.019 to 38.033 1.955 to 1.968
 Small end bush – housing		-
 Piston pin – bush		0.013 to 0.033
 Big end half bearings		0.250 to 0.500

 Type	4 CYLINDERS	6 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS	mm	
 Size X Max. tolerance on connecting rod axis alignment —	—	
 Journals 1 Crankpins 2 Main half bearings S 1 Big end half bearings S 2 *provided as spare part	82.99 to 83.01 68.987 to 69.013 2.456 to 2.464 1.955 to 1.968	
 Main bearings 3 No. 1 – 5 3 No. 2 – 3 – 4 3	87.982 to 88.008 87.977 to 88.013	
 Half bearings – Journals No. 1–5 / 1–7 No. 2–3–4 / 2–3–4–5–6 Half bearings – Crankpins	0.064 to 0.095 0.059 to 0.100 0.064 to 0.090	
 Main half bearings Big end half bearings	+ 0.250 to + 0.500	
 Shoulder journal X 1	37.475 to 37.550	
 Shoulder main bearing X 2	31.730 to 32.280	
 Shoulder half-rings X 3	37.28 to 37.38	
 Output shaft shoulder	0.095 to 0.270	

	Type	4 CYLINDERS	6 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM		mm	
	Valve guide seats on cylinder head $\varnothing 1$		8.019 to 8.039
	Valve guides $\varnothing 2$ $\varnothing 3$ Valve guides and seats on head	— — —	— — —
	Valve guides		—
	Valves: $\varnothing 4$ α $\varnothing 4$ α	7.963 to 7.943 60° 7.963 to 7.943 45°	
	Valve stem and guide		0.052 to 0.092
	Housing on head for valve seat: $\varnothing 1$ $\varnothing 1$	46.987 to 47.013 43.637 to 43.663	
	Valve seat outside diameter; valve seat angle on cylinder head: $\varnothing 2$ α $\varnothing 2$ α	47.063 to 47.089 60° 43.713 to 43.739 45°	
	Sinking	0.356 to 1.102 0.104 to 0.84	
	Between valve seat and head	0.050 to 0.102 0.050 to 0.102	
	Valve seats		—

	Type	4 CYLINDERS	6 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM		mm	
	Valve spring height: free spring H under a load equal to: 329 N H1 641 N H2		63.05 49.02 38.20
	Injector protrusion X		–
	Camshaft bush housings No. 1–5 Camshaft housings No. 2–3–4		59.222 to 59.248 54.089 to 54.139
	Camshaft journals: 1 ⇒ 5 Ø 1 ⇒ 7 Ø		53.995 to 54.045
	Camshaft bush outside diameter: Ø		59.222 to 59.248
	Bush inside diameter Ø		54.083 to 54.147
	Bushes and housings on block		–
	Bushes and journals		0.038 to 0.162
	Cam lift:  H  H		– –

 Type	4 CYLINDERS	6 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM	mm	
 Tappet cap housing on block Ø 1		–
 Tappet cap outside diameter: Ø 2 Ø 3		15.924 to 15.954 15.965 to 15.930
 Between tappets and housings		0.025 to 0.070
 Tappets		–
 Rocker shaft Ø 1		21.963 to 21.975
 Rockers Ø 2		19.000 to 19.026
 Between rockers and shaft		0.025 to 0.063

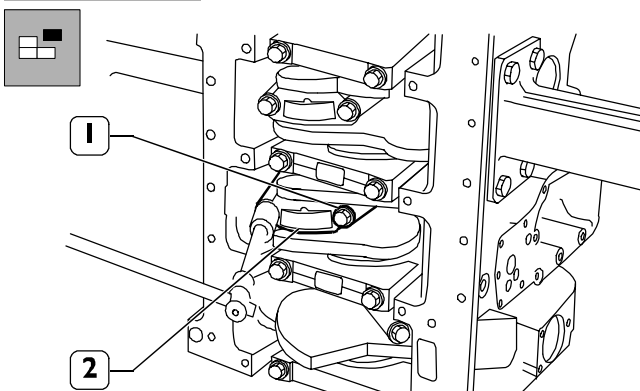
ENGINE OVERHAUL ENGINE REMOVAL AT THE BENCH

The following instructions are prescribed on the understanding that the engine has previously been placed on the rotating bench and that removal of all specific components of the equipment have been already removed as well. (See Section 3 of the manual herein).

The section illustrates therefore all the most important engine overhaul procedures.

The following operations are relating to the 4 cylinders engine but are analogously applicable for the 6 cylinders.

Figure 1



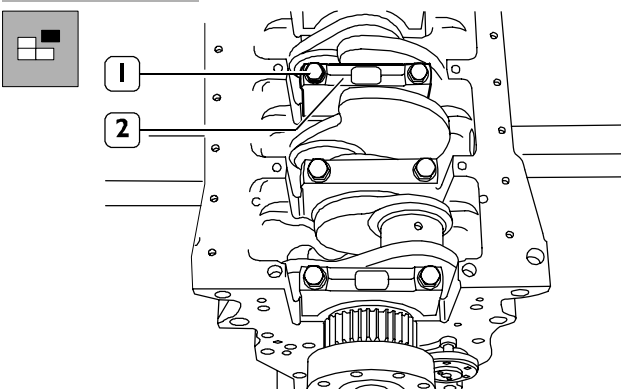
70158

Remove the screws (1) fastening the connecting rod caps (2) and remove them.

Withdraw the pistons including the connecting rods from the top of the engine block.

 Keep the half-bearings into their housings since in case of use they shall be fitted in the same position found at removal.

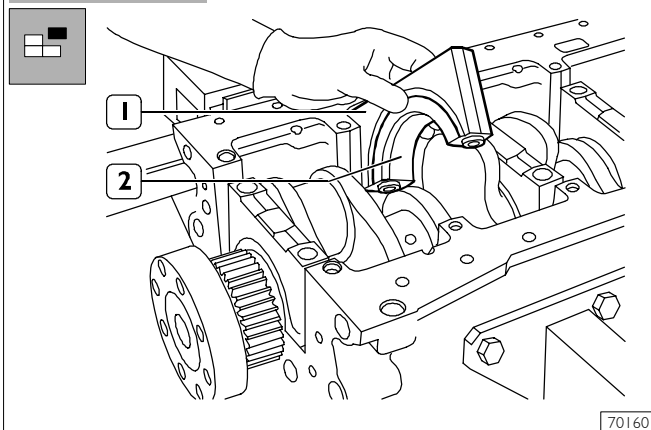
Figure 2



70159

Remove the screws (1) and the main bearing caps (2).

Figure 3

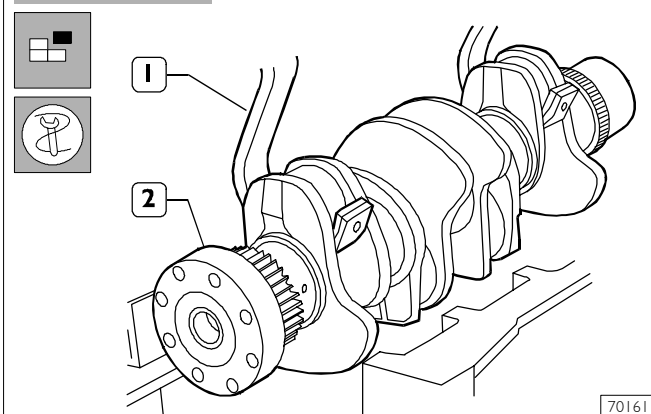


70160

The second last main bearing cap (1) and the relevant support are fitted with shoulder half-bearing (2).

 Take note of lower and upper half-bearing assembling positions since in case of reuse they shall be fitted in the same position found at removal.

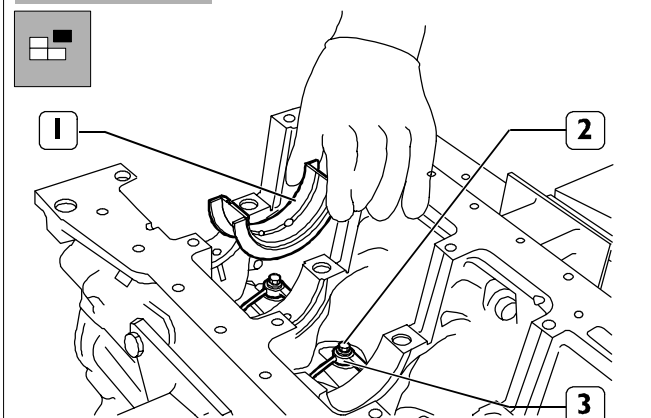
Figure 4



70161

Use acceptable tools (1) and hoist to remove the output shaft (2) from the block.

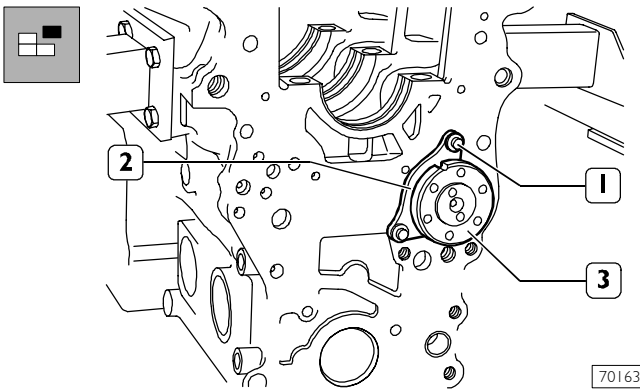
Figure 5



70162

Remove the main half-bearings (1).
Remove the screws (2) and remove the oil nozzles (3).

Figure 6

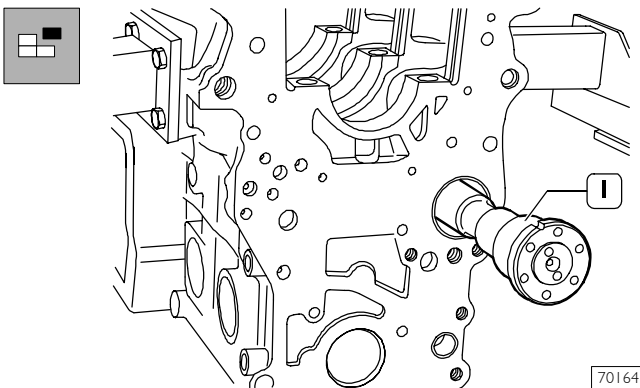


Remove the screws (1) and disconnect camshaft (3) retaining plate (2).



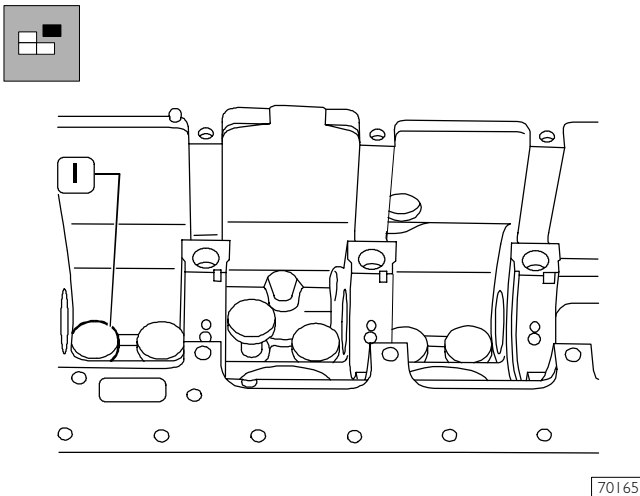
Take note of plate (2) assembling position.

Figure 7



Withdraw carefully the camshaft (1) from the engine block.

Figure 8

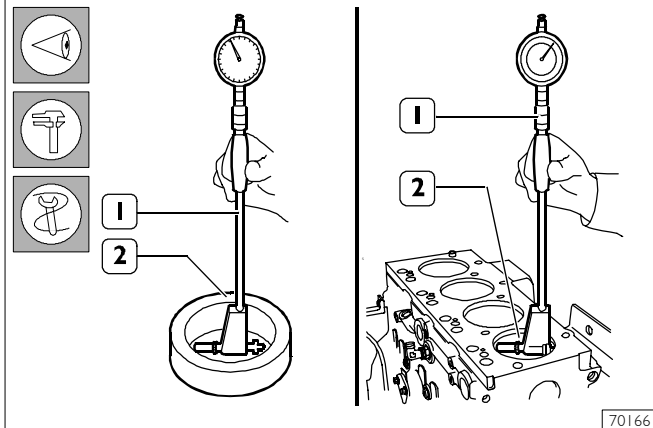


Withdraw the tappets (1) from the engine block.

REPAIR OPERATIONS CYLINDER UNIT

Checks and measurements

Figure 9



Once engine is disassembled, clean accurately the cylinder-block assembly.

Use the proper rings to handle the cylinder unit.

The engine block shall not show cracks.

Check operating plug conditions and replace them in case of uncertain seal or if rusted.

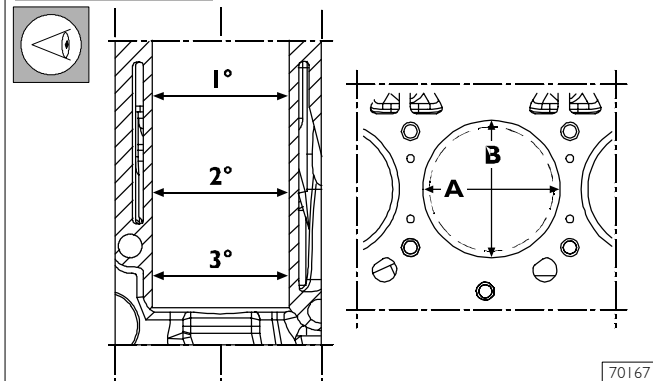
Inspect cylinder barrel surfaces; they shall be free from seizing, scores, ovalisation, taper or excessive wear.

Inspection of cylinder barrel bore to check ovalisation, taper and wear shall be performed using a bore dial gauge (1) fitted with the dial gauge previously set to zero on the ring gauge (2) of the cylinder barrel diameter.



Should the ring gauge be not available, use a micrometer for zero-setting.

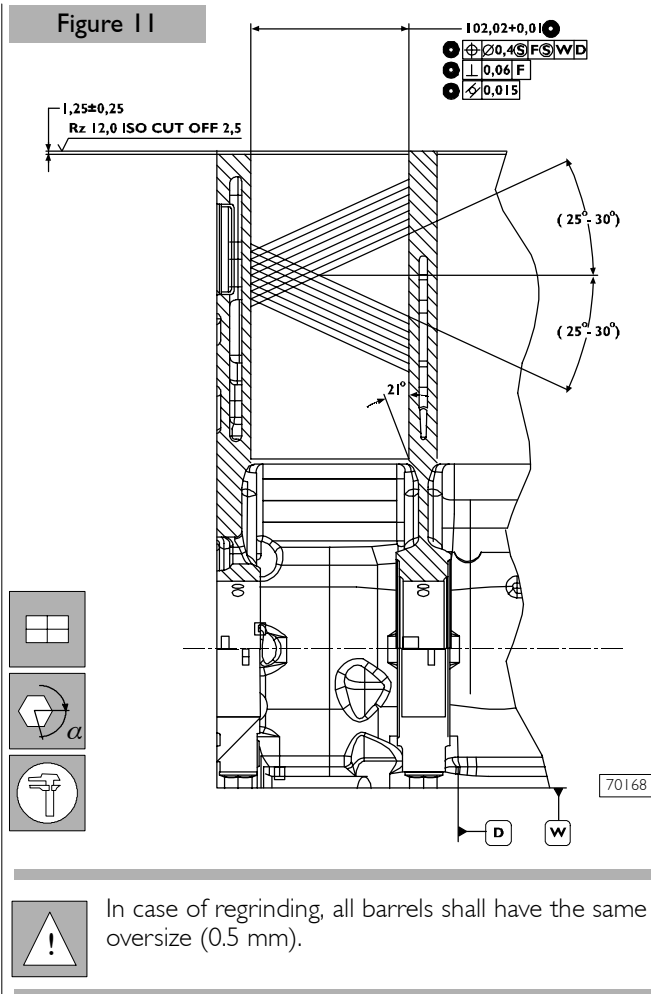
Figure 10



Measurements shall be performed on each cylinder; at three different heights in the barrel and on two planes perpendicular with each other: one parallel to the longitudinal axis of the engine (A), and the other perpendicular (B). Maximum wear is usually found on plane (B) in correspondence with the first measurement.

