F32 TIER 3 SERIES

Agricultural application

F5AE9484G*A011
F5AE9484B*A008
F5AE9454H*A003

Technical and Repair manual

This publication provides unit and relevant component repair data, specifications, instructions and methodologies.

This publication has been drawn up for qualified and specialised personnel.

Before performing any operation check that the part relevant to the unit on which you must work is available along with all safety devices for accident-prevention, such as, goggles, helmet, gloves, shoes, etc. and hoisting and transporting equipment.

Operations are to be performed by following the indications included here, using the special equipment indicated and assuring proper repair, compliance with schedule and operator's safety requirements.

Each repair must aim to restore operating efficiency and safety in compliance with the FPT provisions.

FPT cannot be held liable for modifications, alterations or other interventions non authorised by FPT on the vehicle and if the unit is warranted the above mentioned interventions will cause its expiration.

FPT is not liable for repairing interventions.

FPT will provide further details required to carry out the interventions and all the instructions that are not included on this publication.

Data included in this publication may not be up-to-date therefore subject to Manufacturer's modifications that can be added at any time for technical or commercial purposes and also to meet new law regulations in other Countries.

If issues on this publication differ from what is actually noticed on the unit, please get in touch with the FPT network before starting any intervention".

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F32 SERIES

F32 Series **Part I**

Introduction

PREFACE

Manuals for repairs are split into Parts and Sections, each one of which is marked by a numeral; the contents of these sections are indicated in the general table of contents.
The sections dealing with things mechanic introduce the specifications, tightening torque values, tool lists, assembly detaching/reattaching operations, bench overhauling operations, diagnosis procedures and maintenance schedules.
The sections (or parts) of the electric/electronic system include the descriptions of the electric network and the assembly's electronic systems, wiring diagrams, electric features of components, component coding and the diagnosis procedures for the control units peculiar to the electric system.
Section 1 describes the engines 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.
The appendix contains a list of the general safety regulations to be respected by all installation and maintenance engineers in order to prevent serious accidents taking place.
The manual uses proper symbols in its descriptions; the purpose of these symbols is to classify contained information. In particular, there have been defined a set of symbols to classify warnings and a set for assistance operations.

SYMBOLS - Warnings

Danger for persons

Missing or incomplete observance of these prescriptions can cause serious danger for persons' safety.

Danger of serious damage for the assembly

Failure to comply, both fully or in part, with such prescriptions will involve serious damage to the assembly and may sometimes cause the warranty to become null and void.

General danger

It includes the dangers of above described signals.

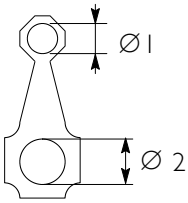
Environment protection

Moreover, it describes the correct actions to be taken to ensure that the assembly is used in such a way so as to protect the environment as much as possible.

NOTE It indicates an additional explanation for a piece of information.

Service operations

Example



Ø 1 = Seat of small end bush

Ø 2 = Seat of connecting rod bearings.

Close applying the required torque
Close applying the required torque + angular value

	Removal Disconnection
	Refitting Connection
	Removal Disassembly
	Fitting in place Assembly
	Tighten to torque
	Tighten to torque + angle value
	Press or caulk
	Regulation Adjustment
	Visual inspection Fitting position check
	Measurement Value to find Check
	Equipment
	Surface for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Lubrication Damp Grease
	Sealant Adhesive
	Air bleeding
	Intake

	Exhaust
	Operation
	Compression ratio
	Tolerance Weight difference
	Rolling torque
	Rotation
	Angle Angular value
	Preload
	Number of revolutions
	Temperature
	Pressure
	Oversized Higher than.... Maximum, peak
	Undersized Less than.... Minimum
	Selection Classes Oversizing
	Temperature < 0 °C Cold Winter
	Temperature > 0 °C Hot Summer

GENERAL WARNINGS

Warnings shown cannot be representative of all danger situations possibly occurring. Therefore, it is suggested to contact immediate superiors where a danger situation occurs which is not described.

Use both specific and general-purpose toolings according to the prescriptions contained in respective use and maintenance handbooks. Check use state and suitability of tools not subjected to regular check.

Manual handling of loads must be appraised beforehand, because this not only depends on the weight but also on the size and path.

Handling with mechanical means must be done with lifters that are suitable for weight, shape and volume. Hoisters, ropes and hooks used must contain clear indications on maximum carrying capacity acceptable. The use of said means is compulsorily permitted to authorised personnel only. Stay duly clear of the load, and, anyhow, never under it.

In disassembling operations, always observe provided prescriptions; prevent mechanical parts being taken out from accidentally striking workshop personnel.

Workshop jobs performed in pairs must always be performed in maximum safety; avoid operations which could be dangerous for the co-operator because of lack of visibility or of his/her not correct position.

Keep personnel not authorised to operations clear of working area.

You shall get familiar with the operating and safety instructions for the assembly prior to operating on the latter. Strictly follow all the safety indications found on the assembly.

Do not leave the running assembly unattended when making repairs.

When carrying out work on the assembly lifted off the ground, verify that the assembly is firmly placed on its supporting stands, and that the manual/automatic safety devices have been actuated in the event that the assembly is to be lifted by means of a hoist.

When you have to operate on assemblies powered by natural gas, follow the instructions contained in the document, as well as all the specific safety standards provided for.

Only remove radiator cap when the engine is cold by cautiously unscrewing it in order to let system residual pressure out.

Inflammable fuel and all inflammable fluids and liquids must be handled with care, according to what contained on harmful materials 16-point cards. Refuelling must be performed outdoors with the engine off, avoiding lit cigarettes, free flames or sparks in order to prevent sudden fires/bursts. Adequately store inflammable, corrosive and polluting fluids and liquids according to what provided by regulations in force. Compulsorily avoid to use food containers to store harmful liquids. Avoid to drill or bore pressurised containers, and throw cloths impregnated with inflammable substances into suitable containers.

Worn out, damaged or consumable parts must be replaced by original spares.

During workshop activity, always keep the work place clean; timely clear or clean floors from accidental liquid or oil spots. Electric sockets and electric equipment necessary to perform repair interventions must meet safety rules.

Put on, where required by the intervention, garments and protections provided in accident prevention rules; contact with moving parts can cause serious injuries. Use suitable, preferably tight-fitted garments, and avoid to use jewels, scarves, etc.

Do not leave the engine in motion at workshop locations not provided with a pipe to scavenge exhaust gas outside.

Avoid to breathe fumes coming from heating or from paint welding because they can cause damages to health; operate outdoors or in suitably ventilated areas. Put on proper inspirator if paint powder is present.

Avoid contact with hot water or steam coming from the engine, radiator and pipings because they could cause serious burns. Avoid direct contact with liquids and fluids present in vehicle systems; where an accidental contact has occurred, refer to 16-point cards for provisions to make.

Clean the assemblies and carefully verify that they are intact prior to overhauling. Tidy up detached or disassembled parts with their securing elements (screws, nuts, etc.) into special containers.

Check for the integrity of the parts which prevent screws from being unscrewed: broken washers, dowels, clips, etc. Self-locking nuts with an insert made of nylon must always be replaced.

Avoid contact of rubber parts with diesel oil, petrol or other not compatible substances.

Before washing under pressure mechanical parts, protect electric connectors, and central units, if present.

Tightening screws and nuts must always be according to prescriptions; FPT commercial and assistance network is available to give all clarifications necessary to perform repair interventions not provided in this document.

Before welding:

- ❑ Disconnect all electronic central units, take power cable off battery positive terminal (connect it to chassis bonding) and detach connectors.
- ❑ Remove paint by using proper solvents or paint removers and clean relevant surfices with soap and water.
- ❑ Await about 15 minutes before welding.
- ❑ Equip with suitable fire resistant protections to protect hoses or other components where fluids or other materials flow which may catch fire easily on welding.

Should the vehicle be subjected to temperatures exceeding 80°C (dryer ovens), disassemble drive electronic central units.

The disposal of all liquids and fluids must be performed with full observance of specific rules in force.

GENERAL WARNINGS ON THE ELECTRIC SYSTEM

If an intervention has to be made on the electric/electronic system, disconnect batteries from the system; in this case, always disconnect, as a first one, the chassis bonding cable from batteries negative terminal.

Before connecting the batteries to the system, make sure that the system is well isolated.

Disconnect the external recharging apparatus from the public utility network before taking apparatus pins off battery terminals.

Do not cause sparks to be generated in checking if the circuit is energised.

Do not use a test lamp in checking circuit continuity, but only use proper control apparatuses.

Make sure that the electronic devices wiring harnesses (length, lead type, location, strapping, connection to screening braiding, bonding, etc.) comply with FPT system and are carefully recovered after repair or maintenance interventions.

Measurements in drive electronic central units, plugged connections and electric connections to components can only be made on proper testing lines with special plugs and plug bushes. Never use improper means like wires, screwdrivers, clips and the like in order to avoid the danger of causing a short circuit, as well as of damaging plugged connections, which would later cause contact problems.

To start up the engine, do not use fast chargers. Start up must only be performed with either separate batteries or special truck.

A wrong polarisation of supply voltage in drive electronic central units (for instance, a wrong polarisation of batteries) can cause them to be destroyed.

Disconnect the batteries from the system during their recharging with an external apparatus.

On connecting, only screw up connector (temperature sensors, pressure sensors etc.) nuts at prescribed tightening torque.

Before disconnecting the junction connector from an electronic central unit, isolate the system.

Do not directly supply electronic central units servo components at nominal vehicle voltage.

Cables must be arranged such as to result to be parallel to reference plane, i.e. as close as possible to chassis/body structure.

Once the intervention on the electric system has been completed, recover connectors and wiring harnesses according to original arrangement.

NOTE Connectors present must be seen from cable side. Connectors views contained in the manual are representative of cable side.

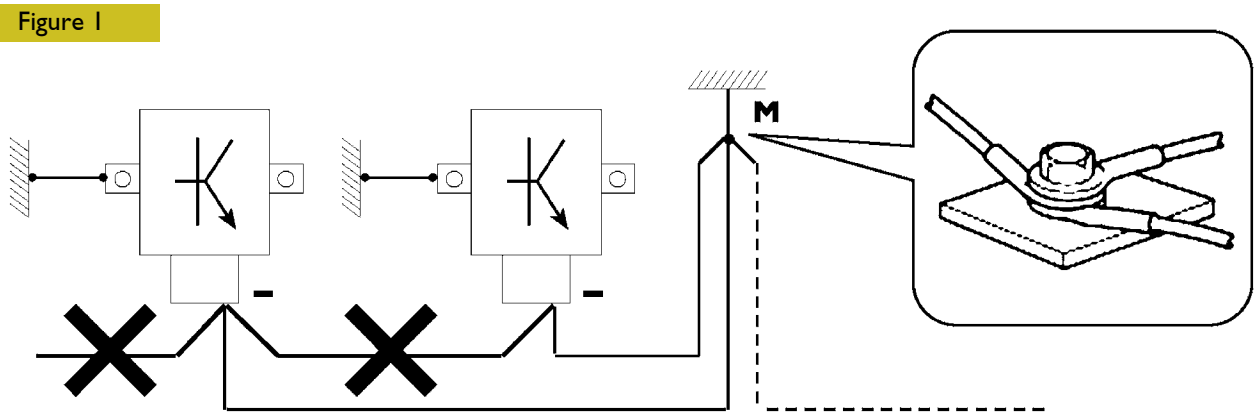
Bonding and screening

Negative leads connected to a system bonded point must be both as short and possible and "star"-connected to each other, trying then to have their centering tidily and properly made (Figure 1, re. M).

Further, following warnings are to be compulsorily observed for electronic components:

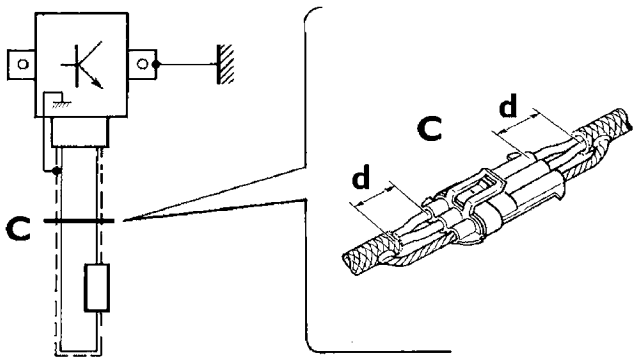
- Electronic central units must be connected to system bonding when they are provided with a metallic shell.
- Electronic central units negative cables must be connected both to a system bonding point such as the dashboard opening bonding (avoiding "serial" or "chain" connections), and to battery negative terminal.
- Analog bonding (sensors), although not connected to battery negative system/terminal bonding, must have optimal isolation. Consequently, particularly considered must be parasitic resistances in lugs: oxidising, clinching defects, etc.
- Screened circuits braiding must only electrically contact the end towards the central unit entered by the signal (Figure 2).
- If junction connectors are present, unscreened section **d**, near them, must be as short as possible (Figure 2).
- Cables must be arranged such as to result to be parallel to reference plane, i.e. as close as possible to chassis/body structure.

Figure 1



1. NEGATIVE CABLES "STAR" CONNECTION TO SYSTEM BONDING **M**

Figure 2



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2. SCREENING THROUGH METALLIC BRAIDING OF A CABLE TO AN ELECTRONIC COMPONENT – **C.** CONNECTOR **d.** DISTANCE → 0

CONVERSIONS BETWEEN THE MAIN UNITS OF MEASUREMENT OF THE INTERNATIONAL SYSTEM AND MOST USED DERIVED QUANTITIES

Power

1 kW = 1.36 metric HP
1 kW = 1.34 HP
1 metric HP = 0.736 kW
1 metric HP = 0.986 HP
1 HP = 0.746 kW
1 HP = 1.014 metric HP

Torque

1 Nm = 0.1019 kgm
1 kgm = 9.81 Nm

Revolutions per time unit

1 rad/s = 1 rpm x 0.1046
1 rpm = 1 rad/s x 9.5602

Pressure

1 bar = 1.02 kg/cm^2
1 kg/cm^2 = 0.981 bar
1 bar = 10^5 Pa

Where accuracy is not particularly needed:

- Nm unit is for the sake of simplicity converted into kgm according to ratio 10:1

1 kgm = 10 Nm;

- bar unit is for the sake of simplicity converted into kg/cm^2 according to ratio 1:1

1 kg/cm^2 = 1 bar.

Temperature

0° C = 32° F
1° C = (1 x 1.8 + 32) ° F

KEY OF LECTURE OF THE HEADINGS AND FOOTNOTES

Type of vehicle

Section title

Page number

MOTORI NEF F4HE — SEZIONE 4 - REVISIONE MECCANICA GENERALE 11

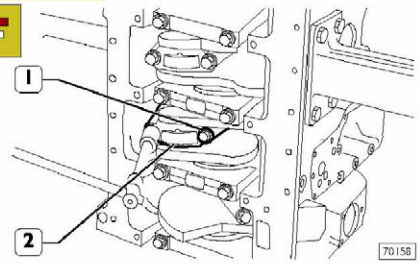
REVISIONE MOTORE 4 E 6 CIL. SMONTAGGIO DEL MOTORE AL BANCO

La trattazione seguente prevede che il motore sia stato montato sul cavalletto rotativo e si sia proceduto alla rimozione di tutti i componenti specifici dell'applicazione Iveco Motors (vedere la Sezione 3 del presente manuale).

La sezione riguarda quindi tutte le più importanti procedure di revisione del basamento motore.

Le operazioni seguenti riguardano il motore 4 cilindri, ma risultano analoghe per il 6 cilindri.

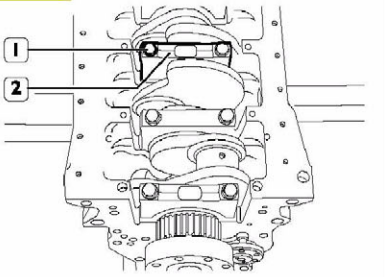
Figura 1



Svitare le viti di fissaggio (1) e rimuovere i cappelli di biella (2). Sfilare gli stantuffi completi di bielle dalla parte superiore del basamento.

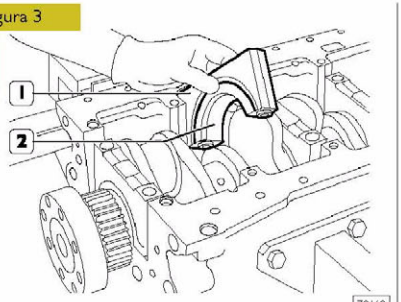
NOTA Mantenere i semicuscinetti nei rispettivi alloggiamenti, poiché, in caso di un loro utilizzo, dovranno essere montati nella posizione riscontrata allo smontaggio.

Figura 2



Rimuovere le viti (1) e smontare i cappelli di banco (2).

Figura 3

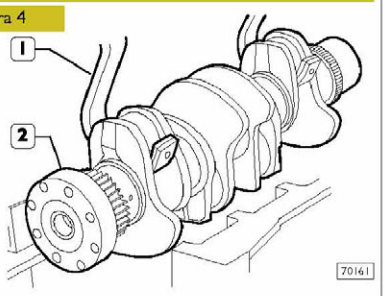


Il penultimo cappello di banco (1) e il relativo supporto hanno il semicuscinetto (2) dotato di spallamento.

NOTA Le viti M12 dei cappelli di banco, devono essere sostituite se il diametro nominale della parte filettata che non lavora, presenta un diametro < 0,1 mm rispetto al valore nominale.

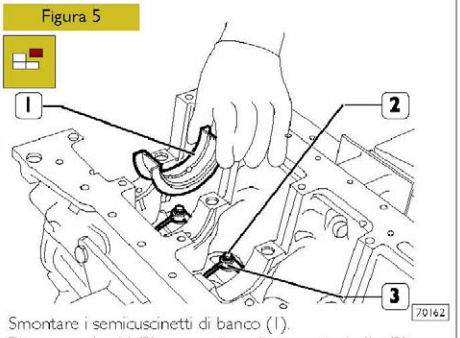
NOTA Annotare la posizione di montaggio dei semicuscinetti inferiori e superiori, poiché in caso di un loro riutilizzo, dovranno essere montati nella posizione riscontrata allo smontaggio.

Figura 4



Con l'attrezzo 99360500 (1) e sollevatore rimuovere l'albero motore (2) dal basamento.

Figura 5



Smontare i semicuscinetti di banco (1).
Rimuovere le viti (2) e smontare gli spruzzatori olio (3).

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Part I
F32 SERIES

UPDATING

Section	Description	Page	Date of revision
3	Industrial application	34	March 2011
4	Mechanical overhaul	30, 31, 32, 33	April 2012

SECTION 1

General specifications

ENGINE VIEWS

Figure 1

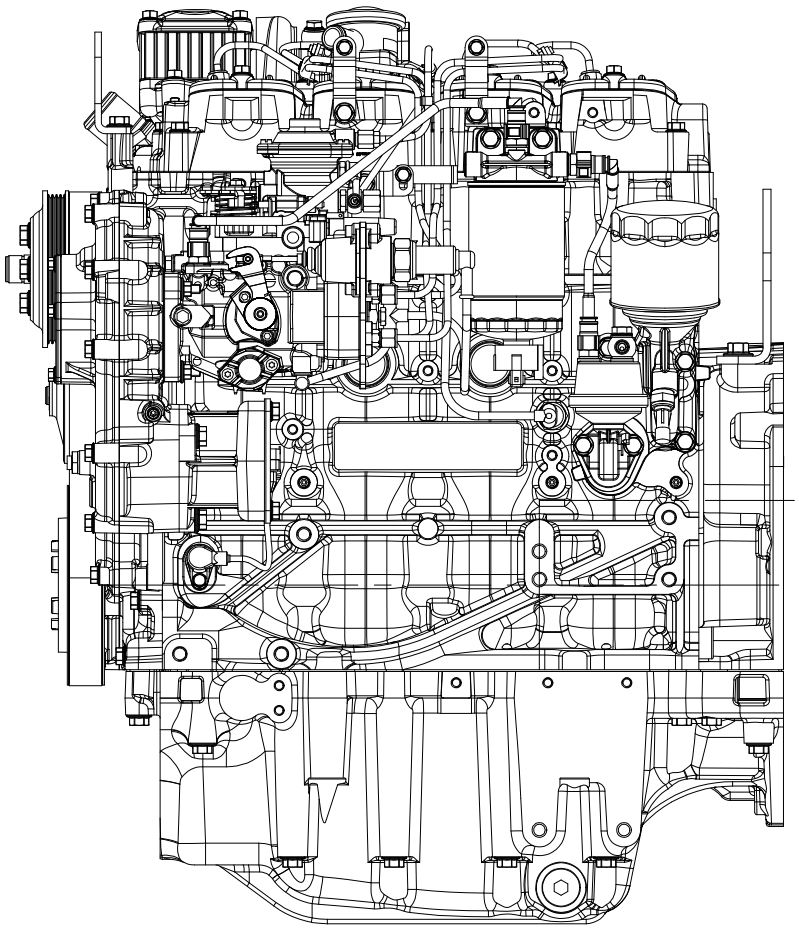

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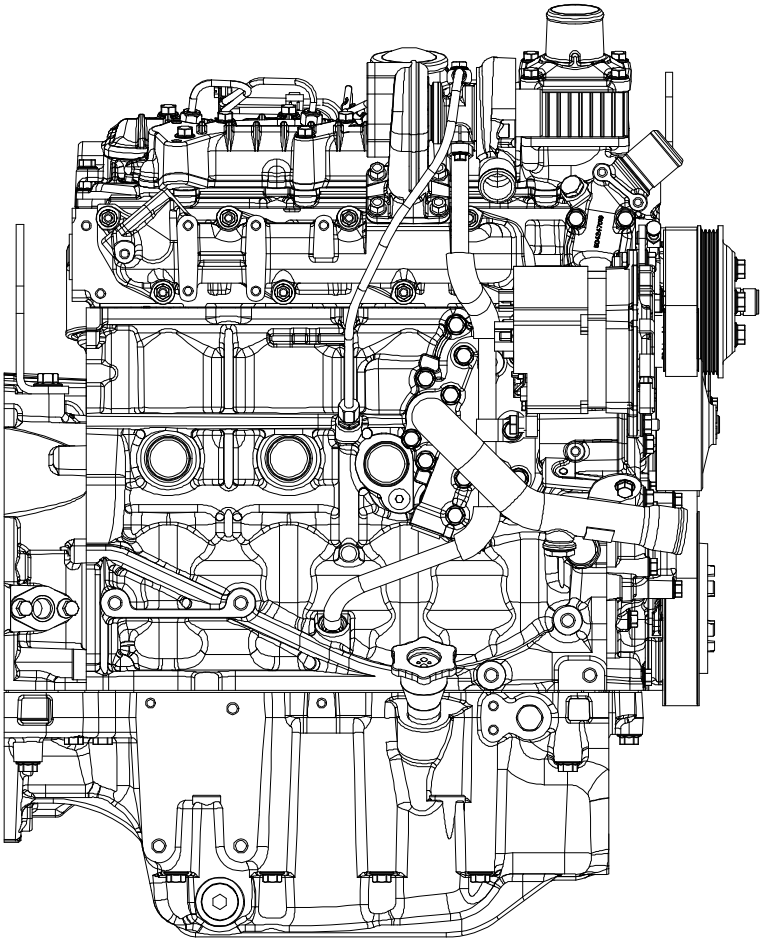
Figure 2



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ENGINE LUBRICATION SYSTEM

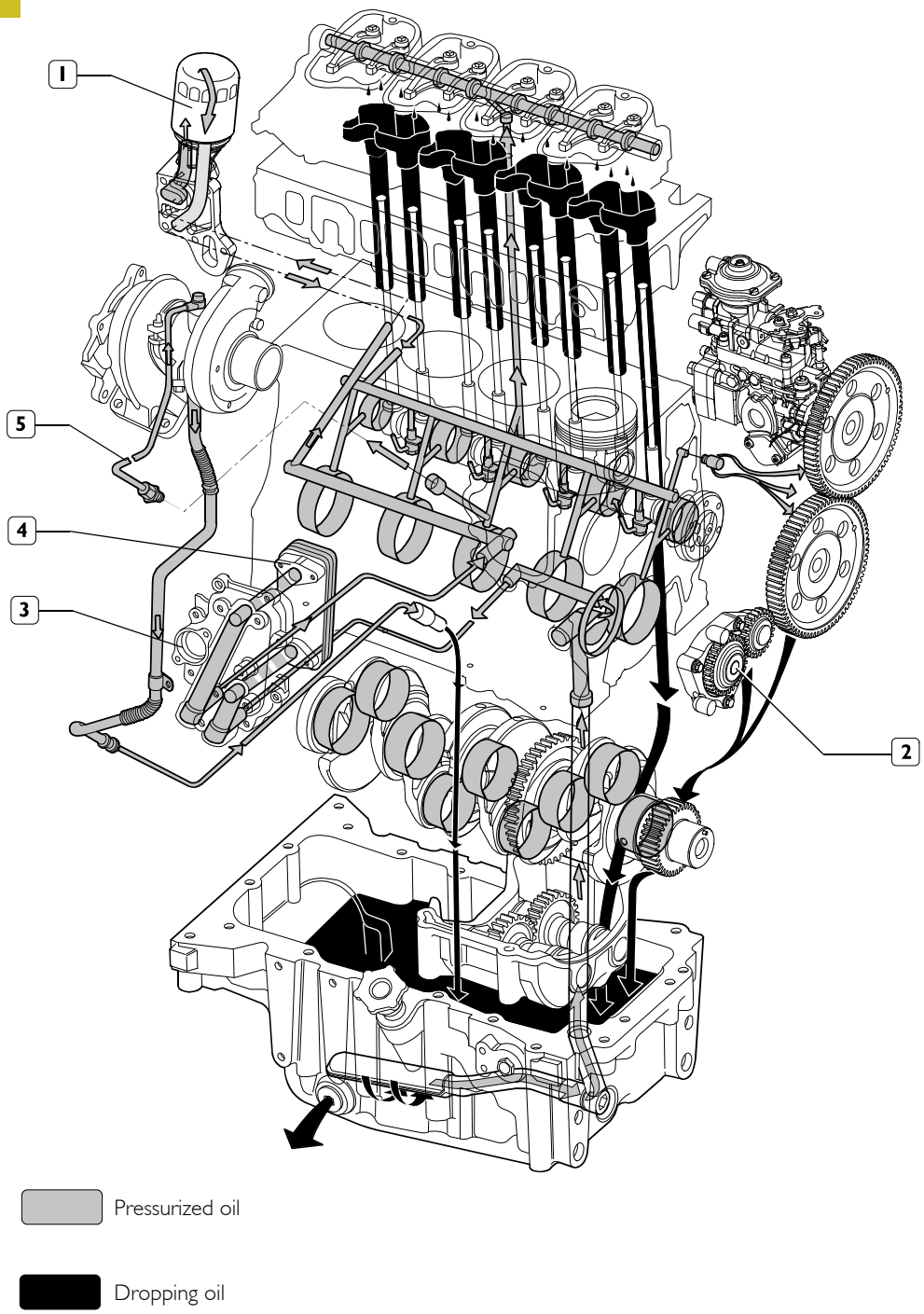
Forced circulation lubrication is controlled by the rotor oil pump housed in the front part of the engine basement and driven by the toothed gear splined on the shank of the engine drive shaft.

From the oil pan, the lubrication oil is distributed to the engine drive shaft, the camshaft and the valve control.

The lubrication system also comprises the heat exchanger, he centrifugal blower for the versions with turbosupercharger and eventually the compressor if the compressed air system is also fitted.

All the above mentioned components vary depending on their use and therefore will be illustrated in the specific section.

Figure 3

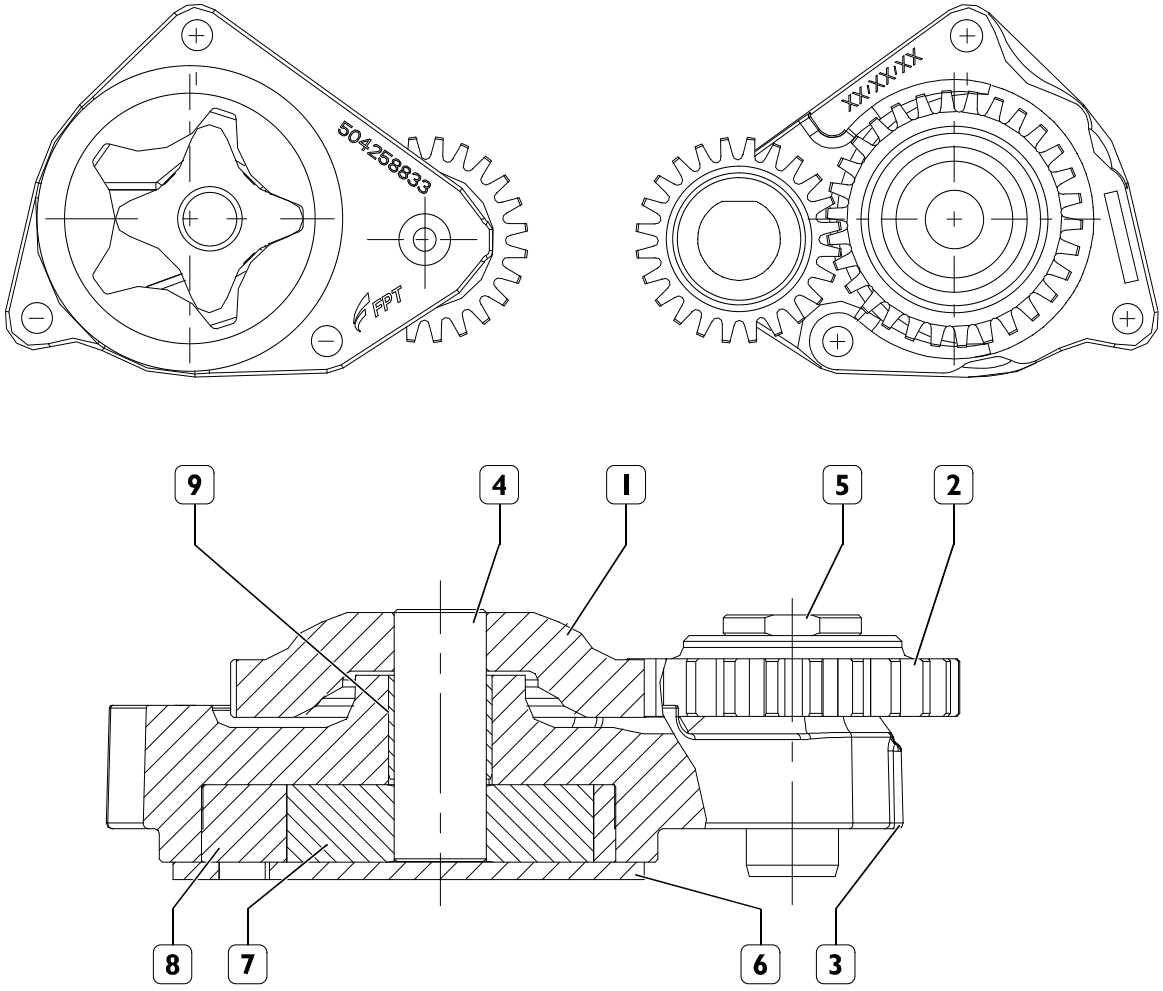


LUBRICATION SYSTEM DIAGRAM

1. Oil filter - 2. Oil pump - 3. Heat exchanging unit - 4. Heat exchanger - 5. Turbosupercharger lubrication feed pipe

Oil pump

Figure 4

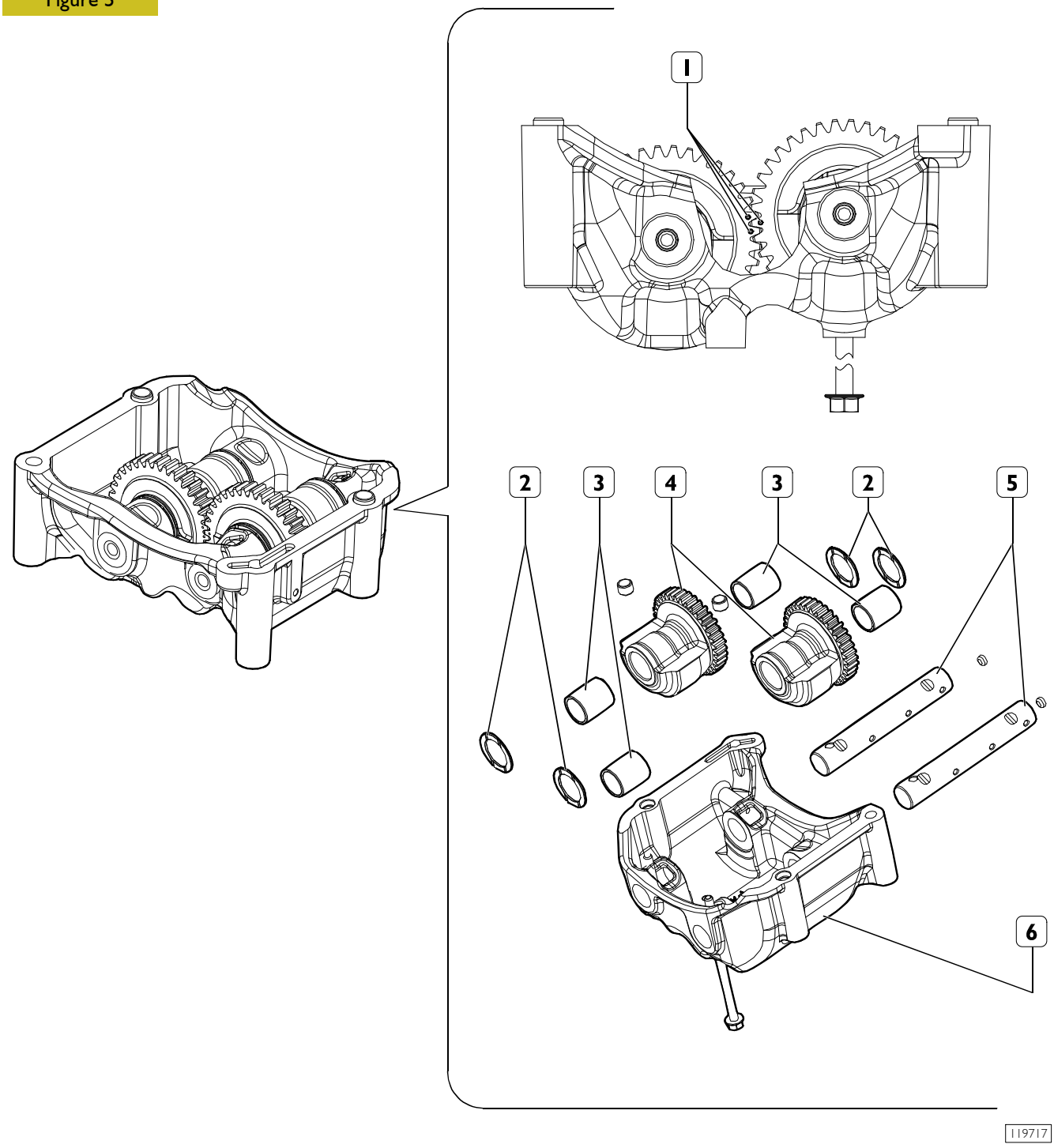


PUMP SPECIFICATIONS	
Rotating speed	750 rpm - 4200 rpm
Feed pressure	2 Bar - 4 Bar
Rated flow	12.2 l/min - 75.9 l/min
Oil type	SAE 15W40
Max. oil temperature	80 °C

1. Main gear - 2. Secondary gear - 3. Pump unit - 4. Drive shaft - 5. Secondary shaft
6. Cover - 7. Internal rotor - 8. External rotor - 9. Bush.

Balancing system with counter-rotating masses

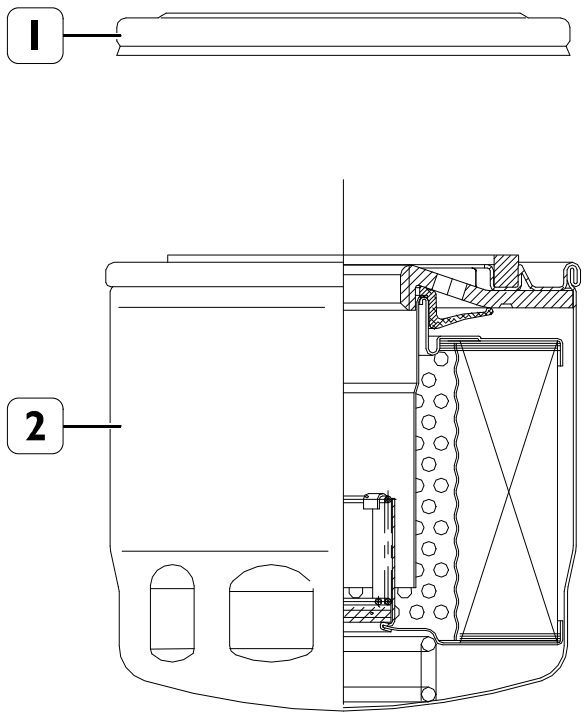
Figure 5



1. References for alignment and timing - 2. Thrust rings - 3. Bushings - 4. Counter-rotating masses - 5. Shafts - 6. Housing

Engine oil filter

Figure 6

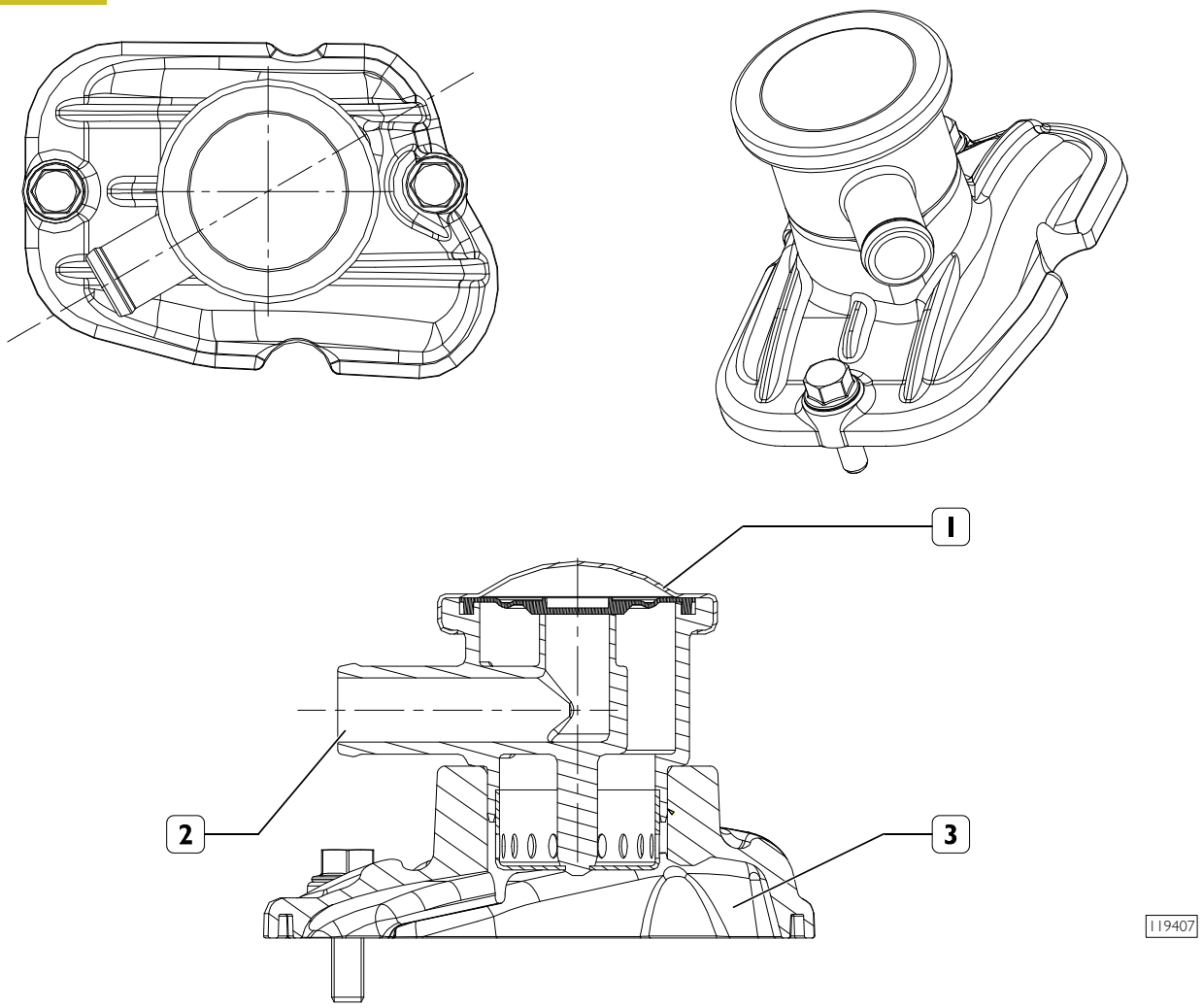


1. Protective cover - 2. Cartridge

Booster pressure:	20 bar (ISO 4548/3)
Dynamic pressure:	0-15 bar (1Hz) > 50,000 cycles (ISO 4548/5)
Operating temperature:	-40 / + 140 °C
Torque wrench setting:	32.5 ± 2.5 Nm
Maximum flow:	50 l/min.
Load loss at the end of life cycle:	2.5 bar
Accumulation:	> 15 gr with 2.5 bar load loss (ISO 16889)

ENGINE OIL VAPOUR RECIRCULATION

Figure 7



1. Valve - 2. Breather - 3. Tappet cover

On the tappet cover (3) there is a valve (1) having the duty to cause condensation of oil vapours making them drop by gravity on the underlying tappet cover (3).

