N SERIES
F4G TIER 3

Agricultural applications (Hyundai)

F4GE9484F*J608
F4GE9454J*J604

Technical and Repair manual

This publication contains data, features, instructions and methods for performing repair interventions on the assembly and its components.

This publication is addressed to qualified, specialised personnel.

Check that you have the publication related to the assembly on which you are about to work available before you start. Make sure that you have all the necessary safety apparatuses, such as, for example, protective eyewear, helmet, gloves, footwear, etc. Check that the working, lifting and transport equipment etc. is available and in working order. Make sure that the group is prepared and secured.

Proceed by carefully observing the instructions contained herein and use the indicated specific tools to ensure correct repair procedures, observance of time schedules and safety of operators.

All repair interventions are aimed at restoring the conditions of operation, efficiency and safety contemplated by FPT.

All on-group interventions, aimed at implementing changes, alterations or other not authorised by FPT will relieve FPT from responsibility. Specifically, the warranty (where applicable) will be immediately cancelled.

FPT cannot be held responsible for repair interventions.

FPT is available to provide any additional information needed for performing the inventions and indications in the cases and situations not contemplated in this publication.

The data contained in this publication may not be up-to-date if changes are made by the manufacturer at any time for technical or commercial reasons or if required to meet legal requirements of countries worldwide.

Contact a FPT dealership before proceeding in the event of differences between the contents of this publication and the actual assembly.

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F4GE N SERIES

F4GE N Series **Part I**

Introduction

PREFACE TO USER'S GUIDELINE MANUAL

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 engine illustrating its features and working in general.
Section 2 describes the type of fuel feed.
Section 3 relates to the specific duty and is divided in four separate parts:
1. Mechanical part, related to the engine overhaul, limited to those components with different characteristics based on the relating specific duty.
2. Electrical part, concerning wiring harness, electrical and electronic equipment with different characteristics based on the relating specific duty.
3. Maintenance planning and specific overhaul.
4. Troubleshooting part dedicated to the operators who, being entitled to provide technical assistance, shall have simple and direct instructions to identify the cause of the major inconveniences.
Sections 4 and 5 illustrate the overhaul operations of the engine overhaul on stand and the necessary equipment to execute such operations.
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.

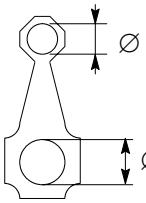
Environment protection

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 = housing for connecting rod small end bush

Ø 2 = housing for connecting rod bearings

Tighten to torque
Tighten to 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
ϱ	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.

The manual handling of loads must be assessed in advance because it also depends, besides weight, on its size and on the path.

Handling by mechanical means must be with hoisters proper as for weight as well as for 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 12-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 12-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.

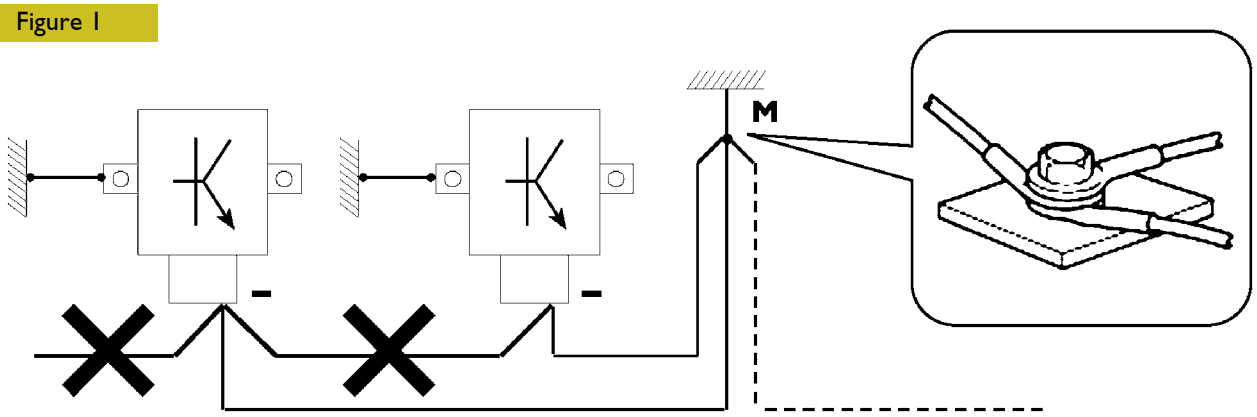
Bonding and screening

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:

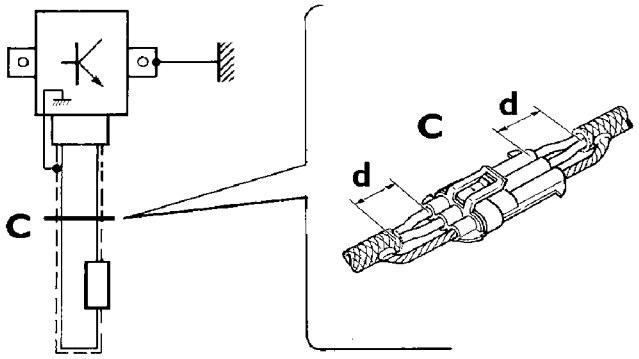
- Electronic central units must be connected to system bonding when they are provided with a metallic shell.
- Electronic central units negative cables must be connected both to a system bonding point such as the dashboard opening bonding (avoiding "serial" or "chain" connections), and to battery negative 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



88039

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

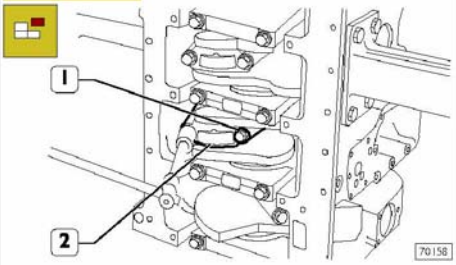
REVISIONE MOTORE 4 E 6 CIL. SMONTAGGIO DEL MOTORE AL BANCO

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.

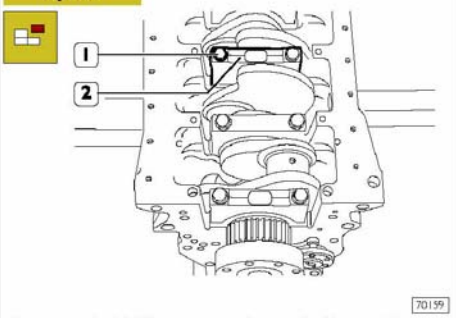
Figura 1



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

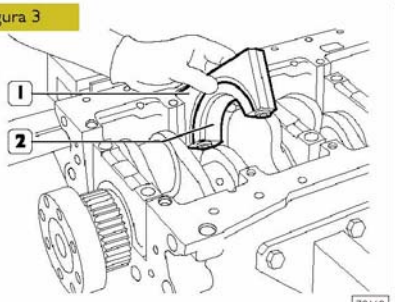
NOTA Mantenere i semicuscinetti nei rispettivi alloggiamenti, poiché, in caso di un loro utilizzo, dovranno essere montati nella posizione riscontrata allo smontaggio.

Figura 2



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

Figura 3

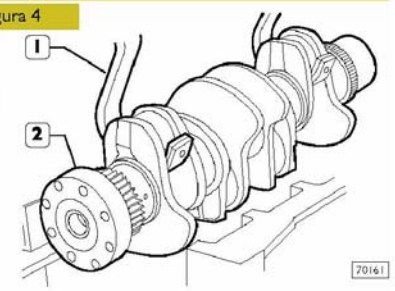


Il penultimo cappello di banco (1) e il relativo supporto hanno il semicuscinetto (2) dotato di spallamento.

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.

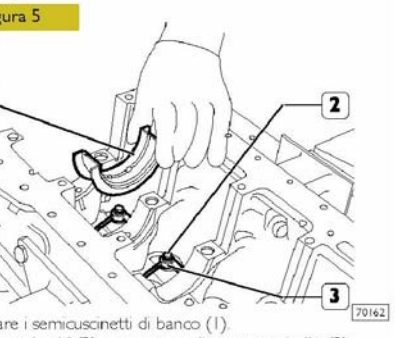
NOTA Annotare la posizione di montaggio dei semicuscinetti inferiori e superiori, poiché in caso di un loro riutilizzo, dovranno essere montati nella posizione riscontrata allo smontaggio.

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 1
F4GE N SERIES

UPDATING

Section	Description	Page	Date of revision

SECTION 1

General Specifications

LUBRICATION

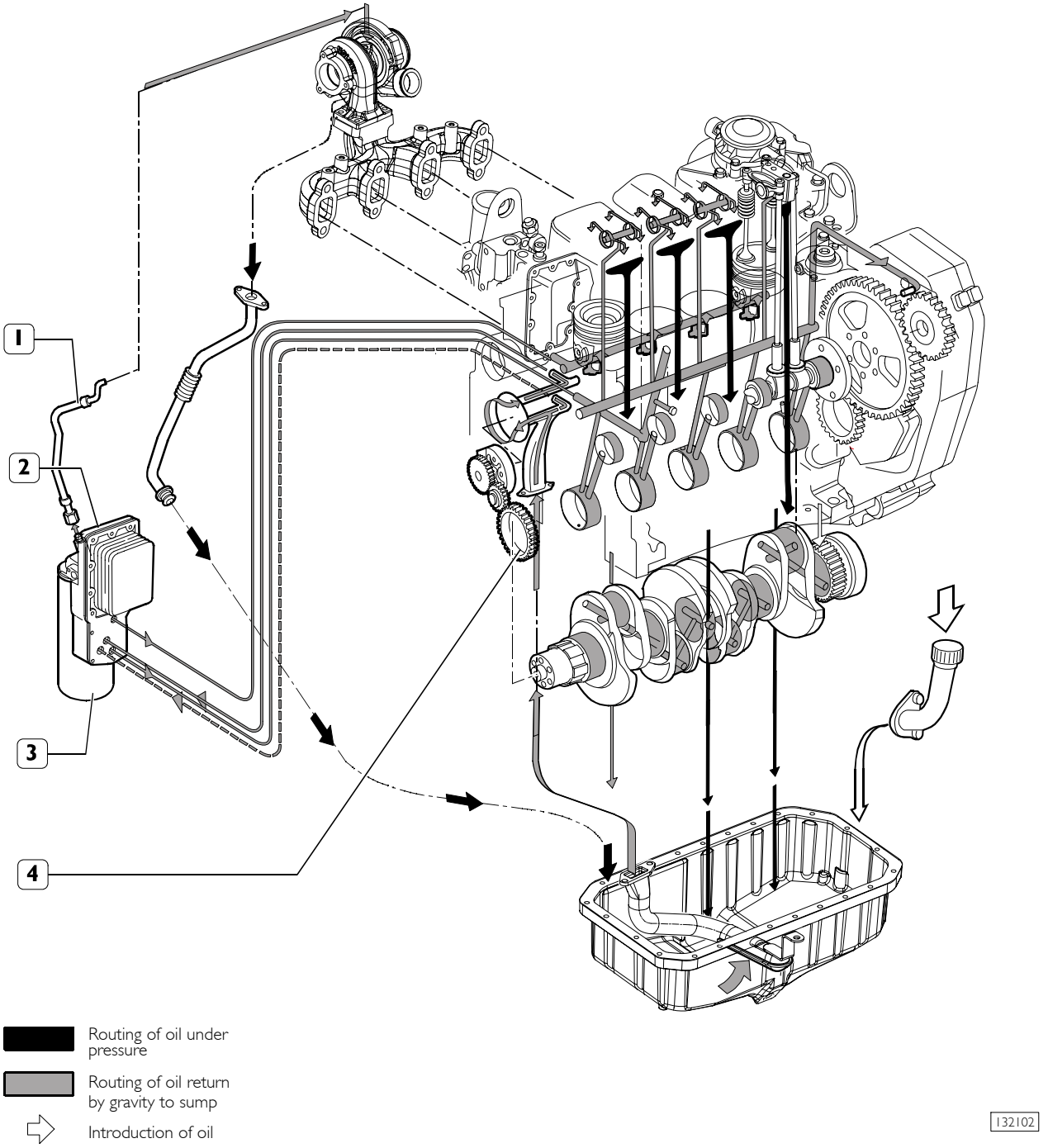
Lubrication by forced circulation is achieved through oil rotary expansion pump, placed in the front part of the basement, driven by the straight-tooth gear splined to the shaft's bar hold.

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

Lubrication involves the heat exchanger and the turboblower.

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

Figure 1

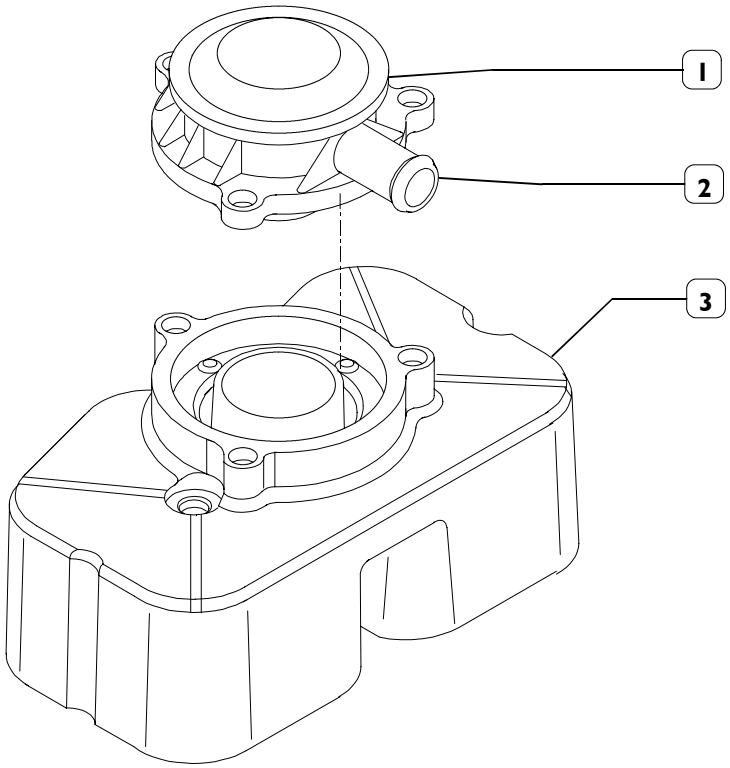


LUBRICATION SYSTEM LAYOUT

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

OIL VAPOUR RECIRCULATING SYSTEM

Figure 2



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

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

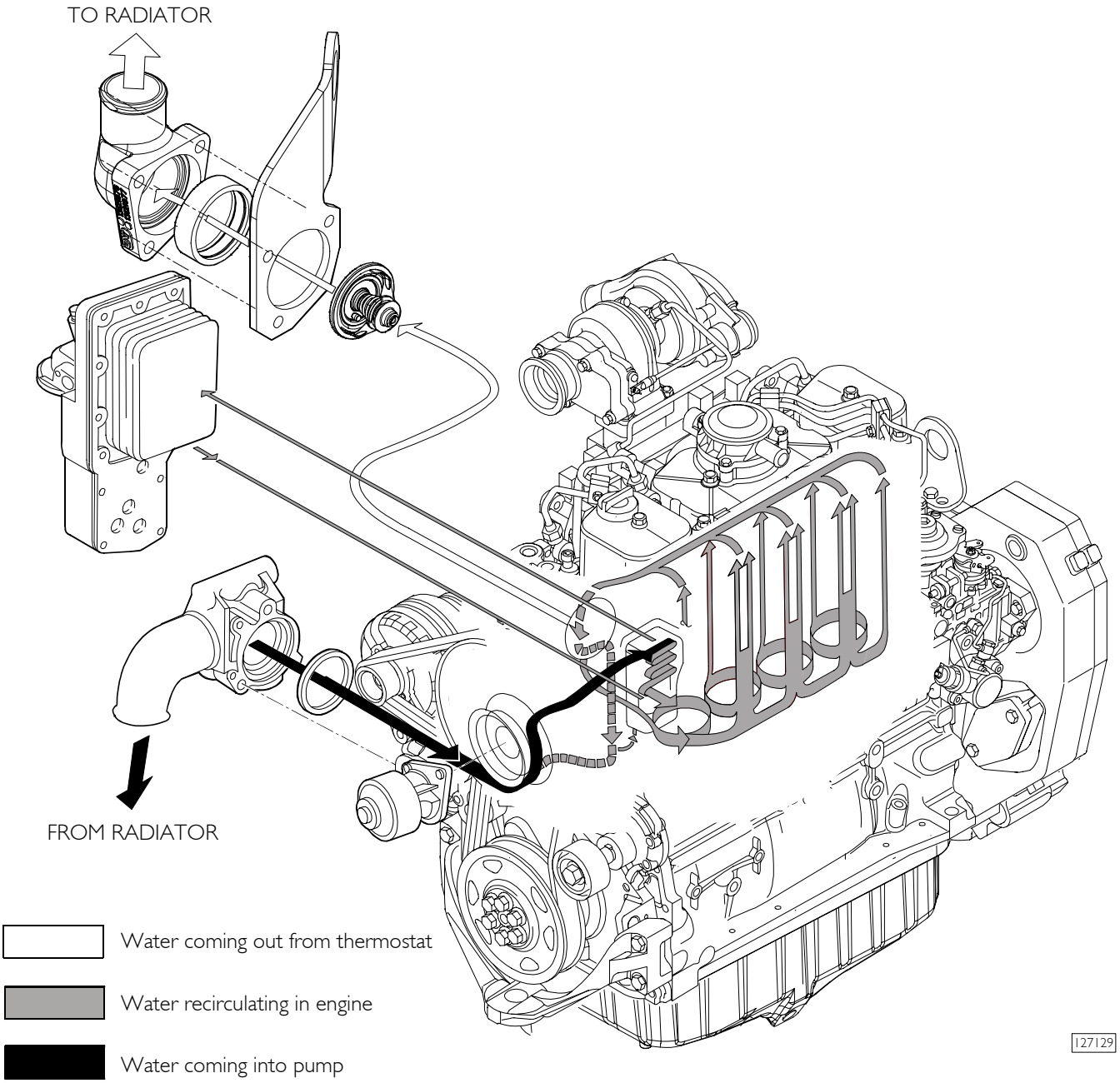
The remaining non-condensed vapours shall be properly conveyed through the breather pipe (2), by suction as an example (connection towards these vapours shall be designed by the Engineer).

COOLING SYSTEM

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

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

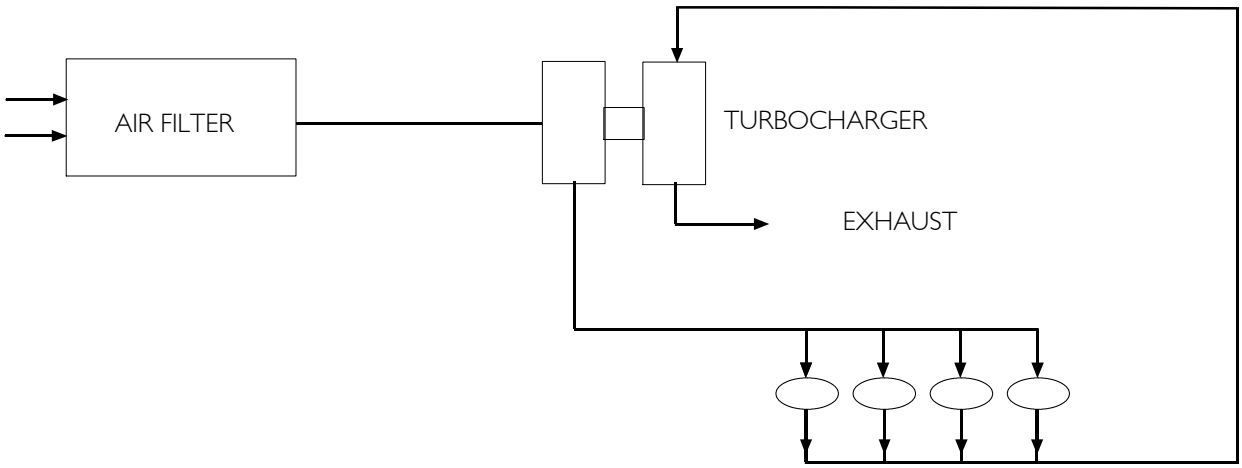
Figure 3



COOLING SYSTEM LAYOUT

AIR INDUCTION BOOST DIAGRAM
Boosting version engines

Figure 4



Description

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

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

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

The air coming out of the compressor is sent via the intake manifold directly to the pistons.

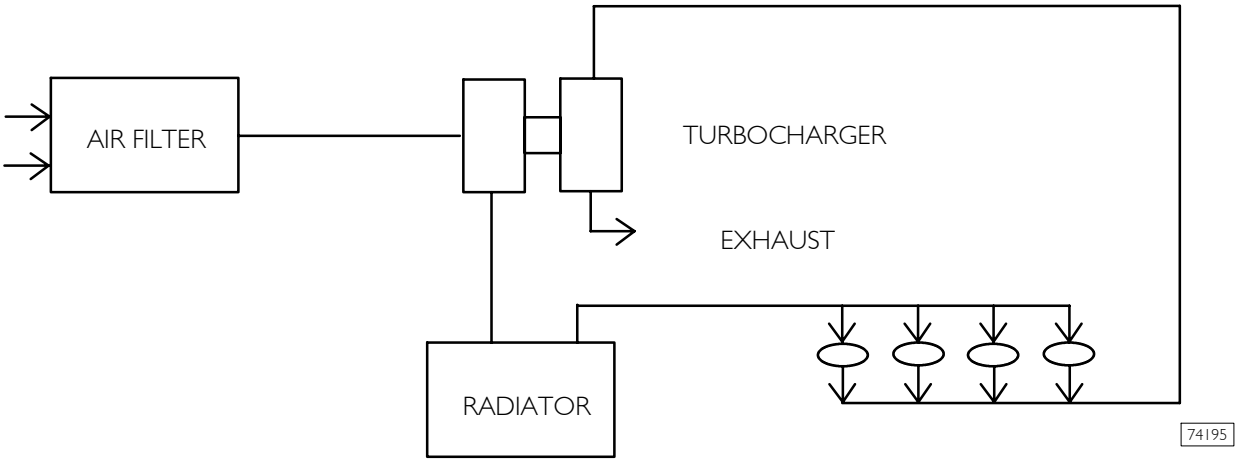
The turbocharger is equipped with a transforming valve to regulate the pressure , that is located on the exhaust collector before the turbine and connected by piping to the induction collector.

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

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

Inter-cooled engine version

Figure 5



4 cylinders version

Description

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

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

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

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

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

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

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

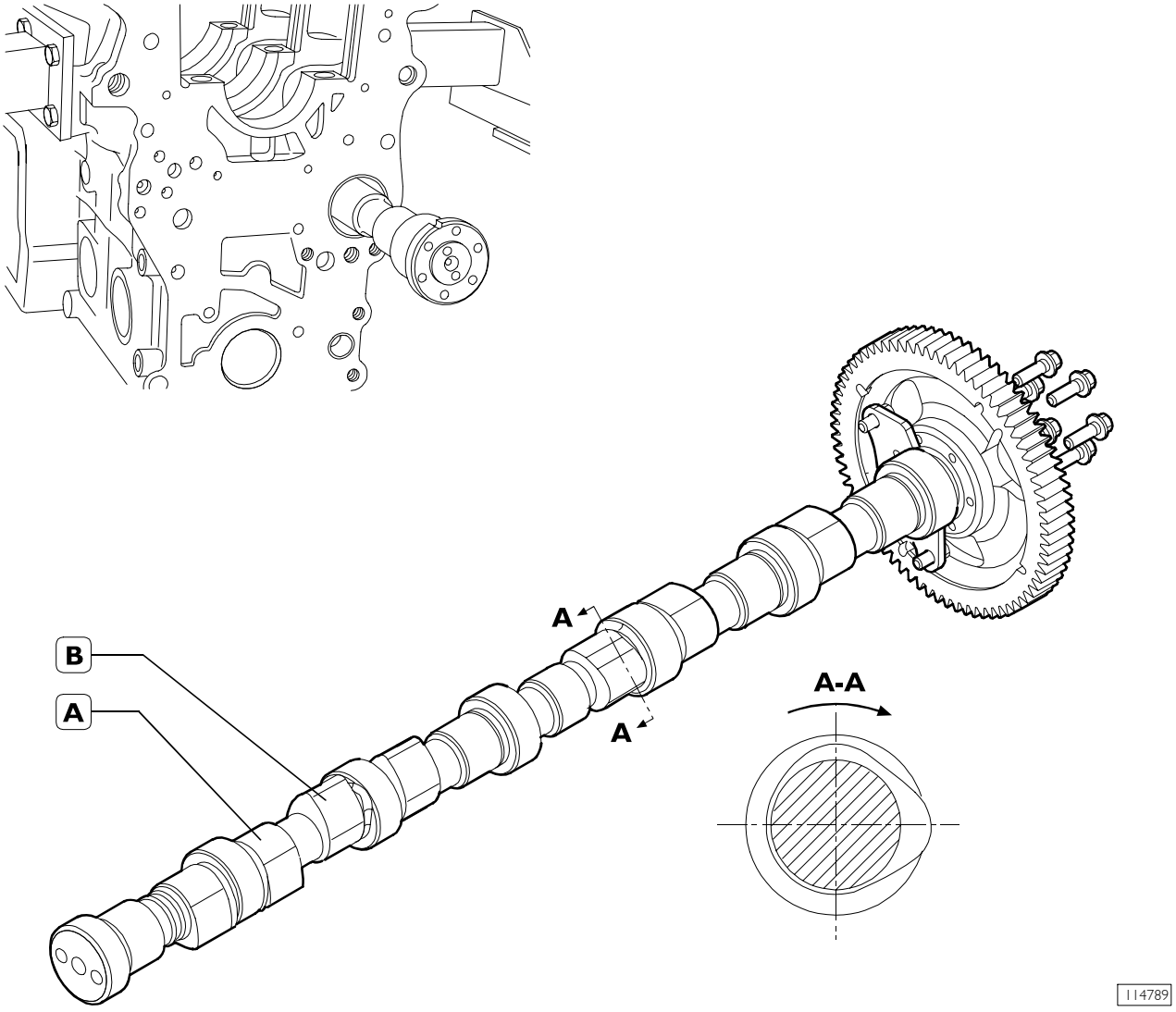
EXHAUST GAS RE-CIRCULATION SYSTEM (EGR)

In the TIER 3 version, the profile of the exhaust cam has been modified in order to allow the partial opening of the relative valve during the aspiration phase (re-circulation of EGR exhaust gas) with the subsequent re-introduction of part of the exhaust gas into the engine cylinders.
The exhaust gases can partially be re-directed into the cylinders so as to reduce the maximum combustion temperature values responsible for the production of nitric acid (NO_X).
The exhaust gas re-circulation system (EGR), reducing the combustion temperature by means of the diminishing of the concentration of oxygen in the combustion chamber, represents therefore an efficient control system of the emission of NO_X .

The internal EGR system is not equipped with any electronically controlled elements: the system is always active. Its configuration does not need additional elements i.e.checking valves, piping or heat exchangers.

The exhaust cam (B) has another lobe apart from the major lobe (see Section. A-A fig.) with respects to the configuration without EGR.
The additional lobe, during the aspiration phase in the cylinder in question, allows a brief opening of the exhaust valve generating re-circulation due to the intake of the exhaust gases caused by depression which is created in the aspiration phase inside the cylinder.

Figure 6



A. Aspiration valve control - B. Exhaust valve control.

SECTION 2

Fuel

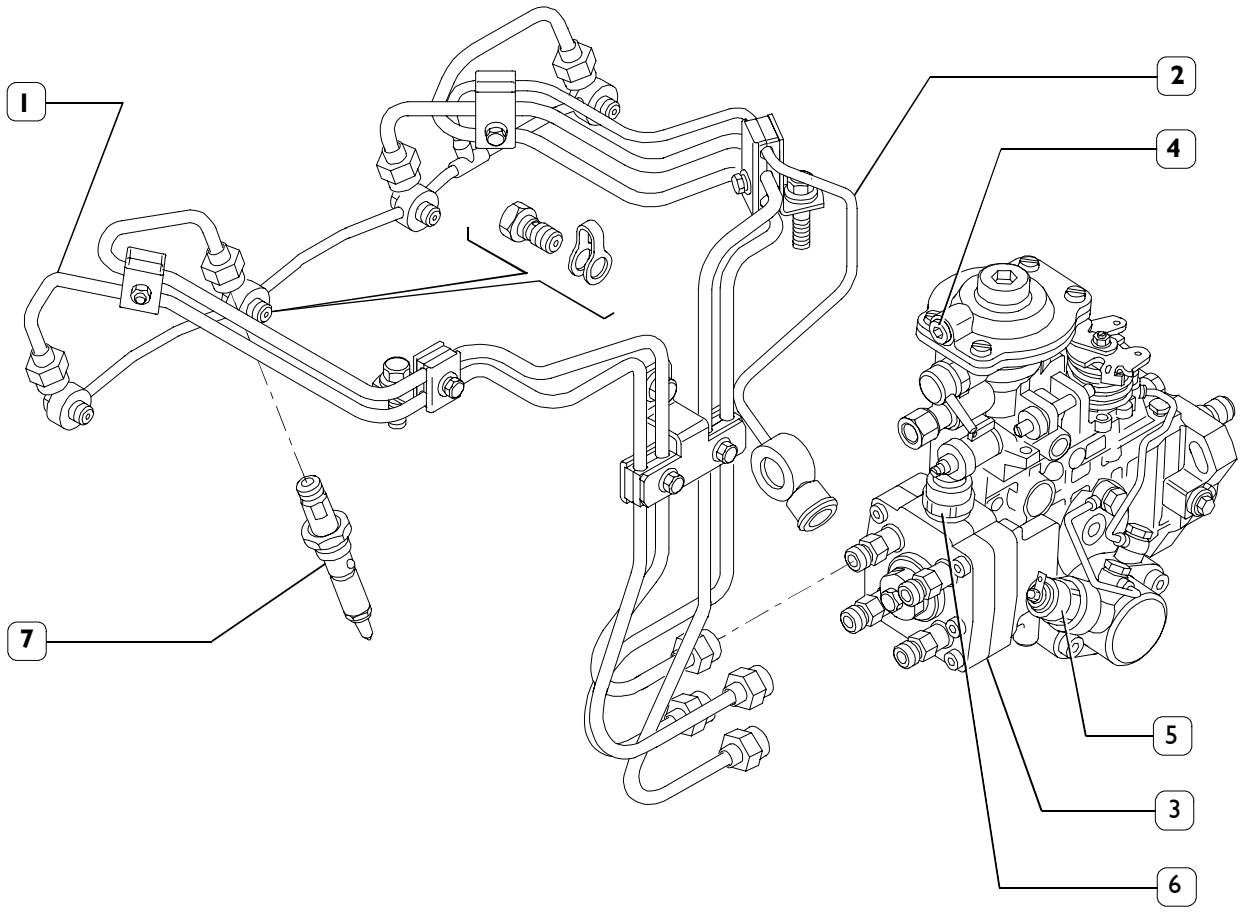
4-CYLINDER ENGINES WITH BOSCH VE 4/12 F ROTARY MECHANICAL PUMP

General information

Fuel feed system is composed by:

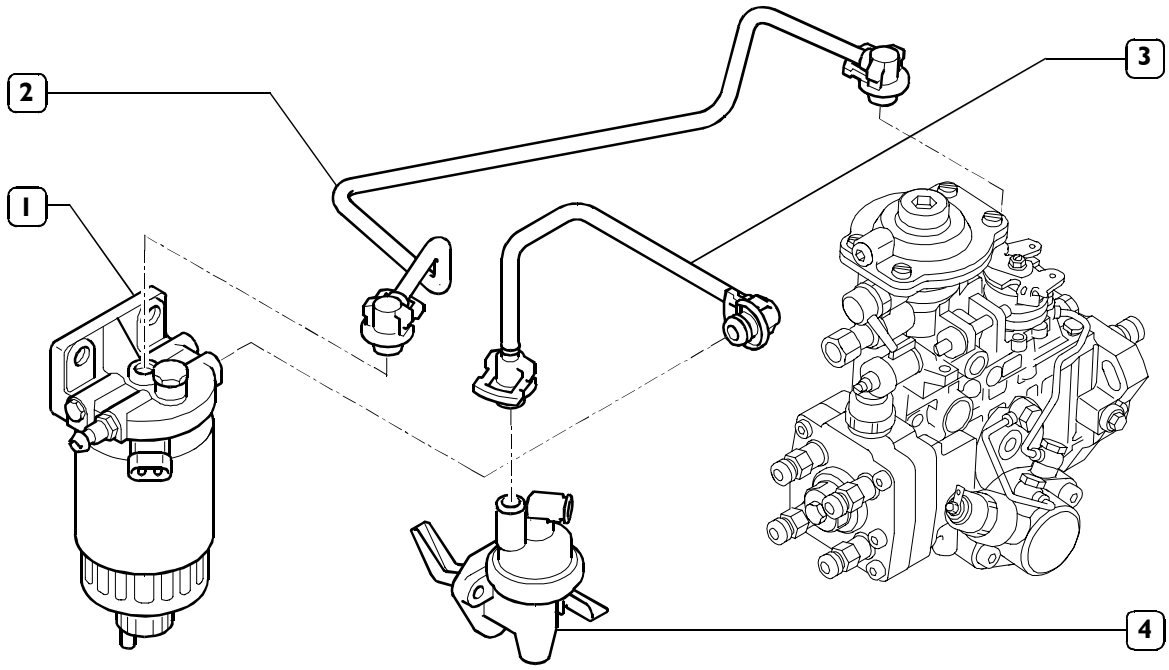
- ❑ Fuel tank (placed on the machine)
- ❑ Fuel delivery and back-flow to tank
- ❑ Fuel pre-filter (if available, it is usually placed close to the engine on the machine frame)
- ❑ Priming pump, assembled to the engine and driven by the camshaft
- ❑ Fuel filter (assembled to the engine in different positions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

Figure 1



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

Figure 2



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

Description of working principles

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

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

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

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

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

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

FEED PUMP

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

Example of identification

V = Distribution rotary plunger

E = Pump dimensions

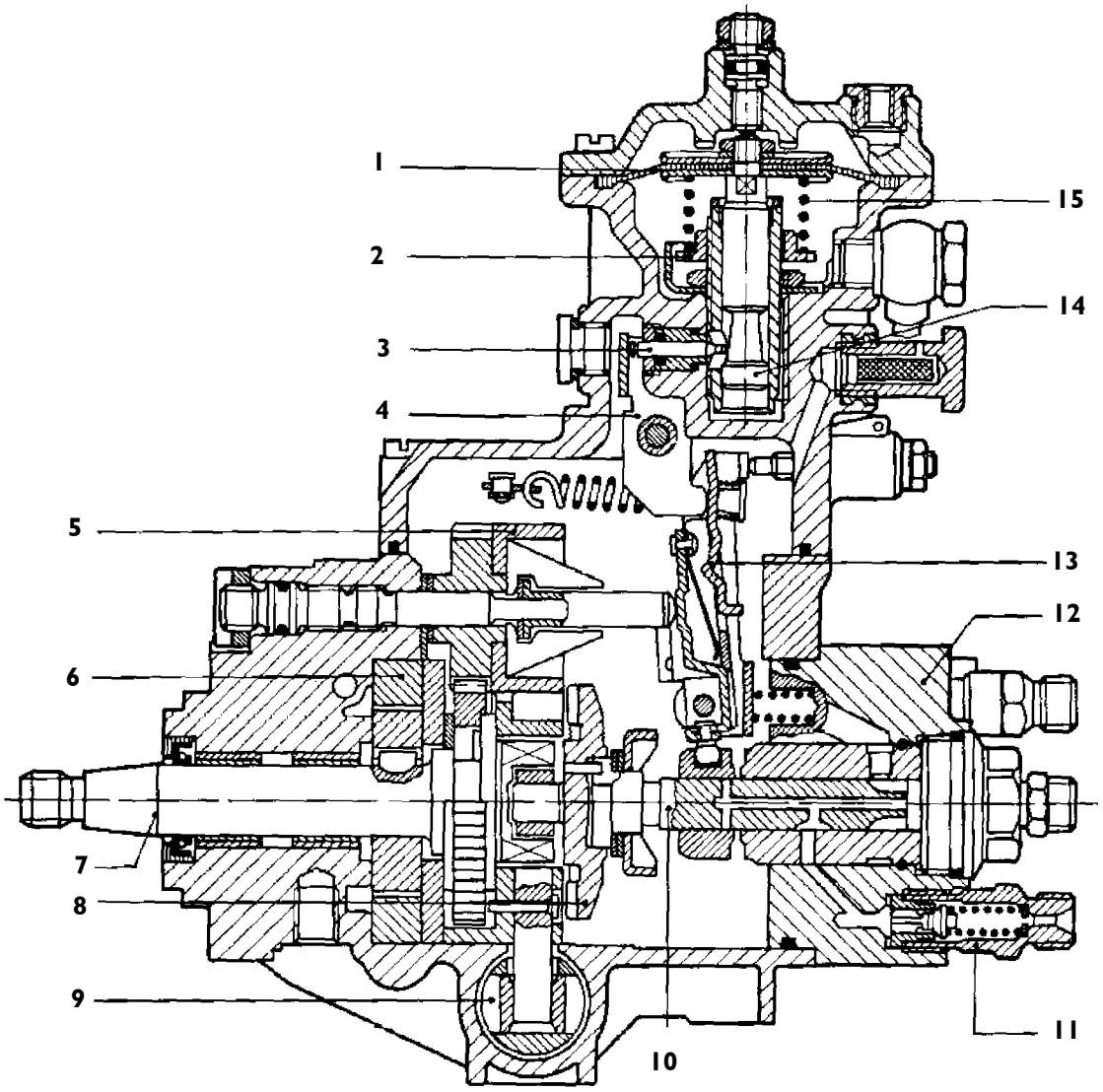
4 = 4 cylinders engine

12 = Distribution plunger in mm.