Should ovalisation, taper or wear be found, bore and grind the cylinder barrels. Cylinder barrel regrounding shall be performed according to the spare piston diameter oversized by 0.5 mm and to the specified assembling clearance.

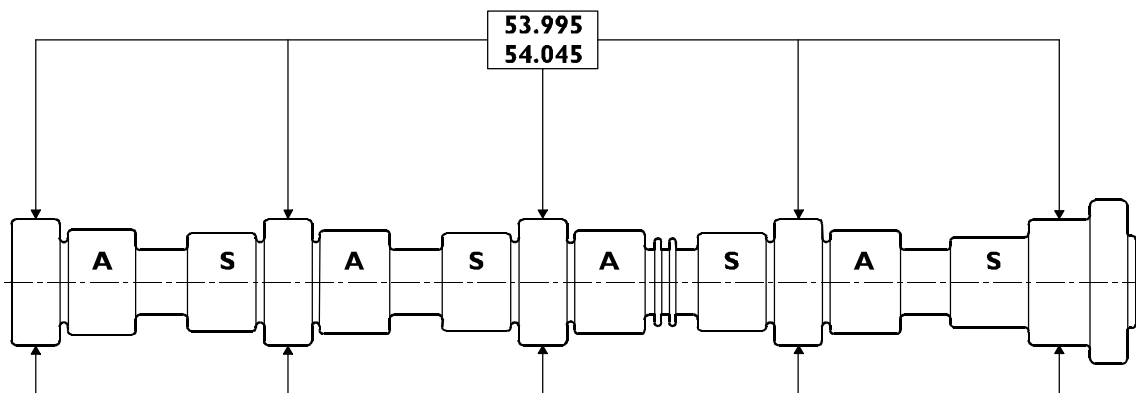
Figure 11



TIMING SYSTEM

Camshaft

Figure 12



CAMSHAFT MAIN DATA (4 CYL.)
Specified data refer to pin standard diameter

Check main bearing housings as follows:

- ☐ fit the main bearings caps on the supports without bearings;
- ☐ tighten the fastening screws to the specified torque;
- ☐ use the proper internal gauge to check whether the housing diameter is falling within the specified value.

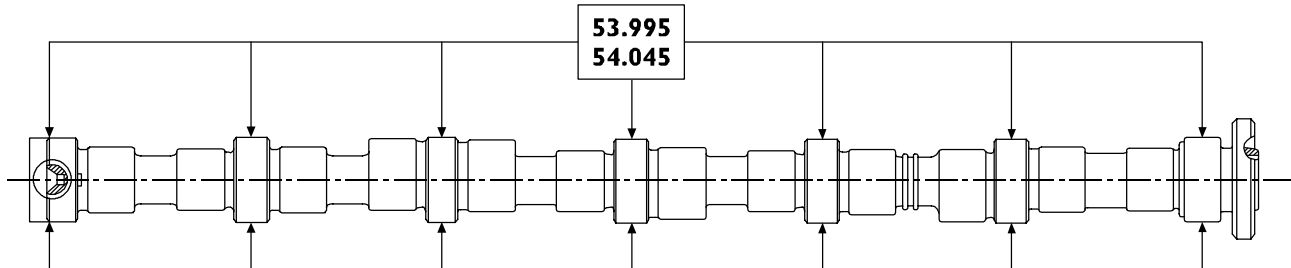
Replace if higher value is found.

Checking head supporting surface on cylinder unit

When finding the distortion areas, replace the cylinder unit.
Planarity error shall not exceed 0.075 mm.

Check cylinder unit operating plug conditions, replace them in case of uncertain seal or if rusted.

Figure 13



70512

MAIN DATA ABOUT CAMSHAFT PINS (6 CYL.)

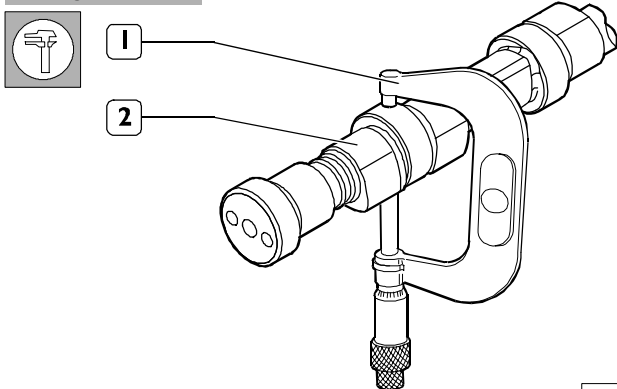
Camshaft pin and cam surfaces shall be absolutely smooth; if they show any traces of seizing or scoring replace the

camshaft and the bushes.

Checking cam lift and pin alignment

Set the camshaft on the tailstock and using a 1/100 gauge set on the central support, check whether the alignment error is not exceeding 0.04 mm, otherwise replace the camshaft. Check cam lift; found values shall be: 6.045 mm for exhaust cams and 7.582 mm for intake cams, in case of different values replace the camshaft.

Figure 14

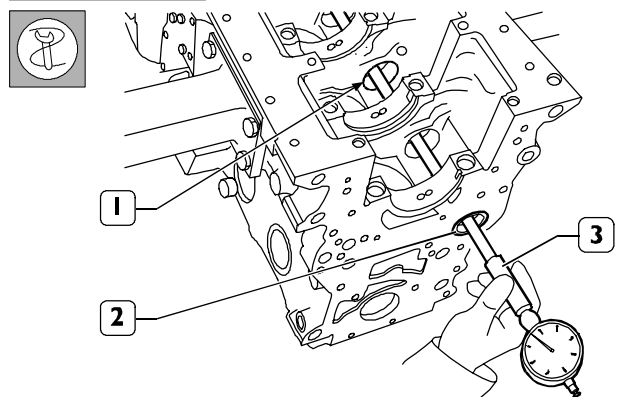


70171

Check camshaft (2) pin diameter using micrometer (1) on two perpendicular axes.

BUSHES

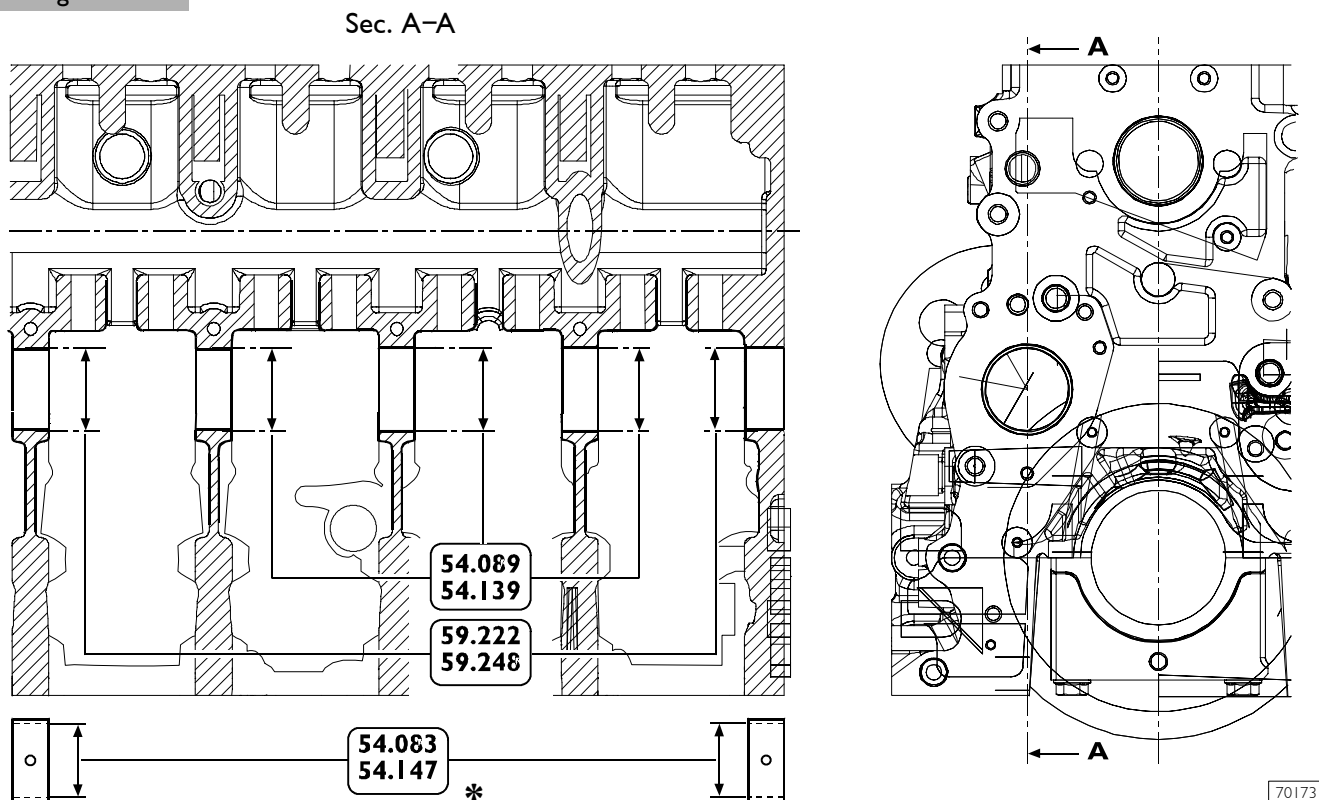
Figure 15



70172

Camshaft bushes (2) shall be pressed into their housings. Internal surfaces must not show seizing or wear. Use bore dial gauge (3) to measure camshaft front and rear bush (2) and intermediate housing (1) diameter. Measurements shall be performed on two perpendicular axes.

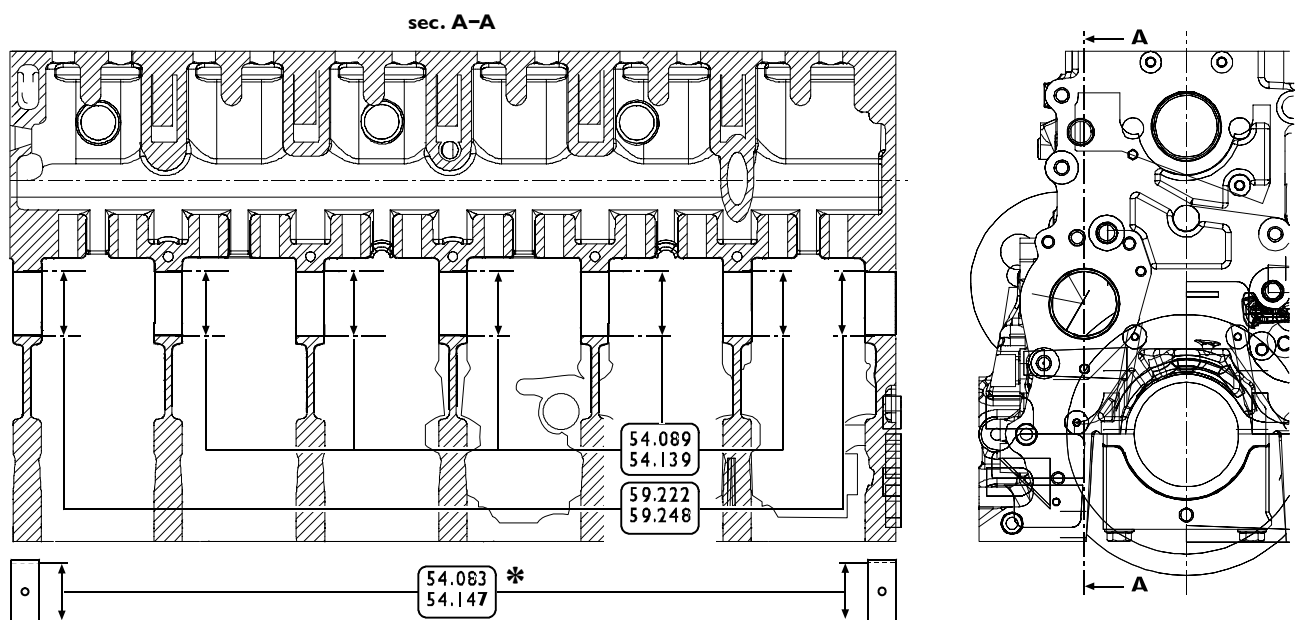
Figure 16



CAMSHAFT BUSH AND HOUSING MAIN DATA

* Value to be obtained after driving the bushes.

Figure 17

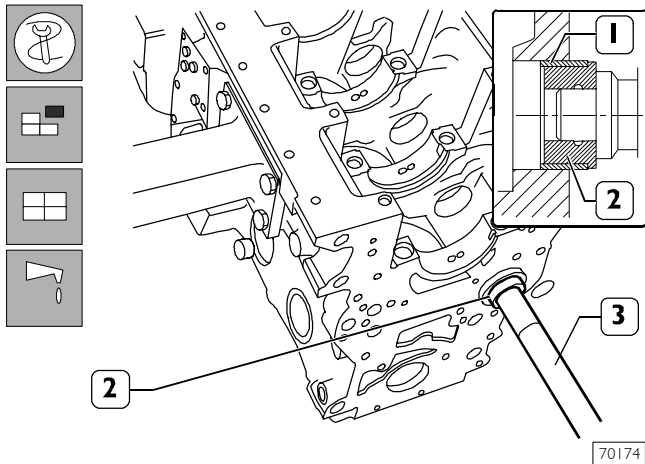


MAIN DATA ABOUT CAMSHAFT BUSHES AND RELATED HOUSINGS

*Height to be obtained after driving the bushes.

Bush replacement

Figure 18



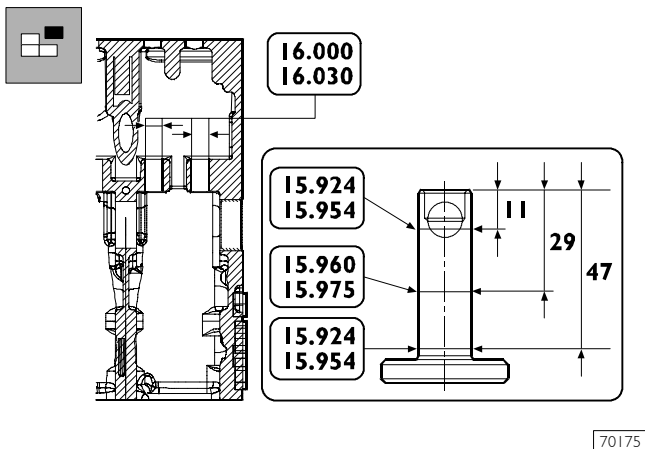
To replace front and rear bushes (1), remove and refit them using acceptable tools (2) and (3).



When refitting the bushes (1), direct them to make the lubricating holes (2) coincide with the holes on the block housings.