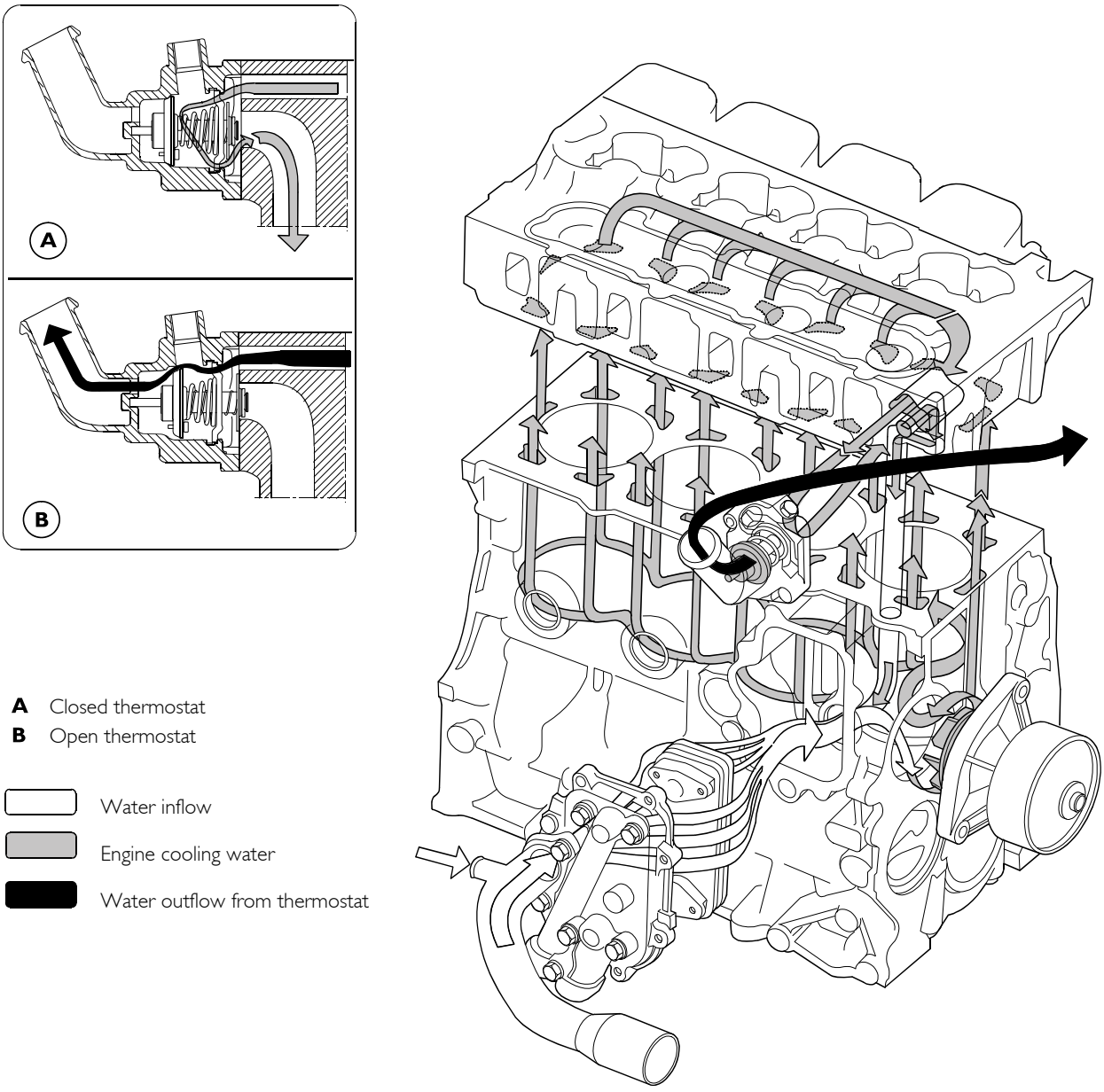
The remaining non condensed vapours will be duly conveyed through the breather (2), for instance by suction (appropriate connection must be provided by the outfitter).

ENGINE COOLING SYSTEM

The closed circuit forced circulation engine cooling system is composed of the following parts:

- ❑ expansion tank: position, form and dimensions may vary depending on the engine fitting;
- ❑ radiator dissipating the heat absorbed by the engine cooling liquid. This component's position and dimensions may vary depending on the outfit;
- ❑ fan increasing the radiator's cooling power. This component may vary depending on the specific engine fitting;
- ❑ heat exchanger cooling the lubricant oil. This component may vary depending on the specific engine fitting;
- ❑ centrifugal water pump positioned in the front part of the engine basement;
- ❑ thermostat controlling cooling liquid circulation.

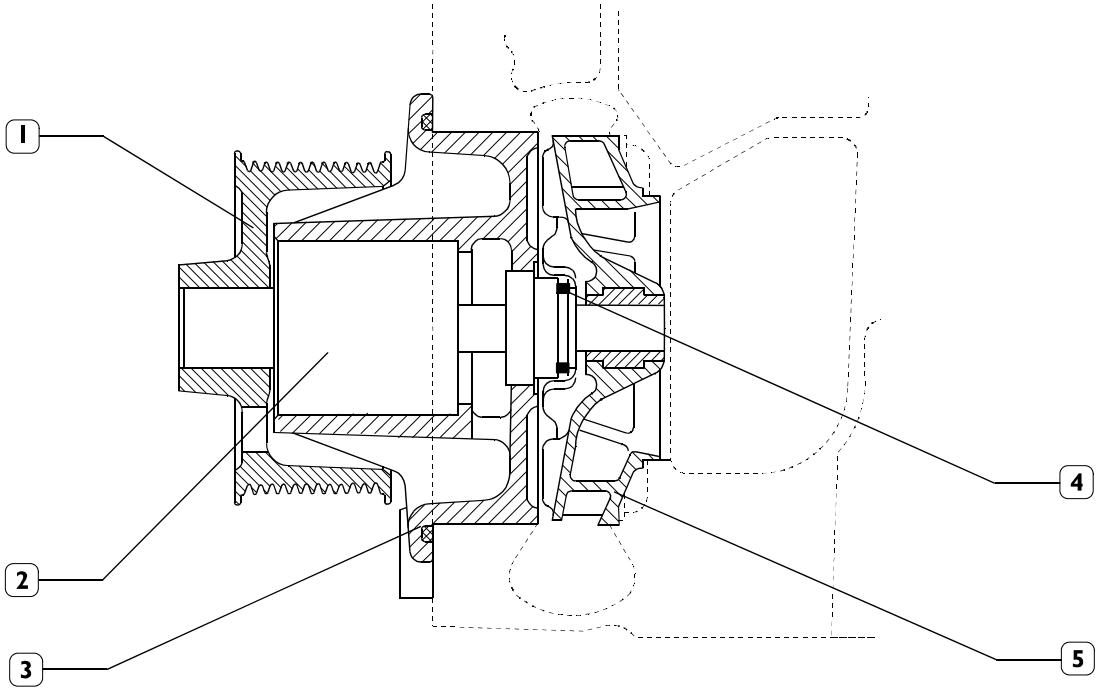
Figure 8



ENGINE COOLING SYSTEM DIAGRAM

WATER PUMP

Figure 9



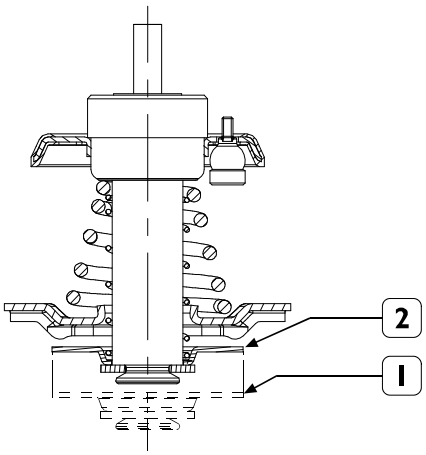
WATER PUMP SECTION

1. Hub - 2. Shaft with bearing - 3. Pump unit - 4. Sheath - 5. Impeller.

The water pump is a centrifugal blade turbine type pump. The pump's bearing (2) is connected to the impeller's shaft as a whole. Water tight between the pump unit (3) and the shaft (2) is ensured by the sheath (4).

THERMOSTAT

Figure 10



THERMOSTAT DIAGRAM

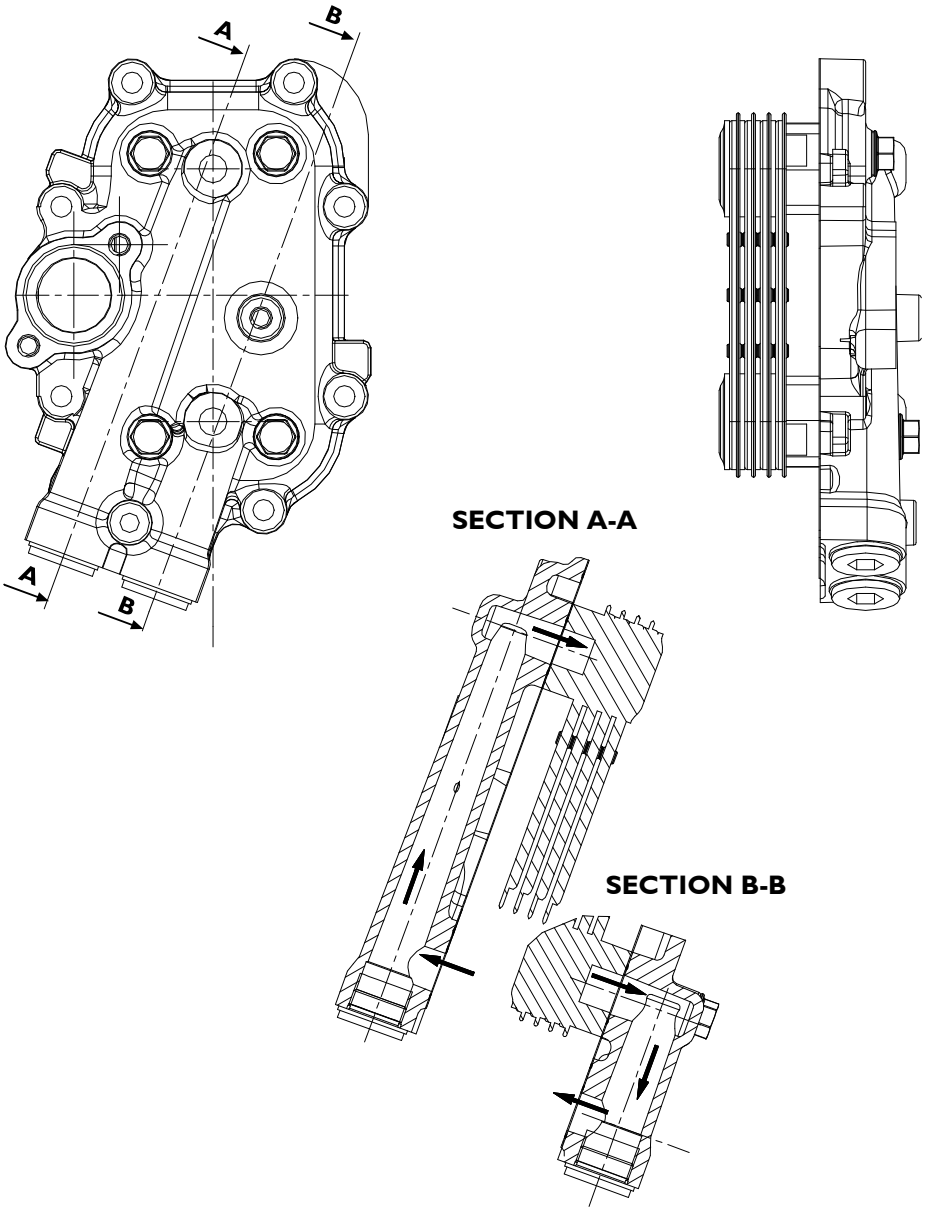
Working system

When the engine is cool, water output from the front part of the cylinder head flows into an inlet containing the thermostat, which cuts out water circulation to the radiator. This way, water circulation will only be possible in the pump-engine circuit, insofar allowing engine heat-up quickly. The thermostat valve starts opening at nearly 80 °C, allowing water circulation into the radiator and also obstructing direct return towards the engine. Check the thermostat efficiency and replace it in case of doubtful functioning.

1. Stroke starts at 79° ± 2 °C
2. 7 mm stroke at 94°±2°C

HEAT EXCHANGER

Figure 11



The heat exchanger within the engine cooling system has the duty to control the engine oil temperature, reducing it by absorbing heat throughout the engine cooling liquid.

EGR EXHAUST GAS RECYCLE SYSTEM

The exhaust gas can be partially recycled to cylinders to reduce maximum temperature values of combustion that produce nitrogen oxides (NOx).

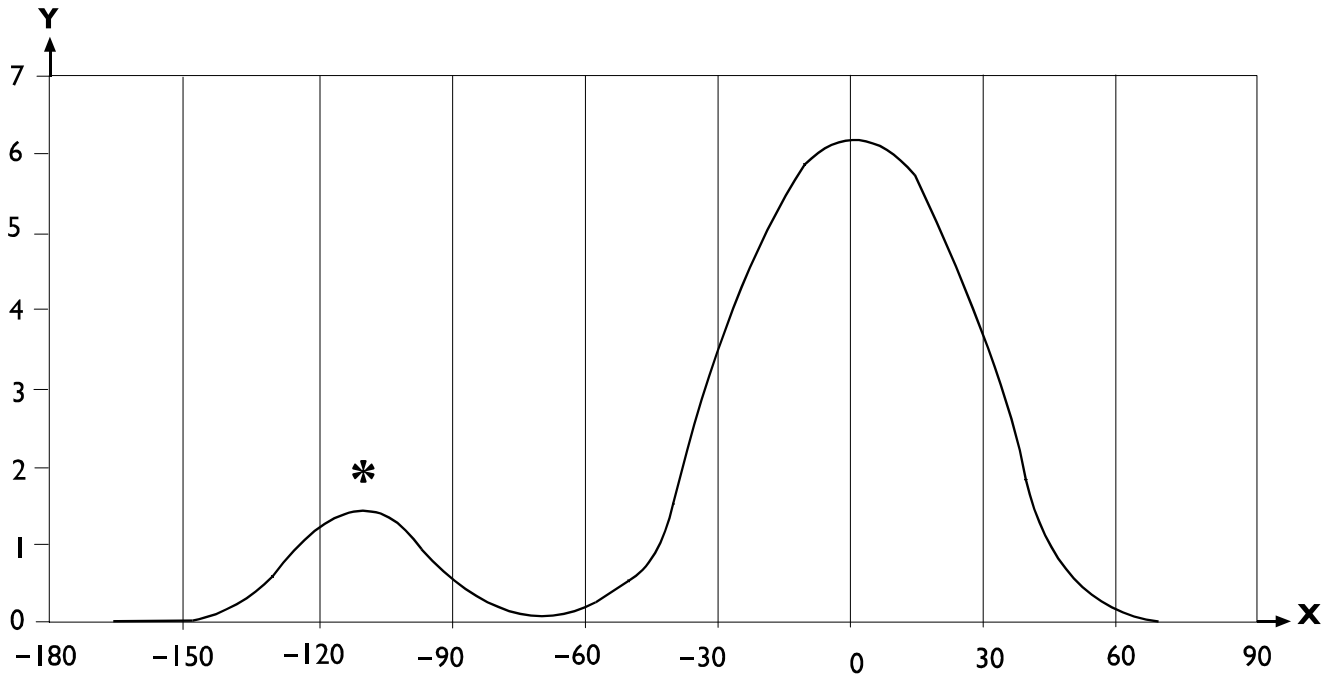
The exhaust gas recycle system (EGR) reduces combustion temperature and therefore is an efficient NOx emission control system.

Internal EGR operating on the intake valves

The specific design of suction cams of the internal EGR system allows part of exhaust gas to be recycled to engine cylinders. This type of EGR, called internal EGR, is not equipped with any electronic control, the system is always active. Its configuration requires no additional parts such as control valves, pipelines or heat exchangers therefore engine profile remains unchanged
Besides main lobe, suction cam has an additional lobe as to configuration without EGR. During concerned cylinder exhaust phase, this lobe allows a shaft advanced opening of intake valve (*). In this way, part of the exhaust gas is trapped in the suction duct and later, during cylinder suction phase, this gas is recycled to cylinder inlet for combustion phase..

Intake cam profile

Figure 12



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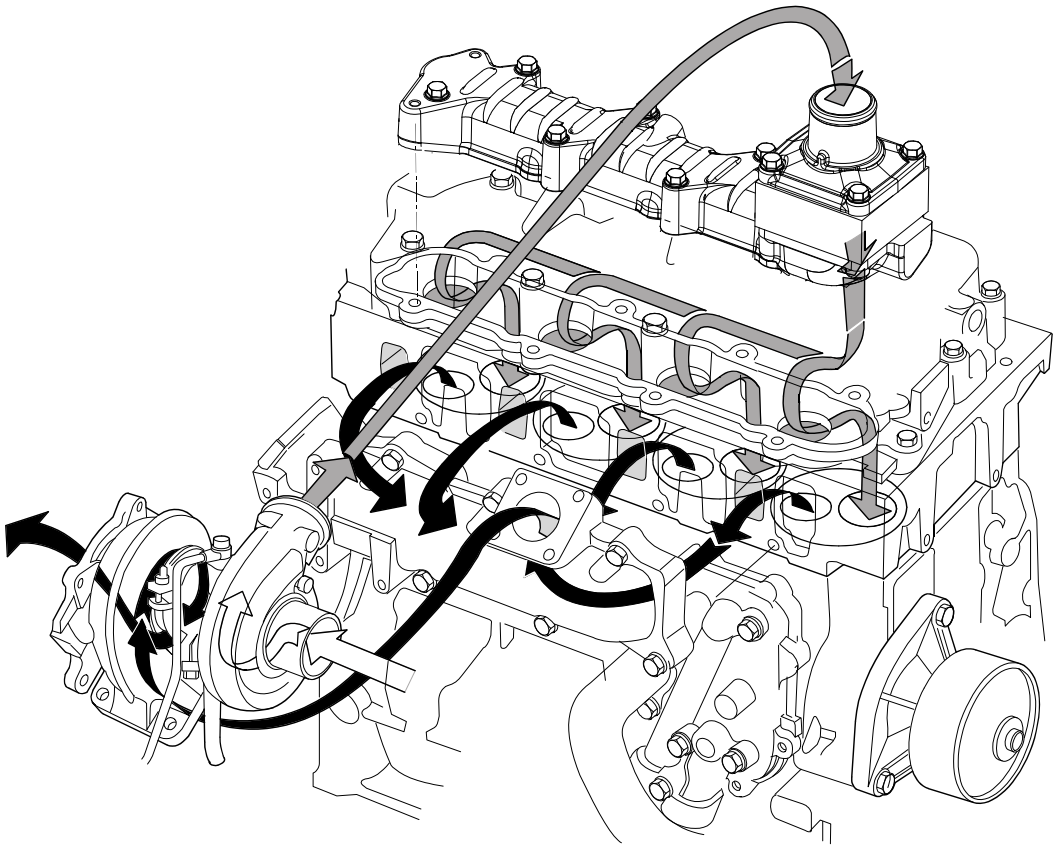
X. Cam rotation angle (degrees) - Y. Cam lift mm

BOOSTING

The boosting system is composed of the following parts:

- ❑ Air filter;
- ❑ Turbosupercharger.
- ❑ An "intercooler" radiator (if fitted)

Figure 13



120019

Sucked air

Heated compressed air

Engine exhaust gas

SECTION 2

Supply

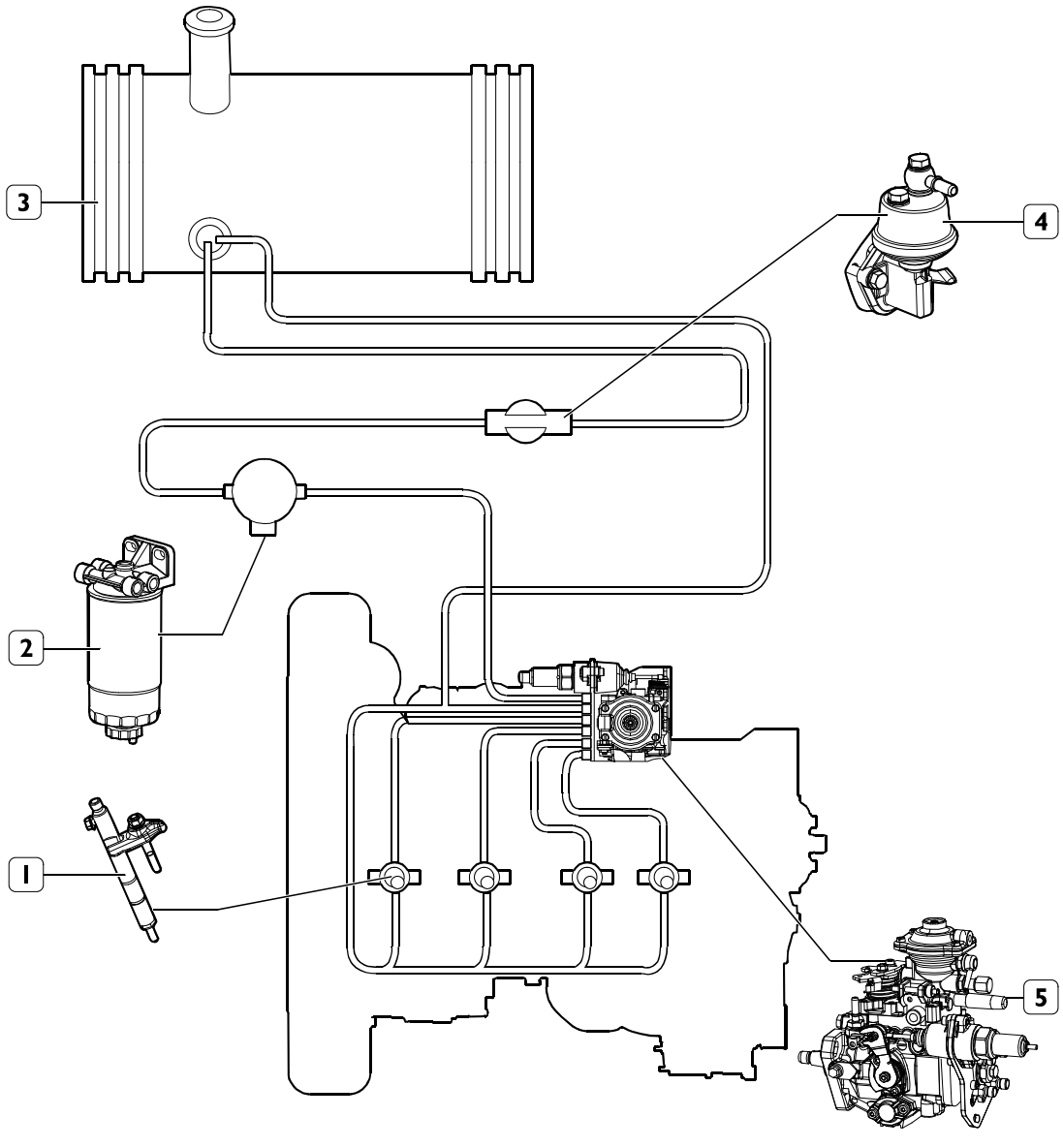
Page

SUPPLY

The engine supply system consists of the following components:

- ❑ Fuel tank (aboard the vehicle)
- ❑ Fuel delivery and return pipes
- ❑ Fuel pre-filter (if fitted, it is placed nearby the engine on the vehicle's chassis)
- ❑ Priming pump, fitted on the engine and driver by the engine camshaft
- ❑ Fuel filter (its position on the engine may vary depending on the outfit and use)
- ❑ Supply rotary pump
- ❑ Injector feed pipe (from the fuel supply pump to the fuel injectors)
- ❑ Injectors

Figure 1

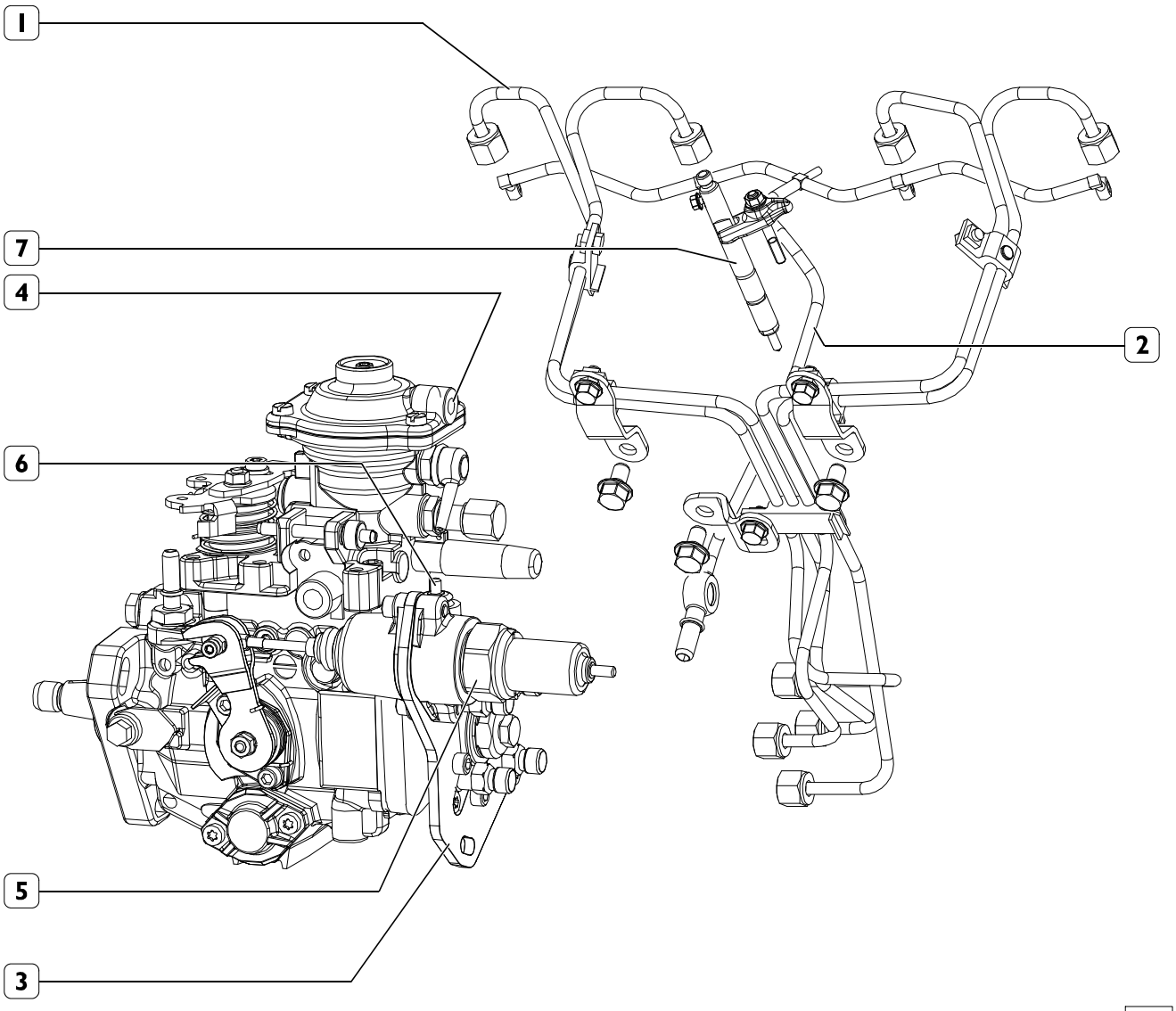


SUPPLY SYSTEM DIAGRAM

1. Injectors - 2. Fuel filter - 3. Tank - 4. Supply rotary pump - 5. Ignition pump.

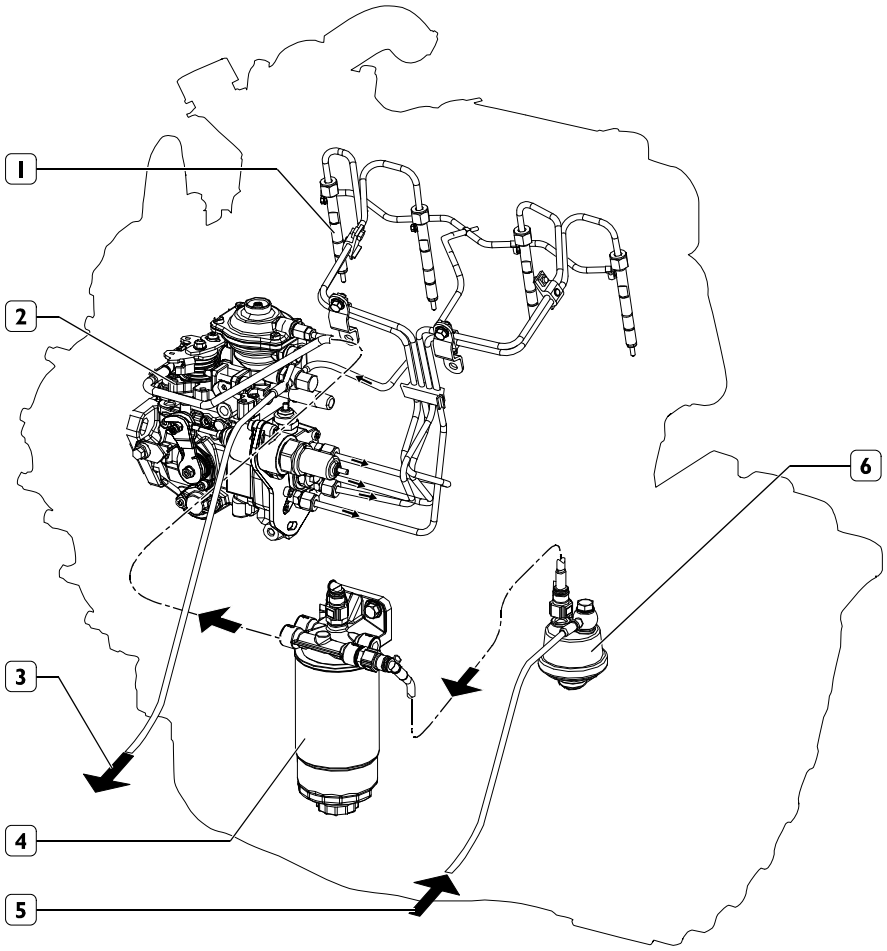
PIPE LAYOUT

Figure 2



1. Injector feed pipe - 2. Fuel exhaust pipe from injectors - 3. Supply rotary pump - 4. Union for pressure gauge pipe within LDA intake manifold - 5. KSB thermal bulb - 6. Solenoid valve - 7. Injector.

Figure 3



119961

Working system description

The fuel (5) is primed from the fuel tank from the priming pump (6). The latter is fitted on the engine basement and is driven by the engine camshaft.

Throughout the filter (4), fuel is conveyed to the transfer pump, which is placed inside the supply rotary pump (2), which is a turbine blade pump type. The supply rotary pump duty is to increase the fuel pressure based on the increase of engine revolutions' number.

Then, the fuel reaches the valve controlling fuel pressure within the supply pump.

The distributor piston further increases such pressure and delivers the fuel to the injectors (1) throughout the delivery pipe fitting.

The fuel leak (3) from the injectors is recovered and sent back to the fuel tank.

SUPPLY PUMP

The rotary type supply pump is driven by a gear which is coupled to the engine camshaft gear.

Identification coding example

V = rotary distributor piston pump

E = pump dimensions

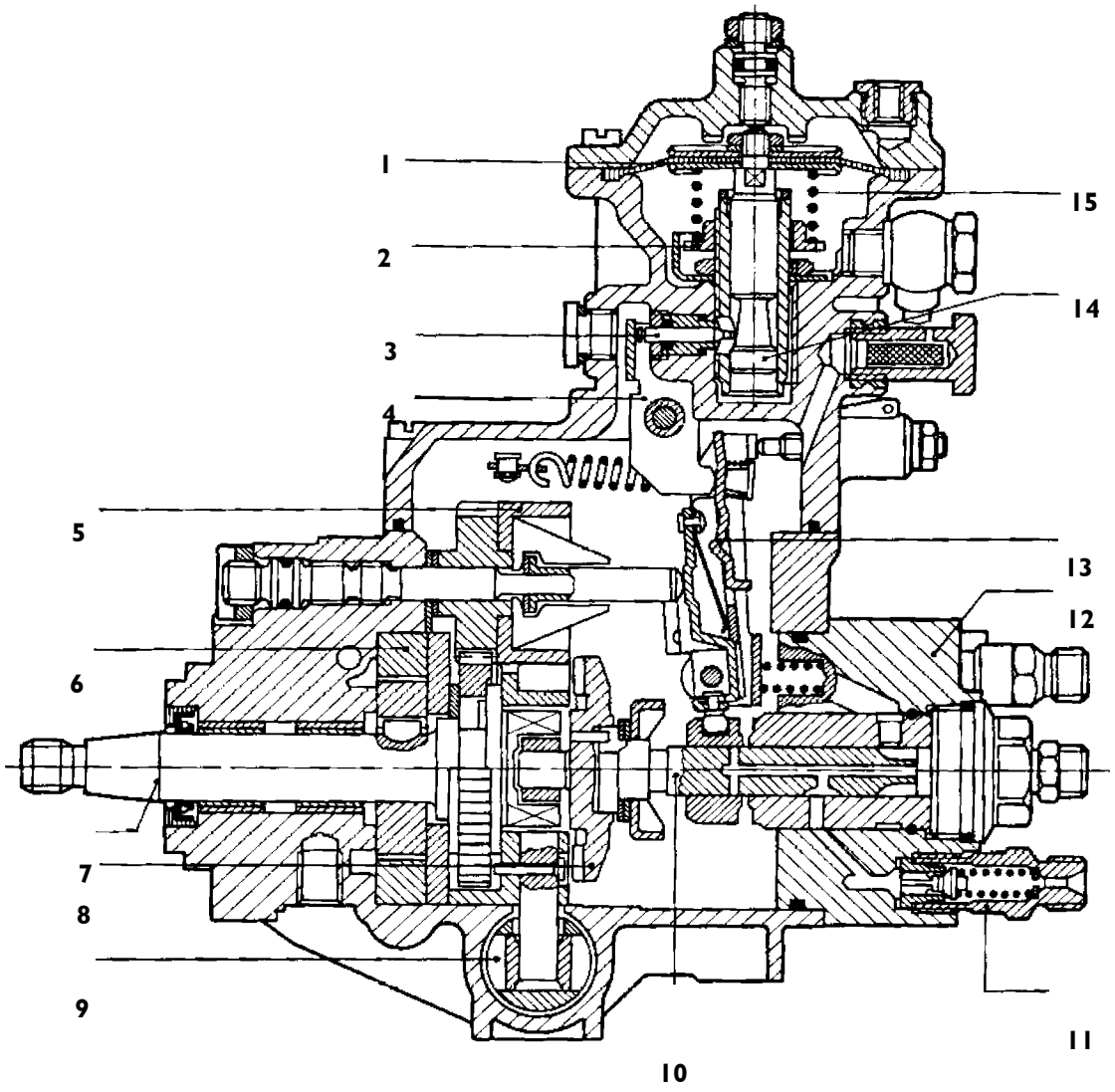
4 = four cylinder engines

12 = distributor piston size in mm

1150 = no. of pump rev./min.

RV = right direction rotation

Figure 4



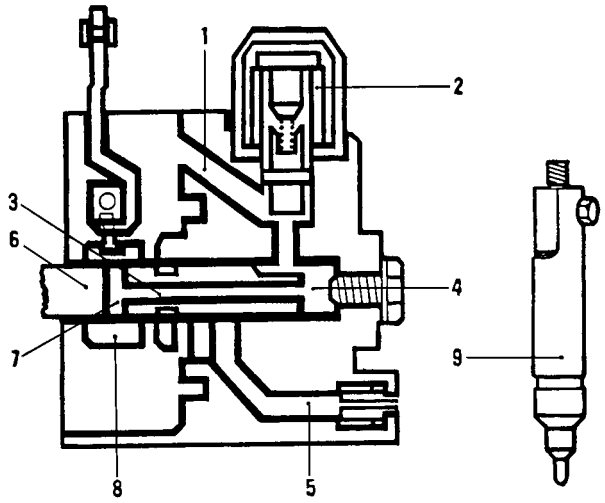
Ignition pump longitudinal section

1. Membrane - 2. Setting ring - 3. Feeler pin - 4. Drive lever - 5. Speed regulator - 6. Transfer pump - 7. Drive shaft - 8. Cam disk - 9. Spark lead adjuster - 10. Distributor piston - 11. Feed pipe fitting - 12. Hydraulic head - 13. Control plate - 14. Adjusting pin - 15. Counter spring.

WORKING SYSTEM DESCRIPTION

Supply phase

Figure 5



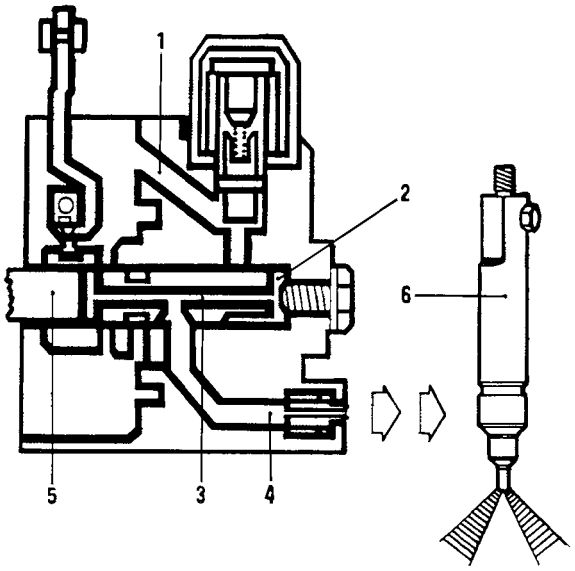
119415

1. Fuel supply pipe - 2. Solenoid valve - 3. Axial groove - 4. Compression chamber - 5. Fuel delivery pipe from pump to injectors - 6. Distributor piston - 7. End of delivery port - 8. Cursor - 9. Injector.

The distributor piston (6) is at B.D.C. and the cursor (8) closes the delivery port (7). The fuel is delivered to the compression chamber (4) through the feed pipe (1) which is kept open by the solenoid valve (2).

Delivery phase

Figure 6



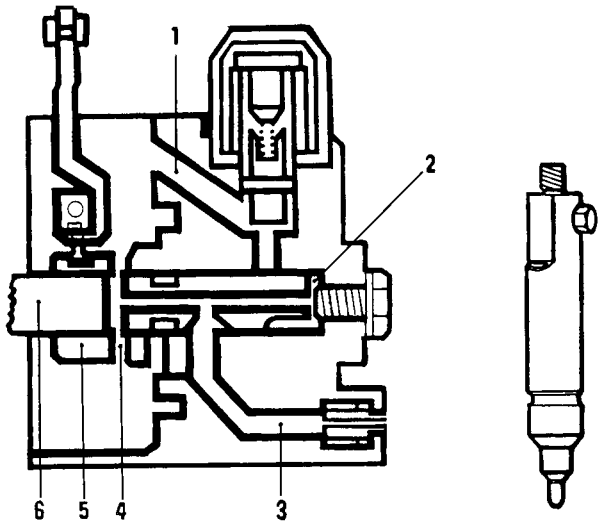
119416

1. Fuel feed pipe - 2. Compression chamber - 3. Distributor piston inner pipe
4. Fuel delivery pipe from pump to injector - 5. Distributor piston - 6. Injector.

The distributor piston (5) driven by the cam disk, goes up to the T.D.C. and simultaneously rotates on its own axle. The combination of the two motions determines the closure of the fuel feed pipe (1) as well as the fuel compression within the chamber (2). The distributor piston inner pipe (5) is connected to the feed pipe (4) thus enabling fuel delivery to the injectors (6).

End of delivery phase

Figure 7



119417

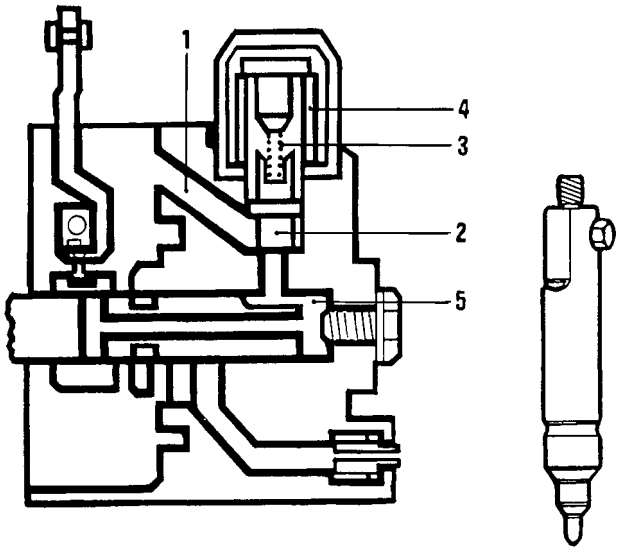
1. Fuel feed pipe - 2. Compression chamber - 3. Fuel delivery pipe - 4. End of delivery pipe - 5. Cursor - 6. Distributor piston.

The distributor piston (6) moving towards the T.D.C. connects the high pressure inner chamber to the pipe (1), thereby establishing pressure balance between the distributor piston inner chamber, the injectors' delivery pipe and the pump interior.

Since such pressure is lower than the one required to start the injector, end of delivery will be determined.

Engine stop

Figure 8



119418

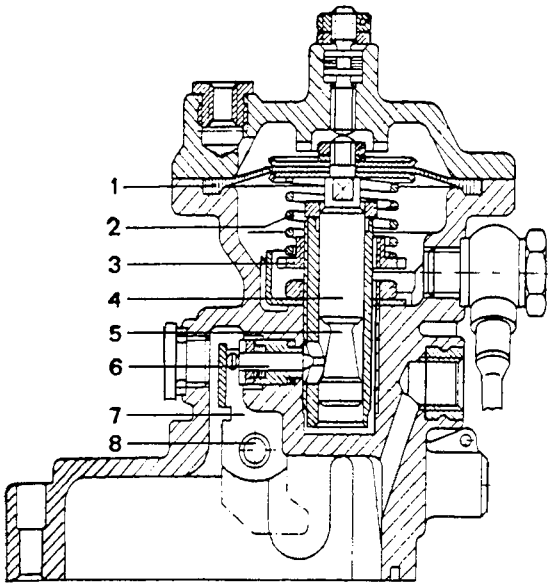
1. Fuel feed pipe - 2. Mobile cap - 3. Spring - 4. Solenoid valve - 5. Compression chamber.

Engine stop is provoked cutting out the starter contact.

The electric flux to the solenoid valve (4) is cut out. The solenoid valve, throughout its spring (3), drives the mobile cap to the end of stroke (2) and the mobile cap obstructs the fuel feed pipe (1).

L.D.A. Load Delivery Adjustment device

Figure 9



Working system

The duty of the L.D.A. device is to adjust the fuel delivery depending on the air pressure within the intake manifold.

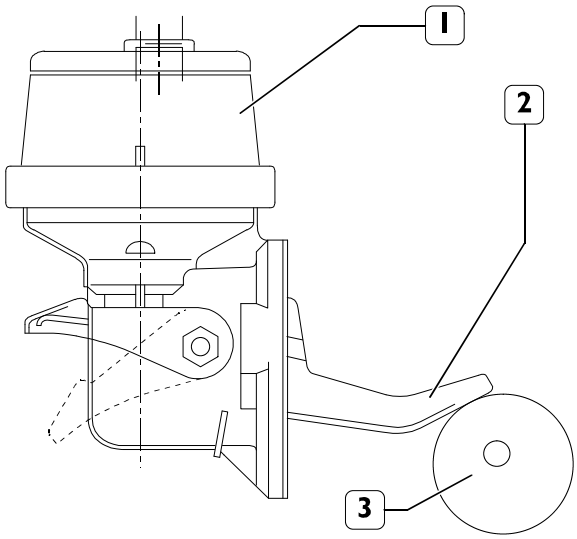
Air pressure acts on the membrane (1), which is tied up to the setting pin (4). In the lower part of the setting pin (4) there is a conical housing (5) in which the feeling pin runs (6).

The setting pin (4) axial motion drives the feeling pin (6) shift and the latter acts on the stop lever (7). The stop lever rotates on its own axle (8) and acts on the control plate in order to adjust the fuel delivery depending on the air quantity within the cylinders.

PRIMING PUMP

The priming pump duty is to prime the fuel from the tank and convey it to the fuel supply pump. It is fitted on the engine basement and driven by the engine camshaft.