1150 = N°. of pump revolutions per minute

LV = Left direction of rotation

Figure 3



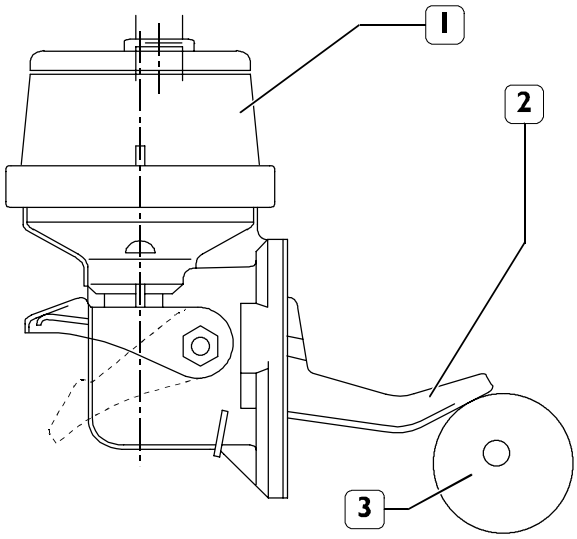
Injection pump longitudinal section

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

PRIMING PUMP

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

Figure 4



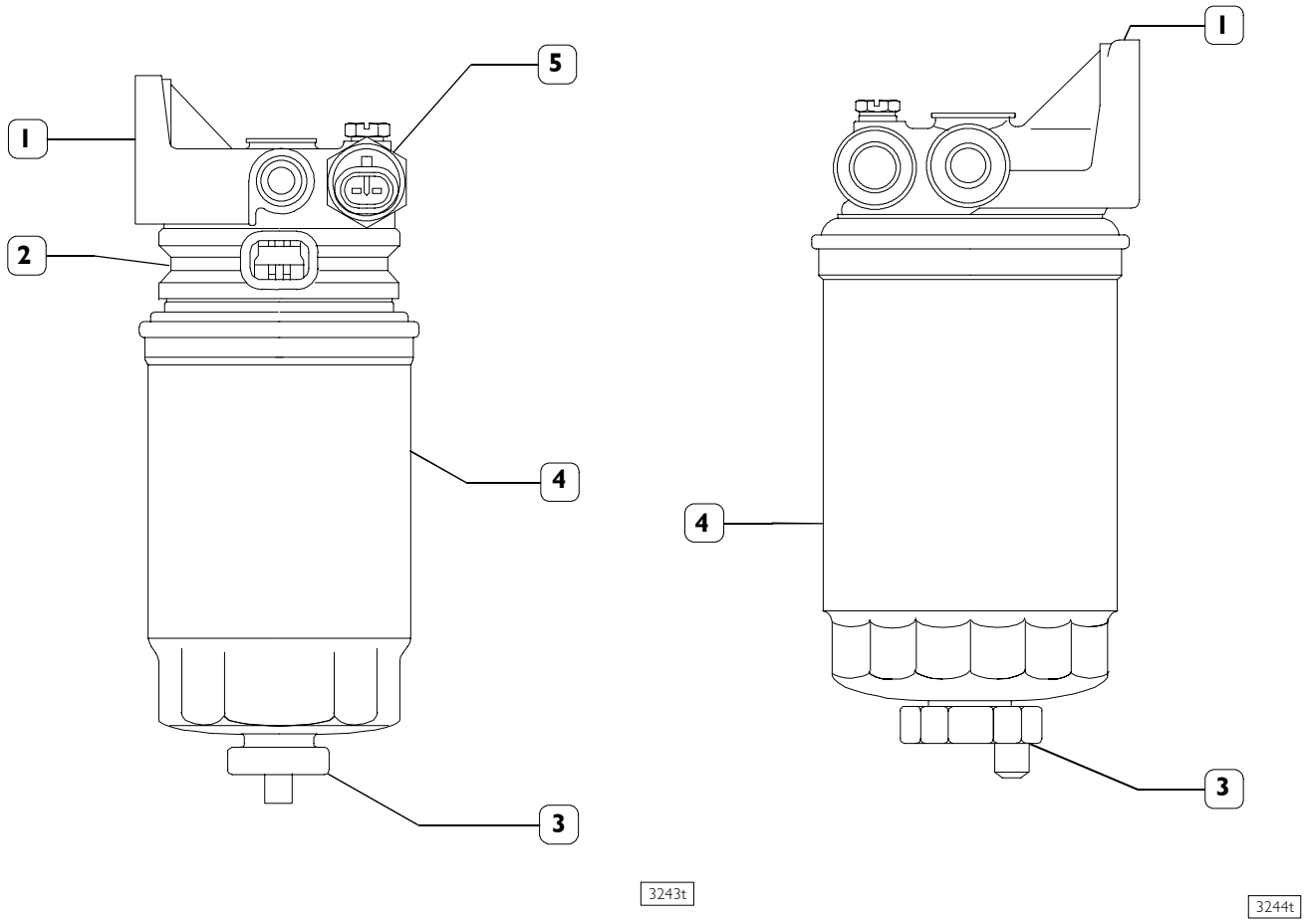
1. Priming pump - 2. Drive lever - 3. Camshaft.

FUEL FILTER

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

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

Figure 5



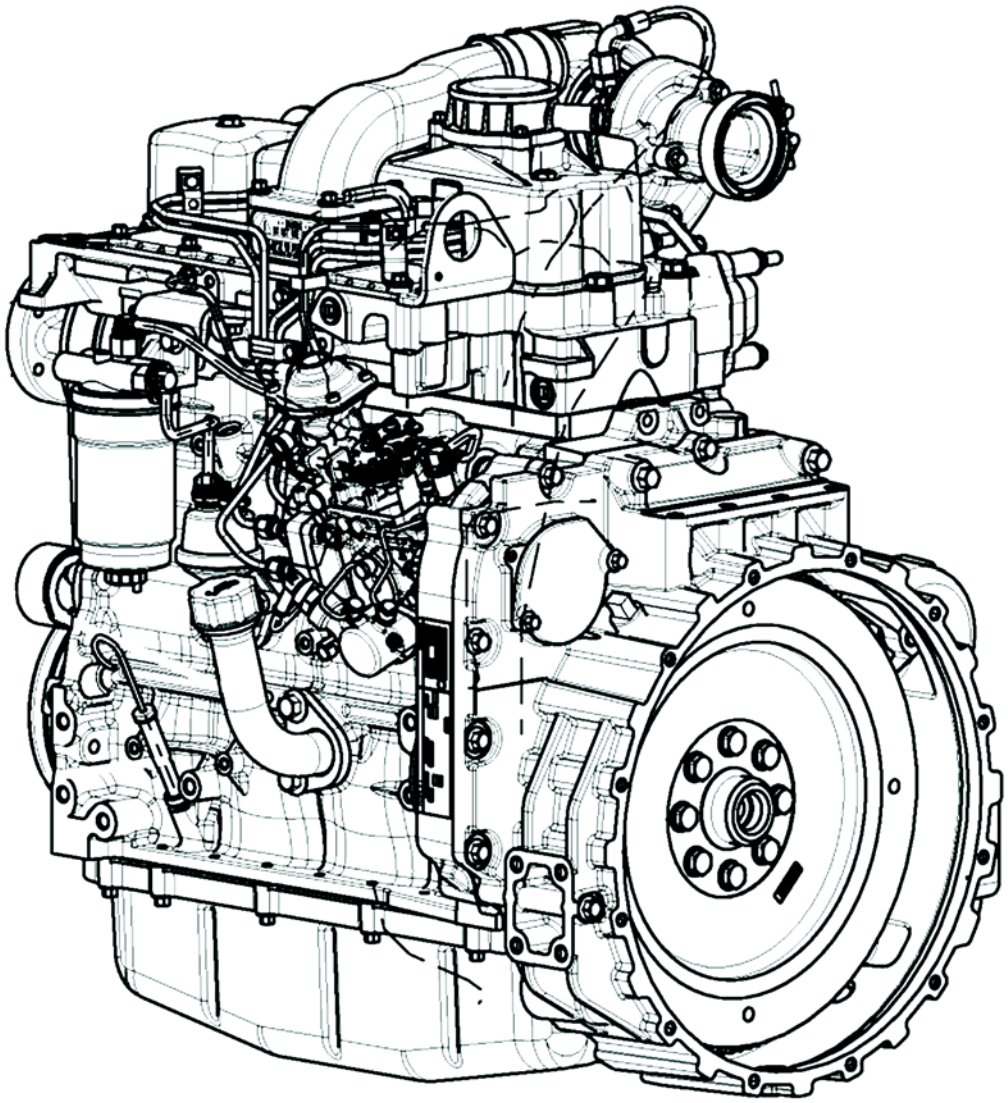
1. Fuel filter bearing- 2. Heater - 3. Water dump screw- 4. Filter cartridge - 5. Temperature sensor.

SECTION 3

Agricultural application

GENERAL INFORMATION

Figure 1



132103

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

They are characteristed by diesel cycle 4 stroke atmospheric or supercharged 4 and 6 cylinders each with 2 valves.

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

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

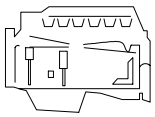
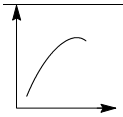
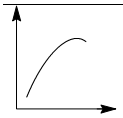
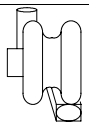
NOTE The picture shows application designed for 4 cylinders version, 2 valves per cylinder, having fuel feed mechanical pump.

NOTE Data, technical specifications and performances granted shall be valid only if the Setter will follow and comply with all installation prescriptions provided by FPT.
Furthermore, the expanders assembled by the Setter must always comply with couple, power and number of revolutions based on which the engine has been designed.

The section herein described is composed or four directories:

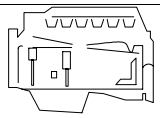
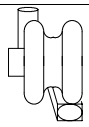
- directory of mechanical overhaul prescribed in accordance to the engine's specific duty, illustrating all necessary operations to remove and assembly the external components of the engine, including cylinder heads, gearbox of the timing system and of the front part cover;
- electrical directory, describing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

CLEARANCE DATA

	Type	**F4GE9454J*604**
ϱ	Compression ratio	17.5:1
 	Max. output kW (HP) rpm	66 (90) 2200
 	Max. torque Nm (kgm) rpm	400 (40.0) 1250
	Loadless engine idling rpm	950
	Loadless engine peak rpm rpm	2430
	Bore x stroke mm Displacement cm^3	104 X 132 4485
	**SUPERCHARGING** Turbocharger type	without intercooler Direct injection HOLSET HX25
 	**LUBRICATION** **Oil pressure (warm engine)** - idling bar - peak rpm bar	Forced by gear pump, relief valve single action oil filter > 0.70 3.1
	COOLING **Water pump control Thermostat** - start of opening °C	By centrifugal pump, regulating thermostat, heat exchanger, intercooler Through belt 81 ± 2
ACEA: E3, E5, E7 URANIA LD7 20W40: 0°C to 40°C (Very hot countries, heavy mission)  15W40: -10°C to 40°C (Europa/Nord American mission) 10W30: -28°C to 35°C (Cold mission)	**FILLING** engine sump* liters engine sump + filter* liters * First filling operation	 13 14

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.

	Type	**F4GE9484F*J608**
ϱ	Compression ratio	17.5:1
	Max. output kW (HP) rpm	74 (101) 2200
	Max. torque Nm (kgm) rpm	430 (43.0) 1250
	Loadless engine idling rpm	 800
	Loadless engine peak rpm rpm	 2430
	Bore x stroke mm Displacement cm^3	104 X 132 4485
	**SUPERCHARGING**	With intercooler
	Turbocharger type	HOLSET HX25
	**LUBRICATION** **Oil pressure (warm engine)** - idling bar - peak rpm bar	Forced by gear pump, relief valve single action oil filter > 0.70 3.1
	COOLING **Water pump control Thermostat** - start of opening °C	By centrifugal pump, regulating thermostat, heat exchanger, intercooler Through belt 81 ± 2
	**FILLING** engine sump* liters engine sump + filter* liters * First filling operation	 13 14

ACEA: E3, E5, E7
URANIA LD7

20W40: 0°C to 40°C (Very hot countries, heavy mission)

15W40: -10°C to 40°C (Europa/Nord American mission)

10W30: -28°C to 35°C (Cold mission)

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

OVERHAUL OF THE ENGINE

Preface

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

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

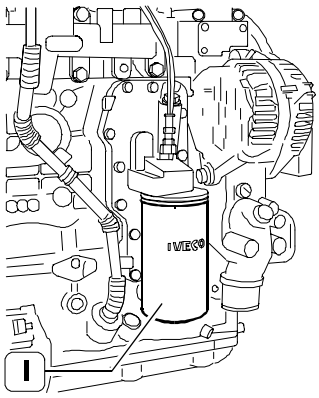
The following information relate to the engine overhaul operations only for what concerns the different components customising the engine, according to its specific duties.

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

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

Engine setting operations for the assembly on turning stand

Figure 2



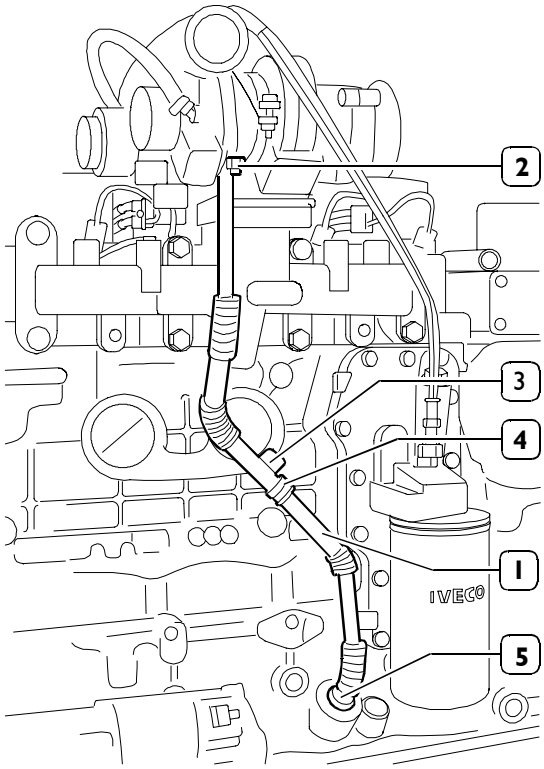
In order to apply the brackets 99361037 to the engine block to fix it on to the stand 99322205 for the overhaul, it is necessary to perform the following operations:

On the right hand side:

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

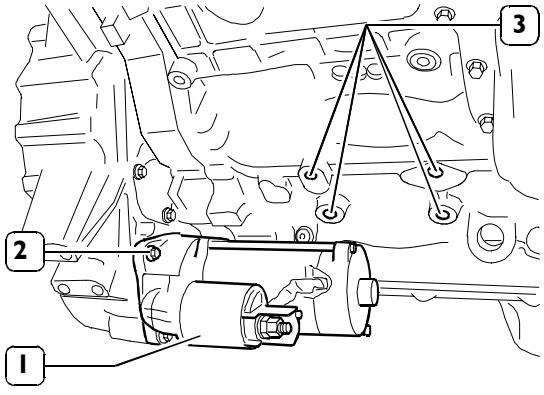
NOTE For some versions, the oil filter (3) is directly assembled on to the heat exchanger:in such case it shall be disassembled using tool 99360076.
Warning: the oil filter contains inside aprx. 1 kg. of engine oil. Provide for oil recovery and disposal in compliance with the law and regulations in force.

Figure 3



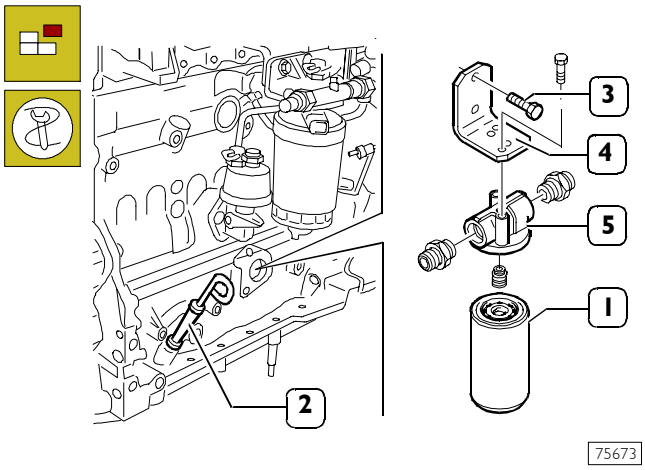
❑ disassemble lubrication oil exhaust pipe from the turbo-blower:
Underneath the turbo-blower loosen the two screws (2), loosen the screw (3) fixing the pipe throughout the stop collar (4) fixing the block; finally loosen and remove the union (5) from the block; plug the pipe ends and the exhaust of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

Figure 4



❑ Disassemble the starter;
Properly hold the starter (2) and loosen the fixing screws (1);
assemble the supporting bracket (99361037) using the threaded ports on the basement.

Figure 5



On the left hand side:

- ❑ Disassemble oil filter (1) and bracket as well (for versions with engine oil filter not directly assembled on to the exchanger);
  Using tool 99360076 operate on oil filter;
  Loosen the screws (3) removing the bracket together with the filter bearing (4 and 5).

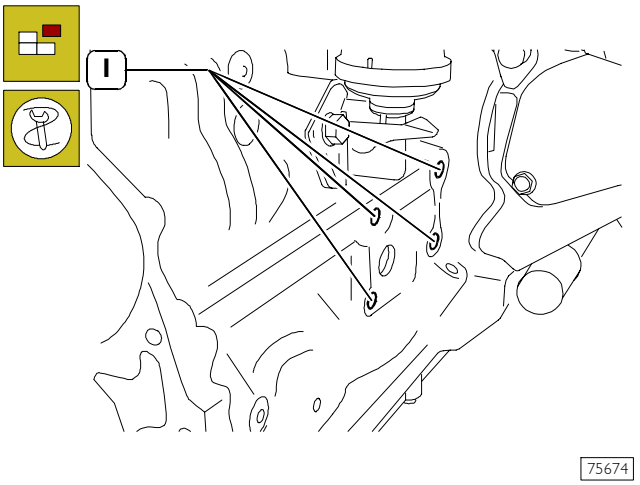
Warning: the oil filter contains inside aprx. 1 kg. of engine oil.
Provide tank with sufficient capacity to contain the liquid.

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

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

- ❑ The plug and the oil filler pipe (for versions with the engine oil filter fitted directly on the heat exchanger).
- ❑ Seal the opening to prevent foreign bodies from entering.
- ❑ Remove the oil level rod together with guide pipe (2); (loosen the guide pipe disassembling from the block); properly pipe the screw-threaded port to avoid inlet of foreign matters.

Figure 6



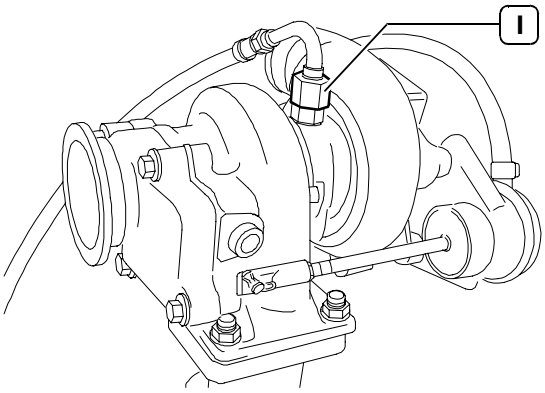
- ❑ Assemble the second bracket 99361037 throughout the screw-threaded ports (1).
- ❑ Lift the engine using the rocker arm 99360595 and put it on the turning stand 99322205.
- ❑ Drain the oil through the cap underneath the plug.

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

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

Disassembly of application components

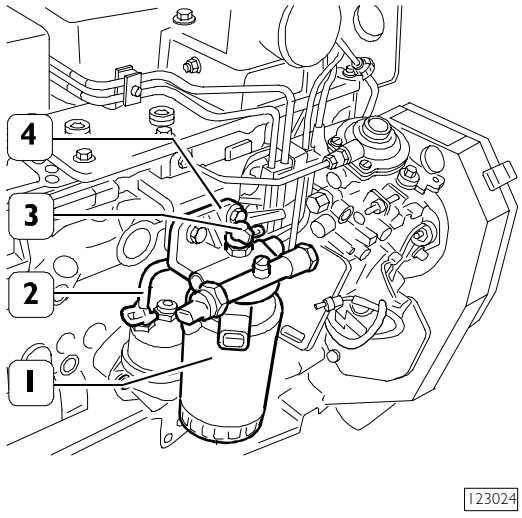
Figure 7



Proceed disassembling the supercharger:

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

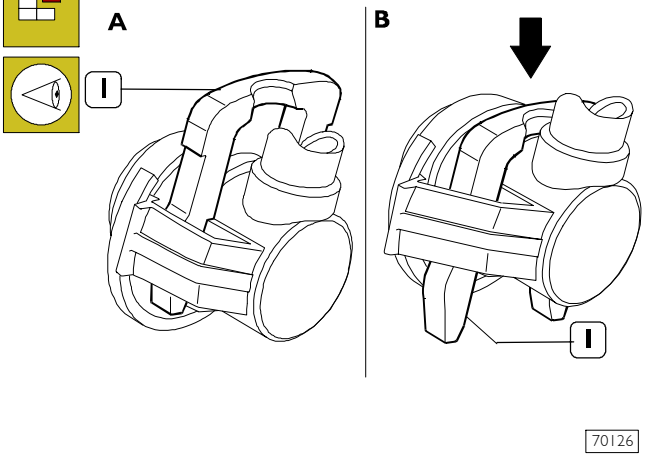
Figure 8



NOTE In some versions, the fuel filter has a heater interposed between filter support and filtering cartridge.
For the versions requiring it, disconnect the electrical connections of such electrical component before removing the fuel filter.

- ❑ Place a container under the fuel filter and screw out the condense drain faucet underneath said filter. Carry out complete drainage of the fuel contained therein.
- ❑ Screw out completely the faucet and, using equipment 99360076 disassemble oil filter (1).
- ❑ Disconnect fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to the feed pump.
- ❑ Remove the fuel filter bearing (4) from the bracket fixed to the engine head.

Figure 9

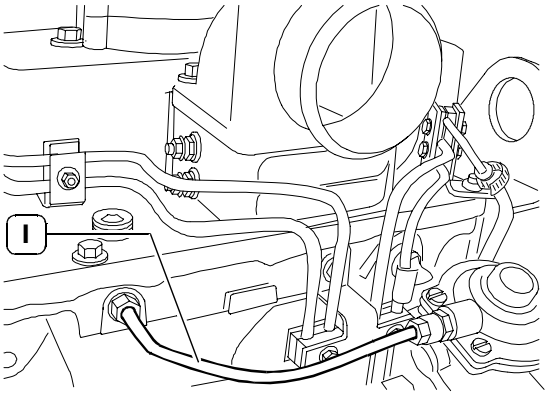


NOTE To disconnect fuel pipelines (2 and 3, Figure 8), in low pressure from the relating pipe fittings, it is Necessary to press the locking fastener (1) as shown in picture **B.**

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

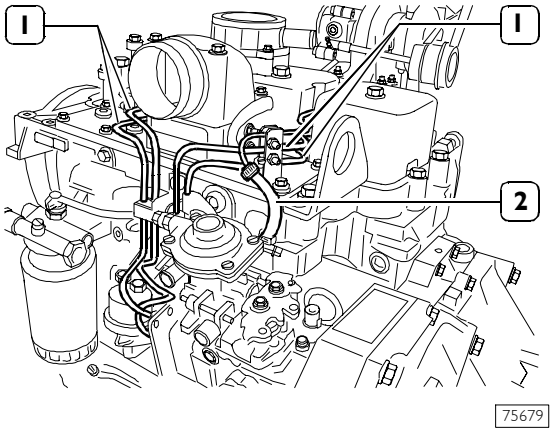
BOSCH VE 4/12 F Pump

Figure 10



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

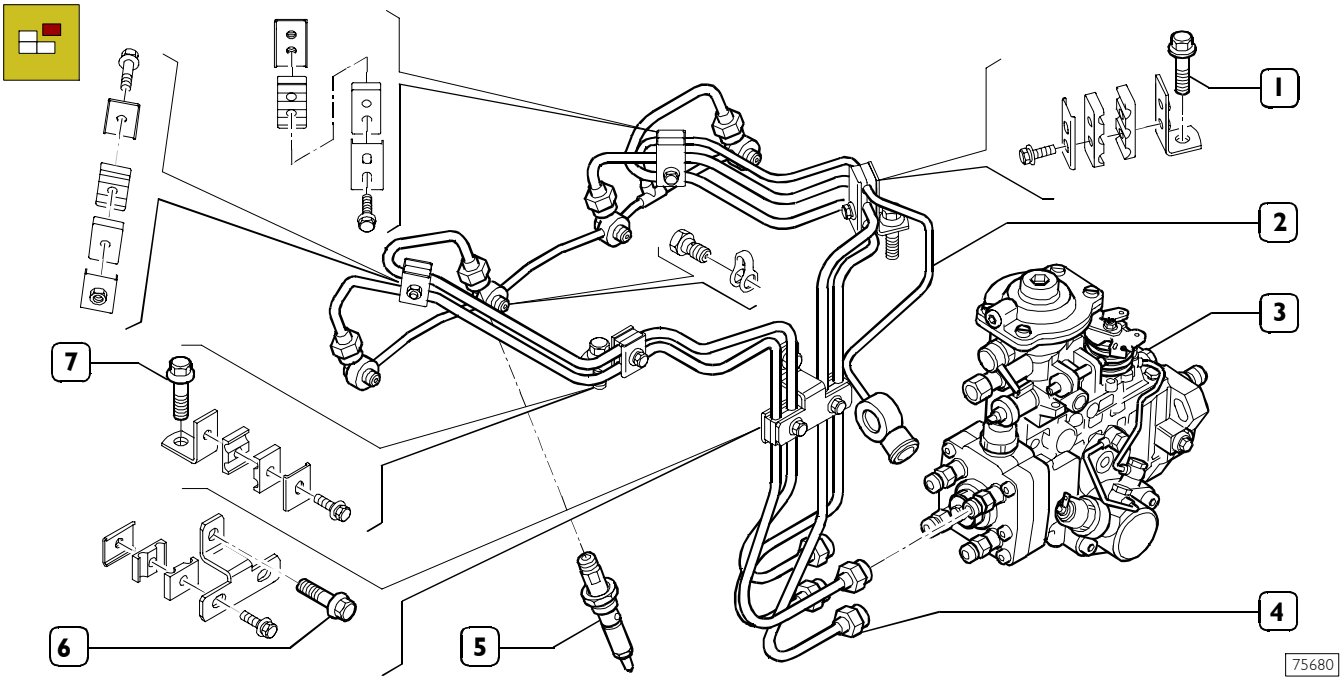
Figure 11



❑ Disconnect the pipelines (1) and (2) that provide feed and fuel recovery between pump and injectors; screw out the nuts fixing the pipes to the pumping elements; loosen the fuel recovery pipe collar on the injection pump; operate on the nuts assembled to the injectors and loosen the screws fixing the fuel recovery pipeline; loosen the screws holding the fixing brackets of such pipelines (1,6, and 7, Figure 12); pipe the pipeline ends.

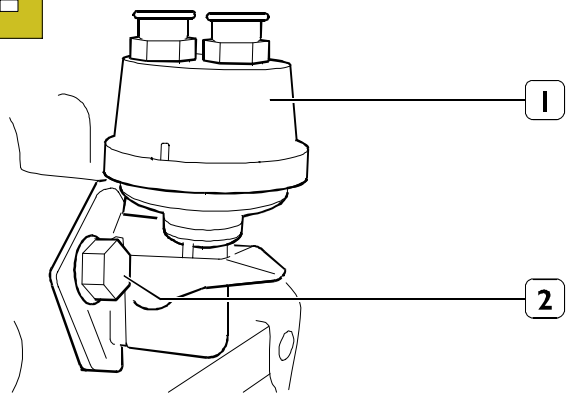
❑ Disassemble the injectors and remove them from their slot: remove the gaskets.

Figure 12



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

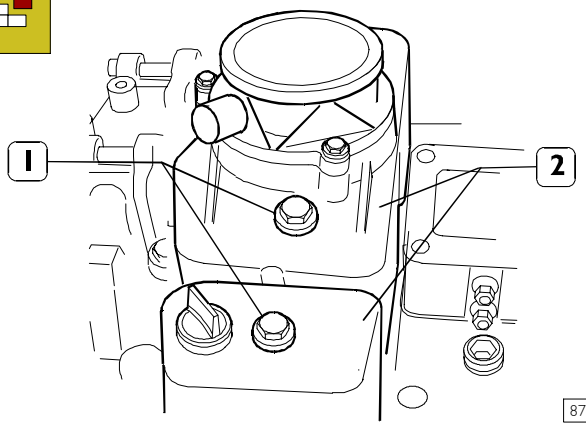
Figure 13



88102

❑ Loosen the two fixing screws (2) and disassemble priming pump (1).

Figure 14

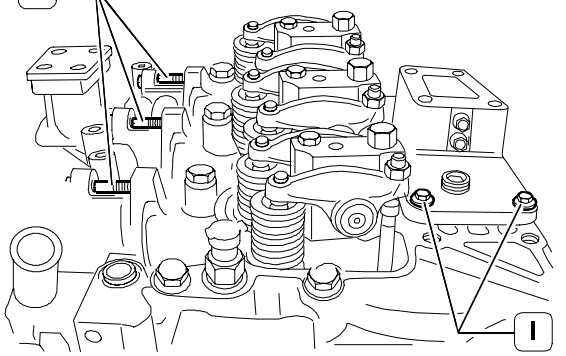


87406

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

NOTE On the cap there is a blow-by valve for the lubrication oil vapours.
All the gaskets shall always be replaced during assembly.

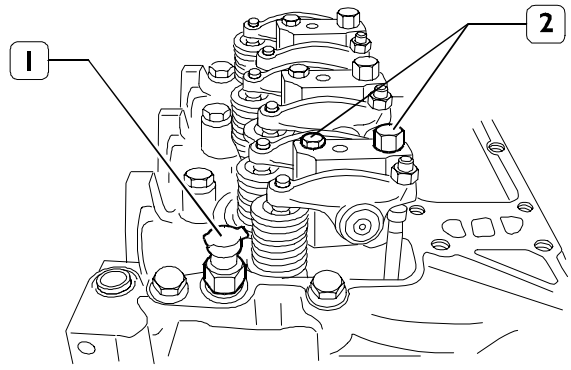
Figure 15



87409

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

Figure 16

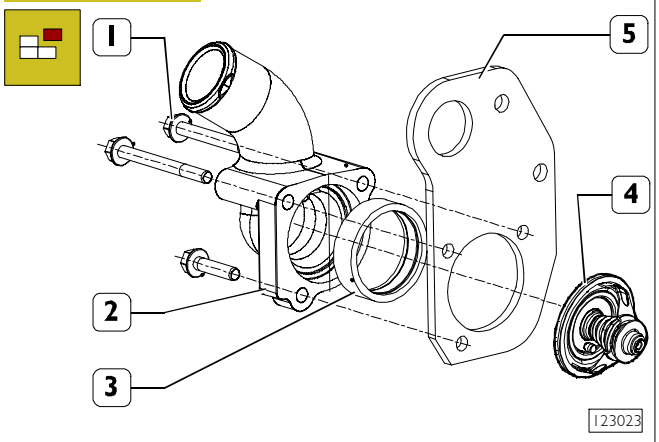


125114

❑ Disassemble rocker arm bearings; loosen the two fixing screws (2) and remove the complete rocker arm bearing; withdraw tappet rods. Repeat the operation for all the remaining rocker arm bearings.

❑ Disassemble water temperature transmitter (1).

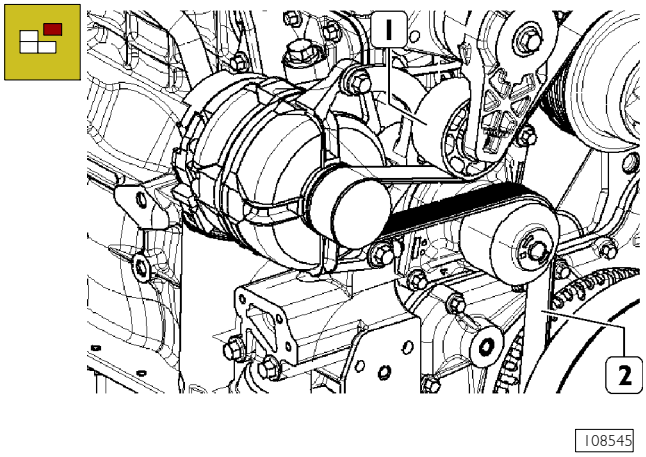
Figure 17



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

NOTE The shape and the size of the thermostat casing vary according to the usage of the engine.
The illustrations therefore provide a general guideline for the operation to be carried out.
The procedures described are therefore applicable.

Figure 18

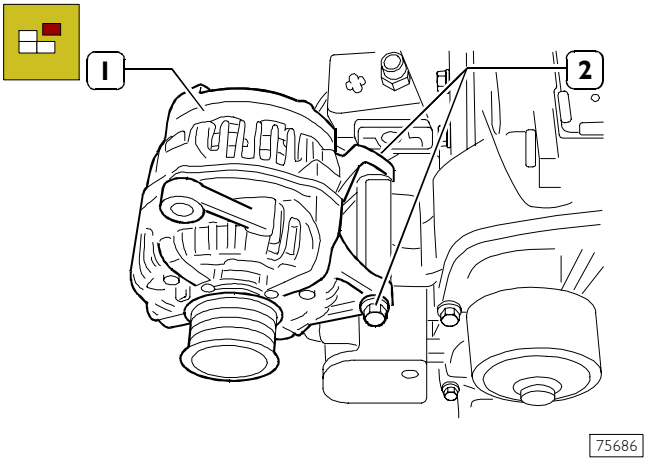


Release on the drive belt tensioner (1) and extract the belt (2) from the belt pulleys from the water pump ones and from the belt rebound pulleys.

Disassemble the belt tensioner (1).

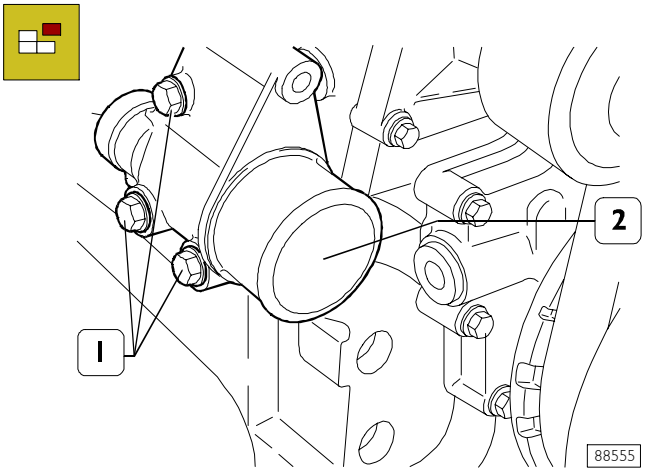
Loosen the screws fixing the alternator to the support and disassemble it.

Figure 19



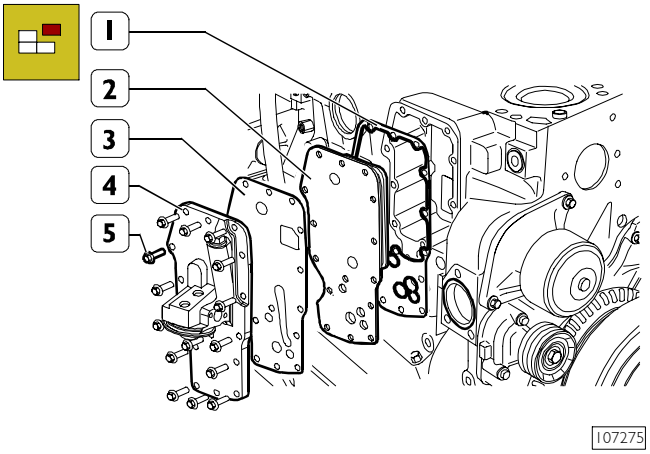
- ❑ Properly hold the alternator (1) separating it from its bearing by loosening the screw (2); remove screw nut and washer.

Figure 20



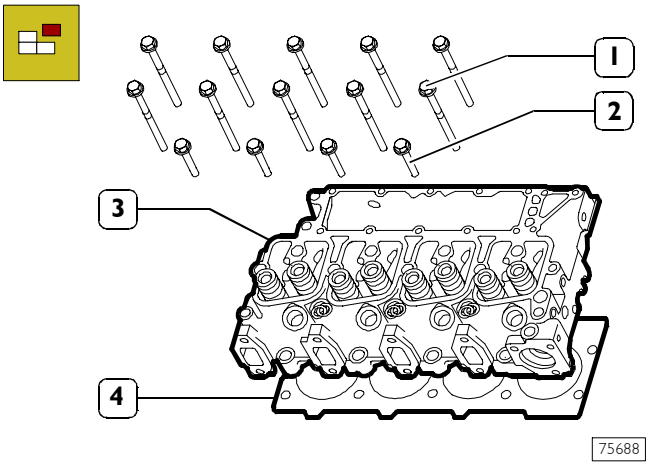
Unscrew the fixing screws (1) and disassemble the pipeline union (2).