Tappets

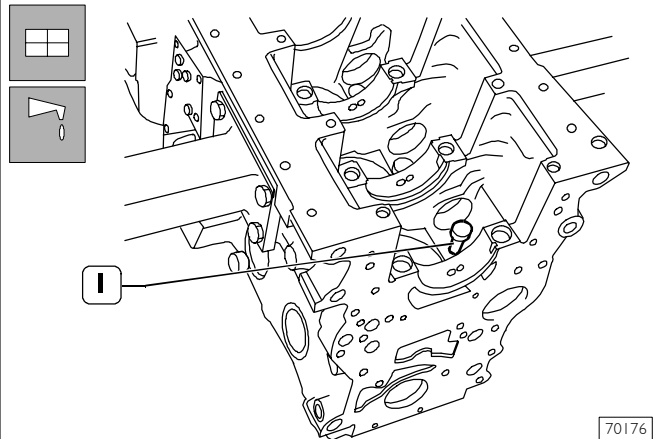
Figure 19



MAIN DATA CONCERNING THE TAPPETS AND THE RELEVANT HOUSINGS ON THE ENGINE BLOCK

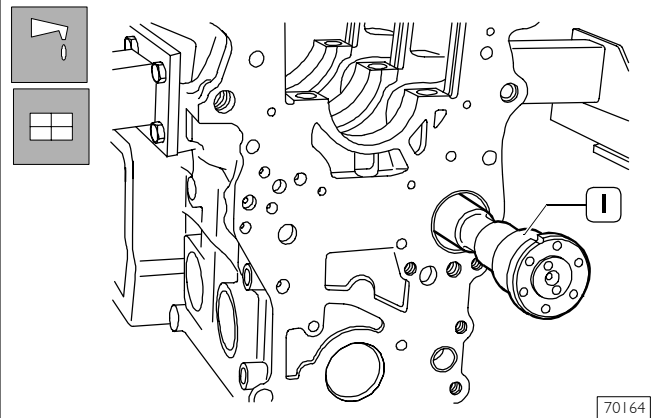
Fitting tappets – camshaft

Figure 20



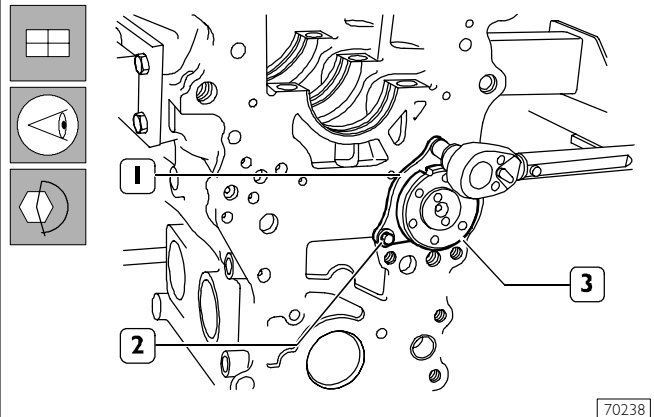
Lubricate the tappets (1) and fit them into the relevant housings on the engine block.

Figure 21



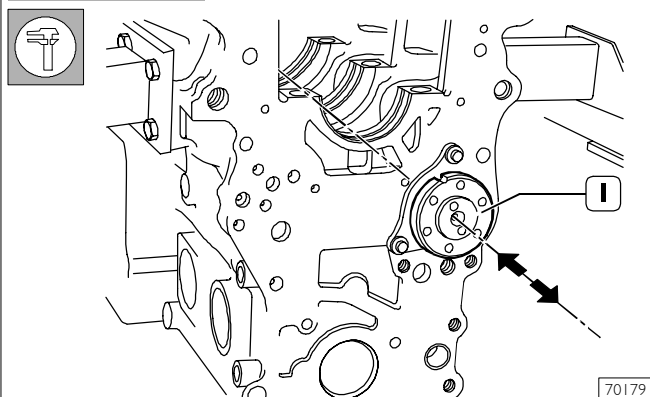
Lubricate the camshaft bushes and fit the camshaft (1) taking care not to damage the bushes or the housings.

Figure 22



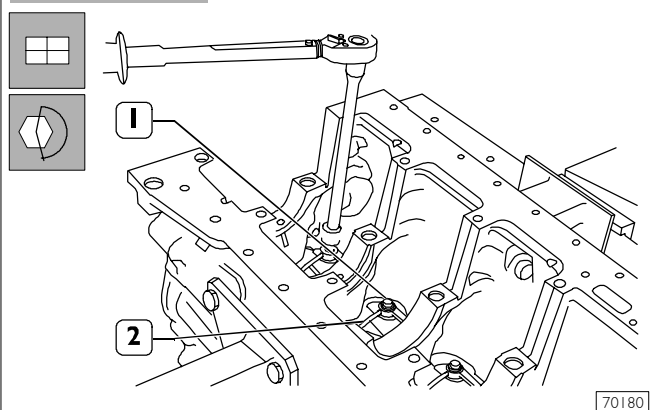
Set camshaft (3) retaining plate (1) with the slot facing the top of the engine block and the marking facing the operator; then tighten the screws (2) to the specified torque.

Figure 23



Check camshaft end float (I).
It shall be 0.23 ± 0.13 mm.

Figure 24

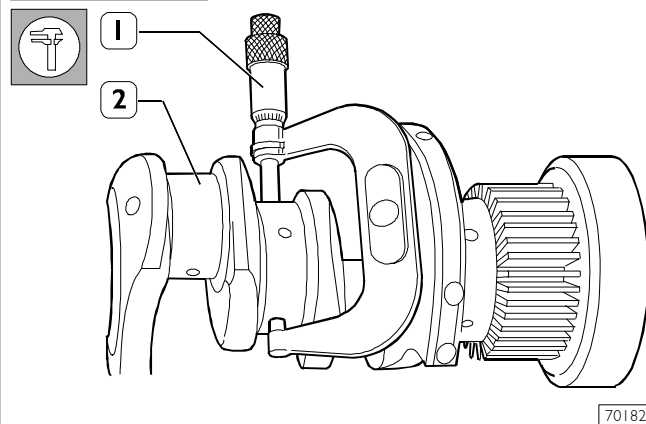


Fit nozzles (2) and tighten the fastening screws (1) to the specified torque.

OUTPUT SHAFT

Measuring journals and crankpins

Figure 25



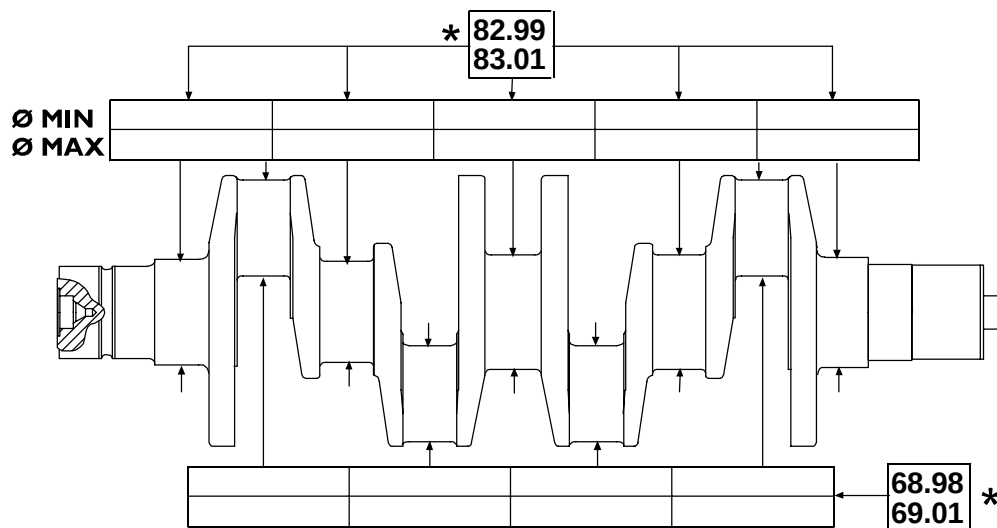
Grind journals and crankpins if seizing, scoring or excessive ovalisation are found. Before grinding the pins (2) measure them with a micrometer (1) to decide the final diameter to which the pins are to be ground.

 It is recommended to insert the found values in the proper table.
See Figure 26.

Undersize classes are:

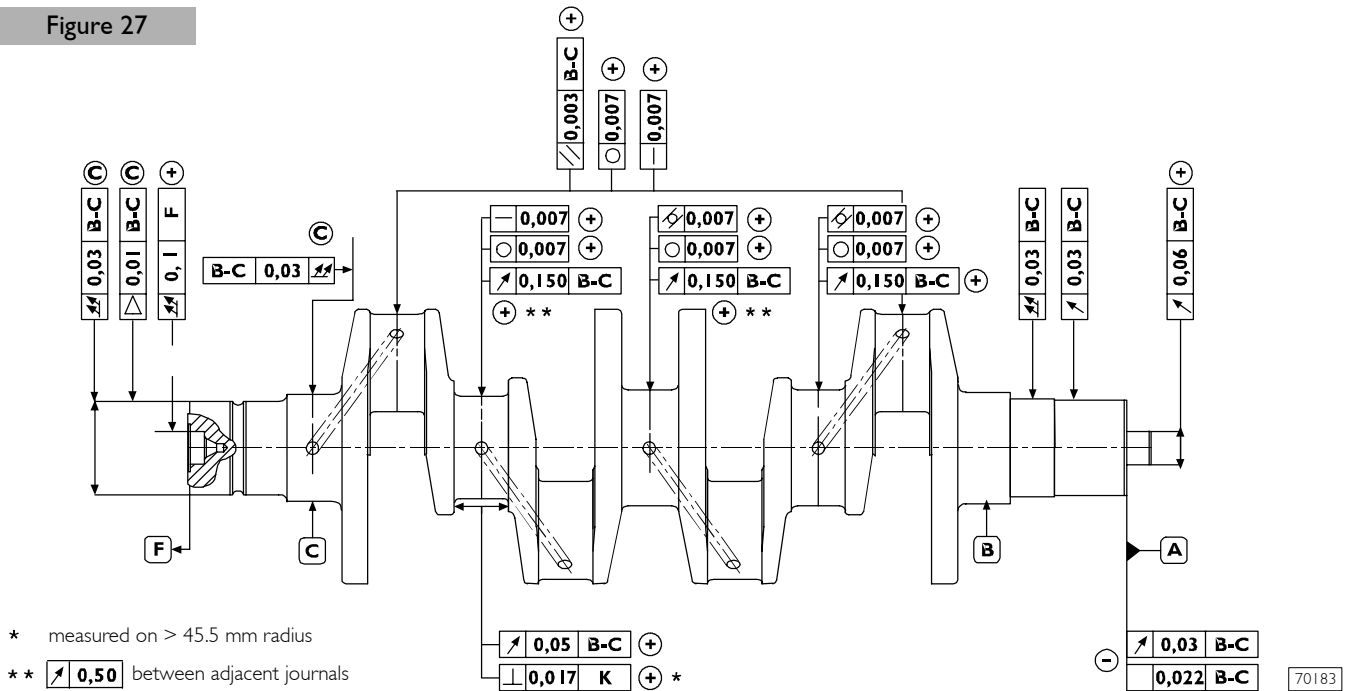
 Journals and crankpins shall always be ground to the same undersize class.
Journals and crankpins undersize shall be marked on the side of the crank arm No.1.
For undersized crankpins: letter M
For undersized journals: letter B
For undersized crankpins and journals: letters MB

Figure 26



FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

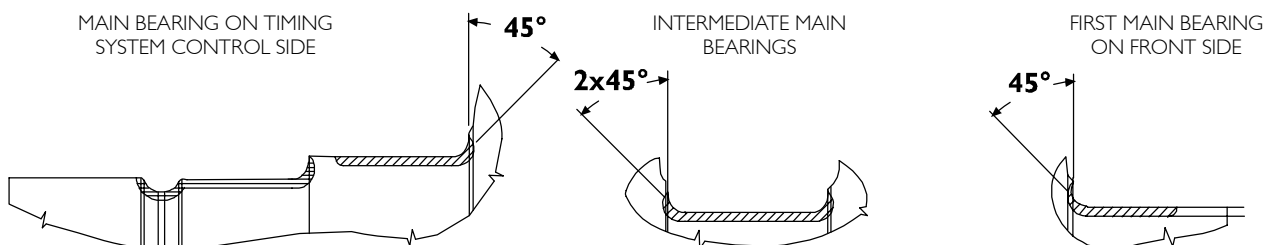
Figure 27



OUTPUT SHAFT MAIN TOLERANCES

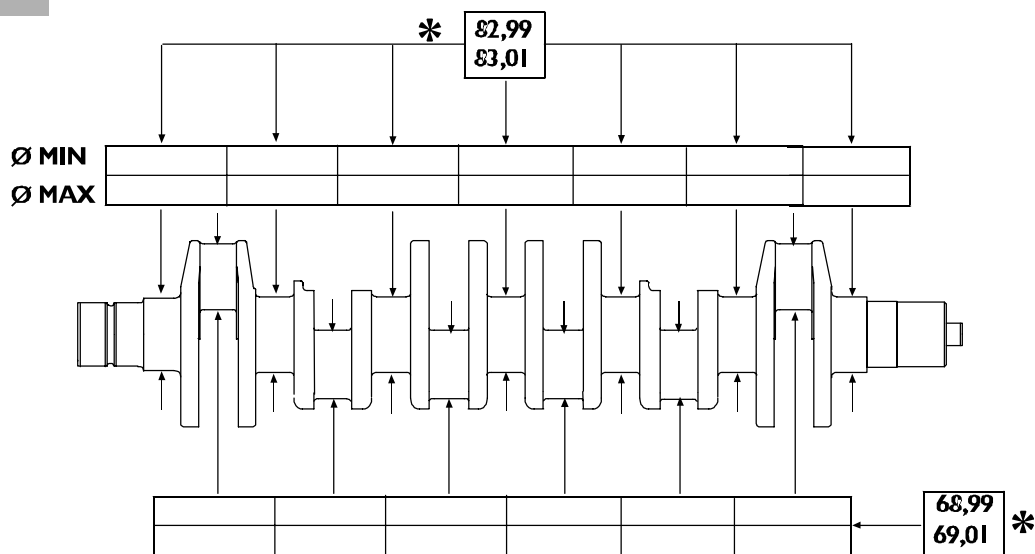
TOLERANCES	TOLERANCE CHARACTERISTIC	GRAPHIC SYMBOL
SHAPE	Roundness	$\bigcirc$
	Cilindricity	$/\bigcirc/$
DIRECTION	Parallelism	$//$
	Verticality	$\perp$
	Straightness	$-$
POSITION	Concentricity or coaxiality	$\bigodot$
OSCILLATION	Circular oscillation	$\nearrow$
	Total oscillation	∇
	Taper	$\rightarrow \Delta$

LEVELS OF IMPORTANCE FOR PRODUCT CHARACTERISTICS	GRAPHIC SYMBOL
CRITICAL	$\bigcirc$
IMPORTANT	$\oplus$
SECONDARY	$\ominus$