Figure 10



88209

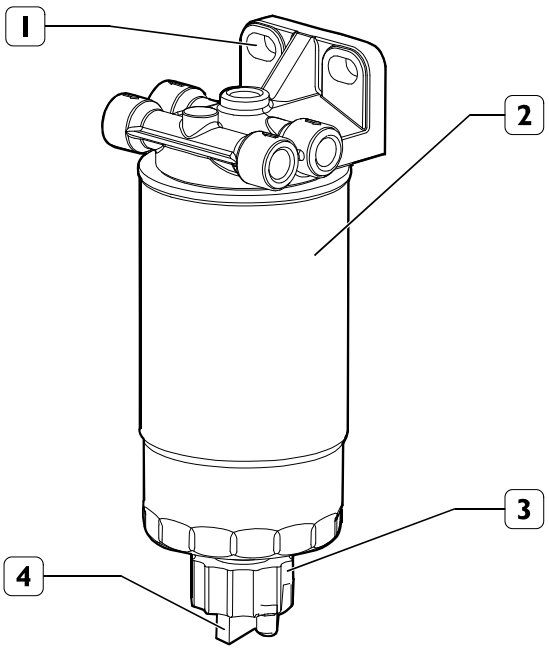
1. Pump - 2. Control lever - 3. Camshaft. - 4. Water sensor

FUEL FILTER

The filter is placed nearby the supply pump and the priming pump. Its duty is to retain impurities and separate water from the fuel in which it is contained.

At the bottom of the filtering cartridge there may be a water drainage device (3).

Figure 11

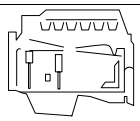
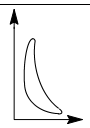
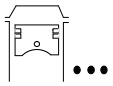
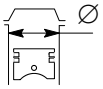
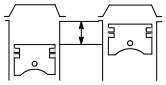
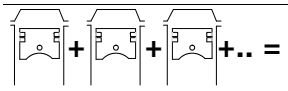
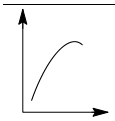


1. Fuel filter support - 2. Cartridge filter - 3. Water drainage device - 4. Water sensor

SECTION 3

Industrial application

MAIN SPECIFICATIONS

			F5AE9454H*A003	F5AE9484B*A008	F5AE9484G*A011
	Type				
	Cycle		Diesel 4 strokes		
	Feeding		Turbocharged	Turbocharged - intercooler	Turbocharged - intercooler
	Injection		Direct		
	N. of cylinders		4 on-line		
	Diameter	mm	99		
	Stroke	mm	104		
	Total displacement	cm^3	3200		
	Compression ratio		17 ± 0.5 : 1		
	Max. power	kW (HP)	53 (72)	57 (77)	65 (88)
		rpm	2300	2300	2300
	Max. power	Nm (kgm)	277 (28)	330 (24)	350 (36)
		rpm	1250	1250	1300
	Loadless engine idling	rpm	850 ± 50	850 ± 50	850 ± 50
	Loadless engine peak	rpm	2750 ± 50	2550 ± 50	2550 ± 50
	COOLING Water pump control **Thermostat** - start of opening	°C	Liquid Through belt 79 ± 2		
 SAE 10W30 SAE 15W40 SAE Z0W40 ACEA E7, APIC13	**OIL SUPPLY** Total quantity 1st filling MIN level (engine off) MAX level (engine off)	l (kg) l (kg) l (kg)	– – – – – –		

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

ENGINE DISASSEMBLY ON BENCH

NOTE Engine disassembly operations to remove the engine from the vehicle are described in the specific section. Engine disassembly operations, as well as engine overhaul, must be executed by qualified engineers only, duly provided with the specific tools required.

NOTE Depending on the appliance, some units may have different position on the engine.

NOTE Before fitting the engine on the rotary stand 99322205, disassemble the parts which may interfere with the bracket 99361043 assembly. Depending on the appliance, it may be necessary to remove the starter and the oil filter.

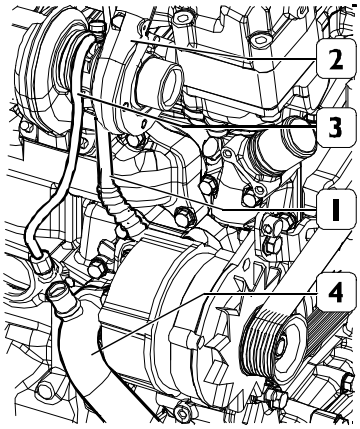
❑ Drain the engine oil from the oil pan collecting it in a suitable container.

Warning! Avoid skin contact with the engine oil: in case of contact wash your skin with running water.

The engine oil is highly polluting: waste disposal must be executed complying with the laws and regulations in force.

❑ Remove the electric wiring from the injection pump.

Figure 1



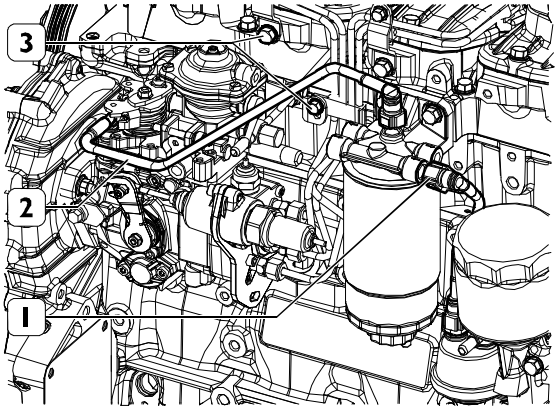
148417

❑ Remove oil delivery pipe connected to the turbocharger (3) and t the oil return pipe (1).

❑ Remove the turbocharger unit (2).

❑ Remove the water hose (4).

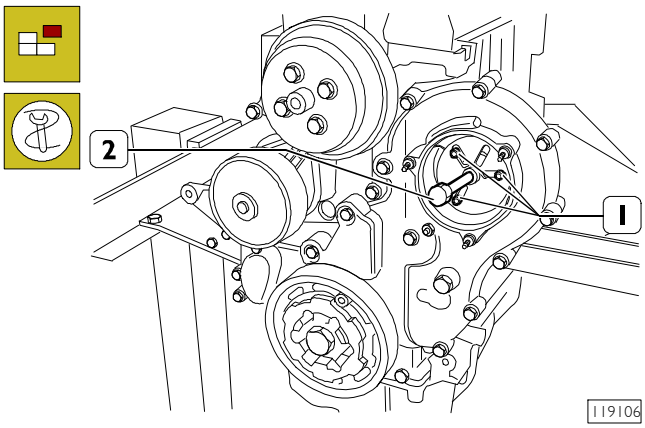
Figure 2



119720

❑ Remove the L.D.A. pipe. Remove the fast clutch fuel pipes from the priming pump to the filter (1) and from the filter to the ignition pump (2), then fit the specially provided caps to the pipes, the pumps and the filter. Unscrew the screws (3), fastening the fuel ignition pipes and remove them.

Figure 3

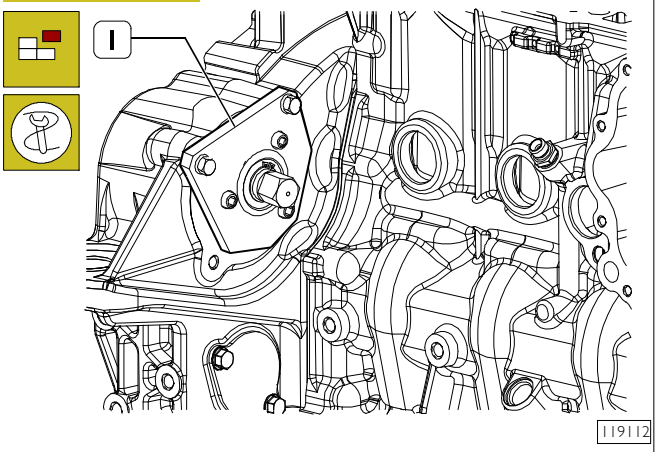


❑ Unscrew the pump fastening screws on the rear part of the gear cover. To disassemble the pump, fit tool 99340025 to the pump wheel and fix it with the three screws (1).
Using the specially provided wrench, slowly tighten the screw (2) holding the rear part of the pump removing the pump completely.

NOTE Before pump disassembly, use the speciallyprovided tool (9936061 2), lock the engine into theposition corresponding to T.D.C. for cylinder 1. Now block with the specific system the pump shaft; this way the pump should be timed, so that when refitting (if no maintenance intervention is required on it) no adjustment is necessary.

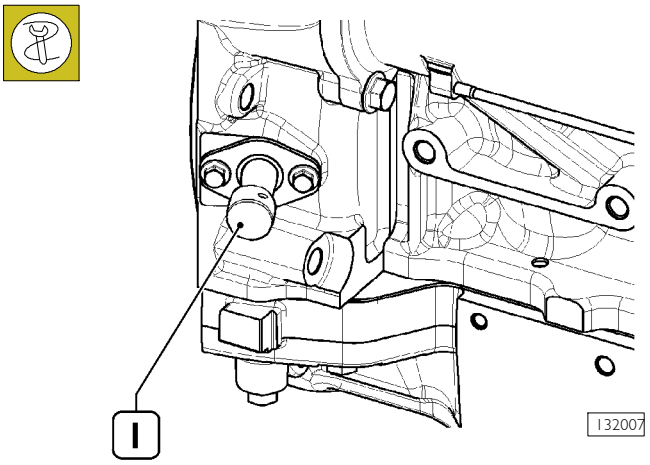
Cylinder 1 T.D.C. search

Figure 4



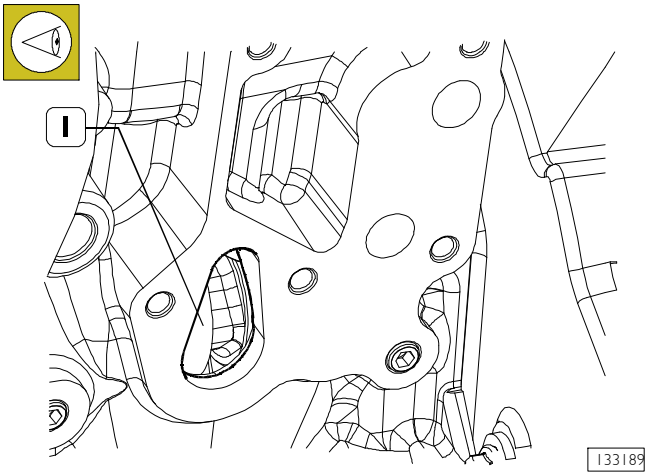
❑ Fit tool (1) 99360339 to flywheel housing to rotate the flywheel (must be used with a suitable wrench).

Figure 5



❑ Loosen the screws of the plate in which tool 99360612 (1) is to be fitted.

Figure 6



Position the engine drive shaft at T.D.C. of cylinder 1 rotating the flywheel until achieving the following conditions:

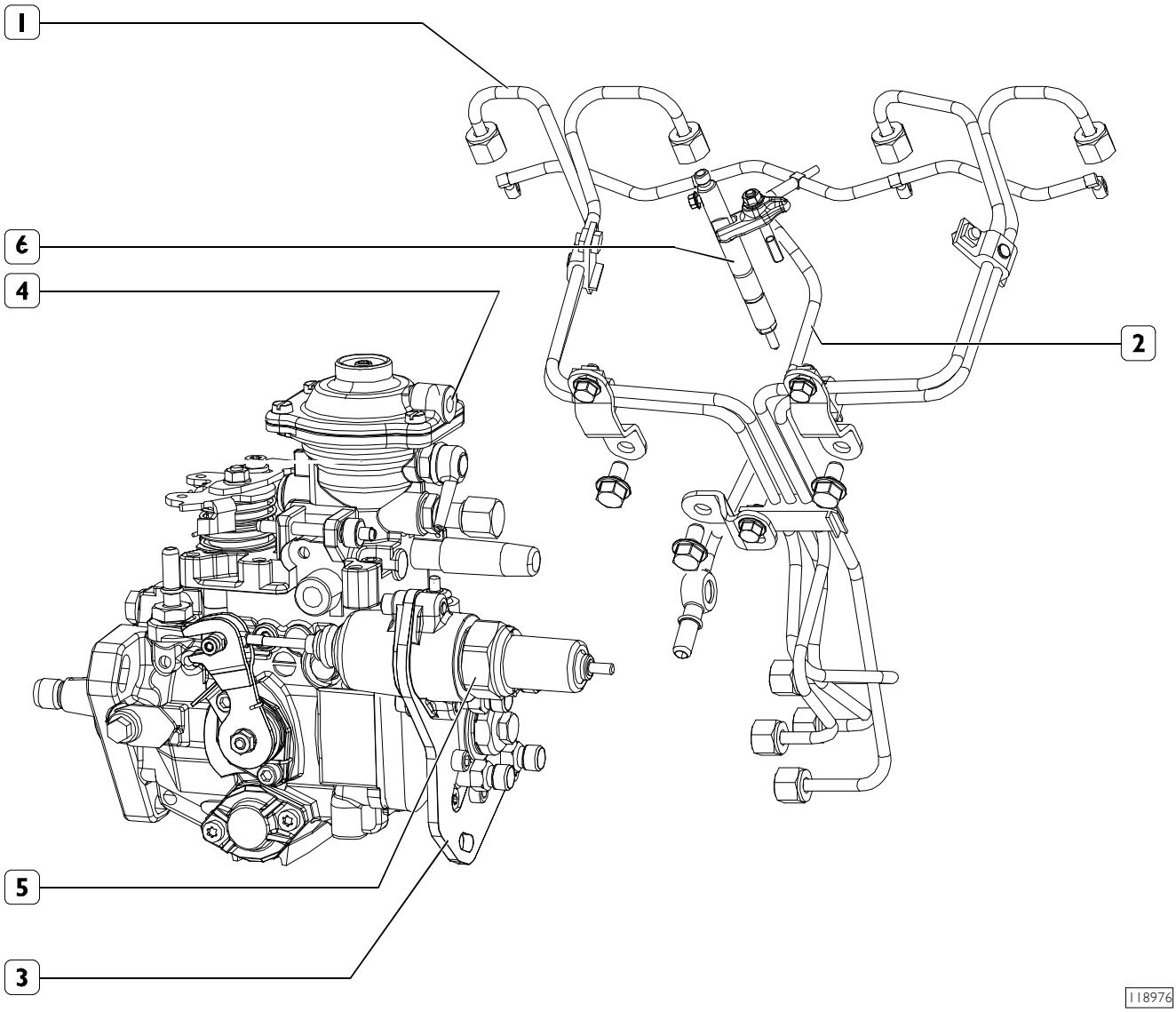
❑ the notch (1) is visible from the inspection hole;

❑ tool 99360612 should be fitted through the carter into the port on the flywheel.

Remove tools and tighten the previously loosened plate screws.

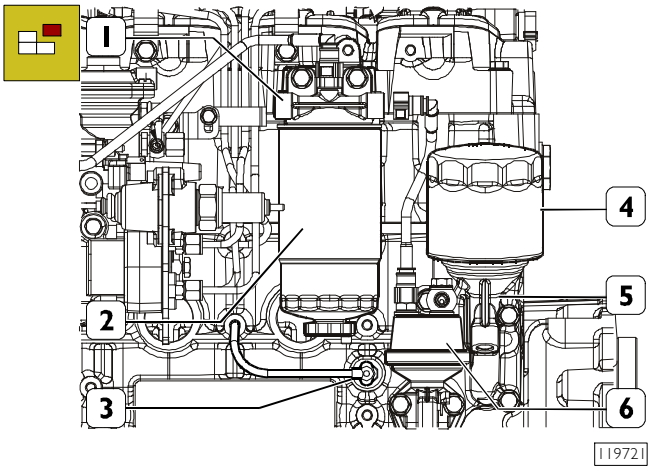
BOSCH VE 4/12F Pump

Figure 7



1. Fuel delivery pipes - 2. Fuel recovery pipes - 3. Mechanical pump - 4. LDA - 5. Wax KSB - 6. Injectors.

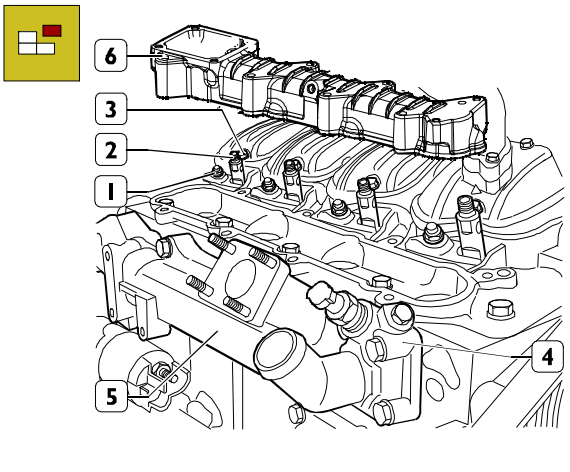
Figure 8



- ❑ Place a container under the diesel fuel filter and unscrew the condense drainage faucet under said filter; completely drain the diesel fuel container therein.
- ❑ Disassemble the diesel fuel filter (1), the filter support (2), the priming pump (3), the oil filter (4), the oil filter support (5), and the KSB water sensor (6).

Warning! The oil filter contains a certain quantity of engine oil.
Collect the engine oil and dispose it complying with the applicable laws and regulations in force.

Figure 9

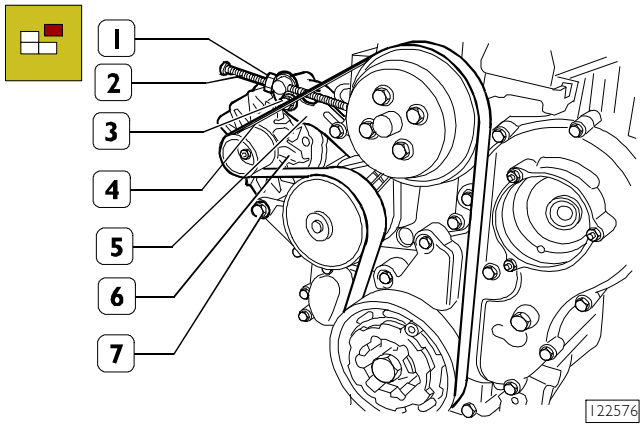


- ❑ Unscrew the injector support fastening screws (1), disassemble the injector supports and remove the injectors (2).
- ❑ Loosen the screws (3) and remove the tappet covers.
- ❑ Remove the intake manifold (6).
- ❑ Remove the thermostat unit (4) and the exhaust manifold (5).

NOTE On the central cover there is a lubrication oil vapour blow-by valve.

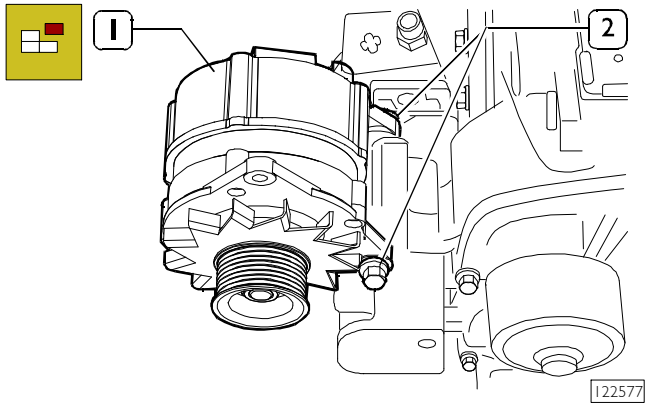
All the gaskets must always be replaced in phase of assembly.

Figure 10



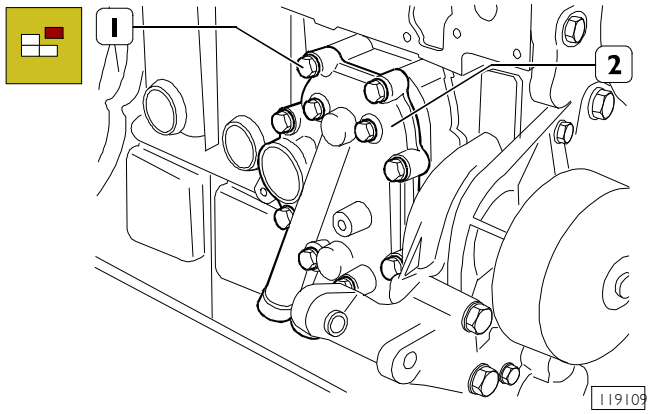
- ❑ Loosen the screw (3) and the relevant screw nut on the belt tensioning bracket (1).
- ❑ Loosen the screws (7) in order to withdraw the belt (4).
- ❑ Remove the belt tensioning bracket (5).
- ❑ Disassemble the pulleys and the guide rollers.

Figure 11



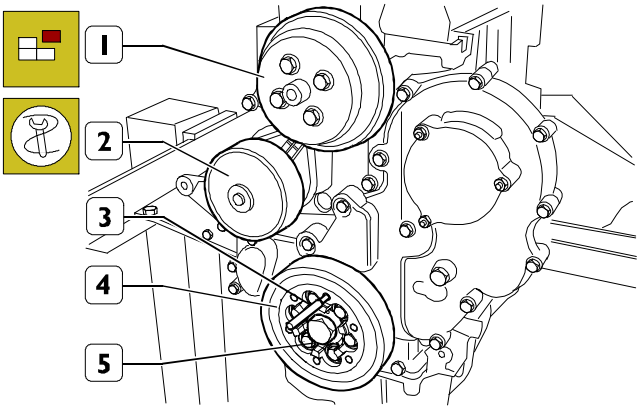
- ❑ Duly hold the alternator (1) and detach it from its support loosening the screw (2): recover nut and washer.

Figure 12



- ❑ Place a container under the heat exchanger (2) to collect the cooling liquid contained therein.
- ❑ Loosen the screws (1) and disassemble the heat exchanger unit (2).

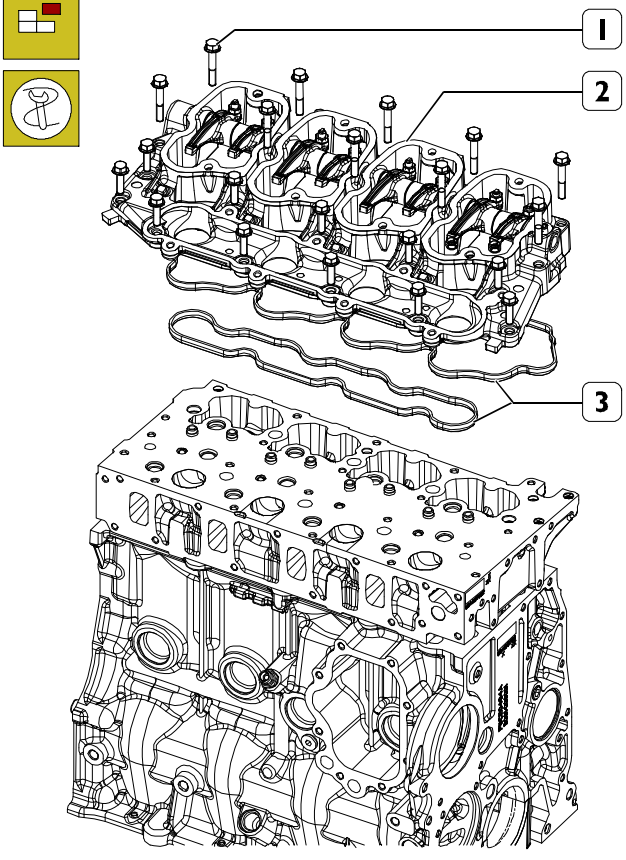
Figure 13



137364

- ❑ Remove the electromagnetic joint support (1) and the water pump (2).
- ❑ Loosen the screw (5) and remove the pulley (4), using a pin (3).

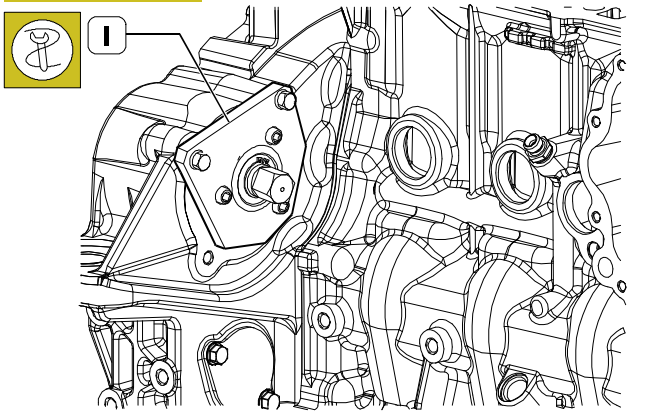
Figure 14



119111

- ❑ Loosen the fastening screws (1), remove the overhead holding the whole rocker arm unit (2) and recover the two gaskets (3).

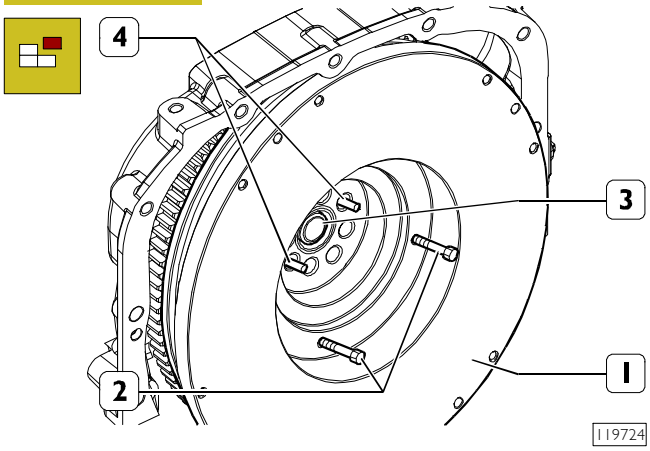
Figure 15



119112

- ❑ Fit tool (1) 99360339 to the flywheel box and, using a wrench, lock the flywheel rotation.
- ❑ Loosen the screws fastening the flywheel to the engine drive shaft.

Figure 16 (Demonstration)

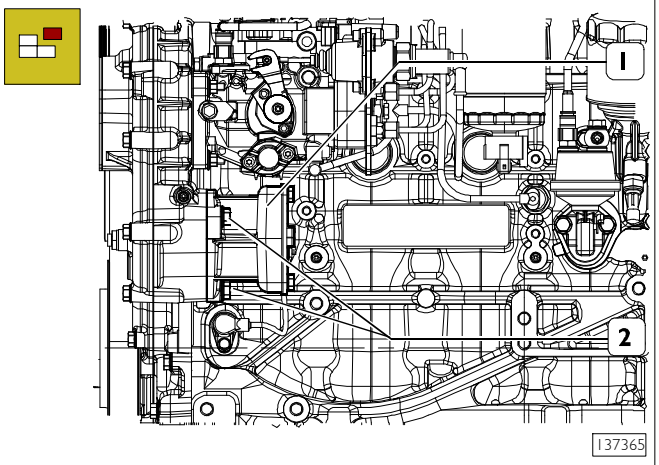


119724

- ❑ Screw two medium length screws in the ports (2), in order to secure the flywheel with a sling.
- ❑ By means of two guide pins (4) previously screwed in the engine drive shaft ports (3), guide the flywheel withdrawal throughout a hoist.
- ❑ Withdraw the flywheel casing grommet.
- ❑ Withdraw the grommet of the timing gearcase.

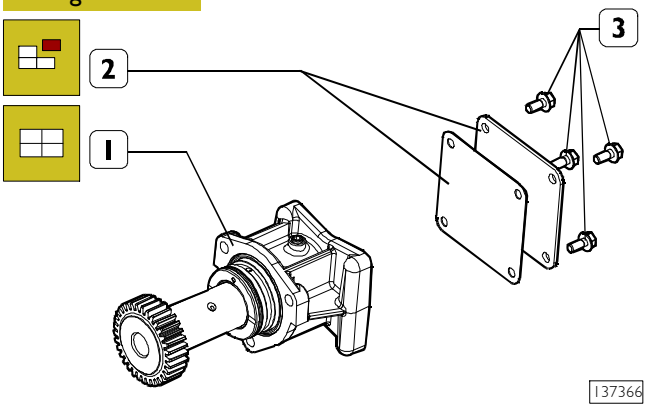
Power take-off

Figure 17



❑ Remove the power take-off (1) by undoing the screws (2).

Figure 18

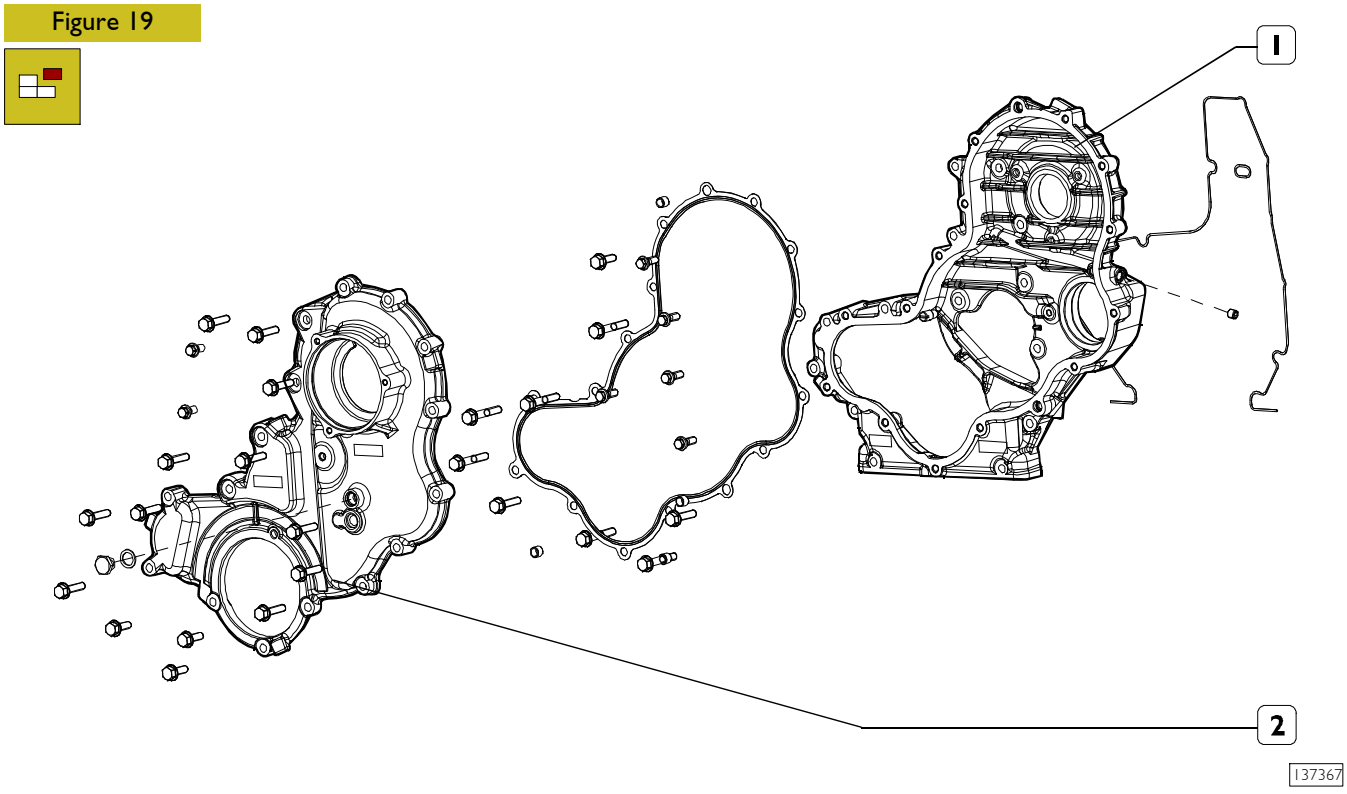


❑ If it is necessary to work on the PTO (1), proceed as shown in the figure to access the various components.

❑ Refit the covers (2), tightening the screws (3) to the prescribed torque.

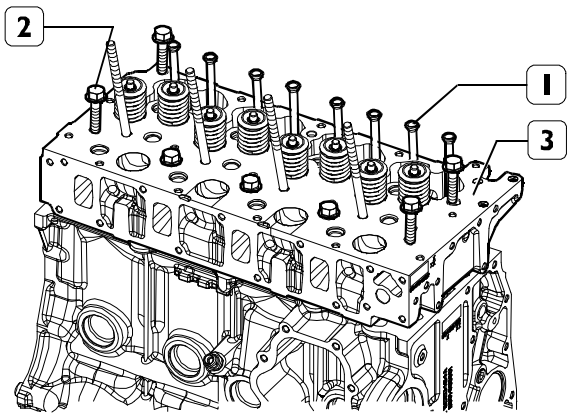
Timing gearcase

Figure 19



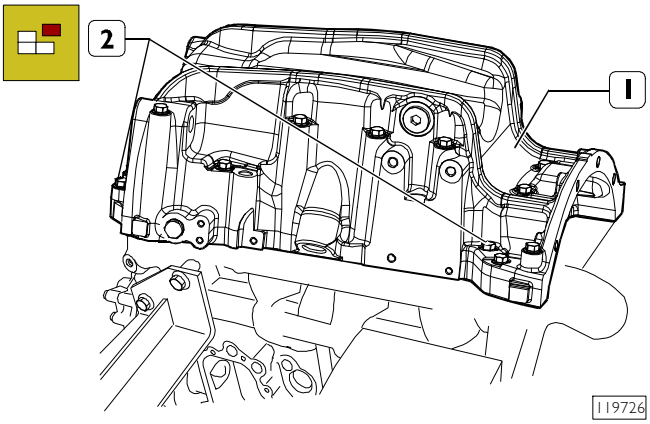
❑ Remove the rear part (1) of the timing system gear cover (2).

Figure 20



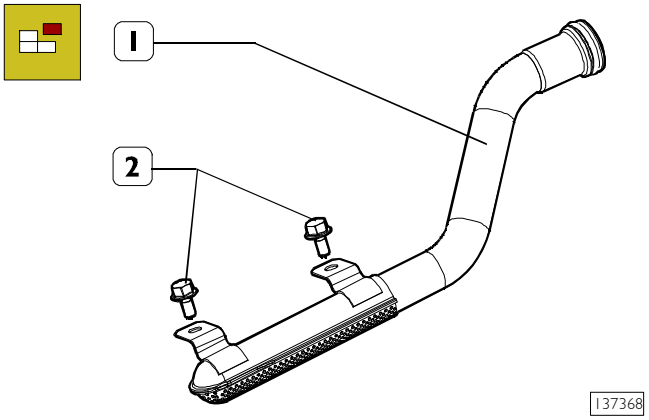
- ❑ Remove the tappet rods (1).
- ❑ Disassemble the cylinder head;
  loosen the cylinder head (3) fastening screws (2);
  hook the brackets with metal ropes and, throughout a hoister, detach the cylinder head with valves from the basement.
- ❑ Remove the cylinder head gasket.

Figure 21



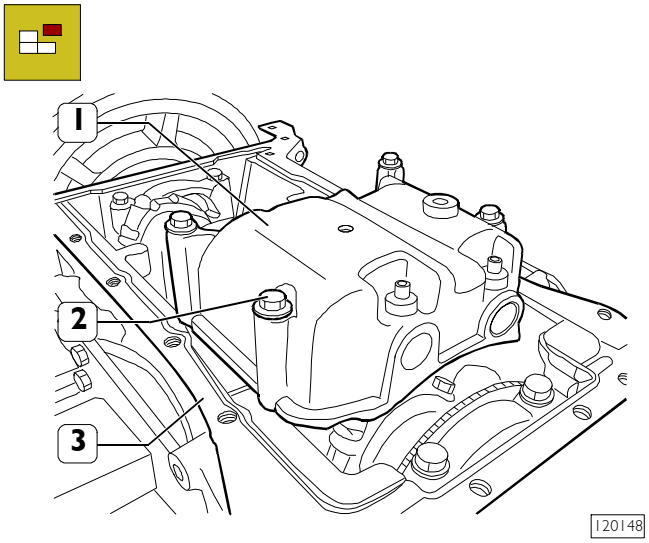
- ❑ Turn the engine upside down.
- ❑ Remove the screws (2) and detach the oil sump (1).

Figure 22



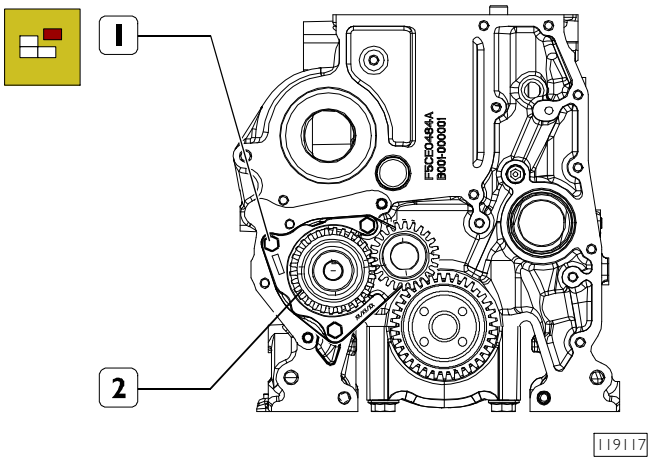
- ❑ Undo the screws (2).
- ❑ Remove the suction strainer (1) from the oil sump.

Figure 23



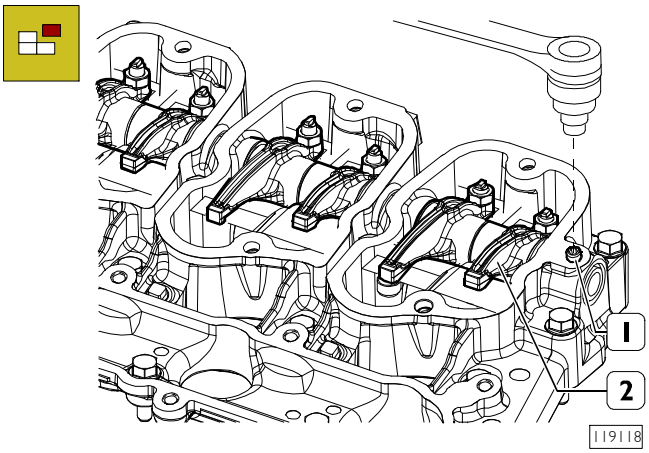
- ❑ Remove the gasket (3).
- ❑ Undo the screws (2).
- ❑ Remove the additional masses (1).

Figure 24



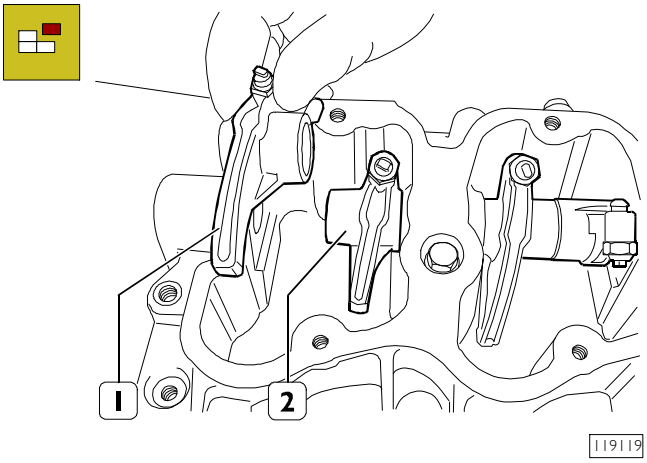
❑ Loosen the screws (1) and remove the oil pump (2).

Figure 25



❑ Loosen the rocker arm fastening screw (1) from the disassembled rocker arm holding unit and then remove the rocker arm.

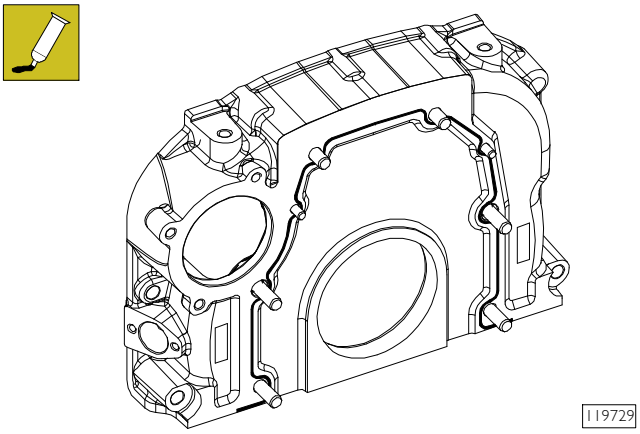
Figure 26



❑ Withdraw the rocker arm (1) from one side recovering the equalizers (2) from the other.

Rear side component assembly

Figure 27



SCHEME FOR THE APPLIANCE OF LOCTITE 5999 SEALER ON THE TIMING GEARCASE

❑ Accurately clean the timing gearcase and the engine basement.

It is absolutely necessary to clean the surface to be sealed in order to obtain perfect tightness.

Apply LOCTITE 5999 sealer on the gearcase in order to form a sealing bead of a few mm.

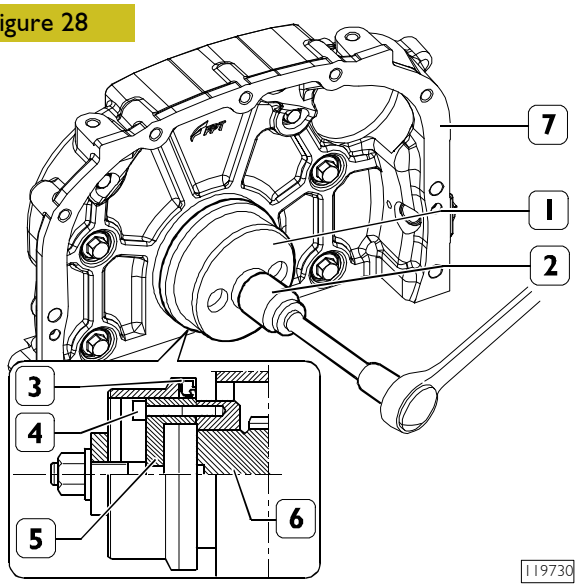
The sealing bead must be homogeneous (no lumps), free of air bubbles, thinner areas and gaps.

Any imperfection must be corrected as soon as possible.

Avoid the excess of sealer: too much sealing material would leak and pour out on both sides of the joint parts and, as a consequence, obstruct the passage of the lubricant.

After having applied the sealer, the parts must be joined within 10 minutes.

Figure 28

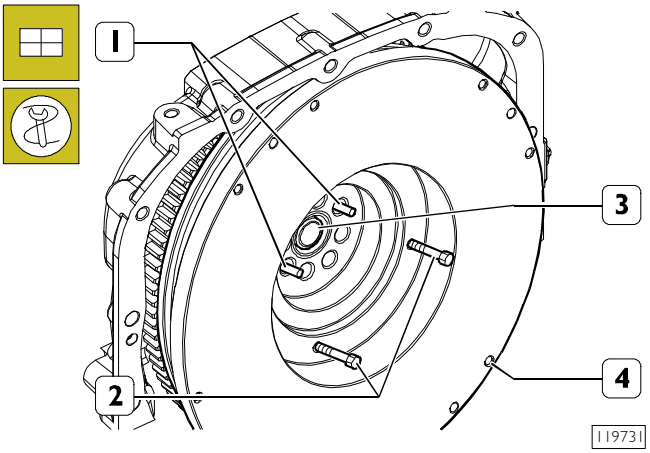


❑ Fit the specific tool 99346259 (5) to the rear shank (6) of the engine drive shaft, fix it with the screws (4) and spline the new grommet (3) thereon.