Figure 21



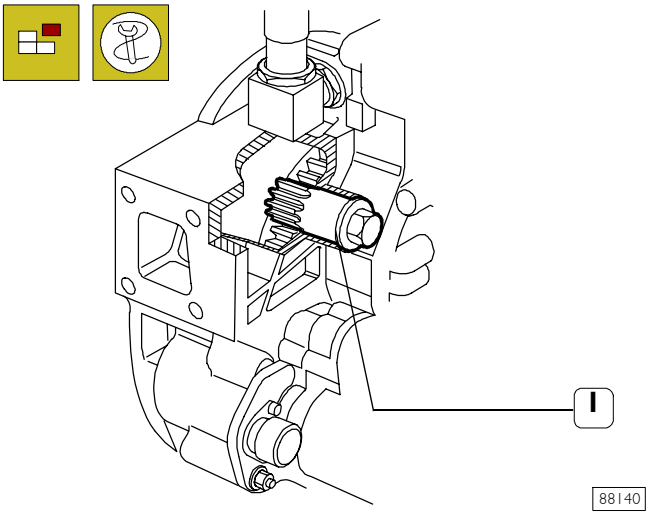
- ❑ Loosen the screws (5) and disassemble the oil filter/heat (2) exchanger bearing (4), interlayer plate (3) and relating gaskets (1).
- ❑ Disassemble injection pump (see specific procedure) and the power take-off underneath.

Figure 22



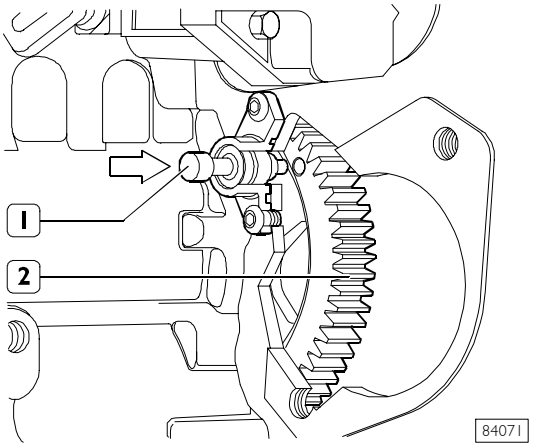
- ❑ Disassemble cylinder head;
  loosen the screws (1) and (2) fixing the cylinder head (3); hook the brackets with metal ropes and, throughout a hoist withdraw cylinder head from the block.

Figure 23



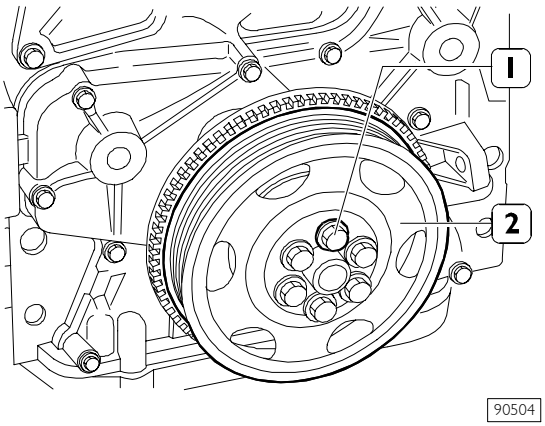
Fit tool 99360330 (2) in the starter motor housing to be able to rotate the flywheel.

Figure 24



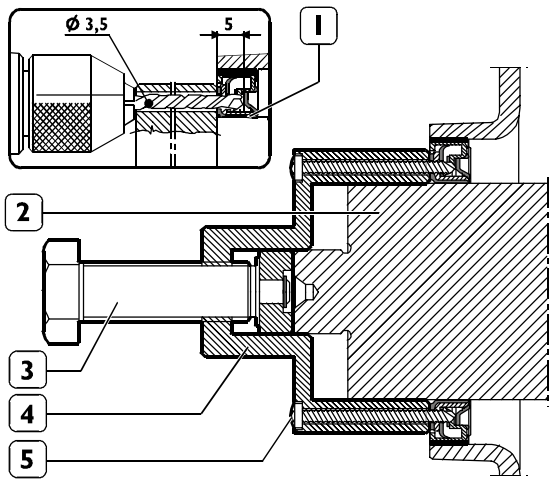
Turn the flywheel until, when pushing the pin 99360616 (1), it blocks the gear (2).

Figure 25



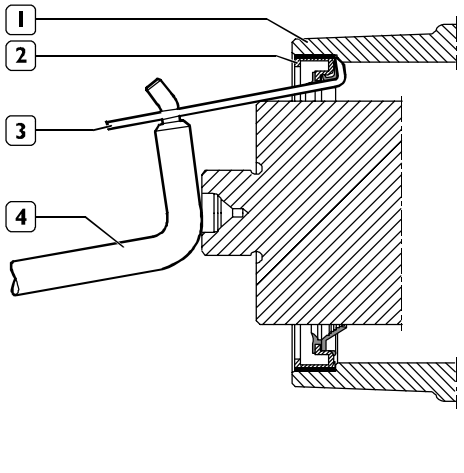
- ❑ Loosen the screws (1) and disassemble the pulley (2).

Figure 26



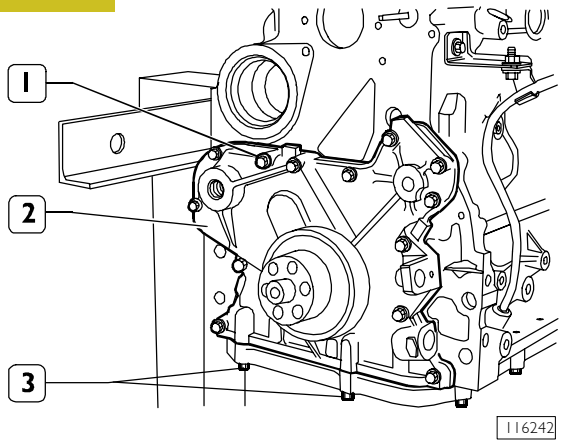
❑ Remove the engine drive shaft fixing ring from the front cover. Use the tool 99340055 (4) to operate on the front tang (2) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring (1) using Ø 3,5 mm drill for a 5mm depth. Fix the tool to the ring tightening the 6 screws specially provided.
Proceed withdrawing the ring (1) tightening the screw (3).

Figure 27



❑ Using the specially provided tie rod (3) for the tool 99363204 and the lever (4), withdraw the external holding ring (2) from the front cover (1).

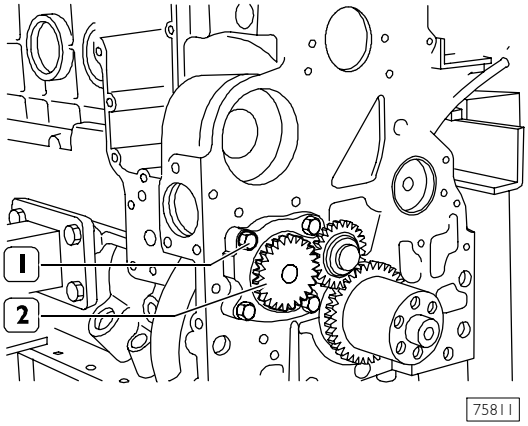
Figure 28



❑ Loosen the screws (1 and 3) and remove the front cover (2).

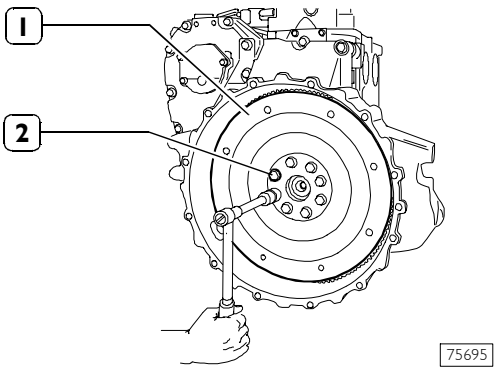
NOTE Take note of the screw (1 and 3) assembly position, since the screws have different length.

Figure 29



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

Figure 30

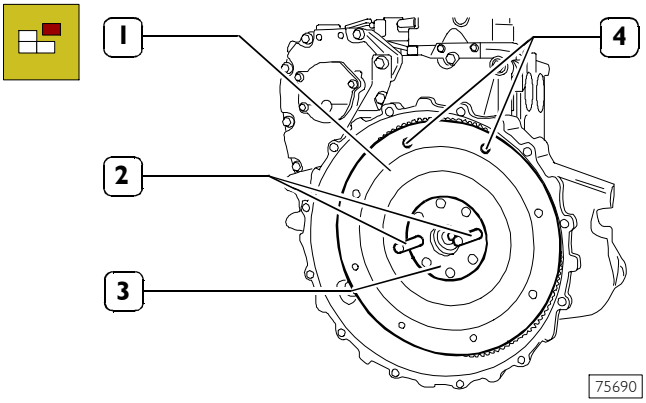


❑ Screw out the opposite screws (2) from the ports where the withdrawal pins shall be introduced (see picture following).

❑ Loosen remaining flywheel fixing screws (1) to the engine drive shaft.

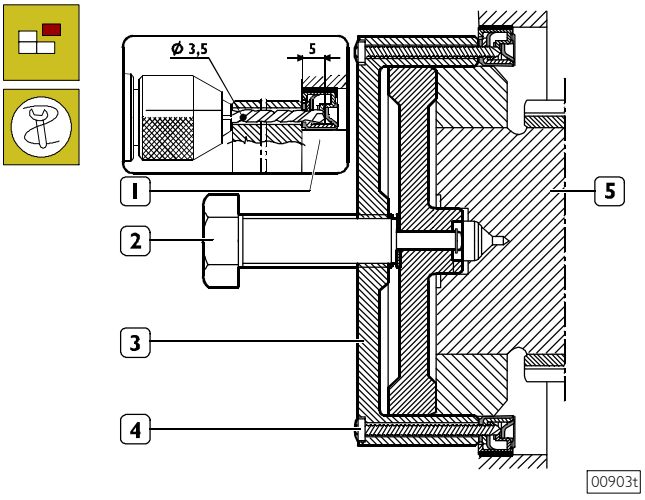
❑ Remove the flywheel block tool (2).

Figure 31 (Demonstrative)



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

Figure 32



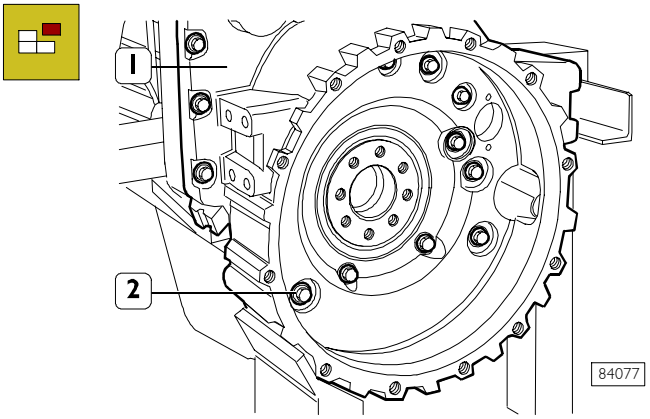
❑ Remove the flywheel cover box fixing ring using the tool 99340056 (3) to operate on the back tang (5) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring using Ø 3,5 mm drill for a 5mm depth.

❑ Fix the tool 99340056 (3) to the ring (1) tightening the 6 screws specially provided (4).

❑ Proceed with drawing the ring (1) tightening the screw (2).

❑ Using the specially provided tie rod (3) for the tool 99363204 and the lever (4), withdraw the external holding ring of the flywheel cover box.

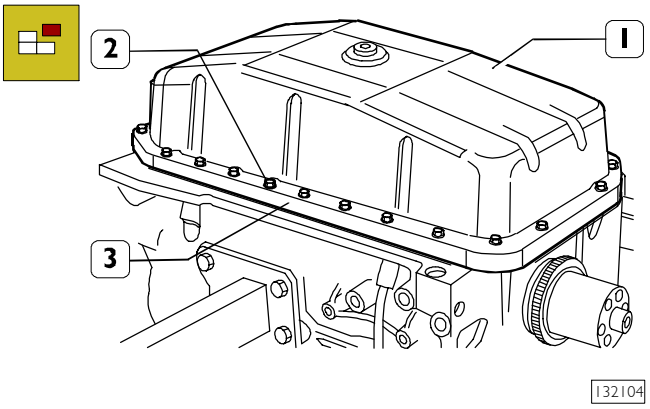
Figure 33



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

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

Figure 34

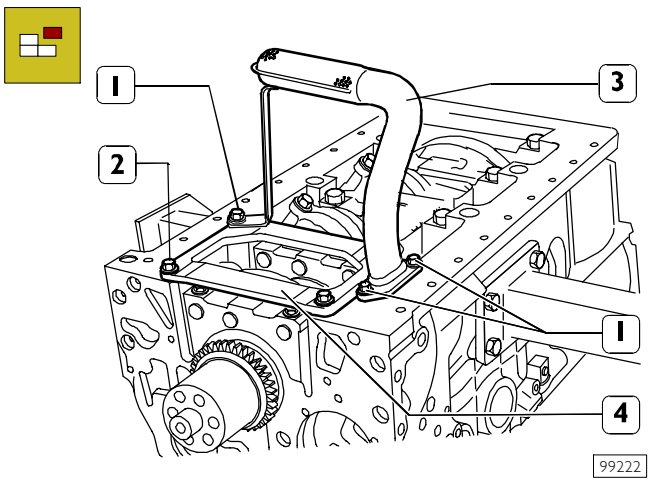


❑ Turn the engine upside-down.

❑ Loosen the screws (2), disassemble the plate (3) and remove the oil pan (1).

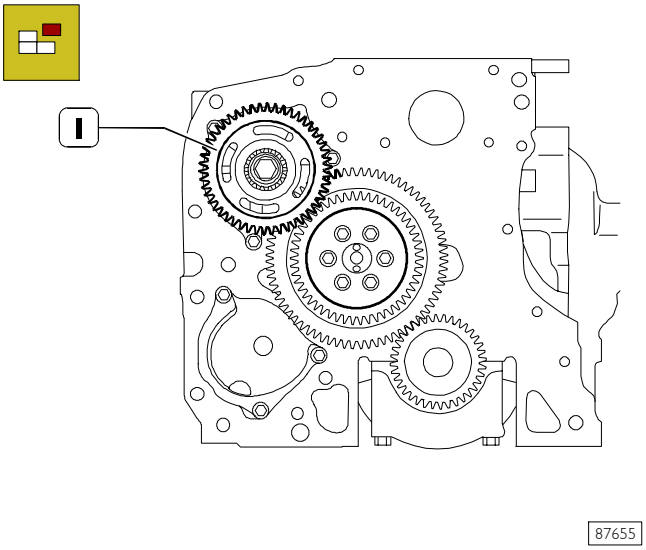
NOTE The shape and the size of the sump vary according to the usage of the engine.

Figure 35



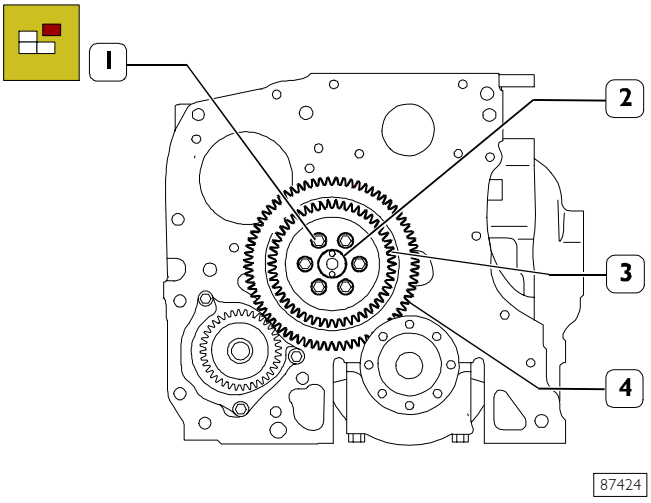
- ❑ Loosen the screws (1) and disassemble the oil suction rose pipe (3).
- ❑ Loosen the screws (2) and remove the stiffening plate (4).

Figure 36



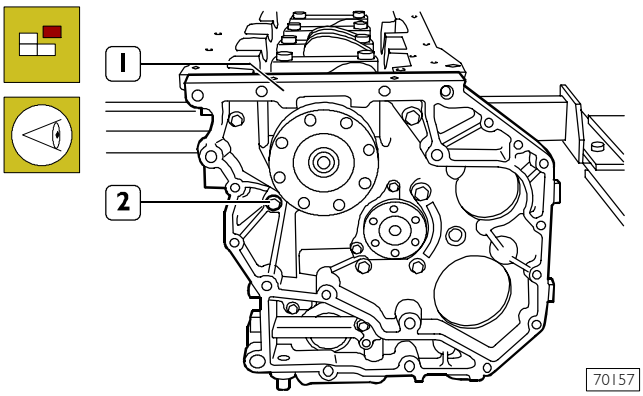
- ❑ Remove the gear (1) transmitting motion to the ignition pump and the relevant support.

Figure 37



- ❑ Remove the screws (1) and disassemble the gears (3) and (4) from the camshaft (2).

Figure 38



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

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

Installation of rear components

Figure 39

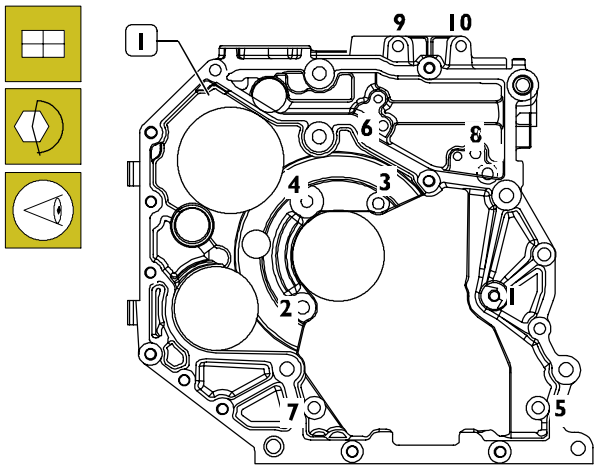


DIAGRAM SHOWING SCREW TIGHTENING TO FIX REAR GEARBOX

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

❑ Reassemble to box (1) to the engine block.

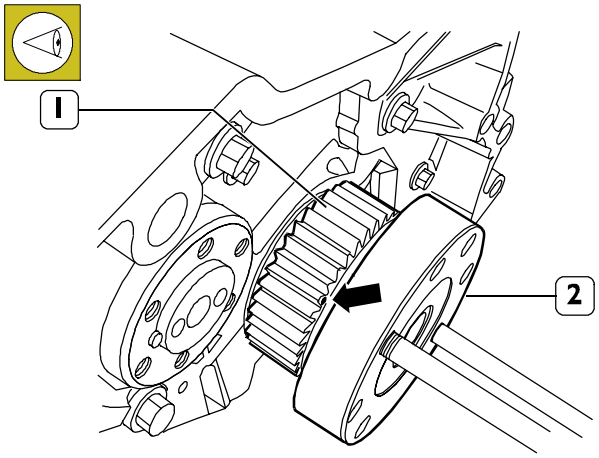
❑ Tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking couples listed here below, following the order as shown in the picture.

Screws M8	20 ÷ 28 Nm
Screws M10	44 ÷ 54 Nm

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

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

Figure 40

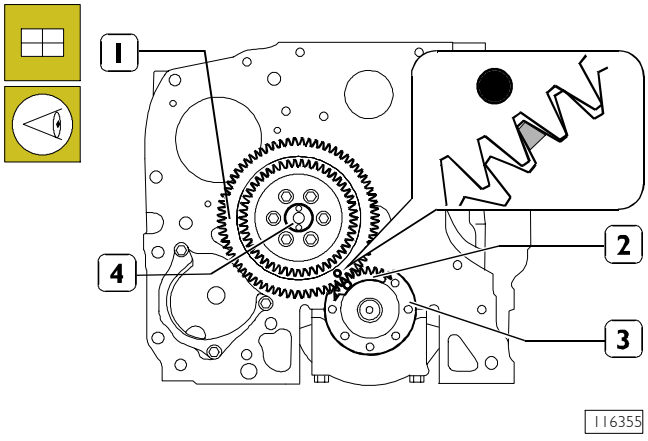


70211

❑ Use a felt pen to mark the driving gear (1) tooth fitted on the output shaft (2) having the mark (→) for timing on the side surface.

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

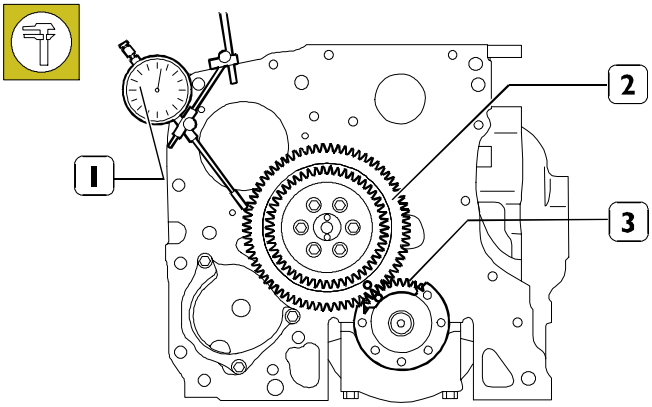
Figure 41



116355

❑ Turn the engine shaft (3) and the distribution shaft (4) so that by mounting the bevel gear on the latter (1) the stencilled mark on the gear (1) coincides with the groove on the gear tooth (2).

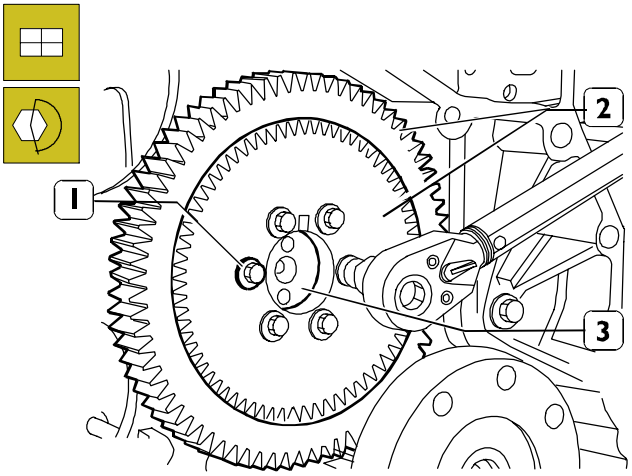
Figure 42



87653

❑ Place the dial gauge (1) on the timing gear (2) and check that the slack between the gears (2) and (3) is included in the range between 0,076 ÷ 0,280 mm.

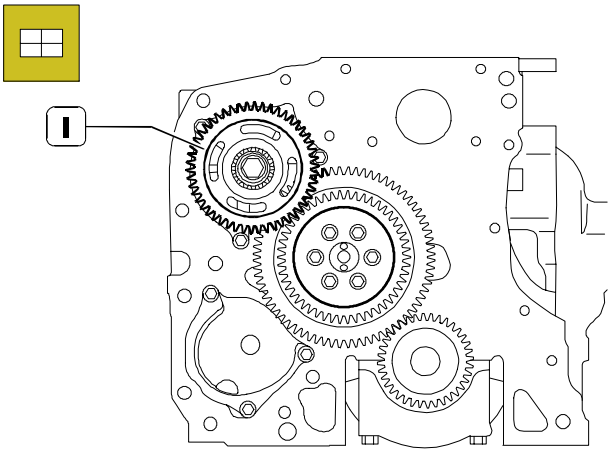
Figure 43



87654

❑ Fit the screws (1) fastening the gears (2) to the camshaft (3) and tighten them to the prescribed pair.

Figure 44



87655

❑ Spline the gear (1) transferring motion to the ignition pump.

Figure 45

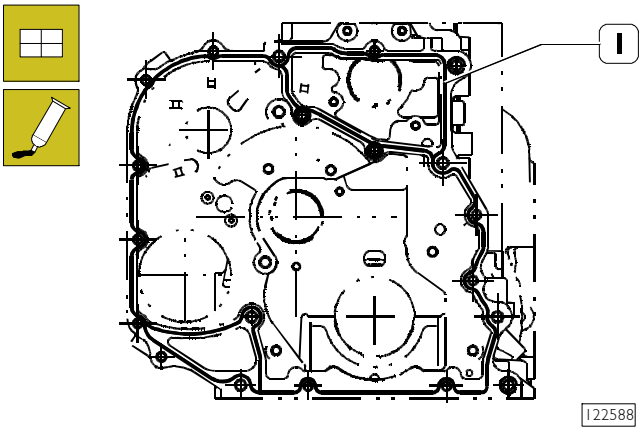


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION

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

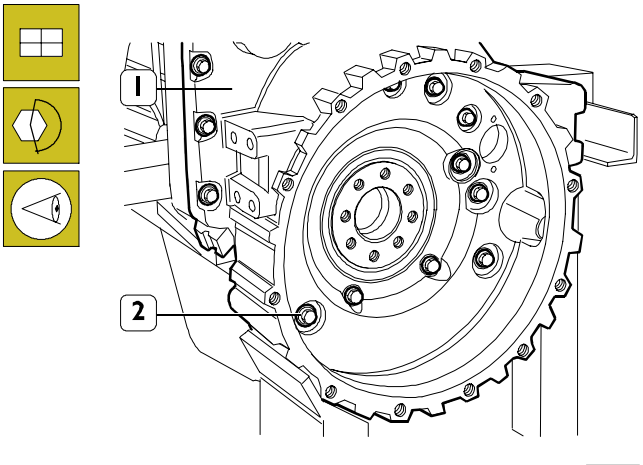
Apply sealing LOCTITE 5205 on the box in order to form a kerbstone of a few mm. Diameter. It must be uniform (no crumbs), with no air blisters, thinner or irregular zones.

Any eventual imperfection shall be correct as soon as possible.

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

Couplings must be assembled within 10 minutes after completing the sealing operation.

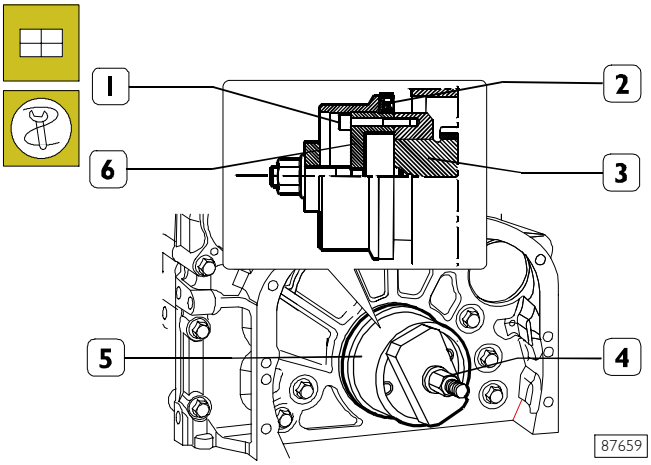
Figure 46



- ❑ Re-assemble the box (1) to the engine basement.
- ❑ Tighten the fastening screws (2) to the same position detected before disassembly.

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

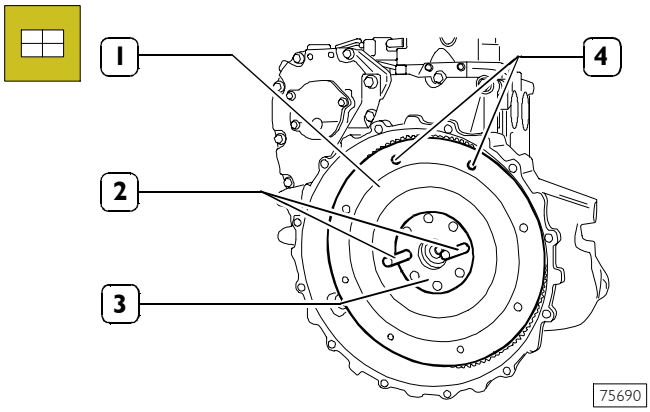
Figure 47



- ❑ Apply to the rear tongs hold (3) of the engine drive shaft the part (6) of the tool 99346253, fix it with the screws (1) and spline the new tight ring to it (2).
- ❑ Place the part (5) on the part (6), tighten the nut (4) until tight ring assembly (2) into the flywheel box is completed.

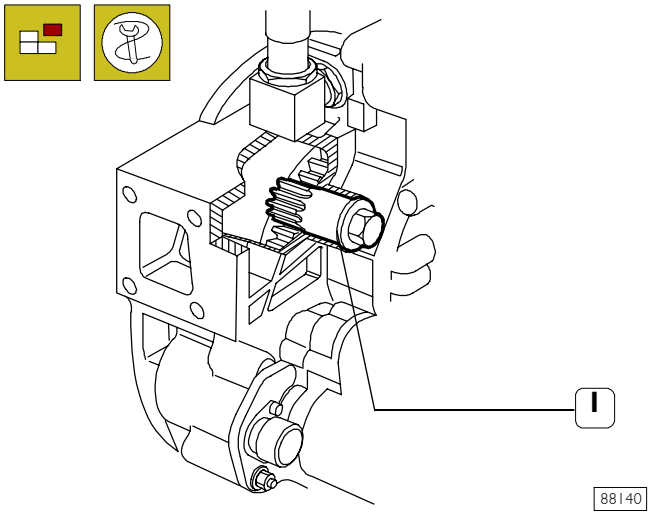
Flywheel installation

Figure 48 (Demonstration)



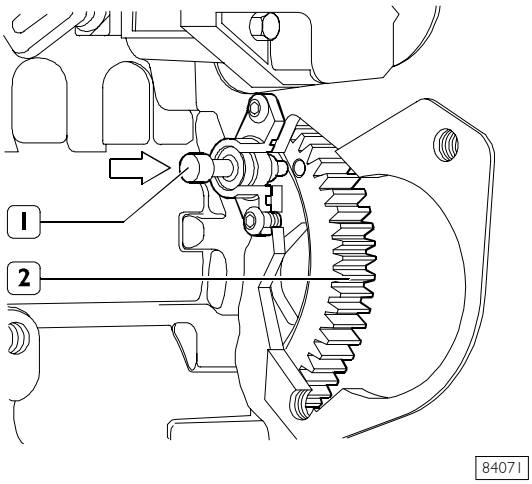
- ❑ Screw up two hooks or trail rings in the flywheel (1) threaded ports (4) for handling .
- ❑ Using a hoist, handle the flywheel to place it in its housing inside the flywheel cover box.
- ❑ Screw up to pins (2) having appropriate length, in the shaft ports (3) and using them as guide, assemble the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

Figure 49



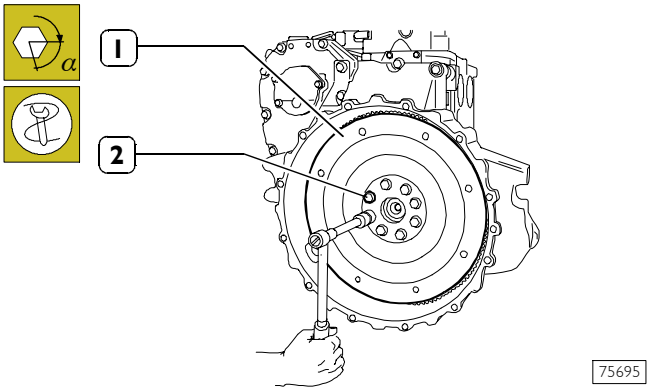
Fit tool 99360330 (2) in the starter motor housing to be able to rotate the flywheel.

Figure 50



Turn the flywheel until, when pushing the pin 99360616 (1), it blocks the gear (2).

Figure 51



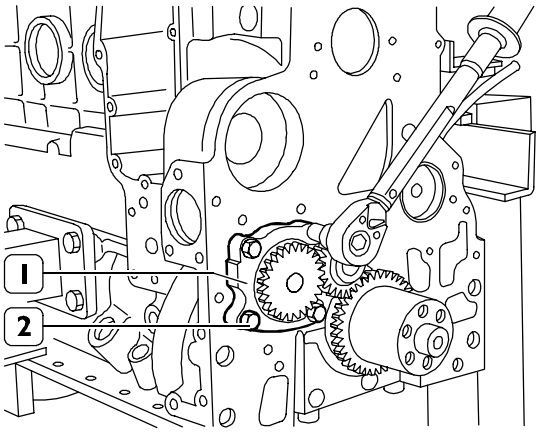
Tighten the engine flywheel (1) fixing screws (2) in two phases:

- ❑ 1st phase; tightening by means of dynamometric wrench to couple 30 ± 4 Nm;
- ❑ 2nd phase, 60° ± 5° angle dwell with tool 99395216.

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

Installation of front components

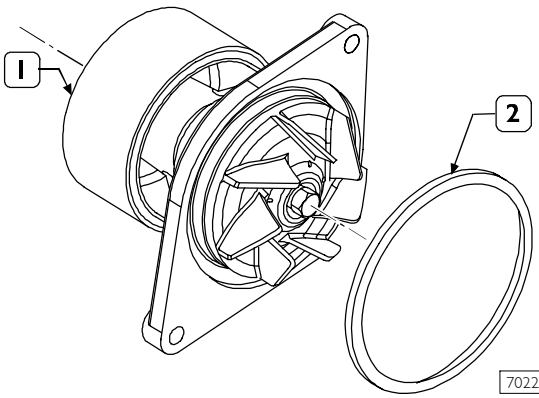
Figure 52



70220

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

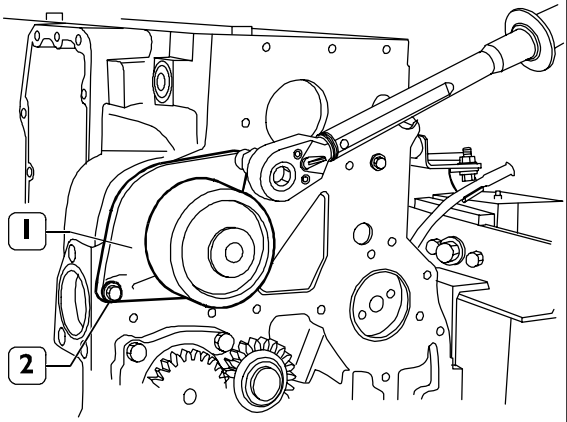
Figure 53



70221

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

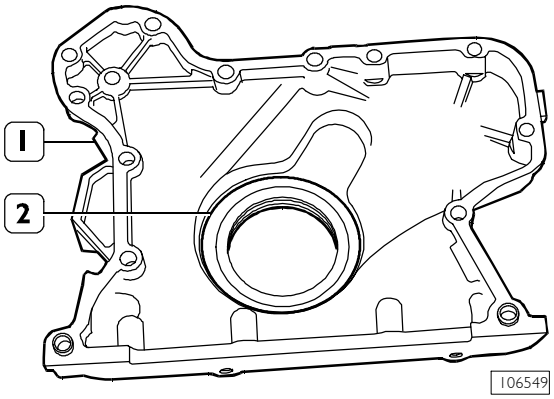
Figure 54



76112

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

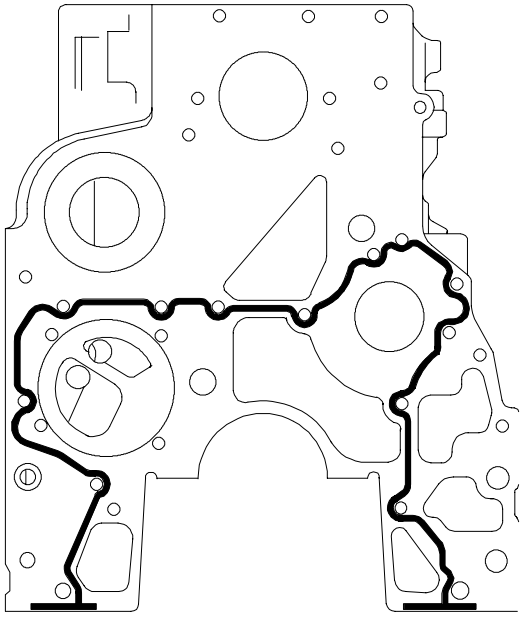
Figure 55



106549

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

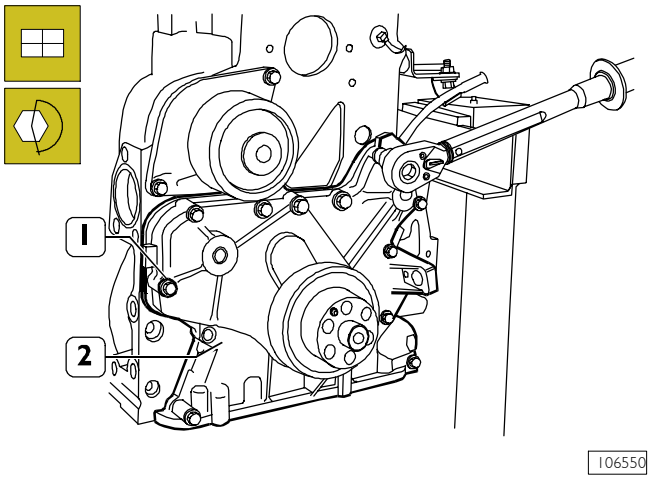
Figure 56



75710

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

Figure 57



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

Figure 58

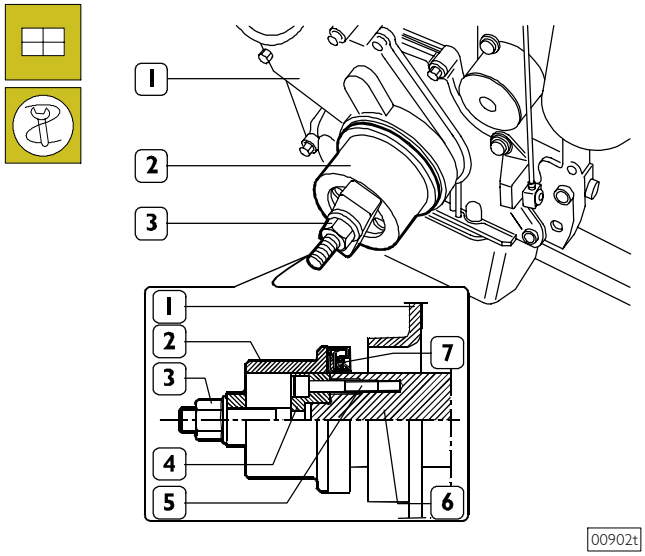
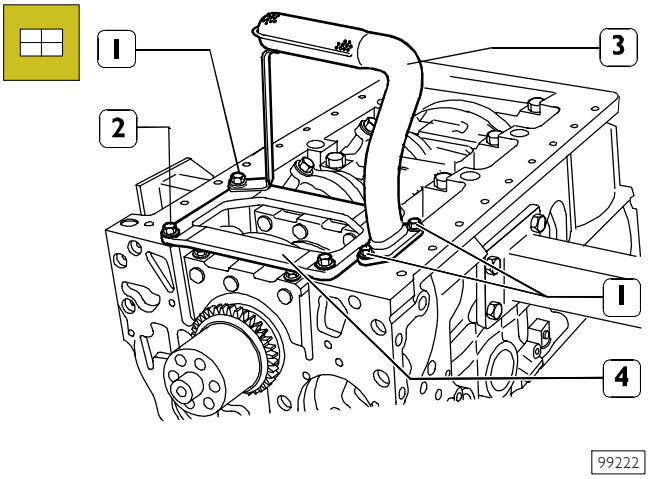
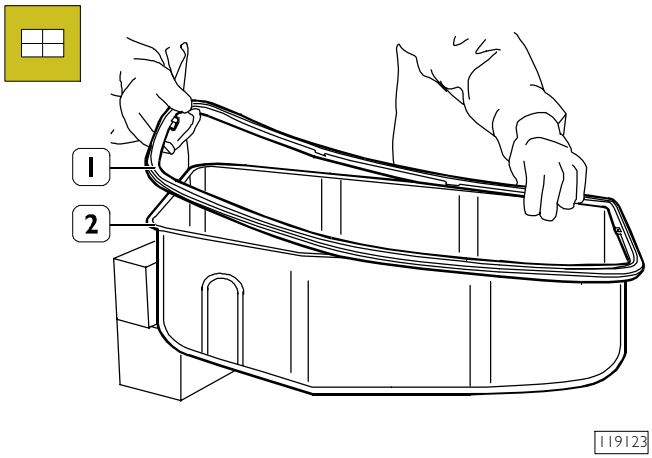


Figure 59



❑ Assemble the plate (4), the rose pipe (3), tighten the fixing screws (1, 2 and 4) and fix them to the prescribed couple.