70237

Figure 28

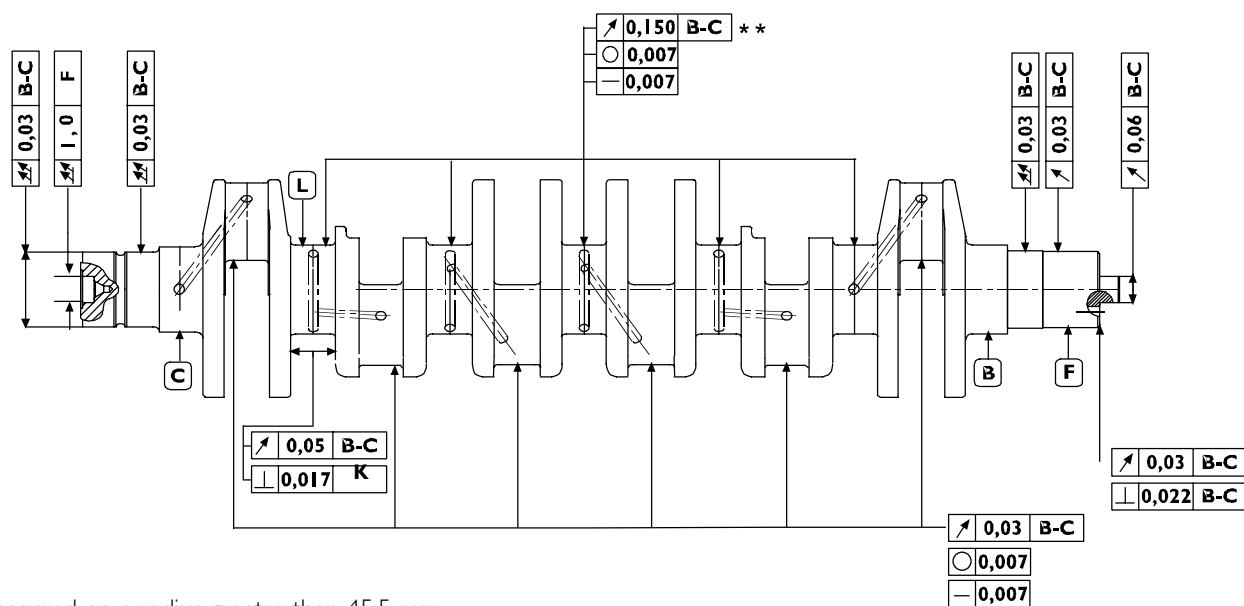


FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

70514

*Rated value

Figure 29

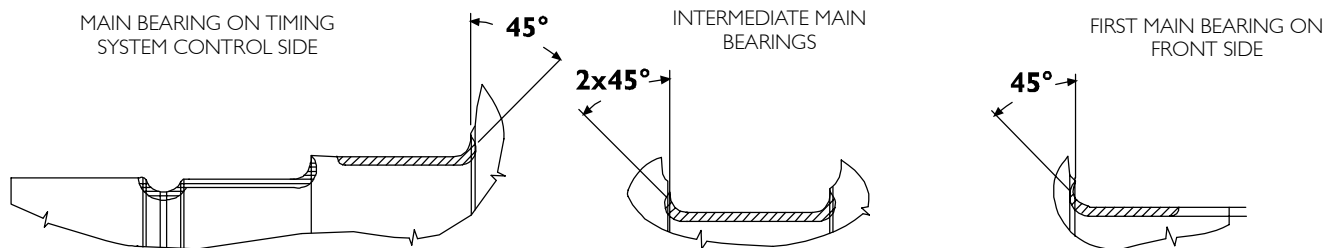


* Measured on a radius greater than 45.5 mm

** 0.500 between adjacent main journals

70577

MAIN OUTPUT SHAFT TOLERANCES

Figure 30

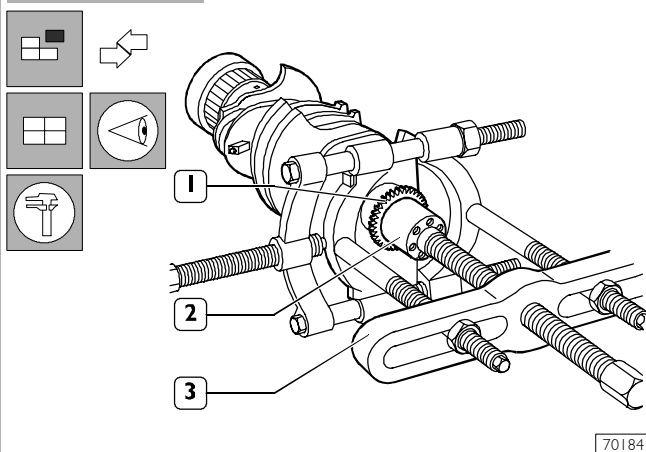
70237

TOLERANCES	TOLERANCE CHARACTERISTIC	GRAPHIC SYMBOL
SHAPE	Roundness	○
	Cilindricity	/○/
DIRECTION	Parallelism	//
	Verticality	⊥
	Straightness	—
POSITION	Concentricity or coaxiality	⊙
OSCILLATION	Circular oscillation	↗
	Total oscillation	↗↘
	Taper	→▷

LEVELS OF IMPORTANCE FOR PRODUCT CHARACTERISTICS	GRAPHIC SYMBOL
CRITICAL	⊙
IMPORTANT	⊕
SECONDARY	⊖

Replacing oil pump control gear

Figure 31

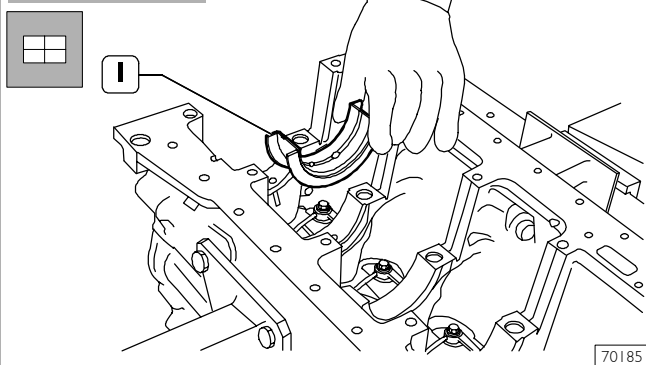


Check that gear toothing (1) is not damaged or worn, otherwise remove it using the proper puller (3).

When fitting the new gear, heat it to 180°C for 10 minutes in an oven and then key it to the output shaft.

Fitting main bearings

Figure 32



Refit the main bearings that have not been replaced, in the same position found at removal.

Main bearings (1) are supplied spare with 0.250 – 0.500 mm undersize on the internal diameter.

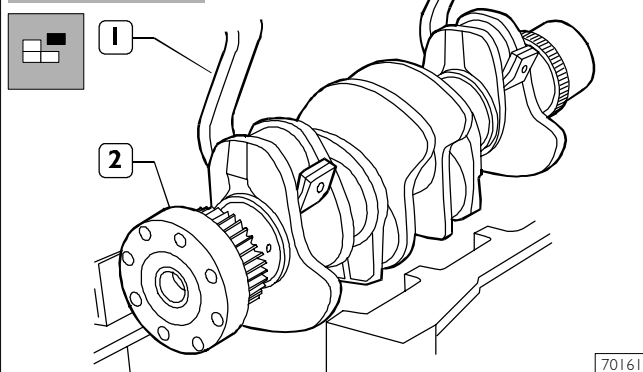
Do not try to adapt the bearings.

Clean accurately the main half bearings (1) having the lubricating hole and fit them into their housings.

The second last main half bearing (1) is fitted with shoulder half rings.

Finding journal clearance

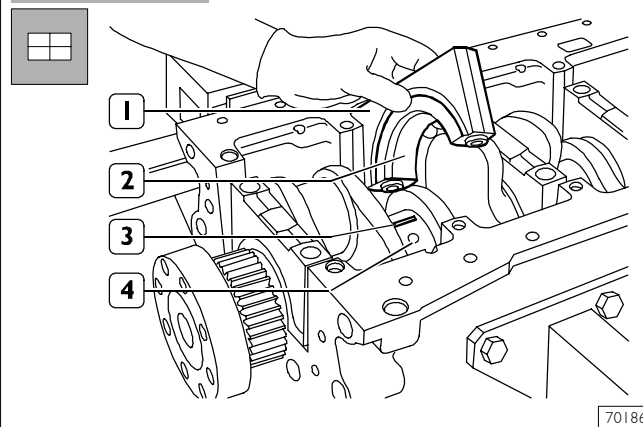
Figure 33



Refit the output shaft (2).

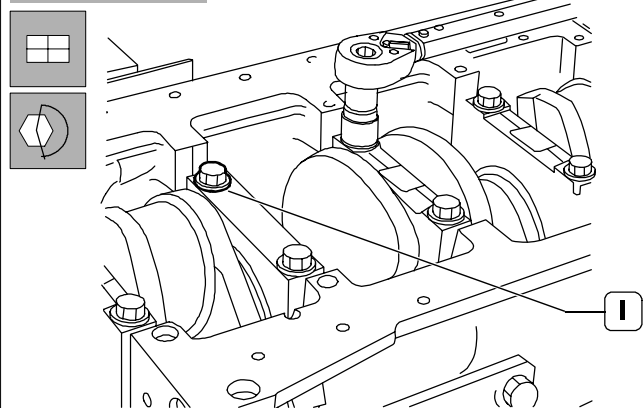
Check the backlash between output shaft main journals and the relevant bearings as follows:

Figure 34



- ☐ clean accurately the parts and remove any trace of oil;
- ☐ position a piece of calibrated wire (3) on the output shaft pins (4) so that it is parallel to the longitudinal axis;
- ☐ fit caps (1), including the half bearings (2) on the relevant supports.

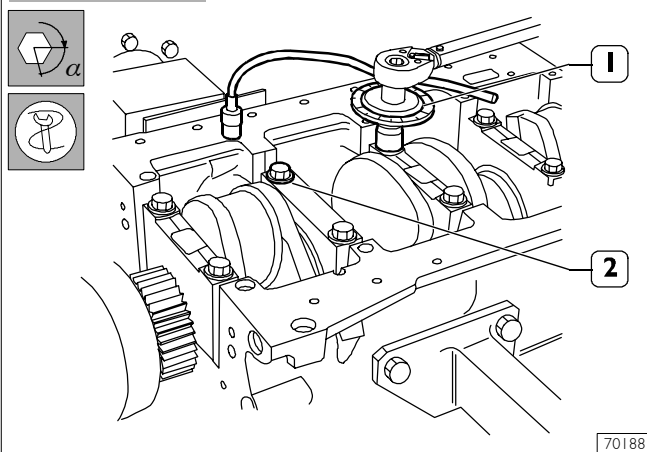
Figure 35



Tighten the pre-lubricated screws (1) in the following three successive stages:

- ☐ 1st stage, with dynamometric wrench to 50 ± 6 Nm.
- ☐ 2nd stage, with dynamometric wrench to 80 ± 6 Nm.

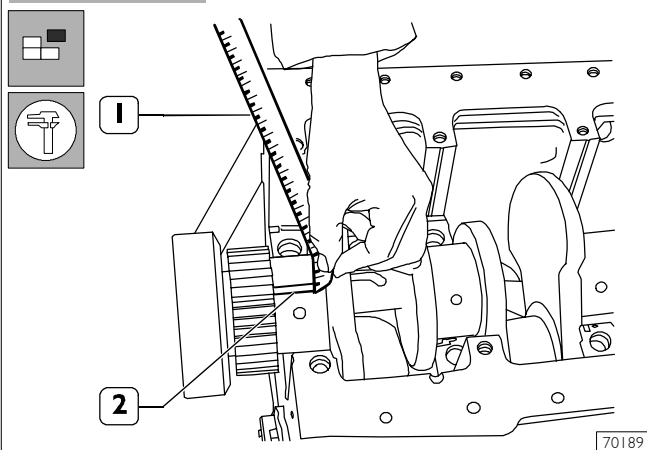
Figure 36



70188

- ☐ 3rd stage, using acceptable tools (1) set as shown in the figure, tighten the screws (2) with $90^\circ \pm 5^\circ$ angle.

Figure 37



70189

- ☐ Remove caps from supports.

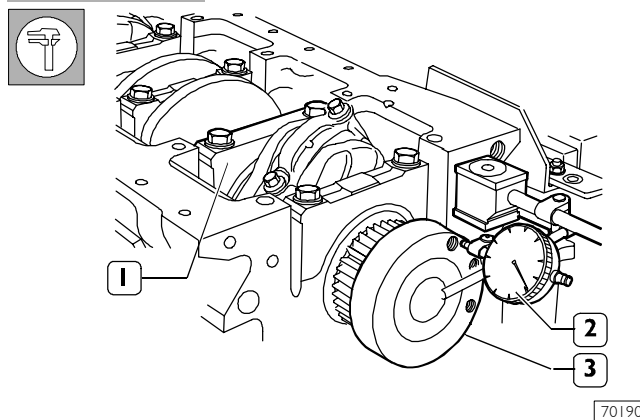
The backlash between the main bearings and the pins is found by comparing the width of the calibrated wire (2) at the narrowest point with the scale on the envelope (1) containing the calibrated wire.

The numbers on the scale indicate the backlash in mm.

Replace the half bearings and repeat the check if a different backlash value is found. Once the specified backlash is obtained, lubricate the main bearings and fit the supports by tightening the fastening screws as previously described.

Checking output shaft shoulder clearance

Figure 38



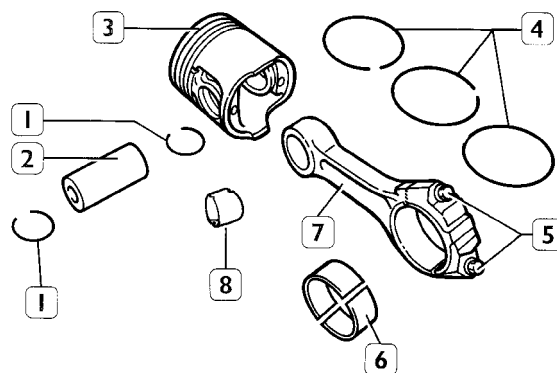
70190

This check is performed by setting a magnetic-base dial gauge (2) on the output shaft (3) as shown in the figure, standard value is 0.068 to 0.41.

If higher value is found, replace main thrust half bearings of the second last rear support (1) and repeat the clearance check between output shaft pins and main half bearings.

CONNECTING ROD – PISTON ASSEMBLY

Figure 39



70191

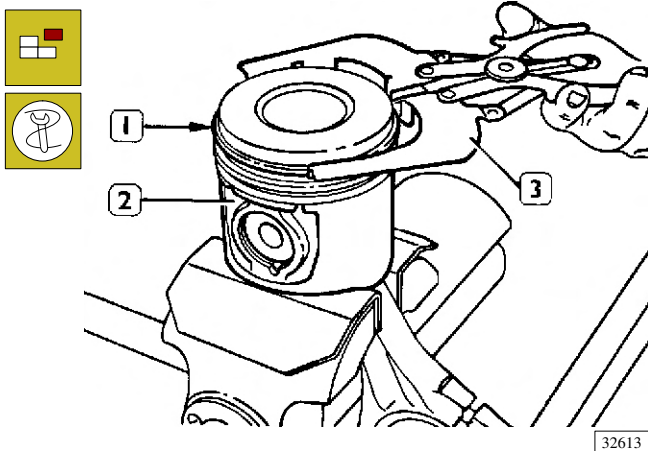
CONNECTING ROD – PISTON ASSEMBLY COMPONENTS

1. Stop rings – 2. Pin – 3. Piston – 4. Split rings – 5. Screws – 6. Half bearings – 7. Connecting rod – 8. Bush.



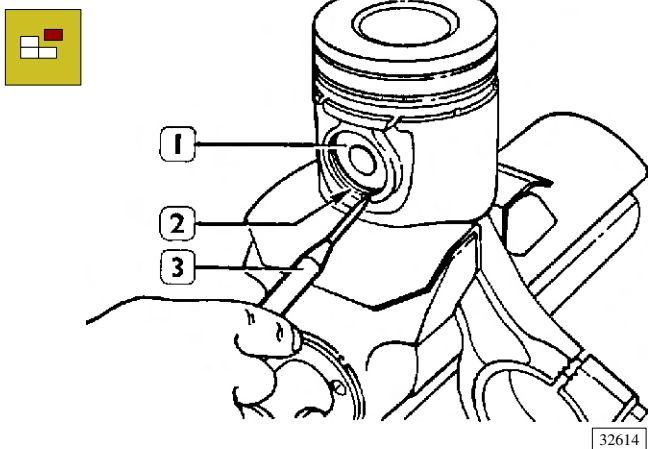
Pistons are supplied spare with 0.5 mm oversize.