❑ Position part (1) on part (5), tighten the screw nut (2) until the grommet has been fitted (3) into the flywheel casing (7).

Flywheel assembly

Figure 29 (Demonstration)



❑ Screw two hooks or eyebolts on the flywheel (4) through the ports (2).

❑ By means of a hoister, draw the flywheel up to its housing inside the casing.

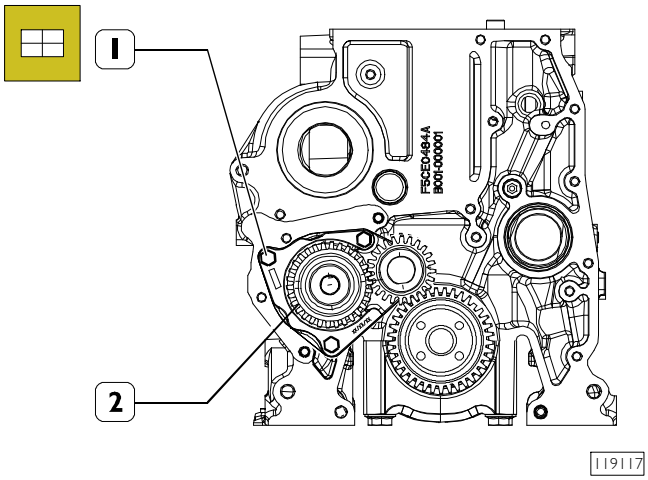
NOTE The flywheel has a reference dowel that couples with the relevant seat on the box.

❑ Screw two pins (1) of appropriate length into the shaft's ports (3) and, using them as a guide, duly fit the engine flywheel (4) into its casing.

❑ Tighten the screws fastening the engine flywheel to the engine drive shaft. Fit the tool 99360339 to the flywheel casing in order to lock the engine flywheel rotation.

Front side component installation

Figure 30



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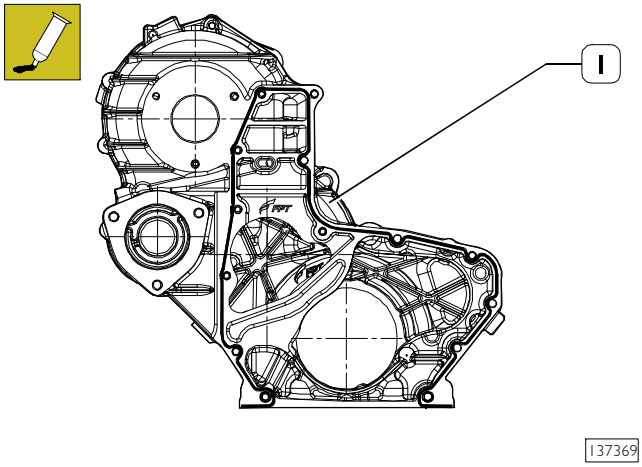
- ❑ Assemble the oil pump (2).
- ❑ Tighten the fastening screws (1) to the prescribed torque wrench.

Figure 31



137369

SCHEME FOR THE APPLIANCE OF LOCTITE 5999 SEALER

NOTE It is absolutely necessary to clean the surface to be sealed in order to obtain perfect tightness.

Apply LOCTITE 5999 sealer on the gearcase in order to form a sealing bead of a few mm.

The sealing bead must be homogeneous (no lumps), free of air bubbles, thinner areas and gaps.

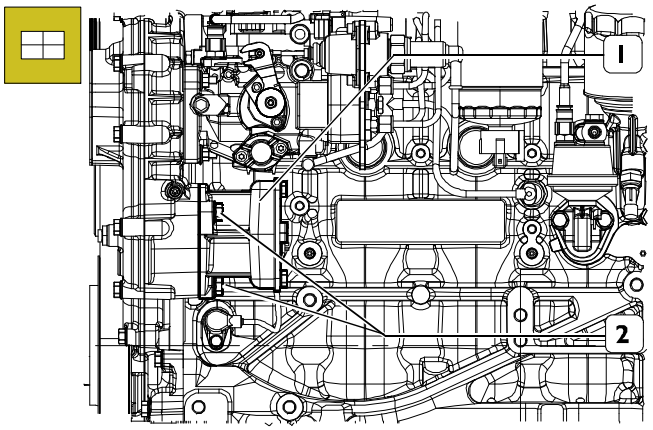
Any imperfection must be corrected as soon as possible.

Avoid the excess of sealer: too much sealing material would leak and pour out on both sides of the joint parts and, as a consequence, obstruct the passage of the lubricant.

After having applied the sealer, the parts must be joined within 10 minutes.

- ❑ Assemble the front case (1) and tighten the fastening screws to the prescribed torque wrench.

Figure 32

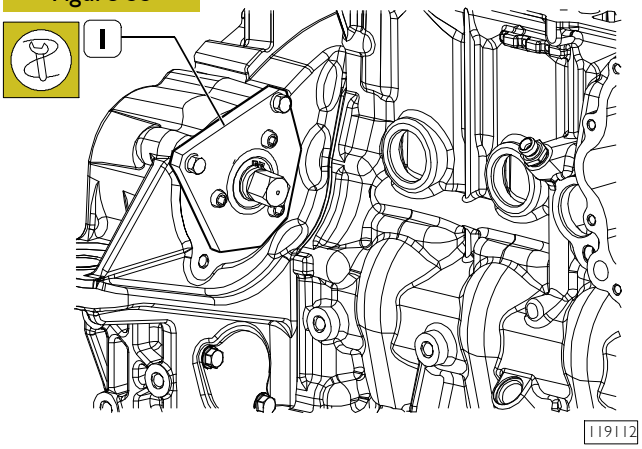


137365

- ❑ Remove the PTO (1) tightening the screws (2) to the prescribed torque.

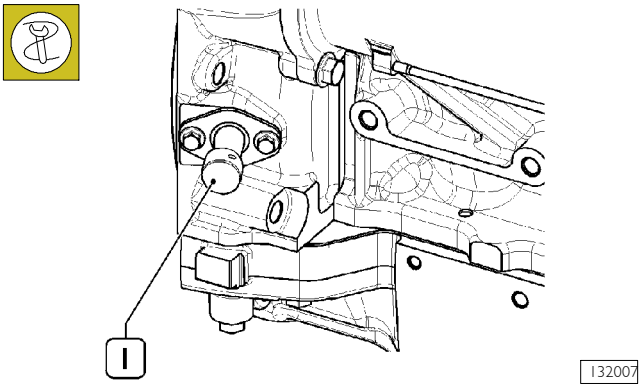
Timing

Figure 33



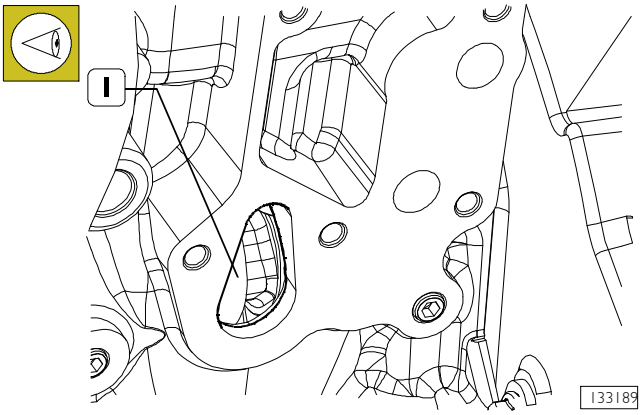
❑ Fit tool (1) 99360339 to flywheel housing to rotate the flywheel (must be used with a suitable wrench).

Figure 34



❑ Loosen the screws of the plate in which tool 99360612 (1) is to be fitted.

Figure 35



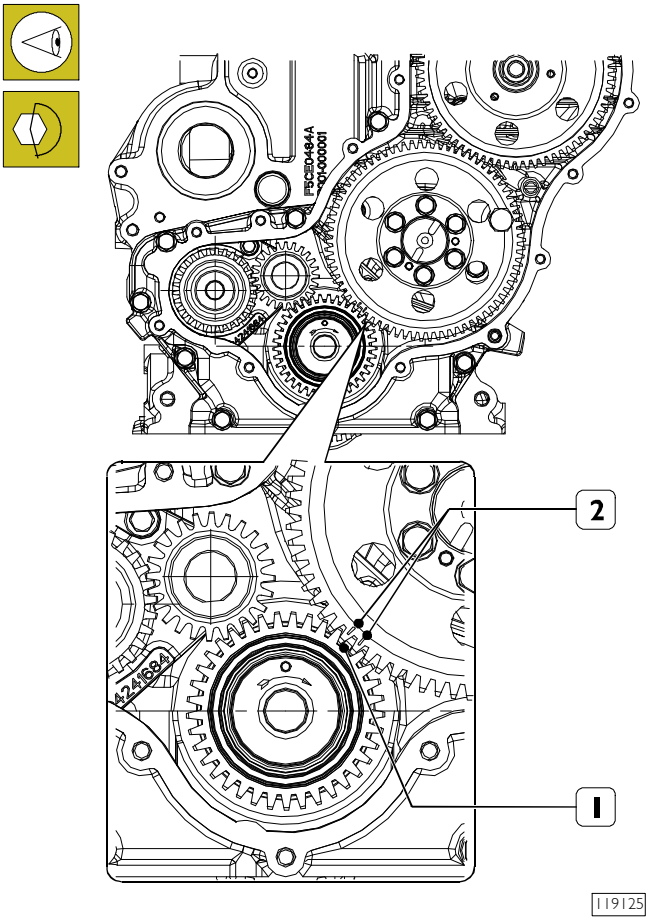
Position the engine drive shaft at T.D.C. of cylinder 1 rotating the flywheel until achieving the following conditions:

❑ the notch (1) is visible from the inspection hole;

❑ tool 99360612 should be fitted through the carter into the port on the flywheel.

Remove tools and tighten the previously loosened plate screws.

Figure 36



❑ Seize the 45° bevel tooth (1) of the engine drive shaft gear with the timing gear tooth marked with two notches (2), as shown in the figure.

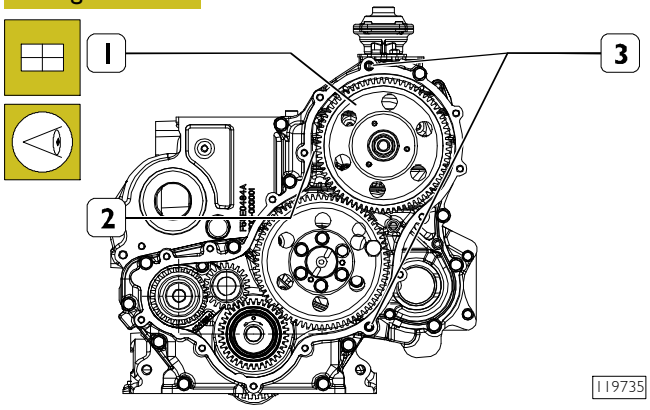
❑ Rotate the camshaft keeping the timing gear fix until the camshaft's pin fits into the relevant housing within the timing gear.

❑ Screw the screws of the transmission gear without fully tightening them.

❑ With magnetic base comparator, check the clearance among the engine shaft gear and the cam shaft gear: it must be 0.068 ÷ 0.168 mm.

❑ Screw the fastening screws (1) of the transmission gear.

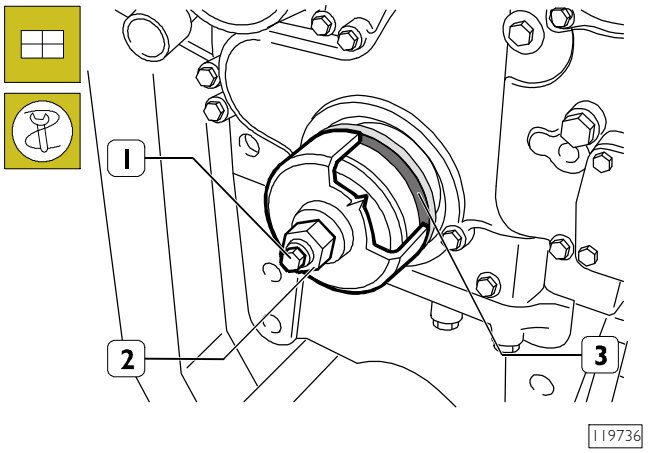
Figure 37



- ❑ Fit the ignition pump cogwheel (1) into its housing.
- ❑ Fit the pre-set ignition pump into its housing on the engine, inserting the shaft into the gear hole.
- ❑ Tighten the three screw nuts on the rear part of the timing gearcase and the front cover fixing the shaft to the gear.
- ❑ Unblock the pump with magnetic base comparator, check the clearance among the engine shaft gear and the oil pump gear: it must be 0.068 ÷ 0.168 mm.
- ❑ Fit the new gasket using the centring pins (2) on the casing for its correct positioning.
- ❑ Fit the casing's cover using the centring pins (2) to correctly position it and then tighten the fastening screws to the prescribed torque wrench.
- ❑ Unlock the fly-wheel

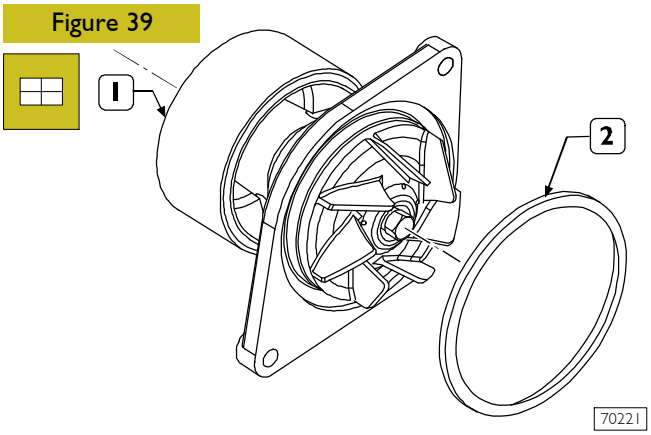
NOTE To carry out the correct ignition pump assembly, proceed as shown in the specific section.

Figure 38



- ❑ Fit the inner part of tool 99346262 to the front shank of the engine drive shaft. Make sure that the engine drive shaft pin is correctly fitted into the tool spline in order to avoid damaging it. Fix it with the screw (1) and spline the new grommet thereon.
- ❑ Place the outer section of the tool on the previously fitted one, tighten the screw nut (2) until completely fitting the grommet (3) into the casing.

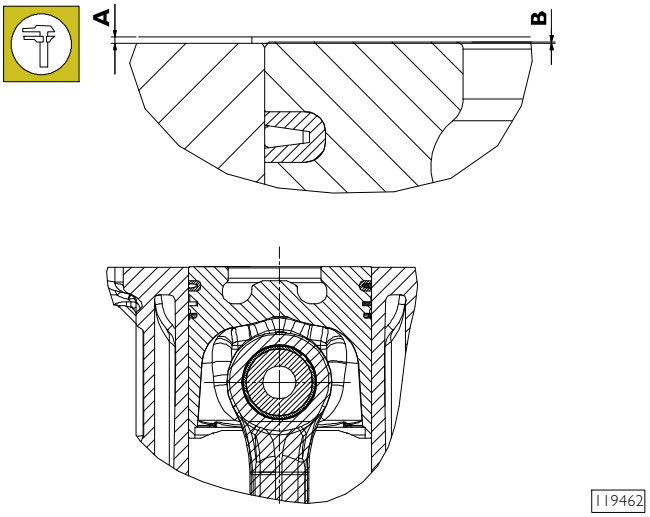
Figure 39



- ❑ Fit a new grommet (2) to the water pump (1).
- ❑ Assemble the water pump (1).
- ❑ Tighten the fastening screws to the prescribed torque wrench.

Piston projection measurement

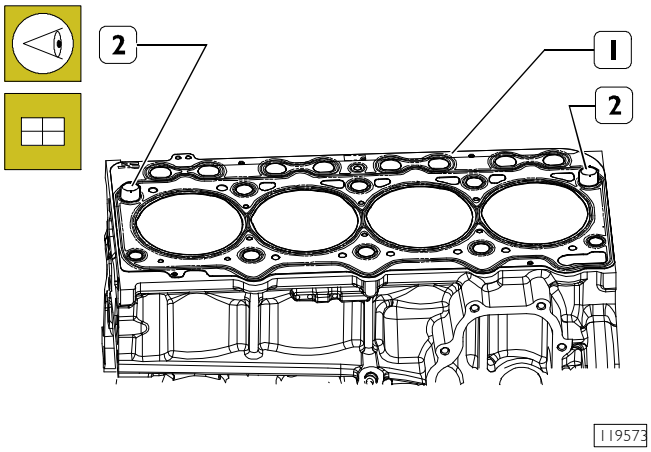
Figure 40



Piston projection from basement A (mm)	Engine gasket thickness B
	Thickness (mm)
From 0.07 to 0.07	0.80
From 0.08 to 0.22	0.70

- ❑ Measure the piston projection and refer to the table above to select the appropriate thickness of the sheath.

Figure 41



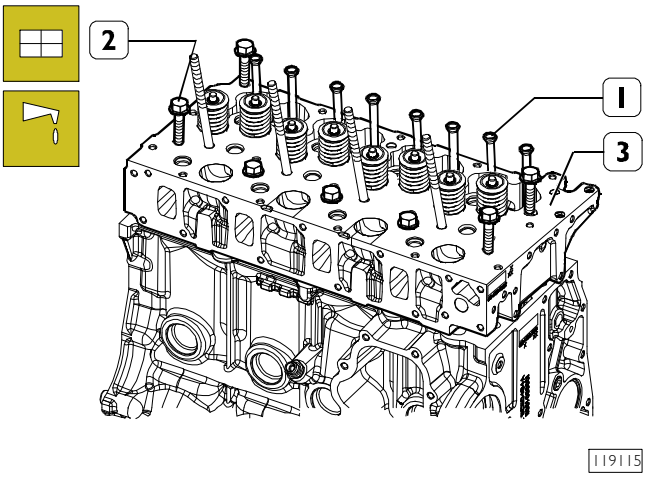
❑ Fit the gasket (1) on the basement centring it taking the pins (2) as a reference. The gasket's thickness must be selected based on the piston projection in respect to the upper plan of the basement.

NOTE Check that the block's laying plan is clean.

Do not grease the gasket. It is recommended to keep the gasket inside its wrapping until it has to be fitted.

The fitting direction is univocal and defined by the centring pins on the basement, which must match with the ports on the gasket.

Figure 42



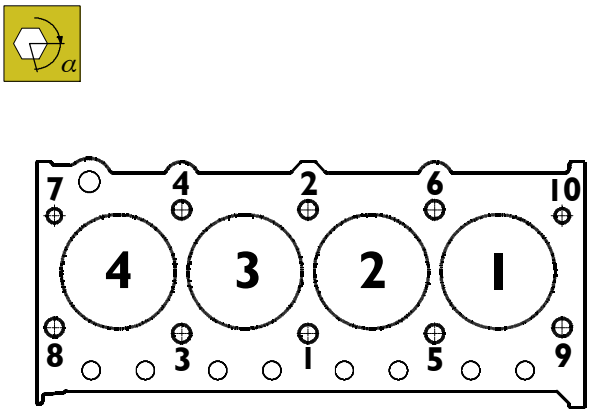
NOTE Always use new screws for assembly.

❑ Lubricate the head fastening screws (2) and tighten them to the prescribed torque wrench.

❑ Place the head (3) on the block taking the centring pins as a reference.

NOTE The head screws should be tightened in a precise order.
There follows the locking sequence and the torques to be applied for each type of screw.

Figure 43



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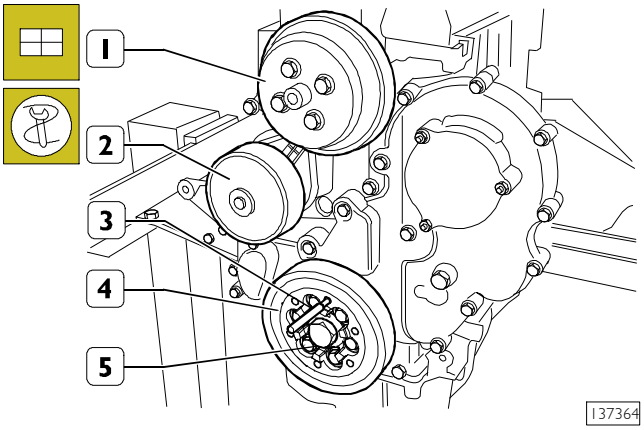
HEAD SCREW LOCKING ORDER

Screws 1,2,3,4,5,6: M15x1,5 6g x193
Screws 7,8,9,10: M12 x1,5 6g x165

- ❑ Lubricate the screws;
- ❑ Tighten the screws with a torque wrench following the locking order described above:
  - M15 Screws: torque 130±6,5Nm;
  - M12 Screws: torque 65±3,25Nm;
- ❑ Tighten the screws further with a torque wrench following the locking order described above:
  - M15 Screws: torque 90±4,5Nm;
  - M12 Screws: torque 90±4,5Nm;
- ❑ Wait a few minutes for settling;
- ❑ Then apply the final angular closing following the locking order described above:
  - M15 Screws: 80°±4°;
  - M12 Screws: 60°±3°.

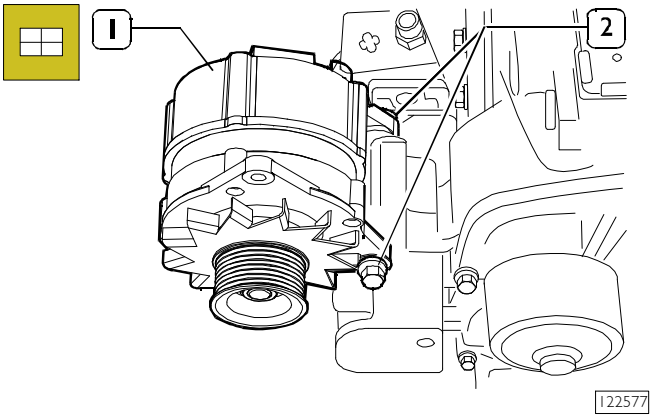
Figure 44



137364

- ❑ Reassemble the electromagnetic joint support (1).
- ❑ Reassemble the pulley (2).
- ❑ Refit the pulley (4) using a pin (3); screw on the screws (5) and tighten them to the prescribed torque.
- ❑ Reassemble the heat exchanger reminding to replace the old gasket with a new one; tighten the fastening screws to the prescribed torque setting.

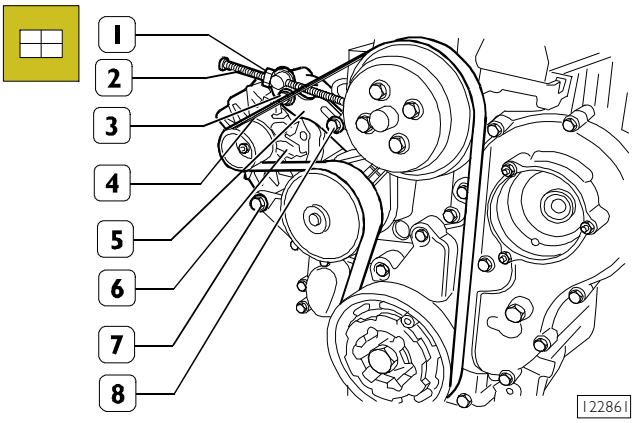
Figure 45



122577

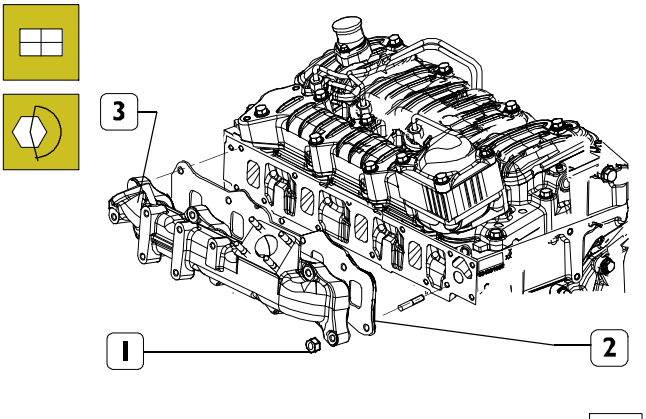
- ❑ Put the alternator back in place (1).
- ❑ Screw up without tightening (2).

Figure 46



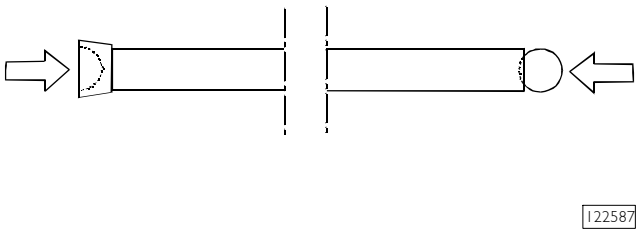
- ❑ Fit the drive belt (4) on the pulley and the guide rollers.
- ❑ Tension drive belt (4) tightening screw (2) until screw (8) reaches the end of the channel in which bracket (5) is seated. Tighten nut (1) and screw (8).
- ❑ Tighten the screw (3) and the screw nut (7) fastening the alternator (6) to the support.

Figure 47



- ❑ Fit the exhaust collector (3) with a new gasket (2) and tighten the fastening screws (1) to the prescribed torque setting.

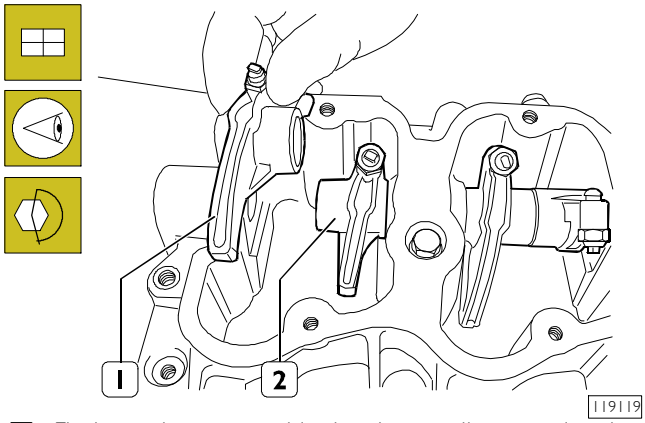
Figure 48



Before reassembly, check that the rocker arm rods must not be deformed; there must be no trace of wear or seizure on the spherical housings of the rocker arm adjusting screws as well as on the tappets (pointers); otherwise these parts must be replaced. The suction valve rods are identical and therefore interchangeable.

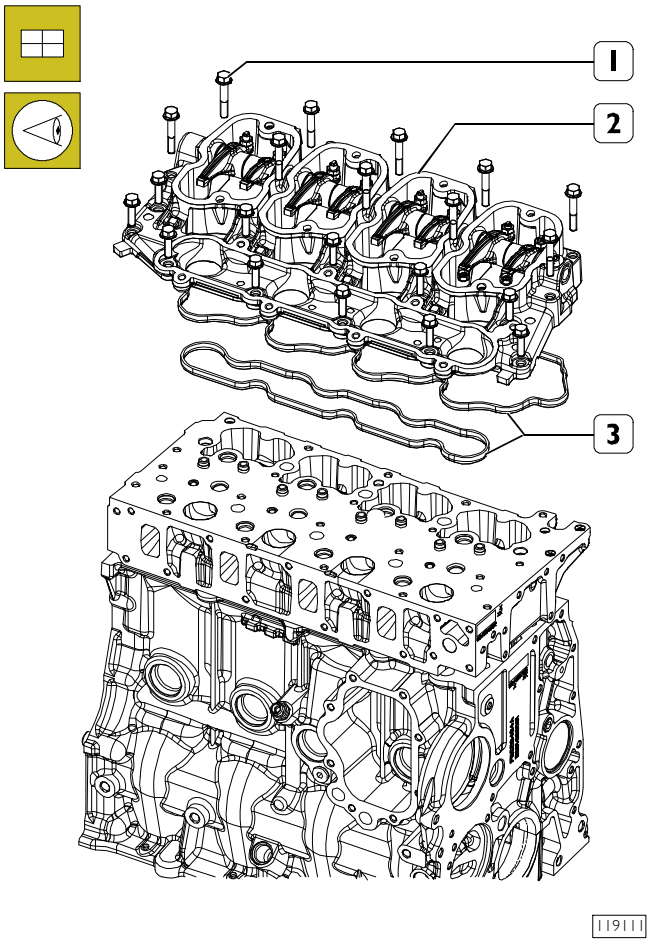
- ❑ Fit the control rods in their housing.

Figure 49



- ❑ Fit the rocker arm positioning the equalizer couples: the suction equalizer first (short rod) and then the exhaust equalizer (long rod) (2).
- ❑ Tighten the fastening screw (1).

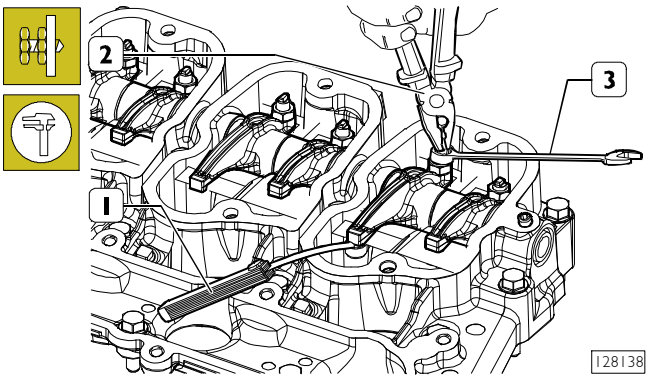
Figure 50



- ❑ Replace the gaskets (3), reassemble the rocker arm holding case (2) and tighten the fastening screws to the prescribed torque setting.
- ❑ After having completed the assembly, check that the rocker arms are correctly positioned on the valves and the tappet control rods.

Rocker arm-valve clearance adjustment

Figure 51



On TIER 3 engines with internal EGR it is not possible to use the valve clearance adjustment procedure in which all the valve clearances can be checked using just 2 different crankshaft positions.

Each cylinder must be checked by taking it to the T.D.C. (top dead centre) at the end of compression and adjusting the clearance of both valves on the cylinder in question.

Position the crankshaft at TDC of cylinder 1.
Rotate crankshaft as required (see table) and check that intake and exhaust valves are both closed and not in a balanced position.

For cylinder 4 it is possible to check the correct position of the crankshaft with tool 99360612.

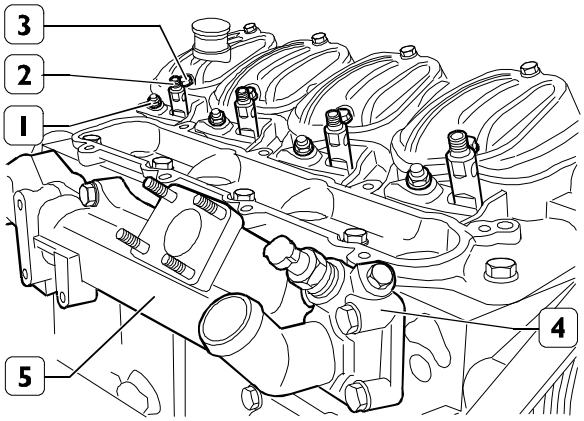
Adjust the clearance between the rockers and valves using a pair of pliers (2), a wrench (3) and a feeler gauge (1).

Clearance shall be as follows:
- intake valves 0.25 ± 0.05 mm
- exhaust valves 0.50 ± 0.05 mm.

FIRING SEQUENCE 1 - 3 - 4 - 2

Starting and crankshaft rotation	Balance valves of cylinder no.	Adjust clearance of intake and exhaust valves of cylinder no.
1 to TDC	1	1
180°	3	3
180°	4	4
180°	2	2

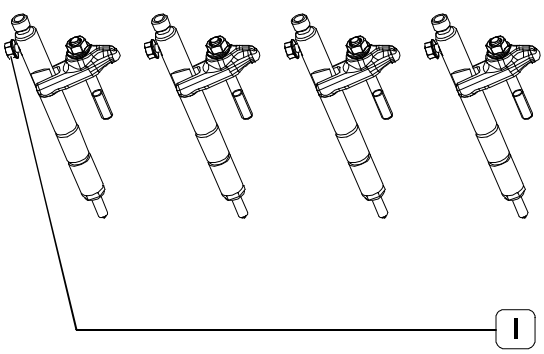
Figure 52



120020

❑ Reassemble the injectors (2) replacing the grommets. Tighten the fastening screws(1) to the prescribed torque setting.

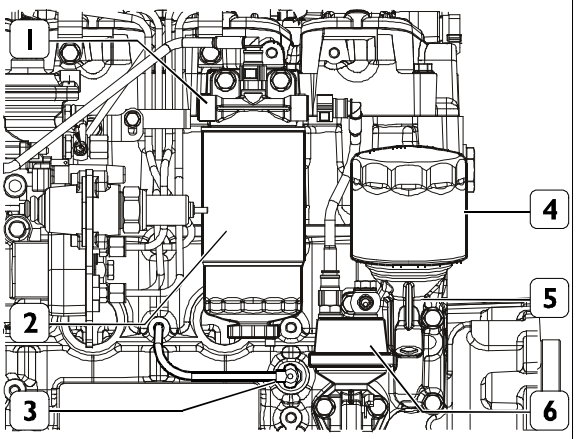
Figure 53



119128

❑ Make the holes (1) for fuel exhaust all face the same direction.

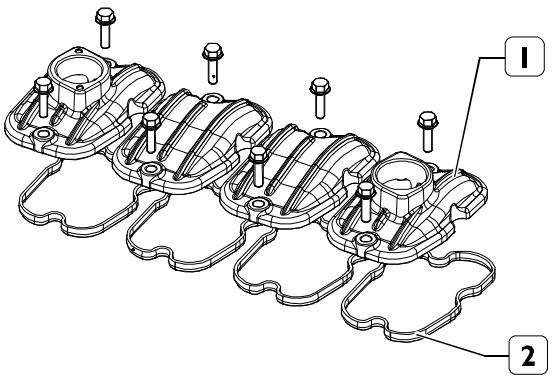
Figure 54



119721

❑ Reassemble the KSB water temperature sensor (6), the oil filter support (5), the priming pump (3), the diesel fuel filter support (2), the fuel filter (1) and the oil filter (4).

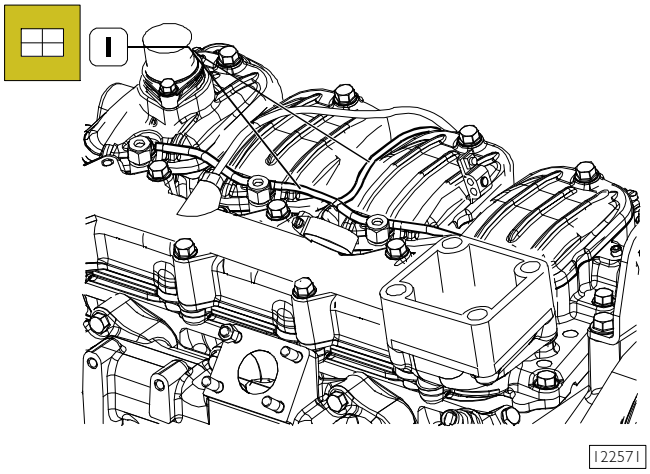
Figure 55



119905

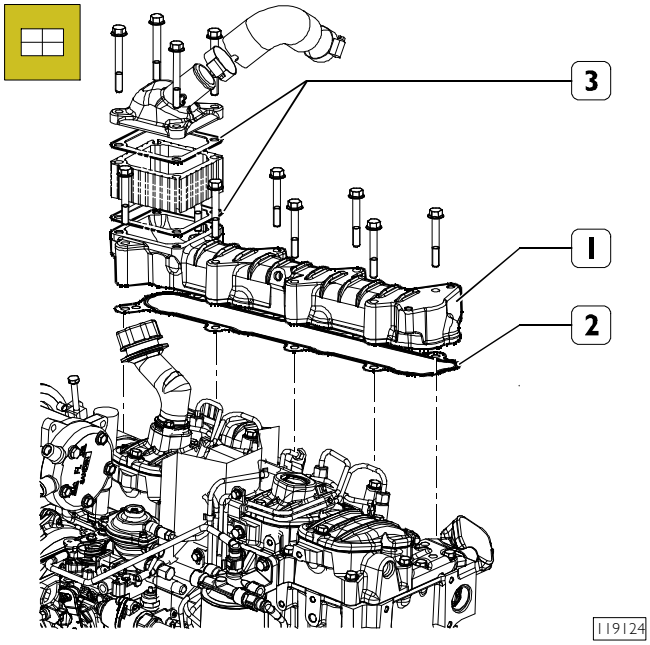
❑ Fit the head covers (1) replacing the gaskets (2).

Figure 56



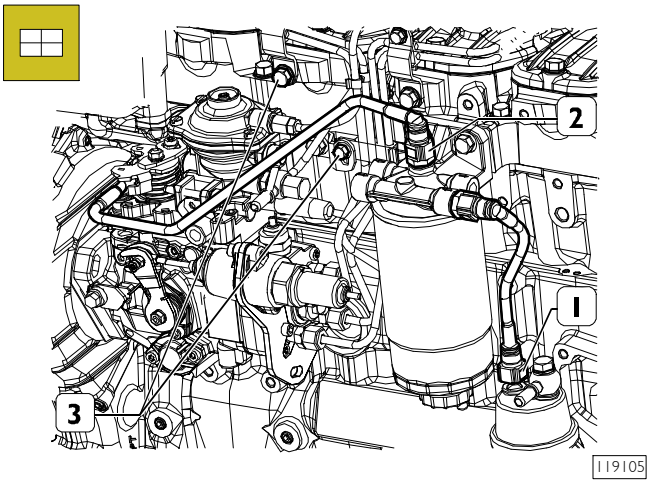
❑ Reassemble the fuel exhaust pipes (1).

Figure 57



❑ Reassemble the whole intake manifold (1) replacing the gasket (2) and (3).

Figure 58

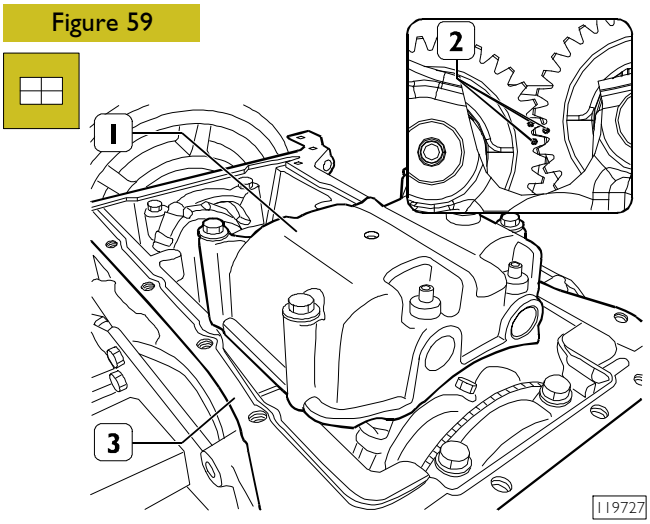


❑ Reassemble the pipe from the pump to the injector and tighten the brackets' fastening screws (3).

❑ Reassemble the pipe from the pump to the fuel filter (2) and from the fuel filter to the priming pump (1).

❑ Reassemble the L.D.A. pipe

Figure 59

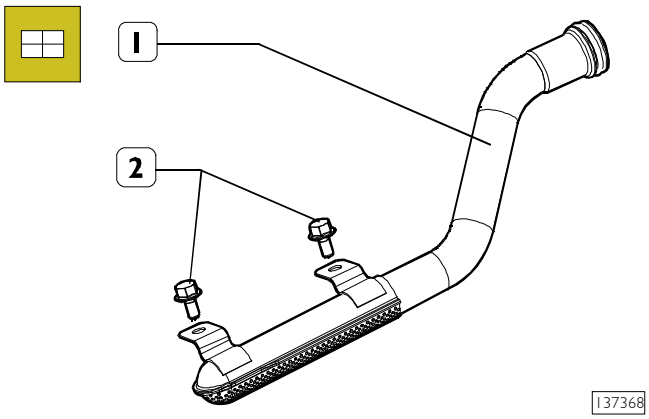


❑ Set the crankshaft at the TDC of the cylinder (1);

❑ In the above-mentioned conditions (engine in phase), fit the box containing the additional masses (1) taking care to make the reference marks (2) tally as shown in the figure.
Set the new gasket (3) on the crankcase;

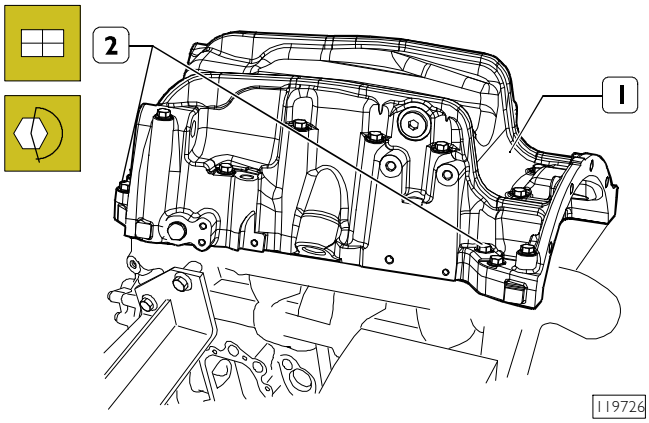
❑ Remove tool 99360612.

Figure 60



- ❑ Fit the suction strainer (1) back onto the oil sump;
- ❑ Tighten the screws (2) to the prescribed torque.

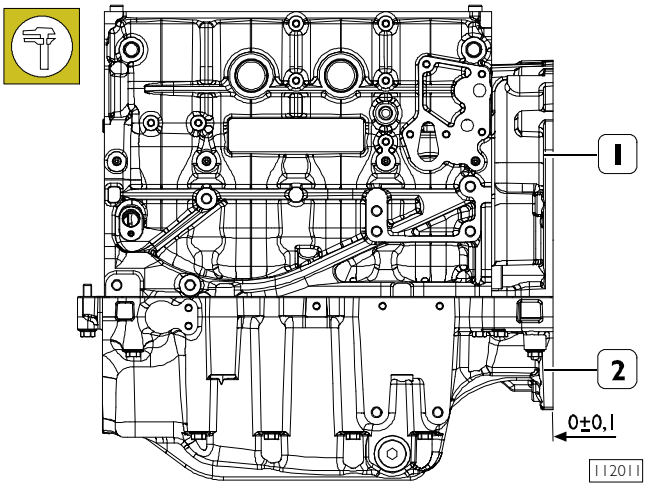
Figure 61



- ❑ Fit the oil sump (1);
- ❑ Tighten the screws (2) to the prescribed torque.

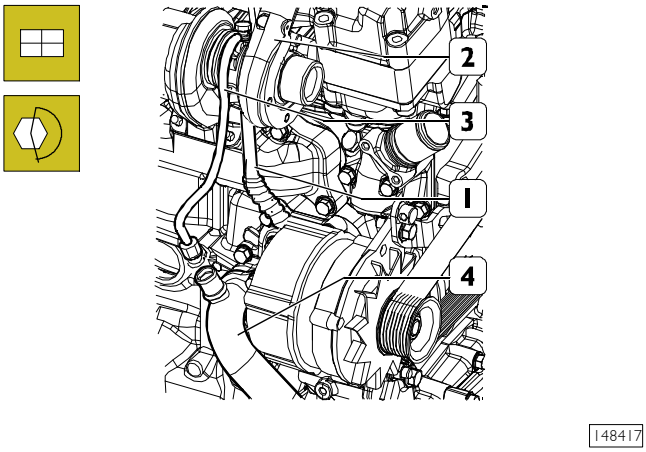
NOTE Before assembly, check that the port threads and the gaskets show no trace of wear or dirt.