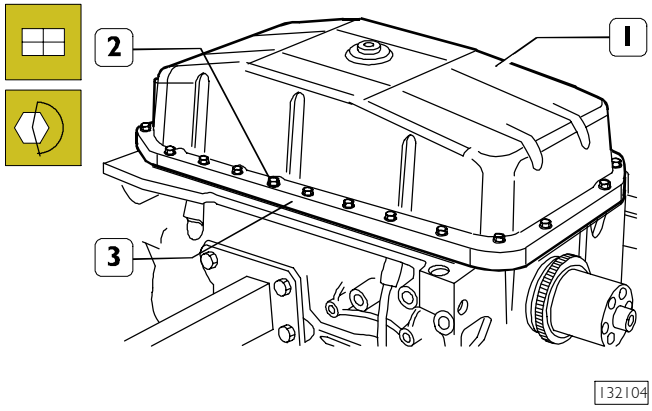
Figure 60



Set the gasket (1) on the oil sump (2).

NOTE The shape and the size of the sump vary according to the usage of the engine.

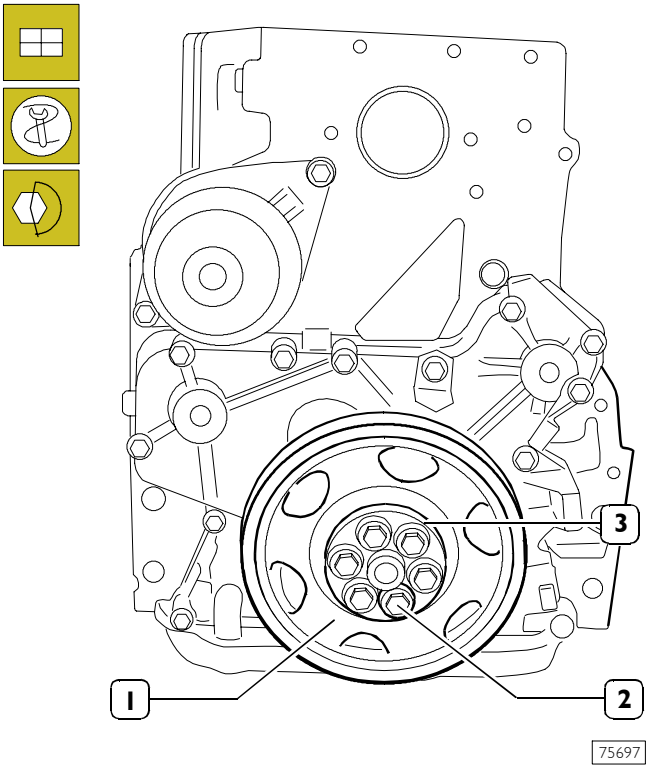
Figure 61



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

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

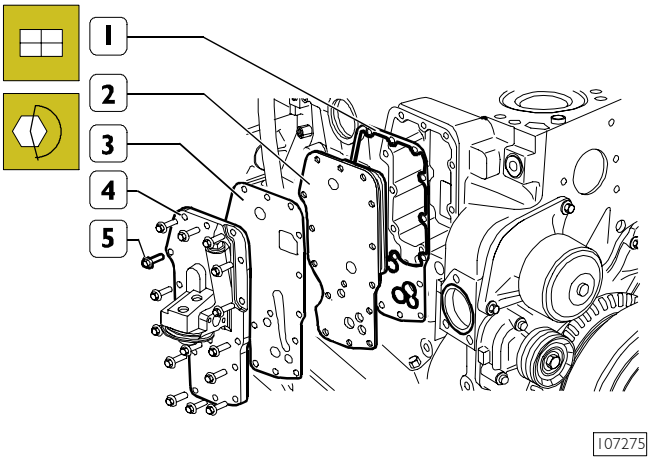
Figure 62



❑ Assemble the pulley (1) to the engine drive shaft , and the distance ring (3).

❑ Tighten the fixing screws (2) and lock them to the 110 ± 5 Nm couple.

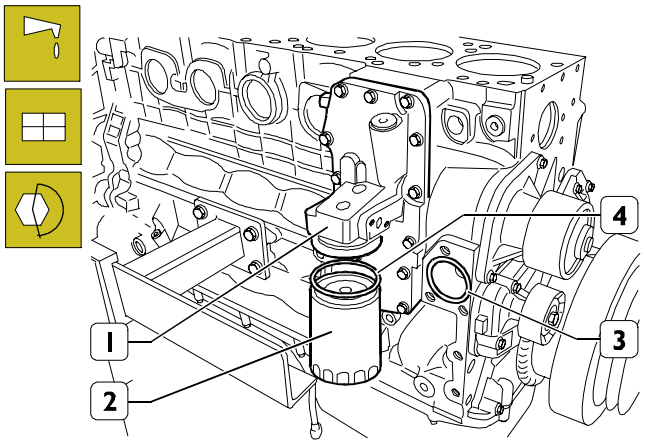
Figure 63



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

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

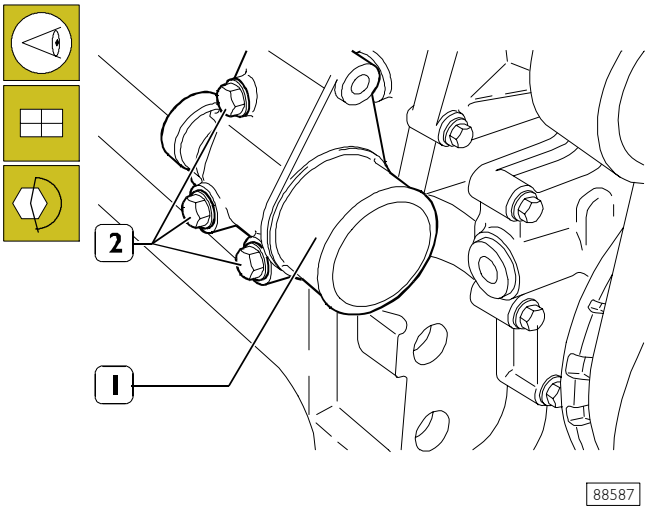
Figure 64



122589

- ❑ Lubricate the fixing ring (4) using engine oil and place it on the oil filter (2).
- ❑ Tighten the oil filter (2) manually on the connector for the support (1) until it is in the end of travel position, tighten the oil filter (2) a further ¾ of a turn (for versions with the engine oil filter fitted directly on the heat exchanger).
- ❑ Place a new fixing ring on the block housing (3).

Figure 65

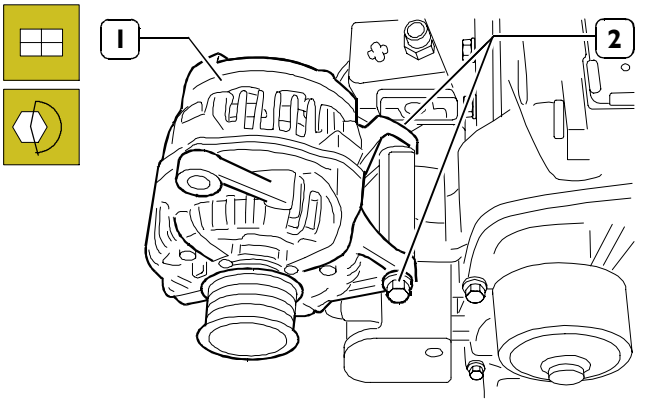


88587

Assemble pipeline union (1) and tighten screws (2) up to the prescribed torque.

NOTE Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

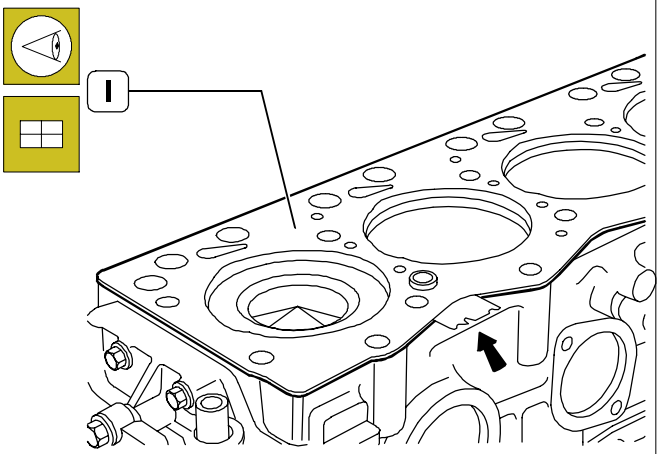
Figure 66



75686

- ❑ Connect the alternator (1) to the support.
- ❑ Tighten the screw without locking it (2).

Figure 67



87759

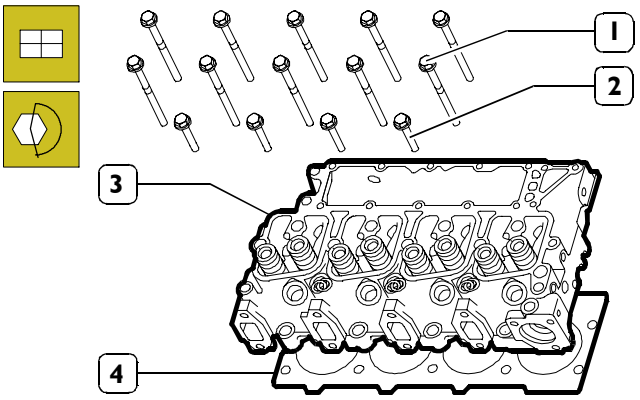
- ❑ Place the gasket (1) over the block.
  The choice of the gasket's thickness shall be made in consideration of the cylinder protrusion measured with respect to the block's upper surface.

NOTE Verify that the engine block stand is clean.

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

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

Figure 68

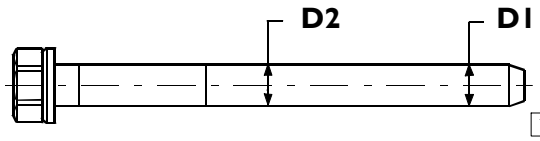


75688

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

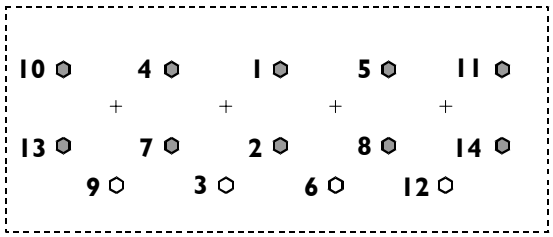
NOTE If the valves have been removed from the head, it is necessary to assemble them before assembling the head itself on the engine block.

NOTE Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:
if D1 - D2 < 0,1 mm the screw can be utilised again;
if D1 - D2 > 0,1 mm the screw must be replaced.



75703

Figure 69



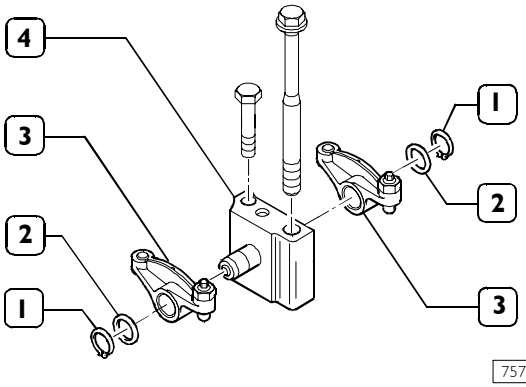
76115

❑ Lubricate cylinder head bolts and install to head.

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

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

Figure 70

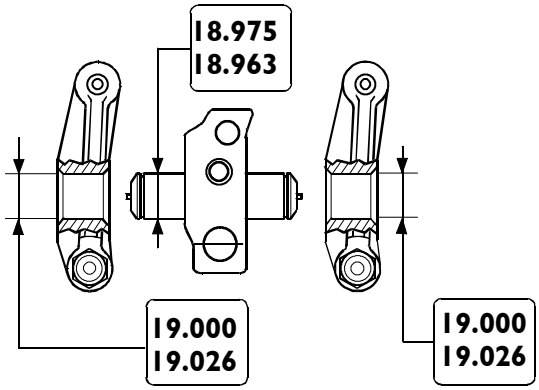


75705

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

ROCKER ARM UNIT COMPONENTS:
1. Elastic ring - 2. Spacer- 3. Rocker arms- 4. Support.

Figure 71

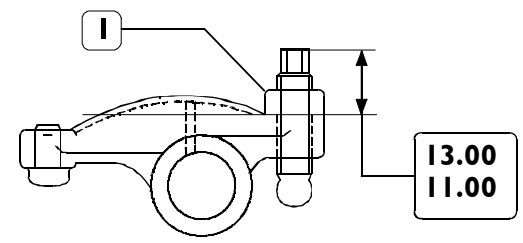


75704

SHAFT AND ROCKER ARM BASIC DATA

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

Figure 72

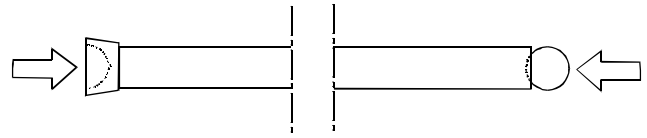


11639

ROCKER ARM ADJUSTMENT SCREW

If unscrewed, check adjustment quota.
Tighten the screw-threaded nut (1) to the i 4 ÷ 6 Nm couple.

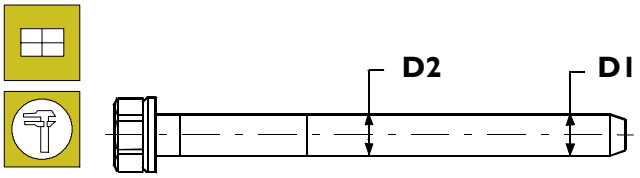
Figure 73



122587

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

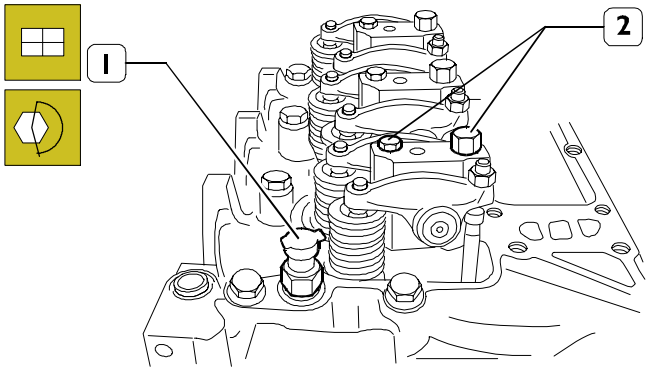
Figure 74



75703

❑ Insert the tappet driving rods and the Rocker Arm unit. Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:
if D1 - D2 < 0,1 mm the screw can be utilised again;
if D1 - D2 > 0,1 mm the screw must be replaced;

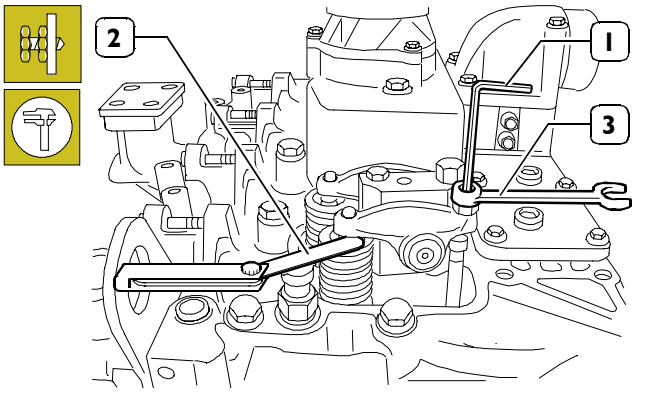
Figure 75



125114

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

Figure 76



75806

On TIER 3 engines, due to the additional lobe for the INTERNAL E.G.R., it is not possible to use the valve clearance adjustment procedure that requires adjusting the clearance of all the valves by positioning the crankshaft 2 times only.

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.

Remove the rocker covers of the cylinder; remove the injector and place the tool 99395097(see Figure 98) to set the cylinder top dead centre position (end-of-compression phase). Pre-load the gauge.

The searched condition is obtained by rotating the engine shaft properly until you find the maximum value on the comparator and then checking that the intake and exhaust valves are both closed.

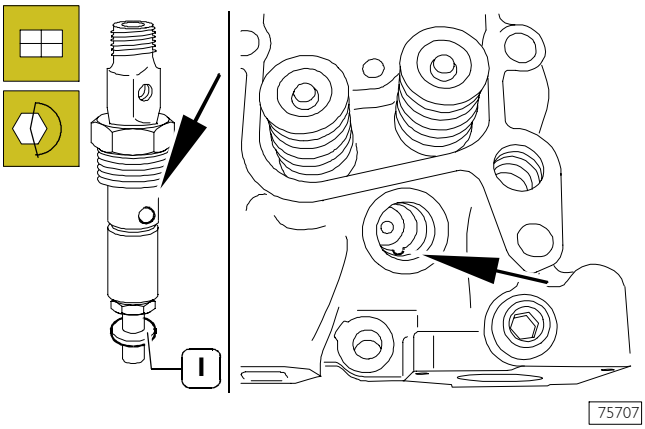
Adjust the slack between rocker arms and valves using socket wrench (1), point wrench (3) and feeler gauge (2).

Correct slack is:
- suction valves 0.25 ± 0.05 mm
- exhaust valves 0.50 ± 0.05 mm.

IGNITION SEQUENCE: 1 - 3 - 4 - 2

Engine shaft starting and rotation	Bilance valves cylinder n°	Adjust intake and exhaust valves clearance cylinder n°
1° al PMS	1	1
180°	3	3
180°	4	4
180°	2	2

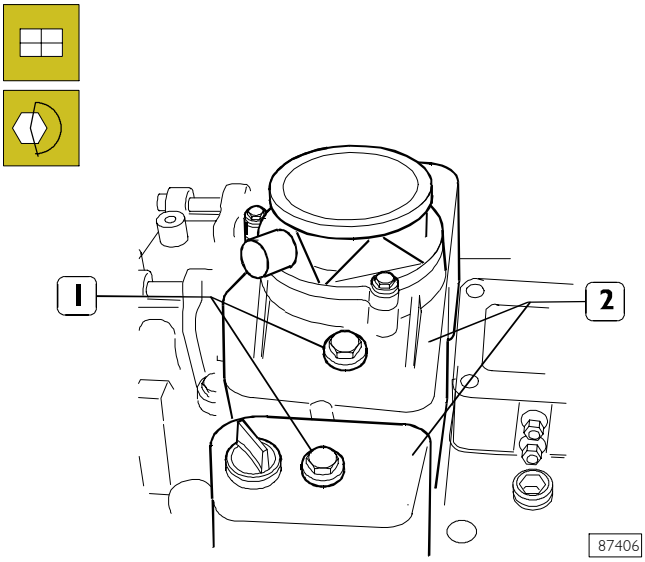
Figure 77



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

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

Figure 78 (Demonstrative)



❑ Assemble cylinder covers (2) with the respective gaskets;

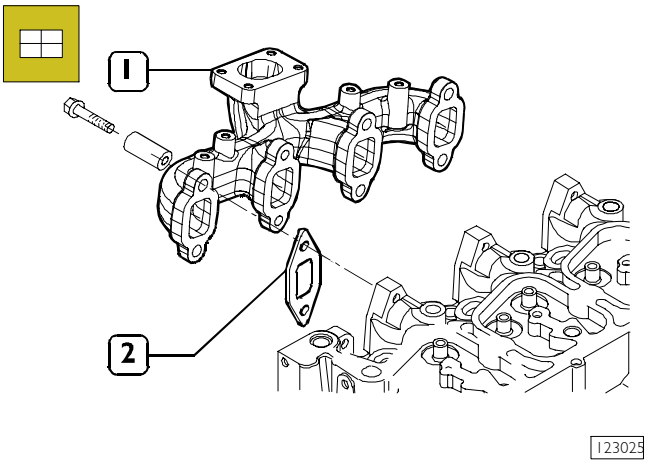
❑ Fit the seal nods and tighten the screws fixing them to the prescribed couple.

NOTE Always replace the gaskets using new ones.

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

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

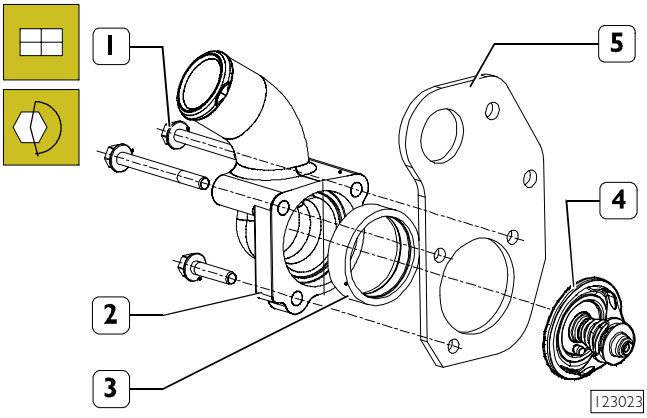
Figure 79



❑ Assemble exhaust manifold (1) providing new gaskets (2).

NOTE The illustration of exhaust manifold may be not matching your model. Anyhow, described procedure is applicable.

Figure 80



❑ Assemble thermostat unit (2) including thermostat (4) and gasket (3).

❑ Tighten the screws to the prescribed couple.

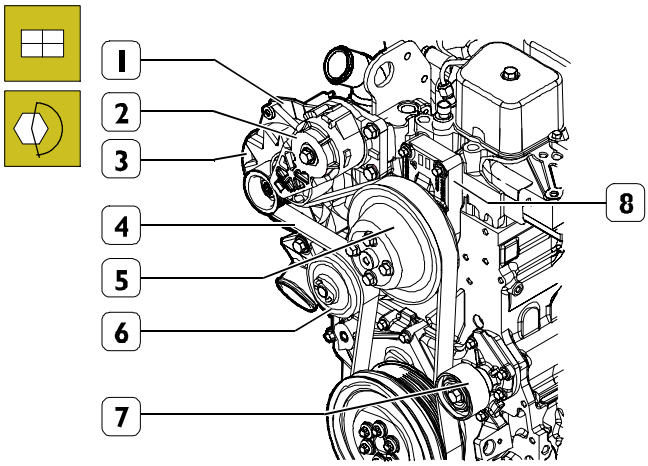
NOTE The screws (1) have been have been utilised to fix the bracket (3).

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

The gasket must be new.

NOTE The shape and the size of the thermostat casing vary according to the usage of the engine.
The illustrations therefore provide a general guideline for the operation to be carried out.
The procedures described are therefore applicable.

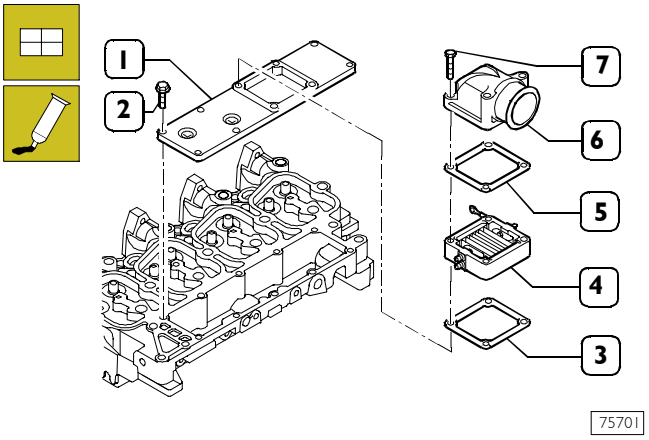
Figure 81



- ❑ Assemble the pulley fan bearing (8) tightening the screws to the prescribed couple.
- ❑ Assemble the alternator (1) tensioning bracket.
- ❑ Mount pulley (5) and secure it to support through screws.
- ❑ Assemble the transmission pulley (7).
- ❑ Refit the automatic belt tensioner (2), tightening the fixing bolt to the recommended torque.
- ❑ Assemble belt Poli-V (4) on the pulley (5) of the engine shaft, on the jockey pulley, on the water pump (6) and on the alternator (3), tighten (syn.: tension) the belt by means of the automatic belt tensioner (2).

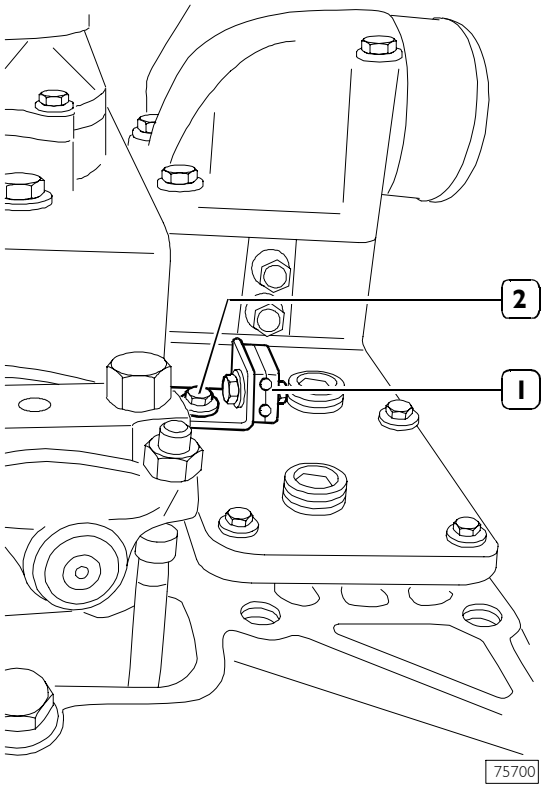
NOTE If the old belt is to be reassembled examine it carefully in order to see if there may be incisions or evident signs of yielding.

Figure 82



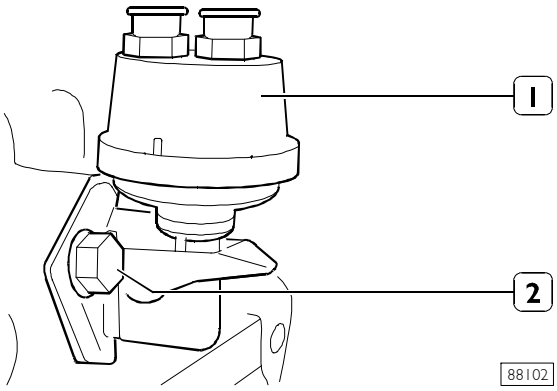
- ❑ Apply on the surface joining the suction manifold plate (1) a sufficient coat of Loctite 5999 and provide. fixing the screws to the prescribed couple.
- ❑ If the duct (6) from the intake manifold plate (1) has been removed, refit it after having fitted a new gasket (5) and components (3) and (4).
- ❑ Tighten the screws (7) to the prescribed couple.

Figure 83



❑ Assemble the brackets (1) fixing the fuel pipelines to the injectors: use the same screws (2) fixing the manifold plate as shown in the picture.

Figure 84



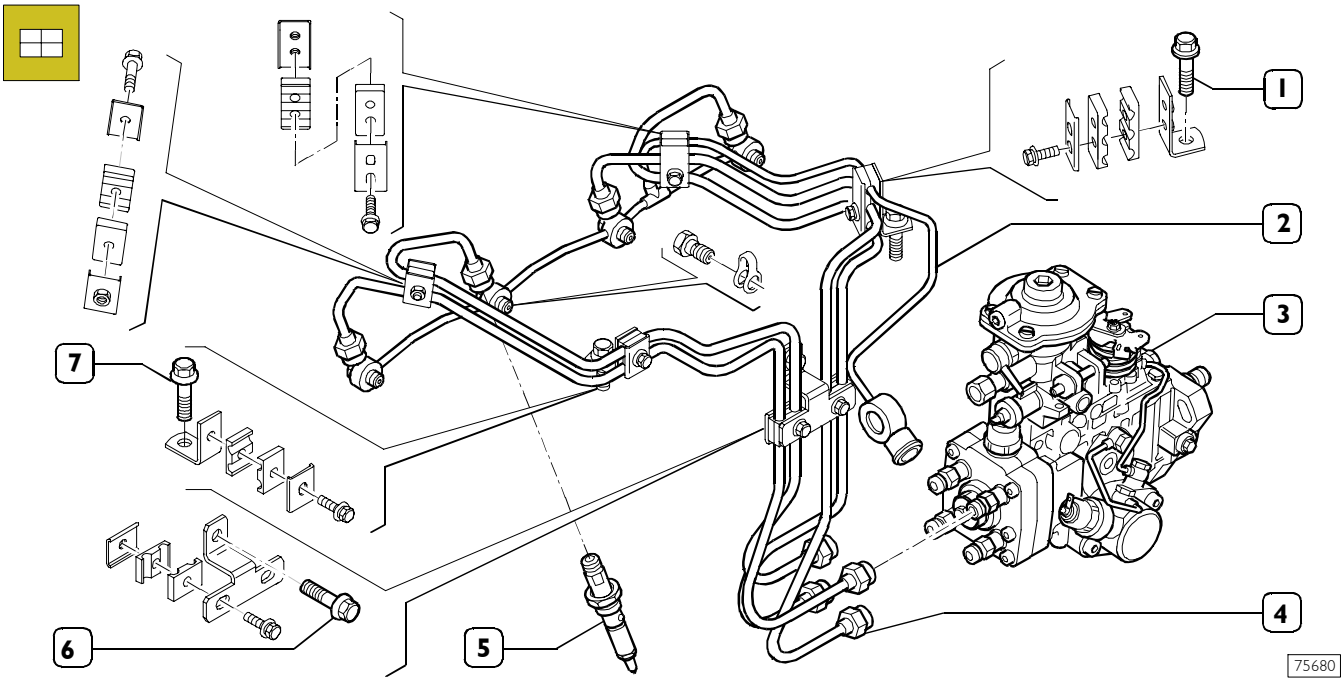
❑ Assemble priming pump (1) providing new gasket and tighten the screws (2) to the prescribed couple.

❑ Also assemble feed pump (see specific procedure) and the power take-off underneath.

NOTE Pump mounting requires specific procedure contained in this section.

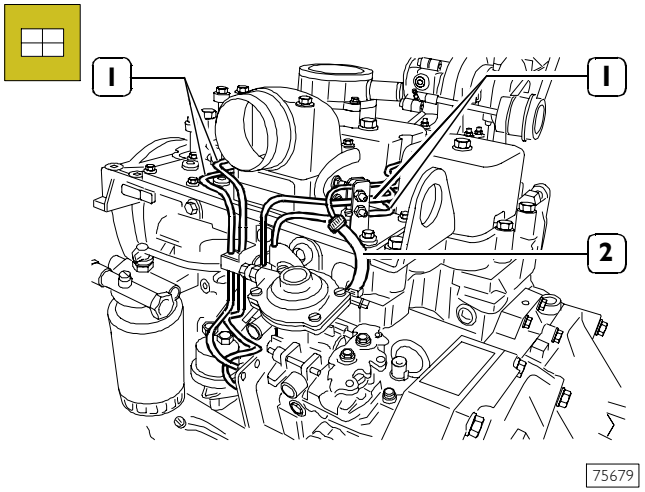
BOSCH VE 4/12 F pump

Figure 85



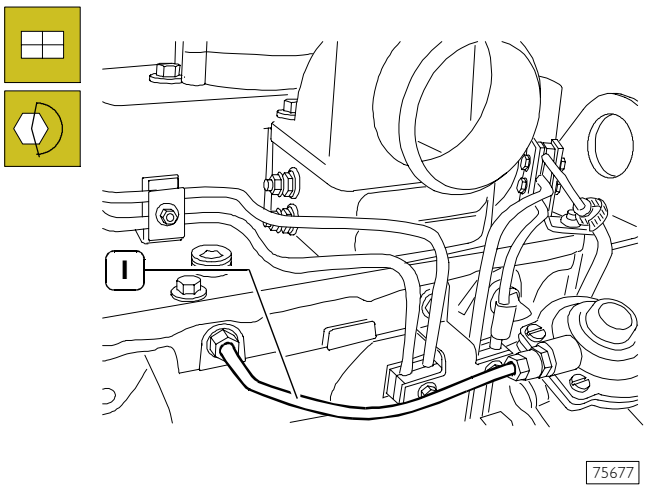
1. Rear bracket fixing screw (on suction collector plate) - 2. Fuel recovery pipeline to pump - 3. Rotary feed pump - 4. Connection nut to pumping elements - 5. Injector - 6. Bracket fixing screw to injection pump side- 7. Front bracket fixing screw (on suction collector plate).

Figure 86



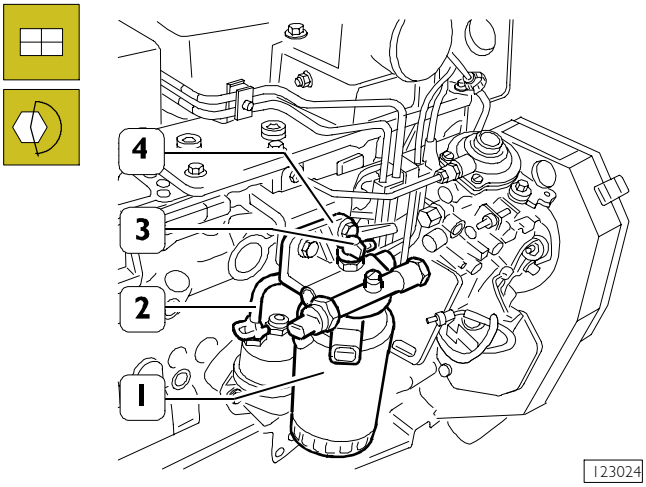
❑ Assemble the pipes (1) and (2) providing fuel feed and recovery between pump and injectors;
Screw up the locking nuts and tighten the screws fixing the fuel recovery manifold; fix the pipes to the injectors throughout the brackets previously assembled.

Figure 87



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

Figure 88



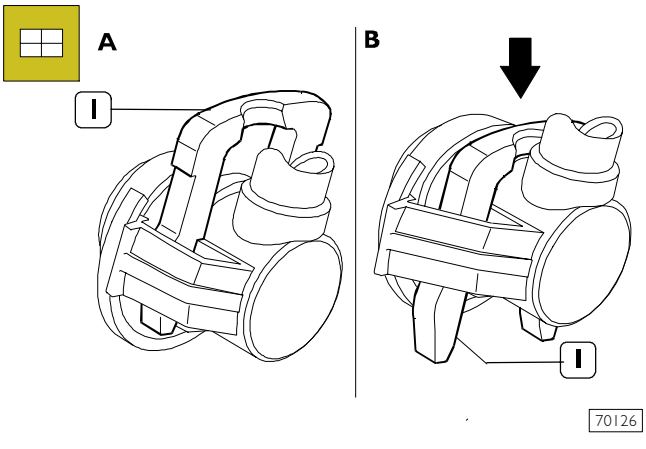
❑ Assemble the fuel filter bearing (4) to the bracket fixed to the engine head.

❑ Connect the fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to feed pump.

❑ Using 99360076 equipment assemble fuel filter (1).

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

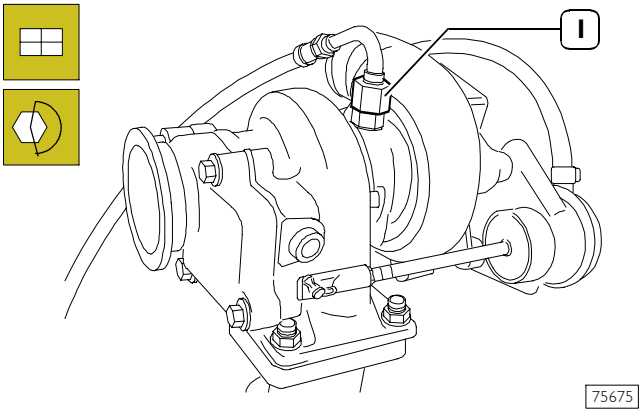
Figure 89



NOTE To connect fuel pipelines (3 and 4, Figure 89) in low pressure from the relating connection unions it is necessary to press the locking fastener (1) as shown in picture B.