Figure 40



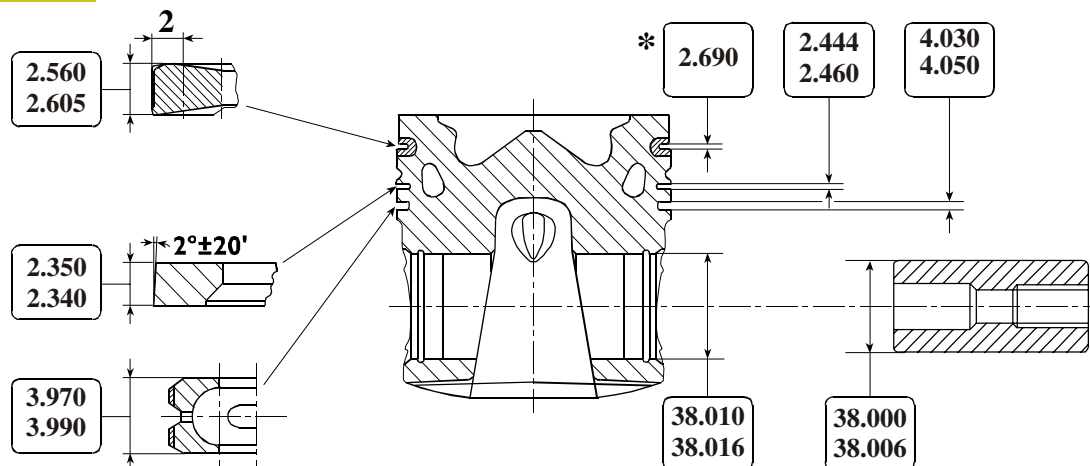
Remove split rings (1) from piston (2) using pliers 99360183 (3).

Figure 41



Piston pin (1) split rings (2) are removed using a scribe (3).

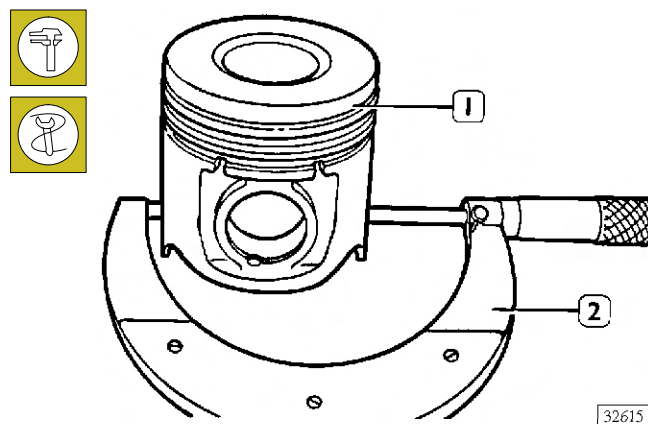
Figure 42



Pistons

Measuring piston diameter

Figure 43

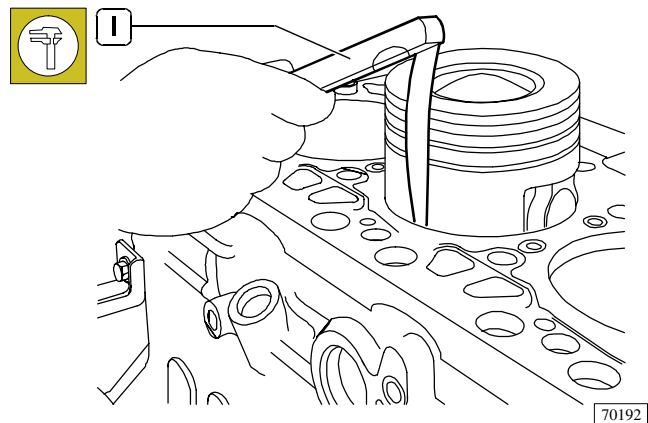


Using a micrometer (2), measure the diameter of the piston (1) to determine the assembly clearance.

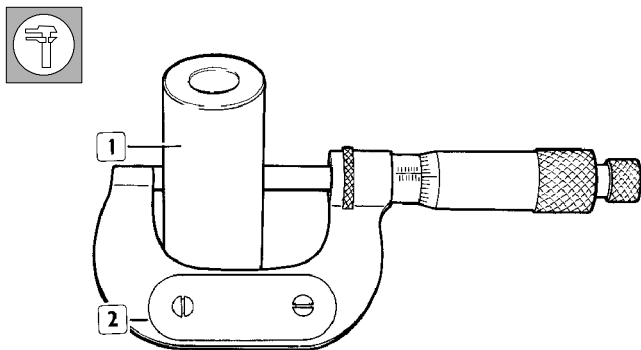


The diameter shall be measured at 12 mm from the piston skirt.

Figure 44

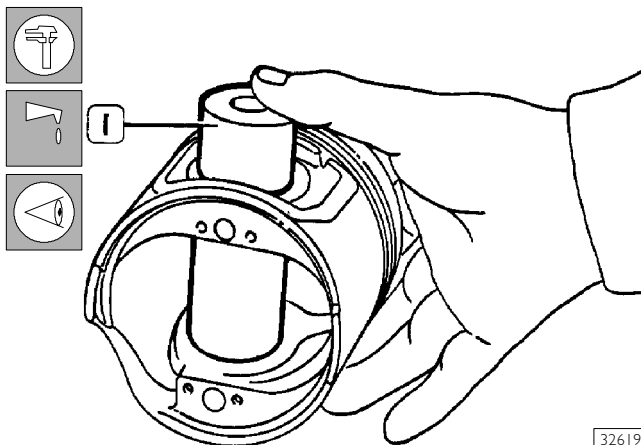


The clearance between the piston and the cylinder barrel can be checked also with a feeler gauge (1) as shown in the figure.

Piston pins**Figure 45**

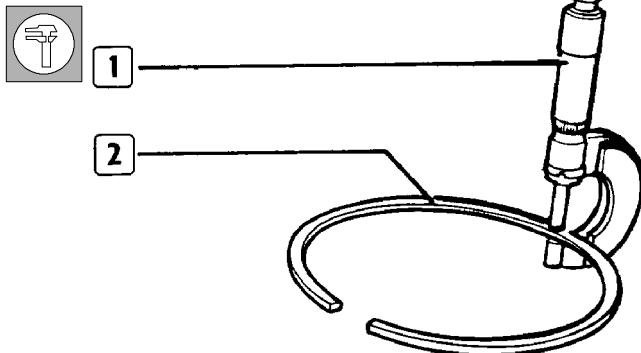
18857

To measure the piston pin (1) diameter use the micrometer (2).

Conditions for proper pin-piston coupling**Figure 46**

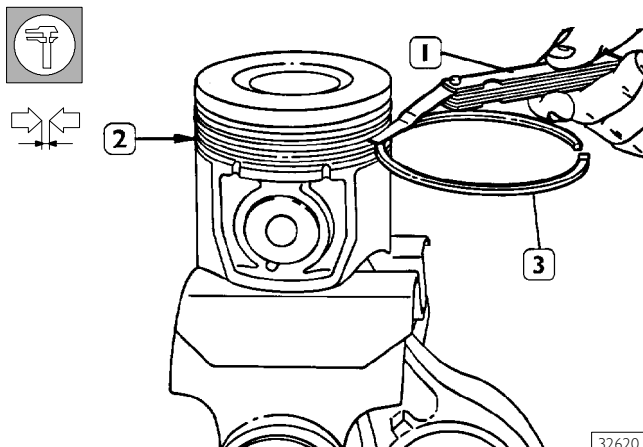
32619

Lubricate the pin (1) and its seat on piston hubs with engine oil; the pin shall be fitted into the piston with a slight finger pressure and shall not be withdrawn by gravity.

Split rings**Figure 47**

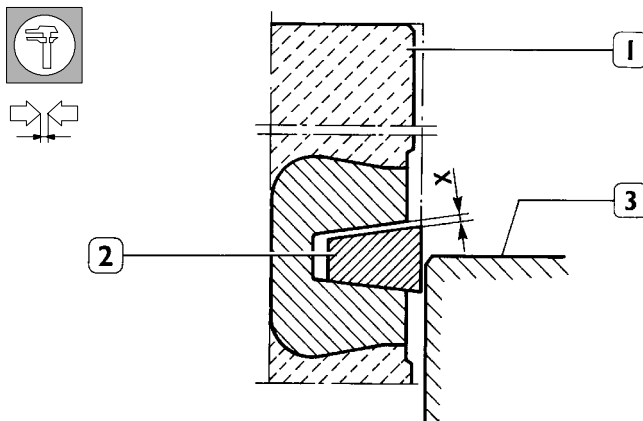
16552

Use a micrometer (1) to check split ring (2) thickness.

Figure 48

32620

Check the clearance between the sealing rings (3) of the 2nd and 3rd slot and the relevant housings on the piston (2), using a feeler gauge (1).

Figure 49

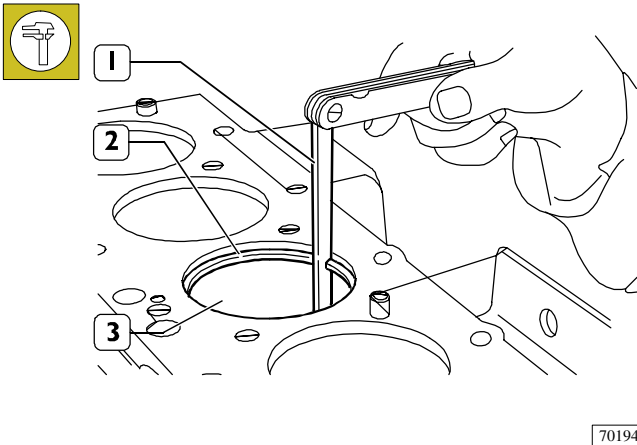
41104

**DIAGRAM FOR MEASURING THE CLEARANCE X
BETWEEN THE FIRST PISTON SLOT AND THE
TRAPEZOIDAL RING**

Since the first sealing ring section is trapezoidal, the clearance between the slot and the ring shall be measured as follows: make the piston (1) protrude from the engine block so that the ring (2) protrudes half-way from the cylinder barrel (3).

In this position, use a feeler gauge to check the clearance (X) between ring and slot: found value shall be the specified one.

Figure 50

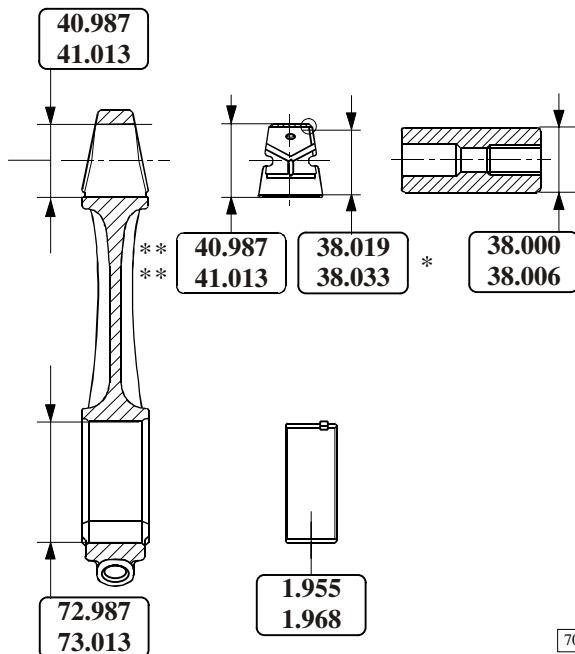


70194

Use feeler gauge (1) to measure the clearance between the ends of the split rings (2) fitted into the cylinder barrel (3).

Connecting rods

Figure 51



70195

MAIN DATA FOR CONNECTING ROD, BUSH, PISTON PIN AND HALF BEARINGS

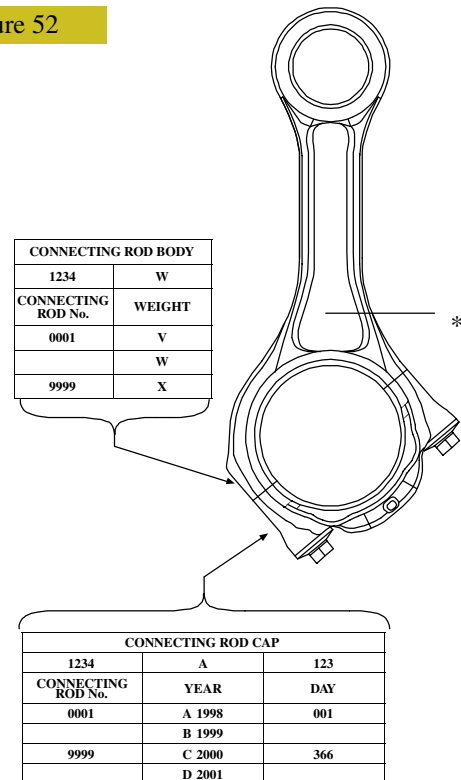
* Value for inside diameter to be obtained after driving in connecting rod small end and grinding.

** Value not measurable in released condition



The surface of connecting rod and rod cap are knurled to ensure better coupling. Therefore, it is recommended not to smooth the knurls.

Figure 52



70196



Every connecting rod is marked as follows:

On body and cap with a number showing their coupling and the corresponding cylinder. In case of replacement it is therefore necessary to mark the new connecting rod with the same numbers of the replaced one.

On body with a letter showing the weight of the connecting rod assembled at production:

V, 1820 to 1860 (yellow marking);

W, 1861 to 1900 (green marking);

X, 1901 to 1940 (blue marking);

Spare connecting rods are of the W class with green marking *.

Material removal is not allowed.

Bushes

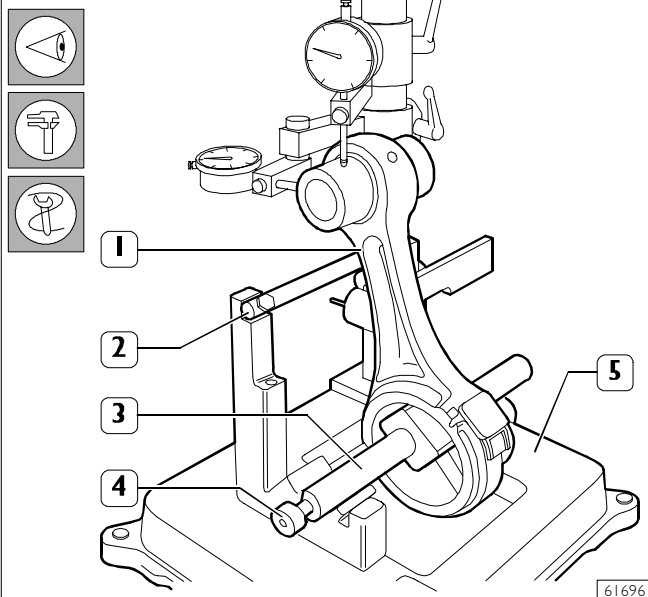
Check that the bush in the connecting rod small end is free from scoring or seizing and that it is not loosen. Otherwise replace.