Figure 62



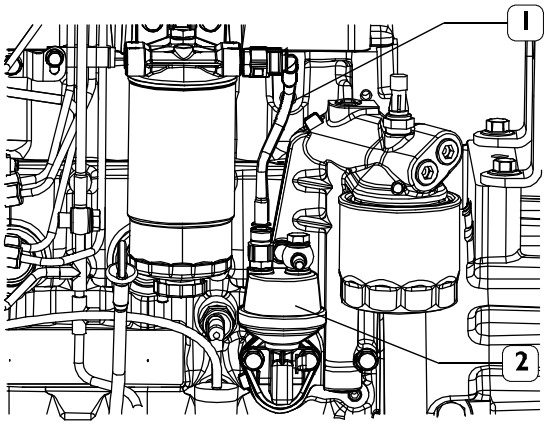
- ❑ Check that the misalignment between the flywheel cover housing (1) and the oil sump (2) is between 0 ± 0.1 mm.

Figure 63



- ❑ Reassemble the turbocharger (2) unit.
- ❑ Reassemble the pipe (4) and fit the clip in the correct housing.
- ❑ Reassemble the oil delivery pipe (3) and the return pipe (1).

Figure 64



- ❑ Disconnect the fuel filter pipe (1) and act on the priming pump (2) drainage lever.
- ❑ Continue drainage until fuel discharge is completed.
- ❑ Connect the pipe (1) to the filter.
- ❑ Connect the electrical wiring.

Checks and inspections

The following checks must be executed after the engine fitting on vehicle.

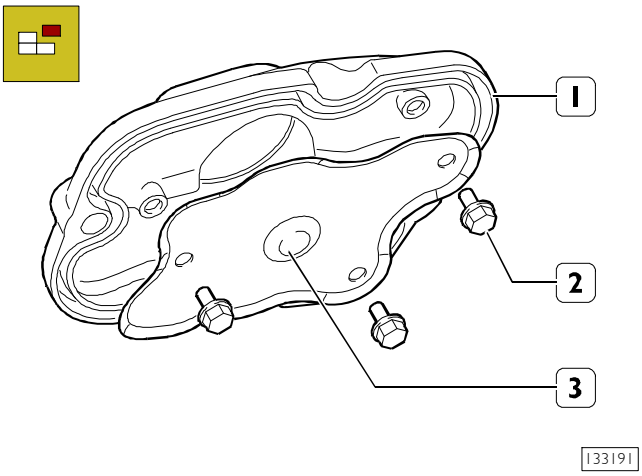
Check that the liquid refuelling or top up has been provided to the correct levels prescribed.

Start the engine, keep it running at a number of rev./min. slightly over idling and wait until the cooling liquid temperature reaches the value prescribed for thermostat valve opening and then provide checking the following:

- ❑ check there is no water leak from the manifolds connecting the engine cooling circuit pipes and the cabin interior heating pipes, eventually further tightening the O-rings.
- ❑ Carefully check the fuel filter pipe fittings.
- ❑ Check there is no oil leakage from cylinder head and cover, oil pan and basement, heat exchanger oil filter and relevant housings in between the various lubrication circuit pipes.
- ❑ Check there is no fuel leakage from the fuel pipes.
- ❑ Check there is no air leak from the pneumatic pipes (if fitted).
- ❑ Check that the warning lights on the instrument panel and equipment disconnected upon engine disconnection efficiently work.
- ❑ Check and carefully bleed the engine cooling system throughout reiterated drainage.

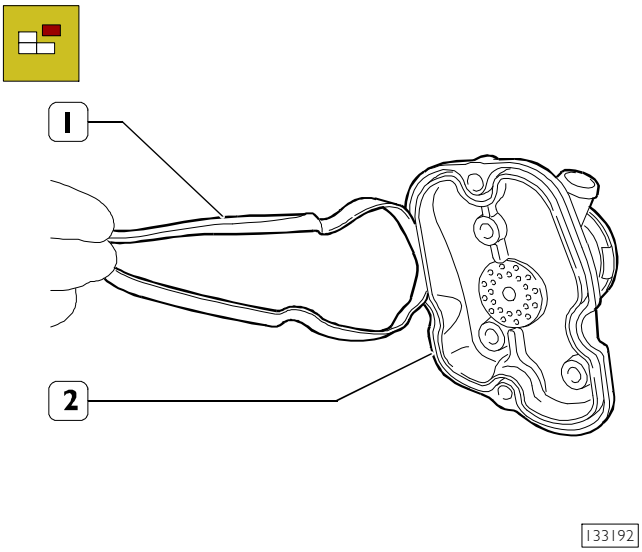
Rocker cover blow-by removal and refitting

Figure 65



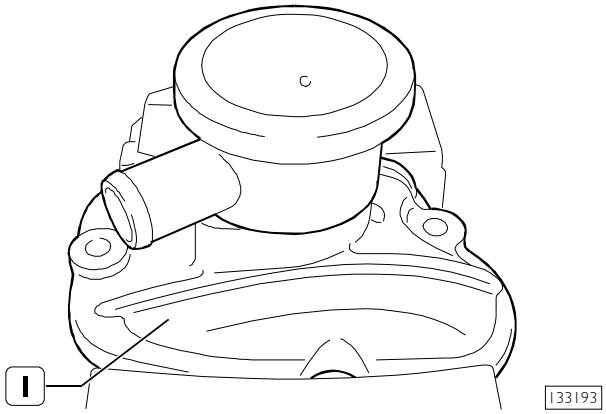
❑ Unscrew the screws (2) from the tappets cover (1) with the blow-by filter and remove the plate guard (3).

Figure 66



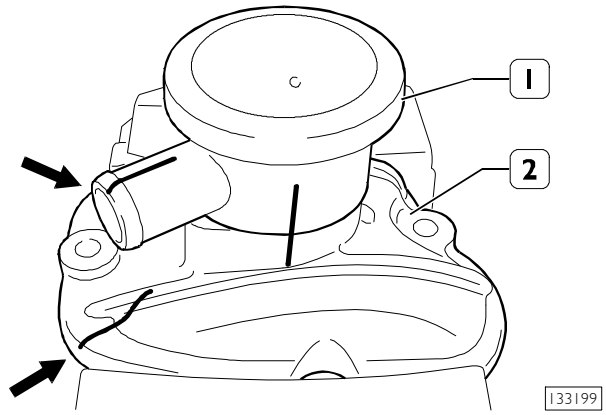
❑ Remove the gasket (1) from the rocker cover (2).

Figure 67



❑ Secure the rocker cover (1) in a vice.

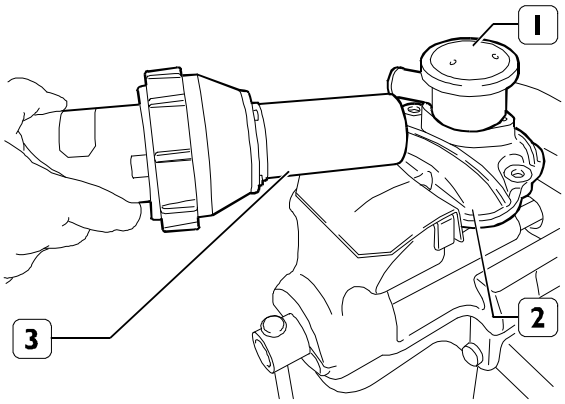
Figure 68



❑ Mark the relative position (as pointed out by the arrows) among the blow by (1) and the rocker cover (2).

NOTE In case of replacement of the blow-by unit (1) it is important to mark the cover (2) for the correct positioning of the blow-by pipe (1).

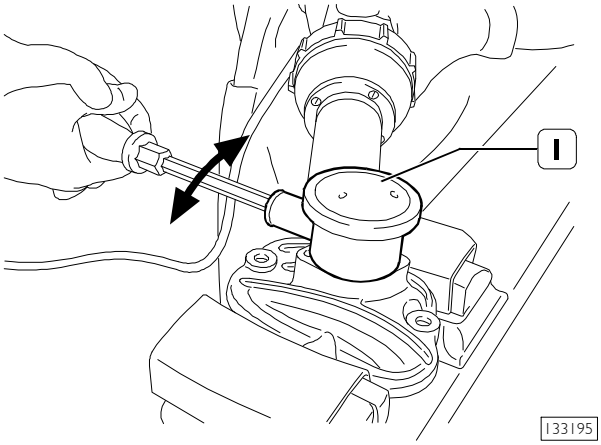
Figure 69



To remove the blow-by (1) from the rocker cover (2) it is necessary to free the elements from the hold of the sealant.

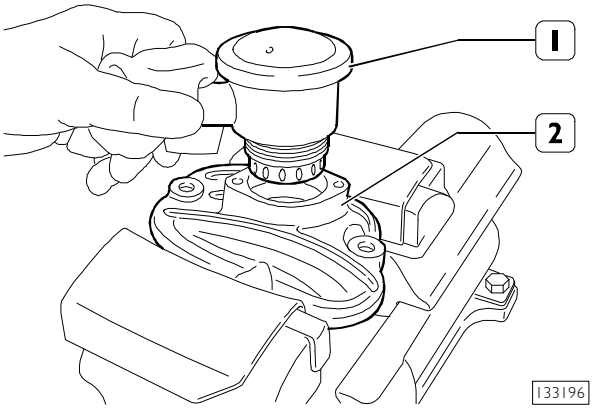
❑ With special hot air device (3) heat the concerned area between blow-by and cover.

Figure 70



Inserting a screwdriver in the blow-by pipe (1) try to rotate the blow-by alternatively in both clockwise and counterclockwise directions (1) up to when it makes free from the hold of the sealant.

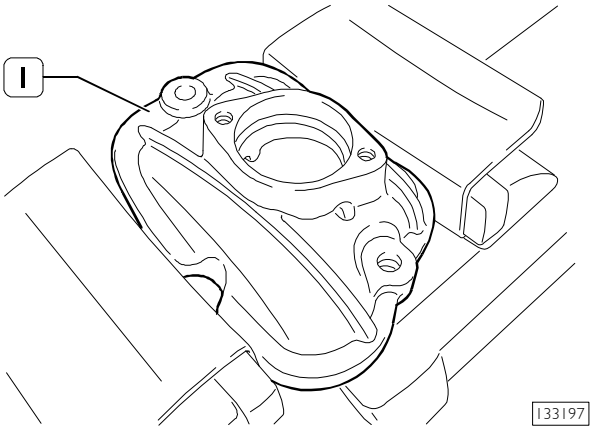
Figure 71



Remove the blow-by (1) from the rocker cover (2).

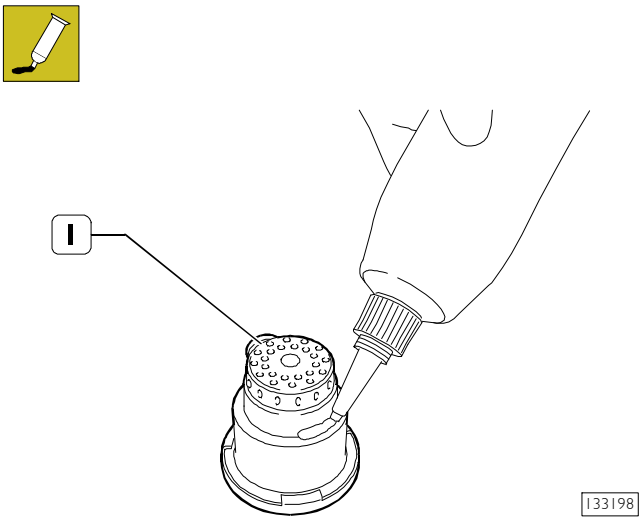
Handle with suitable protections; hot parts.

Figure 72



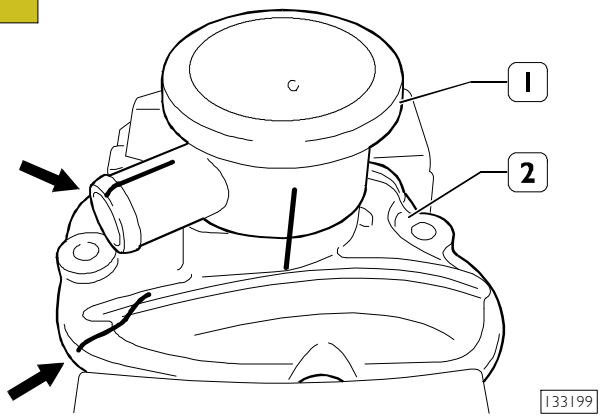
Clean the blow-by seat on the rocker cover (1) from possible traces of sealant.

Figure 73



❑ Apply a regular layer of LOCTITE 510 all around the blow-by body (1).

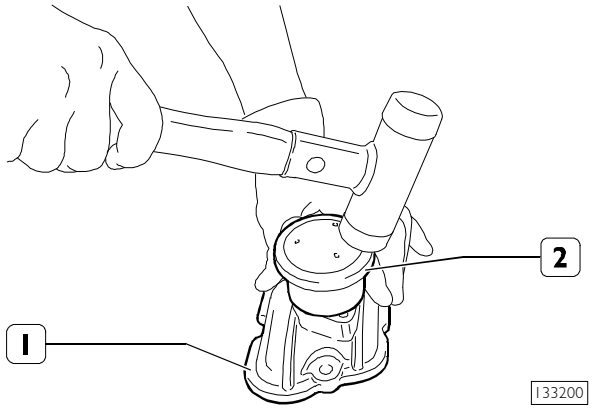
Figure 74



❑ Fit the blow-by (1) on the rocker cover (2) having care to position the exit hole (1) in the correct direction.

NOTE The position of the blow-by exit hole can vary according to the specific applications of the engine. A wrong positioning of the blow-by body (1) on the cover (2) may, therefore, result in difficult while refitting the engine aboard specific applications.

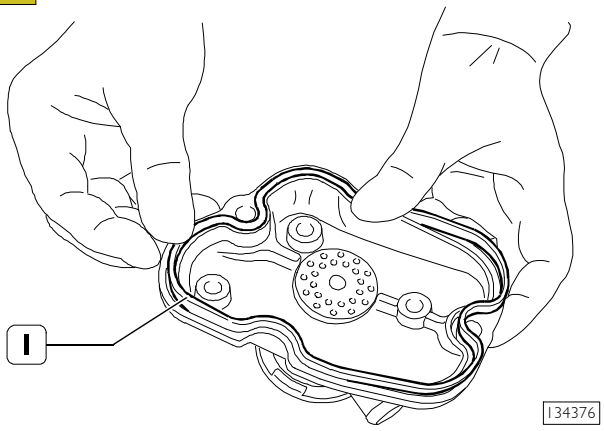
Figure 75



❑ Lean the complete cover assembly on a stiff surface.

❑ By means of a plastic hammer make sure that the blow-by (2) goes completely inside its seat on the rocker cover (1).

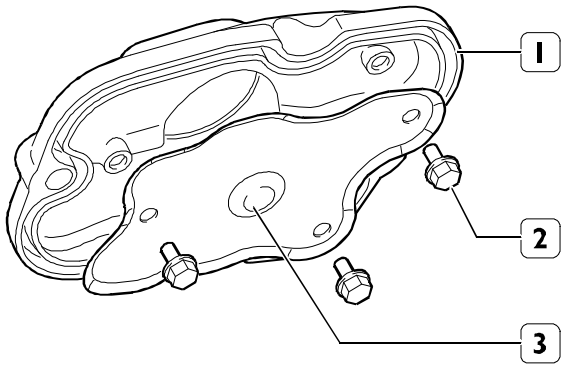
Figure 76



❑ Position a new gasket (1) in its seat on the rocker cover.

NOTE The position of the gasket in the seat is univocal.

Figure 77



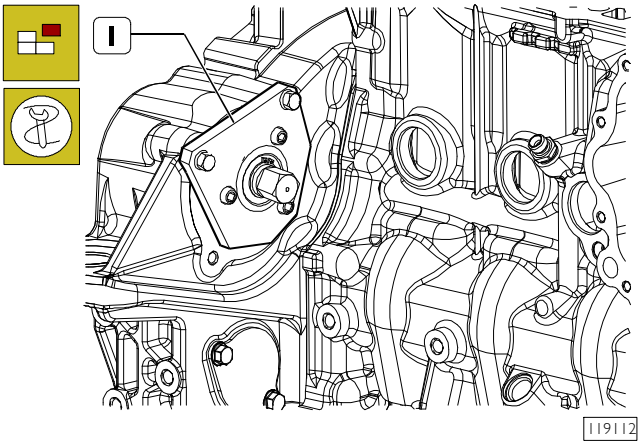
❑ Refit the plate (3) on the tappets cover (1) with the blow-by filter and tighten the M5x10 screws (2).

Rotary feed pump disassembly and assembly procedure

NOTE This procedure prescribes that:

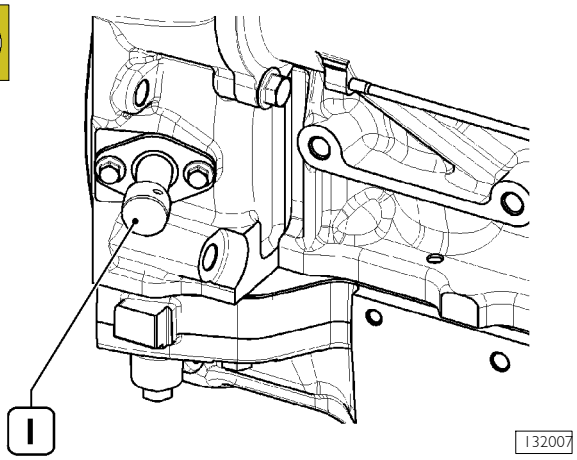
- ❑ the fuel pipes (from the pumping elements to the injectors, recovering blow-by from the injectors to the pump and the supply from the priming pump) have all been removed;
- ❑ the electrical connections have been disconnected.
- ❑ Accelerator cable shall be disconnected.

Figure 78



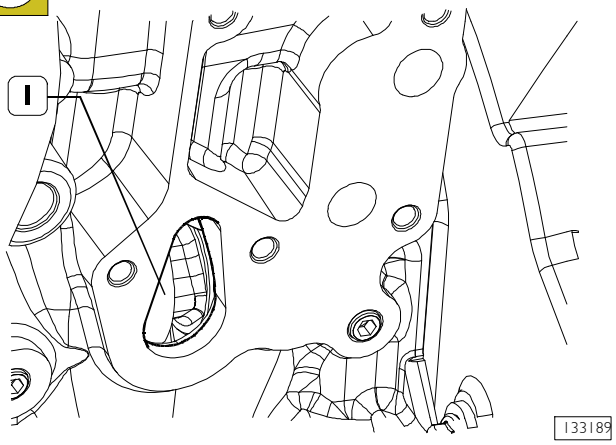
- ❑ Fit tool (1) 99360339 to flywheel housing to rotate the flywheel (must be used with a suitable wrench).

Figure 79



- ❑ Loosen the screws of the plate in which tool 99360612 (1) is to be fitted.

Figure 80

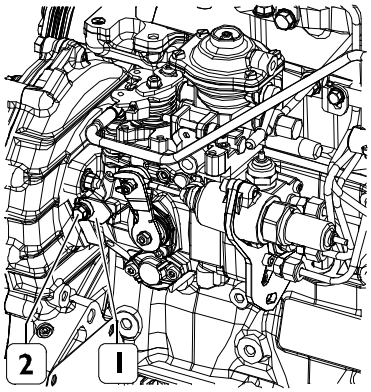


Position the engine drive shaft at T.D.C. of cylinder 1 rotating the flywheel until achieving the following conditions:

- ❑ the notch (1) is visible from the inspection hole;
- ❑ tool 99360612 should be fitted through the carter into the port on the flywheel.

BOSCH VE 4/12 F Pump

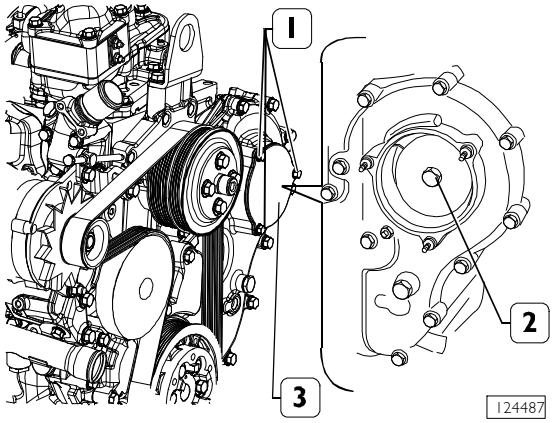
Figure 81



128131

- ❑ Unscrew the side screw that locks the pump shaft partially (2) and remove spacer (1). This must be kept on a side (we recommend to fix it on the pump with a wire or a clip).
- ❑ Tighten the lateral screw (2) blocking rotation of the pump shaft.

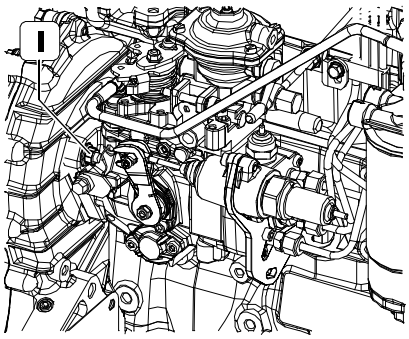
Figure 82



124487

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

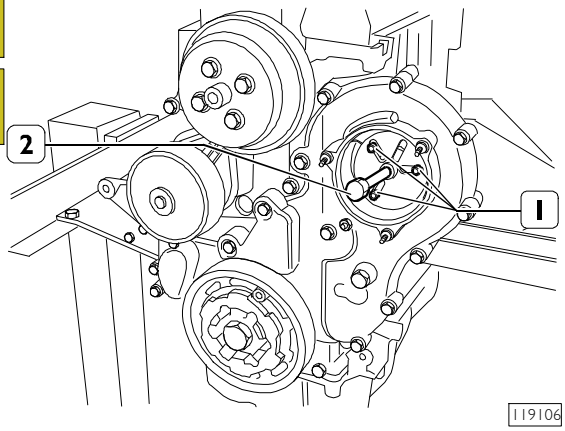
Figure 83



128132

- ❑ From the pump side, loosen the fixing nuts (1) without removing them in order to enable moving the pump backwards using 99340025 extractor.

Figure 84



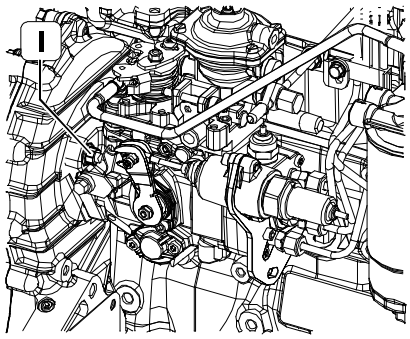
119106

- ❑ Assemble the 99340025 (2) extractor throughout the three threaded ports (1) 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.

When the supply pump is to be assembled on the engine the P.M.S. conditions at compression end stage cylinder No. 1 must be carried out.

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

Figure 85

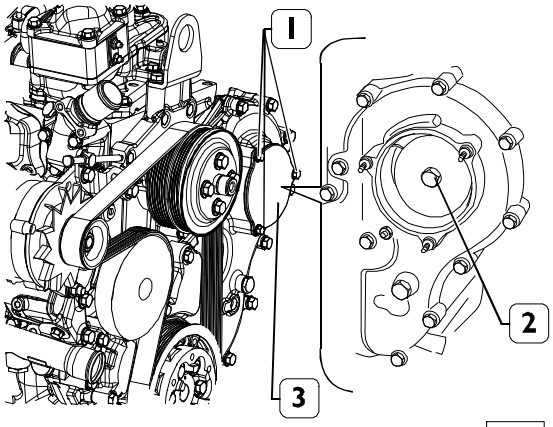


128132

- ❑ 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.

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

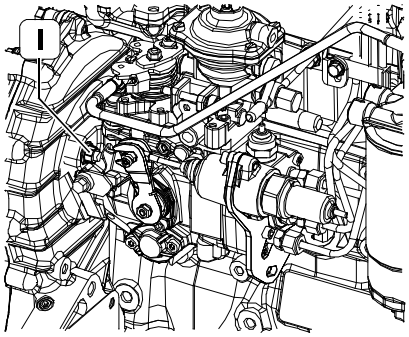
Figure 86



124487

- ❑ On the timing side, throughout the specially appointed port, fit the washer and screw up the fixing nut (2) to the pump shaft. Lock the nut to the prescribed pair.

Figure 87



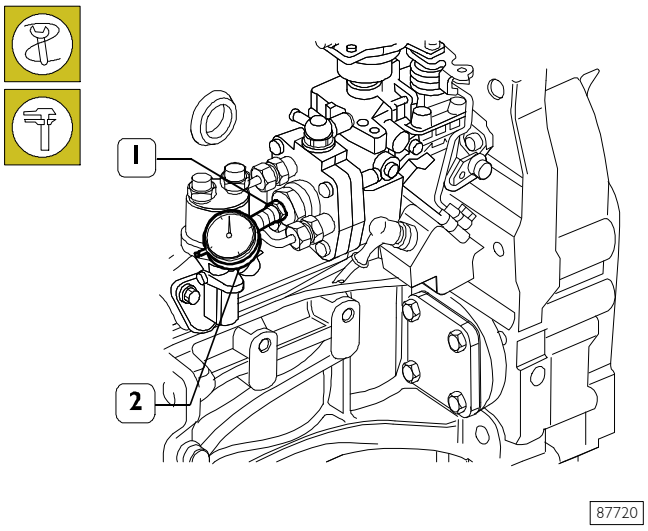
128132

- ❑ Loosen screw (1) that prevents pump shaft rotation and insert spacer (2). Tighten screw (1)so that it locks spacer (2): in this way the supply pump shaft will be able to rotate freely.
- ❑ Assemble the cover (3, Figure 86) including gasket and tighten the screws (1, Figure 86).
- ❑ Tighten the previously loosened plate screws.
- ❑ 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 KSB.

NOTE If the pump has been removed with the engine mounted, connect the accelerator cable, if present in the application.

Injection pump static advance control on engine at cylinder 1 TDC

Figure 88 (Demonstration)



With injection pump inserted in its housing and retaining screws released, fit dial gage 99395603 (2) and dial gage holder 99395100 (1), preloading rod by 2,5 mm.

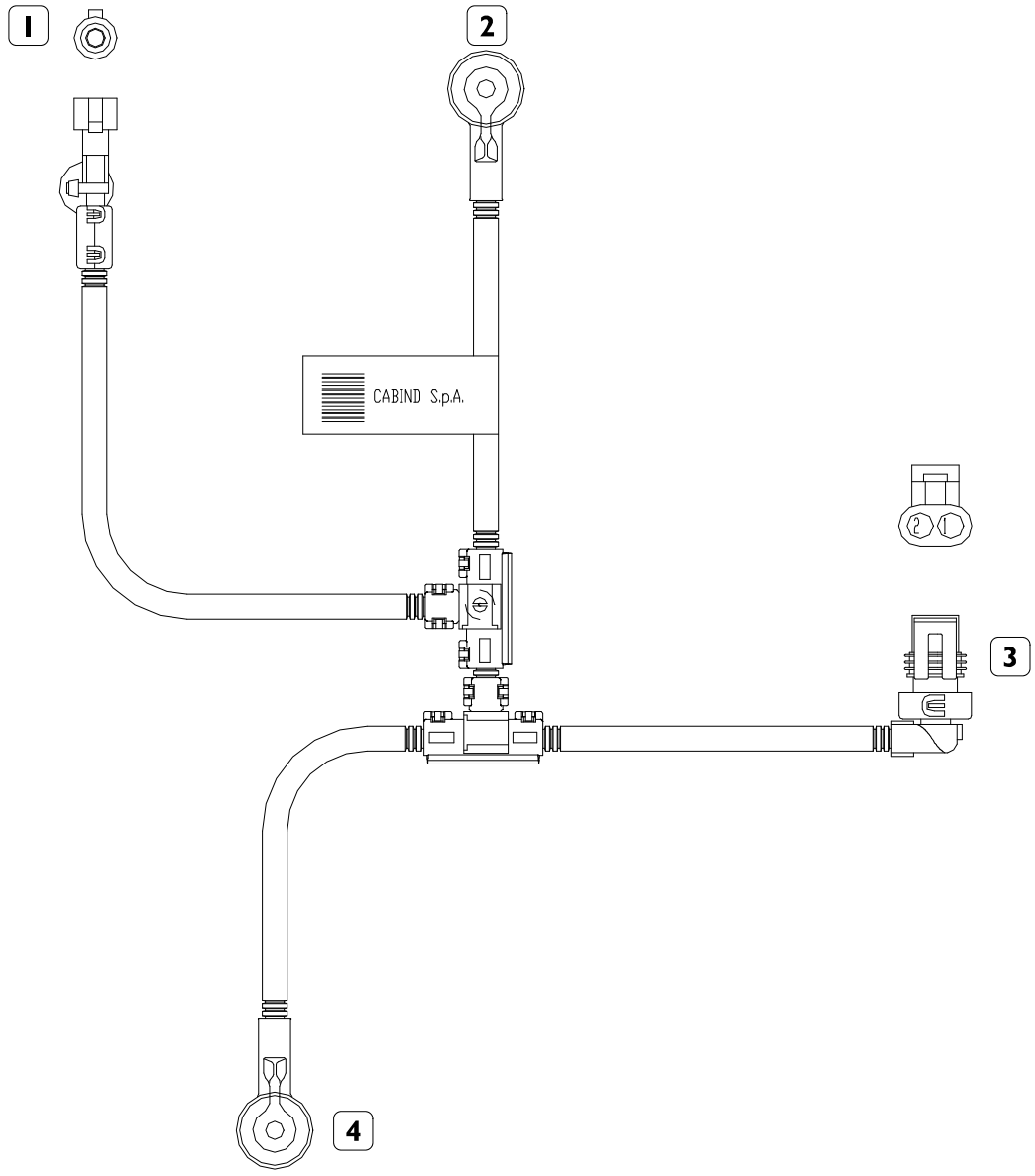
- ❑ Rotate crankshaft and move from 1st cylinder at TDC to end of compression phase condition.
- ❑ Reset dial gage and rotate crankshaft in opposite direction to return to 1st cylinder at TOD during compression. In this position, the dial gage fitted on pump must display values below:
  - 0.80 ± 0.05 mm (53 kW engines);
  - 0.76 ± 0.05 mm (57 and 65 kW engines).
- ❑ After these conditions have been verified, lock the pump in place by tightening the relevant nuts onto the corresponding torque. On the other hand, if these conditions are not verified, you should contact the specialised assistance service, as it will not be possible to rotate the pump for reasons linked to the TIER 3 standards.

NOTE The advance control should be performed while the KSB is hot, i.e. previously excited, in order to cancel out the advance with which the cold pump operates.

PART TWO - ELECTRICAL EQUIPMENT

KSB - BOSCH PUMP CONNECTION CABLE

Figure 89

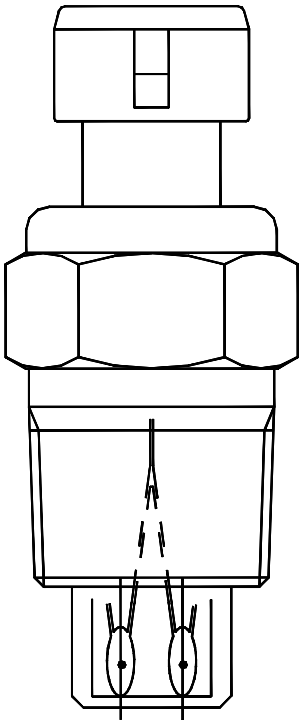


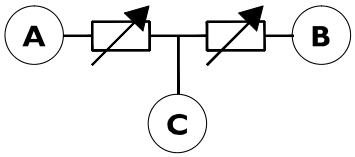
1. Interface - 2. KSB signal - 3. Air sensor - 4. Electrostop

Engine cooling liquid temperature sensor

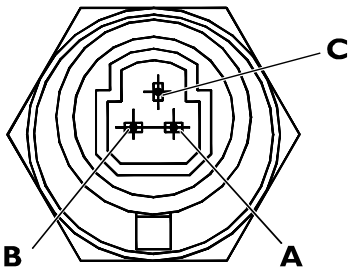
The sensor is fitted on the thermostat unit. It consists of two NTC thermistors with two reophores.

Figure 90





Calibration 80 °C [k]Ω	Calibration 20 °C [k]Ω	Calibration 10 °C [k]Ω
0.304 - 0.342	2.262 - 2.760	8.244 - 10.661

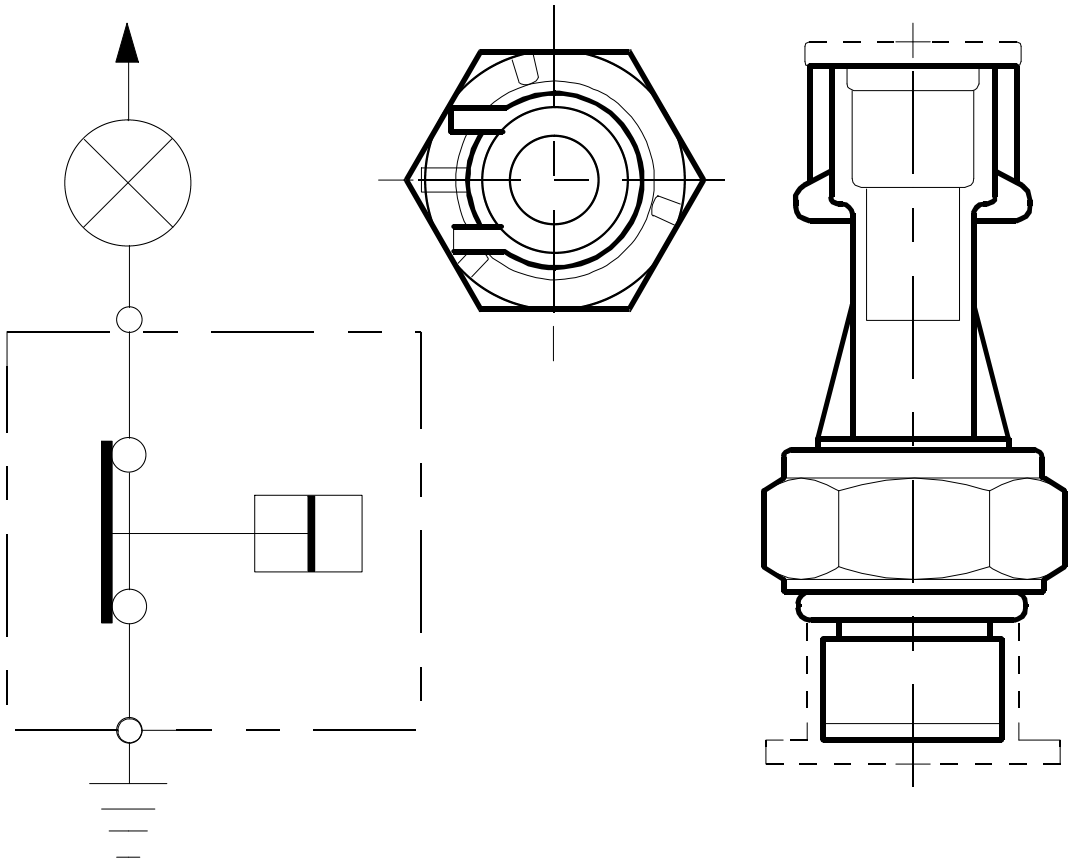


119454

Characteristics	
Working temperature range	
- Connector's side	-40 °C ÷ 130 °C; 150 °C for periods < 10 min.
- Bulb's side on engine	-40 °C ÷ 140 °C
Voltage	6 ÷ 28 V

Oil pressure switch

Figure 91

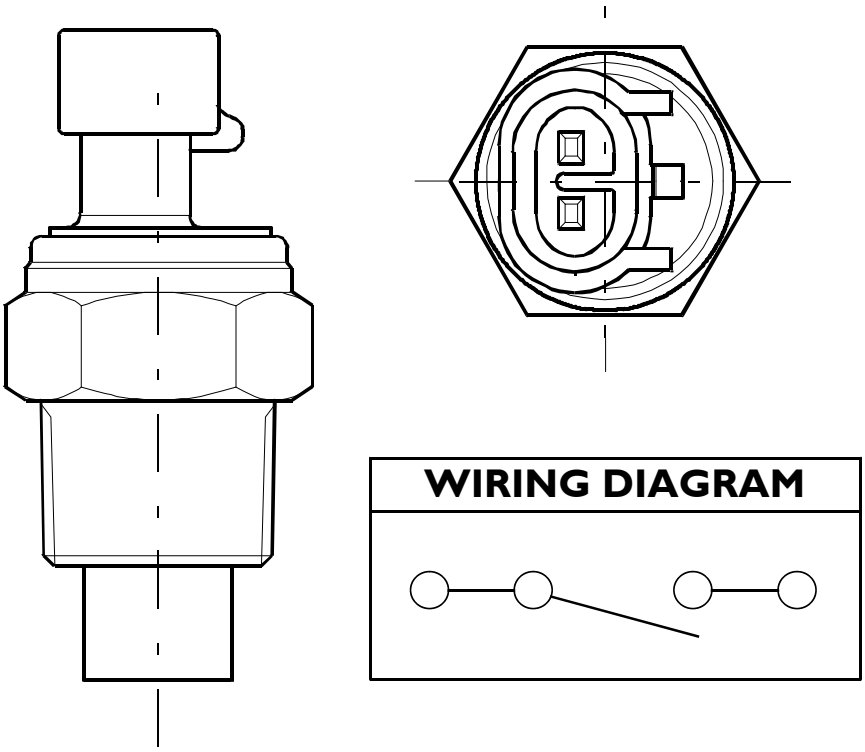


Characteristics

Voltage:	12 ÷ 24 V
Contact closure with decreasing pressure:	0.6 bar
Contact opening with increasing pressure:	0.9 bar

Cooling liquid temperature sensor for KSB

Figure 92



Characteristics.	
Contact closing temperature	65 ± 5 °C
Maximum load on contacts	Max 15A

Engine drive shaft sensor

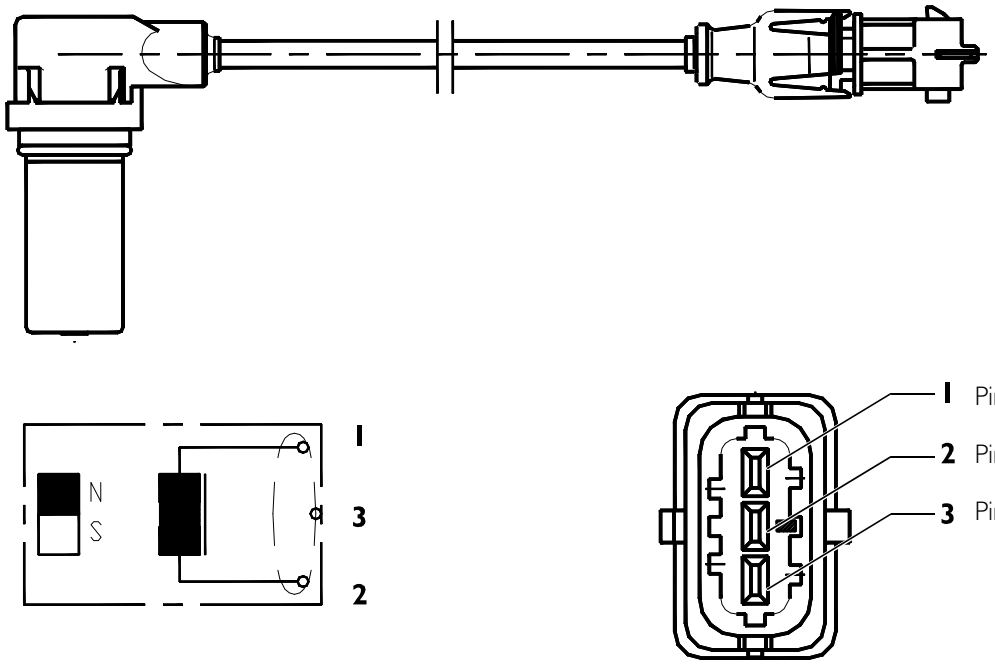
It is an inductive type sensor placed on the front left side of the engine.

It generates signals obtained by the magnetic flow lines closing up through the openings of a phonic wheel splined on the engine drive shaft.

The same signal is used to pilot the electronic revolution counter eventually fitted on the vehicle instrument panel.

It is connected to the Electronic Control Unit pins 25C (signal) and 24C (signal). The third pin is for shielding. The Sensor's resistance value is nearly 900 Ω.

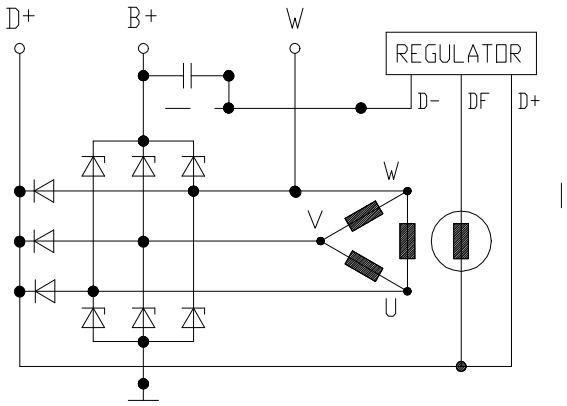
Figure 93



Torque setting	8 ± 2 Nm

ISKRA 14V Alternator

Figure 94



WIRING DIAGRAM

Specifications for use

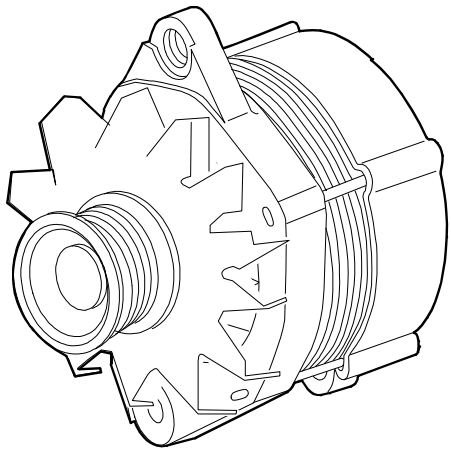
Vehicle electric system rated voltage: 12 V
Suitable for coupling with battery of any capacity
It must work with the battery connected.

Connection with inverted polarity is not allowed.