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

Figure 90



Proceed assembling the turbocharger:

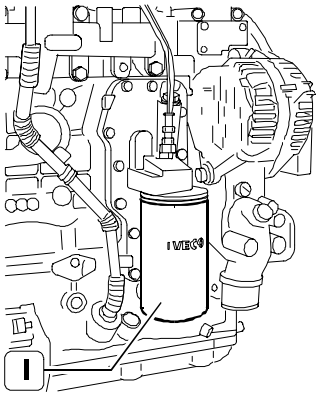
- ❑ Hold the turbocharger and place it on the exhaust manifold after having interposed the gasket.
- ❑ Screw up the fixing nuts of the turbocharger to the exhaust manifold tightening them to the prescribed couple.
- ❑ Tighten the lubrication pipe fixing ring. Operate in the same way on the other end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

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

- ❑ Using rocker arm 99360595 hold the engine and loosen the screws fixing the brackets to the turning stand 99322205.
- ❑ Disassemble the brackets 99361037 from the engine after having properly put it on a wooden bearing.

Completion of engine

Figure 91

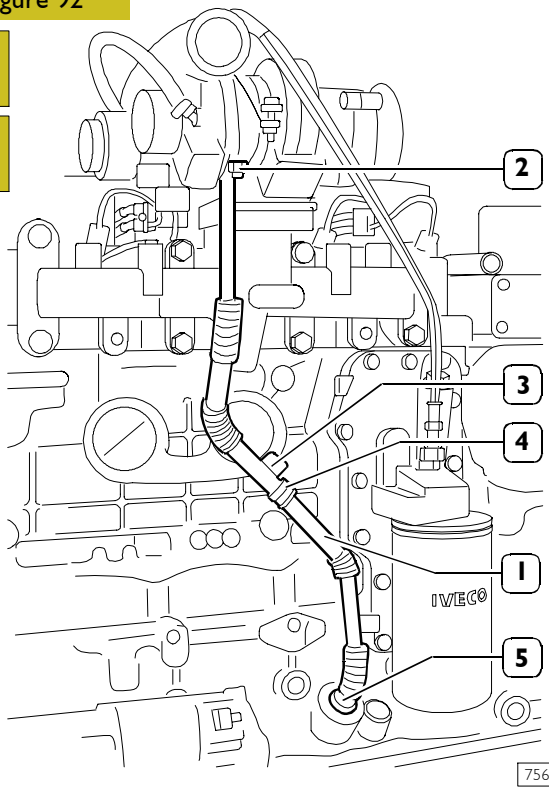


On the right hand side:

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

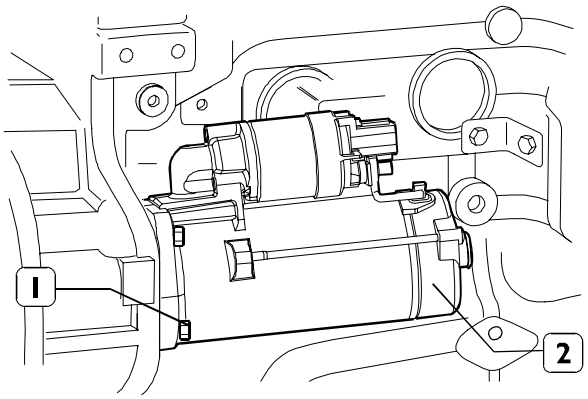
NOTE In some cases, the oil filter (3) is directly placed on the heat exchanger: in this case it shall be assembled using tool 99360076.

Figure 92



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

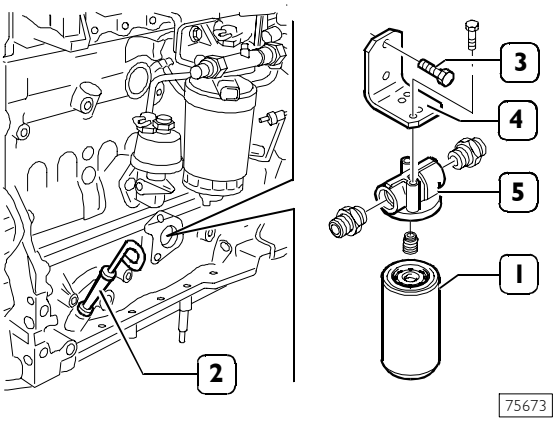
Figure 93



87712

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

Figure 94



75673

On the left hand side:

❑ Assemble oil filter (1) together with bracket (for the versions with engine oil filter not directly assembled to the exchanger); tighten the screws (3) assembling the bracket (4) including filter bearing (5).
Using tool 99360076 screw up oil filter;

❑ The plug and the oil filler pipe (for versions with the engine oil filter fitted directly on the heat exchanger);

❑ Assemble oil level rod together with guide pipe (2).

❑ Fill up engine oil.

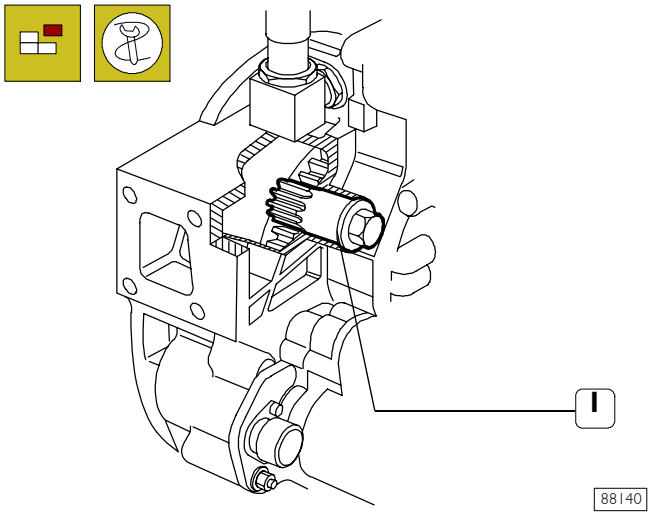
❑ Install the engine on the machine (for installation operations please apply to specific issue).

Rotary feed pump disassembly 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 95



Disassemble the starter from the flywheel box and use tool 99360330 to rotate the flywheel.

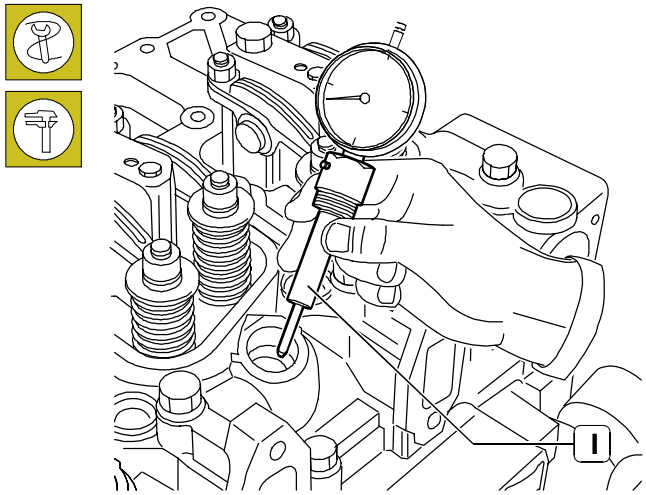
In case feed pump replacement is necessary, this shall be supplied pre-set already as spare part.

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

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

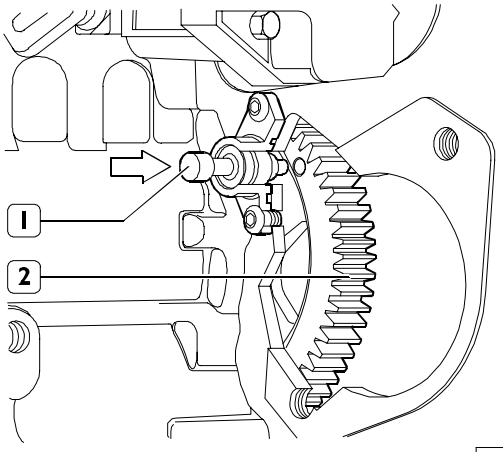
Find the top dead centre with the tool (99395097) - False injector

Figure 96



Remove the rocker covers of the 1st cylinder; remove the 1st injector and place the tool (1) to set the 1st cylinder top dead centre position (end-of-compression phase). Pre-load the gauge.
The searched condition is obtained by rotating the engine shaft properly until you find the maximum value on the comparator and then checking that the intake and exhaust valves are both closed.

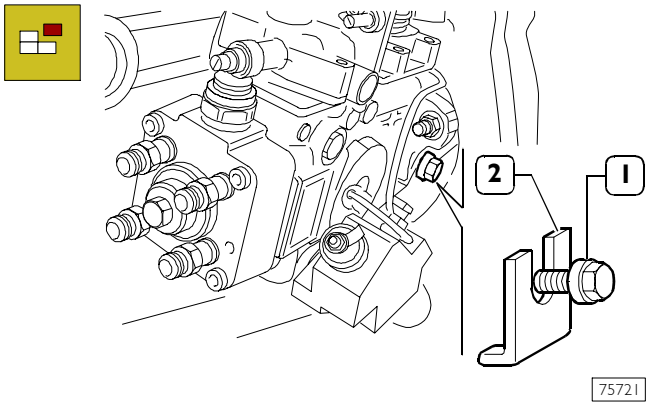
Figure 97



Turn the flywheel until, when pushing the pin 99360616 (1), it blocks the gear (2) obtaining the TDC of the 1° cylinder.

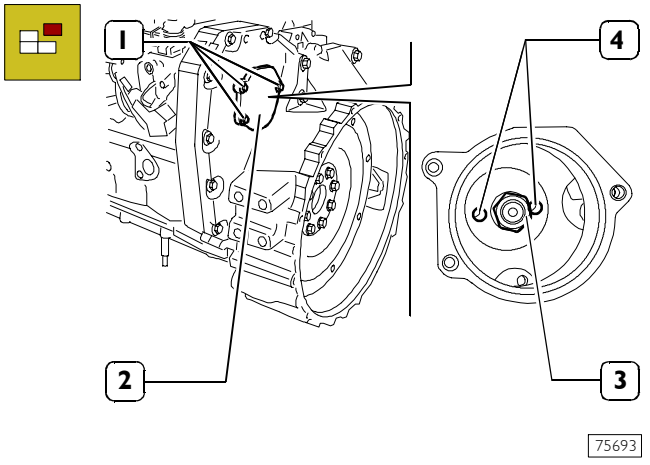
BOSCH VE 4/12 F Pump

Figure 98



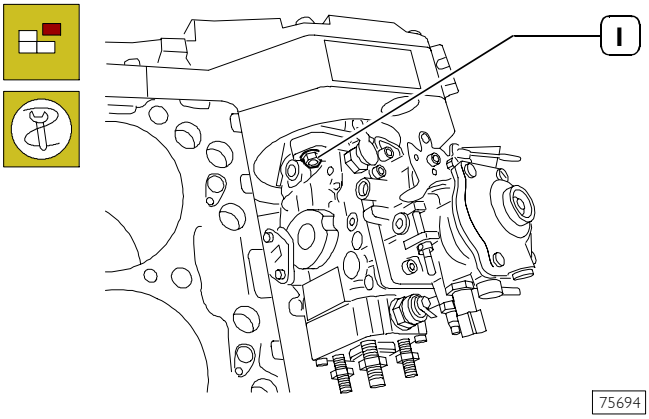
- ❑ Unscrew the side screw that locks the pump shaft partially (1) and remove spacer (2). This must be kept on a side (we recommend to fix it on the pump with a wire or a clip).
- ❑ Tighten the lateral screw (1) blocking rotation of the pump shaft.

Figure 99



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

Figure 100

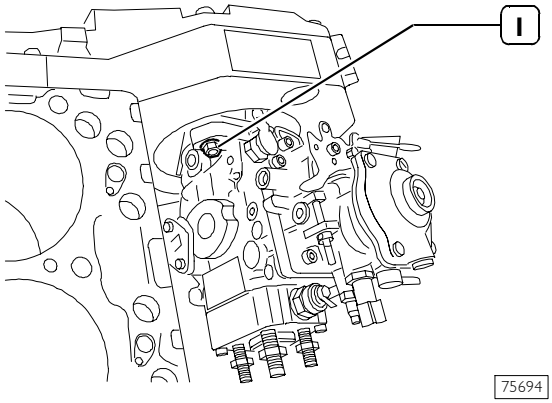


- ❑ From the pump side, loosen the fixing nuts (1) without removing them in order to enable moving the pump backwards using 99340035 extractor.
- ❑ Assemble the 99340035 extractor throughout the two threaded ports (4, Figure 99) and withdraw the gear from the pump shaft.
- ❑ Properly hold the feed pump 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.

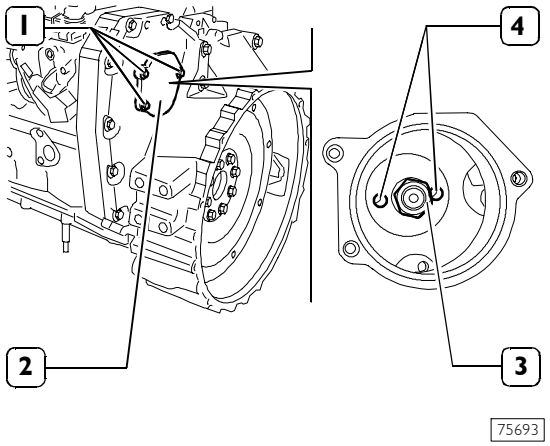
Figure 101



- ❑ 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.

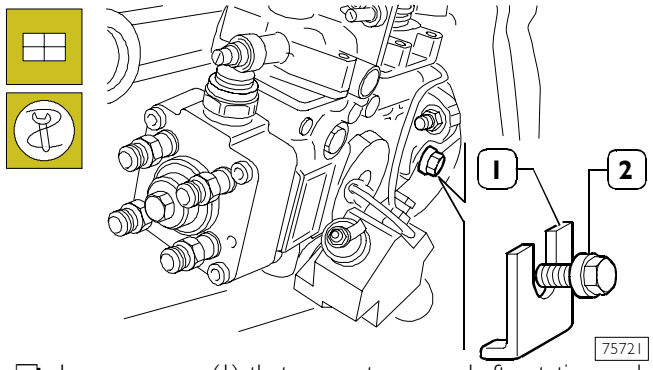
NOTE The gasket removed during pump disassembly shall not be utilised again.
Always use original spare parts.

Figure 102



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

Figure 103

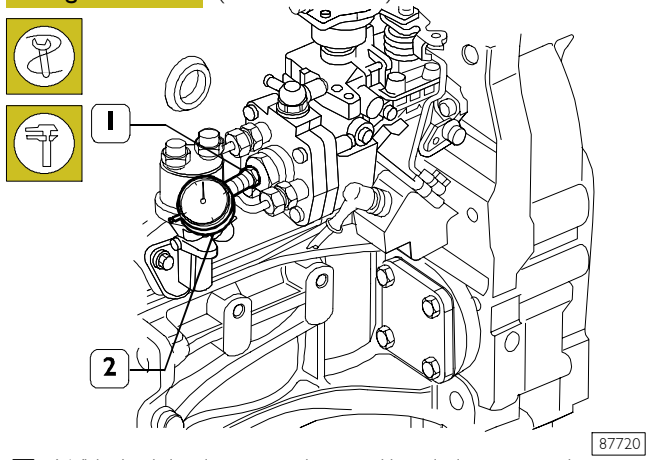


- ❑ Loosen screw (1) that prevents pump shaft rotation and insert spacer (2). Tighten screw (1)so that it locks spacer (2): in this way the supply pump shaft will be able to rotate freely.
- ❑ Assemble the cover (2, Figure 102) including gasket and tighten the screws (1, Figure 102).
- ❑ Disassemble the flywheel rotation/locking tool 99360330; arrange the starting motor in its seat.
- ❑ 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.

Ignition pump control and timing

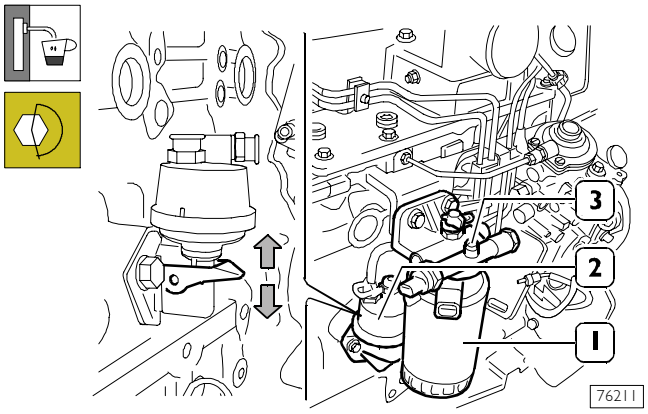
Figure 104 (Demonstration)



- ❑ With the injection pump inserted in relating seat and securing screws loosened, mount comparator 99395603 (2) and 99395100 gauge tool (1), preloading the rod by 2.5 mm.
- ❑ Rotate the engine derive shaft to shift from the condition of the first cylinder to TDC end of compression phase. Reset the dial gauges and rotate the engine drive shaft into the opposite direction until recovering the condition of the 1st cylinder to TDC in phase of compression (see Figure 97).
From this position on the comparator applied on the pump it must be possible to read the value listed on the pumping element pre-lift table. Section 4.
- ❑ Rotate the pump in anti-clockwise direction if the stroke is shorter or in clockwise direction if the stroke is longer, until obtaining the stroke prescribed.
- ❑ Checking these conditions, lock the pump by tightening the relevant nuts to the prescribed pair.

Feed system bleed procedure

Figure 105

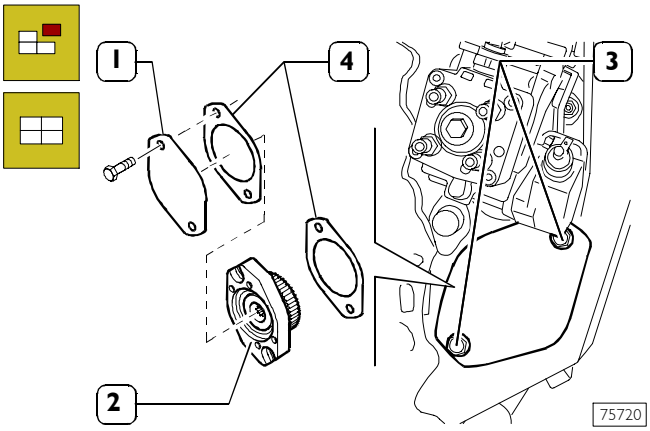


In case any operation has been executed on the components of the feed circuit, it is necessary to execute bleeding of air within the system.

- ❑ Loosen the air bleed screw (3) on the fuel filter (1) and operate the bleed lever for the priming pump (2) repeatedly.
- ❑ Continue executing this operation until when fuel drains from the bleeder vent screw.
- ❑ Tighten the air bleed screw (3) to a torque of 7 ÷ 9 Nm.

Power take-off disassembly and assembly procedure

Figure 106 (Demonstration)



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

Disassembly of such mechanism shall be executed as following:

- ❑ Loosen the two screws (3) and after having removed the cover (1) with a specially provided extractor, withdraw the power take-off (2).
- ❑ The two gaskets (4) shall be replaced in phase of reassemble.
- ❑ Vary out the assembly fitting the power take-off in its housing, providing new gasket and checking the sprocket gear meshing.
- ❑ Assemble cover and gasket and tighten the screws to the prescribed couple.

Checks and inspections

NOTE The following tests shall be made after engine assembly to the vehicle.
Preventively check that the liquid levels have been correctly restored.

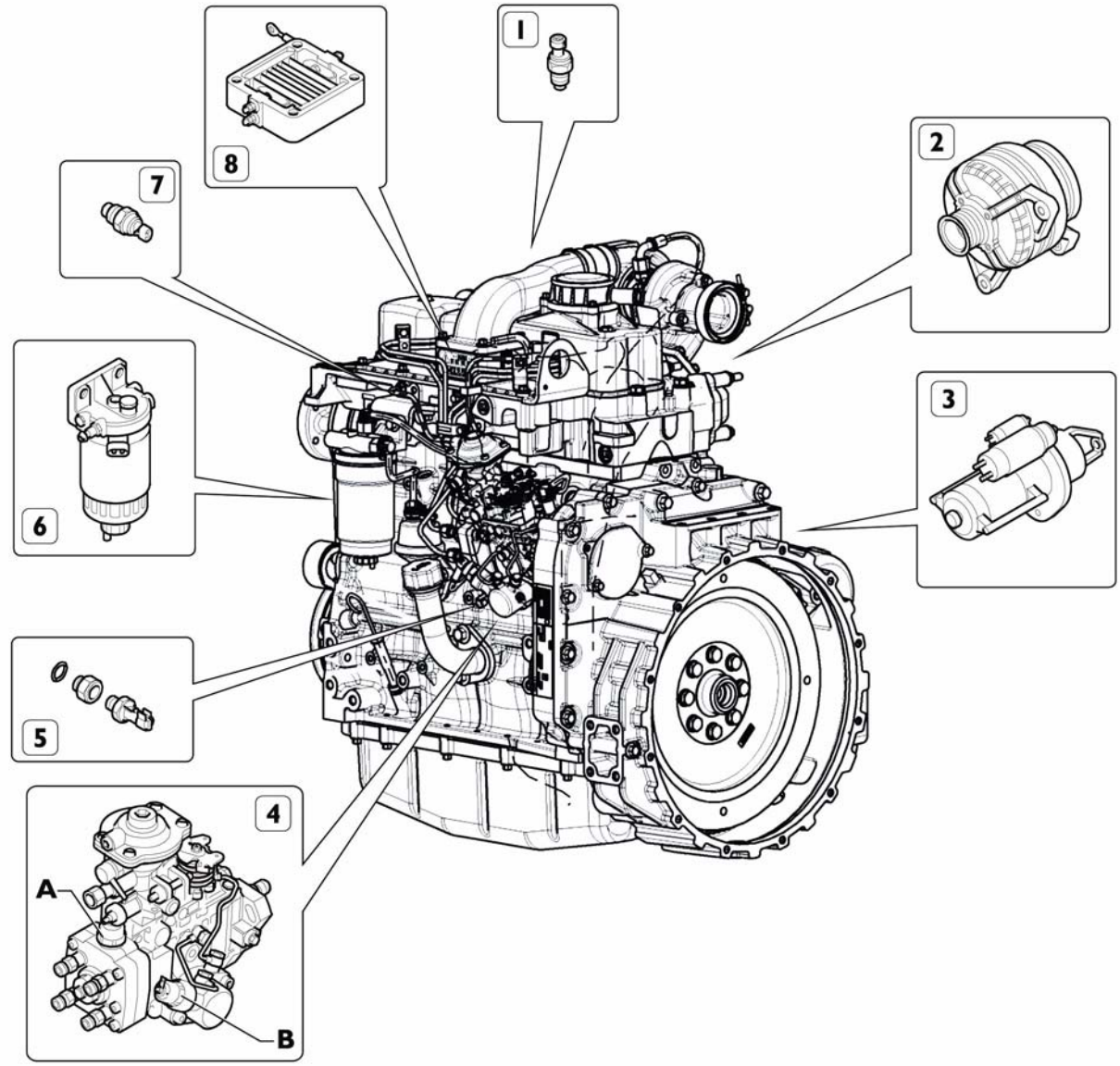
Start the engine, let it run at revolution regimen slightly higher than idling and wait that the cooling liquid temperature reaches the value enabling thermostat opening, then check that:

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

PART TWO -
ELECTRICAL EQUIPMENT

ELECTRICAL COMPONENT LAYOUT

Figure 107

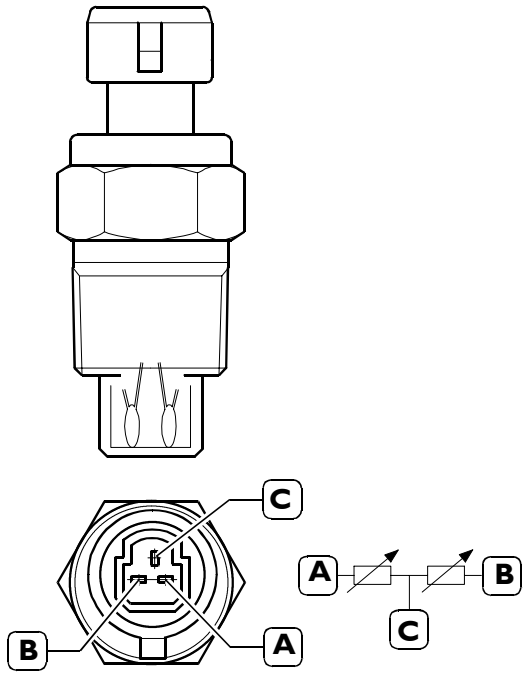


Below there are listed the electric components which are present on F4GE94--- engines.

1. Cooling liquid temperature sensor;
2. Alternator;
3. Starter;
4. (A) Engine STOP solenoid,
   (B) KSB electromagnet;
5. Oil pressure sensor;
6. Fuel heater (where provided for);
7. KSB Water temperature sensor;
8. Resistance for cold start up;

Cooling liquid temperature sensor

Figure 108



It is a component integrating a temperature sensor.

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

Specifications:

Range of working temperatures:

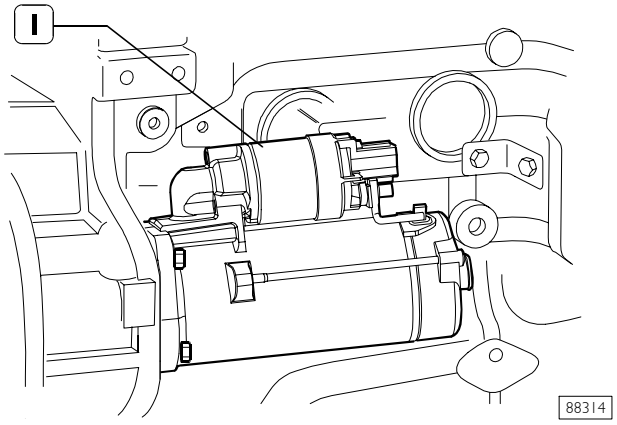
Connection side	-40 ÷ 130 °C/(+150 °C for < 10 min.)
Bulb side on engine:	-40 ÷ 140 °C
Working tensions:	6 ÷ 28 V

Settings:

80 °C	0.304 ÷ 0.342 kΩ
20 °C	2.262 ÷ 2.760 kΩ
-10 °C	8.244 ÷ 10.661 kΩ

Starter

Figure 109



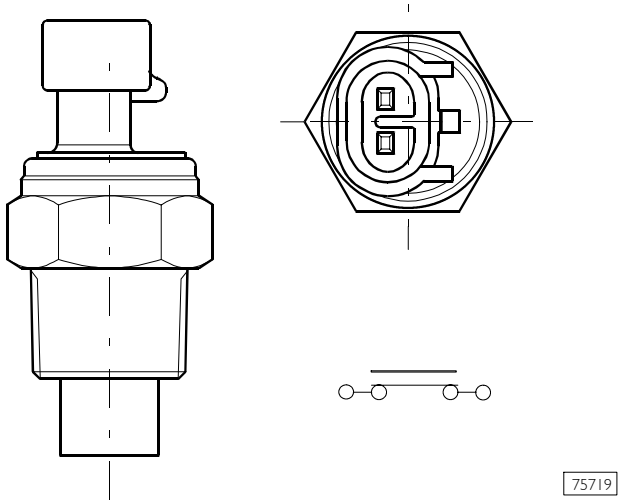
Starter is usually driven by starting unit placed on the vehicle dashboard and provides positive tension to the tele-switch assembled to the starter itself.

Specifications:

BOSCH 3 kW - 12V

KSB Water temperature sensor

Figure 110



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

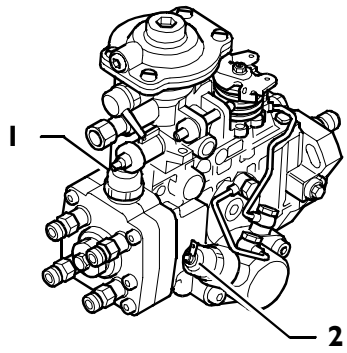
Specifications:

Working tensions:12 ÷ 24 V

Electrical Power load:	2.5 A (induction) 5.0 A (resistance)
Setting:	63±3 °C Contact opening upon increasing temperature 53±3 °C Contact closure upon decreasing temperature

Electromagnets assembled to feed pump

Figure 111

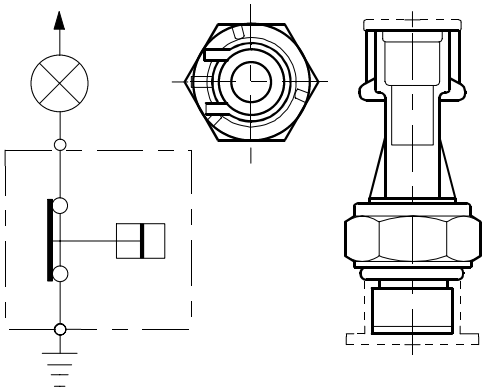


75724a

1 - Engine STOP solenoid;
2 - KSB Electro-magnet

Oil pressure sensor

Figure 112



75722

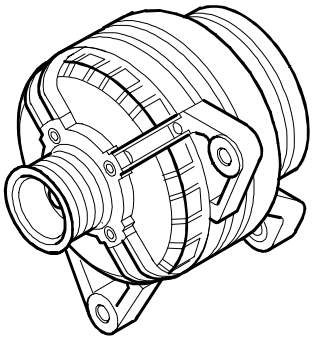
It is assembled to the block on the engine's left hand side.

Specifications:

Working tensions:	12 ÷ 24 V
Contact closure upon lower pressure:	0.6 bar
Contact opening upon higher pressure:	0.9 bar

Alternator

Figure 113



75725

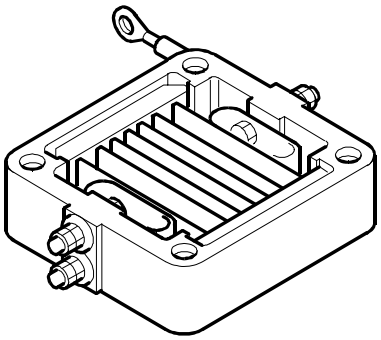
It is place front view on the right hand side of the engine, and is driven by tooth belt.

Specifications:

Working tension:	12 V
Current delivered:	90A (at 6000 rpm)
Absorption in stand-by:	≤ 1mA
Sense of rotation:	clockwices

Pre-post heating resistor

Figure 114



75723

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

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

Specifications:

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

PART THREE - TROUBLESHOOTING

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

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

ANOMALY	POSSIBLE CAUSE	REMEDY	NOTE
The engine overheats	Faulty water pump.	Check the unit and replace if necessary. Replace the gasket.	
	Malfunctioning thermostat.	Replace the thermostat.	
	Fouling in coolant openings in the cylinder head and cylinder groups.	Wash following the standards specified for the type of descaling product used.	
	Water pump drive belt slack.	Check and adjust the tightness of the belt.	On applications provided with automatic tensioner, check corret worching of such device.
	Coolant level too low.	Top-up radiator with coolant.	
	Incorrect engine timing.	Check timing and tune correctly.	
	Incorrect calibration of injection pump.	Correct the delivery rate of the pump on a bench so that the injection is at the specified rate.	See your FPT dealer.
	Dry air cleaner blocked.	Clean the air filter or replace if necessary.	
Engine operation is irregular and lacks power	Incorrect timing of injection pump.	Check timing and correctly set pump.	
	Faulty automatic advance variator	Check operation on injection pump test setup; if values found do not correspond to requirements, change variator spring.	See your FPT Dealer
	K.S.B. automatic cold advance device malfunctioning.	Check or replace injection pump.	
	Excessive piston wear.	Check or replace injection pump.	
	Incorrect calibration of speed regulator.	Check and correctly calibrate the regulator.	See your FPT Dealer

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

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

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

PART FOUR - MAINTENANCE PLANNING

MAINTENANCE SCHEDULE

On purpose to guarantee the right engine use please follow the below indicated maintenance schedule.

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

Maintenance operations	Frequency (hours)
Visual check of engine	Daily
Check presence of water in fuel filter or pre-filter	Daily
Check of belt wear status	-
Check and setting of tappet clearance	3600
Oil and filter replacement	600
Fuel filter and prefilter replacement	600
Belt replacement	1800

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.

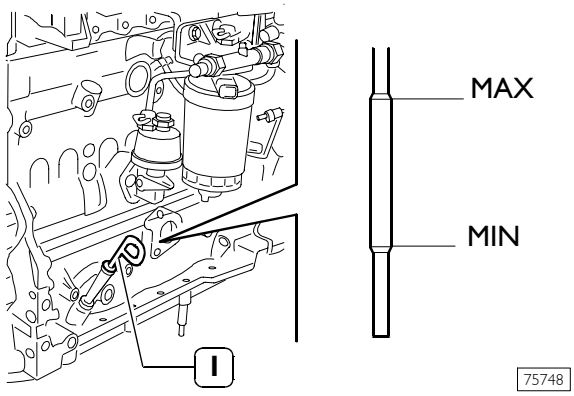
MAINTENANCE PROCEDURES
Checks and controls

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 115 (Demonstration)

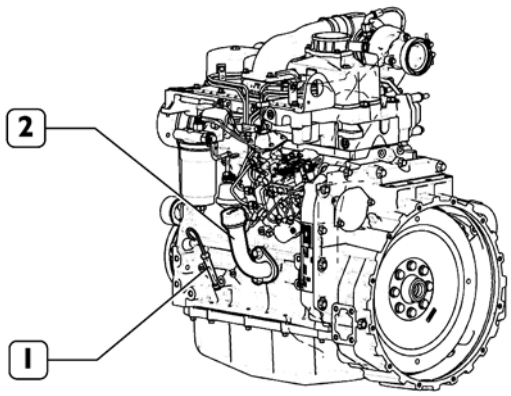


Draw off the rod from its slot and check that the level is within the etched tags of minimum and maximum level.

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

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

Figure 116



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

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

The engine oil is highly polluting and harmful.

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

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

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

Check of fuel system

The check must be executed both when the engine disconnected and when it is running.
The check operation consists in examining the fuel pipelines running from the tank to the pre-filter (if provided in the specific equipment), to the filter, to the injection pump and to the injectors.

Cooling system check

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

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

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

Due to the high temperatures achieved by the system, do not operate immediately after the engine's disconnection, but wait for the time deemed necessary for the cooling.
Protect the eyes and the skin from any eventual high pressure jet of cooling liquid.

The coolant should be checked every year before the winter, assessing the density and it should be changed every two years.

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

NOTE 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.

There is a bleed screw at the base of the fuel filter for draining any water in the filter.

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

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

Check of drive belt tensioning

There is an automatic tensioner which corrects the belt tension.

Check of belt's tear and wear status

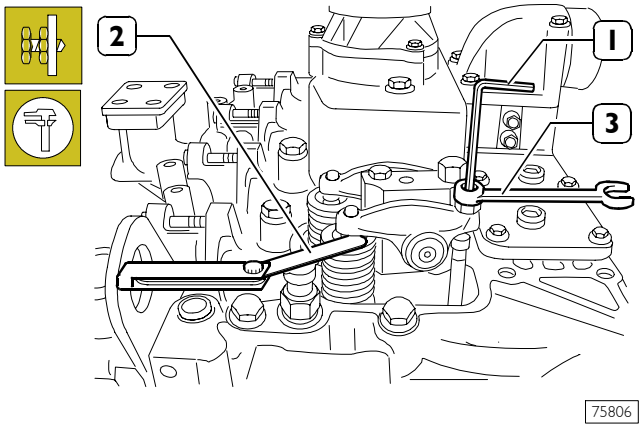
Carefully verify the belt's surface in order to detect any sign of incision, crack, excessive wear in correspondence of toothing; check end and surface grinding.

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 117



On TIER 3 engines, due to the additional lobe for the INTERNAL E.G.R., it is not possible to use the valve clearance adjustment procedure that requires adjusting the clearance of all the valves by positioning the crankshaft 2 times only.

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.

Remove the rocker covers of the cylinder; remove the injector and place the tool 99395097 (see Figure 98) to set the cylinder top dead centre position (end-of-compression phase). Pre-load the gauge.

The searched condition is obtained by rotating the engine shaft properly until you find the maximum value on the comparator and then checking that the intake and exhaust valves are both closed.

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

Correct slack is:
- suction valves 0.25 ± 0.05 mm
- exhaust valves 0.50 ± 0.05 mm.

IGNITION SEQUENCE: 1 - 3 - 4 - 2

Engine shaft starting and rotation	Bilance valves cylinder n°	Adjust intake and exhaust valves clearance cylinder n°
1° al PMS	1	1
180°	3	3
180°	4	4
180°	2	2

Oil motor and filter replacement

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

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

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

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

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

The oil motor is very pollutant and harmful.

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

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

Dispose of the residual properly following the rules.

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

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

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

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

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

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

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

❑ The filter is composed by a support and a filtering cartridge. For the cartridge replacement use 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 with a new one and screw manually until when the gasket is in contact with the support.

❑ Tigthen by means of the 99360076-tool of three fourth turn.

❑ Operate the motor for some minutes and check the level through the dipsick again. If it is necessary, carry out a topping up to compensate the quantity of oil used for the filling of the filtering cartridge.

Fuel filter replacement

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

Avoid to breathe the vapors coming from filter.

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

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

However the following operations are valid for all applications.

❑ Drain the fuel inside the filter by operating the water release screw. Collect the fuel in a container without impurities.