Removal and refitting shall be performed using the proper beater.

When refitting take care to make coincide the oil holes set on the bush with those set on the connecting rod small end. Grind the bush to obtain the specified diameter.

Checking connecting rods

Figure 53

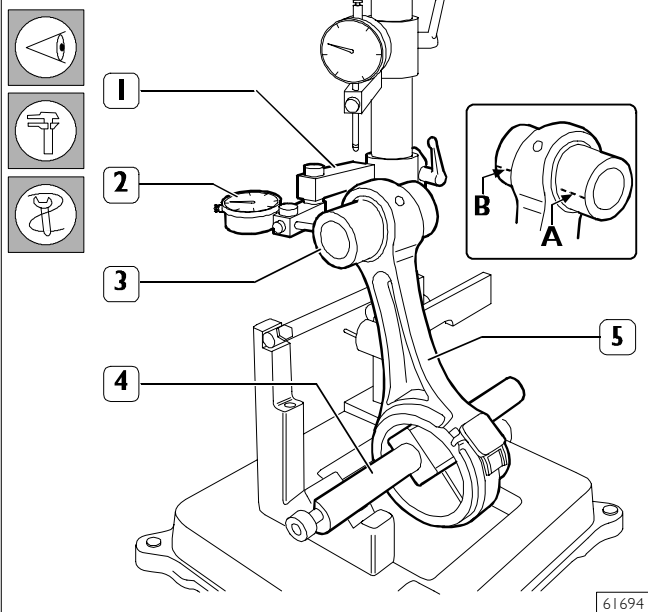


Check that the axes of the connecting rods (1) are parallel using acceptable tools (5) as follows:

- ☐ fit the connecting rod (1) on acceptable tool (5) spindle and lock it with screw (4);
- ☐ set the spindle (3) on V-blocks by resting the connecting rod (1) on the stop bar (2).

Checking torsion

Figure 54

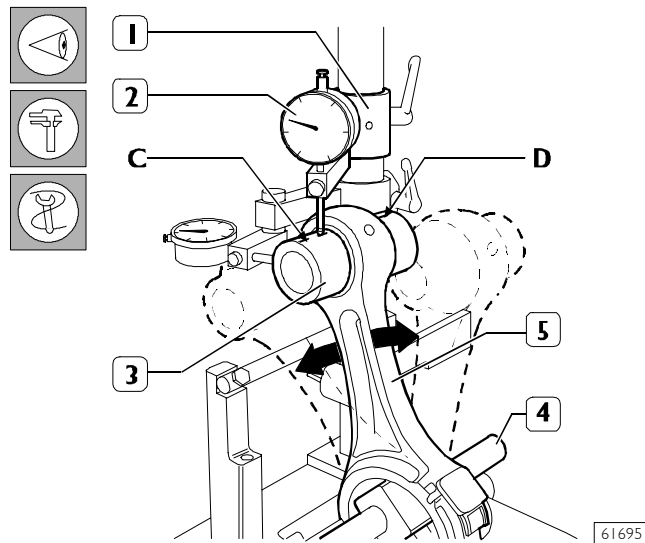


Check connecting rod (5) torsion by comparing two points (A and B) of pin (3) on the horizontal plane of the connecting rod axis.

Position the dial gauge (2) support (1) to obtain a preload of approx. 0.5 mm on the pin (3) in point A and then set the dial gauge (2) to zero. 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 shall not exceed 0.08 mm.

Checking bending

Figure 55



Check connecting rod (5) bending by comparing two points C and D of the pin (3) on the vertical plane of the connecting rod axis.

Position the vertical support (1) of the dial gauge (2) to rest the latter on pin (3), point C.

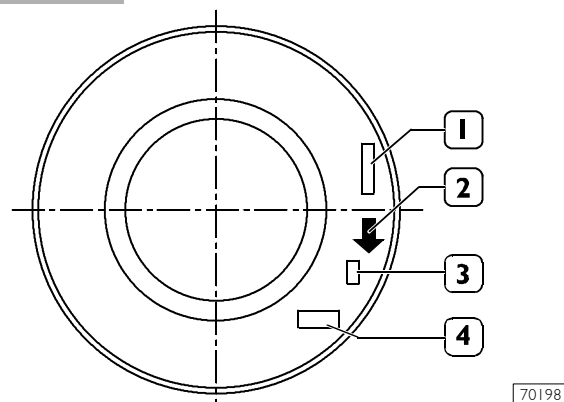
Move the connecting rod forwards and backwards to find pin top position, then in this condition reset the dial gauge (2).

Move the spindle with the connecting rod (5) and repeat the check of the top point on the opposite side D of the pin (3). The difference between point C and point D shall not exceed 0.08 mm.

Fitting connecting rod-piston assembly

Connecting rod-piston coupling

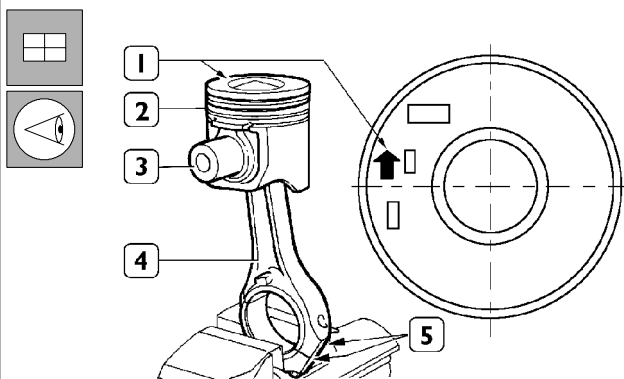
Figure 56



The piston crown is marked as follows:

1. Part number and design modification number;
2. Arrow showing piston assembling direction into cylinder barrel, this arrow shall face the front key of the engine block;
3. Marking showing 1st slot insert testing;
4. Manufacturing date.

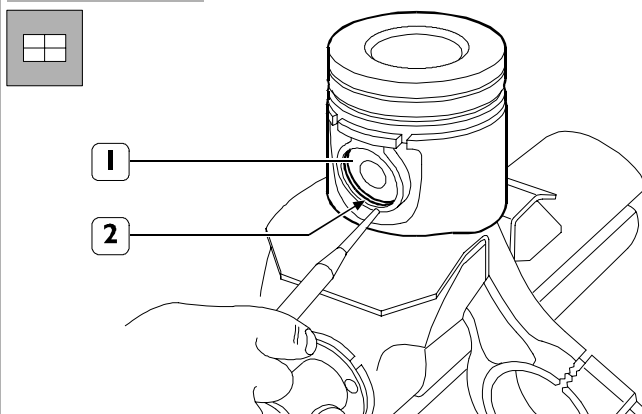
Figure 57



70199

Connect piston (2) to connecting rod (4) with pin (3) so that the reference arrow (1) for fitting the piston (2) into the cylinder barrel and the numbers (5) marked on the connecting rod (5) are read as shown in the figure.

Figure 58

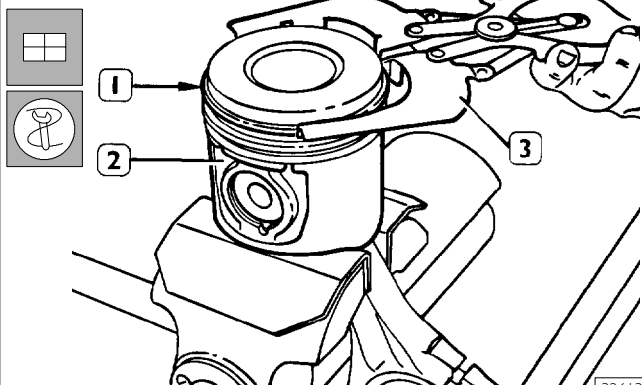


72705

Position the piston (1) on the connecting rod according to the diagram shown in the figure, fit the pin (3) and stop it by the split rings (2).

Fitting split rings

Figure 59



32613

Use acceptable tools (3) to fit the split rings (1) on the piston (2).

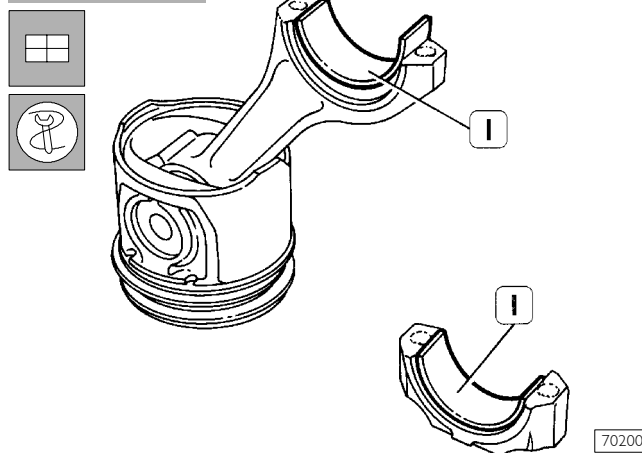
Split rings shall be fitted with the marking "TOP" facing upwards and their openings shall be displaced with each other by 120°.



Split rings are supplied spare with the following sizes:

- standard, yellow marking;
- 0.5 mm oversize, yellow/green marking;

Figure 60



70200

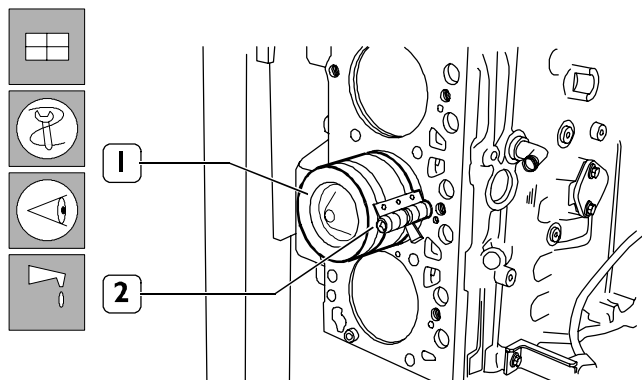
Fit half bearings (1) on connecting rod and cap.



Refit the main bearings that have not been replaced, in the same position found at removal. Do not try to adapt the half bearings.

Fitting connecting rod-piston assembly into cylinder barrels

Figure 61



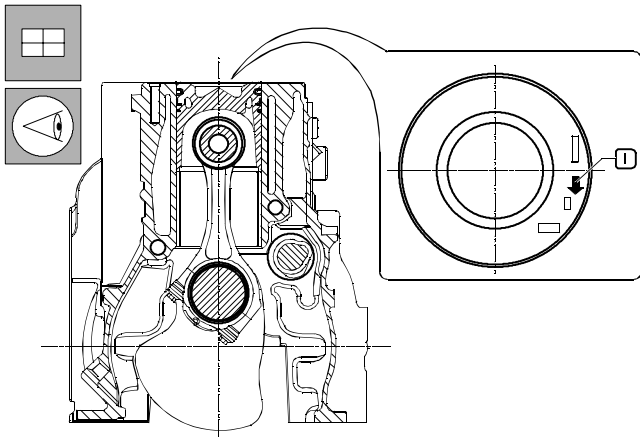
70201

Lubricate accurately the pistons, including the split rings and the cylinder barrel inside.

Use acceptable tools (2) to fit the connecting rod-piston assembly (1) into the cylinder barrels and check the following:

- ☐ the number of each connecting rod shall correspond to the cap coupling number.

Figure 62



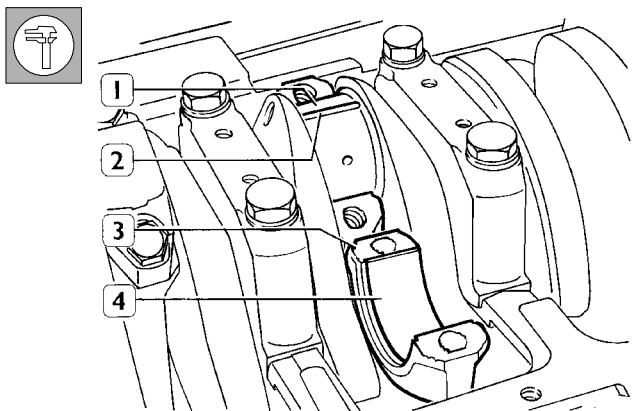
70202

DIAGRAM FOR CONNECTING ROD-PISTON ASSEMBLY FITTING INTO BARREL

- ☐ Split ring openings shall be displaced with each other by 120° ;
- ☐ connecting rod-piston assemblies shall have the same weight;
- ☐ the arrow marked on the piston crown shall be facing the front side of the engine block or the slot obtained on the piston skirt shall be corresponding to the oil nozzle position.

Finding crankpin clearance

Figure 63

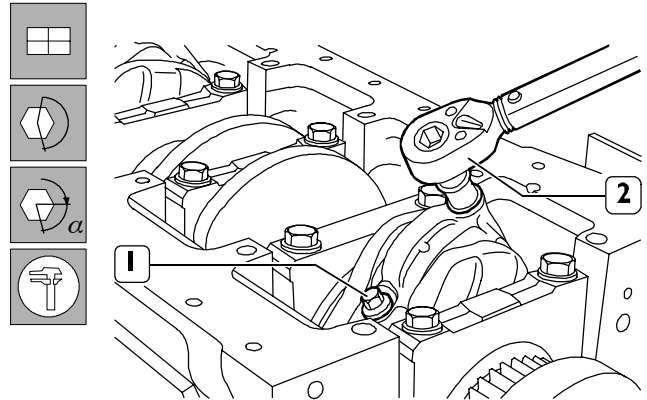


70203

To measure the clearance proceed as follows:

- ☐ clean the parts accurately and remove any trace of oil;
- ☐ set a piece of calibrated wire (2) on the output shaft pins (1);
- ☐ fit the connecting rod caps (3) with the relevant half bearings (4).

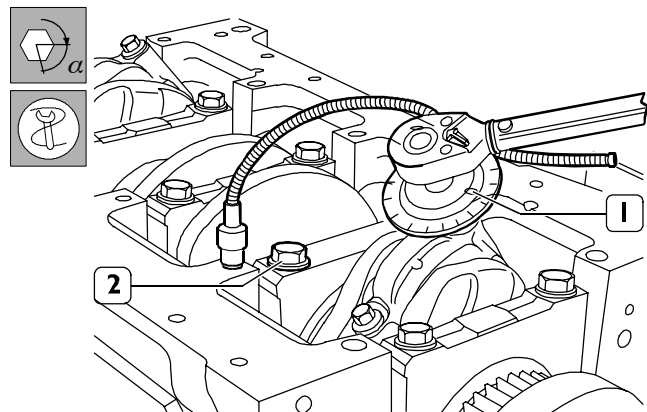
Figure 64



70204

- ☐ Lubricate the screws (1) with engine oil and then tighten them to the specified torque using the dynamometric wrench (2).