Operating specifications

Rated voltage	14 V
Rated current delivery	80A at 6.000 rpm
Drive side direction of rotation	clockwise
Maximum continuous speed	≤15.000 min^{-1}

Figure 95



PART THREE - TROUBLESHOOTING

FAILURE	POSSIBLE ROOT CAUSE	RECOMMENDED TESTS OR REMEDY	NOTES
The engine does not start	Discharged of damaged battery	Check the battery and recharge it. Replace the battery if necessary	
	Battery terminal connections corroded or loose	Clean, check and tighten the battery terminal screw nuts. Replace the terminals and the screw nuts if excessively corroded.	
	Incorrect timing of the ignition pump	Check the ignition pump timing.	Apply to FPT Technical Service.
	Deposits or water presence in the fuel tank	Disconnect the pipes and clean them with compressed air jet. Disassemble the ignition pump and clean it. Eliminate any presence of water in the fuel tank and refuel.	Always bleed the supply system.
	Insufficient fuel reserve	Refuel	
	No supply	Overhaul or replace the supply or transfer pumps	
	Air bubbles in the fuel pumps or in the ignition pump	Check the pipes to ascertain the cause of air presence and the supply pump. Eliminate any air from the ignition pump interior loosing the specially provided cap and manually operating the supply pump.	
	Defective starter	Repair or replace the starter	

FAILURE	POSSIBLE ROOT CAUSE	RECOMMENDED TESTS OR REMEDY	NOTES
The engine does not start at low temperatures	Supply system obstruction by formation of paraffin crystals due to the use of unsuitable fuel.	Change the existing fuel with other fuel suitable for low temperatures. Replace the fuel filter.	
	K.S.B. device for cold spark lead change is incorrectly working.	Overhaul or replace the supply pump.	Apply to FPT Technical Service
The engine stops	Idle too low.	Adjust the idle level throughout the adjusting screw.	
	Ignition pump irregular delivery	Regulate delivery.	Apply to FPT Technical Service
	Impurities or presence of water in the fuel pipes.	Disconnect the pipes and clean them with compressed air jet. Disassemble the ignition pump and clean it. Eliminate any presence of water in the fuel tank and refuel.	Always bleed the supply system.
	Fuel filter clogged.	Disassemble and replace the fuel filter if necessary.	
	Presence of air in the supply and ignition systems.	Check the pipes for cracks or loose pipe fittings. Replace the worn parts. Eliminate air any air from inside the pipes and then bleed the ignition pump and the fuel filter loosing the specially provided caps and manually operating the priming pump.	
	Ignition pump controls broken.	Replace the ignition pump.	
	Incorrect slack between camshaft and tappets.	Adjust the slack replacing the adjusting plates.	
	Burnt, corroded or cracked.	Replace the valves, overhaul or replace the valve housings on the cylinder head.	

FAILURE	POSSIBLE ROOT CAUSE	RECOMMENDED TESTS OR REMEDY	NOTES
The engine excessively heats up	Defective water pump.	Check the whole unit and replace it if necessary; replace the sheath.	
	Defective thermostat.	Replace the thermostat.	
	Incrustation within the various cooling liquid passages of the cylinder head and unit.	Accurate washing is necessary. Follow the instructions prescribed for the specific incrustation removal product to be used.	
	Insufficient tension of the water pump drive belt.	Check the belt tensioning and adjust it.	In case of appliances equipped with automatic tensioning device, check that the device is correctly working.
	Cooling liquid level too low.	Top up the radiator cooling liquid to the level required.	
	Incorrect engine timing.	Check timing.	
	Ignition pump incorrect calibration (too high or too low)	Adjust the pump delivery on bench. Ignition must be set up according to the prescribed delivery.	Apply to FPT Technical Service
	Obstructed air filter.	Clean the air filter and replace it if necessary.	
Insufficient engine power and irregular functioning	Ignition pump incorrect timing.	Check timing and proceed setting up the ignition pump correctly.	
Insufficient engine power and irregular functioning	Defective spark lead automatic changing device.	Test the ignition pump functioning on bench. If the values detected to not comply with the prescribed ones, replace the changing device spring.	Apply to FPT Technical Service
	K.S.B. automatic spark lead changing device failure.	Adjust or replace the ignition pump.	
	Piston excessive wear.	Proceed with engine overhaul and replacement of worn parts.	
	Incorrect speed regulator calibration.	Check the regulator and calibrate it.	Apply to FPT Technical Service

FAILURE	POSSIBLE ROOT CAUSE	RECOMMENDED TESTS OR REMEDY	NOTES
Insufficient engine power and irregular functioning	Partial nozzle obstruction or defective injectors.	Clean the nozzles throughout the specially provided equipment and overhaul the injectors.	
	Impurities or presence of water in the supply and ignition systems.	Accurate cleaning is necessary as well as refuelling.	Always bleed the supply system.
	Incorrect slack between camshaft and tappets.	Check the slack and adjust it.	
	Defective turbocharger.	Replace the whole unit.	
	Obstructed air filter.	Clean the air filter or replace it.	
	Defective L.D.A. device.	Check that the membrane is not perforated and that the counter spring is appropriate and correctly loaded (test on bench). Check the pressure within the intake manifold is correct in relation to the engine speed at full load.	Apply to FPT Technical Service
	Incorrect adjustment of the tie rods connecting the accelerator pedal and the regulator's lever.	Adjust the tie rods in order to be able to take the control lever to maximum delivery position.	
Anomalous engine strokes	Defective injectors.	Replace the injectors.	
	Obstructed fuel pipes.	Disassemble the pipes, clean them and replace those that are seriously dented.	
	Ignition pump incorrect setting.	Correct the pump setting so that ignition may be carried out according to the prescribed spark lead angle.	Apply to FPT Technical Service

FAILURE	POSSIBLE ROOT CAUSE	RECOMMENDED TESTS OR REMEDY	NOTES
Anomalous engine strokes	Engine strokes cause excessive slack of one or more crankshaft bearings or big end bearings or excessive shoulder slack.	Grind the engine drive shaft pins and fit undersize bearings. Replace the thrust bearing half rings.	
	Unbalanced engine drive shaft.	Check the engine drive shaft alignment.	
	Loose flywheel fastening screws.	Replace the loose screws and tighten them to the prescribed torque setting.	
	Connecting rod misalignment.	Replace the connecting rod.	
	Noisy piston pins for excessive slack of piston hubs and connecting rod bush. Loose bushes in their housing on the connecting rod.	Replace the piston pin and/or the piston and the connecting rod bush.	
	Noisy timing	Adjust the slack between camshaft and tappet and check there are no broken springs. Furthermore, check that the slack between valve stems and valve guides as well as tappets an relevant seat.	
Anomalous engine fumes. Black or dark grey fumes.	Excessive pump maximum delivery.	Disconnect the pump and adjust its delivery referring to the calibration table of the screw nuts.	Apply to FPT Technical Service
	Defective or incorrectly adjusted K.S.B. device.	Adjust the ignition pump or replace it.	Apply to FPT Technical Service
	The ignition pump is excessively delayed (or spark lead changing device is defective).	Correct setting, check the spark lead changing device.	

FAILURE	POSSIBLE ROOT CAUSE	RECOMMENDED TESTS OR REMEDY	NOTES
Anomalous engine fumes. Black or dark grey fumes	Ignition pump spark lead is excessive.	Correct the adjustment.	
	The nozzles (or some of them) are partially or totally obstructed.	Replace the injectors with a series or new injectors or, as an alternative, clean and recondition the original ones using the specific equipment.	
	Clogged or deteriorated air filter.	Clean or replace the air filter.	
	Loss of compression within the engine due to: worn or stuck snap rings; worn cylinder barrel; deteriorated or incorrectly calibrated valves.	Overhaul the engine or limit the inspection to the parts of interest.	
	Unsuitable injectors' type, different type of injectors or incorrectly calibrated injectors.	Replace the injectors.	
	Incorrect ignition pipe internal diameter, dented pipe ends due to repeated locking.	Check the conditions of the pipe ends or pipe fittings and eventually replace the pipes.	
Blue, blue-grey and whitish grey fumes.	Excessive spark lead.	Adjust the pump setting.	Apply to FPT Technical Service
	K.S.B. automatic cold spark lead device is not malfunctioning.	Calibrate the ignition pipe or replace the K.S.B. unit.	Apply to FPT Technical Service
	Defective injectors.	Replace the injectors.	
	Oil leakage from the piston rings caused by worn or stuck rings or barrels worn inside.	Overhaul the engine	
	Engine oil leaking through the intake valve guides, due to worn guides or valve stems.	Recondition the cylinder head.	
	Engine is too cold (thermostat is not working or defective)	Replace the thermostat.	

PART FOUR - MAINTENANCE PLANNING

SCHEDULED MAINTENANCE
Servicing Plan

Engine lubrication frequency has been calculated presuming the use of fuel with content of Sulphur < 0.5%. WARNING! In case of use of fuel containing a percentage of Sulphur e > 0.5 %, the engine oil replacement interval must be halved.

Use engine oil SAE: 10W30, 15W40, 20W40; Standard ACEA E7, APIC13

Overhaul and/or basic maintenance

Checks and regular servicing	Frequency (hours)
Engine visual inspection	Daily
Check engine oil level	Daily
Check air filter	Daily
Check battery	Every six months
Check cooling liquid level	Daily
Check the wear conditions of the alternator's belt and of the water pump	500 (2)
Check for presence of water in the filter	Every six months (1)
Tappet check and adjustment	1000
Change engine oil	500
Replace engine oil filter	500
Replace fuel filter	500 (3)
Replace the alternator's belt and the water pump	1000
Change the cooling liquid	Every 2 years

(1) Using fuel complying with EN590 Standard

(2) Depending on appliance

(3) Using filters with filtering degree < 12 μ and β > 200 μ filtering efficiency

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 of 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.

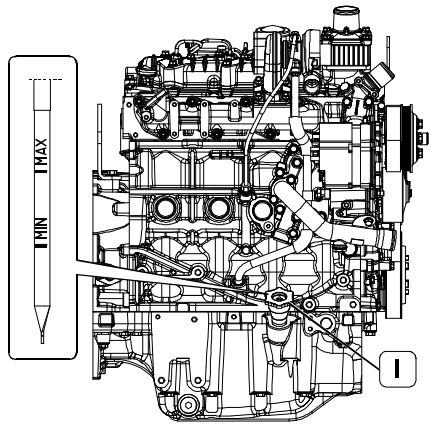
MAINTENANCE PROCEDURES
Checks and controls

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 96



Draw off the rod (1) 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.

Use only recommended oil or oil having the requested feature for the motor functioning. In case of topping up, don't mix oils having different features.

To provide filling, operate through the lateral top (1).

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 of from the heat exchanger.

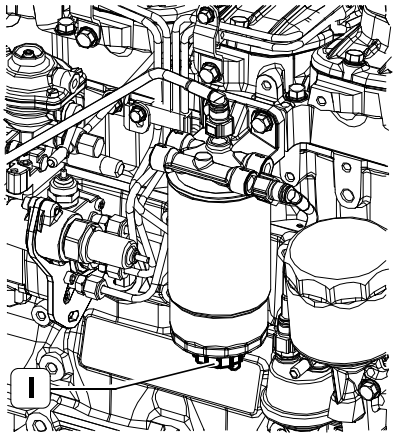
The engine oil is highly polluting and harmful.
In case of contact with the skin, rinse well with water and detergent.
Adequately protect the skin and the eyes, operate in full compliance with safety regulations.
Disposal must be carried out properly, and in full compliance with the law and regulations 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.

Figure 97



127699

Fuel filter is equipped with pump tap-valve (1) to drain the water eventually mixed with fuel.

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

Lock the tap (1) (max 0.5 Nm locking couple) as soon as fuel starts bleeding.

Check of belt's tear and wear status

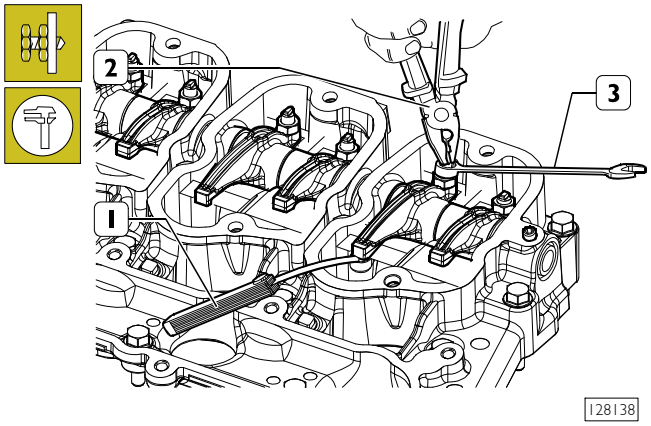
Carefully verify the belt's surface in order to detect any sign of incision, crack, excessive wear in correspondence of toothing; check end and surface grinding.

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 98



On TIER 3 engines with internal EGR it is not possible to use the valve clearance adjustment procedure in which all the valve clearances can be checked using just 2 different crankshaft positions.

Each cylinder must be checked by taking it to the T.D.C. (top dead centre) at the end of compression and adjusting the clearance of both valves on the cylinder in question.

Position the crankshaft at TDC of cylinder 1 (see figures 5 and 6).
Rotate crankshaft as required (see table) and check that intake and exhaust valves are both closed and not in a balanced position.

For cylinder 4 it is possible to check the correct position of the crankshaft with tool 99360612.

Adjust the clearance between the rockers and valves using a pair of pliers (2), a wrench (3) and a feeler gauge (1).
Clearance shall be as follows:
- intake valves 0.25 ± 0.05 mm
- exhaust valves 0.50 ± 0.05 mm.

FIRING SEQUENCE 1 - 3 - 4 - 2

Starting and crankshaft rotation	Balance valves of cylinder no.	Adjust clearance of intake and exhaust valves of cylinder no.
From 0.07 to 0.07	1	1
180°	3	3
180°	4	4
180°	2	2

Oilmotor 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.

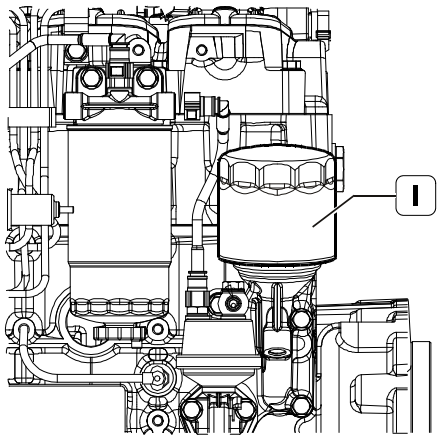
In case of topping up, don't mix oils having different features.

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.

Figure 99



- ❑ The filter is composed by a support and a filtering cartridge. For the cartridge replacement use the 9936076-tool.

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 cartidge (1) with a new one and screw manually until when the gasket, previously moistened by smearing with oil, is in contact with the support.
- ❑ Tigthen by means of the 99360076-tool and lock related nuts at predefined torque.
- ❑ 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.

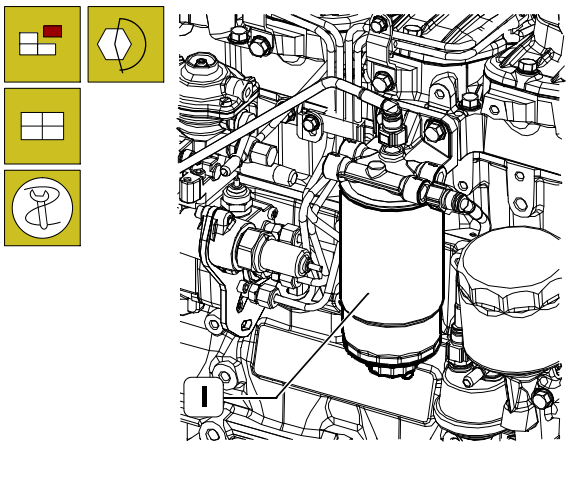
Fuel filter replacement

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.

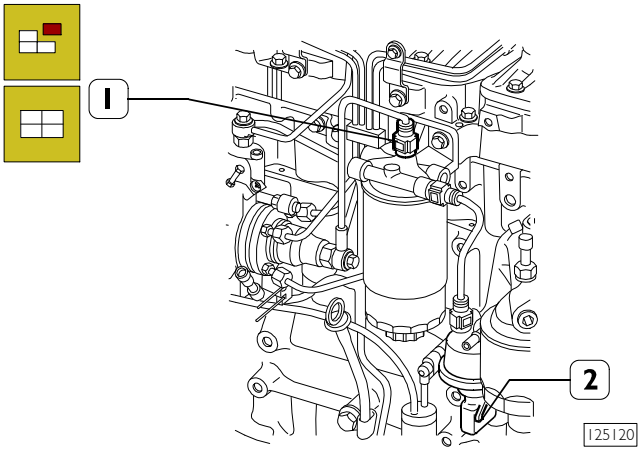
Figure 100



- ❑ Drain the fuel inside the filter by operating the water release tap. Collect the fuel in a container without impurities.
- ❑ Unscrew the cartridge (1) by using the 99360076-tool.
- ❑ 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 cartdrige until when the gasket is completely on its seat.
- ❑ Tigthen through the 99360076-tool at 16-20 Nm torque.

Bleeding procedure:

Figure 101



- ❑ Loosen the fuel outlet manifold, located on the upper part of the filter (1).
- ❑ Make sure that any diesel coming out will not dirty the auxiliary member drive belt or be dispersed into the environment.
- ❑ Use the pre-filter hand pump until the diesel coming out is free from any residual air or perform the same operation using the mechanical feed pump (2).
- ❑ Lock the manifold loosened as above to the required torque.
- ❑ Dispose of any diesel expelled during the above operation in accordance with the law.
- ❑ Start the engine and run it at minimum speed for a few minutes to eliminate any residual air.

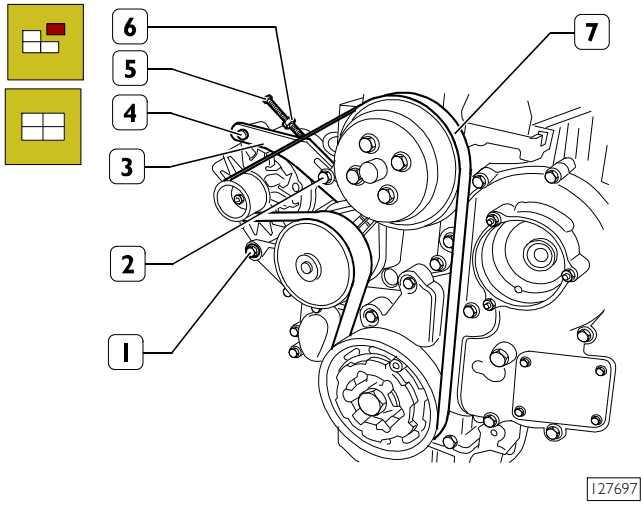
NOTE Should it be necessary to accelerate the bleeding phase, the hand pump can be used during start-up.

Alternator belt replacement

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 102

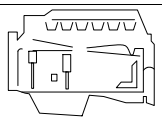
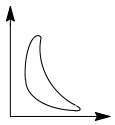
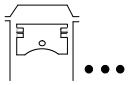
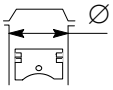
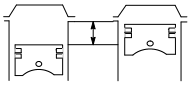
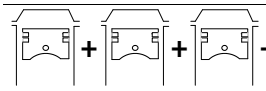
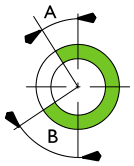
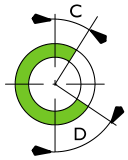
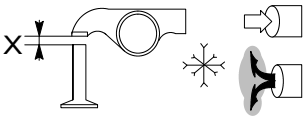
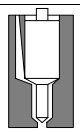
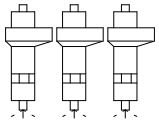


- ❑ Loosen screw (3) and the relevant nut on belt stretching bracket (4).
- ❑ Loosen the screws (7, 8, 2) and the screw nut (1) in order to withdraw the belt (4).
- ❑ Fit the new belt (4) on the pulleys and guide rollers.
- ❑ Tighten the driving belt (4) screwing up screw (2) until the screw (8) reaches the end of the groove which is on the bracket (5). Tighten the nut (1) and the screw (8).
- ❑ Tighten the screw (3) and the bolt (7) that fixes the alternator to the support.

SECTION 4

Mechanical overhaul

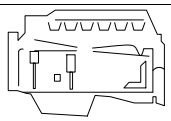
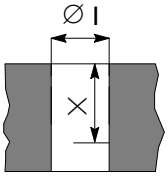
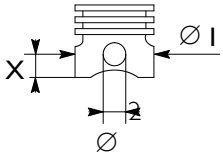
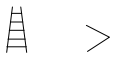
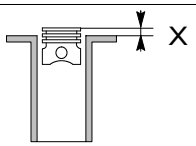
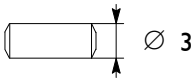
GENERAL SPECIFICATIONS

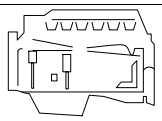
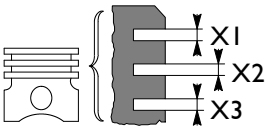
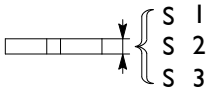
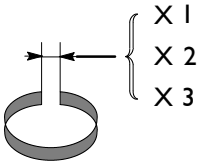
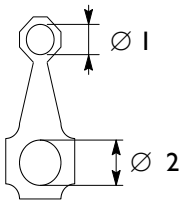
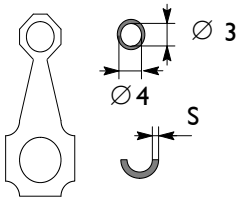
	Type		4 CYLINDERS
	Cycle		Diesel* 4 strokes
	Power		See the specifications reported in Section 3
	Injection		Direct
	Number of cylinders		4
	Bore	mm	99
	Stroke	mm	104
	Total displacement	cm^3	3200
   	**TIMING** start before T.D.C. end after B.D.C. start before B.D.C. end after T.D.C.	 A B D C	 19° ± 30' 37° ± 30' 61° ± 30' 21° ± 30'
	Checking timing X	 mm mm	 0.25 ± 0.05 0.50 ± 0.05
	FUEL FEED Injection Type:	 Bosch	 VE 4/12F
	Nozzle type		BOSCH DSLA138PV 33
	Injection sequence		1 - 3 - 4 - 2

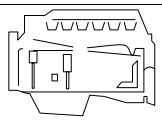
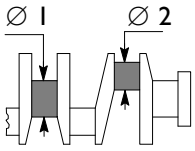
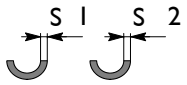
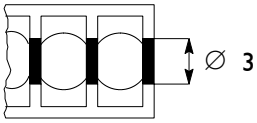
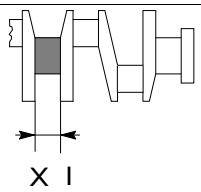
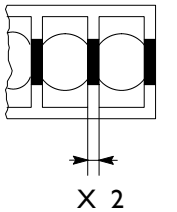
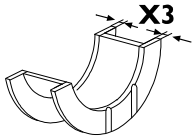
* Only use normally available diesel fuel (Standard EN 590).

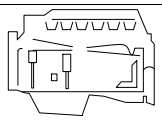
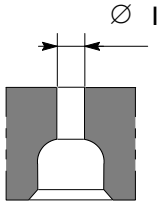
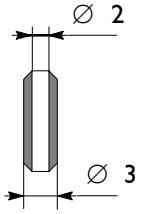
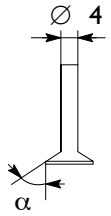
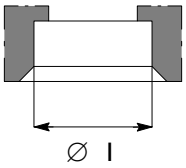
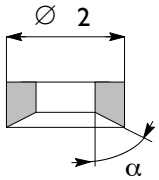
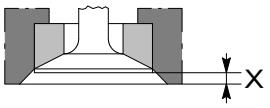
NOTE EN 590 specifications distinguish different classes of diesel fuel, identifying the characteristics of those best suited to low temperatures
It is entirely up to the Oil companies to comply with these regulations, which foresee that fuels suited to the climactic and geographic conditions of the various Countries be distributed.

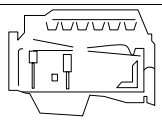
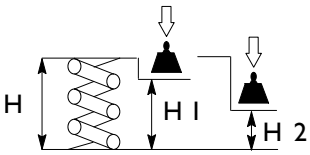
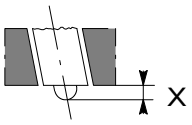
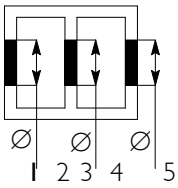
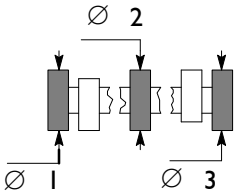
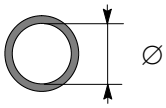
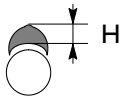
DATA - ASSEMBLY SLACKS

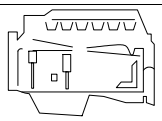
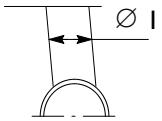
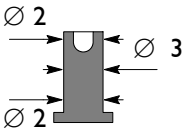
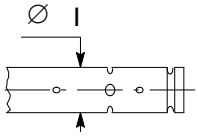
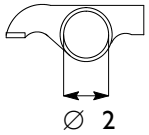
	Type	4 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		mm
	Cylinder barrels Ø1 > Ø1	99 to 99.02 0.4
	Spare pistons type: Size X Outside diameter Ø 1 Pin housing Ø 2	 10 98.908 to 98.918 36.003 to 36.009
	Piston – cylinder barrels	0.082 to 0.112
	Piston diameter Ø 1	0.4
	Piston protrusion X	-0.22 ÷ +0.07
	Piston pin Ø 3	35.996 to 35.999
	Piston pin – pin housing	0.004 to 0.013

	Type	4 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		**mm**
	Split ring slots X1* X 2 X 3 * theoretical measurement on a Ø of $96^{-0.25}$ mm	2.21 2.05 to 2.07 2.54 to 2.56
	Split rings S 1* S 2 S 3 *measured at 1.5 mm from external Ø	2.068 to 2.097 1.970 to 1.990 2.470 to 2.490
	Split rings - slots 1 2 3	- 0.060 to 0.100 0.050 to 0.090
	Split rings	0.4
	Split ring end opening in cylinder barrel: X 1 X 2 X 3	 0.20 to 0.35 0.60 to 0.80 0.30 to 0.60
	Crankshaft bearing bush seat Ø 1 Big end bearing seat X 0	39.460 to 39.49 67.833 to 67.841 67.842 to 67.848
	Crankshaft bearing bush diameter Internal Ø 4 Ø 3 Crankshaft half bearings Red Blue Green	 36.010 to 36.020 39.570 to 39.595 1.875 to 1.884 1.883 to 1.892 1.891 to 1.900
	Piston pin – bush	0.011 to 0.024
	Big end half bearings	0.254; 0.508

	Type		4 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS			mm
	Crankshaft bearing pins No. 1-2-3-4 No. 5 Big end bearing pins	 Ø 1 Ø 1 Ø 2	 76.182 to 76.208 83.182 to 83.208 64.015 to 64.038
	Crankshaft half bearings Big end half bearings	S 1 S 2	2.165 to 2.174 1.877 to 1.883
	Crankshaft supports No. 1-2-3-4 No. 5	 Ø 3 Ø3	 80.588 to 80.614 87.588 to 87.614
	Half bearings – Journals No. 1-2-3-4 No. 5		 0.064 to 0.095 0.059 to 0.100
	Half bearings - Crankpins		0.033 to 0.041
	Main half bearings Big end half bearings		0.127; 0.254; 0.508
	Crankshaft pin for shoulder	X 1	31.85 to 32.150
	Crankshaft support for shoulder	X 2	32.50 to 32.55
	Shoulder half-rings	X 3	2.51 to 2.56
	Engine drive shaft shoulder		0.095 to 0.270

	Type		4 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM			**mm**
	Valve guide seats on cylinder head	Ø 1	12.960 to 12.995
	Valve guides	Ø 2 Ø 3	0.023 to 8.038 12.950 to 12.985
	Valves:		
		Ø 4 α	7.985 to 8.000 60° 30' ± 0° 10'
		Ø 4 α	7.985 to 8.000 60° 30' ± 0° 10'
	Valve stem and guide		0.040 to 0.053
	Valve seat on cylinder head		
		Ø1	39.987 to 40.013
		Ø1	43.787 to 43.813
	Valve seat outside diameter; valve seat angle on cylinder head:		
		Ø 2 α	40.063 to 40.088 60° ± 1°
		Ø 2 α	40.863 to 43.88 60° ± 1°
	Recessing of valve	X X	0.3 to 0.7 0.3 to 0.7
	Between valve seat and head		0.050 to 0.101 0.050 to 0.101
	Valve seats		-

	Type		4 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM			**mm**
	Valve spring height: free spring under a load equal to: 270 N 528 N	 H H1 H2	 44.6 34 23.8
	Injector protrusion	X	1.7 to 2.35
	Seat for camshaft no. 1 bushes (flywheel side) Camshaft housings No. 2-3-4 No. 1-5		59.222 to 59.248 50.069 to 50.119 40.069 to 40.119
	Camshaft supporting pins 1 2 ⇒ 4 5	 Ø	53.995 to 54.045 39.975 to 40.025 49.975 to 50.025 53.995 to 54.045
	Bush inside diameter	Ø 5	54.083 to 54.147
	Bushes and journals		0.038 to 0.162
	Cam lift:  	 H H	 5.511 6.213

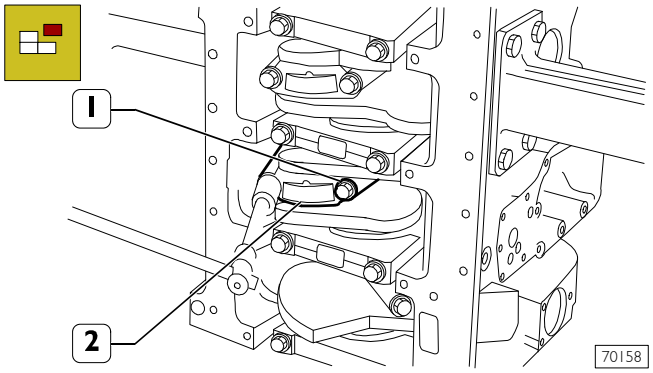
	Type		4 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM			**mm**
	Tappet cap housing on block	Ø 1	15,000 ÷ 15,018
	Tappet cap outside diameter:	Ø 2 Ø 3	15.924 to 15.954 15.960 to 15.975
	Between tappets and housings		0.03 to 0.068
	Tappets		-
	Rocker shaft	Ø 1	18.979 to 19.000
	Rockers	Ø 2	19.020 to 19.033
	Between rockers and shaft		0.020 to 0.054

ENGINE OVERHAUL
ENGINE DISASSEMBLY ON BENCH

To execute the operations described here following, it is necessary to fit the engine on the rotary stand after having removed all the appliance's specific components (see Section 3 of the herein manual).

This section illustrates all the more important procedures of engine bock overhaul.

Figure 1

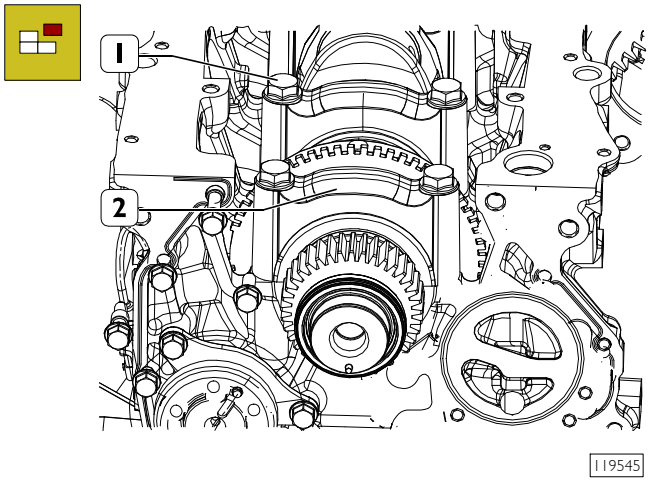


Loosen the screws(1) fastening the connecting rod caps (2) and remove the fastening the connecting rod caps.

Withdraw the pistons with the connecting rods from the upper part of the crankcase.

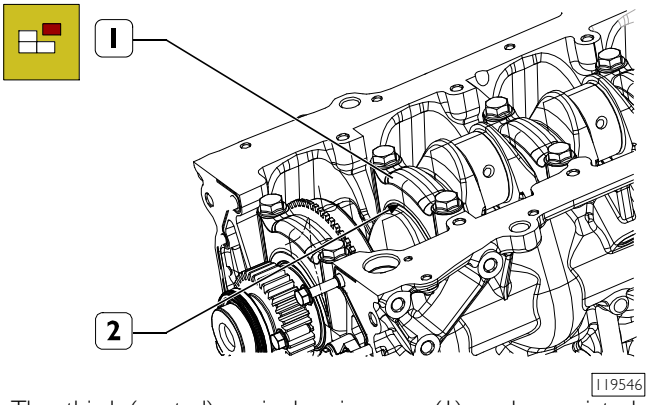
NOTE Keep the half bearings in their respective housings since, in case of reuse after the overhaul, they will have to be reassembled in the same position.

Figure 2



Loosen the screws (1) and disassemble the crankshaft bearing caps (2).

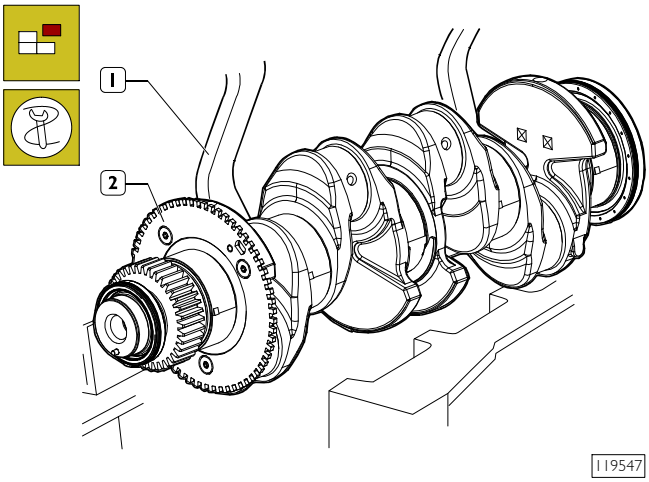
Figure 3



The third (central) main bearing cap (1) and associated support have a bearing-half (2) equipped with thrust.

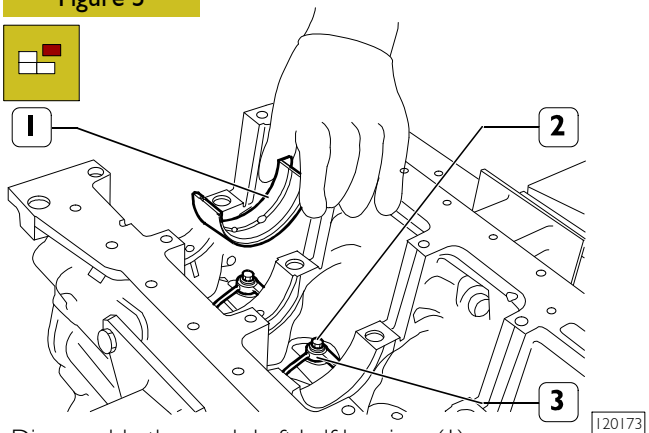
NOTE Note down the assembly position of the upper and lower half bearings since, in case of reuse after the overhaul, they will have to be reassembled in the same position.

Figure 4



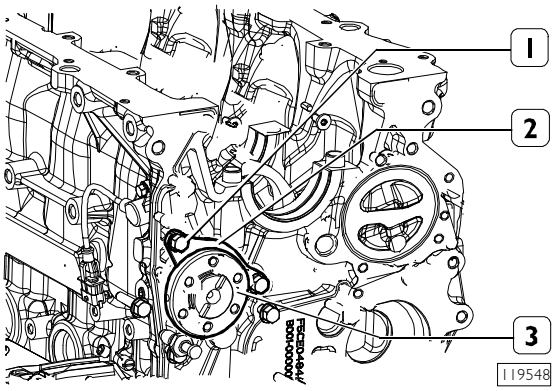
Using tool 99360500 (1) and a hoister, remove the engine drive shaft (2) from the crankcase.

Figure 5



Disassemble the crankshaft half bearings (1).
Loosen the fastening screws (2) and disassemble the oil nozzles (3).

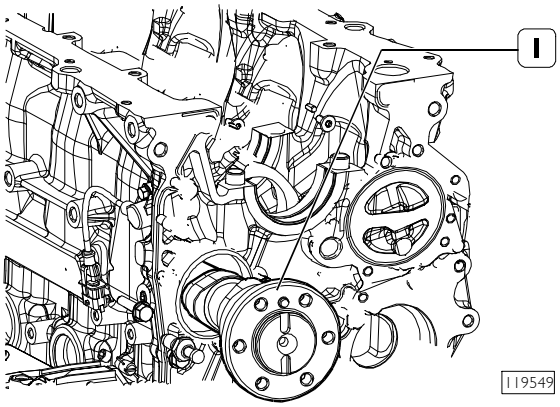
Figure 6



Loosen the fastening screws (1) and disassemble the camshaft (3) holding plate (2).

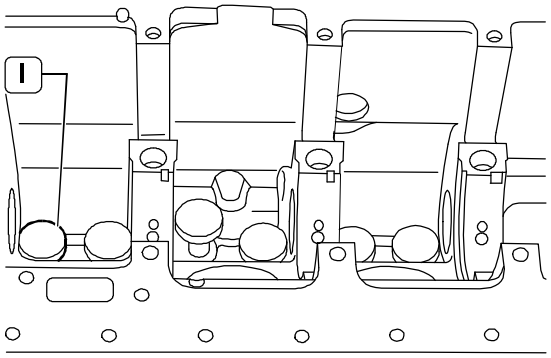
NOTE Note down the plate assembly position (2).

Figure 7



Carefully withdraw the camshaft (1) from the engine bock.

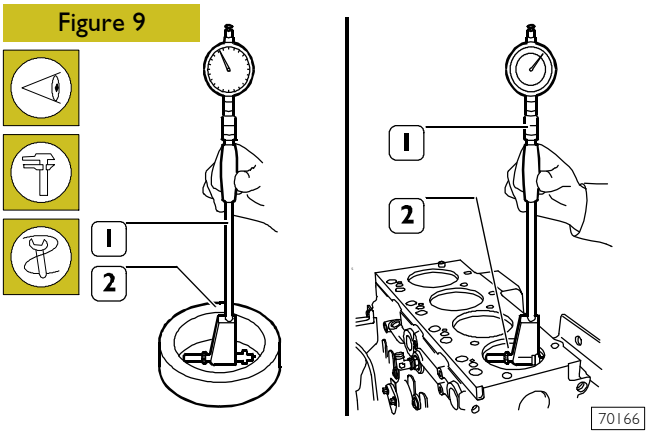
Figure 8



Withdraw the tappets (1) from the engine bock.

REPAIRS
CYLINDER UNIT
Checks and measurements

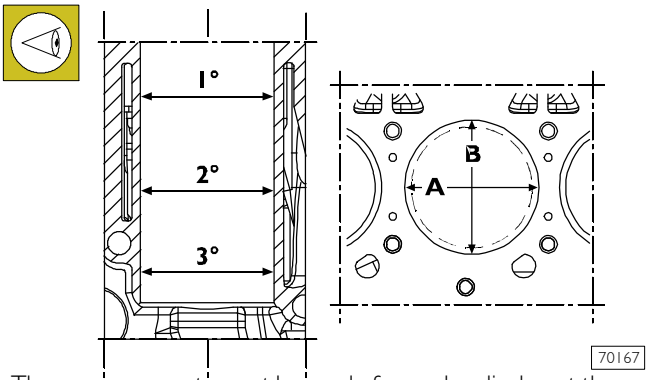
Figure 9



Once completed the engine disassembly, carefully clean the cylinder-crankcase units.
Use suitable eyebolts to handle the cylinder unit. Carefully check the crankcase has for cracks. Check the conditions of the processing caps: replace them if oxidized or in case their tight is doubtful. Check the surface of the cylinder barrels: there must be no trace of meshing, scratches, oval or conical shaping and excessive wear.
Cylinder barrel inner diameter check to detect any oval or conical shaping or wear shall be executed throughout the bore meter (1) equipped with comparator, which must be previously be reset on the ring calliper (2) of the cylinder barrel diameter.

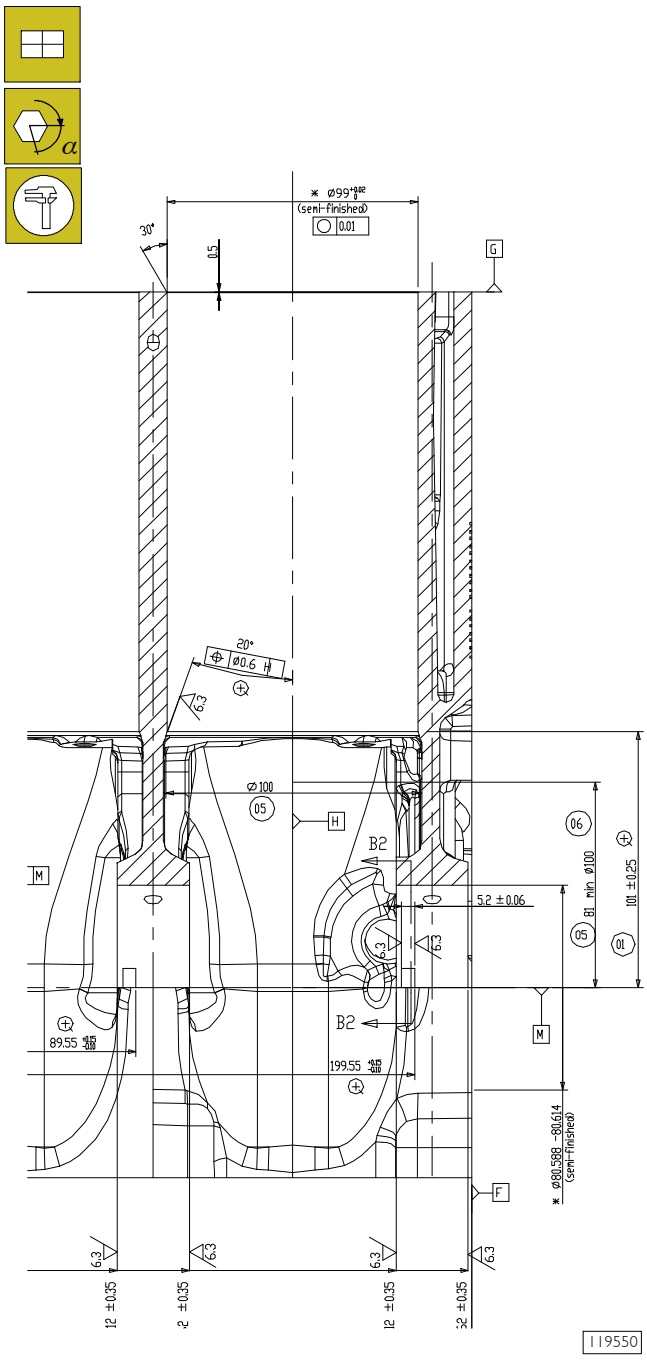
NOTE If the ring calliper is unavailable, use a micrometer for reset.

Figure 10



The measurements must be made for each cylinder, at three different heights from the barrel and on two perpendicular planes: one parallel to the engine longitudinal axle (A) and the other perpendicularly (B). Generally, maximum wear is detected on the perpendicular plane (B) and with the first measurement.
If oval or conical shaping or wear is detected, proceed boring and grinding the cylinder barrels. Cylinder barrel grinding must be executed based on the spare pistons' diameter plus 0,4 mm of the rated value and at the prescribed assembly slack.