❑ Unscrew the cartridge by using 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.

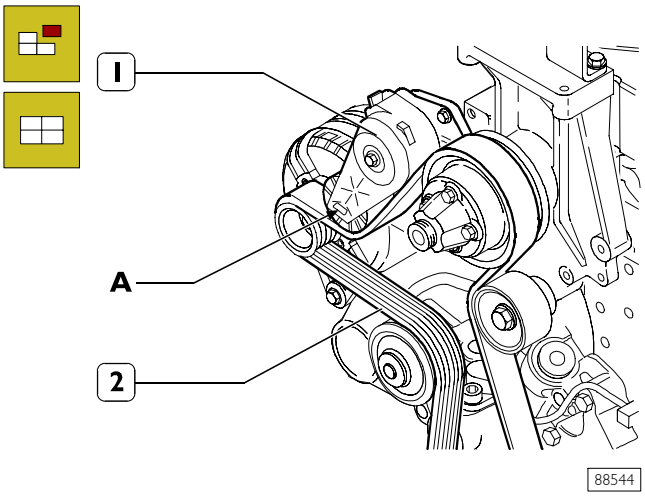
❑ Tigthen through the 99360076-tool at 10-5 Nm torque.

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 118

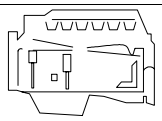
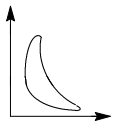
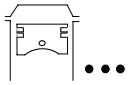
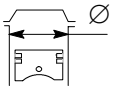
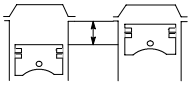
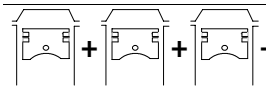
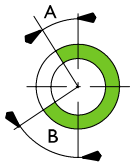
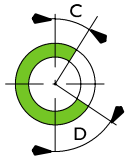
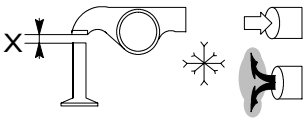
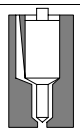
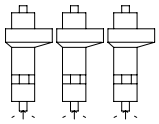


- ❑ By means of a square wrench of proper size act on point A, indicated on the figure, of the automatic belt tightener (1) and release the pressure.
- ❑ Remove the control belt (2) from the driven and intermediate pulleys.
- ❑ Replace the worn belt with a new one.
- ❑ Place the belt on the pulleys and the guide rollers.
- ❑ Place the automatic tightener in order to key the belt in the functioning position.
- ❑ Check proper position in the races of the pulleys.

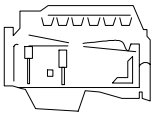
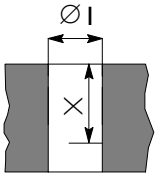
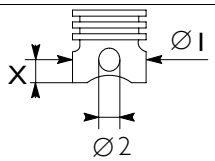
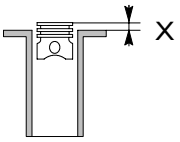
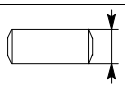
SECTION 4

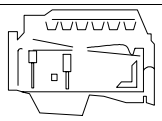
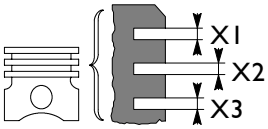
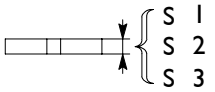
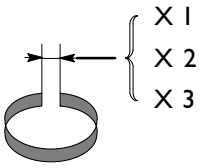
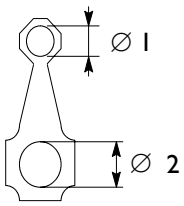
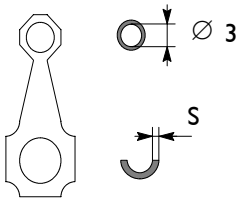
Overhaul and technical specifications

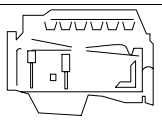
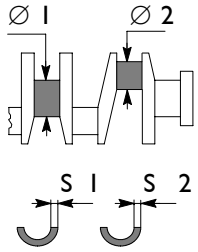
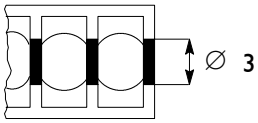
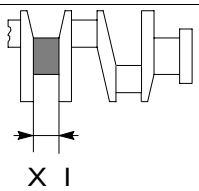
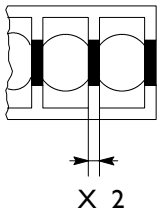
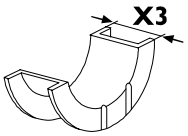
GENERAL SPECIFICATIONS

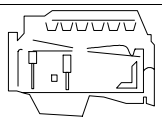
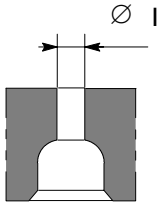
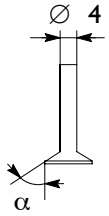
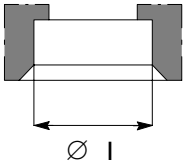
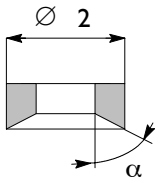
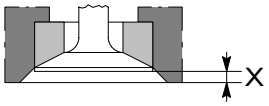
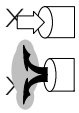
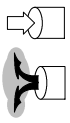
	Type		4 CYLINDERS
	Cycle		Four-stroke diesel engine
	Power		See properties described in Section 3
	Injection		Direct
	Number of cylinders		4
	Bore	mm	104
	Stroke	mm	132
	Total displacement	cm^3	4485
   	**TIMING** start before T.D.C. end after B.D.C. start before B.D.C. end after T.D.C.	 A B D C	 18.5 29.5 67 35
	Checking timing X	mm mm	0.25 to 0.05 0.50 to 0.05
	FUEL FEED Injection Type:	 Bosch	 VE 4/12 F
	Nozzle type		DSLA 145 P
	Injection sequence		1 - 3 - 4 - 2

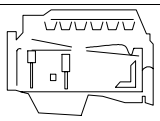
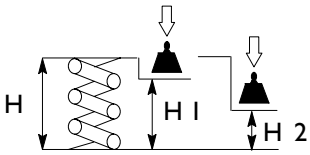
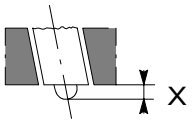
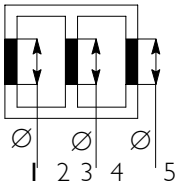
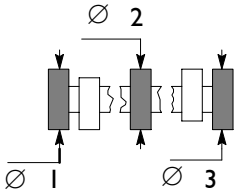
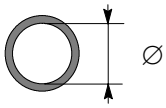
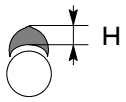
CLEARANCE DATA

	Type	4 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		mm
	Cylinder barrels ⌓ Ø1 >	104.000 to 104.024 0.4
	Spare pistons type: Size X Outside diameter Ø 1 Pin housing Ø 2	 55.9 103.714 to 103.732 38.010 to 38.016
	Piston – cylinder barrels	0.268 to 0.310
	Piston diameter Ø 1	0.4
	Piston protrusion X	0.28 to 0.52
	Piston pin Ø 3	37.994 to 38.000
	Piston pin – pin housing	0.010 to 0.022

	Type		4 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS			**mm**
	Split ring slots * measured on a Ø of 99.00 mm	X1 X 2 X 3	2.705 to 2.735 2.440 to 2.460 4.030 to 4.050
	Split rings	S 1 S 2 S 3	2.560 to 2.605 2.350 to 2.380 3.970 to 3.990
	Split rings - slots	1 2 3	0.100 to 0.175 0.060 to 0.110 0.040 to 0.080
	Split rings		0.4
	Split ring end opening in cylinder barrel:	X 1 X 2 X 3	0.30 to 0.40 0.60 to 0.80 0.30 to 0.55
	Small end bush housing Big end bearing housing	Ø 1 Ø 2	40.987 to 41.013 72.987 to 73.013
	Small end bush diameter Inside Spare big end half bearings	Ø 3 S	38.019 to 38.033 1.955 to 1.968
	Piston pin – bush		0.037 to 0.016
	Big end half bearings		0.250 to 0.500

	Type		4 CYLINDERS
CYLINDER UNIT AND CRANKSHAFT COMPONENTS			**mm**
	Journals Crankpins	Ø 1 Ø 2	82.990 ÷ 83.010 68.987 ÷ 69.013
	Main half bearings Big end half bearings	S 1 S 2	2.456 to 2.464 1.955 to 1.968
	Main bearings No. 1 – 5 No. 2 – 3 – 4	 Ø 3 Ø 3	 87.982 to 88.008 87.977 to 88.013
	Half bearings – Journals No. 1 – 5 No. 2 – 3 – 4		 0.440 to 0.106 0.039 to 0.111
	Half bearings - Crankpins		0.038 to 0.116
	Main half bearings Big end half bearings		0.250 to 0.500
	Shoulder journal	X 1	37.475 to 37.550
	Shoulder main bearing	X 2	32.180 to 32.280
	Shoulder half-rings	X 3	37.28 to 37.38
	Output shaft shoulder		0.095 to 0.270

	Type	4 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM		**mm**
	Valve guide seats on cylinder head Ø 1	8.019 to 8.039
	Valves:  Ø 4 α  Ø 4 α	7.960 to 7.980 60° 7.960 to 7.980 45°
	Valve stem and guide	0.039 to 0.079
	Housing on head for valve seat:  Ø1  Ø1	46.987 to 47.013 43.637 to 43.663
	Valve seat outside diameter; valve seat angle on cylinder head:  Ø 2 α  Ø 2 α	47.063 to 47.089 60° 43.713 to 43.739 45°
	Sinking 	0.136 to 0.872 0.050 to 0.830
	Between valve seat and head 	0.050 to 0.102 0.080 to 0.102
	Valve seats	-

	Type		4 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM			**mm**
	Valve spring height: free spring under a load equal to: 329 N 641 N	 H H1 H2	 63.50 / 65.69* 49.02 38.20
	Injector protrusion	X	-
	Camshaft bush housings No. 1-5 Camshaft housings No. 2-3-4-5		59.222 to 59.248 54.089 to 54.139
	Camshaft journals: 1 ⇒ 5	Ø	53.995 to 54.045
	Bush inside diameter	Ø	54.083 to 54.147
	Bushes and journals		0.038 to 0.152
	Cam lift:  	 H H	 - -

* Installed as an alternative

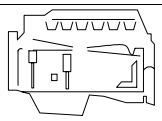
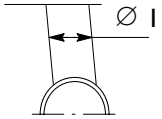
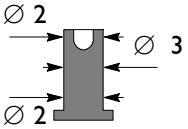
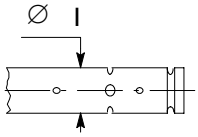
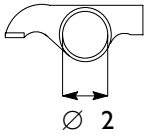
	Type		4 CYLINDERS
CYLINDER HEAD – TIMING SYSTEM			**mm**
	Tappet cap housing on block	Ø 1	16.000 to 16.030
	Tappet cap outside diameter:	Ø 2 Ø 3	15.929 to 15.959 15.965 to 15.980
	Between tappets and housings		-
	Tappets		-
	Rocker shaft	Ø 1	18.963 to 18.975
	Rockers	Ø 2	19.000 to 19.026
	Between rockers and shaft		0.025 to 0.063

TABLE OF PRE-DELIVERY VALUES FOR BOSCH INJECTION PUMPS VE 4/12 F

	Technical Code	Pre-lift (mm)
4-CYLINDER ENGINES	F4GE9454F*J604	0.7 ± 0.05
	F4GE9484F*J608	0.8 ± 0.05

NOTE INJECTION PUMP CALIBRATION

Overhaul and calibration interventions are up to BOSCH assistance network.

The contract technical specification containing the data to calibrate the pump at the bench is identified by the code shown on injection pump body and is available at BOSCH technical assistance network.

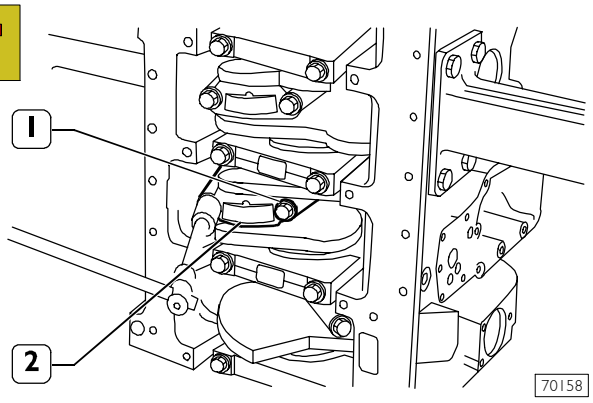
Otherwise, refer to FPT Technical Assistance Service.

ENGINE OVERHAUL
ENGINE REMOVAL AT THE BENCH

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

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

Figure 1

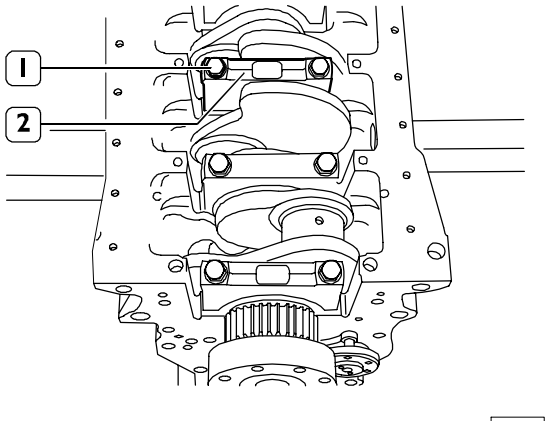


Remove the screws (1) fastening the connecting rod caps (2) and remove them.

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

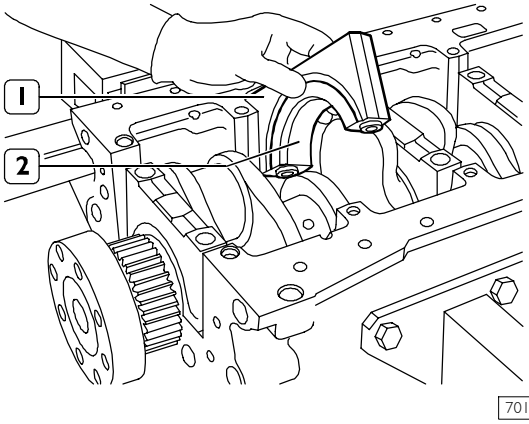
NOTE Keep the half-bearings into their housings since in case of use they shall be fitted in the same position found at removal.

Figure 2



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

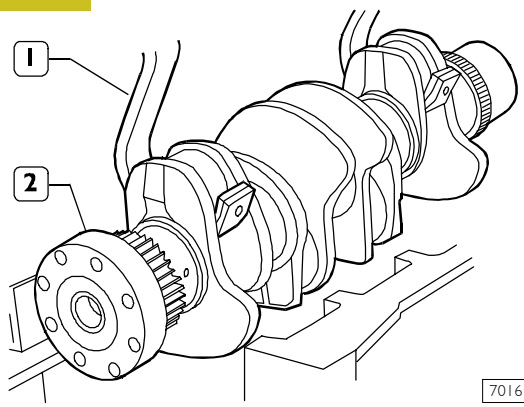
Figure 3



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

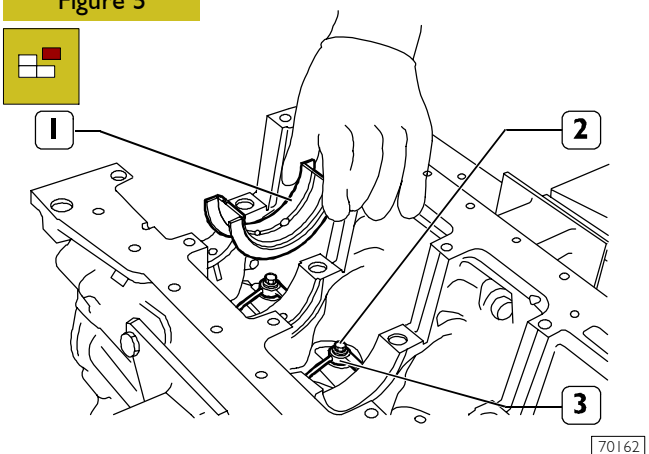
NOTE Take note of lower and upper half-bearing assembling positions since in case of reuse they shall be fitted in the same position found at removal.

Figure 4



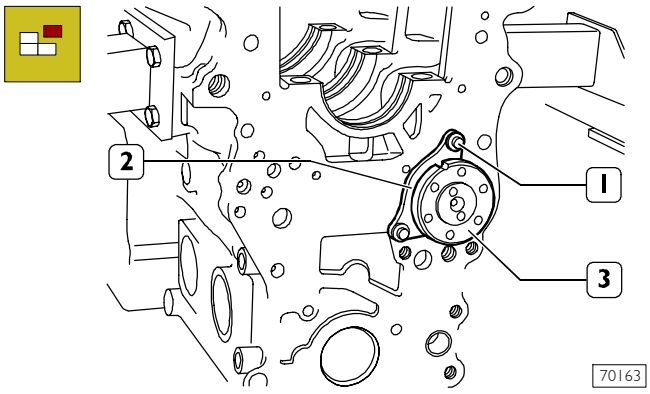
Use tool 99360500 (1) and hoist to remove the output shaft (2) from the block.

Figure 5



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

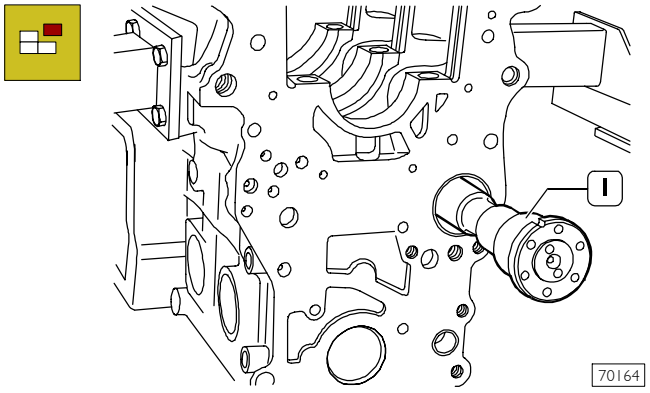
Figure 6



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

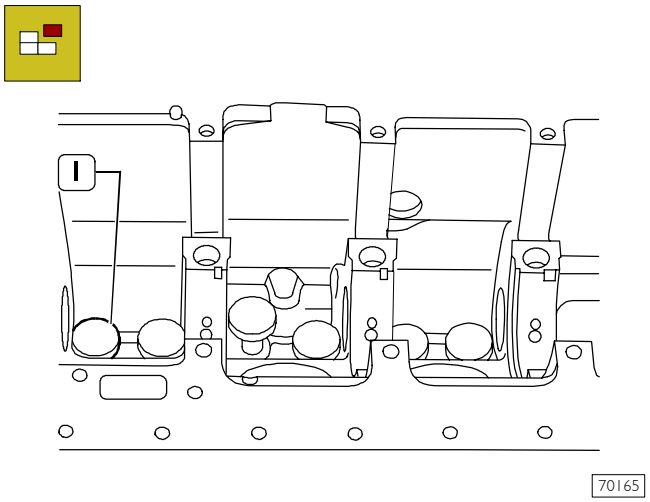
NOTE Take note of plate (2) assembling position.

Figure 7



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

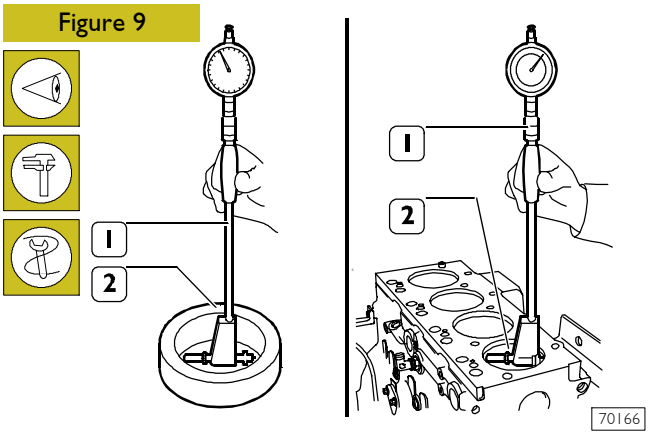
Figure 8



Withdraw the tappets (1) from the engine block.

REPAIR OPERATIONS
CYLINDER UNIT
Checks and measurements

Figure 9



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

Use the proper rings to handle the cylinder unit.

The engine block shall not show cracks.

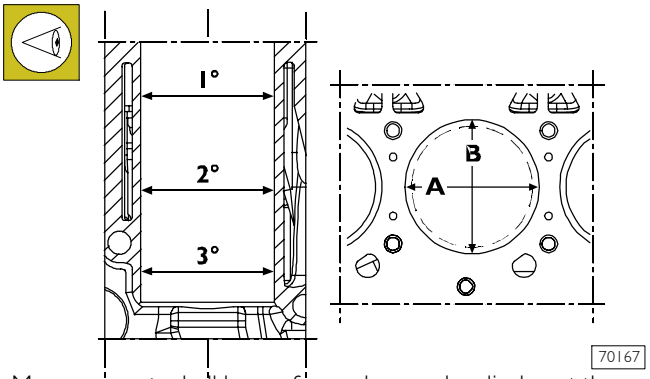
Check operating plug conditions and replace them in case of uncertain seal or if rusted.

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

Inspection of cylinder barrel bore to check ovalisation, taper and wear shall be performed using the bore dial gauge 99395687 (1) fitted with the dial gauge previously set to zero on the ring gauge (2) of the cylinder barrel diameter.

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

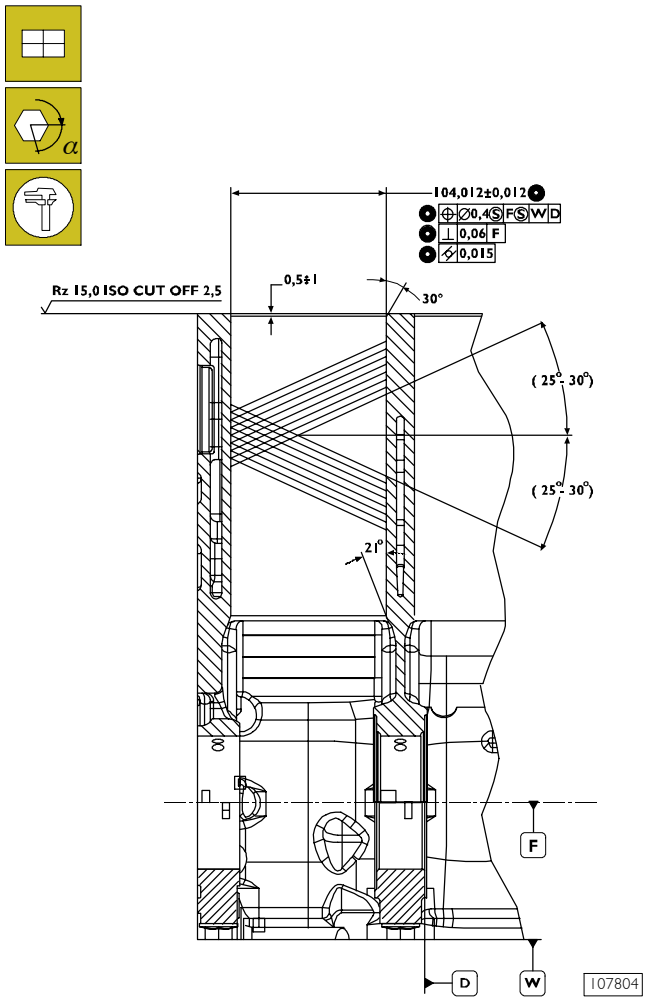
Figure 10



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

Should ovalisation, taper or wear be found, bore and grind the cylinder barrels. Cylinder barrel regrinding shall be performed according to the spare piston diameter oversized by 0.4 mm and to the specified assembling clearance.

Figure 11



NOTE In case of regrinding, all barrels shall have the same oversize (0.5 mm).

Check main bearing housings as follows:

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

Replace if higher value is found.

Checking head supporting surface on cylinder unit

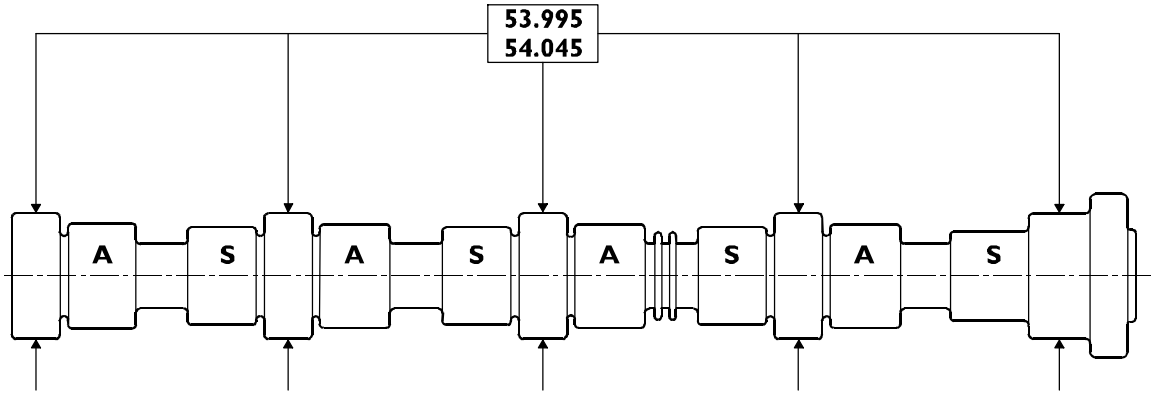
When finding the distortion areas, replace the cylinder unit.

Planarity error shall not exceed 0.075 mm.

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

TIMING SYSTEM
Camshaft

Figure 12



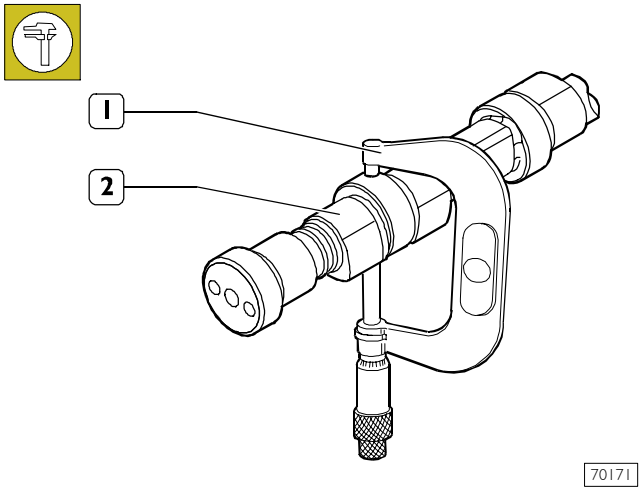
CAMSHAFT MAIN DATA
Specified data refer to pin standard diameter

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

Checking cam lift and pin alignment

Set the camshaft on the tailstock and using a 1/100 gauge set on the central support, check whether the alignment error is not exceeding 0.04 mm, otherwise replace the camshaft.

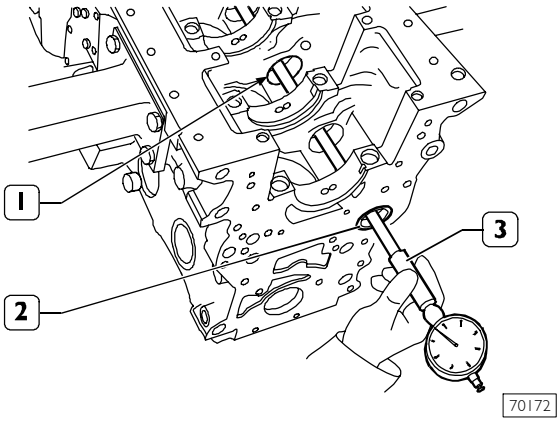
Figure 13



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

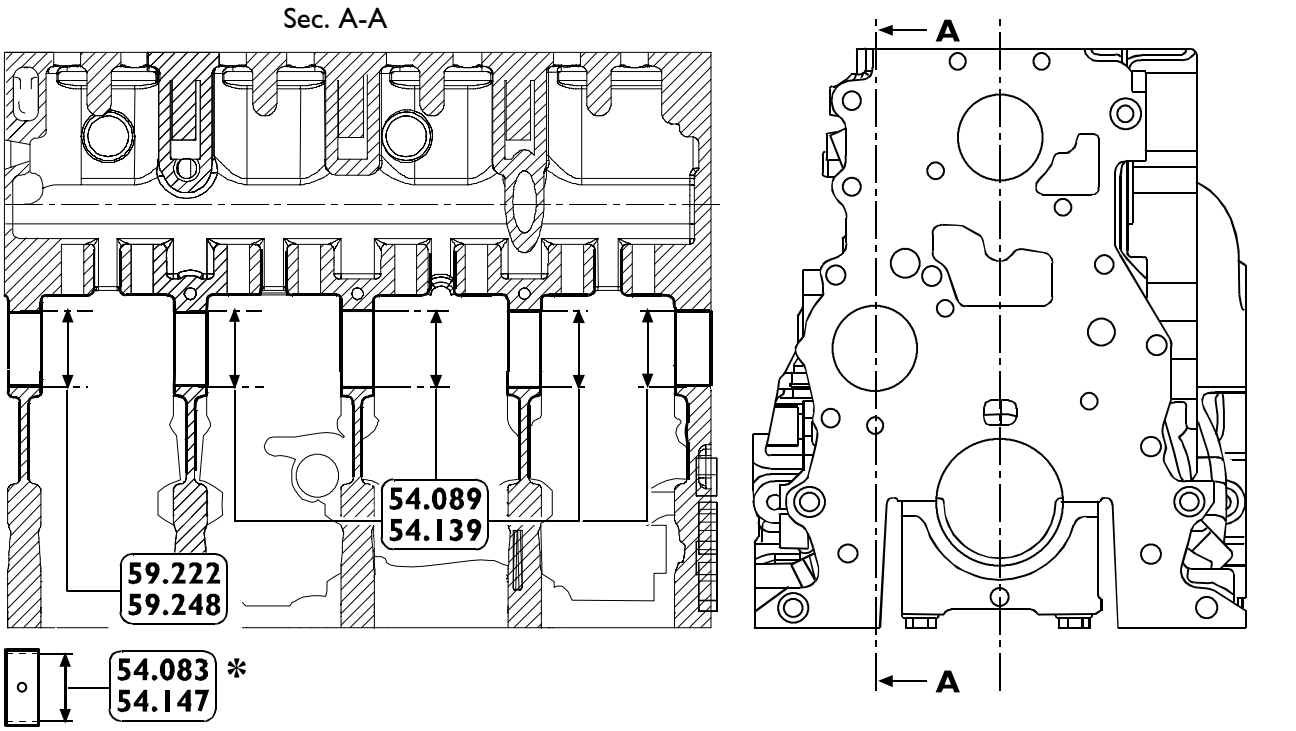
BUSHES

Figure 14



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

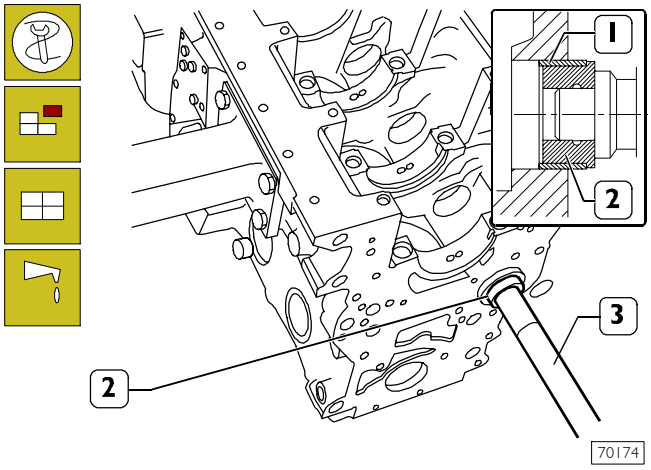
Figure 15



CAMSHAFT BUSH AND HOUSING MAIN DATA
* Value to be obtained after driving the bushes.

Bush replacement

Figure 16

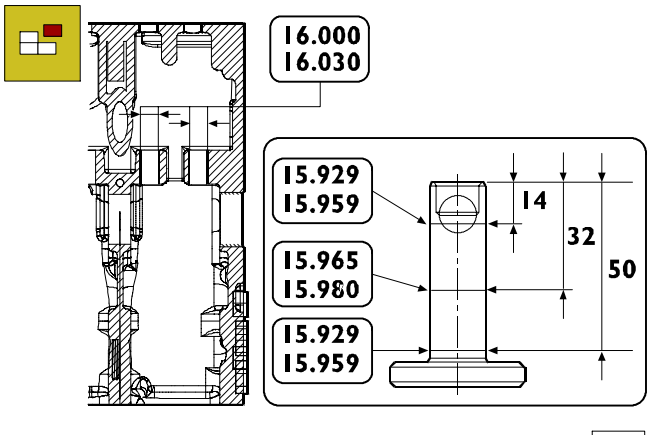


To replace front and rear bushes (1), remove and refit them using the beater 99360362 (2) and the handgrip 99370006 (3).

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

Tappets

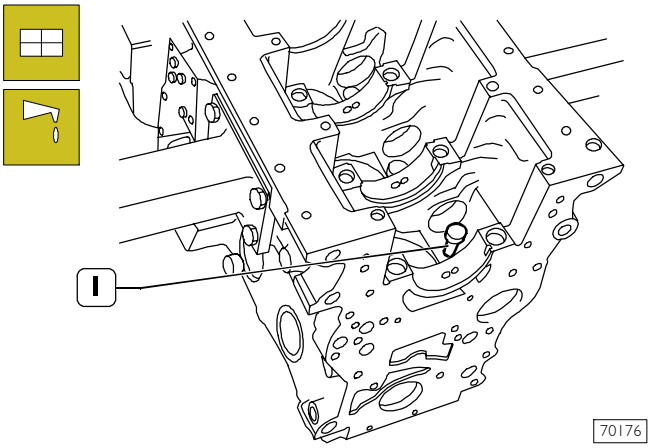
Figure 17



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

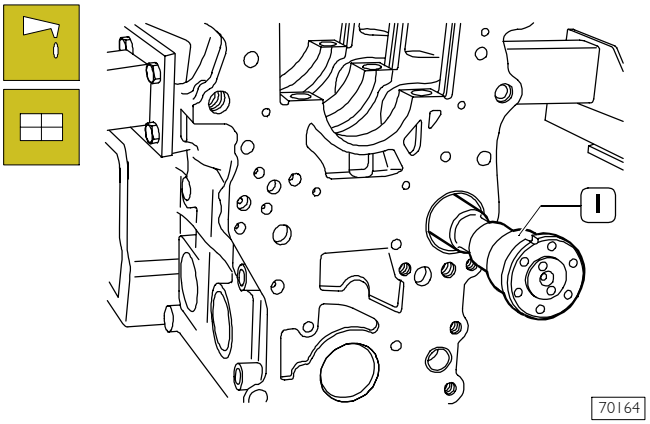
Fitting tappets – camshaft

Figure 18



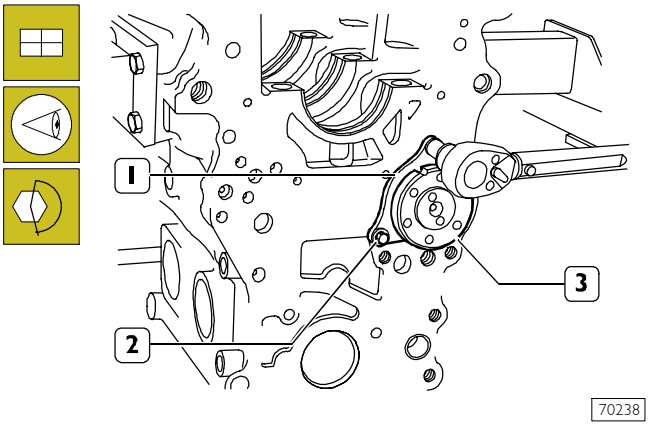
Lubricate the tappets (1) and fit them into the relevant housings on the engine block.

Figure 19



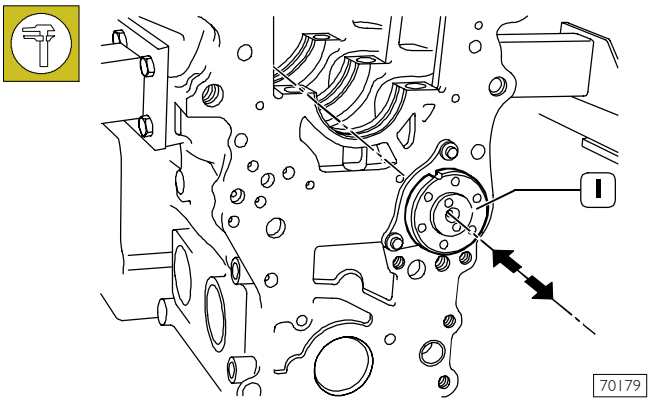
Lubricate the camshaft support bearing and install the camshaft (1) being careful to ensure that the bearing or the shaft support seats are not damaged during the operation.

Figure 20



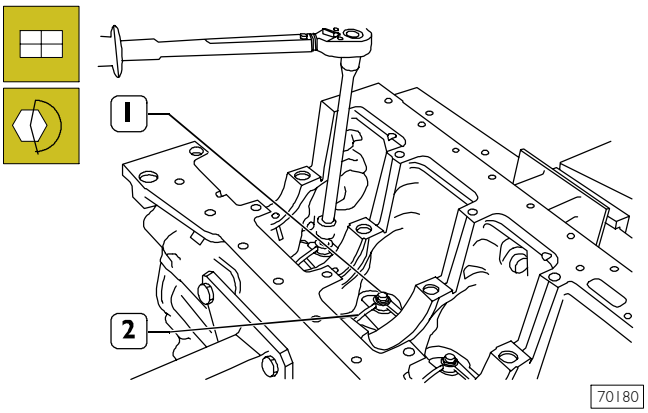
Set camshaft (3) retaining plate (1) with the slot facing the top of the engine block and the marking facing the operator, then tighten the screws (2) to the specified torque.