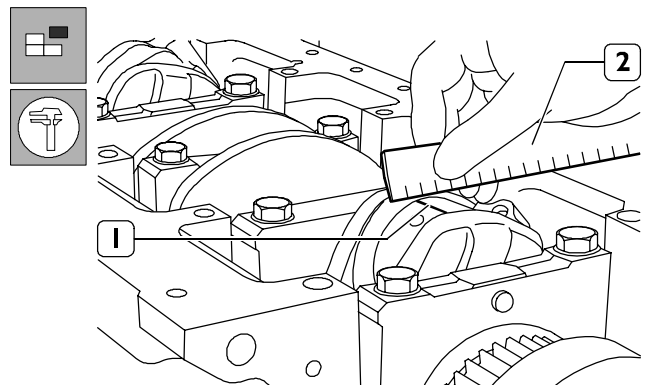
Figure 65



70205

- ☐ Apply acceptable tools (1) to the socket wrench and tighten screws (2) of 60°

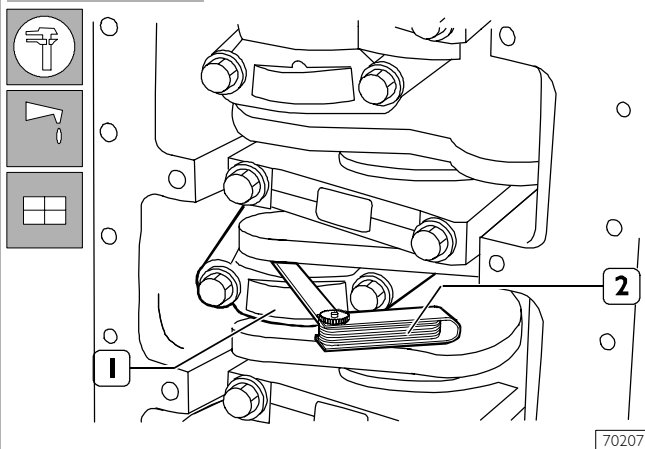
Figure 66



70206

- ☐ Remove the cap and find the existing clearance by comparing the calibrated wire width (1) with the scale on the wire envelope (2).

Figure 67



If a different clearance value is found, replace the half bearings and repeat the check.

Once the specified clearance has been obtained, lubricate the main half bearings and fit them by tightening the connecting rod cap fastening screws to the specified torque.

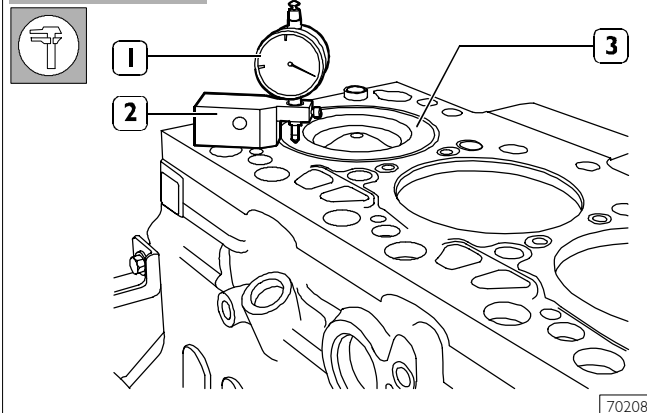


Before the final fitting of the connecting rod cap fastening screws, check that their diameter measured at the centre of the thread length is not < 0.1 mm than the diameter measured at approx. 10 mm from screw end.

Check manually that the connecting rods (1) are sliding axially on the output shaft pins and that their end float, measured with feeler gauge (2) is 0.250 to 0.275 mm.

Checking piston protrusion

Figure 68



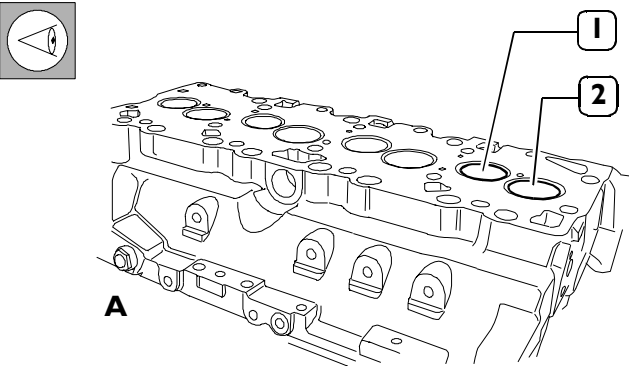
Once connecting rod-piston assemblies refitting is over, use dial gauge (1) fitted with base (2) to check piston (3) protrusion at T.D.C. with respect to the top of the engine block.

Protrusion shall be 0.28 to 0.42 mm.

CYLINDER HEAD

Removing the valves

Figure 69



75750

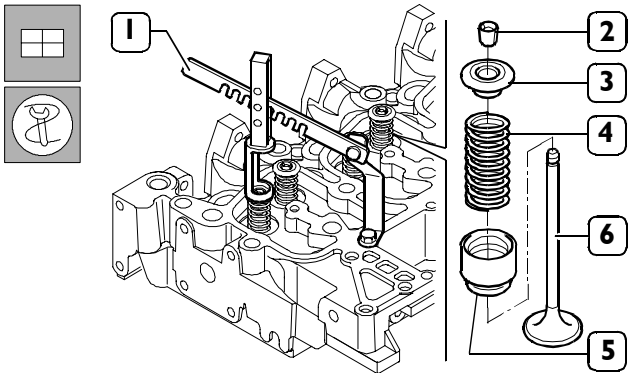
Intake (1) and exhaust (2) valves have heads with different diameter.



Should cylinder head valves be not replaced, number them before removing in order to refit them in the same position.

A = intake side

Figure 70



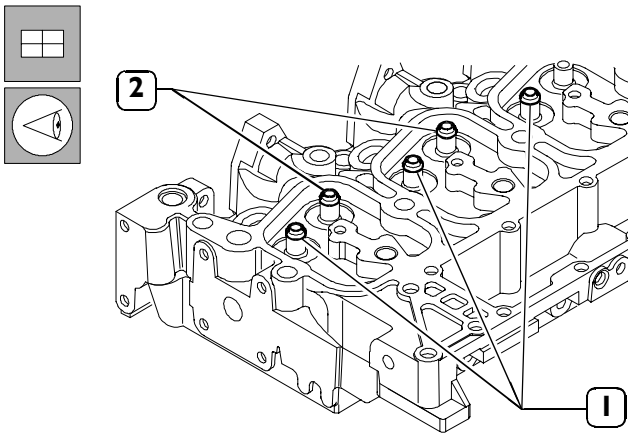
75751

Valve removal shall be performed using acceptable tools (1) and pressing the cap (3) so that when compressing the springs (4) the cotteners (2) can be removed. Then remove the cap (3) and the springs (4).

Repeat this operation for all the valves.

Overturn the cylinder head and withdraw the valves (5).

Figure 71



75752

Remove sealing rings (1 and 2) from the valve guide.

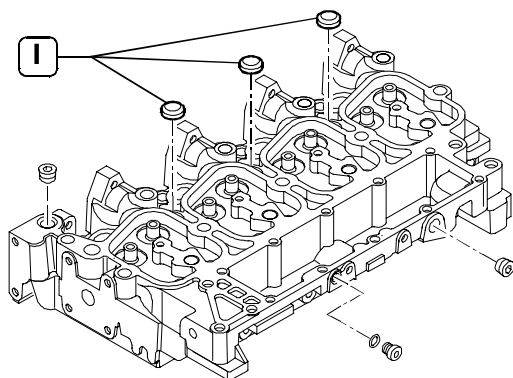


Sealing rings (1) for intake valves are yellow.

Sealing rings (2) for exhaust valves are green.

Checking cylinder head wet seal

Figure 72



75753

This check shall be performed using the proper tools.

Use a pump to fill with water heated to approx. 90°C and 2 to 3 bar pressure.

Replace the cup plugs (I) if leaks are found, use the proper beater for their removal/refitting.



Before refitting, smear the plug surfaces with water-repellent sealant.

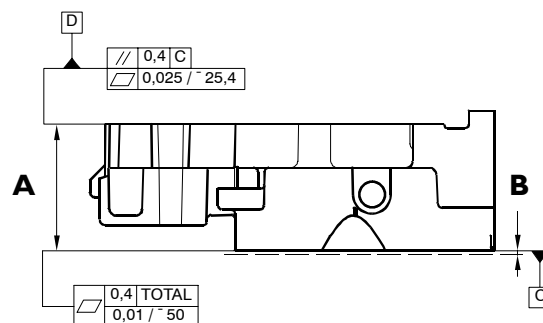
Replace the cylinder head if leaks are found.

Checking cylinder head supporting surface

Distortion found along the whole cylinder head shall not exceed 0.20 mm.

If higher values are found grind the cylinder head according to values and indications shown in the following figure.

Figure 73



75756

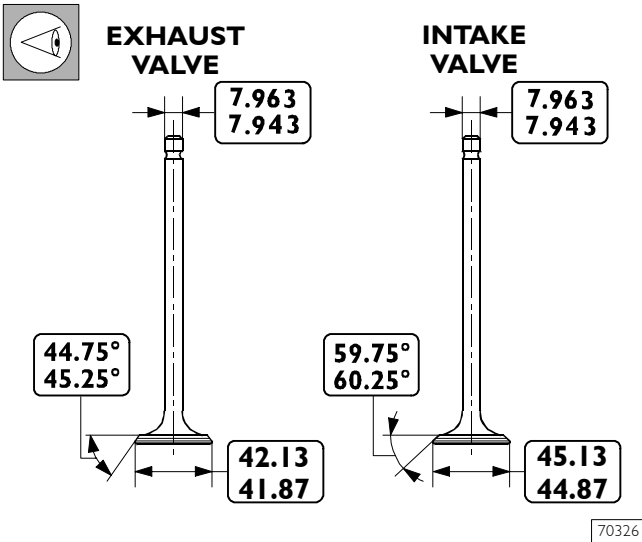
The rated thickness A for the cylinder head is 95 ± 0.25 mm, max. metal removal shall not exceed thickness B by 1 mm.



After grinding, check valve sinking. Regrind the valve seats, if required, to obtain the specified value.

VALVES

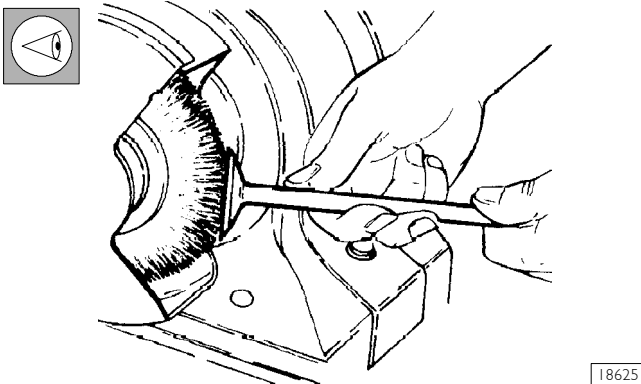
Figure 74



INTAKE AND EXHAUST VALVE MAIN DATA

Removing carbon deposits, checking and grinding valves

Figure 75

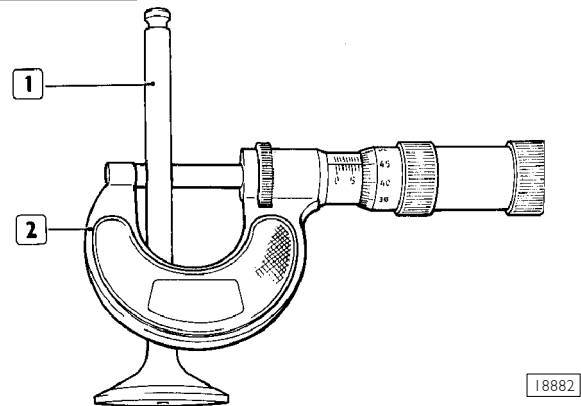


Remove carbon deposits from valves using the proper metal brush.

Check that the valves show no signs of seizing, scoring or cracking.

Reground the valve seats, if required using acceptable tools and removing as little material as possible.

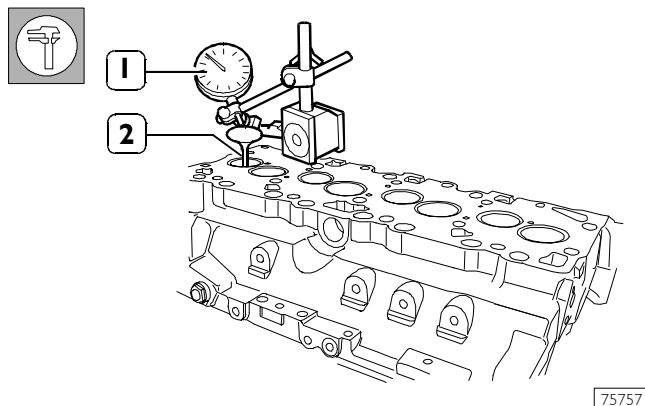
Figure 76



Check the valve stem (1) using a micrometer (2), it shall be 6.960 to 6.980.

Checking clearance between valve stem and valve guide and valve centering

Figure 77

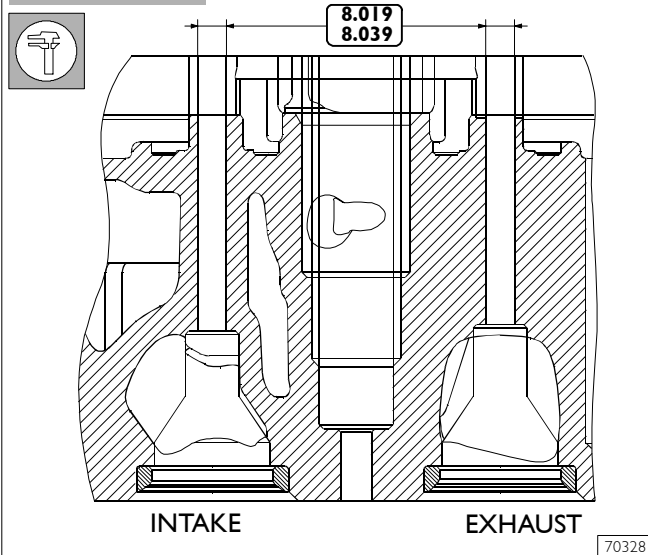


Use a magnetic base dial gauge (1) set as shown in the figure, the assembling clearance shall be 0.052 ± 0.092 mm.

Turn the valve (2) and check that the centering error is not exceeding 0.03 mm.

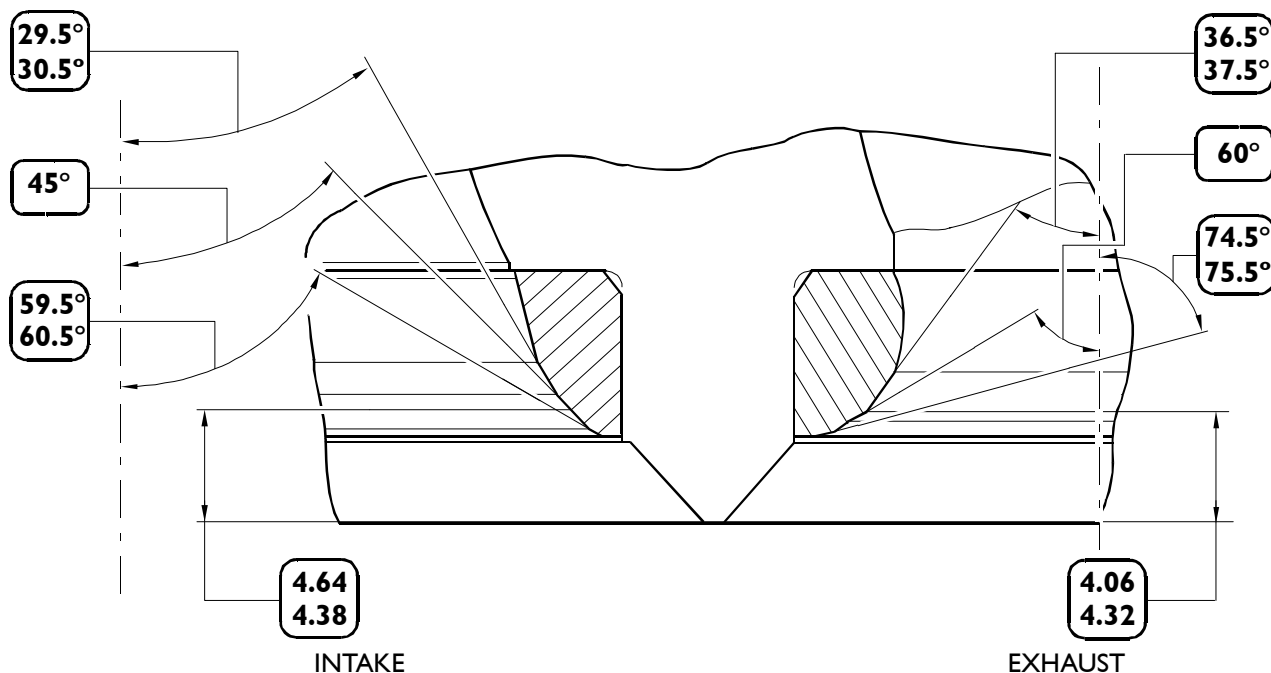
VALVE GUIDE

Figure 78



Use a bore dial gauge to measure the inside diameter of the valve guides, the read value shall comply with the value shown in the figure.