Figure 11



NOTE In case of grinding, all the barrels must result having the same oversize (0.4 mm).

Check the crankshaft bearing seats proceeding as follows:

- ❑ fit the crankshaft bearing caps on the supports without bearings;
- ❑ tighten the fastening screws to the prescribed torque setting;
- ❑ with a suitable comparator, check that the inner barrel diameter corresponds to the prescribed value.

If the detected value is higher, replace the crankcase.
Il terzo (quello centrale) cappello di banco (1) e il relativo supporto hanno il semicuscinetto (2) dotato di spallamento.

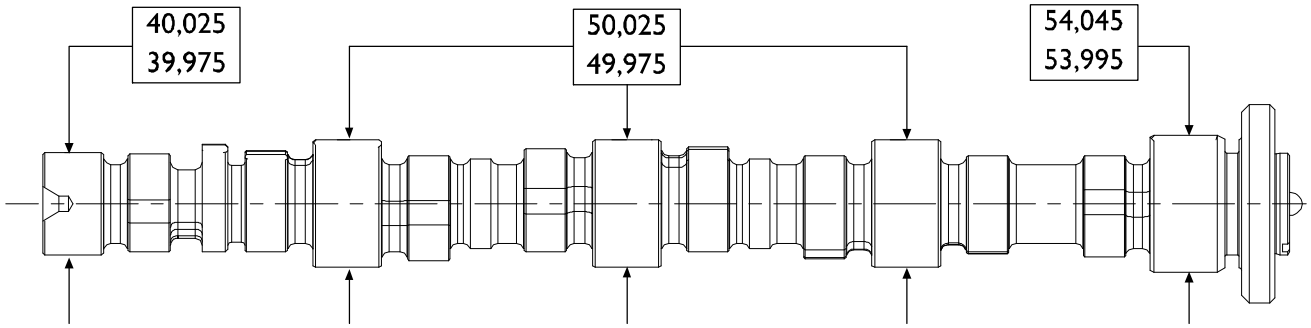
Checking head base surface on cylinder unit

After having detected any deformed areas, grind the head base surface using a grinding machine.

Planarity error must not exceed 0.075 mm. Check the conditions of the cylinder unit processing caps: replace them if oxidized or in case their tight is doubtful.

TIMING SYSTEM
Camshaft

Figure 12



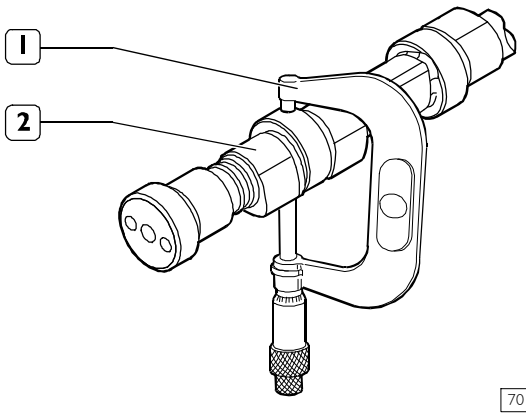
MAIN DATA ABOUT CAMSHAFT PINS

The surface of the camshaft pins and of cams must be extremely smooth. In case any trace of meshing or scratches are detected, replace the shaft and the relevant bushes.

Checking cam lift and pin alignment

Place the camshaft on footstocks and, throughout a centesimal comparator placed on the central support, check that the radial oscillation does not exceed 0.015 mm otherwise replace the shaft.

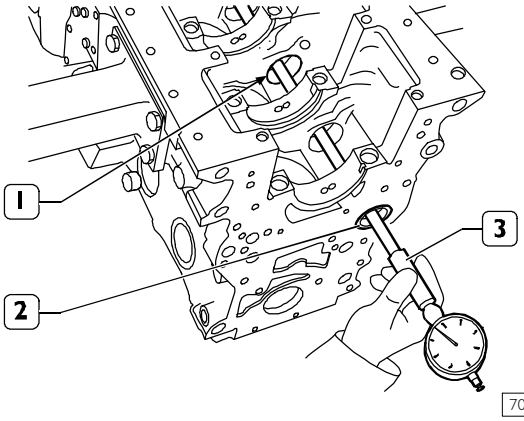
Figure 13



Using a micrometer (1), check the diameter of the camshaft (2) supporting pins on the two perpendicular axles.

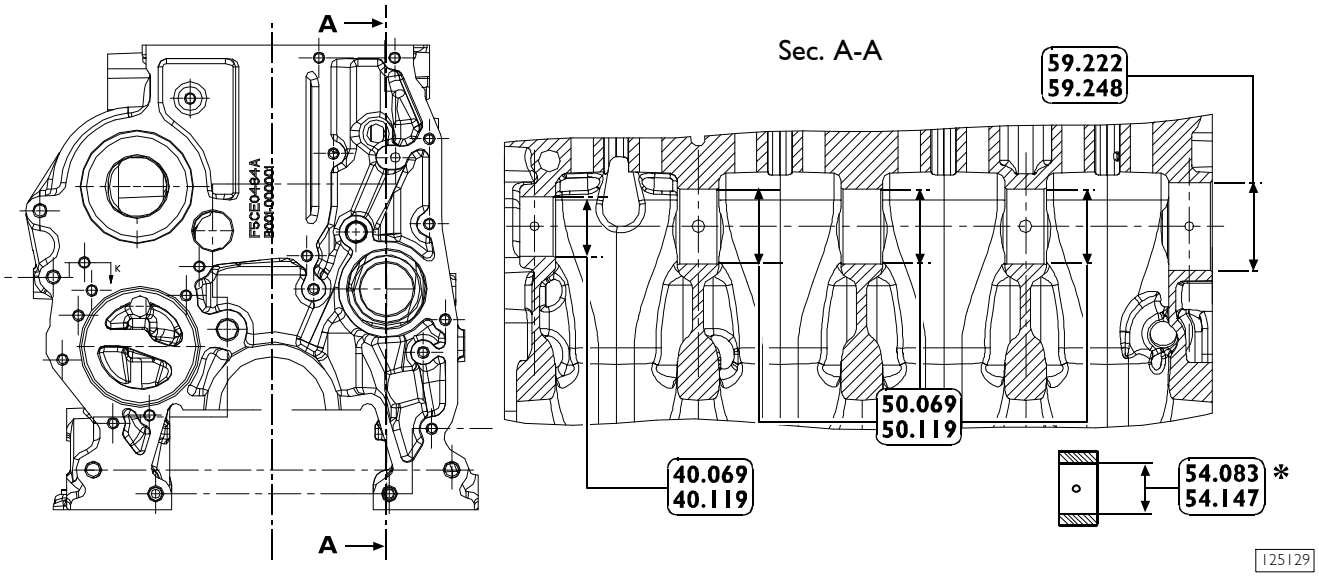
BUSH

Figure 14



The front camshaft bush (2) must be thrust in the respective seat.
There must be no trace of meshing or wear in the inner surface.
Using a bore meter (3) measure the front adiameter of the camshaft bush (2).
Measurements must be made on two perpendicular axles.

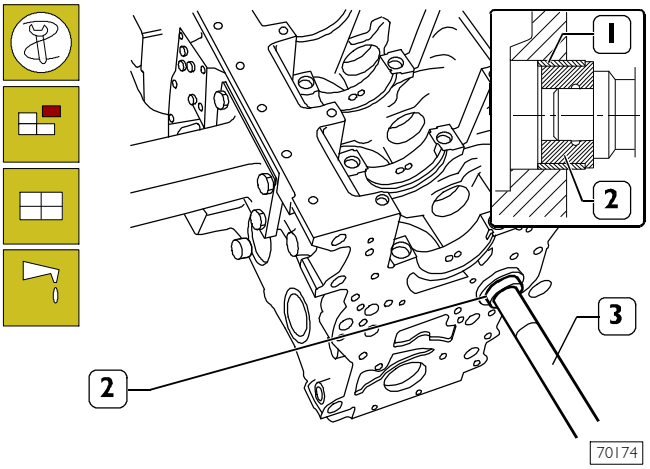
Figure 15



MAIN DATA OF THE CAMSHAFT BUSH AND RELEVANT SEAT
* Quota to obtain after bush fixing.

Bush replacement

Figure 16

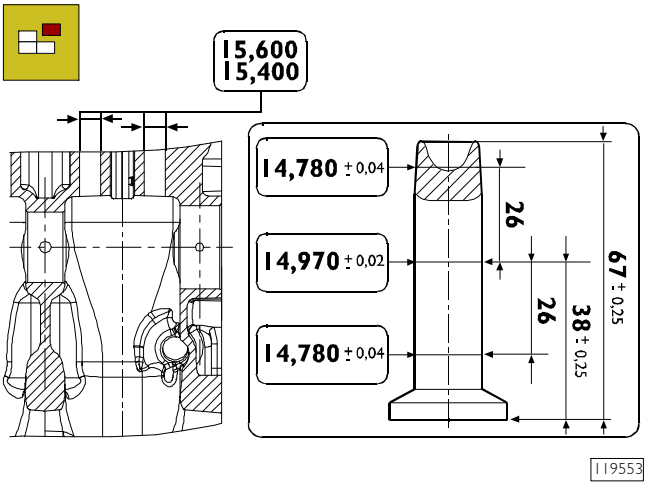


Use the beater 99360362 (2) and handgrip 99370006 (3) to disassemble and replace the bush (1).

NOTE In phase of assembly, the bush (1) must be oriented making the lubrication ports coincide with those on the crankcase.

Tappets

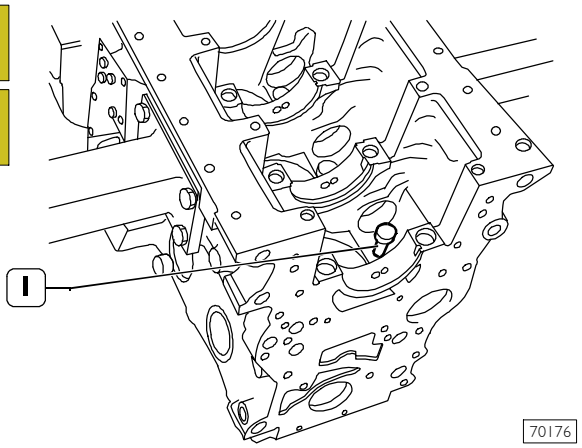
Figure 17



TAPPET AND RELEVANT SEAT ON CRANKCASE MAIN DATA

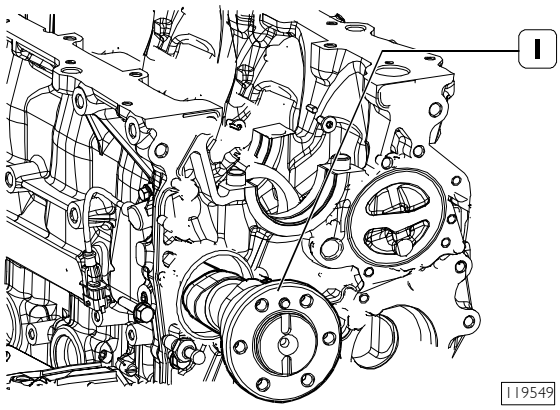
Tappet - camshaft assembly

Figure 18



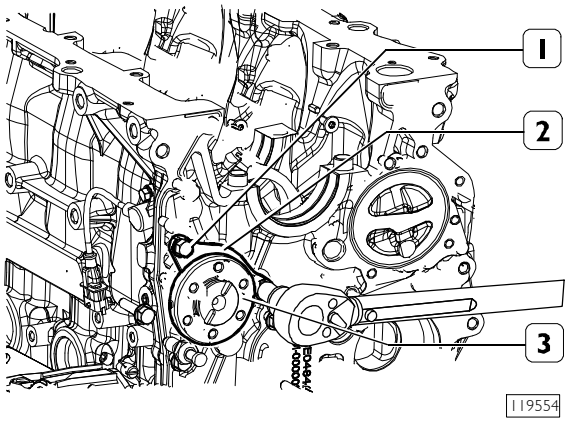
Lubricate the tappets (1) and fit them into the relevant seats on within the crankcase.

Figure 19



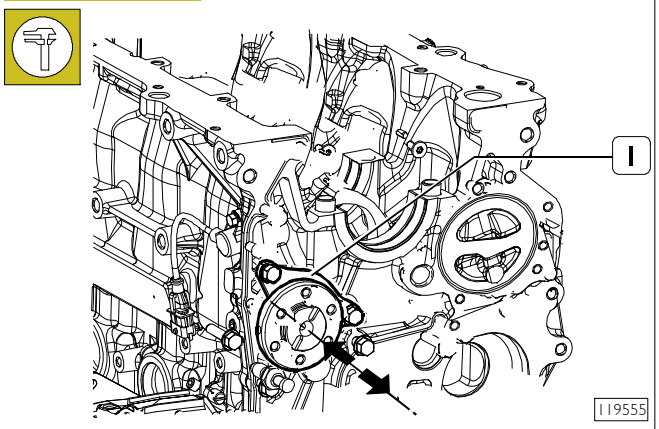
Lubricate the camshaft supporting bush and assemble the camshaft (1) paying attention, during the aforesaid operation, not to damage the bush or the shaft's seats

Figure 20



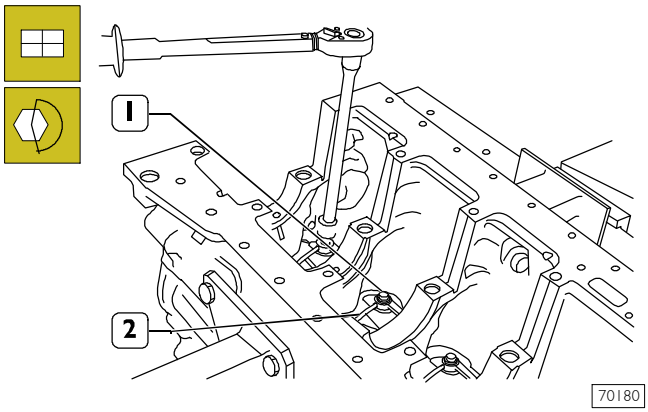
Position the camshaft (3) holding plate (1) with the slot towards the upper side of the crankcase and the marking towards the operator; tighten the fastening screws (2) to the prescribed torque setting.

Figure 21



Check the camshaft axial shaft (1).
The prescribed value is 0.23 ± 0.1 3 mm.

Figure 22

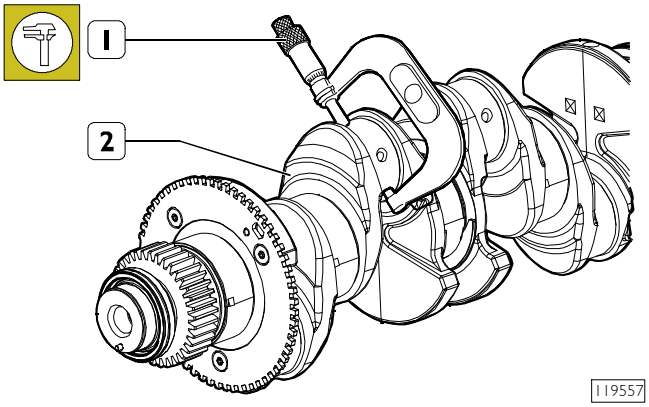


Fit the nozzles (2) and tighten the fastening screws (1) to the prescribed torque setting.

ENGINE DRIVE SHAFT

Measurement of main journals and crankshaft bearing pins

Figure 23



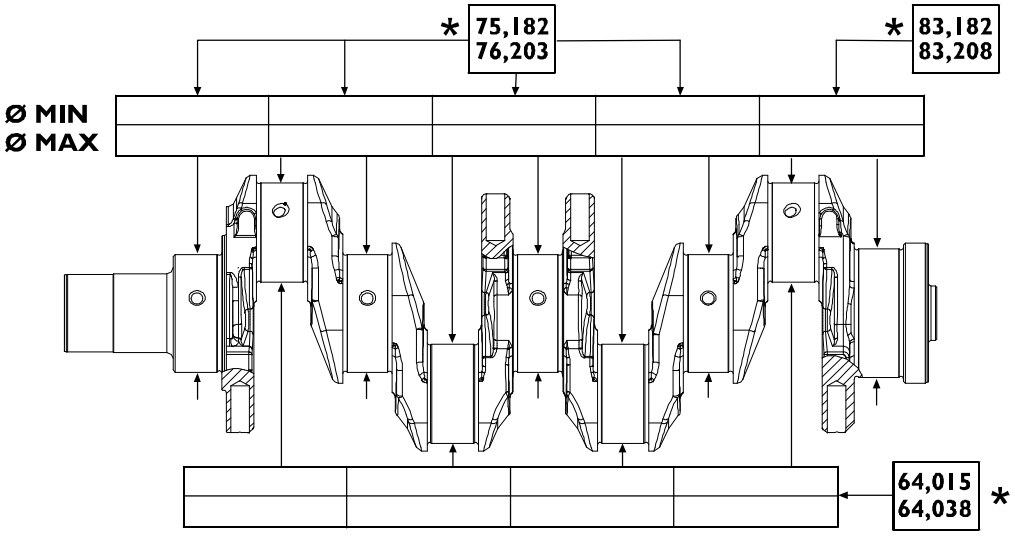
In case meshing, scratches or excessive oval shaping is detected on the main journals and crankshaft bearing pins, it is necessary to grind the pins. Before proceeding with pin (2) grinding, measure the shaft pins by means of a micrometer (1) in order to establish to which diameter the pins must be reduced.

NOTE Itis recommended to note down the values detected in a prospect.
See Figure 24.

Undersize classes are: 0.254 - 0.508 mm.

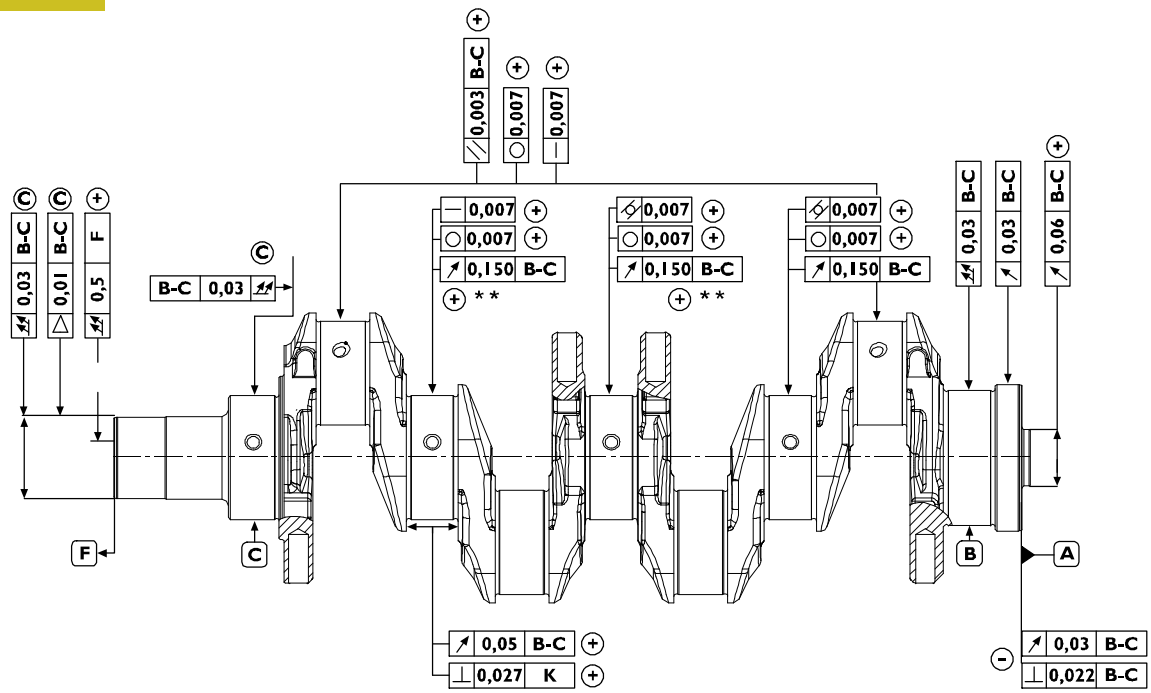
NOTE The main journals and crankshaft bearing pins must always be grinded to the same undersize classes in order not to alter the shaft's balance.

Figure 24



PROSPECT REPORTING MEASUREMENT VALUES OF
THE ENGINE DRIVE SHAFT MAIN JOURNALS AND CRANKSHAFT BEARING PINS
* Rated value

Figure 25

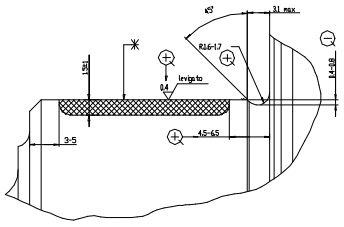


ENGINE DRIVE SHAFT MAIN TOLERANCES

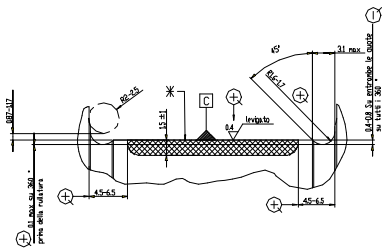
TOLERANCES	TOLERANCE CHARACTERISTIC	GRAPHIC SYMBOL
SHAPE	Roundness	○
	Cilindricity	/○/
DIRECTION	Parallelism	//
	Verticality	⊥
	Straightness	—
POSITION	Concentricity or coaxiality	◎
OSCILLATION	Circular oscillation	↗
	Total oscillation	⌰

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

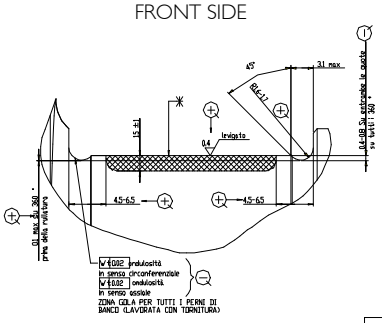
TIMING SIDE BENCH



INTERMEDIATE BENCHES

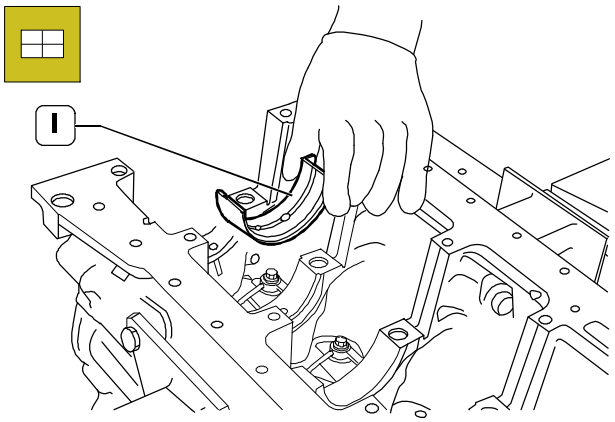


FIRST BENCH ON FRONT SIDE



Crankshaft bearing assembly

Figure 26



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NOTE If it is not necessary to replace the crankshaft bearings, these shall be reassembled in the same order and position they were before disassembly.

The spare crankshaft bearings (1) have undersize internal diameter of 0.254 - 0.508 mm.

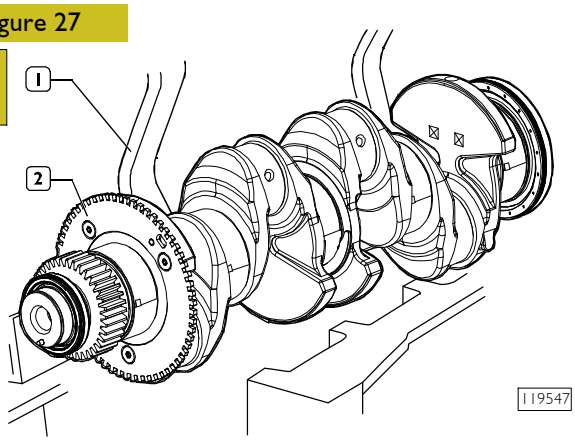
NOTE Do not try to adapt the bearings.

Carefully clean the crankshaft half bearings (1) having lubrication port and fit them in their respective seats.

The penultimate crankshaft half bearing (1) is provided with shoulder half rings.

Crankshaft assembly

Figure 27



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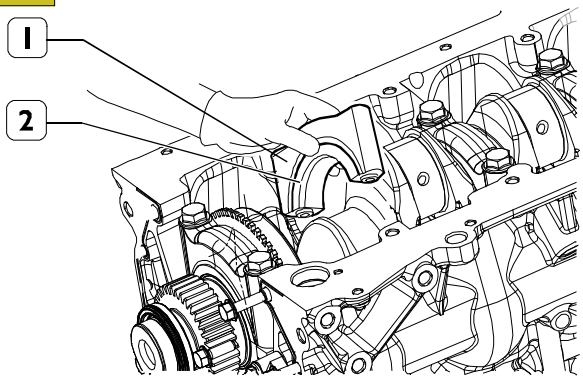
Assemble the engine drive shaft (2).

Figure 28



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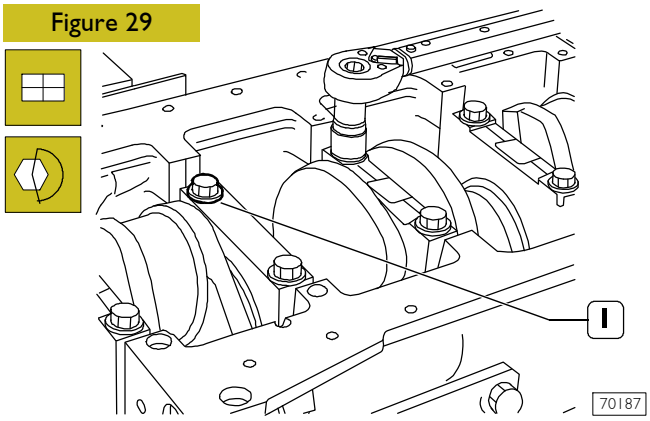
- ❑ carefully clean the parts and eliminate any oil residuals;
- ❑ ffit the caps (1) and the half bearings (2) on the relevant supports.

NOTE Always use new screws in phase of assembly.

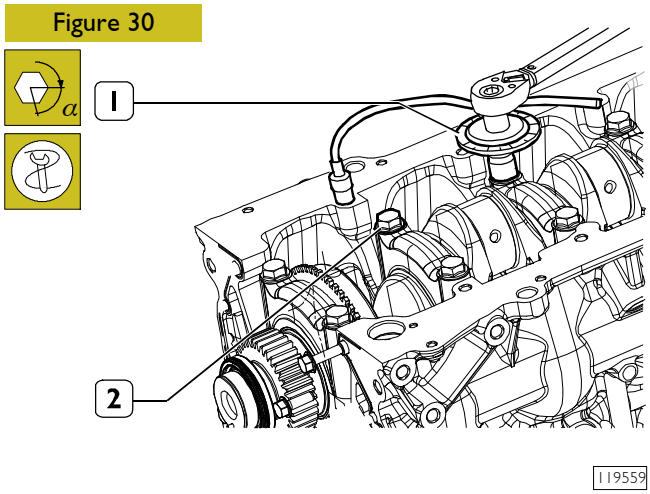
Figure 29



Tighten the pre-lubricated screws (1) and tighten them in three subsequent phases:

- ❑ 1st phase with torque wrench setting at 50 ± 2.5 Nm.
- ❑ 2nd with torque wrench setting at 80 ± 4 Nm.

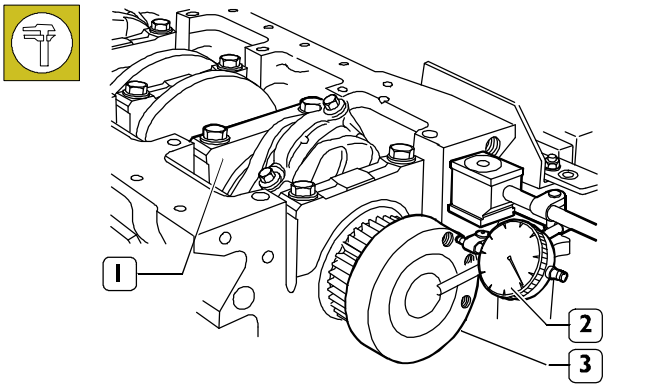
Figure 30



- ❑ 3rd phase using tool 99395216 (1) fitted as shown in the figure and further tighten the screws (2) by 90° ± 4.5° angle.

Checking output shaft shoulder clearance

Figure 31

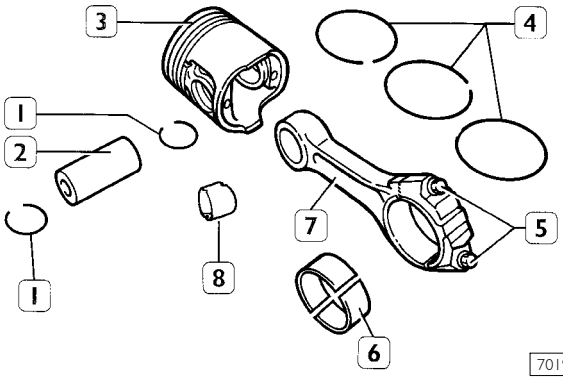


The check of the shoulder clearance is performed with a magnetic based comparator (2) placed on the engine shaft (3) as indicated in the figure.

If the clearance is above the one prescribed replace the semi-crankshaft bearings of the thrust hold rear support next to the last (1) and check again the clearance between the engine shaft pins and the semi-crankshaft bearings.

CONNECTING ROD – PISTON ASSEMBLY

Figure 32

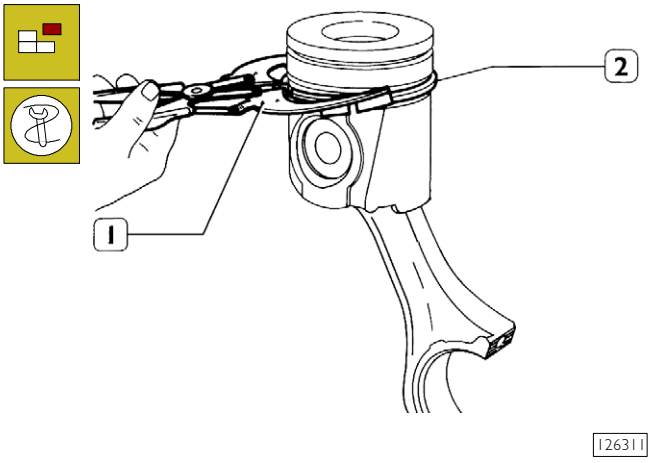


CONNECTING ROD-PISTON UNIT COMPONENTS

1. Grommets. - 2. Pin. - 3. Piston. - 4. Snap rings. - 5. Screws - 6. Half bearings. - 7. Connecting rod. - 8. Bush.

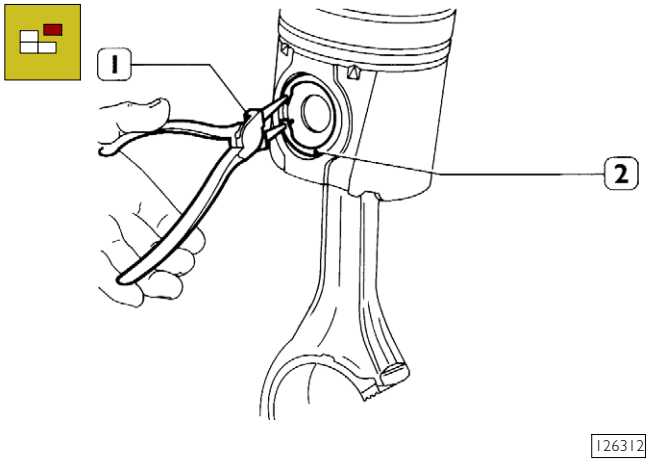
NOTE The spare pistons are supplied with standard dimensions or oversize by 0.4 mm.

Figure 33



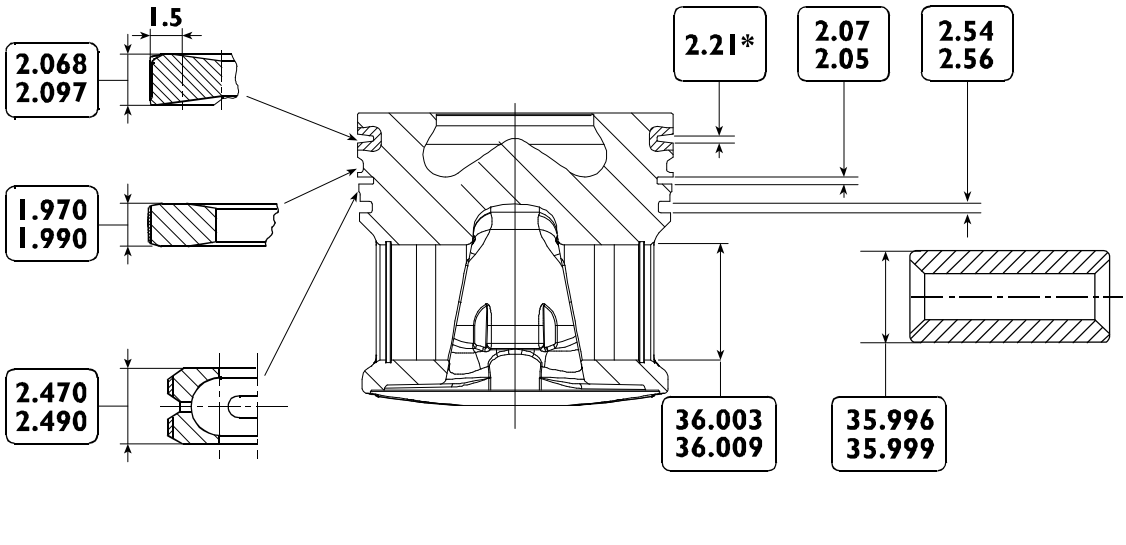
Using pincers 99360183 (1), remove the snap rings (2) from the piston.

Figure 34



Remove the piston pin (2) grommet using the round tippedpliers (1).

Figure 35

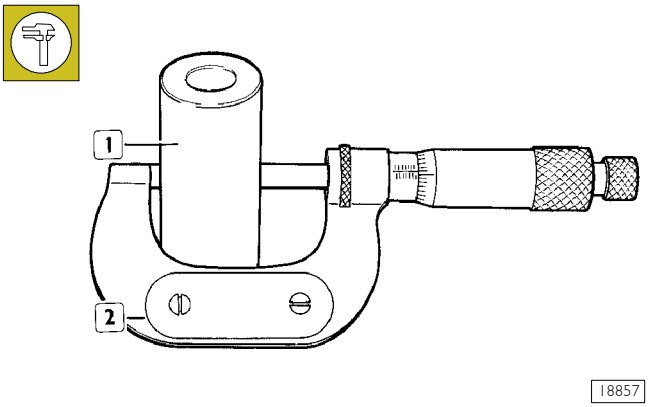


MAIN DATA OF THE PISTON, PINS AND SNAP RINGS

* Quota detected on Ø 96 mm.

Piston pins

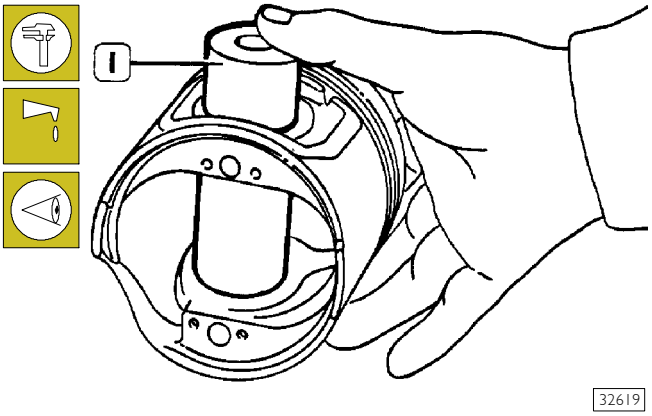
Figure 36



Measurement of the piston pin diameter (1) throughout a micrometer (2).

Conditions for the correct coupling of pins and pistons

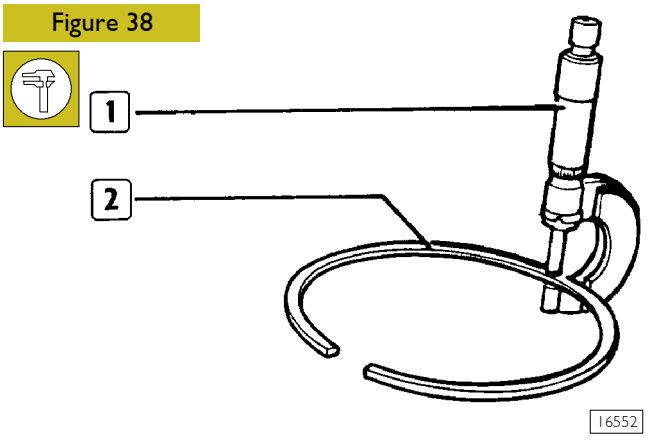
Figure 37



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.

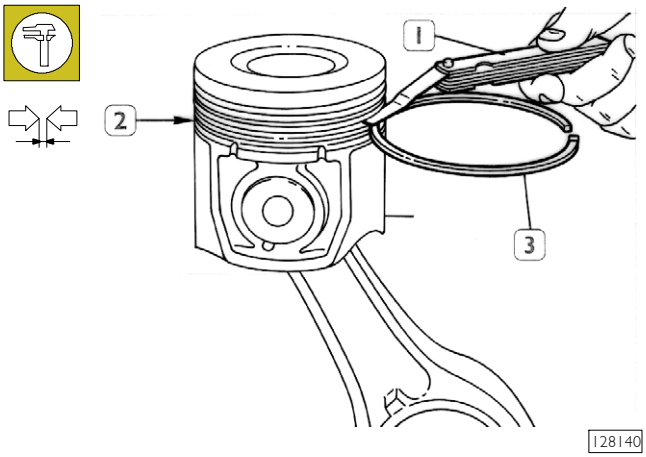
Split rings

Figure 38



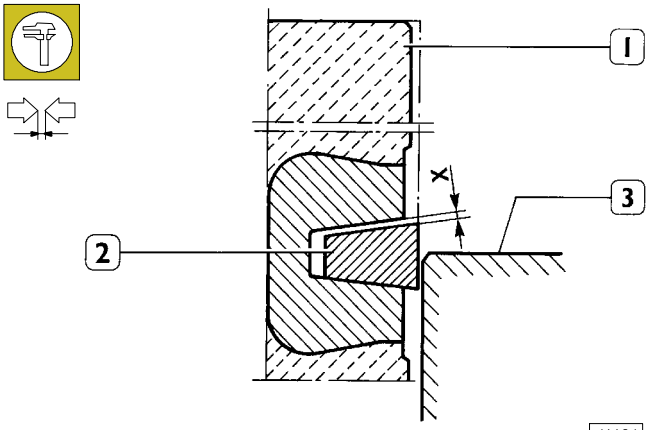
Check the thickness of the grommets (2) throughout a micrometer (1).

Figure 39



Check the slack between the grommets (3) of the 2nd and 3rd slots and relevant housing on the piston (2) using calliper and gauges (1).

Figure 40

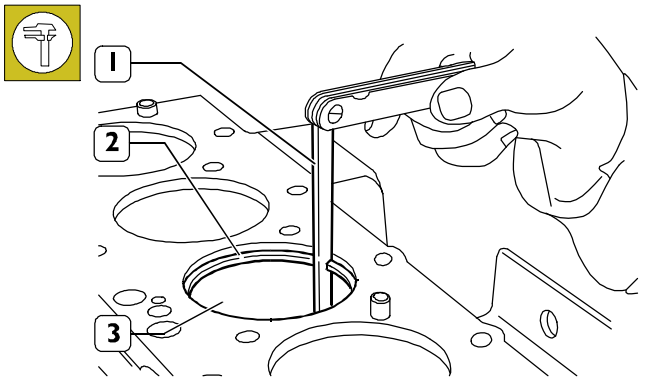


SCHEME FOR THE MEASUREMENT OF SLACK BETWEEN THE FIRST PISTON SLOT AND THE TRAPEZOIDAL GROMMET

Due to the particular for of the first grommet, having trapezoidal section, the slack between said grommet and the slot must be measured as follows: the piston (1) must be projected from the crankcase so that nearly half of the grommet (2) in question comes out of the cylinder barrel (3).

In this position, using a gauge calliper, measure the slack (X) between grommet and slot: the slack must comply with the prescribed value.

Figure 41



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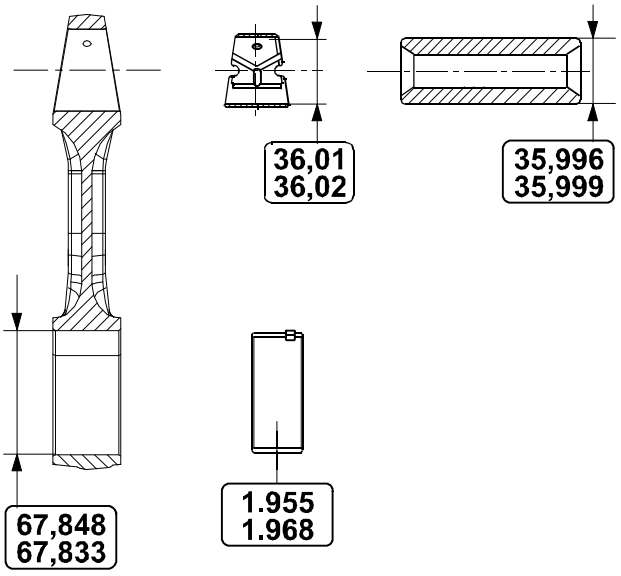
Measurement of slack between the snap ring ends (2) fitted into the cylinder barrel (3) throughout gauge calliper (1).

Connecting rods

Figure 42



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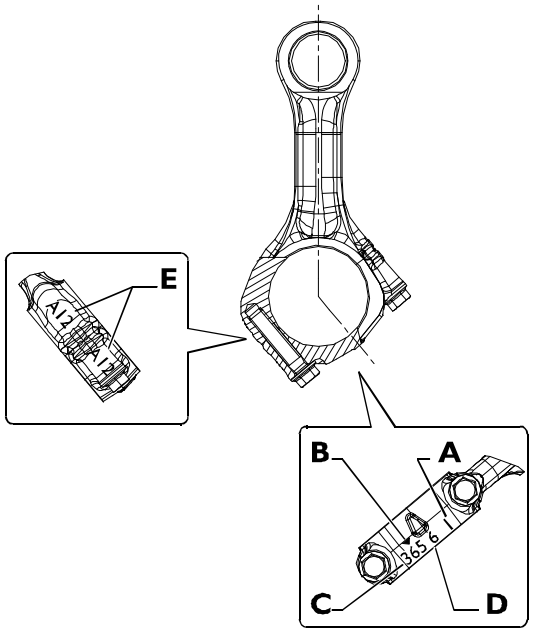
NOTE The connecting rod-connecting rod cap surfaces are knurled to ensure better coupling. Therefore, it is recommended not to remove the knurling.

Figure 43



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A. Class of weight - B. Part number - C. Date of production (DD/MM) - D. Date of production (year) - E. Marking for connecting rod-cap coupling.

NOTE In phase of assembly, ensure that all the connecting rods belong to the same manufacturer and class of weight.