Figure 21



Check camshaft end float (1).
It shall be 0.23 ± 0.13 mm.

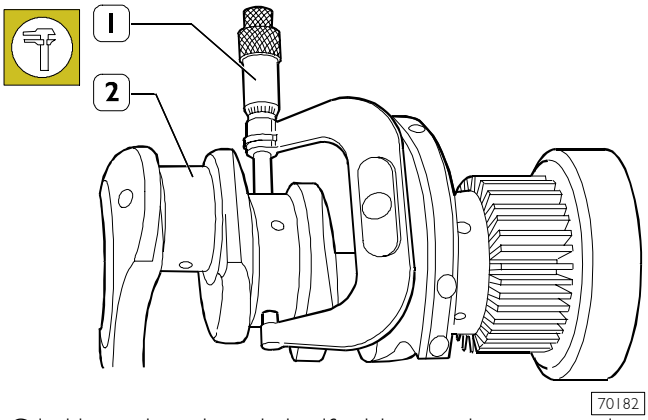
Figure 22



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

OUTPUT SHAFT
Measuring journals and crankpins

Figure 23



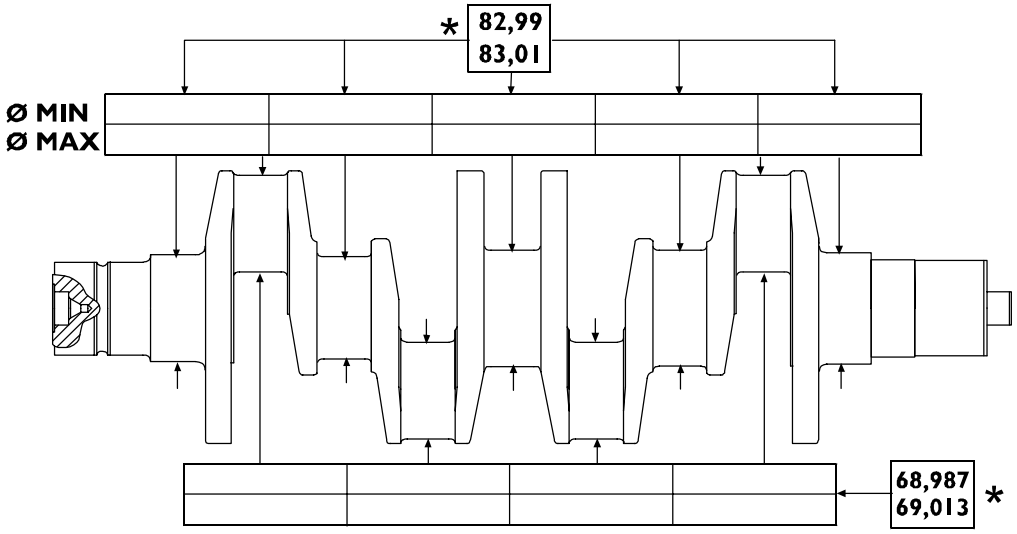
Grind journals and crankpins if seizing, scoring or excessive ovalisation are found. Before grinding the pins (2) measure them with a micrometer (1) to decide the final diameter to which the pins are to be ground.

NOTE It is recommended to insert the found values in the proper table.
See Figure 24.

Undersize classes are: 0.250 - 0.500 mm.

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

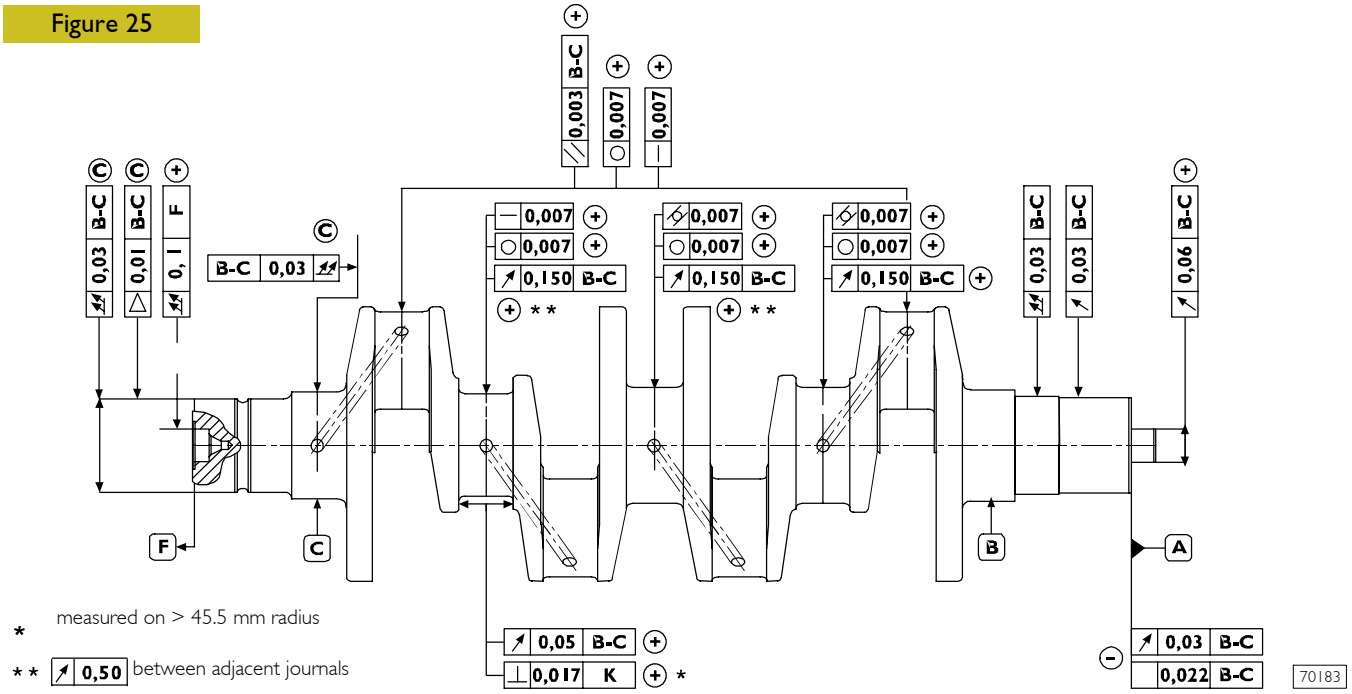
Figure 24



FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

*Rated value

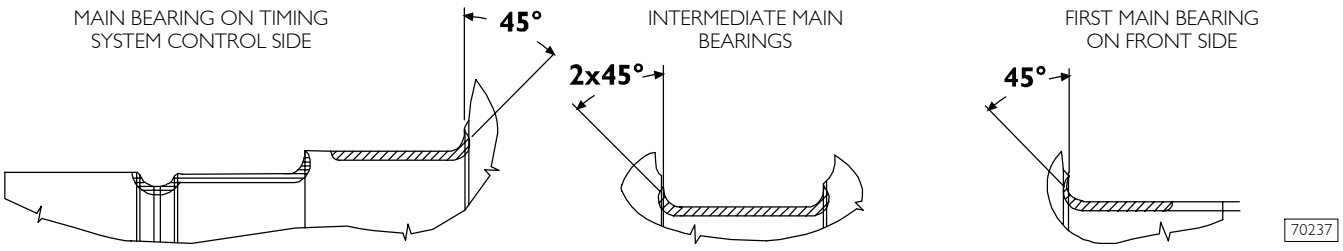
Figure 25



OUTPUT SHAFT MAIN TOLERANCES

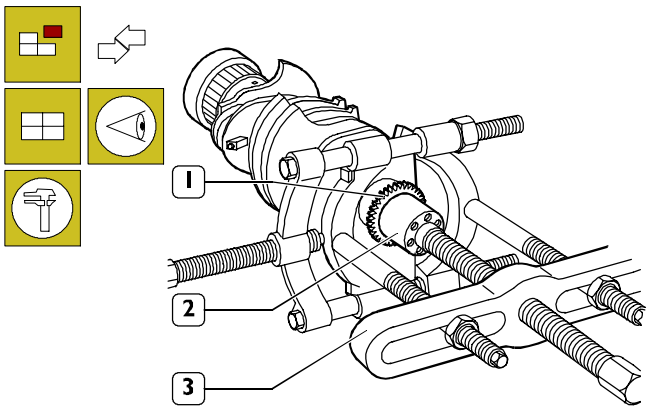
TOLERANCES	TOLERANCE CHARACTERISTIC	GRAPHIC SYMBOL
SHAPE	Roundness	○
	Cilindricity	/○/
DIRECTION	Parallelism	//
	Verticality	⊥
	Straightness	—
POSITION	Concentricity or coaxiality	⓪
OSCILLATION	Circular oscillation	↗
	Total oscillation	⌰

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



Replacing oil pump control gear

Figure 26

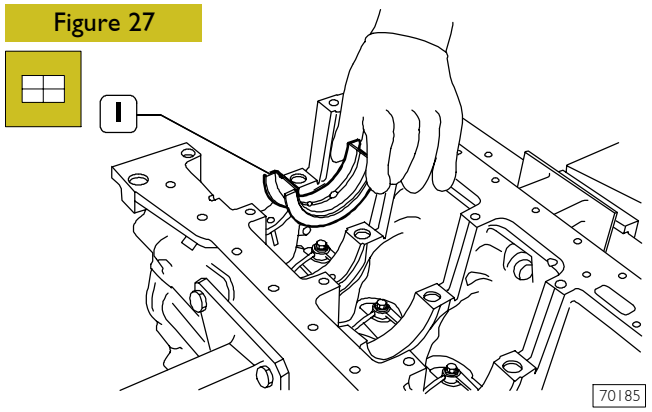


Check that gear toothing (1) is not damaged or worn, otherwise remove it using the proper puller (3).

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

Fitting main bearings

Figure 27



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

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

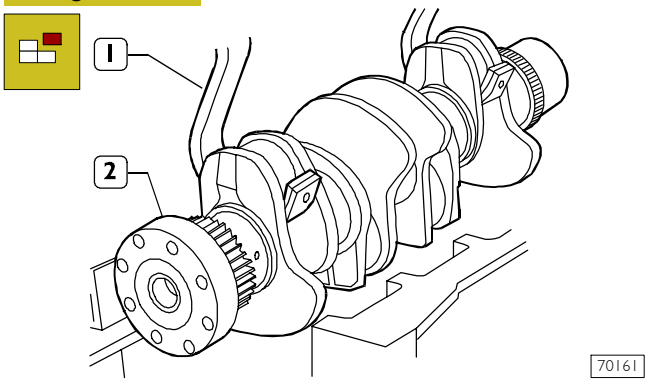
NOTE Do not try to adapt the bearings.

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

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

Finding journal clearance

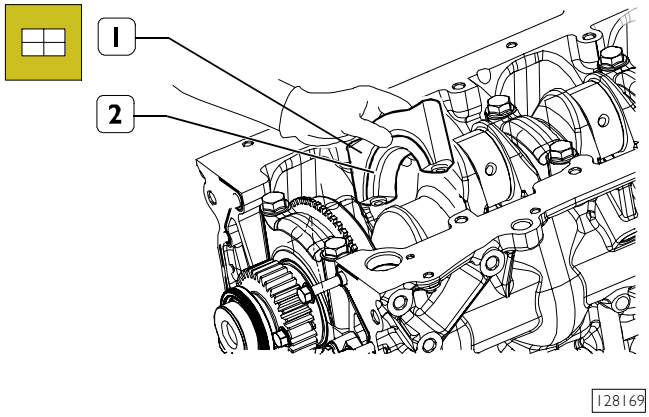
Figure 28



Refit the output shaft (2).

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

Figure 29



- ❑ clean accurately the parts and remove any trace of oil;
- ❑ fit caps (1), including the half bearings (2) on the relevant supports.

NOTE Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:
if D1 - D2 < 0,1 mm the screw can be utilised again;
if D1 - D2 > 0,1 mm the screw must be replaced.

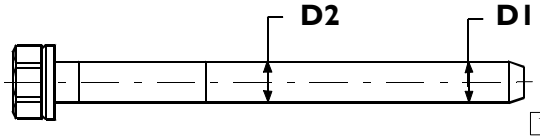
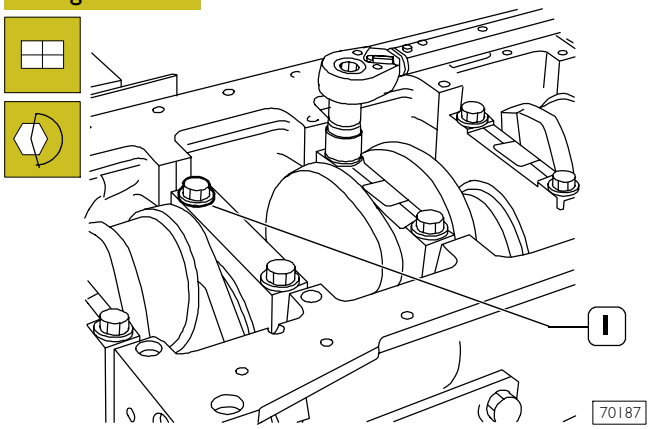


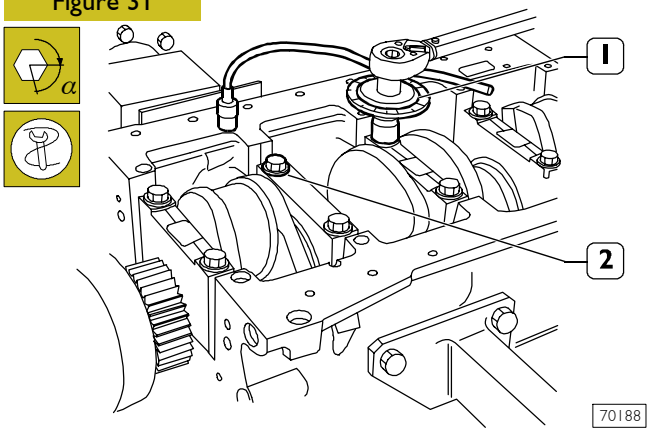
Figure 30



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

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

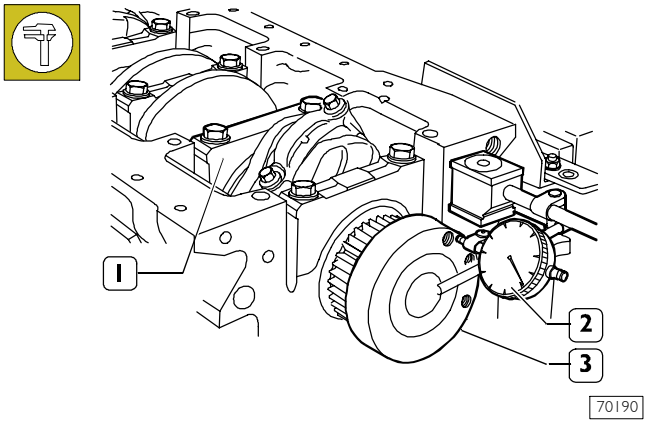
Figure 31



- ❑ 3rd stage, with tool 99395216 (1) set as shown in the figure, tighten the screws (2) with 90° ± 5° angle.

Checking output shaft shoulder clearance

Figure 32

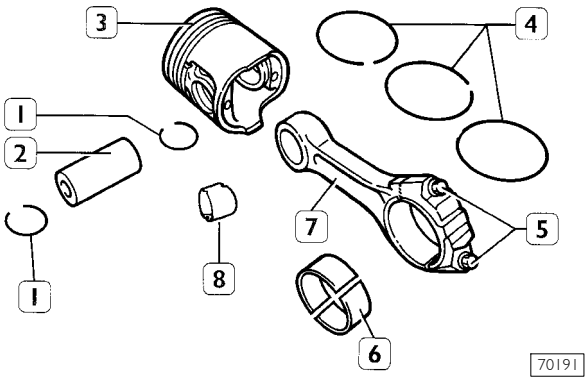


This check is performed by setting a magnetic-base dial gauge (2) on the output shaft (3) as shown in the figure, standard value is 0.068 to 0.41.

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

CONNECTING ROD – PISTON ASSEMBLY

Figure 33



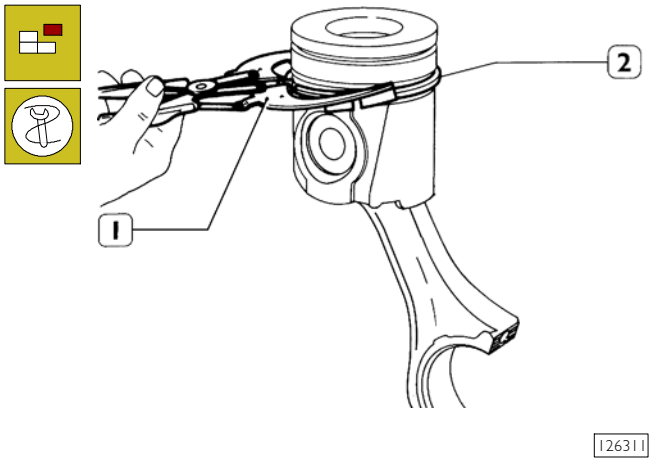
CONNECTING ROD – PISTON ASSEMBLY COMPONENTS

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

NOTE The pistons are supplied spare with the following sizes:

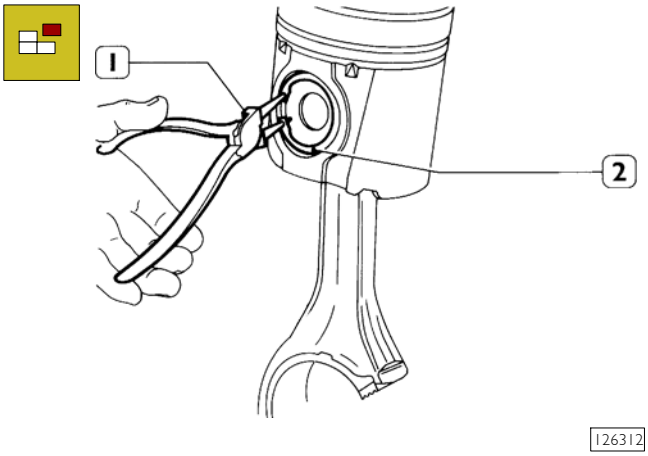
- standard;
- 0.4 mm oversize.

Figure 34



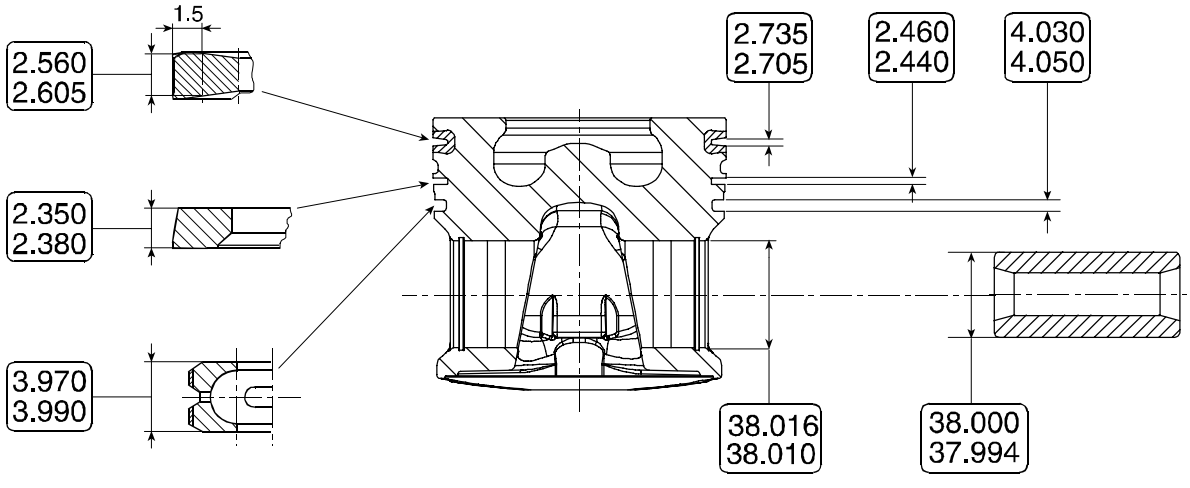
Remove split rings (2) from piston using pliers 99360183 (1).

Figure 35



The circlips (2) retaining the gudgeon pin are removed using round-nose pliers (1).

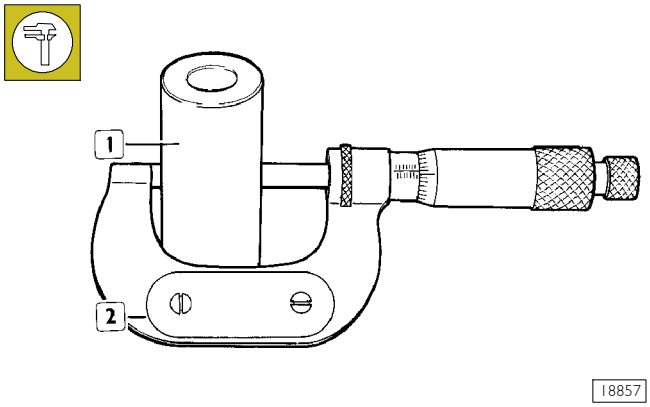
Figure 36



MAIN DATA CONCERNING KS. PISTON, PINS AND SPLIT RINGS

Piston pins

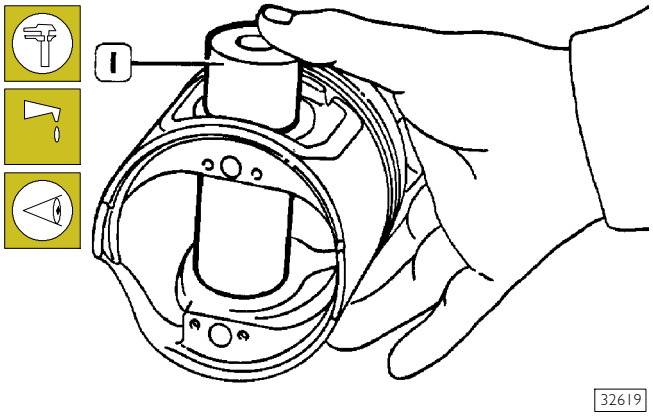
Figure 37



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

Conditions for proper pin-piston coupling

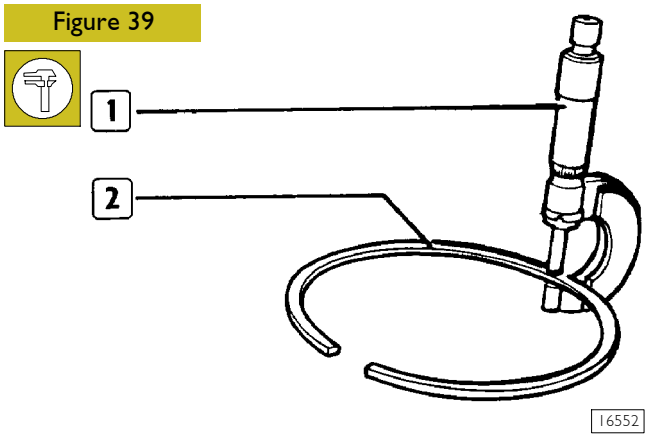
Figure 38



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.

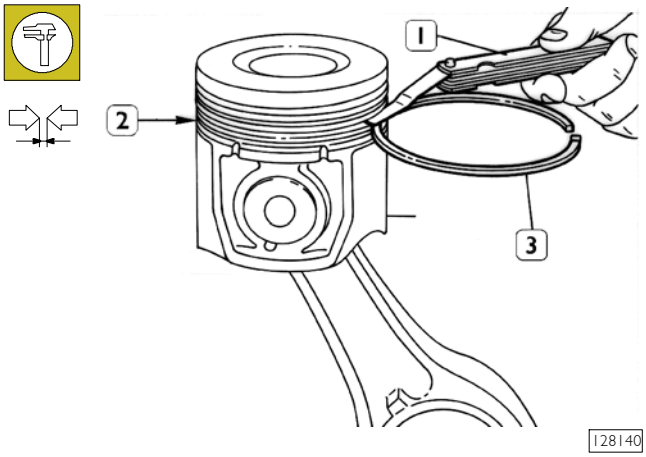
Split rings

Figure 39



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

Figure 40



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

Figure 41

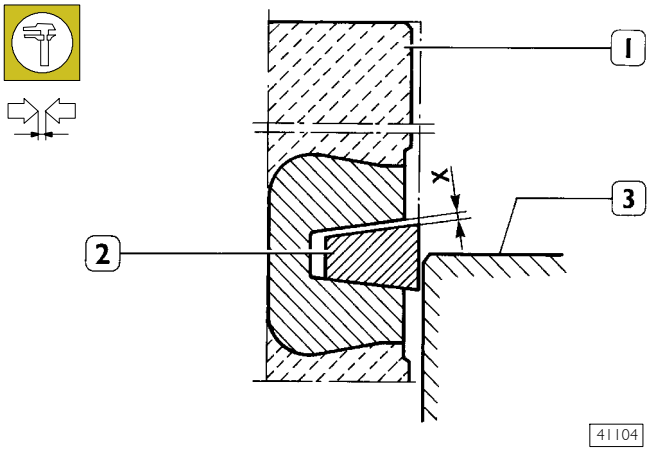
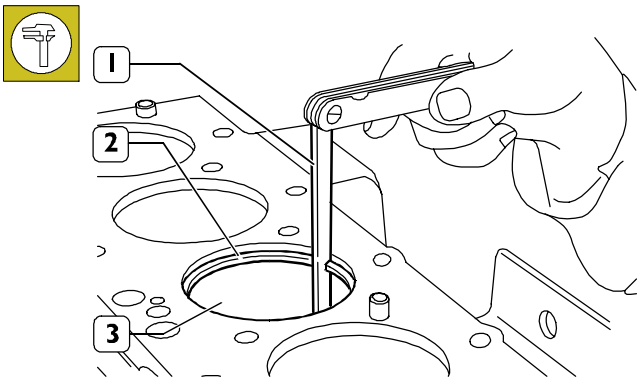


DIAGRAM FOR MEASURING THE CLEARANCE X BETWEEN THE FIRST PISTON SLOT AND THE TRAPEZOIDAL RING

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

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

Figure 42



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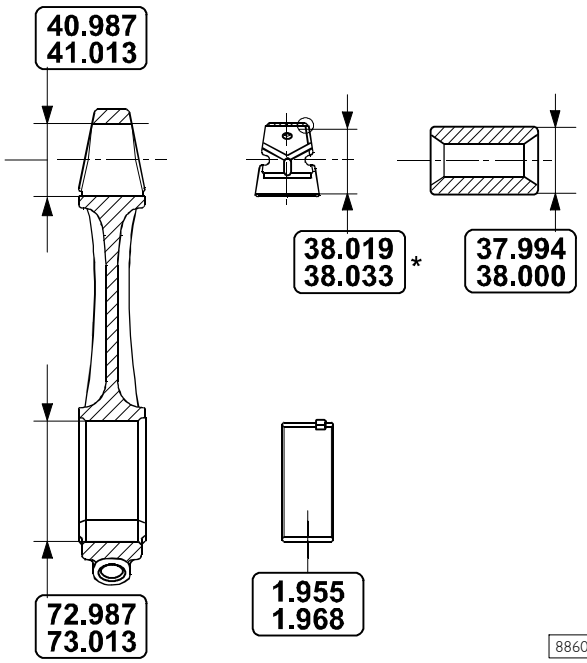
Use feeler gauge (1) to measure the clearance between the ends of the split rings (2) fitted into the cylinder barrel (3).

Connecting rods

Figure 43



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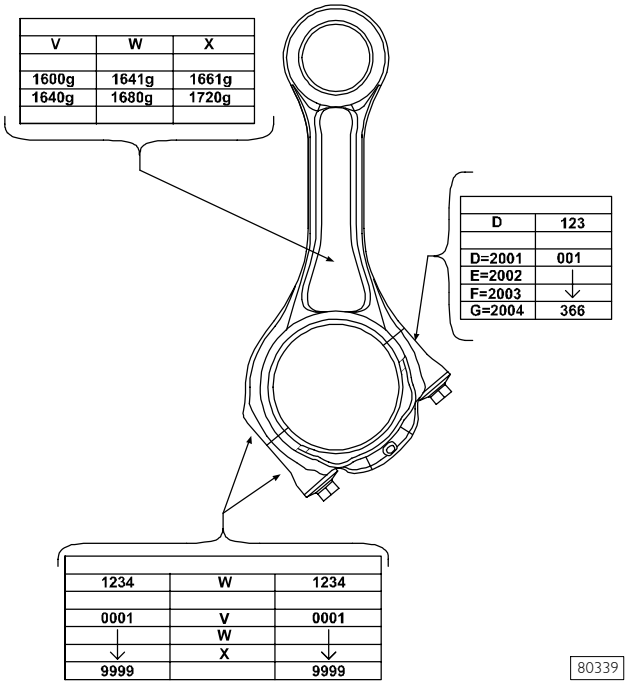
NOTE The surface of connecting rod and rod cap are knurled to ensure better coupling.
Therefore, it is recommended not to smooth the knurls.

Figure 44



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NOTE Every connecting rod is marked as follows:

- On body and cap with a number showing their coupling and the corresponding cylinder.
  In case of replacement it is therefore necessary to mark the new connecting rod with the same numbers of the replaced one.
- On body with a letter showing the weight of the connecting rod assembled at production:
  - V, 1820 to 1860 (yellow marking);
  - W, 1861 to 1900 (green marking);
  - X, 1901 to 1940 (blue marking);

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

Material removal is not allowed.

Bushes

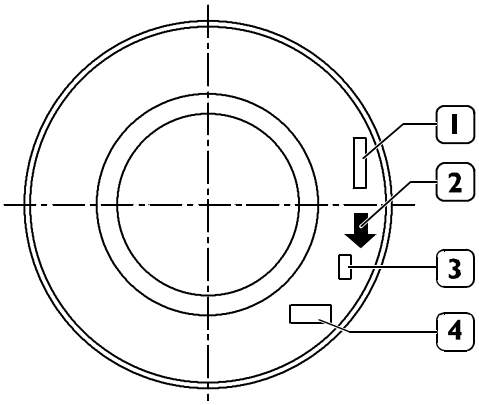
Check that the bush in the connecting rod small end is free from scoring or seizing and that it is not loosen. Otherwise replace.

Removal and refitting shall be performed using the proper beater.

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

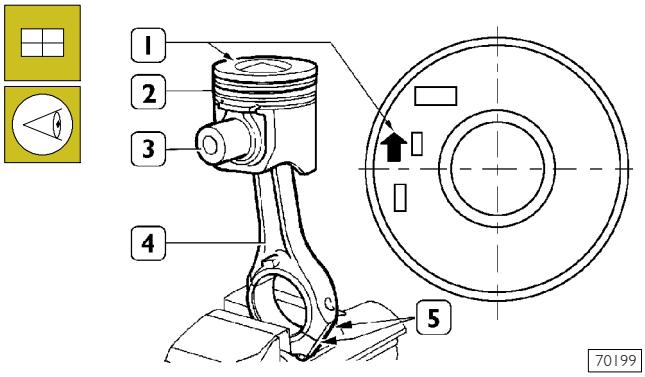
Fitting connecting rod-piston assembly
Connecting rod-piston coupling

Figure 45



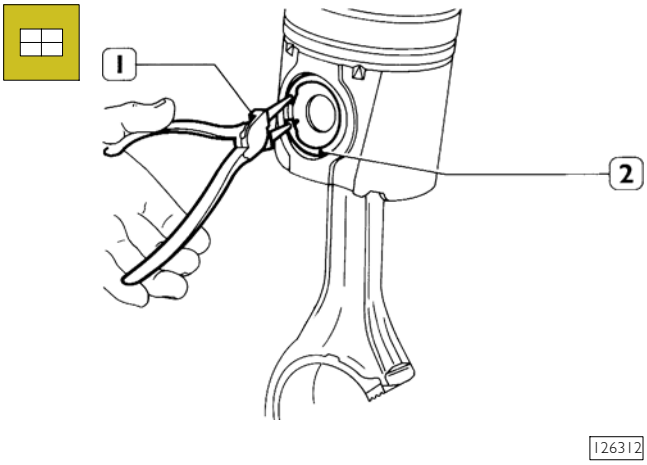
The piston crown is marked as follows:
1. Part number and design modification number;
2. Arrow showing piston assembling direction into cylinder barrel, this arrow shall face the front key of the engine block;
3. Marking showing 1st slot insert testing;
4. Manufacturing date.

Figure 46



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

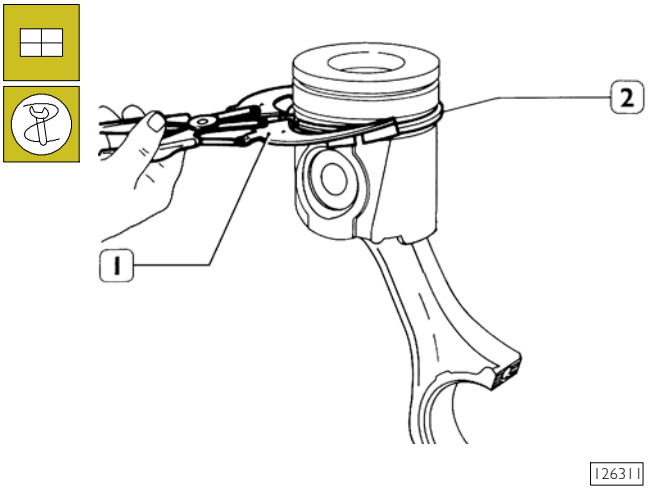
Figure 47



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

Fitting split rings

Figure 48

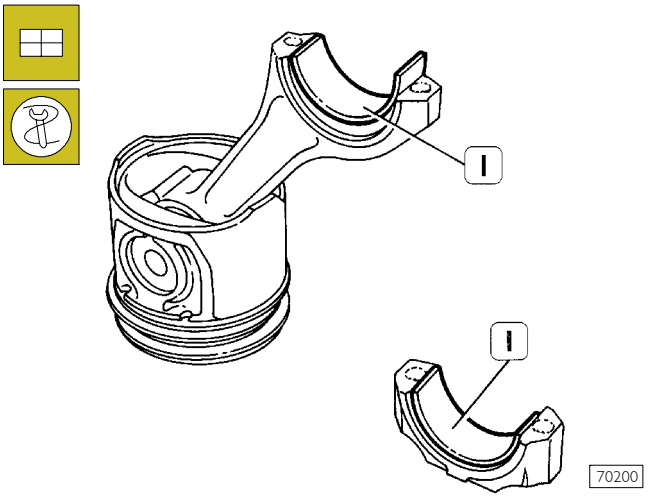


Use pliers 99360183 (1) to fit the split rings (2) on the piston. Split rings shall be fitted with the marking "TOP" facing upwards and their openings shall be displaced with each other by 120°.

NOTE Split rings are supplied spare with the following sizes:

- standard;
- 0.4 mm oversize.

Figure 49

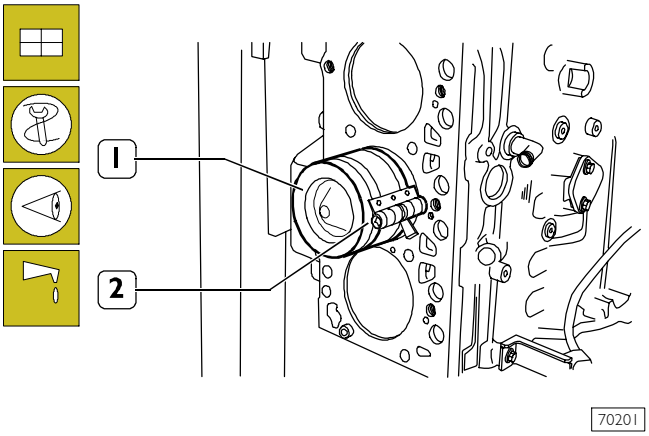


Fit half bearings (1) on connecting rod and cap.

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

Fitting connecting rod-piston assembly into cylinder barrels

Figure 50



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

Use band 99360605 (2) to fit the connecting rod-piston assembly (1) into the cylinder barrels and check the following:

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

Figure 51

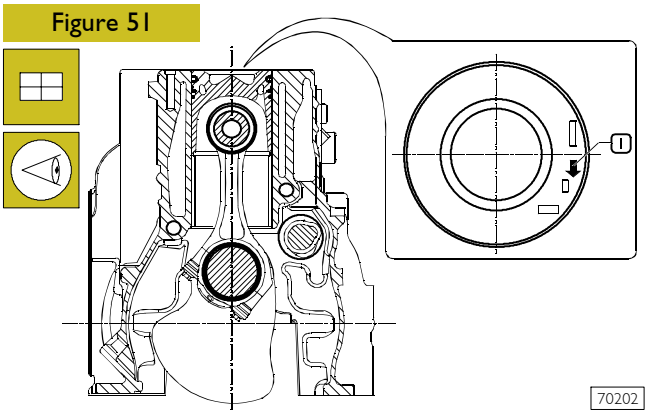
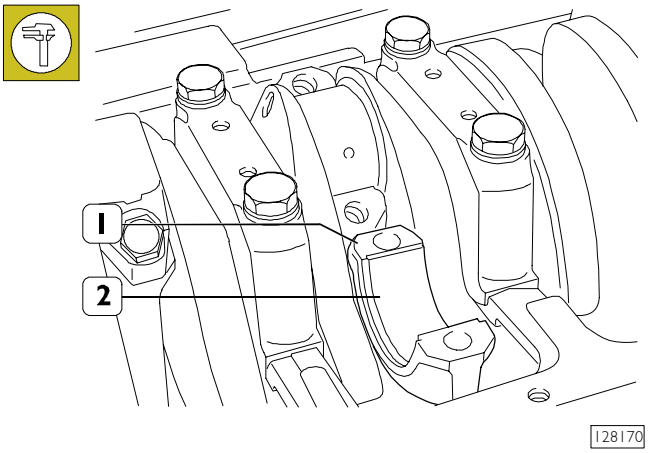


DIAGRAM FOR CONNECTING ROD-PISTON ASSEMBLY FITTING INTO BARREL

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

Finding crankpin clearance

Figure 52



To measure the clearance proceed as follows:

- ❑ clean the parts accurately and remove any trace of oil;
- ❑ fit the connecting rod caps (1) with the relevant half bearings (2).