Figure 80



VALVE SEAT MAIN DATA

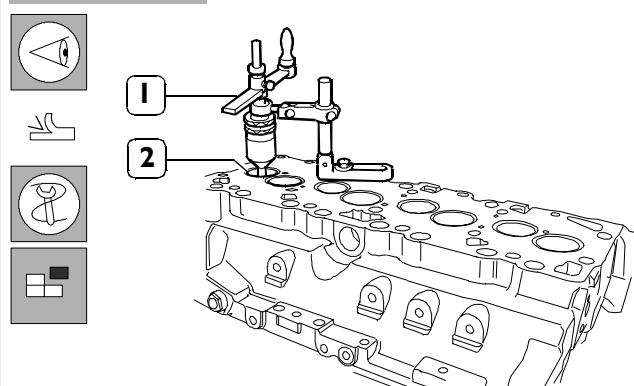
75755

Should valve seats be not reset just by regrinding, replace them with the spare ones. Use acceptable tools (Figure 79) to remove as much material as possible from the valve seats (take care not to damage the cylinder head) until they can be extracted from the cylinder head using a punch.

VALVE SEATS

Regrinding – replacing the valve seats

Figure 79



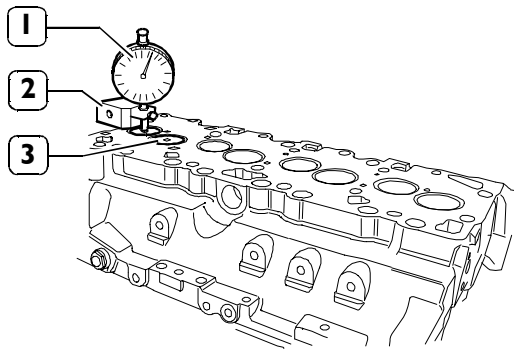
75754

Check the valve seats (2). If slight scoring or burnout is found, regrind seats using acceptable tools (1) according to the angle values shown in Figure 80.

Heat the cylinder head to 80° – 100°C and using the proper beater; fit the new valve seats, previously cooled, into the cylinder head.

Use acceptable tools to regrind the valve seats according to the values shown in Figure 80.

Figure 81

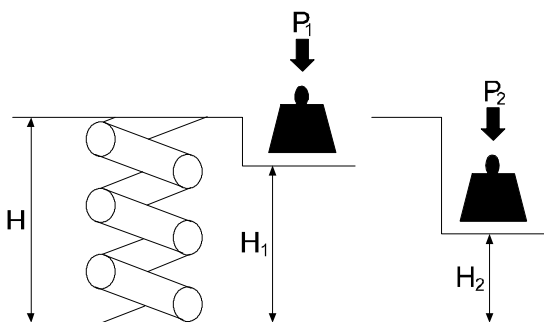


75758

After regrinding, check that valve (3) sinking value is the specified one by using the base (2) and the dial gauge (1).

VALVE SPRINGS

Figure 82



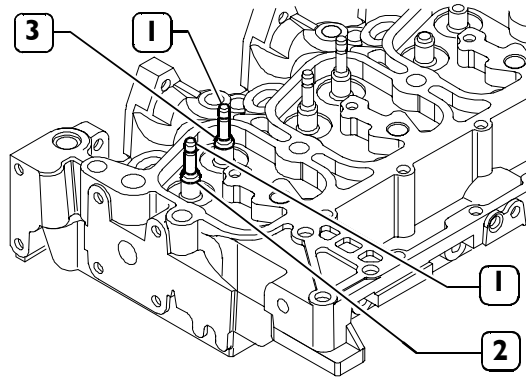
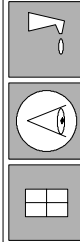
50676

MAIN DATA TO CHECK INTAKE AND EXHAUST VALVE SPRINGS

Before refitting use acceptable tools to check spring flexibility. Compare load and elastic deformation data with those of the new springs shown in the following table.

FITTING CYLINDER HEAD

Figure 83



75759

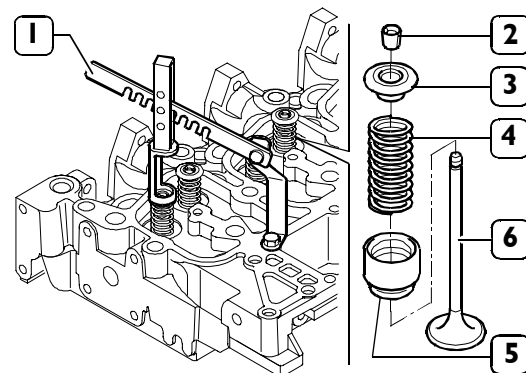
Lubricate the valve stems (1) and fit them into the relevant valve guides according to the position marked at removal.

Fit the sealing rings (2 and 3) on the valve guide.



Sealing rings (2) for intake valves are yellow and sealing rings (3) for exhaust valves are green.

Figure 84

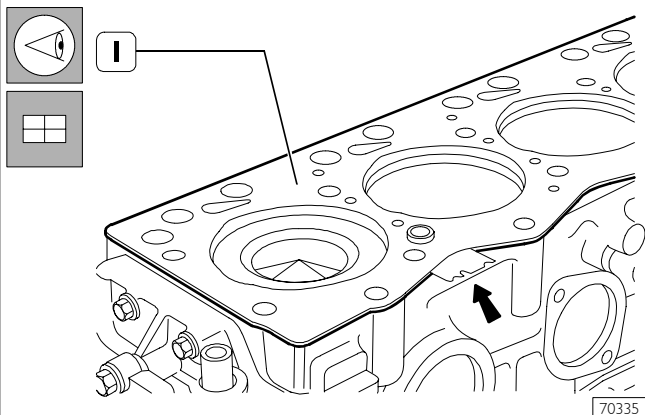


75751

Position on the cylinder head: the spring (4), the upper cap (3); use acceptable tools (1) to compress the spring (4) and lock the parts to the valve (5) by the cotters (2).

Refitting the cylinder head

Figure 85



Check cleanness of cylinder head and engine block coupling surface.

Take care not to foul the cylinder head gasket.

Set the cylinder head gasket (I) with the marking "N. of component" (I) facing the head.

The arrow shows the point where the gasket thickness is given.



Before re-utilising the fixing screws for the cylinder head, verify there is no evidence of wear or deformation and in that case replace them.

TIGHTENING TORQUE

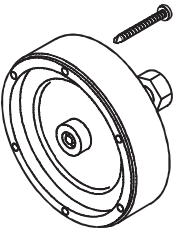
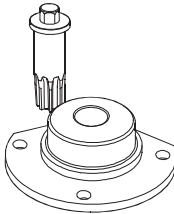
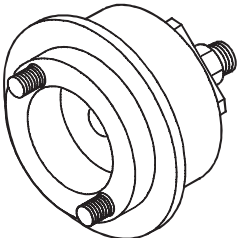
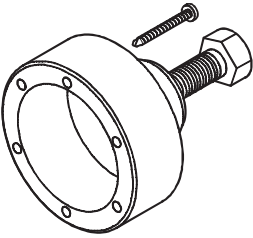
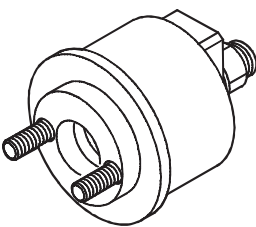
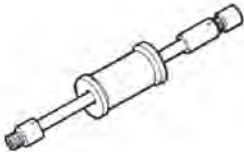
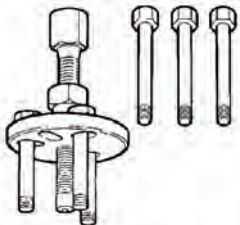
COMPONENT		TORQUE	
		Nm	kgm
Screw M8 for fastening cylinder barrel lubricating nozzles		15 ± 3	1.5 ± 0.3
Screw M12 for fastening output shaft caps	1 st stage	50 ± 6	5 ± 0.6
	2 nd stage	80 ± 6	8 ± 0.6
	3 rd stage	$90^\circ \pm 5^\circ$	
Screw M8 for fastening camshaft longitudinal retaining plate		24 ± 4	2.4 ± 0.4
Screw M8 for fastening camshaft gear		36 ± 4	3.6 ± 0.4
Screw M11 for fastening connecting rod caps	1 st stage	60 ± 5	6 ± 0.5
	2 nd stage	$60^\circ \pm 5^\circ$	

SECTION 5

Tools

	Page
TOOLS.	3

TOOLS

TOOL No.	DEFINITION	TOOL No.	DEFINITION
380000663	 Crankshaft Rear Seal Puller	380000988	 Tool for Rotating the Engine Flywheel
380000664	 Crankshaft Rear Seal Installer		
380000665	 Crankshaft Front Seal Puller		
380000666	 Crankshaft Front Seal Installer		
380000671	 Injector Puller		
380000979	 Injector Pump Puller		

APPENDIX

	Pagina
SAFETY PRESCRIPTIONS	3

SAFETY PRESCRIPTIONS

Standard safety prescriptions

Particular attention shall be drawn on some precautions that must be followed absolutely in a standard working area and whose non fulfillment will make any other measure useless or not sufficient to ensure safety to the personnel in-charge of maintenance.

Be informed and inform personnel as well of the laws in force regulating safety, providing information documentation available for consultation.

- ☐ Keep working areas as clean as possible, ensuring adequate aeration.
- ☐ Ensure that working areas are provided with emergency boxes, that must be clearly visible and always provided with adequate sanitary equipment.
- ☐ Provide for adequate fire extinguishing means, properly indicated and always having free access. Their efficiency must be checked on regular basis and the personnel must be trained on intervention methods and priorities.
- ☐ Organize and displace specific exit points to evacuate the areas in case of emergency, providing for adequate indications of the emergency exit lines.
- ☐ Smoking in working areas subject to fire danger must be strictly prohibited.
- ☐ Provide Warnings throughout adequate boards signaling danger, prohibitions and indications to ensure easy comprehension of the instructions even in case of emergency.

Prevention of injury

- ☐ Do not wear unsuitable cloths for work, with fluttering ends, nor jewels such as rings and chains when working close to engines and equipment in motion.
- ☐ Wear safety gloves and goggles when performing the following operations:
 - filling inhibitors or anti-frost
 - lubrication oil topping or replacement
 - utilization of compressed air or liquids under pressure (pressure allowed: ≤ 2 bar)
- ☐ Wear safety helmet when working close to hanging loads or equipment working at head height level.
- ☐ Always wear safety shoes when and cloths adhering to the body, better if provided with elastics at the ends.
- ☐ Use protection cream for hands.
- ☐ Change wet cloths as soon as possible
- ☐ In presence of current tension exceeding 48–60 V verify efficiency of earth and mass electrical connections. Ensure that hands and feet are dry and execute working operations utilizing isolating foot-boards. Do not carry out working operations if not trained for.
- ☐ Do not smoke nor light up flames close to batteries and to any fuel material.
- ☐ Put the dirty rags with oil, diesel fuel or solvents in anti-fire specially provided containers.

- ☐ Do not execute any intervention if not provided with necessary instructions.
- ☐ Do not use any tool or equipment for any different operation from the ones they've been designed and provided for: serious injury may occur.
- ☐ In case of test or calibration operations requiring engine running, ensure that the area is sufficiently aerated or utilize specific vacuum equipment to eliminate exhaust gas. Danger: poisoning and death.

During maintenance

- ☐ Never open filler cap of cooling circuit when the engine is hot. Operating pressure would provoke high temperature with serious danger and risk of burn. Wait until the temperature decreases under 50°C.
- ☐ Never top up an overheated engine with cooler and utilize only appropriate liquids.
- ☐ Always operate when the engine is turned off: whether particular circumstances require maintenance intervention on running engine, be aware of all risks involved with such operation.
- ☐ Be equipped with adequate and safe containers for drainage operation of engine liquids and exhaust oil.
- ☐ Keep the engine clean from oil tangles, diesel fuel and or chemical solvents.
- ☐ Use of solvents or detergents during maintenance may originate toxic vapors. Always keep working areas aerated. Whenever necessary wear safety mask.
- ☐ Do not leave rags impregnated with flammable substances close to the engine.
- ☐ Upon engine start after maintenance, undertake proper preventing actions to stop air suction in case of runaway speed rate.
- ☐ Do not utilize fast screw-tightening tools.
- ☐ Never disconnect batteries when the engine is running.
- ☐ Disconnect batteries before any intervention on the electrical system.
- ☐ Disconnect batteries from system aboard to load them with the battery loader.
- ☐ After every intervention, verify that battery clamp polarity is correct and that the clamps are tight and safe from accidental short circuit and oxidation.
- ☐ Do not disconnect and connect electrical connections in presence of electrical feed.
- ☐ Before proceeding with pipelines disassembly (pneumatic, hydraulic, fuel pipes) verify presence of liquid or air under pressure. Take all necessary precautions bleeding and draining residual pressure or closing dump valves. Always wear adequate safety mask or goggles. Non fulfillment of these prescriptions may cause serious injury and poisoning.

- ☐ Avoid incorrect tightening or out of couple. Danger: incorrect tightening may seriously damage engine's components, affecting engine's duration.
- ☐ Avoid priming from fuel tanks made out of copper alloys and/or with ducts not being provided with filters.
- ☐ Do not modify cable wires: their length shall not be changed.
- ☐ Do not connect any user to the engine electrical equipment unless specifically approved.
- ☐ Do not modify fuel systems or hydraulic system unless specific approval has been released. Any unauthorized modification will compromise warranty assistance and furthermore may affect engine correct working and duration.

For engines equipped with electronic gearbox:

- ☐ Do not execute electric arc welding without having priority removed electronic gearbox.
- ☐ Remove electronic gearbox in case of any intervention requiring heating over 80°C temperature.
- ☐ Do not paint the components and the electronic connections.
- ☐ Do not vary or alter any data filed in the electronic gearbox driving the engine. Any manipulation or alteration of electronic components shall totally compromise engine assistance warranty and furthermore may affect engine correct working and duration.

Respect of the Environment

- ☐ Respect of the Environment shall be of primary importance: all necessary precautions to ensure personnel's safety and health shall be adopted.
- ☐ Be informed and inform the personnel as well of laws in force regulating use and exhaust of liquids and engine exhaust oil. Provide for adequate board indications and organize specific training courses to ensure that personnel is fully aware of such law prescriptions and of basic preventive safety measures.
- ☐ Collect exhaust oils in adequate specially provided containers with hermetic sealing ensuring that storage is made in specific, properly identified areas that shall be aerated, far from heat sources and not exposed to fire danger.
- ☐ Handle the batteries with care, storing them in aerated environment and within anti-acid containers. Warning: battery exhalation represent serious danger of intoxication and environment contamination.