Bushes

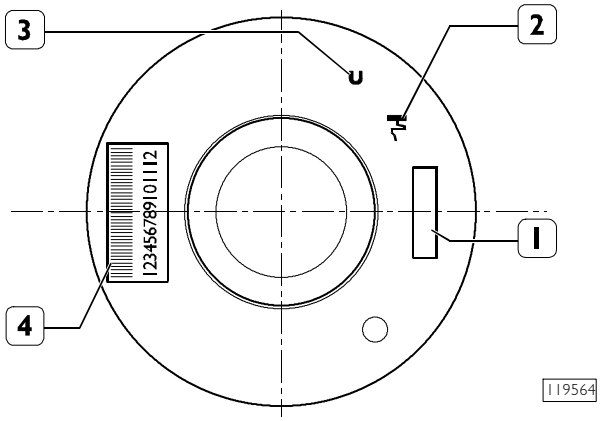
Check that the connecting rod shoe bush is not loose and that there is no trace of meshing or scratches otherwise replace it.

Disassembly and reassembly must be executed using a suitable beater.

When fixing it, make sure that the ports for oil passage on the bush and on the connecting rod coincide. Throughout a boring machine, bore the bush in order to obtain the prescribed diameter.

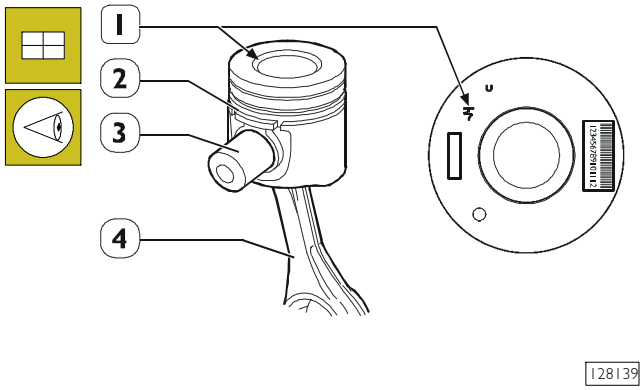
Connecting rod-piston unit assembly
Connecting rod-piston coupling

Figure 44



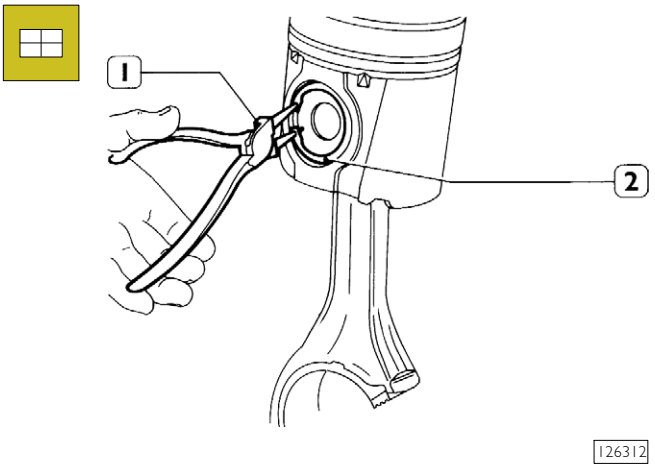
The following references are marked on the piston crown:
1. Spare part number and modification number;
2. Symbol indicating the installation mark for the piston inside the cylinder liner; it should be turned towards the flywheel side (the symbol (2) may be represented as illustrated in the figure or with an arrow, in accordance with production requirements);
3. Stamping proving 1st slot insert inspection;
4. Date of manufacture

Figure 45



Throughout the pin (3), connect the piston (2) to the connecting rod (4) following the indication of the reference arrow (1) to correctly fixing the piston (2) into the cylinder barrel, also taking into consideration the numbers (5) printed on the connecting rod (4), as shown in the figure.

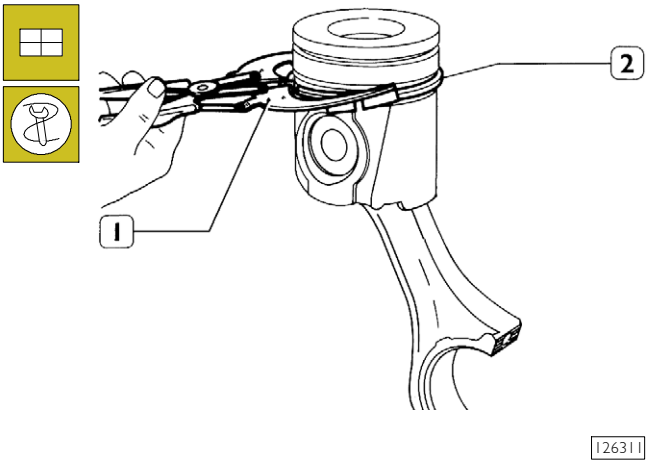
Figure 46



Fit the pin snap rings (2).

Snap ring assembly

Figure 47

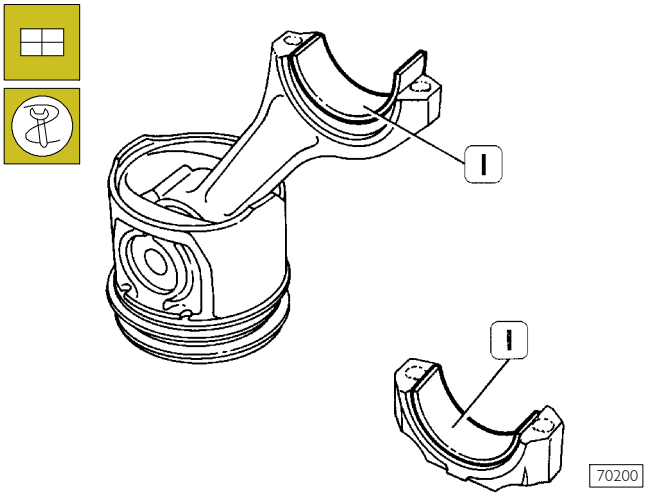


Use the pincers 99360183 (1) to fit the snap fasteners (2) to the piston.
The snap rings must be fitted with "TOP" marking upwards. Furthermore, ring opening must be misaligned by 120°.

NOTE The spare snap rings are available in the following sizes:

- standard;
- oversize by 0.4 mm.

Figure 48

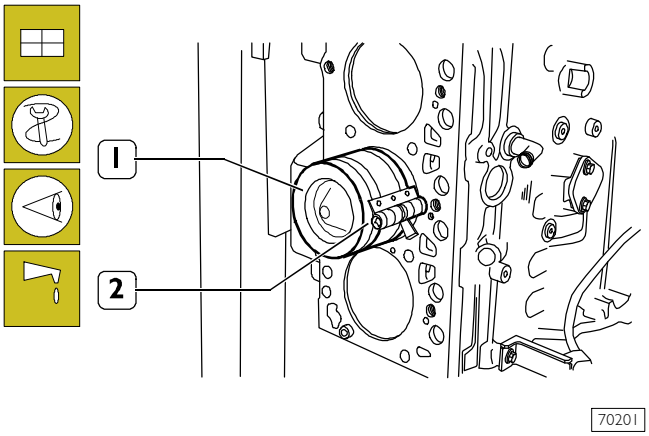


Fit the half bearings (1) on the connecting rod and cap.

NOTE if it is not necessary to replace the big end bearings, reassemble the existing ones in the same order and position they were before disassembly.
Do not adapt the half bearings.

Fitting connecting rod-piston assembly into cylinder barrels

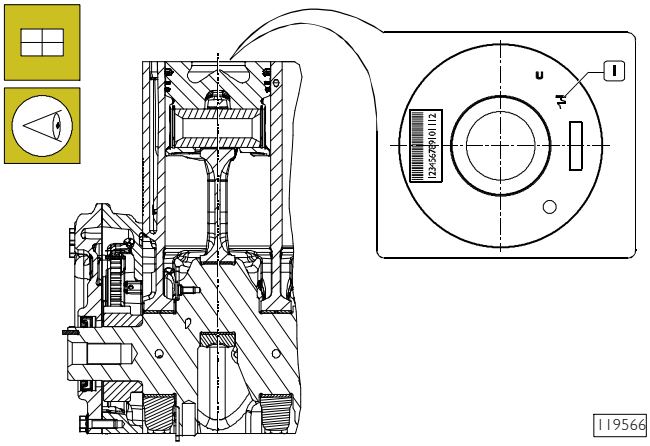
Figure 49



Lubricate the pistons, the snap pins and the cylinder barrel interior.
Using the band 99360605 (2), fit the connecting rod-piston unit (1) into the cylinder barrel, checking that :

- ❑ the number of each connecting rod corresponds to the coupling cap number.

Figure 50



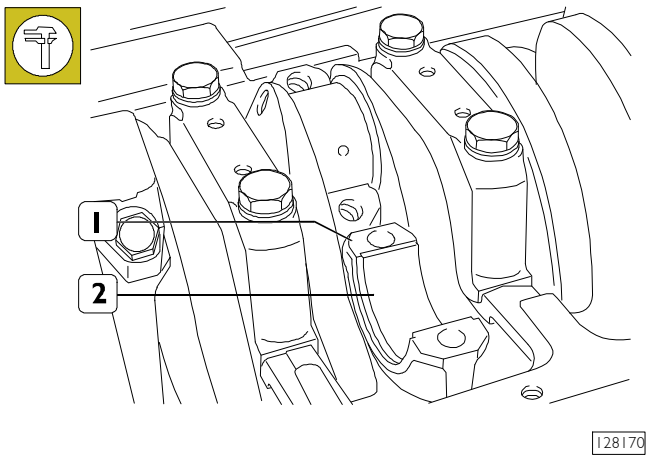
SCHEME FOR CORRECTLY FIXING THE CONNECTING ROD-PISTON UNIT INTO THE HOLLOW

- ❑ The snap rings' openings must be misaligned by 120°;
- ❑ all the connecting rod/piston units must have the same weight;
- ❑ the engine drive shaft sign (1) printed on the piston crown must be turned towards the flywheel while the notch on the piston shield must match the oil nozzles' position.

Warning! The connecting rod must not collide with the cylinder wall.

Connecting rod caps fitting

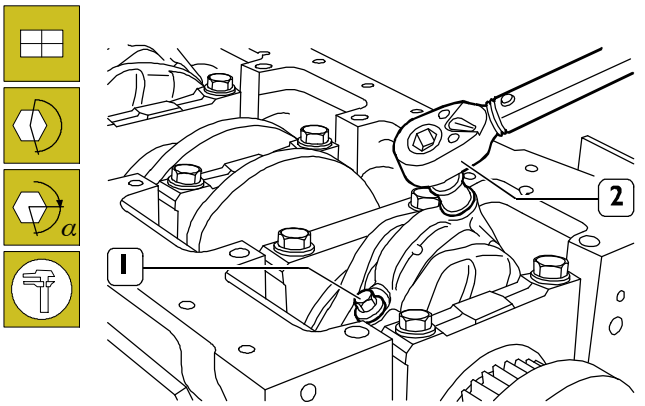
Figure 51



- ❑ carefully clean the parts eliminating any oil residuals;
- ❑ fit the connecting rod caps (1) and the relevant half bearings (2).

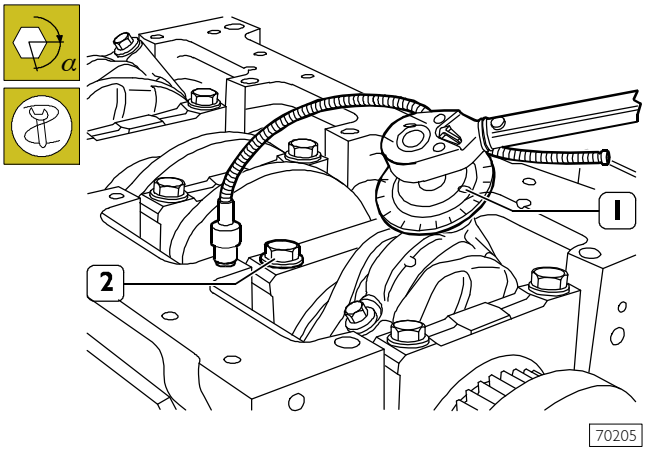
NOTE Always use new screws in phase of assembly.

Figure 52



❑ lubricate the fastening screws (1) with engine oil and tighten them to the prescribed torque setting (50 ± 2.5 Nm) using a torque wrench.

Figure 53



❑ fit the tool 99395216 (1) to the socket wrench and then further tighten the screws (2) by 70° ± 3.5'.

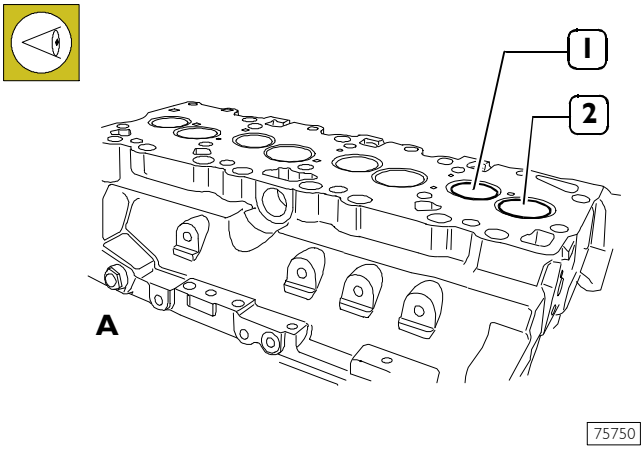
Check manually that the connecting rods are slidingaxially on the output shaft pins.

Piston projection check

NOTE See page 18 of Section 3.

CYLINDER HEAD
Valve disassembly

Figure 54

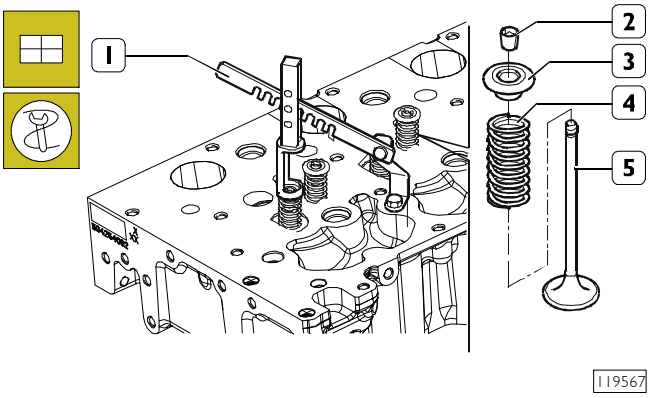


The intake valves (1) and exhaust valves (2) have different head diameter.

NOTE Number the valves before removing them from the cylinder head in order to be able to reassemble them in the same order in case replacement is not necessary.

A = intake side

Figure 55

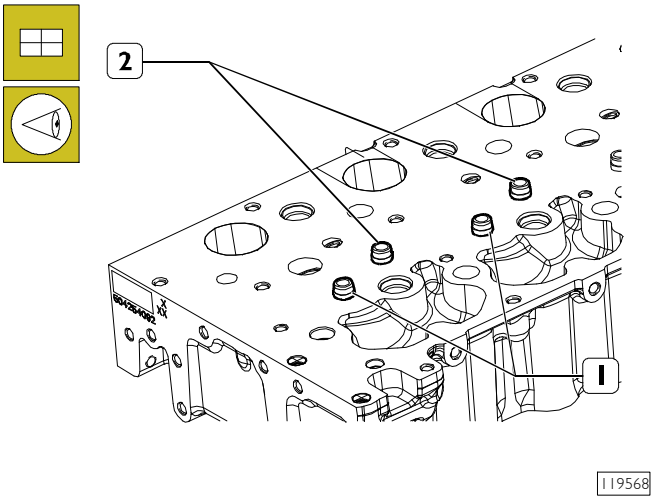


Valve disassembly must be executed using tool 99360268 (1) to slightly press the plate (3) so that, compressing the spring (4), it is possible to remove the half cone (2). Then remove the plate (3) and the spring (4).

Repeat the operation in correspondence of each valve.

Turn the cylinder head upside down and withdraw the valves (5).

Figure 56



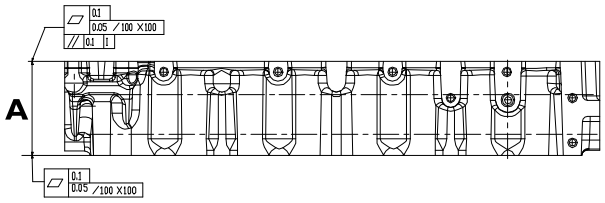
Remove the grommets (1 and 2) from their valve guides.

Cylinder head base surface check

Any deformation detected on the whole length of the cylinder head must not exceed 0.20 mm.

In case higher value is detected, grind the cylinder head in order to obtain the prescribed value. Refer to the main specifications reported here following and follow the instructions accompanying the figures below.

Figure 57

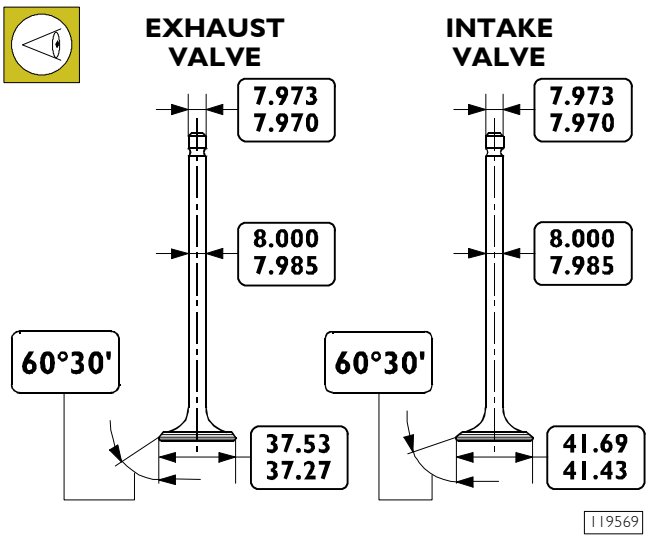


119591

A rated thickness of the cylinder head is 90 ± 0,1 mm.

VALVES

Figure 58

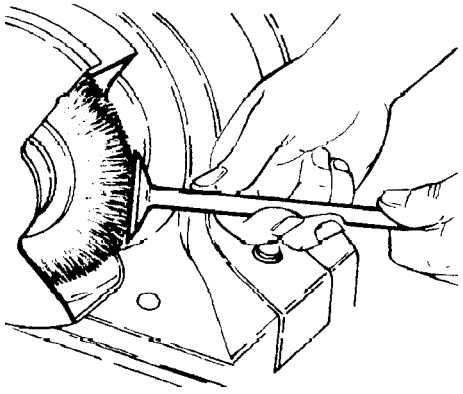


119569

INTAKE AND EXHAUST VALVE MAIN DATA

Valve scaling, checking and grinding

Figure 59



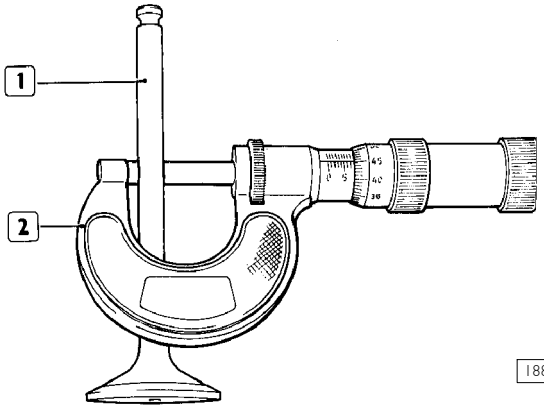
18625

Eliminate carbon deposits from the valves using the specially provided metal brush.

Check the valves for meshing, cracks or burns.

If necessary, grind the valve seats removing as less material as possible.

Figure 60

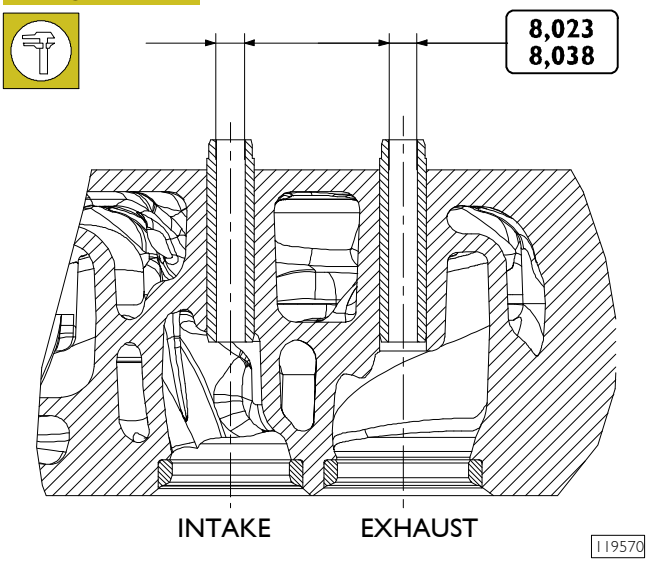


18882

Using a micrometer (2) measure the valve stem (1): the prescribed value is 7,985 to 8,000 mm.

VALVE GUIDE

Figure 61



Using a bore meter, measure the valve guide inner diameters, which must correspond to the values reported in the figure below.

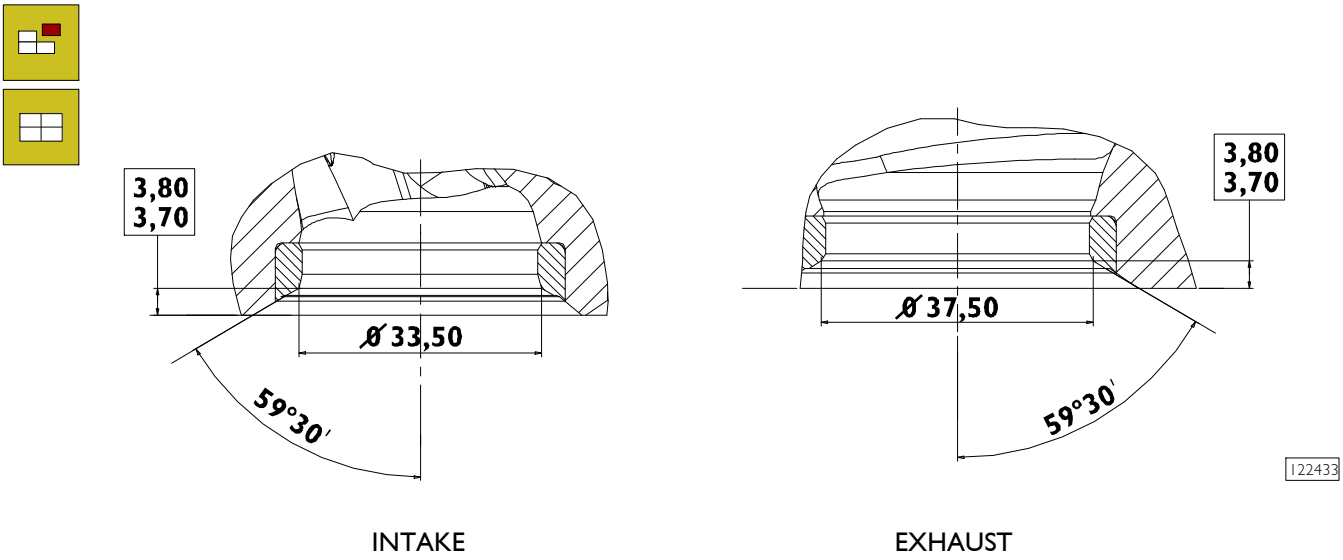
Valve guide replacement

Valve guide assembly and disassembly is performed with beater 99360288.

Insert the valve guide in the cylinder head so that they stick out from it for 8.1 ÷ 8.9 mm.

VALVE SEATS

Figure 62



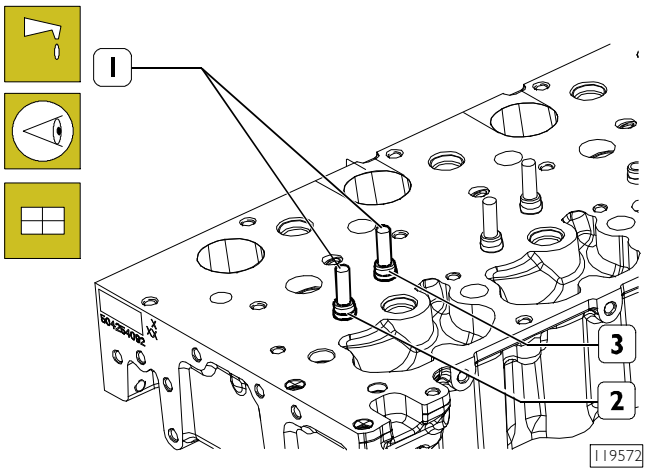
VALVE SEAT SPECIFICATIONS

If the valve seat are damaged replace them with the spare ones included in the supply. With the tools and being careful not to indent the cylinder heads, remove as much material as possible form the valve seats until removal from cylinder head is possible by means of a punch.

Heat cylinder head up to 80° ÷ 100°C and with the beater assemble the new valve seats previously cooled in them.

CYLINDER HEAD ASSEMBLY

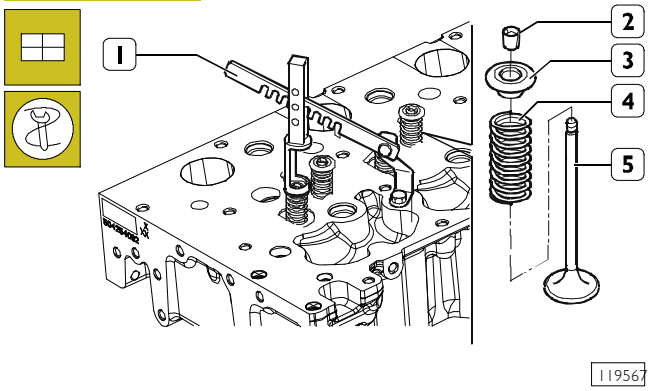
Figure 63



Lubricate the valve stems (1) and fit them in the relevant valve guides in the same position they were before disassembly.

Fit the grommets (2 and 3) to the valve guide using tool 99360292.

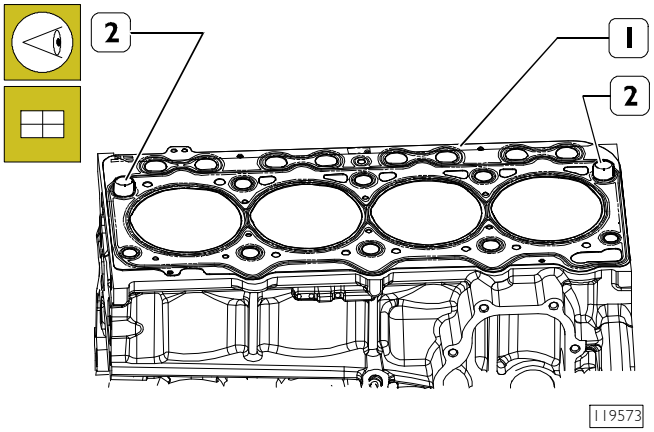
Figure 64



Place the spring (4) and the upper plate (3) on the cylinder head. Using tool 99360268 (1), compress the spring (4) and constrain the parts to the valve (5) throughout the half cones (2).

Cylinder head reassembly

Figure 65



Check that the cylinder head and crankshaft coupling surfaces are clean.
Do not foul the cylinder head gasket.
Fit the gasket (1) on the crankshaft in the correct centred position, taking the pins as reference (2).

TORQUE SETTING

PART			TORQUE	
			Nm	kgm
	Motor vent cover fastening	(M6x1 6g x 18)	10 ± 1	1 ± 0.1
Engine bock	Crankshaft caps - pre-tightening - tightening - angle tightening		50 ± 2.5 80 ± 4 90°	5 ± 0.25 8 ± 0.4
	Piston cooling nozzle		18 ± 1.8	1,8 ± 0.18
	3/8" conical threaded cap		40 ± 4	4 ± 0.5
	1/8" conical threaded cap		15 ± 1.5	0.7 ± 0.15
	Water drainage cap		25 ± 2.5	2.5 ± 0.25
	Oil turbo delivery pipe fixing		40 ± 4	4 ± 0.4
Timing gearcase	Conical threaded cap		15 ± 1.5	0.7 ± 0.15
	Gear cooling nozze		15 ± 1.5	0.7 ± 0.15
	Cover fastening	(M8x1.25 6g x 25)	25 ± 2.5	2.5 ± 0.25
	Cover fastening	(M8x1.25 6g x 35)	25 ± 2.5	2.5 ± 0.25
	Cover fastening	(M8x1.25 6g x 16.5)	25 ± 2.5	2.5 ± 0.25
	Gearcase fastening	(M8x1.25 6g x 22.5)	25 ± 2.5	2.5 ± 0.25
	Gearcase fastening	(M8x1.25 6g x 25)	25 ± 2.5	2.5 ± 0.25
	Gearcase fastening	(M8x1.25 6g x 35)	25 ± 2.5	2.5 ± 0.25
	Gearcase fastening	(M8x1.25 6g x 50)	25 ± 2.5	2.5 ± 0.25
	Front cover fastening	(M6x1 6g x 16)	10 ± 1	1 ± 0.1
	Rear cover fastening	(M8x1.25 6g x 18)	25 ± 2.5	2.5 ± 0.25
Flywheel case	Case fastening	(M8x1.25 6g x 25)	35 ± 3.5	2.5 ± 0.25
	Case fastening	(M12x 1.75 6g x 30)	110 ± 11	11 ± 1.1
	Plate fastening		25 ± 2.5	2.5 ± 0.25
Cylinder head	Cylinder head fastening First phase Second phase Third phase	(M15x 1.5 6g x 193)	130 ± 6.5 90° ± 4.5° 70°	13 ± 0,65 9 ± 0.45
	Cylinder head fastening First phase Second phase Third phase	(M12x 1.5 6g x 165)	65 ± 3.25 90° ± 4.5° 60°	6 ± 0.325 9 ± 0.45
	Exhaust manifold stud bolt		20 ± 2	2 ± 0.2
Overhead	Rocker arm dowel		25 ± 2.5	2.5 ± 0.25
	Overhead fastening	(M8x1.25 6g x 30)	27 ± 2.7	2.7 ± 0.27
	Overhead fastening	(M8x1.25 6g x 50)	27 ± 2.7	2.7 ± 0.27
	Threaded cap		20 ± 2	2 ± 0.2
	Valve adjusting nut		20 ± 2	2.5 ± 0.25
	Inspection cover fastening		25 ± 2.5	2.5 ± 0.25

PART			TORQUE	
			Nm	kgm
Intake manifold	Intake manifold fastening	(M8x1 .25 6g x 60)	32 ± 3.2	3.2 ± 0.32
	Intake manifold fastening	(M8x1.25 6g x 55)	32 ± 3.2	3.2 ± 0.32
	Throw fastening to intake manifold		27 ± 2.7	2.7 ± 0.27
Exhaust manifold	Exhaust manifold fastening		30 ± 3	3.0 ± 0.3
	Turbo-blower stud screw		18 ± 1.8	1.8 ± 0.18
	Engine drive shaft pulley fastening		350 ± 17.5	35 ± 1.75
Connecting rod	Connecting rod cap fastening - pre-tightening - angle tightening		50 ± 2.5	5 ± 0.25 70°
	Phonic wheel fixing		15 ± 1.5	1.5 ± 0.15
Timing	Thrust block fastening		25 ± 2.5	2.5 ± 0.25
	Gear fastening		36 ± 3.6	3.6 ± 0.36
Injectors	Injector stud screw fastening		20 ± 2	2 ± 0.2
	Injector fastening nut - tightening		28 ± 2.8	2.8 ± 0.28
	Engine cable fastening		25 ± 2.5	2.5 ± 0.25
Fuel filter	Union fixing to support		28 ± 2.8	2.8 ± 0.28
	Fuel filter fastening		25 ± 2.5	2.5 ± 0.25
Supply pump	Supply pump fastening		25 ± 2.5	2.5 ± 0.25
	Inlet		25 ± 2.5	2.5 ± 0.25
	Fast clutch		25 ± 2.5	2.5 ± 0.25
Injector scar	Injector fastening		6 ± 0.6	0.6 ± 0.06
	Pump fastening		25 ± 2.5	2.5 ± 0.25
Turbo blower	Collector fastening screw nuts		28 ± 2.8	2.8 ± 0.28
	Oil delivery inlet fixing		25 ± 2.5	2.5 ± 0.25
	Delivery pipe fastening screw nut		28 ± 2.8	2.8 ± 0.28
	Exhaust pipe fixing to heat exchanger		25 ± 2.5	2.5 ± 0.25
	Exhaust pipe fixing to turbo		15 ± 1.5	1.5 ± 0.15
Cooling pipe	Water pipe fixing to the heat exchanger		25 ± 2.5	2.5 ± 0.25
	Water pipe fixing to the support		25 ± 2.5	2.5 ± 0.25
	Threaded cap	(M35x1.5 x 13)	75 ± 7.5	7.5 ± 0.75
	Threaded cap	(M16x1.5 con. x9)	28 ± 2.0	2.8 ± 0.28

PART			TORQUE	
			Nm	kgm
Oil level check	Oil pressure control valve fastening		60 ± 6	6 ± 0.6
	Stirrup fastening to block		10 ± 1	1 ± 0.1
Oil filter body	Cartridge union		45 ± 4.5	4.5 ± 0.45
	Oil filter fastening		25 ± 2.5	2.5 ± 0.25
	Oil filter cartridge fastening		30 ± 3	3 ± 0.3
	Oil pump fixing - pre-tightening - tightening		 6 ± 0.6 35 ± 3.5	 0.6 ± 0.06 3.5 ± 0.35
Heat exchanger	Threaded caps		45 ± 4.5	4.5 ± 0.45
	Exchanger unit fixing		25 ± 2.5	2.5 ± 0.25
	Heat exchanger fastening		25 ± 2.5	2.5 ± 0.25
Temperature regulator	Thermostat unit fixing		25 ± 2.5	2.5 ± 0.25
	Bleed vent fixing		40 ± 4	4 ± 0.4
	Water pump fastening		25 ± 2.5	2.5 ± 0.25
Fan support	Bearing fixing		40 ± 4	4.0 ± 0.4
	Fan support fixing		25 ± 2.5	2.5 ± 0.4
	Pulley fixing		40 ± 4	4.0 ± 0.4
	Control outlet rear cover fastening		25 ± 2.5	2.5 ± 0.25
Alternator group	Support fastening to block	(M10x1.5 6g x 50-60)	50 ± 5	5 ± 0.5
	Alternator fastening (screw + nut)		50 ± 5	5 ± 0.5
	Push rod fixing		50 ± 5	5 ± 0.5
	Alternator push rod fixing (screw + nut)		50 ± 5	5 ± 0.5
	Support fastening to block	(M10x1.5 6g x 35)	50 ± 5	5 ± 0.5
Manoeuvre hook	Front hook fastening		50 ± 5	5 ± 0.5
	Rear hook fastening		70 ± 7	7 ± 0.7
LDA	Manifold side pipe fastening		15 ± 1.5	1.5 ± 0.15
	Pump side pipe fastening		15 ± 1.5	1.5 ± 0.15

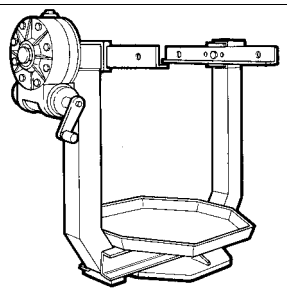
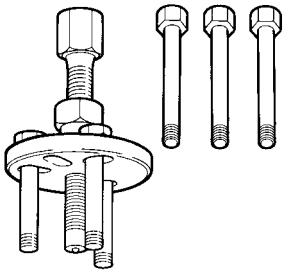
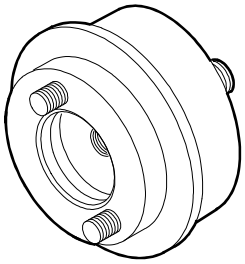
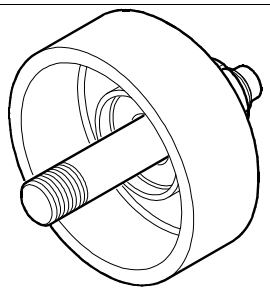
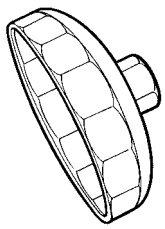
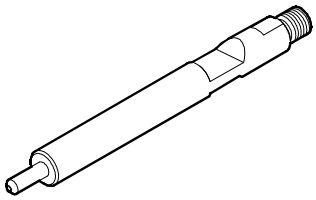
PART		TORQUE	
		Nm	kgm
Sensors	Time impulse transmitter fastening	10 ± 1	1 ± 0.1
	Oil pressure sensor fastening	28 ± 2.8	2.8 ± 0.28
	Thermometric switch fastening	36 ± 3.6	3.6 ± 0.36
	Water temperature sensor fastening	25 ± 2.5	2.5 ± 0.25
Injection pump	Gear to pump retaining nut - pre serraggio - pre-tightening	 18 ± 1.8 90 ± 9	 1.8 ± 0.18 9 ± 0.9
	Stud bolt for injection pump	4 ± 0.4	0.4 ± 0.04
	Fuel pump retaining nut	25 ± 2.5	2.5 ± 0.25
High pressure	Fastening to pump and injector	28 ± 2.8	2.8 ± 0.28
	Pipe fastening screws	10 ± 1	1 ± 0.1
Oil sump assembly	Side plug (M16x1,5)	40 ± 4	4 ± 0.4
	Side plug (M22x1,5)	50 ± 5	5 ± 0.5
	Front plug (M35x1,5)	40 ± 4	4 ± 0.4
	Sump fastening	70 ± 7	7 ± 0.7
	Balancing mass housing fastening	70 ± 7	7 ± 0.7

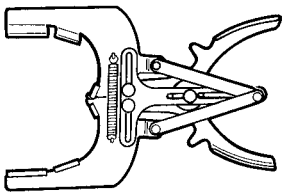
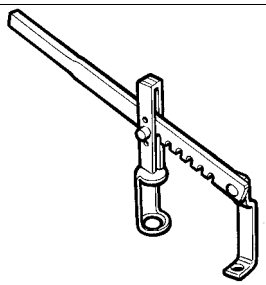
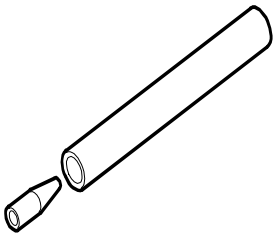
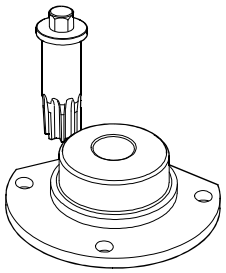
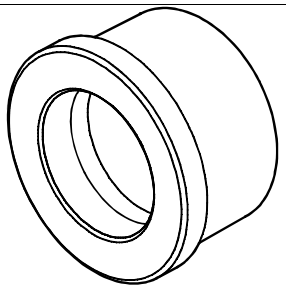
SECTION 5

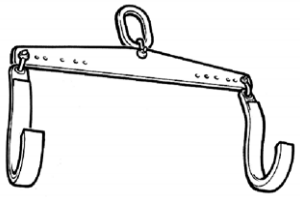
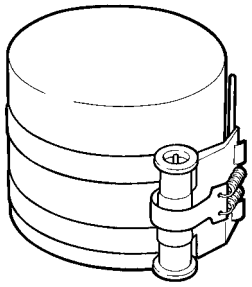
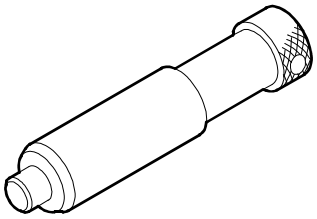
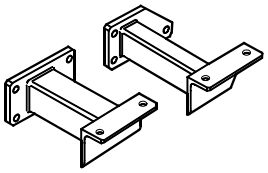
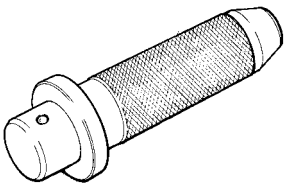
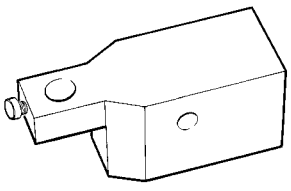
Tools

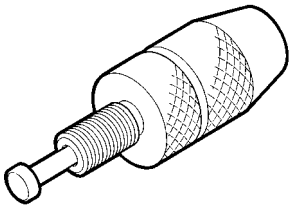
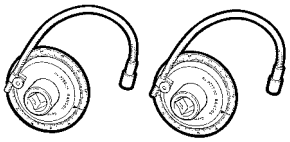
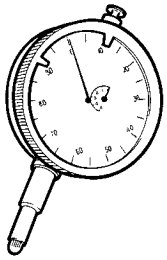
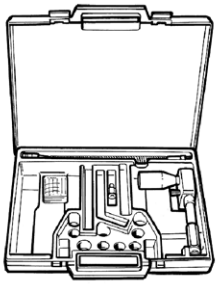
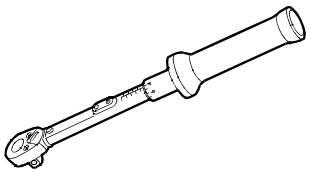
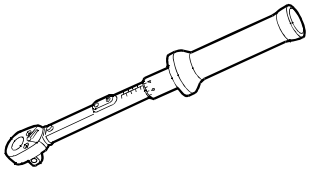
Pagina

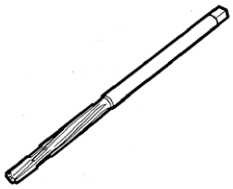
TOOLS

TOOL No.		DEFINITION
99322205		Revolving stand for overhauling units (1000daN capacity, 120 daN/m torque)
99340025		Tool to remove output shaft front gasket
99346259		Tool for fitting output shaft rear gasket
99346262		Tool for fitting output shaft front gasket
99360076		Tool for disassembling cartridge filters
99360145		Adapter for counterpressure checking in cylinders (use with 99395682)

TOOL No.		DEFINITION
99360183		Pliers for removing/refitting piston rings (65 – 110 mm)
99360268		Tool for removing/refitting engine valves
99360288		Beater for valve guide disassembly and reassembly
99360292		Shrink fitter for gasket assembly
99360339		Tool for rotating the engine flywheel
99360362		Beater for removing/refitting camshaft bushes (to be used with 99370006)

TOOL No.		DEFINITION
99360500		Tool for crankshaft lifting
99360605		Ring for plunger introduction into the cylinder barrel (60 ÷ 125 mm)
99360612		Tool for engine T.D.C. positioning
99361043		Brackets for fastening engine to revolving stand 99322205
99370006		Handgrip for interchangeable beaters
99370415		Gauge base for different measurements (to be used with 99395603)

TOOL No.		DEFINITION
99395100		Dial gauge holder for rotary injection pump timing (use with 99395603)
99395216		Pair of gauges with 1/2" and 3/4" square head for angle tightening
99395603		Dial gauge (0 ÷ 5 mm)
99395682		Diesel engine cylinder compression control device
99389813		Dynamometric wrench (20 -120 Nm) with 1/2" square coupling
99389817		Dynamometric wrench (60 -320 Nm) with 1/2" square coupling

TOOL No.		DEFINITION
99390310		Sleeker for valve guide

Appendix

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 unit 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 by FPT.
- ❑ Do not modify fuel systems or hydraulic system unless FPT 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 priory 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.