NOTE Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:
if D1 - D2 < 0,1 mm the screw can be utilised again;
if D1 - D2 > 0,1 mm the screw must be replaced.

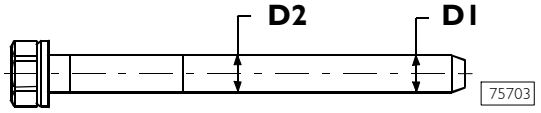
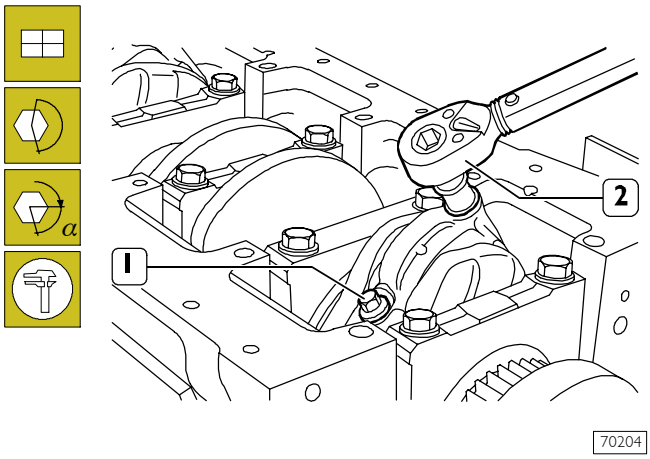
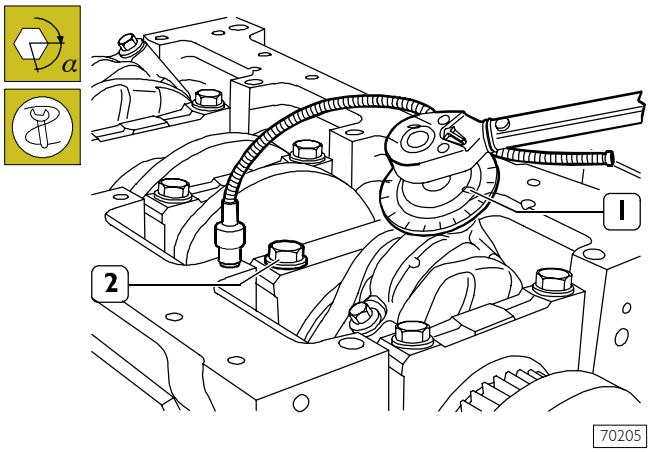


Figure 53



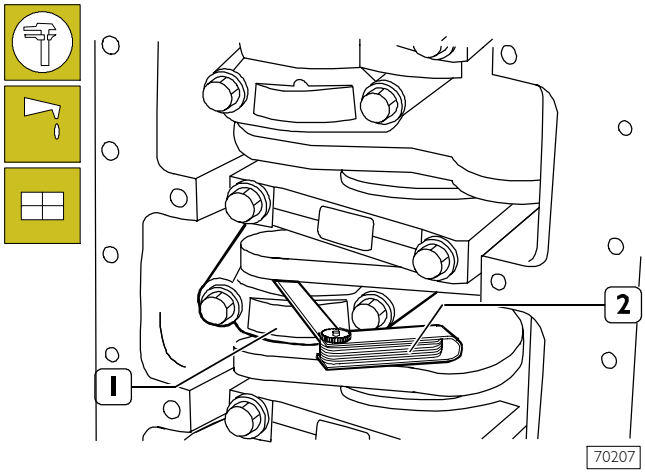
❑ Lubricate the screws (1) with engine oil and then tighten them to the specified torque using the dynamometric wrench (2).

Figure 54



❑ Apply tool 99395216 (1) to the socket wrench and tighten screws (2) of 60° ± 5°.

Figure 55



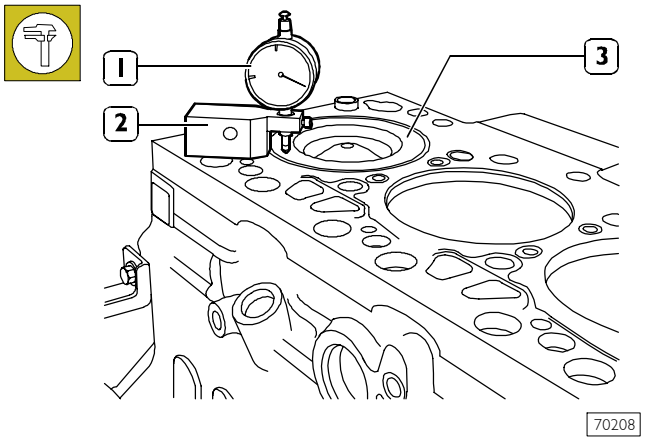
If a different clearance value is found, replace the half bearings and repeat the check.

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

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

Checking piston protrusion

Figure 56

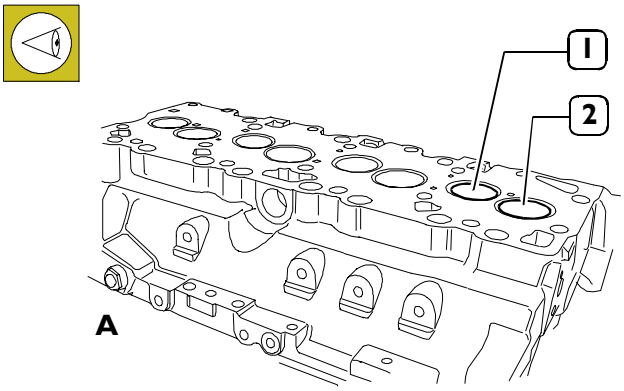


Once connecting rod-piston assemblies refitting is over, use dial gauge 39395603 (1) fitted with base 99370415 (2) to check piston (3) protrusion at T.D.C. with respect to the top of the engine block.

Protrusion shall be 0.28 to 0.52 mm.

CYLINDER HEAD
Removing the valves

Figure 57



75750

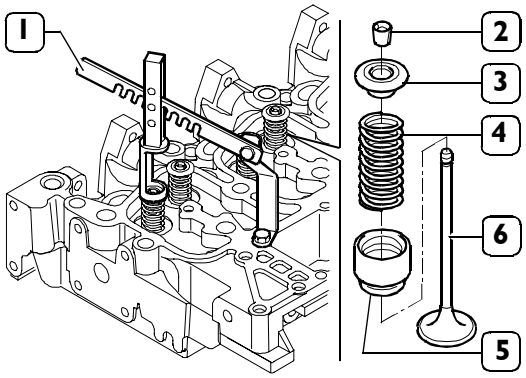
Intake (1) and exhaust (2) valves have heads with the same diameter.

The central notch (→) of the exhaust valve (2) head distinguishes it from the intake valve.

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

A = intake side – S = exhaust side

Figure 58



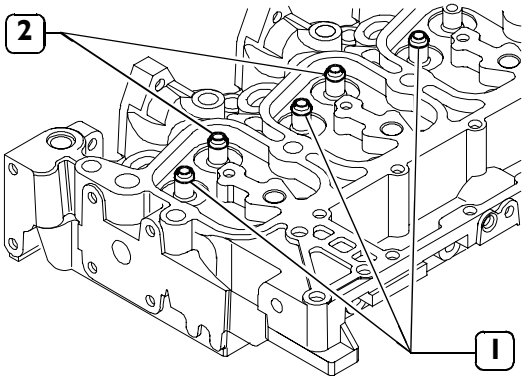
75751

Valve removal shall be performed using tool 99360268 (1) and pressing the cap (3) so that when compressing the springs (4) the cotters (2) can be removed. Then remove the cap (3) and the springs (4).

Repeat this operation for all the valves.

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

Figure 59



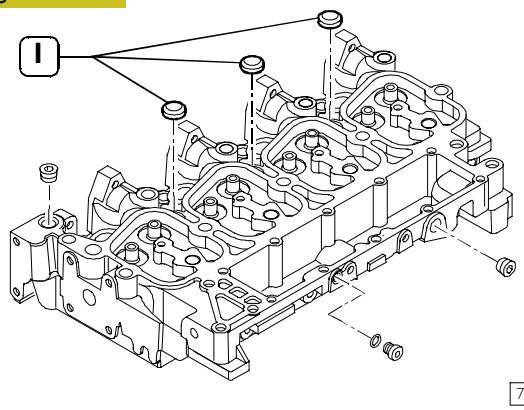
75752

NOTE Sealing rings (1) for intake valves are yellow.

Sealing rings (2) for exhaust valves are green.

Checking cylinder head wet seal

Figure 60



This check shall be performed using the proper tools.

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

Replace the cup plugs (1) if leaks are found, use the proper beater for their removal/refitting.

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

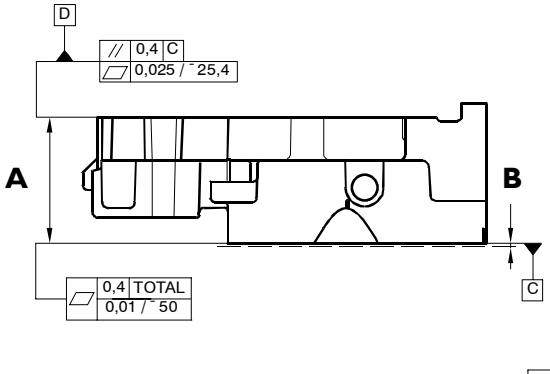
Replace the cylinder head if leaks are found.

Checking cylinder head supporting surface

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

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

Figure 61

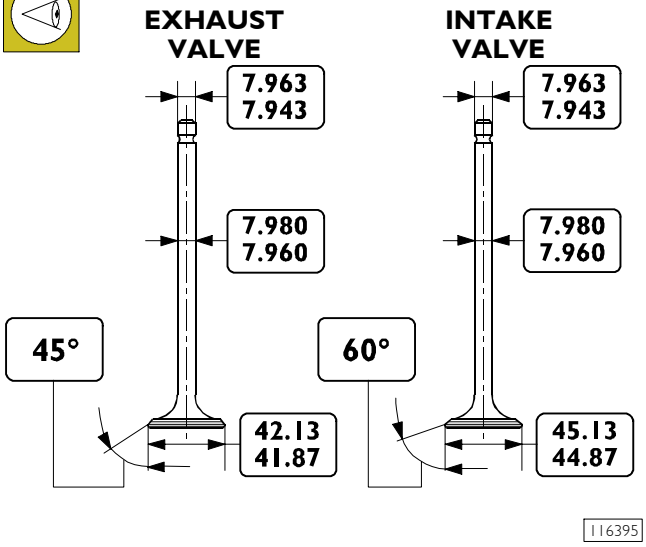


The rated thickness A for the cylinder head is 95 ± 0.25 mm, max. metal removal shall not exceed thickness B by 0.13 mm.

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

VALVES

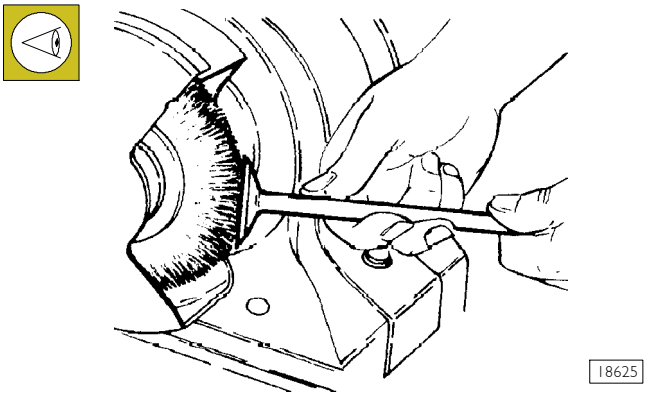
Figure 62



INTAKE AND EXHAUST VALVE MAIN DATA

Removing carbon deposits, checking and grinding valves

Figure 63

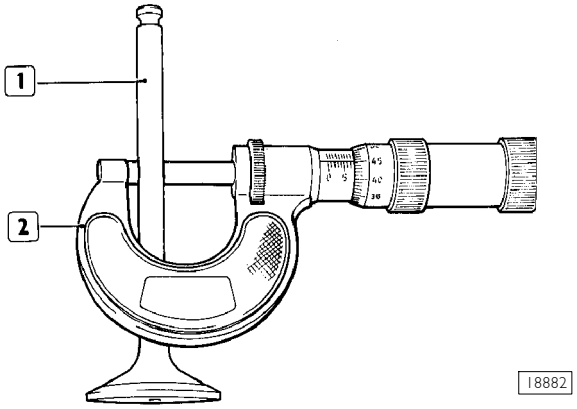


Remove carbon deposits from valves using the proper metal brush.

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

Regrind the valve seats, if required, removing as less material as possible.

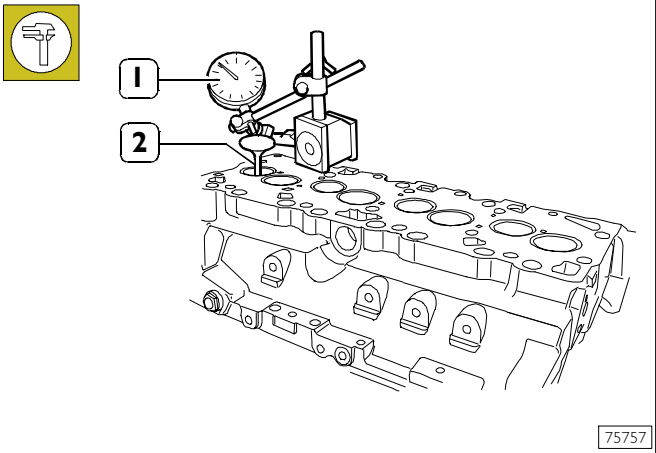
Figure 64



Check the valve stem (1) using a micrometer (2), it shall be 7.943 to 7.963.

Checking clearance between valve stem and valve guide and valve centering

Figure 65

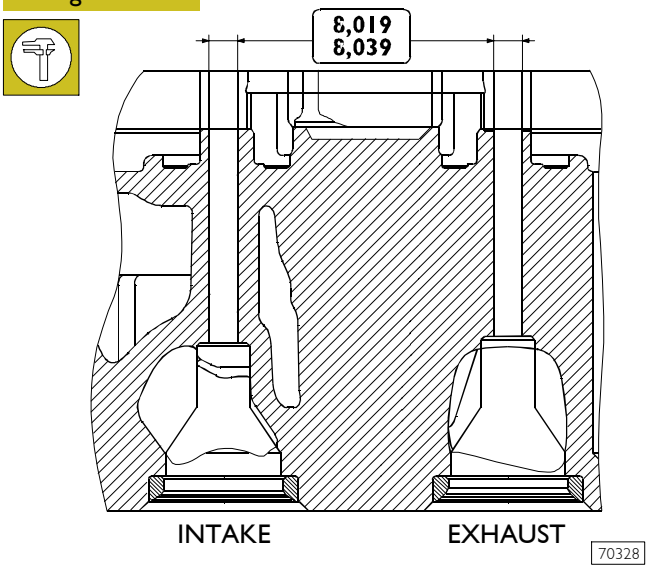


Use a magnetic base dial gauge (1) set as shown in the figure, the assembling clearance shall be 0.056 ± 0.096 mm.

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

VALVE GUIDE

Figure 66

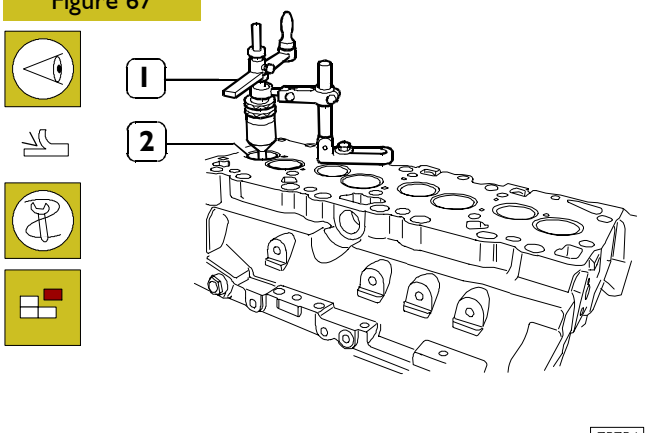


Use a bore dial gauge to measure the inside diameter of the valve guides, the read value shall comply with the value shown in the figure.

VALVE SEATS

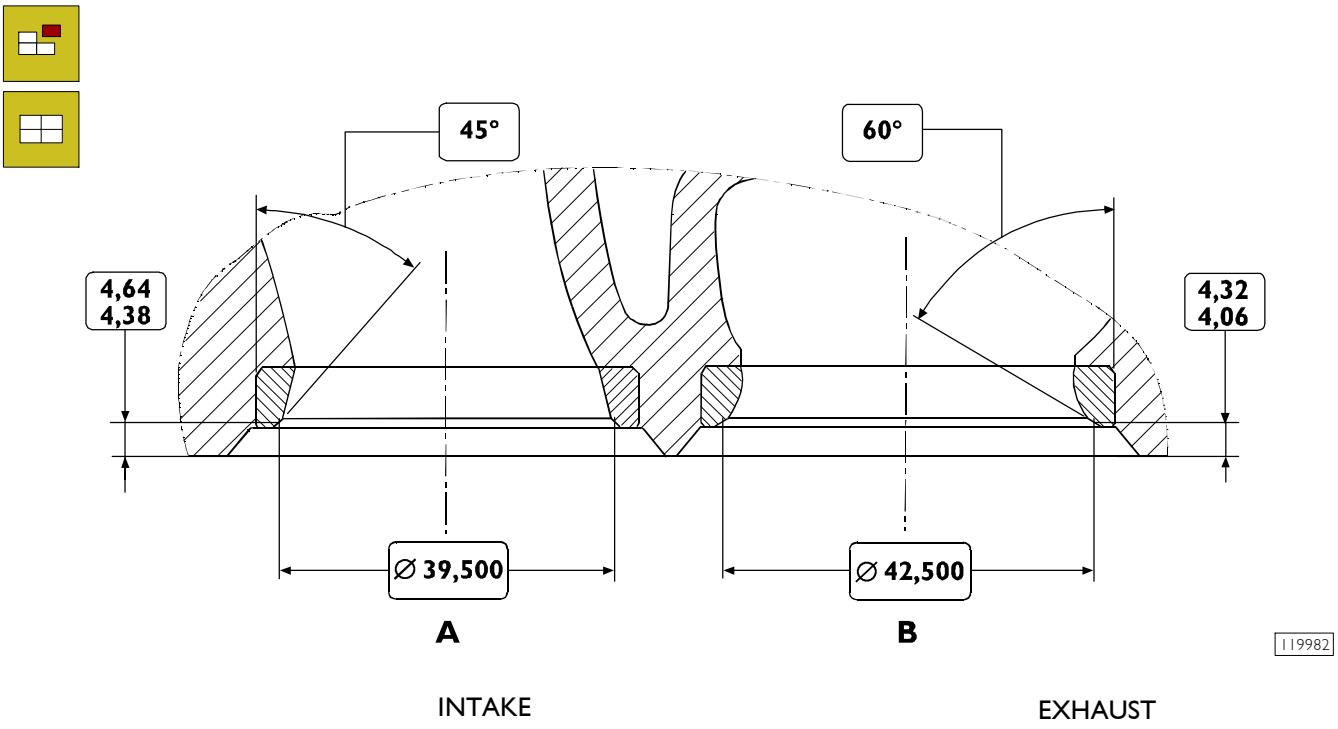
Regrinding – replacing the valve seats

Figure 67



Check the valve seats (2). If slight scoring or burnout is found, regrind seats using adequate tool (1) according to the angle values shown in Figure 68.

Figure 68



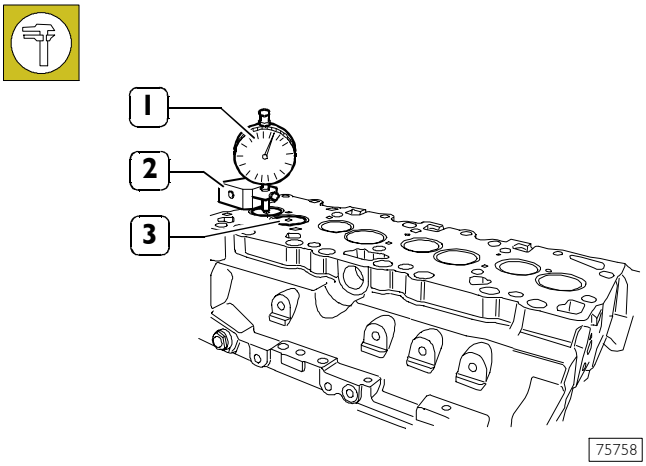
VALVE SEAT MAIN DATA

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

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

Use adequate tool to regrind the valve seats according to the values shown in Figure 68.

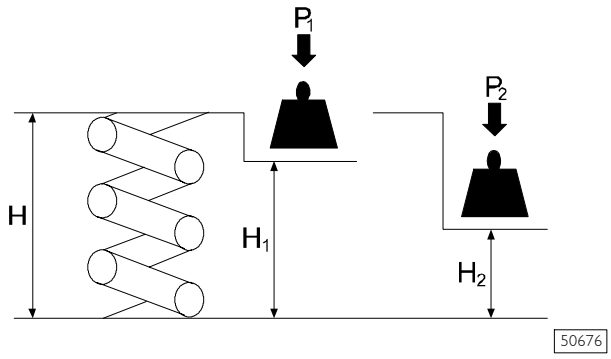
Figure 69



After regrinding, check that valve (3) sinking value is the specified one by using the base 99370415 (2) and the dial gauge 99395603 (1).

VALVE SPRINGS

Figure 70



MAIN DATA TO CHECK INTAKE AND EXHAUST VALVE SPRINGS

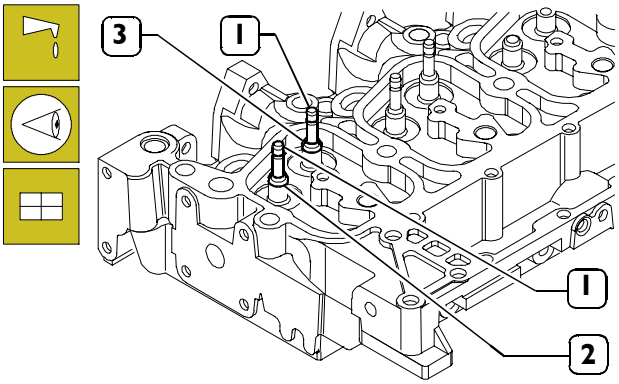
Before refitting use adequate tool to check spring flexibility. Compare load and elastic deformation data with those of the new springs shown in the following table.

Height		Under a load of
mm		N
H (free)	63.50/65.69*	0
H_1	49.02	329
H_2	38.20	641

* Installed as an alternative

FITTING CYLINDER HEAD

Figure 71

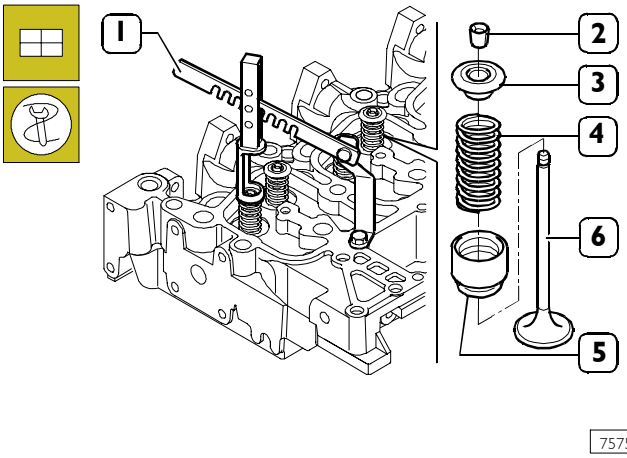


Lubricate the valve stems (1) and fit them into the relevant valve guides according to the position marked at removal.

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

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

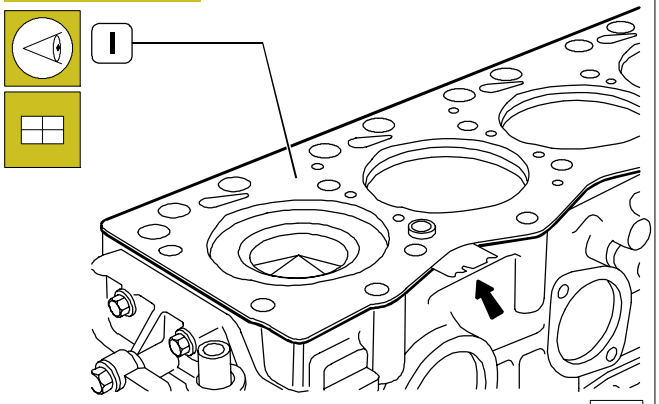
Figure 72



Position on the cylinder head: the spring (4), the upper cap (3); use tool 99360268 (1) to compress the spring (4) and lock the parts to the valve (5) by the cotters (2).

Refitting the cylinder head

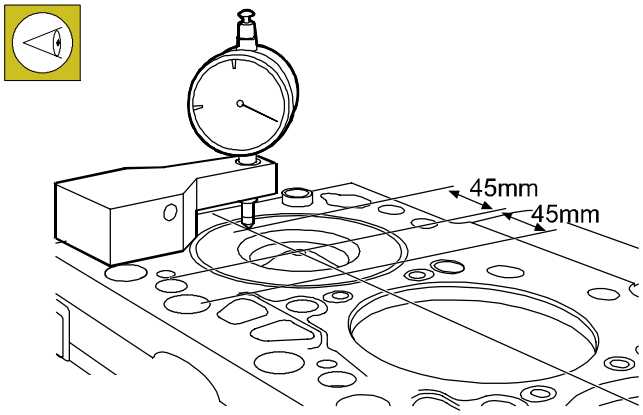
Figure 73



87759

Check cleanness of cylinder head and engine block coupling surface.
Take care not to foul the cylinder head gasket.
Set the cylinder head gasket (1) with the marking "TOP" (1) facing the head.
The arrow shows the point where the gasket thickness is given.

Figure 74



88775

There are two types of head seals, for the thickness (1.25 mm Type A and 1.15 mm Type B) take the following measures:

- ❑ for each piston detect, as indicated on Figure 74, at a distance of 45 mm from the centre of the piston overhandings S1 and S2 in relation to the engine base upper plane then calculate the average:

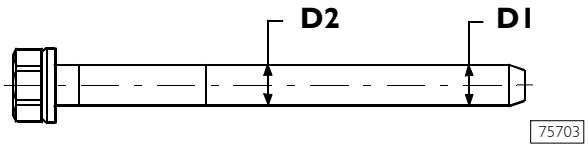
$$S_{cil1} = \frac{S1 + S2}{2}$$

For 4 cylinder versions:

Repeat the operation for pistons 2, 3 and 4 and calculate the average value.

$$S = \frac{S_{cil1} + S_{cil2} + S_{cil3} + S_{cil4}}{4}$$

NOTE Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:
if D1 - D2 < 0,1 mm the screw can be utilised again;
if D1 - D2 > 0,1 mm the screw must be replaced.



75703

TIGHTENING TORQUE

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

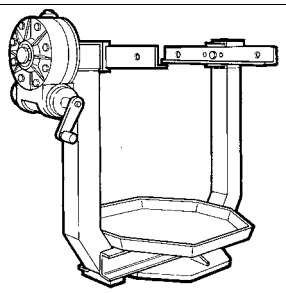
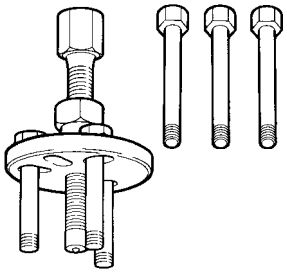
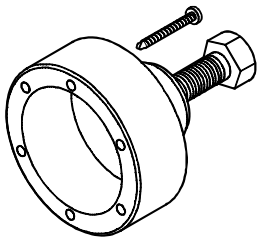
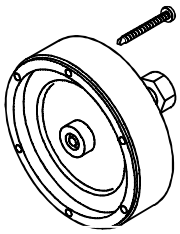
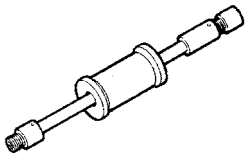
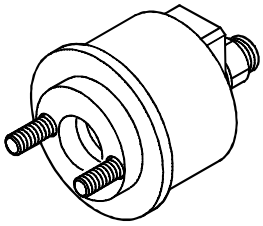
COMPONENT		TORQUE	
		Nm	kgm
Rear lifting bracket (M12x1.75x30)		77 ± 12	7.7 ± 1.2
Crankshaft pulley (M12x1.75x10.9)		110 ± 5	11.0 ± 0.5
Flywheel housing			
(M12x120)		85 ± 10	8.5 ± 1.0
(M12x80)		85 ± 10	8.5 ± 1.0
(M10x80)		49 ± 5	4.9 ± 0.5
(M10x40)		49 ± 5	4.9 ± 0.5
Flywheel housing (M12x1.25)	1st stage	30 ± 4	3.0 ± 0.4
	2nd stage	60° ± 5°	
Assy rear cover plate to flywheel housing (M8x1.25x16)		24 ± 4	2.4 ± 0.4
Fuel injectors		60 ± 5	6.0 ± 0.5
Fuel lift pump		24 ± 4	2.4 ± 0.4
Turbocharger to exhaust manifold (M10)		43 ± 6	4.3 ± 0.6
Oil feed to oil filter head		24 ± 4	2.4 ± 0.4
Oil feed to turbocharger (M12x1.5)		35 ± 5	3.5 ± 0.5
Oil drain (M8x1.25x16)		24 ± 4	2.4 ± 0.4
Alternator to alternator support (M8x1.25x30)		24 ± 4	2.4 ± 0.4
Alternator to water inlet conn. assy (M8x1.25x30)		24 ± 4	2.4 ± 0.4
Lower alternator mounting (M10x1.25x25)		24 ± 4	2.4 ± 0.4
Alternator upper pivot to support (M10)		49 ± 5	4.9 ± 0.5
Alternator mounting hardware (M12x1.75x120)		43 ± 6	4.3 ± 0.6
Alternator wiring (M6x1.0 nut)		10 ± 2	1.0 ± 0.2
Automatic belt tensioner mount (M10)		45 ± 5	4.5 ± 0.5
Starter motor to gear case (M10)		49 ± 5	4.9 ± 0.5
Screw M8 for fastening cylinder barrel lubricating nozzles		15 ± 3	1.5 ± 0.3
Screw M12 for fastening output shaft caps	1st stage	50 ± 6	5 ± 0.6
	2nd stage	80 ± 6	8 ± 0.6
	3rd stage	90° ± 5°	
Screw M8 for fastening camshaft longitudinal retaining plate		24 ± 4	2.4 ± 0.4
Screw M8 for fastening camshaft gear		36 ± 4	3.6 ± 0.4
Screw M10 for fastening connecting rod caps	1st stage	60 ± 5	6 ± 0.5
	2nd stage	60° ± 5°	

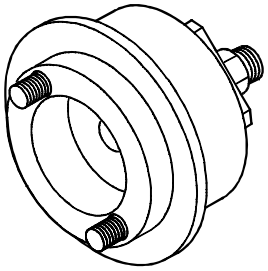
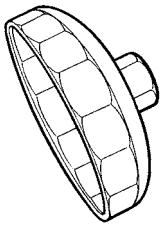
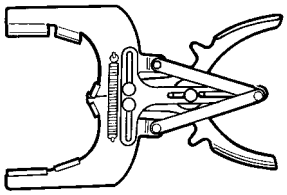
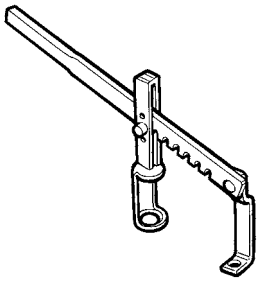
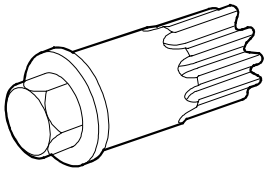
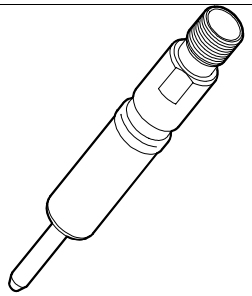
SECTION 5

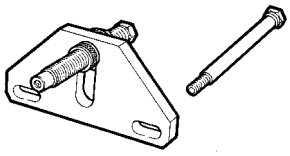
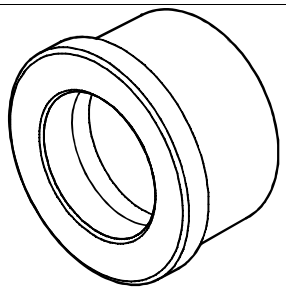
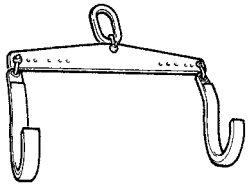
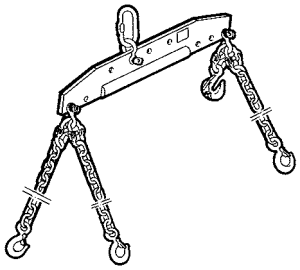
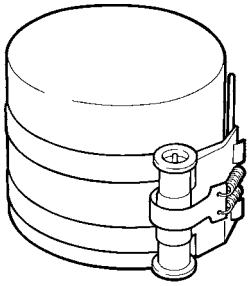
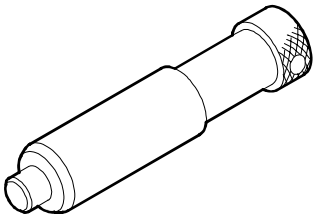
Tools

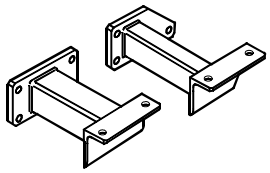
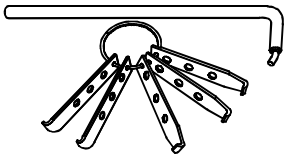
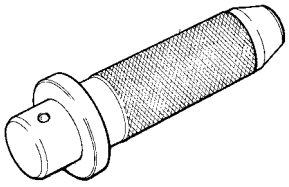
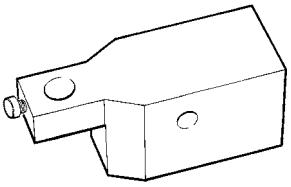
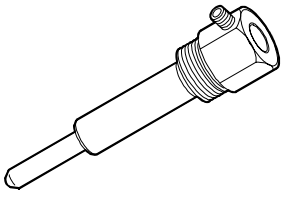
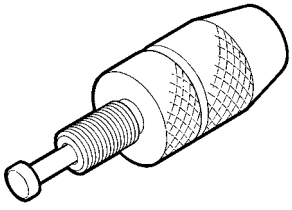
Page

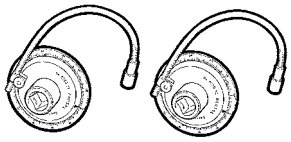
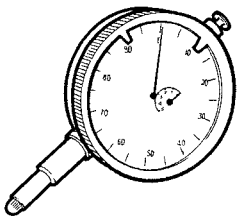
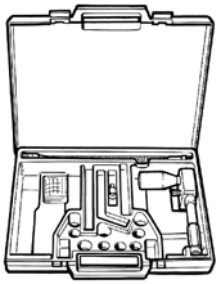
TOOLS

TOOL NO.		DESCRIPTION
99322205		Revolving stand for overhauling units (1000 daN capacity, 120 daN/m torque)
99340035		Injection pump gear extractor
99340055		Tool to remove output shaft front gasket
99340056		Tool to remove output shaft rear gasket
99340205		Injector pull-our tool
99346252		Tool for fitting output shaft rear gasket

TOOL NO.		DESCRIPTION
99346253		Tool for fitting output shaft rear gasket
99360076		Tool to remove oil filter (engine)
99360183		Pliers for removing/refitting piston rings (65 – 110 mm)
99360268		Tool for removing/refitting engine valves
99360330		Flywheel crank handle
99360344		Adapter, cylinder compression test (use with 99395682)

TOOL NO.		DESCRIPTION
99360351		Tool for stopping the engine flywheel
99360362		Beater for removing/refitting camshaft bushes (to be used with 99370006)
99360500		Tool for lifting the output shaft
99360595		Lifting rig for engine removal/refitting
99360605		Band for fitting piston into cylinder barrel (60 – 125 mm)
99360616		Engine TDC positioning tool

TOOL NO.		DESCRIPTION
99361037		Brackets for fastening engine to revolving stand 99322205
99363204		Tool to remove gaskets
99370006		Interchangeable willow handgrip
99370415		Gauge base for different measurements (to be used with 99395603)
99395097		Tool to check top dead centre (use with 99395604)
99395100		Dial gauge holder for rotary injection pump timing (use with 99395603)

TOOL NO.		DESCRIPTION
99395216		Pair of gauges with ½" and ¾" square head for angle tightening
99395603		Dial gauge (0 – 5 mm)
99395604		Dial gauge (0 – 10 mm)
99395682		Diesel fuel engine cylinder compression control device

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.